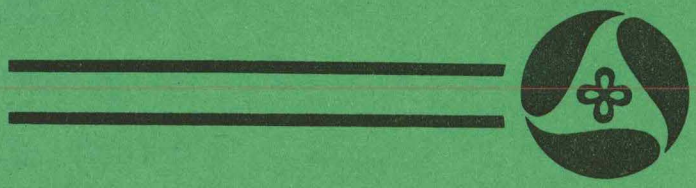
Investigation Phase for the

Value Engineering Study: "Repair of Transverse Cracking in Asphalt Pavement"

Iowa Highway Division

January 1988



Iowa Department of Transportation

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Investigation Phase Report

For

Value Engineering Study

Repair of Transverse Cracking

In Asphalt Pavement

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Abstract

This Value Engineering Study was initiated by the U.S. Department of Transportation - Federal Highway Administration, to evaluate the repairing of transverse cracks in asphalt pavement.

This study involves the gathering of data on types of equipment, work crews, labor costs and material costs in order to identify the very best and safest method for repairing these cracks.

Some of the questions to be addressed are:

1. Is crack sealing really extending pavement life?
2. What season of the year is best for crack sealing?
3. Should cracks be sealed prior to overlay of asphalt cement pavements?
4. What is causing the transverse cracks?
5. What is the best material for crack sealing?
6. What is the very best, safe, method for repairing cracks in asphalt cement pavement surfaces?

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INTRODUCTION

The Iowa Department of Transportation allocates a portion of its resources to the repair and maintenance of transverse cracks in asphalt cement concrete surfaces. In order to extend the serviceability life of asphalt cement concrete surfaces, transverse crack maintenance is made a part of the highway program by in-house crack maintenance by Department Maintenance personnel and authorizing the contracting of transverse crack maintenance as part of the annual Contract Maintenance and Construction programs. Currently, studies are in progress to reduce the need for crack maintenance on new pavements and to prolong the life of crack maintenance performed.

This investigative phase report is intended to present the current methods of crack maintenance utilized on asphalt cement concrete in Iowa and identify studies made on this subject. This investigative phase report is not intended to be used as the final report of the Value Engineering Study of the Repair of Transverse Cracking in Asphalt Pavement.

CURRENT METHODS OF TRANSVERSE
CRACK MAINTENANCE IN ASPHALT CEMENT CONCRETE SURFACES

Maintenance of transverse cracks in asphalt cement concrete surfaces comprises a substantial portion of the Department's Highway Maintenance program. Methods of transverse crack maintenance on asphalt cement concrete pavements are identified within the Department's Standards for Maintenance Activities for Work Performed by Department Maintenance Personnel. These methods are also identified within current Supplemental Specifications and Special Provisions (see appendix) for work authorized for contracting to parties outside the Department. Generally, there are three maintenance activities routinely performed on transverse cracks on asphalt cement concrete surfaces: joint and crack filling, joint and crack routing and sealing, and slurry leveling.

The Iowa Department of Transportation recognizes a need to provide maintenance of transverse cracks in asphalt cement concrete surfaces in order to extend the serviceable life of the pavement. When a typical random transverse crack is not repaired or maintained, the pavement adjacent to the crack tends to deteriorate. Settlement or depressions near the crack and secondary cracks develop.

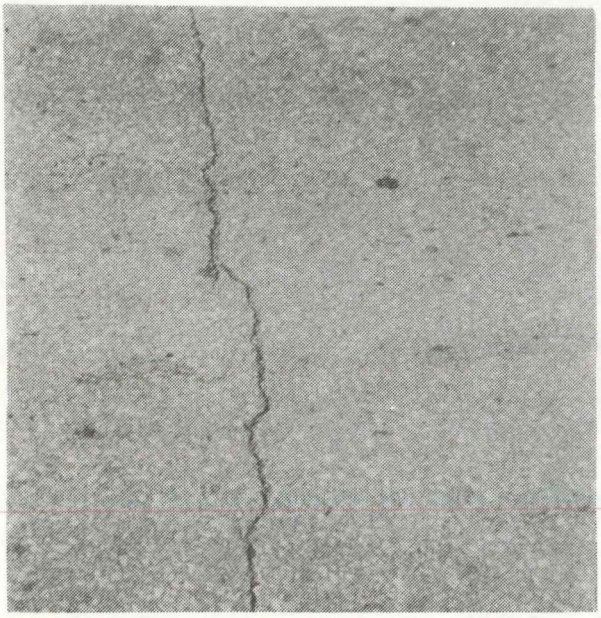

Fig 1

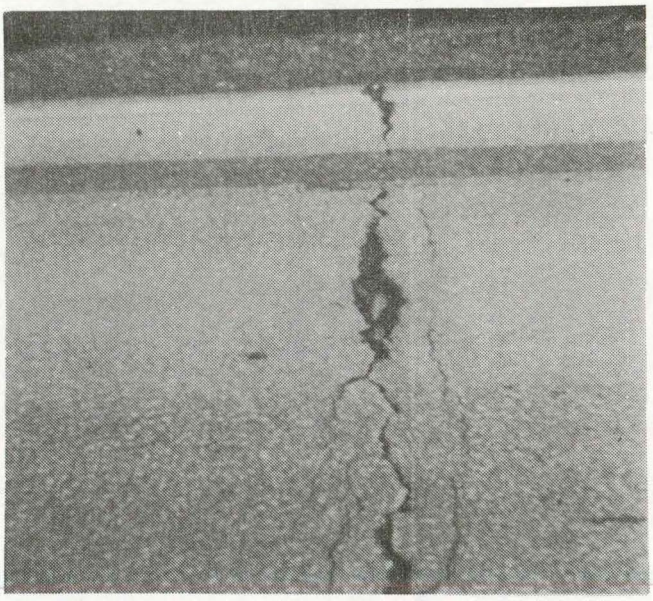

Fig 2

Cores of an asphalt cement concrete pavement were obtained in a pattern shown in Figure 3 below. The cores were taken adjacent to a transverse crack to study joint deterioration and pavement condition of a pavement with no crack maintenance provided. (Figure 3)

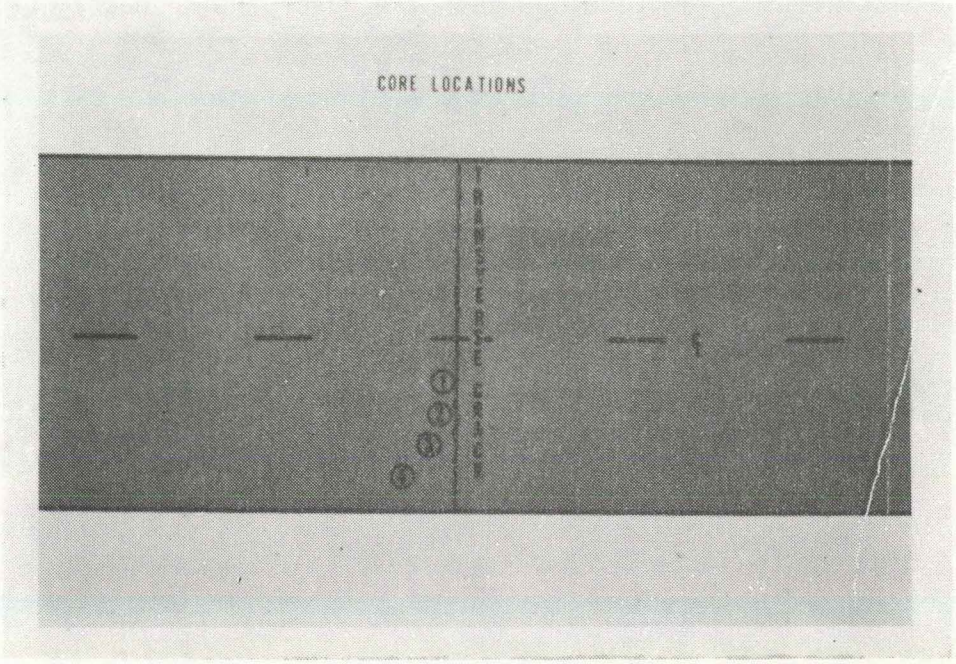

Fig 3

The cores taken at these locations exhibit delamination between the pavement layers. The core to the extreme right in Figure 4 was taken from a point nearest the crack. At this location, the pavement was deteriorated to the extent that the lower portions of the pavement could not be contained in the core sample. The core at the left was taken from the sample location farthest from the joint.

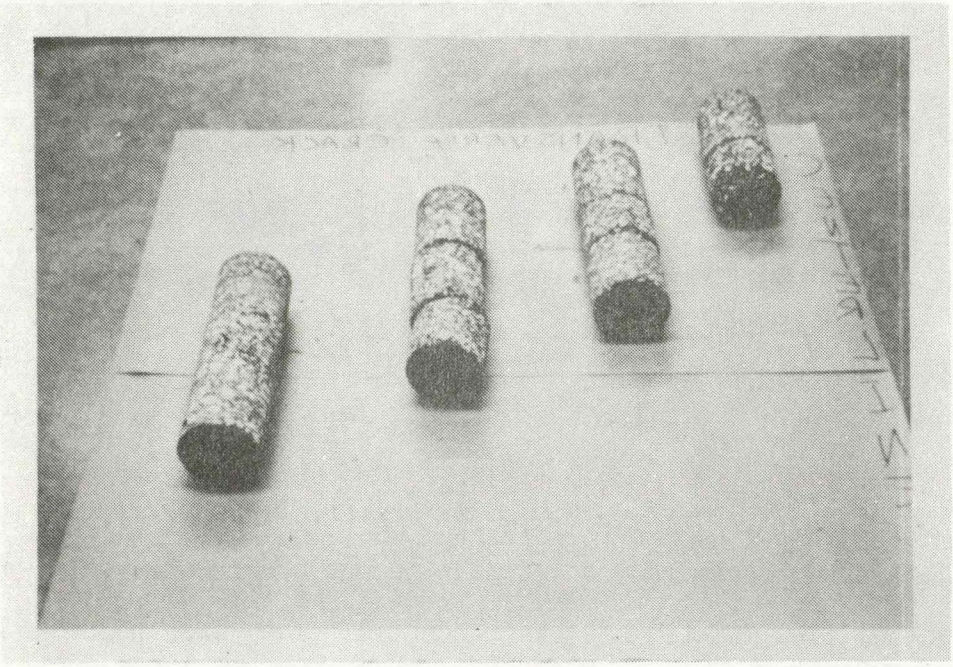

Fig 4

A joint or crack can be very narrow at the surface such as in Figure 5.

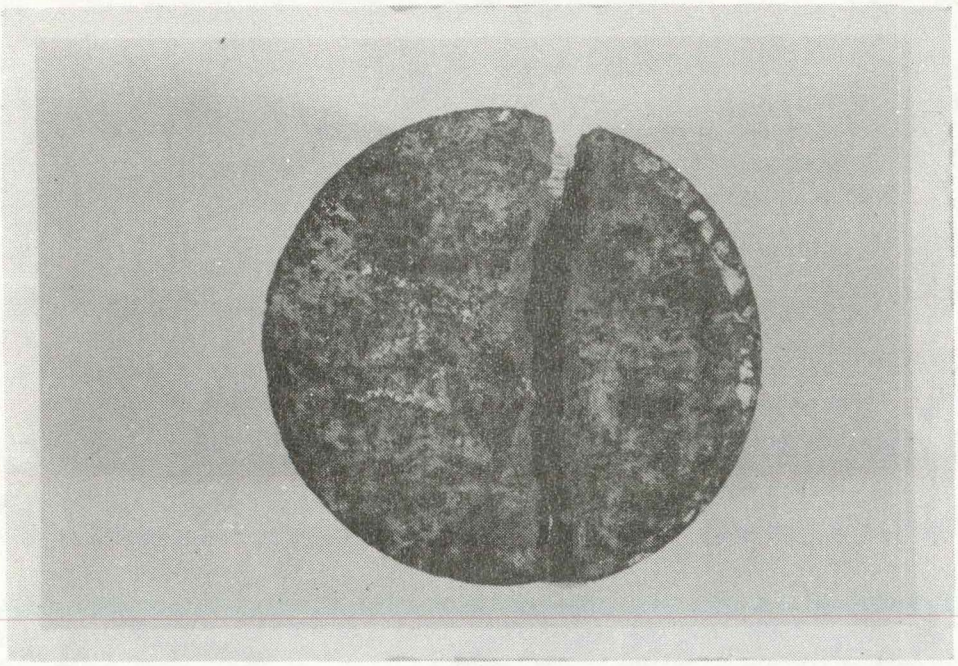

Fig 5

Crack deterioration can be much more severe in the lower portion of the pavement as shown in Figure 6.

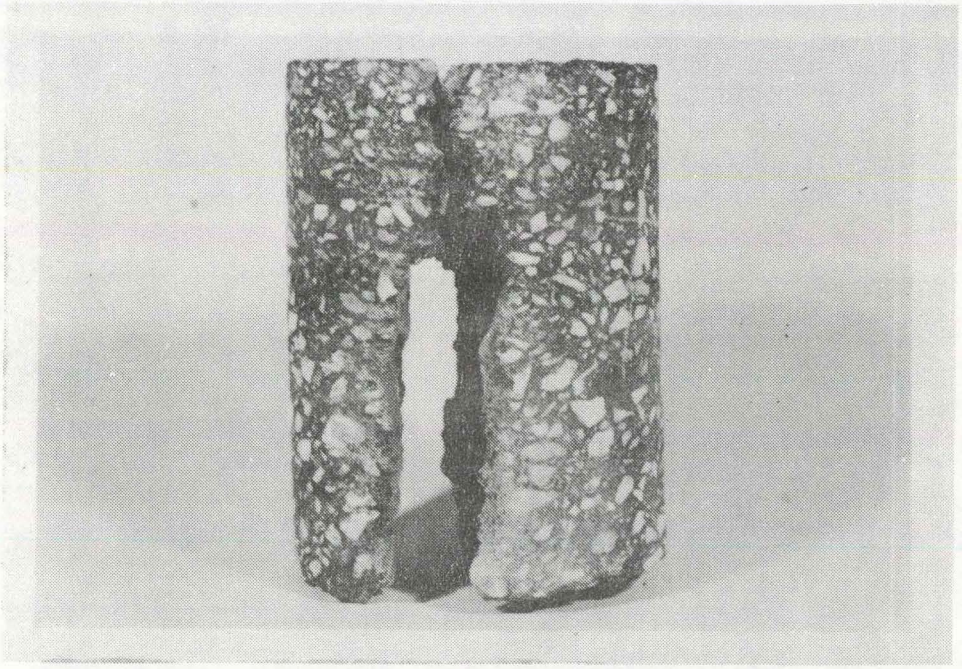

Fig 6

Figure 7 depicts cores taken from an asphalt cement concrete pavement after joint and crack filling maintenance was performed. The lower pavement layers are held together and are more stable than the pavement which had no joint and crack filling performed.

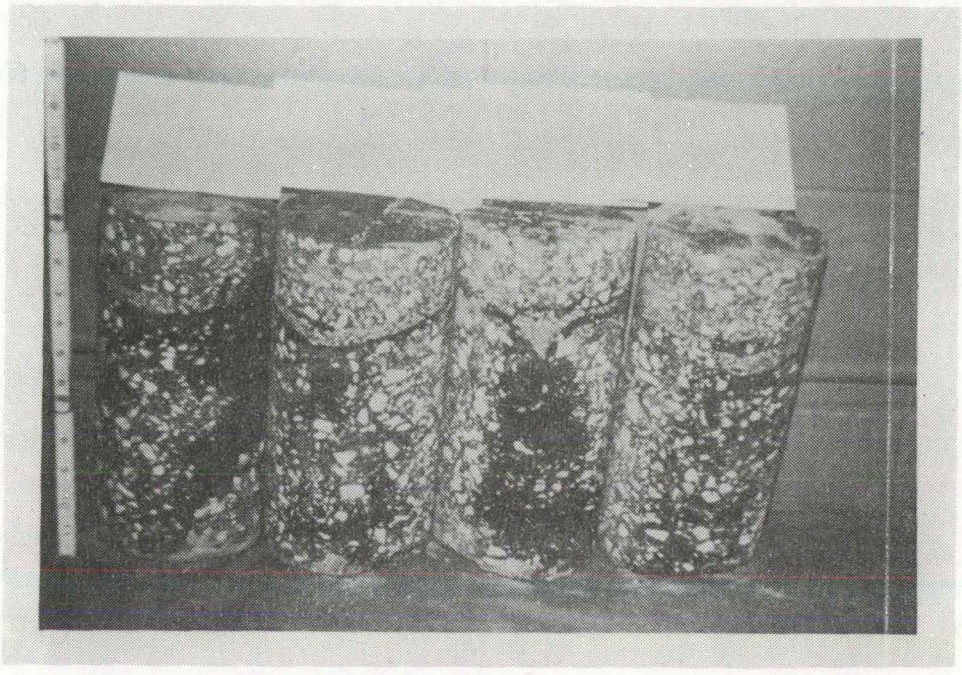

Fig 7

JOINT AND CRACK FILLING

The procedures and material requirements are identified in Maintenance Standard - Joint and Crack Filling, Function Code 612 and Special Provision, SP-589 (see appendix). Joint and crack filling includes operations necessary to fill cracks and joints in asphalt cement concrete paved surfaces with emulsified asphalts and asphalt cement to reduce entry of moisture and foreign material into the pavement. Cracks are filled as soon as they are open wide enough to accept filler material. Joint and crack filling can be performed during the entire year. The bulk of this work by Department Maintenance personnel is accomplished during the months January through May. Crack filling may be suspended during July and August if tracking and soiling of the pavement becomes a problem.

Materials:

1. Asphalt cement concrete hot mixture 1/2 or 3/8 inch mixture size (a cold premix mixture may be substituted).
2. Tack coating material.
3. Filler material shall be emulsified asphalt. Grade CRS-2 or CRS-2P winter, summer.
4. Blotting material - sand or agricultural lime.

Equipment:

1. High-pressure water equipment (2,000 PSI) (when needed).
2. High-pressure air capable of blowing debris from a crack.
3. Air chisel and hand tools to remove loose materials adjacent to cracks.

4. Heating kettle or distributor for applying filler material through a hand operated nozzle.
5. Squeegee (when needed).

Recommended crew size:

1 - Waterblaster (when needed)

1 - Air compressor truck driver

1 - Distributor truck driver

2 - Wand operators

1 - Crack cleaner

1 - Squeegee (when needed)

1 - Sander (when needed)

Provide necessary traffic control

Procedure:

1. Cleaning is performed with high-pressure air or water equipment. Water is not allowed at temperatures below 32 degrees F.
2. Cracks wider than 1 inch shall be cleaned, tacked and filled with hot mix. Crack cleaning shall continue until all debris is removed to a depth of 3 inches within the crack opening. Crack surfaces are tacked and the crack is filled with hot mix tamped into place and leveled with the pavement surface. A thin application of emulsion is placed and tight squeegeed.
3. Cracks 1/4 inch to 1 inch wide are cleaned with air or water pressure to remove debris to a depth of at least 1 inch. The crack should be cleaned to sound material but not deeper than 3 inches. The cleaned crack is filled with filler material using a hand operated wand. The

nozzle of the wand allows placing filler material in the crack without soiling the pavement surface.

4. Cracks less than 1/4 inch wide are cleaned sufficiently to remove debris and filled with emulsion filler material.
5. Sand or aggregate dams are constructed at the pavement edges to prevent filler material from running out the lower ends of the cracks.
6. When secondary cracks have developed, the cracks are squeegeed and blotting material is applied.
7. In filling cracks, a second pass may be necessary to ensure complete filling of the crack before leaving the work zone.

Figure 8 shows a typical crack ready for joint and crack filling. The crack has debris in it which must be removed and also secondary cracking is exhibited.

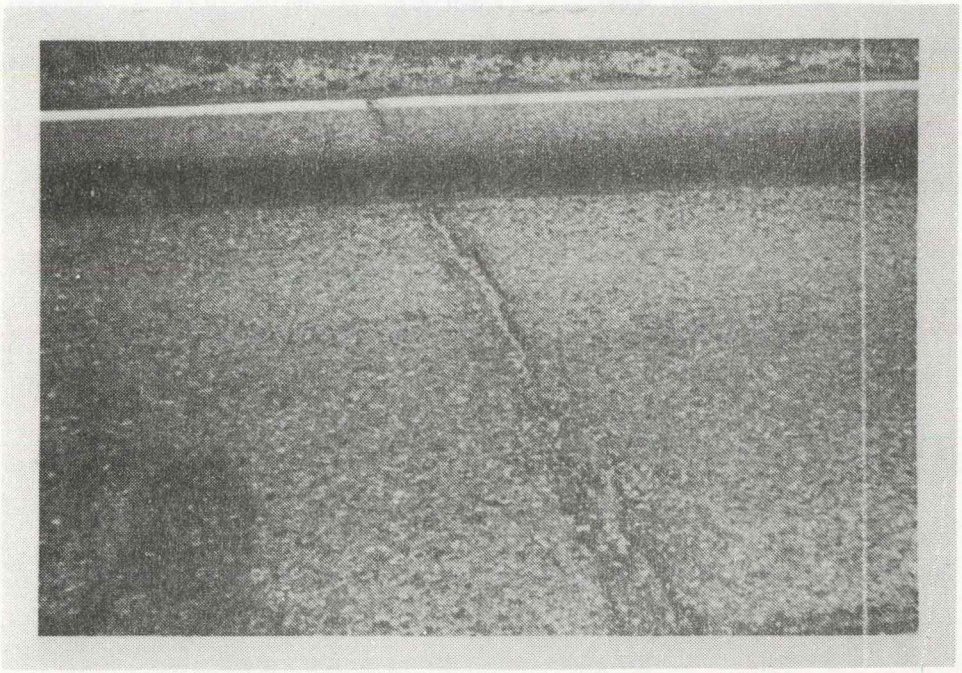

Fig 8

The crack is cleaned using compressed air or high-pressure water when needed. Water is used only when temperatures are above 32 degrees F. (Figure 9)

Fig 9

The intent is to clean the crack deep enough to form a reservoir for the filler material, not necessarily the full depth of the asphalt cement concrete surface. (Figure 10)

Fig 10

Cracks wider than 1 inch are cleaned, tacked and filled with compacted asphalt cement concrete mix prior to placing a thin application of CRS-2 tight squeegeed across the crack. (Figure 11)

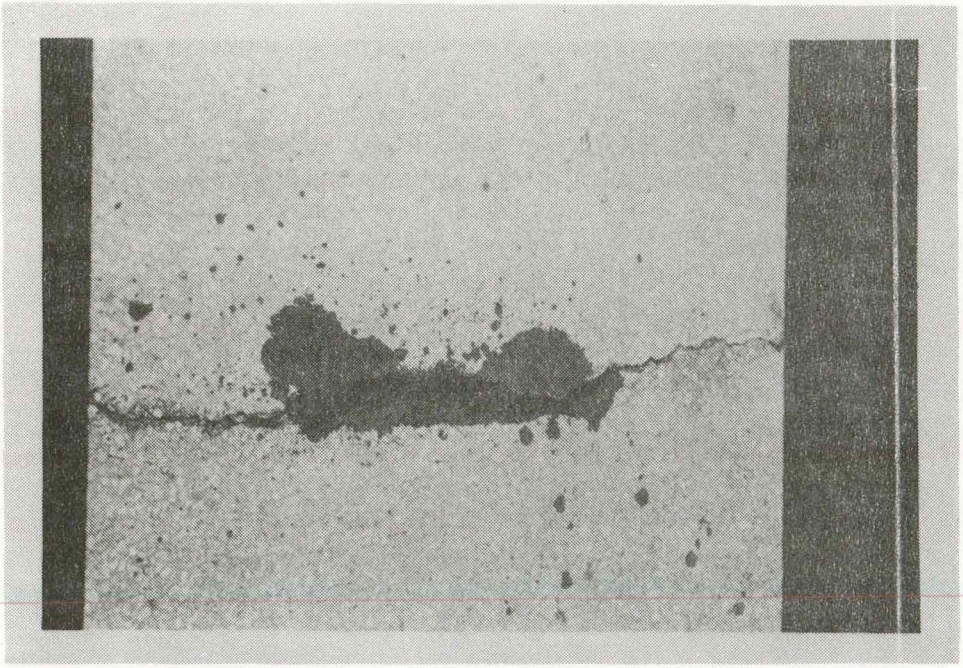

Fig 11

Crack filler material is placed in the cleaned crack. An aggregate dam was constructed at the low point of the crack to prevent the filler material from running out of the crack. (Figure 12)

During the filling operation, the filled cracks are monitored to detect subsidence of the filler material into the cracks. When necessary, the cracks are refilled to the top of the crack if subsidence occurs..

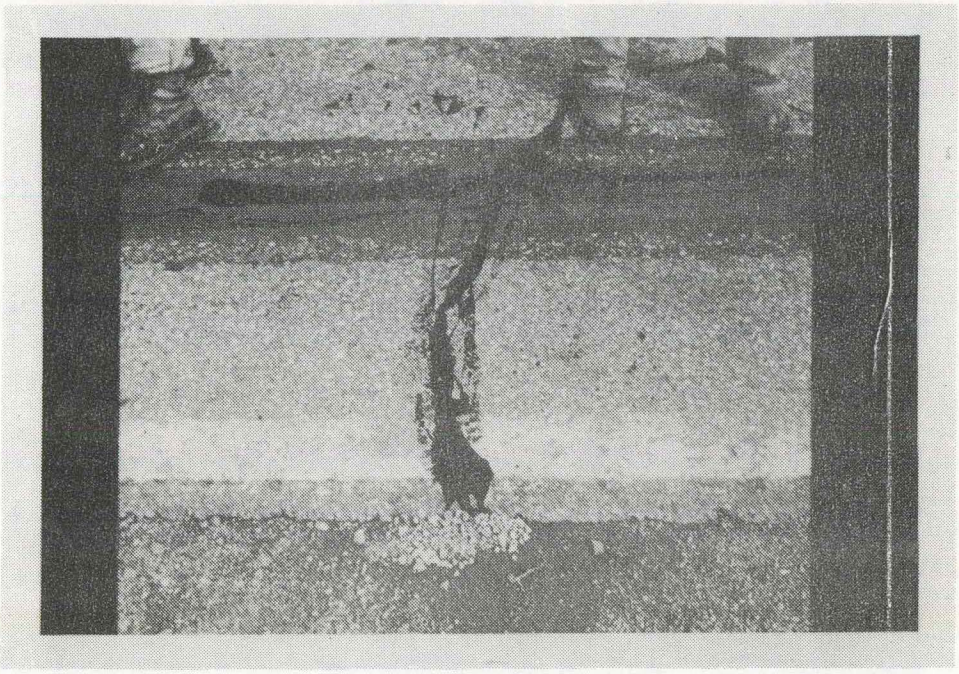

Fig 12

Cracking of some pavements is extensive. Two wands on one distributor is shown in Figure 13. The hose of one wand is supported by an overhead boom. The filler material is heated to temperatures between 125 degrees F. and 185 degrees F. If a tight squeegee is used, traffic can be placed back on the highway very quickly.

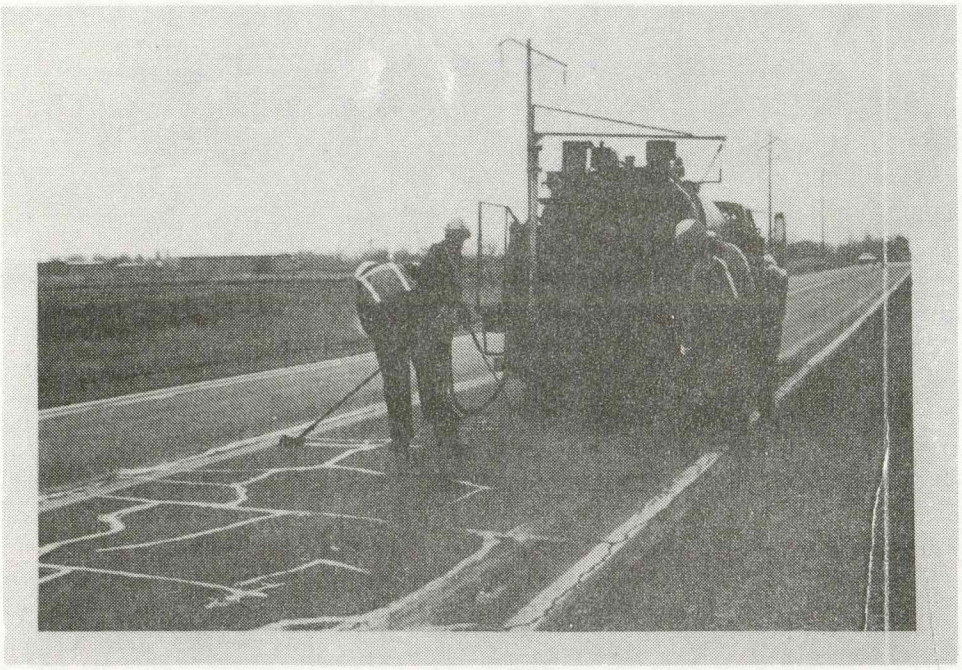

Fig 13

Figure 14 exhibits a pavement surface on which joint and crack filling has been completed. On this pavement surface, a squeegee was not used.

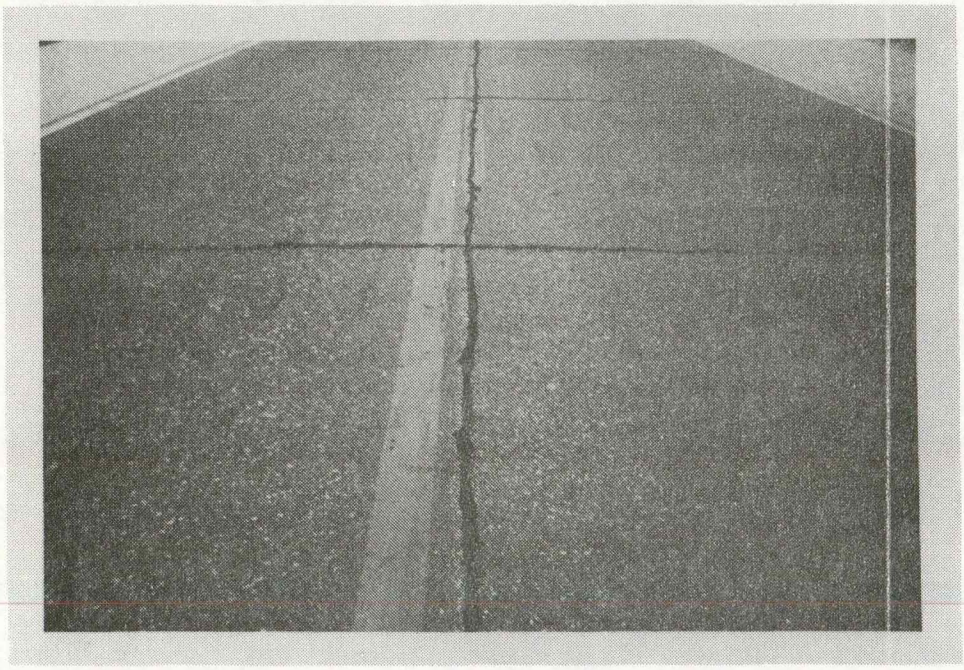

Fig 14

Figure 15 exhibits a squeegee used for joint and crack filling. It consists of a 2-inch wide metal frame with rubber belting attached with bolts. The squeegee is required when secondary cracks have developed adjacent to the primary crack.

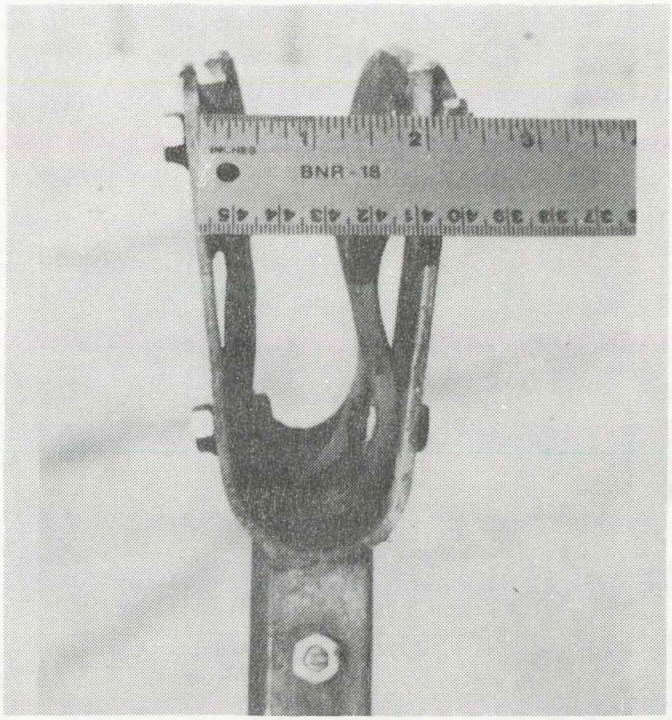

Fig 15

A finished crack filling operation where tight squeegee was used is depicted in Figure 16. This work can have a neat appearance.

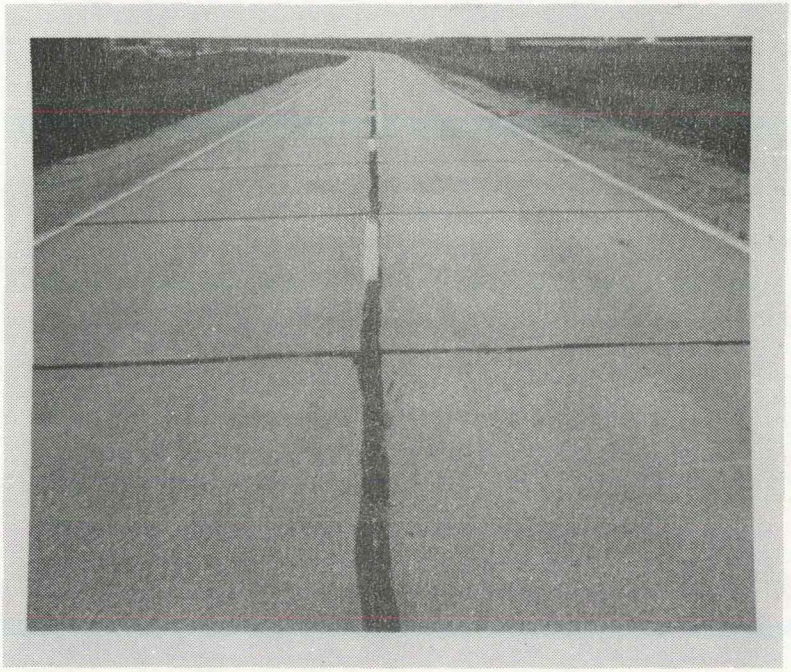

Fig 16

Some overfilling is shown in Figure 17. The crack is sealed to prevent intrusion of water and foreign materials.

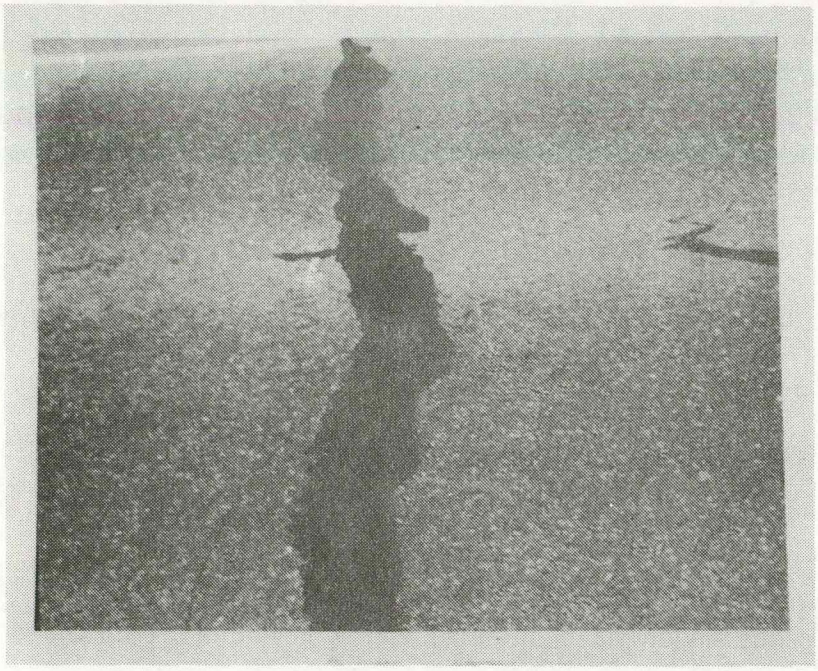

Fig 17

Figure 18 exhibits the need to tight squeegee the cracks to avoid tracking of the filler material. In warmer months, some filler material is forced from the cracks due to thermal expansion of the pavement and some tracking may occur at this time.

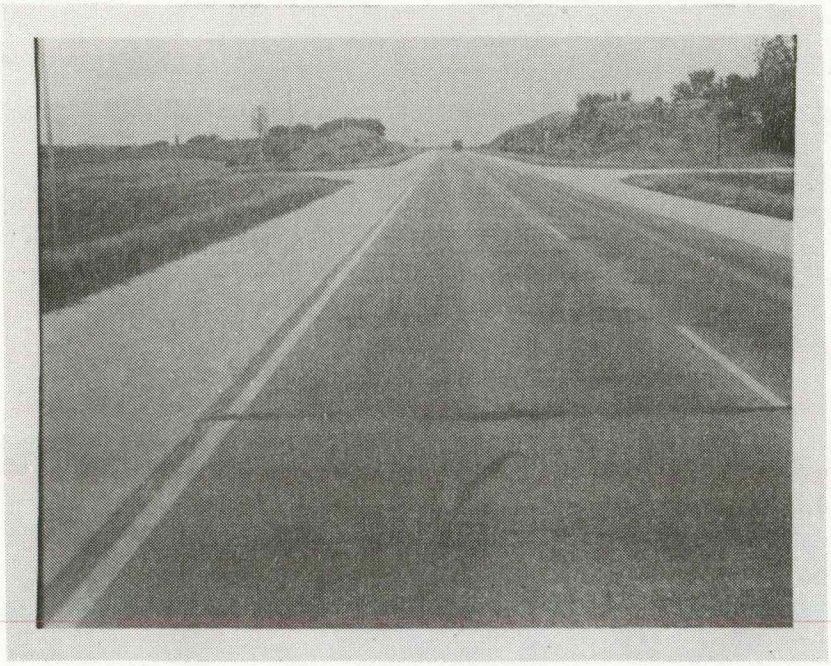

Fig 18

JOINT AND CRACK ROUTING AND SEALING

Procedures and material requirements are identified in Maintenance Standard - Joint and Crack Routing and Sealing, Function Code 616 and Supplemental Specification SS 1049 (see appendix).

Joint and crack routing and sealing includes operations necessary to seal random cracks and joints in asphalt cement concrete paved surfaces with hot pour sealing compound to seal cracks and joints against entry of moisture and foreign materials into the pavement. Cracks and joints are sealed as soon as they are open wide enough to become visible and movement is apparent. Generally pavements which have been recently paved or resurfaced with an asphaltic cement concrete mix and cracking is completed, are candidates for routing and sealing operations. Normally this work is performed during the warmer months beginning in March or April and extending through September. A minimum air and surface temperature of 40 degrees F. is required to perform this work.

Materials:

1. Hot-pour joint sealing material.
2. Backer rope of a size that compression is required for installation.

Equipment:

1. Routing or sawing equipment.
2. Air compressors capable of blowing debris from a crack prior to

placing sealing material.

3. Equipment used for heating and placing the premixed material shall be of the oil-jacketed, double boiler type, capable of heating the material to 400 degrees F. and pumping the material into the prepared cracks.
4. High-pressure water equipment (when needed).

Recommended crew size:

Crack Preparation

2 - Crack routers

1 - Water blaster (when needed)

1 - Sand blaster (when needed)

1 - Air compressor truck driver

1 - Crack cleaner

Crack Sealing

1 - Applicator loader and observer

1 - Melter applicator truck driver

1 - Wand operator

1 - Crack cleaner

1 - Squeegee operator

Provide necessary traffic control

Procedure:

1. Cracks with an average opening 1/2 inch or less are routed or sawed to provide a sealant reservoir of 1/2 inch width by a nominal 1 inch

depth.

2. Cracks with an average opening of more than 1/2 inch will not require routing or sawing but need to be cleaned of all foreign material to a depth necessary to accommodate the sealer material and backer rope used.

3. Backer rope is placed in the crack to a depth which will allow at least 5/8 inch clearance above the backer rope for the sealer.

4. Cracks prepared for the sealer are clean and dry prior to sealing. The entire reservoir is overfilled slightly with sealant and tightly squeegeed with a narrow squeegee. The squeegee is operated within approximately 1 foot of the wand tip used in placing the sealant.

5. The lanes are opened to traffic only after the sealant has set sufficiently so it will not pick up under traffic.

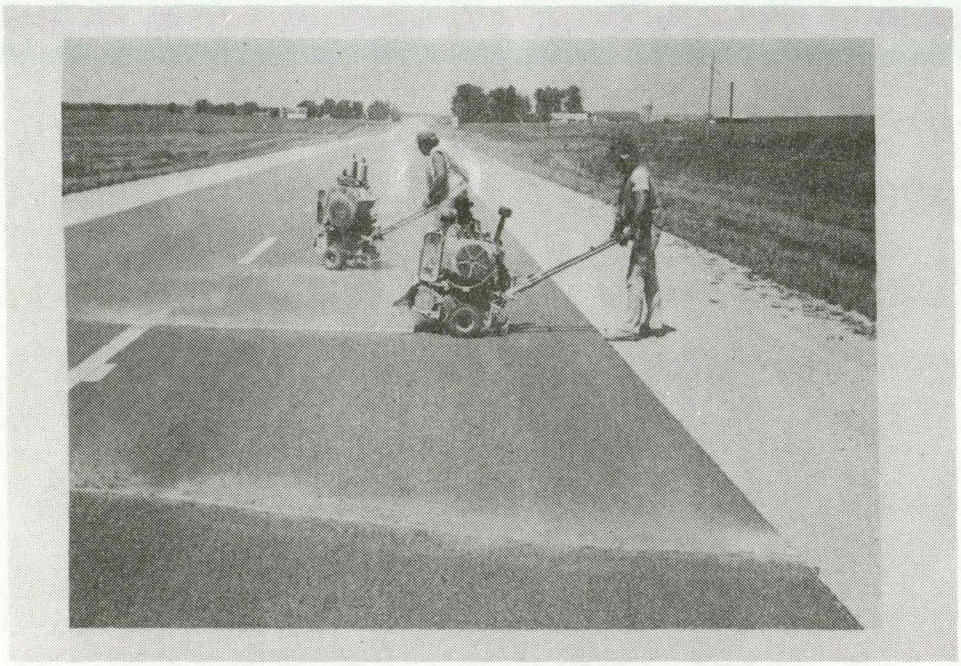

Fig 19

The two crack routers shown in Figure 19 are typical of routers used both by Department Maintenance personnel and Contractor's crews. Cracks less than 1/2 inch wide are routed to a depth of 1-inch and cracks wider than 1/2 inch are routed deep enough to provide 5/8 inch clearnace above the backer rope for the sealant..

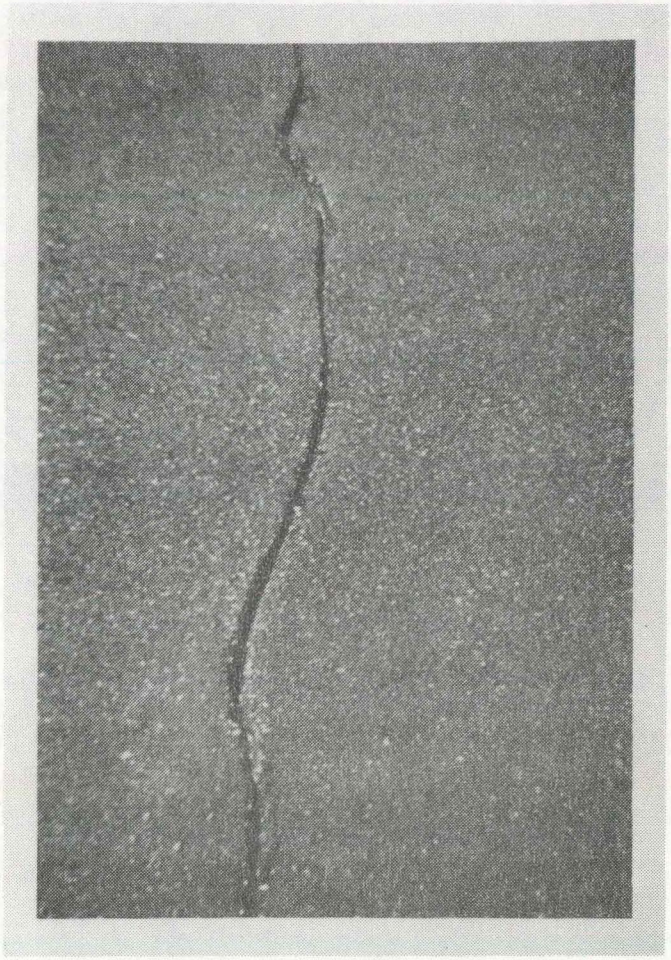

Fig 20

Compressed air or high pressure water is used to clean a typical routed crack as shown in Figure 20.

Figure 21 shows a typical melter-applicator used to heat the hot-pour sealant. Department crews are advised to closely monitor the sealant temperature using a mercury thermometer and not to reheat large quantities of sealer; this is accomplished by heating only the material intended to be used each day.

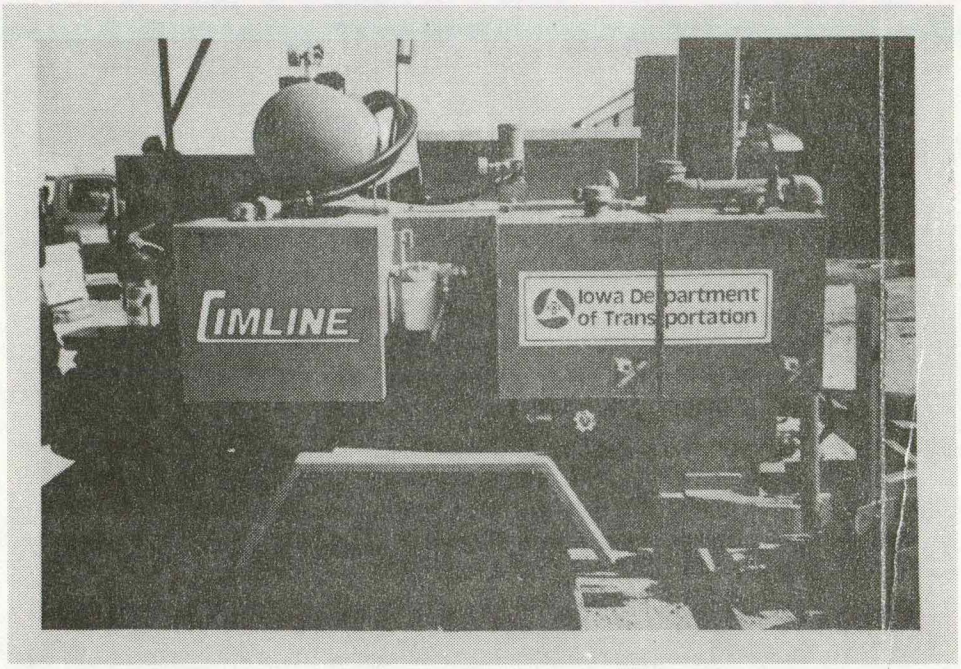

Fig 21

Material heated to too high a temperature or reheated too often may be ruined and require that the meltor-applicator be cleaned of old sealant. (Figure 22)

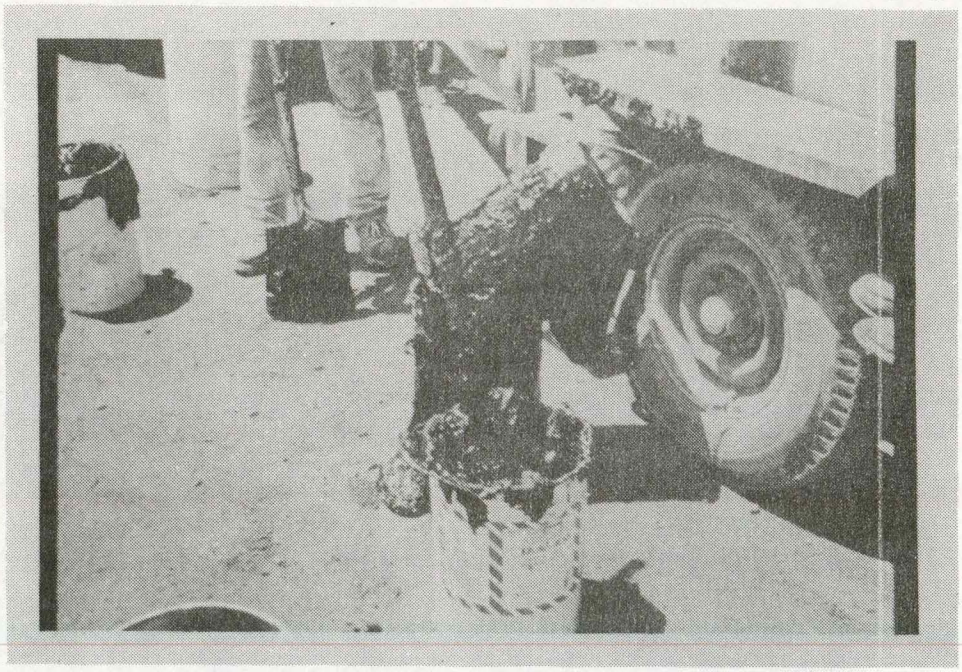

Fig 22

Hot sealer is placed in the prepared crack or joint slightly overfilling the reservoir as shown in Figure 23. Sealer is placed in the prepared crack within three days after the crack routing and sawing operation has been completed.

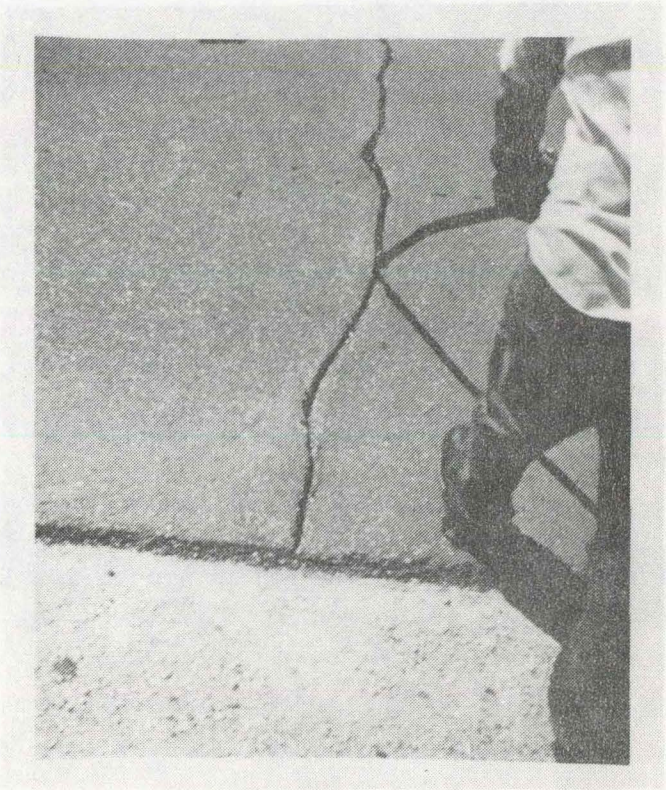

Fig 23

The crack is then tight squeegeed immediately after the sealer is placed in the reservoir. The squeegee should be operated within 1 foot of the wand tip as depicted in Figure 24.

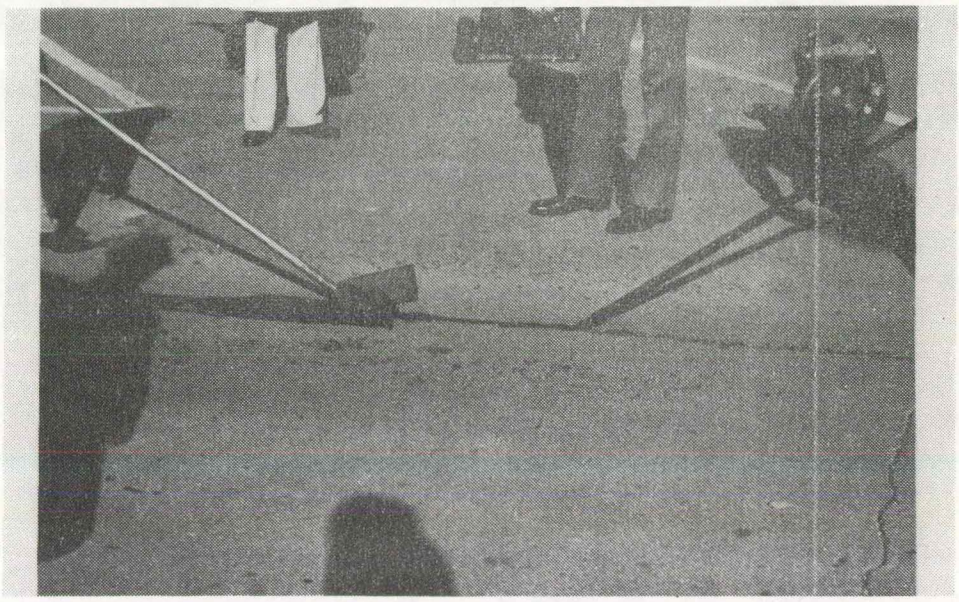

Fig 24

A 2 inch wide squeegee is used to tight squeegee the sealer after the sealer is placed in the reservoir. (Figure 25)

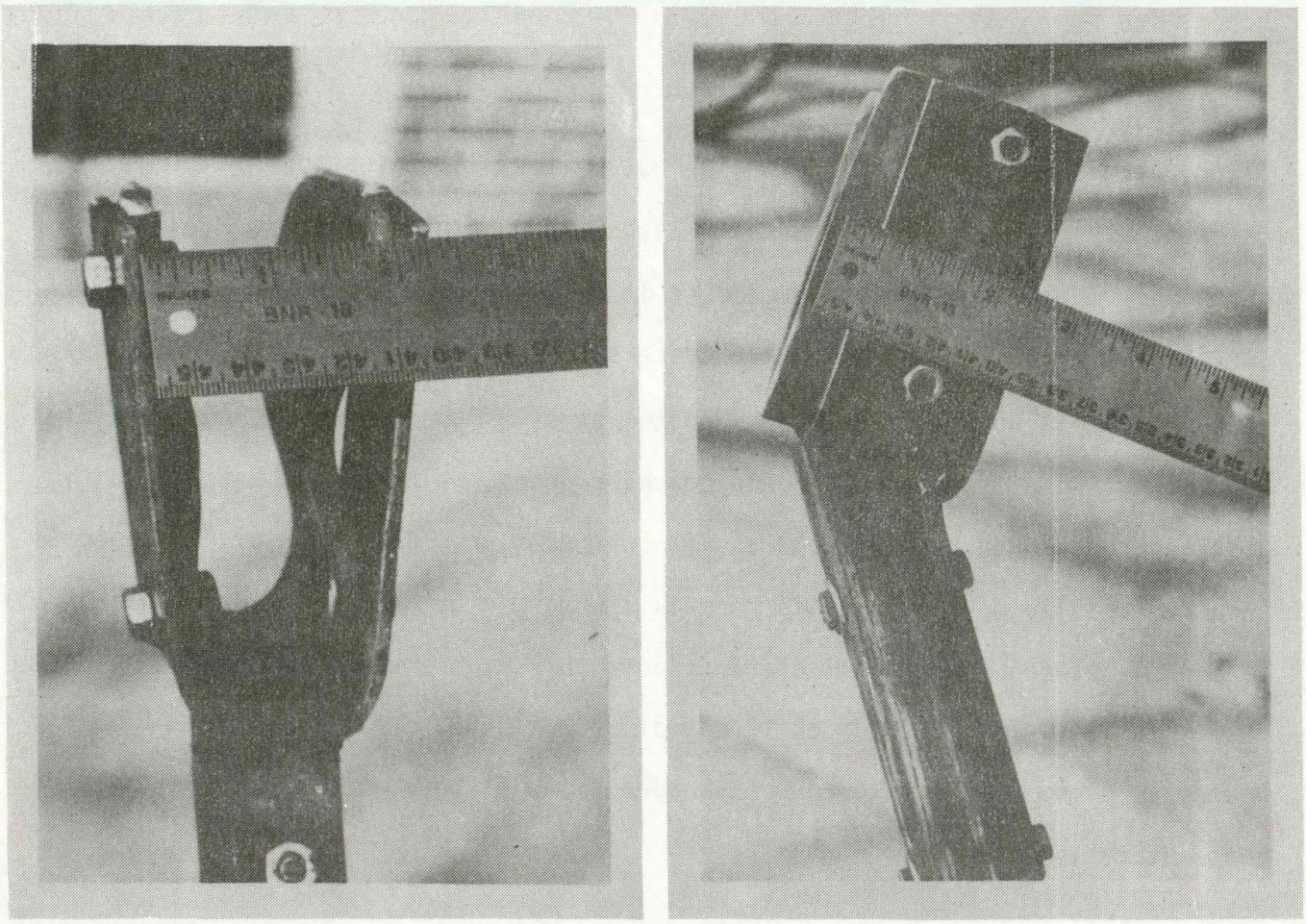

Fig 25

SLURRY LEVELING

Procedures and material requirements are identified in Maintenance Standard - Other Surface Maintenance - Function Code 625 and Special Provision SP-443 (see appendix).

Slurry leveling includes operations necessary to fill depressions in the pavement at and adjacent to cracks in asphalt cement concrete pavement surfaces. Cracks are slurry leveled to improve the ride characteristics and serviceability of asphalt cement concrete surfaces and to fill cracks in those surfaces. This work is scheduled when the edges of the crack have rolled down, creating a depression at each crack or joint, which can be measured with a straight edge and rule. Preparatory work for slurry leveling would be joint and crack filling. This work is normally performed by Department Maintenance personnel between April and the end of September. This season of operation is typical of work performed by contract with a party outside the Department. Slurry leveling is not allowed when shaded areas of the pavement have a temperature less than 50 degrees F.

Materials:

1. Asphalt emulsion, Type CSS-1H or SS-1H
2. Aggregate, commercially available agricultural limestone.
3. Water

Equipment:

1. Slurry mixing equipment, capable of delivering accurately a predetermined proportion of aggregate, water and asphalt emulsion to the mixing chamber and discharging the thoroughly mixed product.

2. Spreading equipment, metal lutes of varying width used to spread the slurry in the depressed area.

Recommended crew size:

1 - Slurry truck driver

1 - Slurry truck operator

3 - Lute operators

Provide necessary traffic control.

Procedure:

1. Preparatory work such as crack filling is completed and the surface to which the slurry is to be applied is cleaned of dust and foreign material.

2. Slurry mixture is placed in the area to be slurry leveled and then spread using a lute wide enough to traverse the depressed area and provide a smooth riding surface.

3. The slurry leveling placed is then allowed to cure until such time that the area may be opened to traffic without pickup or raveling of the mixture.

Figure 26 shows the depressed area near the transverse crack being measured with a straight edge and a rule. Slurry leveling can improve ride characteristics of a pavement surface. In this photo, preparatory work would be joint and crack filling with asphalt emulsion. This work is normally scheduled during the warmer months. Minimum surface temperature for placing slurry leveling is 50 degrees F. as measured in the shaded portion of the pavement.

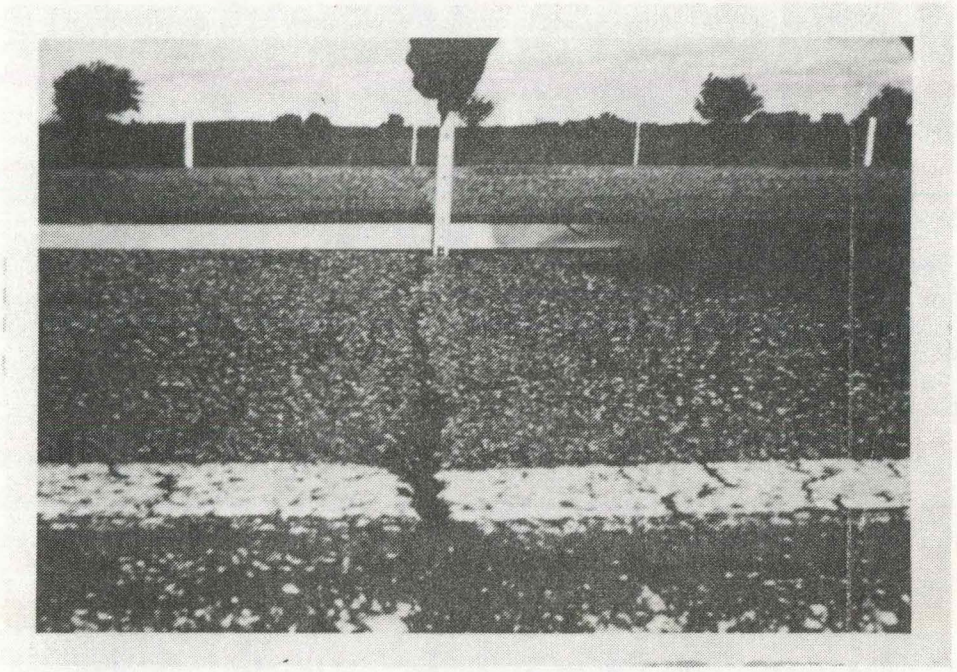

Fig 26

The slurry mixture is composed of asphalt emulsion, Type CSS-1H or SS-1H, water and commercially available agricultural limestone. Figure 27 shows the slurry mixture being deposited on the road surface prior to spreading with a lute.

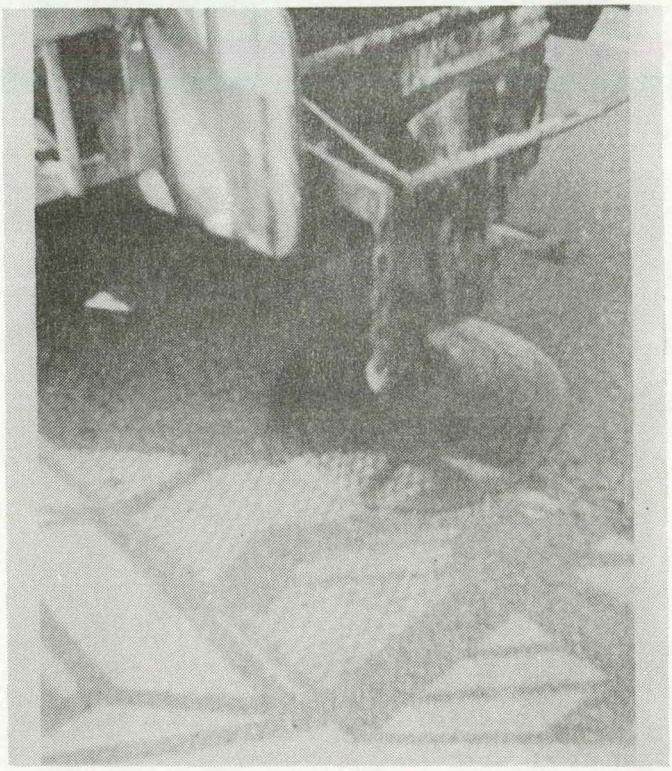

Fig 27

Figure 28 is a picture of a metal lute used to spread the slurry mixture across the length of the joint. The face of each lute is slightly arched to allow clearance of 1/8 inch to 3/16 inch in the center of the lute. This aids in controlling the spread.

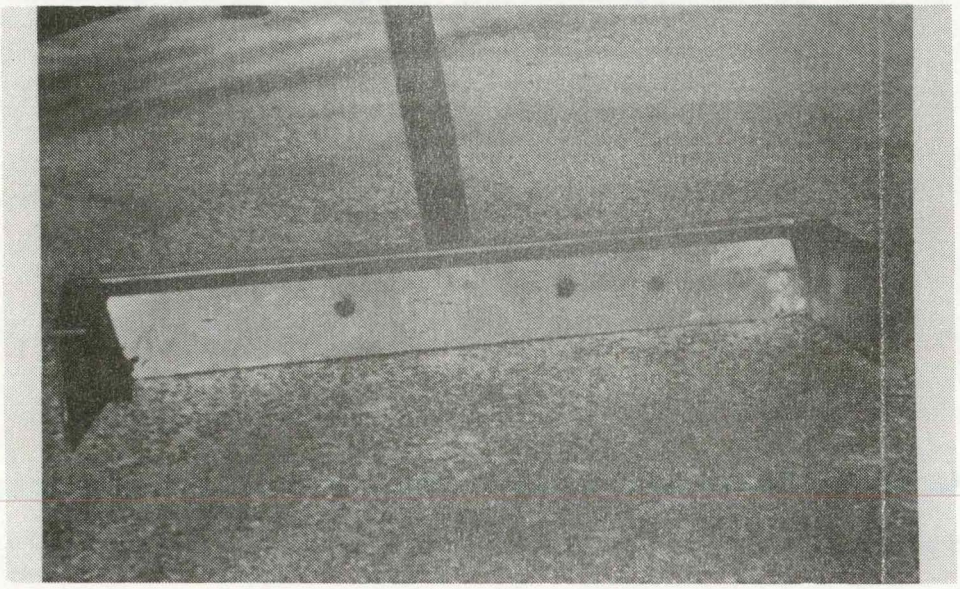

Fig 28

In Figure 29, the mixture is spread across the width of the lane crack. One lane is completed at a time so the road does not have to be closed.

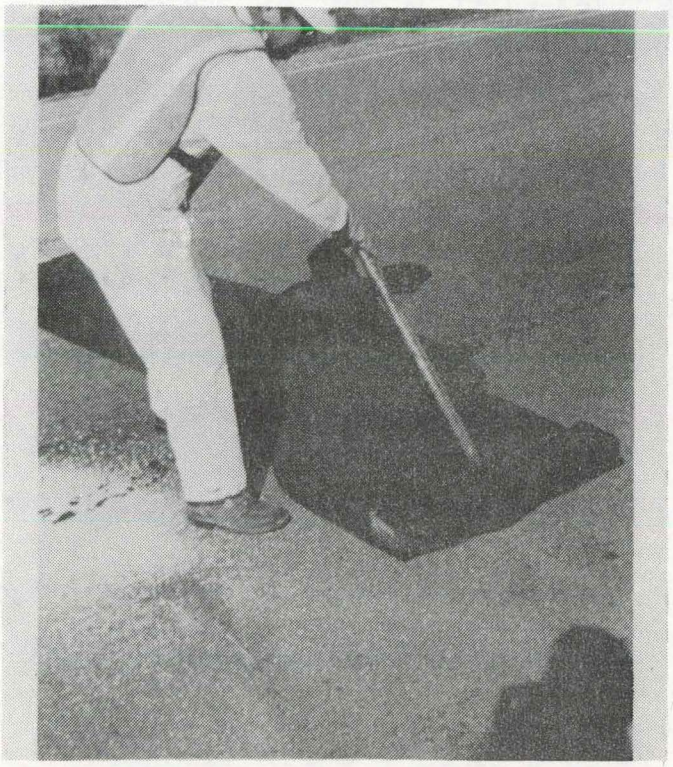

Fig 29

In Figure 30 the slurry leveling placed is then allowed to cure. When the mixture has cured sufficiently so traffic will not damage the mixture, the constructed lane is opened.

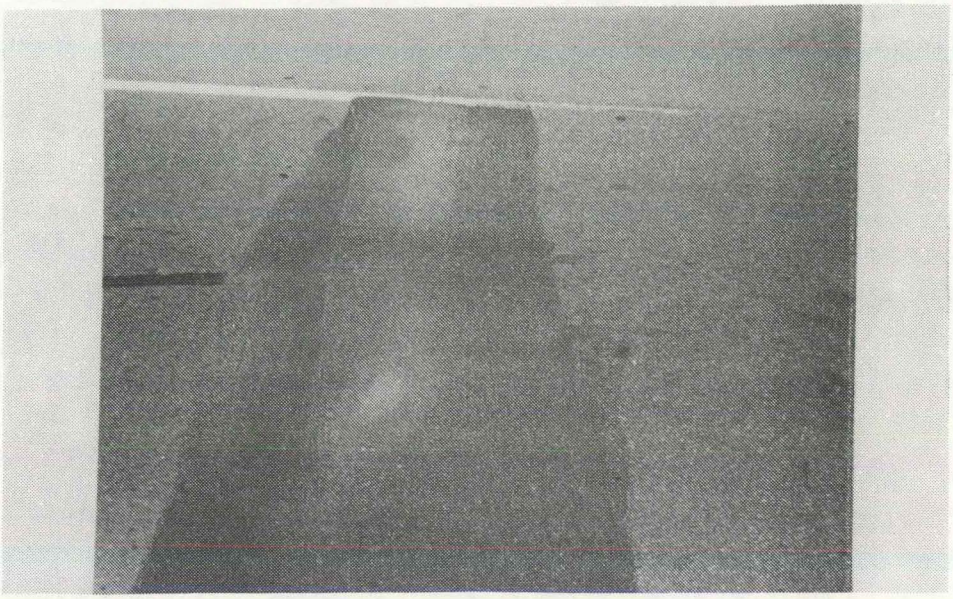

Fig 30

Fiscal Year 1987

Work Accomplished

Cleaning and Filling Cracks:

DOT Maintenance	Maint. Projects by Contract	Construction Projects by Contract (1986 Calendar Year)
339,136 gallons @ $7.48/gallon *	33,679 gallons @ $1.63/gallon	33,975 gallons @ $2.54/gallon
	110.9 miles @ $1,002.77/mile	13.70 miles @ $700.00/mile
	78 tons A.C.C. @ $229.19/ton	

Crack and Joint Routing and Sealing

DOT Maintenance	Maint. Projects by Contract	Construction Projects by Contract (1986 Calendar Year)
33,289 gallons	Cracks 1/2 inch or less	Cracks 1/2 inch or less
@ $13.12/gallon *	229,027 L.F. @ $0.35/L.F.	292,046 L.F. @ $0.42/L.F.
	cracks greater than 1/2 inch	cracks greater than 1/2 inch
	18,770 L.F. @ $0.48/L.F.	2504 L.F. @ $0.42/L.F.

Slurry Leveling of Joints

	Maint. Projects by Contract	Construction Projects by Contract (1986 Calendar Year)
	54.23 miles @ $1,038.77/mile	96.14 miles @ $687.46/mile
	10,738 gallons asphalt emulsion @ $2.11/gallon	18,990 gallons asphalt emulsion @ $1.64/gallon

Note:
Costs do not include traffic control costs.

*Includes all costs associated with function and 1.6 overhead factor.

FORMAL AND INFORMAL STUDIES PERFORMED IN IOWA TO MINIMIZE THE EFFECTS OF TRANSVERSE CRACKING IN ASPHALT CEMENT CONCRETE PAVEMENTS

In 1980 the Iowa Department of Transportation participated in a cooperative study with the highway agencies of Kansas, Nebraska, North Dakota, and Oklahoma. This study was sponsored and funded by the FHWA. A value engineering approach was used for the study. Transverse cracking data from existing roadways was collected and analyzed. This study did not involve new research, but conclusions were drawn by reviewing the available data. Complete documentation of this study is contained in Iowa's final report for Project HR-1020 dated February 1981 and in the Summary Report issued November 1981 by the FHWA.

This study was divided into three areas:

- Mix design
- Maintenance
- 3R rehabilitation

In Iowa, the roads analyzed as a part of this study were the 2100 miles of asphalt pavements having an asphalt surface and a flexible base with a total thickness of 8 inches or more.

An inventory of these roads indicated the majority had transverse cracks at 30-60 foot intervals. However, 208 miles had less than 5 cracks per 500 feet and 113 miles had more than 50 cracks per 500 feet. There were no conclusive findings in the analysis of those roads that exhibited extremely close spacing except that apparently soil cement base will result in high frequency of crack spacing and asphalt pavements constructed on rolled stone base or asphalt treated base tend to have fewer cracks. Also, most roads that had severe cracking problems were in the northeast corner of the state which may indicate geological location and climatological influence on transverse cracking.

An "in-depth" review of the projects that exhibited a high frequency of transverse cracks included examination of the job mix and construction reports. No connection between the job mix design and crack frequency could be developed.

The study did identify fifteen (15) factors involved in the mix design process that should be considered in designing an asphalt pavement that would be more resistant to transverse cracking. These factors will not be addressed here but are included in the final report.

The study also examined the maintenance of transverse cracks. The maintenance standard stated "Cracks will not be filled until they are open 1/4 inch or more." The procedure used to fill them included cleaning with a broom or compressed air and filling to within 1/4 inch below the surface with an emulsified asphalt. Wide cracks were "choked with vermiculite or sawdust to approximately 1½ inches below the surface" before placing bituminous filler to reduce the amount of bitumen required and to improve the quality of the filler.

During this study, Iowa was also considering the use of a blend of ground rubber with penetration grade asphalt cement for use of crack filler. South Dakota had reported success with using this material by eliminating the need to refill for three to five years.

The study also examined the total costs for performing the crack filling. They varied with the type of winter experienced and the amount performed. Average costs per gallon of sealant increased from $3.45/gallon in fiscal 1979 to $4.32/gallon in fiscal 1980. The use of a "full circulating wand" instead of "pouring pots" showed potential for significantly reducing statewide crack-filling costs.

Liquid crack-filling materials commonly used in Iowa during this study period were penetration grade a.c. (120-150), cutback (MC-800) and emulsion (CRS-2).

The trend seemed to point toward increased use of emulsions. They had less tendency to bleed and track. However, their use was limited in freezing weather and storage problems persisted.

It was noted that delay of crack filling can result in severe pavement deterioration and loss of rideability. These defects were corrected with emulsion slurry by leveling the depressed areas with a squeegee.

Transverse cracks were not classified as "surface failure," however the maintenance or repair of surface failure was discussed by the study group. Fog seals, seal coats, and patching were identified as appropriate measures for repairing surface deficiencies.

The study also identified several construction techniques for eliminating or retarding reflective cracking in an ACC overlay. These will not be described here but are included in the final report.

Several conclusions and recommendations were outlined in the final report.

Conclusions

1. Pavement management systems may eventually create a much better data base relative to costs and effectiveness of the various pavement maintenance strategies.
2. There are no treatments currently available which will effectively reduce transverse crack reflection, particularly if the crack is temperature or flexure related.
3. Variability of asphalt from source to source indicates a need for improved design and construction to insure the best possible performance.
4. Factors contributing to transverse cracking of asphalt pavements vary from one geographic area to another. Any recommendations should acknowledge this fact and be tempered accordingly.
5. Fog seals can do much to reduce the aging of asphalt surfaces.
6. Proper timing for placement of fog seals, chip seals, thin overlays with or without fabrics or for milling to restore rideability or improve surface texture can do much to preserve an existing pavement.
7. Transverse cracking is more severe when the mat or surface is placed on subbases or bases containing portland cement or lime.

8. Most of the deterioration and stripping at transverse cracks occurs in the base course indicating a need for more concern in the design of asphalt treated bases.
9. Cracks that have been effectively sealed are not as badly deteriorated as those which have not been sealed.
10. Treating or sealing cracks as they occur can effectively reduce the amount of deterioration which usually develops because of water infiltration.
11. A better quality, cost effective crack-filling or sealing material is needed.
12. Asphalt-rubber is an effective and durable crack sealing material. Routing may be beneficial.
13. Full depth patching is a costly repair technique and the results are not always desirable.
14. Improved surface preparation techniques are needed in the sealing and patching or surfaces prior to placing overlays.
15. Heater scarification can economically correct minor surface distortions and shallow surface cracks.
16. Cold milling is an effective treatment of an asphaltic surface prior to the use of fabric and as a leveling operation prior to overlay.
17. Better under slab drainage systems may reduce the amount of transverse cracking and rate of deterioration. Drainage should be reviewed prior to 3R projects and better pavement drainage provided if deemed necessary.
18. Fabrics or asphalt rubber membranes should be included as one method for prevention or retardation of reflective cracking through overlays and to retard moisture infiltration.
19. Thick overlays are a means of retarding early reflection of transverse cracks.

Recommendations

1. Continued research at the national level to look further into the transverse cracking problem with emphasis on environment, soils and their effect on cracking, admixtures, fabrics, membranes, crack relief layers, etc.
2. Further investigation into the temperature susceptibility and hardening rates of asphalt cements and the actual performance of the asphalt on a source by source basis.

3. Continued regional meetings of technical people for an exchange of information, possibly on an annual basis.
4. Promote research to develop new test procedures and methods which will require less sophisticated and less costly equipment.
5. Develop positive procedures to require timely sealing of cracks.
6. Strengthen specifications and/or requirements for preparing pavement surfaces for overlays.
7. Recommend field compaction requirements that will yield density and void levels to assure maximum durability.
8. More restrictions should be placed on the use of absorptive aggregates.
9. Develop more and better instruction and programs for training agency and contractor personnel in areas of asphalt pavement construction and quality control.

Project HR-1020 produced numerous conclusions and recommendations, but no agreement as to the major factors contributing to transverse cracking or methods of preventing or reducing the occurrence of transverse cracking were identified. It did focus attention on the problem and generated ideas for research.

As a direct result of Project HR-1020, the Iowa Department of Transportation funded two research projects to further evaluate procedures to reduce the adverse effects of transverse cracking.

Research Project HR-217 was initiated to identify the effectiveness of using low temperature susceptible asphalt cement (low Pen Vis number) on reducing the frequency of transverse cracks. Also, preventing the deterioration associated with random cracking by sawing and sealing joints in the ACC surface was evaluated.

This research was incorporated into a Jones County asphalt concrete paving project on Iowa 64 from U.S. 151 to the west junction of Iowa 38. Eight research sections were established to study three variations in asphalt concrete pavement.

The first variation was the comparison of a high and low temperature susceptible AC from two different sources. An AC produced by Amoco Oil Company at the Wood River, Illinois, refinery exhibited one of the lowest temperature susceptibilities of any AC commonly used in Iowa. Also, an AC from Amoco Oil Company of Sugar Creek, Missouri, had a high temperature susceptibility. These two asphalt cements were used to compare the frequency of transverse cracks. It was noted that 3½ years after construction, the crack interval in the Sugar Creek AC was 35 feet and the interval for the Wood River AC was 170 feet.

The second variation was to saw and seal transverse joints at spacings of 40, 60, 80, and 100 feet. The saw cut was a nominal 1/4" wide and a minimum of 3 inches deep. The joints were sealed with an upgraded rubber asphalt sealant.

Initially the joints were cut with a 1/4" carborundum blade without water. There were problems with the cutting residue adhering to the surfaces within the cut. The procedure was modified to use compressed air cleaning immediately following the cutting operation.

Construction was completed in August 1980. All transverse joints appeared well sealed through October 1981. Iowa experienced an extended period of severely cold temperatures during the 1981-1982 winter. On March 1, 1982, a visual inspection revealed substantial failure of the sealant material. The bond between the sealant and the face of the saw cut failed due to the thermal contraction stress from severe temperatures.

It was noted that joints at closer spacings and improved cleaning techniques were performing slightly better than the longer interval. No transverse cracks developed between the sawed joints.

The third variation was to increase the AC content in the asphalt treated base (ATB) by one percent. The intended AC was 4.75% for all ATB except the two increased AC sections placed at 5.75%. The interval between transverse cracks in the areas with increased AC content in the ATB was 528 feet as compared to 170 feet in the remainder of the project.

Conclusions

1. An improved sealant or sealing procedure is needed if transverse joints are to be used in asphalt pavements.
2. The PVN is an effective measure of the temperature susceptibility of asphalt cements.
3. The use of a high temperature susceptible asphalt cement produced severe transverse cracking.
4. The use of asphalt cements with low temperature susceptibility will reduce the frequency of transverse cracking.
5. An increased asphalt cement content in the ATB will reduce the frequency of transverse cracking.

The second research project initiated as a result of the FHWA study was Project HR-232. This project was in Jones and Jackson Counties on Iowa 64 from Wyoming to Monmouth. Construction occurred from July 1981 through September 1981.

The objective was to evaluate the effectiveness of a layer of engineering fabric on reducing the frequency of transverse cracking. The design specified was 9 inches of asphalt treated base (ATB), 1½ inches of Type B binder course, and 1½" of Type B surface course.

The thickness of ATB was reduced from 9 inches to 8 inches where the fabric was used. The fabric used was H01 black nonwoven Petromat (R). AC-10 was used to tack the fabric between ATB lifts.

The fabric did not prevent transverse cracking although the frequency of cracks was slightly lower in the fabric areas.

The fabric sections with 8" of ATB exhibit greater deflections than the 9" thick ATB sections without fabric. It would appear that the fabric contributes very little to the structural capability.

Conclusions

1. Engineering fabric does not prevent transverse cracking of asphalt cement concrete.
2. Engineering fabric may retard the occurrence of transverse cracking.
3. Engineering fabric does not contribute significantly to the structural capability of an asphalt concrete pavement.

In the spring of 1983, Iowa Highway Research Board Project HR-213 involved the evaluation of six crack preparation methods and seven "sealant" materials on both full depth asphalt concrete pavement and portland cement concrete pavement that had been resurfaced with asphalt cement concrete. The work occurred between April 22, 1983, and May 23, 1983, on Iowa 7 in Webster County from the Calhoun County line easterly 6.34 miles.

The crack preparation methods that were evaluated are:

- No preparation
- Blow with compressed air
- Clean with high pressure water (2000 psi) and air dry. The washer used was a Vangard High Pressure Water Blaster Model 1020G capable of delivering 10 gallons per minute at 2000 psi
- Rout with Crafco router and blow with compressed air
- Saw with Cimline crack saw and blow with compressed air
- Saw with Cimline crack saw, blow with compressed air, and install backer rod

Cracks that were less than 1/2 inch wide were routed or sawed so that the reservoir was 1/2 inch wide.

The sealant materials used were:

- CRS-2 emulsion
- Crafco - asphalt/rubber
- Prismo - asphalt/rubber
- Maxwell Products Elastoflex-4
- Allied, Product 9001
- W. R. Meadows, Hi-Spec
- W. R. Meadows, Soft Seal

Crack cleaning with the water blaster was quick and effective in removing dirt, debris, and vegetation. It appeared to produce a cleaner crack than cleaning with compressed air.

Cracks in the full depth asphalt sections were filled to within two inches of the surface with CRS-2 emulsion before they were sealed.

A review of this experimental work was made on September 26, 1983, and again on March 29, 1985.

An evaluation summary is included in Appendix A. Most sealants were performing satisfactory in all sections after four months. However, nearly all had failed after two years.

It was concluded that air blowing and/or high pressure water blasting is not adequate preparation for cracks less than 3/8" wide when a hot pour sealant is used. These cracks must be routed or sawed to provide a reservoir for the sealant.

It was also concluded that CRS-2 emulsion is appropriate for crack filling on aged ACC pavements, but periodic refilling is necessary throughout the remaining life of the pavement.

The Iowa Department of Transportation is also evaluating the effectiveness of constructing a sawed transverse joint in asphalt concrete resurfacing over portland cement concrete.

In 1986 an asphalt resurfacing project was let to contract that involved resurfacing of U.S. 59 in Shelby County from Harlan northerly approximately six miles. The typical design provided for 3-inch overlay.

A change order was negotiated with the contractor that involved referencing the existing transverse joints of the PCC pavement onto the shoulder prior to resurfacing and constructing eight different types of transverse joints in the asphalt cement concrete after resurfacing was completed.

A negotiated price of $1.79 per lineal foot was agreed to for the 15,360 lineal feet of joint. It is felt a lower price may result from competitive bidding.

The sealant material used was W. R. Meadows Soft Seal. The joint configurations were as follows:

	Joint Depth	Joint Width	Preparation
	3/4"	1/4"	Every joint, blow clean, fill
Both Required	2"	1/4"	
	3/4"	3/8"	Every joint, sandblast, blow clean, fill
Both Required	2"	1/4"	
	1 1/4"	3/8"	Every joint, sandblast, blow clean, insert 1/2" backer rope, fill
	1 1/2"	1/2"	Every joint, sandblast, blow clean, insert 5/8" backer rope, fill
	1"	1/2"	Every joint, sandblast, blow clean, fill
	1"	1/2"	Every other joint, sandblast, blow clean, fill
	1"	1/2"	Every third joint, sandblast, blow clean, fill
	1"	1/2"	Every fourth joint, sandblast, blow clean, fill

The construction problem encountered was accurate referencing of the existing joints. It became necessary to blade the granular shoulder material away from the edge of pavement to locate the joints in the PCC pavement.

Where sandblasting was used in preparation for sealing, it was observed that some AC was removed from some of the aggregate adjacent to the sawed joint.

In the fall of 1987, these joints were reviewed and found to be performing satisfactorily.

TABLE II
EVALUATION SUMMARY

Section	Pave.Type *Unit No.	Sealant	Cleaning **Method	Bond Condition 4 Months	2 Years
1	90	Crafco	Air**	Well Bonded	Failed
2	90	Crafco	Air**	Well Bonded	Failed
3	90	Crafco	Air	Well Bonded	Failed
4	90	Crafco	Water	Well Bonded	100% Failed
5	80	Crafco	Air**	Excellent	Failed
6	80	Crafco	Air**	Acceptable	Failed
7	80	Crafco	Air	Good	High % Failed
8	80	Crafco	Water	Good	High % Failed
9	80	Prismo	Air**	Well Bonded	Failed
10	80	Prismo	Air**	Well Bonded	Failed
11	80	Elastoflex	Air**	Well Bonded	Adequate
12	80	Elastoflex	Air**	Well Bonded	Adequate
13	80	Allied	Air**	Satisfactory	30% Failed
14	80	Allied	Air**	Satisfactory	25% Failed
15	90	Prismo	Air**	Well Bonded	100% Failed
16	90	Prismo	Air**	Well Bonded	100% Failed
17	90	Elastoflex	Air**	Well Bonded	Large Cracks 100% Failed
18	90	Elastoflex	Air**	Well Bonded	Large Cracks 100% Failed
19	90	Allied	Air**	Well Bonded	Large Cracks 100% Failed
20	90	Allied	Air**	Well Bonded	Large Cracks 100% Failed
21	90	Hi-Spec	Air**	Well Bonded	High % Failed
22	90	Hi-Spec	Air**	Well Bonded	High % Failed
23	90	Hi-Spec	Air	Well Bonded	100% Failed
24	90	Hi-Spec	Water	5% Failed	100% Failed
25	90	CRS-2	None	100% Failed	100% Failed
26	90	CRS-2	Air	100% Failed	100% Failed
27	90	CRS-2	Water	75% Failed	100% Failed
28	90	SofSeal	Air**	Well Bonded	90% Failed
29	80	Hi-Spec	Air**	Well Bonded	10% Failed
30	80	Hi-Spec	Air**	Well Bonded	10% Failed
31	80	Hi-Spec	Air	Well Bonded	90% Failed
32	80	Hi-Spec	Water	Well Bonded	90% Failed
33	80	CRS-2	None	100% Failed	100% Failed
34	80	CRS-2	Air	100% Failed	100% Failed
35	80	CRS-2	Water	100% Failed	100% Failed
36	80	SofSeal	Air**	Satisfactory	100% Failed

*Pavement Type:
Unit 80 - Composite asphalt over Portland Cement
Unit 90 - Full depth asphalt

**Routed by Crafco router or Cimline saw

Iowa Department of Transportation

SUPPLEMENTAL SPECIFICATION
for
CRACK CLEANING AND SEALING
(ACC Surfaces)

January 19, 1988

THE STANDARD SPECIFICATIONS, SERIES OF 1984, ARE AMENDED BY THE FOLLOWING ADDITIONS AND MODIFICATIONS. THESE ARE SUPPLEMENTAL SPECIFICATION, AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

1049.01 DESCRIPTION. This work shall consist of routing and cleaning of cracks in the asphalt cement concrete surface and sealing of the prepared cracks with a joint sealer.

1049.02 MATERIALS. The joint sealer shall be a material meeting requirements of 4136.02A. A hot-pour sealer will be required.

Backer rope used in conjunction with this sealer shall meet requirements of 4136.02C. The rope shall be of a size that compression is required for installation in the crack so it maintains its position during the filling operation, so more than one size may be necessary to complete the work.

1049.03 EQUIPMENT.

A. Routing or sawing equipment shall be mechanical and power driven, capable of cutting the cracks to the required dimensions. Equipment designed to "plow" the cracks to dimension will not be permitted.

B. Air compressors shall provide moisture- and oil-free compressed air and shall be of sufficient size to blow sand and other foreign material from the crack prior to placing the sealant material.

C. Equipment used for heating and placing the premixed material shall be of the oil-jacketed, double-boiler type, capable of heating the material to 400 degrees F and pumping the material into the prepared cracks.

1049.04 CONSTRUCTION.

A. Class I Cracks. Cracks which have an average opening of 1/2 inch or less shall be routed or sawed to provide a minimum sealant reservoir of 1/2-inch width by a nominal 1-inch depth.

Backer rope may be used. If used, the depth of cleaning and routing or sawing shall be increased if necessary, and the backer rope shall be placed in the crack to a depth that will provide at least 5/8-inch clearance above the backer rope for the sealer. The backer rope shall be dry when placed.

B. Class II Cracks. Cracks which have an average opening greater then 1/2 inch will not require routing or sawing, but they shall be thoroughly cleaned of all foreign material to a depth necessary to accommodate the sealer material and the backer rope to be used.

Backer rope shall be placed in the crack to a depth that will provide at least 5/8-inch clearance above the backer rope for the sealer. The backer rope shall be dry when placed.

C. Prior to opening to traffic, asphalt cement concrete and foreign material resulting from crack preparation shall be removed from the roadway by brooming, compressed air, or other methods satisfactory to the Engineer.

D. Cracks shall be clean and dry prior to sealing. The entire crack reservoir shall be slightly overfilled with sealant and tightly squeegeed with a narrow V-shaped squeegee, immediately after placement of the sealant, and while still hot. The squeegee shall be operated within approximately 1 foot of the wand tip used to place the sealant. Sealant on the roadway surface in excess of 1/2 inch on each side of the crack edge will not be acceptable.

1049.05 LIMITATIONS. Crack cleaning and sealing shall be done only when the ambient air and pavement surface temperatures are above 40°F. When near this minimum, additional air blasting or drying time or both may be necessary to assure a satisfactory bond to the crack surfaces. Crack sealing after September 30 will not be allowed.

The work shall be conducted on only one lane of the pavement width at a time. When work encroaches on an adjacent lane, a flagger will be required at that location.

The work schedule shall be adjusted so that all barricades and equipment are removed from the roadbed from 30 minutes before sunset to 30 minutes after sunrise. No work will be permitted on Sundays or holidays described in 1108.03.

Articles 1107.08 and 1107.09 shall apply.

Lanes may be opened to traffic only after the sealer has set sufficiently so it will not pick up under traffic. Powder may be applied to the sealer, but only after the sealer surface has set so as to avoid penetration of the powder into the sealer.

Cracks shall be sealed within 3 working days after preparation.

1049.06 METHOD OF MEASUREMENT. The Engineer will compute the lengths of Class I and Class II cracks satisfactorily cleaned and sealed. The lengths of transverse cracks will be computed from a count of these cracks and the nominal pavement width. Centerline cracks will be computed as a straight line from the beginning to the end of joint cleaning and sealing. Random cracks cleaned and sealed will be measured along the actual length.

1049.07 BASIS OF PAYMENT.

A. Class I Routing and Sealing will be paid for at the contract price per linear foot.

Payment shall be full compensation for all labor, equipment, materials, and incidentals required for crack routing, cleaning, and furnishing and placing sealant.

B. Class II Cleaning and Sealing will be paid for at the contract price per linear foot. Payment shall be full compensation for all labor, equipment, materials, including backer rope, and incidentals required for cleaning and furnishing and placing sealant.

Iowa Department of Transportation

SPECIAL PROVISIONS
for
MAINTENANCE CLEANING AND FILLING CRACKS
ACC Surfaces

February 26, 1985

589.01 DESCRIPTION. This work is for cleaning and filling cracks in an existing pavement or paved shoulder. It involves filling large cracks and spalled areas with ACC, and filling smaller cracks with filler material. This type of work is intended primarily for existing pavements that are not to be resurfaced. If additional work is to be required, it will be defined elsewhere in the contract documents.

589.02 MATERIALS. Asphalt cement concrete shall be a hot mixture meeting requirements of Section 2203 (1/2- or 3/8-inch mixture size), or 2306, or better, or, subject to approval of the Engineer, a similar mixture from a commercial source. A cold premix mixture may be used with approval of the Engineer. The premix shall meet requirements of Section 4202, 4203, or 4204. The Engineer's approval of the use of a premix will be based on the availability of the specified hot mixture when this work is being done and the length of haul.

Tack-coat material shall meet requirements of 2212.02C.

Filler material shall be emulsified asphalt meeting requirements of Section 4140, Grade CRS-2.

Blotting material shall be a sand meeting requirements of Section 4125 or 4112, or a similar sand approved by the Engineer.

589.03 EQUIPMENT. Equipment shall include the following:

A. High-pressure water equipment capable of delivering water with a pressure of 2,000 psi from a nozzle to the crack being cleaned.

B. High-pressure air capable of blowing sand and other foreign material from a crack.

C. Air chisel or hand tools to remove loose and spalled material adjacent to cracks.

D. Heating kettle or pressure distributor for applying filler material through a hand-operated wand or nozzle.

589.04 CLEANING AND FILLING. Cleaning may be done with high-pressure air or water equipment, except water blasting equipment will not be allowed when the temperature is below 32° F. In all cases, cleaning shall include removal of vegetation from the cracks. Cleaning methods other than those specified in this specification may be necessary to remove vegetation. Other methods shall be subject to approval of the Engineer.

When specifically required by the plans, a soil sterilant, such as Spike or an approved equal, shall be placed in the crack prior to placing the filler material.

For filling cracks, a hand-operated wand or pouring pot shall be used, which is capable of placing the filler material into the crack and filling to the adjacent surface. The nozzle or spout shall be small enough to place the filler material into the crack without soiling the adjacent surface.

All cracks filled with emulsion shall be tightly squeegeed with a narrow, 2-inch or less, V-shaped, rubber-edged squeegee, immediately after placement of the filler. Measures shall be taken to hold the filler in place, preventing run-out at pavement or shoulder edges and low areas; this may be done by use of a sand dam or an application of blotter material, in conjunction with the squeegee operation.

A. Cracks wider than 1-inch shall be made free of loose and spalled material within the opening and loose material adjacent to the opening and shall be cleaned with high-pressure water, blown free of water, tacked, and filled with hot mix. Loose and spalled material shall be removed with an air chisel, picks, or other hand tools.

The cracks shall be cleaned of loose and spalled material, old crack filler when deemed necessary by the engineer, sand, and other foreign debris by the use of high-pressure water. Cleaning shall continue until essentially all debris and loose materials have been removed to a depth of 3 inches within the crack opening.

The cleaned cracks shall be blown free of water.

The crack surfaces shall be lightly tacked with tack-coat material as a hand operation.

The cracks shall be filled with the hot mix specified, rodded and tamped into place and leveled with the adjacent surface. The mixture shall be warm and pliable when placed. This mixture shall be placed prior to filling cracks with emulsion. A thin application of emulsion shall be placed over the hot mix and tightly squeegeed.

B. Cracks 1/4-inch to 1-inch in width shall be cleaned with air pressure or high-pressure water sufficient to remove old crack filler when deemed necessary by the Engineer, sand, and other foreign debris. The depth of cleaning shall be at least 1 inch. The depth shall be to sound material, but a depth greater than 3 inches will not be required.

Cracks shall be filled with emulsion filler material. A hand-operated wand shall be used which is capable of placing the filler material into the crack and filling it to the adjacent surface. The nozzle attached to the wand shall be small enough to place filler material into the crack without soiling the adjacent surface.

C. Cracks less than 1/4-inch shall be cleaned sufficiently to remove old crack filler when deemed necessary by the Engineer, sand, and other foreign debris.

Cracks shall be filled with emulsion filler material.

D. Map-cracked areas shall be covered with emulsion filler material with a suitable hand-operated squeegee.

The filler material shall be a thin, smooth application.

The filler material shall be promptly blotted with a light application of blotter material.

589.05 LIMITATIONS. On projects where a fog seal or other surface treatment is to be done in conjunction with this work, the crack filling shall be done first. Except when this work is in preparation for a seal coat or slurry seal, crack filling may not be allowed on pavements in the months of July and August if tracking or soiling of the pavement becomes a problem. Crack filling on paved shoulders will be allowed during this time.

When filling cracks with emulsion, sufficient time shall be allowed for the emulsion to flow to the bottom of the crack and to fill it completely full. In filling, a second pass may be necessary before leaving the work zone.

One additional filling (or refilling) will be necessary where the filler has settled into the crack opening. These areas will be identified by the Engineer.

The cleaned cracks need not be filled the same day they are cleaned. However, at the time of filling, cracks shall be free of standing water (to be determined by visual examination). Recleaning may be necessary if the openings become contaminated before being filled. The work may be done as a single, coordinated operation.

The work shall be conducted on only one lane of the pavement at a time, and in accord with the traffic-control plan and 1107.09. Use of a pilot car may be required.

Traffic shall be permitted to use the pavement during this construction, and all operations shall be so conducted as to provide a minimum of inconvenience to traffic.

The work schedule shall be adjusted so that all traffic lanes can be opened to public traffic at the end of the workday. All barricades and equipment shall be removed from the roadbed from 30 minutes before sunset to 30 minutes after sunrise. No work will be permitted on Sundays or holidays described in 1108.03.

589.06 METHOD OF MEASUREMENT. The Engineer will measure the work of maintenance cleaning and filling cracks, satisfactorily completed, as follows.

A. Cleaning and Filling Cracks.

1. **Pavement Maintenance.** The Engineer will calculate the number of miles of mainline pavement on which cracks were cleaned and filled. The calculations will be based on the centerline distance of mainline, two-lane pavement, corrected for mainline pavement of more than two lanes, including climbing lanes. At intersections, rest areas, and interchanges designated for cleaning and filling, the additional areas of widened pavement, ramps, storage lanes, turning lanes, paved medians and parking in rest areas will not be separately measured for pavement.
2. **Shoulder Maintenance.** The Engineer will calculate the number of miles of paved shoulders on which cracks were cleaned and filled. The calculations will be based on the centerline distance of the adjacent mainline pavement, a single measurement for shoulders on both sides of the pavement. At intersections, rest areas, and interchanges designated to be cleaned and filled, the additional areas of paved shoulders on ramps, gores, and turning lanes will not be measured separately for payment.

Between limits for which cleaning and filling is intended for either pavement or shoulders, no deductions will be made for bridges, intersections, or other interruptions where cracks are not to be cleaned and filled.

B. ACC for Crack Filling. The Engineer will compute the weight of hot mixture used for filling cracks larger than 1-inch, based on actual weight. Mixture wasted or otherwise not used in the work will be deducted, based on actual weights or estimates.

C. Filler Material (Maintenance). The Engineer will compute the volume of filler material placed, using the method described in 2307.06B. The total quantity will include the material placed in cracks and used to cover map-cracked areas.

Blotting material and tack-coat material will not be measured separately for payment.

589.07 BASIS OF PAYMENT. For the work of maintenance cleaning and filling cracks, the Contractor will be paid as follows:

A. Cleaning and Filling Cracks (Pavement Maintenance) or (Shoulder Maintenance). For the number of miles of pavement or shoulders on which the cracks were cleaned and filled, the Contractor will be paid the contract price per mile.

B. ACC for Crack Filling. For the number of tons of ACC used in filling cracks over 1-inch, the Contractor will be paid the contract price per ton.

C. Filler Material (Maintenance). For the number of gallons of filler material placed in cracks and joints, the Contractor will be paid the contract price per gallon.

These payments will be considered full compensation for cleaning the cracks, furnishing and placing the ACC and filler material and all blotting and tack-coat material that is necessary, and for furnishing all equipment and labor therefor, in accord with the plans and this specification.

Article 1109.03 shall not apply to these items.

Iowa Department of Transportation

SPECIAL PROVISIONS
for
CRACK AND JOINT FILLER AND SEALER
for
PAVEMENT MAINTENANCE

August 19, 1987

SECTION 4201 OF THE STANDARD SPECIFICATIONS, SERIES OF 1984, IS COMPLETELY REVISED AS FOLLOWS. THESE ARE SPECIAL PROVISIONS, AND THEY PREVAIL OVER THE PROVISIONS OF SECTION 4201 OF THE STANDARD SPECIFICATIONS.

706.01 GENERAL. This specification describes material for sealing and filling joints and cracks in rigid and flexible pavement. The material to be furnished will be the type designated in the contract.

706.02 ASPHALT EMULSION.

A. Polymer-Modified Asphalt Emulsion, CRS-2P. This bituminous material shall be a polymer-modified asphalt emulsion, Grade CRS-2P, intended for use as a winter crack filler.
The materials that impart the improved, polymer-modified qualities to the asphalt emulsion shall be incorporated into the base asphalt before the asphalt is emulsified. The addition of latex, rubber, or other additives will not be acceptable.

B. Asphalt Emulsion, CRS-2M. This bituminous material shall be a CRS-2 emulsion with specific modifications designed to make this emulsion suitable for use as a sealer and filler. The asphalt emulsion shall be homogeneous, within 30 days after delivery, and provided separation has not been caused by freezing, the asphalt emulsion shall be homogeneous after thorough mixing. See also Note 5 in Paragraph C.

C. Test Requirements. The asphalt emulsion shall meet the following requirements. Tests are in accord with AASHTO T 59-83I, except as noted.

	CRS-2P		CRS-2M, Note 5	
	Minimum	Maximum	Minimum	Maximum
Tests on Emulsions:				
Viscosity, Saybolt Furol at 122°F (50°C), sec	50	350	100	400
Storage stability test, 24 hr, %	--	1, Note 1	--	1, Note 5
Demulsibility, 35 ml 0.8% sodium dioctyl sulfosucinate, %	40	--		
Classification test	passes		passes	
Particle charge test	positive, Note 2		positive, Note 2	
Sieve test, %	--	0.10	--	0.10
Distillation:				
Oil Distillate, by volume of emulsion, %	--	1.0	--	1.0
Residue, %	65		65	--
Cure test	passes, Note 3			
Stretch test	passes, Note 4			
Tests on residue from distillation Test:				
Penetration, 77°F (25°C), 100 g, 5 sec	120	200	100	150
Ductility, 77°F (25°C), 5 cm/min, cm	40	--	40	--
Ductility, 39°F (4°C), 5 cm/min, cm	30	--		
Solubility in trichloroethylene, %	97.5	--	97.5	--
Softening Point (Ring and Ball, AASHTO T 53), °F	100	--		
Elastic Recovery by means of Ductilometer, %, Note 6	55	--		

Footnotes:

1. Storage Stability. In addition to requirements of AASHTO T 59, on examination of the test cylinder after the emulsion has been standing undisturbed for 24 hours, the surface shall show no white, milky colored substance but shall be a homogeneous brown color throughout.
2. Particle Charge Test. If the particle charge test is inconclusive, asphalt emulsion with a pH value of 6.7 will be acceptable. (AASHTO T 200.)
3. Cure Test. Pour approximately 1 gram or 1 milliliter of the emulsion onto a metal surface. Allow to cure at a minimum temperature of 80°F under a bright light for 4 hours. The outdoors in sunlight may be used as testing site. After the 4-hour curing period, the emulsion shall show no tackiness or tendency to stick the finger when pressed.
4. Stretch Test. Pour onto a 1-quart friction can lid or similar flat container enough emulsion to cover the surface from 1/16 to 1/8 inch. Immediately, and while the emulsion is still brown, embed with thumb pressure several clean, sharp-edged, 3/8- to 1/2-inch stones. Cure in oven at 100°F for a minimum of 8 hours. Remove from oven and allow to cool at room temperature for 1 hour. Lift the stones from the surface. The asphaltic material must stretch out a distance of at least 3 inches before breaking.
5. The manufacturer shall compound the asphalt emulsion with the proper types and quantities of materials so that a storage life at above-freezing temperatures of at least 4 months from the date of delivery may be anticipated.
6. ASTM D 113, except elongate to 20 cm at 5 cm/min--clip strands--Recovery after 1 hr at 50°F, %.

706.03 HOT-POURED JOINT SEALER. This sealer shall be composed of petropolymers and shall be supplied in solid form. The sealer shall be of the hot-pour type and shall meet requirements of ASTM D 3405 with the following modifications:

Penetration at 77°F (25°C)	90-150
Bond at -20°F (-29°C), standard specimen, 3 cycles, 200% extension	Passes

Backer rope used in conjunction with hot-pour joint sealers shall be of a composition approved by the Engineer. The rope must withstand without damage, the high temperatures inherent to the sealers. The backer rope shall have a maximum of 5 percent absorption when immersed in water for 24 hours with the ends sealed. The backer rope shall be of a size that compression is required for installation in the joint, so that it maintains its position during the sealing operation. Backer rope shall be dry. Inspection and acceptance of backer rope shall be in accord with Materials IM 436.04.

706.04 METHOD OF MEASUREMENT. Emulsified asphalt will be measured by weight as delivered in truck transports. Quantities will be corrected to U.S. Standard gallons at 60°F.

Hot-poured joint sealer shall be packaged in containers of 60 pounds or less and with polyethylene liners and shall be on pallets weighing not more than approximately 2,160 pounds each. The containers shall not be stacked higher than four containers on the pallets. The quantity delivered will be determined from the net weight of the containers, using a conversion factor determined by the Engineer.

706.05 BASIS OF PAYMENT. For the number of gallons of emulsified asphalt or hot-poured joint sealer delivered, the Contractor will be paid the respective contract price.

SPECIAL PROVISION

for

SLURRY LEVELING

March 17, 1983

443.01 DESCRIPTION. This work shall involve filling depressions in the pavement at and adjacent to cracks.

443.02 MATERIALS. This work shall be done with an emulsion slurry mixture of the following composition.

A. Asphalt Emulsion shall meet requirements of AASHTO M 208, Type CSS-1h or SS-1h, except the Saybolt Furol Viscosity at 77 degrees F shall not be less than 15 seconds or more than 50 seconds, and the Cement Mixing Test will not be required. A certified analysis of each lot of material shall be furnished at time of delivery.

B. Aggregate shall be a commercially available agricultural limestone produced from sources which normally show an abrasion loss not greater than 40 (grading A or B) and a freezing-and-thawing loss not greater than 10 (Laboratory Test Method 211, Method A) when tested using aggregate crushed to 3/4-inch maximum size.

The aggregate shall have the following gradation.

Sieve Size	Percent Passing
3/8 inch	100 -----
No. 8	85 to 100

C. Water. All water used with the slurry mixture shall be potable and shall be free from harmful soluble salts.

D. Composition and Quality of Mixture. Aggregate proposed for use on the project will be sampled by representatives of the contracting authority to determine a job-mix formula. After consulting with the contractor, a job-mix formula for the mixture will be set by the engineer on the basis of gradation, asphalt content, durability, stability, and asphalt compatability. This formula shall remain in effect until modified in writing by the engineer. When noncomplying results or other unsatisfactory conditions make it necessary, the engineer will establish a new job-mix formula, after consulting with the contractor. Should a change in sources of materials be made, a job-mix formula shall be set before the new material is used.

E. Stockpiling of Aggregate. Precautions shall be taken to insure that stockpiles do not become contaminated with oversized rock, clay, silt, or moisture in excess of that which would interfere with the amount of asphalt required in producing the desired homogeneous mixture. The stockpile shall be kept in areas that drain readily. Segregation of the aggregate will not be permitted.

F. Storage. The contractor shall provide suitable storage facilities for the asphalt emulsion. The container shall be equipped to prevent water from entering the emulsion. Suitable and adequate heat shall be provided to prevent freezing and to facilitate handling of the asphalt emulsion.

G. Sampling. Samples of materials and the finished slurry surface shall be furnished by the contractor as directed by the engineer during the process of the work.

H. Asphalt Content. The estimated asphalt residue content is 8 to 14 percent of the dry aggregate.

443.03 EQUIPMENT. All equipment, tools, and machines shall be subject to approval of the engineer and shall be maintained in satisfactory working order at all times.

A. Slurry-Mixing Equipment. The slurry-mixing machine shall be a mixing unit, capable of delivering accurately a predetermined proportion of aggregate, water, and asphalt emulsion to the mixing chamber and discharging the thoroughly mixed product. The aggregate shall be prewetted immediately prior to mixing with the emulsion. The pugmill shall be capable of thoroughly blending all ingredients together.

When a continuous mixer is used, the mixer shall be calibrated. The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time. The emulsion pump shall be of the positive-displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time. The water pump for dispensing water to the mixer shall be equipped with a valve to establish the required water flow.

B. Spreading Equipment. Metal lutes of varying widths shall be used for spreading the slurry mixture in the depressed areas. The face of each lute shall be indented slightly (1/8 to 3/16") to aid in controlling the spread. The contractor may contact the Office of Maintenance concerning design of these lutes.

443.04 APPLICATION OF SLURRY. The surface to which the slurry leveling is to be applied shall be clean of dust and foreign material. Scraping and brooming may be necessary. The engineer may require the surface to be moistened.

The slurry leveling mixture shall be spread in depressions at and adjacent to cracks in the pavement. Spreading shall be for the full width of the depression. The slurry shall be leveled with a metal lute of the proper width to provide a smooth-riding surface. The slurry leveling shall be neat in appearance, and spillage around and between leveled areas will not be allowed. Waste at the pavement edge shall be kept to a minimum.

The slurry leveling shall be allowed to cure until such time as the area may be opened to traffic without pickup or raveling of the leveling mixture. Any damage caused to the leveling mixture by premature opening to traffic is to be repaired or replaced by the contractor at his expense.

443.05 LIMITATIONS. When this work is in conjunction with crack cleaning and filling, the slurry leveling shall be done only after the crack has been cleaned and filled. It may be done as one coordinated operation.

No more slurry shall be placed than can be opened to traffic 1/2 hour before sundown of the same working day. When traffic is being carried through the work, the entire roadbed shall be free of construction equipment at the close of each day.

Slurry leveling mixture shall not be placed when the temperature on a shaded portion of the road is less than 50 degrees F.

443.06 MAINTENANCE OF TRAFFIC. Suitable methods, such as barricades, flaggers, pilot cars, etc., shall be used to protect the public and the uncured slurry surface from all types of traffic. Any damage to the uncured slurry will be the responsibility of the contractor. The road will not be closed for construction. The work shall be conducted on only one lane of the pavement at a time. Normal traffic shall not be delayed unnecessarily. The provisions for handling traffic are to be according to the traffic-control plan and 1107.09. Use of a pilot car may be required.

The work schedule shall be adjusted so that all traffic lanes can be opened to public traffic at the end of the work day. All barricades and equipment shall be removed from the roadbed from 30 minutes before sunset to 30 minutes after sunrise. No work will be permitted on Sundays and holidays described in 1108.03.

443.07 METHOD OF MEASUREMENT. The work of slurry leveling, satisfactorily completed, will be measured as follows:

A. Slurry Leveling. The number of miles of slurry leveling will be computed by the engineer, based on two-lane pavement width.

B. Asphalt emulsion for Slurry Leveling. The volume of asphalt emulsion used for slurry leveling will be measured by the method described in 2307.068.

443.08 BASIS OF PAYMENT. The work of slurry leveling will be paid for as follows:

A. Slurry Leveling. For the number of miles of slurry leveling completed, the contractor wil be paid the contract price per mile. This payment shall be full compensation for furnishing all the materials for the slurry mixture except the asphalt emulsion, for mixing and placing the mixture, and for furnishing all equipment, tools and labor therefore.

B. Asphalt Emulsion for Slurry Leveling. For the number of gallons of asphalt emulsion used in the slurry leveling mixture, the contractor wil be paid the contract price per gallon.

MAINTENANCE STANDARD

IOWA DEPARTMENT OF TRANSPORTATION
Highway Division
Office of Maintenance

APPROVED BY: _____ Maint. Engr. Date: Revised 12-13-85

FUNCTION TITLE: Joint and Crack Filling FUNCTION CODE: 612

FUNCTION CATEGORY: ROADWAY SURFACE

WORK PROGRAM CATEGORY: Routine Limited

DESCRIPTION & PURPOSE:

All operations associated with filling of cracks and constructed joints in ACC paved surfaces with emulsified or cutback asphalts to reduce entry of moisture and foreign materials.

Crack and joint filling on asphalt shoulders adjacent to ACC Pavement and filled concurrently with the pavement cracks and joint may be charged to this function. Other joint and crack filling on shoulders and filling the joint between pavement and paved or stabilized shoulder will be charged to function 632.

LEVEL OF MAINTENANCE (Quality Std.):

The term "cracks" shall include transverse expansion joints, built-in construction joints, longitudinal and transverse cracks caused by shrinkage, settlement or structural problems.

Cracks should be filled as soon as they are open wide enough to accept filler material.

A narrow squeege should be used on flexible base pavements where secondary cracks have developed adjacent to the primary crack and for all crack filling just prior to a surface restoration project.

SCHEDULING GUIDE: Normal monthly accomplishment as a percent of total program.

JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
3	4	3	3	4	5	13	17	18	14	11	5

Accounts for 2.3% of total maintenance manhours.

RECOMMENDED PROCEDURES:

Refer to Appendix A to select the proper traffic control plan.
Code traffic control to function 673.

1. Clean cracks with compressed air, water blaster or brooming to remove dirt, sand or aggregate.

2. Pour filler in cracks being careful not to overfill.

3. If filler is accidentally spilled on to surface or when a squeege is used, blot with lime dust, sand or other fine material.

4. Sand or aggregate should be used to construct dams to prevent filler from running out the lower end of cracks.

Provide safety equipment as required for the operation.

Reference:

MATERIALS:

Emulsified asphalt
Sand or Aggregate Lime

RECOMMENDED CREW SIZE:

1 - Waterblaster (when necessary)
1 - Air compressor truck driver
1 - Distributor truck driver
2 - Wand operators
1 - Crack cleaner
1 - Squeegee, when used
1 - Sander, when used

RECOMMENDED EQUIPMENT:

2 - Dump trucks
1 - Distributor
2 - Recirculating wand
1 - Water blaster (when available)
Hand tools as needed
1 - Air compressor

ACCOMPLISHMENT:

Unit: Gallon of filler
Standard Rate: 4.31 gallon per manhour
Daily Production: 169 - 241 - 313

IOWA DEPARTMENT OF TRANSPORTATION
Highway Division
Office of Maintenance

APPROVED BY: Leland D Smith Maint. Engr. Date: Revised 6-12-87

FUNCTION TITLE: Joint and Crack Routing and Sealing FUNCTION CODE: 616

FUNCTION CATEGORY: ROADWAY SURFACE

WORK PROGRAM CATEGORY: Routine Limited #

DESCRIPTION & PURPOSE:

All operations associated with sealing of random cracks, reflection cracks and construction joints in P.C.C. and A.C.C. paved surfaces with hot pour sealing compound to seal cracks and joints against entry of moisture, incompressibles and other foreign materials.

Crack and joint sealing on paved shoulders (A.C.C. or P.C.C.) adjacent to paved roadways and sealed concurrently with the pavement cracks and joints may be charged to this function. Other crack and joint sealing on shoulders and sealing the joint between the pavement and paved or bituminous shoulder will be charged to function 632.

LEVEL OF MAINTENANCE (Quality Std.):

The term "cracks" shall include transverse expansion joints, built-in construction joints, longitudinal and transverse cracks caused by shrinkage settlement and structural problems. Cracks should be routed and sealed as soon as they are open wide enough to become visible and movement is apparent.

Cracks or joints 1/2 inch or more in width do not need to be routed, but must be thoroughly cleaned and dry prior to sealing. Unit 10 surfaces should be sand blasted.

Cracks and joints cleaned deeper than 1 1/2 inches will need to be choked with backer rod, dry sawdust, vermiculate, etc. to about 1 1/2" below the surface to reduce the quantity of sealant required and to improve the quality of the seal.

A narrow (2" or less wide) squeege should be used on ACC surfaces to aid in placement of the sealer and to insure a quality seal.

SCHEDULING GUIDE: Normal monthly accomplishment as a percent of total program.

JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
5	5	12	9	6	4	6	6	12	13	12	10

RECOMMENDED PROCEDURES:

Refer to Appendix A to select the proper traffic control plan.
Code traffic control to function 673.

1. Rout all cracks less than 1/2 inch in width.
2. Clean cracks and joints 1/2 inch or more in width with compressed air, water blaster, or sand blaster when required, to remove dust, dirt, sand, moisture, or other foreign material.
3. Place hot sealer in prepared crack or joint (ACC surfaces) slightly overfilling the reservoir and follow immediately with the narrow squeege.
4. A squeege should not be used when sealing PCC pavements.

Provide safety equipment as required for the operation.

Reference: See sealant manufacturer's instructions for heating and applying sealer

MATERIALS:

Hot pour sealer
Backer rod - sawdust - vermiculite, etc.

RECOMMENDED CREW SIZE:

Crack Preparation
2 - Crack routers or
1 - Water blaster (when necessary)
1 - Sand blaster (when necessary)
1 - Air compressor truck driver
1 - Crack cleaner

Crack Sealing
1 - Applicator loader and observer
1 - Melter applicator truck driver
1 - Wand operator
1 - Crack cleaner
1 - Squeege operator

RECOMMENDED EQUIPMENT:

2 - Crack routers or
1 - Water blaster (when necessary) / with truck
1 - Sand blaster (when necessary) / with truck (PC only)
1 - Air compressor
Hand tools as needed

1 - Dump truck
1 - Melter/applicator
1 - Air compressor
Hand tools as needed

ACCOMPLISHMENT:

Unit: Gallon of Sealant
Standard Rate: 4 gallon per manhour
Daily Production: 192 - 256 - 320