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Construction Report



MATERIALS and TECHNOLOGY DIVISION



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Construction Report

J. E. Simonsen
A. W. Price

A Highway Planning and Research Project
by the Michigan Department of Transportation
in cooperation with the
Federal Highway Administration

Research Laboratory Section
Materials and Technology Division
Research Project 86 G-267
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Michigan Transportation Commission
William Marshall, Chairman;
Rodger D. Young, Vice-Chairman;
Hannes Meyers, Jr., Shirley E. Zeller,
William J. Beckham, Jr., Stephen Adamini
James P. Pitz, Director
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ABSTRACT

For the past 20 years the Michigan Department of Transportation's Research Laboratory has conducted several studies to develop effective maintenance procedures for concrete pavement. The procedures have been developed for daylight closures to minimize the inconvenience and hazard to motorists caused by the maintenance operations. By 1982 (following evaluation of cast-in-place repairs, with and without dowelled joints) the Department used dowelled repairs as a standard procedure. The dowels are loose fitting (1/16-in. clearance) in holes drilled in the adjacent slabs. The restoration work described in this report uses repair techniques previously developed, in addition to new ones. The pavement selected for restoration is a 20 year old, 9-in. reinforced concrete slab with 71-ft joint spacings, and joints sealed with preformed neoprene seals. Deteriorated joints were repaired using full-depth repairs having dowelled joints with the dowels grouted-in-place using an epoxy grout. Some mid-slab failures were repaired by tying the new concrete to the existing slab using grouted-in-place No. 10 deformed bars. The deteriorated intersections of the longitudinal and transverse joints were restored using 2 ft by 4-ft full-depth repairs tied in place with grouted-in No. 5 deformed bars. Spalls along the joint grooves were repaired, partial-depth, with fast-set premixed mortar, the neoprene seals were replaced with silicone sealant, the longitudinal joints were resealed using a low-modulus hot-poured sealant, and surface pop-outs were fixed using fast-set premixed mortar. The performance of the various restoration techniques will be evaluated for a five-year period.

INTRODUCTION

Since 1970, the Michigan Department of Transportation's concrete pavement maintenance program has included the use of full-depth repairs of distressed areas. The repair procedures developed by the Research Laboratory were designed to allow the repairs to be opened to traffic during daylight hours in order to limit possible hazards caused by overnight lane closures. Initially, precast slab repairs were used to prevent night closures. Subsequently, cast-in-place repairs were used with calcium chloride accelerator in the repair concrete. These cast-in-place repairs were developed primarily to reduce cost and increase daily production, they were undowelled and intended to serve for an interim five-year period. By the late seventies, changes in available funding resulted in the need for alternative repair procedures with longer service lives. Experimental work with dowels installed in machine-drilled holes, and the performance of 12-year old repairs with dowels in hand-drilled holes, indicated that the use of loose fitting dowels (1/16-in. hole clearance) would increase the repair's service life to 10 or more years. Dowelled repairs of this type are currently specified for concrete pavement maintenance.

In 1976 the Department began a study aimed at developing a preventive maintenance program for reinforced concrete pavements having neoprene sealed transverse joints. The procedures developed were to be such that traffic could be maintained through the repair area and the work performed during daylight hours. Following laboratory testing to determine the most promising fast-set patching materials and development of repair procedures, a nine-mile section of I 69 in Calhoun County was selected as a field testing site. The experimental procedures applied on I 69 involved the use of five fast-set patching materials for joint groove spall repairs; removing damaged or malfunctioning contraction joint seals and resealing with new neoprene seals; and removing tight and frayed neoprene expansion joint seals, resawing the joint grooves, and resealing the joints with either a liquid sealant or a new neoprene seal. The work was done by MDOT Research and Maintenance forces.

Based on the I 69 field work experience and the performance of the spall repairs and resealed joints, specifications for experimental contract maintenance work were prepared. A first contract covering a section of I 75 in Arenac County was let in 1983 and a second contract was let in early 1984 which included an eight-mile section of M 47 in Saginaw County. In addition to joint groove spall repairs and resealing transverse joints, full-depth repairs were made at severely deteriorated joints and transverse cracks. Further, less severely deteriorated cracks underwent spall repair, routing, and sealing with a liquid sealant. Similar materials and procedures were also used to seal the resawed longitudinal joints.

The use of bars, cemented into drilled holes in hardened concrete using a polyester or epoxy grout, has been common for many years in some phases of construction work. However, only relatively recently has the use of grouted dowel bars been used in concrete pavement repairs, and

its use has met with mixed success. The difficulty in obtaining reliable and consistent results has been traced to problems in mixing and injecting the grout into the horizontal holes.

To overcome these problems the industry has introduced epoxy and polyester grouts that mix in the nozzle of the injection equipment. This has eliminated the mixing problem and the injection difficulty as well, since the nozzle can deposit the grout in the back of the hole. Thus, when the bar is inserted in the hole the grout flows out around the bar, ensuring proper embedment and bond. The injection tool can be calibrated to deposit the exact amount of epoxy needed to embed the bar.

In the spring of 1985, the Research Laboratory, in cooperation with the Maintenance Division, installed five full-depth lane repairs on north-bound I 69 south of Charlotte, using the above described method of grouting the dowels into the predrilled holes. This experimental work revealed that the use of the prepackaged two-component grout was a feasible method for grouting dowels in hardened concrete. Subsequent load-deflection tests confirmed that an increase in load transfer efficiency was obtained compared with repairs utilizing loose fitting dowels.

Based on the experimental work described above, an extensive restoration project was envisioned which used previously developed procedures, modified as needed, as well as new ones to restore the distressed or failed areas of a pavement. A proposal for this research project was submitted to the Federal Highway Administration to perform this work under the Highway Planning and Research (HPR) program. The proposal was approved in October 1986, and in 1987 the project was begun.

The restoration procedures outlined in the proposal were:

- 1) Full-depth lane repairs with grouted-in-place epoxy coated dowels.
- 2) Full-depth lane repairs with grouted-in-place epoxy coated No. 10 deformed bars.
- 3) Partial lane width full-depth repairs at the intersection of the transverse and longitudinal centerline joints.
- 4) Partial depth repair of pop-outs and spalls along the joint grooves.
- 5) Routing and sealing of transverse cracks.
- 6) Removing existing neoprene seals and resealing with a silicone sealant.
- 7) Resawing and resealing the longitudinal centerline joint.

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of

the Federal Highway Administration or the Michigan Department of Transportation. This report does not constitute a standard, specification, or regulation.

Objectives

The experimental work was undertaken to evaluate the field performance of the various repair techniques and to determine the merit of restoring concrete pavements while not too seriously flawed, to substantially increase their service life.

Selecting a Restoration Project Candidate

Concrete pavements considered for restoration must meet certain criteria. One of the most important factors is that the underlying base is capable of providing adequate support and drainage. To correct base problems would require removing and replacing the existing slab which would be reconstruction rather than restoration of the pavement. Improving the drainage would, as a minimum, require installation of edge drains which would result in extensive work on the shoulders. A polished surface may require diamond grinding to restore adequate friction levels, and though feasible, it would increase the restoration cost substantially.

Most concrete pavements in Michigan that have been built in the last 20 years do not exhibit severe base or drainage problems nor do they show extensive loss of surface friction. Therefore, the only factors considered in selecting restoration candidates are aggregate quality and working joints. Experience has shown that partial-depth spall repairs along joint grooves and routing and sealing of cracks is not worthwhile in pavements showing signs of serious D-cracking. Pavements with this problem are best maintained by removing the affected D-cracked area full depth. In extreme cases, overlaying or reconstruction may be necessary.

Non-working joints, by restraining movement during contraction cycles, cause increased tension in the concrete. Consequently, the reinforcement eventually fractures at one or two cracks between the joints. These cracks now act as undowelled joints allowing unimpeded access for water and incompressibles into the pavement section. In time faulting may occur at the cracks. To correct this problem a full-depth dowelled repair is necessary. On pavements where most movements occur at mid-slab cracks, a cost analysis would be required to determine if restoration costs would compare favorably with overlay or reconstruction costs. However, such mid-slab cracks are known to cause reflective cracking in bituminous overlays.

Existing Project Description

A 20-year old concrete pavement on I 69 in Calhoun County was selected for restoration work. Based on its surface condition D-cracking was not a problem but pop-outs, caused by a few expansive aggregates included in the mix, were present in the pavement surface. Nearly all

transverse joints appeared to be working. The main distress in the pavement was compression failure of most of the expansion joints and a few contraction joints. Open transverse cracks, acting as joints, were present in some slabs as well as cracks still held tight by the reinforcement. The 20-year old neoprene seals were not entirely effective anymore and spalling of the joint grooves had occurred. The longitudinal centerline joint was originally sealed with a cold mastic sealant which was no longer effective, but the tie bars were still holding the slabs together tightly.

The selected pavement is a 4.2-mile section of I 69 located between the M 60 interchange and the overpass for J Drive South. It was constructed in 1967 and each roadway consists of two 12-ft, 9-in. reinforced concrete lanes. The dowelled joints were spaced at 71 ft and the contraction joint grooves were sawed 1/2 in. wide by 2-1/2 in. deep. Expansion joints were installed at every fifth joint on the southbound roadway and on the southern one mile of the northbound roadway. The longitudinal centerline joint was sawed 1/8 by 2 in. deep. The pavement was placed on a 10-in. sand layer overlain with a 4-in. aggregate base. Drainage was provided through the sand layer by extending it to the ditch foreslope. The 1986 total average daily traffic (ADT) volume was 12,000 and the commercial volume was 2,400. No maintenance work, other than routine patching with cold patch bituminous material, had been done at the time the restoration work started.

Condition Survey

A condition survey was conducted to ascertain the amount of each type of distress present in the pavement. Since all distressed areas must be repaired on a restoration project the need for assigning distress levels to the problem areas is not necessary. Thus, the survey was done primarily to obtain quantities of the distressed items. It should be noted that coring at the intersection of the transverse and longitudinal joint was done prior to the surface condition survey to determine a minimum full-depth repair area needed to correct failures at this location. Previous experience had determined that most failures at these joint intersections were caused by full-depth deterioration of the concrete. Based on examination of the cores, it was decided that a 2-ft wide by 4-ft long full-depth repair would be the minimum size and would cover most failures.

The types of distress for which quantities were obtained were:

- 1) Expansion and contraction joint compressive failures
- 2) Cracks with fractured reinforcement
- 3) Spalls along joint grooves
- 4) Surface pop-outs
- 5) Cracks still held tightly together by the reinforcement
- 6) Transverse joints to be resawed and resealed
- 7) Longitudinal joints to be resawed and resealed

The survey was conducted under traffic from the right-hand shoulder and the quantities were estimated values. Illustrations of the various types of distress are shown in Appendix A.

Contract Repair Quantities

The repair quantities for contract bidding purposes were based on the condition survey results. Table 1 gives the quantity for each repair item and the unit bid prices of the successful contractor are included:

TABLE 1
Repair Quantities and Costs

Bid Item	Quantity	Unit	Unit Cost
Full-Depth Lane Repairs	2,622	sq yd	\$ 75.77
Full-Depth Centerline Repairs	317	sq yd	261.75
Partial-Depth Spall Repairs	1,103	lin ft	28.24
Surface Pop-out Repairs	1,538	each	15.00
Miscellaneous Pavement Repairs	219	sq yd	64.20
Sawing and Sealing Cracks	4,112	lin ft	1.75
Sawing and Resealing Transverse Joints	13,854	lin ft	4.30
Sawing and Resealing Longitudinal Joints	47,400	lin ft	1.40

The work to be done and the material to be furnished by the contractor under each bid item shown above are described as follows:

Full-depth lane repair included furnishing all labor, equipment, and materials required to: saw and remove the distressed concrete; drill and grout the dowel bars; place the reinforcement and the concrete; finish and cure the concrete, and seal the joints.

Full-depth centerline repair included furnishing all labor, equipment, and materials required to: saw and remove the distressed concrete; drill and grout the tie bars; place, finish, and cure the concrete; and seal the perimeter.

Partial-depth spall repair included furnishing all labor, equipment, and material required to: saw the repair perimeter; chip out the unsound concrete and clean the area; reform the joint groove; and place, finish, and cure the fast-set mortar.

Surface pop-out repair included furnishing all labor, equipment, and materials required to: chip out the unsound concrete; sandblast and clean the area; and place, finish, and cure the fast-set mortar.

Miscellaneous pavement repair included furnishing all labor, equipment, and materials required to: saw and remove the distressed concrete; drill and grout dowel bars; place the reinforcement and load transfer assembly; place, finish, and cure the concrete; and seal the joints.

Sawing and sealing cracks included furnishing all labor, equipment, and materials required to: saw the groove, sandblast and clean the joint groove; and seal the groove with a hot-poured sealant.

Sawing and resealing transverse joints included furnishing all labor, equipment, and materials required to: remove the existing seal; resaw the joint groove; sandblast and clean the joint groove; install the backer rod; and seal the joint groove with silicone sealant.

Sawing and resealing longitudinal joints included furnishing all labor, equipment, and materials required to: resaw the joint groove, clean the joint groove; and seal the joint groove with a hot-poured sealant.

Special Provisions covering the above bid items were prepared for the contract work and copies are included in Appendix B.

CONSTRUCTION

The experimental project (Michigan Project IR 13073, Job No. 25975A, Federal No. IR 69-1 (061) 24, Federal Item NPO787) was awarded to the low bidder, Kelcris Corp. of Williamston, MI, on June 10, 1987. Since most of the work was governed by Special Provisions, the Department sponsored a pre-bid meeting at which the Special Provisions and suggested construction procedures were discussed and clarified. Pre-construction meetings were also held with the Department's supervisory construction personnel and with the contractor's personnel. In addition, Research Laboratory personnel who developed the repair procedures and prepared the Special Provisions were on the job site throughout the construction period to monitor the work and provide technical assistance.

Construction operation began in September and was completed in November of 1987. The work was completed without any major delays but minor delays caused by equipment breakdown and adverse weather were encountered.

Although the restoration work was designed to accommodate daylight closures only, on this project the contractor was permitted to use overnight closures. One lane closure per direction was allowed at any time except that no lane closures were allowed on holiday weekends. The contract also required the contractor to recast all full-depth repairs the same day that the distressed concrete section was removed. The traffic closures were accomplished with lighted plastic drums for barricades and lighted arrow-bar flashers at the beginning of a lane closure.

A brief description of each type of restoration work follows.

Full-depth repairs

The end limits of the repairs were sawed full-depth using a diamond bladed saw and the larger sections of the distressed concrete slab were lifted out without disturbing the base material (Fig. 1). After final clean out by hand the dowel holes were machine drilled. Two groups of five

dowels, spaced 12 in. apart, are used in each end of a lane repair. Each dowel group is centered in each half-lane width, resulting in the first dowel being 12 in. from the lane edge and in a 24 in. spacing in the center of the 12-ft lane. The contractor used a five-gang drilling machine, hydraulically powered, to drill the holes. The dimensions of the holes were 1-3/8 in. diameter with a nominal depth of 7-1/2 in.

The drilled holes were cleaned using oil-free compressed air and inserting an air wand into the back of the hole. The contractor elected to use an epoxy grout to fasten the dowels into the holes. He also chose to use a dispensing pump utilizing five gallon containers of each grout component. The grout components were pumped through a mixing nozzle and deposited in the back of the holes. The epoxy coated dowel bars, 1-1/4 in. diameter by 16 in. long, were then inserted in the holes and forced to the back of the holes by hand pressure. Forcing in the dowels in this manner resulted in the grout flowing out around the bar which ensured proper grouting.

Considerable pressure was required to fully insert the bars and to alleviate the laborious task, the contractor built a pneumatic ram to force the dowels in place. This equipment worked well when properly aligned with the dowel bar being inserted. The contractor experienced frequent malfunction of the grout dispensing equipment and about half way through the job he switched to prepackaged cartridges. The two prepackaged epoxy components were extruded and mixed through the nozzle using an air-operated ram.

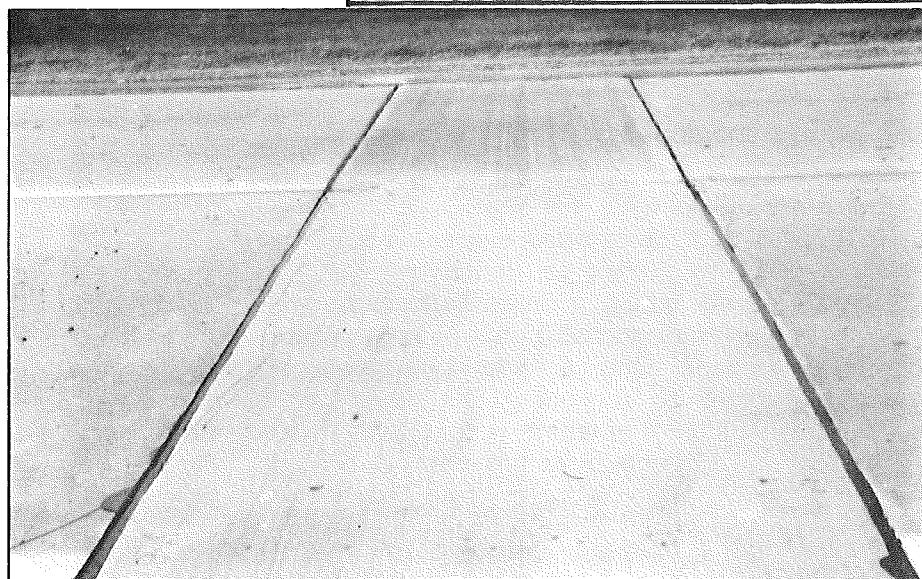
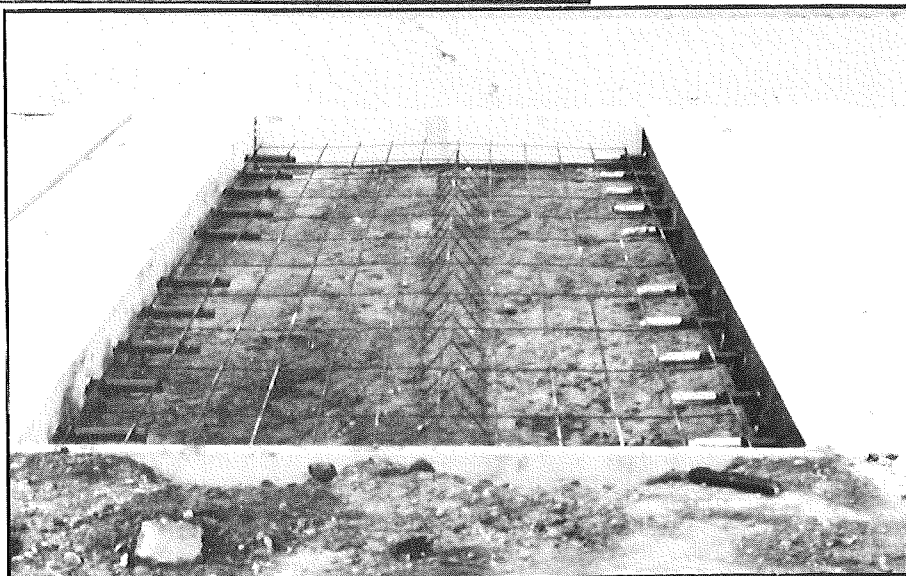
Three types of joints were used with the full-depth lane repairs: contraction, expansion, and fixed or tied joint. For contraction joints the free ends of the dowels were coated with an RC 250 asphalt. For expansion joints the filler board hole locations were marked on the filler board prior to grouting the dowels in place, and the holes were drilled by a hand-held drill. The board was then placed against the concrete end face and the dowel bars were grouted in place. The RC 250 asphalt coat was then applied and an expansion cap placed on each free dowel end. The construction of tied joints was the same as for contraction joints except that instead of dowels, No. 10 epoxy coated deformed bars were grouted into the drilled holes and the RC 250 asphalt coat was eliminated.

Once the treatment of the dowels or deformed bars was completed the repair area was formed and the reinforcement installed (Fig. 2). A 9-sack ready mixed concrete was used to reconstruct the failed areas. The concrete was consolidated using a hand-held immersible vibrator, screeded off, floated, broomed, and a curing compound applied. The transverse joint grooves were formed using a 1 by 1-in. wood strip inserted in the fresh concrete just prior to screeding the concrete surface. The joint grooves were sandblasted and cleaned with oil-free compressed air just prior to sealing with a low-modulus hot-poured sealant. Figure 3 shows a typical finished repair.



◀ Figure 1. Removing distressed pavement section.

Figure 2. Repair area ready for concrete placement. (Contraction joint on the left, expansion joint on the right). ▶



◀ Figure 3. Finished concrete repair.

Full-depth centerline repairs

As previously mentioned, cores taken at the intersection of the transverse and longitudinal joints indicated that removal of a 2-ft wide by 4-ft long area of the slab would be sufficient to remove the deteriorated concrete. During construction it was found that in the majority of cases this area was adequate in size but in a few cases it was necessary to increase the area to remove all the unsound concrete. Figure 4 shows a sawed deteriorated joint intersection.

Full-depth saw cuts were made parallel to and 12 in. on each side of the centerline and 24 in. on each side of the transverse joints. On about half of the repairs the contractor was allowed to oversaw the corners whereas on the other half no overcuts were permitted. This variation in sawing the perimeter was made to determine if overcutting will propagate cracking.

The overcut sections were lifted out without any problems utilizing lift pins (Fig. 5). On the sections that were not overcut the contractor freed up the bottom of the corners by drilling holes through the areas that were not sawed and then lifted out the section. In both cases the debris in the repair area was cleaned out by hand (Fig. 6). The new concrete was tied into the existing concrete using 24-in. epoxy coated No. 5 deformed bars epoxy grouted into 3/4 in. diameter holes 6 in. deep (Fig. 7). The bars were located 4 in. from the surface of the slab. Four bars were used in the transverse direction and four in the longitudinal direction. The transverse bars were a nominal 10 in. from the ends of the repair and the longitudinal ones were 6 in. from each side. The holes were drilled by hand-held drills, downward at about a 20° angle to allow drilling in the confined space. Once the bars were in place they were bent down so as to be approximately parallel to the surface. The dowels removed with the concrete were not replaced but a 3/4 in. thick full-depth filler board was installed in line with the transverse joint to ensure that the new concrete would not be subjected to excessive compression. Figure 8 shows a finished repair before sealing.

The replacement concrete was a 9-sack ready mixed concrete which was placed, consolidated, finished, and cured in the normal manner. The repair perimeter was edged and an attempt was made to seal this groove with a low-modulus hot-poured sealant. The sealant, however, did not penetrate the very narrow and shallow groove so this sealing operation was discontinued after trying a few of the repairs. The overcuts were sealed with hot-poured sealant in all cases.

The research procedure outlined in the project proposal included full-depth repair of a substantial length of centerline where the tie bars had fractured and concrete deterioration had occurred. However, on this project the centerline joint was in excellent condition except at the intersection with transverse joints; thus the only centerline repairs performed were the 2 by 4 ft sections where the joints meet. Based on the experience

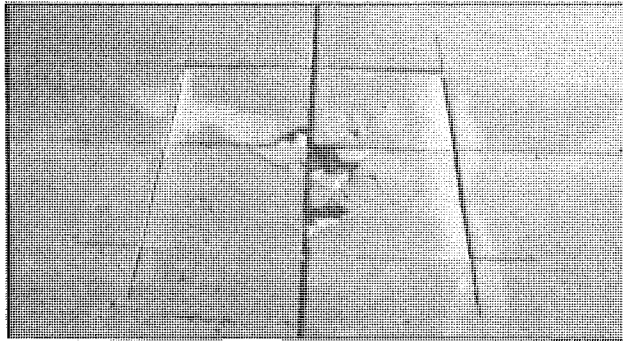


Figure 5. Lifting out distressed concrete at joint intersection.

Figure 4. Sawed perimeter of a typical deteriorated joint intersection.

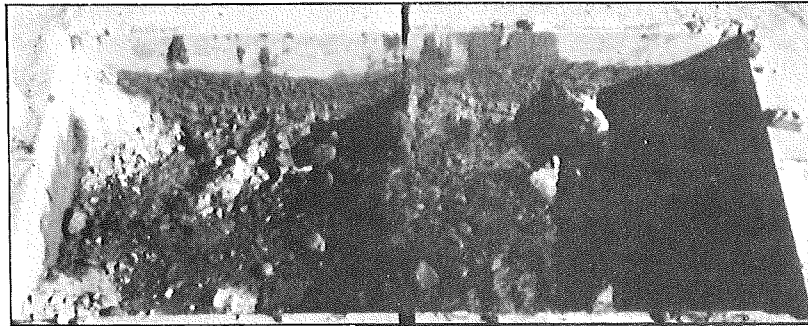
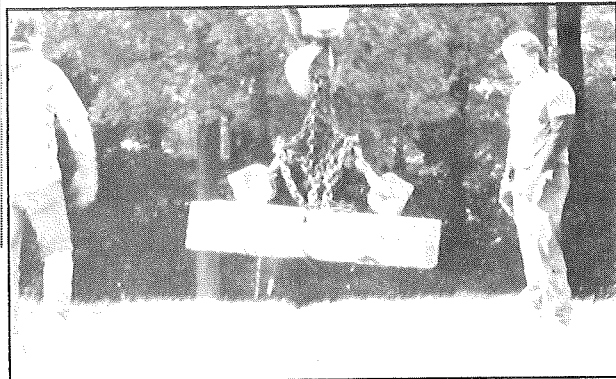


Figure 6. Deteriorated concrete in bottom of repair area.

Figure 7. Joint intersection ready for concrete placement.

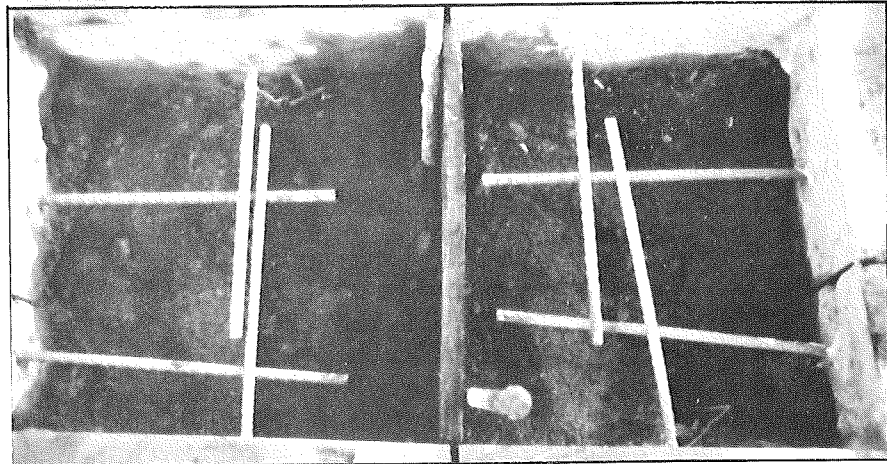


Figure 8. Finished repair before sealing joints.

gained by making these repairs, it is evident that full-depth repair of long sections of the centerline joint is possible from a construction point of view. It appears, however, that the cost would be prohibitive. Using the bid price for the 2 by 4 ft repairs, the cost would be \$58/lin ft for a 2-ft wide repair. This price would be reduced considerably if a substantial length of joint were to be repaired, but even reducing the price to that for the transverse joint repairs, the cost would still be high (\$17/lin ft).

Resealing transverse joints

All contraction joints and a few expansion joints were resealed using a silicone sealant. The existing neoprene seals were removed by pulling them out by hand. The grooves were then sawed to a nominal 1 in. width and a 2-1/4 in. depth, so the final seal dimensions would accommodate the stresses anticipated by the movements occurring with a 71-ft slab length. Just prior to sealing the joints, the grooves were sandblasted followed by a final cleaning with compressed air free of oil and water. Then a 1-1/4-in. diameter closed cell polyethylene foam rod was installed in the groove to the required depth (Fig. 9). The silicone sealant was pumped into the groove through a wand and the sealant tooled (Fig. 10) to ensure contact with the groove walls (Fig. 11). The specified seal depth was $7/16 \pm 1/8$ in.

Resealing longitudinal joints

The longitudinal centerline joint was originally sawed 1/8 in. wide by 2 in. deep and sealed with a cold-applied mastic sealant. This sealant was no longer effective and was replaced with a hot-poured low-modulus sealant. A new groove 3/8 in. wide by 1 in. deep was sawed over the original sawed groove (Fig. 12). To accomplish this, the contractor made two saw cuts; the first one removed the old hardened sealant and the second one sawed the groove. The groove was sandblasted and cleaned with oil-free compressed air prior to sealing the joint with a hot-poured sealant (Fig. 13).

Sealing transverse cracks

Transverse cracks with the reinforcement still intact were sealed to retard the rate of corrosion of the steel. A groove 5/8 in. wide by 3/4 in. depth was sawed over the crack using a random crack saw equipped with a small diameter (8 in. or less) diamond blade (Fig. 14). Any spalls along the cracks were repaired using a fast-set mortar. The routed groove was sandblasted and cleaned with oil-free compressed air prior to sealing with a low-modulus hot-poured sealant (Figs. 15 and 16).

Surface pop-out repairs

The coarse aggregate used in the original concrete contained a few expansive aggregates which had caused pop-outs in the pavement surface. The larger ones were selected to be repaired with the fast-set mortar

Figure 9. Installing backer rod in re-sawed joint groove.

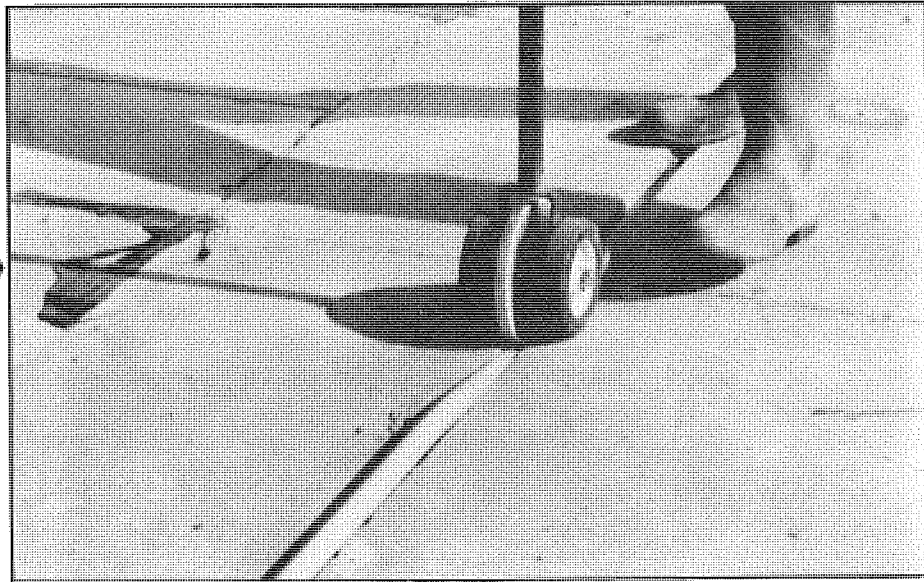


Figure 10. Installing and tooling silicone sealant.

Figure 11. Finished silicone sealed joint groove.

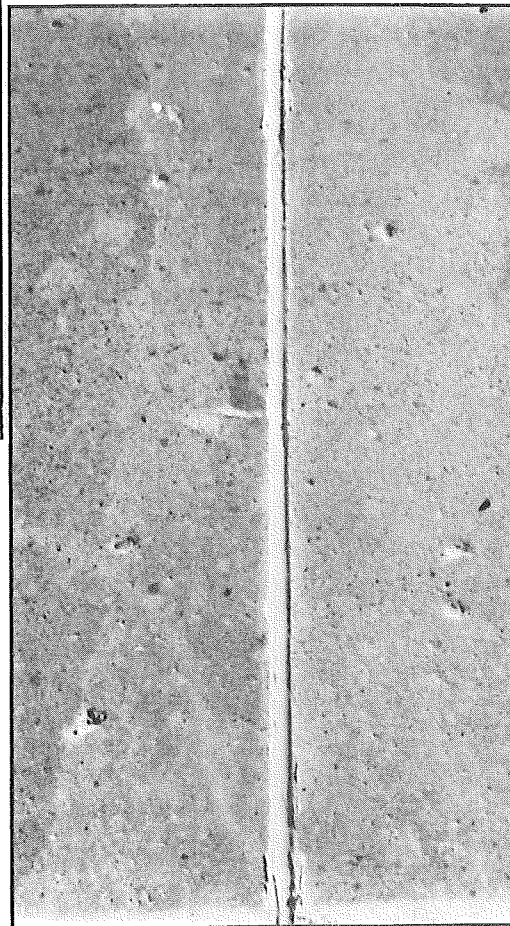




Figure 12. Resawing longitudinal joint groove.

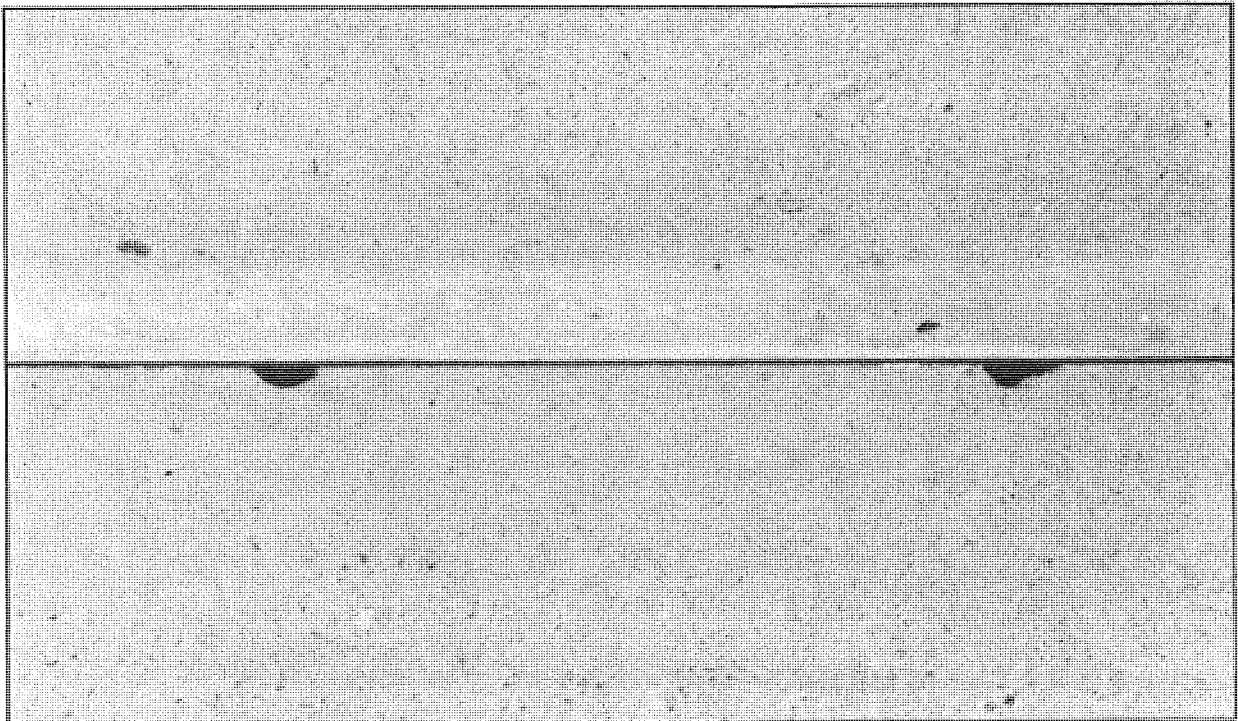
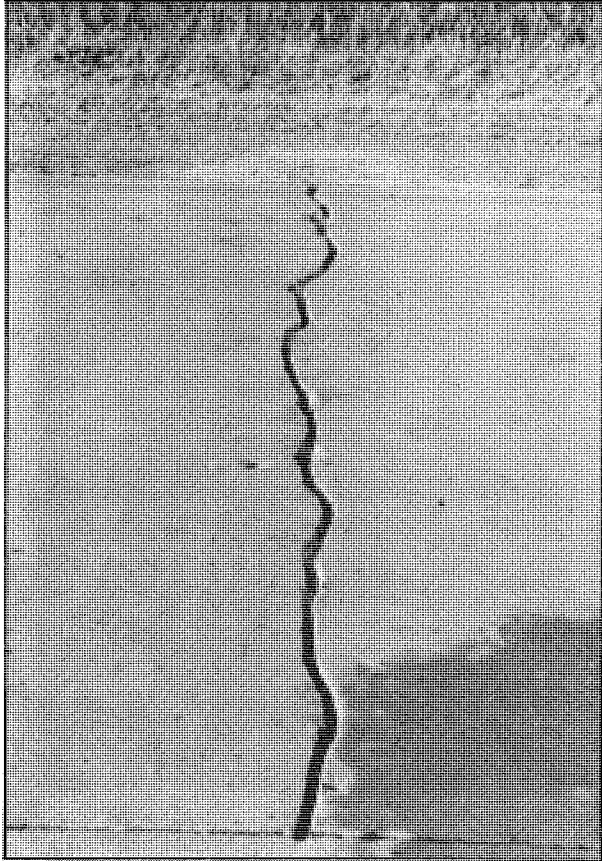
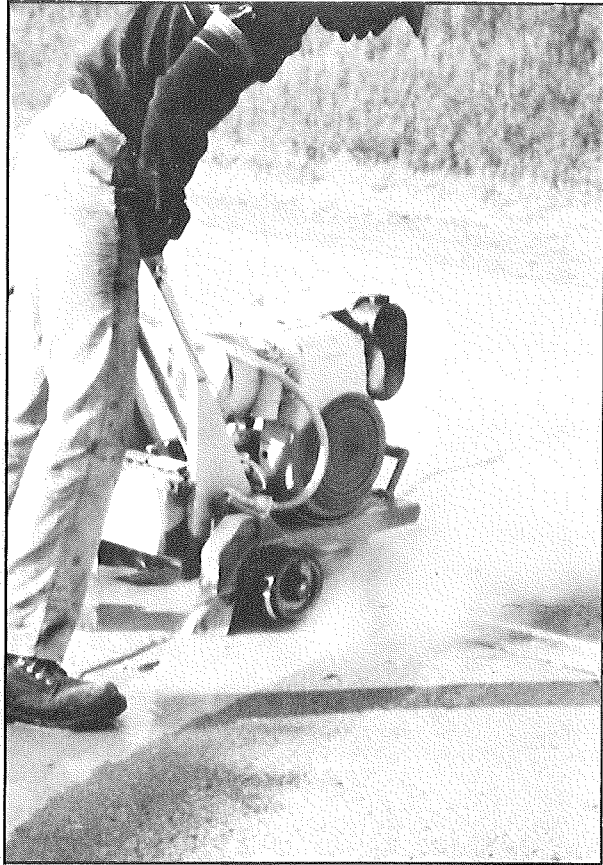


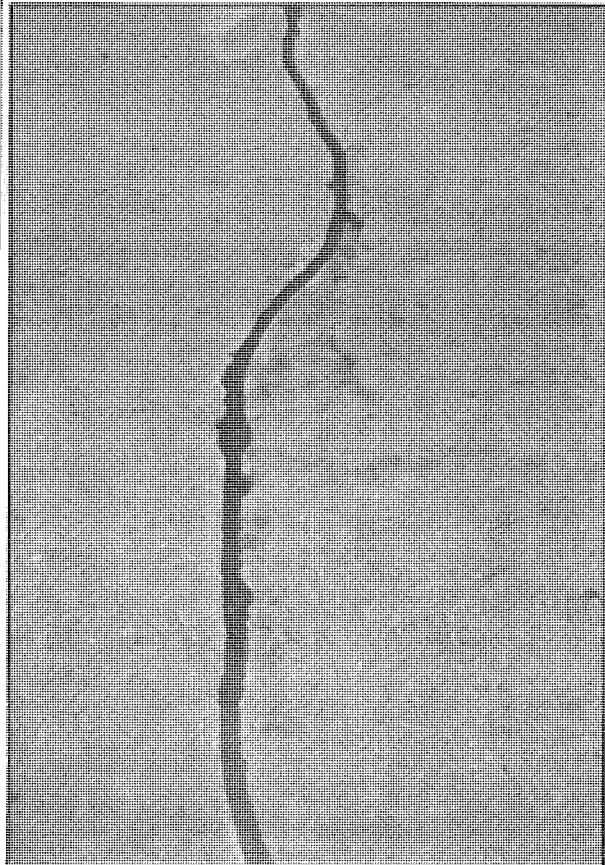
Figure 13. Longitudinal joint groove after resealing.

Figure 14. Sawing groove over trans-verse crack. ▶



▲
Figure 15. Sawed groove ready for sealant installation.

Figure 16. Sealed crack. ▶



used for spall repair. The pop-outs were prepared for repair by removing any unsound concrete or aggregate using an air hammer, then sandblasting followed by cleaning with oil-free compressed air. The mortar mix was placed, consolidated, and finished flush with the pavement surface by hand trowelling as shown in Figures 17 and 18.

Partial-depth repairs

The perimeter of the spall repairs was located 2 in. beyond the distressed area with a minimum width and length of 6 in. specified. The perimeter saw cuts were made 1-3/4 in. deep and the concrete within the cuts was removed using a lightweight air hammer (Fig. 19). The joint groove through the repair area was formed to the proper width using styrofoam (Fig. 20). In cases where the depth of the repair extended beyond the groove bottom the plane-of-weakness crack was recreated by extending the styrofoam to the bottom of the repair area.

The repair area was cleaned with oil-free compressed air and prewetted just prior to placing the fast-set mortar. The mortar was mixed in small batches in a portable mixer at the repair site. The mortar was placed in the repair area and finished by hand trowelling (Fig. 21). Curing was accomplished by covering with burlap for two hours.

It was planned to experiment with partial-depth repairs on long sections of the centerline joint. However, this experiment was deleted from the primary project site because there were only minor isolated spalls along the joint.

Several thousand feet of partial-depth repair were made on the centerline joint in 1984 on a project on I 69 near M 71 in Shiawassee County. Both bituminous and concrete were used to replace the deteriorated concrete. A documentation of those repairs is included here, rather than build such repairs at the Calhoun Co. site where they were not needed. First, the unsound concrete was removed to a depth of about 1-1/2 in. and a width of 12 in. using a cold milling wheel with carbide teeth. The resulting edges were badly ravelled. The area was cleaned with oil-free compressed air. For the concrete repairs, the mix was placed and finished, and a plastic strip was inserted at the centerline location to form the plane-of-weakness joint. Bituminous repairs were made with a sand type mixture, placed and levelled by hand, and compacted with a roller. A recent inspection revealed that both repair types have cracked severely and separation and raveling along the edges have occurred. Figures 22 through 25 illustrate the condition of the repairs. It is evident that this procedure is not satisfactory and better repair techniques are needed.



Figure 17. Placing fast-set mortar in pop-out.

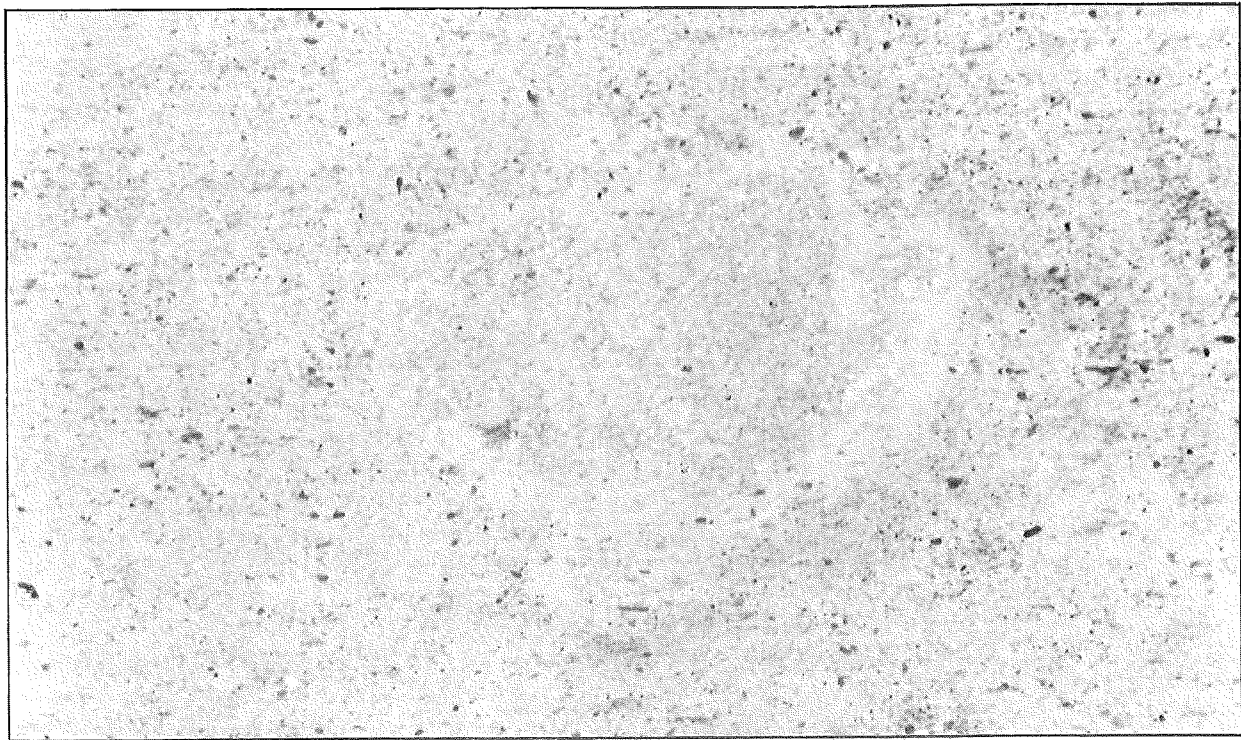
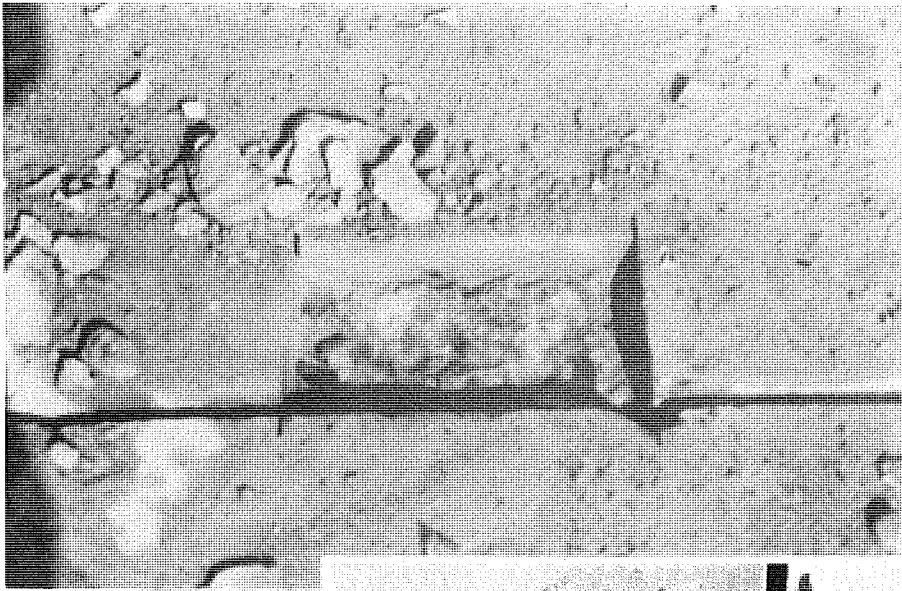
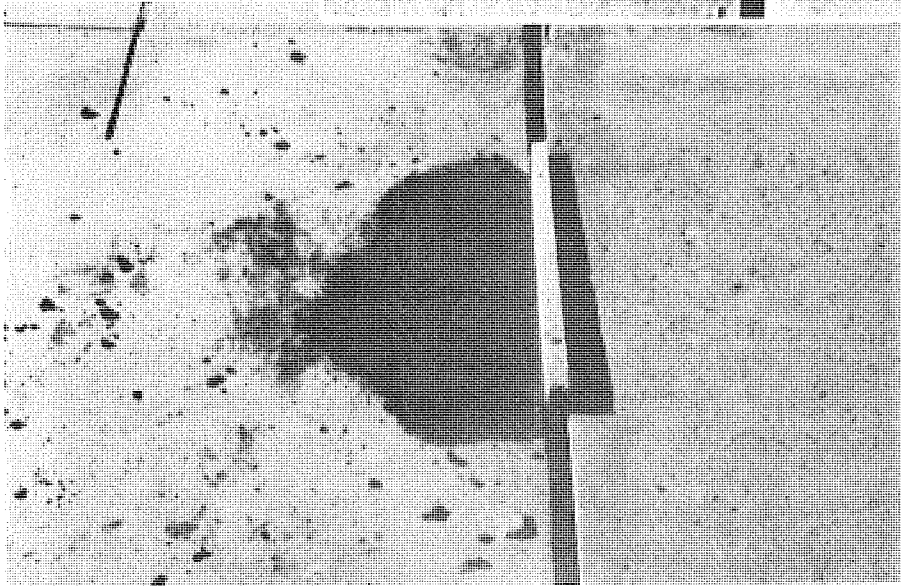
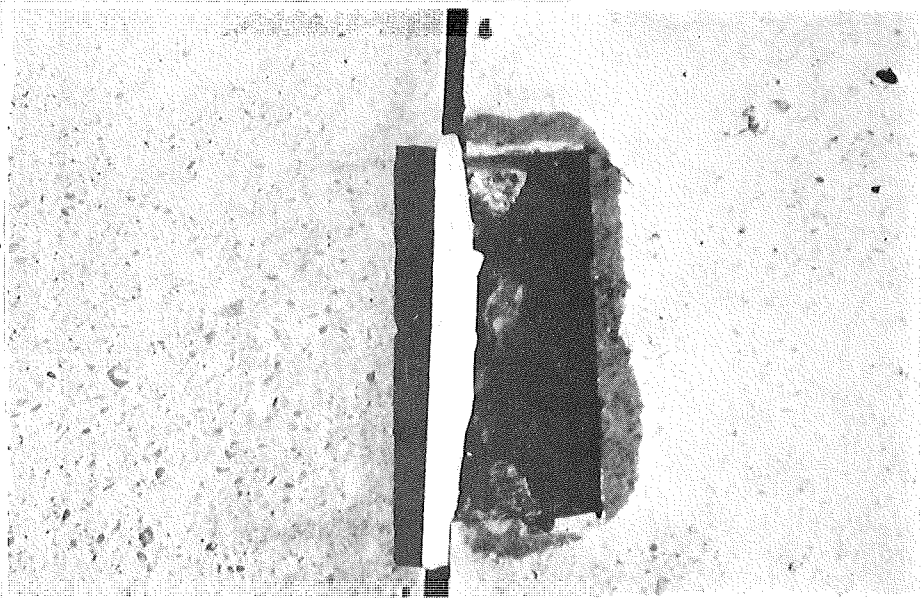


Figure 18. Finished pop-out repair.



◀ Figure 19. Partial-depth repair area with sawed perimeter and unsound concrete removed.

Figure 20. Repair area pre-wetted and groove forming material in place. ▶



◀ Figure 21. Finished repair before curing.

Figure 22. Typical condition of centerline joint on I 69 repaired with bituminous material in 1984.

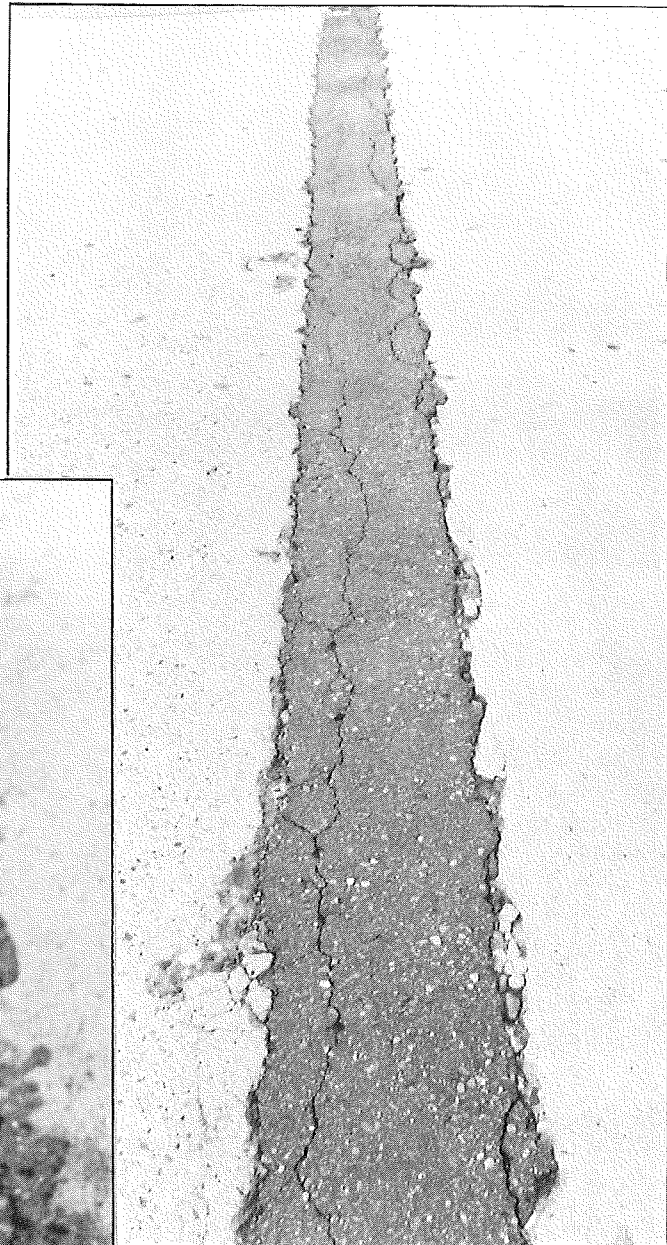


Figure 23. Ravelling along edges and cracking over plane-of-weakness crack.

Figure 24. Typical condition of centerline joint repaired in 1984 on I 69 using concrete.

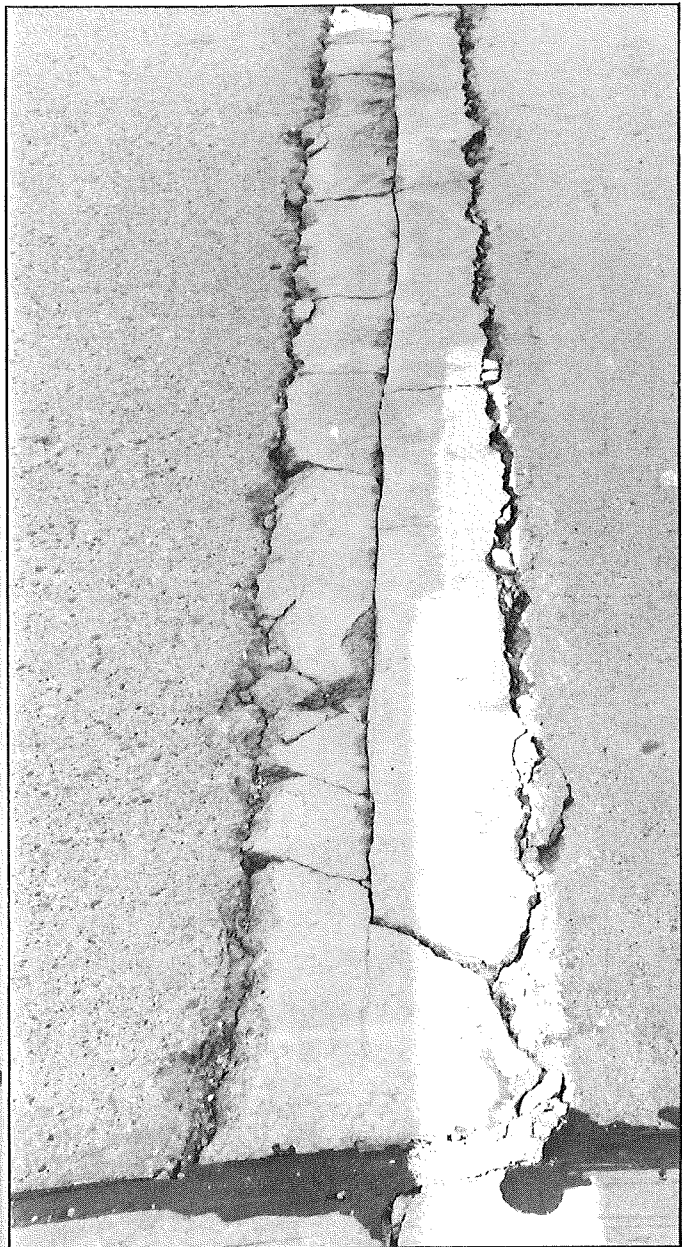
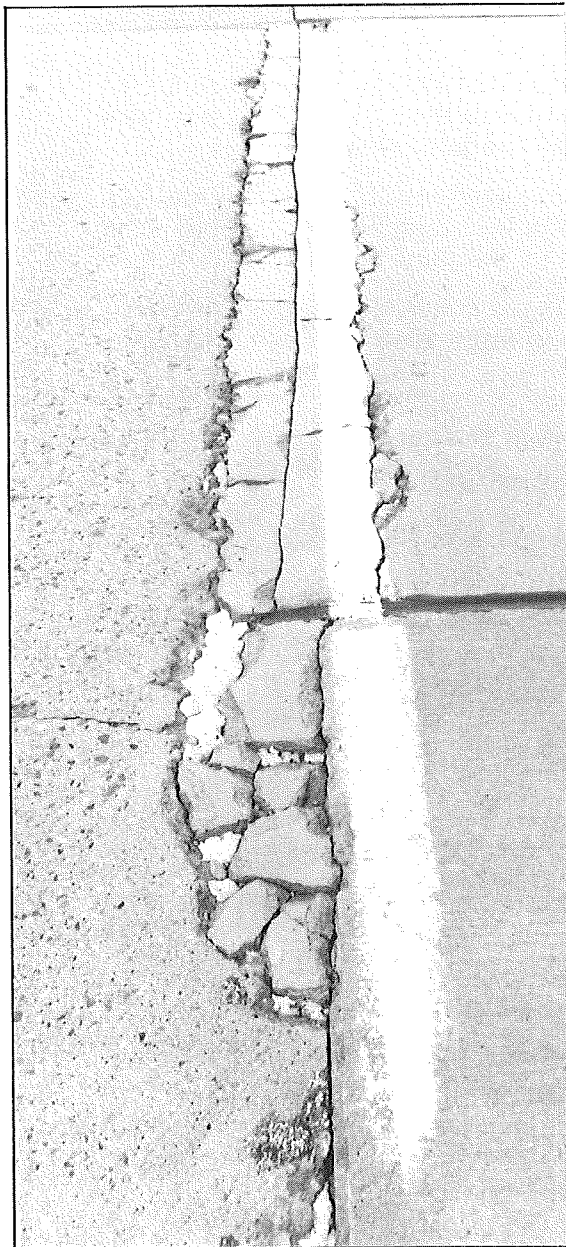


Figure 25. Ravelling along edges and severe cracking have occurred. Some of the concrete pieces are missing.

TABLE 2
PERFORMANCE RATING SYSTEM RATING LEVELS

	Rating	Degree	Description
Sealing	5	None	Seal is intact and in the condition as constructed.
	4	Slight	Seal has experienced adhesion, cohesion, and/or spalling defects in less than 5 percent of the joint area.
	3	Moderate	Seal has experienced adhesion, cohesion, and/or spalling defects in less than 25 percent, but more than 5 percent of the joint area.
	2	Severe	Seal has experienced adhesion, cohesion, and/or spalling defects in less than 50 percent, but more than 25 percent of the joint area.
	1	Deteriorated	Seal has experienced adhesion, cohesion, and/or spalling defects in more than 50 percent of the joint area.
Weathering	5	None	Seal is intact and in the condition as constructed.
	4	Slight	Seal surface aged or oxidized.
	3	Moderate	Seal surface has weather checking.
	2	Severe	Seal surface has alligator cracking.
	1	Deteriorated	Seal surface has eroded.
Debris Intrusion	5	None	Seal is intact and in the condition as constructed.
	4	Slight	Seal is intact and in the condition as constructed with debris accumulated, but no intrusion.
	3	Moderate	Seal has accumulated debris with scattered intrusion.
	2	Severe	Seal has accumulated debris with much intrusion.
	1	Deteriorated	Seal is broken and eroded by excessive intrusion of debris.

EVALUATION

The performance of the restored pavement will be monitored for a period of five years. The performance factors being evaluated are: horizontal movement of joints and cracks, faulting of joints, effectiveness of sealants, partial-depth repair and centerline repair performance, and load transfer efficiency of repair dowels.

A brief description of the evaluation procedures for each performance factor follows. Since the evaluation is conducted under traffic from the shoulder, only the traffic (right-hand) lane is being evaluated.

Horizontal movement of joints and cracks

Twelve transverse joints on each roadway resealed with silicone sealant, 14 repair joints on each roadway, and 14 transverse cracks scattered throughout both roadways have been instrumented with gage plugs for measuring their opening and closure. Measurements will be made summer and winter.

Faulting measurements

The joints and cracks instrumented with gage plugs will be measured for faulting once a year in the summertime.

Sealant effectiveness

The instrumented joints and cracks plus 40 silicone sealed joints, 20 hot-poured sealed cracks, and four 200-ft sections, two each roadway, of the resealed centerline joint will be evaluated using the rating system given in Table 2 which was developed by the Pennsylvania Department of Transportation. The evaluation will be done once a year in the wintertime.

Partial-depth and pop-out repairs

Visual inspections will be made in the wintertime to monitor any cracking, spalling, or fractures that may occur.

Load transfer efficiency

The Department is currently in the process of buying a Falling Weight Deflectometer and it is planned to use this equipment to measure the load transfer capability of the grouted-in-place dowels, if the work load will permit it. These measurements will be scheduled for the early morning hours or on cool days when the upward curling of the slab is minimal.

DISCUSSION

Observation of the repair procedures revealed no major problems in conducting the work as specified. Minor delays and some difficulties did occur as discussed below. The experience gained on this job will be valuable for improving specifications to be used on any future job that the Department may schedule.

Most delays were caused by malfunction of the pump-injection system the contractor elected to use in mixing and injecting the epoxy grout into the predrilled holes. The problem resulted from the equipment dispensing incorrect proportions of the two components. In some instances this resulted in shutdown of the full-depth repair work. About midway through the project the contractor switched to prepackaged cartridges which worked very well. To prevent delays in the grouting process on future jobs the contractor would be required to have back-up equipment on standby.

The full-depth centerline repairs, barring unforeseeable performance problems, could be an important type of repair where the deterioration is confined to the joint intersections or relatively short sections of roadway. It was determined on this project that by overcutting the corners the distressed concrete could be lifted out quickly, whereas when overcutting was not permitted, substantial air hammer work was necessary in the unsawed corners. If the overcut corners do not promote cracking then overcutting would be allowed on any future jobs.

On these repairs a groove was edged around the repair perimeter with the intention that the groove would be sealed. It was determined that sealing the very narrow groove was not feasible and thus the edging of the repairs would not be required on future projects. The re-establishing of the centerline joint groove through the repairs was not required, but the contractor did saw grooves through some which were sealed when the centerline joint was resealed.

The establishment and sealing of the joint greatly improved the appearance of the repair and should be specified on future projects.

The completion date of the project was scheduled for November 1, 1987; however, due to delays the contract was not completed before November 8. On some days the temperature and moisture conditions were not very conducive to working with epoxy and joint sealants. On cold days the epoxy was preheated or stored in heated quarters to make it workable, and on damp mornings the joint grooves could not be sealed before the concrete dried out later in the day. It is obvious that this type of work is best suitable for warmer weather and consideration should be given to set the completion date no later than September 15.

At certain times during the construction operation it was necessary that the traffic use part of the outside shoulder to allow room for the

equipment. This resulted in the shoulders failing in some areas, requiring repair. On this contract these repairs were done by the Department's maintenance personnel. On future contracts the repair of shoulders should be the contractor's responsibility and repair quantities included as a bid item in the project proposal.

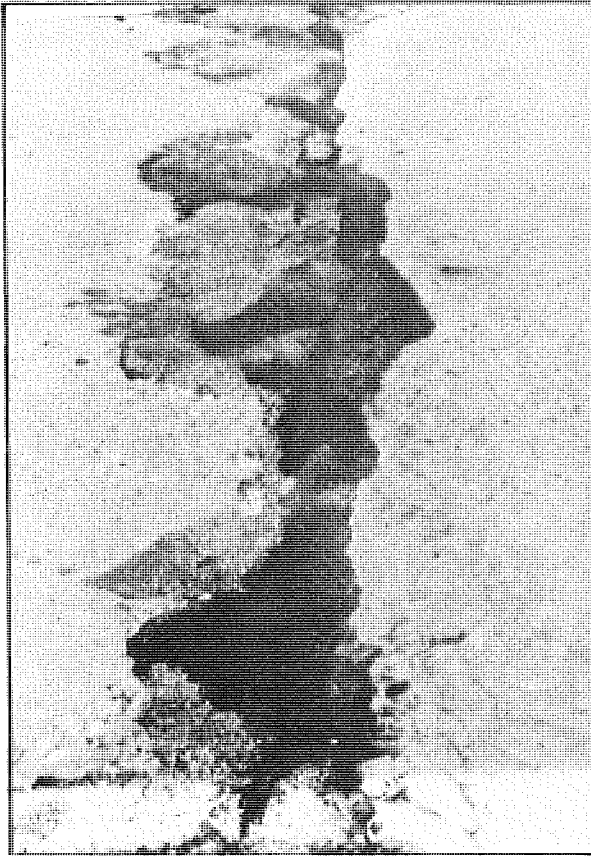
It is anticipated that the performance trend of the restored pavement should be discernable in two to three years with final conclusions being available after the five-year planned evaluation period. Based on the information recorded during the construction period it appears that the joint repairs with tied joints will be equal in performance to dowelled ones and it is suggested that they be used for mid-slab repairs and could also be used on one end of a repair at the joints. This would eliminate a substantial number of joints which would reduce the noise effect they cause when car tires ride over them.

The use of silicone seals in resealing joints has an advantage over using hot-poured sealants. Silicone sealant eliminates the need for a double boiler kettle for heating the sealer and it can also be used in small quantities at a time without wasting material. Experimental seals of this type on new construction projects indicate that they outperform hot-poured seals. From our experience up to now, it looks as though silicone sealant would be ideal as a maintenance sealant.

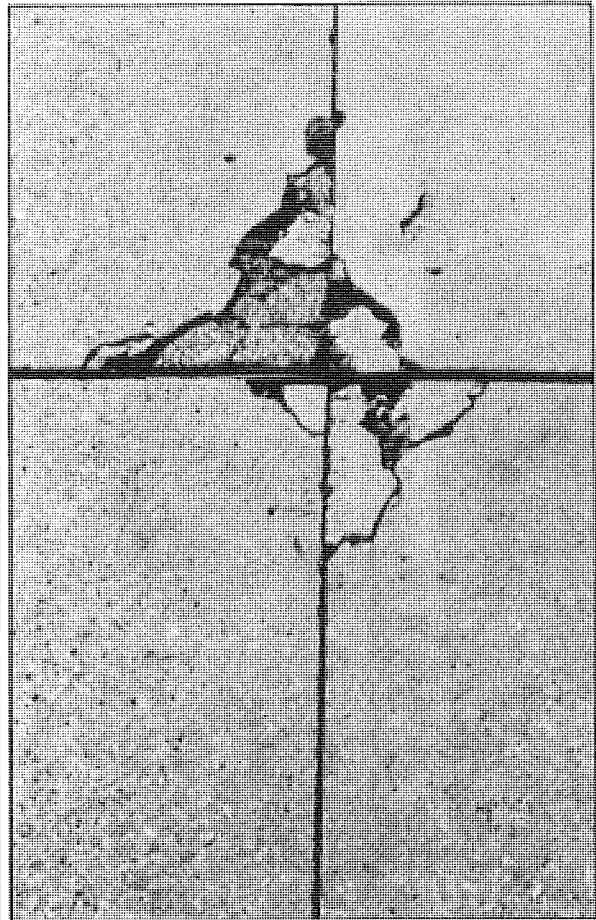
There is no plan at this time to discontinue the use of loose fitting dowels in repairing concrete pavements of the age currently being repaired. Rather, the grouted-in-place dowels should be specified for use where an occasional repair is needed in a relatively new pavement. In such cases the repairs may need to last for 15 to 25 years which would justify the additional cost of grouting the bars in place.

One of the most failure prone repair techniques is the partial-depth repair. It is labor intensive work requiring patience to ensure that all unsound concrete is removed, the repair surface is clean, the joint is properly formed, and that the fast-set material is properly proportioned and mixed and has not exceeded its working time. Even under the best conditions a 5 to 10 percent failure rate of the repairs within a three-year period could occur. At this time, there is some question whether or not partial-depth repairs are cost effective using the material and equipment now available. As more performance data become available, the question of cost effectiveness probably will be resolved.

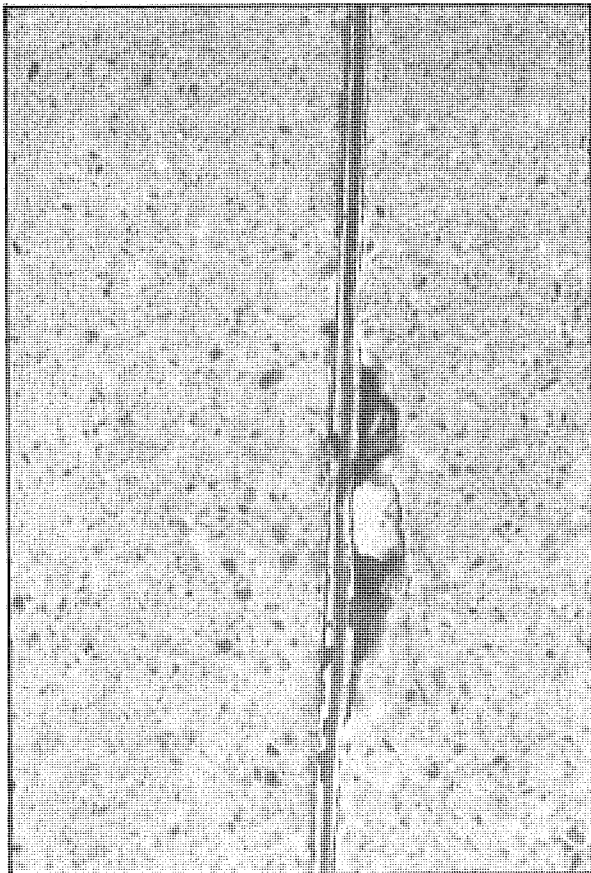
APPENDIX A



◀ Figure 1A. Transverse joint compression failure.



▲ Figure 2A. Failure at intersection of the transverse and longitudinal joint.



◀ Figure 3A. Joint groove spall.

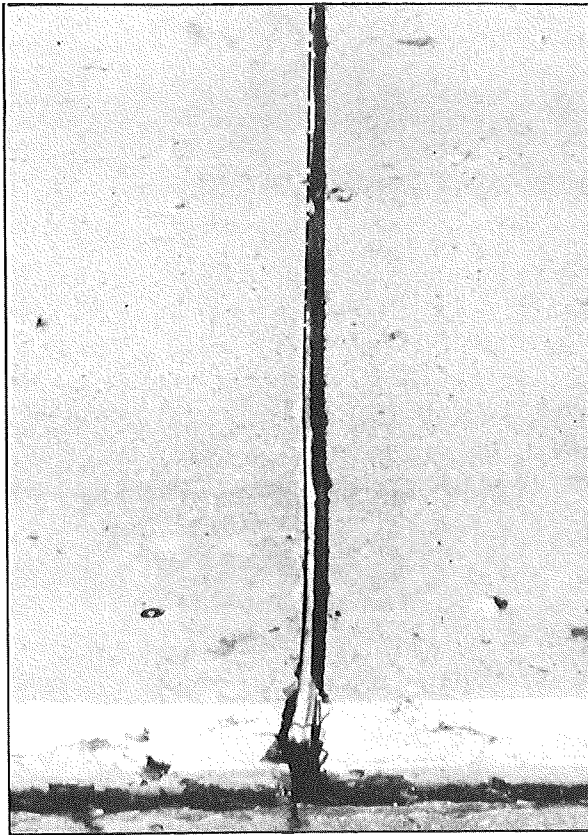


Figure 5A. Transverse crack with fractured steel.

Figure 4A. Ineffective neoprene seal.



Figure 6A. Transverse crack with reinforcement intact.

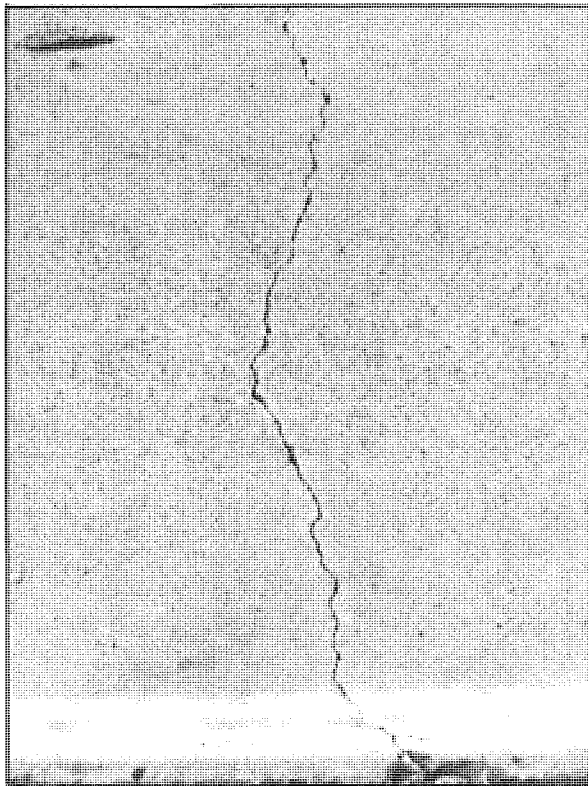


Figure 7A. Surface pop-out.

APPENDIX B

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
DOWELLED OR TIED CONCRETE PAVEMENT REPAIR

M&T:JES8

1 of 2

02-27-87

a. Description.-This special provision covers concrete pavement repairs utilizing 1-1/4 inch by 16-inch long, epoxy coated dowel bars or No. 10 deformed epoxy coated bars 18 inches long, both to be grouted-in-place in drilled holes with a polyester or epoxy grout.

All work and materials shall be in accordance with the 1984 Standard Specifications (primarily Section 4.52 Concrete Pavement Repair), with the exceptions and additions specified herein.

b. Materials.

Dowel Bars.-The dowel bars shall be 1-1/4 inch diameter by 16 inches long (both ends sawed) and shall be epoxy coated in accordance with Subsection 8.16.08-a (Type B coating).

Tie Bars.-The tie bars shall be No. 10 deformed bars 18 inches long and shall meet the requirements of Subsection 8.16.10-a. The bars shall be epoxy coated for their entire length, and shall have at least one sawed end.

Debonding Coat.-Type B coated dowels shall be coated with a bituminous material meeting the requirements of RC-250, as specified in Section 8.04. The RC-250 coat shall be applied after the dowels are installed in the field.

Grout.-The polyester or epoxy grout shall be selected from the list of Qualified Products for Grouting Dowel Bars and Tie Bars attached to this special provision.

Joint Sealant.-The hot-poured sealant shall be in accordance with the Special Provision for Low-Modulus Hot-Poured Joint Sealant contained in this proposal.

Equipment.

Drill.-The depth of the drilled holes specified in Subsection 4.52.03-e shall be 7-1/2 inches \pm 1/2 inch.

Grout Dispenser.-The grout dispensing equipment shall be capable of properly proportioning the components and mixing them while they are extruded through a nozzle. The nozzle shall be of sufficient length to deposit the grout in the back of the hole.

c. Construction.-The construction shall be in accordance with Construction Methods as specified in 4.52 Concrete Pavement Repair with the following exceptions:

Once the dowel bar or tie bar holes have been cleaned with oil-free compressed air (the air wand shall be inserted into the back of the hole), and just prior to inserting the bars in the holes, the approved grout material shall be deposited in the back of the holes. The amount of grout in each hole shall be of sufficient quantity to completely fill the space around the bar as it is inserted into the hole using hand pressure. The grout extruded during the bar insertion shall be wiped around the bar at the joint face with a gloved hand or hand trowel. Excess grout on the concrete joint face and the bar shall be wiped off.

After the grout has set, the portion of all dowels extending into the repair area shall be uniformly coated with liquid asphalt meeting the requirements of RC-250. For expansion joints, the filler material shall be in place prior to applying the RC-250 asphalt, and an expansion cap shall be placed on the end of each protruding dowel after the RC-250 coat has been applied. The alternate procedure of using a cylindrical plug inserted in the holes in lieu of an expansion cap will not be permitted. Tie bars shall not be coated with RC-250. Transverse joint grooves at tied joints shall be 1/4 inch wide by 1/2 inch deep and formed by edging the repair and shall be sealed with a hot-poured sealant.

d. Measurement and Payment.-The completed work as measured for DOWELLED OR TIED CONCRETE PAVEMENT REPAIR will be paid for at the contract unit prices for the following contract items (pay items).

<u>Pay Item</u>	<u>Pay Unit</u>
Contraction Joint Cr (Modified).....	Linear Foot
Expansion Joint Er (Modified).....	Linear Foot
Grouted-In-Place Tied Joint.....	Linear Foot

The payment for Contraction Joint Cr (Modified) and Expansion Joint Er (Modified) includes all the work for Contraction Joint Cr and Expansion Joint Er and in addition includes furnishing and installing the grout material, furnishing epoxy coated dowels, furnishing and applying the RC-250 asphalt coating, and furnishing and installing the expansion caps.

The Pay Item for Grouted-In-Place Tied Joint will be Lineal Feet and the Pay Item will include the cost of drilling and cleaning the holes, furnishing the tie bars, the grout material, injecting the grout in the hole, installing the bars, and edging and sealing the transverse repair edges.

QUALIFIED PRODUCTS
FOR
GROUTING DOWEL BARS AND TIE BARS

Product Name	Manufacturer & Representative	Grout Type
Hilti C-10	Hilti Fastening Systems 1431 Opus Place, Suite 522 Downers Grove, Illinois 60515 Michael Casey (312) 971-2556	Polyester
Mark 198	Poly-Carb 33095 Brainbridge Road Cleveland, Ohio 44139 Hormus Irani (216) 248-1223	Epoxy
Solid Bond 200	Adhesive Technology Corp. 21850 88th Place South Kent, Washington 98031 Dennis Fogh (206) 872-2240	Epoxy

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
FULL-DEPTH CENTERLINE JOINT REPAIR

M&T:JES5

1 of 3

02-27-87

a. Description.-This special provision covers full-depth repair at the intersection of the longitudinal centerline joint and the transverse joints in concrete pavement.

All work and material shall be in accordance with the 1984 Standard Specifications (primarily Section 4.52 Concrete Pavement Repair), with the exceptions and additions specified herein.

b. Materials.

Tie Bars.-Straight tie bars shall meet the requirements of Subsection 8.16.10-a. The bars shall be No. 5 Grade 40 deformed, 24 inches long and epoxy coated for the entire length.

Grout.-A polyester or epoxy grout for fastening the tie bars in drilled holes shall be selected from the list of Qualified Products for Grouting Dowel Bars and Tie Bars attached to this special provision.

Joint Sealant.-The hot-poured sealant shall be in accordance with the Special Provision for Low-Modulus Hot-Poured Joint Sealant contained in this proposal.

Equipment.

Drill.-At the Contractor's option, tie bar holes 3/4 inch in diameter by 6 inches deep may be drilled with a hand-held drill.

Grout Dispenser.-The grout dispensing equipment shall be capable of properly proportioning the components and mixing them while they are extruded through a nozzle. The nozzle shall be of sufficient length to deposit the grout in the back of the holes.

c. Construction Methods.

General.-Unless otherwise directed by the Engineer, the repairs shall be 2 feet wide and 4 feet long.

Removing Pavement (Lift Out Method).-The perimeter of the repairs shall be sawed full-depth with overcuts at each corner required. The distressed area of concrete shall be removed by lifting it out. Any concrete rubble left in the repair area shall be removed by use of hand tools. Disturbance of the base material will not be permitted.

Removing Pavement (Break Out Method).-The perimeter of the repairs shall be sawed full-depth, but overcuts at the corners will not be permitted. The concrete within the sawed limits shall be removed by use of hand-held air hammers and hand tools. Care shall be exercised to prevent undercutting at each corner of the removal area. The disturbed base material shall be recompactd by use of a hand-held air operated tamper.

Tie Bar Installation.-Tie bar holes shall be drilled at the locations and to the diameter, depth, and angle shown on the Detail for Full-Depth Centerline Joint Repair attached to this special provision. The drilled holes shall be cleaned with oil-free compressed air just prior to installing the bars. The air wand shall be inserted into the back of the hole to ensure proper cleaning. Once the holes are cleaned, a sufficient quantity of grout shall be deposited in the

back of the holes to completely fill the space around the bar when it is inserted. The tie bars shall be inserted by hand using sufficient pressure to ensure the bars are embedded for the full depth. Excess grout extruded from the hole shall be wiped around the bar at the hole opening with a gloved hand or hand trowel. After the grout has hardened, the tie bars shall be bent downward until they are parallel to the pavement surface. At the Contractor's option, the tie bars may be bent prior to grouting them in place.

Joint Construction.-At the existing transverse joint location, a 3/4 inch bituminous filler board shall be installed in line with the existing joint as shown on the attached detail. The longitudinal joint shall not be extended through the repair area. A groove, approximately 1/4 inch wide by 1/2 inch deep, shall be edged around the perimeter of the repair.

Joint Sealing.-The perimeter joint, including sawed overcuts, shall be sealed with hot-poured joint sealant.

d. Measurement and Payment.-Measurement and payment for the completed work as measured for FULL-DEPTH CENTERLINE JOINT REPAIR will be paid for at the contract unit prices for the following contract items (pay items).

<u>Pay Item</u>	<u>Pay Unit</u>
Removing Pavement (Lift Out Method).....	Square Yard
Removing Pavement (Break Out Method).....	Square Yard
Concrete Pavement Repair _____ in.,	
Non-reinforced (Special).....	Square Yard
Grouted-In-Place Tie Bars.....	Each

The item Removing Pavement (Lift Out Method) includes the cost of sawing the perimeter, lifting out the distressed concrete without disturbing the base, and loading, hauling, and disposing of the material removed.

The item Removing Pavement (Break Out Method) includes the cost of sawing the perimeter, breaking and removing the distressed concrete, and loading, hauling and disposing of the material removed, and recompacting the base.

Concrete Pavement Repair, Non-reinforced (Special), of the thickness specified, will be measured by area in square yards. Longitudinal and transverse measurements for area will be made along the actual surface of the roadway. Payment for Concrete Pavement Repair, Non-reinforced (Special) includes payment for furnishing, placing, consolidating, finishing, and curing the concrete, furnishing and placing the bituminous filler board, and edging and sealing the joint groove around the repair perimeter.

Payment for Grouted-In-Place Tie Bars includes drilling and cleaning the holes, furnishing the tie bars and the grout material, injecting the grout in the holes, and installing the bars.

QUALIFIED PRODUCTS
FOR
GROUTING DOWEL BARS AND TIE BARS

Product Name	Manufacturer & Representative	Grout Type
Hilti C-10	Hilti Fastening Systems 1431 Opus Place, Suite 522 Downers Grove, Illinois 60515 Michael Casey (312) 971-2556	Polyester
Mark 198	Poly-Carb 33095 Brainbridge Road Cleveland, Ohio 44139 Hormus Irani (216) 248-1223	Epoxy
Solid Bond 200	Adhesive Technology Corp. 21850 88th Place South Kent, Washington 98031 Dennis Fogh (206) 872-2240	Epoxy

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
RESEALING TRANSVERSE JOINTS WITH SILICONE

M&T:AWP2

1 of 3

02-27-87

a. Description.-This work consists of removing existing neoprene or hot-poured sealant, resawing the joint groove, cleaning the joint, and sealing the joint with a silicone sealant.

The location of the joints to be resealed shall be as shown in the proposal or as directed by the Engineer.

All work and materials shall be in accordance with the 1984 Standard Specifications with exceptions and additions specified herein.

b. Materials.-The silicone sealant shall be a low-modulus sealant having a one part formulation which does not require a primer for proper bonding to portland cement concrete. The sealant shall meet the following requirements:

<u>Property</u>	<u>Value</u>	<u>Test Method</u>
Shelf Life, months	6 min (from date of shipment)	
Flow, inches	0.3 max	ASTM C 639
Extrusion Rate, grams/minute	90-300	MIL S 8802
Tack Free Time, minutes	35-75	MIL S 8802
Specific Gravity	1.010-1.515	ASTM D 792 (Method A)

Tests on Sealant Cured 7 Days at 75 F and 50% RH

Durometer Hardness, Shore A	5-25	*ASTM D 2240
Tensile Stress at 150%		
Elongation, psi	45 max	*ASTM D 412 (Die C)
Elongation, %	700 min	*ASTM D 412 (Die C)

Bond test, -20 F, 100% Elongation, 3 cycles

Non-Immersed	Pass	**Departmental
Water-Immersed, 96 hours	Pass	**Departmental

*The hardness, tensile stress, and elongation specimens shall be prepared from a sheet of material 1/8" to 3/16" thick which has been cast and cured on a sheet of polyethylene.

**Bond tests shall be run in triplicate on sealant sections 1/2"W x 3/8"D x 2"L, poured and tooled between sawed concrete blocks. A cycle shall consist of 100% extension at -20 F at a rate of 1/8 inch per hour. The specimens shall be allowed to recover at laboratory temperature for four hours, then conditioned for a minimum of four hours at -20 F before starting a cycle. Failure is determined by one or more of the three specimens exhibiting 10% or more adhesion or cohesion failure after three cycles.

The containers of the sealant shall be plainly marked with the manufacturer's name or trade name, color, lot number, and date of manufacture. The sealant will be sampled by a representative of the Department and tested by the Department. A minimum of three weeks will be required for testing from the time the sample is received.

c. Construction.

Seal Removal.-All existing neoprene joint seals shall be removed from the joint grooves. The portion of the neoprene seal in the vertical joint groove at the edges of the pavement need not be removed. For joint grooves that have closed beyond their design limits, it may be necessary to run a single saw cut through the length and depth of the joint seal to relieve the pressure and facilitate removal. Hot-poured sealant shall be removed by plowing or sawing.

Spall Repair.-Spalls along the joint groove which are directed to be repaired by the Engineer, shall be repaired as specified in the Special Provision for Joint Spall Repair contained in this proposal. Spalls shall be repaired prior to sawing the joint groove.

Joint Sawing.-The joint groove shall be resawed to dimensions shown on the Detail for Resealing Transverse Joints with Silicone attached to this special provision. The joint groove shall extend across concrete widening and concrete ramps, but shall not extend down the edge of the concrete. The new saw cut shall be centered over the old joint groove to produce a finished joint with two freshly sawed faces. Immediately after sawing the joint, the joint groove shall be flushed with water having sufficient pressure to remove all slurry and debris from the joint faces and reservoir.

Joint Preparation.-Immediately prior to sealing, the joint shall be cleaned to remove all dust and contamination from the joint faces and reservoir.

Cleaning shall consist of sandblasting followed by a final cleaning with compressed air free of oil and water and having a minimum pressure of 90 psi. After the final cleaning, the closed cell polyethylene backer rod shall be inserted into the transverse joint groove to the depth shown on the Detail for Resealing Transverse Joints with Silicone.

Joint Sealing.-The joint groove shall be sealed after the insertion of the backer rod and prior to becoming contaminated. At the time of sealing, the joint groove faces shall be dry and dust free. The silicone shall be pumped into the joint groove in a continuous operation to properly fill and seal the joint groove. A list of recommended pumps for this procedure can be obtained from the supplier of the sealant. In conjunction with or immediately after placement, the sealant shall be tooled to force it against the joint faces and to obtain the correct depth.

A temporary dike (consisting of a piece of the backer rod inserted vertically in the joint groove) shall be installed near the centerline to terminate the sealant. The dike shall be removed when the adjacent lane is sealed and the newly placed sealant shall be tooled to force it against the end of the previously placed sealant. In the event the adjacent lane has not been resawed prior to sealing the first lane, the dike shall be placed in the first lane a minimum of 12 inches from the unsawed area to permit sawing the adjacent lane without damaging the sealant.

The joint faces and pavement surface shall be dry at the time of sealing. The joints shall not be sealed when the air or pavement temperature is below 40 F. Traffic shall not be allowed on the sealed joints for a minimum of three hours after tooling, unless otherwise directed by the Engineer.

d. Measurement and Payment.-The completed work as measured for RESEALING TRANSVERSE JOINTS WITH SILICONE will be paid for at the contract unit price for the following contract unit (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Resealing Transverse Joints with Silicone.....	Linear Foot

Payment for Resealing Transverse Joints with Silicone includes all labor, equipment, and materials required to remove all existing sealants and resaw, clean, and seal the joints, with the exception of spall repair which will be paid for separately as provided for in the Special Provision for Joint Spall Repair contained in this proposal.

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
RESAWING AND SEALING LONGITUDINAL
PAVEMENT JOINTS

M&T:AWP4

1 of 1

02-27-87

a. Description.-This work includes all labor, equipment, and material required to resaw and seal existing longitudinal concrete pavement joints.

All work and materials shall be in accordance with the 1984 Standard Specifications with the exceptions and additions specified herein.

The longitudinal joints shall be resawed to the dimensions specified, cleaned, and sealed with a low-modulus hot-poured joint sealant as directed by the Engineer.

b. Materials.-The joint sealant shall be in accordance with the Special Provision for Low-Modulus Hot-Poured Joint Sealant contained in this proposal.

c. Construction.-The joints shall be sealed with the hot-poured sealant as specified in Subsection 4.50.22-c of the 1984 Standard Specifications with the following exceptions and additions:

1. All spalls along the longitudinal joint which are directed by the Engineer to be repaired, shall be repaired as specified under the Special Provision for Joint Spall Repair contained in this proposal. The spalls shall be repaired prior to resawing the longitudinal joint.
2. The existing longitudinal joints shall be resawed to a depth of 1 inch to 1-1/4 inch and a width of 3/8 inch to 1/2 inch. Immediately following the sawing operation, the joint groove shall be flushed with water of sufficient pressure to remove the slurry and debris from the joint groove. The longitudinal joints shall be sawed prior to resealing the intersecting transverse joints.
3. The joints shall receive a final cleaning, just prior to sealing, as specified in Subsection 4.50.21 of the 1984 Standard Specifications.
4. The joint groove shall be sealed flush to 1/8 inch (after cooling) below the surface of the pavement. The faces of the joint groove and the pavement surface shall be dry at the time of sealing.

d. Measurement and Payment.-The completed work as measured for RESAWING AND SEALING LONGITUDINAL PAVEMENT JOINTS will be paid for at the contract unit price for the following contract item (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Resawing and Sealing Longitudinal Pavement Joints.....	Linear Foot

Payment for Resawing and Sealing Longitudinal Pavement Joints includes all labor, equipment, and materials required to saw, clean, and seal the joints, with the exception of spall repair, which will be paid for separately as provided in the Special Provision for Joint Spall Repair contained in this proposal.

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
REPAIR OF CONCRETE PAVEMENT SURFACE POP-OUTS

M&T:AWP3

1 of 1

02-27-87

a. Description.-This work shall consist of cleaning and repairing pop-out areas in the surface of the concrete pavement with a fast set mortar.

The areas to be cleaned and repaired shall be as shown in the proposal or as directed by the Engineer.

All work and materials shall be in accordance with the 1984 Standard Specifications with the following exceptions and additions.

b. Materials.-The fast set repair mortar shall be in accordance with the Special Provision for Prepackaged Fast Set Mortar contained in this proposal.

c. Equipment.-The chipping hammers used to prepare the repair area shall be light weight (15 pound class maximum), unless otherwise approved by the Engineer.

d. Construction.

Repair Area Preparation.-All unsound concrete and bituminous patching material shall be removed from the repair area with chipping hammers. All surfaces of the repair area shall be sandblasted to remove all contamination, followed by a final cleaning with oil-free compressed air having a minimum pressure of 90 psi.

Mortar Placement.-The mortar shall be mixed, placed, consolidated, finished, and cured as specified in the Special Provision for Prepackaged Fast Set Mortars as contained in this proposal.

e. Measurement and Payment.-The completed work as measured for REPAIR OF CONCRETE PAVEMENT SURFACE POP-OUTS will be paid for at the contract unit price for the following contract item (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Repair of Concrete Pavement Surface Pop-outs.....	Each

Payment for Repair of Concrete Pavement Surface Pop-outs includes all labor, equipment, and materials required to prepare the repair area and place, consolidate, finish, and cure the patching mortar, with the exception of furnishing and mixing the repair mortar which will be paid for separately as provided in the Special Provision for Prepackaged Fast Set Mortar contained in this proposal.

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
PREPACKAGED FAST SET MORTAR

M&T:AWP7

1 of 2

02-27-87

a. Description.-This special provision covers prepackaged fast set mortars for use as a concrete repair material.

All work and material shall be in accordance with the 1984 Standard Specifications with the exceptions and additions specified herein.

b. Materials.-The prepackaged fast set mortar shall be one of the materials listed in Table 1 (Prepackaged Mortar) attached to this special provision.

The aggregate used to extend the mortar shall be natural, clean, surface dry pea stone of the size and gradation recommended by the manufacturer of the prepackaged mortar material.

c. Surface Preparation.-The surface of the repair area shall be clean and free of contamination at the time of placing the repair material. The surface shall be dry or damp (free of standing water) at the time of placement as specified in Table 1.

d. Mixing.-The water, prepackaged mortar mix, and aggregate shall be mixed together in a paddle type mortar mixer for a minimum of two minutes or until the mixture is of a uniform consistency.

e. Placement.-Immediately after mixing, the material shall be placed in the repair area, consolidated, and finished. Caution! In warm weather, the working time (after mixing and prior to initial set) may be 5 minutes or less. Retempering or remixing of the material will not be permitted. The material shall be firmly worked into the bottom and sides of the repair area to insure good bond and consolidation. The repair area shall be completely filled before any portion of the material has taken an initial set. Immediately after placing and consolidating the material, it shall be trowelled off to produce a surface flush to 1/16 inch below the existing surface.

f. Curing.-Immediately after the initial set, the material shall be cured as specified in Table 1.

g. Temperature Limitations.-The repair material shall not be placed when the air temperature is above 90 F or below 40 F.

When the air temperature is less than 50 F, the components of the repair material (water, prepackaged mortar, and aggregate) shall be heated to 75-85 F prior to mixing. In addition, the concrete at the repair area shall be slowly heated until it is warm to the touch prior to placing the material.

When the air temperature is greater than 80 F, the prepackaged mortar and aggregate shall be kept cool and ice water shall be used as the mix water.

h. Opening to Traffic.-Traffic shall not be allowed on the completed repair for at least 2 hours after the material has been finished, unless otherwise approved by the Engineer.

i. Measurement and Payment.-PREPACKAGED FAST SET MORTAR will be measured in cubic feet as determined by multiplying the number of units used by the yield per extended unit factor (Table 1) and will be paid for at the contract unit price for the contract item (pay item).

Pay Item Pay Unit
 Prepackaged Fast Set Mortar.....Cubic Foot

Payment for Prepackaged Fast Set Mortar includes all labor, equipment, and material required to furnish and mix all components of the material.

TABLE 1
 PREPACKAGED MORTAR

Product Name	Manufacturer	Prepackaged Weight (Pounds) per Unit	Aggregate Extension (Pounds) per Unit	*Mix Water (Quarts) per Extended Unit	Yield (cu ft) per Extended Unit	Cure Type & Length	Bonding Surface Condition
Burke Fast Patch 928	Burke Company P.O. Box 5818 San Mateo, CA 94402 (415) 349-7700	50	25	3.25 to 3.75	0.52	Wet Burlap 2 hr.	Clean & Damp
Durapatch Hi Way	L & M Construction Chemicals, Inc. 8316 Blondo St. Omaha, NE 68134 (402) 393-3371	50	25	3.00 to 3.75	0.52	Wet Burlap 2 hr.	Clean & Damp
Five Star Highway Patch	US Highway Products 405 Stillson Rd. Fairfield, CT 06430 (203) 336-7930	50	30	3.00 to 3.50	0.58	Wet Burlap 2 hr.	Clean & Damp

*The mix water used shall be the minimum amount within this range which produces a mix that is basically self-consolidating and self-leveling.

MICHIGAN
DEPARTMENT OF TRANSPORTATION
BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
LOW-MODULUS HOT-POURED JOINT SEALANT

M&T:AWP

1 of 1

02-27-87

a. Description.-This special provision covers a low-modulus hot-poured joint sealant used to seal joints and cracks.

b. Material.-The low-modulus hot-poured sealant shall meet the requirements of the 1984 Standard Specifications, Subsection 8.16.04-a with the following exceptions and additions:

1. Bond.-The sealant shall be tested at -20F for 3 complete cycles at 100 percent extension. The fine aggregate incorporated into the concrete mixture used to make the bond blocks shall be 2NS sand.
2. Penetration at 77F.-The penetration at 77F shall be 120+20.
3. Penetration at 0F.-The penetration at 0F shall be not less than 40. Two specimens shall be prepared and tested after being conditioned for 24 hours at 0F. The test shall be completed within 20 seconds after removal from the freezer.
4. Packaging and Marking.-The containers in which the material is packaged shall be legibly marked with a non-fading weather-resistant type of ink or paint. The markings shall include the manufacturer's name, or trade name, batch number, recommended pouring temperature, and the maximum safe heating temperature.
5. Sampling and Testing.-The sealant will be sampled by a representative of the Department. A minimum of two weeks will be required for testing from the time the sample is received.

MICHIGAN
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SPECIAL PROVISION
FOR
SAWING AND SEALING PAVEMENT CRACKS

M&T:AWP5

1 of 1

02-27-87

a. Description.-This work includes all labor, equipment, and material required to saw, repair spalls, clean, and seal cracks with hot-poured joint sealant.

All work and materials shall be in accordance with the 1984 Standard Specifications with the exceptions and additions specified herein.

The location of the cracks to be sealed will be as shown in the proposal, on the plans, or as directed by the Engineer.

b. Materials.-The joint sealant shall be in accordance with the Special Provision for Low-Modulus Hot-Poured Joint Sealant contained in this proposal.

c. Equipment.-The cracks shall be sawed with a random crack saw designed to follow the path of the crack. The saw shall be equipped with a diamond blade with a maximum diameter of 8 inches.

d. Construction.

Spall Repair.-All spalls along the crack which are directed by the Engineer to be repaired, shall be repaired as specified in the Special Provision for Joint Spall Repair contained in this proposal. The spalls shall be repaired prior to sawing the crack.

Sawing.-The cracks shall be sawed to a width of 5/8 inch to 3/4 inch and a depth of 3/4 inch to 7/8 inch. Immediately following the sawing operation, the crack shall be flushed with water of sufficient pressure to remove the slurry and debris from the sawed groove.

Cleaning.-Immediately prior to sealing, both faces of the sawed groove shall be sandblasted followed by a final cleaning with oil-free compressed air having a minimum pressure of 90 psi.

Sealing.-The sawed groove shall be sealed flush to 1/8 inch (after cooling) below the surface of the pavement. The faces of the sawed groove and the pavement surface shall be dry at the time of sealing.

e. Measurement and Payment.-The completed work as measured for SAWING AND SEALING PAVEMENT CRACKS will be paid for at the contract unit price for the following contract item (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Sawing and Sealing Pavement Cracks.....	Linear Foot

Sawing and Sealing Pavement Cracks will be measured in a straight line from end of crack to end of crack in linear feet.

Payment for Sawing and Sealing Pavement Cracks includes all labor, equipment, and materials required to saw, clean, and seal the cracks, with the exception of spall repair which will be paid for separately as provided in the Special Provision for Joint Spall Repair contained in this proposal.

MICHIGAN
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BUREAU OF HIGHWAYS

SPECIAL PROVISION
FOR
JOINT SPALL REPAIR

M&T:AWP1

1 of 2

02-27-87

a. Description.-This work includes furnishing all labor, equipment, and materials necessary to remove all unsound concrete, reform the joint groove, and patch the spall area with a prepackaged fast set mortar.

All work and material shall be in accordance with the 1984 Standard Specifications with the exceptions and additions specified herein.

The size and location of the repair areas will be as shown in the proposal or as determined by the Engineer. The total length of spall and volume of material for bidding purposes has been increased from that shown on the log to allow for increase in spalls since the initial survey and to include the increase in area due to the repair procedure.

b. Material.-The fast set repair mortar shall be in accordance with the Special Provision for Prepackaged Fast Set Mortar contained in this proposal.

Fiber joint filler shall conform to Subsection 8.16.03 of the 1984 Standard Specifications.

c. Equipment.-Chipping hammers for the removal of the unsound concrete shall be light weight (15 pound class maximum), unless otherwise approved by the Engineer.

Concrete saws for sawing the perimeter of the repair area shall be equipped with a diamond blade or blades with a maximum diameter of 12 inches.

d. Construction.

Repair Area Preparation.-Unless otherwise approved by the Engineer, the repair limits shall be constructed by sawing. The depth of the saw cut shall be 1-3/4 inch \pm 1/4 inch. The saw cut to control the width of the repair area shall be 2 inches beyond the widest portion of the spall (6-inch minimum width) and approximately parallel to the joint groove. The saw cuts to control the length of the repair shall be 2 inches beyond the length of the spall (minimum of 6 inches apart) and approximately perpendicular to the joint groove. Additional saw cuts may be made within the repair area to facilitate the removal of the unsound concrete.

The unsound concrete shall be removed by hand chipping with a light weight chipping hammer. The slope of the bottom of the repair area shall not exceed 1 vertical to 4 horizontal, unless otherwise approved by the Engineer.

All areas of the existing concrete which must bond to the patching material shall be freshly sawed or chipped to remove all unsound concrete and contamination.

The repair area shall be cleaned with oil-free compressed air or high pressure water, and any other tools required to remove all slurry and debris.

All waste material and debris shall be disposed of by the Contractor as directed by the Engineer.

Joint Groove Forming.-When the spall repair area is along a transverse joint, a temporary joint groove shall be formed 1/2 inch wide and to the depth of the existing joint groove adjacent to the repair area. The form material shall be 1/2 inch thick and shall be either styrofoam or fiber joint filler. In the

event that the repair area extends below the bottom of the joint groove, the plane of weakness crack shall be recreated by extending the form material to the bottom of the repair area or by positioning a piece of 1/4 inch thick polyethylene foam sheet against the existing concrete between the bottom of the form material and the bottom of the repair area.

All dowel bars exposed in the repair area shall be coated with a heavy grease to prevent a bond between the dowel bar and the repair mortar.

When the spall repair area is along a longitudinal joint, a temporary joint groove shall be formed 1/4 inch wide. The temporary form material shall be 1/4 inch thick styrofoam or fiber joint filler. The form material shall extend to the bottom of the repair area.

When the spall repair area is along a crack, a temporary joint groove 1/4 inch wide shall be formed along the path of the crack. The form material shall be 1/4 inch thick polyethylene foam sheet material and shall extend the full depth of the repair area.

Repair Mortar Placement.-The repair mortar shall be placed, consolidated, finished, and cured as specified in the Special Provision for Prepackaged Fast Set Mortar contained in this proposal.

Joint Sawing and Opening to Traffic.-The repair mortar shall be cured for a minimum of 2 hours prior to sawing the joint groove or opening to traffic, unless otherwise approved by the Engineer.

e. Measurement and Payment.-The completed work as measured for JOINT SPALL REPAIR will be paid for at the contract unit price for the following contract unit (pay item).

<u>Pay Item</u>	<u>Pay Unit</u>
Joint Spall Repair.....	Linear Foot

Payment for Joint Spall Repair includes all labor and materials required to saw the repair limits, remove the unsound concrete, form the temporary joint groove, and to place, consolidate, finish, and cure the repair mortar, with the exception of furnishing and mixing the repair mortar which will be paid for separately as provided for in the Special Provision for Prepackaged Fast Set Mortar contained in this proposal.