LOW COST FLY ASH - SAND STABILIZED ROADWAY

CONSTRUCTION REPORT
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-259

Highway Division

Iowa Department of Transportation

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LOW COST FLY ASH - SAND STABILIZED ROADWAY

JAN 1986

BY
S. J. KLASSEN, P.E.
DES MOINES COUNTY ENGINEER
AND

KEVIN JONES, P.E.
OFFICE OF MATERIALS
IOWA DEPARTMENT OF TRANSPORTATION
AMES, IOWA
515-239-1382

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ACKNOWLEDGEMENT

Research Project HR-259 was sponsored by the Iowa Highway Research Board and the Iowa Department of Transportation. Partial funding for this project was from the Secondary Road Research Fund in the amount of $89,390.

The authors wish to extend appreciation to the Des Moines County Board of Supervisors and the Iowa DOT for their support in developing and conducting this project. We also want to thank Central Paving Corporation for their cooperation during the project. The Des Moines County inspection personnel also deserve recognition for the extra effort put forth on the project.

INTRODUCTION

Fly ash, a by-product of coal-fired electricity generating plants, has for years been promoted as a material suitable for highway construction. Disposal of the large quantities of fly ash produced is expensive and creates environmental concerns. The pozzolanic properties make it promotable as a partial portland cement replacement in pc concrete, a stabilizer for soil and aggregate in embankments and road bases, and a filler material in grout. Stabilizing soils and aggregates for road construction has the potential of using large quantities of fly ash.

Iowa Highway Research Board Project HR-194, "Mission-Oriented Dust Control and Surface Improvement Processes for Unpaved Roads", included short test sections of cement, fly ash, and salvaged granular road material mixed for a base in western Iowa. The research showed that cement fly ash aggregate (CFA) has promise as a stabilizing agent in Iowa. There are several sources of sand that when mixed with fly ash may attain strengths much greater than fly ash mixed with salvaged granular road material at little additional cost.

OBJECTIVES

The objectives of the research were:

1. To develop a low cost fly ash stabilized roadway using locally available unprocessed sand.

2. To correlate field strength characteristics and performance of the base with laboratory strength characteristics and pavement design assumptions.

PROJECT DESCRIPTION

The project is located on Des Moines County Road H-40 adjacent to the Mississippi River Levee (Figure 1). In addition to cars, the road carries grain hauling traffic to an AGRI Industry grain storage and shipping terminal. For an AASHTO design structural number of 4, the annual 18-kip equivalent axle loads in the southbound direction are about 27,000.

Three test sections of cement, fly ash and sand base of various thicknesses were constructed. A 3-inch asphaltic concrete wearing surface was placed 24 feet wide on all sections. The sections are:

Section No.	Sta. to Sta.		Intended Base Thickness (In.)
1	10+00	15+00	7
2	15+00	25+00	8 1/2
3	25+00	60+00	10

MATERIALS

The basic base mix for 1 cubic yard based on dry weight of the sand was:

Cement, Type I, 5.1%	145 lbs.
Fly Ash, Type C, 13.7%	390 lbs.
Sand	2840 lbs.
Water	155 lbs.

The fly ash was a Type C from the Ottumwa Generating Station at Chillicothe, Iowa. The haul distance to the plant was about 90 miles. Results of the fly ash tests are in Tables 1 and 2.

FIGURE 1 PROJECT LOCATION

DES MOINES COUNTY
IOWA

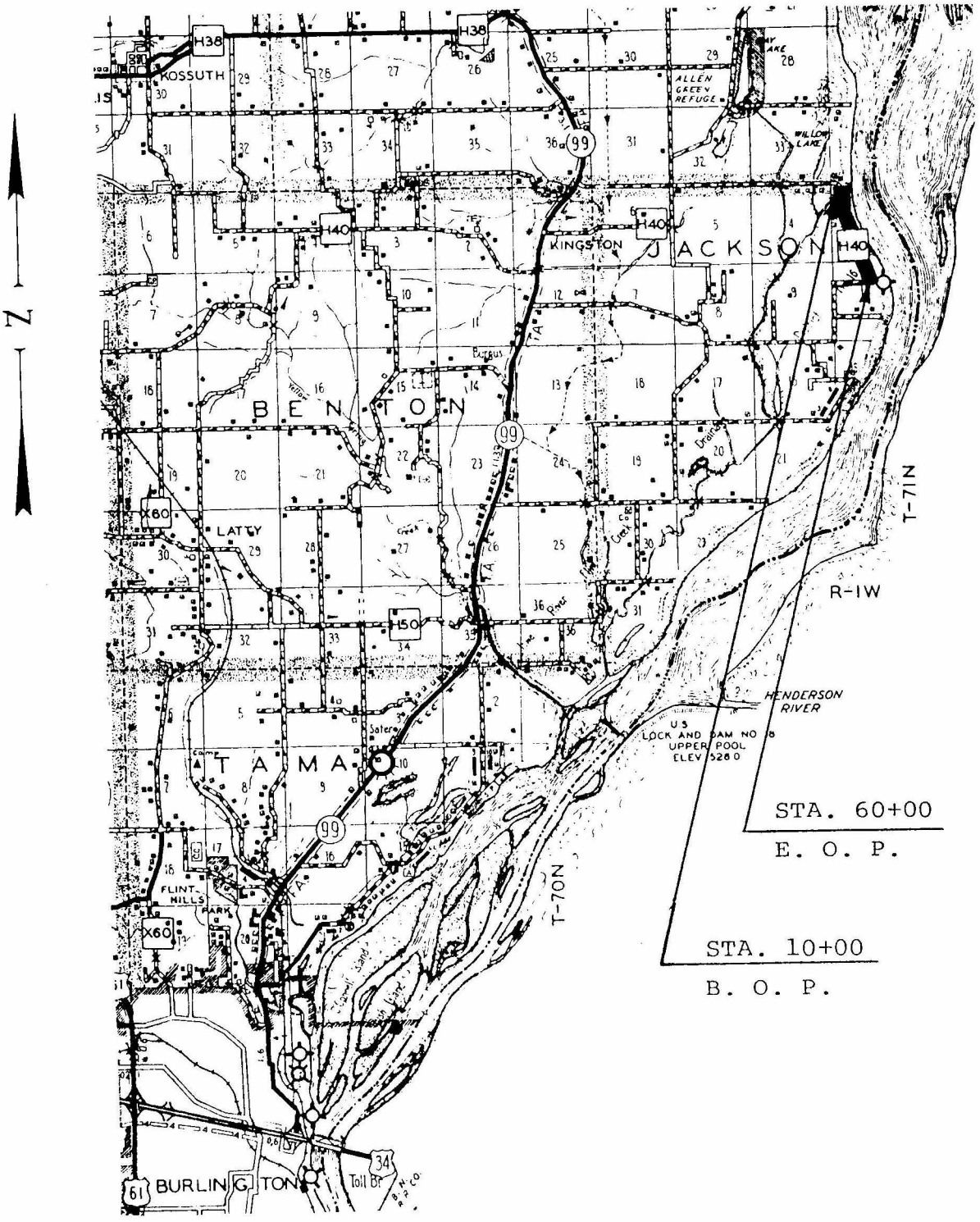


TABLE 1
RESULTS OF FLY ASH
CHEMICAL ANALYSIS

	Percent		Percent
SIO_2	37.23	Available Alkali	2.08
AL_2O_3	22.07	SO_3	1.90
FE_2O_3	5.03	Moisture	0.09
NA_2O	2.76	Loss on 800° C Ignition	0.28
K_2O	0.45	MGO	3.86
Alkali Equivalent	3.06	CAO	23.24

TABLE 2
RESULTS OF FLY ASH
PHYSICAL TESTS (ASTM C-311-77)

Specific Gravity	2.57	325 Mesh	86.0% PSG
Pozz. Activity		Spec. Surf.	13136 CM2/CM3
7 Day	119.4%	Compressive Strength	
28 Day	103.4%	Fly Ash & Sand	
Water Requirement	88.4%	1 day	188 P.S.I.
Autoclave	0.05%	7 day	378 P.S.I.

The sand is a dredge sand from the Mississippi River. The gradation is in Table 3.

TABLE 3
SAND GRADATION

Sieve Size	% Passing
3/8"	100
#4	99
#8	96
#16	85
#30	50
#50	5.0
#100	1.2
#200	1.1

Several mixes were tried with various percentages of portland cement, fly ash and water. The water content on trial mixes was held as low as practical because historically soil cement bases are prone to shrinkage cracking during

cure. With the poorly graded sand, enough fly ash could not be economically added to produce a maximum density mix. The mix proportions chosen yielded a laboratory compressive strength of 820 psi on 4-inch diameter specimens compacted by Standard Proctor and moist cured for 7 days at 73°F.

Midwest Testing and Engineering, Inc. conducted tests on the mix for Midwest Fly Ash and Materials, Inc., the supplier of the fly ash. The testing was in accordance with ASTM C 593-76 with 4-inch Proctor specimens compacted in 3 lifts with a 10-pound hammer and cured at 100°F in sealed containers. The relationship between compressive strength, dry density and the moisture content is shown in Figure 2. Specimens vacuum saturated and tested for compressive strength yielded a strength of 1360 psi after 7 days of 100°F cure.

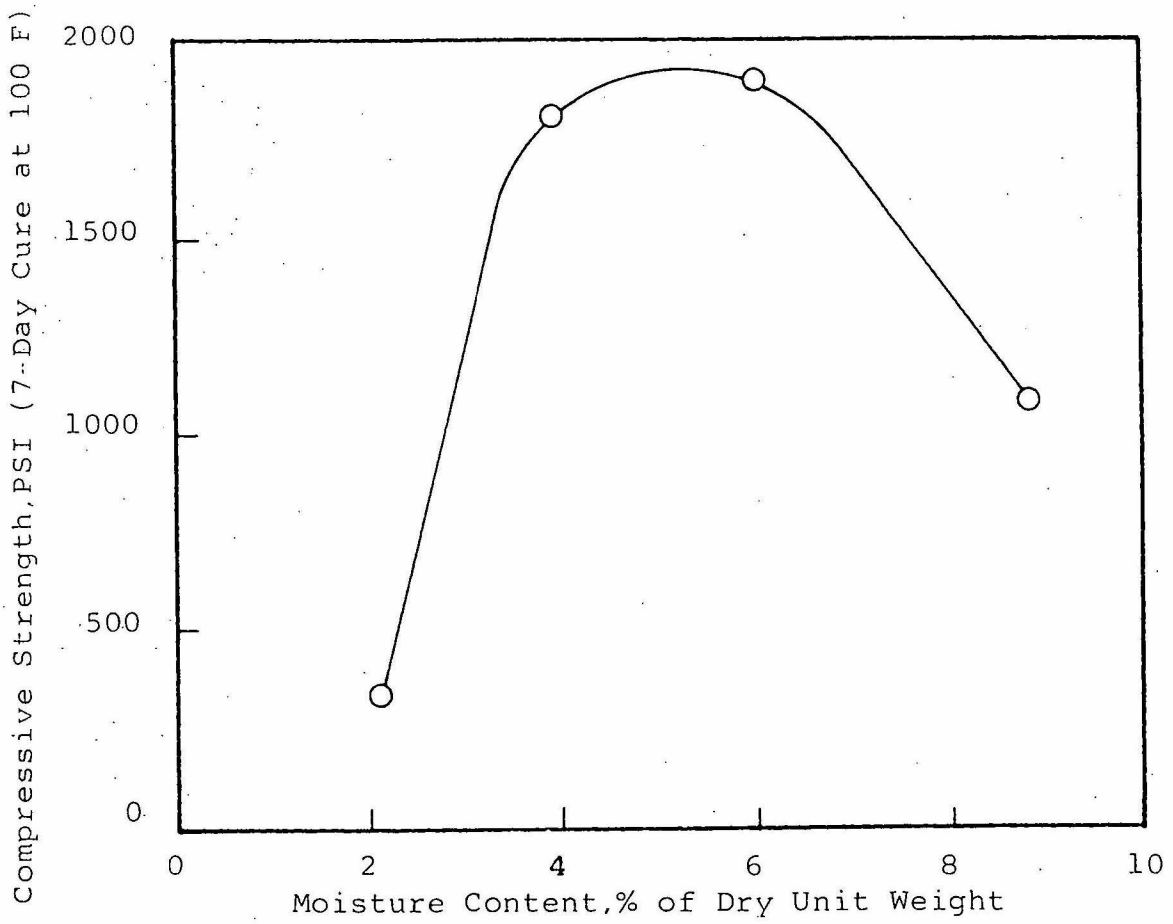
PAVEMENT DESIGN

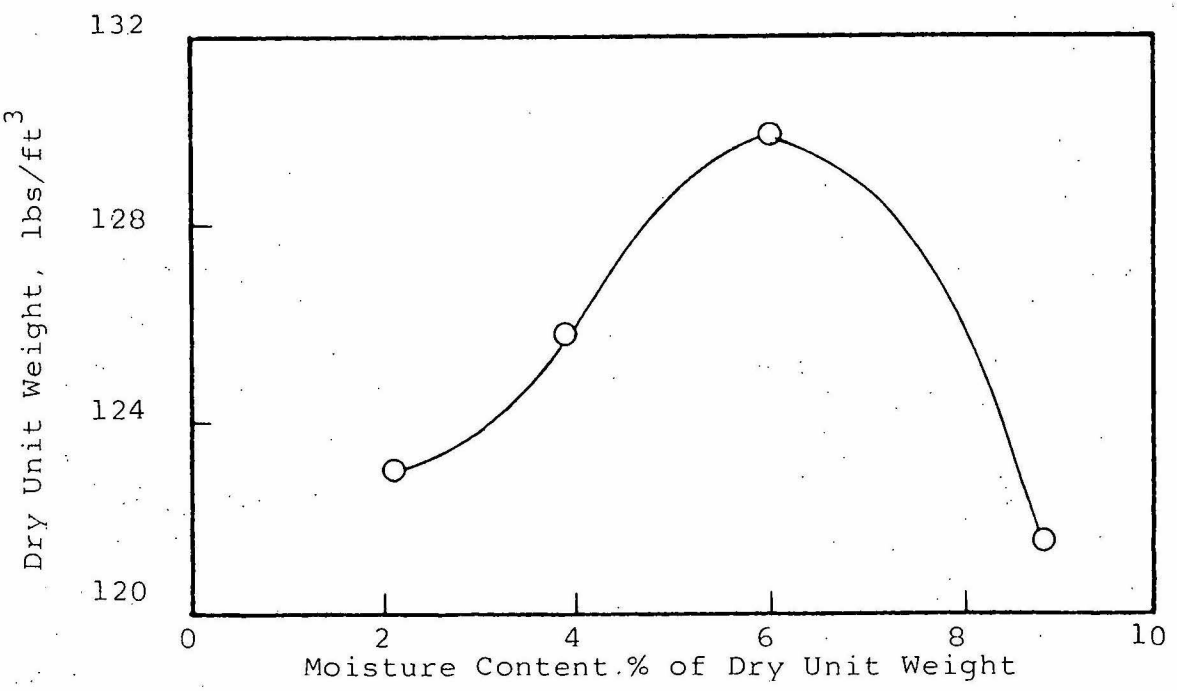
The major traffic generator, AGRI Industry, provided traffic volume, type and loading information to Des Moines County for the pavement design. Based on this information, equivalent 18-kip axle load applications were estimated at 27,000 per year for an AASHTO structural design number (SN) of 4 for a 20 year design period. AASHTO Flexible Design Procedures were used to determine the appropriate pavement thicknesses.

The pavement design assumptions were:

Soil Support value (S)	2 1/2
Regional Factor (R)	3.0
Serviceability Index (Pt)	2.0
Structural Coefficient for ACC	0.44
Structural Coefficient for CFA	0.30

FIGURE 2 PROJECT MIX STRENGTH AND DENSITY VERSUS MOISTURE CONTENT





Required structural number for 20 year design period = 4.20

CFA thickness = SN-3" (ACC coef.) /CFA coef.

= 4.20-3" (0.44) /0.30 = 9.6"

The calculated design life for the 8 1/2-inch base section using the same assumptions is about 10 years. Design life for the 7-inch base section is about 4.5 years.

CONSTRUCTION

Central Paving Corporation of Indianola, Iowa, was the successful bidder for the project and a tied project of 4 miles of pcc paving. The contract and special provisions are in Appendix A. The project was let July 7, 1983, for the 1983 construction season. However, the start of construction was delayed until 1984.

Des Moines County Maintenance forces prepared the grade in July 1984. A batch-type stationary pcc mixer was set up four miles west of the project on IA 99 (Figure 3). Sand was delivered to the plant site by Des Moines County and provided to the contractor at no charge. The mixer was charged with seven yards of mix in the same manner as for pc concrete. The mixer's slump meter went off the scale due to the zero slump mix, making it useless for monitoring the water content of the mix.

Base construction began on August 1, 1984. The mix was hauled to the grade in dump trucks and deposited in the subgrade trimmer (Figure 4). The sand and clay subgrade was occasionally unstable and trucks would become stuck while unloading.

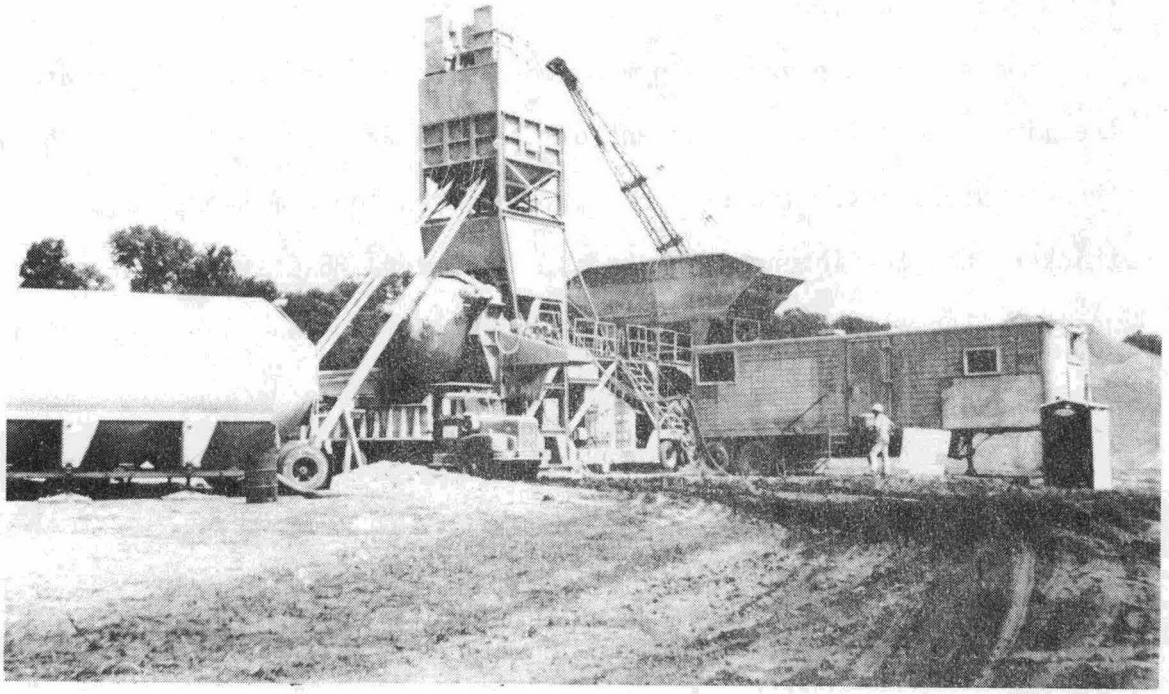


Figure 3 Plant used to Produce Base Mix

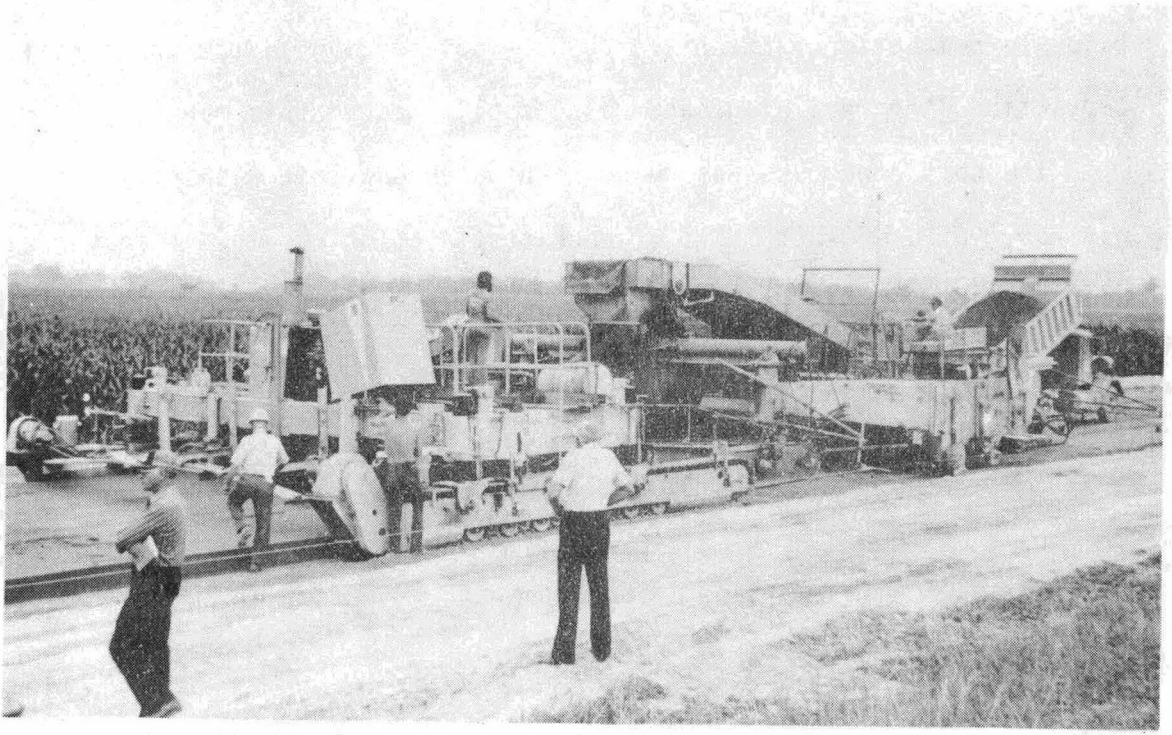


Figure 4 Paving Train Placing Material

The mix did not flow like concrete ahead of the slip form paver (Figure 5). However, the mix could be spread enough with the swivel chute to fill the slipform paver. Pan vibrators on the paver partially consolidated the mix. About 87 to 90 percent of Standard Proctor Density was obtained with the pan vibrators. The slipform paver placed loose mix one to two inches thicker than the intended thickness. A Hyster 625-C steel drum rubber drive-wheel roller with a 17,700 pound operating weight was initially tried for consolidation. The mix was not mechanically stable enough to support the roller. Mix tended to shove ahead of the drum and the rubber tire dug in when the roller direction was reversed. Next, a Bros VM-278 double steel drum, double drive roller with a 25,000 pound operating weight was tried. The mix still tended to shove ahead of the drums and the roller occasionally became stuck. Finally, a sheepfoot roller was used for initial rolling (Figure 6). At 1 to 1 1/2 hours after placement, the steel drum roller accomplished the final rolling without problem (Figure 7). Lab testing by Midwest Testing and Engineering had indicated no loss of strength for time delays of up to 2 hours prior to compaction. Except for a 500-foot section left with no roller compaction, the remaining base was consolidated in this manner.

The compacted base was cured with water until it was sealed with 0.2 gal./sq. yd. of MC-70. Half of each test section received transverse contraction joints at a 20-foot spacing. The joints were skewed 6:1 from perpendicular and cut to a depth of 1/4 the base thickness.

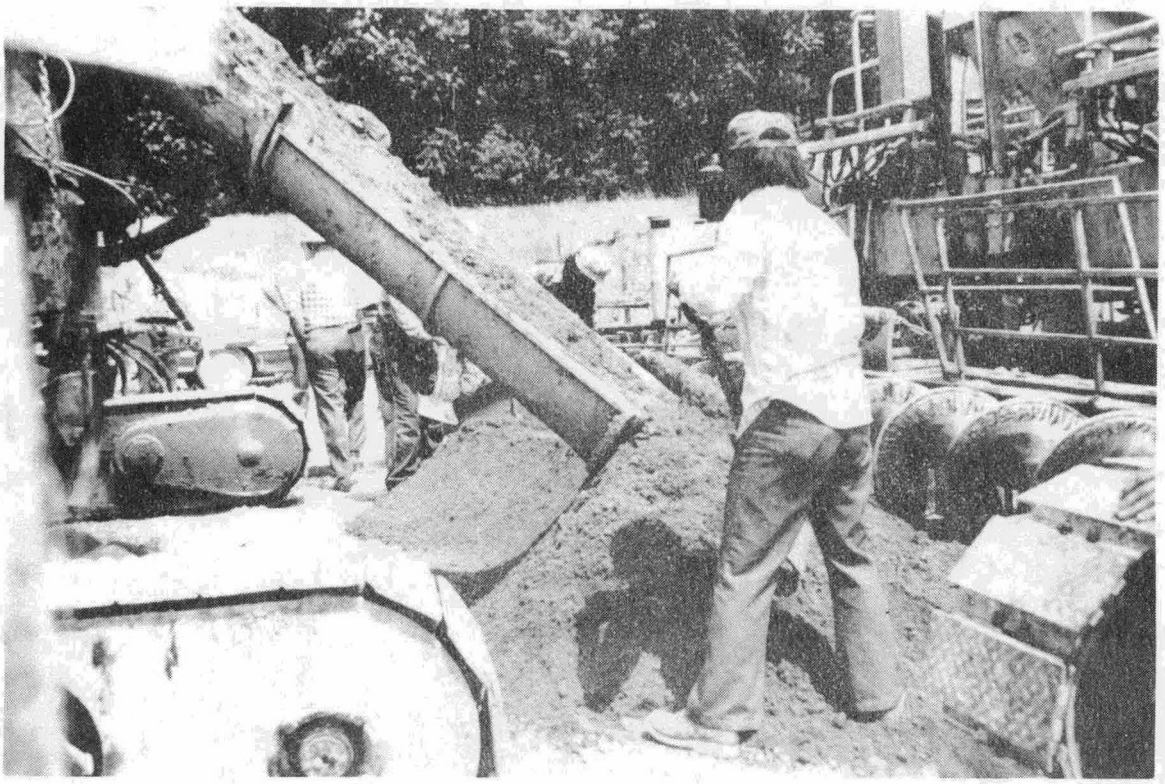


Figure 5 Subgrader Depositing Mix Ahead of Paver

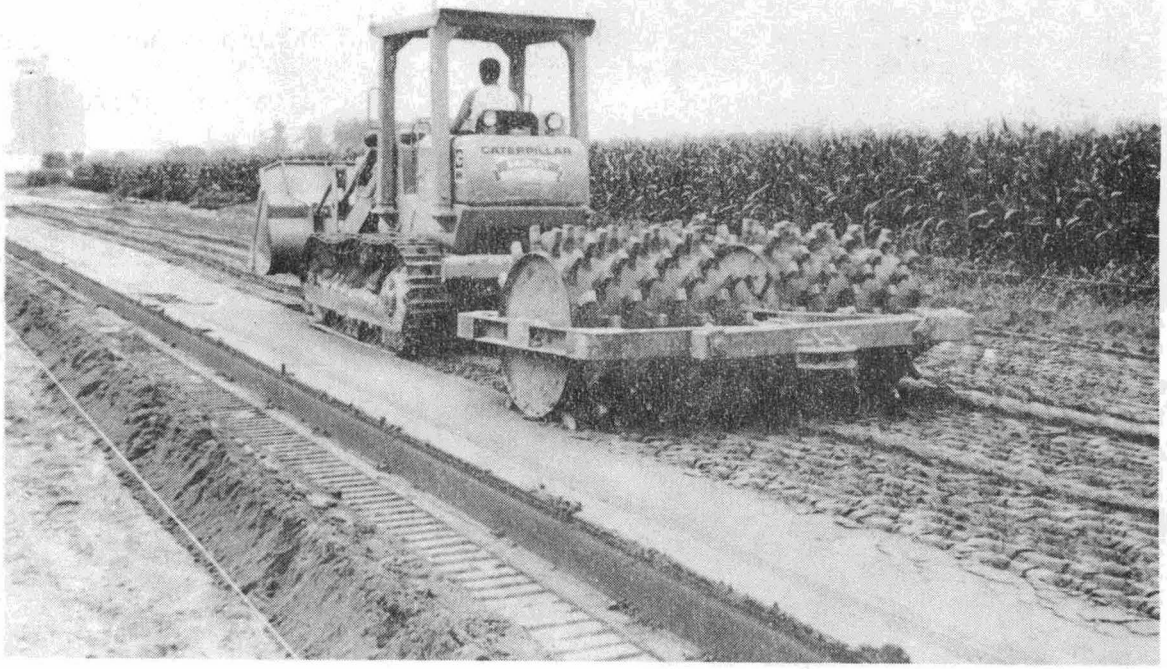


Figure 6 Sheepfoot Roller Performing Initial Consolidation

Figure 7 Double Drum Roller Performing Final Consolidation

Placement of the base was completed on August 4, 1984. The daily high temperature ranged from 85 to 89°F and the daily low temperature ranged from 66 to 71°F during construction. There was no precipitation was recorded during the period of placement.

During the first 14 days of cure the average daily high temperature was 88°F and the average daily low temperature was 67°F. Precipitation during the period was 0.32 inches for the 14-day period. For the second 14 days of cure, the average daily high temperature was 83° and the average daily low temperature was 61°F. Precipitation during the second 14 days was 1.47 inches.

The special provisions required the asphaltic concrete wearing surface to be placed after the 28-day cure period and within 10 days after the cure period. Shipley Construction Company of Burlington, Iowa, was sub-contracted to place the Type B, Class I, 3/4 inch asphaltic concrete mix. Originally, a 500-foot section of double-course seal coat was planned. Due to the uneven base surface, the seal coat section was eliminated and the asphaltic concrete was placed over the entire project in two 1 1/2-inch lifts instead of one 3-inch lift. The asphalt concrete was placed between September 7 and 15, 1984.

DENSITY TESTING

The target density for the base was 100 percent of the density determined by compacting a specimen from production mix in accord with AASHTO T-99, with a minimum density of 95 percent of that density. Two specimens were molded during the first full day of production. The average density was 126.2 lbs/cu ft at a moisture content of 4.95 percent. Density of the base was determined using a nuclear gauge.

One roller pass with just the steel drum roller produced a density of 92 to 94.5 percent of the Proctor density. The average density of 10 tests after rolling was 97.6 percent of Proctor. Density test results are in Appendix B.

COMPRESSIVE STRENGTH TESTING

Cores were taken at 14, 28, 91 and 313 days after placement (Table 4). A large variation in compressive strength was observed. However, on the average, the strength has continued to increase even after the winter season.

TABLE 4
COMPRESSIVE STRENGTH (PSI)
FROM BASE CORES

Test Date	8-16-84	8-31-84	11-2-84	6-14-85
Cure	13-16 days	27-28 days	91-92 days	313-314 days
	805	867	965	2192
	750	1803	1765	1186
	1100	422	873	1532
	810		891	935
	420		1277	
	520			
Avg.	734	1031	1154	1461

STRUCTURAL TESTING

The Iowa DOT Road Rater was used to determine the structural rating of the research sections. The road rater has been correlated to AASHTO structural layer coefficients and modulus of subgrade reaction (k).

Testing was conducted at both 25 and 30 Hz Road Rater settings. The 30 Hz setting produces more force at a higher displacement to enable testing of pcc pavements and composite ac over pcc pavements. For comparison purposes the pcc pavement adjacent to the research project was also tested. The 25 Hz Road Rater setting is normally used for testing flexible pavements. This setting produces a more realistic structural rating for the sand-fly ash base. It may not, however, be realistic to compare the 25 Hz sand-fly ash base data to the 30 Hz pcc data. The results of the Road Rater testing are in Table 5.

TABLE 5
ROAD RATER SUMMARY
4-13-85

SECTION	STA. TO STA.		FREQ. (HZ)	NO. TESTS	AVE. S.R.	80% S.R.	SOIL K
1 - 7" CFA/3" AC	10+00	15+00	30	6	3.1	2.75	225+
2 - 8 1/2" CFA/3" AC	15+00	25+00	30	11	3.5	3.1	225+
3 - 10" CFA/3" AC	25+00	60+00	30	41	3.4	2.7	205
7 1/2" PCC			30	24	3.4	2.85	200
1 - 7" CFA/3" AC	10+00	15+00	25	6	4.4	4.1	205
2 - 8 1/2" CFA/3" AC	15+00	25+00	25	10	5.2	4.7	200
3 - CFA/3" AC	25+00	60+00	25	41	4.9	4.1	180

It should be noted that the S.R.'s for the various base thicknesses do not test as expected. The southbound lane from Sta. 20+00 to Sta. 55+00 of the 10" base tests 25 percent lower than does the northbound lane. The centerline of the new road is 20 feet left of the old centerline leaving half of the northbound lane over the old roadway base. Average structural rating southbound is 4.3 and northbound 5.5 in the 10" section. The effect of the old base can also be seen in the difference in the modulus of subgrade reaction (k). The average k southbound is 150 and the average k northbound is 195. The majority of the heavy traffic is expected to be on the southbound lane. Based on AASHTO Flexible Design Procedures using a regional factor of 3.0, a soil support value of 2.5 and a seviceability index of 2.0, the southbound pavement should carry about 600,000 18-kip equivalent axle loads.

PROJECT COSTS

The bid price for sand-fly ash base in place was $15.00 per ton. This price did not include the cost of the sand nor the cost of transporting it to the plant site. The total cost per mile for each section is shown in Table 6. The tied pcc paving project of 7 1/2-inch pavement cost $127,776 per mile.

TABLE 6
TEST SECTION COSTS ($/MILE)

Bid Item	7" Subbase	8 1/2" Subbase	10" Subbase
Sand - Fly Ash Subbase	$73,497	$89,258	$105.019
Primer Bitumen	4,280	4,280	4,280
Asphalt Concrete Base 3"	95,088	95,088	95,088
Total	$172,865	$188,626	$204,387

Commonly, research projects involving unique construction techniques and sections of short lengths will be bid higher by contractors than standard construction. The frequent changeovers and uncertainty of success result in higher prices.

DISCUSSION AND SUMMARY

The CFA mixture was successfully mixed in a standard stationary batch-type pcc mixer and placed with a standard pcc slip form paving machine. With the recent allowance of fly ash in certain pcc pavement mixes, equipment for adding fly ash is becoming common among Iowa contractors. The major difficulty yet to be overcome is the consolidation of the material. The mix was too unstable to be compacted with typical steel drum rollers. One possible solution is to develop a large, high amplitude pan vibrator to achieve the desired consolidation. Another possible solution is to add sufficient limestone screenings to the mix to increase its stability.

The main objective of the project was to develop a low cost fly ash stabilized roadway. It is evident by the bid prices for the research section that the low cost was not achieved on this project. Bid price for the cement-fly ash-sand mix was $15.00 per ton in place. Of the $15.00, about $5.00 is the cost of the fly ash and the portland cement. The sand was provided to the contractor at the plant site at no charge. The remaining $10.00 cost was for

providing water and mixing, hauling and placing the mix as well as part of the mobilization cost. This cost appears to be inflated due to the research nature of the project. The cost of the asphalt concrete wearing surface is about 30 to 50 percent higher than what would be expected for a normal project. Costs for a future project of this type will almost certainly be much less.

The average compressive strength on field cores obtained after ten months of service have not approached the 7-day compressive strength for laboratory specimens cured at 100°F. However, 3 cores obtained from the roadway have tested near or above the laboratory specimen strength. Typical lime-fly ash-aggregate mixtures have been reported as generally having strengths ranging from 500 to 1000 psi after about one year of service. The average compressive strength for the roadway after 10 months of service is 1460 psi, well above the typical lime-fly ash aggregate mixture.

The other objective of the project is to correlate field performance with pavement design assumptions. At this early date, Road Rater data and visual observations are the only performance information available. The road has been in service for over one year and serviced two fall seasons of heavy grain hauling to the river terminal. Some small "ripples" occurred in the surface during construction and will probably necessitate an overlay after the evaluation period.

APPENDIX A

CONTRACT AND SPECIAL PROVISIONS

COST CENTER 801000 OBJECT 860

PROJ NO FM-29(2)--55-29 COUNTY DES MOINES

RES ENGR S. J. KLASSEN ADDRESS BURLINGTON

LETTING DATE JULY 5, 1983 LIQUIDATED DAMAGES $140.00

SPECIAL PROV 11/9/82 #915, 3/17/83 #920, 10/11/72 #A15, 7/6/83 SP-484, 7/6/83 SP-486

DATE STARTED FIELD COMP CERT. COMP

FORM 830019 8-77 H-380

CONTRACT NO. 21450

TYPE OF WORK ASPH. CEMENT CONC. PAV'T. PROJECT NO. FM-29(2)--55-29

MILES .947 COST CENTER 801000 OBJECT 860

COUNTY DES MOINES

ON SECONDARY ROAD FROM NEAR THE E 1/4 COR. Nw 1/4 SEC. 10-71-1W NORTHERLY APPROX. 1 MILE

THIS AGREEMENT MADE AND ENTERED BY AND BETWEEN THE COUNTY OF DES MOINES, IOWA

PARTY OF THE FIRST PART AND

CENTRAL PAVING CORPORATION OF INDIANOLA, IOWA 07150

PARTY OF THE SECOND PART

WITNESSETH, THAT THE PARTY OF THE SECOND PART FOR AND IN CONSIDERATION OF $ $171,733.00 PAYABLE AS SET FORTH IN THE SPECIFICATIONS CONSTITUTING A PART OF THIS CONTRACT, HEREBY AGREES TO CONSTRUCT VARIOUS ITEMS OF WORK AND TO FURNISH 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	3,980	CU. YDS.	5.00	19,900.00
2	CONSTRUCTION OF SAND-FLY ASH SUBBASE	6,156	TONS	15.00	92,340.00
3	BASE, TYPE B CLASS 1 ASPHALT CEMENT CONCRETE	1,645	TONS	30.00	49,350.00
4	PRIMER OR TACK-COAT BITUMEN	3,476	GALS.	1.50	5,214.00
5	ASPHALT CEMENT	99	TONS	10.00	990.00
6	BINDER BITUMEN, FURNISH & APPLY MC-3000 OR CRS-2	733	GALS.	3.00	2,199.00
7	AGGREGATE, COVER, ON ROAD 1/2 IN.	37	TONS	20.00	740.00
8	SAMPLES		LUMP SUM		1,000.00
				GRAND TOTAL	$171,733.00

PARTY OF THE SECOND PART CERTIFIES BY HIS SIGNATURE ON THIS CONTRACT UNDER PAIN OF PENALTIES FOR FALSE CERTIFICATION, THAT HE HAS COMPLIED WITH 121 I.A.C. 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 30, 1983

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 FM-2*(2)--55-29 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
50 WORKING DAYS	NOV. 10, 1983

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

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

COUNTY OF DES MOINES, IOWA

BY _____
PARTY OF THE FIRST PART

CENTRAL PAVING CORPORATION OF INDIANOLA, IOWA

BY _____
PARTY OF THE SECOND PART

Iowa Department of Transportation

SPECIAL PROVISION
for
SAND-FLY ASH SUBBASE

Project FM-29(2)--55-29, Des Moines County
Research Project HR 259

July 6, 1983

THE STANDARD SPECIFICATIONS OF THE IOWA DEPARTMENT OF TRANSPORTATION, SERIES OF 1977, SHALL APPLY TO THIS PROJECT EXCEPT AS AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

484.01 GENERAL. This work consists of mixing and placing a sand-fly ash subbase, using a mixture of sand, fly ash, cement, and water. The mixture shall be prepared and placed according to the plans and this specification. Several thicknesses are required.

This is a research project designed to provide important information concerning this type of subbase. The requirements of the plans and specifications may be modified to meet these research goals.

A conventional asphalt cement concrete base is specified as a wearing course.

484.02 MATERIALS. Sand for this subbase will be furnished by the County at no cost to the contractor. The contractor shall furnish all other materials. The materials shall be as follows:

A. Sand is to be a locally available dredge sand. Preliminary tests show the following characteristics.

Sieve Size	% Passing
1/2 inch	100
3/8 inch	99
No. 4	99
No. 8	97
No. 16	91
No. 30	60
No. 50	5.4
No. 100	0.4
No. 200	0.2

Specific Gravity: 2.670

The sand will be furnished by the County, delivered to the contractor's plant site, at no cost to the contractor.

B. **Fly Ash** shall be Type C, meeting requirements of ASTM C 618. Fly ash shall be furnished by the contractor from sources approved by the engineer in accord with I.M. 491.17. Currently approved, uncertified sources are as follows:

Neal #4	Sioux City
Council Bluffs #3	Council Bluffs
Chillicothe	Ottumwa
Lansing	Lansing
Alma	Alma, Wisc.

C. **Cement** shall be Type I, meeting requirements of Section 4101.

D. **Water.** Section 4102 shall apply.

E. **Sealer Bitumen.** Paragraph 2207.02D shall apply.

F. **Final Mixture.** The final mixture shall be a combination of the following approximate quantities of individual materials, estimated for 1.0 cubic yard and based on dry weight of sand. The amount of water used may be adjusted by the engineer.

Cement, 5.0%	145 lbs.
Fly Ash, 13.7%	390 lbs.
Sand	2840 lbs.
Water	155 lbs.

484.03 EQUIPMENT. Equipment to be used shall be as follows:

A. **Proportioning and Mixing** shall be in a stationary plant. A conventional PCC plant described in 2001.21 is expected. A stationary plant of another type will be considered for approval, including a pugmill mixer described in 2001.08A.

B. **Placing Equipment** shall be capable of placing the mixture to the full width and required thickness in one pass. A conventional slip form paver is required, with no internal vibrator. Use of a pan vibrator is encouraged.

The subbase mixture shall be dumped from the shoulder into a machine that spreads the mixture over the area to be paved.

C. **Compaction Equipment.** Initial compaction shall be by a vibratory roller or compactor meeting requirements of 2001.05F. Final compaction shall be by a steel- or rubber-tired roller meeting requirements of 2001.05B or C.

D. Distributor. Sealer bitumen shall be spread by a hand operated spray or other equipment that does not operate on the subbase.

484.04 SUBGRADE. The subgrade and trackline will be constructed by the County. Construction will include a stabilized trackline or other means to provide for slip-form paver operation. No trimming of the subgrade is anticipated.

484.05 CONSTRUCTION. The mixture shall be spread to the full width and full thickness in one operation. The thickness is to be varied as shown on the plans.

The mixture shall be compacted immediately after spreading. Compaction shall be to a target density of 100 percent of the density determined by compaction of samples of production mixture in a single, molded specimen in accord with AASHTO T 99, with a minimum density of 95 percent. The compaction and compaction procedure shall be based on maximum achievable compaction. An initial test section is contemplated. Compaction of the outside 1 foot may be minimized by the engineer and will not be subject to test. The engineer may modify or delete these compaction requirements.

An application of water may be necessary to facilitate compaction. A moist surface condition shall be maintained until the sealer bitumen is applied.

484.06 SEALER BITUMEN. The completed subbase surface and edges shall be sealed at the rate of 0.2 gallon per square yard. The sealer shall be applied the same day the subbase is placed. This shall be done without the operation of equipment on the subbase. At the contractor's option, the subbase may be moist cured for 14 days by a procedure approved by the engineer.

484.07 JOINTS. Some joints shall be sawn. Only those areas designated on the plans are to be sawn. Sawing of transverse joints shall be in accord with 2301.26.

484.08 ACC BASE. The contractor shall furnish and place a Type B ACC base on the completed subbase in accord with the plans and requirements of Section 2203. Placement of the full thickness in one lift is contemplated, with Class I compaction.

484.09 LIMITATIONS. The road will be closed to traffic during this construction.

The subbase is to be constructed on a new centerline adjacent to the existing road, which will remain in place during this construction.

Because of the sandy character of the new subgrade, all subbase construction and all delivery of materials therefor shall be accomplished with no equipment operating on the subgrade. Only the spreading machine and the paver shall operate on the trackline; there will be no subgrade correction.

Except for sawing, there shall be no traffic or equipment operated on the completed subbase during a 28-day curing period.

Within 10 working days after the curing period, the contractor shall place the ACC base wearing course.

484.10 SHOULDERS. The shoulders will be constructed by the County after the wearing course is placed.

484.11 METHOD OF MEASUREMENT. The engineer will compute the quantity of sand-fly ash subbase furnished and placed from weights of individual truck loads.

At the contractor's option, this quantity will be determined from batch weights and a count of batches.

The quantity of sealer bitumen used will be determined according to 2307.06B.

484.12 BASIS OF PAYMENT. For the construction of sand-fly ash subbase, the contractor will be paid the contract price per ton. Such payment shall be full compensation for mixing and placing the subbase mixture, for furnishing the cement, fly ash, and water required, for compaction, for sawing joints as specified, and for furnishing all equipment and labor therefor.

For the quantity of bituminous material used as sealer bitumen, the contractor will be paid the contract price per gallon. If the subbase is moist cured, the cost of curing will be considered incidental to the subbase construction and will not be paid for separately.

The items involved in the ACC base for wearing course will be paid for according to Section 2203, including contractor-furnished samples.

APPENDIX B

BASE DENSITY TEST RESULTS

BASE DENSITY TEST RESULTS

LOCATION	% MOISTURE	DRY DENSITY (PCF)	% PROCTOR DENSITY
23+50, 7' LT.	5.98	122.4	97.0
24+25, 3' RT.	6.45	120.9	95.8
25+00, 6' LT.	4.93	122.5	97.1
25+75, 4' RT.	4.83	126.2	100.0
30+00, CL	5.94	122.6	97.2
31+50, 3' LT.	6.05	122.7	97.2
33+00, 5' RT.	5.08	125.5	99.5
34+50, 10' RT.	5.22	124.9	99.0
35+75, 8' RT.	5.73	125.2	99.2
38+50, CL	5.10	124.1	98.3