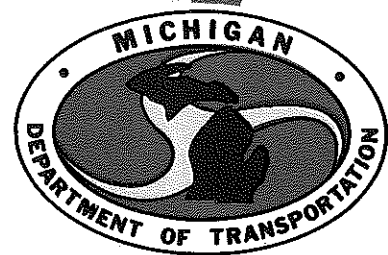
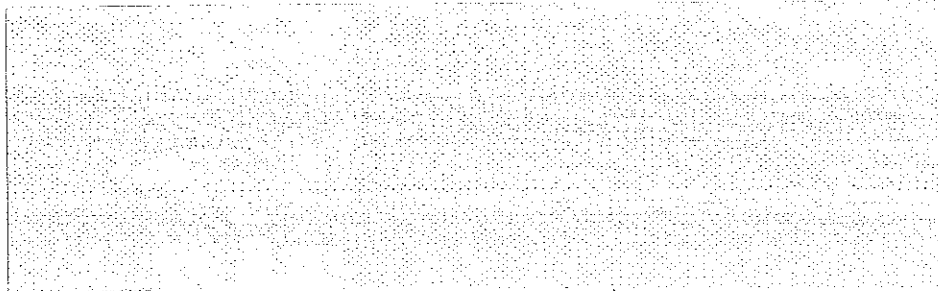


EVALUATION OF SERVICISED FLEX LOK FILLER
FOR PRESSURE RELIEF JOINTS
Final Report



MATERIALS and TECHNOLOGY DIVISION



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**EVALUATION OF SERVICISED FLEX LOK FILLER
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Final Report**

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**Research Laboratory Section
Materials and Technology Division
Research Project 77 G-224
Research Report No. R-1270**

**Michigan Transportation Commission
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Rodger D. Young, Vice-Chairman;
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Shirley E. Zeller, William J. Beckham, Jr.
James P. Pitz, Director
Lansing, March 1986**

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INTRODUCTION

One of the major problems associated with older jointed portland cement concrete pavements is that of joint blow-ups. Joint blow-ups normally occur when the joint interfaces have deteriorated to the extent that they can no longer withstand the compressive forces generated by the thermal expansion of the concrete.

One method used to reduce its occurrence, and thus the possible traffic hazard caused by a blow-up, is to construct pressure relief joints at periodic intervals along the length of the pavement.

Michigan's first major attempt at constructing pressure relief joints consisted of sawing a 3-3/4-in., full-depth joint groove across the width of the pavement. The concrete in the groove area was removed and a 4 by 9-in. polyethylene foam plank was forced into the groove to act as a filler. This method was satisfactory as long as the foam was properly installed and sufficient pressure was exerted against the joint faces to hold the foam in place. In several installations, however, the foam worked out of the joint groove, thus allowing the groove to fill with debris which prevented the joint from closing.

Measurements made on the polyethylene foam which came out of the joint indicated that the material had taken a permanent 'set.' It was assumed that due to the set the foam could not exert sufficient pressure against the joint faces should the joint open up during cooler weather.

Laboratory Evaluation

Laboratory tests were conducted on the polyethylene foam which was currently being used to determine the effect of time, temperature, and compression on the recovery value of the foam. Initial evaluations indicated that the polyethylene foam did indeed have poor recovery values when compressed at typical summer pavement temperatures. Tests were then conducted on samples of polyethylene foam of other densities to determine if they exhibited better recovery values. The results of the tests indicated that the values were not significantly different. Tests were then conducted on other types of foams, such as cross-linked polyethylene, GRS rubber, and urethane, to determine if they exhibited better recovery properties. The results of these tests (Fig. 1) indicated that the urethane foam had the best compressive recovery properties. Based on the compressive recovery test values and other laboratory evaluations, a decision was made to change from polyethylene to polyurethane foam as a filler for the pressure relief joints.

At the time the decision was made to change to a urethane foam, the only known commercially available foam that would be suitable for this use was Serviced Flex Lok pressure relief joint filler. The material, as manufactured, was 4-1/2 in. wide, 7-3/4 in. deep, and 8 ft long. The Department's specifications (Appendix A) for the joint groove and filler

material were modified to conform to the requirements and physical properties of the Serviced material.

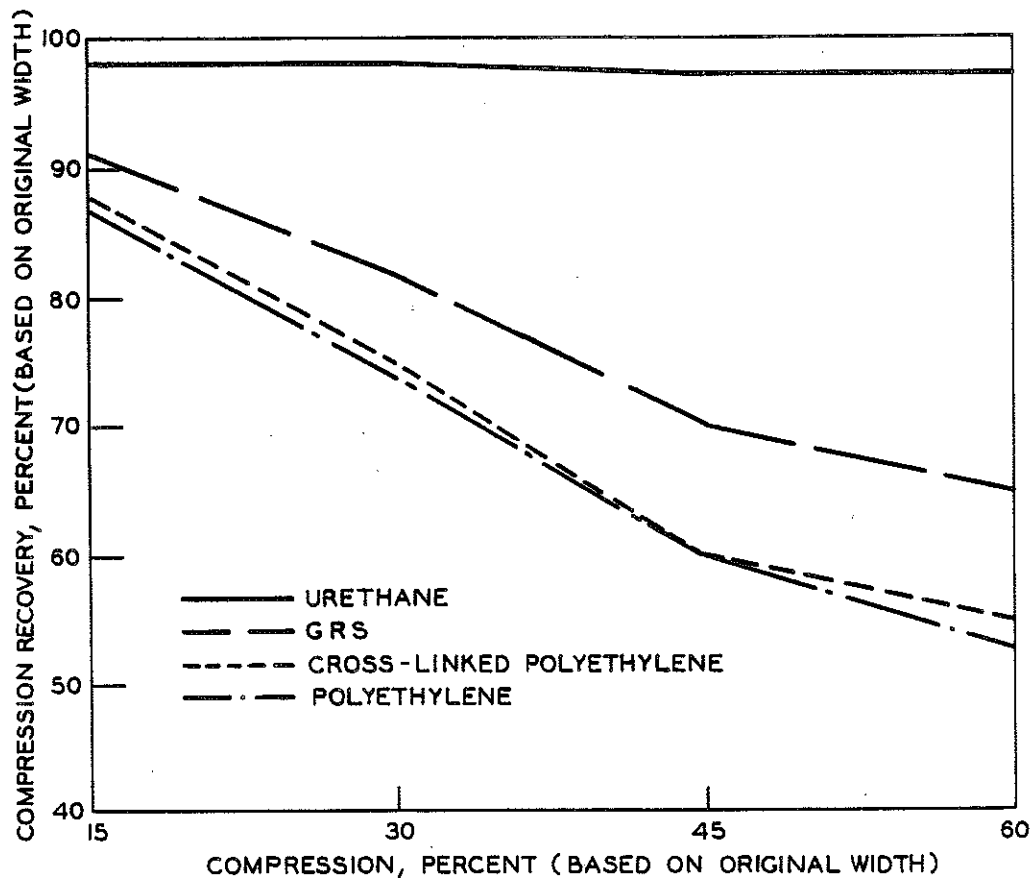


Figure 1. Compressive recovery values, 24 hours after release, when compressed 120 hours at 100 F.

Scope

The first major project in Michigan to incorporate the Serviced Flex Lok filler was a 50.9-mile section of US 27 (dual 24-ft concrete pavement) in Gratiot, Isabella, and Clare Counties. This pavement was constructed between 1959 and 1963. The basic construction of the pavement consisted of 99-ft reinforced slabs, load transfer assemblies with baseplates, and formed joint grooves sealed with hot-poured sealant.

The repair contract for this project consisted of constructing pressure relief joints in conjunction with full-depth joint repair with fast-set portland cement concrete. The pressure relief joints were located in conjunction with the full-depth repairs to provide approximately 4 in. of relief for every 1,000 ft of pavement length. The project required approximately 12,700 lin ft of pressure relief joint at a contract price of \$17/lin ft.

Construction Procedure

Since one lane of the pavement had to be open to traffic at all times, the normal procedure was to construct pressure relief joints in one lane one day and then complete the joint in the adjacent lane the following day.

The joint grooves were sawed with concrete saws equipped with diamond blades. The initial saw cut was made perpendicular to the centerline of the pavement with a modified saw. The saw was set up to accommodate two 12-in. diameter blades, spaced to make two parallel cuts 3-3/4 in. apart (Fig. 2). The saw cut was started at the shoulder and continued slightly beyond the centerline (Fig. 3). The dual cuts were approximately 3-1/2 in. deep. These cuts were extended full depth using a concrete saw with a 26-in. diameter blade. Four passes were normally used to complete the cut full depth, two in each of the initial cuts. When the groove was sawed in the adjacent lane the next day, the procedure was basically the same, except that the saw cut ended at the centerline. This resulted in a continuous joint across the width of the pavement including connected ramps.

After the groove was cut full depth, the strip of concrete remaining between the two saw cuts was broken into segments approximately 3 ft long and removed by hand. All small pieces of broken concrete were then removed from the groove area and the base repaired as needed (Fig. 4).

The walls of the joint groove were coated with a lubricant-adhesive immediately prior to installing the urethane filler (Fig. 5). Since the Servicised Flex Lok material was factory molded in 8-ft lengths, it was required in the specifications that it be spliced into 12-ft lengths prior to delivery to the project site. The 12-ft long sections were installed in the groove by an installation machine which compressed the thickness of the foam filler and forced it into the groove (Fig. 6). The installation machine was a modified version of the machine designed and constructed by the Department to install the polyethylene foam plank joint filler.

Basically, the machine consists of a 12-ft long tapered width chute, a 12-ft long collapsible width ram, and two hydraulic cylinders. The hydraulic cylinders force the collapsible ram down onto the foam filler, thus forcing it into the taper of the chute. As the ram is forced deeper into the chute, the foam filler is compressed in width and forced into the joint groove until the top of the foam is approximately 3/4 in. below the surface of the pavement. The installation machine is normally mounted on a heavy vehicle which provides mobility, hydraulic pressure, and downward force to hold the machine in position.

The shoulder area is recompacted and repaired as needed (Fig. 7). Prior to installing the length of filler in the adjacent lane the next day, the end of the installed filler was coated with the lubricant-adhesive and the second length of filler was installed in such a manner to ensure that

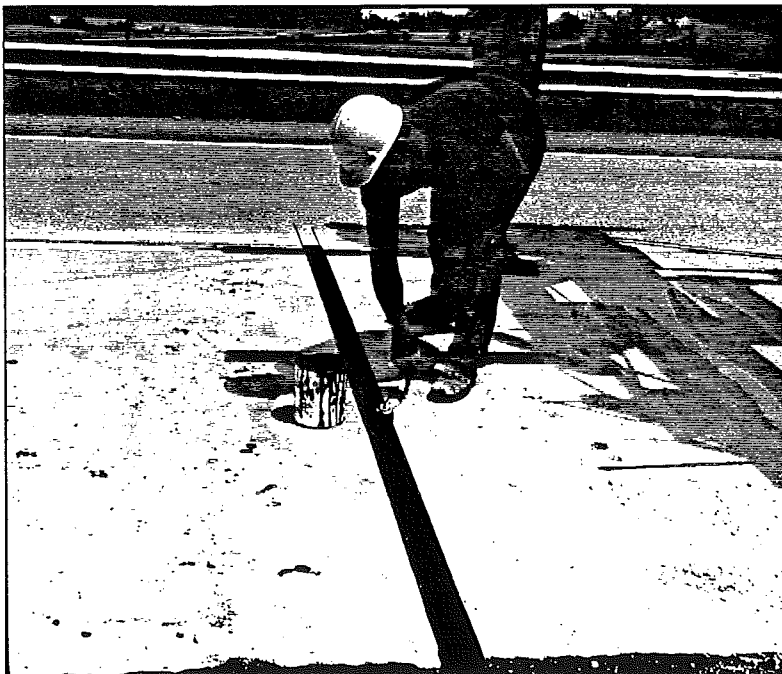
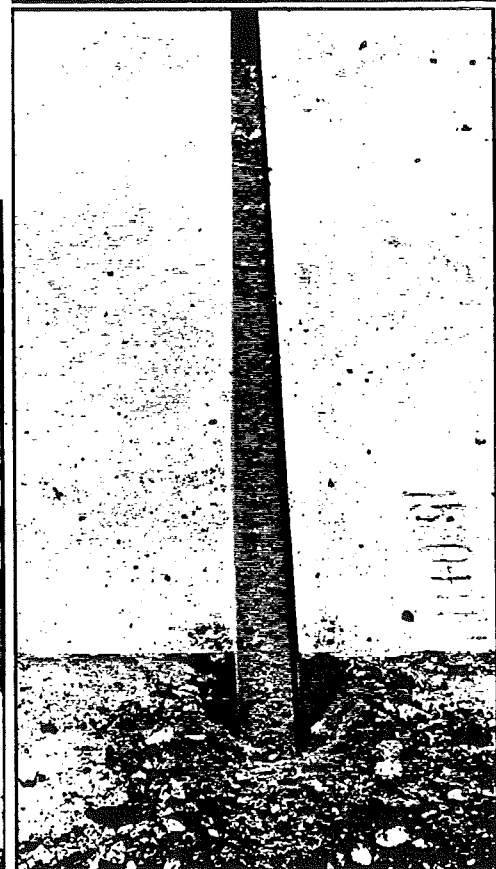
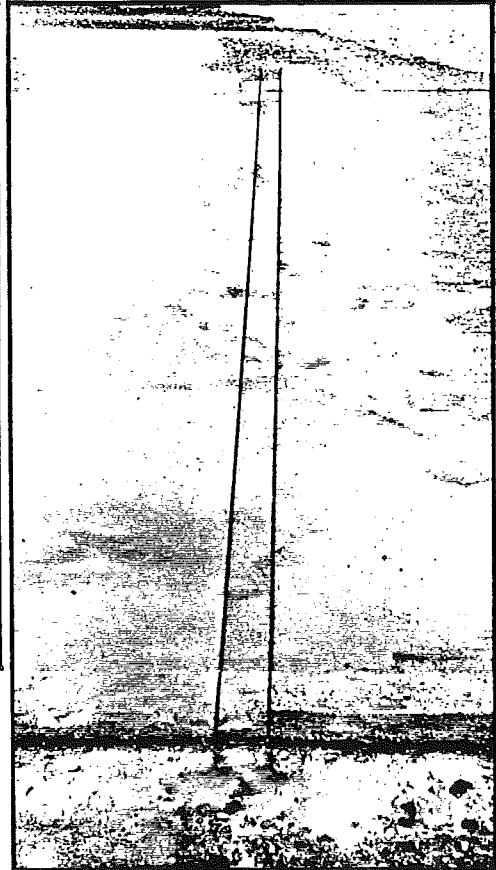


Figure 2. Initial saw cut using dual blades to make parallel grooves 3-3/4 in. apart.

Figure 3. Initial saw cuts from shoulder extending past the center line.

Figure 4. Concrete and debris has been removed from joint area.

Figure 5. Applying lubricant-adhesive to the joint faces prior to installing the filler.



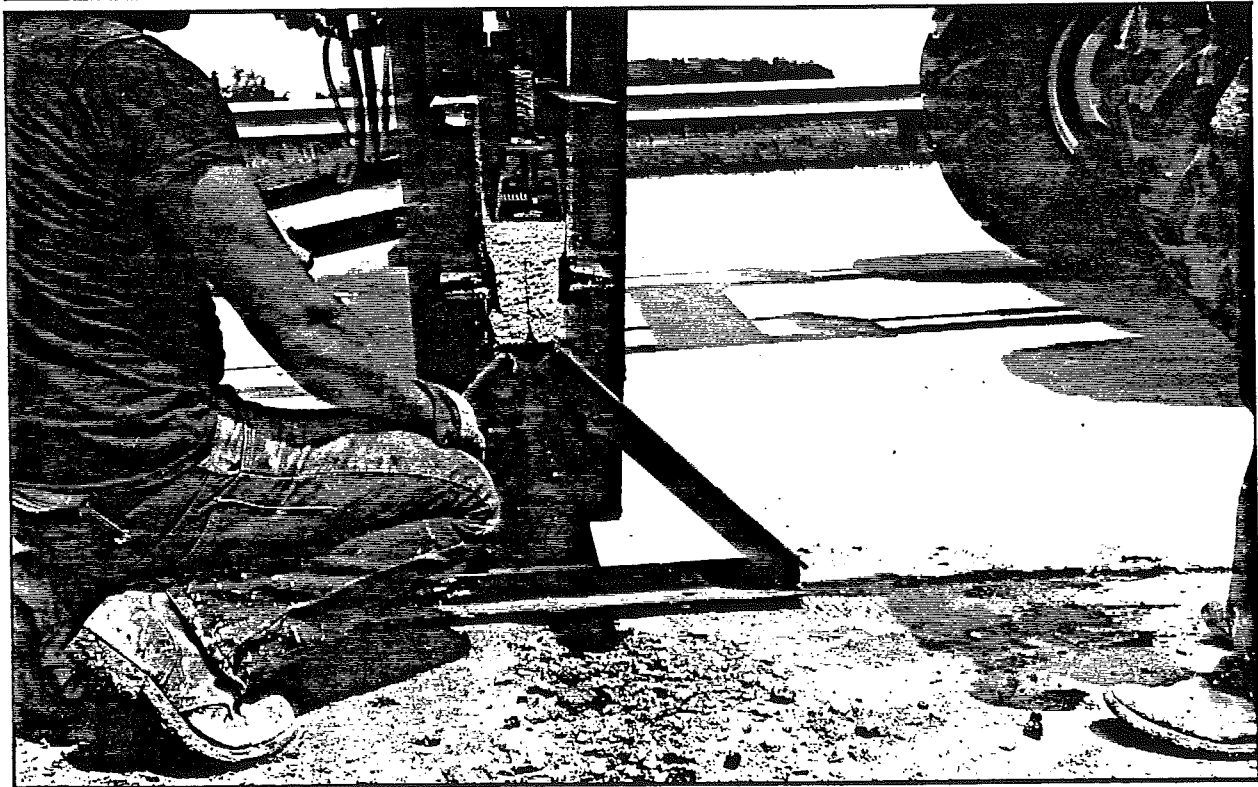
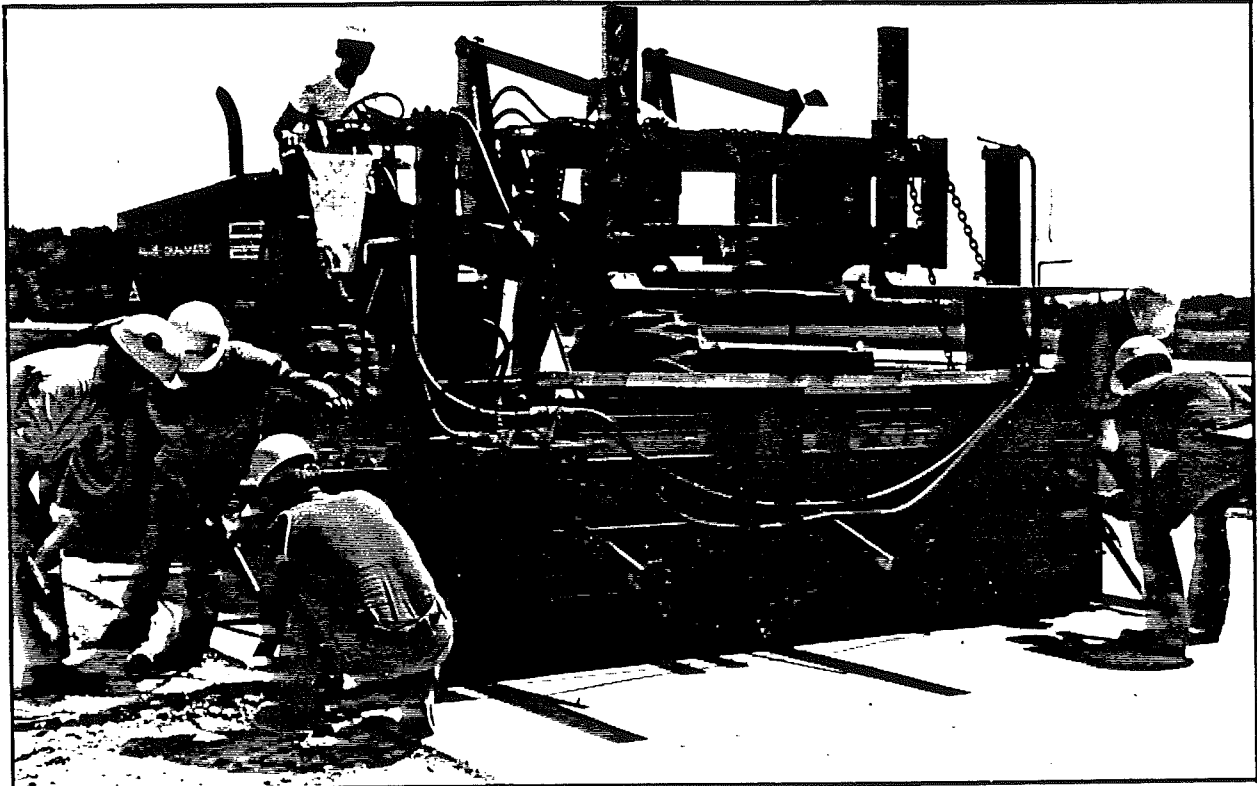
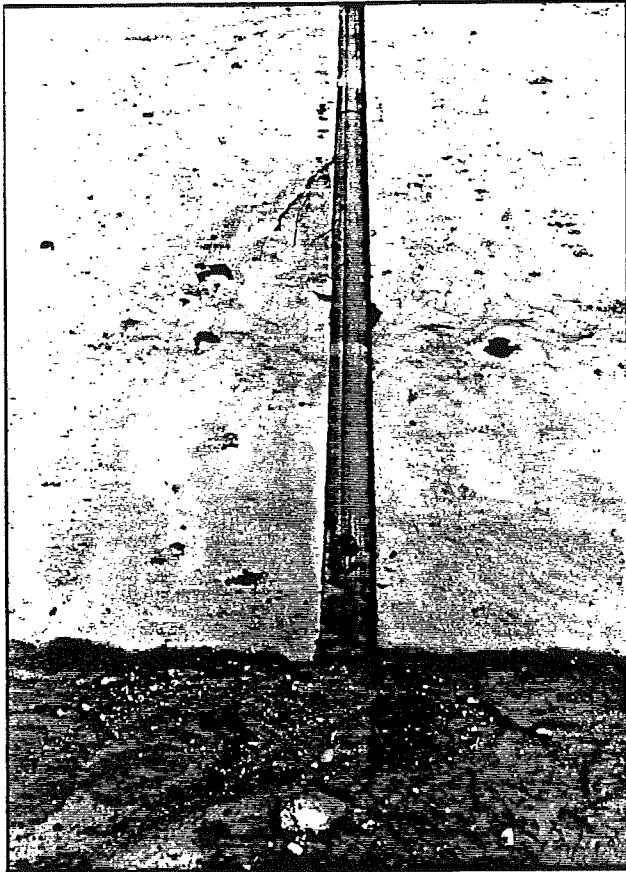
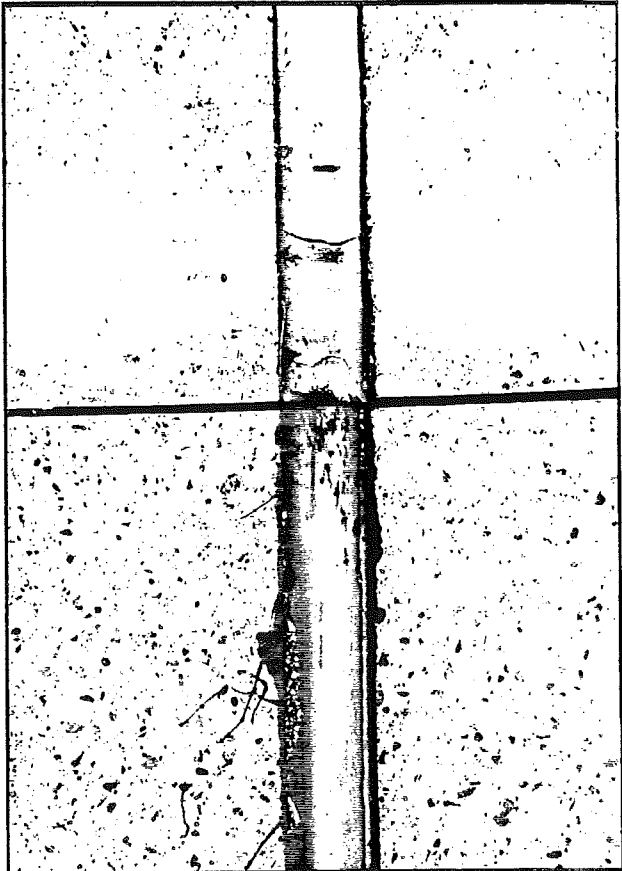


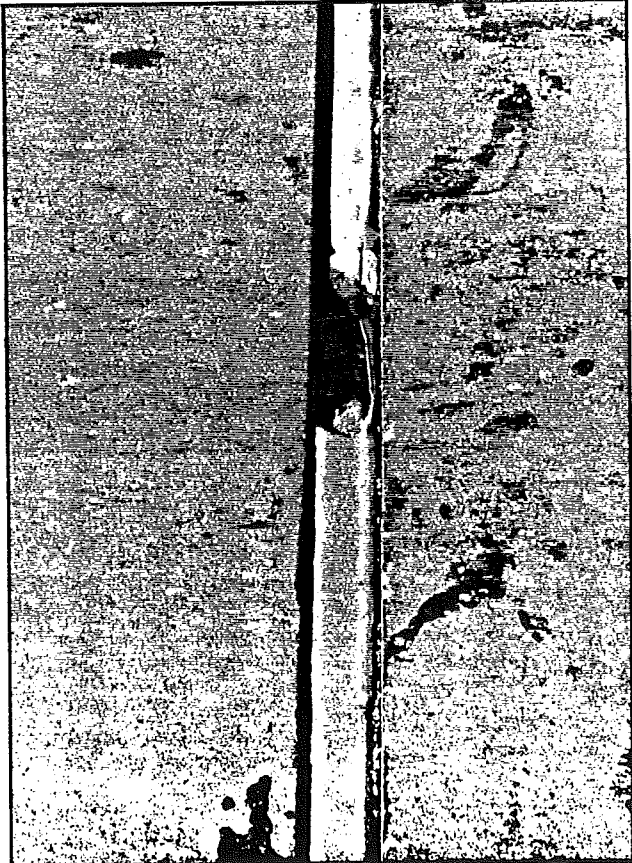
Figure 6. Installation machine mounted on a front-end loader (top). Urethane filler being installed in the joint groove by the compressible ram installation machine (bottom).



◀ Figure 7. The filler has been installed in one lane and the shoulder repaired.



▲ Figure 8. Butt-splice at the center line of pavement.



◀ Figure 9. Minor damage to filler caused by traffic or snow removal equipment.

it was tightly abutted to the first section, thus creating a field splice at the centerline of the pavement (Fig. 8).

Field Evaluation

The construction phase of the project was conducted in the summer of 1977 under the supervision of the Construction Division. Research Laboratory personnel were at the job site periodically to monitor the installation procedures.

The first comprehensive field evaluation was conducted in March 1978. This inspection consisted of visually inspecting each of the 500-plus joints for general appearance, traffic damage, and condition of the splices. Measurements were also taken at each joint to determine the width of the joint, the depth to the top of the filler, and the amount of faulting between the joint faces. The pavement temperature at the time of the survey was approximately 40 F.

The results of the field inspection indicated that the pressure relief joint filler was performing adequately at the time of the inspection. The following items were noted from the inspection data:

- 1) Five joints had minor damage which did not affect their performance (Fig. 9).
- 2) Forty-two joints were faulted approximately 1/4 in.
- 3) All of the splices in the filler were satisfactory.
- 4) Twelve joints were 1/4 to 3/8 in. wider than originally sawed (Table 1).
- 5) Sixty-seven joints were as wide or up to 1/4 in. wider than originally sawed (Table 1).

TABLE 1
JOINT WIDTH VS. THE NUMBER OF JOINTS

	Joint Width, Inches							
	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.75	3.75-4.0	4.0-4.25
No. Joints 1978 (40°F)	0	0	6	46	130	252	67	12
No. Joints 1980 (80°F)	15	91	122	148	105	32	0	0

The second field evaluation was conducted in July 1980 when the pavement temperature was approximately 80 F. The type of observations and measurements were basically the same as in the previous evaluation. The following items were noted from the inspection data:

1) One additional joint had received minor damage, which did not affect its performance.

2) The number of faulted joints was approximately the same. Eight of these joints, however, had increased in severity and were faulted 1/2 to 5/8 in. Normally the faulted joints were less than 10 ft from an open transverse crack.

3) In general, all the joints had closed to a width less than that to which they were sawed (Table 1).

The third and final inspection was conducted in March 1981 when the pavement temperature was approximately 30 F. Eight sections consisting of 10 joints per section were randomly selected from the total project. Each joint was visually observed and its width measured. The joint width measurements indicated that all of the joints inspected increased in width due to the 50 F decrease in temperature from the previous inspection. The average increase was 0.28 in. with a range of 0.11 to 0.58 in.

Conclusion

It is evident from the results of this project that the Servicised Flex Lok material performs very adequately as a filler for pressure relief joints, if properly installed. However, we believe that the good performance is attributed mainly to the physical properties of the material and not the shape factor.

Our laboratory test data indicate that the urethane foam has sufficient compression recovery to accommodate the increased joint width due to thermal contraction of the concrete pavement after installation of the pressure relief joint.

Recommendations

Based on the results of this study and the inspection of subsequent construction projects we recommend the following:

1) The maximum joint width at the time of installing the filler should not exceed 3-3/4 in. This should provide a safety factor for the increase in width due to thermal contraction.

2) The pressure relief joints should be located as far as possible from an open transverse crack or a joint to eliminate the short slab condition which can result in severe faulting.

3) Pressure relief joints should be used only when the condition of the pavement requires pressure relief. The use of unneeded pressure relief joints will normally result in adjacent pavement joints and transverse open cracks increasing in width. This increased width will allow increased intrusion of debris which will prevent the joint or crack from closing.

This can result in increased pavement pressure, increased joint deterioration, and increased faulting at the open cracks.

4) Pressure relief joints should normally not be installed in neoprene sealed pavements. The installation of pressure relief joints will normally result in the loss of adjacent neoprene compression seals, because these joints will open to a width greater than the design limit of the sealer. If pressure relief joints are installed in neoprene sealed pavements, the sealer in the two consecutive joints on both sides of the pressure relief joint should be removed, the joints sawed wider, and sealed with a hot-poured sealant. If the pavement is generally in good condition, but requires some pressure relief, it would be more advisable to use a full-depth doweled joint repair with expansion filler. These joint repairs could be located at open transverse cracks or distressed joints.

APPENDIX

MICHIGAN
DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION
FOR
PRESSURE RELIEF JOINTS FOR CONCRETE PAVEMENT

a. Description.-This work shall consist of constructing pressure relief joints of the type specified and at the locations shown on the plans or as directed by the Engineer.

b. Classification:

Pressure relief joints constructed in concrete pavements will be designated as Type 1 Pressure Relief Joints.

Pressure relief joints in bituminous resurfaced concrete pavements will be designated as Type 2 Pressure Relief Joints.

c. Materials.-The material shall meet the requirements specified in the designated Sections of the Standard Specifications and as specified herein.

Mortar, Type I ----- 7.02

Concrete Patching Mixture, Type P-FS --- 7.03

Bituminous Patching Mixture CP-3- ----- 7.11

Admixtures and Curing Materials----- 8.24

Joint Filler.-The joint filler shall be preformed, flexible, cellular, molded, urethane foam filler, Serviced Flex Lok or an approved equal, having the following physical properties:

<u>Property</u>	<u>Requirements</u>	<u>Test Method</u>
Size		
Width @ top, in.	4-1/2±1/8	
Height, in.	7-3/4±1/4	
Length, ft	8 min	
Weight per foot, lb	1.6 - 2.0	
Tensile Strength, psi	25 min	ASTM D 1564
Compressive Force vs Deflection of 2-inch cubes cut from filler		ASTM D 2406
at 25% deflection, psi	7±2	
at 65% deflection, psi	22±3	
Water Absorption, percent by volume (one inch thick specimens)	30 max	AASHTO T 42
Compression Recovery, 50 percent deflection, 168 hr @ 100 F, percent of original thickness (measured 24 hr after release from clamp at laboratory temperatures), speci- mens are 2-inch cubes cut from filler.	90 min	Department

Prior to field delivery, the urethane foam filler shall be joined into lengths equal to the width of one lane of pavement.

The urethane foam filler may be butt spliced by the following method:

1. The two ends to be spliced shall be sawed square to ensure full contact and to remove the skin surface.
2. Fully coat the two ends with a liberal coat of contact cement (AnchorWeld, Hybond 80, Weldwood, or equal).
3. Allow to dry as recommended by the cement manufacturer. (A second coating may be required due to absorption.)
4. Place the two ends tightly in contact and hold in place for at least one minute.
5. Allow the contact cement to cure for 24 hours or until the filler can be handled without any separation at the butt splice.

d. Equipment:

1. Concrete Saw.-The concrete saw shall be equipped with a diamond blade, or approved equal. The saw blade shall be of sufficient size to saw pavements full depth for thicknesses up to 10 inches.
2. Joint Installing Machine.-The machine for placing the 4-1/2-inch urethane foam filler shall be capable of compressing and installing the filler in a groove approximately 3-1/2 inches in width without damaging the filler. Plans for fabricating such a machine are available from the Department and the machine may be inspected by prospective bidders at the Department's Research Laboratory.

e. Constructing Type 1 Joints.-A 3-1/2-inch wide joint, within a tolerance of $\pm 1/4$ inch, shall be sawed full depth through the concrete pavement.

The concrete shall be carefully removed from the joint to avoid damage to the pavement ends and to avoid disturbance of the aggregate base.

The urethane filler shall be installed by machine. Immediately prior to installing the urethane filler, the joint faces shall be coated with the urethane adhesive supplied with the filler. The joint faces shall be relatively clean and dry before the adhesive is applied. No other solutions shall be used either on the machine or joint faces. Butt joints shall be used at longitudinal lane joints, but care shall be taken to ensure the filler ends are coated with adhesive and firmly in contact with each other. The filler shall be installed to a depth approximately 1/2 inch below the pavement surface. Where the total depth of the groove is such that there will be a void beneath the filler, the bottom portion of the groove below the filler shall first be filled with strips of urethane foam or polyethylene foam. These strips may be placed by hand without precompression.

f. Constructing Type 2 Joints.-Type 2 joints shall be constructed in bituminous resurfaced concrete pavements in accordance with the following requirements.

1. Temperature Limitations.-When the air temperature is between 45 F and 35 F, the fast-set concrete shall not be placed unless the concrete temperature is at least 60 F. When the air temperature is below 35 F, fast-set concrete shall not be placed.
2. Pavement Preparation.-Two saw cuts shall be made through the bituminous resurfacing and into the concrete pavement for a depth of approximately 2 inches. These cuts shall be made at a distance

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of at least 12 inches on either side of the location where the pressure relief joint will be constructed.

Where the combined thickness of the concrete pavement and the bituminous resurfacing can be sawed full depth, the bituminous resurfacing and approximately 2 inches of the concrete pavement shall be removed. (The 3-1/2-inch joint will be sawed in the newly constructed patch after the fast-set concrete has attained a strength of 300 psi.) Just prior to placing the fast-set concrete patch, the concrete surface shall be blast cleaned with air, water, or sand to remove all dust and loose material. A creamy mixture of Type I mortar shall be brushed over the exposed concrete surface.

Where the combined thickness of the concrete pavement and the bituminous resurfacing are such that the total pavement thickness cannot be sawed full depth, sufficient bituminous resurfacing shall be removed in the area of the proposed relief joint to permit operating the saw on the exposed surface of the existing concrete pavement. The 3-1/2-inch joint shall be sawed in the pavement. The bituminous surface and approximately 2 inches of the concrete surface shall be removed from the area between the outer saw cuts and the concrete from the 3-1/2-inch joint shall also be removed. After removal of all excess material, the 3-1/2-inch joint sawed in the existing concrete shall be extended to match the height of the bituminous overlay by use of forms. Just prior to placing the fast-set concrete patch, the concrete surface shall be blast cleaned with air, water, or sand to remove all dust and loose material. The forms shall be oiled and a creamy mixture of Type I mortar brushed over the exposed surface.

3. Placing Concrete.-The fast-set concrete shall be placed and consolidated by use of an immersion type vibrator and the surface shall be finished to the elevation of the existing bituminous surface by screeding, floating, and brooming. The placement operations shall be scheduled in such manner that each repair is completed within 20 minutes after addition of the calcium chloride.

Test beams for determining modulus of rupture shall be cast as directed by the Engineer. The test beams shall be cured the same as the new patch. If the beam tests indicate that a modulus of rupture of 300 psi cannot be attained under the prescribed temperature and calcium chloride addition rate, adjustment in the amount of calcium chloride added to each cubic yard shall be made to attain the required strength for the next day's repairs within the allowed lane closure time.

4. Application of Curing Compound.-Concrete curing compound shall be applied to the fast-set concrete patch as soon as the free water has left the surface.
5. Protection from Cold Weather.-When the temperature is below 65 F, insulation blankets having a minimum thickness of 2 inches shall be placed over the new concrete as soon as the curing compound has dried sufficiently to allow the blanket to be placed without damage to the curing membrane. Edges and seams in the blanket

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shall be secured to prevent penetration of wind. Curing blankets may be removed when the concrete has attained a flexural strength of 300 psi.

6. Forming Joints.-After the fast-set concrete has attained a strength of 300 psi, the joint shall be constructed by sawing a 3-1/2-inch joint through the fast-set concrete patch and the existing pavement or by carefully removing the form from the joint, as applicable; the joint cleaned of loose material; and the 4-1/2-inch urethane foam filler installed as specified for Type I joints. Where the total thickness of patch and existing pavement is such that a void would be left below the filler, the bottom portion of the joint groove below the filler shall first be filled with cut strips of urethane foam or polyethylene foam. These strips may be placed by hand and without precompression.
7. Shoulder Replacement.-Any damage to shoulders due to the Contractor's operation shall be repaired. Materials removed from the shoulder shall be disposed of by the Contractor. The voids remaining shall be filled with one of the hot bituminous mixtures described under Section 7.10 or with bituminous patching mixture CP-3 as specified in Subsection 7.11.03 of the 1976 Standard Specifications. The bituminous material shall be compacted by mechanical or hand methods suitable for the size hole being patched. The voids shall be filled and compacted flush with the surrounding shoulder. Bituminous plant mixtures shall be compacted while hot.
8. Opening to Traffic.-Traffic will not be permitted on fast-set concrete patches until the concrete has attained a flexural strength of at least 300 psi, usually within 4 to 7 hours after placement.

g. Method of Measurement:

Pressure Relief Joints, of the type specified, will be measured in linear feet of joint constructed.

h. Basis of Payment.-The completed work as measured for PRESSURE RELIEF JOINTS FOR CONCRETE PAVEMENT will be paid for at the contract unit prices for the following contract items (pay items).

<u>Pay Item</u>	<u>Pay Unit</u>
Pressure Relief Joint, Type 1 - - - - -	Linear Foot
Pressure Relief Joint, Type 2 - - - - -	Linear Foot

Removal of bituminous overlays and 2 inches of the underlying concrete pavement and placement of fast-set concrete patches will not be paid for separately but payment for the work will be considered as having been included as part of the contract unit price bid for Type 2 joints.

Where Type 2 joints are called for and the bituminous overlay and underlying concrete are removed and the Engineer directs that a pressure relief joint should not be constructed, reconstruction of the pavement with fast-set concrete or a bituminous mixture and other work completed will be paid for as Extra Work if the individual pay items involved have not been included in the proposal.