Cleaning and Resealing of Concrete Pavement Joints by Contract

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The proper maintenance of the seal in the joints of concrete pavement has for some time been a major problem in our maintenance operations. With the ever increasing scope of maintenance work the department has not been able to keep up with the proper maintenance of the joints.

A small amount of experimental cleaning and resealing of joints with a hot rubber asphalt compound was done by the maintenance forces at an average cost of $0. 253 per linear foot. It was felt that this cost would be considerably reduced if the work were done on a larger scale and by contract. A program was set up and two projects totaling 29 miles in length were completed by contract. The average final unit costs for cleaning and resealing joints and cracks were $0. 099 per linear foot on one contract and $0. 112 per linear foot on the second contract. These unit prices include only the cost of cleaning and applying the seal plus the cost of the material. It is estimated that $0. 02 per linear foot will cover the cost of traffic control and protection.

In addition to the resealing of the joints, a two-inch relief joint was cut in the pavement every 1, 000 feet to provide expansion space in hot weather and to reduce the number of yearly blowups now occurring in our pavements twenty years of age or older. The relief joints were formed by sawing through the 8-inch pavement on a line parallel to and 2 inches from one of the joint faces. This 2-inch opening was filled with several pieces of 1-inch premoulded fiber board up to within 1½ inches from the surface of the concrete. The joint was then sealed with hot rubber asphalt compound of the same type used in resealing the pavement joints.

It is quite apparent from the observed condition of older pavement joints in Connecticut that the cleaning and resealing of joints is well worthwhile. In view of the fact that the older joints are by now quite filled with foreign material and the present method does not clean the full depth of joint, it has been deemed advisable to rearrange the schedule of joint sealing. In the future, this corrective work will be done on pavements up to five years of age first and then gradually progress to the older pavements, thus preventing the newer pavements from approaching the condition of distress now so prevalent on the older roads.

● AS of June 30, 1954 the Connecticut State Highway Department had 821 miles of concrete pavement, varying in age from 2 years to about 35 years, together with about 50 miles of access ramps. With a steady increase in the constructed mileage of concrete roads the problem of properly maintaining the joints has become acute. Realizing that the joints are an inherent weakness in the concrete pavement and therefore a source of disintegration of the concrete, it was decided to clean and reseal them by contract.

Early in 1954 a program was developed for the cleaning and resealing of joints by contract on about 70 miles of concrete pavement. Included in this program was also a provision for the sawing of 2 in. relief joints the full width and depth of the concrete pavement at intervals of 1, 000 ft. The sawing of relief joints was to be done only on pavements constructed prior to 1934 since up to this time load transfer units at the joints had not been used. Each summer has seen the occurrence of numerous blowups in the concrete pavements which are 20 years of age or older and for this reason the cutting of 2 in. relief joints was included in the proposed work to eliminate this condition.

Specifications, based on the experience of the Minnesota Highway Department (1), were written and quantities were derived for the work to be done on two contracts. Both contracts called for the cleaning and resealing of joints, the cutting of 2 in. relief strips and patching of the spalled areas at the joints with bituminous concrete. The first project was 10 miles of 4-lane concrete pavement on US 1 in the towns of Milford, Orange, and West Haven. This pavement varies in age from 25 to 30 years and is subjected to very heavy truck traffic. The expansion joint spacing varies from 40 to 66 ft and the width of pavement varies from 36 to 40 ft. There are no transverse dummy joints in this pavement and the ratio of the final length of transverse cracks to the total length of transverse joint was 2. 05 to 1.

The second project was 19 miles of dual-lane concrete pavement on 12 miles of divided highway, Routes US 5 and 15, in the towns of Meriden, Berlin, Newington, and Wethersfield. This pavement, which is also subjected to very heavy truck traffic, varies in age from 13 to 30 years with the major portion being about 15 years old. The expansion joint spacing on about one-third of this project is 75 ft, with transverse dummy joints every 25 ft. The remaining portion has an expansion joint spacing which varies from 60 to 75 ft with no transverse dummy joints. The total width of the dual lanes is approximately 25 ft. The ratio of the final length of transverse cracks to the total length of transverse joint was 2 to 5. If the 5. 5 miles of pavement with an expansion joint spacing of 75 ft and a dummy joint spacing of 25 ft were omitted, the ratio of the final length of transverse cracks to the length of transverse joint would be 3 to 5.

It is of interest to note that on Project No. 1, where the age of concrete pavement is 25 to 30 years, the ratio of transverse cracks to transverse joint is 2 to 1 and in pavement of similar design in Project No. 2 at about 15 years of age the ratio of transverse cracks to transverse joint is 3 to 5. The pavement in which transverse dummy joints were incorporated contains predetermined cracks in the ratio of 2 to 1 from the date the pavement was poured. It appears that if the predetermined transverse cracks or dummy joints were omitted in the pavement design, at least in this particular instance, the joint maintenance as well as some of the riding discomfort would have been reduced.

The old joint seal removed from the joints on both projects was an asphalt cement in which a filler was incorporated. The joint sealing material specified in the resealing program was a rubber asphalt compound of both the hot-poured type and the cold-poured type conforming to Federal Specifications SS-S-164 (Feb 12, 1952) and SS-S-159 (Feb 13, 1952), respectively.

On October 25, 1954 bids were received for the cleaning and resealing of joints on the aforementioned projects. The prices of the low bidder (the same contractor was low bidder on both projects) are shown in Table 1.

TABLE 1

LOW BID PRICES FOR CLEANING AND RESEALING JOINTS

		US 1		US 5 and 15	
		Quantity	Unit Price	Quantity	Unit Price
Dense Graded Bituminous Concrete	ton	40	45.00	11	45.00
Clean and Reseal (Hot Seal)	l. f.	133,967	.046	218,962	.05
Clean and Reseal (Cold Seal)	l. f.	70,563	.046	58,510	.05
Sealing Compound (Hot Seal)	lb	81,847	.15	131,713	.16
Sealing Compound (Cold Seal)	lb	43,111	.15	35,106	.16
Relief Joint Construction (Hot Seal)	l. f.	1,310	2.50	300	2.50
Relief Joint Construction (Cold Seal)	l. f.	690	2.50	None	
Trafficmen	hr	1,440	2.20	1,920	2.00

Due to the lateness of the season the contractor was not permitted to start work until April 1, 1955. The appearance of the joint seal on US 5 and 15 prior to and after resealing is shown in Figures 1 through 3. Figure 2 indicates very well the typical condition of too many of our transverse joints. The age of this seal is not definitely known but is probably not less than two years. In all cases where tie bars were used at the longitudinal joints the old joint seal in the longitudinal joint appeared to be in comparatively good condition. In our early concrete pavements where tie bars were not used the

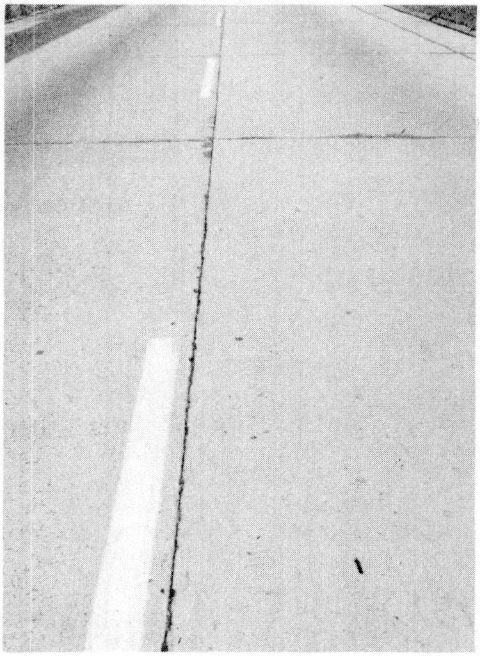

Figure 1. Joints on US 5 and 15 prior to cleaning.

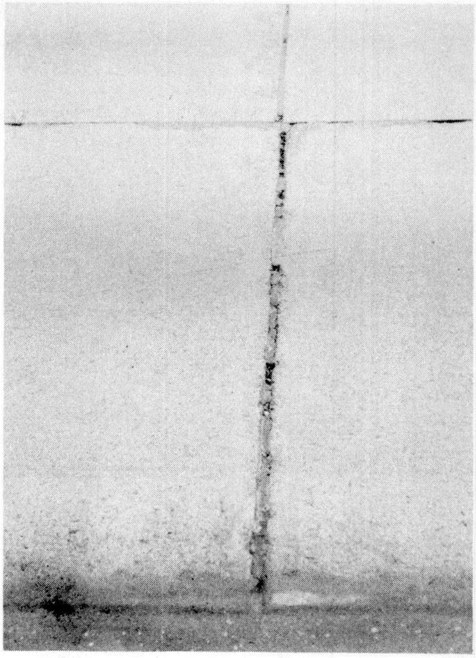

Figure 2. Typical condition of seal in transverse joint prior to cleaning and resealing.

longitudinal joint has opened up considerably in many areas as a result of lateral movement of the slabs and in these cases the joint seal is in poor condition. At this time some thought has been given to eliminating the resealing of the longitudinal joint in those pavements where tie bars were used and the joint seal appears undisturbed. The length of longitudinal joint in a dual lane pavement with a concrete gutter strip becomes quite significant where cost is concerned and from past observations the resealing of the longitudinal joint contributes little to the relief of damaging stresses at the transverse joints. Figure 15 shows there is no guarantee even shortly after resealing the longitudinal joint that the joint will be watertight. On a dual lane divided highway such as US 5 and 15 the ratio of the total length of longitudinal joint to the total length of transverse joint is about 2 to 1. Sixty-six percent of the total cost is for the resealing of the longitudinal joint and 33 percent for the transverse joint. Yet the most familiar types of pavement disintegration begin at the transverse joints.

The condition of the cold-poured seal on US 1 several weeks after the joints were resealed is shown in Figure 4. The use of

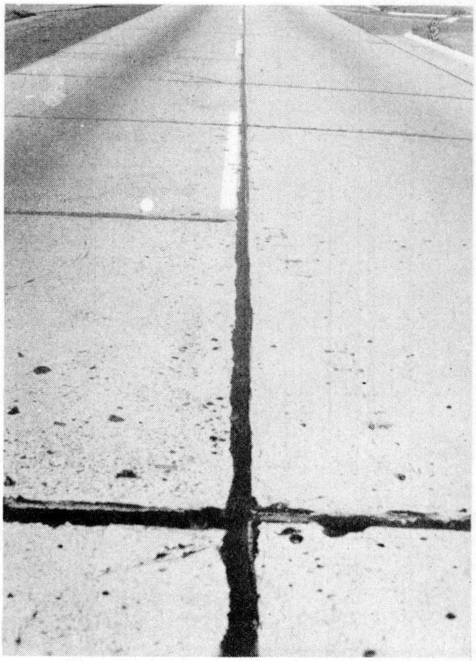

Figure 3. Joints after cleaning and resealing.

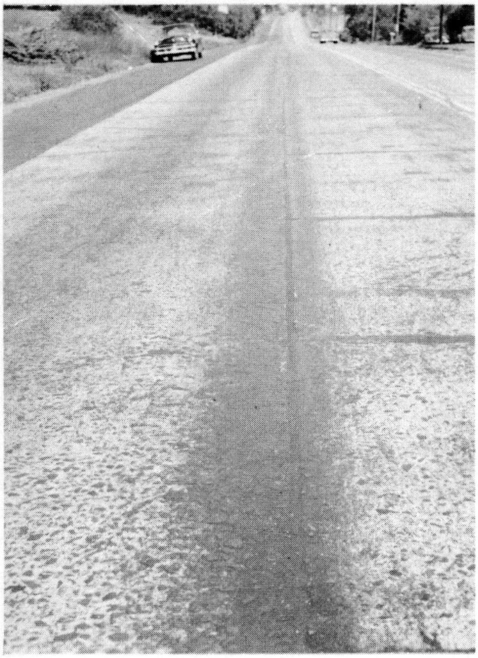

Figure 4. Appearance of joints two weeks after resealing with cold-poured type seal.

the cold-poured type seal was called for to determine if this material could be successfully used. In the past our experience in sealing the joints of newly constructed pavement with the cold-poured type has not been successful except where it was used in sawed joints. The air temperature at the time of resealing the joints on US 1 was between 85 F and 90 F. A paper tape was placed over the fresh seal and on the same day upon the completion of the resealing in this area the road was opened to traffic. Shortly after traffic began to travel over this area the paper tape began to pull away from the joint with some of the seal adhering to it. Once the tape was removed the fresh seal was tracked over the pavement resulting in a rather messy condition.

C. W. McCaughery in a report on "Joint Sealing Maintenance Operations," Proceedings, Highway Research Board, Vol 33, p 358 (1954) mentions a similar experience when the contractor sealed the joints of new concrete pavement with cold seal during the months of July and August. There appears to be an air temperature limitation on the use of cold seal particularly during hot weather and although it has been successfully used in the sawed joints during warm weather its use in the wider transverse joints has not proved satisfactory. In any case, further use of the cold-poured type seal was discontinued on this project for the time being.

The operational procedure and equipment used in cleaning and resealing the joints was essentially the same as that of the Minnesota Highway Department. A hydraulically operated vee shaped tooth mounted on a small 30 hp tractor was used in the initial removal of the old seal. When the air temperature was below 75 F this device did an excellent job of cleaning the seal from the joint, however, as the temperature rises the seal becomes quite tacky and is not removed as cleanly from the joint. The joint cutting machine follows the tractor removing or loosening up the remaining seal and foreign material in the joint to a depth of not less than 1 inch. Nine cutters were used in the cutter head when cleaning and grooving transverse joints and cracks. The cutter head used to clean the longitudinal joints contained six cutters. The respective cost of these cutters was $1. 25 each and $1. 05 each and they last from thirty minutes to one hour. When these cutters become worn they will chip the sides of the concrete badly unless they are replaced at once. In some cases it is difficult to follow precisely the path of a crack with this grooving equipment. In such cases the groove may be partly along the crack and partly in concrete adjacent to the crack. Several passes with the joint cutter are then required to cut a groove directly over the crack. The result is a groove of varying width which, however, is filled with seal. A self propelled vacuum cleaner was used to remove the debris from the pavement and it did a very good job. Prior to the resealing the joints were blown out with compressed air at 100 psi. The joint seal was packaged in thin rubber sanks enabling the operator to easily remove the paper covering and place the seal and rubber sack together in the melter. A mechanical melter of 500-600 lb capacity with a mechanical agitator maintained the seal temperature between 400 F and 450 F by an oil bath type of indirect heater. The best pouring temperature for the seal used on these projects appeared to be between 390 F and 400 F. The melted seal was transferred to pouring pots which maintained the necessary temperature also by an oil bath. A leather shoe on the applicator acts as a reservoir and a wiper to maintain a steady flow of material into the joint and to wipe the surplus from the joint edges. The concrete joint must be dry when the seal is poured; even slight dampness of the concrete will prevent a good bond between the seal and the concrete.

The extent to which joint deterioration has progressed in much of our older concrete pavement is indicated in Figure 5. This concrete is 30 years old and outside of the evident distress at the joints the surface is in good condition. The expansion joint spacing is 60 ft with bar mat reinforcement as visible in Figure 5. Load transfers were not installed in any of our concrete pavements at that time. The original joint filler which was of the premoulded bituminous type ½-in. thick, has become so impregnated with silt or sand as to make recognition very uncertain. Transverse joints in this condition are going to be more susceptible to localized pressures due to the infiltration of varying amounts of silt or sand since there is no compressible gasket left which might absorb such pressures created by the restrained expansion of the pavement. Examination of the joint seal during the summer in a pavement only 3½ years old indicated considerable fine silt was accumulating in some of the joints between the contact areas of the joint and the seal although at the time the external appearance of the seal gave no indication of the possibility of such a condition. However, the following winter at temperatures of 10 F to 14 F this same seal was badly cracked and in places pulled away from the joint face thus providing a ready opening for the entrance of foreign material. The following summer, traffic appeared to knead the cracks together and blacken the surface of the seal so that a casual observation would seem to indicate satisfactory condition of the seal. Observations made of the joint seal on a pavement 7½ years old indicated the seal was completely removed in a few joints with partial removal in numerous joints. Upon the removal of seal from what appeared to be a well sealed joint, considerable foreign material was uncovered between the seal and the concrete varying from fine silt up to ⅜ inch stone. Nine samples of joint seal were removed from the joints of a concrete pavement 3½ years old and taken to the laboratory where 10 percent to 83 percent insoluble material was found in the seal. In all cases, the observed joint seal has been a rubber asphalt compound of the hot-poured type.

Figure 5. Spalled joint with wire fabric showing.

On the basis of the severe joint spalling and the observations of the condition of the asphalt rubber compound in use, our joint sealing program is being revised. Those pavements which are 3 to 5 years old will be resealed first followed by those which are over 5 years old and up to 10 years of age and progressing to the older pavements last. The idea is to prevent our newer pavements from approaching the condition of distress now prevalent in our older pavements.

The reduction of the expansion space and in many cases the complete closure of the expansion joint itself is the forerunner of blowups on our concrete highways. On US 1 between New Haven and Greenwich, a distance of 45 miles, our maintenance department reported 58 blowups during the summers of 1952 through 1955. In 1955 seven blowups were reported on US 1 within the area where the two inch relief joints were to be cut. Although the contractor started the work of cleaning and resealing the joints in April 1955, no attempt was made to saw the relief joints until July. By this time the pressure developed within the restrained concrete pavement had reached the point where it was impractical to attempt to saw the concrete. In each attempt that was made the saw became bound before cutting half way through a ten foot lane and a jackhammer with paving breaker was required to remove the saw from the pavement. The contractor was per-

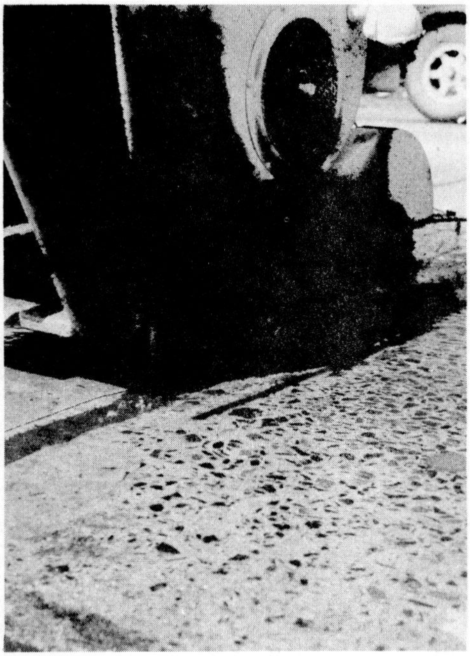

Figure 6. Twenty-two inch concrete saw attached to 28 horsepower motor.

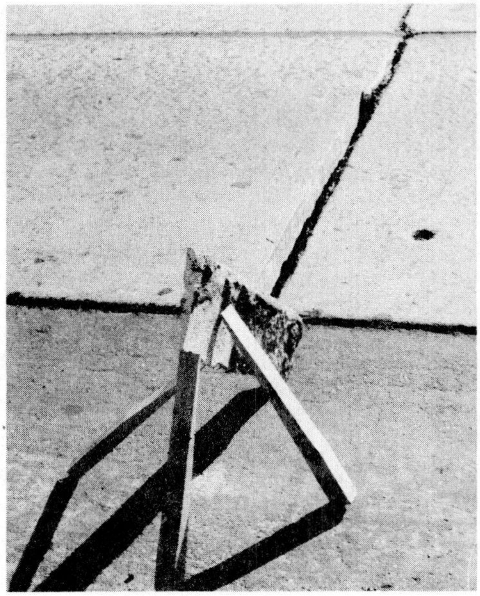

Figure 7. View of inclined joint face.

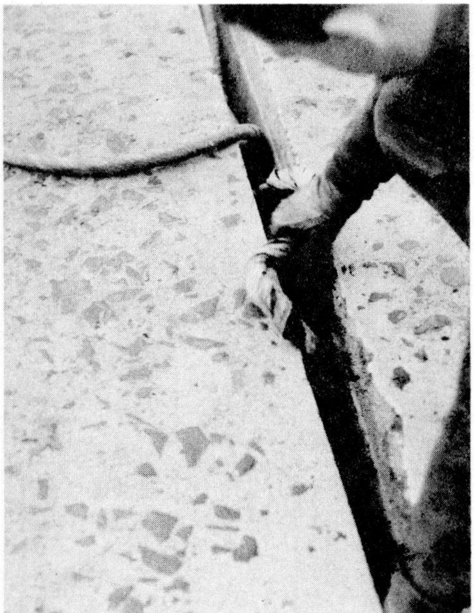

Figure 8. Paper rope being placed in relief joint.

Figure 9. Special tamping device to level off joint filler.

mitted to suspend this work until cooler weather prevailed.

In September work was resumed on the construction of relief joints. By observing the pattern of blowups which have occurred on US 1 over the past five years an interval of 1,000 ft was established between relief joints. The actual procedure was to select the expansion joint nearest to the 1,000 ft interval and mark off a line 2 in. from and parallel to one face of the joint. In this way one saw cut was made at each relief joint. Figure 6 shows the 22 in. saw blade and the 28 hp motor used to saw the concrete. The average cutting speed with this equipment in 8 in. concrete with trap rock aggregate was 2 in. per minute and the highest observed cutting speed was 3 in. per minute. It required 36 working days to saw through 49 joints or a length of 1,900 ft. In this period, four 22 in. blades costing approximately $300 each were used to cut the concrete. At air temperatures of 60 F or lower, no difficulty was encountered in cutting the concrete pavement but at air temperatures of 70 F to 80 F some difficulty was encountered as evidenced by the fact it required seven working days to saw five joints or 200 ft of concrete. Under normal operating conditions two joints or 80 ft of concrete could be cut in one day. At air temperatures above 80 F it was impractical to attempt the sawing of the pavement.

Figure 10. Sealed relief joint.

In some cases where the joint seal made it difficult to remove the sawed concrete a jackhammer was used to break the concrete into small pieces. At times the pavement would close up the saw cut requiring the use of a jackhammer again to break up the sawed concrete. Occasionally the sawed portion could be removed by hand and Figure 7 shows a portion of the concrete removed from a joint. The triangular cross section of the sawed portion indicating inclined joint faces is typical at a large number of the sawed relief joints and an inclination of 3 in. per ft was not uncommon. The majority of observed blowups have occurred as a result of this condition. The paper rope in Figure 8 was placed at the bottom of the joint where the pavement depth was greater than 8 in. so as to maintain the tops of the 1 in. by 6½ in. premoulded fiber board (non-extruding type) 1½ in. below the concrete. This paper rope is not satisfactory. It absorbs water and soon becomes a soggy mass which will rot and thus leave a cavity for the joint filler to drop down. The possible use of scrap sponge rubber in place of the paper rope is being investigated. A special tamping foot was devised by the contractor (Figure 9) to level off the top of the fiber board filler and the accompanying brooming of the filler helped to fill any irregularities in the joint width. The temperature of the joint seal was kept as low as possible and still maintain a liquid flow from the hand pouring kettle. This was done to prevent the seal from ponding at the edge of pavement. The joint seal was kept ¼ to ½ in. below the pavement to provide space for the compressed seal due to pavement expansion during the following summers and to prevent traffic from tracking the fresh seal. A completed relief joint is shown in Figure 10.

In November, four months after the transverse joints and cracks were resealed on US 1, an examination was made of the seal condition. Figure 11 is a typical resealed joint on US 1. Although the seal was poured flush with the pavement with two applications there is now a very noticeable slump in the seal at the transverse expansion joints. The air temperature at the time this inspection was made was between 50 F and 60 F. On the basis of the difficulty encountered in sawing this pavement the highly probable tempera-

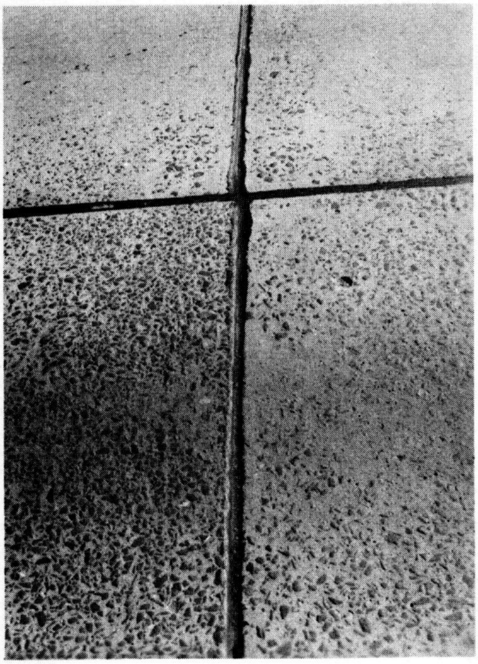

Figure 11. Typical resealed transverse expansion joint on US 1.

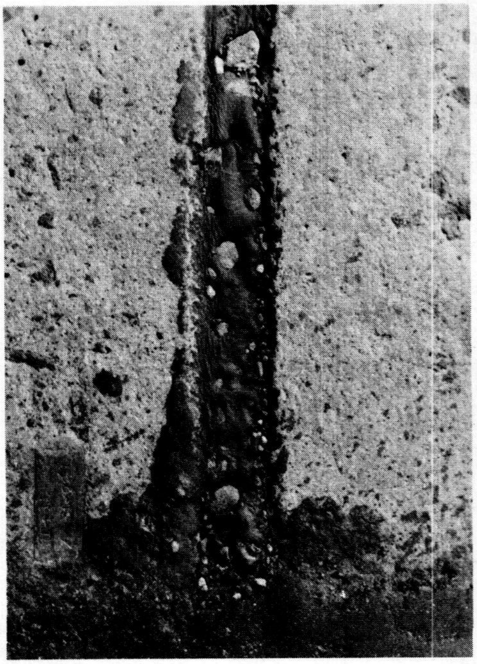

Figure 12. The embedded stone in the joint seal will cause some displacement of asphalt in the summer.

ture at which restrained expansion begins is somewhere between 65 F and 75 F. If it is assumed that the concrete, on the day inspection was made, had contracted through a temperature of 25 F the expected opening might be 0.09 in. which in this width of joint seal would not cause the amount of necking down now visible. In several cases where the sawed concrete in the relief joints was removed by hand, evidence of where the joint seal had run down into the joint was found in air pockets in the concrete near the subgrade. It is quite possible that despite the fact that the joints were tightly closed at the time the seal was poured, some of this seal did flow down through the joint. The condition of the joint seal in some of the resealed joints on US 1 is shown in Figures 12, 13, and 14. In Figure 12 considerable coarse material is becoming embedded in the seal. The extraneous material appears to be one of the causes why each summer the joint seal at numerous joints continues to spread over the pavement under the action of traffic without any apparent loss of material in the joint. The brass plate in the lower left hand corner indicates the date on which this pavement was poured (April 30, 1928). Figure 13 is a typical condition of the joint

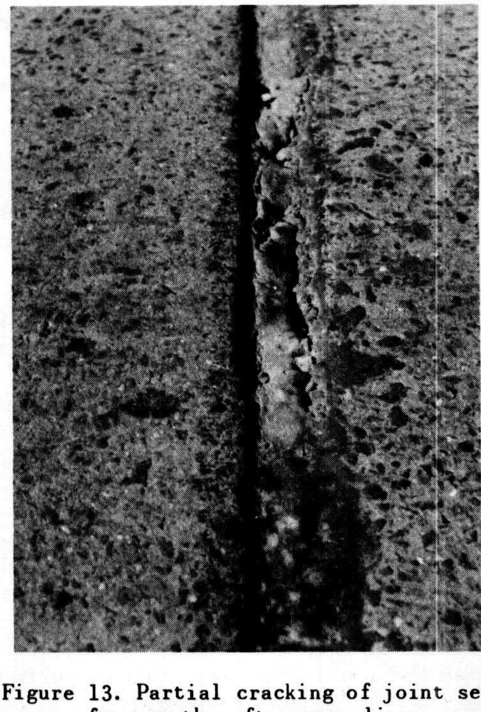

Figure 13. Partial cracking of joint seal four months after resealing.

seal observed in three transverse joints and Figure 14 shows condition of joint seal at a transverse crack. Determination of the specific gravity of the joint seal at these cracks indicates an increase in weight of 5. 6 percent to 54 percent. In removing the seal samples, considerable silt and fine sand was encountered under the seal and in the joint. Figure 15 shows considerable subsurface water coming out of the resealed longitudinal joint on US 5 and 15 the day after a rain. The water is visible on the pavement for three to five days after a heavy rainfall. There are no visible cracks in the longitudinal seal in this area.

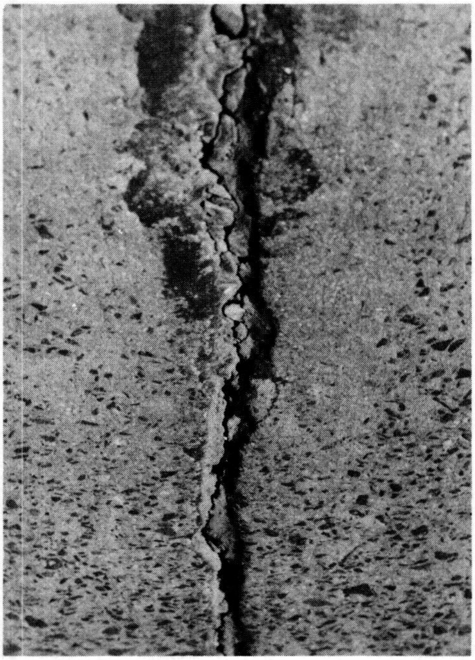

Figure 14. Seal failure four months after crack was resealed.

Figure 16 is a resealed transverse joint in the same areas as the longitudinal joint in Figure 15. Water could be observed through the two openings in the joint seal standing within 1 in. of the top of pavement and the pumping action caused by heavy trucks passing over the joint forced considerable water out of the joint.

The proper maintenance of joints is well worthwhile provided the joint seal will maintain, to a reasonable extent, a clean and unhampered joint over a reasonable period of time. Final measurements show that 242,164 linear feet of joint and cracks were cleaned and resealed with 74,350 lb of hot seal on US 5 and 15. This work was done in 59 working days by one crew working about 8 hours per day. On the basis of the above measurements and the unit bid prices,

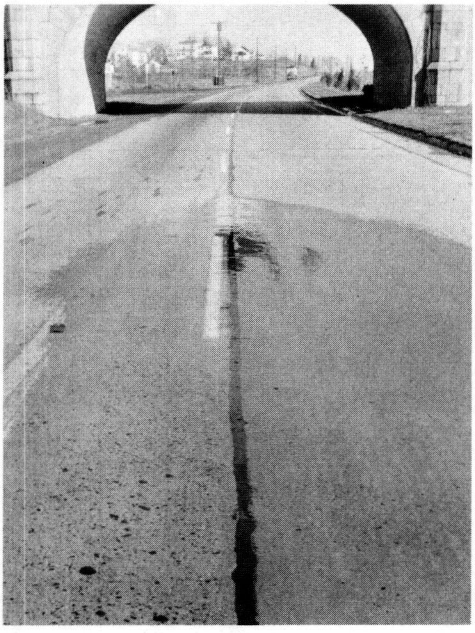

Figure 15. Subsurface water coming through the resealed longitudinal joint on US 5.

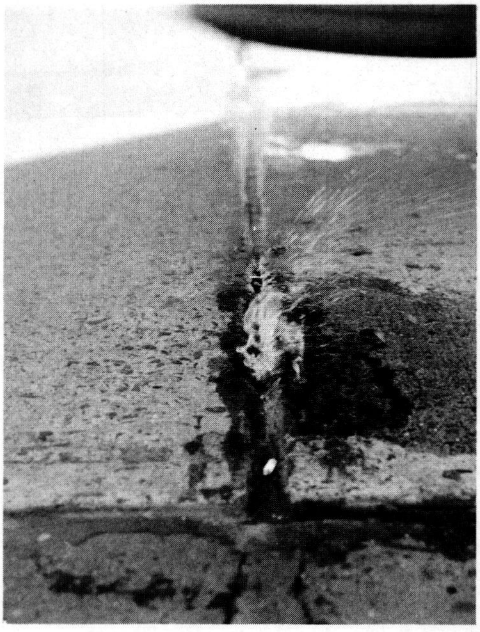

Figure 16. Pumping at resealed transverse joint.

one pound of seal was used per 3.26 ft of joint; the average cost per linear foot was $0.099 and the average length completed per day was 4,104 ft. It is estimated that the cost of trafficmen plus traffic signs would add another $0.02 per foot to the above unit cost making a total of $0.119.

On Route US 1 the final measurements show that 247,643 linear feet of joint and cracks were cleaned and resealed with 107,821 lb of hot seal. This work was done in 42 working days by one crew working about 8 hours per day. On the basis of the above measurements and the unit bid prices, one pound of seal was used per 2.30 ft of joint; the average cost per linear foot was $0.111 and the average length completed per day was 5,896 linear feet. The cost of trafficmen and traffic signs is not included in the above cost but it is estimated that $0.02 per foot covers this cost making a total of $0.131. A greater amount of seal per unit length was used on this project due to the width of the longitudinal joint in many places. Lateral movement of the pavement on unstable base caused widening of the longitudinal joint in some cases up to 2 in.

Our maintenance forces have done a limited amount of cleaning and resealing of joints at a cost of $0.253 per foot. In Bulletin 63 it was stated that the bid prices for rubber asphalt joint filler in place obtained in 1951 in Minnesota were $0.248 to $0.290 per pound. Applying the factors obtained on US 5 and 15 and US 1 to the average Minnesota cost per pound, unit costs of $0.083 per linear foot and $0.117 per linear foot respectively are arrived at. This compares favorably with our unit costs of $0.099 and $0.111.

Unquestionably the time at which this work should be done is late in the summer or early fall. Seasonal joint movement based on numerous measurements taken on joint spacings of 40 ft to 160 ft show openings of 0.2 in. to 0.7 in. For a spacing of 75 ft the average opening is 0.3 in. Joint seal placed in the middle of the summer will be subjected to stretching throughout the entire temperature range of about 100 F. It is quite probable the use of cold seal will also be more successful as well as the sawing of the relief strips. Further inspection of the resealed joints is planned for this coming winter when conditions are particularly unfavorable for the seal. In the meantime the cleaning and resealing of joints by contract will be continued.

References

1. "Resealing Joints and Cracks in Concrete Pavement (Minnesota)," Bulletin 63, Highway Research Board, 1952.