EFFECTS OF VARIOUS SEALING SYSTEMS ON PORTLAND CEMENT CONCRETE JOINTS

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•NEOPRENE compression seals are becoming recognized as the most effective means of sealing expansion and contraction joints in concrete pavements, bridges, and other projects where joints are needed for the expansion and contraction of the structural mass. The question has arisen of whether the use of compression seals actually increases the life of the joints with a corresponding increase in the life of the structure. The purpose of this study is to answer this question with regard to the use of compression seals in concrete pavements.

The evaluation of joint conditions after years of exposure required that we find projects or adjacent projects that were structurally the same. The joint sealant would be the only variable. We were fortunate in finding five locations where direct comparisons could be made. Each of these projects was more than 2 miles in length and contained neoprene compression seals. Each project contained numerous joints, which made it easy to reach conclusions concerning relative joint conditions. All of the seals were made by the same manufacturer.

Photographs were taken of joints at random to verify their general conditions. Thirty to 40 pictures were taken of each state's installation; the photographs shown in this report generally summarize the conditions that were found.

SEALING SYSTEM SURVEY

Minnesota

The first commercial neoprene compression sealed joints used in Minnesota highways were placed in the late fall of 1964 on I-90 in the westbound lanes starting at the west side of the Mississippi River Bridge and extending to Dresbach, Minnesota. The seals were installed manually. Both $^{11}/_{16}$- and $^{13}/_{16}$-in. materials were placed in $^{3}/_{8}$-in. joints at 46½-ft spacings. Figure 1 shows a typical joint in the eastbound lanes sealed with two-component polysulfide material; Figure 2 shows a typical joint sealed with neoprene. All of the polysulfide-sealed joints show spalls where the faces of the joint break away (Fig. 3) because, although adhesion of the joint material is excellent in places, the extensibility of polysulfide joints is limited. The neoprene-sealed joints show slight raveling of the joint edges, particularly where the seal is installed deeper than $^{1}/_{8}$ in. below the pavement surface (Fig. 4).

Figure 5 shows that polysulfide sealant material becomes embedded with incompressible stones and debris. Adhesion to the faces of the joint was nonexistent in most areas.

Figure 6 shows a neoprene seal after 7 years of service. The seal was of a tapered design and was replaced in later installations by a parallel-sided design that gave greater surface contact for holding the seal in the joint. Note that the joint below the seal is clean. The ruptured lubricant film has been forced to the bottom of the joint by the insertion of the seal in squeegee-like fashion.

Care must be exercised in the placing of neoprene to prevent stretching of the seal. Figure 7 shows a typical break that was caused by excessive stretching of the seal due to manual methods. These openings allow incompressible debris to enter the joint.

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Figure 1. Polysulfide-sealed joint.

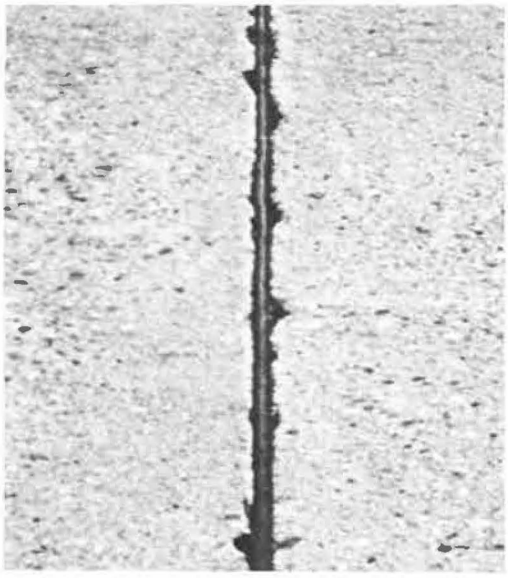


Figure 2. Neoprene-sealed joint.

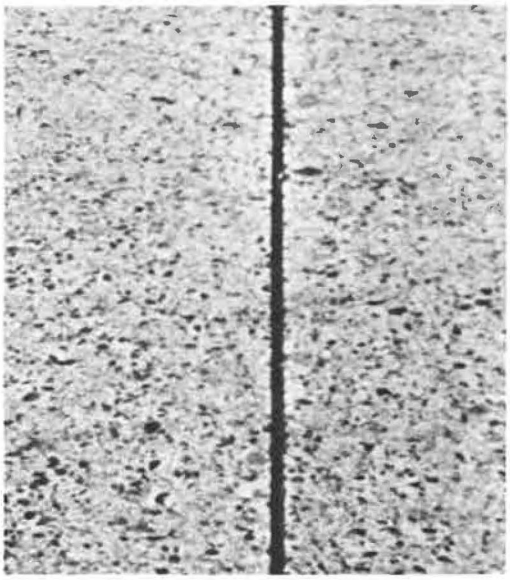


Figure 3. Polysulfide-sealed joint with spalls.

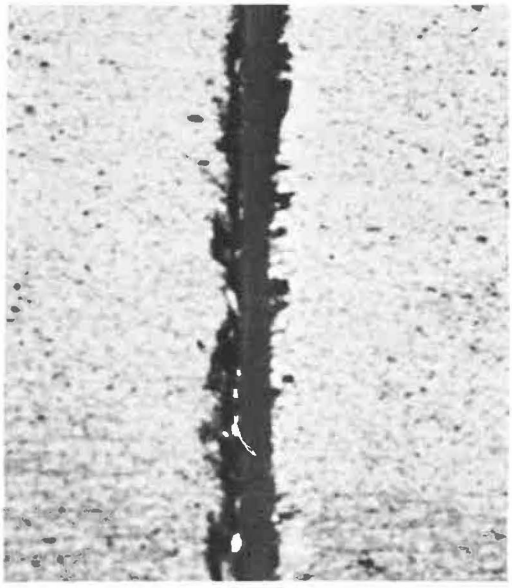


Figure 4. Neoprene-sealed joint with ravels.

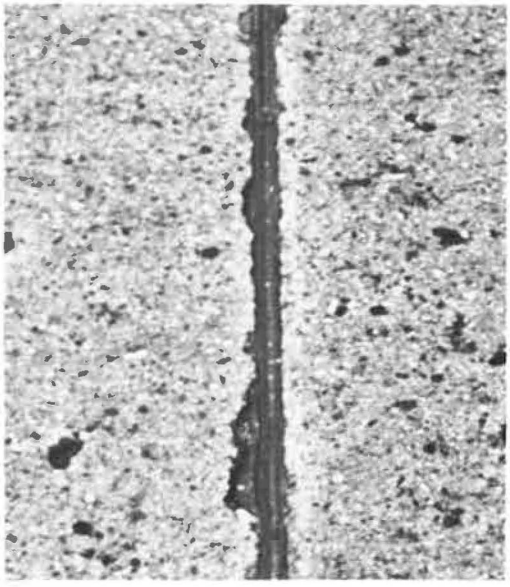


Figure 5. Polysulfide seal with embedded debris.

Figure 6. Neoprene seal.

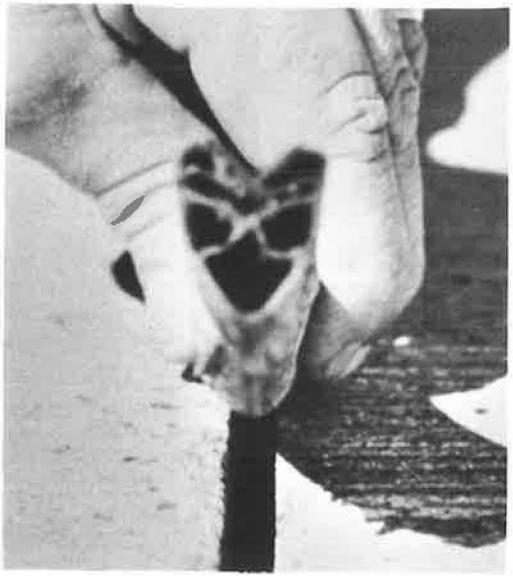
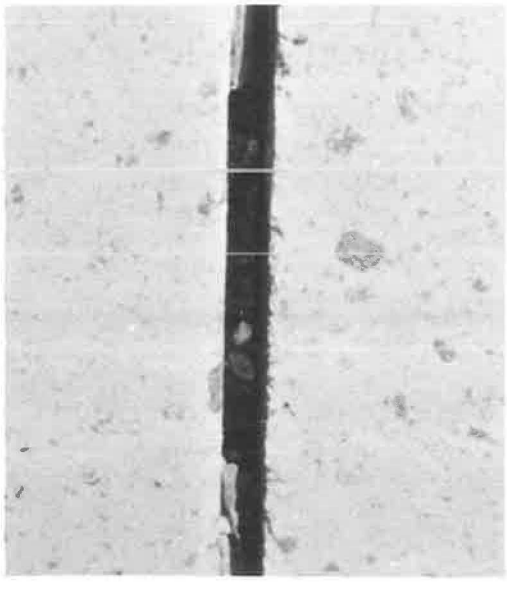


Figure 7. Break in neoprene seal.



North Dakota

The first project to utilize neoprene compression seals in North Dakota was completed in 1964. The seals were installed by hand; $^{13}/_{16}$-in. materials was used at 45-ft spacings. The sections, more than 1 mile each, were placed in westbound I-94, west of Sweet Briar Dam. Three types of sealants were used in each: hot-poured asphalt, coal-tar epoxy, and neoprene compression seals. After 1 year, the neoprene was the only seal still working. Because of the extreme temperature range experienced, however, the seal size was increased to a width of $1\frac{1}{4}$ in. to facilitate large joint movement.

Figure 8 shows a hot-poured asphalt-sealed joint after 7 years of service. Figure 9 shows a neoprene-sealed joint of like service. Figure 10 shows a coal-tar epoxy joint that has spalls at intermittent points. Figure 11 shows a 1-in. wide liquid-sealed joint. A large sponge insert was used to gain a shape factor. Figure 12 shows a hot-poured joint that is full of incompressible material. This material contributes to the rapid deterioration of the joint faces.

Figure 13 shows a neoprene seal pulled after 7 years of service. The joint faces are clean and smooth, and the seal is fully resilient.

Figure 8. Hot-poured asphalt-sealed joint.

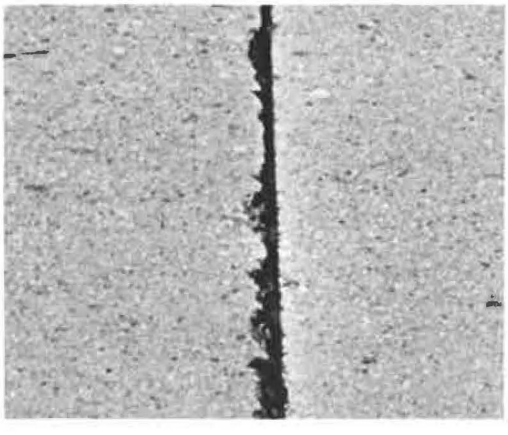


Figure 9. Neoprene-sealed joint.

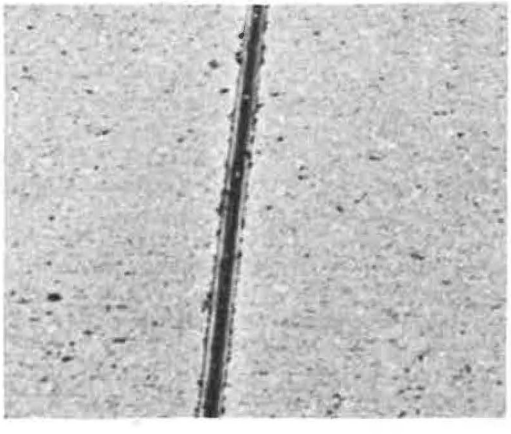


Figure 10. Coal-tar epoxy joint.

Figure 11. Liquid-sealed joint.

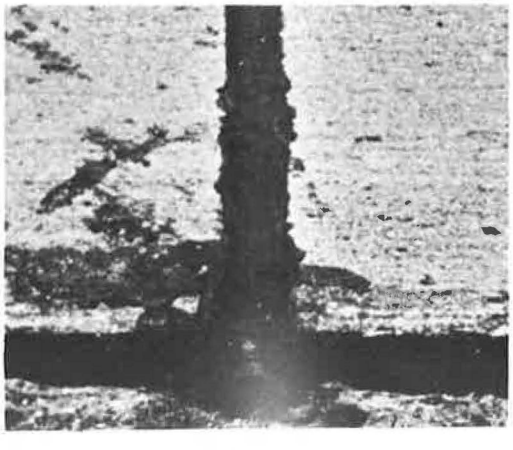


Figure 12. Hot-poured joint.

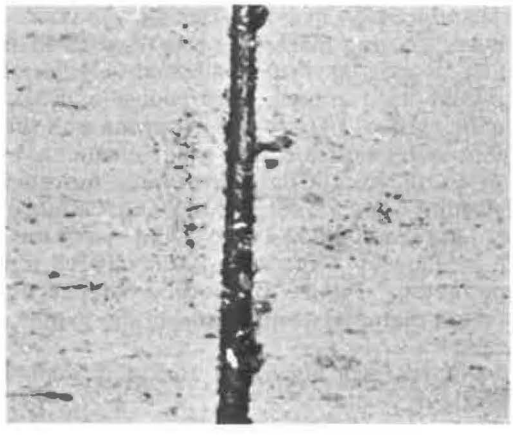
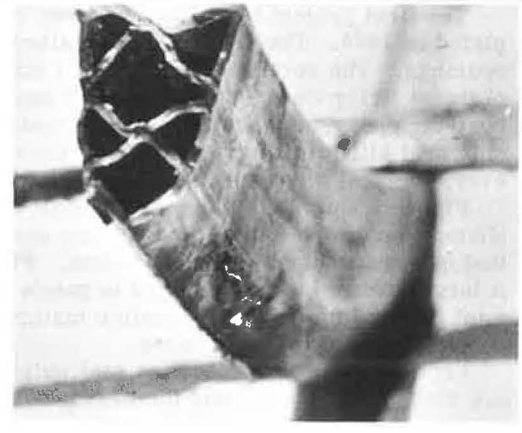


Figure 13. Neoprene seal.



Michigan

Prior to adopting neoprene compression seals as the standard seal for all jointed pavement in 1965, Michigan specified hot-poured rubber asphalt as the standard material. Figure 14 shows a typical asphalt joint that has been resealed with SAO asphalt; Figure 15 shows a section of pavement sealed with neoprene. A seal 1¼ in. wide was used in ½-in. styrofoam-formed joints at 71-ft joint spacings. This was the first major neoprene project in the state. It was accomplished by machine in the fall of 1964. Machine placement provides uniform depth control and eliminates stretching. It is defined as the placing of a seal from a roll or strip automatically into the pavement slab without manual or outside assistance (force).

Figure 16 shows the ability of a neoprene compression seal of proper design and size to conform to small irregularities in the joint face. The pavement surface in this figure shows the effect of studded-tire wear. Figure 17 shows a joint with the compression seal removed. The joint is clean, and the plane-of-weakness crack is closed. There is no infiltration of debris.

Figure 18 shows a blowup that was repaired in the asphalt-sealed section immediately adjacent to the neoprene-sealed section. No blowups have occurred in the neoprene-sealed sections.

Figure 14. Resealed asphalt-sealed joint.

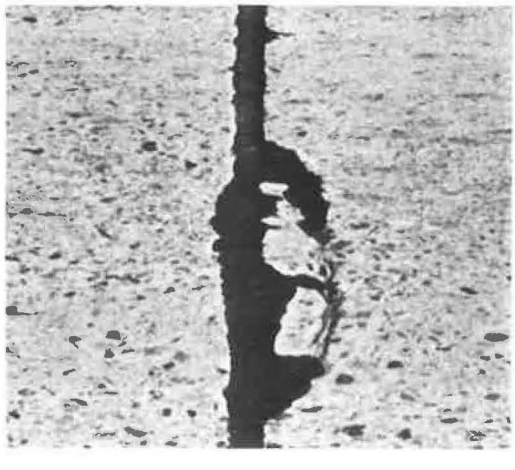


Figure 15. Neoprene-sealed joint.

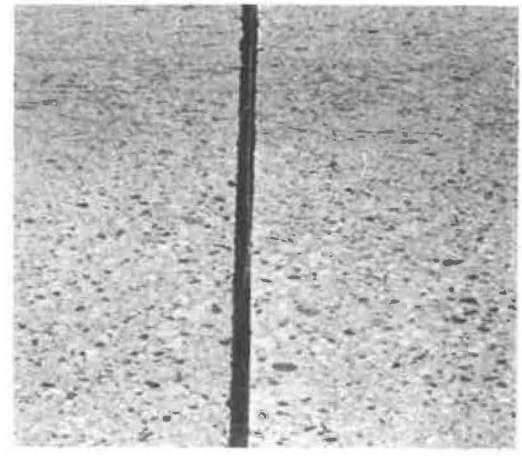


Figure 16. Neoprene conforming to irregular joint.

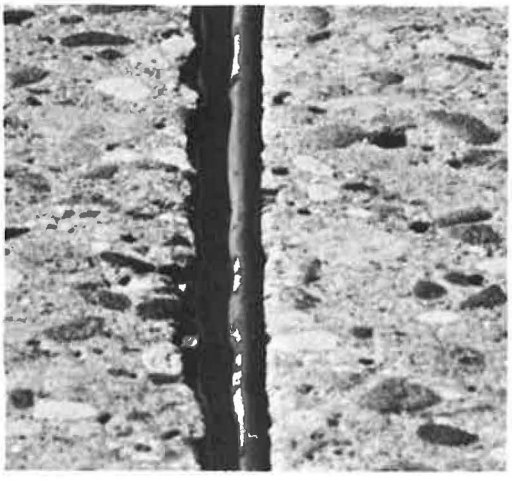


Figure 17. Clean joint with plane-of-weakness crack closed.

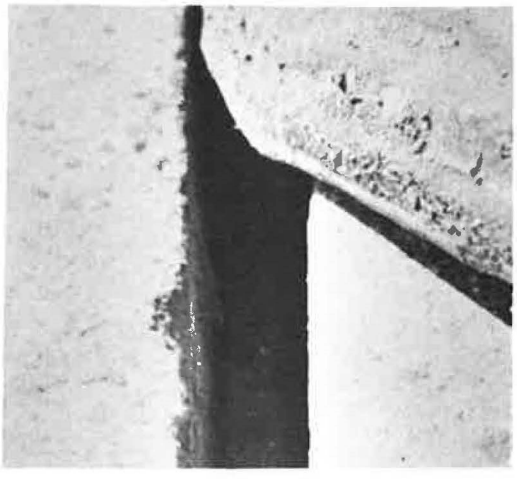


Figure 18. Blowup patch.

Ohio

Ohio's first project using neoprene compression seals was built in the spring and summer of 1965 on US-23 around Upper Sandusky. An $^{11}/_{16}$-in. compression seal was used in $^{1}/_{4}$-in. joints on 60-ft centers for the transverse contraction joints. The $^{1}/_{8}$-in. longitudinal joint was sealed with $^{5}/_{16}$-in. neoprene.

Figure 19 shows a liquid-sealed joint in the section of pavement adjacent to the neoprene-sealed section. Figure 20 shows a typical neoprene-sealed joint. The liquid-sealed section of pavement is approximately 1 year older than the neoprene section.

An inspection of the liquid-sealed joints shows a considerable amount of compacted debris in the joints, which causes substantial edge spalling of the joints (Fig. 21). Figure 22 shows that such an accumulation of debris in the neoprene-sealed joint is impossible because of lack of space. A longitudinal joint was sealed with neoprene; the joint shows no signs of spalling or deterioration (Fig. 23).

The longitudinal joint was sealed with neoprene on this project and shows no signs of spalling or deterioration, as shown in Figure 23.

Figure 19. Liquid-sealed joint with spalls.

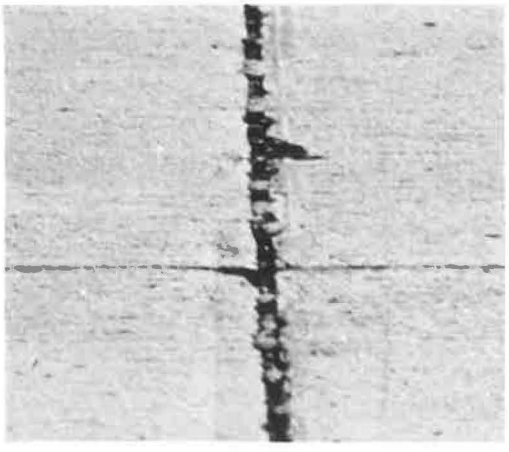


Figure 20. Neoprene-sealed joint.

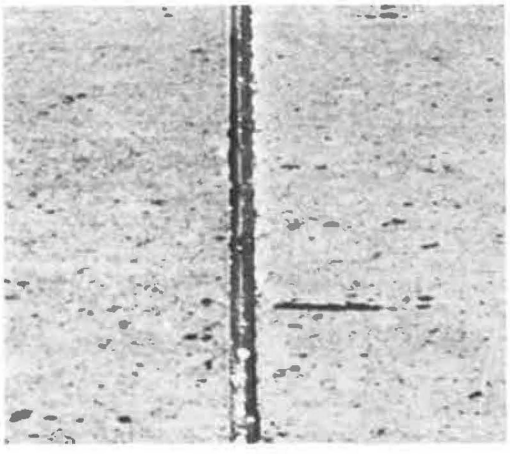


Figure 21. Incompressible materials causing spalls.

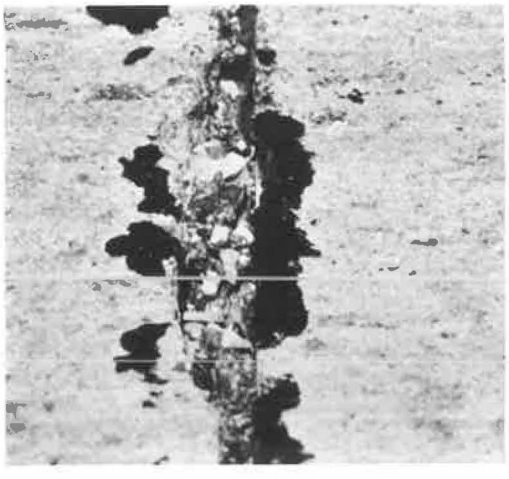
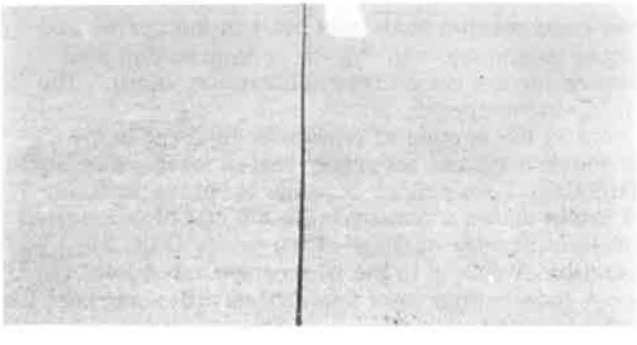


Figure 22. Neoprene-sealed joint at optimum depth.

Figure 23. Longitudinal joint sealed with neoprene.



California

In 1964, a 4-mile section containing neoprene compression seals was placed in I-80 in the Donner Summit area. In addition, within this area 3 sections, containing 12 joints each, were sealed with a two-component polysulfide type of material that is used at elevations above 3,500 ft. Three sections, containing 12 joints each, were left unsealed as is standard below elevations of 3,500 ft (commonly referred to as valley areas).

All of the joints were sawed on a skew of 4 ft in 24 ft. They were sawed $\frac{1}{8}$ to $\frac{3}{32}$ in. wide and placed at an average of 15-ft spacings. In the case of the neoprene joints, seals $\frac{5}{16}$ in. wide were used. They were hand installed by the roller tool method.

Of all the joints surveyed in this study, these were the worst. At this installation, there is excessive pavement wear and subsequent joint abrasion because the use of chains is required for nearly 3 months following periods of snowfall.

Figure 24 shows an unsealed joint in a truck lane. Figures 25 and 26 show polysulfide-sealed and neoprene-sealed joints in a truck lane. The loss of material at the joint edges exposed the neoprene to traffic that abraded the seal to the extent that the upper portions were shredded off. The polysulfide was completely pulled from the joints in places.

Figure 27 shows an unsealed joint in a passing lane. Although the joint edges are not rounded and worn, considerable damage has occurred to the joint as a result of compaction of incompressible material into the joint. The width of the joint, originally $\frac{1}{8}$ in., is now at least $\frac{1}{4}$ in. Without exception, all unsealed joints were twice the width

Figure 24. Unsealed joint (truck lane).

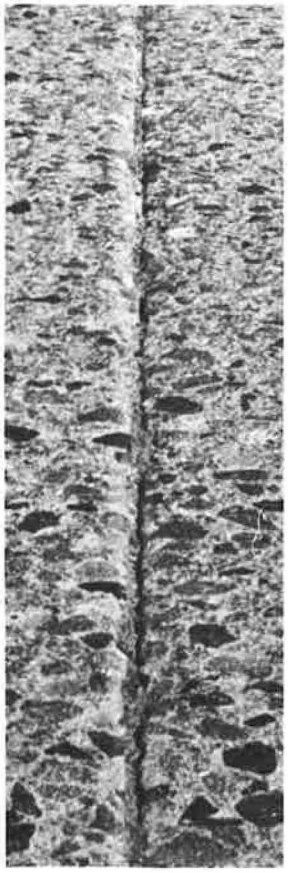


Figure 25. Polysulfide-sealed joint (truck lane).

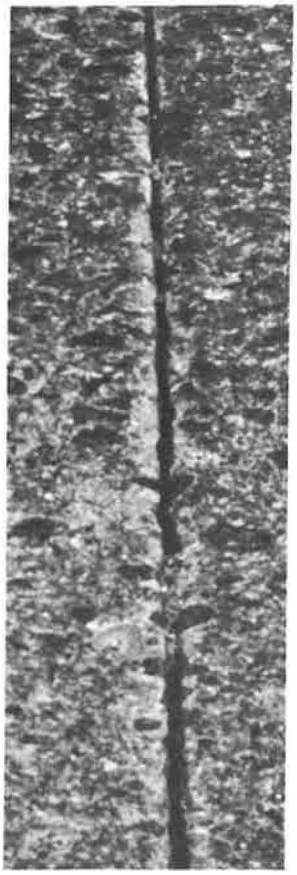


Figure 26. Neoprene-sealed joint (truck lane).

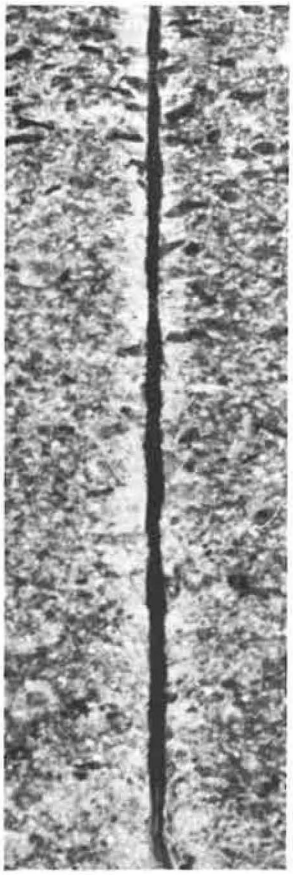


Figure 27. Unsealed joint (passing lane).

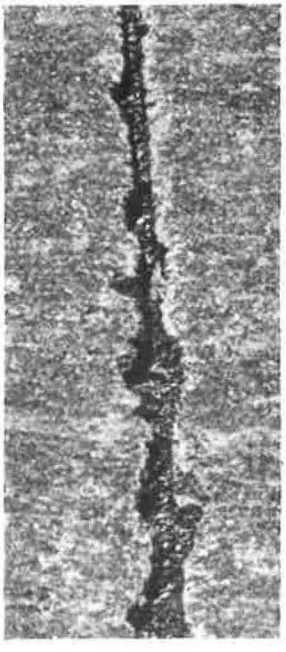


Figure 28. Polysulfide-sealed joint (passing lane).

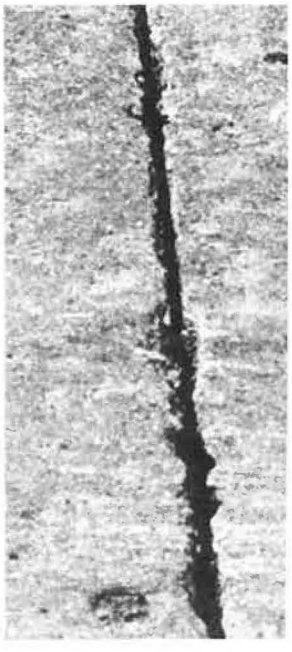


Figure 29. Neoprene-sealed joint (passing lane).

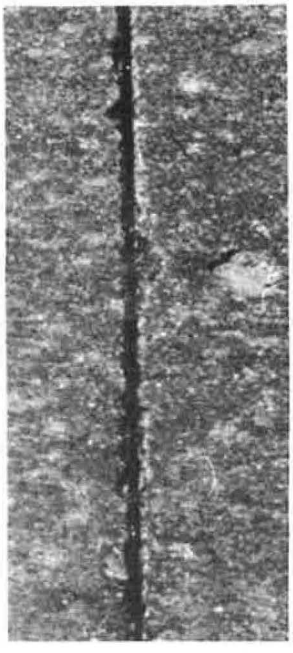


Figure 30. Close-up of unsealed joint (truck lane).

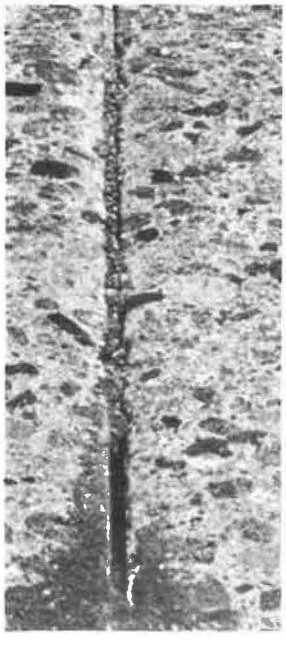


Figure 31. Close-up of polysulfide-sealed joint (truck lane).

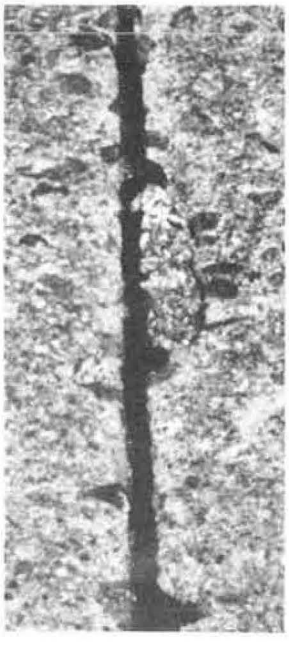


Figure 32. Close-up of neoprene-sealed joint (truck lane).

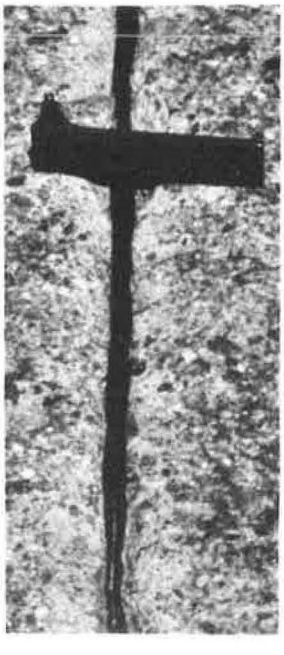


Figure 33. Unsealed joint prior to coring.

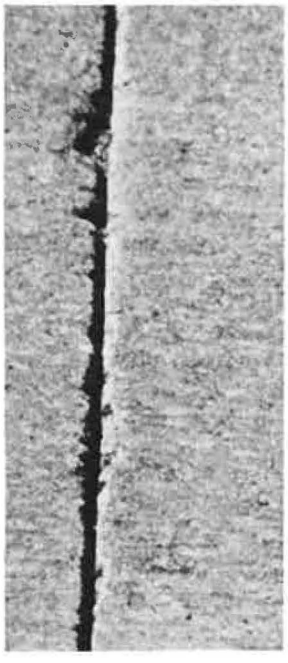


Figure 34. Close-up of core area (unsealed joint).

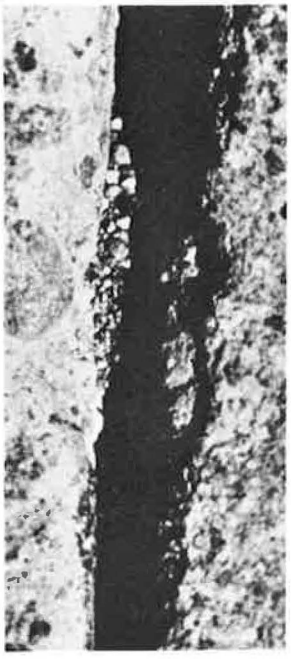


Figure 35. Damaged plane-of-weakness crack (unsealed joint).

Figure 36. Polysulfide-sealed joint prior to coring.

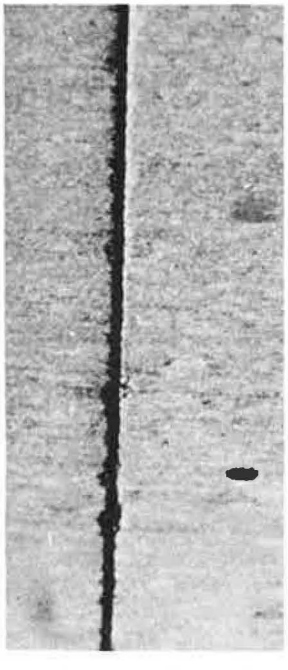


Figure 37. Close-up of core area (polysulfide-sealed joint).

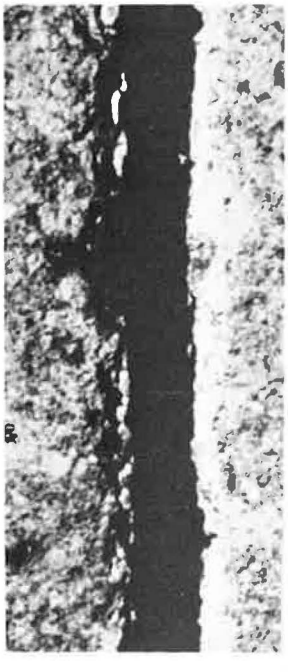


Figure 38. Plane-of-weakness crack (polysulfide-sealed joint).

Figure 39. Neoprene-sealed joint with raveled edges.

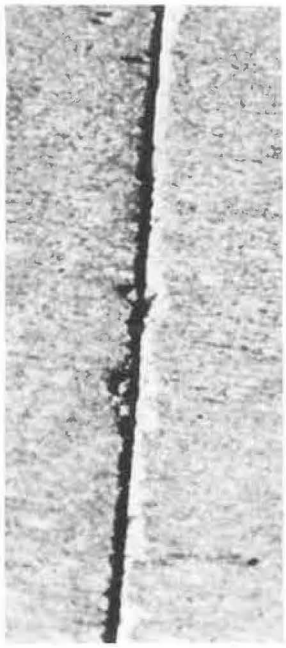


Figure 40. Close-up of core area (neoprene-sealed joint).

Figure 41. Undamaged core (neoprene-sealed joint).

of the neoprene-sealed joints. A comparison of polysulfide-sealed and neoprene-sealed joints in passing lanes is shown in Figures 28 and 29.

Figures 30, 31, and 32 show three types of joints in truck lanes: open or unsealed, polysulfide, and neoprene. The 3-in. rule across the neoprene-sealed joint indicates the extent of edge wear.

The California Division of Highways conducted core tests of the different types of joints. The following pictures are the results of the test program.

Figure 33 shows an unsealed joint prior to coring; Figure 34 shows the core area. Incompressible material can be seen in the joint; however, much of this material was washed away during the coring operation. Figure 35 shows the core hole and the damage caused by the compaction of incompressible material at the bottom of the sawed joint following the plane-of-weakness crack. This accounts for the excessive width of the unsealed joints.

Figure 36 shows a polysulfide-sealed joint prior to coring. Figure 37 shows the core area, and Figure 38 shows the hole with the core removed. Again, there is considerable infiltration, and the plane-of-weakness crack has been forced open.

Figure 39 shows a neoprene-sealed joint that is raveled along the joint edges. Although the upper edges of the seal are shredded (Fig. 40), the seal is still effective because incompressible material has been kept out of the plane-of-weakness crack (Fig. 41). The fact that the neoprene-sealed joints were tight and that the plane-of-weakness crack was able to close completely raises the question of whether much infiltration occurs from the bottom of the joint, especially with cement-treated subbases such as were used here.

Although only one joint of each type is shown here, cores were taken from several joints of each type, and the results were comparable in each case.

CONCLUSIONS

Neoprene seals, by keeping incompressible materials and liquids that carry fine debris and silt from the plane-of-weakness cracks, can prevent functional damage to

joints and thereby extend the life of a structure. This statement cannot be made for the other systems observed in this study. In the five states surveyed in this report, the joints sealed with neoprene were in better overall condition than those sealed with other systems. Minnesota research engineers stated that 98 to 99 percent of their problems with joints have been eliminated since they started using neoprene seals.

No blowups have occurred in the neoprene-sealed sections of pavement under study; however, blowups have occurred in the adjacent sections.

The joints in California that contained no sealant of any type are now at least twice their original width.

Unsealed and liquid-sealed joints showed considerable degradation and damage through the infiltration of incompressible material into the joints. After 6 or 7 years of service, repair or rehabilitation of the joints would be impossible because of the infiltration of incompressible material into the plane-of-weakness cracks. Further damage might be stopped by adequate sealing. A survey should be made in 2 to 3 years to determine the extent of the damage to the slabs. Slab damage is currently minimal with all systems.

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