KANSAS' EXPERIENCE WITH CONCRETE SAW FOR CUTTING CONTRACTION JOINTS IN CONCRETE PAVEMENT

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The State Highway Commission of Kansas began sawing contraction joints in new concrete pavements quite by chance. Like many things that happen accidently this practice proved to be very worthwhile.

First Used in Maintenance—Our maintenance forces have been using the concrete saw for cutting out distressed areas of concrete pavement preliminary to patching for several years. They found that the concrete saw caused much less damage to the concrete adjacent to the area to be patched than did the old pavement breaker or jack hammer method of cutting out bad areas (Fig. 1). The boundaries of the "cut out" areas were not ragged and the under-breakage was much less; hence the efficiency of the patch was very much improved.

As is usually true with new techniques, efficiency improves with experience. Much has been learned about the use of the concrete saw for maintenance over the past several years and for construction during the past 1½ years. This new knowledge has been acquired by the manufacturers as well as the contractors and engineers. Incidentally, the manufacturers have taken a great interest in this new application of the concrete saw and are striving continuously to improve its efficiency, since they envision an entirely new field of use for such equipment.

Concrete Saw Described—Essentially the concrete saws which we have been using are portable outfits weighing between 350 and 500 lb. each, powered by a heavy duty gasoline motor which drives a spindle upon which is mounted a thin circular segmented diamond abrasive wheel (Fig. 2 and 3). The available abrasive wheel diameters that we know of vary from 8 to 18 in. The segmented wheels are approximately ⅛ in. thick made of high grade steel and have numerous commercial diamonds imbedded in their circumference. The abrasive wheel when in operation, is water-cooled from a tank mounted on the machine. The entire assembly is mounted on either two or four rubber-tired wheels balanced so that it can be moved from one location to another quite easily. The saw blades are removable and are usually interchangeable between the machines of different manufacturers. The saw assembly may be guided by hand or light portable guides may be required if the line desired is to be straight. The spindle speed is different in machines of different manufacturers but is usually about 3000 rpm.

The saws will cut to various depths depending upon the diameter of the blades. However, the maximum depth of cut with a single pass has been found to be 2 inches for optimum results and if further depth is desired, it has been found to be more economical to make a second pass.

Initial Use—Early in 1949, the Highway Commission of Kansas was beginning to construct, by contract, a 5-mi. divided lane concrete pavement on US 75 south of Topeka. The joint spacing for this project, as well as that specified in our current design, requires expansion joints at 500-ft. intervals with intermediate contraction joints at 20-ft. intervals.

The construction specifications and plans required that the contraction joints be formed by the usual method of inserting a metal cracker bar having approximate dimensions of ¼- by 2-in. by 11-ft. into the green concrete immediately after the finishing machine passed over the pavement. The purpose of this metal plate was to form a groove, required by the plans, approximately 2 in. deep, tapering in width from ½ in. at the surface to ¼ in. at the bottom. The specifications further required that before the plate was removed, the edges of the groove were to be finished with a tool to form a $\frac{1}{32}$-in. radius. Thus the plate could not be removed when the concrete was of a consistency that slumping would occur, and yet it had to be removed while the concrete was still green. Inspection of other new pavements indicated that the edges of these grooves had a tendency to spall badly, due apparently to the existence of a poor quality of concrete adjacent to this groove.

Since the project south of Topeka was an experimental project utilizing various cements and various finishing methods, a careful check was made of the reaction and appearance of this concrete from the day it was poured. Serious spalling at the contraction joints was occurring sometimes to a considerable depth.

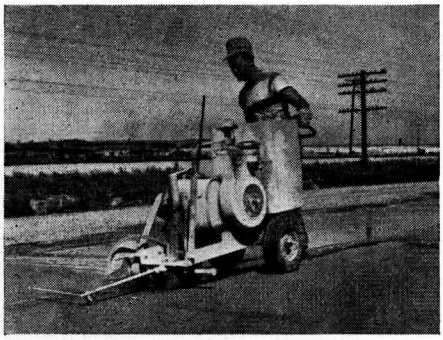

Figure 1. The Saw which Was First Used on the Topeka Test Road to Cut Contraction Joints—This saw was purchased to cut bad areas of concrete pavement preliminary to patching. Here the saw is cutting pavement which is 25 years old.

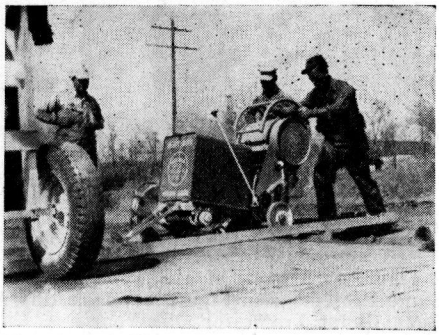

Figure 2. A Typical Saw Differing in Manufacture from the Saw Shown in Figure 1—Portable guides are being used in this photo.

It was apparent that during the process of removing the metal cracker bar and finishing this joint, unsound concrete was being created around these joints (Fig. 4). We were also dissatisfied with the roughness which was developing during this operation which left a slight ridge adjacent to the groove. Joint finishers who were not too skillful and who were inclined to be careless exaggerated this condition. After several unsuccessful attempts to improve the situation the division engineer suggested that the contractor be permitted to try cutting the grooves with a concrete saw which had recently been purchased for maintenance purposes. This was done and the success of the method was immediately obvious to all concerned—engineers and contractors alike.

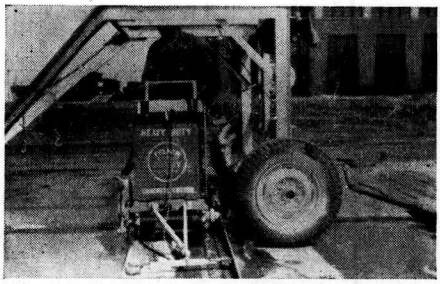

Figure 3. A Front View of the Saw in Figure 2—This picture shows the saw cutting a 2-in. groove at the edge of the angle guide on the left side. The framework is for the purpose of portability down the pavement to the next joint.

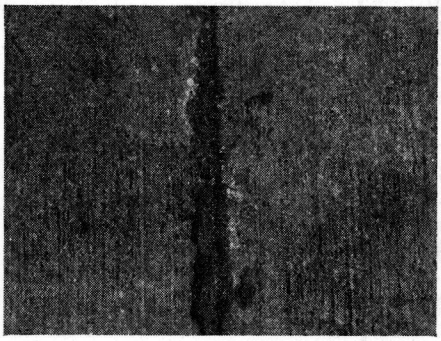

Figure 4. A Typical View of a Hand Formed Joint Which has Spalled to This Extent After Only Two Weeks Traffic—This groove has been filled with thermo-plastic sealing compound.

So definite was the improvement and efficiency of this operation that it was continued for the remainder of this project (Fig. 5) and was used on another project built the same year by the same contractor. It then became a definite requirement that the contraction joints in all 1950 concrete pavements be formed with the concrete saw. With this years experience, the saw has undoubtedly found a permanent place in our specifications. The use of the saw eliminates all of the shortcomings of the hand formed groove such as

spalling, and rough and noisy riding surfaces (Fig. 6).

The contractor likes to saw the joints because he is able to lay pavement continuously without the delays due to slow finishing. Doubtless recent increases in the speed of production of concrete pavements had something to do with the poor workmanship which was becoming prevalent. These advantages have all accrued at little or no increase in cost; in fact, the cost of concrete pavement per square yard during 1950 was less than that during 1949 in spite of this and other advances which normally would have had a tendency to raise the cost. However the benefits would have been great enough to have justified a nominal increase in cost. Doubtless, with more experience by the contractors and by the manufacturers, costs will continue to be reduced and the efficiency continue to be improved. We anticipate that during the 1951 construction season, it is not unlikely that some contractors may find it economical to form the center hinge joint with the concrete saw in lieu of the normal deformed metal strip. This operation was optional in 1950 but none of the contractors have tried it.

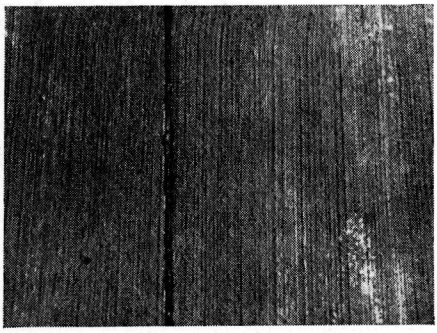

Figure 5. A typical View of a Joint Which Was Formed by Sawing and Filled with Thermo-Plastic Sealing Compound. Note the clean-cut appearance of the joint. After being under traffic for one year this joint still has the same good sound appearance.

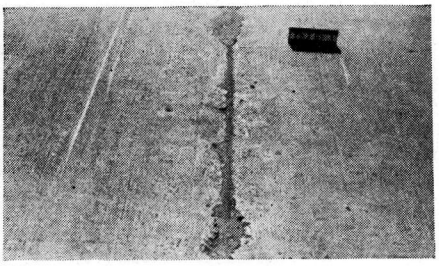

Figure 6. A View of a Hand Formed Joint Which Has Been Under Traffic for One Year

We have had an opportunity to observe the sawed joints which have been under traffic for more than a year (Fig. 7). There were 52 miles of concrete pavement built during 1950 in Kansas, by five separate contractors, and under the supervision of seven project engineers. The contractors between them had four different makes of concrete saws and blades on these projects. The coarse aggregates varied from an extremely hard flint to a relatively soft limestone. The age at the time of sawing has varied from 12 hours to 40 days.

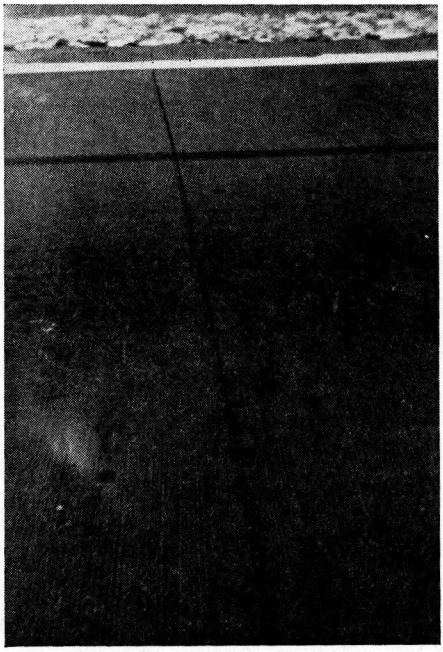

Figure 7. A View of a Sawed Joint on the Same Project as in Figure 6 Which Has Also Been Under Traffic for One Year

This experience has given us a good cross section of ideas regarding the use of the concrete saws. We have found that certain precautionary measures must be taken if membrane curing is used. The Topeka project built in 1949 taught us that where membrane curing solution is used, the drying shrinkage

of the pavement is greater than where moist burlap followed by wet earth is used. Pouring continuously without forming grooves and curing with membrane solution produced erratic cracking at 80- to 100-ft. intervals. Even though moist burlap and wet earth was used for nearly all 1950 projects, a hand-formed groove was required to be formed in the green concrete at 80-ft. intervals in order to avoid shrinkage cracks. Sawing of the intermediate joints at any period from ten hours after the pavement was poured to a maximum of 20 days or until the earth cover was removed was specified. Quite probably the moist burlap and wet earth cure obviates the hand-formed groove and with more study we shall probably omit this requirement and thus saw all joints. Almost without exception, the hand-formed joints at 80-ft. intervals built during 1950 have shown a tendency to spall. They are also noticeable when driving over the pavement in a passenger car. The sawed joints on the other hand, either those which were formed in 1949, or in 1950, have shown no tendency towards spalling and their riding quality is excellent.

Crack Sealing—Since the narrow groove formed by the concrete saw is between $\frac{1}{8}$ and $\frac{3}{16}$ in. wide, difficulty in filling the groove with joint sealing compound was initially encountered. This has now been overcome by the use of pressure equipment which forces the sealing compound to the bottom of the groove (Fig. 8). Most contractors have used a cold-poured type of joint compound during 1950 in lieu of the alternate hot poured type or thermo-plastic type. In general, these grooves have been effectively sealed with either type.

Cracking in Additional Lanes—Initially there was a tendency towards erratic cracking when a widening lane was poured on a multiple lane pavement such as is encountered in urban areas. The contractor would saw the joint in the first 22-ft. width and subsequently pour the additional lanes. This operation caused an erratic crack to be formed in the last lane poured at the location adjoining the original sawed joint. This trouble was circumvented by leaving the curing cover on the first pair of lanes, or other strips until the final lane is poured, then the contractor saws the entire width of the pavement at one time.

Experience with Saw Related—To obtain accurate information of the sawing operation, we interviewed the various contractors who had used these saws, the resident engineers under whose supervision the work was being conducted, and those of our own staff who were on these jobs as observers.

The contractors reported varied efficiency in sawing. They reported that they had obtained from 400 to 3000 ft. for each blade used to cut a groove 2 in. deep. The average blade was used for approximately 1000 ft. Several factors caused the wide spread in the performance of individual saw blades. These factors are separate from the differences in blades of different manufacturers which are

Figure 8. A Typical View of a Sawed Joint on the One-Year Old Topeka Test Road Showing the Good Condition of the Thermo-Plastic Sealing Compound

known to exist. The factors described here are common to the blades of all manufacturers.

1. Keeping the saw in a straight line without sideplay was a very effective means of obtaining greater footage per blade. The portable guides shown in Figure 9 prevent sideplay. Sideplay loosens the granular constituents of concrete and they act as an abrasive tending to shorten the life of the blade by stripping it of its imbedded diamonds. Forcing the saw by applying too much pressure to its forward motion tends to lessen the life of the blade. Maximum life is obtained with gentle pressure that permits the blade to cut its groove as one would use a circular saw for cutting wood. A good cutting speed for the 2-in. cut was found to be about 8 to 10 ft. per min.

2. The use of a large quantity of cooling water was found to be a very effective means of lengthening the life of the saw blades.

Most of the contractors developed movable rigs upon which were mounted large tanks

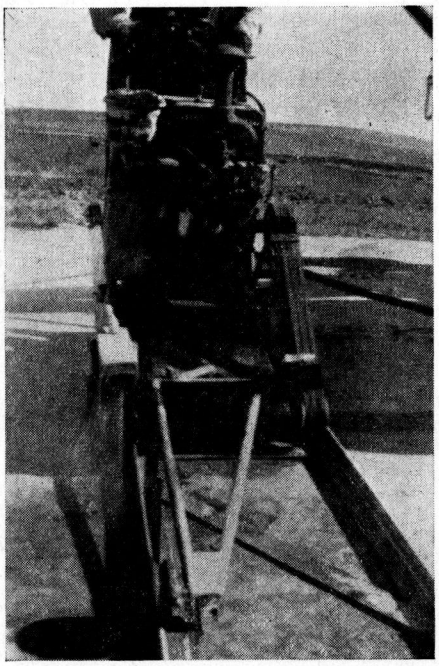

Figure 9. A Photo Showing the Saw Being Used and Guided by a Portable Light-Weight Guide for Straight Sawing

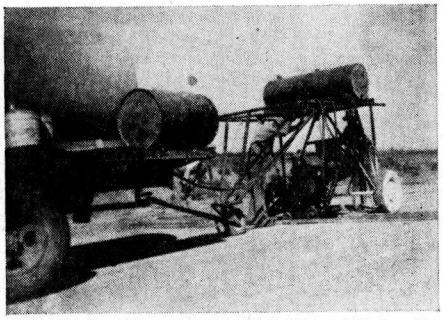

Figure 10. Showing the Auxiliary Water Tank Mounted on the Framework—The tank is being filled from a supply tank wagon. Usually a small water pump is used in conjunction with this extra water supply.

for water supply (Fig. 10). They added a small water pump to this supply and with this large quantity of water playing on the blade constantly, the life of the blade was measurably increased. Heat will wear the diamonds faster and also tends to loosen them.

3. The type of coarse aggregate used in the concrete was a major factor in the life of the blade. Whenever a hard flint or chert-like aggregate had been used, the life of the blade was measurably reduced. These harder aggregates oftimes caused a 50 percent reduction in blade life. On the other hand, when a normal limestone was used, the life of the blade was greater. Some of the manufacturers of these blades have acquired specimens of concrete containing various coarse aggregates and are attempting to develop specific blades best suited for specific aggregates.

4. The age of the concrete is another variable which causes differences in the life of the blade. In fact, as the season progressed, the manufacturers brought out two different

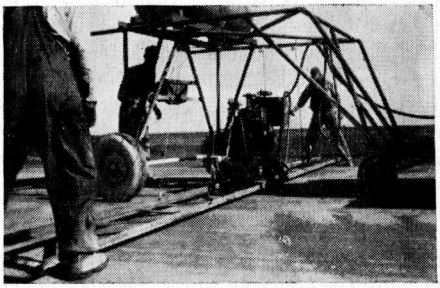

Figure 11. Showing how the Framework is Used to Hoist the Portable Guides and Concrete Saw for Transportation to the Next Joint

blades: one which was designed for use in green concrete; that is, concrete with an age from 10 to 36 hours and another for concrete whose age was 30 days or more. Green concrete adversely affects the blade life as well as hard, dense concrete. Concrete at the age of 30 days seems to provide greatest blade life. There have been no bad results from cutting concrete as young as ten hours after pouring. The groove is sharp and true without rounded edges.

5. The composition of the concrete mix also affected the life of the saw blade. There was a measurable difference in the action of the blade in concrete containing an air-entraining agent over that in which no air-entraining agent was employed. This again probably reflects density rather than any other characteristic of the concrete.

The foregoing discussion has stressed the life of the blades since they are the variable

cost item. Once the concrete saw is purchased it is usually effective and efficient so long as it has adequate power and adequate power transfer facilities, such as the proper V-belts, etc. The blades range in cost from $125.00 to $150.00 each, for a 12-in. diameter blade. Other diameters vary in cost according to their size.

Cost of Pavement—We had specified that each joint be sawed to a 2-in. depth. We wanted to be sure that when a crack formed, it would form beneath the groove cut by the saw. It is possible that future operations might prove that a 1-in. depth would be sufficient to create an adequate plane of weakness. This, of course, would tend to lower the cost of sawing. Since this type of work is quite new and since the experience and data collected during 1950 has, no doubt, proven useful to the individual contractors and to the manufacturers, it is not deemed appropriate to include any actual cost figures nor to give the advantages or disadvantages of various types of saws or blades which have been found. The actual cost for sawing joints has been found to be from 1½ to 2 times the cost of handforming. However, since these costs are subsidiary to the cost of the pavement, they are apparently insignificant as compared to the other cost items inasmuch as our pavement costs have actually been less this past year. In fact, prices during the latter part of the year were less than those earlier in the year, reflecting the gain in experience and the completion of charging off the joint sawing machine.

No dissenting voices of contractors nor engineers have been heard, disputing the statement that forming the joint with a saw is a tremendous improvement over the old hand-finishing methods. They agree without exception that spalling at these locations is positively eliminated, that the riding quality of the surface is measurably improved, and that the technique is practical and the cost reasonable. We feel certain that because of development work this year, the costs for next years work will be less. The ultimate variable determining the efficiency of these diamond edge blades will, no doubt, be the type of coarse aggregate which is used in the concrete. The other factors such as water supply, type of blade, trueness of groove will tend to be reduced to common values. We have satisfied ourselves that the technique is an advancement over former methods in every way.