USE OF LONGITUDINAL SUBDRAINS IN THE 3R PROGRAM

FINAL REPORT
Project HR-509

DEPARTMENT OF TRANSPORTATION
IOWA

Highway Division
December 1981

FINAL REPORT
FOR
PROJECT HR-509

USE OF
LONGITUDINAL SUBDRAINS
IN THE
3R PROGRAM

BY

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515/239-1447

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

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INTRODUCTION AND PROBLEM STATEMENT

Construction of the interstate highway system began in 1956. This U.S. network of highways 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 about 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

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 to provide bedding and cover for the tubing was:

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.

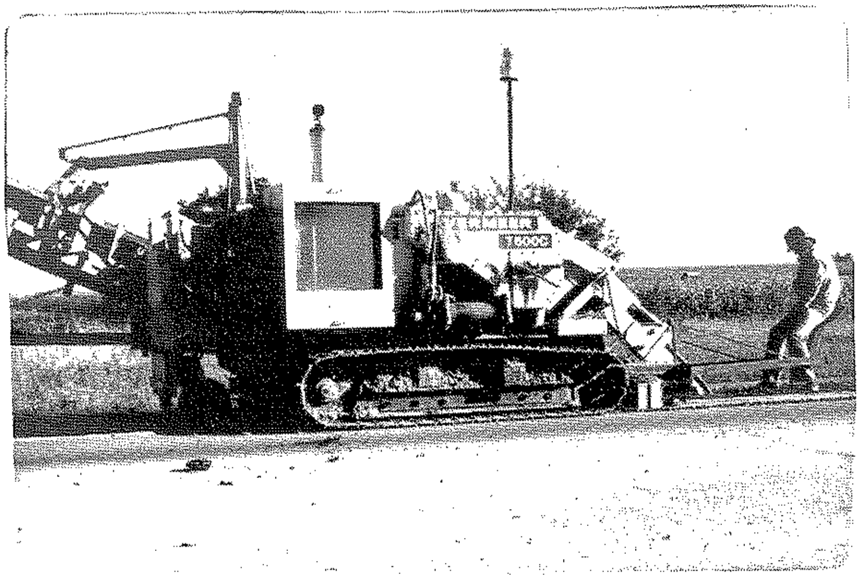


Figure 1: Vermeer T-600C Trencher

Figure 2: Disc Cutter Wheel to Aid in Alignment

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

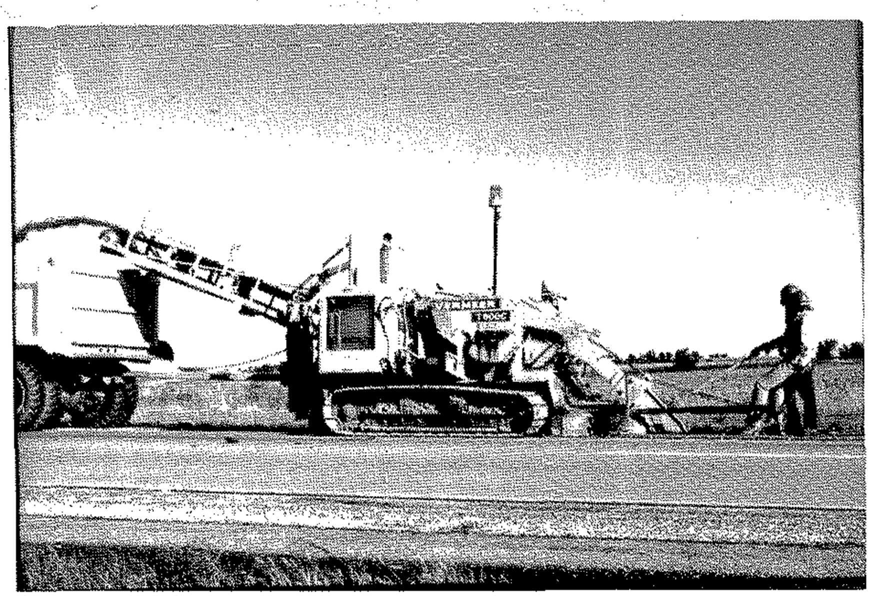


Figure 3: Loading Excavated Material

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

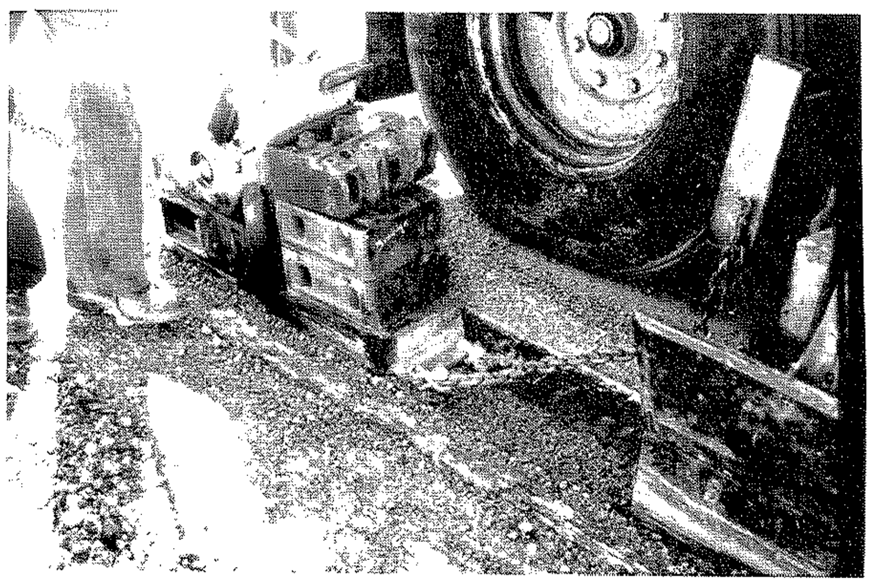


Figure 6: Vibrating Pan Compaction of Porous Backfill

The pavement was then broomed prior to placement of the 6" thick 3/4" type B asphalt concrete surface. 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 (Figure 8) even before the 1/2" cover aggregate placement over the full width of the shoulder.

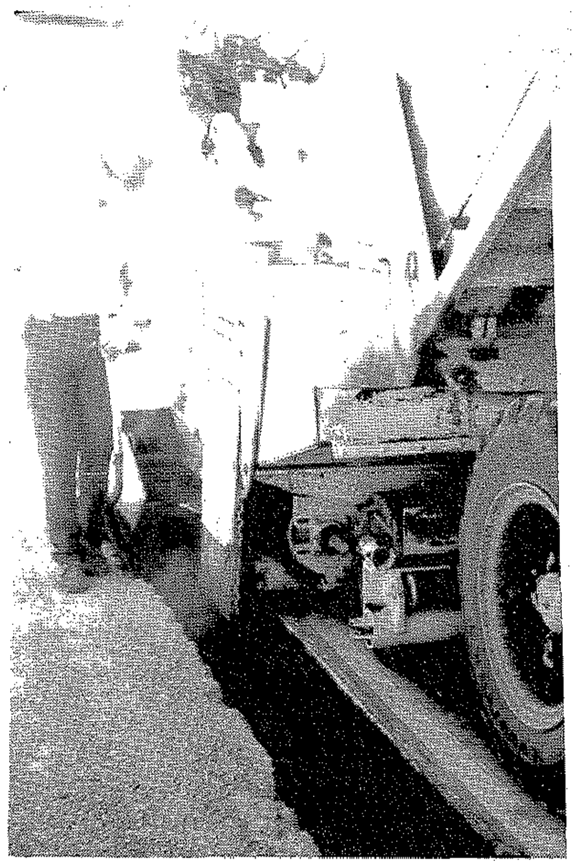


Figure 7: Placing Asphalt Concrete with Blawknox RW-38

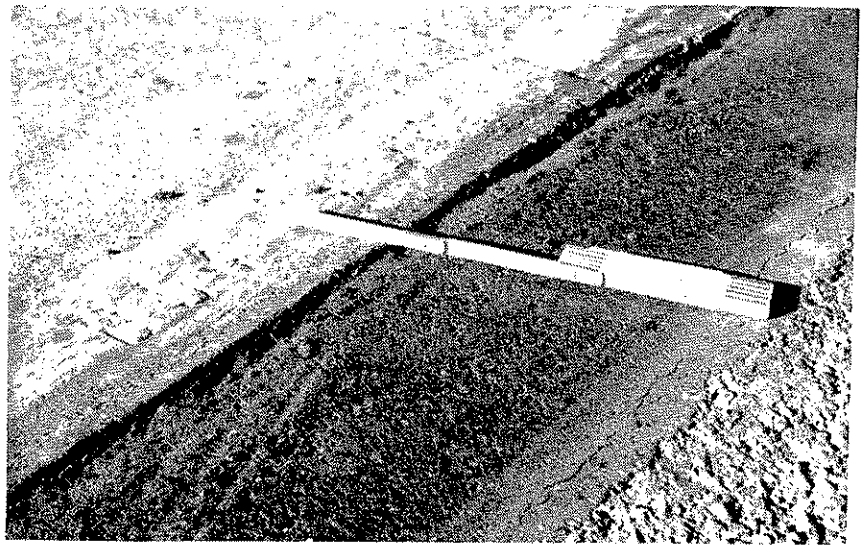


Figure 8: Finished Trench Prior to Cover Aggregate Placement

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 capability to drain water from beneath the pavement.

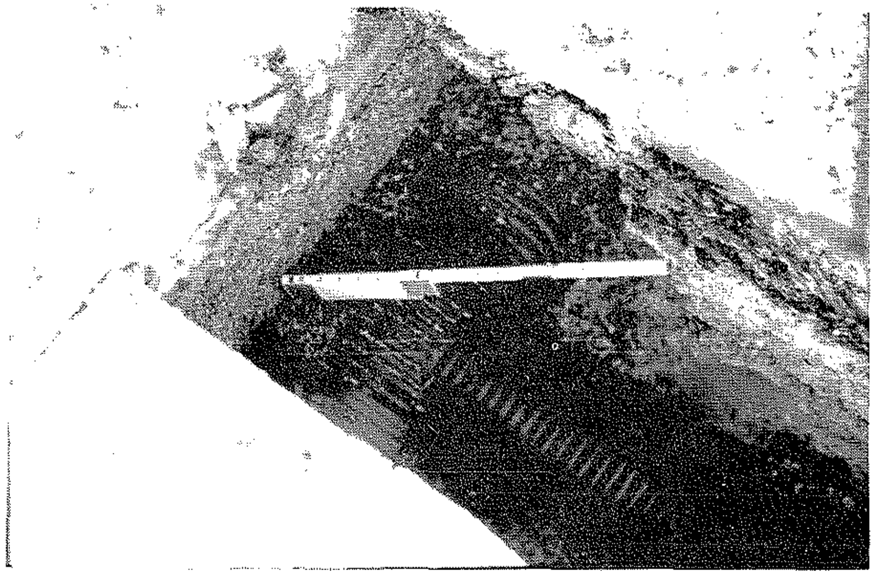


Figure 9: Preformed T for Outlet

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. Others 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.

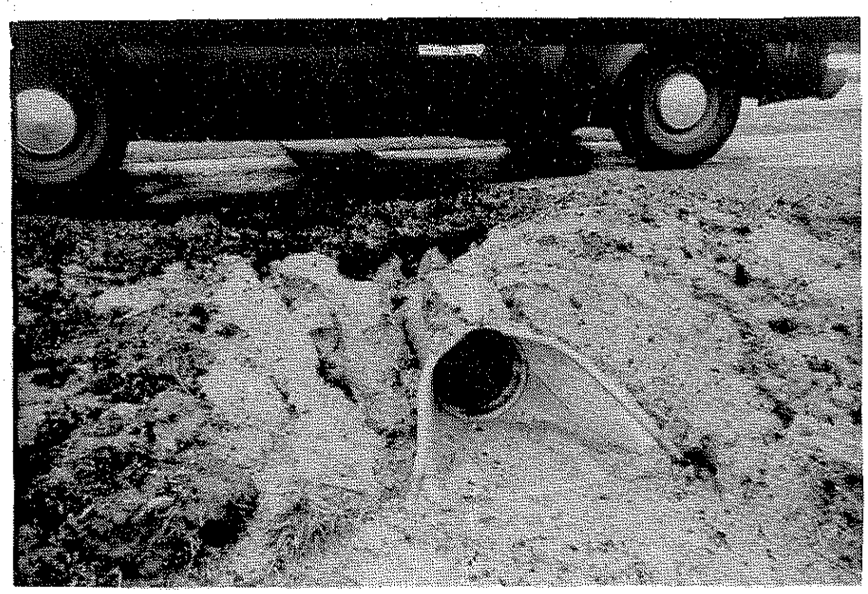


Figure 11: Erosion Around the RF-22 Outlet

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

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 stop 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 County 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. Better drainage characteristics are definitely desirable on both projects.

SUBDRAIN EVALUATION

Periodic monitoring of the flow from the subdrain outlets is continuing. Rainfall during the 1980-1981 period was below normal. There were very few periods with rainfall sufficient for comparison of flow from selected outlets in relationship to the amount of rainfall. A summary of the results of the periodic flow checks is provided in Table I.

TABLE I: SUBDRAIN OUTLET FLOW SUMMARY

(Number of outlets exhibiting indicated condition)

Date		05-03-79	08-20-79	08-23-79	11-09-79	04-11-80	09-04-80	11-26-80	04-08-81	04-29-81	06-15-81	07-28-81	08-03-81	08-26-81	10-15-81	11-23-81
Amount of Rainfall		1.1"	4"	2"	fall	---	---	---	---	---	1.5"	1.5"	1"	1"	---	.5"
FLOW:	Dry	9	12	24	104	63	14	55	70	18	12	2	18	5	5	1
	Trace	83	28	65	24	56	52	51	48	90	53	101	86	108	68	84
	Small Stream (less than 1/8")	10	72	26	0	11	64	24	12	22	65	27	26	15	57	0
	1/8" Stream	0	7	4	0	0	0	0	0	0	0	0	0	0	0	0
	1/4" Stream	0	10	1	0	0	0	0	0	0	0	0	0	0	0	44

It is evident from the data that the greater outflows (1/8" or 1/4" stream) are dependent on heavy rainfall. Equally impressive is the number of outlets that exhibit a trace or small stream after periods with very limited rainfall.

The Present Serviceability Index (PSI) is a pavement condition rating scale with "0" being bad and "5" being excellent. The PSI is determined by combining a riding quality value 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 was determined annually thereafter.

PAVEMENT CONDITION

	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
8-01-80	3.52	0.78	2.74	3.65	0.71	2.94
10-19-81	3.53	0.78	2.75	3.68	0.71	2.97

The graphical plot of PSI in figure 12 indicates no significant change in the rate of pavement deterioration when compared to an adjacent section of pavement without longitudinal subdrain installation.

Joint faulting was determined initially (October, 1978) and annually thereafter.

JOINT 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"
October, 1980	0.20"	0.18"

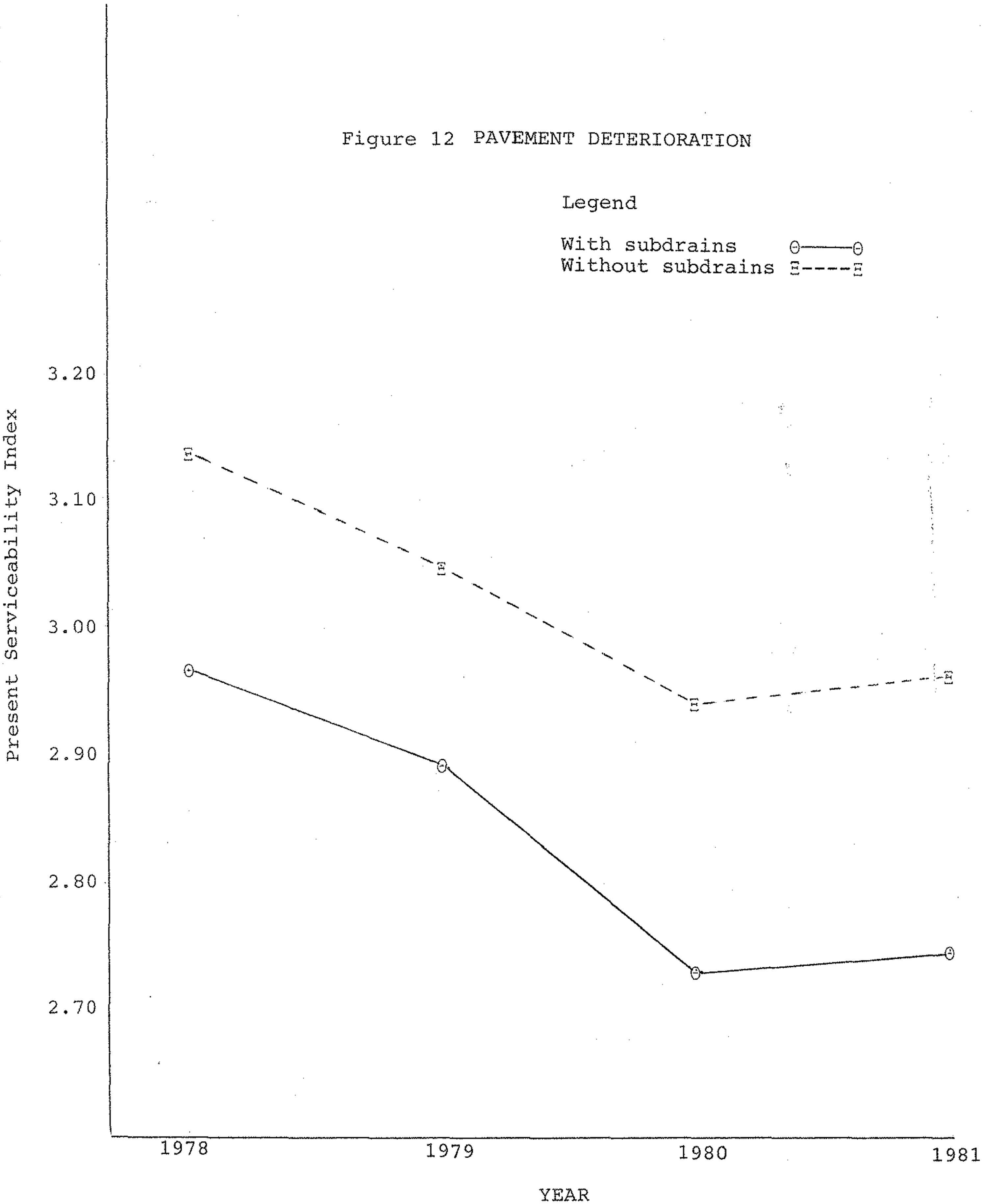


Figure 12 PAVEMENT DETERIORATION
Legend
With subdrains
Without subdrains
Present Serviceability Index
3.20
3.10
3.00
2.90
2.80
2.70
1978
1979
1980
1981
YEAR

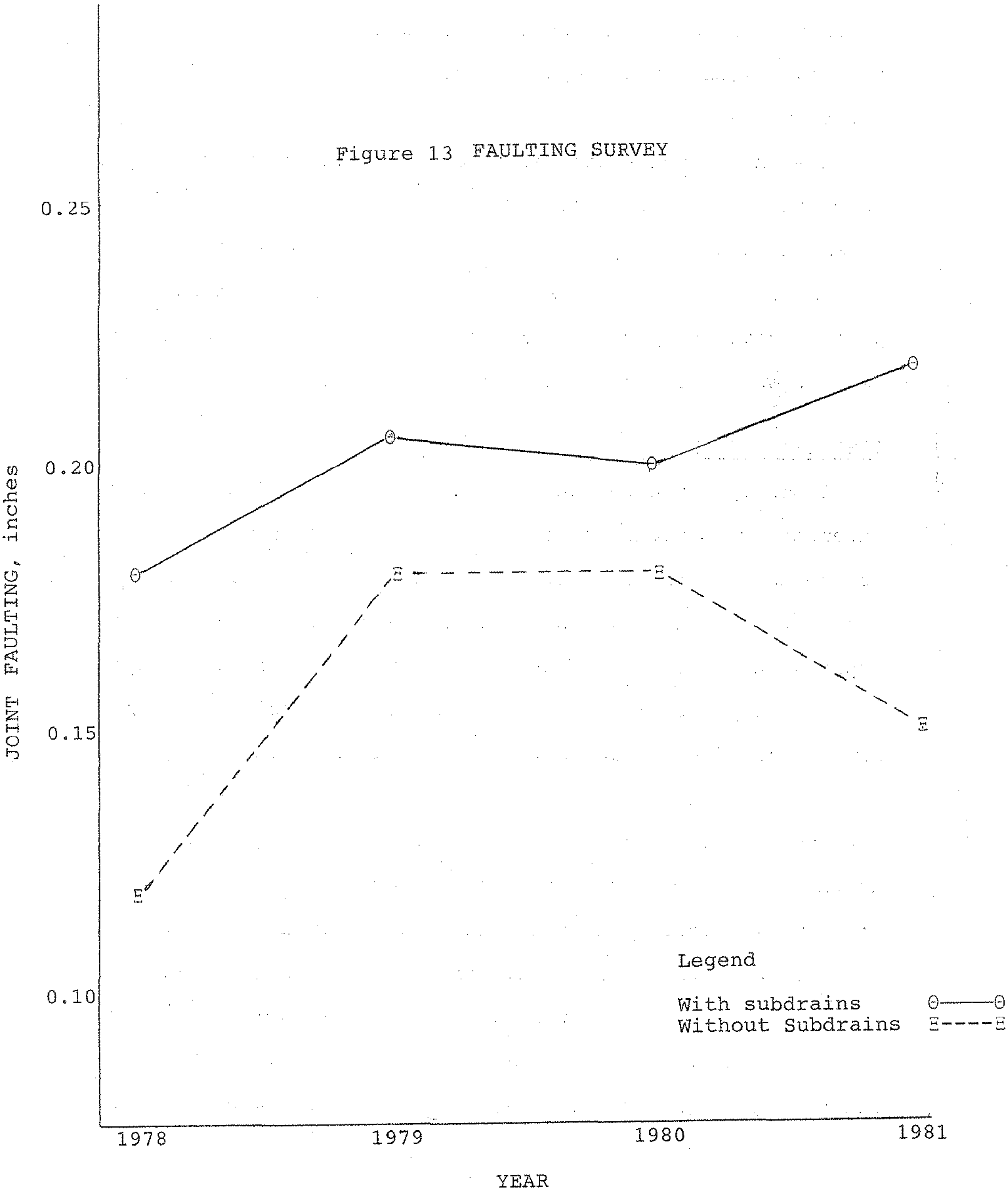
Again, a graphical plot (Figure 13) does not indicate significant difference between the pavement within the subdrain project and the adjacent pavement without subdrains. The data seem to be quite variable which could be due to weather or temperature variations.

Visual evaluation of the roadway has been made periodically. One general conclusion of the review panel is that the shoulders have been stabilized. There has been no evidence of faulting between the pavement slab and the shoulder. In addition, there has been no settlement of the subdrain trench area. The Resident Maintenance Engineer has supported this improved shoulder stability with the fact that required maintenance has decreased. There is less distortion and damage from heavy vehicle use of the shoulders.

The chip seal wearing surface on the shoulder has proven inadequate as it has been abraded away in areas used by heavy vehicles.

Three areas were excavated on July 16, 1980 (2 years after installation) to physically examine both the plastic tubing and porous backfill material. Two of the excavated areas were selected to coincide with patches that were pumping. The patches were placed after the edge drain installation. The first excavation at station 313+25 EB was at an outlet. There was a change in grade in this general area which coupled with the outlet would reduce the velocity of the water. The longitudinal plastic pipe was nearly plugged with a silt sized material for about 15' just downgrade from the outlet. This silty material appeared to have been pumped from beneath the patch.

Figure 13 FAULTING SURVEY



Inspection of the plastic pipe in the second excavation near a pumping patch revealed clean flowing water with no material deposit. There was, however, a cementing of the porous backfill material by the fine pumped material. The subdrain was functioning properly.

The third excavation was made near a pavement break-up or punch-out. Inspection of the plastic pipe revealed a flow of clear water as the system was functioning as designed.

Through the 14-mile project, there are approximately ten patches that are pumping very badly. Patches that were placed near pressure relief joints generally exhibit failure.

DISCUSSION OF RESULTS

Based upon the continual flow of water from outlets during extended dry periods and the relatively high flow immediately following periods of rainfall, it appears that the subdrains are effective in allowing the water to drain from beneath the slab. Improved shoulder stability has been noted since subdrain installation. Considering these two aspects, the evaluation panel members unanimously agree that longitudinal subdrains are beneficial.

There has been no significant change in the rate of pavement condition deterioration nor has there been a significant reduction in the rate of pavement faulting. There are a number of factors which may contribute to the lack of effectiveness. This was the first of our longitudinal subdrain projects and the depth of the trench was 2'0". A minimum of 3" of porous backfill bedding was required beneath the 6" diameter corrugated plastic pipe. The existing pavement was 10" thick with 4" of subbase. This left the top of the pipe 5" below the bottom of the slab which may have been a minimum to provide adequate drainage and drawdown. At the time of this project, full depth patching of pcc pavement on the interstate was 16" thick. The bottom of the patch slab was only 5" above the bottom of the subdrain pipe. The patch also presents a transverse barrier to water flow beneath the original 10" pavement. In the opinion of the evaluation team, this results in an increased amount of water at the patch resulting in severe pumping of the fine material beneath the patch. In some cases, this fine material is carried into the plastic pipe and deposited thus plugging the subdrain.

Another factor that may contribute to the continued deterioration is the relative lack of permeability of the crushed stone base. The percolation testing revealed how slowly water could drain into the subbase material. During a field review 15 minutes after a relatively heavy period of rain, water was observed spurting approximately three inches above the pavement surface when a truck crossed a patch about 10 feet longitudinally from a subdrain outlet. From this testing and observations, it is evident that water flows very slowly in the subbase.

The fact that the joints were badly faulted (average of 0.18") and the lower portion of the slab had crumbled at many joints may have prevented a reduction in the rate of deterioration. This pavement may have been too badly deteriorated to demonstrate a significant difference in the pavement condition. Very simply, the subdrain treatment may have been installed too late to significantly reduce deterioration.

CONCLUSIONS

It is evident from this experimental project that:

1. The subdrains were beneficial by removing water from beneath the pavement and providing improved shoulder stability.
2. The subdrains were not effective in reducing the rate of deterioration on this project.
3. The subbase material on this project does not have adequate permeability to allow for rapid removal of water.
4. The longitudinal subdrains on this project were not placed deep enough.
5. Patching procedures at the time of this project resulted in pumping of fine material and in some cases resulted in plugging of the subdrain pipe.

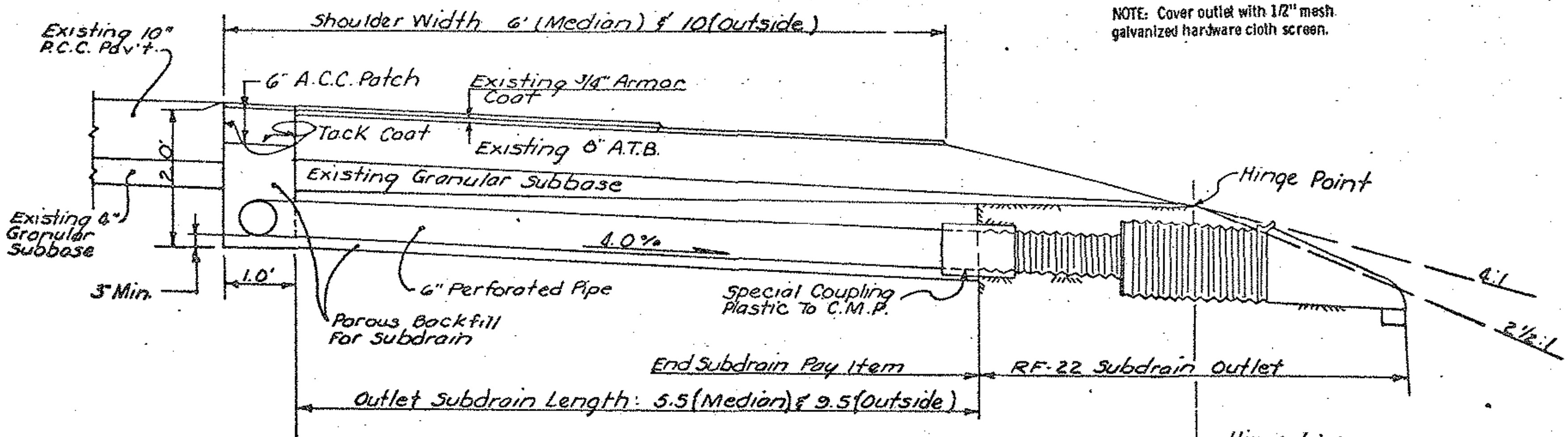
RECOMMENDATIONS

1. Longitudinal subdrains should be deeper than the design used on this project.
2. Longitudinal subdrains should be considered on all projects and especially those with evidence of water or drainage problems.
3. Crushed stone bases or subbases should have a permeability sufficient to allow water to drain relatively rapidly.
4. Porous bedding over a layer of filter fabric should be placed beneath pavement patches.
5. Standards and specifications to improve patching procedures should continue to be developed.

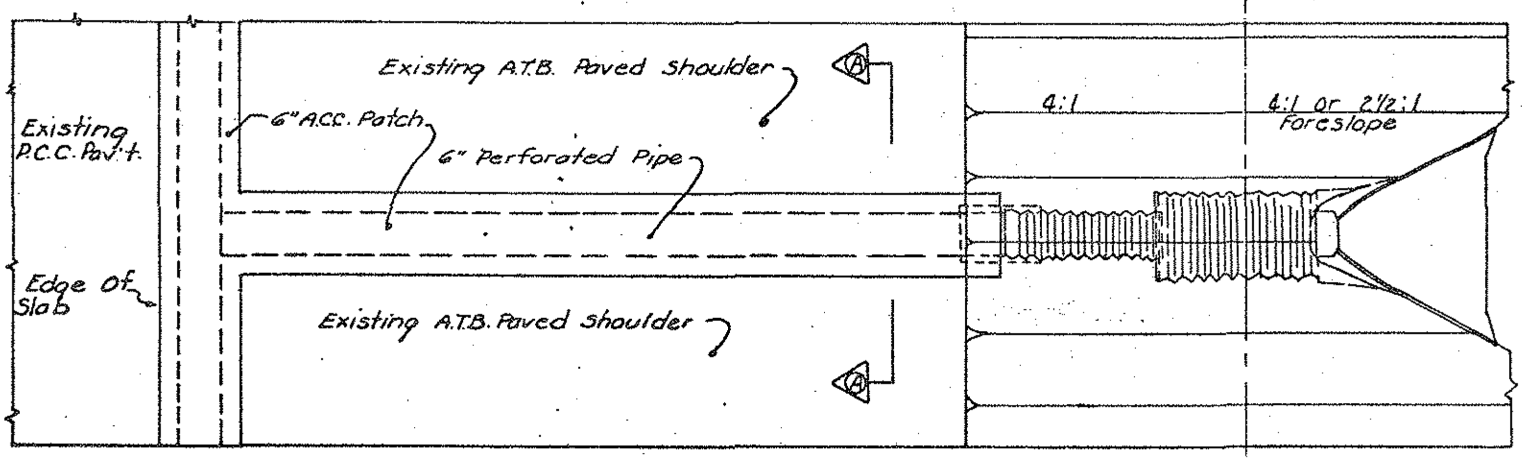
ACKNOWLEDGEMENTS

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 complimented for implementing techniques that made construction of the project a success. Robert Choate and the Grinnell Maintenance personnel are obtaining periodic flow measurements. The data on riding quality and faulting is being obtained by Charles Potter and the Special Investigations personnel. Charles Potter, Ken Isenberger, Kermit Dirks, and Vernon Marks were the evaluation team for this project.

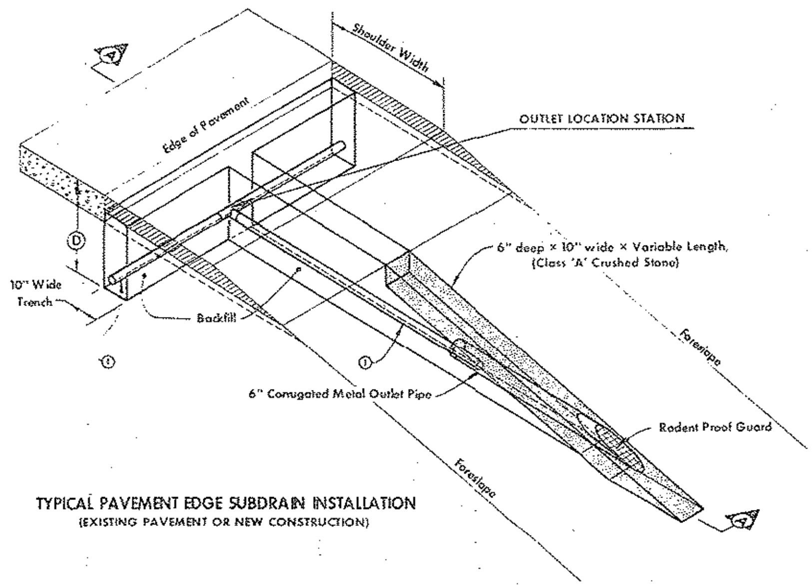
NOTE: Cover outlet with 1/2" mesh galvanized hardware cloth screen.



TYPICAL CROSS SECTION AT SUBDRAIN OUTLET

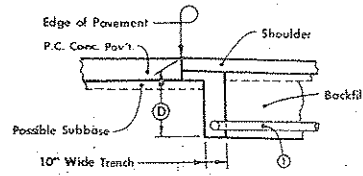


PLAN VIEW OF SUBDRAIN OUTLET

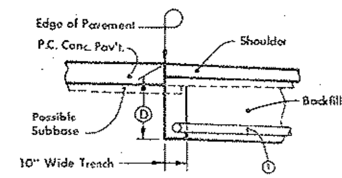


TYPICAL PAVEMENT EDGE SUBDRAIN INSTALLATION
(EXISTING PAVEMENT OR NEW CONSTRUCTION)

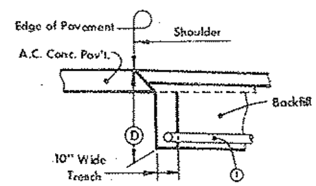
① 4" Perforated Subdrain (Polyethylene, Corrugated Tubing).



P.C.C. Pavement (Option 1)



P.C.C. Pavement (Option 2)



A.C.C. Pavement

SECTION A-A
TYPICAL SUBDRAIN OUTLET
(NEW CONSTRUCTION)

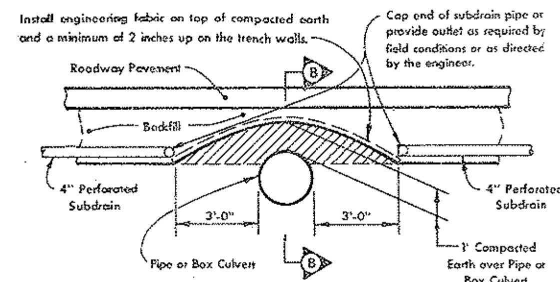
GENERAL NOTES:

Details indicated hereon are for the construction of longitudinal 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 Longitudinal Subdrains" for details of individual subdrain installations.

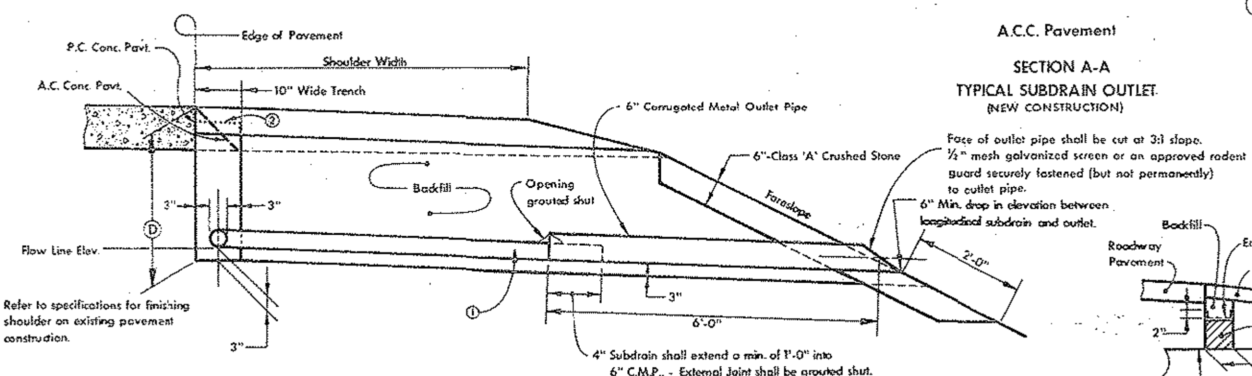
Each outlet shall be covered with ½" mesh galvanized screen or an approved commercial rodent guard. The guard shall be securely fastened (but not permanently) to the outlet pipe end by means approved by the engineer.

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 "Longitudinal 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.

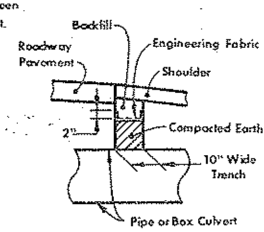


TYPICAL DETAILS
SUBDRAIN INSTALLATION AT
R.C.B. CULVERTS OR RF-1 CONCRETE PIPE CULVERTS
(If culvert is 1 ft. or more below trench bottom, no subdrain outlets should be provided. Carry subdrain over culvert.)



② Refer to specifications for finishing shoulder on existing pavement construction.

SECTION A-A
TYPICAL SUBDRAIN OUTLET
(EXISTING PAVEMENT)



SECTION B-B

DETAIL SHEET	**500-7**
Revision Date 8-14-81	
DETAILS OF LONGITUDINAL SUBDRAINS	

COST CENTER 601000 OBJECT 878

PRO. 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-2878

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 CC	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