80-3

USE OF LONGITUDINAL SUBDRAINS IN THE 3R PROGRAM

Progress Report
Project HR-509

DEPARTMENT OF TRANSPORTATION
IOWA

Highway Division
May 1980

IOWA DEPARTMENT OF TRANSPORTATION

Director

Raymond Kassel

Vernon J. Marks

Materials-Research

June 26, 1980

HR-509

CNL

Progress Report HR-509, "Use of Longitudinal Subdrains in the 3R Program"

Attached is one copy of the research report noted above. The research involved the installation of edge subdrain on 14 miles of I-80 in Poweshiek County. The objective was to alleviate pumping and faulting of the jointed pcc pavement. After periods of rainfall, there is substantial flow from the outlets. At this time, there is some data that would indicate a reduction in the rate of faulting but the data is not adequate to support a conclusion.

VJM/jc
Attachment
cc:attachment

D. E McLean
G. Calvert
R. McIntire
C. L. Huisman
T. E. McElherne
K. McLaughlin
J. V. Bergren
B. C. Brown
D. Stohlmeyer
F. O. Bloomfield
L. Richardson

H. Schiel
G. Sisson
C. Pestotnik
K. Davis
District Engineer (6)
I. MacGillivray
Library (7)
AASHTO-AMRL-Lab Dick Hay
Adjoining States Materials Engineers

CNL
p/s note—
Some day we may need your comments on this, should others think this is for us too—
then send to KHD for Library

PROGRESS REPORT
FOR
PROJECT HR-509

USE OF LONGITUDINAL SUBDRAINS IN THE 3R PROGRAM

BY

VERNON J. MARKS
RESEARCH ENGINEER
515/296-1447

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
AMES, IOWA 50010

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USE OF LONGITUDINAL SUBDRAINS IN THE 3R PROGRAM

INTRODUCTION AND PROBLEM STATEMENT

Construction of the interstate highway system began in 1956. This U.S. network of highway consists of more than 41,000 miles with 790 miles in Iowa. There have been many benefits of the controlled access roadway, but probably the most significant is the improved safety for the motorist.

In Iowa, we have always endeavored to utilize quality locally available materials in our construction using the most economical or cost effective methods. Obviously when the effort is to build a cost effective system, there will be some portions of the network that will not perform as well as expected. In the design of our interstate, the main consideration for base construction under the pavement was structural capacity. The material was dense graded with the aim of supporting the pavement and distributing the load as it is transferred to the underlying grade. The drainage characteristic of the base was apparently not given adequate consideration. On jointed portland cement concrete (pcc) pavement, the water that is trapped immediately beneath the pavement causes severe problems. The traffic causes rapid movement of the water resulting in the hydraulic pressures or "pumping" (movement and redeposit of base fine material) resulting in faulting between individual slabs.

Recognizing the need for maintaining this large national highway network, the Federal Highway Administration has initiated a funding program for resurfacing, restoration and rehabilitation (3R). Many miles of the system are more than 20 years old and in need of major maintenance. This new 3R Program necessitated a complete inventory of the Iowa interstate system to establish priorities and to identify those sections in need of immediate remedial treatments.

PROJECT LOCATION

One section of highway that was identified by the 3R inspection team was I-80 in Poweshiek County from Iowa 146 to the Brooklyn Interchange (13.6 miles). This pavement is a 10 inch thick mesh reinforced pcc with doweled transverse joints at a 76.5 foot spacing. The pavement was placed on a relatively dense graded 4 inch crushed limestone "granular subbase". The inspection team noted that many transverse joints were faulted. Edge pumping was evident along most of this section with damage to the shoulders. The shoulders had settled ½ to 1 inch below the edge of pavement. The pavement was constructed in 1964 and has a traffic volume of over 14,000 vehicles per day with about 4,000 of these being trucks. Many full depth patches were placed and pressure relief joints cut in the fall of 1977.

OBJECTIVE

The objective of this evaluation is to determine if longitudinal subdrains are effective in preventing or reducing pumping, faulting and related deterioration.

SUBDRAIN DESIGN

used 4"

The subdrain design utilized 6" diameter commercially available slotted polyethylene corrugated agriculture tubing complying with ASTM F-405. It was placed continuously adjacent to the outside edge of pavement for the entire 14 miles of the project. Subdrain was placed adjacent to the inside edge of pavement 500' either direction from the low point of vertical curves. The detailed design is given in Appendix A1. The gradation of the porous backfill is:

Sieve Size	% Passing
3/4"	100
1/2"	95 - 100
3/8"	50 - 100
#4	15 - 50
#8	0 - 5

A new detailed design (Appendix A2) has recently been developed with modifications to alleviate initial problems.

CONTRACT

The project was let on June 20, 1978, with a starting date of August 14, 1978. The successful low bidder was

Manatt's Incorporated of Brooklyn, Iowa. The total bid (Appendix B) was $1,213,872. which included 159,347 lineal feet of subdrain at $5.03 per lineal foot. The work period was set at 100 days.

CONSTRUCTION

For construction, the interstate traffic was restricted to one lane with appropriate signing and traffic control. Installation of the subdrain began on September 11, 1978. The contractor established a very efficient equipment train to accomplish the subdrain installation. The contractor's goal was to place 3000 lineal feet of subdrain per day. This was a new operation for the contractor and as with all new operations, there is a learning period. The first day only 240 feet were placed with about 700 feet the second day. On September 25, the contractor reached his goal of 3000 feet in one day.

The first operation utilized a Vermeer T-600C (Figure 1) trencher to cut the one foot wide, 2 foot deep trench. Initially, this trencher was equipped with a disc cutter wheel (Figure 2) to aid in maintaining proper alignment. Later, this was of questionable benefit. The trencher cut very neat side walls and alleviated some initial concern that chunks might be torn from the asphalt concrete shoulder surfacing. It was, however, relatively severe to the trencher's cutting teeth.

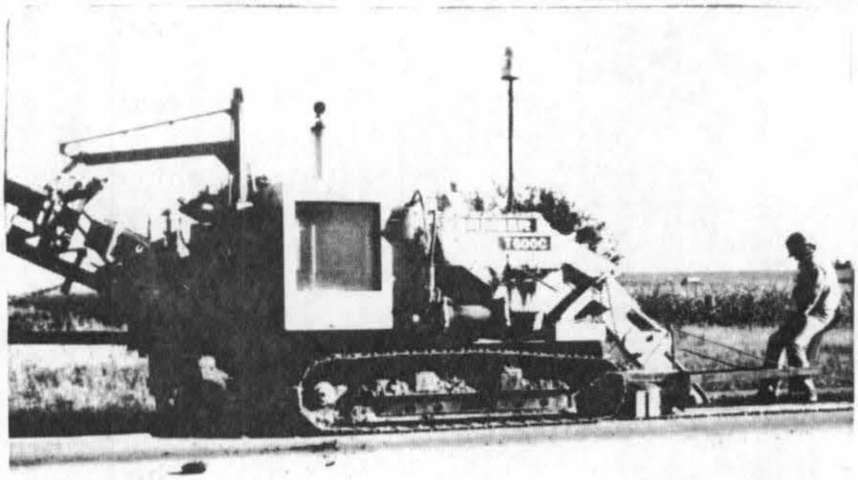


Figure 1: Vermeer T-600C Trencher

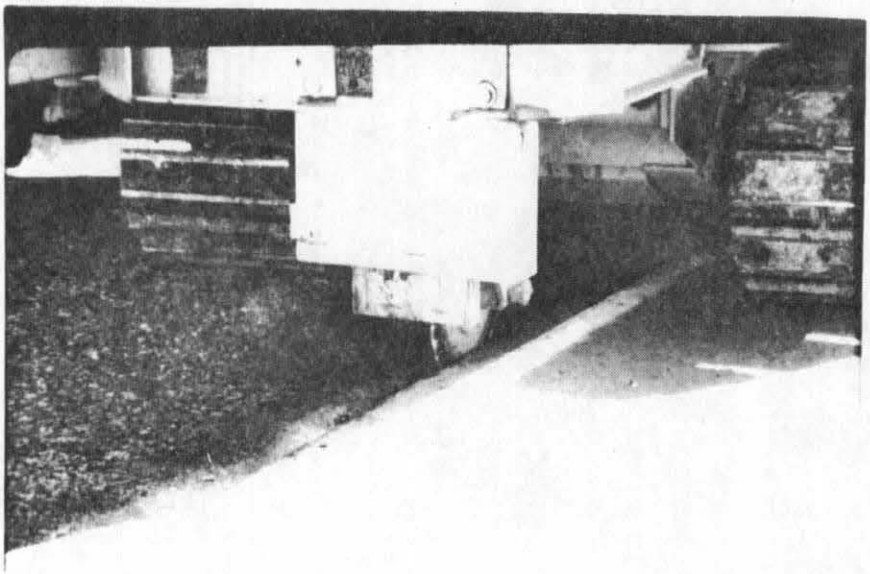


Figure 2: Disc Cutter Wheel to Aid in Alignment

A side elevator of the trencher deposited the material directly into trucks (Figure 3).

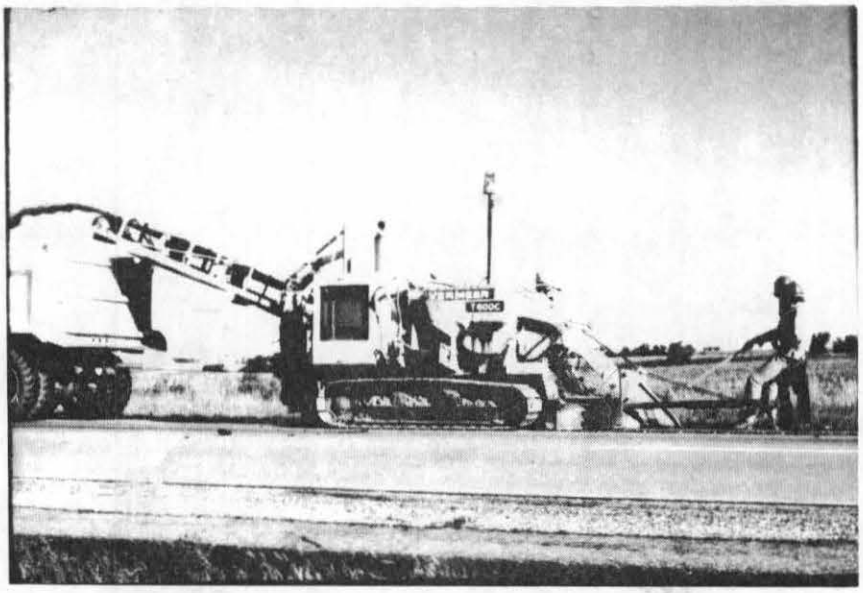


Figure 3: Loading Excavated Material.

Polyethylene tubing deteriorates if exposed to sunlight and therefore, a note on the plans required protected storage even though the producer claimed that an additive would protect the tubing for up to six months. The tubing was placed in the trench manually (Figure 4).

Figure 4: Hand Placement of the Tubing

The next operation in the train was the proper placement of the porous backfill material using a Blawknox RW-38 road widener (Figure 5) with a special box attachment. This operation caused the most problems and required special attention. With proper modifications, the tubing was threaded through a guide in the special attachment and the 3" bedding beneath the pipe was achieved. A vibrating pan unit (Figure 6) was attached to the special box for compaction of the porous backfill.

Figure 5: Blawknox RW-38 Placing Porous Backfill

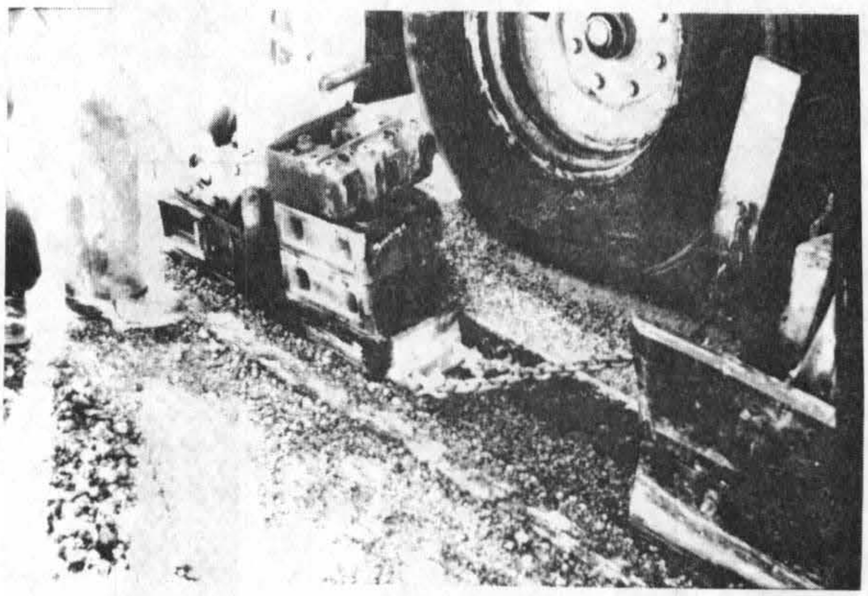


Figure 6: Vibrating Pan Compaction of Porous Backfill

The pavement was then broomed prior to placement of the 6" thick 3/4" type B asphalt concrete shoulder. The asphalt was placed with a second Blawknox RW-38 road widener (Figure 7). The asphalt concrete was compacted with a small 30" vibratory roller. The filled trench was very neat even before the ½" cover aggregate placement (Figure 8).

Figure 7: Placing Asphalt Concrete with Blawknox RW-38

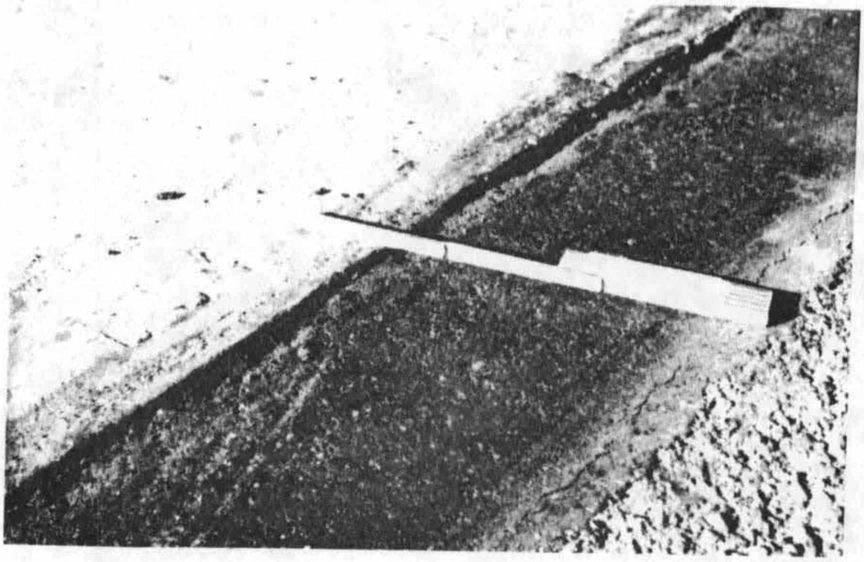


Figure 8: Finished Trench Prior to Cover Aggregate Placement

Preformed polyethylene T's (Figure 9) were used at outlet locations (at 1000' intervals). The porous backfill at the outlet was manually placed. Earth fill was tamped around the RF-22 subdrain outlets (Figure 10).

During construction, water would flow into the open trench and partially fill the new pipe overnight. Following a rain, outlets of completed sections would flow from a trickle to a depth of one to two inches. This was an early indication of their potential benefit.

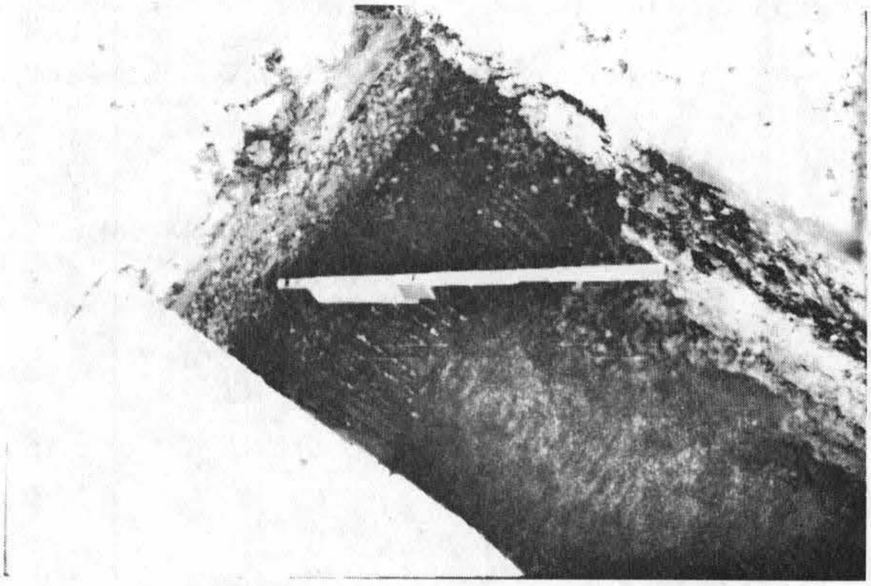


Figure 9: Preformed T for Outlet

Figure 10: Tamping Earth Fill Around the RF-22 Outlets

The reinforced concrete pipe median drains caused some problem during construction. Some were not deep enough to allow a two foot deep trench. Other had cavities that would allow the loss of porous backfill resulting in subsequent early settlement. Without special treatment, these situations could also lead to future piping along the median drain. The remedy for the problem on this project was to excavate over the median pipe and tack coat the pipe with asphalt cement. Two layers of filter fabric were then placed on the tack coat followed by capping with asphalt concrete hot mix.

Construction was not completed during 1978. Another problem was recognized in the early spring of 1979. The RF-22 outlets froze shut during the winter period. Early spring flow from the subdrains eroded the earth fill around the RF-22 outlet (Figure 11). This problem was solved by carrying the porous backfill the total length of the RF-22 outlet.

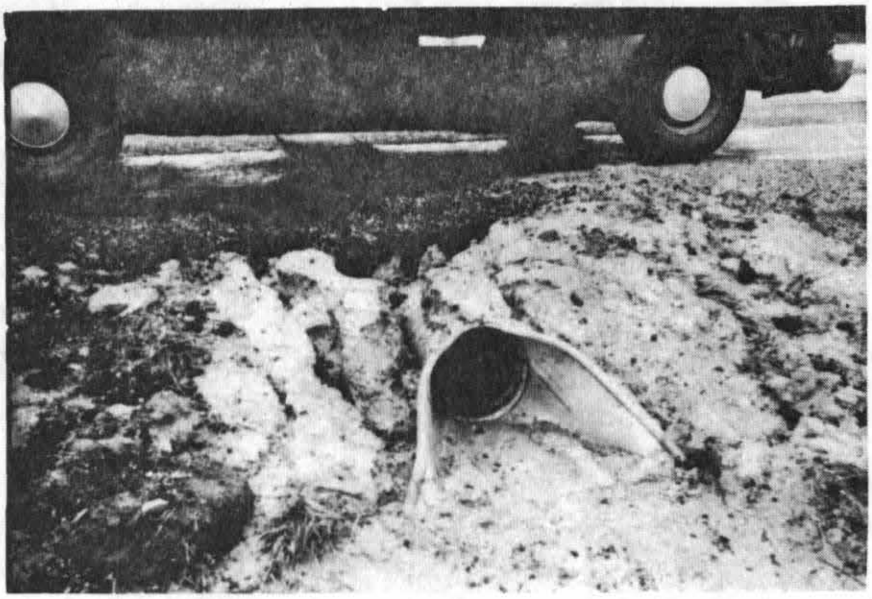


Figure 11: Erosion Around the RF-22 Outlet

SUBGRADE PERCOLATION TESTING

The 4" thick granular subbase material on the Poweshiek project was a crushed limestone with a typical grading as follows:

Sieve Size	% Passing
1 1/2"	100
1"	97
3/4"	93
3/8"	80
#4	74
#10	60
#40	37
#200	23

5-12
96

There was some question as to the percolation characteristic of this material. A somewhat crude test was used as a measure of this characteristic. A 4¼" diameter core hole was drilled through the concrete slab taking care to quit drilling quickly after breaking through the slab to avoid disturbance of the granular subbase. The core hole was immediately filled with water. The subsidence was measured at 5 minutes (A). The core hole was refilled and the subsidence measured at 10 minutes (B). In some cases, the core hole was refilled and the subsidence measured at 15 minutes (C). This test was conducted at three locations with the results as follows:

				Reading		
				A	B	C
Poweshiek	Sta.	434+70	EB	1-1/2"	1-1/4"	
	Sta.	544+20	EB	5-1/2"	4"	3-9/16"
	Sta.	323+96	WB	7-7/16"	6"	6"
Jasper	Sta.	1793+25	WB	5/8"	1/4"	

The Jasper granular subbase was a blend of sand-gravel and limestone and is included for comparison. A typical gradation of the blended granular subbase material used in Jasper Co. is:

Sieve Size	% Passing
1"	100
3/4"	94
3/8"	87
#4	83
#8	78
#10	76
#40	39
#60	21
#100	12
#200	8.2

The Poweshiek subbase material has better percolation characteristics than the Jasper subbase. Obviously, better drainage characteristics are desirable in the Poweshiek project.

SUBDRAIN EVALUATION

The flow from the subdrain outlets has indicated their effectiveness. As noted, some flow began immediately after installation. Periodic flow checks have been made. Many of these have been made after periods of rainfall. A summary of those periodic checks is provided in Table I.

TABLE I: SUBDRAIN OUTLET FLOW SUMMARY

Date	5/3/79	8/20/79	8/23/79	11/9/79	4/11/80
Amount of Recent Rainfall	1.10"	4."	2."	fall	--
FLOW: Dry	9	12	24	104	63
Trace	83	28	65	24	56
Small stream (less than 1/8")	10	72	26	0	11
1/8" stream	0	7	4	0	0
1/4" stream	0	10	1	0	0
	[illegible]	[illegible]	[illegible]	128	130

It is evident from the values in Table I that the outflow is very dependent on rainfall and subsequent runoff. It is also apparent from the August 20 and 23 results that the decrease in flow after rainfalls is relatively rapid. The 1980 spring rainfall has been substantially below normal.

The Present Serviceability Index (PSI) is a rating scale of pavement condition with 0 being bad and 5 being excellent. The PSI is obtained by combining a riding quality such as the Longitudinal Profile Value (LPV) with a deduction for cracking and patching (C&P) deterioration. The PSI was determined when the project was initiated (9/22/78) and will be determined annually thereafter.

	Subdrain Project			Adjacent to the project		
DATE	LPV	C&P	PSI	LPV	C&P	PSI
9-22-78	3.71	0.74	2.97	3.80	0.66	3.14
6-25-79	3.68	0.78	2.90	3.76	0.70	3.06

From the test results, there is still deterioration and related loss in riding quality on both the pavement included in the subdrain project and an adjacent pavement included in the subdrain project and an adjacent pavement section tested for comparison. There is presently no significant difference with regard to the subdrains.

One specific aim of the subdrains was to eliminate pumping and prevent increase in faulting.

Date	Subdrain Project (Avg. of 62)	Adjacent To The Project (Avg. of 6)
October, 1978	0.18"	0.12"
December, 1979	0.21"	0.18"

Even though the faulting has increased, the test values would indicate that the rate of increase is less than the rate for an adjacent pavement without subdrains. Additional testing will be necessary to verify this trend.

Initially there was concern that an edge rut problem may develop due to subsequent settlement of the trench area. There is no evidence of settlement as of this date.

EVALUATION SUMMARY

Based upon the flow from the outlets observed during periodic checks and evidence of water flow at the outlets, it appears that to date the subdrains are effective in draining the subbase and subgrade. Because of the limited data available at this time, the pavement condition and faulting results are inconclusive.

ACKNOWLEDGEMENTS

The project results from the initial promotion and subsequent design by Ralph Britson and Kermit Dirks of the Office of Road Design. Construction was under the direction of John Peters and the Marshalltown Construction personnel. The

contractor, Manatt's Incorporated, is to be complemented for implementing techniques that made construction of the project a success. Robert Choate and the Grinnel Maintenance personnel are obtaining periodic flow measurements. The data on riding quality and faulting is being obtained by Charles Potter and the Special Investigation personnel.

7-10-80

Several troubling thoughts:

1. Does outflow after rain indicate drainage from base or is it water running down in crack between pavement & shoulder. There is a noticeable crack with a rather permeable granular layer (page 3) below.

2. Is the percolation procedure (page 13-14) suspect? Why not take some material and run percolation (permeability) tests. Difficult to believe material with 23% minus 200 is more permeable than material with 8.2 minus 200, particularly when Sk/Ahu ratio is 83 vs 76.

3. Can 62 faults be compared to 6.
3/16" faults barely perceptible.

4. No difference is serviceability yet.

5. No comment on reduction of edge pumping. Still pumps!

over

CVL

P.S. Morse has been installed near Iowa City.

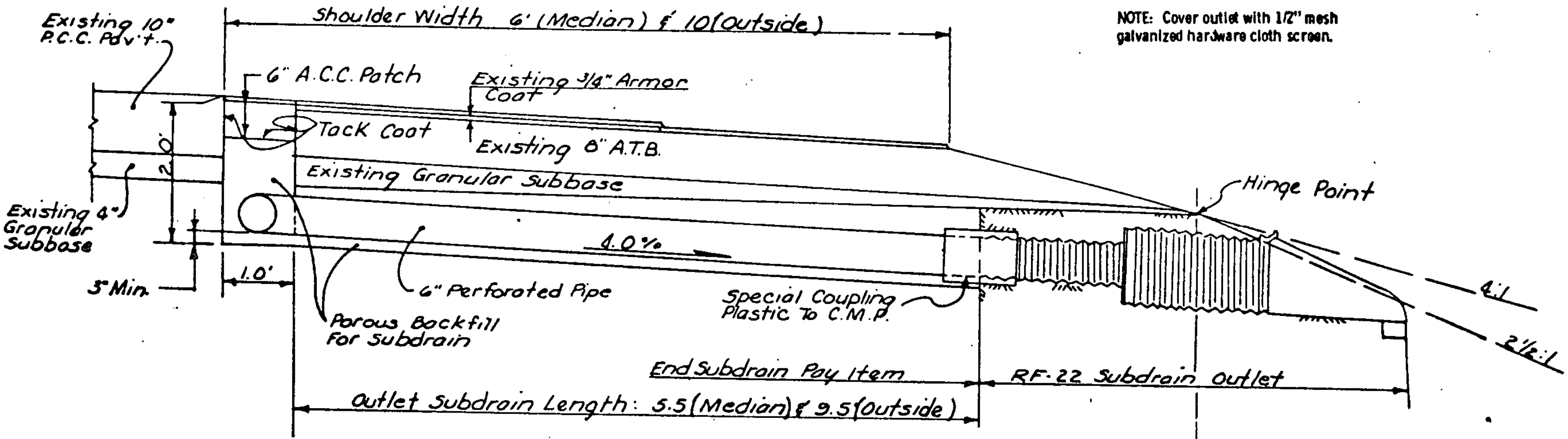
6. No soils in pumping. Only stain. Some dredgers call it "blowing."

7. No cover at faults! Usually low side stays at grade and high side rises. True here? If so, how, why?

8. Seems a half hearted effort to confirm preconceived idea.

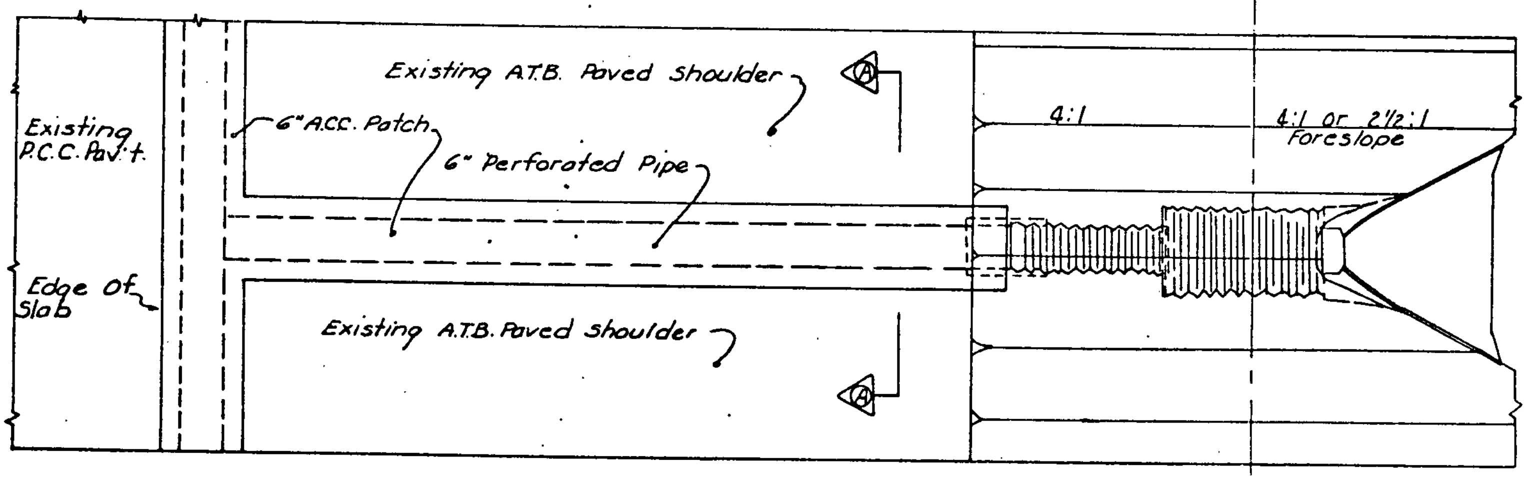
9. What done about freezing shut at most critical period. Easy to remedy.

NOTE: Cover outlet with 1/2" mesh galvanized hardware cloth screen.

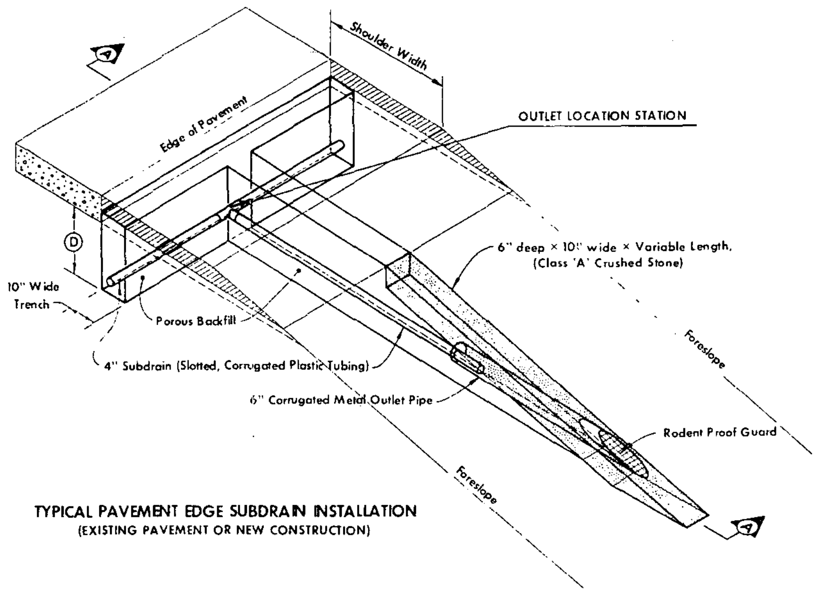


TYPICAL CROSS SECTION AT SUBDRAIN OUTLET

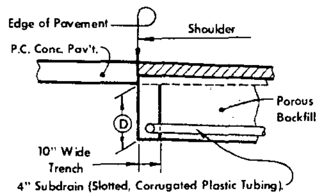
Hinge Line



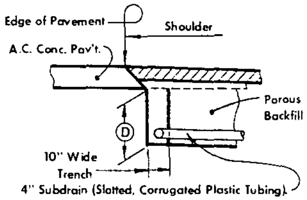
PLAN VIEW OF SUBDRAIN OUTLET



TYPICAL PAVEMENT EDGE SUBDRAIN INSTALLATION
(EXISTING PAVEMENT OR NEW CONSTRUCTION)



P.C.C. Pavement



A.C.C. Pavement

SECTION A-A
TYPICAL SUBDRAIN OUTLET
(NEW CONSTRUCTION)

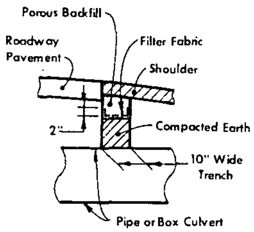
GENERAL NOTES:
Details indicated hereon are for the construction of pavement edge subdrains and outlets. All work and materials used in the installation shall be in conformance with applicable Standard Road Plans, current Standard and Supplemental Specifications. Refer to "Tabulation Of Pavement Edge Subdrain" for details of individual subdrain and installations.

Each outlet shall be covered with ½" mesh galvanized screen or an approved commercial rodent guard. The guard shall be securely fastened to the outlet pipe end by means approved by the engineer.

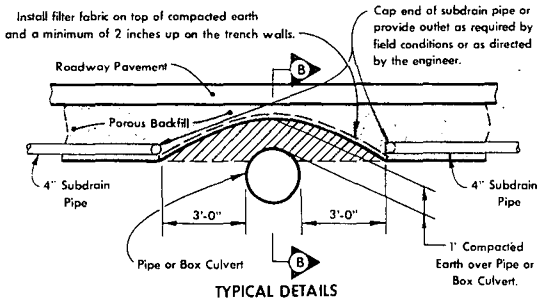
Subdrain trench shall be located adjacent to edge of roadway pavement. On new construction projects, the subdrain shall be placed after the mainline paving and prior to shoulder placement. On new projects with tied P.C.C. Shoulders, trench location shall be as determined by the engineer. On existing roadways, the trench shall be capped with material per current Standard and Supplemental Specifications.

Price bid for "Subdrain, As Per Plan" (in lin. ft.) shall be considered full compensation for all installation work and materials necessary as detailed hereon, included in current Standard and Supplemental Specifications and as required by project plans.

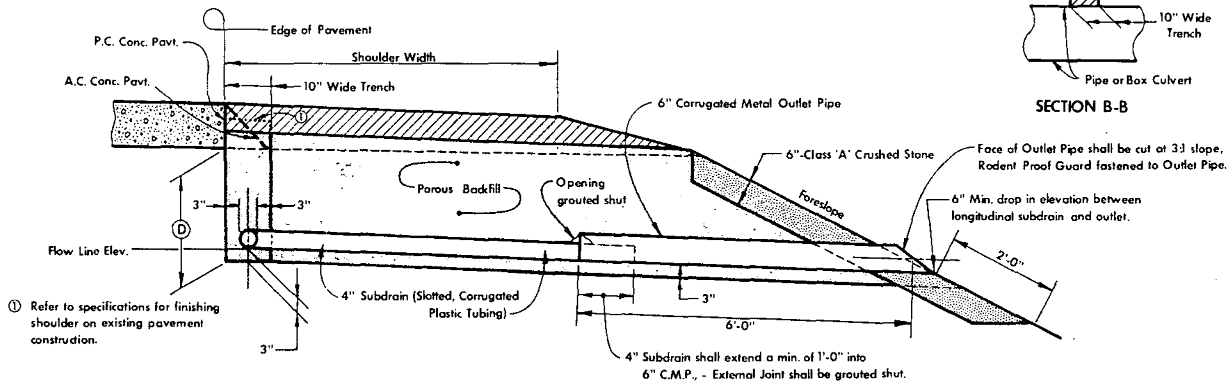
Project quantities includes length for both the subdrain at the edge of pavement and the subdrain in the outlet.



SECTION B-B



TYPICAL DETAILS
SUBDRAIN INSTALLATION AT
R.C.B. CULVERTS OR RF-1 CONCRETE PIPE CULVERTS
(If culvert is 1 ft. or more below trench bottom, no subdrain outlets should be provided. Carry subdrain over culvert.)



① Refer to specifications for finishing shoulder on existing pavement construction.

SECTION A-A
TYPICAL SUBDRAIN OUTLET
(EXISTING PAVEMENT)

DETAIL SHEET	500-7
Revision Date NEW ISSUE 4-18-80	
DETAILS OF PAVEMENT EDGE SUBDRAIN	

COST CENTER 601000 OBJECT 878

PROJ NO IR-80-5(89)183--12-79 COUNTY POWESHIEK

RES ENGR JOHN PETERS 521500 ADDRESS MARSHALLTOWN, IOWA

LETTING DATE JUNE 20, 1978 LIQUIDATED DAMAGES $280.00

SPECIAL PROV 9/75 #PR-1273, 1/31/78 #823, 5/25/76 #788,
10/11/77 #814, 11/8/77 #820, 6/20/78 #831

DATE STARTED ______ FIELD COMP. 7-3-79 CERT COMP 8-10-79

436 11-19-79

FORM 650019 8-77 H-3878

CONTRACT

NO. 15129

TYPE OF WORK PAVEMENT REPAIR PROJECT NO. IR-80-5(89)183--12-79

MILES 14.015 COST CENTER 601000 OBJECT 878

COUNTY POWESHIEK

ON I-80 FROM 1 MILE EAST OF IOWA 146 INTERCHANGE EAST
APPROX. 14 MILES TO BROOKLYN INTERCHANGE

THIS AGREEMENT, MADE AND ENTERED BY AND BETWEEN THE IOWA DEPARTMENT OF TRANSPORTATION
ROBERT R RIGLER, STEPHEN GARST, DONALD K GARDNER, ALLAN THOMS,
W. F. MCGRATH, BARBARA DUNN, & L. STANLEY SCHOELERMAN PARTY OF THE FIRST PART, AND
MANATTS, INC. OF BROOKLYN, IOWA 28200

PARTY OF THE SECOND PART.

WITNESSETH, THAT THE PARTY OF THE SECOND PART, FOR AND IN CONSIDERATION OF $ **1,213,872.49 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
1	PATCHES, FULL DEPTH	2,000	SQ. YDS.	82.50	165,000.00
2	PATCHES, PARTIAL DEPTH	325	SQ. YDS.	72.00	23,400.00
3	PATCHES, ASPHALT CEMENT CONCRETE SURFACE	140	TONS	50.00	7,000.00
4	SUBDRAIN, AS PER PLAN	159,347	LIN. FT.	5.03	801,515.41
5	SUBDRAIN OUTLET, RF-22	146	ONLY	171.79	25,081.34
6	DRAIN, TRENCH	828	LIN. FT.	25.00	20,700.00
7A	~~BINDER BITUMEN, FURNISH & APPLY~~ CRS-2	105,244	GALS.	.72	75,775.68
8A	AGGREGATE, COVER, ON ROAD 1/2 IN.	5,262	TONS	18.13	95,400.06
				GRAND TOTAL	$1,213,872.49

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 17(8) OF THE 1975 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 JUNE 15, 1978

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 IR-80-5(89)183--12-79 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
APPROX AUG. 14,1978	100 WORKING DAYS

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__

IOWA DEPARTMENT OF TRANSPORTATION JUN 5 1978

BY ______
PARTY OF THE FIRST PART

MANATTS, INC. OF BROOKLYN, IOWA

BY ______
PARTY OF THE SECOND PART