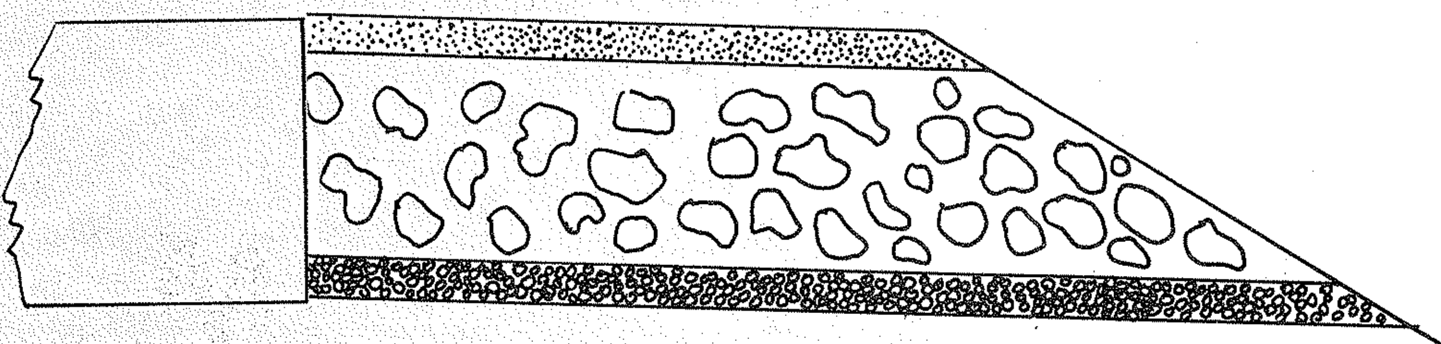
Jim - File

Macadam Base Shoulders



Final Report
Project HR-181
September 1981

Highway Division

FINAL REPORT
FOR
RESEARCH PROJECT HR-181

MACADAM BASE SHOULDERS

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SEPTEMBER, 1981

ABSTRACT

Highway safety and pavement performance can be directly influenced by the type of shoulders that are constructed. Shoulder design alternatives have always been rather limited. Moreover, the use of some of the alternatives has always been restricted by funding limitations.

This research project seeks to explore the use of modified macadam base construction for shoulders. This type of shoulder design could offer the designer another option when paved or stabilized shoulders are being considered. Macadam base construction has in the past been shown to be quite strong and freedraining.

Two macadam base shoulder designs were developed and constructed for this research project. A new roadway embankment and P.C.C. pavement were constructed on a section of US 6 east of Adel in Dallas County. The macadam base shoulders were constructed adjacent to the pavement as part of the project. The north shoulder was finished with a choke stone course and bituminous surface treatment and the south shoulder was finished with a two (2) inch layer of Type B Class II asphalt concrete.

Macadam stone base shoulders can be built with relatively minor construction problems with comparable strength and less cost than asphalt treated base shoulders. The macadam stone base shoulders have performed well with very little maintenance necessary. The improved drainage substantially reduces deterioration of the pavement joints.

TABLE OF CONTENTS

ACKNOWLEDGEMENT

Research project HR-181 was sponsored by the Iowa Highway Research Board and the Highway Division of the Iowa Department of Transportation.

The authors wish to extend appreciation to Messrs. R.H. Given, George Calvert, C. L. Huisman, Lowell Zearley, Don Anderson, R. I. Bortle, Harold Dowden, Ken Meeks and John Lane of the Highway Division of the Iowa Department of Transportation. Their assistance and cooperation contributed greatly to this project. Special recognition and gratitude is extended to Larry Torrence of the Des Moines Residency who was the project inspector for this work and to Marcus Lamoreux of the Office of Materials who assisted in the development of this report.

INTRODUCTION

Highway safety dictates the need for high quality, well maintained roadway shoulders. The safety aspects of highway shoulders may not always be apparent, but are of considerable importance. Shoulders must provide a safe, untraveled portion of the roadway for motorists to use when emergencies arise. Shoulders can be useful in providing adequate drainage for the highway. They also provide a "buffer" zone between the highway and the roadside ditches. Shoulders, which are properly designed, can reduce and facilitate maintenance of the mainline pavement. This is especially true for paved shoulders.

To be an effective safety aid to the motorist, the roadway shoulders must be properly maintained. Maintenance, such as edge rut and washout repair, is expensive and time consuming. The designer must consider maintenance costs when designing highway shoulders. The designer must recommend the most economical type of shoulder construction which can withstand normal motorist use associated with that particular highway.

The three types of shoulders that are commonly used on Iowa roads are:

1. Soil or soil-aggregate shoulders
2. Stabilized aggregate shoulders
3. Paved shoulders

The soil and soil-aggregate and stabilized shoulders are the most economical to construct and are used on many lower traffic volume highways. Paved shoulders are used primarily on interstate and other high traffic volume highways. The construction costs of paved shoulders are much higher than either of the other two types of shoulders but paved shoulders require less maintenance and have more load bearing capacity.

A need therefore exists for a highway shoulder with maintenance and load bearing qualities similar to that of paved shoulders but that can be constructed more economically.

One such potential alternative is macadam stone shoulders. Macadam stone bases have been placed on a few experimental projects(*) in the state. On the short term, these bases have performed adequately with no major problems reported. Because of the initial

(*) Less, Roger A. and Paulson, Charles K. "Experimental Macadam Stone Base - Des Moines County" Iowa Department of Transportation and Des Moines County, September 1977.

success of these projects, it has been proposed that a macadam stone shoulder topped with a bituminous wearing surface may be an economic alternative to the standard paved shoulders.

OBJECTIVES

The objectives of this research project are:

1. To determine the feasibility of using a macadam stone shoulder in place of the standard paved shoulder.
2. To determine if there are any major problems associated with macadam shoulder construction.
3. To compare the actual construction and maintenance costs of the macadam shoulders to the construction costs of recently built paved shoulders.
4. To evaluate the structural performance of the macadam shoulders.

DESIGN AND CONSTRUCTION

The research work was incorporated into Dallas County project RF-6-3(11)--35-25 completed in July, 1977. The portion of this project where the experimental shoulders were constructed is on U.S. 6 from the Raccoon River bridge east approximately 1500 feet to another bridge (Figure 1). The Average Daily Traffic for this highway is 4070 VPD, with 180 of these being trucks.

The macadam shoulders were constructed ten (10) feet wide with a three layer system with a total thickness of nine (9) inches (Figure 2). On the typical cross section, the bottom layer is a nominal thickness of 2 inches of granular material. The second layer is 6 inches nominal thickness of macadam stone (specifications in Appendix A). The top layer is a surface with a nominal thickness of 2 inches. These three layers would total 10 inches but the actual thickness was 9 inches. Due to the open grading of the macadam stone there is an intermingling at both interfaces of the shoulder system.

Two different 2 inch nominal thickness wearing surfaces, one placed on each side of the highway were studied. The south shoulder was surfaced with Type B Class II asphaltic concrete and the north shoulder was surfaced with a choke stone (same material as granular blanket course) and a bituminous surface treatment (1/2 inch seal coat).

Aggregate for the macadam and choke stone was obtained from a limestone quarry located in NE 1/4 Section 10, Twp 76, Range 29. This crushed stone was produced by the Gendler Stone Company from the geologic formation known as the Argentine. The various materials were characterized in the laboratory in Tables 1 through 6. Material quantities and rates of application are summarized in Table 7. After the nine (9) inch PCC pavement was placed, the contractor shaped the shoulder subgrade to the cross-section shown in Figure 2. The "loamy sand" select treatment subgrade was quite friable even though it had been originally compacted with moisture and density control. This caused some difficulty during the placement and compaction of the granular blanket. The subgrade was disturbed by the trucks bringing in the granular blanket aggregate. Continual subgrade repair was necessary. The plan quantity estimate for this two inch layer was 15.2 tons per station; the actual quantity was 17.4 tons per station.

Next, the six inch macadam stone base layer was placed using a Jersey spreader powered by a crawler tractor (Figure 3). This spreader was also used for placing the granular blanket and stone choke course. Again, some difficulty was experienced by the contractor during placement. The bulk and weight of the aggregate caused the spreader to ride up. Some shaping was therefore necessary. A motor grader was used for this purpose. The blading of the aggregate tended to cause localized segregation of the large particles. Plan quantities of this material were sufficient for this course of the structure.

A vibrating steel drum roller was used to compact all stone layers (Figure 4). Rolling of the outer half of the macadam base course was found to be hazardous as the uncompacted, unconfined material would displace outward without warning. This resulted in considerable damage to a roller that capsized on one occasion and rolled down the foreslope. The exposed sloping edge was compacted with the roller secured to a motor grader. Procedural compaction specifications were used (Appendix A).

The crushed stone choke course required on the north shoulder was placed and compacted without difficulty with the Jersey spreader and vibratory roller. The quantity for this course overran approximately 70 percent due to the open texture of the macadam base course. The contractor was able to finish this course to closely match the edge of the pavement with good cross-section and profile control (Figure 4).

After the choke stone course on the north shoulder and macadam base course on the south shoulder were completed, MC-70 cutback asphalt primer was applied. The outside slopes of the exposed macadam base were primed at an average rate of 0.72 gallon per square yard. The choke stone course was primed at a rate of 0.22 gallon per square yard while the open texture macadam base course was primed at an average rate of 0.36 gallon per square yard. It was found that two partial applications, one from each direction, were needed on the macadam base course in order to obtain coverage of the large aggregate particles exposed on the surface. The penetration of the primer into the base course caused a 70 percent overrun of the plan quantity. The priming operations are shown in Figure 5.

A bituminous surface treatment (chip seal coat) was applied on the north shoulder. CRS-2 cationic emulsion binder bitumen was applied at an average rate of 0.27 gal./s.y. Gravel cover aggregate, graded as shown in Table 4 was then applied at an average rate of 37.3 lbs./s.y. A sizeable overrun for this material was incurred because the plan quantity was estimated on the basis of the requirements for a sand seal rather than a 1/2 inch chip seal coat. Conventional equipment and procedures were employed for this work (Figure 6).

The south shoulder was choked and surfaced with one layer of Type B Class II asphalt concrete at a rate of 17.7 tons per station; the quantity overran approximately 47 percent due to the large voids and the irregularities in the macadam base course. Conventional equipment and procedures were used to place and compact this material. No difficulties were encountered during this operation. Refer to Tables 3, 5, and 6 for test data and Figure 7 for display of placement and compaction operations.

IMPLEMENTATION OF MACADAM BASE SHOULDERS

The November 1977 progress report for this research noted numerous potential benefits and established the feasibility of constructing macadam base shoulders. The progress report was written only four months after construction, but the Road Rater structural data of the shoulder with the 2" Type B asphalt concrete surface compared very favorably with asphalt treated base shoulders on the interstate.

Based on that report and impressive performance with no need for maintenance through 1978, the design for Clayton F-13-3(22)--20-22 on Iowa route 13 north of Elkader specified macadam base shoulders (Figure 8). Approximately one half of the shoulders on the Ia. 13 project (constructed September, 1979) were constructed with a 2" granular blanket on the grade. The contractor encountered substantial difficulty in finishing the surface of the macadam base prior to placement of the asphalt concrete surface.

The design was modified (Figure 9) to place the 2" of granular material on top and facilitate the placement of the asphalt concrete. The remaining shoulders were constructed to this design.

The structural capacities of the two Ia. 13 designs are quite comparable (4.18 and 3.82 from Table 8) but are weaker than the Adel macadam base with the asphalt concrete surface.

In the first two years, the Ia. 13 macadam base shoulders have required no maintenance and are performing very well. There are very few transverse cracks. There is some cracking between the mainline and the shoulders due to differential movement. No shoulder settlement is noted at this time.

COST COMPARISON

It is extremely difficult to make valid cost comparisons due to size of projects, proximity to the quarry, rapid inflation and the absence of asphalt treated base and macadam stone base construction in the same year. The contract with bid prices for this project is shown in Table 9. It is obviously unrealistic to use the macadam stone base costs of HR-181 for comparison due to the small quantities.

The best cost data available for macadam stone base shoulders is the Iowa 13 project built in 1979. The cost comparison will therefore utilize average 1979 prices in conjunction with shoulder quantities per station.

Using this method, the cost of a 10 ft. wide macadam stone base shoulder per station is:

2" Granular material	17.4 ton @ 7.00	=	$121.80
6" Macadam Stone Base	36.3 ton @ 5.85	=	212.36
2" Type "B" Asphalt Concrete	17.7 ton @ 12.47	=	220.72
Asphalt Cement @ 6.0%	1.06 ton @ 113.96	=	120.80
Prime	48.0 gal. @ 0.64	=	30.72
Total cost of macadam stone base shoulder per station		=	$706.40

Similarly, the cost of an 8" thick 10 ft. wide asphalt treated base shoulder is:

8" Asphalt Treated Base Class I	46.67 ton @ 10.96	=	$511.50
Asphalt Cement @ 4.5%	2.1 ton @ 113.96	=	239.32
Prime	6.07 gal. @ 0.64	=	3.88
Binder Bitumen	16.66 gal. @ 0.85	=	14.16
Sand Cover Aggregate	0.55 ton @ 15.00	=	8.25
Total Cost of Asphalt Treated Base Shoulder Per Station		=	$777.11

The maintenance personnel in Dallas and Clayton Counties have indicated minimal maintenance for the macadam stone base shoulders with an asphalt surface. With this and the similar structural data, it is reasonable to assume that the maintenance costs will be similar to asphalt treated base shoulders.

MAINTENANCE

The only maintenance of the macadam base shoulders has been strip sealing of the cracks with a CRS-2 asphalt emulsion. The crack between the pavement and shoulder has been sealed on the shoulder with the seal coat surface. The transverse cracks on the asphalt concrete surfaced shoulder have been sealed.

DISCUSSION OF CONSTRUCTION PROBLEMS

The biggest problems encountered during construction were subgrade distortion and macadam base course compaction safety. Subgrade problems are not uncommon whenever haul units traverse earth subgrades. This problem is not therefore considered a significant deterrent. Protecting the vibratory roller and operator from harm while compacting the outside portion of the macadam stone base layer can be accomplished by securing the roller to another piece of construction equipment during this operation. This type of precaution is also required on some other types of work. It is therefore believed that contractors can develop appropriate safety measures. No other significant construction control or procedural problems were noted. The finished shoulders display good appearance, workmanship, and exhibit satisfactory cross-section and longitudinal profile.

Other than the problem of finishing the macadam stone, there were no construction problems on the Ia. 13 project. The instability of the macadam stone under the roller was not recognized as a problem.

DRAINAGE BENEFITS OF MACADAM STONE BASE

Pavement performance surveys would indicate that inadequate drainage contributes to most pavement deterioration. In PCC pavement, slab pumping, faulting and D-cracking are directly related to the amount of water under the slab. Stripping and subsequent crack depression in asphalt concrete pavement is also accelerated by the amount of water available.

Recent pavement designs have given substantial consideration to providing a dense base with little or no consideration of permeability. Consequently there are serious deterioration problems with many "trench section" type designs. Surface water infiltrates the joints and cracks and is trapped beneath the slab by the relatively impermeable base and shoulders.

The PCC pavement joint seals on this project have failed (Figure 10) and surface water can readily enter the joints. Water can also enter through the shoulder surface. There is no indication of water related deterioration on this project. It would appear that the excellent drainage characteristics of the macadam stone base allows the water to escape from beneath the slab and prevents the detrimental hydraulic action.

PERFORMANCE

The Iowa DOT uses the Road Rater to determine the relative strength of a grade, base or pavement. It imparts a dynamic loading that oscillates from 800 to 2,000 pounds and measures surface movement or deflection with accelerometers.

The macadam stone base shoulders compared favorably with interstate shoulders (Table 8). As expected, the shoulder with the sealcoat surface was the weaker of the two with average deflections ranging from 3.55 to 4.27 mills over a four year period depending on the particular conditions at the time of testing. The deflections for the shoulder with the asphalt concrete surface ranged from 2.72 to 3.30 mills. The sealcoat surfaced shoulder exhibited essentially the same strength as an I-80 shoulder with four inches of asphalt concrete over a six inch thick rolled stone base (4.24 mills vs 4.32 mills in August, 1977). The asphalt concrete surfaced shoulder yielded a deflection of 2.89 mills (August, 1977) and approximately the same strength as an 8 inch thick asphalt treated base shoulder on I-35 (2.82 mills).

Deflection data through September, 1981 does not indicate a loss of strength since construction in 1977.

The seal coat surface shoulder has performed well for four years with strip sealing of the joint between the mainline PCC pavement and the shoulder with CRS-2 asphalt emulsion as the only maintenance. There are many areas where the sealcoat surface is broken and in need of maintenance. No macadam stone has been dislodged and very little loss of material from the broken areas is apparent. The most adverse aspect of the sealcoat surfaced shoulder is a subsidence which has resulted in an edge rut of approximately one inch (Figure 11) through most of the project.

There is no subsidence nor edge rut on the asphalt concrete surfaced shoulder. Transverse cracking has ocurred at a 21 foot interval on this shoulder (Figure 12). These cracks do not correspond to the 20 foot joint spacing of the PCC pavement. The AC surface is apparently interlocked relatively well to the PCC slab which results in a typical dividing of the transverse crack near the joint (Figure 13). The transverse cracking has been sealed with CRS-2 asphalt emulsion but has re-opened and is not presently sealed. There is no indication of any deterioration of the transverse cracks by stripping. Apparently the excellent drainage characteristics of the macadam stone prevents adverse water action.

CONCLUSIONS

The following conclusions are supported by this research:

1. Macadam stone base shoulders can be built with relatively minor construction problems.

2. The construction cost for macadam stone base shoulders should be less than that of 8 inch asphalt treated base (4-1/2 % AC) shoulders in locations where aggregate is in close proximity (10 miles) to the project.

3. The asphalt concrete surfaced macadam stone base shoulder has given excellent performance. Both designs have required minimal maintenance.

4. The macadam stone shoulder provides improved lateral drainage and substantially reduces joint deterioration of the PCC pavement.

5. The macadam stone shoulders provide strength comparable to asphalt treated base shoulders.

Figure 1

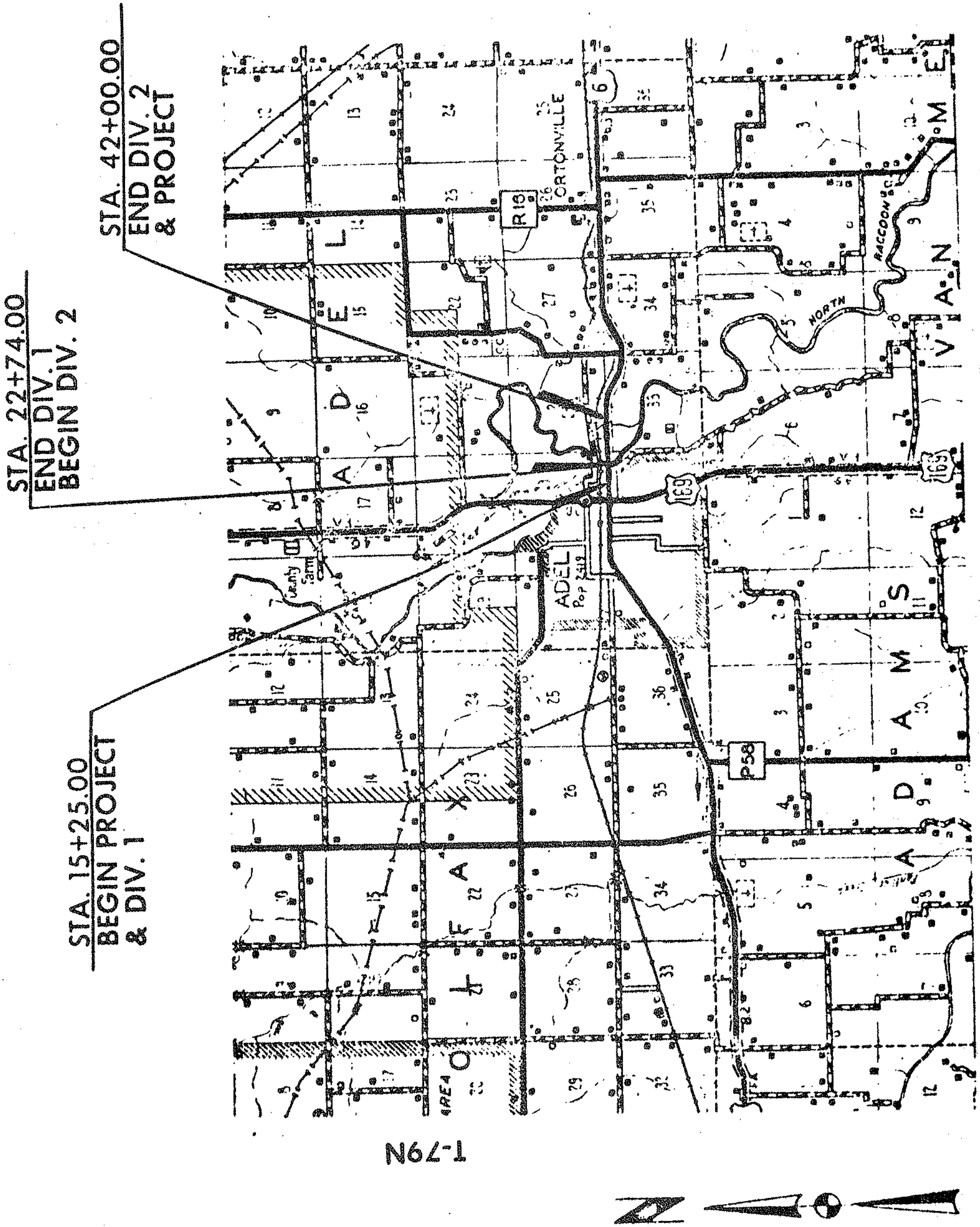
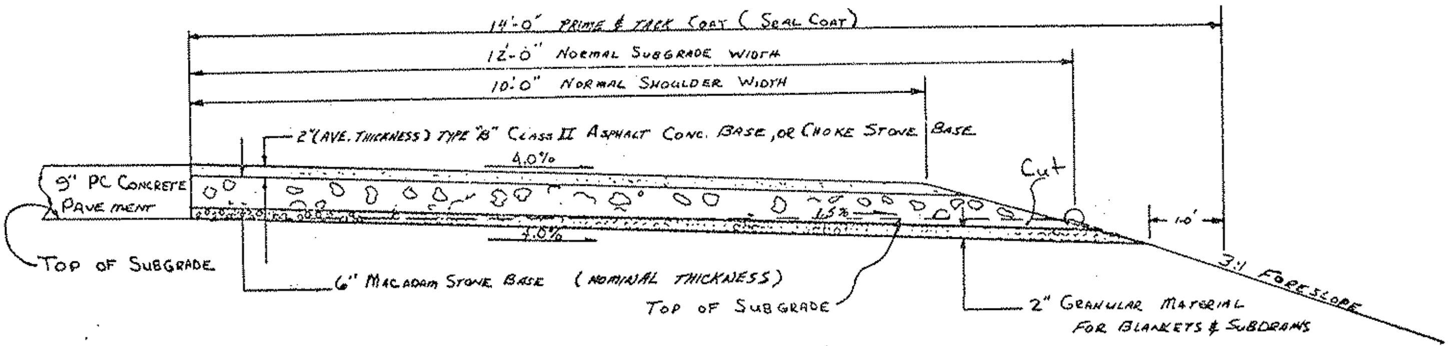

STA. 42+00.00
END DIV. 2
& PROJECT
STA. 22+74.00
END DIV. 1
BEGIN DIV. 2
STA. 15+25.00
BEGIN PROJECT
& DIV. 1
ORTONVILLE
ADEL
NORTH
RACCOON R.
T-79N

Figure 2



FROM STA. 25+67.5 TO STA. 40+04.9 = 14.374 STAS

10' SHOULDER / STA	
ITEM	RATE
PRIME & TACK COAT (SEAL COAT) ①	31.11 GAL/STA. *
TYPE "B" CLASS II ASPHALT CONC. BASE	12.06 TON/STA *
CHOKE STONE BASE	12.06 TON/STA *
MACADAM STONE BASE	36.46 TON/STA. *
GRANULAR MATERIAL (BLANKET & SUBDRAINS)	15.17 TON/STA. *

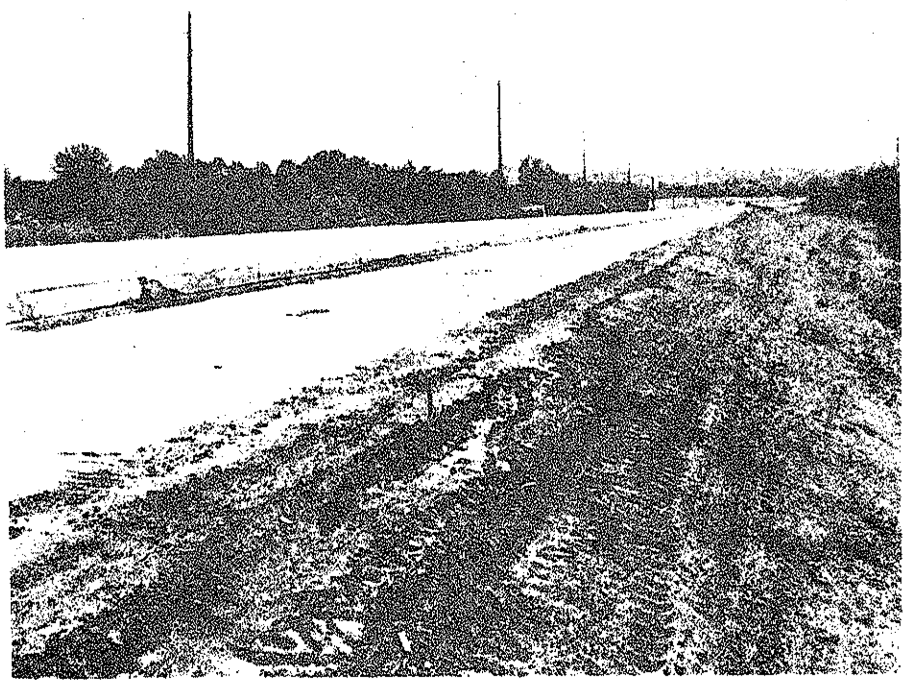
ITEM	RATE
6" STABILIZED SHOULDER MAT.	38.50 TON
EARTH SHOULDER 60% SHRINK	41.23 CU. YD.

TYPICAL SECTION
OF
PAVED SHOULDER- MACADAM BASE ALTERNATE

*RATES ARE FOR ONE SHOULDER PER STA
① ONE APPLICATION

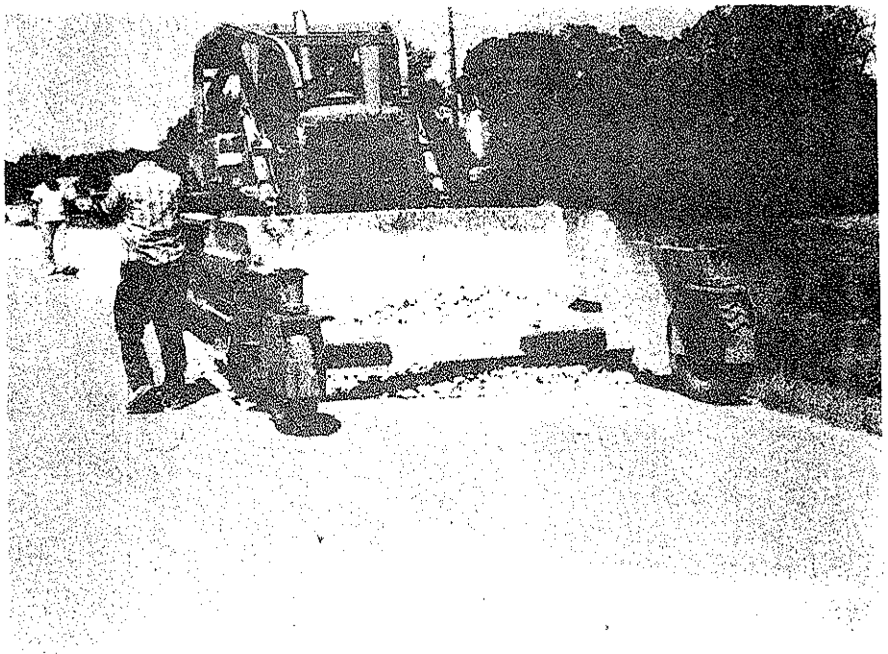
DALLAS COUNTY
RF-6-3(1)--35-25
HR-181

TYPICAL CROSS SECTION

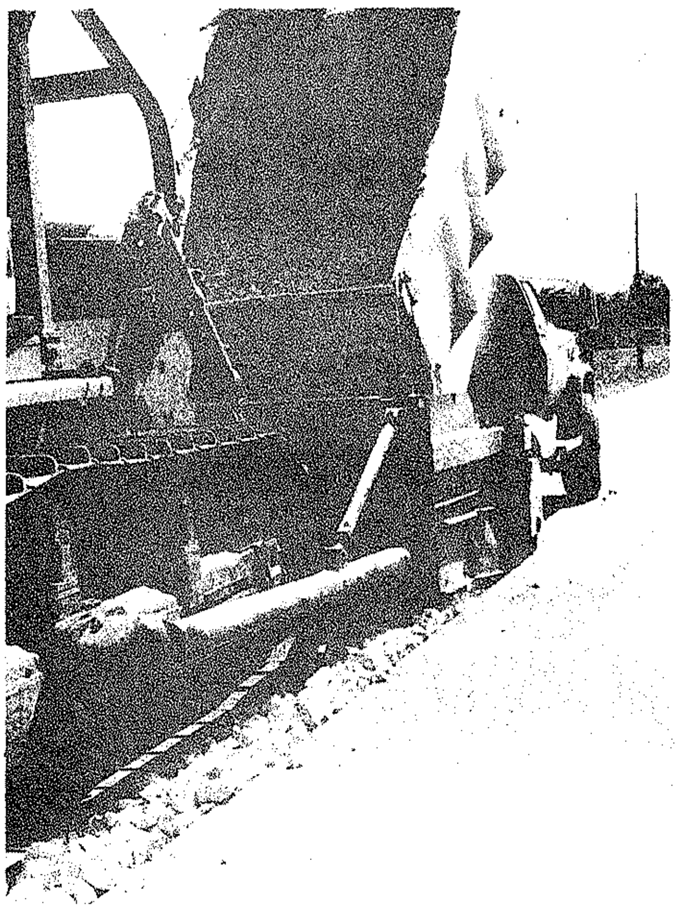


TYPICAL CROSS SECTION OF CORRECTED SUBGRADE

Figure 3

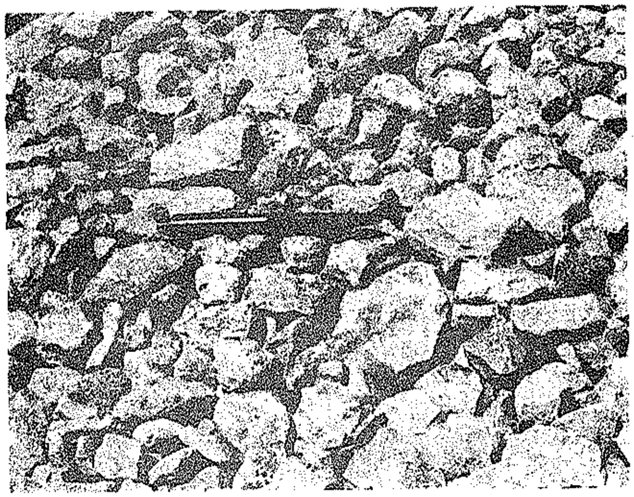


MACADAM STONE PLACEMENT WITH JERSEY SPREADER ON COMPLETED GRANULAR BLANKET



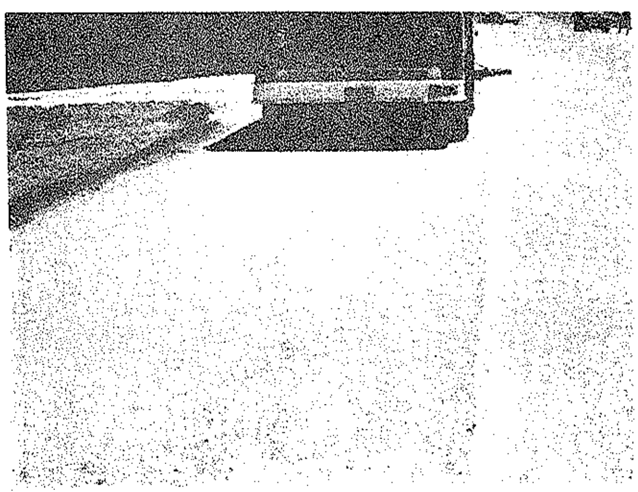
MACADAM STONE PLACEMENT

Figure 4



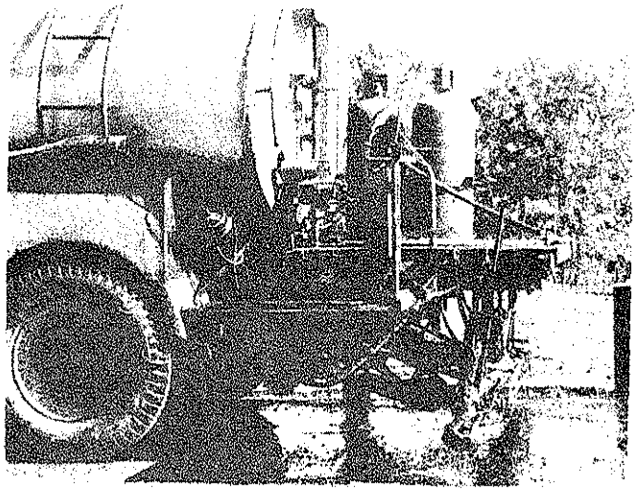
SURFACE OF MACADAM BASE BEHIND SPREADER

COMPACTION OF CHOKE STONE COURSE ON NORTH SHOULDER

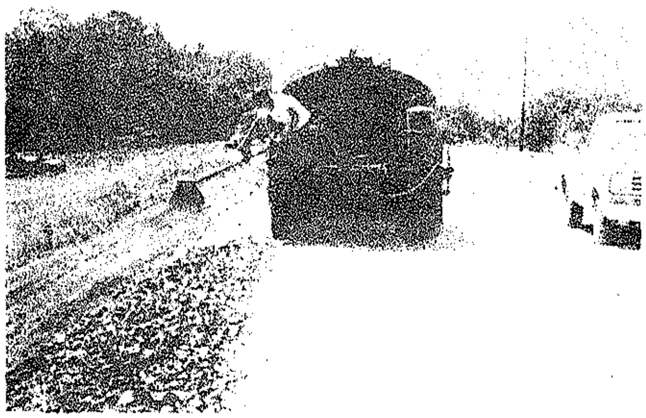


FINISHED CHOKE STONE

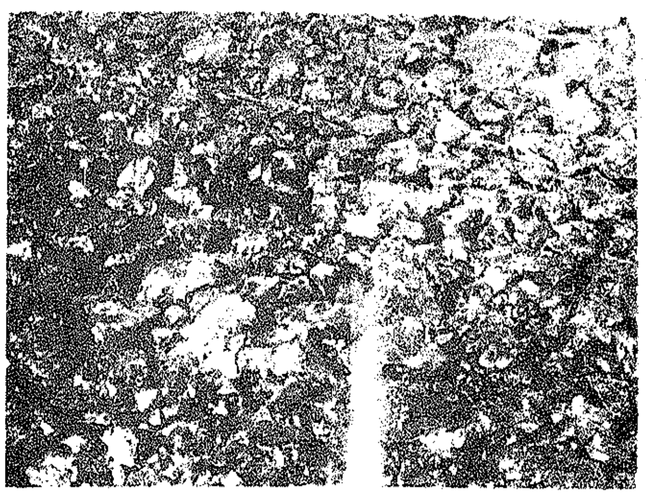
Figure 5



PRIMING OF CHOKE STONE COURSE

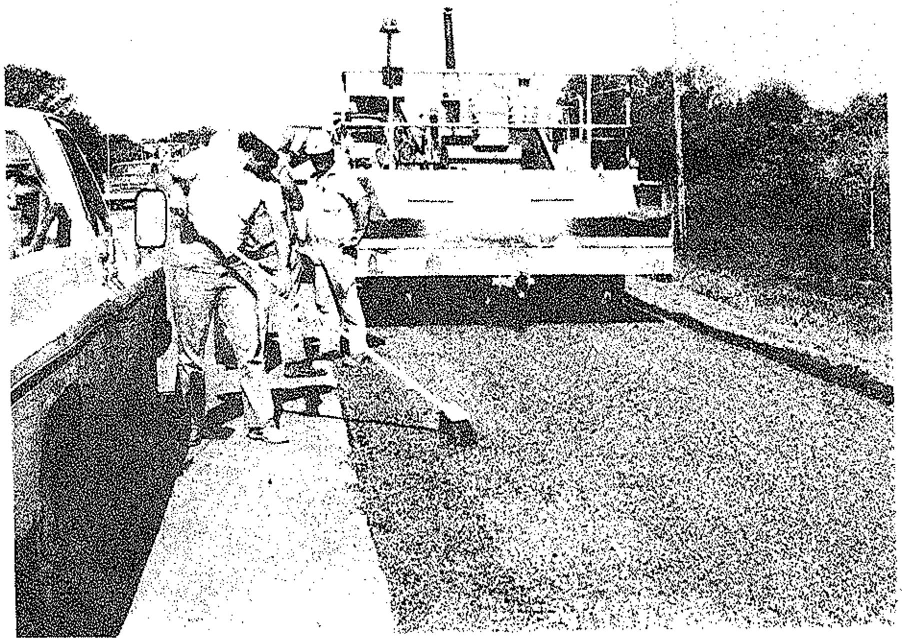


PRIMING EDGE OF SOUTH SHOULDER

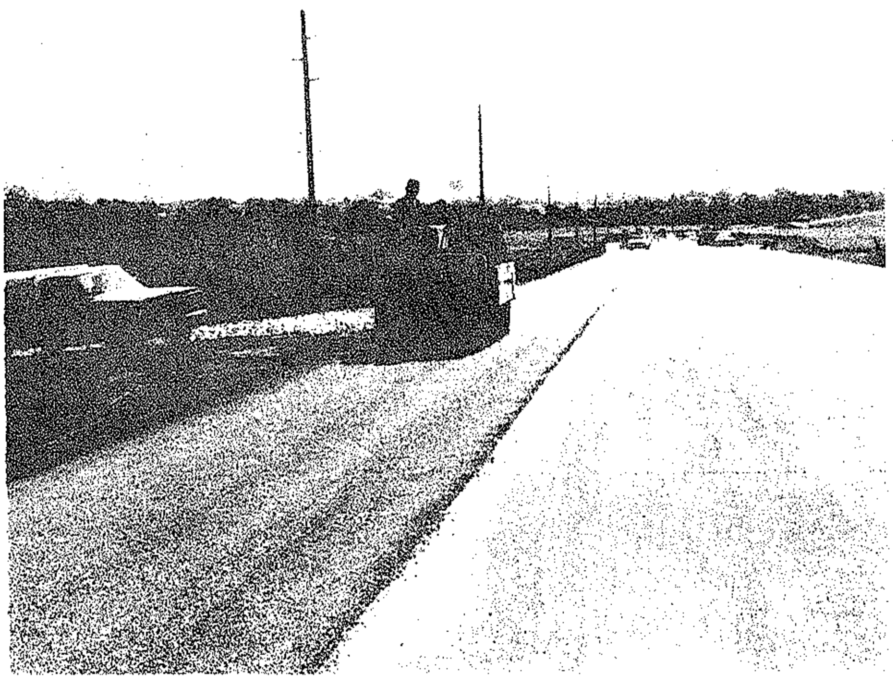


PRIMED MACADAM BASE COURSE OF SOUTH SHOULDER

Figure 6

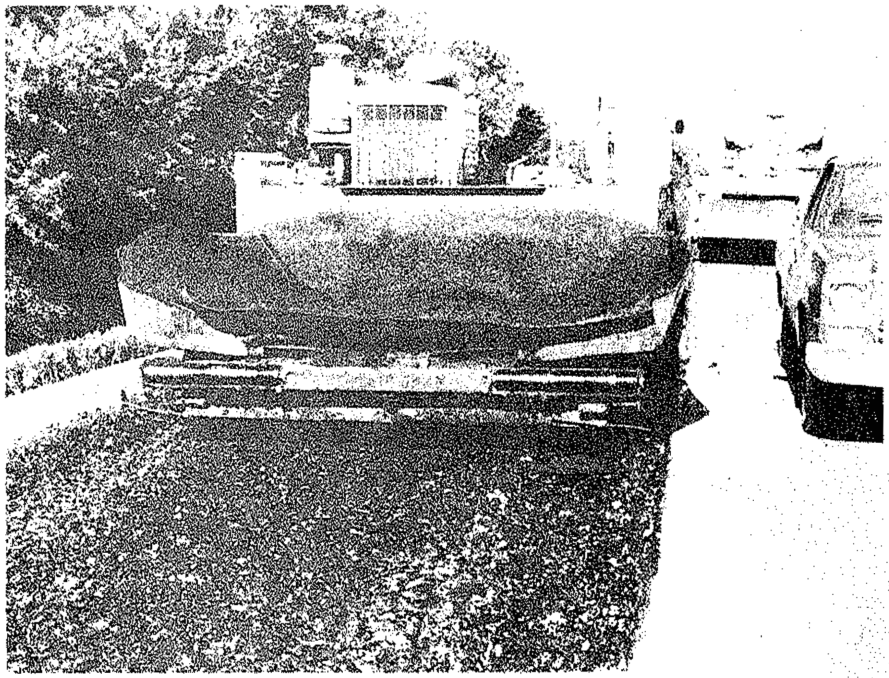


PLACING COVER AGGREGATE ON NORTH SHOULDER

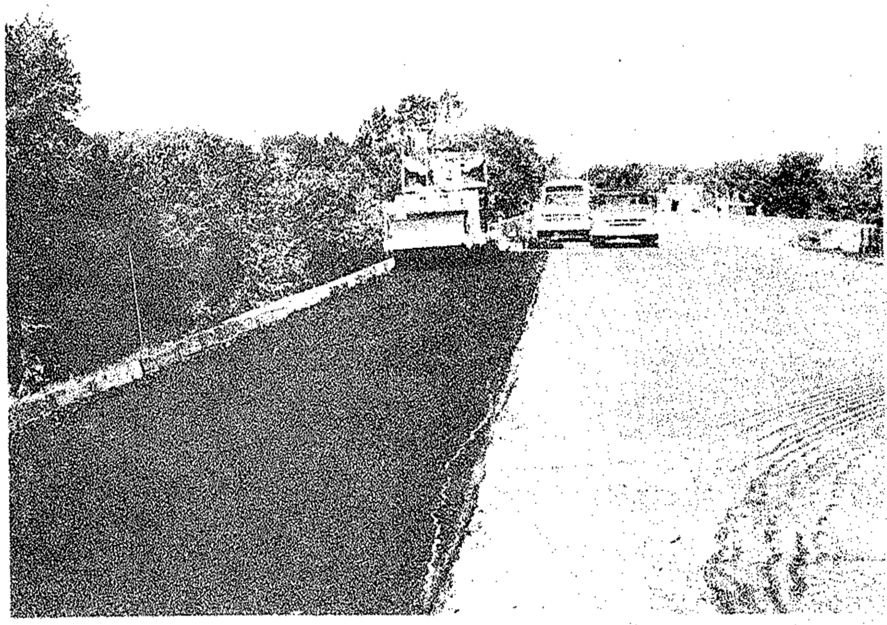


COMPACTION OF COVER AGGREGATE

Figure 7



PLACING ASPHALT CONCRETE ON MACADAM BASE COURSE



COMPACTING ASPHALT CONCRETE ON SOUTH SHOULDER

Figure 8

Typical Cross Section
for Macadam Stone Base Shoulders
on Iowa 13

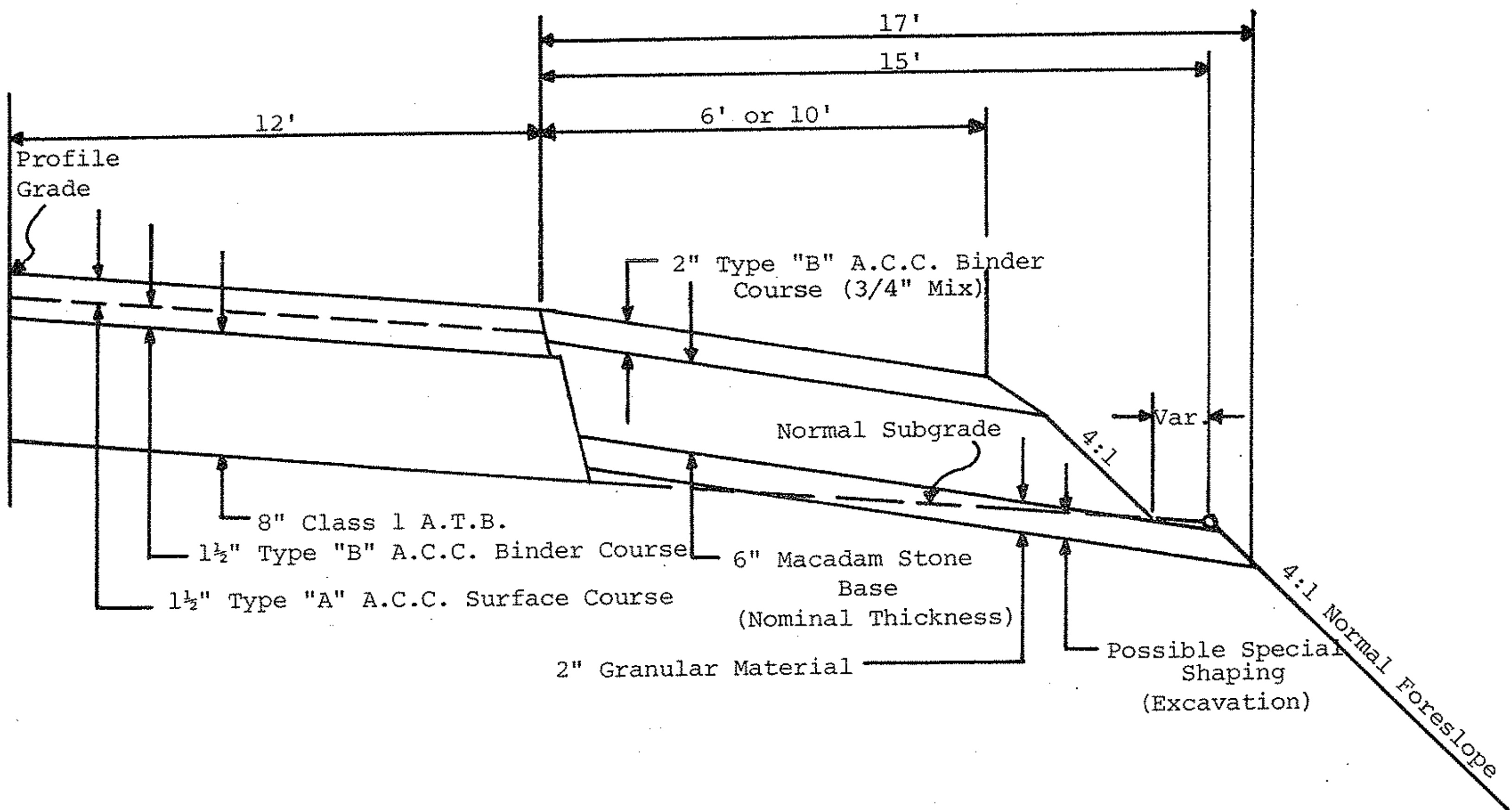


Figure 9

(Modified)
Typical Cross Section for Macadam
Stone Base Shoulders on Iowa 13

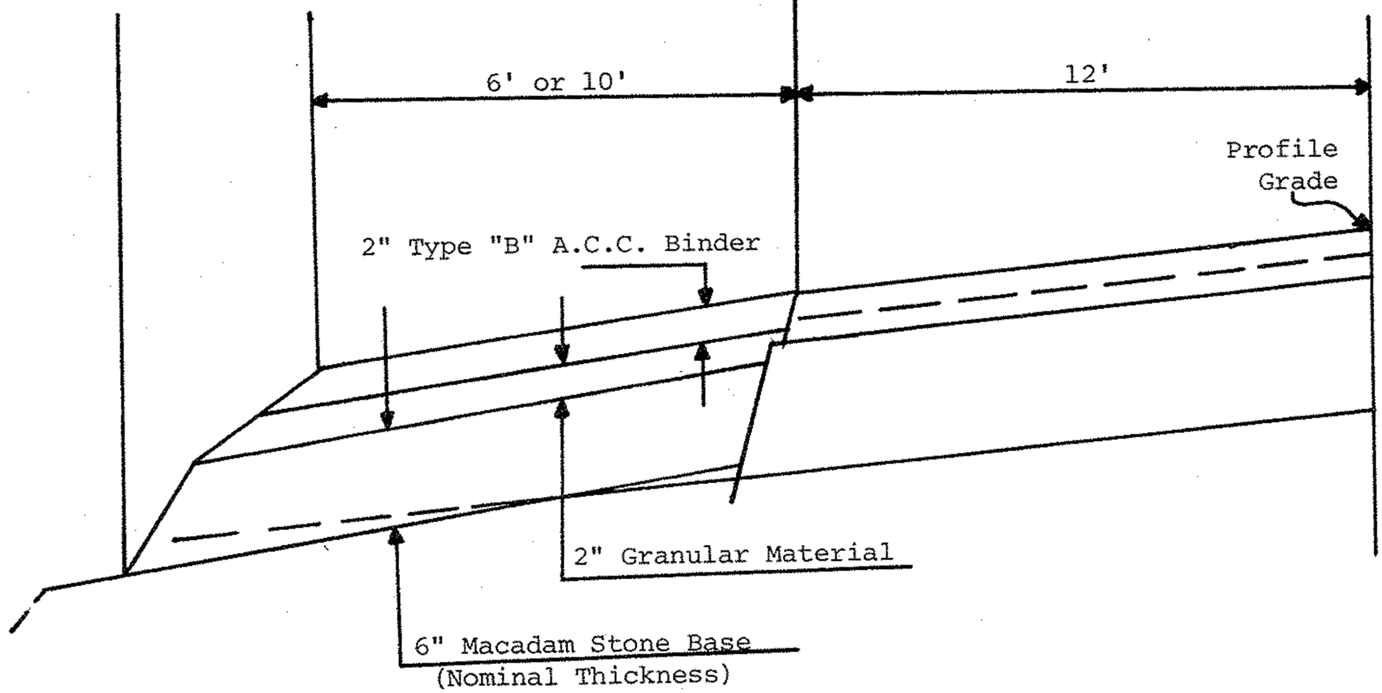
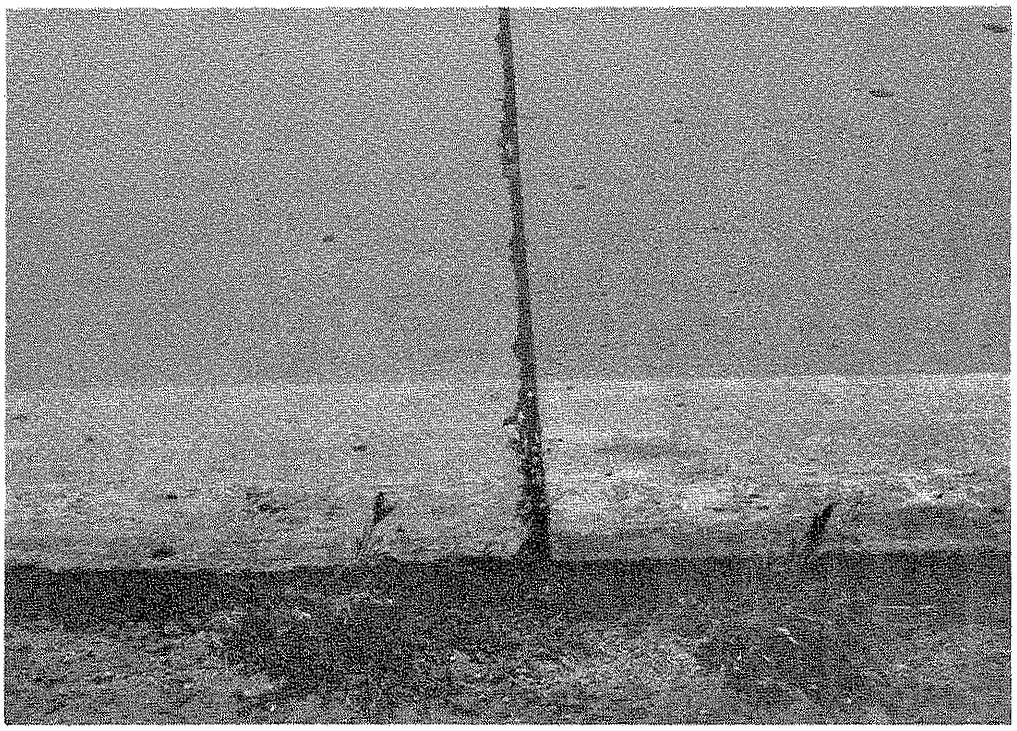


Figure 10

FAILURE OF PCC PAVEMENT JOINT SEAL

Figure 11

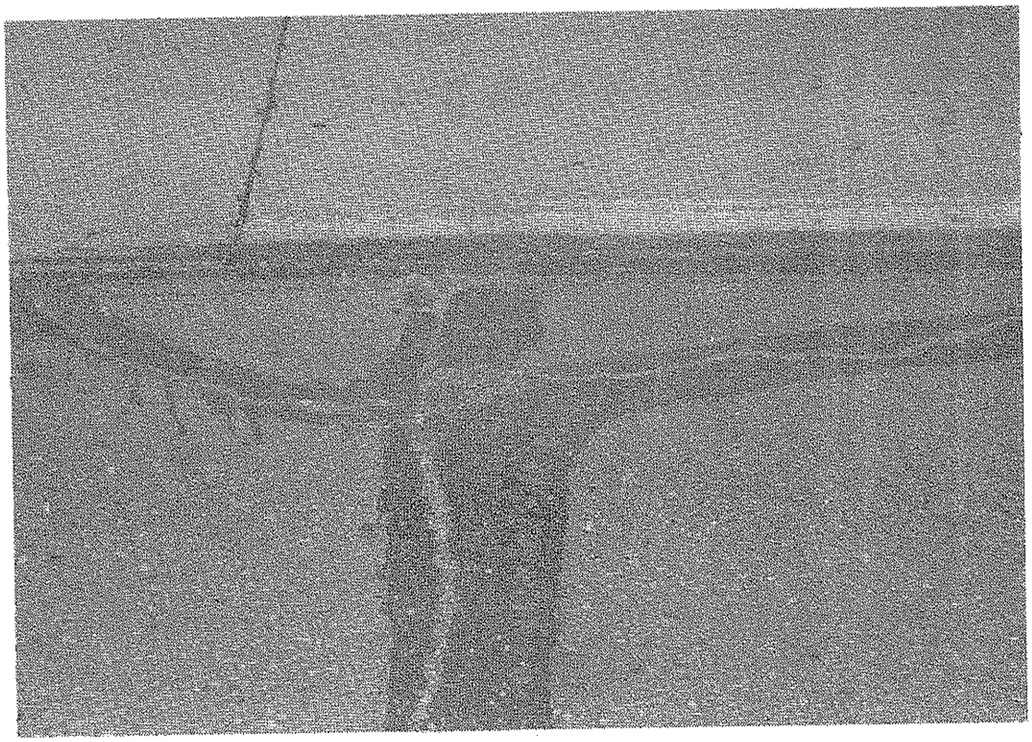


EDGE RUT ON THE SEAL COAT SURFACED SHOULDER

Figure 12

TRANSVERSE CRACKING AT A 21 FOOT INTERVAL

Figure 13



DIVIDING OF THE TRANSVERSE CRACK
NEAR THE PCC PAVEMENT

Table 1

Research Project HR-181

Gradation of Crushed Limestone
used for
Granular Blanket and Choke Course

Sieve Size	Percent Passing GC7-185	GC7-188	GC7-189
1"	100	100	100
3/4"	93	91	92
1/2"	76	64	75
3/8"	60	50	62
No.4	39	31	42
No.8	27	22	30
No.200	10.8	8.6	--

Table 2

Research Project HR-181

Gradation of Crushed Limestone
used for
Macadam Stone Base Course

Sieve Size	Percent Passing GC7-184	GC7-186	GC7-187
4"	99	98	95
3"	93	80	85
2"	75	57	63
1"	24	17	18

Table 3

Research Project HR-181

Characteristics
of
Asphalt Concrete Choke and Surface Course

Sieve Size	Percent Passing 1DBC7-225A	Percent Passing ABC7-197
3/4"	100*	100*
1/2"	94	95
3/8"	88	84
No.4	75	70
No.8	59	56
No.16	44	41
No.30	28	27
No.50	14	13
No.100	8.2	7.7
No.200	6.8	6.2
Lab Density**	2.37	2.37
Rice Solid Sp. Gr.	2.45	--
Percent Voids	3.3	--
Percent Asph. Cement***	5.6	5.5
Marshall Stability	--	1382
Marshall Flow	--	8

*Aggregate - Pit run gravel from glacial deposit located in NW 1/4-28-79-27, Dallas County.

**50 Blow Marshall Compaction.

***Extracted A.C. Content - Intended 5.5% by wt. of mix.

Table 4

Research Project HR-181

Gradation of Gravel
used for
Cover Aggregate

Sieve Size	Percent Passing 4DB7-181
1/2"	100
3/8"	71
No.4	7.6
No.8	0.9
No.200	0.4

Table 5

Research Project HR-181

Density and Thickness
of
Asphalt Concrete Core Samples

No.	Thickness	Density*
1	2.50"	96.2%
2	2.25"	97.5"
3	2.00"	94.9"
4	2.50"	97.0"
5	2.75"	95.4"

*Percent of Lab Density (2.37)

Table 6

Research Project HR-181

Characteristics
of
Asphalt Materials Incorporated

85-100 Penetration Asphalt Cement

Original Penetration	94
Original Absolute Visc.	656 Poise
Original Ductility	130+CMs
TFO Wt. Loss	0.03%
Pen. of TFO Residue	58
Abs. Visc. of TFO Residue	1250 Poise
Ductility of TFO Residue	130+CMs
Source - American Oil Company Sugar Creek, Missouri	

MC70 Primer Material

Kinematic Viscosity	106 Centistokes
Residue by Vol. above 680^{O}F.	70.0%
Residue by Wt. above 680^{O}F.	75.3%
Residue From Distallation	
Penetration	164
Absolute Viscosity	334 Poise

CRS 2 Binder Bitumen

Saybolt Viscosity @ 122^{O}F.	197 Seconds

Table 7

Research Project HR-181

Tabulation of Quantities

Material	Plan Quantity	Actual Quantity
Granular Blanket	436 tons	500.55
Macadam Base	1048 tons	1044.05
Choke Stone	174 tons	247.35 tons
Type B Asphalt Concrete	174 tons	255 tons
Primer Bitumen	894 gal.	1319.5 gal.
Binder Bitumen	312 gal.	433 gal.
Cover Aggregate	11 tons	29.75 tons

Rates of Application

Granular Blanket Aggregate	17.4 tons/sta.
Macadam Base Aggregate	36.3 tons/sta.
Choke Stone Aggregate	17.2 tons/sta.
Type B Asphalt Concrete - Right Shoulder	17.7 tons/sta.
Primer - Left (North) Shoulder/Choke Stone	0.22 gal./s.y.
Primer - Right (South) Shoulder/Macadam Base	0.36 gal./s.y.
Primer - Macadam Base Slope (3-1/2')	0.72 gal./s.y.
Binder Bitumen - Left Shoulder	0.27 gal./s.y.
Cover Aggregate - Left Shoulder	37.3 lbs./s.y.

Table 8

Research Project HR-181

Road Rater Deflection Data Comparisons

Project Location	Paved Shoulder Type & Thickness	Average Deflection/Mils August 1977	July 1978	May 1979	November 1980	September 1981
US 6 E. of Adel - HR-181	Macadam Base/Sealcoat Surface	4.24	4.27	4.25	4.07	3.55
US 6 E. of Adel - HR-181	Macadam Base/A.C. Surface	2.89	3.00	3.30	2.63	2.72
I-35 - US 20 No. to C-70	Asphalt Treated Base Class I 4.5% A.C. 8"	2.82	3.08			
US 30 Boone to Ia. 17	Asphalt Treated Base Class II 3.5% A.C. 6"	3.52	4.64	5.09		
I-80 Cass County E. of US 71	Rolled Stone Base 6"/Asph. Conc. Surf. 4"	4.32	----			
Iowa 13 North of Elkader	A.C. Surface/Macadam Base Granular Choke					4.18
Iowa 13 North of Elkader	A.C. Surface/Macadam Base Granular Blanket					3.82

Table 9

Highway Division
CONTRACT

NO. 12378

FORM 583 D 3-74 H-4974

Type of Work GRADE & PORTLAND CEMENT PAVEMENT Project No. RF-6-3(11)--35-25

Miles .390 COST CENTER 611000 OBJECT 876

County DALLAS

ON U S 6 AT ADEL FROM 6TH STREET EAST 0.5 MILE

THIS AGREEMENT made and entered by and between the Iowa Department of Transportation, Des Moines, Iowa, consisting of the following members:

ROBERT R RIGLER, STEPHEN GARST, DONALD K GARDNER, ALLAN THOMS,
W. F. MCGRATH, ANN PELLEGRENO, & L. STANLEY SCHOELERMAN, party of the first part, and

A.M. COHRON & SON, INC. OF ATLANTIC, IOWA 08500

party of the second part.

WITNESSETH: That the party of the second part, for and in consideration of $ ****283,302.01, 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	EXCAVATION, CLASS 10, ROADWAY & BORROW	83,396	CU. YDS.	.74	61,713.04
2	EXCAVATION, CLASS 12, BOULDERS	10	CU. YDS.	4.00	40.00
3	OVERHAUL	116,906	STA. YDS.	.01	1,169.06
4	BACKFILL, SELECTED, SOIL	8,738	CU. YDS.	.95	8,301.10
5	CULVERT, CORR. METAL ROADWAY PIPE, 72 IN. DIA.	96	LIN. FT.	50.00	4,800.00
6	REMOVAL OF EXISTING STRUCTURES		LUMP SUM		13,000.00
7	SURFACING, GRANULAR, CLASS A CRUSHED STONE - ON ROAD	535	TONS	8.00	4,280.00
8	SEWER, 1500D STORM, 15 IN. DIA.	12	LIN. FT.	16.00	192.00
9	SEWER, 2000D STORM, 15 IN. DIA.	108	LIN. FT.	13.50	1,458.00
10	SEWER, 1500D STORM, 18 IN. DIA.	52	LIN. FT.	14.60	759.20
11	SEWER, 2000D STORM, 18 IN. DIA.	16	LIN. FT.	17.10	273.60
12	SEWER, 1500D STORM, 30 IN. DIA.	82	LIN. FT.	26.00	2,132.00
13	INTAKE, RA-3	4	ONLY	1,020.00	4,080.00
14	INTAKE, RA-3 - MODIFIED	2	ONLY	1,050.00	2,100.00
15	INTAKE, RA-16B	2	ONLY	525.00	1,050.00
16	MANHOLE, RA-2 - MODIFIED	1	ONLY	1,000.00	1,000.00
17	REMOVAL OF PAVEMENT	4,089	SQ. YDS.	2.00	8,178.00
18	REMOVAL OF SIDEWALK	149	SQ. YDS.	1.00	149.00

Party of the second part certifies by his signature on this contract that he has complied with 324.17(8) of the 1975 Code of Iowa as amended.

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 Iowa Department of Transportation under date of MAY 20, 1976.

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 1972, together with special provisions attached, together with the general and detailed plans, if any, for said project RF-6-3(11)--35-25, 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 on or before, and shall be completed on or before:

Approx. or Specified Starting Date or Number of Working Days	Specified Completion Date or Number of Working Days
APPROX JUNE 28,1976	150 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 instruments of like tenor, as of the ______ day of JUN 3 1976, 19____

IOWA DEPARTMENT OF TRANSPORTATION

By James W. [illegible]
Party of the First Part

A.M. COHRON & SON, INC. OF ATLANTIC, IOWA

By Keith Harlan
Party of the Second Part

CONTRACT NO. 12378 PROJECT RF-6-3(11)--35-25 PAGE 2

ITEM NO	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT
19	TOPSOIL, STRIP., SALVAGE AND SPREADING	5,032	CU. YDS.	1.10	5,535.20
20	COMPACTING EMBANKMENT WITH MOISTURE & DENSITY CONTROL	6,721	CU. YDS.	.30	2,016.30
21	SEWER, 1500D STORM, 24 IN. DIA.	6	LIN. FT.	40.00	240.00
22	PAVEMENT, STANDARD OR SLIP FORM P. C. CONC., CLASS A, 9 IN.	5,997	SQ. YDS.	15.00	89,955.00
23	BRIDGE APPROACH SECTION REINFORCED AS PER PLAN	242	SQ. YDS.	36.00	8,712.00
24	SURFACE TREATMENT OF P. C. CONCRETE PAVEMENT	6,239	SQ. YDS.	.24	1,497.36
25	DRIVES, P.C. CONCRETE, 9 IN.	81	SQ. YDS.	13.00	1,053.00
26	BRIDGE END DRAIN, RF-35	2	ONLY	400.00	800.00
27	CURB, EXTRUDED ASPHALT	38	LIN. FT.	6.50	247.00
28	SODDING	19	SQUARES	60.00	1,140.00
29	SIDEWALK, P. C. CONC., 4 IN.	1,256	SQ. FT.	1.50	1,884.00
30	RAILING, FORMED STEEL BEAM	700	LIN. FT.	7.00	4,900.00
31	GUARD RAIL, POSTS, BEAM	136	ONLY	38.00	5,168.00
32	GUARD RAIL, END ANCHORAGES, BEAM	8	ONLY	300.00	2,400.00
33	PRIMER OR TACK-COAT BITUMEN	894	GALS.	.60	536.40
34	BASE, TYPE B CLASS 2 ASPHALTIC CONCRETE	174	TONS	30.00	5,220.00
35	BASE, CHOKE STONE	174	TONS	11.00	1,914.00
36	BASE, MACADAM STONE	1,048	TONS	11.00	11,528.00
37	GRANULAR MATERIAL	436	TONS	11.00	4,796.00
38	SEEDING, SPECIAL AREAS	.500	ACRES	1,000.00	500.00
39	SEEDING & FERTILIZING	8.300	ACRES	300.00	2,490.00
40	MULCHING	8.500	ACRES	250.00	2,125.00
41	SHOULDER FINISHING, EARTH	12.470	STAS.	150.00	1,870.50
42	BINDER BITUMEN	312	GALS.	5.00	1,560.00
43	AGGREGATE, COVER	11	TONS	25.00	275.00
44	FIELD LABORATORY	1	ONLY	3,000.00	3,000.00
45	CLEARING & GRUBBING	20.755	ACRES	350.00	7,264.25
				GRAND TOTAL	$283,322.01

APPENDIX A

SPECIAL PROVISIONS FOR MACADAM SHOULDERS

GENERAL. This work shall involve preparing the subgrade; furnishing, placing, and compacting a granular blanket material; a Macadam stone base course; choke stone base course; asphaltic concrete; applying a prime coat and a bituminous seal coat, all as required by the plans and these specifications.

PREPARATION OF THE SUBGRADE. The subgrade shall be prepared by blading and shaping the present subgrade to the required cross sections as shown in the typical cross section. Rolling shall be done in conjunction with the blading and shaping to maintain uniform density in the subgrade. Preparation of subgrade shall be incidental to the construction of the shoulders.

GRANULAR BLANKET MATERIAL. The Granular Blanket Material shall consist of crushed stone placed on the prepared subgrade and thoroughly compacted, all in accordance with the plans and these specifications.

A. Materials for the Granular Blanket Material shall be the same as specified in the Choke Stone Base section.
B. Equipment shall be the same as specified in the Macadam Stone Base section.
C. Construction. The Granular Blanket Material shall be constructed in accordance with requirements 2208.04 except that density requirements of 2208.04D will not apply. The Granular Blanket shall be compacted by not less than 4 passes of a vibratory roller complying with the requirements of 2001.05F, or as directed by the engineer.

MACADAM STONE BASE. The Macadam Stone Base shall consist of crushed stone placed on the Granular Blanket Material and thoroughly compacted, all in accordance with the plans and these specifications.

A. Materials for the Macadam Stone Base shall be the product of crushing limestone, subject to the approval of the engineer, and meeting the following requirements:
   1. Abrasion Loss. The percentage of wear, determined in accordance with AASHO T-96, Grading A or B, shall not exceed 45.
   2. Soundness. When subjected to the freezing-and-thawing test, ISHC Laboratory Test Method 211, Method A, the percentage loss shall not exceed 10.
   3. Gradation. The material shall be produced by a primary crusher with the grates, breaker bars or jaws adjusted to produce a maximum size of 4 inches. The material shall be screened over a 1-inch screen. The material retained on the 1-inch screen shall be hauled, spread, and compacted as the Macadam stone base material.

B. Equipment shall comply with 2001.01 and the following requirements:
   1. Weighing Equipment. Article 2001.07 shall apply.
   2. Compaction Equipment. A self-propelled vibratory roller shall be used to compact the Macadam stone base. Article 2001.05F shall apply. Other types of rollers complying with article 2001.05B, C and D may be required, at the direction of the engineer, to obtain the desired surface.
   3. Spreading Equipment shall be capable of uniformly spreading base material to the required thickness.
   4. Motor Patrols. Article 2001.15 shall apply.

C. Construction. Macadam stone base shall be constructed on the granular blanket material in accordance with the following requirements:
   1. Spreading Base Material. Article 2208.04C shall apply, except this material shall not be wetted.
   2. Compaction. Promptly after the material has been spread, it shall be compacted to stabilization. Compaction shall continue until the base material is interlocked and seated.

D. Fillets for Intersecting Roads, Drives, and Turnouts shall be constructed in accordance with the plans and these specifications.

E. Maintenance of Completed Base. Article 2205.12M shall apply.

CHOKE STONE BASE. The Choke Stone Base shall consist of crushed stone placed on the Macadam Stone Base and thoroughly compacted and primed with a bituminous primer, all in accordance with the plans and these specifications.

A. Materials for the choke stone base shall be the product of crushing limestone meeting the following requirements:
   1. Quality. Choke Stone Base material shall be from the source used for the Macadam Stone Base course material, a product of that operation.
   2. Gradation. The material shall be produced by a primary crusher with the grates, breaker bars or jaws adjusted to produce a maximum size of 4 inches. The material shall be screened over a 1-inch screen. The material passing the 1-inch screen shall be further processed as necessary to meet the following gradation requirements when tested by means of laboratory sieves:

Sieve Size	Percent Passing Min. Max.
1 inch	97-100
#8	30

      This material shall be hauled, spread, and compacted as the choke stone base material.
   3. Primer Bitumen shall be MC-70 meeting requirements of Section 4138.

B. Equipment shall comply with 2001.01 and the following requirements:
   1. Weighing Equipment. Article 2001.07 shall apply.
   2. Compaction Equipment. Article 2001.05F shall apply with the addition of a smooth-faced, steel roller, meeting requirements of 2001.05B, for the final rolling.
   3. Equipment for Cleaning the Base. Article 2001.14 shall apply.
   4. Equipment for Heating the Bitumen. Article 2001.11 shall apply.

5. Equipment for Distributing Bitumen. Article 2001.12 shall apply.
6. Equipment for Applying Water. Article 2001.12 shall apply.
7. Prewetting Equipment. Article 2001.09 shall apply if prewetting is done.
8. Spreading Equipment shall be capable of uniformly spreading base material to the required thickness.
9. Motor Patrols. Article 2001.15 shall apply.

C. Construction. Choke stone base shall be constructed on the Macadam Stone Base in accordance with the following requirements:
   1. Delivery of Base Material. The material may be prewetted before delivery to the Macadam stone base. The engineer may control the rate of delivery of material to reduce the time material will remain on the base in an uncompacted condition to the practical minimum.
   2. Moisture Content. If the material is prewetted before delivery, or if water is added after delivery to the base, water shall be uniformly distributed throughout the material so that all particles are uniformly wet. The amount of water shall be within 2.0 percentage points of the amount determined as field optimum to produce maximum density together with stability with the field compaction procedure. This moisture content will usually be 85 to 90 percent of the optimum determined according to Laboratory Test Method 103. This moisture content shall be maintained in the material until compaction of the base has been completed.
   3. Spreading Aggregate. Article 2208.04C shall apply.
   4. Compaction. Promptly after the material has been spread, it shall be thoroughly and uniformly compacted by three passes of a vibratory roller meeting requirements of 2001.05F. During the compaction process, such wetting, shaping, and edge trimming shall be performed as may be necessary to insure proper compaction and to achieve the required profile, crown, cross section, and edge alignment. An additional final rolling with a smooth-faced, steel roller will be required. The finished surface of the base shall be free from irregularities and loose material and shall have a smooth-riding surface.

D. Fillets for Intersecting Roads, Drives, and Turnouts shall be constructed in accordance with the plans and these specifications.

E. Priming Base Course and Subgrade. Article 2205.14 shall apply to priming of the base course and the adjacent subgrade.

F. Maintenance of Completed Base. Paragraph 2205.12M shall apply.

G. Winter Seal. Article 2205.15 shall apply.

METHOD OF MEASUREMENT. The quantities of the various classes of work involved in the construction of accepted portions of the base will be measured by the engineer as follows:

A. Granular Blanket Material will be measured in tons computed by the engineer from weights of individual truck loads, including free moisture in the material at the time of delivery, and will include base material for fillets at intersecting roads, drives, and turnouts. Moisture added after delivery of the material to the roadbed will not be measured for payment.

B. Macadam Stone Base will be measured in tons computed by the engineer from weights of individual truck loads, and will include base material for fillets at intersecting roads, drives, and turnouts.
C. Choke Stone Base will be measured in tons computed by the engineer from weights of individual truck loads, including free moisture in the material at the time of delivery, and will include base material for fillets at intersecting roads, drives, and turnouts. Moisture added after delivery of the material to the roadbed will not be measured for payment.
D. Primer or Tack-Coat Bitumen. Paragraph 2307.06B shall apply.

BASIS OF PAYMENT. For the performance of the various classes of work involved in construction of the base, measured as provided above, the contractor will be compensated as follows:

A. Granular Blanket Material. For the number of tons of Granular Blanket Material placed,the contractor will be paid the contract price per ton.
B. Macadam Stone Base. For the number of tons of Macadam Stone Base placed, the contractor will be paid the contract price per ton.
C. Choke Stone Base. For the number of tons of Choke Stone Base placed, the contractor will be paid the contract price per ton.
D. Primer and Tack-Coat Bitumen. For the number of gallons of primer or tack-coat bitumen measured for payment, the contractor will be paid the contract price per gallon. Article 1109.03 shall not apply to this item.

This payment shall be considered full compensation for furnishing all materials, including water, and for all operations involved in the construction of the base and not paid for in other items.

BITUMINOUS SEAL COAT. Section 2307 shall apply.

TYPE B CLASS II ASPHALTIC CONCRETE BASE. Section 2203 shall apply.