Memorandum to Dean D. V. Terrell
Director of Research

For the past year the Research Laboratory has been investigating joint filling compounds for concrete pavements with the object of determining whether extenders of one type or another placed in the hot-poured rubber-asphalt filler could reduce the cost without reducing the efficiency of these materials. Also included in the investigation was a search for new or different materials that might serve the same purpose but have properties that would make them more desirable or less expensive than the rubber-asphalt fillers. Because of the inconvenience and danger involved in the heating process to 450°F., and also the difficulty of controlling the rubber-asphalt types, a cold applied filler became of primary interest.

After some preliminary work in the laboratory with a variety of products, permission was obtained and an agreement reached with the contractor on the Lexington-Harrodsburg Road (Project F-369(4) 24(3)) to fill a few joints in this newly constructed pavement last fall. Included in the experimental installation were several hot-poured materials and one cold-applied mastic filler which had been used previously with apparent success by the Bureau of Reclamation for sealing joints in concrete on irrigation projects. It was our opinion that if the mastic could seal joints to keep water in a canal over a long distance in an arid region, it has possibilities for sealing water out or away from subgrades beneath pavements in this region. The only exceptional consideration was traffic which did actually exist to a considerable magnitude in these canals during construction and prior to use, but this was not very comparable with highway usage over a long period of time.

Preliminary laboratory tests showed that the material would withstand the standard bond-extension test at low temperature and the flow test at high temperature, but even so there were indications that it would possibly track on the tires of cars passing over the joints for the first few days after pouring. However, when joints were poured on this experimental field installation, practically no tracking occurred even though some traffic passed over these joints almost immediately after they were poured.

In this experimental installation, the mastic filler was placed in joints in relatively fresh concrete, as well as in some where the concrete was 14 days old. Our objective in working with green concrete was to investigate the feasibility of applying this to highways as it had been done in the canals, the principal advantage being in mechanization of the process to include forming and pouring the groove while the concrete is plastic and as it is finished. Properly worked out and integrated in the construction operation, this could be of great advantage with many types of contraction joints provided the filler functioned properly. To the best
of our knowledge it does function satisfactorily under these circumstances, because bond tests made with the mastic filler placed between green mortar blocks were completed in most cases without failure, and those fillers in green concrete on the Harrodsburg Road are showing no signs of failure.

Undoubtedly, one winter of exposure in a pavement is hardly a good test of fillers. Practically all of the fillers which were placed in the road survived the extreme conditions of the past winter without apparent damage, even though a large portion of them failed in the laboratory bond test - some failures occurring on the first cycle (See Table I for a summary). Nevertheless, the fact that they were placed in service made possible an evaluation based on more than just the laboratory tests. Probably this summer and the following winter will be sufficient to show those that have no merit at all, if there are such.

The cold fillers applied on the road were placed with a make-shift pump arrangement (with the exception of two joints that were filled by means of a caulking gun), and without doubt this can be and must be improved greatly if the material is to be feasible. I understand that the Bureau of Reclamation work has resulted in improvements along those lines, but I haven't had an opportunity to observe any of the newer devices. Even with the make-shift method of placement the joints were filled such that the mastic material receded or "shrunk" less than the hot-poured materials upon setting.

As a result of these observations, test data, and other information accumulated in the process of experimentation, the attached recommended Special Specification has been prepared. To the best of our knowledge there are at least three manufacturers who can supply material that will meet the requirements of the specification. These are:

Hunt Process Co.; 7012 Stanford Ave., Los Angeles, California
The Techkote Co.; 821 W. Manchester Ave., Inglewood, California
Presstite Engineering Co.; 3900 Chouteau Ave., St. Louis 10, Mo.

There may be others who deal in mastic products that would fit the requirements. Probably, if material of this description were advertised it would be bid in at about 10 to 12 cents per pound, and maybe even lower.

I recommend that the Specifications Committee review this recommended specification thoroughly, with a view toward including it at least on plans and specifications for projects where there would be a good possibility that it could be tried on a much larger basis than we have been able to apply it heretofore. Like the rubber-asphalt compounds, the mastic filler has no advantage on pavements in service with old-type fillers unless the joints are thoroughly cleaned before the new filler is applied. The work we have done thus far indicates that a cold mastic material properly made and applied has a lot of merit, and I believe that it should be given a more elaborate test on a larger scale.

Respectfully submitted

L. E. Gregg
Associate Director of Research
<table>
<thead>
<tr>
<th>Type</th>
<th>Material</th>
<th>Sta.</th>
<th>*Age of Concrete</th>
<th>Date Joints Filled</th>
<th>Results of Laboratory Bond Tests</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Nastic (Cold Applied)</td>
<td>Paraplastic 85% Extender 15%</td>
<td>72+90</td>
<td>2½ hrs.</td>
<td>10-20-47</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>73+20</td>
<td>3 hrs.</td>
<td>10-20-47</td>
<td></td>
<td></td>
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<tr>
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<td></td>
<td>73+50</td>
<td>17 hrs.</td>
<td>10-21-47</td>
<td></td>
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<tr>
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<td></td>
<td>75+04</td>
<td>17 hrs.</td>
<td>10-21-47</td>
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<tr>
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<td>Paraplastic 70% Extender 30%</td>
<td>76+00</td>
<td>16 hrs. S.</td>
<td>10-21-47</td>
<td>2-Completed 5 cycles (Green mortar specimens)</td>
<td>No attempt to extend test past 5 cycles.</td>
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<tr>
<td></td>
<td></td>
<td>41+20</td>
<td>14 days</td>
<td>10-21-47</td>
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<tr>
<td></td>
<td></td>
<td>41+50</td>
<td>14 days</td>
<td>10-21-47</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>41+80</td>
<td>14 days</td>
<td>10-21-47</td>
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<td>Paraplastic</td>
<td>0-75</td>
<td>2½ Mos.</td>
<td>11-20-47</td>
<td>1-Completed 1 cycle-Broken in handling</td>
<td>Split while removing spacer blocks at cold temperature-Second specimen destroyed before test.</td>
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<tr>
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<td>Caryelastic</td>
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<td>2½ Mos.</td>
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<td>2-50% Failed on 16th cycle</td>
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<td>0+45</td>
<td>2½ Mos.</td>
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<td>2-Failed on 20th cycle</td>
<td>Second specimen broken in handling before test.</td>
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<tr>
<td></td>
<td>Parkal</td>
<td>0+75(2)</td>
<td>2½ Mos.</td>
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<td>Failure in elasticity rather than bond-rupture or parting of the filler.</td>
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<td>1-Failed at 20th cycle</td>
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<td>4 Mos.</td>
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<td>2-Failed on first cycle</td>
<td></td>
</tr>
</tbody>
</table>

*Material sampled from project on Trippe Street, Owensboro, Daviess County Proj. 125-(16)

**Material sampled from project on U.S. 27, Butler-Falmouth Road, Campbell County Proj. FA-367(9).
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Fig. 1. Filling joint at Sta. 73+50 with cold mastic filler. Material was mixed in the hopper of the crude pumping device which is setting on the bridge at left, and from there it was forced through the hose and nozzle operated by man near far edge of pavement. Compressor in the background furnished pressure for operating the pumping device. Concrete at this point was poured 17 hours prior to this filling operation.
Fig. 2. Joint at Sta. 73+50 after about 6½ months of service through severe winter weather. This is the joint shown in Fig. 1 at the time of filling with mastic material.
Fig. 3. Devices used for preparation of bond-extension specimens with cold filler on the job. The hardened mortar blocks at left were made and treated in the standard manner and filled with material placed in hardened concrete at Sta. 41+50. The more elaborate form on the right contained mortar that was green and had been held in place by separator plates of sheet metal until initial set occurred. These specimens were filled by means of the caulking gun which is inserted into the space between two green mortar blocks. Note separator plate in upper left that has been removed from the form.
Fig. 4. Pouring joint at Sta. 0+15 with hot asphalt-rubber compound. Because of small quantities required and the fact that several different products were involved, special containers for heating, and small pouring pots were used in the operation.
Penetration and bond-test specimens prepared at the time of pouring the joint at Sta. 0+15. This procedure was followed throughout in order to substantiate the correlation between field and laboratory performance of the filler materials. Flash point and flow values were previously determined in the laboratory, and no attempt was made to determine the melting time because of great variations in atmospheric temperature during the several days involved in the pouring operation.
Fig. 6. Bond-test specimen representing material poured in joint at Sta. 0-75 illustrates one type of fracture. The sharp cleavage surfaces are indicative of brittleness within the filler at cold temperatures. This specimen failed in handling after completing one extension at cold temperature.
Fig. 7. Failures in bond and in cohesion are illustrated by these two samples which represented material poured at Sta. 0+45. The filler on the left failed internally, while the one on the right failed through lack of bond to the mortar. This condition was typical of those hot-poured specimens in which an extender of stone dust had been placed - none doing well and all but one failing on the first cycle.
Fig. 8. Failure in cohesion of specimens representing material at Sta. 0+75. This condition had developed after 5 cycles of extension and recompression.
Fig. 9. Bond test specimens containing cold-applied mastic filler after 5 cycles of extension. The two specimens on the right have not been recompressed after the fifth cycle.
Commonwealth of Kentucky
Department of Highways

Recommended

SPECIAL SPECIFICATION NO. _____

COLD-APPLIED MASTIC-TYPE
CRACK AND JOINT FILLER COMPOUND

This Special Specification No. _____ covers the material requirements and construction procedure for applying Cold-Applied Mastic Crack and Joint Filler Compound to seal cracks and joints in cement concrete pavement against the infiltration of water. It shall be applicable when indicated on plans, proposals, or bidding invitations and, when applicable, shall supersede all conflicting requirements of the Department's 1945 Standard Specifications, and Supplementary or Special Specifications.

COLD-APPLIED MASTIC-TYPE CRACK AND JOINT FILLER COMPOUND

I. GENERAL. Material furnished under this specification shall be composed of a mixture of dry and liquid ingredients which will form a resilient and adhesive compound capable of effectively sealing cracks and joints in cement concrete pavement against the infiltration of moisture throughout repeated cycles of expansion and contraction, and which will not flow from the joint or be picked up by vehicle tires at summer temperatures after the pavement has been opened to traffic. The compound shall be of such consistency under atmospheric temperatures
that it may be applied under pressure not to exceed 100 pounds per square inch without forming large air pockets or discontinuities. The compound shall remain in this state of consistency for at least two hours after mixing or preparation.

II. SAMPLING. A sample of the ingredients which the contractor proposes to use in preparing the filler shall be furnished the Department of Highways in a quantity sufficient to prepare a minimum representative specimen of one pound of the mastic compound. This shall be taken from materials delivered to the project and shall be furnished at least 30 days before the proposed date of use. The contractor shall provide recommendations by the manufacturer regarding the proportions in which the ingredients shall be mixed.

III. PERFORMANCE REQUIREMENTS. The compounds furnished under this specification, when mixed in accordance with the manufacturer's recommendations and tested in accordance with the methods hereinafter described, shall conform with the following requirements:

1) Penetration (after 24 hours)
   At $32^\circ$ F., 200 g., 60 sec.; not less than 1.00 cm.
   At $77^\circ$ F., 150 g., 5 sec.; not more than 2.20 cm.

2) Flow (after 24 hours) - Not more than 0.5 cm.

3) Bond (after 48 hours) - There shall be no cracking of the material or failure in bond between the materials and the mortar test blocks during or at the end of five cycles.
IV. **APPLICATION.** When noted in plans and specifications, fillers of the Cold-Applied Mastic Type may be applied to joints in hardened concrete or to joints in fresh concrete in the plastic state during or immediately following finishing operations, provided the contractor can devise a means of application that will meet all other requirements and is approved by the Engineer. Joints in hardened concrete shall be filled within 48 hours after the concrete at those joints has been poured and finished. Application shall be by means of a mechanical or pressure apparatus capable of extruding the material as a continuous feed with a pressure not exceeding 100 pounds per square inch. The hopper or supply chamber shall be of such size that the compound will not be retained more than two hours after the time of its preparation. Filling of cracks and joints will not be permitted at temperatures below 32° F.

Proportioning of ingredients shall be in accordance with the manufacturer's recommendations, and mixing shall be accomplished by thoroughly blending the ingredients by hand or mechanical means at prevailing atmospheric temperatures. Heating of the ingredients, the use of solvents or adulterants, and mixing methods that introduce extraordinary quantities of air into the compound will not be permitted.

Prior to filling operations in hardened concrete, all cracks and joints shall be cleaned by means of an air jet, wire brush, or other approved equipment suitable for removing extraneous material including free water. Sufficient compound shall be injected into the joint or crack so that upon completion of the work the surface of the filler will be flush
with the surface of the pavement.

V. METHODS OF TESTING. The following methods of testing shall be used in determining compliance with requirements in Part III:

1. Preparation of material. A batch of approximately 300 grams of the compound shall be prepared by thoroughly mixing the dry and liquid ingredients. From this batch, samples for the tests described below shall be prepared immediately. Exposure for test samples, except where noted otherwise, shall be in air at approximately 77°F from the time of preparation until the time of testing.

2. Penetration. The penetration test shall be made after 23 hours of exposure in air followed by one hour exposure in the water bath at 77°F. One sample shall be prepared by placing the material in a seamless "ointment box" having a diameter of approximately 2.75 inches and a depth of approximately 1.75 inches. Placement shall be made by means of a spatula with care being taken to avoid entrapment of air.

Penetration shall be made by means of a cone which shall be constructed of stainless steel or brass with a detachable hardened steel or stainless steel tip. The cone shall conform to the dimensions specified by Fig. 1 of A.S.T.M. Designation D-217-44 T except that the interior construction may be modified as desired. The outside surface of the
cone and tip shall have a very smooth finish. The total moving weight of the cone and attachments shall be 150 grams for determining the penetration at 77° F., and shall be 200 grams for determining the penetration at 32° F.

In making the test the sample shall be transferred from the bath to the penetrometer and tested immediately. Smoothing of the surface of the specimen prior to each of the individual penetrations shall be permissible. At least three separate penetrations shall be made, all as near to the center of the specimen as possible. The reported penetration shall be the average of those obtained in individual tests. The cone shall be cleaned after each penetration. Operation of equipment shall be in accordance with A.S.T.M. Designation D-217-44 T.

(3) Flow. A portion of the prepared sample shall be troweled into a suitable amalgamated mold 4 cm. wide by 6 cm. long, held firmly in place on a bright tin panel. The sample shall have a uniform depth of 0.32 cm. After 24 hours exposure in air at room temperature, the mold shall be removed and the panel containing the sample shall be placed in an oven maintained at 140° F. ± 2° F. for 5 hours. During the test the panel shall be mounted at an angle of 75 degrees with the horizontal. The total movement (measured in cm.) of the specimen during
the 5-hour test period shall be reported as the flow.

(4) **Bond test.**

The bond test shall be performed on specimens prepared with hardened mortar blocks or with fresh mortar blocks in accordance with practice that will be followed on the construction project. When the filler is to be placed in joints after the concrete has hardened, the bond test specimens shall be made with hardened mortar blocks. Bond test specimens prepared with fresh mortar blocks shall apply when filling of joints in fresh concrete is contemplated.

a. **Extension machine.**—The extension machine used in the bond test shall be so designed that the specimen can be expended at a uniform rate of approximately 0.125 inch per hour for at least 4 hours. It shall consist essentially of one or more screws rotated by an electric motor through suitable gear reductions. Self-aligning plates or grips, one fixed and the other carried by the rotating screw or screws, shall be provided for holding the test specimen in position during the test.

b. **Test Specimens.**

1. **Hardened Mortar Blocks.** Two cement mortar blocks each 1 by 2 by 3 inches in size shall be prepared, using one part of portland cement to two parts, by weight, of clean uniformly graded concrete sand, all of which passes a No. 4 sieve and not more than 5 per cent of which passes a No. 100
sieve. After curing 1 day in moist air and 6 days in water at 70° F., one 2 by 3-inch face of each block shall be surfaced by grinding with a No. 30 HD carborundum stone until the aggregate is uniformly exposed. The blocks shall then be air-dried at room temperature for 24 hours prior to use. In order to conserve time it will be permissible to maintain a supply of cured and ground test blocks. These blocks shall be prepared for use in tests by drying in air at room temperature for 24 hours prior to use.

The mortar blocks, prepared as described in the preceding paragraph, shall be placed with the ground faces parallel and facing each other and with one of the 3-inch edges of each block resting on an amalgamated metal plate. The ground faces shall be spaced 1 inch apart by means of amalgamated metal strips placed at equal distances from the ends leaving a clear opening 2 inches by 2 inches by 1 inch. The test specimen shall be completed by filling this opening with the prepared joint-sealing filler and allowing it to stand at room temperature for 48 hours. Filling shall be done by means of a caulking gun or other suitable apparatus which will extrude the material at a uniform rate. Extreme care must be taken to avoid entrapment of air at the bottom of the specimen and at the faces of mortar blocks. Agitation of the material with a spatula
shall be permissible if air is entrapped by the extrusion process. The mortar test blocks must be held rigidly together by means of clamps, rubber bands, or other suitable means.

2. Fresh Mortar Blocks. When applicable, the specimens shall be prepared with fresh mortar blocks consisting of cement and sand as described in paragraph 4 b-1 above. The mortar shall be contained in suitable forms and spacers arranged such that the finished specimens shall conform with the dimensions given for test specimens with hardened mortar blocks. The mastic filler material shall be applied by a caulking gun or similar apparatus as soon as the mortar has become sufficiently rigid to permit removal of the separator plates on the inner faces, or as soon as the mortar becomes sufficiently rigid to withstand the application of the filler.

c. Extension at low temperature.— The test specimens, prepared as previously described, shall be placed in an atmosphere maintained at $0^\circ$ F. $\pm$ 2° F., for not less than 2 hours, after which the amalgamated plates and strips shall be removed and the specimens mounted immediately in the self-aligning clamps of the extension machine. The specimens shall then be extended at a uniform rate of 0.125 inch per hour for 4 hours. During this period the atmosphere surrounding the test specimens shall be maintained at a temperature of $0^\circ$ F. $\pm$ 2° F.
d. Recompression.-- After extension at low temperature, as previously described, the extension machine and test specimens shall be allowed to warm at room temperature until the specimens can be easily removed from the machine. The spacers described in paragraph b above shall be placed in position between the mortar blocks, and the specimens shall be placed in a horizontal position so that the weight of the mortar block above the sample will compress it and come to rest on the spacers. The specimens shall be warmed in air at room temperature for 2 hours. If compression is not complete, it should be compressed manually to its original thickness.

e. Number of cycles.-- Five cycles, each consisting of extension at low temperature followed by recompression, shall constitute one complete test for bond. In cases where failure occurs in only one of two bond-test specimens and all other requirements are met satisfactorily, an additional set of two bond-test specimens shall be made.