R-493

PERFORMANCE OF HOT-POURED AND COLD-APPLIED JOINT SEALERS

C. C. Rhodes
L. T. Oehler

Research Laboratory Division
Office of Testing and Research

Research Project R-62 G-116
Research Report No. R-493

Michigan State Highway Department
Lansing, February 1965

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This report briefly summarizes the performance of various liquid-type joint sealers used in recent years in Michigan State Highway Department pavement and bridge construction. "Liquid-type" is used here to refer to both hot- and cold-applied materials whose volume remains virtually unchanged when compressed. This classification includes hot-pour, rubber-asphalt sealers; two-component, cold-applied materials; and the single-component, mastic-type compound currently being used only in pavement longitudinal joints. All examples given in this report are joint materials in new concrete pavements and bridges which had been in service less than three years (and in many cases, less than one year) at the time of inspection. The following four projects (two experimental and two regular construction) have been selected as examples:

1. US 27-M 78 between Lansing and Charlotte (Construction Project M 23-17, C14 RN), studied under Research Project 36 G-4(10).

2. I 94 between Mt. Clemens and Marysville (Construction Projects BI 50111I, C12; BI 50111J, C13; BI 50111K, C22; BI 50112A, C1; BI 77111A, C2; BI 77111B, C3; and BI 77111D, C4).

3. I 496 between Mt. Hope and Cavanaugh Roads (Construction Projects I 33045D, C1, and S12 and S14 of 33045D), studied under Research Projects 62 NM-66 and 63 NM-85.

4. Rest Area on Southbound I 75 south of M 57 (Construction Project I 25032C, C7).

US 27-M 78 Between Lansing and Charlotte

This experimental project was undertaken with the cooperation of the newly formed Joint Seal Manufacturers' Association (JSMA), with all six member companies participating. In 1956, the joints of a 24-ft concrete roadway about 10 miles long were sealed with six different makes of each of two types of hot-poured, rubber-asphalt sealer (regular type meeting Federal Specification SS-S-164, and a slightly softer grade); and five brands of cold-applied materials; as well as several products developed especially for this project by the various manufacturers. These special products included both hot-pour and two-component, cold-applied materials of the jet-fuel-resistant type. In all, 24 different joint sealing materials were used in the project.

Installation was finished in the early fall of 1956. An inspection was made in March 1957, at the end of the first winter, by representatives of all six companies and three members of the Research Laboratory Division staff. All agreed on the following points (recorded in the minutes of a meeting immediately following the inspection):

1. That the hot-pour materials in Series 1, 2, and 3A were giving performance superior by a considerable margin to that of the cold-applied materials in Series 3B (two-component) and Series 4 (single-component mastic type).

2. That the softer hot-pour materials produced to Michigan's proposed specification (Series 1) generally appeared to be better than either the regular SS-S-164 materials (Series 2) or the manufacturers' specially developed hot-pour materials (Series 3A), although some individual products were exceptions to this general rule.

3. That the cold-applied, single-component materials meeting current Michigan specifications (Series 4) were entirely unsatisfactory as a class, although some products performed better than others.

4. That the special two-component, jet-fuel-resistant products installed by their respective manufacturers (Series 3B) were better than the cold-applied materials of Series 4, but not on a par with the hot-pour materials of Series 1, 2, and 3A.

Another inspection was made by JSMA and Laboratory representatives two years later, on April 2, 1959, and comparative performance of the five classes of joint sealing materials was again discussed. It was the consensus of the group that:

1. None of the joints in this project now seemed well sealed.

2. All hot-pour materials were giving considerably better performance than cold-applied materials.

3. The regular SS-S-164 materials (Series 2) were proving superior to the softer materials (Series 1) and the specially developed hot-pour materials (Series 3A). This was different from the previous survey, when the softer materials (Series 1) seemed better.

4. The regular Michigan specification cold-applied sealer was a complete failure in transverse joints.

The condition of five brands of regular hot-pour, rubber-asphalt sealer at the end of 2-1/2 years is shown in Figs. 1 through 5. All these examples show loss of sealer adhesion to the joint faces and penetration by stones and dirt in varying degrees, with the material pictured in Fig. 5 showing up best in this regard. Good adhesion can be easily recognized by the "necking down" of the sealer in the joint space, manifested by a light colored dust or powdery film that collects in the depression. Extrusion of sealer, on the other hand, means infiltration of foreign material at some time in the cyclic change of joint width.

Three makes of two-component, cold-applied sealers in the same project are shown in Figs. 6, 7, and 8. The first, PRC (Fig. 6), was of a tough, rubbery consistency that exhibited excellent resistance to penetration, but the force required to extend it was so great that the sealer pulled completely away from the joint faces during cold weather. The second, Allied Materials 9015 H, was a two-component, machine-applied material that lost its resiliency fairly early and also failed in adhesion. The third material, a special two-component, hand-mixed compound prepared by Servicised Products, performed little better than the single-component, mastic type that had failed so badly in transverse joints; it was easily penetrated by stones and failed in both cohesion and adhesion. Fig. 9 shows a typical example of the failure of single-component, mastic-type, cold-applied sealer. Loss of cohesion is extreme and the material affords practically no protection for the joint space against the infiltration of foreign materials.

I 94 Between Mt. Clemens and Marysville

Probably the most universal and extreme failure of hot-poured, rubber-asphalt joint sealers in recent years was found in seven pavement construction projects between Mt. Clemens and Marysville, totaling approximately 30 miles and completed in the summer and fall of 1963. The sealer had failed in most joints before the winter had hardly begun. The projects were surveyed in November 1963, and the results reported by M. G. Brown and D. F. Simmons (Research Report No. R-456) in April 1964. Pictures from that report are reproduced here as Figs. 10 through 15. Since all the sealing was done under varying weather conditions from summer through fall by four different contractors using sealants from three different manufacturers, it proved very difficult to explain why such a high proportion of the sealing was of generally poor quality.

I 496 Between Mt. Hope and Cavanaugh Roads

At about the same time that joint sealing work was finished on the Mt. Clemens-to-Marysville projects, the joints on both roadways and grade separation structures of I 496 between Mt. Hope and Cavanaugh Roads were being sealed with various experimental sealers, in addition to regular hot-pour, rubber-asphalt materials. Locations of these sealers are shown in Fig. 16 and typical condition at the end of one year in Figs. 17 through 21. Fig. 17 shows an experimental two-component, hand-mixed sealer, Presstite 54/404, which had shown up well in Laboratory tests and was recommended for field testing by the Research Laboratory Division. Here, again, the two-component, cold-applied material exhibited excellent resistance to penetration, but suffered considerable loss of bond to the joint faces. The same material in a bridge expansion dam is shown in Fig. 18.

A second experimental, two-component, cold-applied sealer, Products Research Co. Rubbercalk 3000, is shown as placed in a pavement contraction joint in Fig. 19, and in a bridge expansion dam in Fig. 20. This material seems to have somewhat better adhesion than the Presstite 54/404, especially in the bridge joint, but otherwise their characteristics are similar.

A typical joint sealed with hot-poured, rubber-asphalt sealer (Permiteco) is shown in Fig. 21. These joints were also one year old when inspected. This example shows the general failure in adhesion, cohesion, and resilience that characterizes most of the joints sealed with this material.

Rest Area on Southbound I 75 South of M 57

The joints in this area were sealed with a two-component, cold-applied sealer (H. S. Peterson Co.) in August 1964. With the advent of cooler weather, a widespread cohesion failure of the sealant was noticed and the project was inspected on December 29, 1964. Fig. 22 shows separation of the material along the approximate centerline of the joint, which existed to a greater or lesser degree in at least 70 percent of all joints. Although some adhesion failure was noted, it was spotty and of short length. An unusual defect is shown in Fig. 23, which indicates the effect of placing the Ethafoam filler too high in the joint space. No other indication of this type of failure was found. The sealer used in this project was sampled and tested, and met all of the Department's specification requirements.

Discussion

Adequate sealing of joints in concrete pavements and structures has been a continuing, unsolved problem ever since the first pavement was built. Through the years, a great many mechanical devices have been invented, patented, and tried, mostly with indifferent success, and the most widely used method of sealing joints has remained various liquid-type sealers, such as tar, asphalt, and rubber-asphalt. Qualities affecting the performance of liquid-type sealers are temperature susceptibility, ductibility, resilience, internal resistance to extension, weather resistance, adhesiveness, and application characteristics. Performance of the various materials has varied widely depending on how many of these essential favorable qualities they possessed. All failures illustrated in this report can be attributed to the lack of one or more of them. Pavement design, especially joint spacing and size and shape of the joint groove, also greatly affects sealer performance.

While some liquid-type sealers have outperformed others by a considerable margin, and in some cases have done a fairly creditable job, they are all subject to the same limitations imposed by their inherent incompressibility. In Michigan pavements, no matter at what points the construction and sealing operations enter the annual cycle of temperature changes, liquid-type sealers will progressively extrude from the joint space, with simultaneous replacement in the joint by foreign materials entrapped during the extension phase and folded in during the compression phase. This phenomenon is bound to occur except in pavements where considerably narrower ranges of joint width change are brought about by the use of much shorter slabs.

On the other hand, neoprene compression seals are almost entirely free from the limitations of incompressibility because they can change volume with application and release of externally applied forces. For this reason, they have a better chance of doing an adequate sealing job from the outset. It is important, of course, to make sure that the neoprene compound and sealer design are such that optimum performance will be assured.

Supplemental Survey of Sealant Performance in Cold Weather

Immediately after completion of the preceding report on sealant condition, an opportunity arose on January 29, 1965 for observation of performance of neoprene, hot-pour, and cold-applied materials in the Lansing vicinity, under most adverse conditions when the temperature fell to -1 F.

The first project where observations were made was the first experimental installation of extruded neoprene joint sealer on I 96 from M 99 to Waverly Road (Construction Projects EBACI 33083A, C1 and EBACI 33083B, C3). The limitations of this first experimental installation were described in Research Report No. R-484 (November 1964). The neoprene joint seal was relatively loose in the joint groove, and appeared in certain joints to have settled to the bottom of the joint groove (about 3/8 to 1/2 in. below the pavement surface) under this wide-open condition. The sealer was attached to the sides of the joint groove face by frost, but when the sealer was removed the joint groove and the crack below it were clean and free of foreign material (Figs. 24 and 25). The 1-in. wide neoprene seal was fitting more loosely in the joint grooves formed to the 1/2-in. width, in comparison with those formed to the 3/8-in. width. With the presently specified width of 1-1/4 in. for the joint seal in a 1/2-in. joint groove, along with a 71-ft joint spacing, this loose condition of the seal under maximum opening of the joint should be alleviated.

In the same I 96 area, observations were made on the performance of hot-pour sealer. The condition of the seal in two such joints is shown in Figs. 26 and 27. The hot-pour seal under this temperature condition is very rigid and both adhesion and cohesion failure is quite complete for some joints (Fig. 26).

Observations were also made on performance of hot-pour sealers on the nearby experimental transverse joint project, but no photographs were taken there since that project had received its regular periodic evaluation and photographic coverage only two weeks before. This is the third winter for the sealer in these joints. The lengths of adhesion failures along joint grooves had increased and failures along the joint face were deeper than at this time last year.

The last project examined on January 29 was the I 496 installation of experimental cold-applied sealants described earlier in this report. The PRC 3000 sealant (noted as the better of the two cold-applied materials in the survey of December 1964) was soft and resilient even at -1 F. The adhesion failure, however, was complete (Fig. 28).

These observations demonstrated that the neoprene sealer was outperforming the other types of two materials, even though the improvements required in current neoprene specifications were not incorporated in this first experimental neoprene installation.

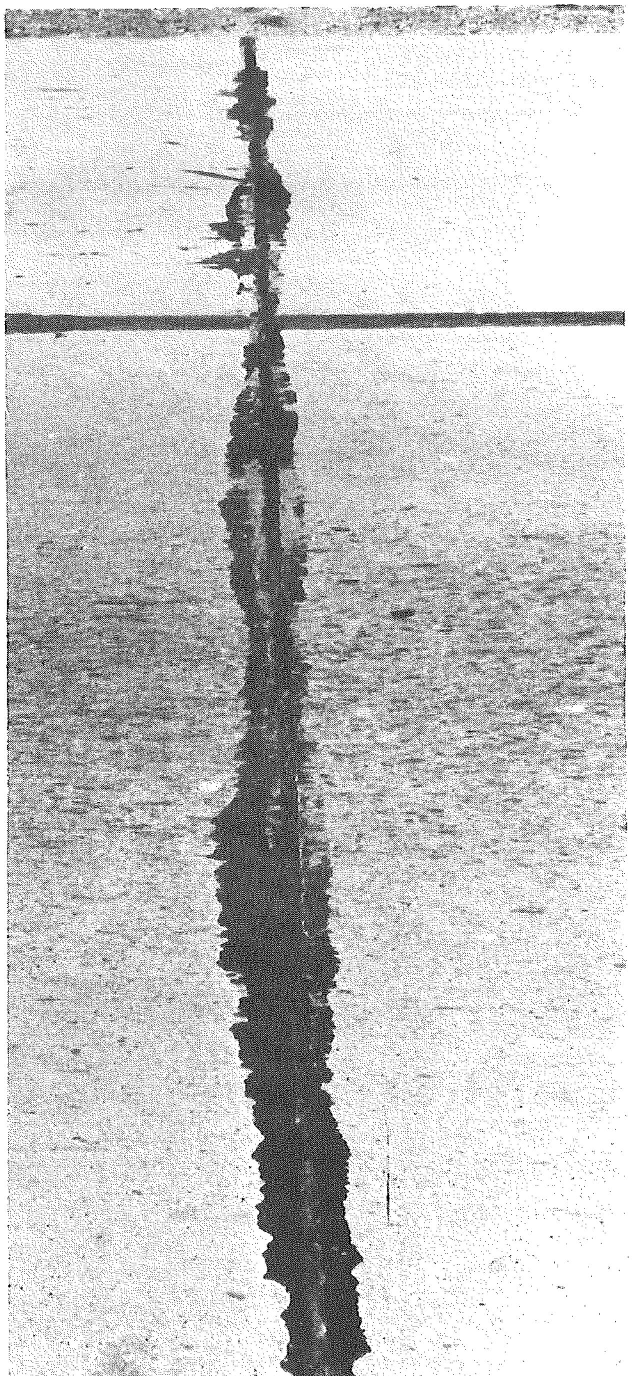


Figure 1. Considerable penetration by stones and almost total loss of adhesion after 2-1/2 years of service: Naugatuck Chemical regular (SS-S-164) hot-pour, rubber-asphalt sealer (Sta. 562+75).

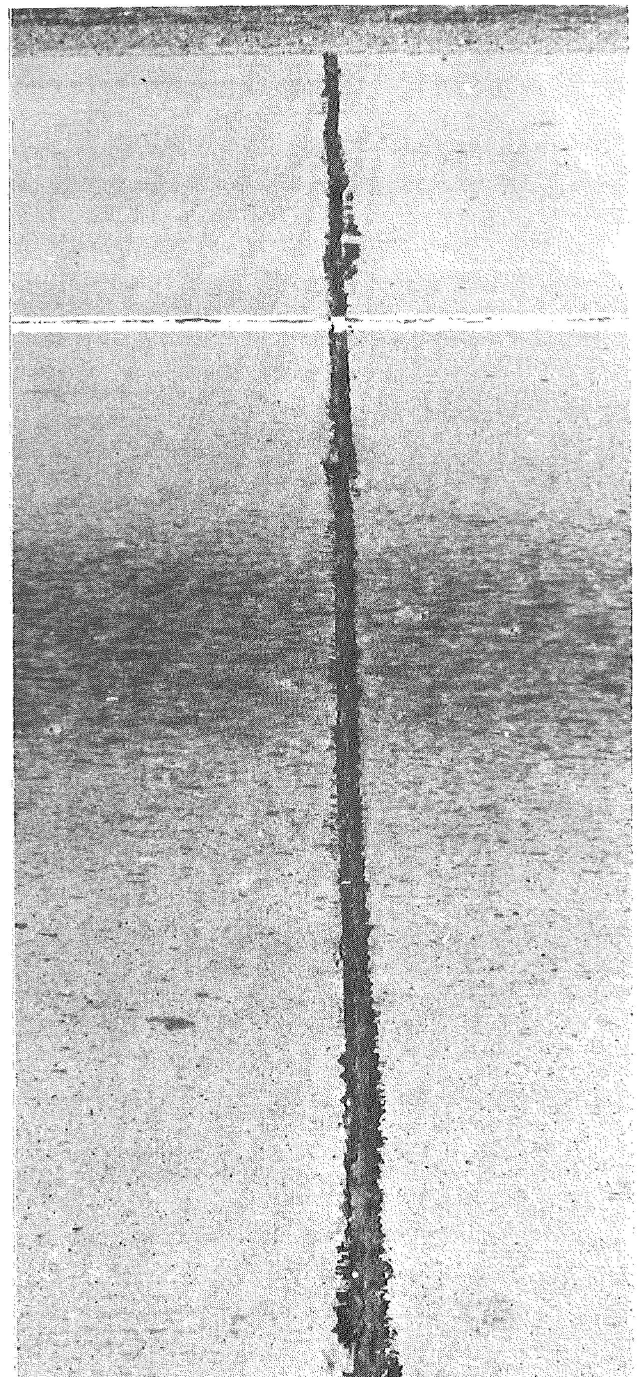


Figure 2. Complete failure (both cohesive and adhesive) and marked lack of resilience after 2-1/2 years of service: Philip Carey regular (SS-S-164) hot-pour, rubber-asphalt sealer (Sta. 586+88).

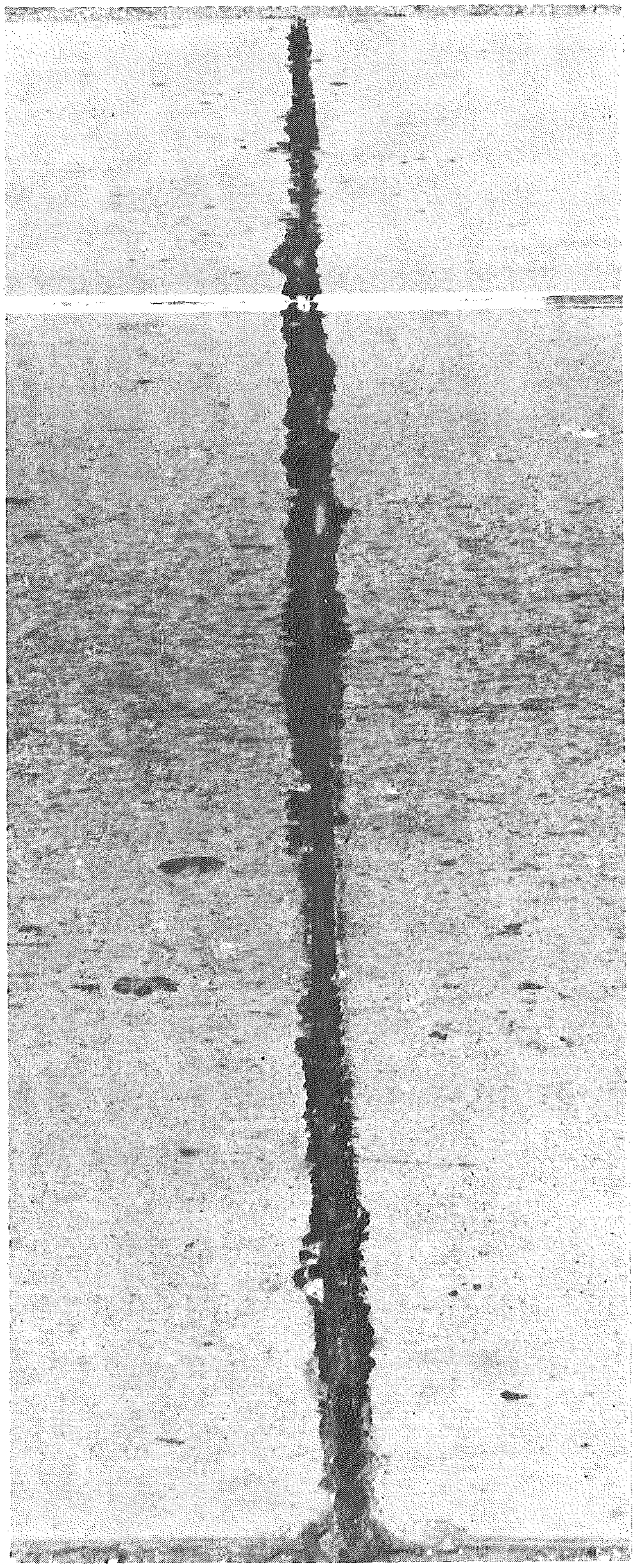


Figure 3. Very little adhesion and considerable penetration at pavement edge after 2-1/2 years of service: Presstite-Keystone regular (SS-S-164) hot-pour, rubber-asphalt sealer (Sta. 608+89).

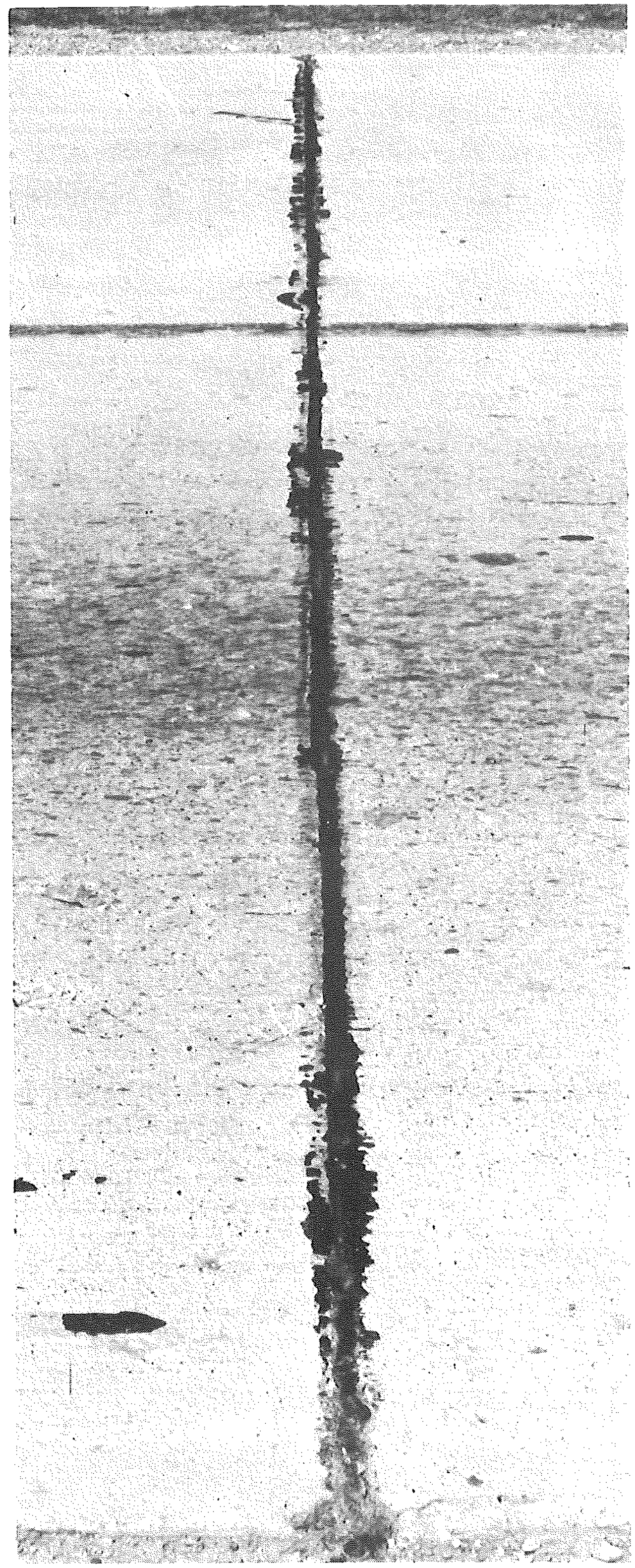


Figure 4. Almost total loss of adhesion after 2-1/2 years of service: Presstite-Keystone regular (SS-S-164) hot-pour, rubber-asphalt sealer (Sta. 641+01).

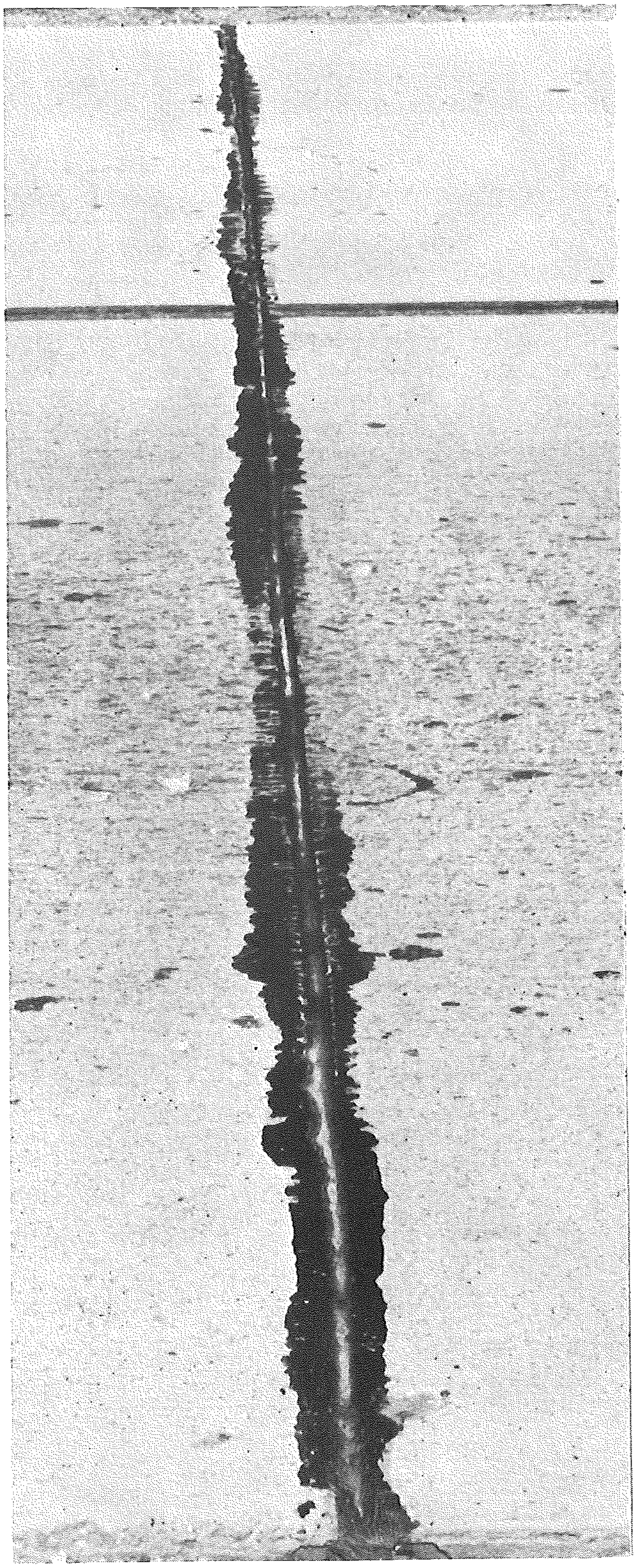


Figure 5. Necking down (light-colored depression) after 2-1/2 years of service, indicating good adhesion along most of the joint: Allied Materials regular (SS-S-164) hot-pour, rubber-asphalt sealer (Sta. 668+40).

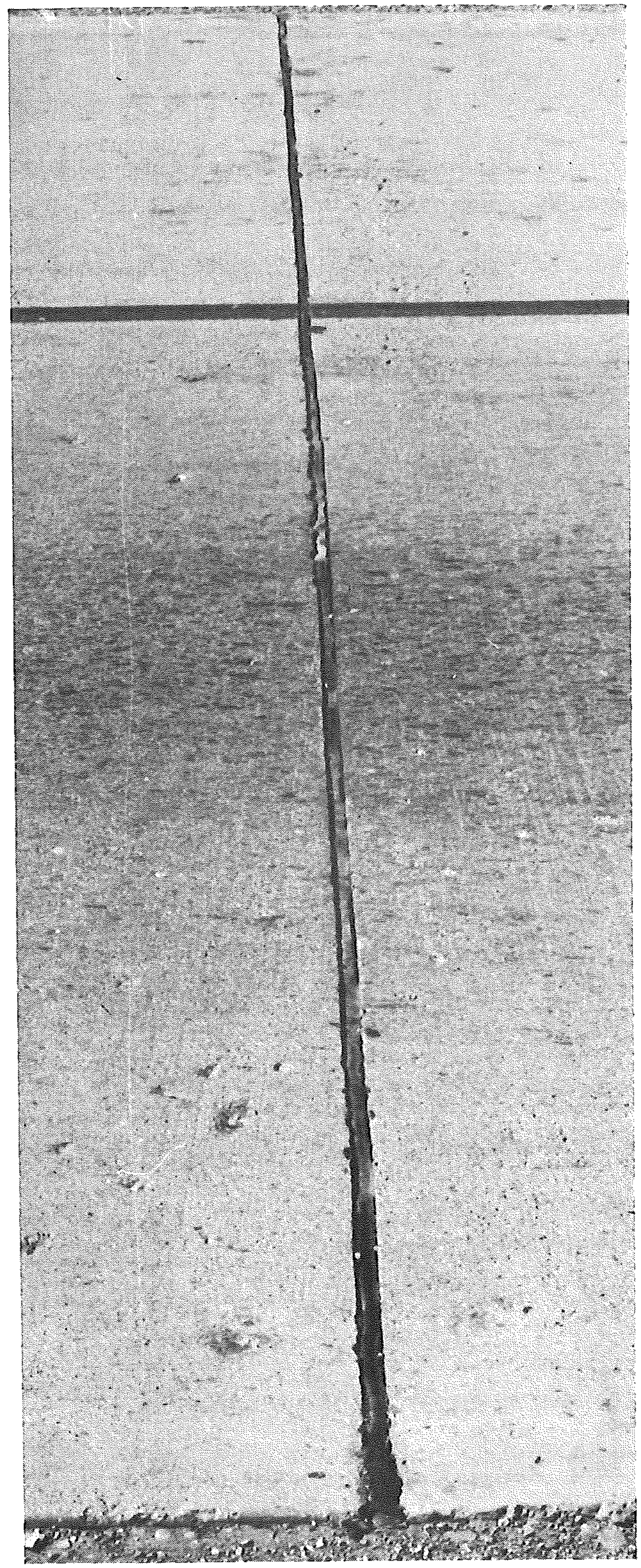


Figure 6. Complete loss of adhesion, but good resistance to penetration by larger stones, after 2-1/2 years of service: Products Research (PRC) two-component, cold-applied sealer (Sta. 436+51).

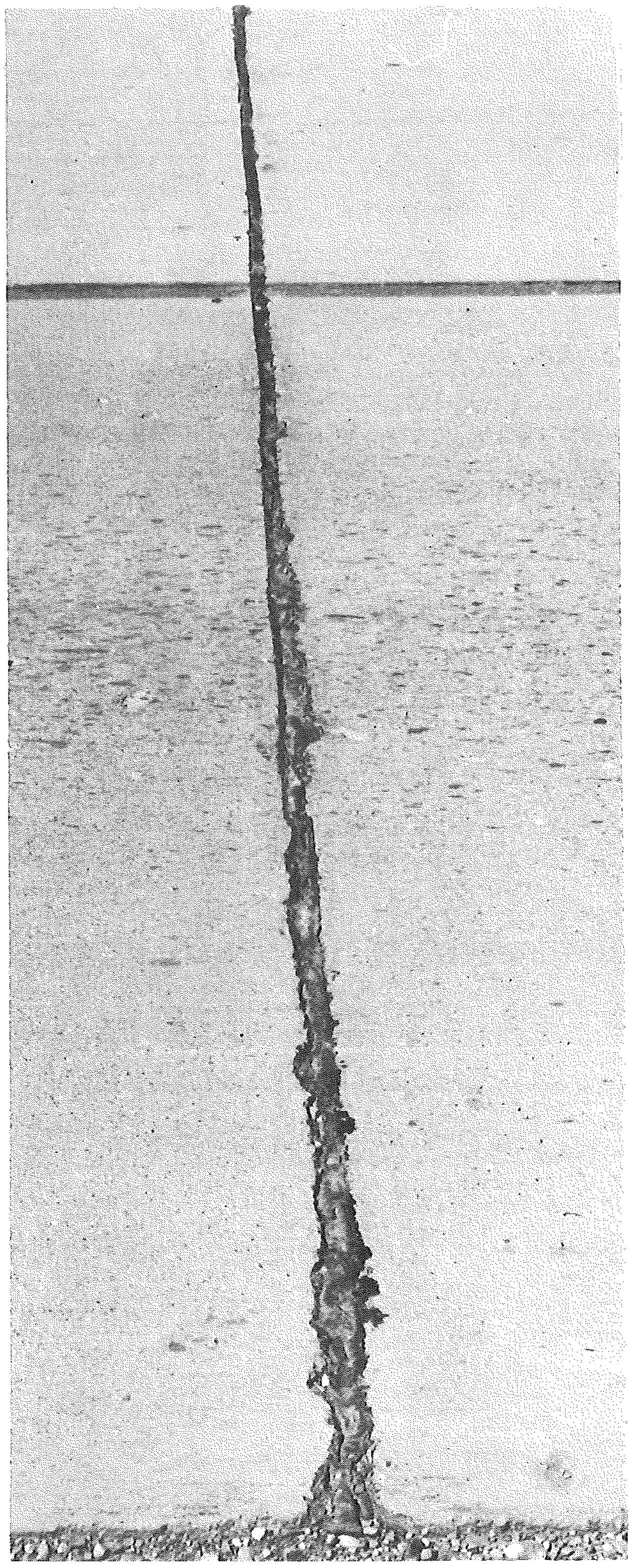


Figure 7. Total adhesion failure and poor resilience after 2-1/2 years of service: Allied Materials 9015 H two-component, cold-applied sealer (Sta. 468+02).

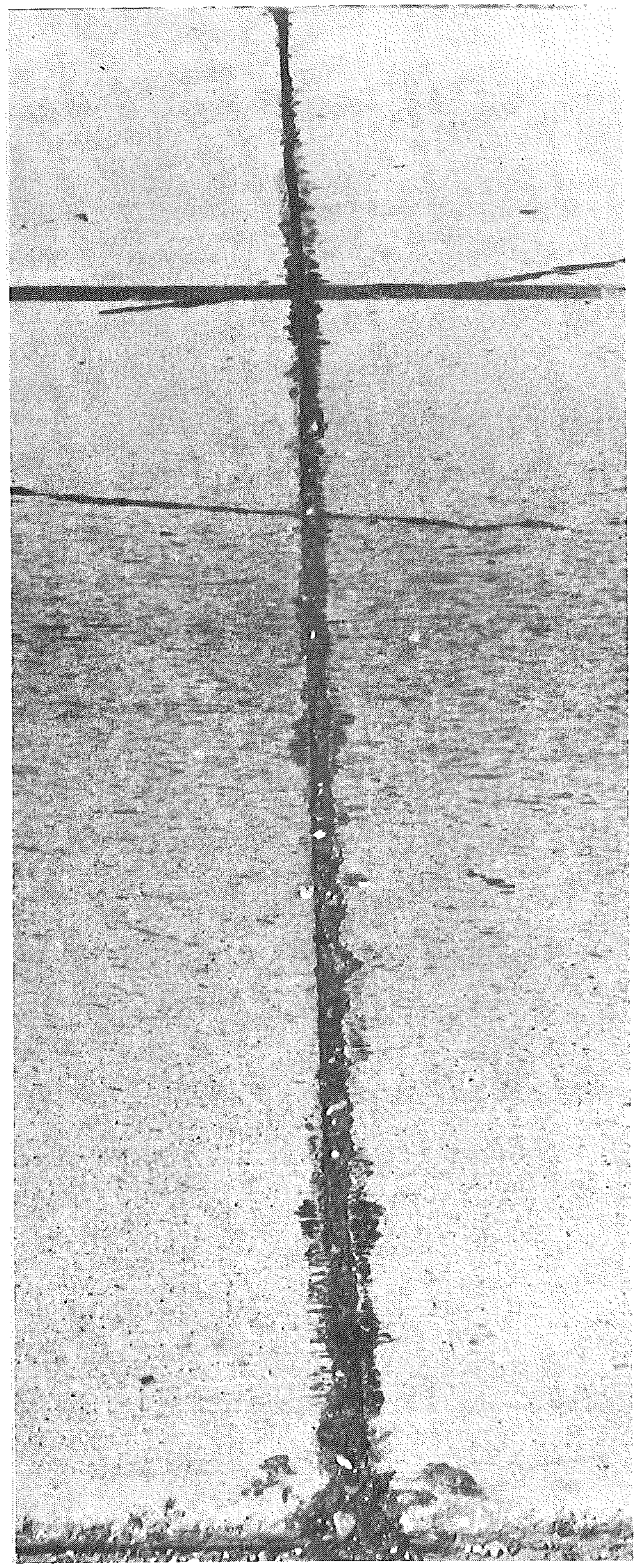


Figure 8. Very poor adhesion and cohesion and little resistance to penetration after 2-1/2 years of service: Servicised two-component, cold-applied sealer (Sta. 480+42).

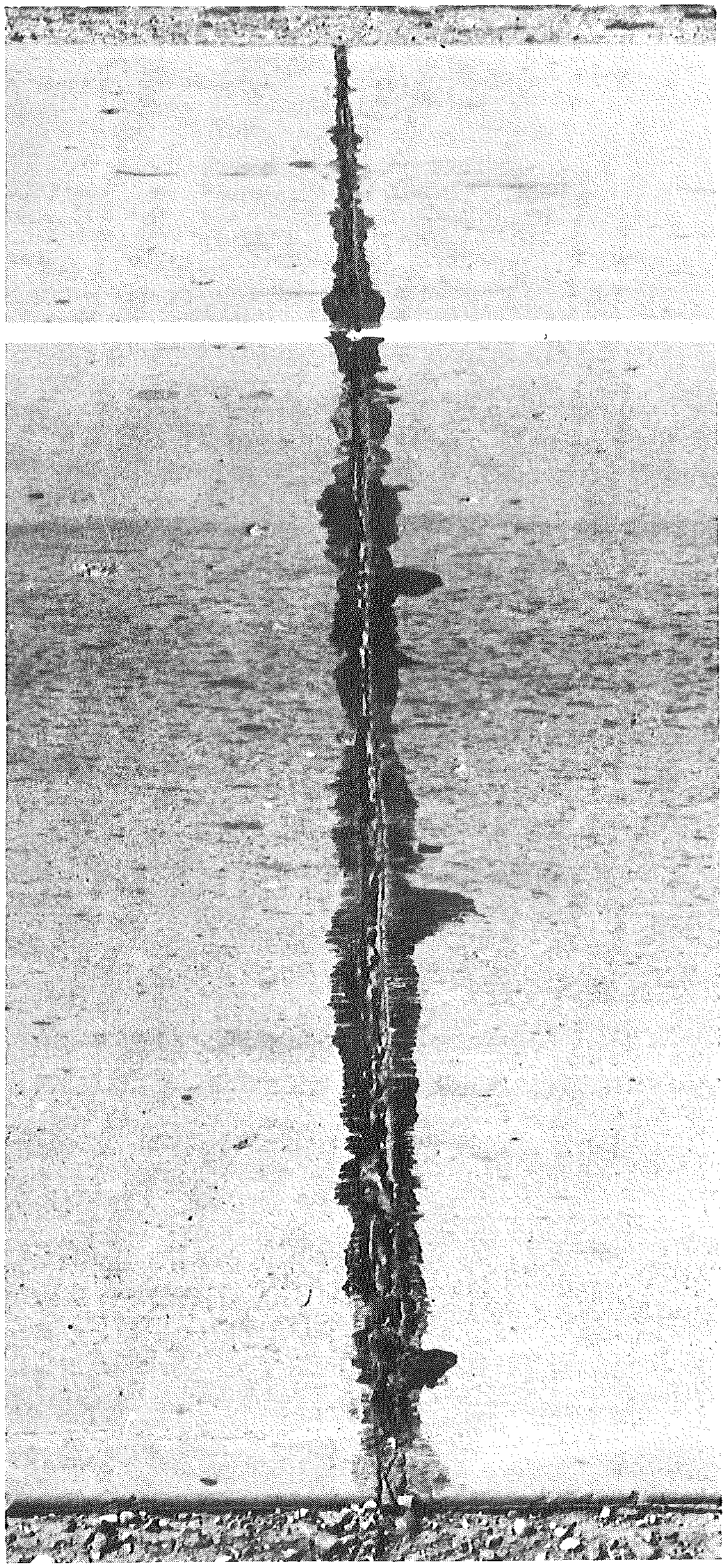
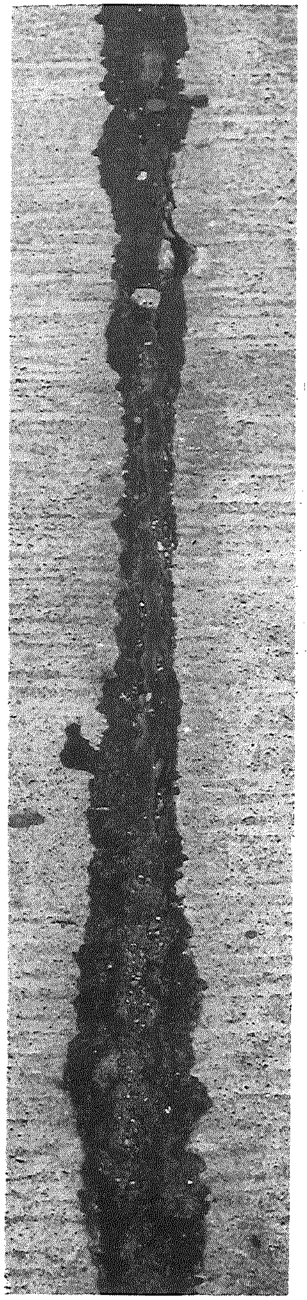


Figure 9. Total failure in cohesion and very little resistance to penetration after 2-1/2 years of service: Presstite-Keystone single-component, mastic sealer (Sta. 420+55).



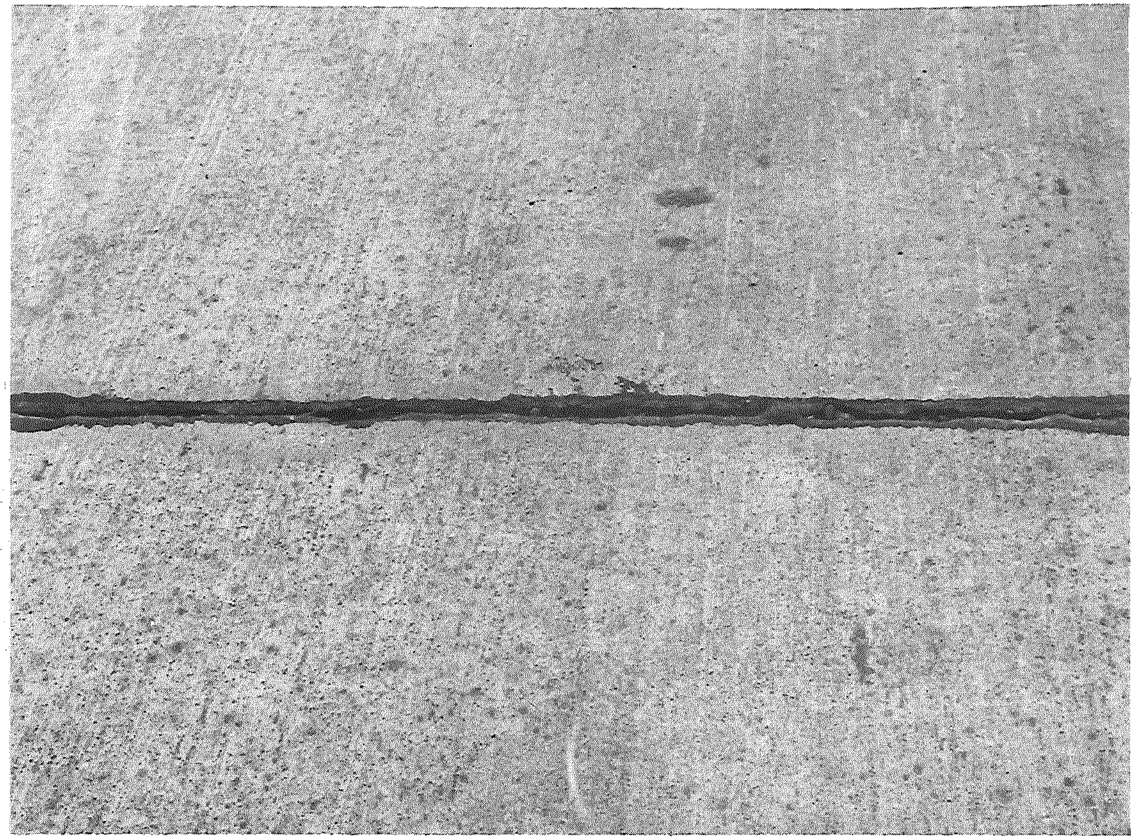


Figure 10 (left). Typical adhesion failure with sand and gravel embedded in joint seal (Project BI 50111 I, C12, Sta. 87+70 SB).

Figure 11 (above). Typical cohesion failure, with much infiltration of dirt and sand into joint (Project BI 50111J, C13, Sta. 343+80 SB).

Figure 12 (right). Typical intermittent adhesion failure with embedded dirt (Project BI 50112A, C1, Sta. 538+60 NB).

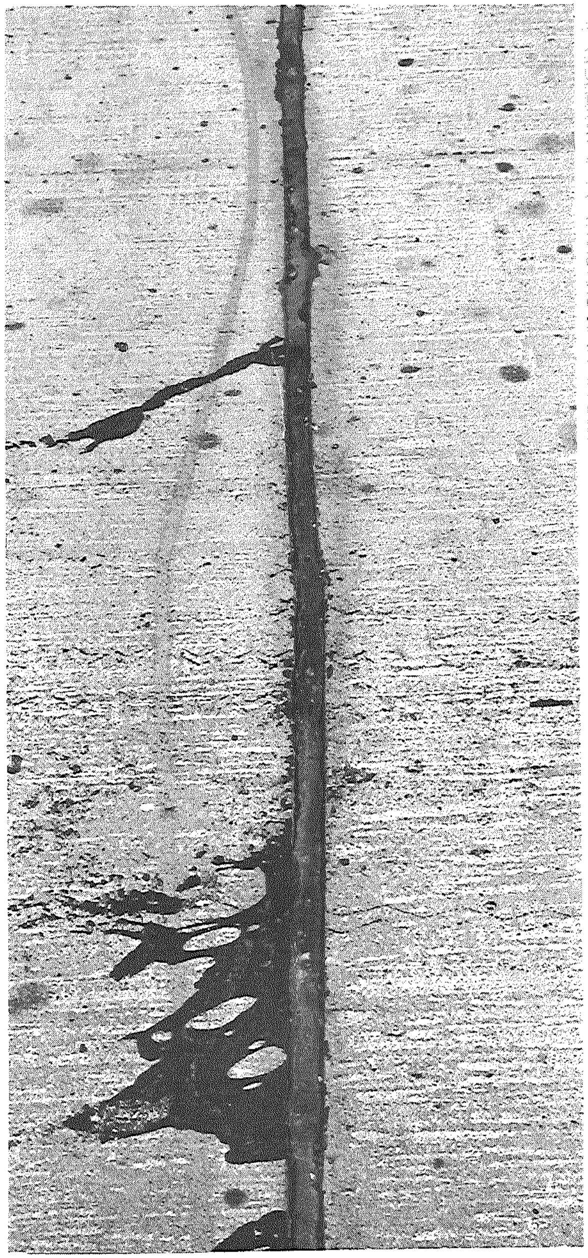


Figure 13. Typical severe adhesion failure with embedded dirt (Project BI 50112A, C1, Sta. 798+02 NB).

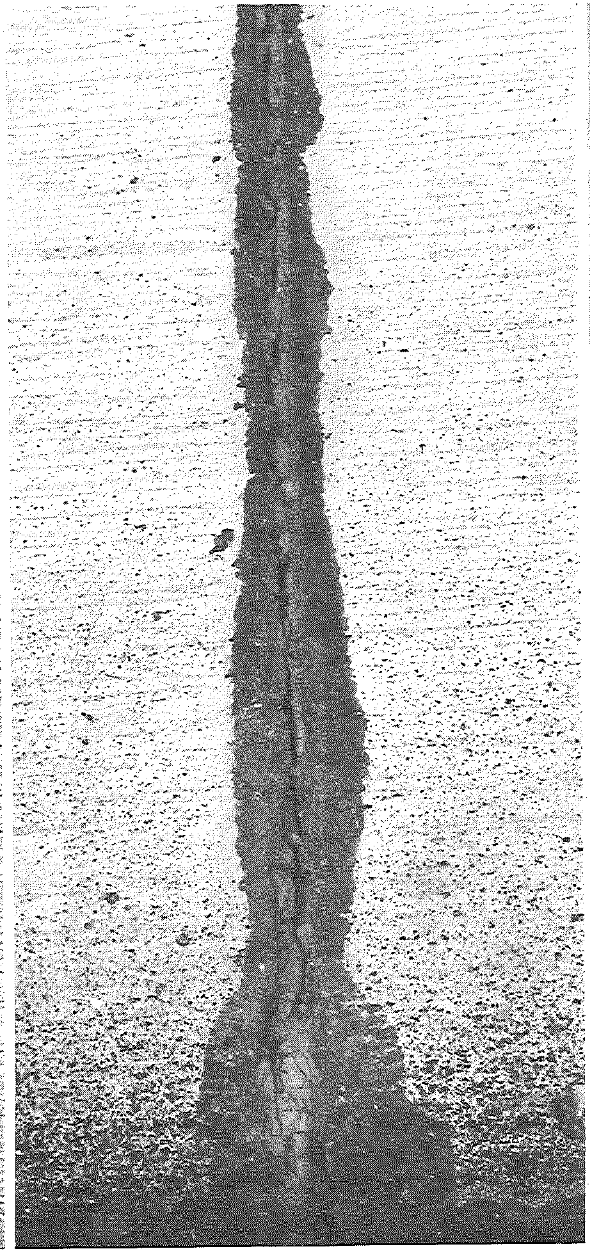


Figure 14. Cohesion failure typical of this area (Project BI 77111A, C2, Sta. 908+02 NB).

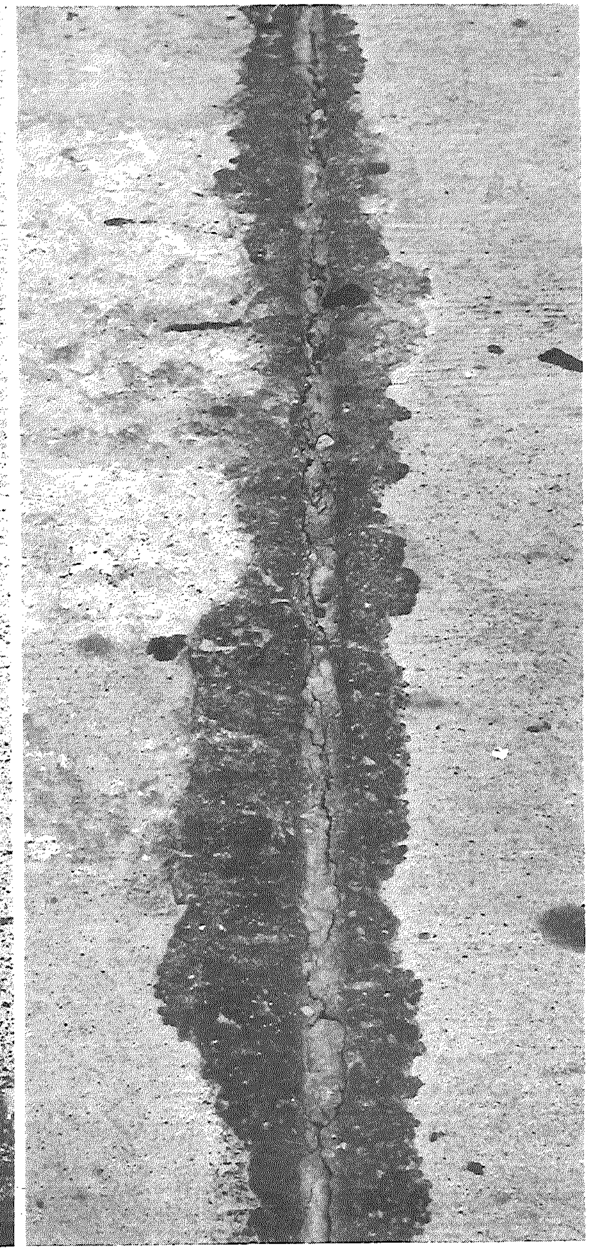


Figure 15. Overfilled joint with typical cohesion - adhesion failure (Project BI 77111B, C3, Sta. 1203+50 NB).

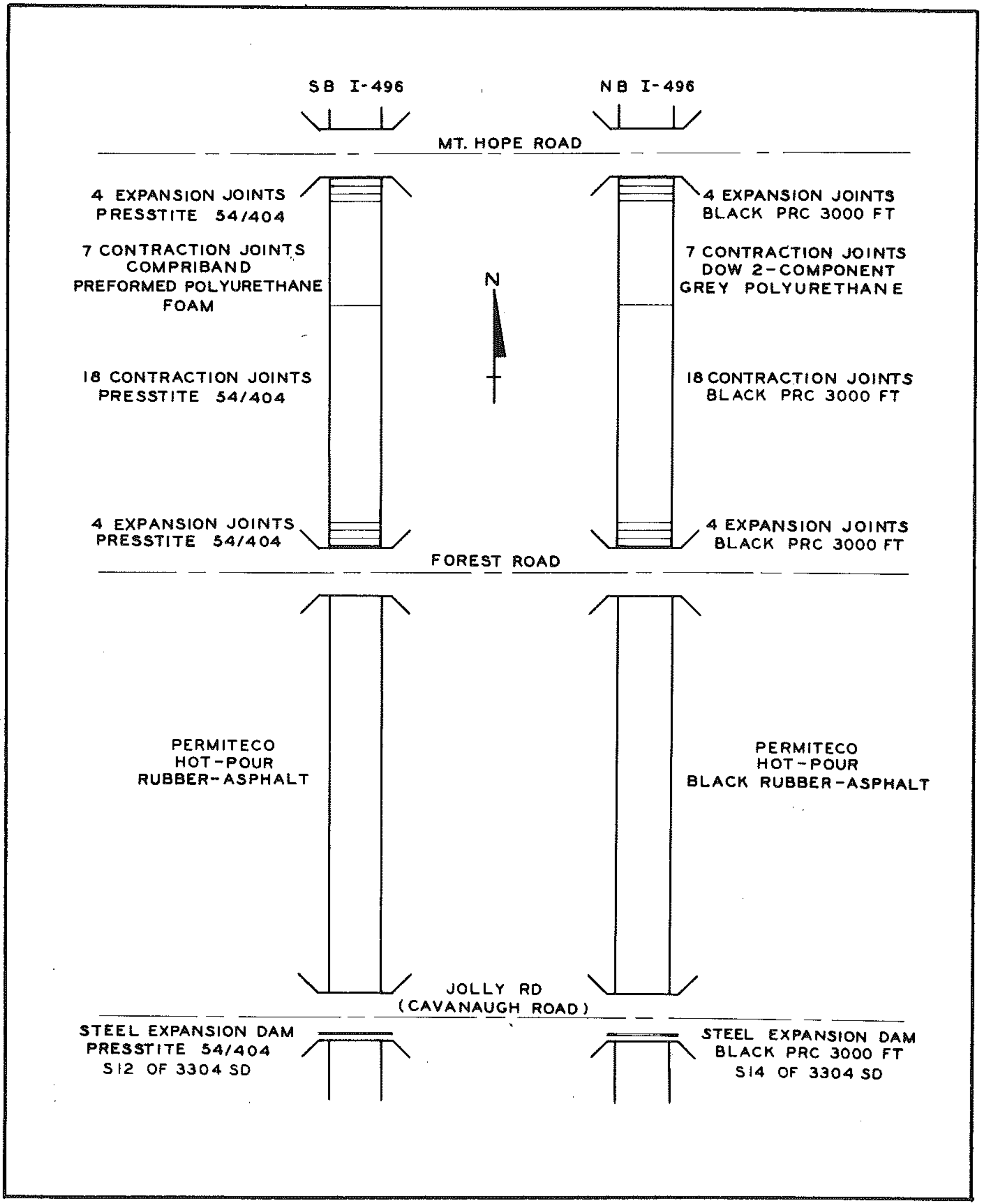


Figure 16. Locations of experiment sealants on I 496 north of I 96.

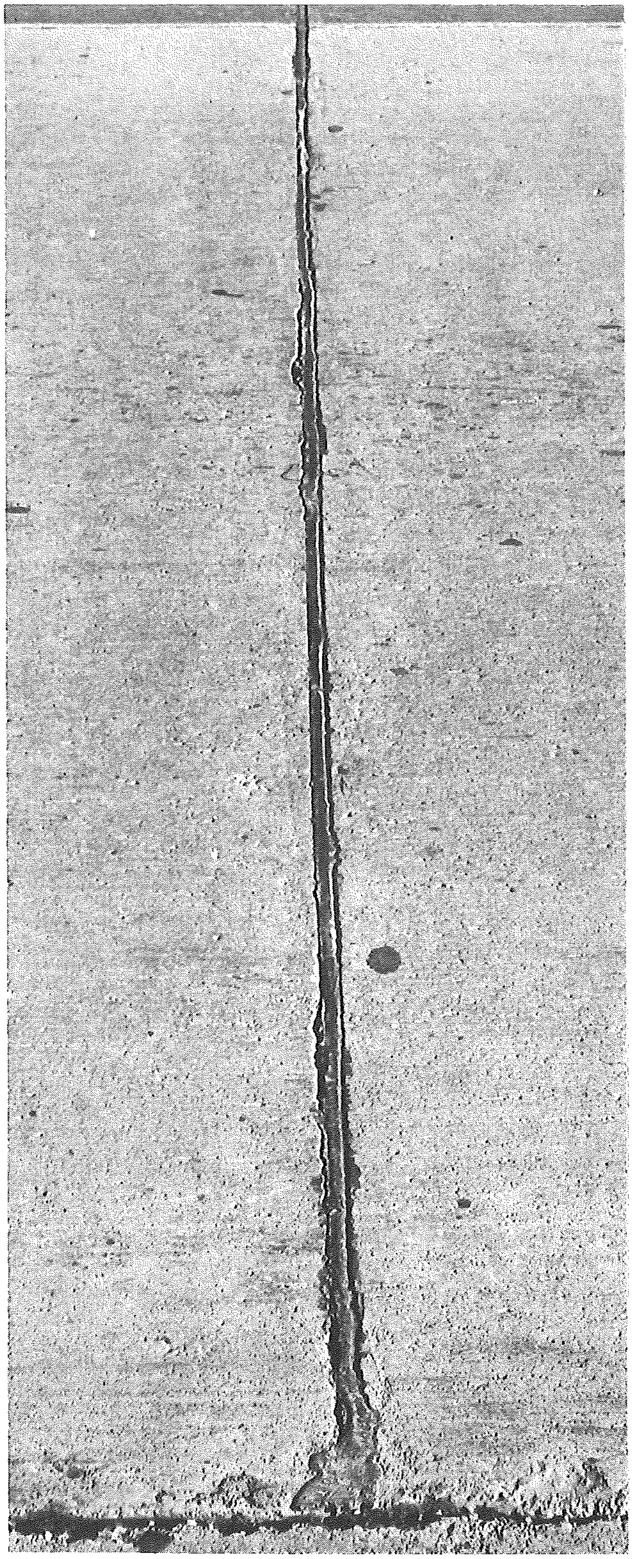


Figure 17. Total loss of adhesion but good resistance to penetration after one year of service: Presstite 54/404 two-component, cold-applied sealer (southbound I 496 between Mt. Hope Rd and Forest Rd).

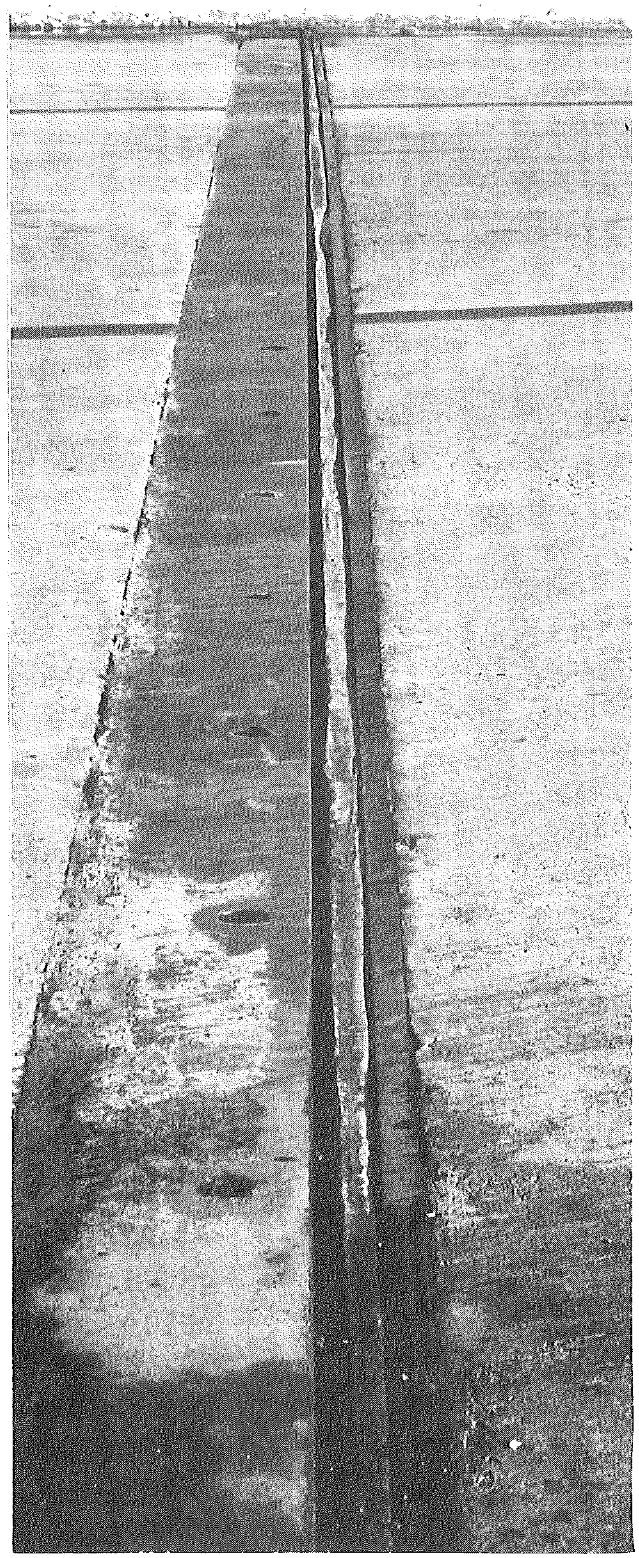


Figure 18. Total loss of adhesion after one year of service: Presstite 54/404 two-component, cold-applied sealer (expansion dam on I 496 structure over Cavanaugh Rd).

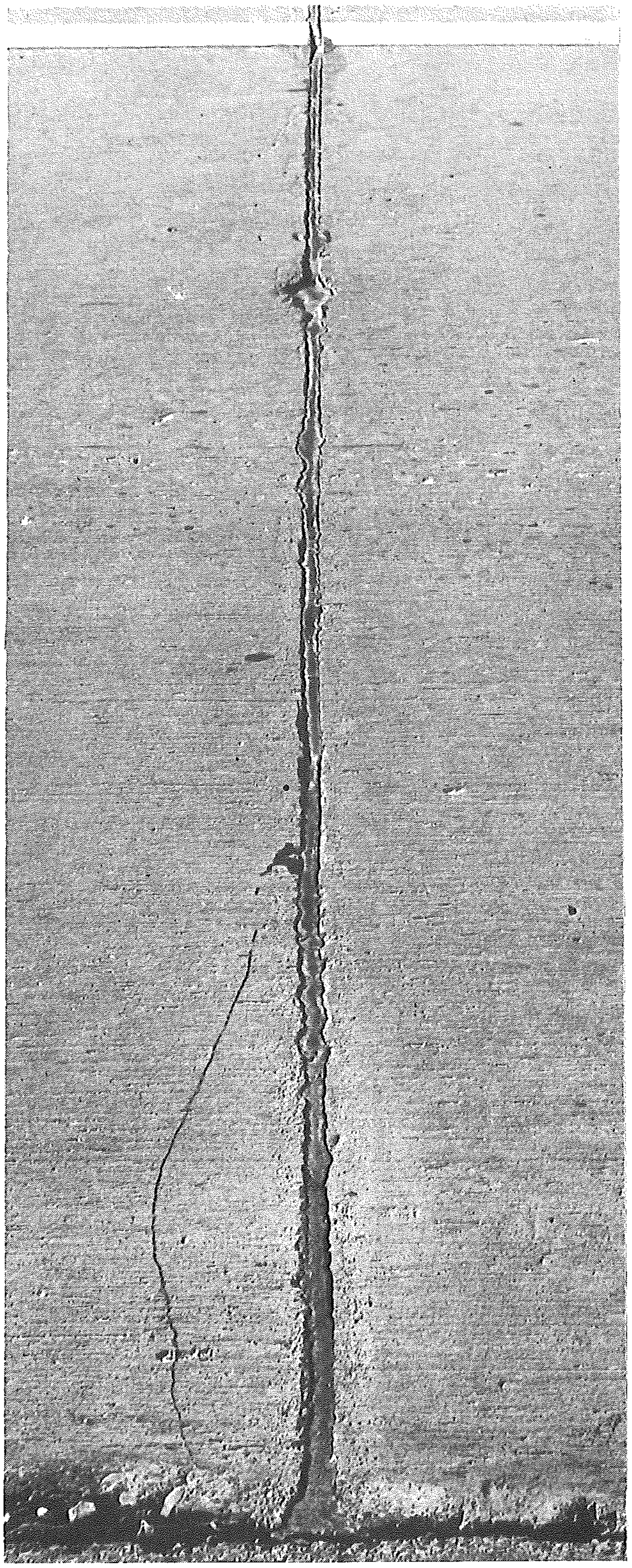


Figure 19. Almost complete loss of adhesion after one year of service: Products Research (PRC) 3000 FT two-component, cold-applied sealer (northbound I 496 between Forest Rd and Mt. Hope Rd).

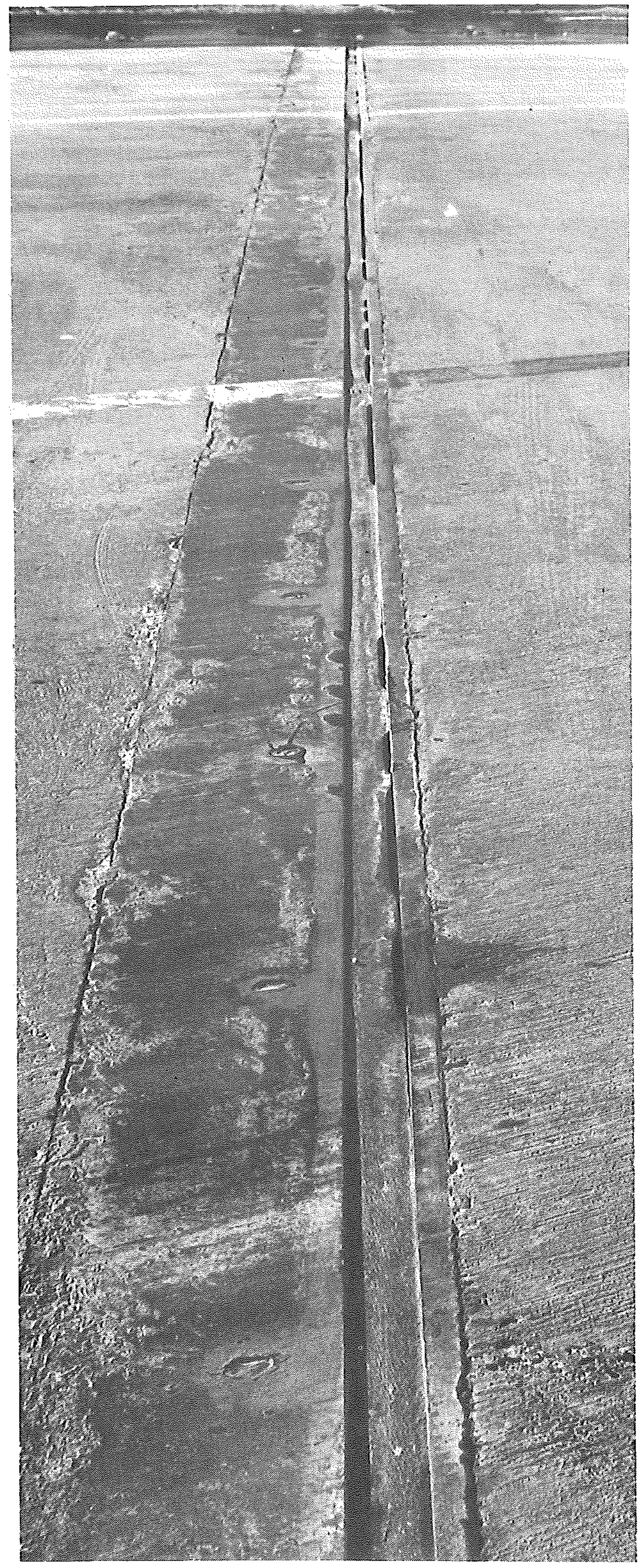


Figure 20. Extensive loss of adhesion after one year of service: Products Research (PRC) 3000 FT two-component, cold-applied sealer (expansion dam on northbound I 496 structure over Cavanaugh Rd).

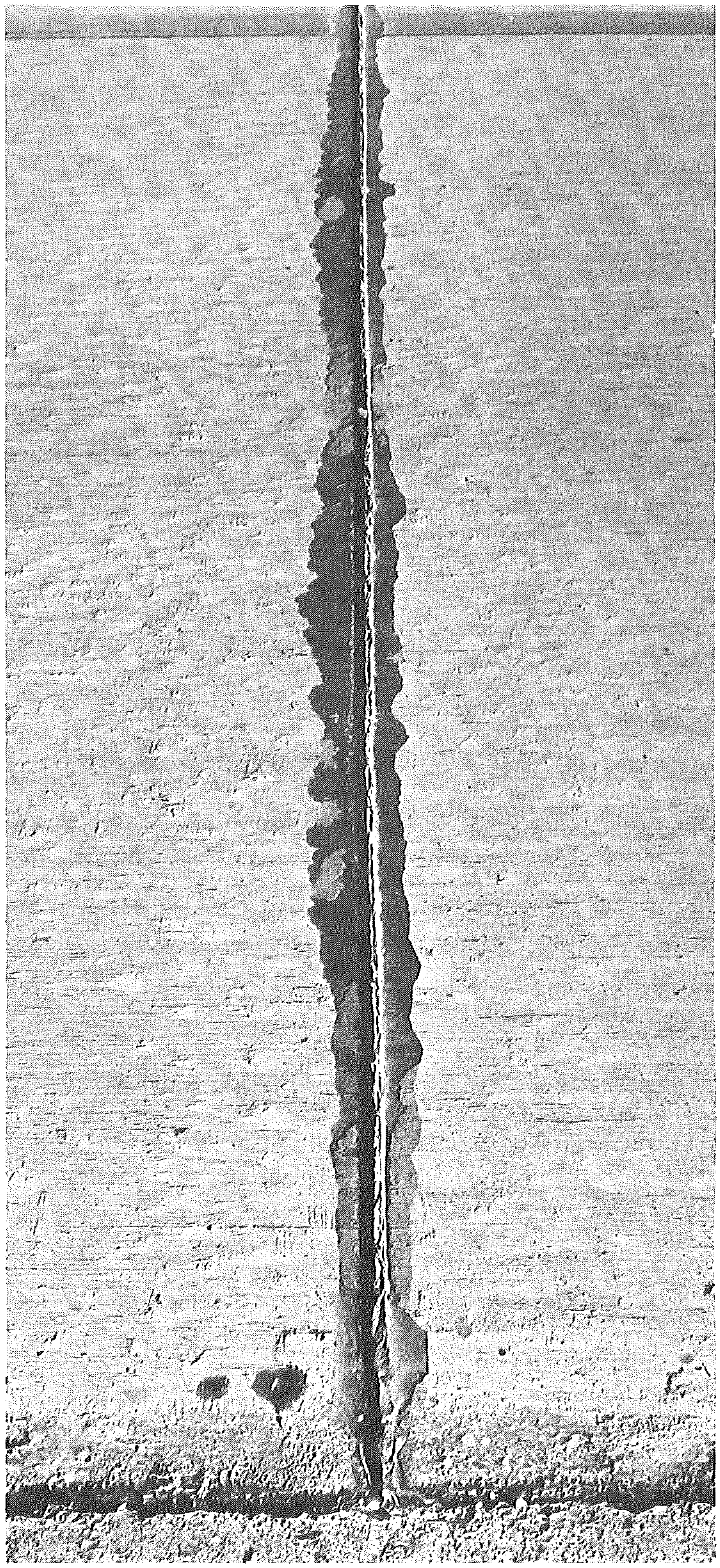


Figure 21. Typical failure in adhesion, cohesion, and resilience after one year of service: Permiteco regular (SS-S-164) hot-pour, rubber-asphalt sealer (northbound I 496 between Cavanaugh Rd and Forest Rd).

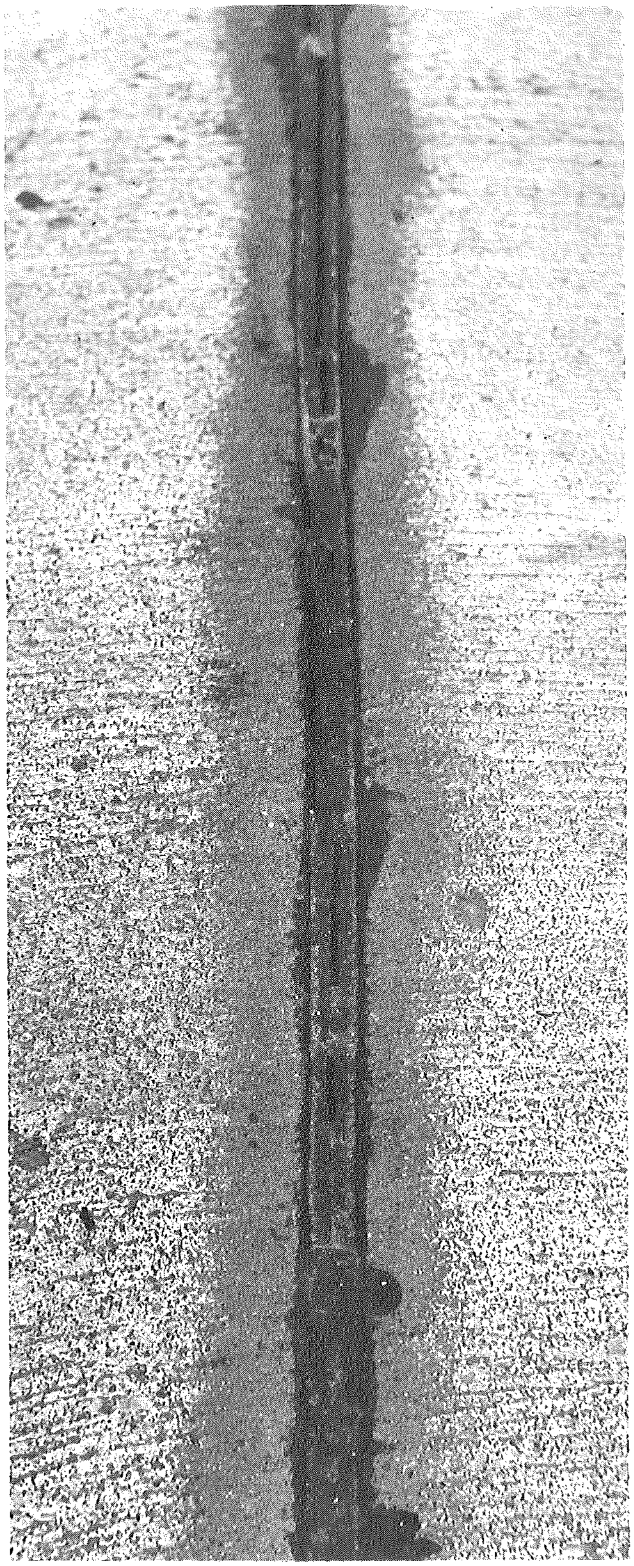


Figure 22. Cohesive failure typical of about 70 percent of this project's joints, after about four months of service: Peterson two-component, cold-applied sealer (I 75 Rest Area).

Figure 23. Effect of Ethafoam filler placed too high in joint, after about four months of service: Peterson two-component, cold-applied sealer (I 75 Rest Area).

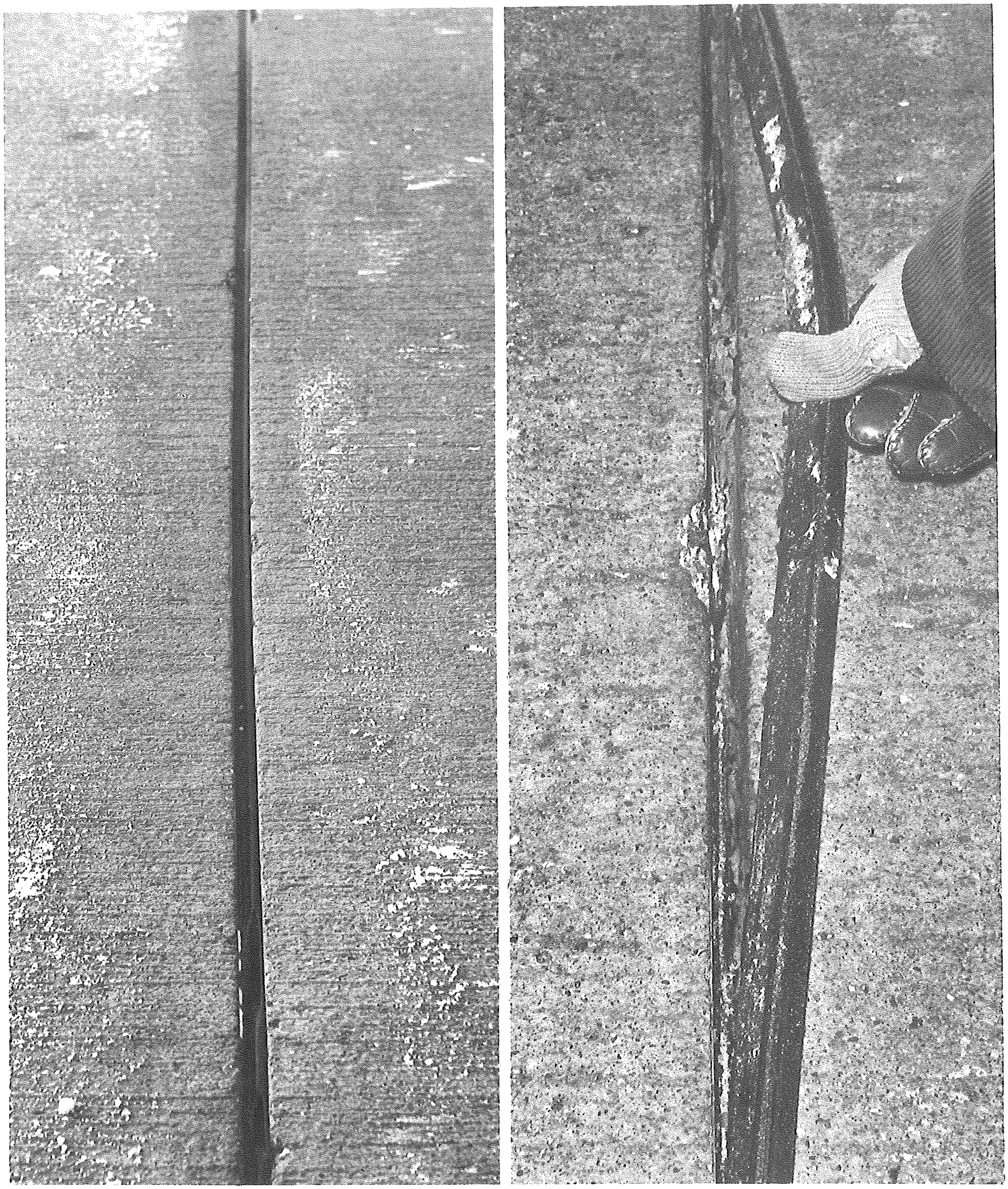


Figure 24. General and detailed views of neoprene sealed joint, showing clean joint groove beneath sealant. Joint was formed by 3/8-in. wide plastic insert, and width when photographed was 0.65 in. (Sta. 662+40, westbound traffic lane, Project EBACI 33083B, C3).

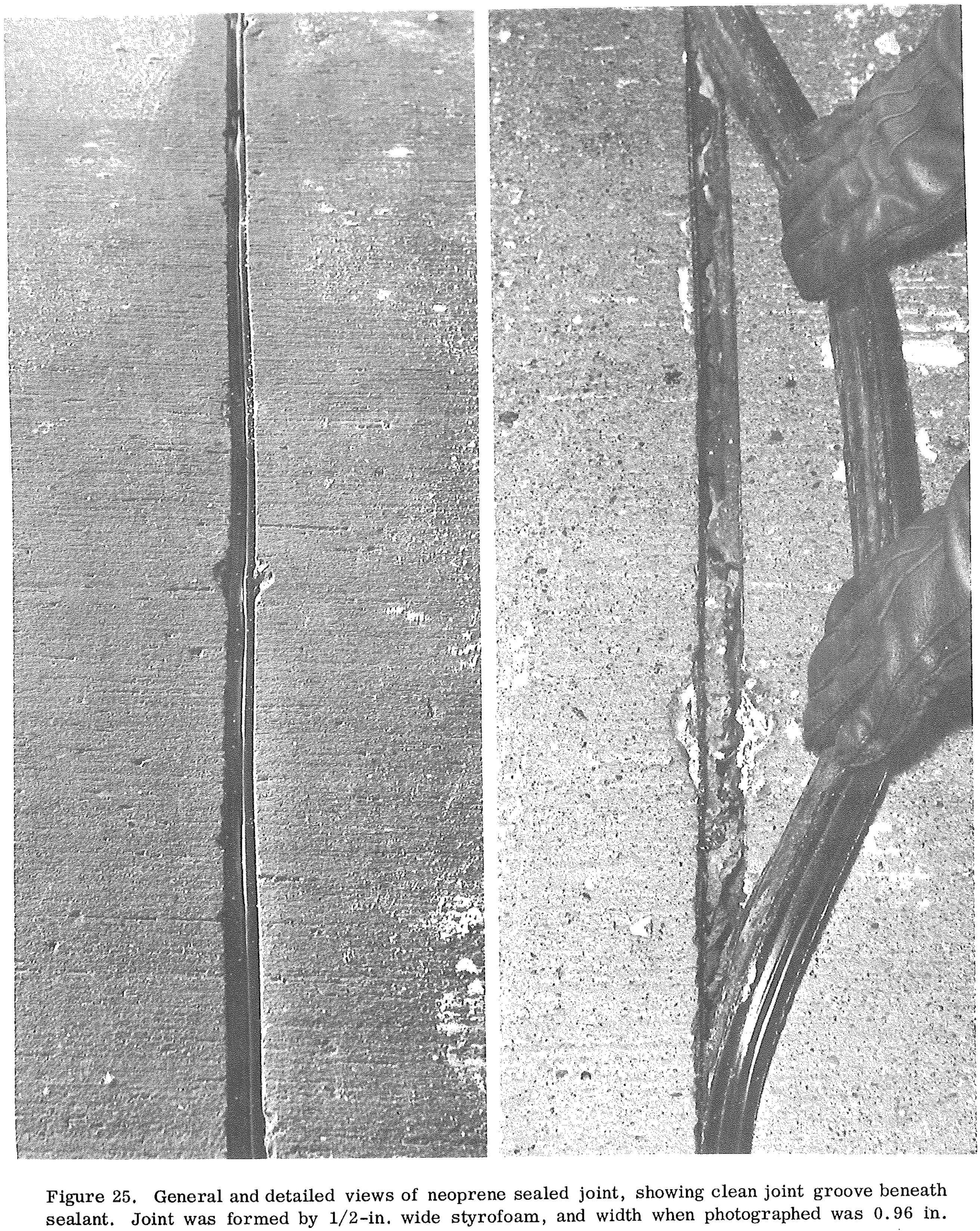


Figure 25. General and detailed views of neoprene sealed joint, showing clean joint groove beneath sealant. Joint was formed by 1/2-in. wide styrofoam, and width when photographed was 0.96 in. (Sta. 600+70, westbound traffic lane, Project EBACI 33083A, C1).

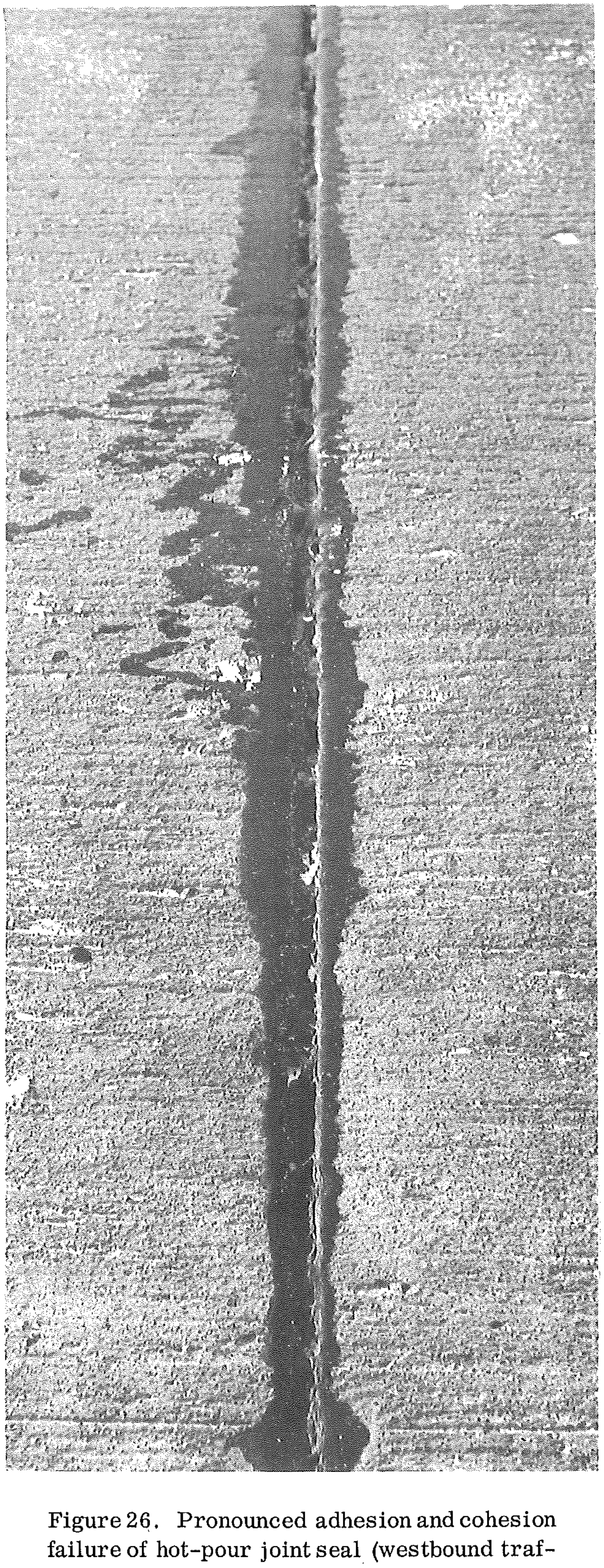


Figure 26. Pronounced adhesion and cohesion failure of hot-pour joint seal (westbound traffic lane, Sta. 649+00, Project EBACI 33083A, C1).

Figure 27. Some cohesion failure of hot-pour joint seal (westbound traffic lane, Sta. 553+08, Project EBACI 23151A, C1).

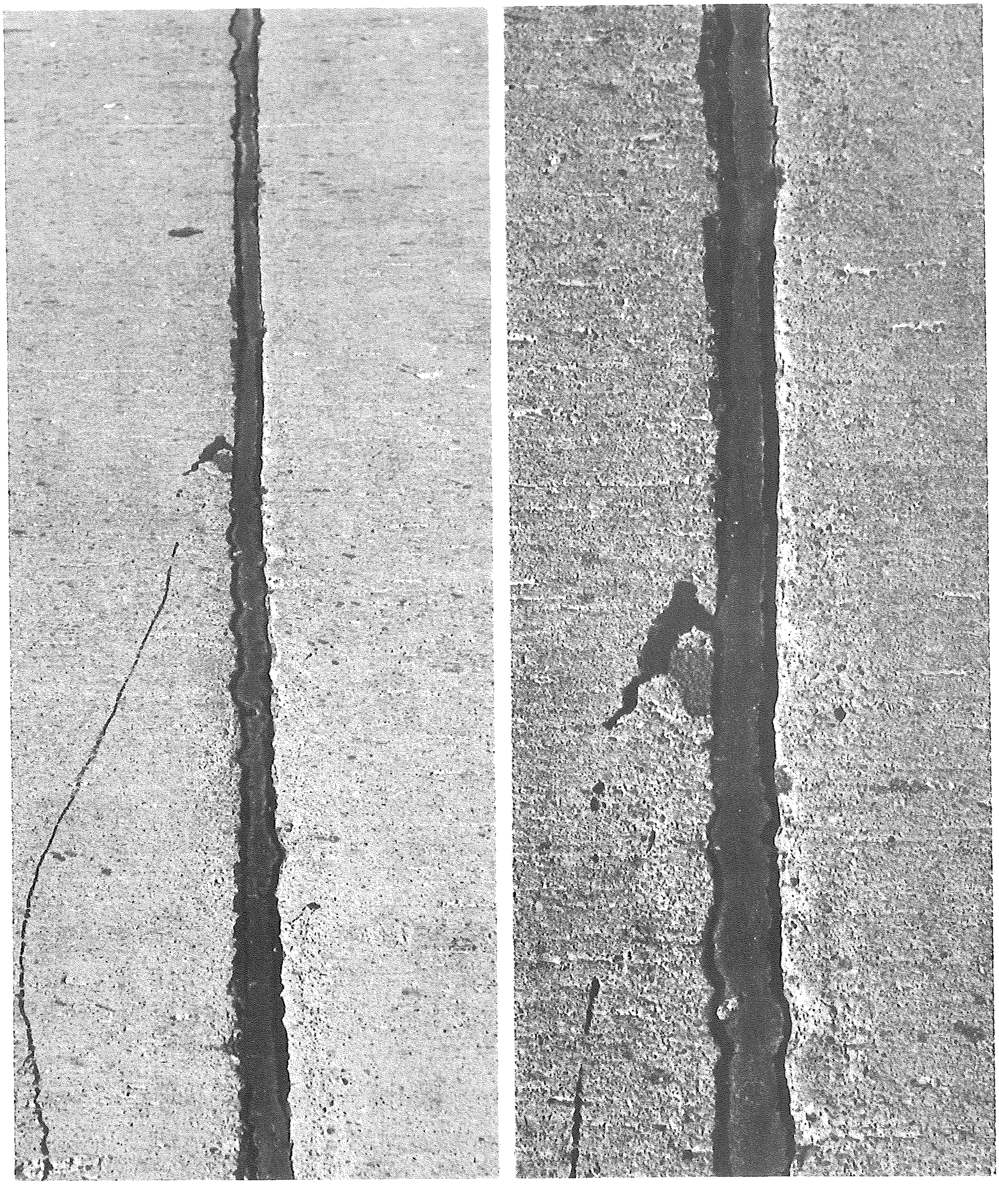


Figure 28. General and detailed views of the same joint shown in Fig. 19, indicating complete lack of cohesion of cold-applied, two-component sealer (Sta. 668+52, northbound traffic lane, Project I 53045D, C1).