State of Illinois
DEPARTMENT OF PUBLIC WORKS AND BUILDINGS
Division of Highways
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August 1, 1967

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INTRODUCTION

Recent experiences with paved shoulders adjacent to concrete pavements in Illinois and elsewhere have suggested that the longitudinal joint at the interface of pavement and shoulder is a critical location for the entrance of water and salt-water solutions. Substantial amounts of vertical and horizontal displacement, longitudinal cracking, and loss of structural capacity of shoulder pavement have been attributed at least in part to the effects of the action of the water and salt-water solutions on underlying layers. If the edge joint can be sealed effectively, it seems probable that the water and salt-water damage can be substantially reduced.

The Bureau of Public Roads, in a Circular Memorandum of November 23, 1964, reported that observations on a limited number of construction projects showed that the longitudinal cracking of the shoulder did not occur where the opening between the through lane and shoulder pavement was sealed immediately following construction.

The performances of a wide variety of materials that had been tried through the years by Illinois in attempting to seal transverse joints and cracks were considered to offer strong indication that a better material was needed to provide the positive protection desired at the longitudinal edge joints.

As part of an effort to find or develop practicable and economical materials and procedures for sealing edge joints, an evaluation of a new hot-pour elastic-type rubber asphalt applied as a maintenance operation was begun in October 1965 by the Bureau of Research and Development with the cooperation of the Bureaus of Maintenance and Materials and of Districts 6 and 10. The new material (Presstite No. 357.5, manufactured by the Presstite Division, Interchemical Corporation, St. Louis, Missouri) had undergone extensive laboratory testing by the manufacturer and had performed satisfactorily in limited field testing by the Minnesota Highway Department. The probability that this material could serve successfully to seal a properly formed and cleaned edge joint appeared to be high enough to warrant this field investigation to evaluate its performance on a variety of paved shoulders in Illinois.

CHARACTERISTICS OF MATERIAL

The principal differences between the new hot-pour elastic-type material and the hot-pour elastic-type material often specified for sealing joints and cracks (A.S.T.M. Designation: D 1190, Standard Specifications for Concrete Joint Sealer, Hot-Poured Elastic Type) are in the bond and resilience characteristics. Although included in Illinois construction specifications for sawed joints, the material passing the A.S.T.M. D 1190 specification has had almost no use because of contractor preference for an alternative cold-applied material.

The A.S.T.M. D 1190 specification requires that bond specimens (three specimens, each 2 inches by 2 inches in cross section normal to the direction of extension and 1 inch long in the direction of extension) endure 5 cycles of extension to 1 1/2 inches at 0 F without development of any crack, separation, or other opening that at any point is over 1/4 inch deep in the sealer or between the sealer and the mortar blocks to which the sealer is bonded. The new elastic-type sealer bond specimens are required to endure 5 cycles of extension to 2 inches at 0 F without development of any crack, separation, or other opening of any depth. This latter requirement can be met by various two-component joint sealers costing considerably more than the sealer tested but not, insofar as could be determined, by single-component hot-pour joint sealers. The test is intended to measure the sealant's ability to maintain a waterproof joint during cold weather when the joint opening is greatest.

The 25 per cent recovery required of the penetration test specimen of the new sealer is a new requirement as the previous specification makes no mention of resilience. Briefly, the resilience test consists of pressing a 0.67-inch diameter steel ball assembly weighing 75 grams into a cured specimen and noting the rebound or recovery which occurs within 20 seconds after removal of the pressing force. This test is intended to measure the sealant's ability to reject foreign material.

The new material is reported to cost approximately $0.18 per pound, as compared with about a $0.11 per pound for material meeting D 1190 requirements, and a $0.0125 per pound for the PAF-2 commonly used by Illinois maintenance forces for crack and joint sealing. At the time this study was undertaken, the joints at the interface of pavement and shoulder were neither grooved nor sealed during construction; and sealed with PAF-2 without grooving as a maintenance operation.

The new sealer, as is the case with all hot-pour elastic-type rubber asphalt materials, requires the use of a double-walled oil bath melter with a mechanical agitator to prevent local overheating.

FIELD INSTALLATIONS

The locations chosen for the test installations are shown in Figures 1 to 3, inclusive. One installation is located on Route FAI 55 near Springfield and another on Route FAI 55 (Stevenson Expressway) near Chicago. With but one exception, the edge joint was grooved to a 1/2-inch width and 3/4-inch depth before sealing; and

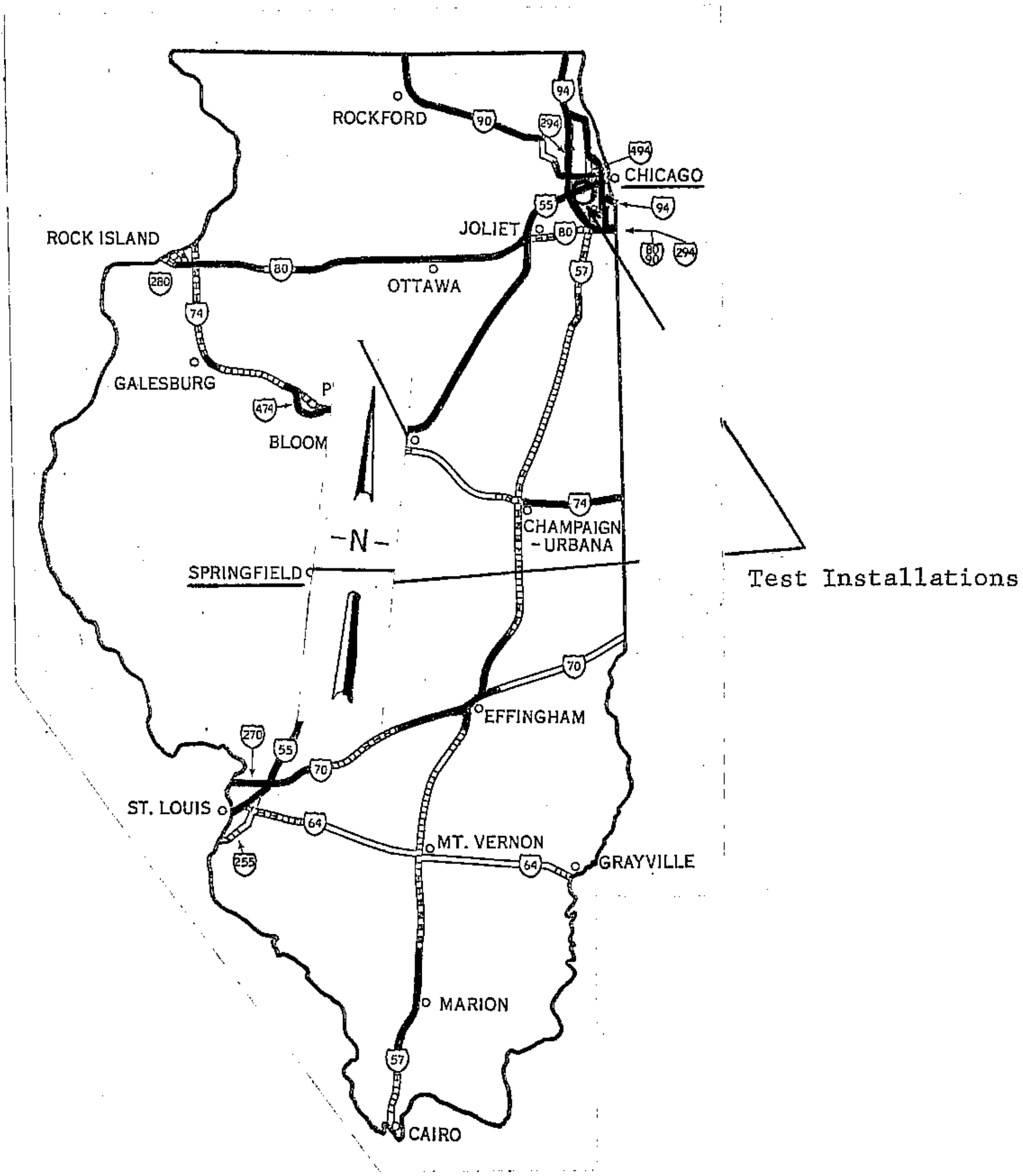
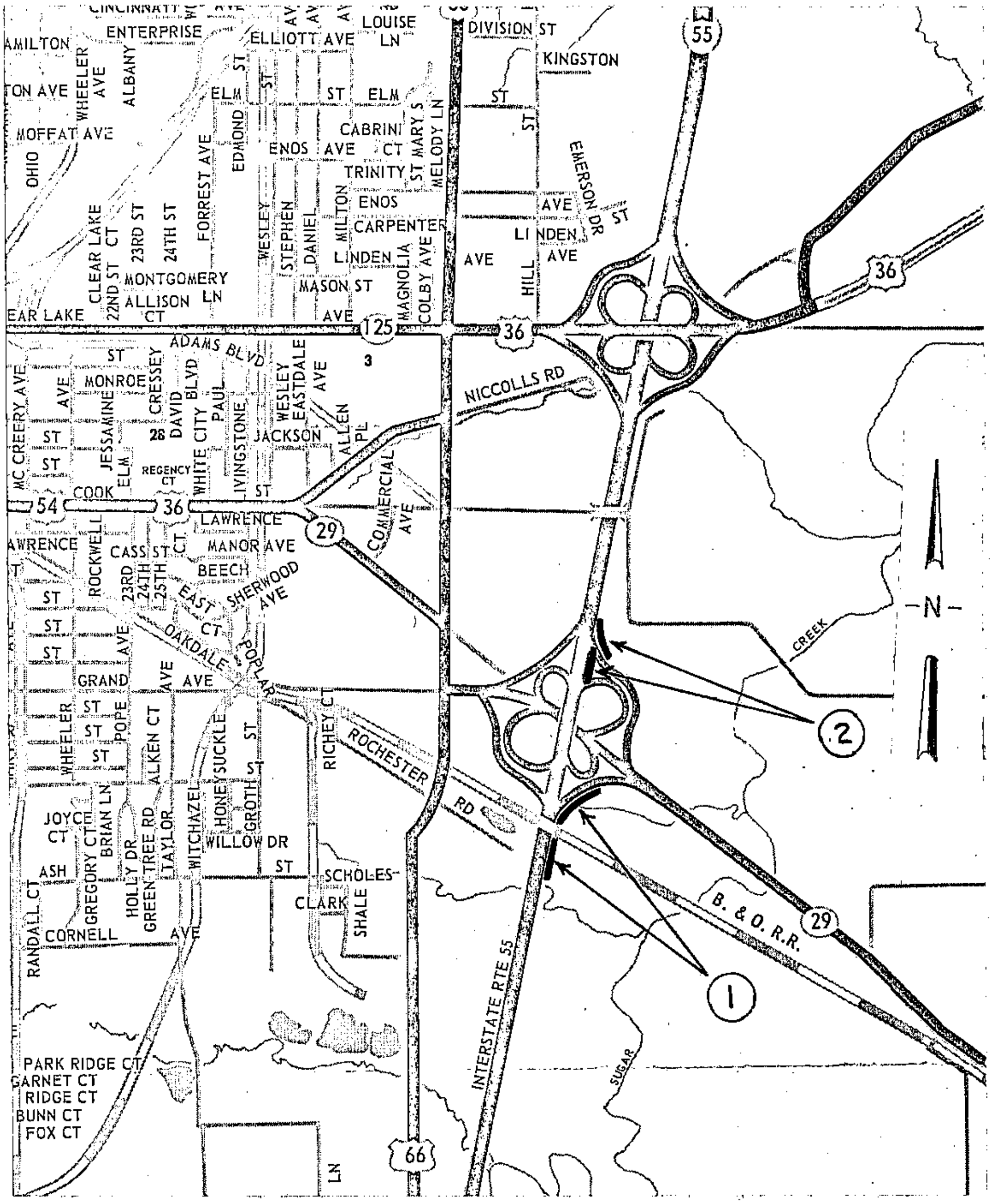


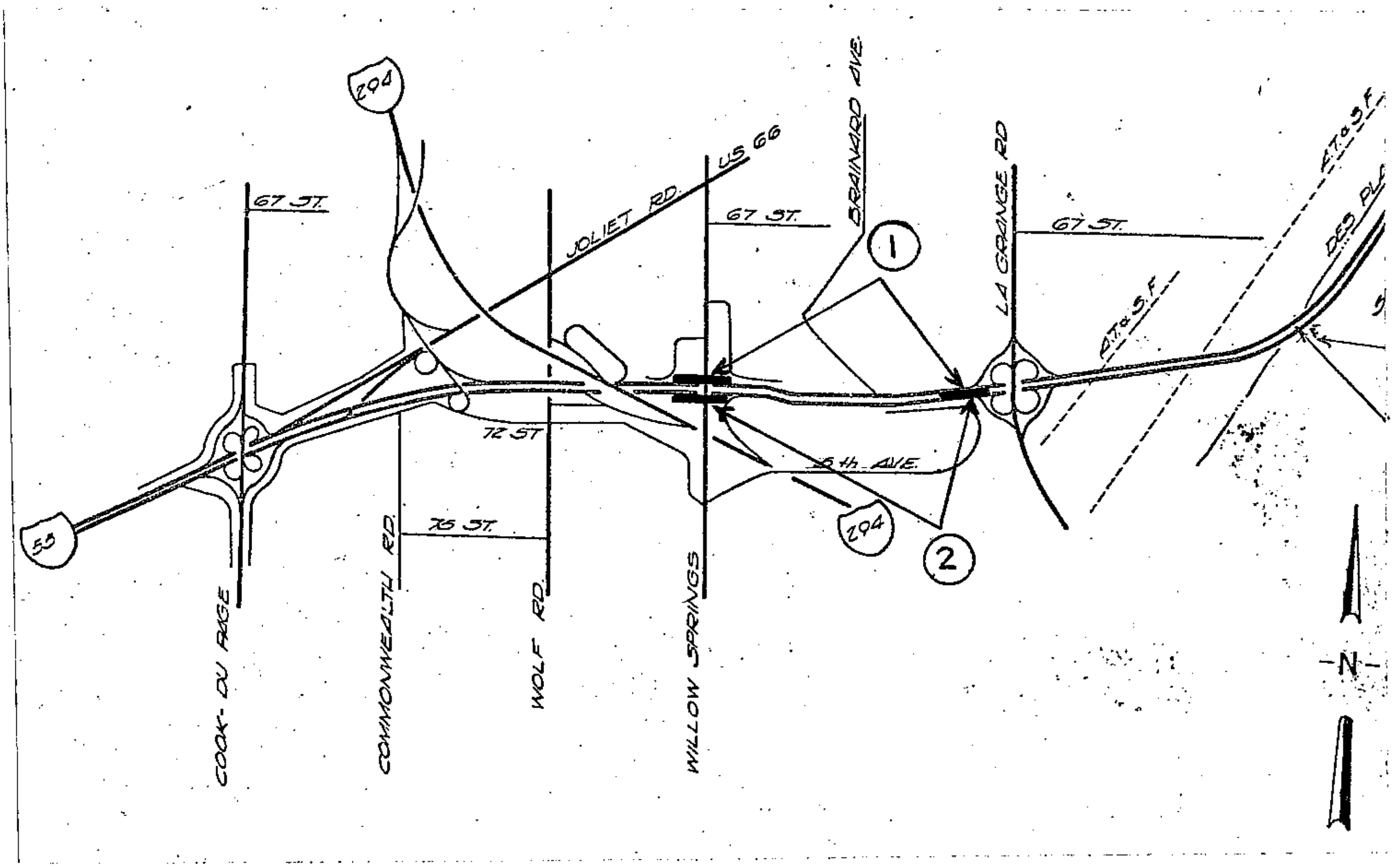
Figure 1. General location of test installations.



① - Test section

② - Control section

Figure 2. Location of Springfield test installation.



① - Test Section

② - Control section

Figure 3. Location of Stevenson Expressway test installation.

in all cases a control section similar to the test section, except for the sealing material (PAF-2), was provided. The one exception to the above occurred on the Stevenson Expressway where a 415-ft. length of joint was sawed to a depth of 2 inches. Following is a description of the experimental installations:

<u>Springfield Bypass</u> (Springfield)

Route: FAI 55

Section: 84-3-2

County: Sangamon

Pavement: 10-inch portland cement concrete

Shoulders: Full depth bituminous-aggregate (PA-1), 10-inch thickness at pavement edge

Test Section: NB Outside Shoulder, Sta. 250+00 to 259+86 and exit ramp (NB Route FAI 55 to EB Route Ill. 29) Sta. 1+24 to 11+58. Total length 2020 feet.
Date sawed - September 28-29, 1965
Date sealed - October 5-6, 1965
Sealant - Presstite No. 357.5 (575 lbs.)

Control Section: NB Outside Shoulder, Sta. 279+42 to 287+83 and entrance ramp (NB Route FAI 55 from WB Route Ill. 29) Sta. 14+00 to 23+32. Total length 1773 feet.
Date sawed - September 29-30 and October 1, 1965
Date sealed - November 1, 1965
Sealant - PAF-2

<u>Stevenson Expressway</u> (Chicago)

Route: FAI 55

Section: 0102-631

County: Cook

Pavement: 10-inch continuously reinforced portland cement concrete

Shoulders: 2 1/2-inch bituminous concrete surface over 7 1/2-inch pozzolanic base

Test Section: WB Outside Shoulder Sta. 1162+63 to 1171+00

Total length 837 feet.

Date sawed - September 30 - October 1, 1965

Date sealed - October 14, 1965

Sealant - Presstite No. 357.5 (220 lbs.)

Control Section: EB Outside Shoulder Sta. 1161+00 to 1171+00.

Total length 1000 feet.

Date sawed - September 30 - October 1, 1965

Date sealed - October 15, 1965

Sealant - PAF-2

Section: 0203-632-HBK

Pavement: 10-inch continuously reinforced portland cement concrete

Shoulders: 2 1/2-inch bituminous concrete surface over 7 1/2-inch cement-aggregate base

Test Section: WB Median Shoulder Sta. 129+40 to 139+40.

Total length 1000 feet.

Date sawed - September 30 - October 1, 1965

Date sealed - October 7 and 13-14, 1965

Sealant - Presstite No. 357.5 (135 lbs. in 585 feet of 3/4-inch deep joint and 255 lbs. in 415 feet of 2-inch deep joint)

Control Section: EB Median Shoulder Sta. 126+00 to 136+00

Total length 1000 feet.

Date sawed - September 30 - October 1, 1965

Date sealed - October 15, 1965

Sealant - PAF-2

Summary of Test Sections

Type Shoulder		Test Section Length (Ft.)	Control Section Length (Ft.)
Full depth bituminous-aggregate		2020	1773
Bituminous concrete surface over pozzolanic base		837	1000
Bituminous concrete surface over cement-aggregate base		1000	1000
	Total	3857	3773

CONSTRUCTION PROCEDURE

The work of sawing and cleaning the joints for the test was done by the respective District maintenance forces. The PAF-2 was furnished and applied in the control sections by the Districts. The Presstite Division, Interchemical Corporation, furnished the Presstite No. 357.5 and the equipment and personnel to apply the sealant.

Elastic-Type Sealant Sections

The joints were grooved by means of conventional concrete sawing machines equipped with 14 1/8-inch diameter, 7/16-inch wide "Conflex" blades C-1350 as shown in Figure 4. One blade could saw about 1000 feet of joint as experienced in the Springfield installation. Special effort was made toward the removal of all bituminous material from the pavement side of the joint. Immediately before application of the sealing material, the sawed joints were blown out with compressed air

Figure 4. Concrete sawing machine.

as shown in Figure 5. A close-up photograph is shown in Figure 6 of the cleaned sawed joint about 1/2 inch wide and 3/4 inch deep. Cut depths were measured from

Figure 5. Blowing compressed air in the sawed joint.

Figure 6. Cleaned joint.

the pavement surface or shoulder, whichever was lower.

The elastic-type test material was delivered to the jobsite in solid rubber-like form in 50-pound containers. An axe and a sledge-hammer were used to open one side of the containers to remove the material as shown in Figure 7. The 50-pound blocks of material were cut into eight pieces and melted in a gravity-type double-walled oil bath melter-applicator at 400 F. The melter-applicator was capable of melting about 150 pounds of material in three hours for the first batch and in about two and one-half hours for succeeding batches.

The melted material was applied directly in the joint opening in one complete pass as shown in Figure 8. In instances where not enough material was applied in the first pass, a second application was necessary. No difficulty was encountered during the operation, but it was learned that the material could not be cooled and remelted successfully at a later date after being heated once to its pouring temperature.

Figure 7. Removing test material from container.

Figure 8. Application of the test material.

PAF-2 (Control) Sections

The same procedures that were used for sawing and cleaning the joints where the elastic-type material was applied were used in the control sections of PAF-2 material. The PAF-2 hot-pour asphalt filler is used as a standard sealant by Illinois maintenance forces to seal contraction and expansion joints during the spring and fall of each year. The material is poured into the joint by a hand-carried pouring pot. Three passes were necessary to obtain a flush joint as shown in Figure 9.

Figure 9. Hand-carried pouring pot used in control section.

Transverse Shoulder Cracks

During the course of the trial installation on the Stevenson Expressway, some transverse cracks in the median shoulder in addition to the longitudinal joint at the pavement-shoulder interface joint were widened and sealed with the elastic-type sealant. A typical shoulder crack is shown in Figure 10.

Figure 10. Typical shoulder crack.

Twenty-six transverse cracks in the median shoulder were widened to a "U" shape about 3/4-inch wide and deep and varying in length from 9 to 10 feet with a Windsor Router. The Windsor Router can widen a 10-foot long crack 3/4-inch wide and deep in two passes in two minutes. The router is operated with the operator moving backwards in order to have an unobstructed view of the crack being widened. The router doing the second pass on a crack is shown in Figure 11.

As the router widens a crack, it also cleans it by using the exhaust of the motor to blow the cuttings. A typical widened crack is shown in Figure 12.

Figure 11. Router widening a shoulder crack.

Figure 12. Widened shoulder crack.

For the purpose of getting a clean joint, the widened crack was blown with air immediately before the sealant was applied. The material was applied at the same temperature and by the same procedure used in sealing the pavement-shoulder interface joints. A sealed transverse shoulder crack is shown in Figure 13.

Figure 13. Presstite sealed shoulder crack.

TEST RESULTS

Periodic inspections have been made of all experimental sections starting immediately after the sealants were applied. A detailed discussion of the performance follows.

Elastic-Type Sealant

The performance of the Presstite No. 357.5 in the pavement-shoulder interface joints was uniformly excellent through its first ten months and one winter of service. During this time no loss of bond was found, no tension cracks occurred, and no significant intrusion of foreign material into the seal was noted on any of the three test sections. The sealant remained resilient and "rubbery" even at below-zero temperatures.

However, during the second winter and early spring of 1967, all test joints started to fail in bond along the pavement-shoulder edges. Usually, in areas of failure, moisture was present in the joint during the spring months. In most cases dirt and gravel have accumulated in the failure cracks. Twenty-three months after application the amount of bond failure computed in per cent of the total length of test joint was 18 and 21 per cent for the Springfield Bypass installations, and 45 and 100 per cent for the Stevenson Expressway (Chicago) installations as shown in Figures 14 and 15.

Figure 14. Typical bond failure in Springfield installation.

Figure 15. Typical bond failure in Stevenson Expressway installation.

Not presently regarded as a cause for apprehension has been the appearance of some bubbles at the surface of the cured sealing material. However, water was observed coming out of some punctured bubbles both in the Springfield and Chicago installation. These bubbles were first observed in a survey made three weeks after the material was placed. They were not observed in subsequent surveys until nine months after the seal was applied. They were still present 14 months later, however.

The bubbles which were observed three weeks after sealing ranged up to about 1/8 inch in diameter and are shown in Figure 16. On the intervening surveys between then and the following July, 1966, they appeared to have collapsed leaving shallow pits in the sealant surface as shown in Figure 17. The bubbles which were observed to reappear in July and August, 1966, and which were still in evidence at the time of the most recent survey on July 1, 1967, are larger than the bubbles observed earlier, ranging in size from 1/8 inch to as much as 3/4 inch in diameter. The larger bubbles appeared only in the 2-inch deep joint groove on the Stevenson Expressway.

Figure 16. Test section three weeks after sealing.

Figure 17. Air bubbles collapsed during cold months.

Upon collapse, these bubbles leave depressions up to 1/4-inch in depth in the surface. These observations are shown in Figure 18 for the Springfield installation and in Figures 19 and 20 for the Stevenson Expressway installation.

Figure 18. Air bubbles reappeared in Springfield installation.

Figure 19. Larger bubbles in 2-inch deep Stevenson Expressway installation.

Figure 20. Smaller bubbles in 3/4-inch deep Stevenson Expressway installation.

The bubbles in the material are believed to result from moisture present in the joint faces at the time of pouring. A laboratory test designed to demonstrate the effects of moisture on the performance of the seal material tends to confirm this belief.

Pairs of standard bond samples designated A to E, inclusive, were prepared under various moisture conditions of the concrete blocks by the manufacturer as follows:

Sample A - Sealant material poured between oven dried and desiccated concrete blocks, after which the sealed specimens were placed in oven for 4 hours at 158 F.

Sample B - Sealant material poured between standard water cured blocks blotted dry, after which the sealed specimens were placed in oven for 4 hours at 158 F (Presstite test No. 213).

Sample C - Sealant material poured between standard water cured blocks air dried in laboratory at 77 F, after which the sealed specimens were placed in oven for 4 hours at 158 F.

Sample D - Sealant material poured between desiccated blocks on moisture saturated blotting paper, after which the sealed specimens were placed in oven for 4 hours at 158 F.

Sample E - Sealant material poured between surface wetted desiccated blocks set on moist blotting paper, after which the sealed specimens were placed in oven for 4 hours at 158 F.

Following the 4 hours' exposure at 158 F, one of each pair of the samples was cut parallel to the bond faces, opened, and placed with the cut faces up next to the matching sample as shown in Figure 21. With the exception of Sample A, all samples contained some evidence of bubbles. Sample B had several small blisters at the top surface; Sample C had craters and blisters at the top surface. Samples D and E each had blisters and craters at the top surface and, in addition, had several deep bubbles which were intersected by the cut. Later the same samples were exposed outside for 7 days with ambient daytime temperatures ranging from 80 F to 90 F. The effect of the increased exposure was to increase the number and size of the bubbles and craters in all sample pairs except Sample A. Figure 21 shows the samples after the seven-day additional exposure. The largest craters were approximately 3/4 inch in diameter.

The test conditions for Samples D and E are obviously extreme. However, they point out the need to avoid sealing pavements under high moisture conditions.

In a further test Sample A was soaked in water for 17 hours and then

Figure 21. Seven-day exposure on manufacturer's test samples.

placed in a container for 2 1/2 hours at 158 F ± 5 F. This was done to determine whether the moisture absorbed by the concrete could penetrate the sealant when exposed to high temperatures and later form bubbles in the surface. The result indicated that if the concrete block is oven dried at the time of pouring, no bubble will develop in the sealant surface. Since this is a condition that will never be attained in the field, it is a fair assumption that some bubbles will develop in the Presstite sealant joint due to moisture present in the concrete, in the shoulder surface, or in the base material at the time of sealing. To minimize the effect of moisture and high temperature, the joint should be reasonably dry at the time of sealing. From the results of this test, it has been concluded that all bubbles occuring in the sealant result directly from moisture present at the time of sealing and there is little likelihood that additional bubbles will form from moisture coming in contact with the sealed joint subsequent to curing.

In an effort to evaluate the possible effects of sealing edge joints on vertical shoulder movements, a program of periodically measuring the difference between pavement and shoulder elevations on the test and control sections was begun in March 1966. However, the data collected to date do not show any well-defined trends.

PAF-2 Sections

The performance of the PAF-2 seal in the control sections has been uniformly poor beginning approximately two months after installation. At the onset of cold weather the PAF-2 became brittle, and, as the cracks opened due to thermal contraction of the abutting pavement and shoulder structures, local failures in both tension and bond were observed. A typical view of a PAF-2 sealed joint is shown in Figure 22. By mid-January 1966, 1/8-inch wide full-depth cracks were common in all control sections. By spring 1966 part of the PAF-2 had disappeared, and intrusion of soil and gravel as shown in Figure 23 was common. With the advent of warm weather in June and July 1966, and the attendant sofening of the PAF-2, many- but not all - of the cracks observed earlier appeared to have healed themselves.

Figure 22. PAF-2 control joint during winter.

Figure 23. Intrusion of foreign material in PAF-2 joint.

Transverse Shoulder Cracks

The performance of the Presstite sealing material in the transverse shoulder cracks was not nearly as good as in the pavement-shoulder interface joints during the first ten months and one winter of service. Eighteen out of 26 sealed shoulder cracks failed along one edge or both edges through various portions of their lengths as shown in Figure 24. Foreign material was found to be infiltrating the openings. At twenty-three months since application 22 sealed shoulder cracks have failed in bond.

Figure 24. Presstite sealed shoulder crack failed.

SUMMARY AND CONCLUSIONS

A new hot-pour rubber asphalt joint sealant known as Presstite No. 357.5 was used to seal approximately 4000 feet of 1/2-inch wide by 3/4-inch deep longitudinal joint at the interface of the concrete pavement and paved shoulder on Route FAI 55 near Springfield and near Chicago.

The following tabulation summarizes the location and type of pavement, type of shoulder, length of the test and control sections, and amount of bond failure in each section involved.

Test and Control Sections

Location and Type Pavement	Type Shoulder	Test Section Length (Ft.)	Test Section Failure (%)	Control Section Length (Ft.)	Control Section Failure (%)
Springfield Bypass - portland cement concrete	Full depth bituminous aggregate	2020	20	1773	100
Stevenson Expressway continuously reinforced portland cement concrete	Bituminous concrete over pozzolanic base	837	100	1000	100
Stevenson Expressway continuously reinforced portland cement concrete	Bituminous concrete over cement aggregate base	1000	45	1000	100
	Total	3857		3773	

Control sections were similar to the test sections except for the sealant which was PAF-2. The test and control sections were completed on November 1, 1965, and were inspected regularly through July 1967.

The performance of the Presstite No. 357.5 seal of pavement-shoulder interface joints was uniformly good with no loss of function for the first ten months and one winter of service, but numerous bond failures occurred during the second winter. Bubbles or pockets which were observed at and near the surface of cured material approximately three weeks and again at nine months until the present time have not detracted from the integrity of the seal. However, water was noted coming out of some punctured bubbles.

The performance of the PAF-2 sealant has been poor almost from the start. Tension cracks and bond failures started to occur early in the first winter and have been so extensive as to render the seal ineffective.

Twenty-six transverse cracks in the median shoulder were widened to a "U" shape about 3/4-inch wide and deep and varying in length from 9 to 10 feet with a Windsor Router.

The performance of the Presstite sealant in the transverse shoulder cracks has been poor. The sealant, in 22 out of 26 sealed shoulder cracks, failed along one edge or both edges through various portions of their lengths.

The results of this investigation suggest that Presstite No. 357.5 placed in a groove 1/2-inch wide by 3/4-inch deep is not completely effective in sealing the longitudinal joint between pavement edge and paved shoulder to prevent surface water and brine solutions from entering the pavement and shoulder structures through this joint.

It is believed that this investigation should be continued to determine the practical life of the sealant material and the effects, if any, of sealing the edge joint on paved shoulder behavior in other areas of the State. The joints should be in a reasonably dry condition at the time of sealing to minimize the occurrence of bubbles in the sealant surface. Other high quality joint sealants and other configurations should be investigated to determine the best combination of joint configuration and sealant for sealing edge joints. Investigations of materials and methods for satisfactorily sealing transverse cracks in paved shoulders also should be conducted.