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Joint and Crack Sealing

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Joint and Crack Sealing

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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

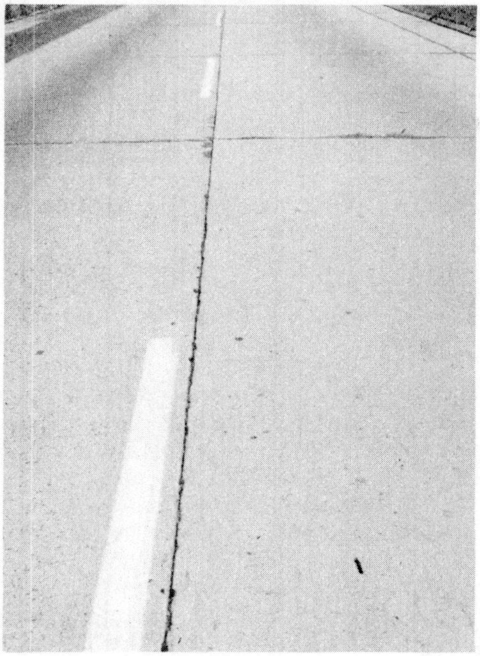

Figure 1. Joints on US 5 and 15 prior to cleaning.

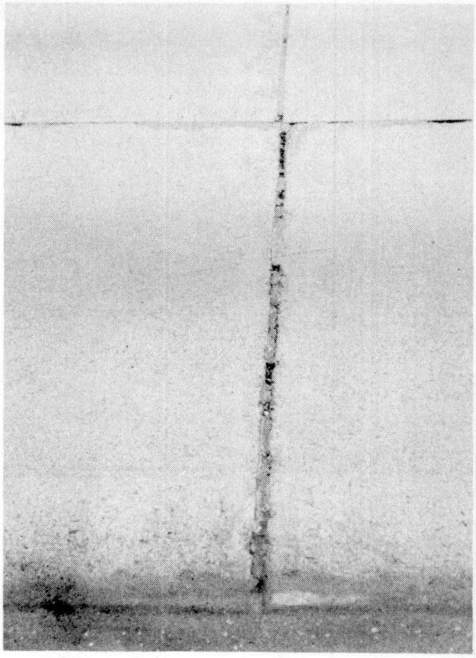

Figure 2. Typical condition of seal in transverse joint prior to cleaning and resealing.

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

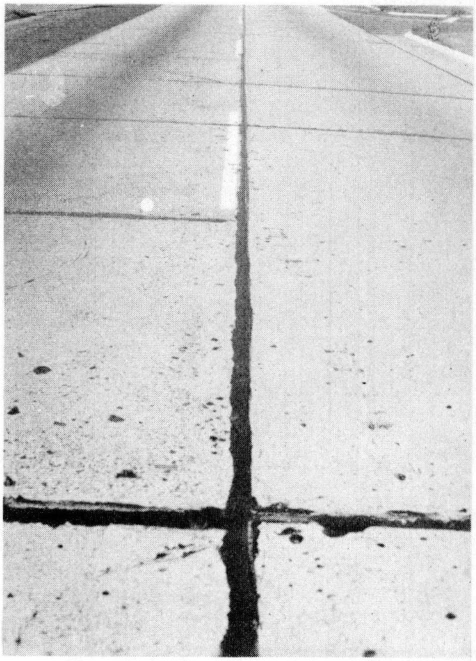

Figure 3. Joints after cleaning and resealing.

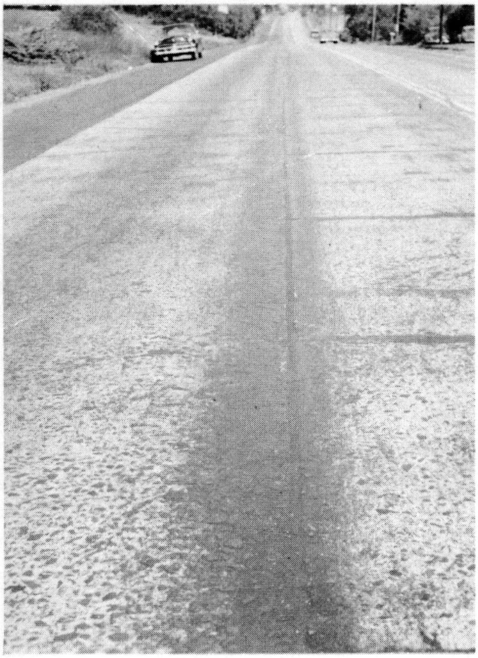

Figure 4. Appearance of joints two weeks after resealing with cold-poured type seal.

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-

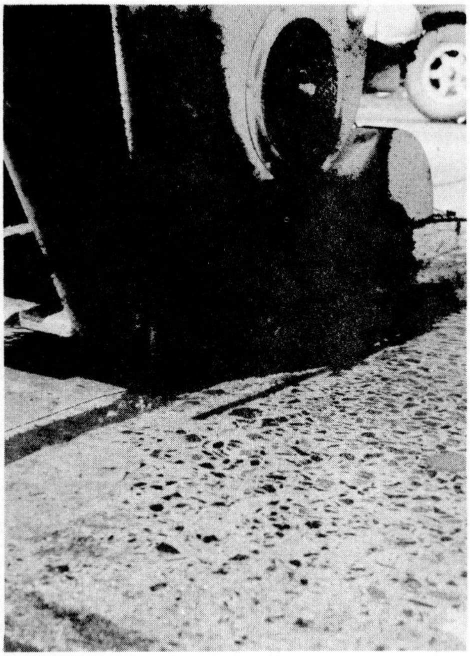

Figure 6. Twenty-two inch concrete saw attached to 28 horsepower motor.

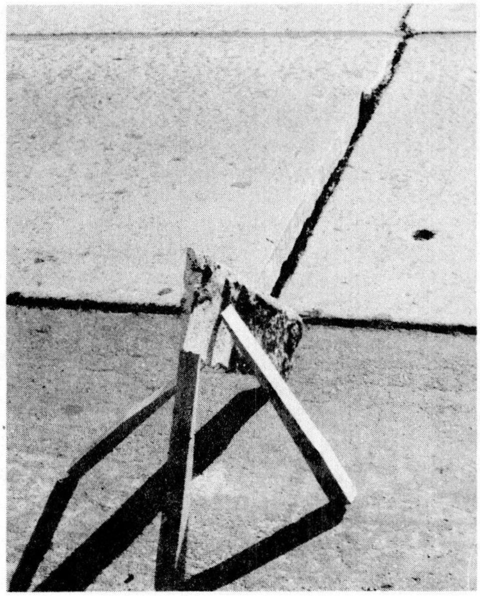

Figure 7. View of inclined joint face.

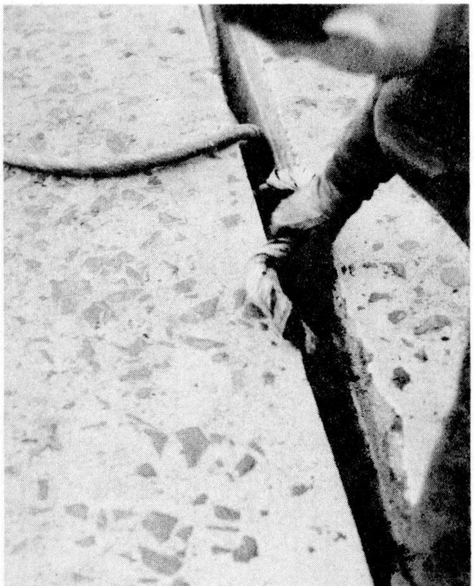

Figure 8. Paper rope being placed in relief joint.

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-

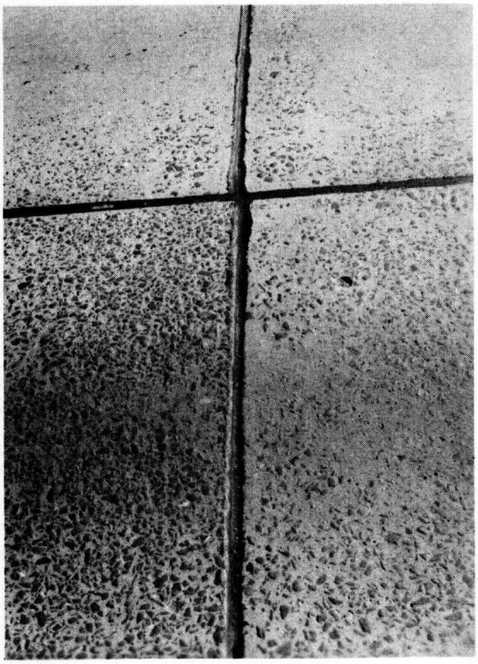

Figure 11. Typical resealed transverse expansion joint on US 1.

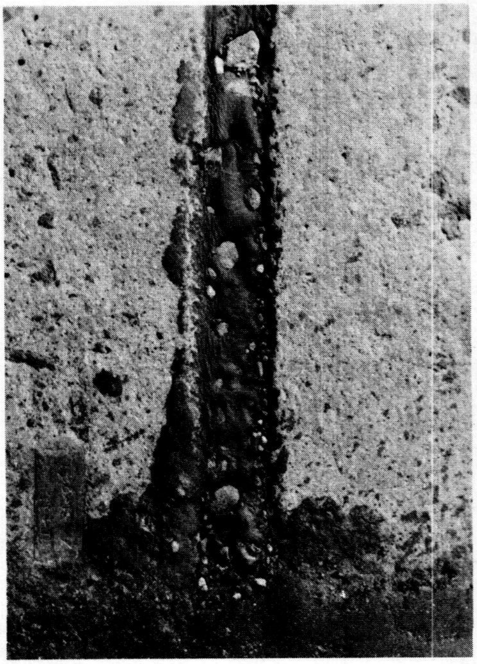

Figure 12. The embedded stone in the joint seal will cause some displacement of asphalt in the summer.

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

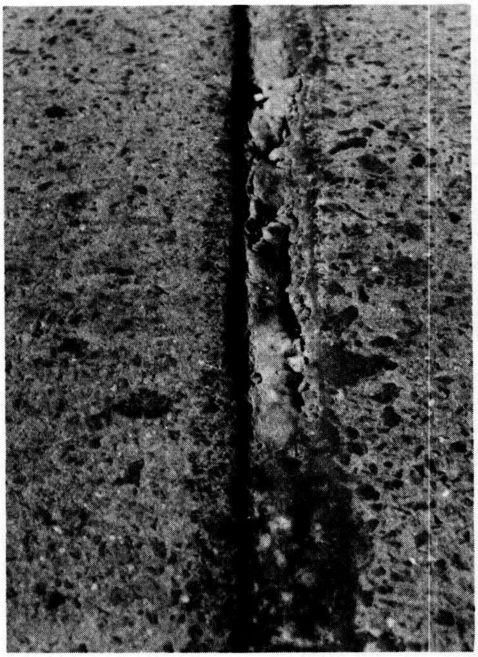

Figure 13. Partial cracking of joint seal four months after resealing.

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.

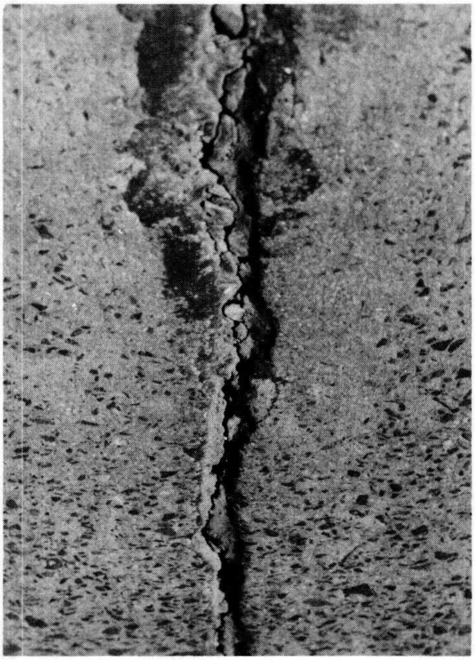

Figure 14. Seal failure four months after crack was resealed.

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,

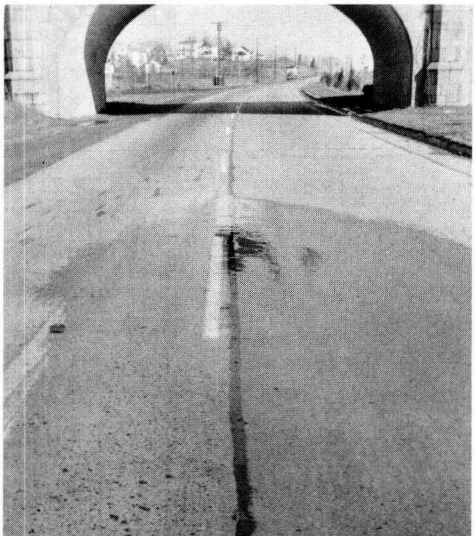

Figure 15. Subsurface water coming through the resealed longitudinal joint on US 5.

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.

Current Practice Questionnaire
Jointing, Fillers, Sealers and Equipment

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Portland Cement Association

● DURING 1955 the Committee on Joint Materials in Concrete Pavement sent out a questionnaire to various highway departments and federal agencies. The questionnaire requested current information concerning jointing practices, types of fillers and sealers as well as equipment used for preparing the joints, heating and applying sealing materials, particular emphasis being placed on sawed contraction joints which are rapidly becoming standard practice.

This report summarizes the replies received from 43 states, the District of Columbia, Hawaii, Department of the Army, Navy and the Civil Aeronautics Administration. However, detailed replies which could be tabulated were received from only 38 states. The results are believed to be interesting and informative. Highway engineers or producers of highway materials will find it worthwhile to study the complete tabulation which is made available with this report. The following is a brief summary of the replies by subjects.

Expansion Joints

Some 24 states (out of 38) use no expansion joints except at fixed objects such as bridges, intersections, etc. An additional two states omit expansion joints except in the cooler construction months during fall and spring. Four states place expansion joints at about 600 ft intervals; one state places them at 246 to 615 ft; one state at 450 ft; three states in the range of 78 to 115 ft; and one state at 60 ft. Two states consider individual projects and show expansion joint spacing on the plans.

The reply from the District of Columbia applies mostly to concrete base; the Navy and Civil Aeronautics Administration to airport pavements; and the Army to pavements for airports and roads. The District of Columbia places expansion joints in concrete pavements at 30 ft intervals on account of underground facilities; the Navy spaces transverse expansion joints at 225 ft; the Civil Aeronautics Administration at 400 to 1,000 ft; and the Army at 40 to 400 ft for roads and 400 ft to none for airports.

The 34 states answering specifically on the type of expansion joint filler, prefer a non-extruding material specifying wood boards, impregnated fiber, cork or rubber. The District of Columbia and all three federal agencies specify non-extruding expansion joint filler.

Contraction Joints

Some 38 states gave detailed answers on the use of contraction joints. Of these, 35 use contraction joints in conjunction with and without expansion joints; one state uses contraction joints in plain pavements only, but none in reinforced pavements, while two states use expansion joints only in all their pavements.

In regard to contraction joints spacing, 17 states use spacings of 15 to 20 ft; 11 states use spacings of 30 to 40 ft; and seven states use spacings ranging from 57 to 100 ft. The District of Columbia places contraction joints at 12½ ft and the three government agencies use spacings ranging from 12½ to 25 ft.

In general, the states and the government agencies use a surface groove type of contraction joint. Some ten states specifically require that they be formed in the plastic concrete at the time of placement; while four states specify the use of premolded or formed type control joints and saw surface grooves for the intermediate contraction joint. Some eight states specify either premolded formed, or sawn surface groove type and of the three federal agencies, two permit sawing and one specifically specifies formed surface grooves.

TABLE 1

State	Expansion Joints			Contraction Joints	
	1E Currently specified?	What spacing?	2E What kind of filler is installed?	1C Currently specified?	What spacing?
Alabama	Yes	600 ft, reduced on schedule as weather cools	Soft pine board preferred, poor results with cane and "korkpak"	Yes	20 ft
Arizona	No	Except at structures built to grade	Redwood	Yes	15 ft
Arkansas	--	----	----	--	----
California	No	Only at bridge and culvert ends	Preformed joint filler, either AASHO M58 or M59	Yes	15 ft
Colorado	No	At bridge ends only	AASHO M33, M58, M59	Yes	20 ft
Connecticut	No	Not at fixed spacings, but at bridges, intersecting side roads, sometimes at end of day's pour	3/4-in redwood, cypress, or white pine preferred, also bit cellular type AASHO M153 type III in specifications	Yes	40 ft
Delaware	No	----	----	Yes	68 ft, being revised
Florida	No	Junction with approach slabs and other locations as specified, including start of pour and street intersections	Premolded filler, cotton seed hull mix filler, and wood board	Yes	20 ft, also match existing joints in multiple-lane construction
Georgia	Yes	600 ft and at all obstructions such as bridges	Redwood, spruce, longleaf pine, and cypress	Yes	30 ft
Idaho	Yes	As shown on plans	Premolded AASHO M153-52 type II	Yes	As shown on plans
Illinois	No	Adjacent to structures and at street intersections in municipalities	Usually bit premold, fiber Also bit premold, preform cork, self-expand, cork, sponge rubber, cork rubber, redwood, and cypress	Yes	100 ft
Indiana	No	In pavement at appr 60 ft from end of certain structures, and at certain points in intersections	Cork, cork-rubber, or fiber	Yes	40 ft
Iowa	No	At bridge and R. R tracks, wood board 500 ft from bridge or R R tracks, bit prem at bridge, "prem," wood together at 15 ft and 30 ft from bridge	----	Yes	20 ft
Kansas	No	Only adjacent to structures, bridges, and urban intersection	Redwood board	Yes	20 ft
Kentucky	No	At three successive panels next to bridge ends	Bituminous impregnated fiber or cork	Yes	20 ft gravel, 50 ft limestone
Louisiana	Yes	450 ft	Cypress or redwood	Yes	45 ft
Maine	No	----	----	Yes	20 ft
Maryland	Yes	600 ft	Generally AASHO M153 type I When specified AASHO M153 type III	Yes	40 ft
Massachusetts	Yes	Not more than 115 ft	Preformed cork AASHO M58-42 Bituminous impregnated fiber M59-42	Yes	57 5 ft
Michigan	No	396 ft before April 15 and after Sept 15 at specified locations regardless of season	Non-extruding, premolded	Yes	99 ft
Minnesota	No	At bridge approach panels, also certain specified locations on urban work	Material to conform to AASHO M59-42	Yes	20 ft
Mississippi	No	Varies with temp , above 70 F none, 56-70 F at 320 ft, 41-55 F at 255 ft, 30-40 F at 190 ft	Soft wood, generally cypress	Yes	31 ft 4 in
Missouri	No	At bridge ends only, two joints at 40-ft spacing, 2-in expansion space each joint	Premolded bit mat'l , AASHO M33-49 Premolded impreg cane or wood fiber AASHO M59-49	Yes	20 ft
Montana	--	No concrete pvt built in recent years	----	--	----
Nebraska	No	3 joints at 49-ft intervals adjacent to R R tracks and bridge approaches	Preformed non-extruding AASHO M153 type III	Yes	16 ft 4 in
Nevada	--	No concrete pavement built in recent years	----	--	----
New Hampshire	--	----	----	--	----
New Jersey	Yes	78-ft intervals, reinforced pavements, at bridges only, plain pavement	Bituminized fiber	Yes	Qualified, only with plain pavement 15 to 20 ft
New Mexico	--	No concrete pavement built in recent years	----	--	----
New York	Yes	95 ft to 100 ft	Premolded bituminous or wood	No	----
North Carolina	No	Only at bridge approaches, spaced 20 ft and 180 ft	Premolded fiber	Yes	30 ft
North Dakota	No	Only at bridges and connections with old pavement	Premolded AASHO M58 or M59	Yes	20 ft
Ohio	No	Structures and intersecting rigid highways only	Preformed AASHO M153 or wooden board	Yes	60 ft
Oklahoma	No	300 ft in municipal work, depending on intersection spacing, rural at bridge ends and intersections only	Premolded bituminous, redwood board	Yes	Usually 15 ft
Oregon	--	No concrete pavement built during past 6 years	----	--	----
Pennsylvania	Yes	Minimum 246 ft, maximum 615 ft	Cork or cork and rubber type M58-42, fiber type M59-42, redwood type M90-42	Yes	61 1/2 ft
Rhode Island	--	----	----	--	----
South Carolina	No	New specs being prepared	Prem, board, cotton seed hulls with asphalt	Yes	30 ft
South Dakota	No	----	----	Yes	20 ft
Tennessee	--	----	----	--	----
Texas	No	Bridge ends and other special locations	Redwood boards 3/4-in thick	Yes	15 ft
Utah	--	----	----	--	----
Vermont	Yes	60 ft	AASHO M58-48 (4 types, approval before use) AASHO M59-49, AASHO M90-42	No	----
Virginia	Yes	Spacing depends on individual project	Premolded bituminous fiber, also wood	Yes	50 ft reinf pav't , 30 ft plain pav't , stone agg , 25 ft plain pav't , gravel aggregate
Washington	No	----	----	Yes	15 ft
West Virginia	Yes	589 ft and at bridges	Preformed cork, self-expanding cork, sponge rubber, cork rubber type, and preformed bituminous cellular	Yes	31 ft
Wisconsin	No	At bridge approaches and urban intersections only	Preformed bituminous fiber type AASHO M59 or cork type I or II, AASHO M58	Yes	80 ft rural pav't 40 ft urban pav't
Wyoming	--	No concrete pavement built since 1934	----	--	----
Dist of Columbia	Yes	30 ft	AASHO M153-52	Yes	12 5 ft when PCC used as base
Hawaii	--	Only pavement built is on accel and decel lanes of multiple-lane roads	----	--	----
Dept of Navy	Yes	225 ft for transverse, 300 ft for longitudinal	Preformed, non-extruding and resilient types Fed. Spec HH-F 341	Yes	Transverse, 15 ft
Dept of Army	Yes	Roads transversely at 40- to 400-ft, runways, aprons, taxiways, etc , 400 ft for slab 10 in or less, none for thicker and aggr of low coefficients of expansion (less than 55×10^{-7})	Preformed bit -treated fiber board or wood board	Yes	Min 12 5 ft to max 25 ft depends on type aggregate
C A A	Yes	400 to 1,000 ft	Premolded, AASHO M153	Yes	20 ft

TABLE 1 (Continued)

State	Contraction Joints			Sawed Joints
	2C Are grooves "formed" type, sawed, or other?			
	3C Formed Cross-Section	Other	4C Sawed Cross-Section	5C How many years specified?
Alabama	1/4-in R lip 3/8-in width at top, depth 1/3 D	----	1/8 in minimum 1/3 D, depth	2
Arizona	2-in depth on 8-in pavement	----	2-in depth on 8-in pav't	1, experimental only
Arkansas	----	----	----	----
California	1 in by 1 3/4 in or 2 in preformed filler 1/4 in max below surface, 1/4 R lip	----	1 1/2 in min depth 1/4 in max width	2 1/2
Colorado	----	----	1/8 in wide 2 in depth	3
Connecticut	3/8 in wide top, 1/4 in bottom, 1/8 R lip Depth 2 1/2 in , 8-in and 9-in pav't , 3 in , 10 in pav't	----	2 in depth 1/8 in wide Not sawing at present	1952-1954, not contemplated at present
Delaware	1/2 R lip 3/8 in top, 1/4 in wide bottom, 3 in depth	----	----	----
Florida	3/8 in wide, 2 in depth, 1/8 R lip	----	2-in depth, width depends on saw blade	Since Apr 1, 1954, 1952-54 by approval
Georgia	----	----	Depth 19 percent pav't thick, Min 1 1/2 in width of saw	2
Idaho	Formed type, no cross-sec shown	----	----	Not specified
Illinois	----	----	2 3/4 in depth, 1/8 min	2
Indiana	1/4 R lip, 1/4 in wide, 1/3 depth, min 2 in	----	1/8 or 1/4 in wide,depth 25 percent of slab thickness	Intermittent for 5 yr, experimental
Iowa	----	----	1 1/2 in depth, 1/8 in width	1 job 1953, all jobs 1954
Kansas	----	----	Transverse 3/16 in wide min 1 1/4 in depth	5
Kentucky	1/4 in wide, 2 1/2 depth	----	1/8 or 1/4 in wide, 1 1/2 in depth	3
Louisiana	1/8 R lip, 1/4 in width, 2 in depth	----	----	----
Maine	At 80-ft intervals 5 1/2 in deep, 3/8 in wide, 8-in slab	----	Intermediate joints 1/8-in wide, 2-in depth, 8-in slab	2
Maryland	Dummy joint forming tool specified by dept, groove 5/16 in top, 1/4 in bot , 3 in deep	----	----	Experimental sawing in 1955
Massachusetts	T-bar grooved 2 in deep, 3/8 in top, 1/4 in bottom width	----	Not less than 1/8 in wide, 1/5 depth of slab	First use in 1955
Michigan	1/4 R, 1/2 in depth, at bottom, 1/8-in by 1-in parting strip	----	Not sawing	----
Minnesota	Wedge shape 3/8 in wide top, 3/16 in bottom, 1 1/2 in depth, at every 80 ft	----	Intermediate points 3/8 in for 1 in and 1/8 in for lower 1/2 in	2
Mississippi	1/4 in R, 2 in depth, 1/4 in — 3/8 in width	Bit strip, 2 in	----	Under consideration
Missouri	----	----	1/8 or 3/16 in wide, 1/4 in depth	2
Montana	----	----	----	----
Nebraska	1/8 in by 3 in preformed filler, 1/8 in below surface space every 6th joint (98 ft), all others sawed	----	2 in depth, 1/8 in width	3
Nevada	----	----	----	----
New Hampshire	----	----	----	----
New Jersey	1/4 in R lip, one side vertical, 1/2 in top, 1/4 in bot , depth t/3	----	Do not saw	----
New Mexico	----	----	----	----
New York	----	----	----	----
North Carolina	1/4 in wide, depth t/4, 1/8 in R lip	----	----	----
North Dakota	1/8-in by 3-in mastic board every 80 ft	----	Intermediate joints 1/8 to 3/16 in wide, 1 3/4 in depth	2
Ohio	1/8-in steel plate placed 1 in below surface	----	----	Considering alternate use for transverse
Oklahoma	----	----	1 1/2 in depth, blade width	Less than 1 year
Oregon	----	----	----	----
Pennsylvania	Formed, no other data	----	----	Not used
Rhode Island	----	----	----	----
South Carolina	No concrete built under new specs	----	----	----
South Dakota	----	----	1/8 in wide, 1 1/2 in depth, in 8-in slab	3
Tennessee	----	----	----	----
Texas	3/4-in by 3/4-in groove over 1/8-in by 1 3/8-in mastic board 5/8 in from surface every 45 ft	Corr metal submerged every 15 ft between formed	----	----
Utah	----	----	----	----
Vermont	----	----	----	----
Virginia	1/4-in width, 1/8 R lip, 2 1/2-in depth for 8 in or less 3-in depth for 9-in or 10-in pavement	----	Width of saw, D same as formed	1
Washington	1/8-in by 2-in groove, hand troweled against side of filler, particular care so depth is only 2 in	----	1/8 in by 2 in	1952-53 only on experimental basis
West Virginia	1/8-in wide, 3-in depth	----	----	----
Wisconsin	----	----	1 1/2-in depth, width generally 1/2 in	3
Wyoming	----	----	----	----
Dist of Columbia	----	Rigid bit impreg strips of paper, 1/2 depth	----	Do not use
Hawaii	----	----	----	----
Dept of Navy	1/8 R lip, 3/8 in top to 1/2 in wide bottom, depth t/4	----	Not recommended	----
Dept of Army	Wedge shape 3/8 in top, 1/4 in bottom, Depth is pavement t/6	----	Double cut joint, depth as in formed, 1/4 in wide top for 1-in depth, then 1/8 in wide	Approx 2
C A A	1/4 R lip 3/8 in wide top, 1/4 in bottom, depth varies as t/6 or t/4 (Min 1 5 in)	----	Sawing permitted, no standard	Permitted but not specified

TABLE 1 (Continued)

State	Contraction Joints				
	Sawed Joints				
	6C Why did you adopt sawing?	7C If width of groove is increased over that obtained by the saw blade alone, what means are employed?	8C In your experience has increasing the groove width proved worthwhile? Why?	9C Do you plan to increase groove width in future? If so, to what width? Why?	
Alabama	By special provision only	----	----	--	----
Arizona	Improve riding qualities	----	----	No	----
Arkansas	----	----	----	--	----
California	Smoother ride less subject to spalling; joint allows less water percolation to subgrade, over-all maintenance reduced, better appearance	----	----	No	----
Colorado	Avoid rough joints	----	----	Yes	1/4 in, better filling with sealer
Connecticut	Improve riding qualities, no further sawing because of change in design	----	----	--	----
Delaware	----	----	----	--	----
Florida	Reduces impact at joint, reduces slab displacement, more economical	Do not require	----	No	----
Georgia	Smoother pavement, more effective control of random cracks	----	----	No	----
Idaho	----	----	----	--	----
Illinois	Assure better quality concrete adjacent to joints and obtain better riding surface	----	Limited experiments with widths of 1/8, 3/8, 1/2 and 3/4 in at 100-ft spacing show little or no benefit from increased width	No	----
Indiana	Experimental	----	Increasing width to 1/4 in results in greater cross-section area of sealer, more effective seal	No	----
Iowa	Prior to 1954 joints formed by insertion of thin bit fiber section, some spalling	----	----	No	----
Kansas	Smoother pavement, less cost, reduce quantities of sealer, higher production, eliminate finishing	----	No, increasing width merely adds to cost without increasing efficiency	No	----
Kentucky	Poor formed joint construction	----	----	--	----
Louisiana	----	----	----	--	----
Maine	Improve riding quality	----	----	No	----
Maryland	----	----	----	--	----
Massachusetts	----	----	----	--	----
Michigan	----	----	----	--	----
Minnesota	Minimizes spalling, improves appearance and riding qualities	Two attached sawblades, one having 1-in greater diameter	Doubtful, extra width does provide reservoir for sealing mat'l and easier to get filler to bottom	No	----
Mississippi	----	----	----	--	----
Missouri	Improve riding characteristics, eliminate spalling of joint edges	----	----	--	Depends on future design of saw blades, wider joint preferred
Montana	----	----	----	--	----
Nebraska	Eliminate spalling at joint	----	----	--	Some thought, no definite plans
Nevada	----	----	----	--	----
New Hampshire	----	----	----	--	----
New Jersey	----	----	----	--	----
New Mexico	----	----	----	--	----
New York	----	----	----	--	----
North Carolina	----	----	----	--	----
North Dakota	Better riding surface, neater joints, less spalling at joints	----	----	No	----
Ohio	2 years longitudinal sawing experience	----	----	--	----
Oklahoma	Provide better riding qualities	----	----	No	----
Oregon	----	----	----	--	----
Pennsylvania	----	----	----	--	----
Rhode Island	----	----	----	--	----
South Carolina	----	----	----	--	----
South Dakota	Improve riding qualities, decrease spalling at joints	----	----	--	----
Tennessee	----	----	----	--	----
Texas	----	----	----	--	----
Utah	----	----	----	--	----
Vermont	----	----	----	--	----
Virginia	Minimize joint spalling	Not found necessary	----	No	----
Washington	Eliminate joint spalling	----	----	--	----
West Virginia	----	----	----	--	----
Wisconsin	Minimize spalling, improve riding qualities, avoid interference during placing of concrete	----	----	--	Wider groove reduces tendency to break bond of sealer, of limited importance due to base construction
Wyoming	----	----	----	--	----
Dist of Columbia	Do not believe sawing insures against development of further cracking	----	----	--	----
Hawaii	----	----	----	--	----
Dept of Navy	----	----	----	--	----
Dept of Army	Quality of concrete at joint and remainder of slab equal, better riding qualities, saving of joint-sealing materials	Beveled joint cut by 3/4 in wide by 1/2 in deep bevel attached to saw machine over previous sawed joint, double cut joint by two saw blades clamped together	Not conclusive	No	----
C A A	----	----	----	--	----

Sawn Contraction Joints

Definite replies were received from 22 states in regard to the reason given for adopting sawed contraction joints. The predominating reasons given were to improve riding qualities of the finished pavement and to avoid spalling at the joints. These same states indicate they have specified and used sawed contraction joints for periods ranging from one to five years.

Replies to questions regarding the method, worth and future utilization of widening the top of surface grooves normally obtained with saw blades are largely negative. Only two states and the Department of the Army have experimented with widened surface grooves and they plan to discontinue the practice in the future. Only one other state, which does not currently require widened surface grooves, plans to require this practice on future work.

Sealing Materials and Equipment

The questionnaire asked for specific information on sealers and equipment used for expansion joints, formed contraction joints and sawed contraction joints. For new construction, answers do not clearly separate sealers and equipment used for expansion joints and formed contraction joints but in a number of cases define the materials and equipment used for sawn joints. Also, sealer and equipment for all joints were divided between hot and cold poured types.

On new construction for expansion and formed contraction joints 25 states out of 34 specify hot poured type sealers; three states specify cold applied types and six states specify either hot or cold. Of the 31 states specifying a hot poured type sealer, 15 states definitely specify a bituminous-rubber compound and 16 states specify bituminous materials some of which may have a rubber admixture. Of the nine states specifying cold poured materials, six require rubber base compound and three a mastic type which may or may not have a rubber base.

For the first sealing of sawed joints, nine states specify cold applied sealers; seven hot poured sealers and five hot or cold sealers. One state does not seal surface grooves.

In reply to a question regarding the possibility of adequately sealing sawed surface grooves, 13 states reported satisfactory filling, eight states reported unsatisfactory filling of the sawed groove to its full depth and one state reports it has no experience at present.

Equipment used for heating sealers for new pavement is to a large extent governed by the type used. Oil bath melting kettles are required for hot rubber-compound sealers and straight flame kettles for bituminous materials. Pressure type dispensing equipment is required for all cold type sealers and generally for hot poured type sealers in sawed contraction joints.

In reply to a specific question regarding the type of sealer giving the most satisfactory service performance, 34 states made definite replies. Of these 25 vote for rubber compound sealers; and nine for bituminous sealers. The District of Columbia and two of the three federal agencies also vote for rubber compounds. On service life, 12 of the 25 states favoring rubber compounds, gave no estimate of the life expectancy but the remaining 13 states estimated the life expectancy range from one to 10 years and averaging about five years. Of the nine states voting for bituminous sealers six gave no estimate and three remaining states replied that the life expectancy ranged from one-half to eight years.

Regarding the question on the effectiveness of sealing materials to prevent infiltration of water and solid foreign material, 16 out of 35 states vote in the affirmative; four give a qualified "yes" answer and 15 do not believe the sealers they use are adequate.

Maintenance

Replies on materials and methods for resealing joints under maintenance do not lend themselves to a quantitative statistical analysis by states. The majority of the states report they use the same materials as used for new construction. An exception is for older pavements where materials originally used will again be employed in kind. All states are in agreement that the joints should be plowed-out, joint faces clean and dry

TABLE 2

State	Sealing Materials and Equipment: 1S What kind of material is used in. A Expansion B. Formed Contraction C Sawed, Joints? Material	Deficiencies	2S Type of equipment used? Deficiencies, if any, noted.	3S From experience, what material is most satisfactory?	4S In sawed joint does method and material used result in complete filling of groove?
Alabama	ABC Rubber-asphalt Presstite	F-336 (a) hot, Enamalite for cold	Oil bath for hot, special mixing and placing machine for cold, pressure for sawed joints	A Wood filler with rubber asphaltic seal, B and C Sealer for all joints if pavement behaves as planned	Sufficient
Arizona	SS-F-336	Does not prevent sand and gravel particles from getting into joints	Gravity, too slow for large projects	SS-F-336	Yes, (if only 2 in. deep)
Arkansas	----		----	----	----
California		Present policy on new construction is no joints sealed, all subgrade of erodible nature under pavement cement-treated, making joint seal unnecessary	----	----	----
Colorado	Cold applied to plain penetration, lack of adherence, inability to fill joints completely		----	Rubber	No
Connecticut	Rubber comp'd SS-S-164, when sawed joints used, Presstite SS-S-159		Hot-poured, oil-jacketed kettles, gravity feed, cold-poured under 80 psi Not entirely satisfactory	Rubber compound of hot-poured type, but not ideal	No
Delaware	Hot-poured asphaltic rubber SS-S164	Material tends to crack with too much heat	Oil bath, gravity filled	Hot-poured asphaltic rubber	----
Florida	AASHO M-18 Grade A, oil asphalt filler		Gravity	AASHO M-18 Grade A	Yes
Georgia	A and C AC-8 asphalt cement		Straight flame, gravity	Hot-poured rubber, too expensive for most purposes	Yes
Idaho	A and B Hot-poured type SS-S-164	----	Straight flame heating not satisfactory because of temp susceptibility of sealer	Hot-poured type	----
Illinois	C Hot-poured SS-S-164 and cold applied ready mixed joint seal compound		C Pressure, oil bath for hot-pressure with cold min adjustment over filled joint, attempts to reduce flow material congealed in nozzle	Hot-poured rubber asphalt, does not provide effective year-round seal, question use based on economics	Usually slight amount of shrinkage occurs with cold-applied material
Indiana	ABC Hot sealer and cold applied mastic Adherence to sides of opening not tenacious		Oil bath, gravity feed for hot, pressure for cold	Hot-poured	Problematical
Iowa	A Asphalt cement 60-70 Pen or rubber asphalt C Hot rubber asphalt SS-S-164		Asphalt cement, heating kettle, rubber type pressure and oil bath	Hot-poured rubber asphalt	Yes
Kansas	Hot- and cold-poured rubber asphalt	Neither maintains a seal for any length of time	Cold-poured, pressure type, hot-poured, oil bath agitating melters, with thermostatic control, satisfactory	No choice	Yes, if quality of work is good, generally poor
Kentucky	Hot-poured rubber and cold-poured mastic		Double boiler type	Hot-poured rubber	Yes
Louisiana	A and B Asphalt mineral filler	Experimenting with cold-applied rubber base	A and B Melting pot, pouring buckets, satisfactory	A and B Asphalt mineral filler	----
Maine	B Mixed asphalt and mineral filler, designation M 89-P G 50-60 C. Flintkote trowel mastic 232		B By gravity C Pressure using very thin nozzles	Only types used are as indicated in 1S, both satisfactory	Yes, joints generally are poured in 3 stages
Maryland	A and B Hot-poured rubber SS-S-164		Oil bath, gravity, but pressure used, discretion of engineer	Hot-poured rubber	No experience
Massachusetts	A and B Thermoplastic SS-F-336A C Presstite No 17 cold material		A and B Oil bath (other indirect methods if approved), gravity C Heavy-duty air pump	----	----
Michigan	A and B Hot-poured rubber C Cold-poured rubber, joints not uniformly sealed		Oil bath, gravity, not satisfactory, pressure fills joints, but need control on rate of application	Hot- and cold-poured rubber asphalt	Quantity of seal per unit length not consistent, need control
Minnesota	Hot-poured rubber-asphalt		Oil bath, pressure applicator	Rubber asphalt	Generally 2nd pouring with non-pressure equip required when 1st shrinks more than 1/8 in. below surface
Mississippi	Hot-poured rubber-asphalt		Oil bath heating, gravity feed	Rubber asphalt SS-S-164	----
Missouri	A and C Cold-poured rubber-asphalt (hot-poured rubber-asphalt, if permitted)		Pressure, double-acting pump with flow compensator and thin nozzle	Cold-applied rubber asphalt	Yes, if adequate care is exercised
Montana	----		----	----	----
Nebraska	A Hot-poured SS-F-336A B A C, 70 to 85 penetration C Cold-poured All lack durability, efficiency to prevent infiltration		A. Gravity oil bath, fairly satisfactory B Gravity, heating kettle not satisfactory C Pressure, difficult to inspect	A Hot-poured type B and C. Not found satisfactory material	No

TABLE 2 (Continued)

State	Sealing Materials and Equipment: 1S What kind of material is used in A Expansion B Formed Contraction C Sawed, Joints? — Material	Deficiencies	2S Type of equipment used? Deficiencies, if any, noted	3S From experience, what material is most satisfactory?	4S In sawed joint does method and mat'l used result in complete filling of groove?
Nevada	----	----	----	----	----
New Hampshire	----	----	----	----	----
New Jersey	A, B Hot-poured rubber asphalt	Slow in melting, too sensitive to excessive heat, not enough range between melting point and safe heat point	Gravity, oil bath, need rapid heating equipment, also preheated compartment	Hot-poured rubber asphalt	----
New Mexico	A, B Presstite No 77 rubber base	Satisfactory	Graco air pressure pumps	Presstite	----
New York	Asphalt 50-60 penetration	Fairly satisfactory, but adherence to joint sides is occasionally weak	Gravity pouring pots	Asphalt 50-60 penetration	----
North Carolina	Asphalt cement, grade AP-5	Penetration 60-70	Gravity	Asphalt cement 60-70 penetration	----
North Dakota	A, B Hot-rubber C Cold-rubber asphalt	----	Hot rubber, oil bath, gravity, cold rubber, pressure	Hot and cold rubber asphalt	Yes
Ohio	Hot or cold rubber	Satisfactory	Hot rubber, Oil bath, gravity, cold rubber, pressure	Cold rubber	----
Oklahoma	Ready mixed cold applied	Sealing filler	Pressure, stored prior to use at temperature of 90 deg	----	Generally yes
Oregon	----	----	----	----	----
Pennsylvania	Rubberized material SSF-336 A		Oil bath	SSF-336A	----
Rhode Island	----	----	----	----	----
South Carolina	----	----	----	----	----
South Dakota	C Asphalt joint filler, hot-poured	----	Pressure satisfactory	From experiments, rubber asphalt mixtures seem most satisfactory	Yes
Tennessee	----	----	----	----	----
Texas	A and B Hot- or cold-poured rubber sealing compound		Pressure for cold-poured Oil bath for hot-poured	Hot-poured rubber compound	----
Utah	----	----	----	----	----
Vermont	AASHO penetration 50-60 M-20-42		Double-shell kettle	----	----
Virginia	Asphaltic hot filler	Flows in hot weather, cracks and becomes brittle in cold weather	Straight flame for A H F	From limited experience with test section, both hot-poured and cold-applied rubber asphalt are satisfactory	Yes
Washington	C Cold rubber asphalt (Presstite No 77) C Premolded rubber, no seal		C Pressure applied, some nozzles are not properly designed to force sealer into narrow joint	A Hot-poured (SSF-336a)	No
West Virginia	A and B Rubber asphalt compound, on secondary roads asphalt cement impregnated with mineral flour is used		Rubber asphalt, double boiler, gravity, mineral meal and asphalt, straight flame, gravity	Rubber asphalt compounds	----
Wisconsin	spec A, B, C Wisconsin type JFA 1951 15-20 percent mineral filler 80-85 percent asphalt 85-100 pen		Ordinary heating kettles, satisfactory	Spec material type JFA for initial sealing spec material type CFA for resealing under maintenance	Yes
Wyoming	----	----	----	----	----
Dist of Columbia	SS-S-164	SS-S-156 and SS-S-159 also permitted for exp joints	Oil bath gravity application	Hot-poured rubber asphalt	----
Hawaii	----	----	----	----	----
Dept of Navy	A, B Hot-poured, Federal spec SS-S-167, cold-poured Fed interim spec SS-S-00170		Double boiler or flue-type heater, direct flame heating not allowed	Hot-poured type satisfactory except for jet operation, for jets SS-S-00170	----
Dept of Army	Airfield, jet, SS-S-00167, other, SS-S-164, roads SS-S-164 or SS-S-171		Pressure, double boiler, for jet seal, gravity for others	Hot-poured SS-S-164, not for jet spillage	Yes, with proper inspection
C A A	Hot-poured materials	Cold-poured and cold-applied have been used satisfactorily	Pressure, cold-applied, no straight flame permitted	Cold-applied containing asphalt rubber	Based on limited experience, yes

TABLE 2 (Continued)

State	Sealing Materials and Equipment		Preparation of Joints Prior to Sealing		
	5S From experience, are materials now used effective in preventing infiltration of water and solid foreign material in joints during winter?	6S What is life expectancy of materials now employed?	1P Do you permit the use of membrane curing?	2P How is membrane curing excluded from joint spaces?	3P What are requirements in regard to cleaning or preparation of joint spaces prior to sealing operations?
Alabama	Satisfactory when functioning properly	No estimate	Yes	By paper covers, not effective in most cases	High-speed revolving broom followed by old saw to clean out groove to bottom
Arizona	No water troubles, but solid foreign material is a problem even in summer	5 to 8 years	Yes	Not required	Cleaning only
Arkansas	----	----	----	----	----
California	----	----	Yes	Not required	No sealing required
Colorado	No	Reseal on spot basis when necessary	Yes	Joint sawed after membrane applied	Joints flushed and blown
Connecticut	No	3 to 5 years	No	----	Thoroughly cleaned of foreign mat'l by scraping and compressed air, joint faces dry when sealer applied
Delaware	Yes, if properly handled	Depends on care in application	No	----	Thoroughly cleaned and then blown clean with compressed air
Florida	Not entirely satisfied	Clean out 6 years to depth of 2 in and reseal, unknown	Yes	Not required	Joints thoroughly cleaned to leave premolded filler exposed along entire top edge and ends to depth of not less than 1 in
Georgia	Probably not	Not known	No	----	Remove all foreign material with compressed air, whitewash 3 in each side of joint
Idaho	Yes	2 to 4 years	Yes	Not required	Joints at edge of pavement carefully opened to entire depth of slab prior to sealing
Illinois	No	Cold-applied 2 years, hot-pour R 3 to 4 years, remains in joint but not adequate seal	Only on patches and base course widening where no joints	----	Sawed joints, flush with water jet followed by compressed air jet, joints to be dry before sealing
Indiana	No	Unknown, but does not exceed 5 years	No	----	Cleaned by brushing, air, or water, to satisfaction of engineer
Iowa	Some joints open too wide for sealer to remain effective, 1/8-in sealer not enough for stretch	Not known	Yes	Small rope in joint to exclude material	Air pressure used to dry and clean out joint
Kansas	No	Not to exceed 3 years	No	----	Sawed wet, blow out with high-pressure air and water followed by air, sawed dry, blow out with high-pressure air only
Kentucky	Best materials used over a period of years	Expect 4 years	Yes	By brushing	Compressed air and brushing
Louisiana	Not unless openings are properly cleaned and prime coat of liquid asphalt is applied prior to sealing	----	Yes	Cleaned later	Air jet cleaning
Maine	Saw joint seal satisfactory, formed joint seal sometimes need renewal in fall months	Not known in use, 2 years	No	----	Clean and dry
Maryland	Generally satisfactory	3 or more years	No	----	Clean, if compressed air used, must be free of oil or water, joint faces dry prior to sealing
Massachusetts	----	Oil asphalt mastic modified with rubber, 2 years	Yes	Not required	None specified, compressed air has been used
Michigan	No, in nearly all cases adhesion to joint faces and resistance to penetration are not sufficient to protect against water and solids	Good materials, 8 to 10 years, poor, 1 year	Yes	Cover each joint	Compressed air jets, wire brushes, and other equipment necessary to clean joint of all extraneous matter, contact faces dry
Minnesota	Yes	Minimum 10 years	No, rare exceptions	----	Joints to be dry, thoroughly cleaned, and blown with jet of compressed air at pressure not less than 85 psi
Mississippi	Wood joint filler and rubber asphalt sealer okay, not perfect, however	First installation in 1948, still in service	Yes	----	----
Missouri	Appears adequate	Not known	Yes	Joints sawed after application of membrane curing	Must be flushed with water jet and blown clean with air jet
Montana	----	----	----	----	----
Nebraska	No	2 to 3 years	Yes, after initial 20-hr cure with wet burlap	Required, contractor's choice	Cleaned with jet of compressed air

TABLE 2 (Continued)

State	Sealing Materials and Equipment		Preparation of Joints Prior to Sealing		
	5S From experience, are materials now used effective in preventing infiltration of water and solid foreign material in joints during winter?	6S What is life expectancy of materials now employed?	1P Do you permit the use of membrane curing?	2P How is membrane curing excluded from joint spaces?	3P What are requirements in regard to cleaning or preparation of joint spaces prior to sealing operations?
Nevada	----	----	----	----	----
New Hampshire	----	----	----	----	----
New Jersey	Material used seems okay	Not known, but some installed 8 years okay	Yes	E joints, by means of strip over joint, C joint, no	Power-driven wire brushes, compressed air, and any other equipment necessary to completely clean joint and dry joint faces
New Mexico	Yes, Presstite No 77 remains pliable even in zero weather and bonds to sides of crack, keeping out foreign matter hot or cold	5 years	----	----	----
New York	No	4 to 8 months	No	----	Thorough cleaning, must be dry when sealed
North Carolina	Satisfactory	No record	Yes, white pigmented only	Not required	Thorough cleaning with broom, and mechanical blower
North Dakota	Believe so	Only used 2 years, No opinion	Special cases only	Joints sawed after application of membrane	Flush with water, wire brushes, chisels, picks, followed with jet compressed air
Ohio	Depends on joint opening, more trouble with 100-ft spacing than 60-ft Trouble with intrusion of granular material during construction on cold rubber	Varies widely	Yes	Cleaned later	Power grooving machine or power wire brush followed by jet of compressed air
Oklahoma	Yes	Not known	Yes	Not required, but membrane to be removed before sealing	Power grooving machine or wire brush (excepting sawed joints) followed by jet of compressed air
Oregon	----	----	----	----	----
Pennsylvania	Yes	Cold, 3 years, hot, 5 years	No	----	Thorough cleaning
Rhode Island	----	----	----	----	----
South Carolina	----	----	----	----	----
South Dakota	No	----	No	----	Clean and dry, if joints cannot be blown clean, a saw must be used
Tennessee	----	----	----	----	----
Texas	No	----	Only on a relatively few projects	Not required	Faces of joint seal space shall be clean and surface dry
Utah	----	----	----	----	----
Vermont	Reasonably satisfactory if maintenance is done in time	1 year	No	----	----
Virginia	No in case of AHF, yes in case of rubber asphalt	1 to 5 years	Yes	Not required	Wire brush, blowing out with air
Washington	Reasonably well	Undetermined	Yes	Joints sawed after membrane applied	Cleaned by jet of compressed air
West Virginia	Best we have found	Don't know, only in use 5 years	Yes	Not required	Power-driven steel brush followed by air jet
Wisconsin	No, cold-poured rubber asphalt used exper effective against water, not against foreign matter	One season to 1 year	Yes	Saw after membrane applied	Remove all dirt and foreign material
Wyoming	----	----	----	----	----
Dist of Columbia	Yes, however, improper application reduces effectiveness of seal	5 to 10 years	No	----	Moisture free, thoroughly cleaned by hand or power tools, blown out with air before sealing
Hawaii	----	----	----	----	----
Dept of Navy	Yes	Varies	Yes	Adequate inspection and construction control	Scrubbed with mechanical wire brush then blown out with compressed air, groove must be dry before sealing
Dept of Army	Yes	Not known	Yes, pigmented only	Require preventive measures	Wire brushes, compressed air, when necessary joint grooving machine, all just prior to sealing
C A A	Yes	5 years	Yes	Contractors option, must be clean prior to seal	Chisels, grinding machines and other suitable equipment to thoroughly clean

TABLE 2 (Continued)

State	Preparation of Joints Prior to Sealing 4P Suggestions in regard to improvements in (a) joint sealing materials, (b) cleaning and/or preparation of joint spaces, and (c) application of sealing materials	Sealing Devices 1D Do you specify the installation of mechanical sealing devices at the bottom and/or ends of joint spaces? Describe purpose, effectiveness and life expectancy	Maintenance 1M What materials and methods will be employed when resealing becomes necessary? A - Expansion joints B - Formed contraction joints C - Sawed contraction joints
Alabama	None	Paper at ends, special nozzle to force material to bottom of groove	Cut out old sealer, broom hard to expose fresh concrete
Arizona	----	No	Probably use SSF-336
Arkansas	----	----	----
California	None	No	When necessary to seal joints that have not been sealed, asphalt emulsion is used, applied by hand pouring pots
Colorado	None	No	Same as original construction
Connecticut	Unattainable as it seems, what is needed is a sealer that expands with decrease in temperature	No	Maintenance forces clean joint and reseal with same material as original, using hand applicators, an experimental project with cleaning by mechanically-driven spade-type cutting wheels, wire brushes followed by compressed air, hot rubber asphalt, oil bath applicator, nozzle-wiping shoes, cold rubber sealer also used
Delaware	More care needed with heating of seal material	No	Hot-poured asphalt rubber (SS-S-164), oil bath, gravity filled
Florida	Joint fillers need better "recovery" characteristics	No	Joint thoroughly cleaned then AASHO oil asphalt filler M-18 grade A
Georgia	Present procedure okay	No	AC-8 straight flame, gravity, except at bridges where hot-poured rubber is used both on new construction and maintenance
Idaho	(c) Need faster method of heating rubber compound	Yes	Cleaning and hot-pouring by hand with either rubberized or straight asphalt, heating with straight flame, oil bath too slow Presently
Illinois	----	No	using PAF-2 pending recommendations from investigation work in progress, gravity straight flame heat used
Indiana	None	No	Liquid asphalt MC-5 or RC4 or 5, hand pouring unless otherwise directed
Iowa	Believe sawed joint should be 1/4 in to 3/8 in wide at top to provide more volume of sealer	No	A Use A C C Do not know at present
Kansas	Materials and equipment satisfactory, principal trouble is use of low-grade workmen and high-speed product, need better work, inspectors and inspection	No	Mat'l and equip optional with maint engr , hot rubber asphalt or asphalt crack filler, gravity applicators, no cleaning or regrooving, heating by asphalt distributor or oil bath as required, results generally poor
Kentucky	None	No	Same or OA-2
Louisiana	Opening properly cleaned and prime coat of liquid asphalt applied prior to sealing	No	Asphalt mineral filler, plow to remove old filler, melting pot and pouring bucket
Maine	Speculation that sawed joints should be 1/4 in for top 1/2 in to facilitate resealing of joints by maintenance crews who do not have use of special equipment	No	None currently required
Maryland	(a)Less range of elasticity, (c)Pressure applicators, care should be taken so applicator tube is such size that filling of joint can be from bottom up	No	Hot-poured rubber asphalt, except a cold type poured rubber asphalt is used in one district experimentally, no conclusions yet
Massachusetts	----	No	A and B Thermoplastic compound, oil bath heater, C No 77 joint sealer, pressure pump
Michigan	(a) Higher resistance to penetration, less susceptible to heat, better adhesive property, (b) sand blasting to clean joints to be required	Base plate 7 1/2 in wide of 16-gage galv steel used under E and C joints, end plates, same mat'l, should last 15 to 20 years No data at present	A and B Hot-pour rubber, old seal will be removed with plows and joint cleaning machinery, joint sand blasted and blown out with compressed air (90 psi), C the same or similar method
Minnesota	None	No	Rubber-asphalt joint sealer, a motor grader scarifier tooth is used to remove old seal, then cleaned with power-driven cutter and brushes, blown out with compressed air, gravity type applicator, oil bath heating
Mississippi	----	No	Joint cleaned with tractor, plow, air jet, and hand tools, and poured with AC-13 modified
Missouri	(a) Would like assurance of continued adherence and long life, (b) be sure joint is clean, (c)joint filled solid to bottom	No	No experience, expect to remove sealer, plow out joint if possible, wire brush, and refill with rubber asphalt using pressure equipment
Montana	----	----	----

TABLE 2 (Continued)

State	Preparation of Joints Prior to Sealing 4P Suggestions in regard to improvements in (a) joint sealing materials, (b) cleaning and/or preparation of joint spaces, and (c) application of sealing materials	Sealing Devices 1D Do you specify the installation of mechanical sealing devices at the bottom and/or ends of joint spaces? Describe purpose, effectiveness and life expectancy	Maintenance 1M What materials and methods will be employed when resealing becomes necessary? A Expansion joints B Formed contraction joints C Sawed contraction joints
Nebraska	Use wider joint (1/4 in) and hot-poured type with pressure application	No	70-85 penetration asphalt cement using pouring bucket
Nevada	----	----	----
New Hampshire	----	----	----
New Jersey	Ideal joint sealer could be injected into joints at normal temperatures (no heating) and would not require elaborate means to prevent it from being picked up by traffic	No	Liquid joint filler grade RA consists of ordinary asphalt in combination with lubricating stock and meeting certain flow and brittleness requirements, heating kettles and narrow-mouth hand-pour pots
New Mexico	----	----	A and B Presstite No 77, cleaned with powered grooving machine and seal applied with pressure pump
New York	More research on a cold-poured rubber or rubber asphalt sealer	No	Asphalt 50-60 penetration, hot-pouring pots in thoroughly clean dry joint
North Carolina	None	No	Thoroughly clean and refill
North Dakota	----	No	Hot-poured asphalt type, hand pouring cans or pots
Ohio	----	No	Cold rubber, pressure pumps
Oklahoma	(a) Joint sealing materials bond needs improvement, more research needed	----	----
Oregon	----	----	----
Pennsylvania	Adequate equipment, standard materials, thorough workmanship	No	Thorough cleaning, hot and cold rubberized material
Rhode Island	----	----	----
South Carolina	----	----	Hot asphalt (85-100 pen or 150-200 pen), poured into top of joint and covered with sawdust or sand, asphalt kettle and pouring pot
South Dakota	----	No	Same as on initial sealing
Tennessee	----	----	----
Texas	Stronger bond between sealer and concrete needed, sensitivity to overheating should be reduced in rubber asphalt	No, an experimental installation shows that an asphalt fiber board would harden, crack and permit pumping	Catalytically blown asphaltic, or cold-poured rubber sealing compound applied with pressure
Utah	----	----	----
Vermont	Want more mechanical equipment	No	Clean joint with compressed air, seal with asphalt AASHO M-20-42, 50-60 penetration
Virginia	----	No	Same as when initially sealed
Washington	----	No	A, B, and C Hot-poured joint sealer applied by gravity
West Virginia	----	No	Rubber asphalt, double boiler, by gravity, for secondary roads asphalt cement impregnated with mineral flour, straight flame, pouring pot
Wisconsin	Believe sealing of joints on new pav'ts placed on adequate foundations could be omitted, experimental proj favorable	No	Hot-poured 1951 standard specification type CFA penetration 85-100
Wyoming	----	----	----
Dist of Columbia	Development of foolproof seal helpful, careful insp by competent personnel needed or sealing will be unsatisfactory	No	Same as for construction
Hawaii	----	----	----
Dept of Navy	----	Yes, outside edges, approv manner	Hot-poured SS-S00170
Dept of Army	Thorough cleaning prior to sealing	No	----
C A A	If joint is thoroughly clean, joint material manufacturer's instructions should be followed	No	Cold-applied rubber asphalt, pressure application, removal of old material by cutting device, grinding faces of joint, brooming, and blowing out with compressed air

TABLE 2 (Continued)

State	Maintenance 2M What kind of sealing material and equipment is currently used in resealing of joints in existing pavements?	Miscellaneous Suggestions for improvement in pavement, joint design or construction methods for preventing infiltration
Alabama	Presstite cold, lay with machine developed for the purpose, joint protected by paper until material sets	Sawed joints should last a long time, open joint with metal protectors and washout channel might be developed
Arizona	SSF-336 on better pavements, asphalt on old, hand methods	----
Arkansas	----	----
California	Resealing of the thermoplastic joint filler by adding a mixture consisting of 50 to 60 percent air-refined asphalt grade 20-35 and 40 to 50 percent liquid asphalt SC 6, portable kettles, hand pouring pots	None
Colorado	----	----
Connecticut	Maintenance forces clean joint and reseal with same material as original, hand applicators, an experimental project with cleaning by mechanically-driven spade-type cutting wheels, wire brushes, followed by compressed air, hot rubber asphalt, oil bath, applicator nozzle, wiping shoes, cold rubber sealer also used	Stress should be on clean joints, use of power over hand recommended, primer material suggested before seal, early sealing prevents excessive collection of foreign matter in joint
Delaware	----	Design and method of construction good, but standards not followed closely enough by construction and maintenance personnel
Florida	----	----
Georgia	----	Know of no method of reasonable cost that prevents infiltration of water in joints, specify every 3rd C joint sawed as soon as possible, others 5 to 12 hours after pouring, joints in curb and widening should be continuous with regular joints in pavement
Idaho	----	----
Illinois	----	----
Indiana	----	Not at this time
Iowa	Asphalt cement and cutbacks, tar heating kettle and bitu distributor	None
Kansas	----	Reduce all types of joints to min by using heavy reinf , use heavy full subbase, maintain continuity by dowelling joints, joint sealing is futile for all practical purposes
Kentucky	Same or OA-2	None
Louisiana	----	Would like to see a plate used under every E, C, and dummy joint, extending 12 in beyond joint in all directions
Maine	----	----
Maryland	----	Believe sawed joints ultimately will replace formed joints
Massachusetts	Thermoplastic compound, oil bath heater oil asphalt mastic (regular), pouring pot, oil asphalt mastic (modified with rubber), pouring pot	----
Michigan	SO A asphalt 85-100 pen , joints raked with hand tool, blown with air, the SO A melted in directly-heated kettle and poured from hand-pour pots	Working with manufacturer to produce better R-asphalt sealer, joint seal industry should send representatives to field to instruct contractors
Minnesota	----	----
Mississippi	AC-13 modified (approx 80 percent) AC-13 with approx 20 percent cutter asphalt	----
Missouri	Narrow joints, RC-3, pouring pots, wide joints, mixture of sawdust and cutback, tamped in place	Not at present, pavement study now being made
Montana	----	----
Nebraska	----	Improvement needed in equipment and applicator nozzles, more durable material, wider sawed joints would aid joint filling

TABLE 2 (Continued)

State	Maintenance: 2M What kind of sealing material and equipment is currently used in resealing of joints in existing pavements?	Miscellaneous: Suggestions for improvement in pavement, joint design or construction methods for preventing infiltration
Nevada	----	----
New Hampshire	----	----
New Jersey	----	Some positive long-lasting prevention of solid material infiltration at ends and bottom, especially in C joints spaced more than 15 to 20 ft
New Mexico	Presstite No 77, pressure pump	----
New York	----	Suggest 600- to 800-ft spacing of expansion joint with sawed contr joints at spacing commensurate with therm characteristics of aggregates and climate conditions, sawed joint depth to control cracking
North Carolina	Similar methods followed as in construction of pavement	No expansion joints, contraction joints spaced 30 ft, no dowels except at end of pour, longitudinal and transv joints filled after curing, prior to traffic
North Dakota	----	----
Ohio	----	----
Oklahoma	Currently using an asphaltic cement, poured	----
Oregon	Use 120-150 asphalt, pouring pot, annually in September	----
Pennsylvania	Hot and cold rubberized material	Careful workmanship
Rhode Island	----	----
South Carolina	----	----
South Dakota	----	----
Tennessee	----	----
Texas	Catalytically blown asphalt, or cold-poured rubber and hot-poured rubber compounds, OA-55 asphalt	----
Utah	----	----
Vermont	----	Eliminate joints as much as possible
Virginia	Same as when initially sealed	----
Washington	----	Elimination of expansion joints will help to eliminate "blow-ups," saw joints good, but too expensive (40 ¢ per ft, including sealer)
West Virginia	----	----
Wisconsin	----	Not considered critical
Wyoming	----	----
Dist of Columbia	----	----
Hawaii	----	----
Dept of Navy	----	Adequate control and inspection during construction, a good subbase of adequate thickness, dense, and well-compacted
Dept of Army	----	----
C A A	----	Current practices are satisfactory if workmanship is good

before resealing. Again the type of heating equipment employed depends on the type of sealer; oil bath heaters are used for rubber compounds and direct flame type for bituminous sealers. Also pressure type applicators are used for cold type sealers. Several states are now using rubber compounds, either hot or cold for resealing all pavements. At least two states plan maintenance contracts for cleaning and sealing joints.

Cleaning of Joints

Replies from 21 states out of 33 show that they permit the use of membrane curing. In answer to the question as to how the membrane is kept out of joint spaces before sealing only three states specify or require protective measures; five states saw the surface grooves after the membrane is applied; and the remaining states require thorough removal of any curing membrane which may find its way into joint space before sealing.

There seems to be little value in a statistical summary regarding cleaning or preparation of the joint spaces prior to sealing operations. All states and agencies are agreed the joint space must be free of all foreign material and dry at the time of sealing. Hooks, old saw blades and mechanically driven brushes are used to clean out the joint spaces, and most states require final cleaning with a jet of compressed air.

Special Mechanical Sealing Devices

The questionnaire specifically asked for information regarding the use and effectiveness of special mechanical sealing devices at the bottom and ends of joint spaces. Very little constructive information was obtained. Only four states and one federal agency report having any experience with such devices and none are able to report definite value. One state reports no value for an asphalt fiber board used experimentally.

Suggestions for Improvement of Sealers and Methods

In reply to the request for suggestions to improve sealing materials and methods of cleaning and sealing joints, only 19 states out of 43 made any reply. Many of the replies are highly speculative but can be briefly summarized as follows:

1. A sealer should expand with decreases in temperature.
2. Sealer less sensitive to overheating at the pouring temperature.
3. Sealer with lesser range in elasticity and better recovery characteristics.
4. Improvement in bond characteristics or the use of a prime coat.
5. More research on sealing compounds.
6. Improve workmanship in cleaning and sealing operations.
7. Larger capacity for oil bath heaters.
8. The development of nozzles which will insure full depth filling of joint space by pressure methods.

Miscellaneous

Under this heading the questionnaire asked for specific suggestions in joint design and construction methods which would prevent the infiltration of water and solid foreign materials into the joint spaces. Some 16 replies were made to the question, the remaining states answering "none" or making no reply. As might be expected answers cover a wide range of ideas but at least six states suggest the elimination or long spacing of expansion joints and the use of sawed contraction joints. Two states suggest more careful workmanship for sealing operation and closer cooperation by joint material manufacturers in the field. Another two states suggest the elimination of as many joints as possible.

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