Final Report

Iowa Highway Research Board

Research Project HR-231

SPECIAL SURFACE PREPARATION PRIOR TO BITUMINOUS OVERLAYS

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DISCLAIMER

The opinions, findings, and conclusions expressed in this report are those of the authors and do not necessarily reflect the official views of Cerro Gordo County or the Iowa Department of Transportation.

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ACKNOWLEDGEMENT

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ABSTRACT

Research project HR-231, "Special Surface Preparation Prior to Bituminous Overlay", was initiated in 1982 to study the effectiveness of three different crack fillers in extending pavement life. In particular, this project was designed to determine if any of the fillers could substantially reduce the rate of subsurface deterioration and general deterioration of an asphalt pavement at crack locations. This project also sought to determine the effects of the various crack filling procedures on different thicknesses of bituminous overlays. The three fillers, a fly ash slurry, an emulsion, and a rubberized asphalt mixture, were used along with a control section with no crack filler material on a 2.5 mile section of Cerro Gordo Trunk Route S-25 south of the town of Thornton. This report discusses the construction and performance of each filler material and makes recommendations concerning future use of any of the materials used.

INTRODUCTION

There are approximately 14,320 miles of rural asphaltic concrete surfaced roadways in the state of Iowa. Approximately 60% of this mileage is on the Secondary Road System. Many of these pavements are experiencing thermal cracking. Water movement through the thermal crack strips asphalt binder from the aggregate and flushes fines from the mix, causing a surface depression to form along the crack. This results in poor ride quality, loss of pavement life, and increased maintenance costs.

Asphaltic concrete overlays of one to three inches temporarily correct the riding surface, but as reflection cracks appear, the degradation continues and the depression is again formed.

A need exists to identify a procedure which will retard or eliminate the cracking and degradation of the new overlay. Ensuring that the thermal cracks are properly filled prior to placement of the overlay may accomplish this goal.

OBJECTIVES

The objectives of the research were:

1. To identify an effective crack sealing procedure which would extend pavement service life and reduce future maintenance costs.

2. To determine the effects of various crack sealing procedures on different thicknesses of bituminous overlays.

PROJECT DESCRIPTION

The project was located on a 2.5 mile section of county Trunk Route S-25, commencing at the Cerro Gordo County line and running north to Thornton, terminating at the Chicago Northwestern Railroad (Figure 1). The pavement section was 22 feet wide. The road was constructed in 1958 with a 4-inch soil aggregate subbase, a 6-inch rolled stone base and a double inverted penetration seal coat. In 1962, 2 1/2 inches of Type B, Class 1 ACC were added. The roadway was again resurfaced in 1969 with 2 inches of Type B, Class 1 ACC. All work met Iowa DOT Standard Specifications at the time of construction. The ADT was approximately 600 VPD having approximately 15% heavy vehicle traffic (truck and farm vehicle traffic).

Thermal cracks were occurring at intervals ranging from 20 to 60 feet, with the majority ranging between 30 and 40 feet. At midwinter, crack widths at the surface varied from 5/8 inch to 2 inches, and depressions along the cracks were from 1/8 to 1/2 inch deep. The pavement was a typical example of thermal crack degradation.

CRACK SEALING MATERIALS

The project plans specified four crack sealing materials and procedures for filling the thermal cracks. The sealing materials to be used were:

1. Emulsified asphalt of the CRS-2 grade. In addition to the thermal crack test sections designated, this material was used for filling random cracks throughout the project (except in the control section, where no cracks were sealed).

2. Hot asphalt rubber. Special provisions required a mix of 75% AC-5 asphalt cement and 25% crumbed or ground rubber. "CRAFCO" brand commercial sealer was delivered and certified to meet the specification.

3. Fly ash-cement grout for pressure injection. The grout was composed of 75% Port Neal #3 Type "C" fly ash and 25% Type 1 portland cement. Percentages were based on volume. Water was added to these materials to obtain a specified fluidity as determined by the Corps of Engineers flow cone method.

4. Emulsion - limestone slurry for pressure injection. A CSS-1 emulsion was found to be compatible with the fine limestone to be used on the project. Proportions were to be 50-50 by weight. The fine limestone gradation is given in Table 1.

CONSTRUCTION

There were 8 experimental sections and 1 control section laid out as shown in Figure 2. Prior to construction, 456 full width thermal cracks were identified in the 9 sections.

Bids were received April 13, 1987, and the contract (Appendix A) was awarded to Weaver Construction Company of Iowa Falls. Crack sealing was sub-contracted to Brower Construction Company of Sioux City and the slurry seal surfacing to Fort Dodge Asphalt Company of Fort Dodge. Crack sealing preparation began May 7 and sealing was completed May 24, 1982. Approximately half of this period was spent idle due to rain delays. Special provisions for crack filling are in Appendix B and a list of equipment used for crack filling is in Appendix C.

Crack Preparation

Thermal cracks in the 8 test sections which were less than 1/2 inch wide were routed to 1/2 inch wide and 1 inch deep. Random cracks in these sections were also routed. High pressure water blasting was used to clean the thermal cracks 1/2 inch or wider. All cracks were air blown immediately prior to sealing. Crack preparation work is shown in Figures 3-5.

Emulsion Sealing

Type A (Figure 2) crack filling was the CRS-2 emulsion hot poured at less than 150°F. The material was poured into the crack until flush with the adjacent surface. The ends of the crack required blocking to prevent emulsion from flowing out of the crack onto the shoulder. Emulsion was also used to fill all random cracks in the 8 test sections. Both a wand and pour pot were used to distribute hot emulsion (Figure 6 - 7). The wand application was not always uniform, resulting in some cracks which were not completely filled.

Application from the pour pot resulted in more uniformly filled cracks. The freshly filled cracks were blotted with sand to prevent tracking.

Asphalt Rubber Sealing

Preparation and placement of the Type B crack filler, asphalt rubber sealer, was accomplished by a 200 gallon "CRAFCO" brand heater and pump manufactured to handle the 60 pound solid blocks of material. The sealer was heated to 450°F and extruded through a hose and wand into the cracks. A horseshoe shaped squeegee about 3 inches wide was used to level and spread the sealer to the edges of the crack (Figure 8). The asphalt rubber material could be applied quicker and easier than the poured emulsion sealer and had no tendency to flow once placed. Some cracks in the asphalt rubber sealant sections had deep voids. These voids tended to reduce the effectiveness of the sealant and also required large amounts of material to fill. These cracks were filled with sand to one inch below the surface before sealing.

Fly Ash-Cement Grout Sealing

The fly ash-cement grout material consisted of 3 parts fly ash to 1 part cement by volume with about 2 parts water added to provide the desired flow characteristics. Only a small batch of about 6 to 8 gallons of grout was mixed at a time using a paddle type mortar mixer. This prevented excessive hold time on the grout prior to placing, yet still allowed for a smooth continuous crack filling operation. Flow of the slurry was measured by the Corps of Engineers flow cone method (Appendix D). This method consists of pouring *the mix into a calibrated cone and measuring the time of* efflux. The grout flow times ranged from 13.8 seconds to 16.0 seconds. Flow time for water through the cone is about half that of the grout.

The grout mix was injected into each crack using a metal injection frame developed by the Iowa DOT Materials Office (Figure 9). The frame consists of a trussed framework for rigidity with a bottom platform about 12 feet long and 17 inches wide. The platform is faced with 3 inches of dense polyurethane foam sealed with a polyethelene membrane. This facing provides intimate contact with the pavement surface to permit pressurizing of the crack. Two injection nozzles run through the platform and are located about 4 feet either side of center. Pilot holes are drilled into the crack to receive the nozzles. A loader bucket is used for transporting the frame between cracks and applying downward force on the frame during application of the grout.

The grout was injected by a pneumatic pump that sucked the grout into hoses leading to the injection nozzles and forced the grout into the crack. On this project pump pressures varied from 30 to 60 psi. Pumping was stopped when grout began breaking the seal between the frame and surface. After removing the frame the surface was leveled and cleaned with a squeegee. Cores taken after installation of the grout revealed that the grout had penetrated to the bottom of the slab and filled the entire void (Figure 10).

Emulsion-Limestone Slurry Sealing

The Type D method, which was believed to hold the most promise for reaching the stated objectives, was the pressure injected emulsion-limestone slurry. The CSS-1 emulsion and fine limestone mix was to be pumped through the injection frame as the fly ash-cement grout had been. This procedure had been used on a primary highway crack filling project with some success and was believed to be a viable procedure. The primary project had used a standard slurry mixer for the grout and fluidity had been maintained.

On this project a mortar mixer was substituted for the slurry mixer, with batch weights of about 80 pounds. All efforts to pump the slurry ended in the slurry plugging the pump, hoses, and nozzles. In the belief that the CSS-1 and the limestone were probably incompatible, the District Materials Engineer ran trial lab mixes with several fresh emulsions. An SS-1 emulsion performed well in the lab, but produced similar results to the CSS-1 on the job. Several factors may have caused the material to break prematurely. The most likely cause was the agitation of the paddle type mixer (Figure 11). A more gentle agitation, like that of a standard slurry machine, could better mix the small batch weight of slurry without the breaking problem.

The failure of this process to work posed the problem of what to do with those sections designated for treatment with this method. It was the joint decision of the project and research engineers that additional areas of fly ash-cement grout and poured emulsion would be appropriate. In addition, it was decided to try a very limited quantity of portland cement-ag lime and fly ash-kiln dust slurry mixes. These were included in the fly ash-cement section which had been added. Installation of the fly ash-kiln dust alternate compared favorably with the fly ash-cement material. The portland cement-ag lime plugged the screen much the same as the emulsion-ag lime slurry had.

Asphalt Surface Treatments

Surface depressions remaining at the thermal cracks in the test sections were leveled by a 1 to 2 foot wide strip seal of CRS-2 emulsion and 3/8 inch cover aggregate. Special provisions required a minimum of 30 days between the completion of crack sealing and the start of the surface treatment phase of the work.

The Type B, Class 1 asphaltic concrete base resurfacing was begun July 8 and completed July 13. A 3900 foot section was placed 1 1/2 inches thick and a 5378 foot section was placed 2 inches thick. One 3852 foot section of bituminous slurry seal surfacing was applied on July 28 and 29, 1982.

DISCUSSION

Of the four crack filling materials, emulsion is the most commonly used sealer in Iowa. The emulsion is poured into the crack and slowly seeps down to the void beneath the surface. Routing of the crack on the surface allows for a reservoir of emulsion to be placed.

Asphalt rubber sealer has been used on a limited basis in Iowa the last few years on asphalt pavement. The material does not flow or seep when placed in the cracks. The purpose of the asphalt rubber material is to provide an elastic seal to the crack surface. A special double jacketed distributor is needed to heat the sealer to above 450°F. Agitation of the heated material is provided to prevent separation. To obtain proper adhesion of the sealer to the crack, the material must be squeegeed into the routed crack.

The purpose of the fly ash-cement grout and the emulsion-limestone slurry was to completely fill the entire void of the crack. Equipment for mixing and placing worked very well for the fly ash-cement grout. Once familiar with the procedure, the contractor could place grout nearly as fast as he had placed the emulsion and the asphalt rubber while using the same number of people. No unique equipment was required other than the simple truss injection frame.

It is regrettable that the emulsion-limestone slurry did not work. The flexible emulsion material may be more desirable for crack filling than the rigid fly ash-cement grout. The mixer used to mix the slurry may have caused the emulsion to break. With the paddle agitation of the mixer the small batch was violently stirred. This coupled with the pumping of the material through the hoses caused the material to set prematurely. The concept of the method was to achieve a mix with crushed limestone suspended in the emulsion.

The crack preparation for all test sections was essentially the same. The pressure injection method did involve the additional task of drilling pilot holes in the pavement for receiving the injection nozzles. Each crack filling procedure required at least three and usually four people for smooth, continuous operation. Normal crew sizes for the contractor's operations were:

Emulsion Sealing
1 - Tar pot vehicle driver
1 or 2 - Wand or pour pot operators
1 - Person to blot emulsion with sand

Asphalt Rubber Sealing
1 - Tar pot vehicle driver
1 - Wand operator
1 - Person to squeegee sealer

Pressure Injection Sealing
1 Mixer operator
1 Loader operator
1 or 2 - Pump operators

To make a total cost comparison of the crack sealing operations based on contract bid prices (Appendix A) would be erroneous. Due to the small quantities of sealer involved and to contractor unfamiliarity with some of the procedures, certain bid items may have been higher than would be expected. The actual quantities of sealer used are given in Table 2. January 1983 cost estimates for the materials used by the contractor are shown in Table 3. The contractor was able to pick up all these items except asphalt rubber either locally or on the way from Sioux City. Only the asphalt rubber cost included delivery from Dubuque, Iowa, to Cerro Gordo County. Given below is an estimate of the contractor's cost for sealer material per foot of crack based on Tables 2 and 3.

Sealant	Estimated Cost	Sealant per Ft. of Crack	Price per Ft. of Crack
Poured Emulsion	$ 0.71/gal.	0.027 gal.*	$ 0.019
Asphalt Rubber	$ 0.35/lb.	0.510 lb.	$ 0.178
Fly Ash - Cement	$ 0.186/gal.	0.18 gal.	$ 0.033
Emulsion - Limestone	$ 0.545/gal.	0.18 gal.	$ 0.098

* - includes routed random cracks

EVALUATION

The project research period was set for five years. In order to evaluate the materials, 456 cracks were selected and used throughout the project for the crack testing. Several tests were run on the project each year in order to gain an understanding of how each crack filling material was performing. The testing schedule is shown below.

Test	Year Performed					
	82	83	84	85	86	87
Road Rater	X	X		X		X
Roughness	X		X	X		
Crack Depression			X	X	X	X
Percent Cracks Reflected		X	X			X
Core Drilling		X				X

Despite the numerous tests conducted on the project, it is difficult to determine which of the three crack filling materials, if any, performed substantially better than the control section. One reason for this is the seemingly contradictory nature of the test results. That is, the results of one test sometimes seemed to contradict the findings of another. A review of each test will be given. Much of the information used was obtained from crack surveys taken in January or February of each year.

Note: Several tests were not performed on sections 8 and 9 because these sections did not have an asphalt overlay.

Percent Cracks Reflected

The ability of a crack filling material to retard or reduce the amount of reflection cracking in an overlay is an obvious benefit. A crack survey was performed each year in order to evaluate each filler's performance in reducing reflection cracking. This survey revealed the first of several unexpected results. All the project sections showed the same pattern of having the larger percentage of cracking occurring in the earlier years (see Figure 12). Also, after the first year, all six test sections were within a narrow range, the maximum percent spread between the best and worst sections in any one year being 16 points. However, the control section, which had no crack filler material, clearly outperformed the test sections in retarding reflection cracking. As can be seen, after the first year the percentage of cracks reflected in the control section was from 16 to 25 percent less than the best performing experimental section.

Crack Depression Survey

A principle objective of the research was to determine if a filler could stop subsurface pavement deterioration and the ensuing formation of crack depressions. Because the control section outperformed the three materials in retarding reflection cracking, one might also think similar results would be obtained from a crack depression survey. However, the opposite was found to be true. Of the cracks that had reflected to the surface, the sections with higher percentages of reflected cracks had smaller crack depressions (see Figure 13). For instance, the fly ash slurry had the largest percentage of reflected cracks and the smallest average crack depression. As expected, the slurry seal sections had higher depression measurements than the other sections. When comparing the two slurry seal sections, however, the rubberized section slightly outperformed the emulsion.

Core Drilling

At the end of the 5-year research period three cores were drilled from each type of crack filling material to determine the subsurface condition of the pavement at the cracks. Since the fly ash had the smallest average crack depression, it was expected the fly ash would have the most solid cores. Once again the results were surprising. As shown in Figure 14, the fly ash mix had deteriorated from the crack. On the other hand, the emulsion mix, which showed the largest average crack depression, had the most solid looking set of cores. The base had a modest amount of aggregate stripped from it, but the emulsion cores indicated the pavement near each crack was in good condition. The same can be said of the rubberized asphalt cores, which showed only slightly more deterioration than the emulsion cores. The core drilled from the control section was also in good condition when compared to the fly ash core.

Roughness Measurements

Not every crack which was in the original pavement was used for evaluation of the project. That is, only a select number of cracks in each section was filled with a material. Those cracks not used were filled with emulsion before being overlaid. Because a large number of these cracks also reflected through the overlay, any roughness measurement will not be totally accurate if used to determine crack filler effectiveness.

It is difficult to determine which material showed the best overall performance when considering both the 1 1/2" overlay and the 2" overlay sections together. However, it appears the fly ash sections performed best, followed by the emulsion and then the rubberized asphalt. Also, the emulsion slurry seal section outperformed the rubberized asphalt slurry seal section in a comparison of the two.

Road Rater

The Road Rater is used to determine the structural capacity of the pavement and the subgrade soil K value. It uses the average of many individual tests to determine the strength of a section of pavement. In as much, it is not designed to give information at particular locations, such as at cracks. Therefore, this test provides a minimal amount of information toward determining which sealant is best.

Rating System

A weighted rating system was developed to determine which sealant showed the best overall performance. Three engineers involved with the project were asked to rank each of the five tests described earlier according to how well it reflected filler performance. Results are shown below.

Test	Engineers' Rank (1 thru 5, 5 being best)			Total
Roughness	3	2	4	9
Percent Cracks Reflected	4	5	2	11
Crack Depression Survey	5	4	4	13
Core Samples	2	3	4	9
Road Rater	1	1	1	3
				==
				45

The individual test sections were then rated according to performance in each test. These results are shown below:

Test	Section							
	1	2	3	4	5	6	7	Total
	RATING (Rating 1 thru 7, 7 being best)							
Roughness	3	5	6½	2	4	6½	1	28
Percent Cracks Reflected	2	4	3	6	5	1	7	28
Crack Depression Survey	4	3	5	6	1	7	2	28
Core Drilling	1	6	5	5	6	1	4	28
Road Rater	5	4	3	6	7	1	2	28

Each section was then given a score in each test. The score was based on the rank of the test and on the section's rating in that test. The score was determined by first dividing the total test ranking by 45 and multiplying the result by the section rating in that test. For instance, the score of section 2 in the roughness test would be (9/45) x 5 = 1.0.

Each section's composite score was the sum of its scores in the five tests.

The composite results are listed below:

Section	Filler	Composite Score	*Percentage	Comparative Rating
1	Fly Ash	2.78	39.7	6th
2	Emulsion	4.31	61.6	4th
3	Rubberized Asphalt	4.68	66.8	3rd
4	Rubberized Asphalt	5.00	71.4	2nd
5	Emulsion	5.711	81.6	1st
6	Fly Ash	2.10	30.0	7th
7	Control (No Filler)	3.422	48.9	5th

*Percentage based on a maximum score of 7.

CONCLUSIONS

Obviously there are some benefits of filling cracks before overlaying. As can be determined from the composite scores, both the emulsion sections and the rubberized asphalt sections outperformed the control section. In these sections the added 1/2 inch overlay thickness appeared to increase overall performance, especially on the 2" emulsion section. The fly ash mix failed to perform as well as expected.

Despite the fact that crack filling does hold certain advantages over the conventional preoverlay maintenance approach, it is believed the benefits of crack filling (with any of the materials described in this report) is not warranted. It is believed the added costs involved with crack filling exceed the added benefits. Therefore, it is suggested current preoverlay maintenance continue until an economically acceptable method is found which improves crack degradation problems.

TABLE 1
Limestone Aggregate Gradation

Sieve No.	Percent Passing
4	100
8	96
16	81
30	67
50	54
100	39
200	21

TABLE 2
Crack Sealing Quantities

Materials	Lin. Ft. of Cracks	Quantity Used	Quantity Per Ft.
Poured Emulsion	24,039 (a)	658 gal.	0.027 gal.
Asphalt Rubber	3,057	1,560 lb.	0.510 lb.
Fly Ash - Cement	495	91 gal.	0.18 gal.
Emulsion - Limestone	0		0.18 gal. (b)

a. includes routed random cracks

b. estimated

TABLE 3
Estimated Material Costs - January 1983

Emulsion	$0.71 per gal.
Asphalt Rubber	$0.35 per lb.
Fly Ash	$10.00 per ton
Cement	$62.30 per ton
Limestone	$ 9.87 per ton

CERRO GORDO COUNTY
IOWA

Figure 1: Project Location

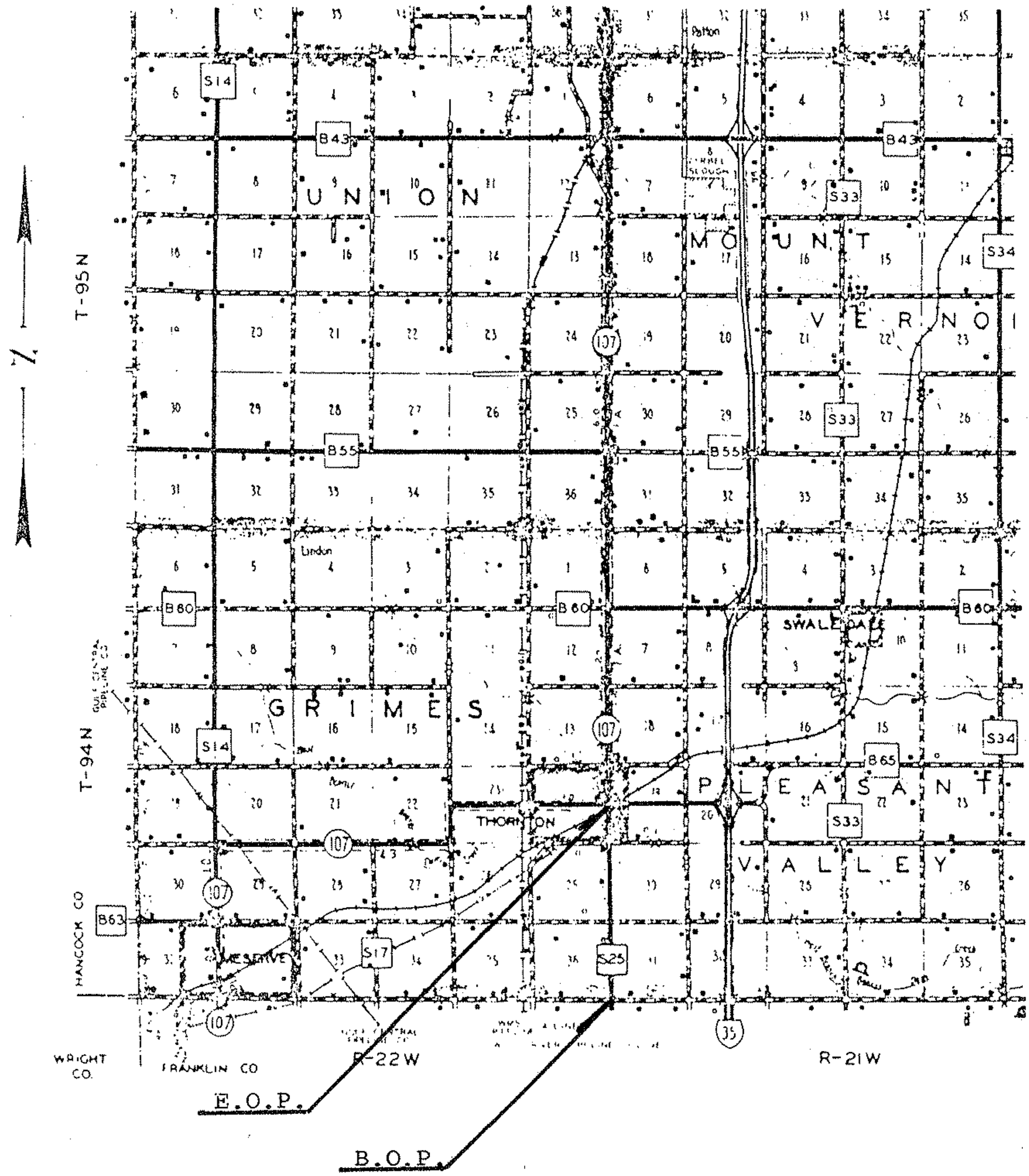
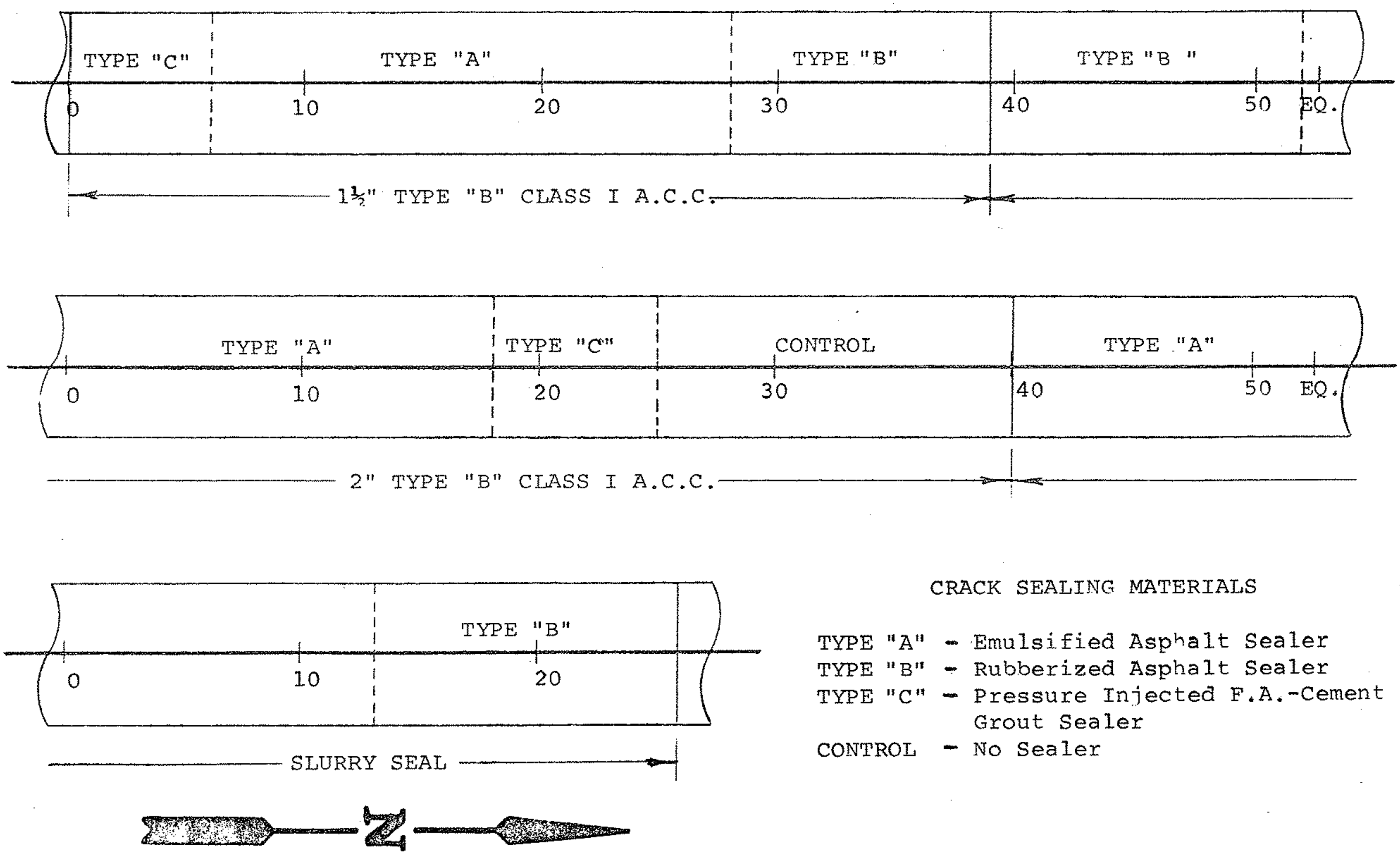


Figure 2: Test Section Layout



CRACK SEALING MATERIALS

TYPE "A" - Emulsified Asphalt Sealer
TYPE "B" - Rubberized Asphalt Sealer
TYPE "C" - Pressure Injected F.A.-Cement Grout Sealer
CONTROL - No Sealer

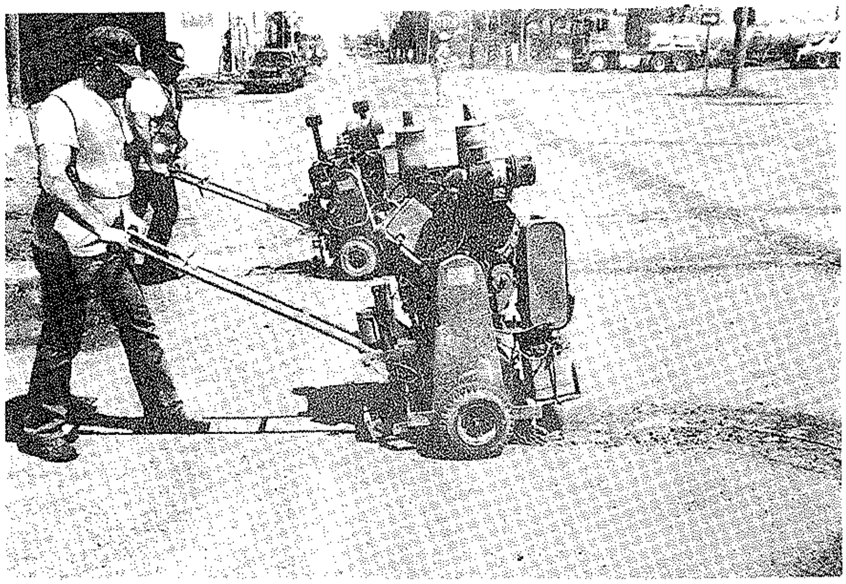


Figure 3 Crack Routing

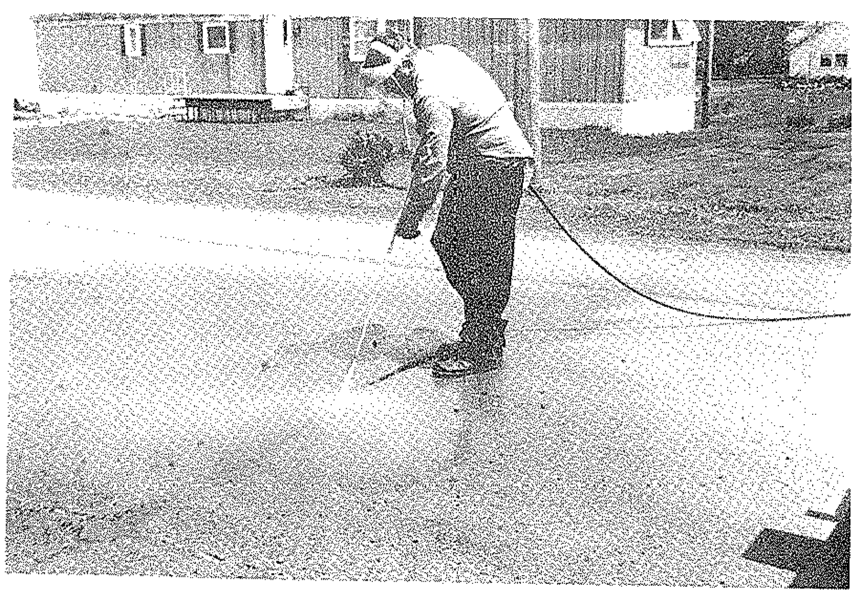


Figure 4 High Pressure Water Blasting Of Cracks

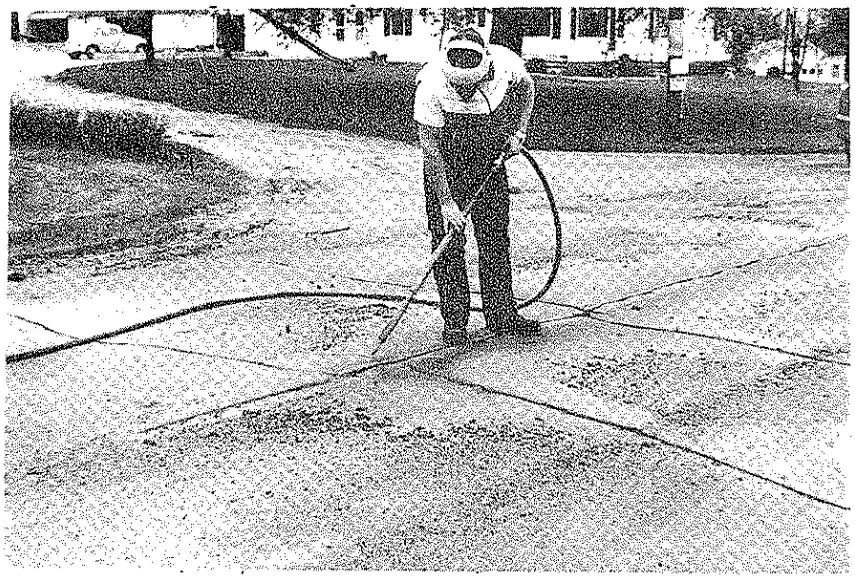


Figure 5 Crack Cleaning With Air Prior To Sealing

Figure 6 Crack Filling With Emulsion From A Wand

Figure 7 Crack Filling With Emulsion From A Pour Pot

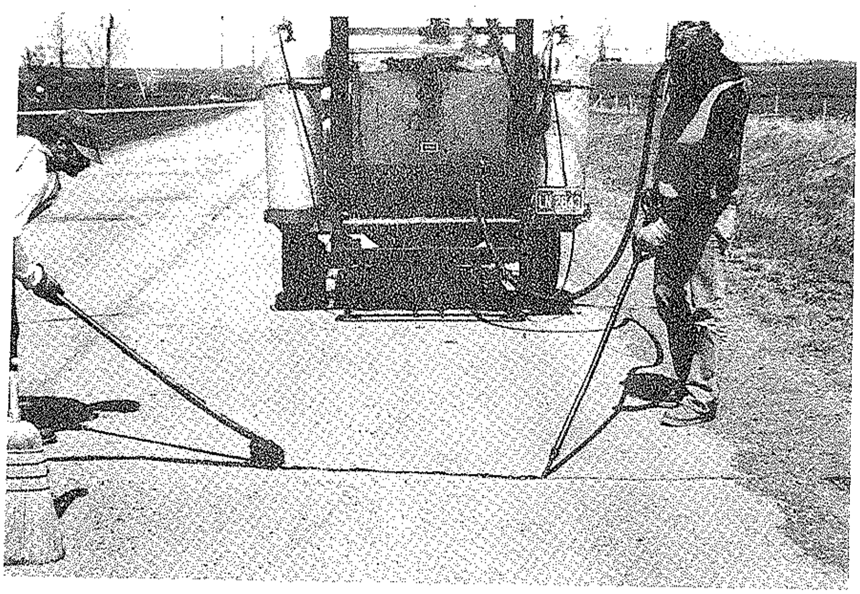


Figure 8 Asphalt Rubber Crack Sealing

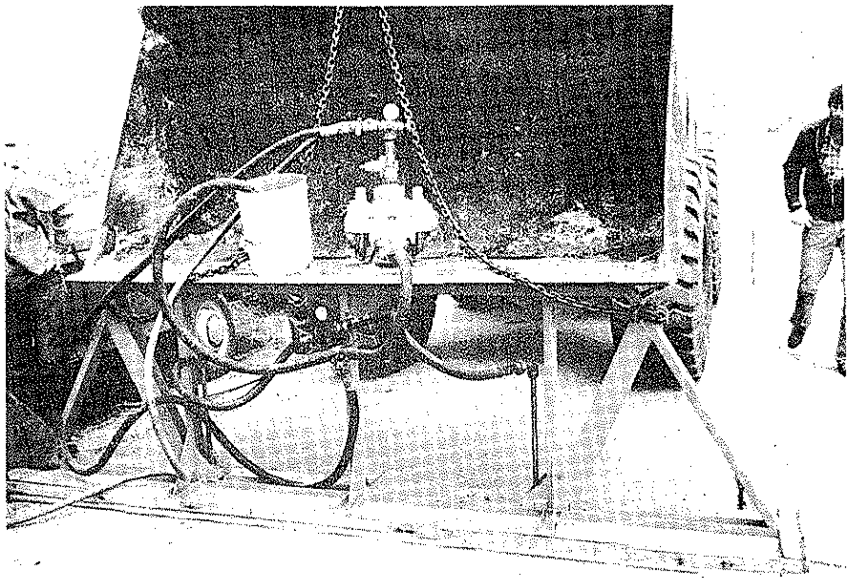


Figure 9 Pressure Injection Frame And Pneumatic Pump

Figure 10 Core Removed From Crack Sealed With Pressure Injected Fly Ash-Cement Slurry (Top of core showing is bottom of pavement slab)

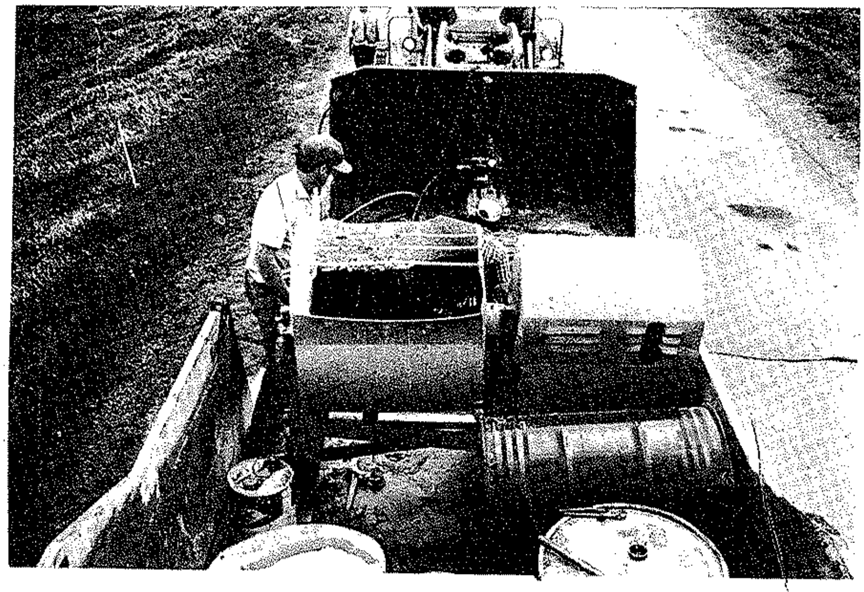


Figure 11 Paddle Type Mixer Used To Mix Material For Pressure Injection Sealing

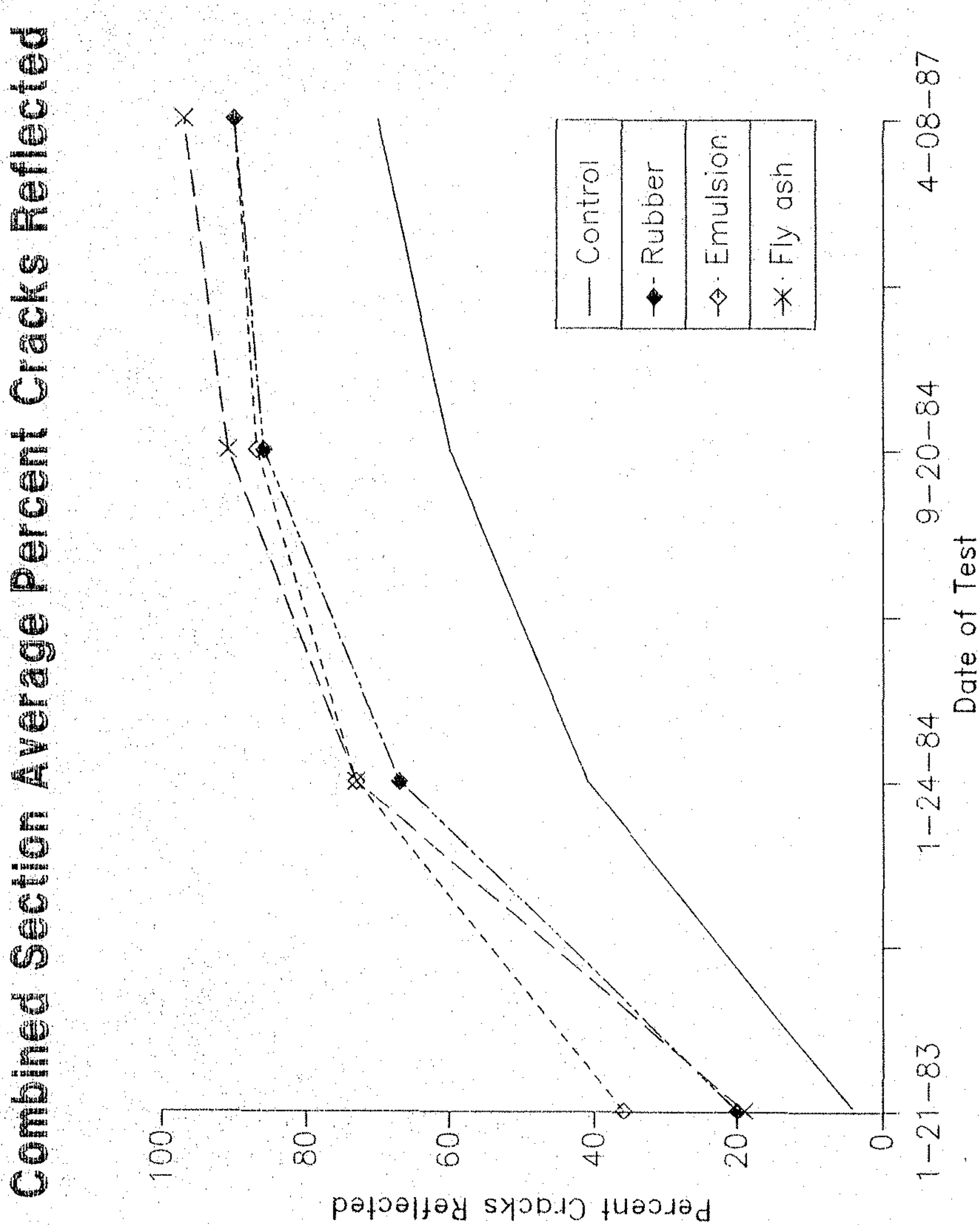


Figure 12 - Percent Cracks Reflected

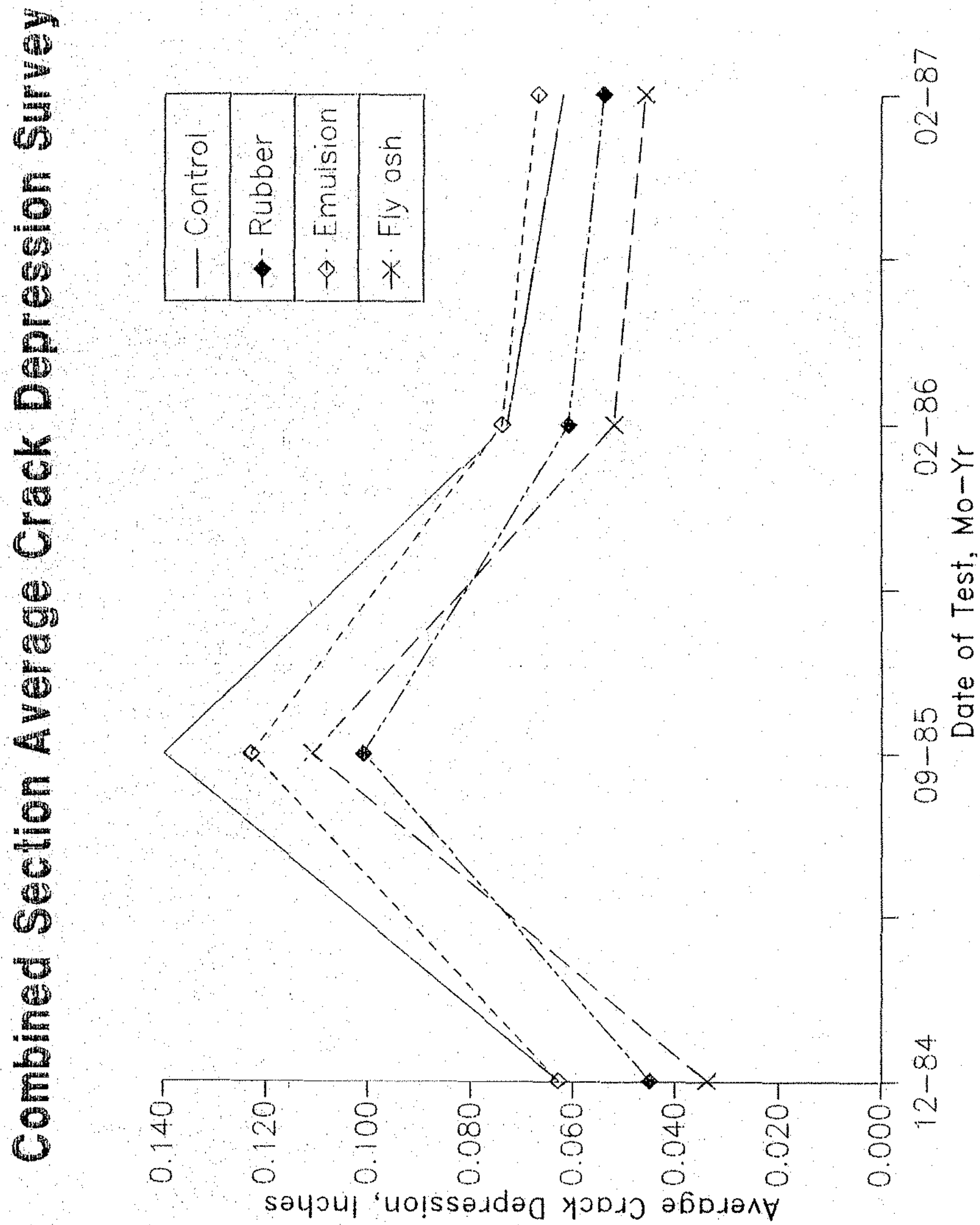


Figure 13 – Crack Depression Survey

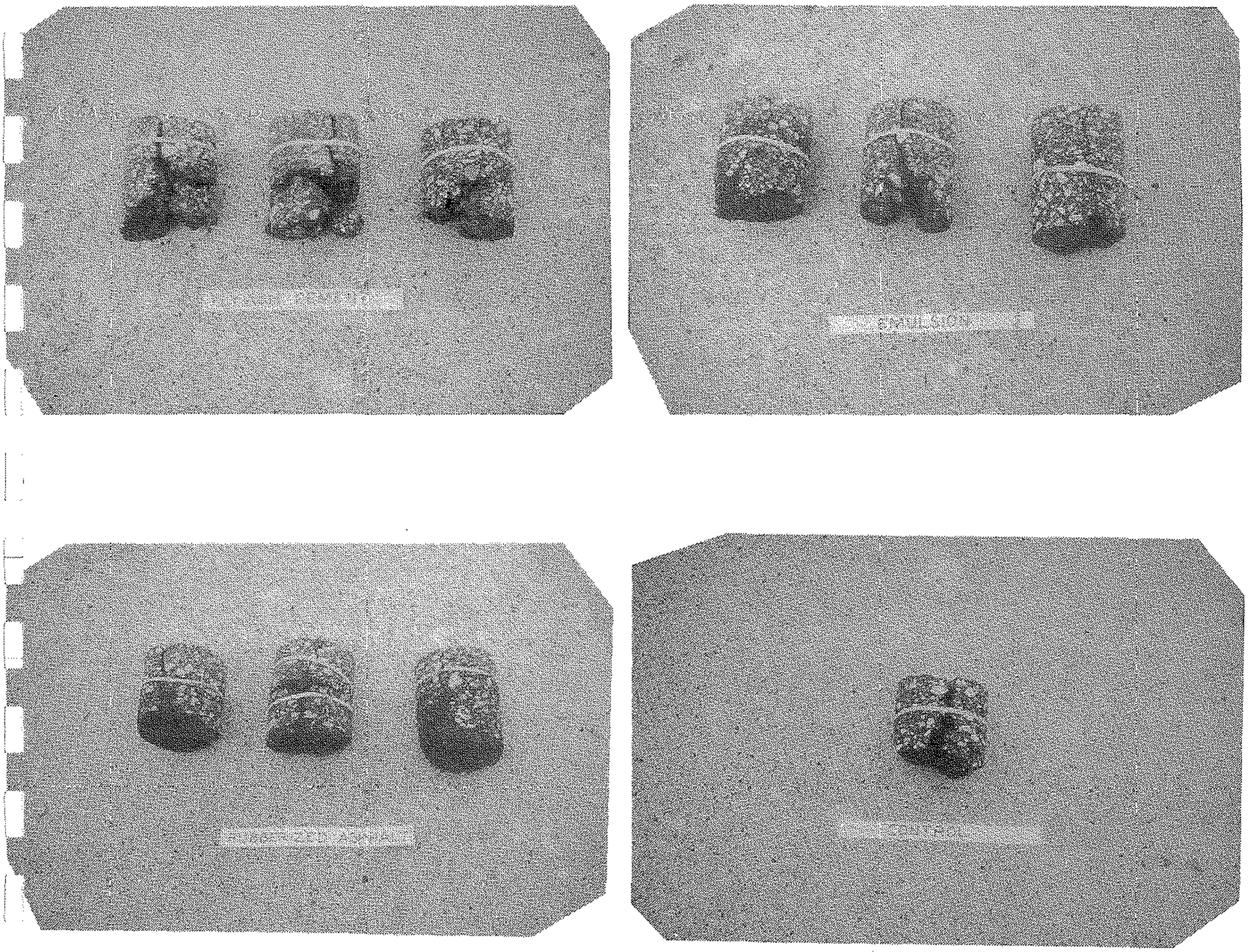


Figure 14 - Cores Taken at Five Years

Appendix A

Rating System Scores

Section Scoring

SECTION	TEST A	TEST B	TEST C	TEST D	TEST E	COMPOSITE SCORE
1	1.156	0.600	0.489	0.200	0.333	2.778
2	0.867	1.000	0.978	1.200	0.267	4.312
3	1.444	1.300	0.733	1.000	0.200	4.677
4	1.733	0.400	1.467	1.000	0.400	5.000
5	2.022	0.800	1.222	1.200	0.467	5.711
6	0.289	1.300	0.244	0.200	0.067	2.100
7	0.578	0.200	1.711	0.800	0.133	3.422

Highest Possible Score = 7.000

A - Crack Depression
B - Roughness
C - Percent Cracks Reflected
D - Crack Depression
E - Road Rater

Appendix B

Test Results

HR-231 Cerro Gordo County
Crack Survey

SECTION NO.	SURFACE	FILLER/SEALER	PERCENT OF CRACKS REFLECTED 1-21-83	1-24-84	9-20-84	4-8-87
1	1½" A.C.	Fly Ash	43	71	86	100
2	1½" A.C.	Emulsion	42	74	88	89
3	1½" A.C.	Rubber	24	68	91	93
4	2" A.C.	Rubber	15	67	79	86
5	2" A.C.	Emulsion	24	70	85	91
6	2" A.C.	Fly Ash	0	74	95	95
7	2" A.C.	Control	4	41	60	70

HR-231 Cerro Gordo County
Roughness Survey

SECTION NO.	SURFACE	FILLER/SEALER	IJK ROADMETER	BPR ROUGHOMETER IN/MI.	
			9-10-82	9-26-84	11-04-85
1	1½" A.C.	Fly Ash	3.35	84	94
2	1½" A.C.	Emulsion	3.55	78	89
3	1½" A.C.	Rubber	3.70	78	88
4	2" A.C.	Rubber	3.35	86	96
5	2" A.C.	Emulsion	3.55	82	92
6	2" A.C.	Fly Ash	3.70	75	88
7	2" A.C.	Control	3.45	94	98
8	Slurry Seal	Emulsion	3.10	122	146
9	Slurry Seal	Rubber	----	14??	160

HR-231 CERRO GORDO COUNTY
CRACK DEPRESSION SURVEY

SECTION NO.	SURFACE	FILLER/SEALER	CRACK DEPRESSION (IN)*															
			A				B				C				Avg.			
			12-84	9-85	2-86	2-87	12-84	9-85	2-86	2-87	12-84	9-85	2-86	2-87	12-84	9-85	2-86	2-87
1	1 1/2" A.C.	Fly Ash	0.07	0.14	0.08	0.07	0.02	0.11	0.07	0.04	0.00	0.12	0.02	0.01	0.04	0.13	0.07	0.05
2	1 1/2" A.C.	Emulsion	0.06	0.13	0.07	0.08	0.06	0.12	0.07	0.07	0.04	0.06	0.02	0.02	0.06	0.12	0.07	0.06
3	1 1/2" A.C.	Rubber	0.08	0.14	0.09	0.10	0.03	0.09	0.04	0.04	0.03	0.05	0.04	0.01	0.05	0.10	0.08	0.05
4	2" A.C.	Rubber	0.08	0.12	0.10	0.12	0.03	0.10	0.07	0.08	0.02	0.05	0.04	0.02	0.04	0.10	0.07	0.07
5	2" A.C.	Emulsion	0.08	0.14	0.10	0.12	0.06	0.14	0.09	0.10	0.01	0.06	0.03	0.03	0.06	0.13	0.09	0.09
6	2" A.C.	Fly Ash	----	----	----	----	0.02	0.09	0.03	0.06	0.00	0.10	0.02	0.01	0.02	0.09	0.03	0.05
7	2" A.C.	Control	0.10	0.16	0.11	0.13	0.06	0.15	0.07	0.08	0.06	0.09	0.04	0.04	0.06	0.12	0.07	0.06
8	Slurry Seal	Emulsion	0.13	0.17	0.12	0.15	----	----	----	----	----	----	----	0.07	0.13	0.17	0.12	0.14
9	Slurry Seal	Rubber	0.12	0.17	0.10	0.12	----	----	----	----	----	----	----	0.05	0.12	0.17	0.10	0.11

A. Cracks reflected by 1-21-83
B. Cracks reflected after 1-21-83 and before 1-24-84
C. Cracks reflected after 1-24-84

*Depression measured in outside wheel path.

Appendix C

Contract

COST CENTER 801CCO OBJECT 860

PROJ NO SN-41A(1)--SL-17 COUNTY CERRO GORDO

RES ENGR WARREN DAVISON ADDRESS MASON CITY IA

LETTING DATE APRIL 13, 1982 LIQUIDATED DAMAGES $140.00

SPECIAL PROV 2/16/82 #899, 10/2/79 #854, 10/11/77 #815,
3/19/82 SP-182, 11/10/81 #884

DATE STARTED ______ FIELD COMP ______ CERT COMP 10-82

FORM ______

CONTRACT NO. 19504

TYPE OF WORK ASPH. CEMENT CONC. RESURF. PROJECT NO SN-418(1)--S1-17

MILES 2.487 COST CENTER 801000 OBJECT 860

COUNTY CERRO GORDO

ON SECONDARY ROAD S25 FROM JCT. IOWA 107, IN E. PART OF THORNTON, SOUTH TO THE FRANKLIN COUNTY LINE

THIS AGREEMENT MADE AND ENTERED BY AND BETWEEN THE COUNTY OF CERRO GORDO, IOWA

PARTY OF THE FIRST PART AND

WEAVER CONSTRUCTION CO. OF IOWA FALLS, IOWA 48C00

PARTY OF THE SECOND PART

WITNESSETH THAT THE PARTY OF THE SECOND PART FOR AND IN CONSIDERATION OF $ ****106,713.33 PAYABLE AS SET FORTH IN THE SPECIFICATIONS CONSTITUTING A PART OF THIS CONTRACT, HEREBY AGREES TO CONSTRUCT VARIOUS ITEMS OF WORK AND OR TO SUPPLY VARIOUS MATERIALS OR SUPPLIES IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS THEREFOR AND IN THE LOCATIONS DESIGNATED IN THE NOTICE TO BIDDERS AS FOLLOWS

ITEM NO	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
	INCLUDES EXPERIMENTAL CRACK SEALING				
1	BASE, TYPE B CLASS 1 ASPHALT CEMENT CONCRETE	2,283	TONS	19.96	45,568.68
2	PRIMER OR TACK-COAT BITUMEN	1,604	GALS.	.89	1,427.56
3	ASPHALT CEMENT	131	TONS	175.10	22,938.10
4	AGGREGATE FOR SLURRY SEAL	71	TONS	28.14	1,997.94
5	SEALING, EMULSIFIED ASPHALT	3,048	GALS.	3.75	11,430.00
6	SEALING, EMULSION SLURRY	.530	TONS	9,385.00	4,974.05
7	SEALING, FLY ASH SLURRY	.100	TONS	37,684.50	3,768.45
8	SEALING, RUBBERIZED ASPHALT	837	LBS.	2.15	1,799.55
9	ROUTING CRACKS	28,900	LIN. FT.	.17	4,913.00
10	SHOULDERS, GRANULAR SURFACING OF	987	TONS	8.00	7,896.00
				GRAND TOTAL	$106,713.33

PARTY OF THE SECOND PART CERTIFIES BY HIS SIGNATURE ON THIS CONTRACT, UNDER PAIN OF PENALTIES FOR FALSE CERTIFICATION, THAT HE HAS COMPLIED WITH 324 ... OF THE 1977 CODE OF IOWA AS AMENDED, IF APPLICABLE.

SAID SPECIFICATIONS AND PLANS ARE HEREBY MADE A PART OF AND THE BASIS OF THIS AGREEMENT AND A TRUE COPY OF SAID PLANS AND SPECIFICATIONS IS NOW ON FILE IN THE OFFICE OF THE PARTY OF THE FIRST PART UNDER DATE OF APRIL 8, 1982

THAT IN CONSIDERATION OF THE FOREGOING THE PARTY OF THE FIRST PART HEREBY AGREES TO PAY THE PARTY OF THE SECOND PART, PROMPTLY AND ACCORDING TO THE REQUIREMENTS OF THE SPECIFICATIONS THE AMOUNTS SET FORTH SUBJECT TO THE CONDITIONS AS SET FORTH IN THE SPECIFICATIONS

THE PARTIES HERETO AGREE THAT THE NOTICE AND INSTRUCTIONS TO BIDDERS, THE PROPOSAL FILED HEREIN, THE GENERAL SPECIFICATIONS OF THE IOWA DEPARTMENT OF TRANSPORTATION FOR 1977 TOGETHER WITH SPECIAL PROVISIONS ATTACHED, TOGETHER WITH THE GENERAL AND DETAILED PLANS IF ANY FOR SAID PROJECT SN-418(1)--SL-17 , TOGETHER WITH SECOND PARTY'S PERFORMANCE BOND ARE MADE A PART HEREOF, AND TOGETHER WITH THIS INSTRUMENT CONSTITUTE THE CONTRACT BETWEEN THE PARTIES HERETO

THAT IT IS FURTHER UNDERSTOOD AND AGREED BY THE PARTIES OF THIS CONTRACT THAT THE ABOVE WORK SHALL BE COMMENCED OR COMPLETED IN ACCORDANCE WITH THE FOLLOWING SCHEDULE

APPROX. OR SPECIFIED STARTING DATE OR NUMBER OF WORKING DAYS	SPECIFIED COMPLETION DATE OR NUMBER OF WORKING DAYS
30 WORKING DAYS	JULY 30, 1982

THAT TIME IS THE ESSENCE OF THIS CONTRACT AND THAT SAID CONTRACT CONTAINS ALL OF THE TERMS AND CONDITIONS AGREED UPON BY THE PARTIES HERETO

IN WITNESS WHEREOF THE PARTIES HERETO HAVE SET THEIR HANDS FOR THE PURPOSE HEREIN EXPRESSED TO THIS AND THREE OTHER IDENTICAL INSTRUMENTS AS OF THE ______ DAY OF ______, 19____

COUNTY OF CERRO GORDO, IOWA

BY ______
PARTY OF THE FIRST PART

WEAVER CONSTRUCTION CO. OF IOWA FALLS, IOWA

BY ______
PARTY OF THE SECOND PART

Appendix D

Special Provisions

IOWA DEPARTME - OF TRANSPORTATION
Ames, Iowa

SPECIAL PROVISION
FOR
EXPERIMENTAL CRACK SEALING

Project SN-418(1)--51-17 Cerro Gordo

March 19, 1982

382.01 DESCRIPTION. This work shall consist of routing and/or cleaning of cracks in an existing asphaltic pavement and filling the cleaned cracks with approved materials as specified, in conjunction with and prior to resurfacing with hot-mixed ACC or slurry seal coat.

382.02 EQUIPMENT. Equipment for routing of cracks shall be capable of cutting the crack to provide a minimum width of 1/2 inch to a minimun depth of 1 1/2 inches along the line of the existing crack.

Equipment for cleaning cracks after routing shall be either the high-pressure water blaster described in the following paragraph or compressed air of pressure sufficient to remove loose material to a deoth of 1 1/2 inches.

Equipment for cleaning cracks that are not routed shall be a high-pressure water blaster capable of a 2,000 psi pressure at the nozzle.

Equipment for placing the crack sealer material shall be suitable for the type of material to be used, subject to approval of the engineer.

A. **Asphalt Emulsion** crack sealer shall be placed with equipment similar to that described in 2001.12, a heating kettle, or pouring pots designed for this purpose.

B. **Slurry Mixtures** shall be placed with equipment which develops sufficient pressure to force the slurry mixture through the full depth and width of the crack without appreciable waste. A surface template shall be provided to retain the mixture in the crack and to minimize extrusion onto the road surface. (The Iowa Department of Transportation owns a template with pump and nozzles suitable for the work on this project. It will be available to the contractor at no cost for project use. The contractor will have to furnish his own air supply, lifting devices, etc., as may be needed for completion of this phase of work.)

C. **Rubberized Ashpalt Material** shall be placed with equipment that is capable of heating the material and extruding it through a hose and nozzle at a pressure adequate to fill the crack fully and to provide intimate contact with the crack faces.

382.03 MATERIALS. Materials to be used for filling thermal cracks designated by the engineer shall be of the following types as designated on the plans.

A. **Emulsified Ashpalt** shall meet requirements of Section 4140, Grade CRS-2.

B. **Pumpable Emulsion Slurry Mixture** shall be composed of agricultural limestone and emulsified asphalt, mixed 50-50 by weight within a tolerance of ± 2 percent. The emulsified asphalt shall meet requirements of Section 4140, Grade CSS-1. The agricultural limestone shall be screened or processed so that 96 percent passes the No. 8 sieve. (One source of this limestone is Weaver Construction Company at Fort Dodge, Iowa.) Compatibility of these materials shall be determined before use.

C. **Rubberized Asphalt** shall be a homogeneous, semi-fluid mixture composed of 75 percent AC and 25 percent ground rubber, meeting the following requirements.

1. The AC shall meet requirements of Section 4137 for AC-5.
2. The rubber shall be a granulated rubber, with a specific gravity of 1.15 ± 0.02, free of fabric, wire, and other contaminating materials, and with not more than 4 percent calcium carbonate. Irrespective of their diameters, the granules shall be less than 1/4 inch in length.
3. The AC shall be between 350 and 450 F prior to the addition of the rubber, the rubber shall then be rapidly added such that each material is within 2 percent of the intended amount, and the combined materials shall be mixed continuously until homogeneity is achieved.
4. Rubberized asphalt prepared away from the jobsite may be accepted when prepared as specified and so certified by the supplier.

D. **Pumpable Fly Ash Slurry** shall be a cement-fly ash mixture meeting the following requirements.

1. Cement shall meet requirements of Section 4101 for Type I cement.
2. Fly ash shall be from a source approved by the engineer.
3. The mixture shall be one part cement and 3 parts fly ash (by volume), with water adequate to achieve fluidity and with additives as approved by the engineer.
4. Fluidity of the mixed slurry shall be measured by the Corps of Engineers flow cone method according to their Specification CRD-C611-80. Time of efflux shall range from 16 to 26 seconds. These measurements will normally be made at least once every 4 working hours. The range of time of efflux may be adjusted by the engineer.
5. The contractor shall submit to the engineer his proposal for materials and additives to be used for this mix design.

Material for filling random and alligator cracks shall be CRS-2 emulsified asphalt.

Blotting material shall be a sand or agricultural limestone. Sand shall meet requirements of Section 4110 or 4112 or shall be a sand of a similar gradation. Agricultural limestone shall have essentially 100 percent passing a 3/8-inch sieve.

Inert filler shall be a sand suitable for the blotting material.

382.04 CONSTRUCTION. Except in the area identified on the plans as the control section, all thermal cracks shall be sealed with the seal material designated for that section. Thermal cracks will be identified by the engineer; these are usually transverse cracks extending for the full width of the pavement, generally in a fairly straight line. Thermal crack less than 1/2 inch in width shall be routed to a depth of at least 1 inch and to a width of at least 1/2 inch. All routed thermal cracks shall be cleaned with either air or water before sealing. All thermal cracks over 1/2 inch in width need not be routed, but they shall be cleaned with water before sealing.

Except in the area identified on the plans as the control section, cracks other than thermal cracks shall be routed, as designated by the engineer, to secure a depth of at least 1 inch and a width of at least 1/2 inch. All cracks to be sealed shall be cleaned before sealing. Cracks that are routed may be cleaned with either air or water; cracks that are not routed shall be cleaned with water.

With either air or water cleaning, there shall be sufficient pressure to remove loose material and leave clean surfaces for proper bonding of the sealer material.

In the control section identified on the plans, cracks will not require treatment prior to resurfacing. In test sections, cracks designated by the engineer to be sealed shall be sealed with the material indicated on the plans for that section; however, for pumpable slurry sections, cracks designated as thermal cracks shall be sealed with the slurry mixture, and other cracks designated for sealing shall be sealed with CRS-2 emulsified asphalt. Cracks to be sealed with rubberized asphalt shall appear dry on visual examination, prior to sealing; other cracks shall be allowed to dry a minimum of 2 hours after cleaning and prior to sealing, when cleaned with water. In the sections designated by the engineer, cracks to be sealed with rubberized asphalt shall be partially filled with inert filler, loosely placed so as to provide a minimum cover of 1 inch of sealer material over the inert filler. Cracks to be sealed with a slurry mixture shall be sealed full depth under a pressure adequate to fill voids.

Surface depressions adjacent to thermal cracks shall be corrected by slightly overfilling with the sealer material or by a separate application of CRS-2 asphalt emulsion. The overfilling or asphalt emulsion shall be immediately smoothed with a hand squeegee and the area sprinkled with 3/8-inch cover aggregate.

All sealing shall be flush with the adjacent surface. With free-flowing material, measures shall be taken to hold sealer in place, preventing runout in low areas. This may be by a hand squeegee and a light application of blotting material.

Any surplus material on the pavement shall be smoothed with a hand squeegee and blotted with sand or agg lime.

382.05 LIMITATIONS. The plans will indicate requirements for traffic control that may be necessary in conjunction with this work.

The work schedule shall be adjusted so that all traffic lanes can be opened to traffic at the end of the workday. All equipment and traffic-control devices shall be removed from the roadbed from 30 minutes before sunset to 30 minutes after sunrise.

The new wearing courses to be placed are designated in the contract documents. Placement of these courses, including surface patches and wedge, leveling, and strengthening courses, shall not be done on these sections for at least 30 days after the crack sealing is completed. If appropriate, the engineer will issue a temporary suspension of work.

382.06 METHOD OF MEASUREMENT. The engineer will compute from measurements the lengths of cracks routed and determine the quantities of various materials used in experimental crack sealing.

382.07 BASIS OF PAYMENT. For the various items of work involved in experimental crack sealing, satisfactorily completed, the contractor will be paid as follows:

1. Routing Cracks. For the number of feet of cracks routed, less than 1/2 inch in width, the contractor will be paid the contract price per linear foot.
2. Sealing, Emulsified Asphalt. For the number of gallons of emulsified asphalt used in experimental crack sealing, the contractor will be paid the contract price per gallon. This quantity is to include asphalt emulsion used in the emulsion slurry mixture.
3. Sealing, Emulsion Slurry. For the number of tons of aggregate used in the emulsion slurry, the contractor will be paid the contract price per ton.
   Emulsified asphalt used in this mixture will be included in the Paragraph 2 quantity.
4. Sealing, Fly Ash Slurry. For the total number of tons of cement used in the fly ash slurry, the contractor will be paid the contractor price per ton.
5. Sealing, Rubberized Asphalt. For the number of pounds of rubberized asphalt used, the contractor will be paid contract price per pound.

Payment for routing shall be full compensation for routing the cracks designated. Payment for each of the items of sealing shall be full compensation for cleaning the cracks and for furnishing and placing the sealer specified. These payments shall also be full compensation for furnishing and placing inert filler in cracks designated, cover aggregate over depressed areas at cracks, and sand or agg lime as blotter material, for traffic control as shown on the plans, and for furnishing all materials, equipment, and labor therefor, in accord with this special provision. Article 1109.03 shall not apply to these items.

Traffic wearing courses required by the the contract are not covered by this special provision.

Appendix E

Corps of Engineers Flow Cone Method

CRD-C 611-80

TEST METHOD FOR FLOW OF GROUT MIXTURES
(Flow-Cone Method)

Scope

1. This method of test covers the procedure to be used both in the laboratory and in the field for determining the flow of grout mixtures by measuring the time of efflux of a specified volume of grout from a standardized flow cone.

Apparatus

2. **(a) Flow Cone.**- The flow cone shall conform to the dimensions and other requirements indicated in Fig. 1.

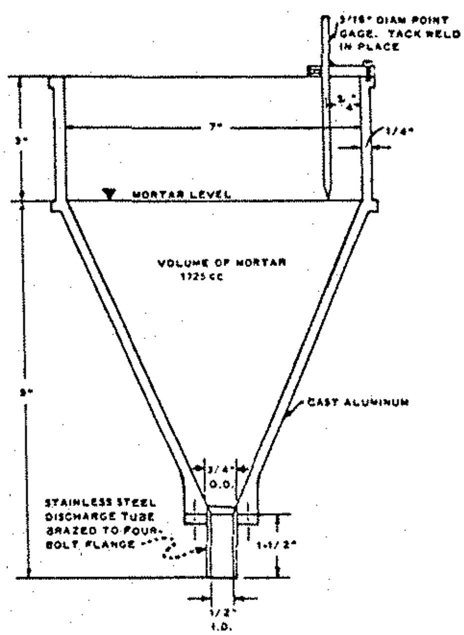


Fig. 1. Cross section of flow cone

SI Equivalents

U. S. Customary, in.	SI, mm
3/16	5
1/4	7
1/2	13
3/4	20
1-1/2	38
3	76
7	177
9	228

(b) Stop Watch.- A stop watch having a least reading of not more than 0.2 sec.

Calibration of Apparatus

3. The flow cone shall be firmly mounted in such a manner that the top will be level and the cone free from vibration. The discharge tube shall be closed by placing the finger over the lower end. A quantity of water equal to 1725 ± 1 cc shall be introduced into the cone. The point gage shall be adjusted to indicate the level of the water surface.

Sample

4. The test sample shall consist of 1725 ± 1 cc of grout.

Procedure

5. Moisten the inside surface of the flow cone (Note 1). Place the finger over the outlet of the discharge tube. Introduce grout into the cone until the grout surface rises into contact with the point gage. Start the stop watch and remove the finger simultaneously. Stop the stop watch at the first break in the continuous flow of grout from the discharge tube when the cone is essentially empty (Note 2). The time indicated by the stop watch is the time of efflux of the grout. At least two tests shall be made for any grout mixture.

Note 1.- A recommended procedure for insuring that the interior of the cone is properly wetted is to fill the cone with water and, one minute before beginning to add the grout sample, allow the water to drain from the cone.

Note 2.- If there is a break in the continuity of discharge prior to essential emptying of the cone, the grout is too thick to be properly tested for flow by this method.

Report

6. The report shall include:

(a) Average time of efflux to the nearest 0.2 sec,

(b) Temperature of the sample at the time of test,

(c) Ambient temperature at the time of test,

(d) Composition of the sample, and

(e) Information on the physical characteristics of the sample.

Appendix F

Equipment List

Equipment List for Crack Filling

Crack Preparation

CRAFCO joint and crack routers (2)
Hotsy water blaster - 2000 psi
Grimmer-Schmidt air compressor - 150 psi

Crack Sealing

CRAFCO Model 5C 220 Kettle - 200 gal.
Sandpiper model SB 1 1/2-A pump
Iowa DOT injection frame
Caterpillar end loader
A small portable mortar mixer
A tandem dump truck
Etnyre Distributor