Pressurized Emulsion Mix—Crack Repair

CHARLES L. HUISMAN
Materials Engineer
Highway Division—Office of Materials
Iowa Department of Transportation

INTRODUCTION

Many sections of primary and interstate asphalt pavement highways in the Iowa system have developed a series of transverse thermal cracks at regular intervals from 40 to 100 ft. over the length of most of the sections. The standard method for filling cracks of this type prior to the experimental procedure, described here, included gravity filling of the cracks in the winter months of January, February, and March with an asphalt emulsion, penetration asphalt, cutback asphalt, or other crack filling materials, depending on the gravity flow of the materials to fill the crack. In cold winter weather, little more than a surface application of crack filling material was accomplished. Consequently, it was necessary to repeat this crack filling operation every winter season for several years before an effective crack fill could be accomplished.

Last winter, at the highway division, we attempted to devise an economical way to repair cracks in the state's asphalt highways; which has lead to development of a new road crack filling method. The method and equipment were developed and constructed by the materials office staff and the machine shop personnel of the materials laboratory. It involves pressure pumping and asphalt slurry mixture into highway cracks. The method was actually developed in a brainstorming session with the highway division director, the deputy director for development, and myself. We had tried to let a repair project on a 34-mile section of U.S. 71, south of Atlantic, Iowa last winter which involved removing pavement along cracks and patching the road. The cost was extremely high and consequently the bids were rejected.

We began to look for a new way to repair the road which would be better than traditional methods. the traditional method of repairing road cracks uses liquid asphalt through a wand which puts the material onto the crack and gravity flow places it in the crack. In this new method, an asphalt slurry mixture made of 50% liquid asphalt and 50% agricultural limestone ground to 100% passing the 1/4 in. sieve is used. The asphalt slurry is pumped into the crack at pressures as high as

120 psi and in the process it displaces any water that is present in the crack of the asphalt pavement.

We had found on this particular section of highway that the thermal cracks in the road would allow water to get under the asphalt and into the subgrade of the pavement. This softened the subgrade and with repeated loading of the asphalt pavement with traffic, caused a depression or sag at the thermal crack. It also generated hydraulic pumping, wherein the water would pump up through the crack and bring with it the fines material of the subgrade developing a cavity, and eventually a rather serious deterioration of the pavement along the crack. We were looking for an inexpensive way to stabilize the asphalt and stop the continued deterioration of the pavement at each of these cracks.

[Editor's Note—The remainder of the text actually consists of 36 figure captions. The captions are the comments the author made for a slide presentation. The 36 following figures were made from color slides which do not reproduce well as black and white photos.]

CRACK CLASSIFICATION AND REPAIR

Figure 1. A closeup of a typical thermal crack on a rural asphalt pavement. Note in the close foreground that the fines of the granular base material are actually pumping out of the pavement onto the shoulder, causing an undermining of the pavement slab and the depression along the crack manifested in alligator cracking.

Figure 2. In an earlier analysis of our typical thermal cracks on the Iowa asphalt pavement sections, we have classified cracks into four categories. This is a typical Class 1 crack on a rural asphalt pavement.

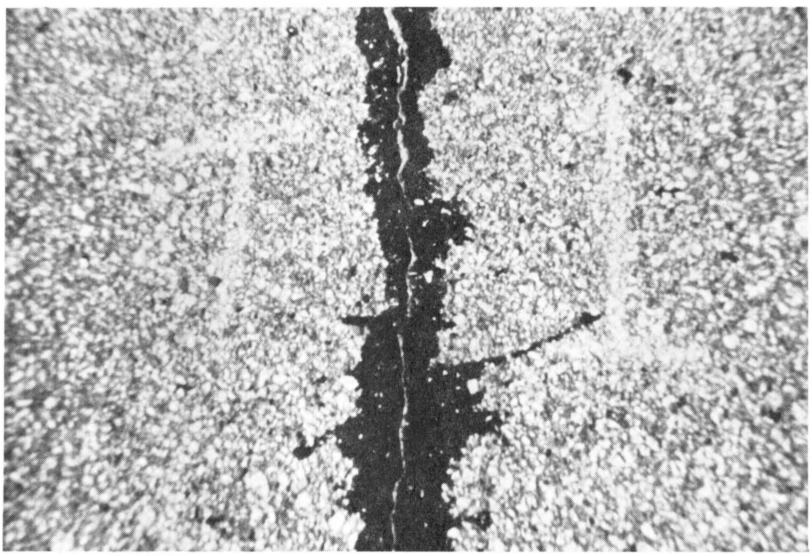

Figure 3. A closeup of that same Class 1 crack with the typical surface crack sealing that had been practiced universally over the state for many years.

CLASS I
A.C. PAVEMENT SURFACE CRACKS

VISUAL CONDITIONS:	METHOD OF REPAIR:
1. 0.0" to 0.25" average depression	1. Blow with compressed air to remove loose material
	2. Seal crack with emulsified asphalt (CRS-2)

Figure 4: Our classification of a Class 1 crack involved a visual indication or measurement of from 0 to 1/4 in. average depression. The standard method of repair was to blow the crack with compressed air to remove loose material and seal the crack with an emulsified asphalt.

Figure 5. A typical Class 2 crack with maintenance crack filling treatment.

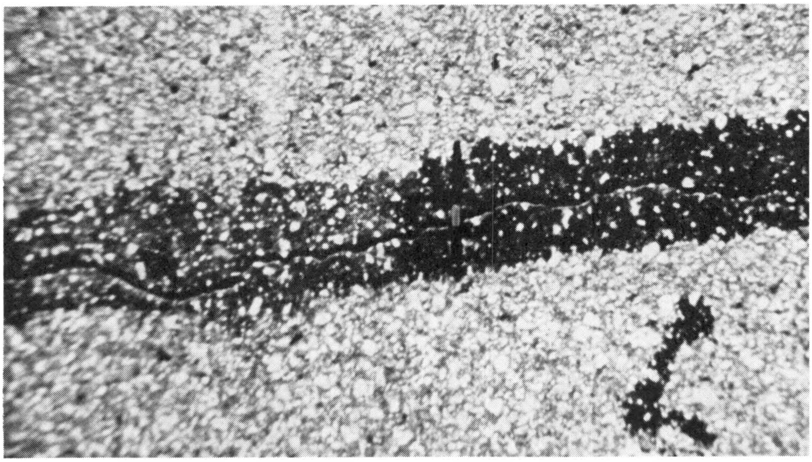

Figure 6. A closeup of the Class 2 crack which exhibited a visual average surface depression of from 1/4 to 1/2 in.

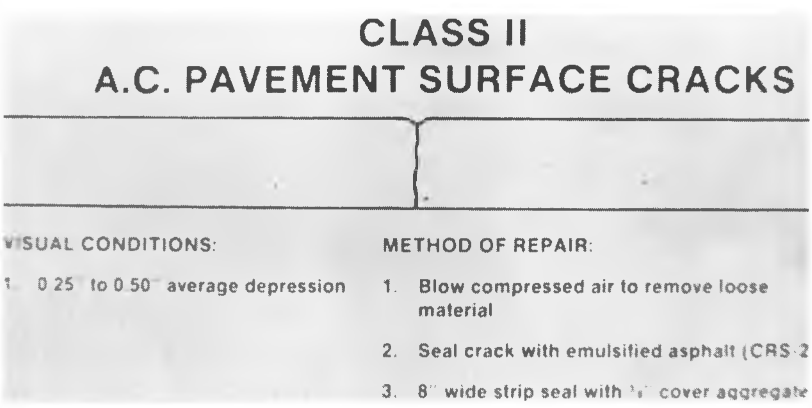

Figure 7. The method of repair involved blowing out and removing the loose material, sealing the crack with emulsified asphalt, followed by an 8-in.-wide strip seal over the crack with 3/8-in. cover aggregate. This filled the gradual depression that developed on each side of the crack.

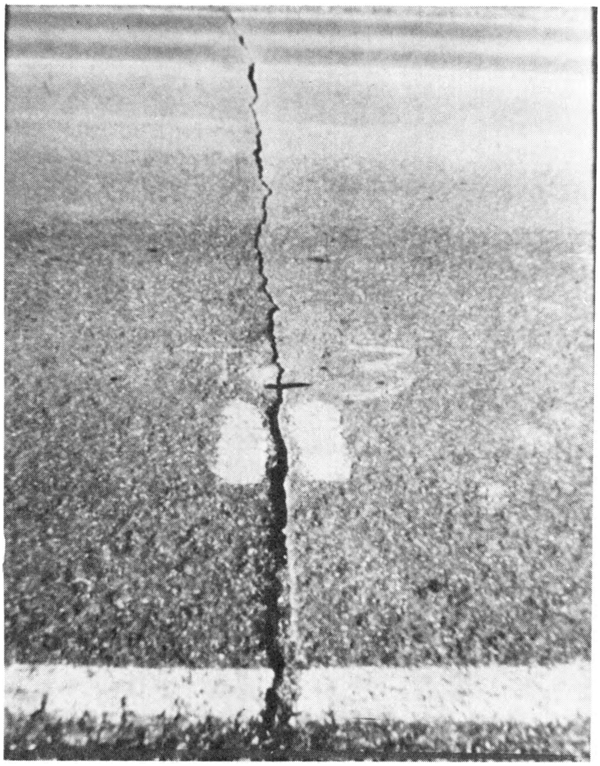

Figure 8. **This typical Class 3 crack on the U.S. 71 project had no prior crack sealing or maintenance treatment. The classification of this crack is made by a 1/2-to 1-in. average depression. It is nearly a straight line transverse crack and occasionally a secondary crack develops on either side of the primary crack.**

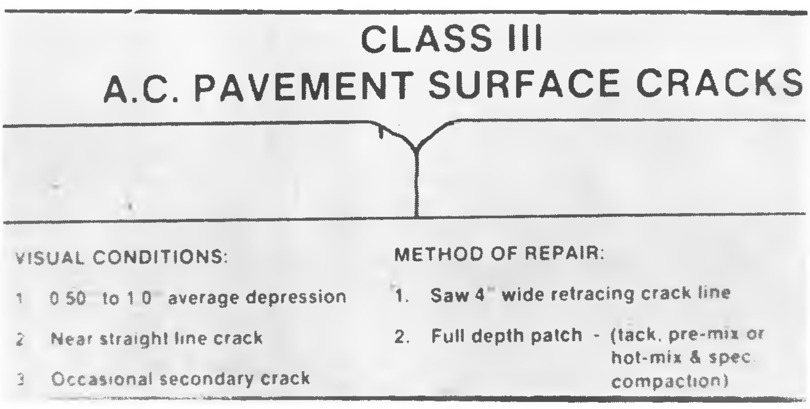

Figure 9. **Our design method of repair was to saw out a 4-in. wide trench, retracing the crack line, and to make a full depth patch with a tacking, premix, or hot mix by standard compaction methods.**

Figure 10. This is a typical Class 4 crack where the deterioration has progressed dramatically from the Class 3 crack. There is no evidence of maintenance repair procedures.

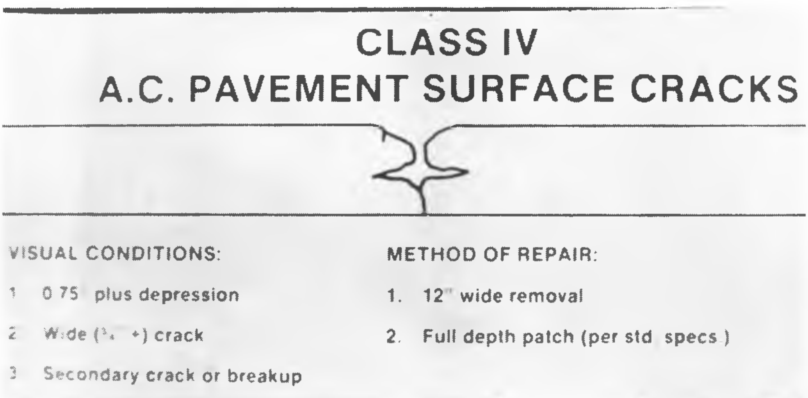

Figure 11. A Class 4 crack has these visual conditions: Usually 3/4 in. or more depression, the crack is 3/4 in. or more wide. It has a secondary crack or area of breakup adjacent to the crack. The method of repair is to remove the pavement 12 in. wide full depth and replace it with an asphaltic concrete patch per our standard specifications.

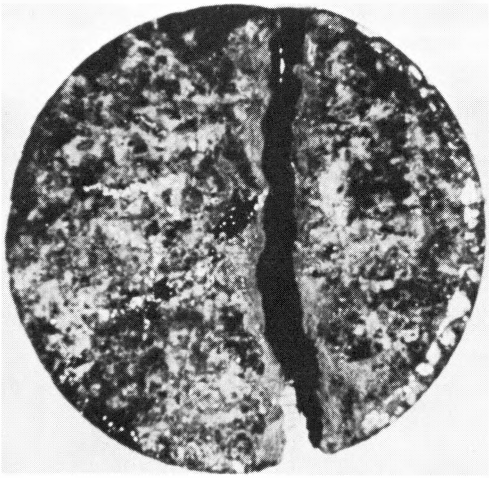

Figure 12. A core of a typical Class 3 crack was taken from the pavement shown in Figure 8.

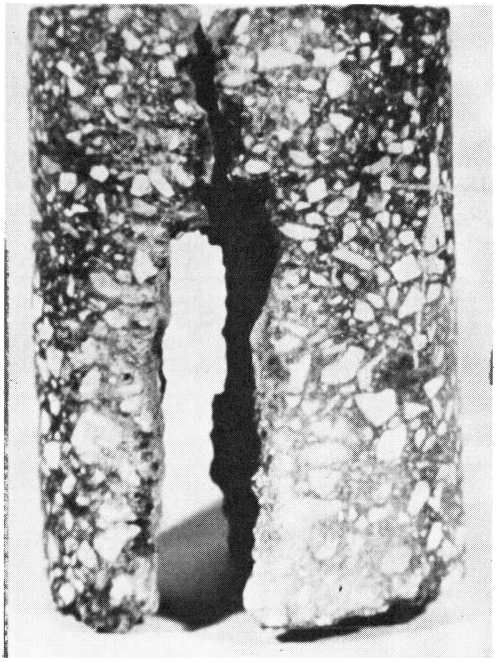

Figure 13. A side view of that same crack. It was very revealing that, at the lower elevations of the asphalt pavement, there was considerable stripping of the asphalt from the aggregate and, with the continued traffic and hydraulic action of water in these cavities and under the pavement, the fines were being pumped out of the pavement and causing rather severe depressions at the transverse thermal cracks.

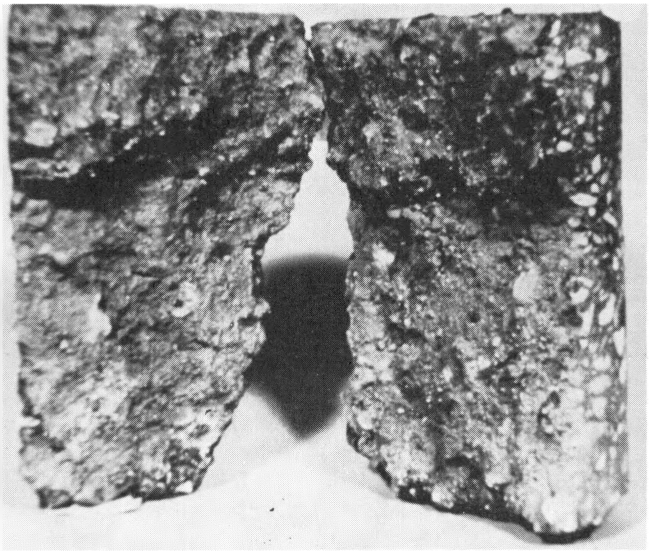

Figure 14. A view from the opposite side of the same core shows a more extensive deterioration on this side of the cored pavement. We concluded from this finding that it would be very difficult to be able to fill these cracks with a cold weather normal surface crack filling operation with wands and gravity filling and that it would be necessary to try to inject a slurry asphalt emulsion mixture into the cracks under pressure.

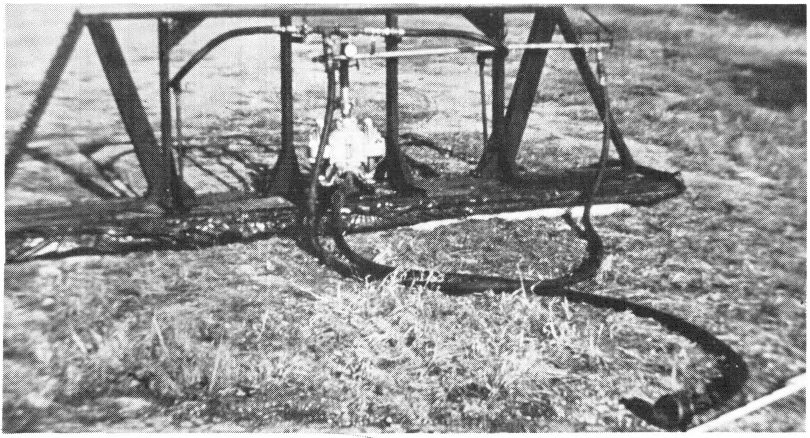

Figure 15. In order to accomplish this, we built this steel truss section that is approximately 11.5 ft. long. The platform is about 18 in. wide, is covered with a 2-in. solid plank platform which is further covered with a 3-in. mat of high density, flexible polyurethane foam covered by a polyethelene membrane. A pneumatic pump is mounted in the center of the truss section and to it's right and left about 4 ft. is the extension of nozzles that protrude through the bottom of this platform. In the foreground, a suction hose sucks slurry into the pump and through the nozzles into the pavement cracks.

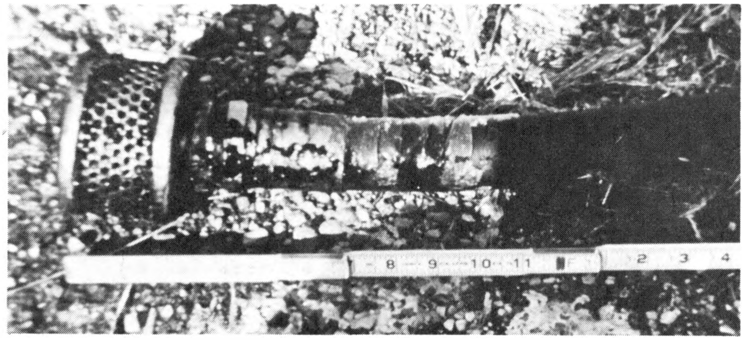

Figure 16. A closeup of the strainer on the end of the suction hose.

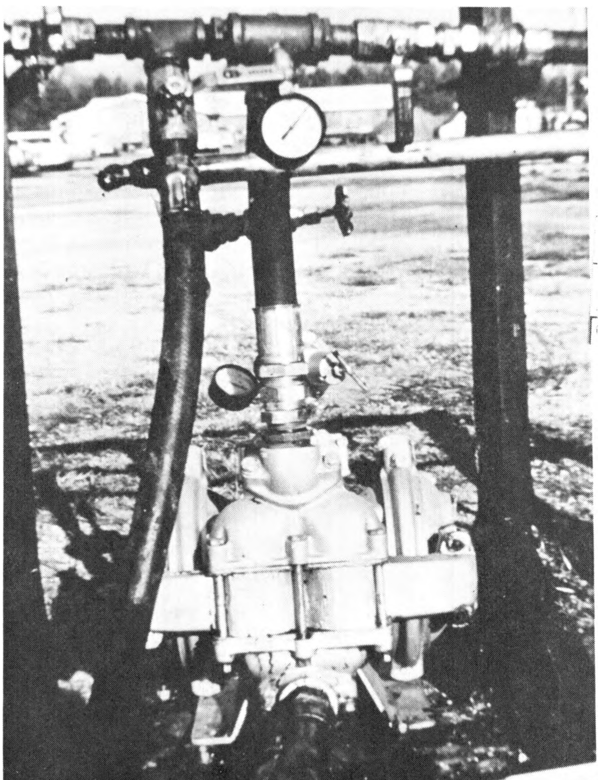

Figure 17. The heart of the pressure injection unit is a Warren-Rupp Sandpiper air-powered diaphragm pump. It is designed to pump viscus and granular liquids at pressures from 2 to 120 psi. The ball check valves in the pump are teflon coated to expedite cleaning after pumping asphalt slurry materials. At the bottom of the pump the inlet hose brings the slurry mixture from the mixer into the pump. At the top of the pump is the discharge line with a pressure gauge. The gauge shows the slurry material pressure as it is extruded and pumped through the nozzle system.

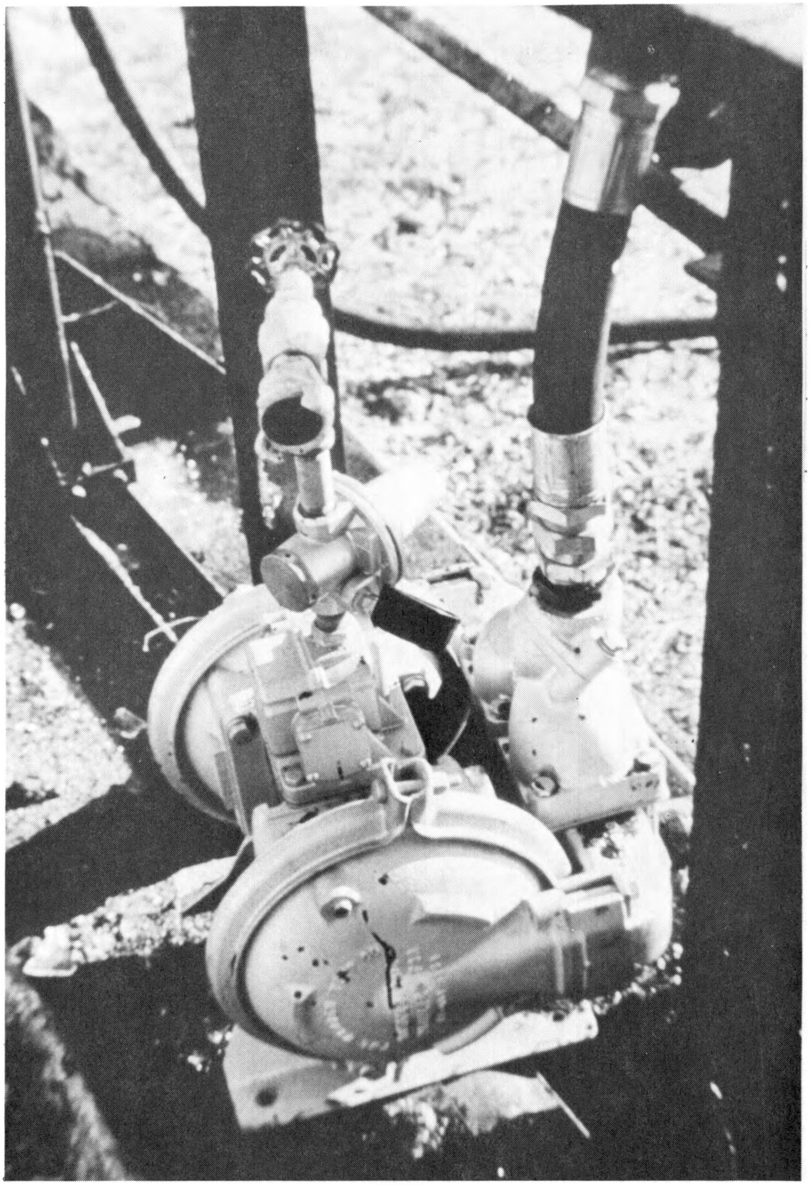

Figure 18. Another view of the pump from the backside shows the air inlet and control valve and also the pressure regulator to modulate the pump's pressure. A unique feature of this pneumatic pump is that it will stop pumping slurry when the pressure of the slurry equals the pressure of the air system furnishing the power to the pump. By adjusting the regulator to the desired pressure, one can also control the pressure of the slurry pumped into the pavement crack providing a range from 2 to 120 psi.

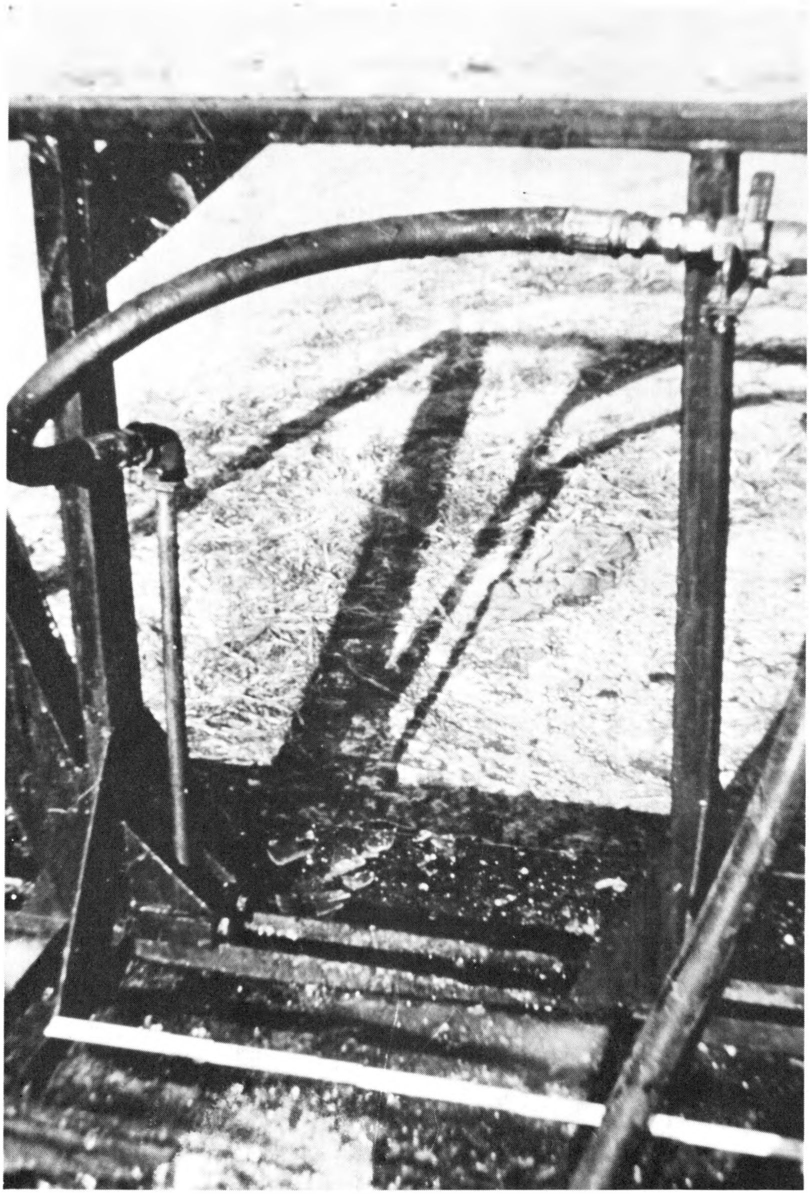

Figure 19. This shows one of the two nozzles which are mounted about 4 ft. either side of the center of the truss section. They have quick shutoff valves on each line going to the nozzles. These nozzles are adjustable to any depth; Ideally the nozzle openings are at about the elevation of the interface of the subbase or subgrade and the asphalt treated base of the pavement.

Figure 20. A closeup of the typical nozzles that were designed and built for this operation. We have used the tungsten carbide tip of the standard pavement scarifier used both by CMI, Galion, etc. It is slotted above the tungsten carbide tip. The original idea of this nozzle design was that the down pressure of the loader would force the nozzle into the pavement crack. We found that this was feasible in fairly warm weather, but it was not feasible in cold winter weather and we had to resort to other methods described in a later caption.

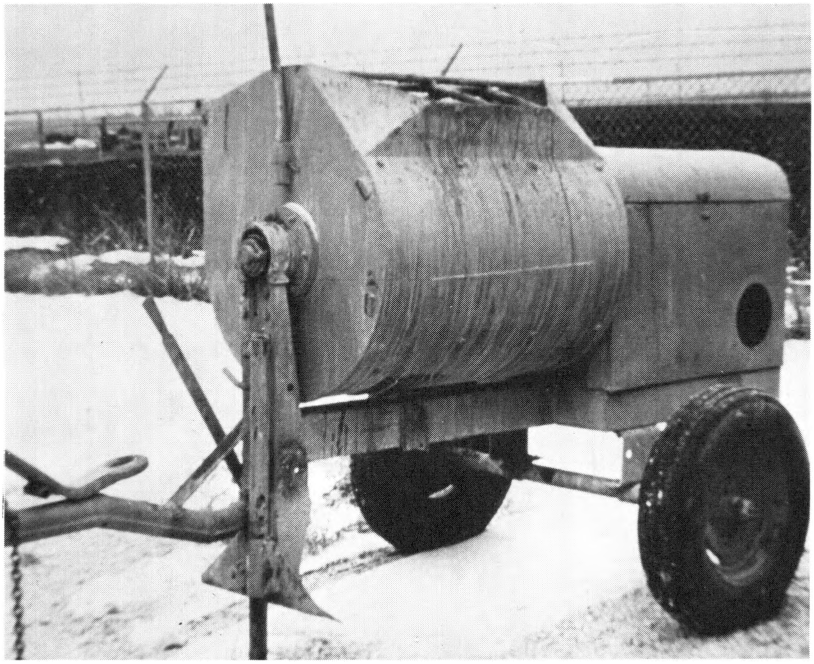

Figure 21. Highway maintenance crews used this typical mortar or plaster mixer for mixing concrete and/or mixing asphalt emulsion and/or slurry mixtures. This was one of the mixers we utilized later on in other crack filling activities. The only modification necessary was the addition of a tapered, threaded tap made in the bottom of the drum so that an elbow, valve, and reservoir could be placed underneath this outlet to control the discharge of the slurry which then was picked up by the pneumatic pump and pumped into the pavement cracks. The pumpable slurry crack sealing mix was designed in our bituminous laboratory and the best formulation for this pumping operation involved a 50% limestone aggregate and a 50% CSS-1 emulsion by weight.

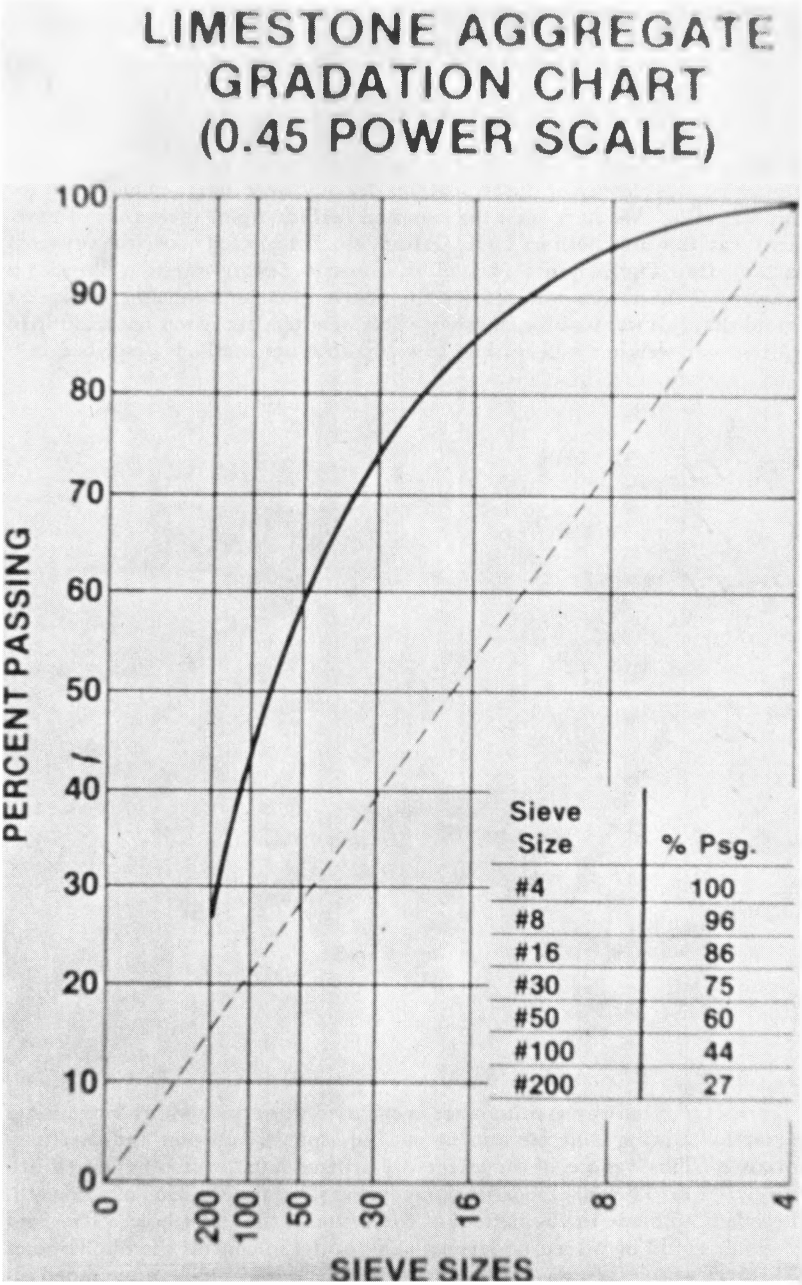

Figure 22. On this typical limestone aggregate gradation chart note 100% passed the No. 4 sieve, up to 27% passed the No. 200 sieve. It is a typical by-product of many of the limestone quarry aggregate producing operations over the southeast two-thirds of the state of Iowa.

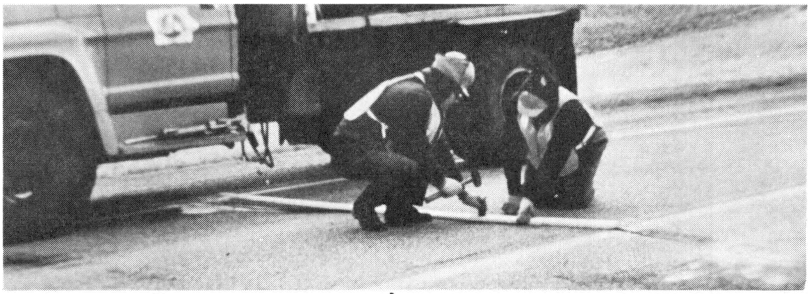

Figure 23. We believe the best time of year to fill asphalt pavement cracks is in the coldest part of the winter or early spring when the cracks are at their maximum opening. This slide shows a two-hole template to mark the positions on the pavement where the nozzles of the pressure truss applicator would be positioned. Only two nozzles are provided on the truss to accommodate positioning along an irregular transverse crack. After the locations were positioned with the template, a hydraulic jack-hammer driven by the maintenance truck's hydraulic system was used to drill the pilot hole for the pressure filling operation.

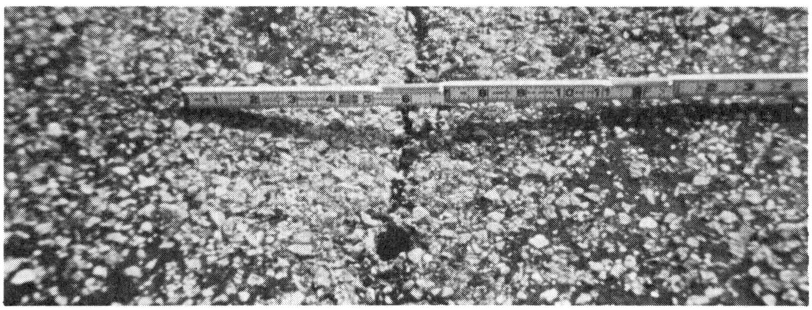

Figure 24.A typical pilot hole drilled at the thermal cracks allows the truss sections to be inserted with it's nozzles.

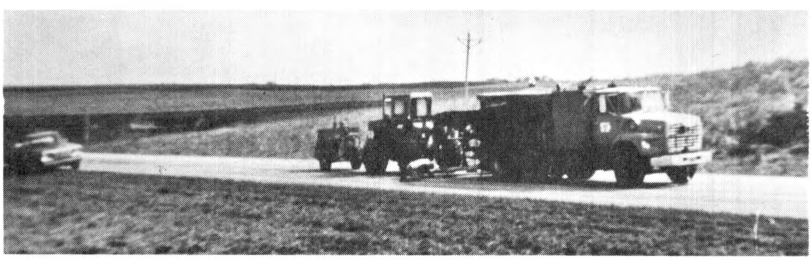

Figure 25. An overview of the equipment involved in the first pressure crack filling operation. The Maintenance Division provided a self propelled large slurry machine to mix the initial slurry mixture to be sure that we had proper proportioning and a homogeneous mix. This was followed by a four-wheel drive loader with the truss suspended on the loader bucket. The loader also towed a 100 cfm compressor which was the pneumatic power source for the Warren-Rupp Sandpiper pump.

Figure 26. The crack sealing operation described here was limited largely to the Class 3 and Class 4 cracks, of which there were more than 3,500.

Figure 27. This typical Class 3 crack is being prepared for filling. The truss section was simply suspended under the loader bucket with a log chain in order to make the truss easily positioned as it was centered over the nozzle pilot holes. It then was lowered into position with the loader bucket.

Figure 28. The total down pressure of the loader and its bucket was applied to the truss section. This pressure would compress the high density foam on the underside of the platform which would actually seal off the pavement surface at the crack interface so that high pressures could be applied and slurry injected into the cavities in the lower elevations of the pavement.

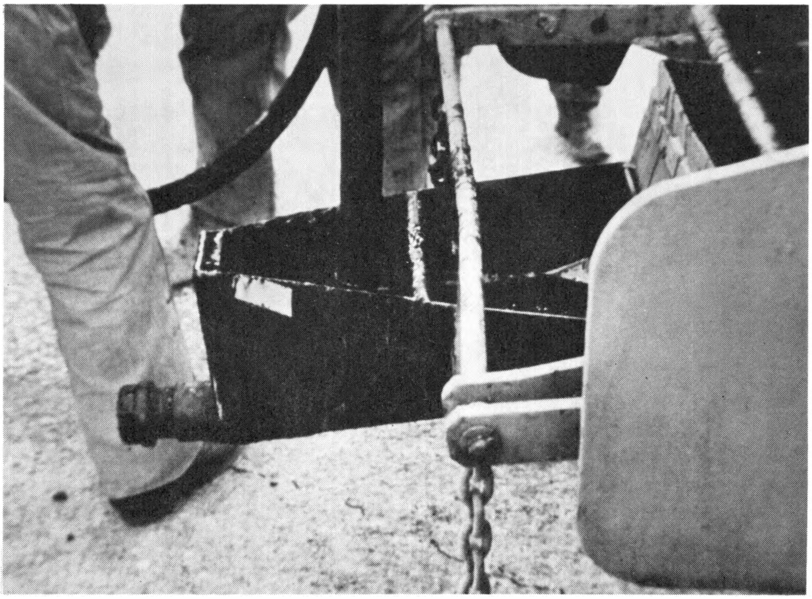

Figure 29. The suction line of the pumping system was placed in the slurry machine reservoir. The pump was activated, and it pumped the slurry through the system into the pavement crack.

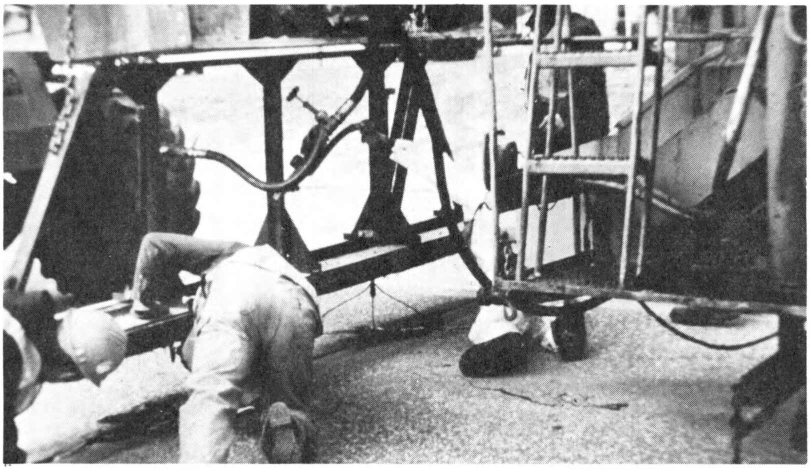

Figure 30. Workers clean out the orifice in one of the nozzles. We found that it was necessary to redesign the nozzle to a slotted opening rather than a simple small round opening in order to keep from plugging when the nozzle was driven into the pavement crack. it is very important that the opening in the side of the nozzle is at the elevation at the bottom of the asphalt section where the pavement cavity is at its greatest dimension.

Figure 31. The pressure of the air reservoir of the compressor is applied to the pneumatic pump. We found that usually a 60 psi pressure on the pump was more than sufficient to pressure inject the slurry into the cracks. We would continue pumping until the slurry material started to extrude at the end of the platform section. In one instance where a crack had seriously faulted and the pavement sagged adjacent to it, we applied the full 120 psi to the system. We were slab pumping the pavement and actually lifting the depressed asphalt pavement back up to it's original constructed elevation. This did not necessarily work in all situations because it depends on the configuration of the cavity beneath the crack.

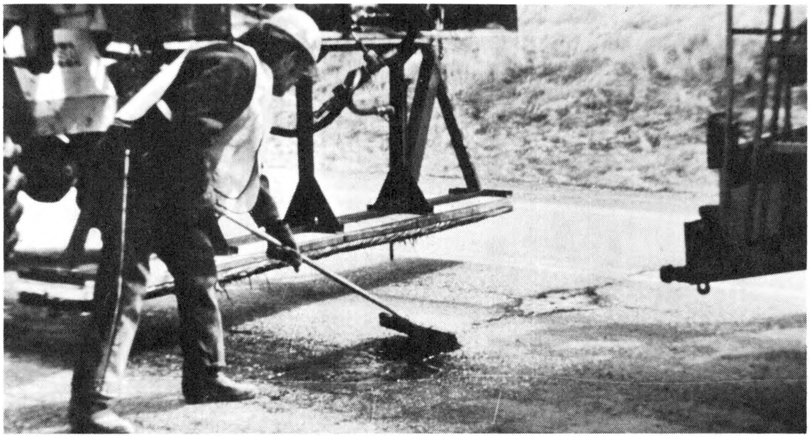

Figure 32. After the pressure injection process was completed, a small amount of slurry material came up around the barrel of the nozzle. This was wiped off with a squeegee.

Figure 33. In areas where there was a transverse trough depression along the axis of the thermal crack, this trough was squeegeed full with the pressure injection slurry material. Note a wet spot in the foreground in the shoulder area adjacent to the crack. We found it not uncommon to pump from 7 to 15 gal. of slurry mixture into some of these cracks. In a few minutes a 6- to 10-ft. diameter circular area saturated with moisture would develop on the shoulder which indicated that the pressure slurry material was displacing the water in the cavity of the crack and was filling and waterproofing this area.

Figure 34. After strike-off of the crack, it was lightly dusted with a fly ash. The fly ash was available because our early inclinations were to use fly ash rather than limestone for the slurry mixture. We found that it did not have the desireable mix characteristics that we found in the limestone-slurry mixture.

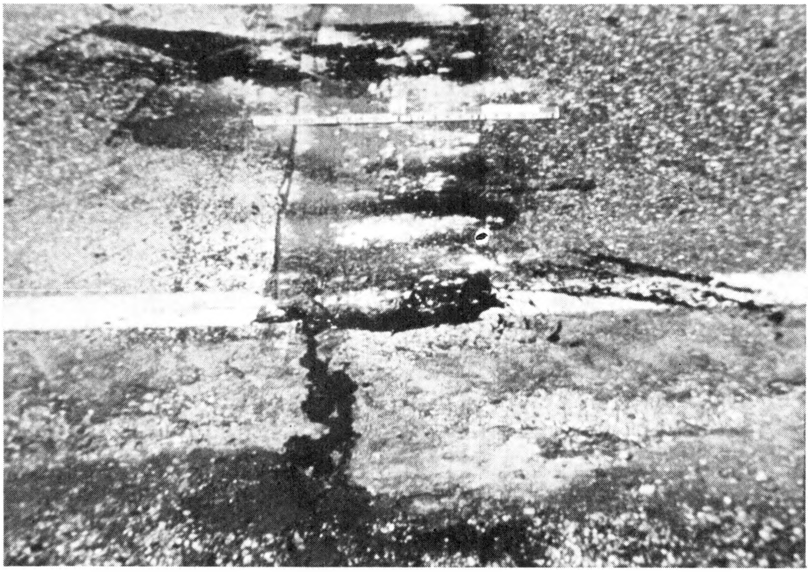

Figure 35. Note in the foreground the displacement of the water in the crack area by the pressure injected slurry and the wet area adjacent to the pavement crack on the shoulder. This is the typical finished crack.

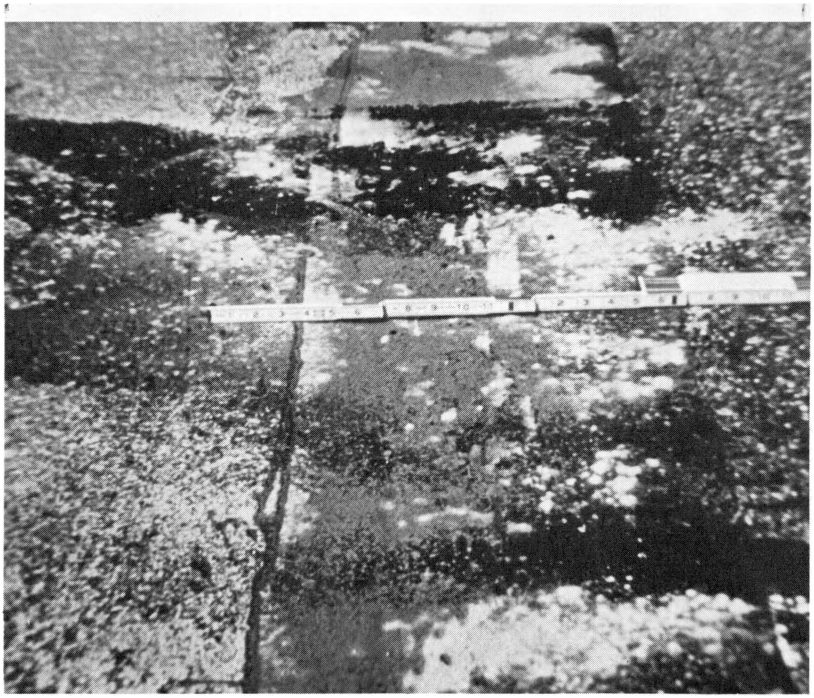

Figure 36. We found that there was little or no tracking of this crack filling operation, even though it was completed in cold weather. Through the warm summer weather of 1980 there was no tracking or flushing of this slurry crack fill material. On a field exam of this pavement in the fall of 1980, an investigation was made to see if the crack filling operation had been successful and if it would be necessary to saw out these cracks and patch them full depth with asphaltic concrete prior to a planned 2-in. overlay or if we could simply leave the repaired cracks as is and resurface over them. The cracks endured very well. The resurfacing project on this highway was let in February. We do not intend to do any further repair work on these pressure injected cracks.