Beginning in 1947, and at various times since then, the Research Laboratory has worked with crack and joint sealers for concrete pavements, and with methods of preparing the cracks and joints to receive the sealer materials. At present there are three formal test sections in the highway system where these materials are under observation. The latest of these actually developed through interest in the sawing of weakened-plane joints in the pavement, but because of certain features related to the joints a new formulation of cold-applied sealer was involved also.

In the attached report, which has been prepared by Dave H. Sawyer, the condition of sealers in the three different projects are described. The materials range from a few months to 4 years in age, and from cold mastic consisting of two components combined on the job to hot poured rubber-asphalt compounds poured at temperature of about 400°F. The performance of the materials seems to vary throughout a comparable range.

Essentially the results show that OA-2 (asphalt cement) sealer is practically worthless, and OA-2 cut back with NC-3 is little if any better. The premixed cold-mastic material was not effective in sealing the joints saved on the project built this past summer, but extraneous factors such as cleaning could have been very influential. Cold-mastic material mixed from two ingredients on the job and extruded into grooved cracks and joints shows variable performance characteristics. Generally the material is in good condition even where it was placed 4 years ago. After two and three years of service, the rubber-asphalt sealer placed in or near two of the projects is in excellent condition.

With regard to the sawing of joints, the results were not particularly favorable. Here again construction conditions could have undue influence. Irregular cracks, some of which undoubtedly formed
before the joints were sawed, marred the performance. Also, in some places fill settlement caused faults to form. Finally, sealing of the joints did not immediately follow the sawing, and one of the factors favoring this procedure was lost. In my estimation, sawed joints offer three potential advantages:

1. Simplicity in finishing the pavement.

2. Greater uniformity of concrete about the joint because disturbances often associated with forming and with hand finishing after the form is removed are eliminated.

3. The opening can be very narrow thus reducing the difficulties of maintenance and improving appearance as well as riding qualities of the pavement.

To utilize these advantages it is necessary to:

1. Saw the joints before shrinkage can cause cracks to form - the earlier the better after the concrete has set sufficiently to resist disturbance from the saw blade.

2. Seal the cracks immediately, so that expensive and difficult cleaning operations are eliminated.

These requirements could possibly involve operation of the saw from a bridge as early as 8 hours after the concrete has been poured, and sealing the joints as rapidly as they are sawed.

Early sealing in green concrete would, of course, eliminate the hot-poured sealers and make this type construction dependent upon the premixed cold-mastic material which at the moment does not appear promising. However, if the mastic did work satisfactorily and the joints were sealed immediately, all work on the finished surface would be completed in a sequence of operations following closely behind the paver. Certainly there are possibilities that pavement could be built in this way at a cost lower than that of the conventional method with preformed joints, even where the setting of load-transfer assemblies are involved.

I understand that sawed joints are under consideration for another bridge-approach project in the next construction season. If so, I hope that there will be provisions by which the potential advantages of the method can be thoroughly investigated.

Respectfully submitted,

L. E. Gregg
Assistant Director of Research

LEG:by
cc: Research Committee Members
Mack Galbreath (3)
Included in this report are observations and data on the performance of various types of crack and joint sealing materials applied to three separate concrete pavements. The factors which are considered pertinent in evaluating the respective conditions of the materials are: length of service, tightness of joint, adherence to the concrete pavement, and ductility. The three materials used on these projects were cold mastic, hot-poured asphalt rubber, and OA-2 cut back with MC-3.

The first and most recent of the pavements considered is the Carrollton Bridge Approach on U.S. 42, designated as Project FI 197 (6) in Carroll County. Interest was centered on premixed cold-mastic type sealer used for the first time on this project. However, sawing of joints in concrete pavement was used for the first time on this project also. In
fact, the narrow openings in these joints mainly accounted for use of the premixed sealer and for the amendment of Special Specification No. 46R to cover the new form of mastic sealer. Construction features and performance of both the sealer and the pavement in general (including a crack survey) are reported.

The second pavement viewed is the section of U.S. 31W extending from the south city limit of Franklin to the Kentucky-Tennessee State Line. The project is designated as PI 239 (4). Several reports dealing specifically with this pavement have been made under different authorship, but they have dealt mainly with performance as it was influenced by elimination of transverse joints. The crack-sealing materials were of secondary interest.

The third pavement is a section of the Lexington-Leestown Road in Fayette County where joints were grooved and resealed with cold-mastic type sealer in 1948. This was the first project of sufficient size to be dependable as an experiment with cold-mastic sealers.

**Carrollton Bridge Approach, U.S. 42**

The 1,410 feet of concrete pavement placed on U.S. 42, during the summer of 1952, was in connection with a new bridge spanning the Kentucky River between Prestonville and Carrollton. In addition 761 feet of connecting pavement (New Castle Approach) was placed simultaneously between Ky. 55 and U.S. 42 at Prestonville. An overall view of this project may be seen in Fig. 1, with the approach to U.S. 42 visible in the left background at Sta. 29+62.
Fig. 1. General view of pavement looking west on U.S. 42, at Sta. 36+30. Bridge in immediate foreground.

Fig. 2. General view of connecting pavement looking toward U.S. 42 from Ky. 55 (New Castle Approach). Note transverse crack in foreground.
The pavement was an 8-inch uniform section with standard construction methods being employed throughout. The concrete consisted of a standard 6-bag mix with Ohio River Gravel serving as the coarse aggregate. A 2-inch compacted layer of crushed limestone (Nos. 6 and 10) was placed for the insulation course.

Paving on U.S. 42 began at Sta. 22+22 with two 11-foot lanes widening out to four 11-foot lanes at Sta. 27+00. From there the ensuing pavement was 44 feet in width continuous to the bridge (Sta. 36+56).

Joints

Three different types of joints were incorporated in the project. Transverse weakened-plane joints (Fig. 3) without load transfer were installed at 80-foot intervals, while contraction joints with load transfer assemblies were placed at the end of construction runs. Sawed joints (Fig. 4) were spaced at 20-foot intervals and grooved to a depth of 2.5 inches as shown in Fig. 5. Specifications required that these joints be sawed in not less than 10 hours and not more than 72 hours after the concrete surface was finished.

Crack Survey

The second crack survey was conducted on December 10, 1952, (see layout in appendix for locations). A total of 34 cracks were apparent at this time, 9 of which appeared in a survey taken in June, 1952. Forty-four percent of these cracks were concentrated in a 220-foot section of pavement which represents only 1.5 percent of the total length on U.S. 42. This situation is attributed to noticable settlement of the mid-traffic lanes.
Fig. 3. Preformed joint prior to sealing with cold mastic filler.

Fig. 4. Sawed joints at Sta. 29+72 before sealing.

Fig. 5. Grooving machine used in sawing joints to a depth of 2 1/2 inches. Joint widths were approximately 3/16 inch at 20 foot intervals.

Fig. 6. Preformed joint filled with premixed cold-applied mastic sealer. Note limited tracking during summer weather.
between Sta. 30/00 and Sta. 33/00. Faulting at sawed joints was prominent in 5 instances around Sta. 24/00, and this occurred only in the south lane. The progressive disintegration of concrete about a crack adjacent to a construction joint at Sta. 24/00 is shown in Figs. 11 and 12.

The 3 cracks located between Sta. 1/00 and Sta. 7/80 (on the New Castle Approach) were prominent at the time of the June, 1952 survey, and they were the only cracks evident over this section of pavement at the time the December survey. Two additional cracks, however, were found in the intersection at Ky. 55.

Premixed Mastic Joint Sealer

Up to the time this project was undertaken, cold mastic material used in this state had been made up from dry and liquid components delivered to the job in separate containers. This necessitated equipment for the mixing, and because the mixture had a very "sticky" consistency the same equipment was used for applying the material*. Extrusion through a nozzle was satisfactory for application of such a viscous compound to cracks or joints having an opening about \( \frac{1}{8} \) inch or greater.

Obviously this combination was not suitable for the sawed joints, so both a different form of material and a different procedure for injecting it into the openings were developed by commercial interests. The new sealer is delivered premixed, it is much less viscous or more "fluid" than the old type, and it is forced into the joint by means of compressed air.

Fig. 7. Crack in south lane at Sta. 24+52. Note condition of shoulder.

Fig. 8. Open preformed joint evidenced by visible water spots. Note corner crack in left foreground.

Fig. 9. One of the more serious examples of spalling - Sta. 33+15. Filler material in preformed joint at right is being displaced by gravel and debris.

Fig. 10. Crack at Sta. 34+23 adjacent to a construction joint on connecting pavement (New Castle Approach).
Fig. 11. Crack in south lane at Sta. 24662 adjacent to a construction joint. Picture taken in July, 1952. (See Fig. 12)

Fig. 12. Crack shown above after 5 months service.
All joints were filled with cold-mastic type sealer in accordance with Special Specification No. 46R-1. Condition of the material in preformed and construction joints was considered fair, while sealer in the sawed joints has tended to separate and become dislodged from the pavement.

Cores were drilled from a preformed joint (Fig. 15) and from a sawed joint (Fig. 16) in an effort to establish the relative thickness or depth of the "crust" which is normally associated with the exposed surface of this material. Cores from joints containing the material and varying in length of service, of course, would be required to definitely establish a rate for this type of progressive deterioration. Nevertheless, evidence of deterioration was obvious.

The pencil line on the core shown in Fig. 15 illustrates the depth to which a hard crust has formed. Obviously, the opening seen in the surface of this core extends downward to the line, and oxidation of the material has proceeded to that depth. Partial openings such as this were prevalent at intermittent points along most joints.

It is difficult to determine in this case whether the sealer was fundamentally at fault, or whether conditions at the time of sealing contributed to the tendencies toward early failure. A great amount of dirt and other foreign matter was contained in the sealer taken with the core. Some of this could have been easily pressed into the sealer after it had been placed in the joint. However, the amount and distribution of extraneous matter indicated that the joint was not satisfactorily cleaned after it was sawed and immediately before the sealer was injected. Certainly there is evidence that failure was at least influenced by the dirt.
Fig. 13. Evidence that sawed joint is open can be seen in intermittent water spots across pavement. Joint was sealed in July, 1952, with cold mastic sealer, Sta. 24/95.

Fig. 14. Water spots seen along joint above are typical of those occurring at most sawed joints during wet weather.
Fig. 15. Core taken from a preformed joint. Line on side of core shows depth of "hard crust" formed due to weathering.
Fig. 16. Core taken from sawed joint. Note absence of material in upper portion of crack.
Simpson County, U.S. 31W

The pavement under observation in Simpson County is a 5.725 mile section of U.S. 31W from Franklin to the Tennessee State Line. The highlight of this pavement (completed in June, 1949) was the elimination of all transverse joints other than construction joints at the close of each paving period. Periodic inspections and reporting have been carried out by W. B. Drake, Research Engineer, and additional information may be obtained from these reports, the latest of which is Report No. 4, issued in December, 1952.

All cracks that occurred in the pavement during the first four months of service were filled with OA-2 asphalt-cement type crack and joint sealer. The inability of most materials to maintain a good seal in ungrooved cracks resulted in a decision to groove all cracks and to incorporate three different types of joint sealer.

This work was carried out at two different times, as follows:

November, 1949 - Cracks between Sta. 185/80 and Sta. 311/00 grooved and sealed with cold mastic sealer.

October, 1950 - Cracks between Sta. 9/11 and Sta. 185/80 grooved and sealed with:

1. OA-2 & MC-3 - 9/11 to 20/00
2. Cold Mastic - 20/00 to 40/30
3. Hot asphalt-rubber - 40/30 to 185/80

For the most part, cracks sealed with the OA-2 cut back with MC-3 are open and additional maintenance will be required in the near future. Figs. 17 and 18 show the condition of material in two of these cracks.
Fig. 17. Grooved crack at Sta. 14/28. Material shown is OA-2 cutback with MG-3. Simpson County.

Fig. 18. Open crack at Sta. 19/60, sealed with OA-2 two years ago. Simpson County.
The cold-mastic placed in 1950 is in good condition, and the hot asphalt-rubber sealer placed the same year is in excellent condition after 2 years of service. Fig. 19 shows a crack at Sta. 60/55 sealed with the rubber-asphalt compound.

There was little difference between the condition of cold mastic placed in 1949, and that placed a year later. A crack at Sta. 310/50, sealed in 1949, is shown in Figs. 20 and 21.

Fayette County, U.S. 421

The experimental installations of mastic sealer on U.S. 421 in Fayette County began 7.00 miles from the west city limit of Lexington and ended 0.20 miles east of the Fayette-Scott County Line in Fayette County. These joints were grooved and resealed with cold-applied mastic type sealer (mixture of dry and liquid ingredients) in November, 1948.

Several inspections of the joints have been made in the interim, but no formal report - other than the University of Kentucky Engineering Experiment Station Bulletin previously mentioned by footnote - has been issued.

The condition of the material in these joints is considered satisfactory, and particularly so with respect to other joints having comparable periods of service. Fig. 23 shows a core extracted from a joint adjacent to the above test section. The joint was re-grooved to remove the old OA-2 material, and filled with hot-poured rubber-asphalt sealer in 1949. Note the excellent seal of this joint and the distinction between the old and newer material.
Fig. 19. Crack sealed with hot poured rubber in 1949 at Sta. 60'55 and in excellent condition. Simpson County

Fig. 20. Crack filled with cold-mastic type sealer in good condition. Simpson County

Fig. 21. Cold-mastic type sealer used in this crack at Sta. 310'50. Simpson County

Fig. 22. View of general condition of cold-mastic type sealer after 3 years service. Simpson County
Fig. 23. Core taken from joint resealed with hot asphalt-rubber in 1949 on Lexington-Leestown Road, Fayette County.
General Observations

The premixed cold-applied mastic sealer placed in construction joints and in preformed joints at Carrollton is in at least fair condition. However, most of the sawed joints sealed with this material are partially open and will require additional maintenance in the near future.

Joints sealed with hot-poured asphalt and cold-mastic sealing material in Simpson County are in good condition. The joints sealed with OA-2 cut back with MC-3 are in poor condition and need to be resealed.

The joints on U.S. 421 in Fayette County which were grooved and sealed with cold-mastic four years ago are in good condition considering service life and other factors such as installation. Considerably more service, free from maintenance, can be expected from these joints.
Layout of concrete pavement on U.S. 42 near Carrollton showing location of preformed, construction and sawed joint. (Sta. 22+42 to Sta. 27+52)
Layout of concrete pavement on U.S. 42 near Carrollton showing location of preformed, construction and sawed joint. (Sta. 27+52 to Sta. 32+52)
Layout of concrete pavement on U.S. 42 near Carrollton showing location of preformed, construction and sawed joint. (Sta. 32+52 to Sta. 36+36)
Layout of concrete pavement, connecting Ky. 55 and U.S. 42 near Carrollton, showing location of preformed construction and sawed joints. (Sta. 0+00 to Sta. 7+80)
Layout of concrete pavement, connecting Ky. 55 and U.S. 42 near Carrollton, showing location of preformed construction and sawed joints. (Sta. 5+00 to Sta. 7+80)