UNIVERSITY OF ARKANSAS

CIVIL ENGINEERING DEPARTMENT

Revised Comprehensive Report

The Performance of Flexible Bases and Pavements In the Loess Terrace Soil Area

Project No. 4

Joint Highway Research Program

March 1963

REVISED

COMPREHENSIVE REPORT OF THE PERFORMANCE OF FLEXIBLE BASES AND PAVEMENTS IN LOESS TERRACE SOIL AREA

By

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Project No. 4
Joint Highway Research Program
Civil Engineering Department
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A STUDY OF THE PERFORMANCE OF FLEXIBLE BASES AND PAVEMENTS

Preface

This project is a joint research effort of the Arkansas Highway Department, the Department of Commerce, Bureau of Public Roads, and the University of Arkansas. The laboratory work of Phase I was performed in the Highway Research Laboratory of the University. The staff was made up of members of the faculty and students of the Department of Civil Engineering. The field work of Phase I was accomplished with the assistance of the maintenance personnel from the Arkansas Highway District 1. The traffic and loadometer studies were made by the Division of Planning and Research.

This report presents the findings of Phase I of this research project. The entire study has as its aim the developing of information that will permit a better design of flexible pavements by the Arkansas Highway Department. In Phase I an intensive study was made of the deflections of the pavements under load, traffic using the roads, and the changing conditions of the roads with time. The pavement, base, and subgrade were sampled for laboratory studies. In-place density determinations were made on both base and subgrade. Soil Conservation Service soil maps were obtained and used for comparing pavement performance with the pedological soil types.

Findings

1. The factors found to influence pavement performance, in order of importance include: total structure thickness, total number of 5000 pound equivalent wheel loads, subgrade volumetric shrinkage, subgrade inplace moisture content, and asphalt ductility.
2. The outer wheel path area is the most critical and will ordinarily fail before the inner wheel path area.
3. Pavement deflection, as recorded by the Benkelman Beam, does not directly indicate the performance capability of a pavement.
4. The outer wheel path Ratio, radius of deflected area divided by the maximum deflection, determined from the Helmer recorder curve does indicate the performance capability of a pavement.
5. Ductility of the asphalt in the pavement influences the surface performance, low ductility results in cracking of the pavement.
6. Seventy-five percent of the Loess Terrace Soil area may be classified as A-4, for all practical purposes the remaining twenty-five percent are classified as A-6.
7. The job with crushed stone base and double surface treatment had a high outer wheel path Ratio, and performed as well as jobs with gravel bases and high type pavement surfaces.

Introduction

This project was started in May, 1958, when a research proposal was submitted to the Arkansas Highway Department by the Department of Civil Engineering of the University of Arkansas. This proposal suggested that a joint research project between the University of Arkansas, the Arkansas Highway Department, and the Department of Commerce, Bureau of Public Roads, be initiated for the purpose of making an intensive study of the construction, performance, and depreciation of flexible base pavements. The information thus obtained would be correlated with data on original construction and soil conditions. It was planned that the data derived from this study would be used by the designers in the future design of flexible base pavements.

This project was to be the first phase of a long-range study of flexible bases and pavements throughout Arkansas. This Phase I was to be confined to one specific area of the State.

Specifically, the items to be studied were the condition of the pavement on the basis of a visual check, deflections, and traffic. Samples of the pavement, base, and subgrades were to be obtained for laboratory investigations. Information on the soils was to be compared with the Agricultural Soil Classifications of the Soil Conservation Service. In-place moisture and density determinations were to be made on both the subgrade and base material. All of this information was to be combined into a performance rating for each pavement structure.

The following conditions were established for choosing the roads to be studied:

1. All of the roads were to be in the Loess Terrace Soil area.

2. The pavements were to be less than six years old.

3. All the roads were to be in one Highway District for convenience. (Subsequently, District 1 was divided into two districts - District 1 and District 10.)

An Advisory Committee was appointed by the Arkansas Highway Department and the Bureau of Public Roads to assist in this study. This committee was composed of:

E. E. Hurley, District Engineer, District 1

E. L. Wales, Engineer of Materials and Tests

R. B. Winfrey, Engineer of Maintenance

Paul E. Schenke, District Engineer, Bureau of Public Roads.

Later E. E. Hurley was transferred, and C. M. Matthews replaced him on the committee. E. L. Wales retired and was replaced by H. W. Schneider. C. A. Shumaker, Engineer of Construction, and George Fry, Assistant Highway Engineer, were added to the committee.

The Loess Terrace Soil area of eastern Arkansas was chosen for Phase I of the study because this area is one of the more uniform soil areas of the State. There were a number of flexible pavement roads in this soil area that met the conditions.

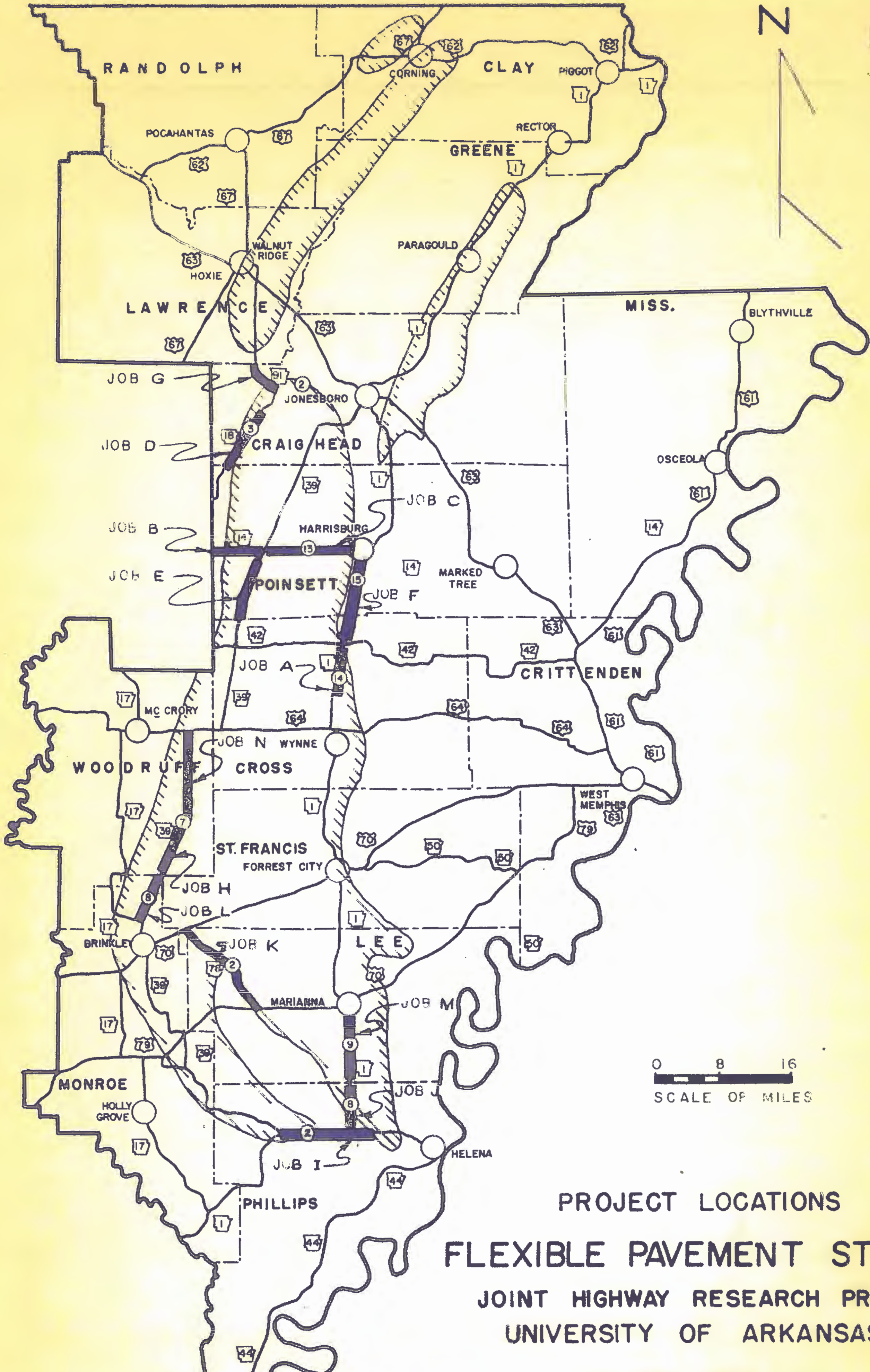
The records of the Highway Department were examined before any roads were chosen for inclusion in the study. Information on the age of the pavements, the type of construction, and cost data was obtained from the Road Log and the Road Life Studies of the Division of Statistics and Analysis, since redesignated the Division of Planning and Research. The Committee and the Project Director examined all of the possible highways in the field and chose 14 jobs from the list for inclusion in this study. These jobs are shown in Table 1. Figure 1 is a map of Districts 1 and 10 showing the locations of these jobs. For the purpose of this study, the term "job" refers to a section of highway constructed under one job number.

TABLE 1

LIST OF PAVING JOBS UNDER STUDY

Job No.	Code	Length	Sta	SH	County	Location
1248	A	9.097	37	1-14	Cross	Vandale N. to Poinsett Co.
		3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,33,35,36				
1252	B	6.060	25	14-13	Poinsett	Waldenburg to Jackson Co.
		2,5,8,12,15,18,21,24				
10297	C	12.563	53	14-13	Poinsett	Waldenburg to Harrisburg
		2,5,8,11,14,17,20,23,26,29,32,35,38,41,44,48				
10417	D	7.172	34	18-3	Craighead	Cash to Poinsett Co.
		None				
10418	E	9.099	43	39-5	Poinsett	Waldenburg to Cross Co.
		2,5,8,11,14,17,20,23,26,29,32,35,38,41				
10479	F	7.784	37	1-15	Poinsett	Cross Co. to Harrisburg
		2,5,8,11,14,17,20,23,26,29,32,35				
10521	G	3.982	14	91-2	Craighead	Lawrence Co. to SH 18
		None				
11436	H	8.850	42	39-7	Woodruff	Monroe Co. to Hilleman
		1,3,5,7,9,11,13,15,17,20,22,24,26,28,30,32,34,36,38,40,42				
11442	I	10.270	46	20-2	Phillips	Marvell to Walnut Corner
		2,5,8,11,14,17,20,24,27,29,33,36,42,45				
11452	J	6.079	30	1-8	Phillips	Walnut Corner N. to Lee Co.
		1,4,8,10,13,17,20,23,26,28				
11458	K	10.377	50	78-2	Lee	Wheatley to Moro
		4,6,9,12,15,18,20,23,26,28,32,35,38,41,43A,45,49				
11465	L	5.927	25	39-8	Monroe	Jct SH 17 to Woodruff Co.
		3,6,9,12,14,16,18,19,21,23,25				
11489	M	7.970	38	1-9	Lee	Phillips Co. to Mariana
		1,4,8,12,14A,17,20,23,26,29,34,37				
11580	N	9.695	39	39-7	Woodruff	Hillemann to Morton
		1,2,3,5,7,9,11,13,15,17,19,21,23,25,27,29,31,36,38				

NOTE: Stations where pavement samples were secured are listed under each job.



PROJECT LOCATIONS

FLEXIBLE PAVEMENT STUDY

JOINT HIGHWAY RESEARCH PROGRAM

UNIVERSITY OF ARKANSAS

FIGURE 1

December 1958

REV. 1/1/62

Plan of Study

It was planned that the jobs would be studied intensively for a period of two or three years. Thereafter these same jobs would be checked from time to time, possibly once a year for a period of ten years or more. The intensive study, called Phase I, is the subject of this report. A different soil area was to be studied at the completion of Phase I, and, at the same time, the jobs of Phase I were to be checked, as indicated above.

The original work plan, as prepared by the Project Director in consultation with the Committee, listed the following procedures:

A visual-condition survey was to be made on each of the jobs at intervals ranging from three to four months. About three sets of deflection tests were to be made each year using the Benkelman Beam. Samples of the pavement, base, and subgrade were to be obtained at intervals of 0.2 to 0.4 mile along each job. These samples were to be taken from the center of the traffic lane. In-place density and moisture determinations were to be made on both base and subgrade. At the same location, a sample of the subgrade was to be obtained at the edge of the pavement for the purpose of determining in-place density and moisture content. Physical properties of the base and subgrade were to be determined in the laboratory. The pavement sample was to be checked for its density and stability in a remolded condition. The asphalt cement was to be extracted from the pavement sample for the determination of the physical properties of the asphalt cement. Traffic and loadometer studies were to be obtained on each of these projects. The Soil Conservation Service was to be contacted for any unpublished information on file regarding the soil classifications.

An identification number was to be painted on the pavement in the center of one traffic lane at intervals of two-tenths mile on all of the jobs. This number, referred to here as a station number, would serve as a location and identification point for all of the subsequent work.

Condition Surveys

Condition surveys by visual inspection were made on each of the jobs. These inspections were made at intervals of about three to four months. A numerical rating was given each pavement at each identification station. This was accomplished by driving slowly over the road and in most cases examining the pavement on foot at frequent intervals between the identification stations. Table 2 shows the criteria used for grading the pavements. All of the condition surveys were made by the same person. Table 3 shows the average condition rating of each of the jobs for the period of the study. The averages shown in Table 3 serve only to indicate the relative quality of the different pavements and, of course, do not indicate the variations that occur from location to location within a given job. The actual condition at each station was combined with other factors studied to give a picture of the performance at an individual location station. It was observed, in making these condition surveys, that the rating given a station varied as much as five percentage points between different periods even when no work had been done on the pavement in the meantime. This difference was due to varying appearance of the pavement under different climatic conditions and to the usual variations in human judgment. This was especially apparent when a condition survey was made after a long period of rainfall. The surface of the pavement had dried out and each crack appeared as a dark line on the pavement. Under this condition many cracks were visible that would not have shown under other conditions.

TABLE 2

CRITERIA FOR CONDITION SURVEYS

EXCELLENT	95-100	
	No defects apparent Good riding surface	
GOOD	90-95	
	Few small isolated cracks Slight surface roughness No patching required	
FAIR	80-90	
	Some isolated cracks Slight surface irregularities Some ravelling at edge of pavement	
AVERAGE	70-80	
	Slight rutting Small areas showing map cracking Small ravelled areas Minor base failures Surface roughness evident	
POOR	55-70	
	Distorted surface Base failures extend entire width of lane Considerable surface cracking Rutting	
FAILURE	Below 55	
	Extensive patching Surface distortion Extensive base failures	

TABLE 3

AVERAGE OF CONDITION SURVEYS

Job	Jan. 1959	Oct. 1959	Dec. 1959	March 1960	Sept. 1960	May 1961	Oct. 1961	Average
A	83	[2]95	93	86	86	86	[2]90	88
B	69	63	70	64	62	68	64	66
C	69	72	69	64	65	63	64	67
D	72	[2]--	77	69	--	63	--	70
E	67	[1]83	77	65	[1]70	60	[1]61	69
F	79	81	76	66	67	61	60	70
G	72	71	74	67	--	65	--	70
H	77	[1]89	84	77	[1]80	66	[3]87	80
I	95	93	94	89	85	81	82	88
J	98	98	98	97	97	95	97	97
K	77	80	78	75	[2]--	77	75	77
L	68	[2]95	92	89	[1]87	72	[1]74	82
M	98	98	98	98	97	98	98	98
N	81	[1]85	85	79	90	68	[3]83	82

[1] - Part of job resurfaced

[2] - Entire job sealed or sealed and resurfaced

[3] - Entire job overlaid

These condition surveys have the distinct advantage of giving the investigator some idea of the amount of maintenance work being done on the pavement. Of course some visual impressions are misleading, but the investigator did form a definite opinion of the general trend of the performance of the pavements. There were other confirming indications of this trend from other data. The first evidence of distress in the pavement showed in the condition surveys. The location of points of failure and the amount of cracking was of considerable value in comparing results of other tests.

Deflections

Benkelman Beam deflections were made three times a year at each of the identification stations on each job. The deflections were made with Beams constructed by the University and equipped with recording devices developed by R. A. Helmer of the Oklahoma Highway Department. The load was supplied by a truck equipped with water tanks so arranged that water could be shifted from one tank to the other to permit accurate control of the load of each rear wheel. The truck was equipped with dual wheels on a single rear axle. The tire pressure was maintained at 90 pounds per square inch, and the load was maintained at 9000 pounds on each set of dual wheels.

A procedure for making the deflection tests was developed and carefully followed on all tests. At the beginning of the test, the rear wheels were positioned exactly on the identification station with the wheels in the traffic lanes. The probe point was inserted between the dual tires with the point four feet in front of the wheel. The front support for the Beam was 3.8 feet back of the wheel at the start of the test. A cord was attached to the truck from the recorder to operate the latter. After the recorder was set, initial readings were taken on the dial gage. The truck was rolled forward at a speed of about three miles per hour until the rear wheel was from six to ten feet beyond the probe point. An operator on each of the beams read the maximum deflection on the dial gage, as well as the initial and final readings of the gage. Figure 2 shows the deflection measurement procedure.

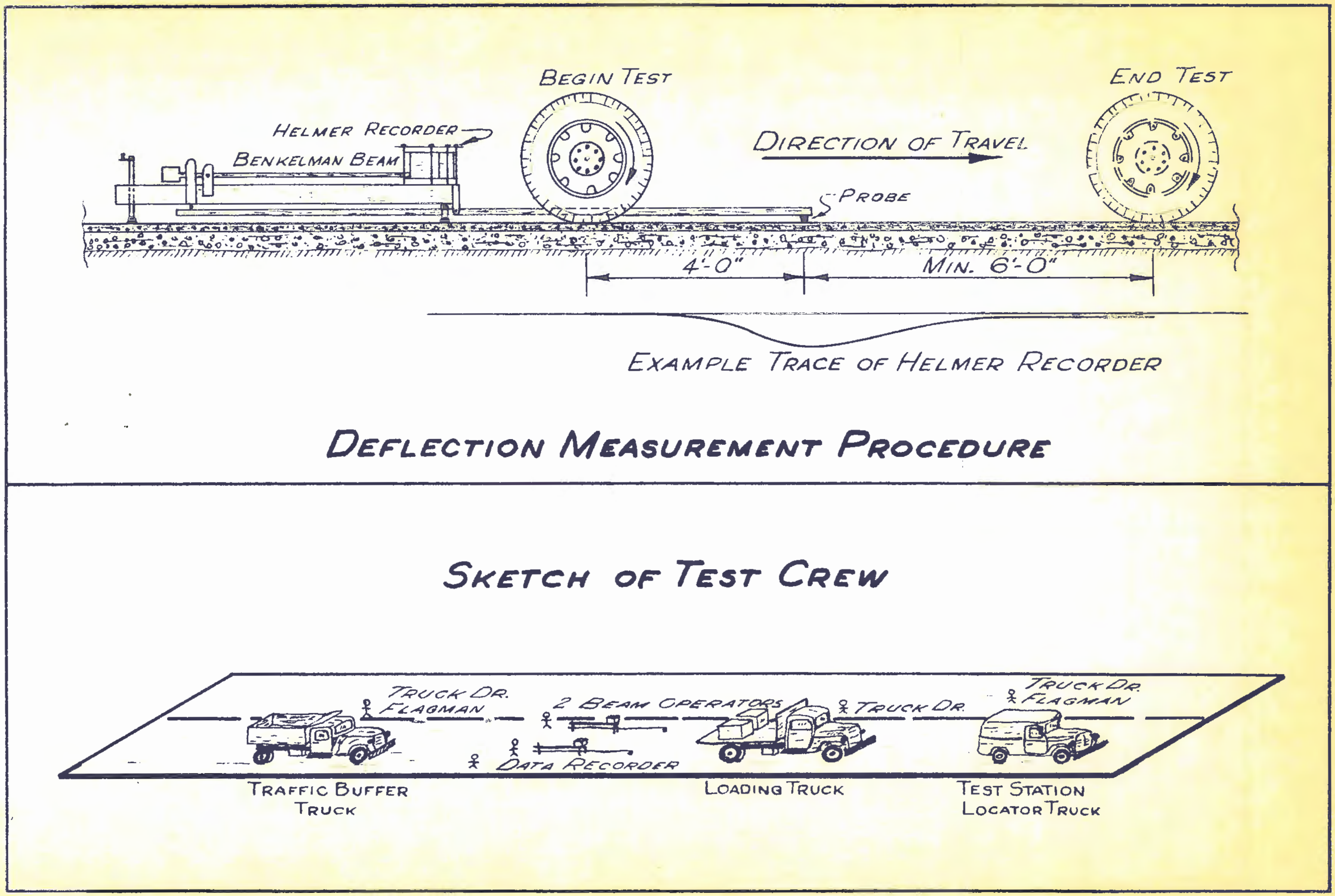
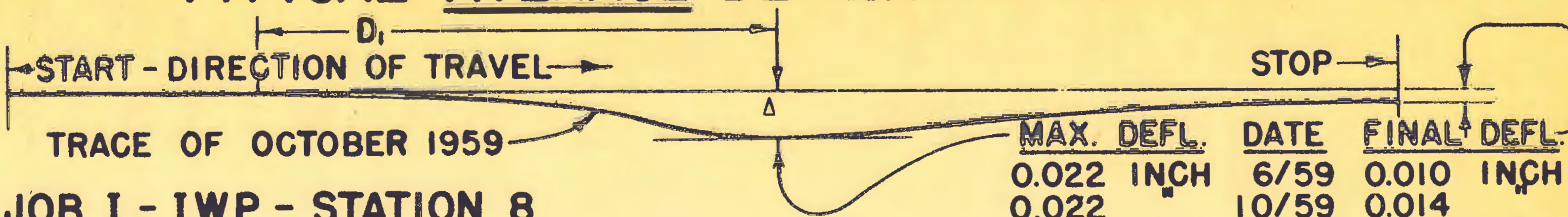

BEGIN TEST
END TEST
HELMER RECORDER
BENKELMAN BEAM
DIRECTION OF TRAVEL
PROBE
4'-0"
MIN. 6'-0"
EXAMPLE TRACE OF HELMER RECORDER
DEFLECTION MEASUREMENT PROCEDURE
SKETCH OF TEST CREW
TRUCK DR.
FLAGMAN
2 BEAM OPERATORS
TRUCK DR.
TRUCK DR.
FLAGMAN
DATA RECORDER
TRAFFIC BUFFER
TRUCK
LOADING TRUCK
TEST STATION
LOCATOR TRUCK

Figure 2

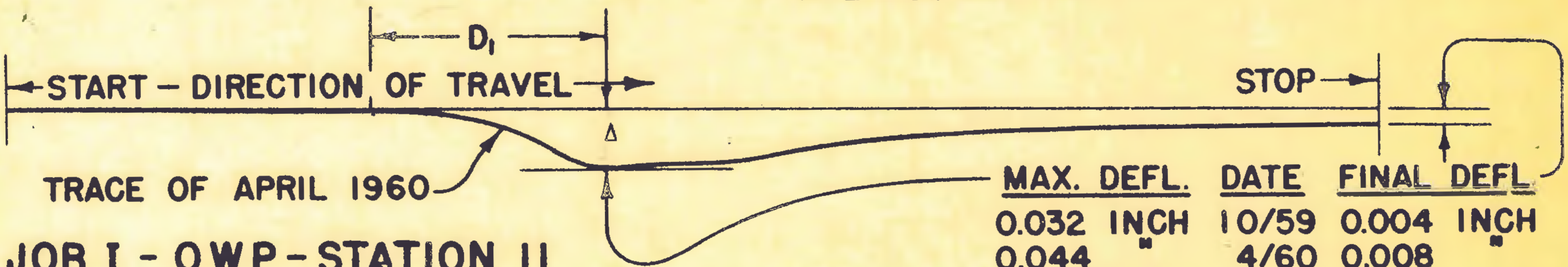
The question arose as to the extent of the zone of influence, that is, how far from the truck tires did the deflection occur and would the truck wheel cause some deflection at the beam supports or probe point at the beginning of the test? Frequent tests indicated that the zone of influence rarely exceeded about three feet in diameter. This zone was determined in two ways. First, the Beam was set on the pavement with the truck well forward of the probe point. The truck was then backed up to the probe point. No deflection was indicated on the dial gage until the truck was less than two feet from the probe point. Another indication of the size of the area of influence was shown by the tracings of the deflection on the recorder chart. In every case there was a horizontal line on the chart for some distance before the recorder indicated the beginning of the deflection. Figure 3 shows typical deflection curves obtained on these jobs. Further tests on deflections were made by positioning the truck wheel immediately over the probe point and allowing it to remain in this position for some time, usually a period of ten to fifteen minutes. There was no increase in the deflection of the pavement with time. In other tests the beams were allowed to remain on the pavement for a period of five to fifteen minutes after the truck had passed, to record the rate of recovery. In these cases it was found that the entire recovery took place immediately after the truck had passed, and there was no residual deflection in the pavement. The residual deflection recorded was due to the friction of the pen on the paper and the flexibility of the recorder beam. The checks on the action of the Beam on the pavement were made by removing the Helmer recorder

TYPICAL AVERAGE DEFLECTION CURVES



JOB I - IWP - STATION 8

MAX. DEFL.	DATE	FINAL DEFL.
0.022 INCH	6/59	0.010 INCH
0.022 "	10/59	0.014 "
0.026 "	4/60	0.016 "
0.032 "	7/60	0.014 "
0.030 "	10/60	0.014 "
0.020 "	7/61	0.006 "
AVERAGE 0.025 INCH		0.012 INCH



JOB I - OWP - STATION 11

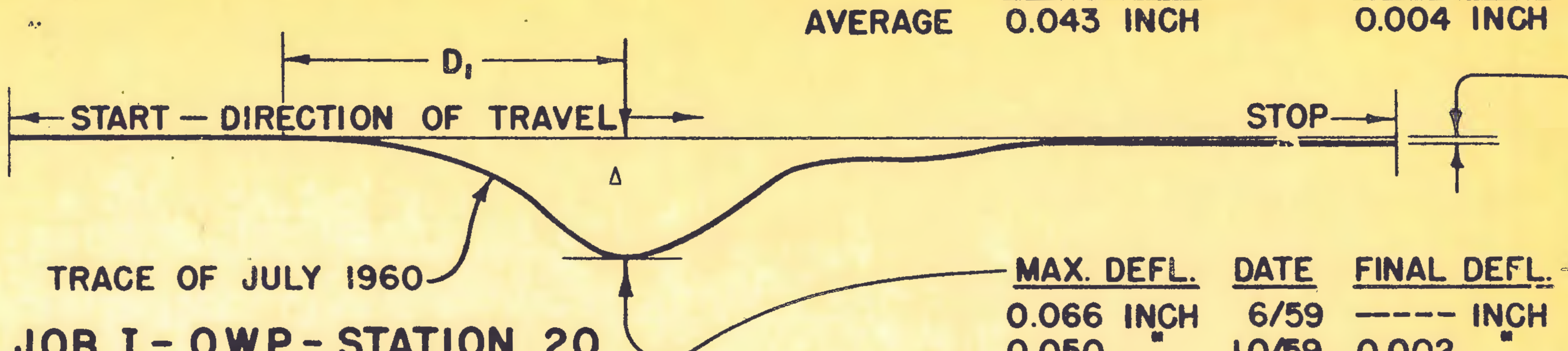
Δ/D

MAX. DEFL.	DATE	FINAL DEFL.
0.032 INCH	10/59	0.004 INCH
0.044 "	4/60	0.008 "
0.038 "	7/60	-----
0.034 "	10/60	0.004 "
0.034 "	4/61	0.010 "
0.036 "	7/61	0.016 "
AVERAGE 0.036 INCH		0.008 INCH

TYPICAL MAXIMUM DEFLECTION CURVES

JOB I - IWP - STATION 33

MAX. DEFL.	DATE	FINAL DEFL.
0.050 INCH	6/59	0.002 INCH
0.030 "	10/59	0.004 "
0.044 "	4/60	0.008 "
0.040 "	7/60	-0.004 "
0.050	10/60	0.008 "
AVERAGE 0.043 INCH		0.004 INCH



JOB I - OWP - STATION 20

$$\text{Ratio} = \frac{D_1}{\Delta}$$

MAX. DEFL.	DATE	FINAL DEFL.
0.066 INCH	6/59	----- INCH
0.050 "	10/59	0.002 "
0.070 "	4/60	0.006 "
0.070 "	7/60	0.002 "
0.056 "	10/60	0.006 "
0.072 "	4/61	0.032 "
0.068 "	7/61	0.012 "
AVERAGE 0.065 INCH		0.010 INCH

TYPICAL DEFLECTION CURVES

BENKELMAN BEAM WITH HELMER RECORDER - 9,000 LB WHEEL LOAD

SCALE: HORIZ. 1 IN = 1 FT - VERT. 1 IN = 0.10 IN

FIGURE - 3

from the Beam and recording the deflection with the dial gage only. In these tests the dial gage always returned to the initial reading after the truck had passed.

Table 4 shows the average deflections for all the jobs and for the seven series of deflections. In most cases the deflection of the high type pavements was low. It is interesting to note that the average deflection in the outer wheel path exceeded the deflection of the inner wheel path by an appreciable amount. Figure 4 shows the average deflection for each of the jobs having high type pavements. The deflection of the outer wheel path usually exceeded the deflection of the inner wheel path by 30 to 40 percent. Job M has the widest shoulders and has a differential deflection of only 0.004 inch, while Job B has the narrowest shoulders and has a differential deflection of 0.005 inches. Figure 5 shows the variation in deflection with season.

Comparison of the deflections for individual jobs showed some interesting results. For instance the deflections on Job I, (7.1 yrs.) were somewhat higher than on most of the other jobs; yet this is one of the better pavements among the jobs having high type pavement. Jobs A (6.4) and F (5.3) had considerably lower deflections, yet these pavements were not in as good a condition as the pavement in Job I. Job A showed considerable cracking. Longitudinal cracks extended for a considerable distance along the middle of the traffic lane and along the centerline of the pavement. Often these cracks were more than 100 feet long. There were also transverse cracks that extended the entire width of the pavement. These transverse cracks were roughly

TABLE 4

AVERAGE DEFLECTIONS - HIGH TYPE PAVEMENT

0.001 Inch

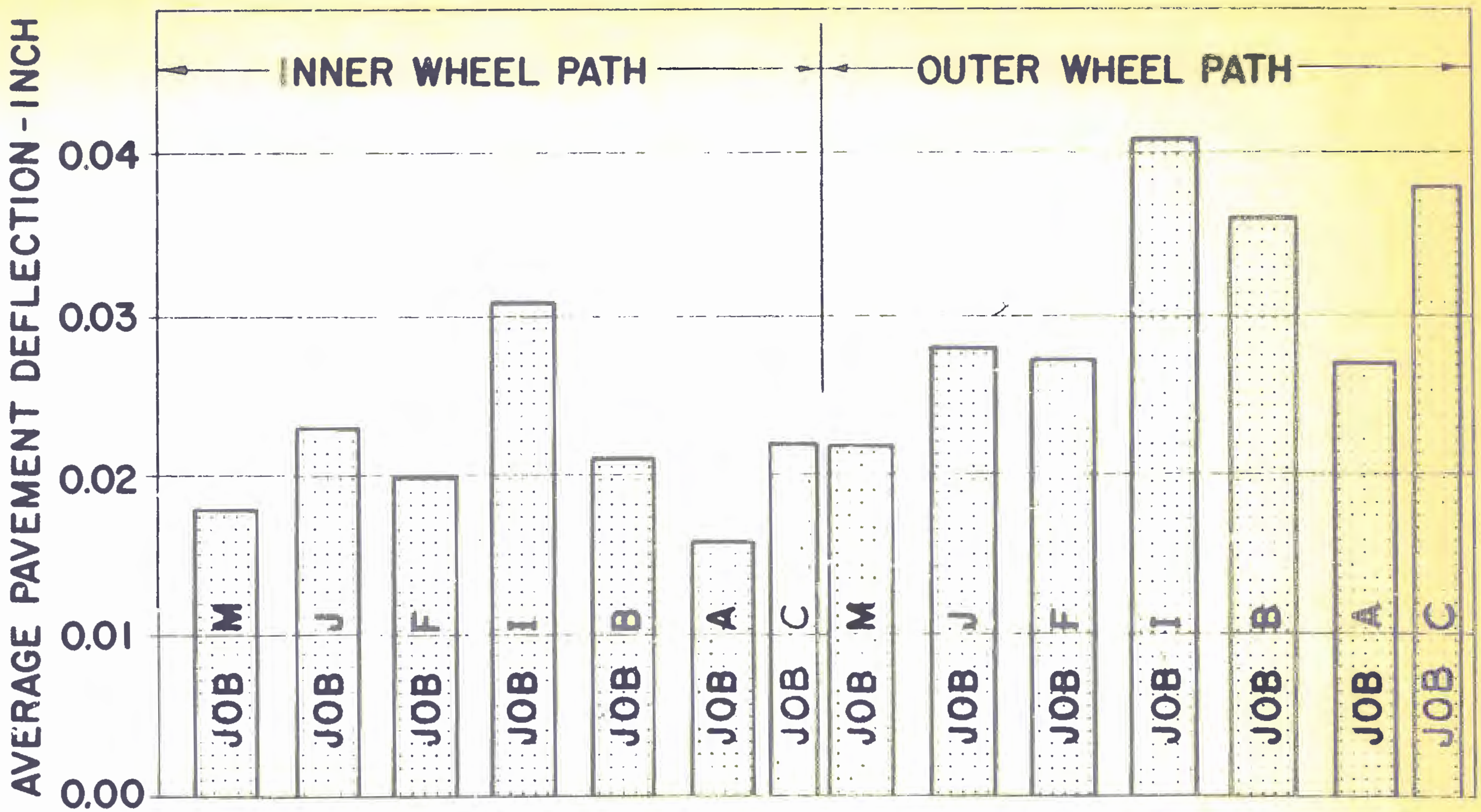
DATE	JOBS A IWP	A OWP	B IWP	B OWP	C IWP	C OWP	F IWP	F OWP	I IWP	I OWP	J IWP	J OWP	M IWP	M OWP	Average IWP	Average OWP
June '59	11	21	17	33	32	34	17	23	28	44	24	35	21	28	21	31
Oct. '59	19	31	26	37	35	40	24	30	30	42	23	29	19	25	25	33
April '60	13	33	18	46	39	47	18	35	34	48	24	34	22	28	24	39
July '60	19	32	20	36	30	34	18	23	30	43	18	28	18	21	22	31
Nov. ' 60	18	18	26	27	30	32	27	23	32	34	26	21	18	17	25	25
April '61	15	30	20	41	29	47	19	36	29	37	19	24	14	21	21	34
July '61	15	24	22	34	29	30	17	20	33	40	28	27	17	15	23	27
Average	16	27	21	36	22	38	20	27	31	41	23	28	18	22	22	31

AVERAGE DEFLECTIONS - LOW TYPE PAVEMENT

0.001 Inch

DATE	JOBS E IWP	E OWP	H IWP	H OWP	K IWP	K OWP	L IWP	L OWP	N IWP	N OWP	Average IWP	Average OWP
June '59	36	27	31	41	20	38	17	28	20	32	25	33
Oct. '59	43	43	38	45	20	32	26	36	29	40	31	39
April '60	49	41	33	37	19	34	19	42	25	49	29	41
July '60	39	32	29	40	18	23	18	23	11	26	23	29
Nov. '60	41	33	32	35	21	19	23	24	24	26	28	27
April '61	44	39	37	47	21	28	16	30	18	41	27	37
July '61	35	23	37	42	21	20	17	27	21	27	26	28
Average	41	34	34	41	20	28	19	30	21	34	27	33

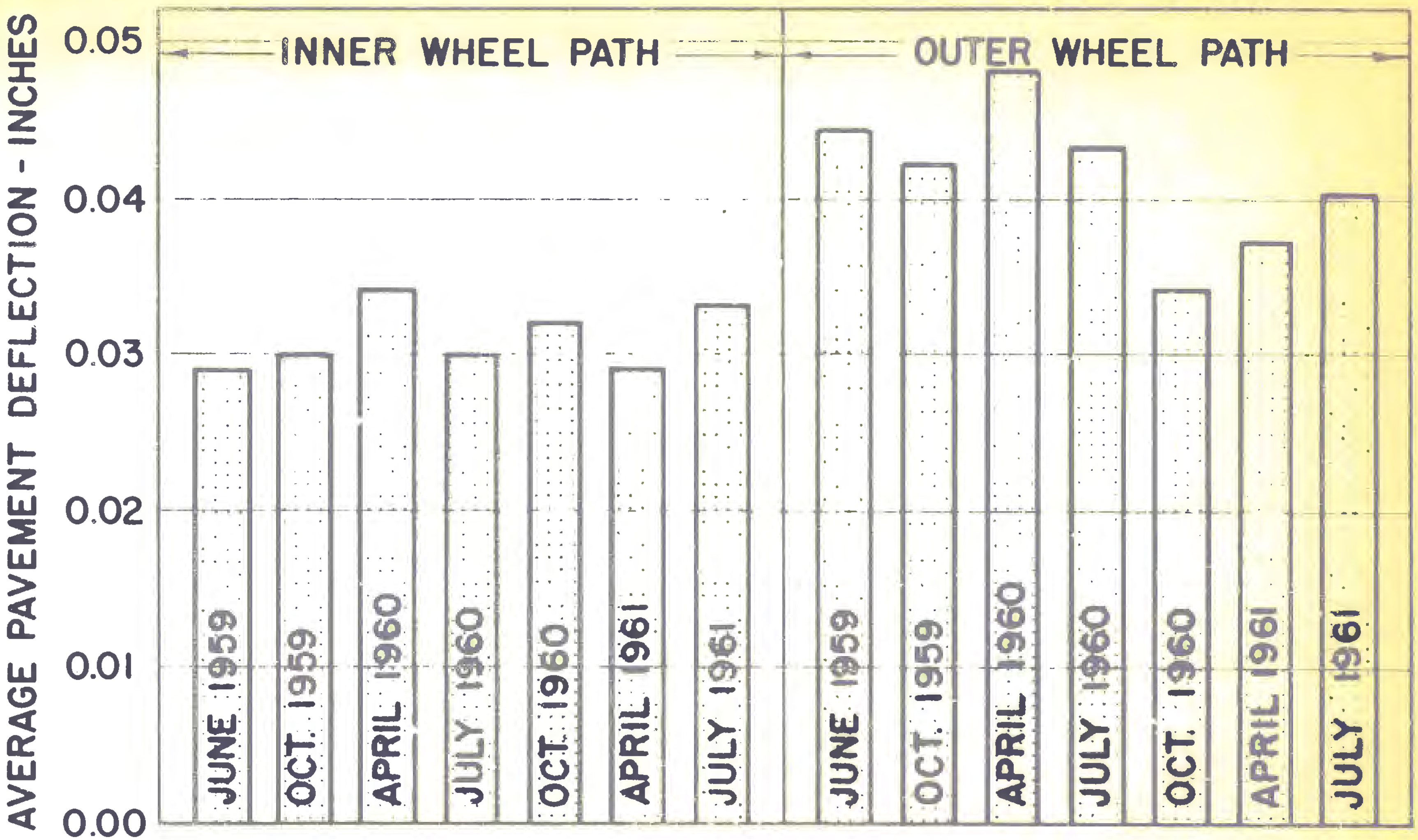
normal to the centerline. These transverse cracks often occurred at intervals as low as 15 to 17 feet and were common at a spacing of 20 to 30 feet. Inspection of Job F revealed many signs of distress and at the end of the study showed very low condition ratings. The outer wheel path was in such poor condition that it had required an almost complete re-surfacing and in many cases the patches were made on top of previous patches. The deflections on this job were as low as some of those on the jobs that were in excellent condition. These low deflections were found before any re-surfacing or patching had been done.



AVERAGE PAVEMENT DEFLECTION VS JOB
BENKELMAN BEAM - 9,000 LB WHEEL LOAD

HIGH TYPE PAVEMENT

FIGURE - 4



JOB I - BENKELMAN BEAM - 9,000 LB WHEEL LOAD

AVERAGE DEFLECTION VS TEST DATE

FIGURE - 5

Asphaltic Concrete Pavement

Samples of the high type pavements were obtained at the same time that base and subgrade samples were taken. Samples about 15 inches square were cut from the pavement with a pneumatic paving breaker. The sampling was done at intervals of two- to four-tenths mile, and at one of the identification stations. The stations where pavement, base, and subgrade samples were taken are referred to as sample stations. The samples were cut from the center of the traffic lane to avoid any possibility of causing rough places in the wheel path. Later, three samples of the pavement were cut for the purpose of checking. These samples were cut, one from each wheel path and one between the wheel paths at five sample stations.

A part of each pavement sample was used for the purpose of determining the present condition of the pavement. A part of this sample was heated in an oven to approximately 240 degrees F., thoroughly mixed and then remolded for Marshall stability tests. The specific gravity of the sample as taken from the pavement was also determined.

A modification of the Abson process was used for recovering the asphalt cement from the pavement. The Faulwetter apparatus was used to extract the asphalt cement from the pavement sample. Trichloroethylene was the solvent used in Method AASHO T 170 to recover the asphalt cement from the solution--the procedure being modified only to the extent that the oil bath was eliminated. This method of recovery was checked in the laboratory before any work was done on the pavement samples, and no changes in the physical properties of the asphalt cement were found.

Table 5 shows the physical properties of the pavement. Table 6 shows the properties of the recovered asphalt cement, and Table 7 shows a summary of these properties. Figure 6 presents a graphical representation of these changes.

These results offer some good comparisons with the conditions of the pavements. Job A, B, and F show the lowest ductility and the highest decrease in penetration. The loss in penetration on Job J is high, but the ductility is still comparatively high. Jobs A, B, and F have extensive surface cracking. These are the single isolated cracks as described previously. Jobs M, J, and I do not show this type of cracking. Job I is somewhat older than some of the jobs that show extensive cracking, yet it is in excellent condition and has no cracking.

The results from Job J indicate that the ductility is still high, but the decrease in penetration has been considerable. This job does not show any cracking at this time even though it is as old as some of the jobs that show serious cracking.

TABLE 5

PAVEMENT SAMPLE TEST RESULTS

Job	Design	Job Tests: AC Brand	Job Tests: Pen.	Job Tests: AC (%)	Job Tests: Voids (%)	Sample Tests: Loc.	Sample Tests: Voids (%) Lab.	Sample Tests: Voids (%) Pvt.	Sample Tests: AC (%)	Sample Tests: Marshall Stab. (lb)	Sample Tests: Flow (0.01 in.)
M	Marshall stab., 1,400 lb; flow, 9; voids, 3.5-4.0%; AC, 5.5%; crushed limestone and local sand	C	64	5.3-5.5	4.0- 6.0	4	4.6	7.4	5.9	2,060	11
						12	3.3	3.9	6.0	3,050	8
						17	4.8	7.3	5.5	2,950	9
						23	5.2	7.8	5.5	2,220	9
						29	4.0	6.4	5.0	2,220	12
						37	1.3	6.7	6.2	4,430	9
						Avg.	3.9	6.6	5.7	2,822	10
J	Marshall stab., 1,300-1,400 lb; flow, 9; voids, 4.0%; AC, 5.8%; crushed syenite and local fine sand	A	68	5.5-5.7	9.5-10.5	4	7.0	10.1	6.1	2,100	12
						13	8.4	10.6	5.9	2,890	11
						20	9.2	12.8	5.9	2,110	9
						28	5.3	8.2	5.6	2,870	10
						Avg.	7.5	10.4	5.9	2,493	11
A	Marshall stab., 950 lb; flow, 5; voids, 6-7%; AC, 6.0%; partially crushed gravel, local pit	C	75	5.7-6.0	9.1-11.6	5	7.0	10.5	6.7	3,360	7
						9	8.9	10.9	5.4	3,900	15
						21	8.8	9.8	6.0	4,750	13
						25	6.2	11.6	6.1	2,650	7
						33	6.9	8.5	5.9	3,650	7
						Avg.	7.6	10.3	6.0	3,662	10
F	Marshall stab., 1,050 lb; voids, 6.5%; AC, 6.0%; partially crushed gravel, local sand	C	65	5.9	8.2-10.2	2	9.0	12.0	5.7	1,820	8
						11	10.2	9.0	6.4	2,650	13
						20	6.4	10.9	6.2	2,700	8
						26	6.4	10.7	5.9	3,150	10
						35	6.9	11.3	6.1	2,800	9
						Avg.	7.8	10.8	6.1	2,624	10

TABLE 5 (continued)

PAVEMENT SAMPLE TEST RESULTS

Job	Design	Job Tests: AC Brand	Job Tests: Pen.	Job Tests: AC (%)	Job Tests: Voids (%)	Sample Tests: Loc.	Sample Tests: Voids (%) Lab.	Sample Tests: Voids (%) Pvt.	Sample Tests: AC (%)	Sample Tests: Marshall Stab. (lb)	Sample Tests: Flow (0.01 in.)
I	Marshall stab., 1,200 lb; flow, 10; voids, 6.4%; AC, 6.0%; crushed syenite and local fine sand	C	66	5.7-6.0	8.5- 9.5	34.9 8	8.3	11.2	6.4	3,920	7
						60.6 14	4.7	7.5	6.9	2,220	7
						43.9 20	5.2	10.4	6.5	2,350	9
						54.5 29	3.2	8.6	6.6	2,200	12
						40.9 36	1.2	5.4	6.1	3,360	8
						45.5 45	7.9	13.0	6.0	3,150	10
						Avg.	5.0	9.4	6.4	2,867	9
B	Not available	C	74	5.7-5.8	7.3-11.4	27.0 2	7.8	10.1	5.9	3,260	7
						27.[illegible] 8	7.6	9.9	6.0	2,860	7
						32.4 21	8.7	13.7	6.0	2,630	8
						Avg.	8.0	11.2	6.0	2,917	7

TABLE 6

PROPERTIES OF RECOVERED ASPHALT CEMENT

		Tests on Orig. AC				Tests on Recovered AC			
Job	Age (yr)	Pen.	Duct.	Brand	Location	Pen.	Duct.	Soft. Point[1]	Ash Content
M	2.8	64	100+	C	1	50	67	59	0.87
					4	34	21	64	0.81
					8	42	8	67	1.20
					12	30	7	65	1.09
					14A	36	24	67	2.27
					17	41	39	63	0.76
					20	42	24	63	1.08
					23	39	36	62	0.79
					26	35	10	64	1.11
					29	35	13	65	1.63
					34	42	32	63	1.27
					37	43	33	62	1.36
					Avg.	39	26	64	1.19
J	5.7	68	100+	A	1	28	8	58	0.53
					4	25	5	--	0.44
					8	20	4		0.41
					10	27	9	65	0.51
					13	20	7	69	0.59
					17	26	40	62	0.54
					20	27	26	62	0.47
					23	26	20	62	0.68
					26	25	15	64	0.78
					28	27	14	63	0.52
					Avg.	25	15	63	0.55
F	5.3	65	100+	C	2	24	5	77	0.47
					8	29	6	--	--
					11	30	8	74	0.97
					14	26	6	--	--
					17	16	2	--	--
					20	26	6	72	0.43
					23	23	5	--	--
					26	25	8	77	0.49
					29	29	9	--	--
					32	20	3	--	--
					35	25	6	73	0.12
					Avg.	24	6	75	0.50
I	7.2	66	100+	C	2	40	30	61	0.35
					5	33	14	64	0.45
					8	23	5	74	0.29
					11	39	24	61	0.34
					14	40	33	58	0.53
					17	34	12	63	0.30

TABLE 6 (continued)

PROPERTIES OF RECOVERED ASPHALT CEMENT

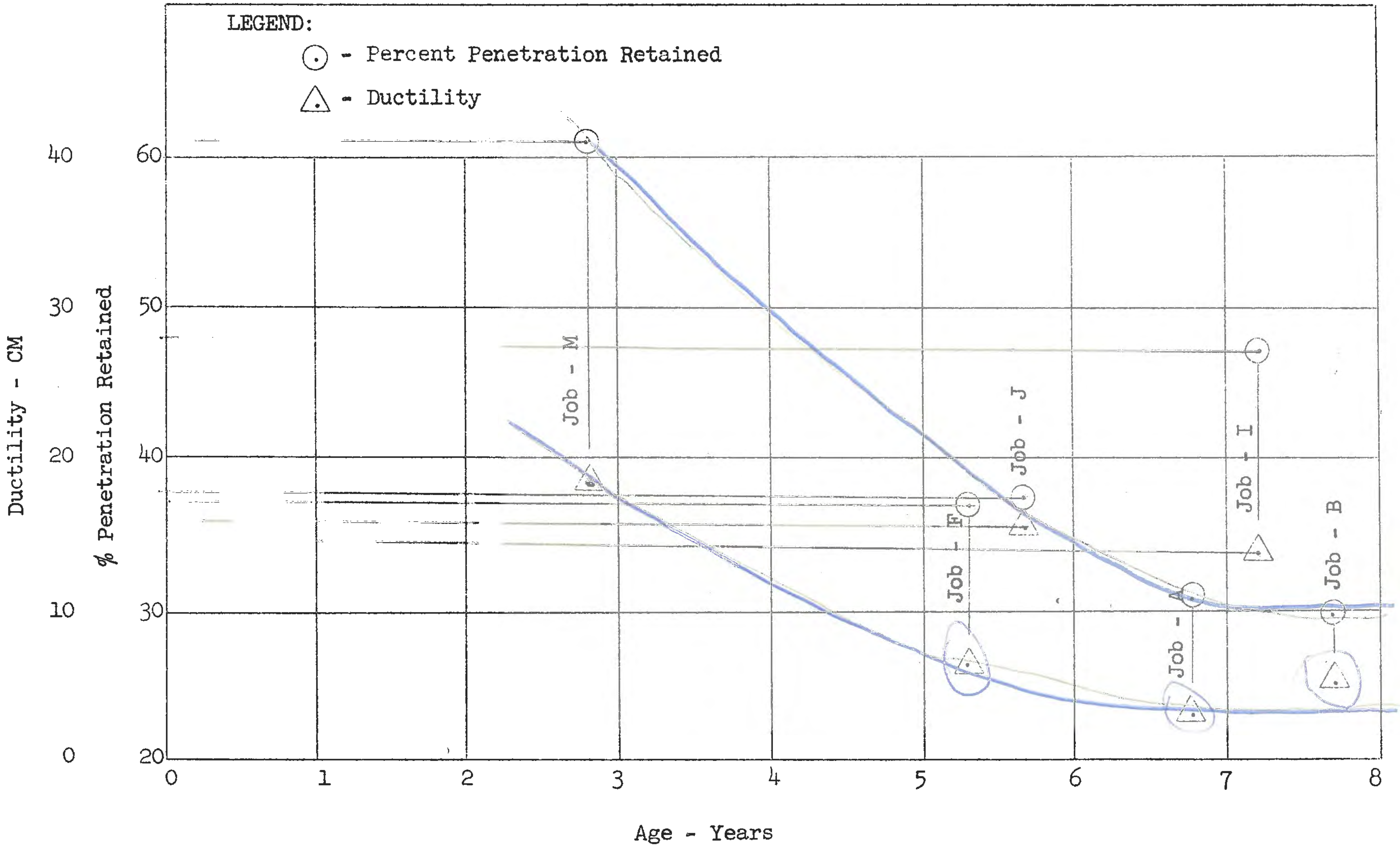
Job	Age (yr)	Tests on Orig. AC Pen.	Tests on Orig. AC Duct.	Brand	Location	Tests on Recovered AC Pen.	Tests on Recovered AC Duct.	Soft Point[1]	Ash Content
					20	29	8	62	0.31
					24	22	5	72	0.26
					27	21	4	75	0.28
					29	36	19	59	0.42
					33	28	8	68	0.28
					36	27	3	70	0.39
					42	25	5	69	0.32
					45	30	7	66	0.33
					Avg.	31	13	66	0.35
A	6.8	75	100+	C	3	25	0	74	0.40
					5	26	0	--	--
					7	23	0	--	--
					9	23	0	75	0.51
					11	24	5	--	--
					13	29	7	--	--
					15	24	6	73	0.65
					17	24	4	--	--
					19	20	5	--	--
					21	13	2	78	0.99
					23	18	3	--	--
					25	23	5	--	--
					27	27	7	--	--
					29	18	3	--	--
					31	--	0	--	--
					33	22	5	--	--
					35	25	5	--	--
					39	26	5	--	--
					Avg.	23	3	75	0.64
B	7.7	74	100+	C	2	20	6	75	0.41
					5	19	0	--	--
					8	20	5	72	0.56
					12	24	6	--	--
					15	24	6	--	--
					18	19	5	74	0.35
					21	24	5	--	--
					24	23	5	--	--
					Avg.	22	5	74	0.44

[1] R&B.

TABLE 7

SUMMARY

Job	Age (yr)	Penetration Orig.	Penetration Final	Penetration Decrease (%)	Ductility	Ash (%)	Softening Point
M	2.8	64	39	39	26	1.19	64
J	5.7	68	25	63	15	0.55	63
A	6.8	75	23	69	3	0.64	75
F	5.3	65	24	63	6	0.50	75
I	7.2	66	31	53	13	0.35	66
B	7.7	74	22	70	5	0.44	74



CHANGE IN DUCTILITY AND PENETRATION WITH AGE

Figure 6

Sampling and Testing of the Base and Subgrade

Sampling and testing of the base and subgrade were accomplished at the same time that samples of the pavement were taken. The density of the base was determined by a balloon density volumeter as soon as the pavement had been removed. A sample of the base material was also taken for laboratory study. A thin-walled sampling tube three inches in diameter and nine inches long was used for determining the density and moisture content of the subgrade. A sample of the subgrade was obtained at the edge of the pavement at the same time and in the same manner as the subgrade sample was obtained from the center of the traffic lane. Table 8 shows the information obtained on the base and subgrade from the high type pavements.

The base densities are probably close to the density at which they were constructed, because there is very little rutting in the inner wheel path to indicate compaction. Job records do not indicate what the density of the base or subgrade was at the time of construction. It is believed that the subgrade on all jobs was constructed at densities somewhat higher than densities existing at the time tested. In any event it is not very probable that they would have been constructed to such a uniform density as now exists.

The subgrade moisture is quite a bit over optimum. No record is available to show what the moisture content was at the time of construction. Observations of construction in this part of Arkansas indicate that the moisture content was probably near or slightly above optimum at the time of construction.

TABLE 8

AVERAGE PHYSICAL PROPERTIES -- High Type Pavements

Item	Unit	Job						
		A	B	C	F	I	J	M
Pavement thickness	inch	2.2	1.9	2.2	1.8	1.8	1.9	2.2
Base thickness	inch	6.2	7.5	6.5	7.0	7.8	10.0[1]	10.3
" in-place density	pcf	126	122	125	122	116	122	126
" in-place moisture	%	3	3	4	2	4	4	3
" maximum density[2]	pcf	131	130	136	133	138	132	138
" optimum moisture	%	7	6	7	7	6	8	6
" % compaction	%	96	83	92	92	84	92	91
" liquid limit	%	19	18	21	17	20	20	18
" plasticity index	-	2	3	6	6	2	2	1
" vol. shrinkage	%	9	6	20	11	14	13	9
" pass No. 4 sieve	%	52	44	48	42	51	51	51
" pass No. 200 sieve	%	5	5	5	5	8	6	5
" % silt (-No. 40)	%	6	7	8	8	12	8	5
" % clay (-No. 40)	%	20	19	21	17	15	16	15
" HRB classification	-	A-1-a	A-1-a	A-1-a	A-1-a	A-1-a	A-1-a	A-1-a
" Group Index	-	0	0	0	0	0	0	0
Subgrade								
" in-place density	pcf	105	100	100	106	101	98	100
" in-place moisture	%	17	20	18	16	19	17	18
" maximum density[2]	pcf	121	118	118	120	117	120	124
" optimum moisture	%	12	14	13	14	13	12	11
" % compaction	%	87	85	85	88	86	82	81
" liquid limit	%	29	36	31	28	30	28	30
" plasticity index	-	8	14	10	6	6	6	5
" vol. shrinkage	%	14	39	30	18	21	21	18
" pass No. 200 sieve	%	95	98	98	92	99	86	86
" % silt (-No. 40)	%	68	53	63	60	67	56	66
" % clay (-No. 40)	%	24	33	29	26	26	22	20
" HRB classification	-	A-4	A-6	A-4	A-4	A-4	A-4	A-4
" Group Index	-	8	10	8	8	6	8	8

[1] - Includes 5 inches of subbase.

[2] - Maximum density was determined by AASHO-T-180 Method A.

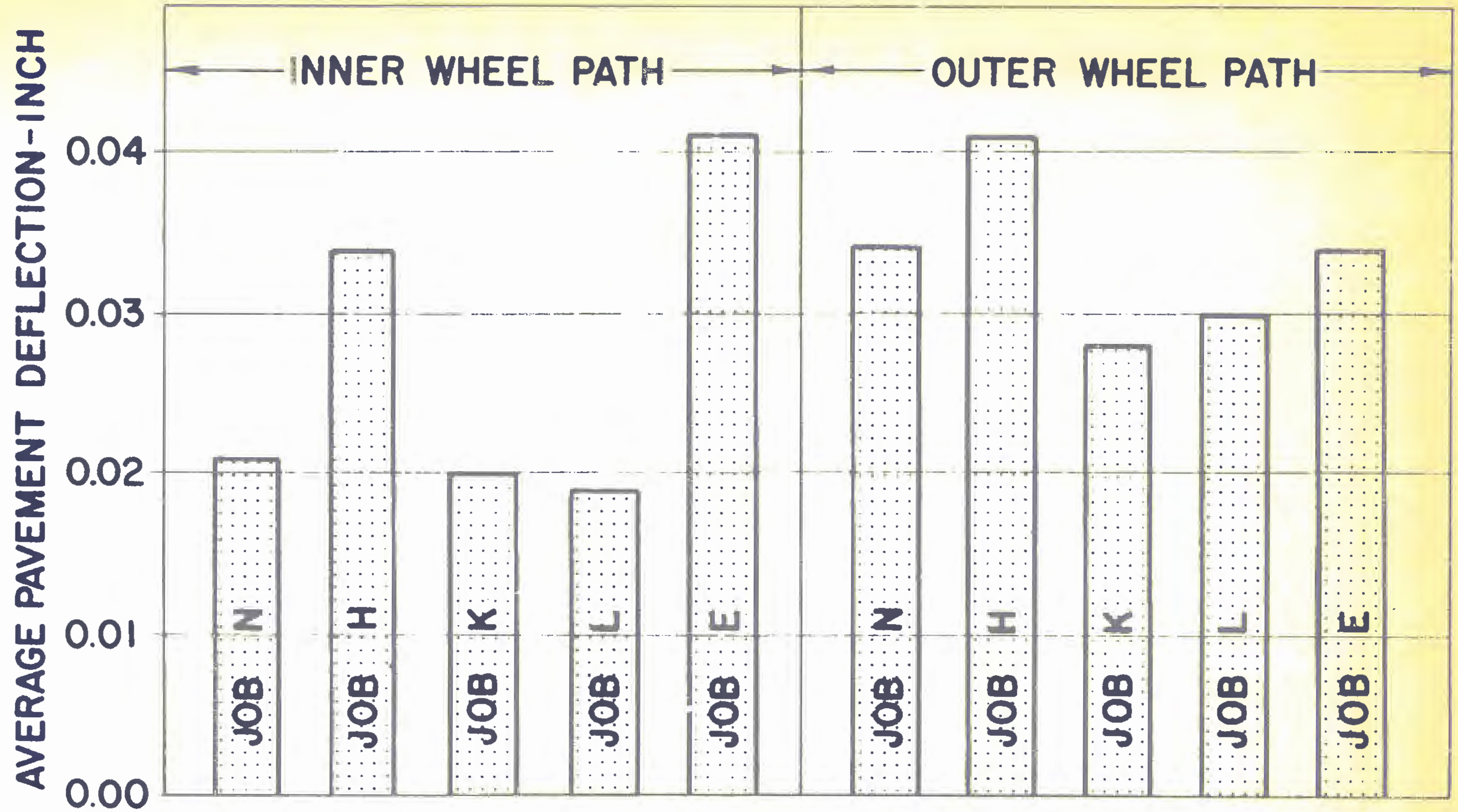
Low Type Pavements

Deflection tests, condition surveys, and sampling operations were done on five jobs having low type pavements. Low type pavements are here classified as those having surface treatment or road mix surfaces. Figure 7 shows the average deflections found on these jobs. It would not be consistent to attempt to classify or grade these jobs on the same basis as the high type pavements. These were constructed to serve much lower standards. In the case of Jobs H, L and N, the surface drainage was much different from that in the majority of the other jobs under study. These three jobs were constructed through an area of very poor drainage. In fact the side ditches were full of water most of the year.

Extensive maintenance was required on these jobs during the period of this investigation. In some cases long sections of these roads were completely re-surfaced. These changes prevented an accurate determination of the performance of these roads.

Job K is the only one of the secondary jobs that exhibited any ability to carry the traffic imposed on it. Figure 8 shows the deflections for this job. The deflections in the inner wheel path were the most uniform of any of the jobs studied and were as low as many of the deflections of the high type pavements. This job was the only one of the secondary roads having a low type pavement on a crushed-stone base. This base was eight inches thick.

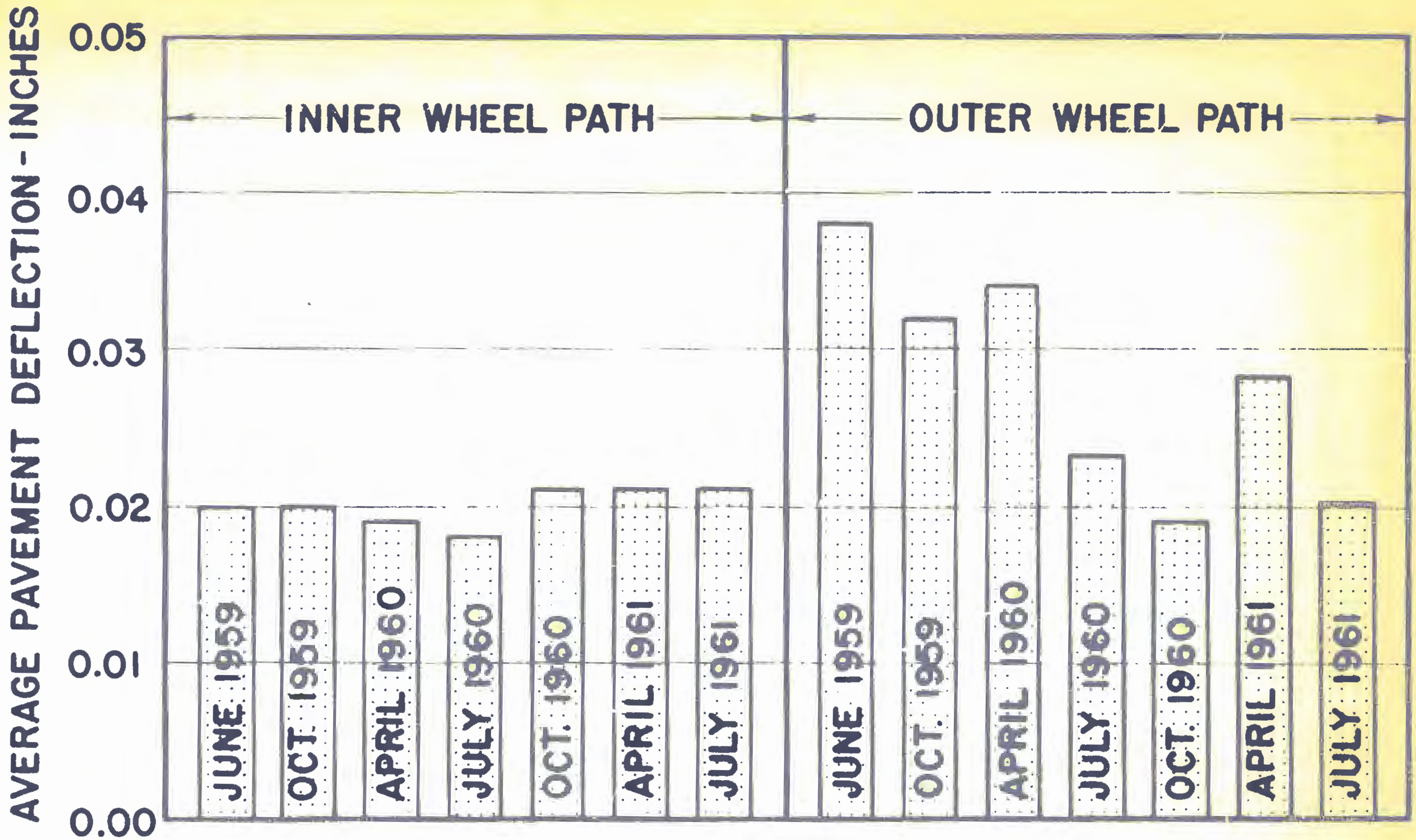
Secondary roads are constructed on a limited budget and intended to serve a local area. It appeared to the investigators that these



AVERAGE PAVEMENT DEFLECTION VS JOB
BENKELMAN BEAM - 9,000 LB WHEEL LOAD

LOW TYPE PAVEMENT

FIGURE - 7



JOB K - BENKELMAN BEAM - 9,000 LB WHEEL LOAD

AVERAGE DEFLECTION VS TEST DATE

FIGURE - 8

secondary pavements were required to serve needs and traffic to a far greater extent than they were designed to do. The cost of maintaining these pavements in a usable condition was unusually high.

Traffic

The traffic data utilized in this report was compiled by the Planning and Research Division of the Arkansas Highway Department. A loadometer study was performed in August, 1959, to augment the existing information concerning the study jobs. Table 9 lists each study job, and gives the pertinent traffic information. This table presents the average daily traffic for 1960, the average daily traffic for the year the pavement was built, the number of equivalent 5000-pound wheel loads, abbreviated EWL, per day for 1960, and the total number of EWL's which had traveled over the road through 1960. This number of EWL's was determined from the method originated by the California Highway Department.

Predictions of total deflections for each job were made. Two different methods were utilized to obtain the results given in Table 9. Only values for the outer wheel path are reported.

First, it was assumed that the average deflection obtained by the Benkelman Beam test, for the seven test series, represented a real number which was indicative of the average deflection experienced by each job to its present age. As all the deflection tests were performed with a 9000-pound wheel load, it was necessary to relate this deflection to the deflection that occurs under other wheel loads. A straight line distribution of deflection versus wheel load was assumed.

Total pavement deflection for both the inner and outer wheel paths were then calculated. These calculations were made to compare

TABLE 9

TRAFFIC

ITEM	JOBS												
	High Type Pavements								Low Type Pavements				
Wheel load/day each lane (1960)	A	B	C	F	I_a	I_b	J	M	E	H	K	L	N
3000 lb.	22	63	46	22	91	113	122	122	17	16	10	16	16
4000 lb.	23	36	16	23	72	89	87	87	15	27	6	27	27
5000 lb.	3	21	6	3	28	43	51	51	8	7	5	7	7
6000 lb.	8	16	0	8	19	26	31	31	6	4	5	4	4
7000 lb.	1	12	8	1	23	34	36	36	3	2	3	2	2
8000 lb.	0	16	18	0	4	16	27	27	1	3	1	3	1
9000 lb.	11	6	6	11	30	48	19	19	4	1	2	1	1
10000 lb.	0	2	3	0	3	2	5	5	1	0	1	0	0
ADT/Lane 1960	500	850	700	650	1050	1900	1075	1050	450	225	287	275	163
ADT/Lane Year Built	150	425	425	375	650	1085	850	1000	325	112	188	100	88
5000 lb. EWL/Day /Lane 1960	201	398	370	201	766	1205	928	928	105	63	97	63	63
Age to 10/61 Days	3405	3405	3438	2526	2891	2891	2343	1215	3011	1922	2252	2493	1427
Total 5000 lb. EWL/Lane x 1000	474	1059	1054	417	2222	2842	1993	1114	277	121	187	116	77
EWL - Total Defl (OWP) Inches x 10^3	6.6	23.3	27.4	7.1	57.8	25.6	33.9	15.6	6.9	3.0	3.0	1.7	1.3
AWL - Total Defl (OWP) Inches x 10^3	2.1	8.3	6.1	1.9	16.0	13.7	11.9	5.2	2.3	1.7	0.9	0.9	0.9

the effect of the EWL and the Actual Wheel load, abbreviated AWL. On the average, the EWL calculations gave approximately 2.5 more deflection than the AWL calculation.

Weather Conditions

The amount of rainfall occuring on each job monthly for the period 1950-1960 was obtained from "Climatological Data for the United States by Sections - Arkansas" published by the U. S. Department of Commerce, Weather Bureau. The average rainfall varied from 49.1 inches to 51.3 inches for all jobs during the reported period. It is therefore assumed that the amount of rainfall is constant for the purposes of this study.

Agricultural Soil Classification Analysis

General

The purpose of this analysis is to determine if relationships exist between engineering properties and agricultural classifications of soil. With this relation determined, the cost of highway design may be greatly reduced. Soil maps could be used to supplement part of the cost of engineering soil surveys which are an essential but expensive portion of the preliminary design of a highway.

When the test pavements were selected for Phase I of this study, it was intended that all the pavements be located in the Loessial Terrace Soil area. However, some of the pavements were selected too close to Crowley Ridge, and a second general classification was encountered. The other class is referred to as Loessial Hills Soil. An agricultural description of these soils was obtained from the Soil Conservation Service and these descriptions follow.

Loessial Hills

The Loessial Hills consist chiefly of deep silty soils over sand or gravelly substratum. Most of the soils are deep, well-drained silt loams that are moderately permeable. A lesser amount is silt loam over clay or sandy clay, with slow permeability. The major soil series are Loring and Grenada. The surface relief is moderately sloping to steep. Elevations range from about 220 to more than 500 feet above sea level.

Loessial Terraces

The Loessial Terrace area consists of silty soils over alluvial sands or clays. Most of the soils are deep, medium textured, very slowly or slowly permeable. Many have a silt pan within 30 inches of the surface. Some have a heavy clay layer within a 36- or 40-inch depth. Yellowish brown color characterized the better-drained soils, while the flatter, poorly drained soils are predominantly gray. The major soil series are Calhoun, Crowley, Oliv er, Richland, and Lintonia. The surface relief varies from nearly level to undulating. Elevation ranges from 180 to 250 feet above sea level.

Procedure

Soils information was obtained from the Soil Conservation Service by a graduate student as part of a thesis for the Master's degree. Strip maps were made at the county offices of the Soil Conservation Service by tracing work maps. The test stations were then superimposed on the strip maps, and the series names matched to information obtained from the laboratory.

Analysis was made of the soil maps at the "series" level and at the series-association level. Finally the entire Loess area was analyzed as a regional association. Statistical methods were used to describe the data for analysis. Whenever possible, a comparison of properties as they exist in the subgrade was made with the properties as reported by the Soil Conservation Service.

The analysis of variance between series shows that the liquid limit is approximately the same for all the series, but the plasticity index of the series has a greater range than could be expected from experimental procedures. From this analysis, 75 percent of the samples tested would be expected to have a plasticity index of 10 or less, and

98 percent of the samples tested could be expected to have a liquid limit of 40 or less.

The coefficient of correlation of liquid limit and plasticity index is 0.884; that is, if the liquid limit is known, the plasticity index can be read directly from a graph of LL vs PI with 88.4 percent reliability. With a liquid limit device, moisture meter, and calibration curve, the liquid limit can be determined; consequently, the plasticity index of a soil could be determined in a matter of minutes. This test could be run in the field on the borrow material, and the classification determined immediately.

Check Samples

Five additional stations were sampled in July, 1962. "Check" samples taken at A-5 (Job A - station 5), I-20, J-28, and M-4 were judged to be in a segment of pavement that was showing signs of failure, or was failing. The check sample taken at A-19 was judged to be in a segment of pavement that was showing very little signs of distress. These check samples were taken as follows: a 15 x 15-inch-square block was cut from the pavement in the outer and inner wheel paths and at the centerline of the traffic lane. Base density, subgrade density, and subgrade moisture content were determined. A sample of subgrade was also obtained at the edge of the pavement. The sampling technique was identical to that followed in securing the "initial" samples. The same laboratory tests were performed on the additional samples noted above as was performed on the "initial" samples.

Densities of the pavement, base, and subgrade plus subgrade moisture of the check samples are given in Table 10. Comparative data from the initial samples, which were obtained only at the centerline of the traffic lane and the edge of the pavement are also presented in Table 10. The specific gravity of the pavement averages about the same for the centerline sample in both tests. It is observed that the pavement was more dense in the wheel path samples than in the centerline sample. In every case the outer wheel path sample had the higher density.

TABLE 10

COMPARISON OF INITIAL SAMPLE RESULTS WITH CHECK SAMPLE RESULTS

Pavement, Base and Subgrade Densities and Subgrade Moisture

Location[1]	Initial Sample		Check Sample			
	¢	ep	IWP	¢	OWP	ep
PAVEMENT SPECIFIC GRAVITY						
A-5	2.212	---	2.199	2.176	2.204	---
A-19	---	---	2.217	2.206	2.278	---
I-20	2.163	---	2.261	2.206	2.273	---
J-28	2.196	---	2.245	2.186	2.252	---
M-4	2.324	---	2.396	2.377	2.401	---
Average	2.234		2.264	2.230	2.282	
BASE DENSITY						
A-5	121	---	120	124	129	---
A-19	132	---	128	137	123	---
I-20	119	---	135	126	121	---
J-28	122	---	123	122	146	---
M-4	125	---	121	145	128	---
Average	124		125	131	129	
SUBGRADE DENSITY						
A-5	108	100	103	110	106	102
A-19	95	100	107	107	101	103
I-20	113	100	132	115	106	103
J-28	101	106	101	101	103	106
M-4	98	101	---	111	106	101
Average	103	101	111	109	104	103
SUBGRADE MOISTURE						
A-5	16	21	17	17	18	20
A-19	21	22	20	17	21	20
I-20	13	20	19	15	19	20
J-28	12	16	21	21	19	18
M-4	24	19	---	18	18	21
Average	17	20	19	18	19	20

[1] - NOTE: "Initial" sample location and "check" sample location varied from each other between 15 feet and 200 feet, along the pavement.

Analysis of Data

Background

The job title sheets for each job are presented in Appendix A, with test-station locations identified. It is noted that a specific "sample" station may be located by use of Appendix A. The 15 x 15-inch-square patch in the centerline of the traffic lane serves to identify each "sample" station in the field.

In analyzing data, Job I was divided into two parts, Job Ib is that part of Job I from Walnut Corners east toward Helena on State Highway 20; Job Ia is the remainder of Job I. Only information obtained from the high type pavements is utilized in the following analysis. These jobs are: A, B, C, F, I, J, and M. In general, the low type pavement data were more erratic and presented larger variations than the high type pavement data. Of the five low type jobs sampled, only Job K did not require resurfacing prior to completion of the field work on this study.

It was observed that the pavement usually fails in the area of the outer wheel path (abbreviated OWP) prior to an inner wheel path (abbreviated IWP) failure. It has been reported earlier that the OWP deflection exceeds the IWP deflection by 30 to 40 percent. From the above two observations pavement performance will be related to OWP deflection or a function thereof.

A brief discussion of the outer wheel path ratio (abbreviated Ratio) is necessary at this point, because this ratio will enter all future equations and graphs. The ratio is defined as the radius of deflected area divided by the maximum deflection (see Figure 3 for sketch), as determined from the graph drawn by the Helmer recorder on the Benkelman Beam. This ratio is considered to represent a modulus of the strength of the pavement structure. Several factors which influence pavement performance and which have not been quantitatively evaluated are:

1. Construction techniques
2. Maintenance performed
3. Rainfall, ground-water variations, and drainage

The ratio measurement reflects the above factors to some extent.

IBM 650 Computer

The IBM 650 computer was utilized to analyze data from this study. The number of variables to be studied was limited to 47 because of the planned use of the "Beaton" program. The Beaton program is a statistical analysis program written for the 650 computer and can handle a maximum of 47 variables at one time. The variables are compared on the basis of the coefficient of correlation. The coefficient of correlation gives the magnitude of the strength of the relationship that exists between two or more variables. A perfect linear relationship of two variables will have a coefficient of correlation of ± 1.000. A coefficient of correlation approaching zero indicates a weak linear relationship between two variables. In other words, one variable does not influence the other variable very much when the coefficient of correlation is small. They are therefore independent of each other.

Data obtained from the study were coded and placed on IBM cards. The items placed on these cards included the greater part of the information obtained during this study. Table 11 lists the 47 variables coded and their location on the IBM card. Digits 1 through 10 are reserved for identification of the "sample" station location. The sample stations were numbered in consecutive order: Sample A-3 was placed on the first card (identified 0000000001), and Sample M-37 occupied the last card, which was identified as (0000000089). Therefore, each sample station had its' significant information placed on "one" IBM card. Actually, two cards were required to hold the 110 digits of information, because the maximum number of digits available per card is 70. In our future discussion a "card" will mean one sample station.

All 89 sample stations, on the high type pavements only, were coded and placed on IBM cards. To determine how much each variable fluctuated from station to station, it was necessary to separate the sample stations into three groups, each station being classed as "good," "poor," or "in-between." This grouping was based primarily on the condition ratings and results from the "check" samples.

Several combinations of cards were assembled and "run" through the 650 computer to determine the coefficients of correlation. These card combinations included:

1. All cards (89 cards)
2. Job A (17 cards)
3. Job B (8 cards)
4. Job C (16 cards)
5. Job F (12 cards)
6. Job Ia (12 cards)
7. Job J. (10 cards)

TABLE 11

IBM 650 CODE - VARIABLES PUNCHED INTO CARDS

1. Card One			2. Card Two		
No.	Digit	Designation	No.	Digit	Designation
1	11-13	Subgrade, inplace density	31	11-12	High △ IWP
2	14-15	" inplace moisture	32	13-14	Average △ IWP
	16-17	" percent compaction	33	15-16	Low △ IWP
4	18-19	" liquid limit	34	17-18	High △ OWP
5	20-21	" plasticity index	35	19-20	Average △ OWP
6	22-23	" shrinkage limit	36	21-22	Low △ OWP
7	24-26	" volumetric shrinkage	37	23-25	Ratio IWP - High
8	27-28	" % passing No. 200	38	26-28	Ratio IWP - Average
9	29-30	" % silt	39	29-31	Ratio IWP - Low
10	31-32	" % clay	40	32-34	Ratio OWP - High
11	33-34	" unconfined strength	41	35-37	Ratio OWP - Average
12	35-36	" Agricultural name	42	38-40	Ratio OWP - Low
13	37-39	Base, inplace density	43	41-42	Radius IWP - High
	40-41	" percent compaction	44	43-44	Radius IWP - Low
	42-43	" liquid limit	45	45-46	Radius OWP - High
16	44-45	" plasticity index	46	47-48	Radius OWP - Average
17	46-47	" % clay (-No. 40 only)	47	49-50	Radius OWP - Low
18	48-49	" thickness			
19	50-51	Pavement thickness			
20	52-54	Total structure thickness			
21	55-57	shoulder width			
22	58-60	ditch depth			
23	61-63	distance OWP △ to ditchline			
24	64-67	total EWL/lane (5000 lb)			
25	68-69	condition rating - average			
26	70-71	condition rating - minimum			
27	72-74	pavement age to 10/61			
28	75-76	asphalt penetration			
29	77-78	asphalt ductility			
30	79-80	asphalt softening point			

8. Job M (12 cards)

9. Sample stations grouped as "poor" (18 cards)

10. Sample stations grouped as "good" (28 cards)

The significant coefficients of correlation (greater than ± 0.500) were tabulated and compared for each run through the computer. Table 12 presents the coefficients of correlation which were greater than ± 0.500 from "run" 1 above.

This procedure brought forth the variables which seemed to influence each other. The coefficient of correlation varied with each combination of cards; any variable which had a consistently low coefficient was discarded from further study at this time. These discarded variables were: 12, 31, 33, 34, 36, 37, 39, 40, 42, 43, 44, 45, 46, and 47 (see Table 11 for their identification).

A study of the means and standard deviations further reduced the number of variables to be considered. Table 13 presents the means and standard deviations for the 47 variables from "run" 1. To compare the dispersions of two or more sets of data, the coefficient of variation may be used. This coefficient of variation (abbreviated V) is defined as:

$$V = \frac{\bar{\sigma}}{\bar{x}} \times 100$$

(where $\bar{\sigma}$ is the standard deviation and $\bar{x}$ is the mean)

The coefficient of variation expresses (in percent) the magnitude of the variation relative to the quantity which is being measured. It is particularly advisable to employ the coefficient of variation if we have to compare the variation of several sets of measurements which are given in different units of measurement or in different scales, which is the case in trying to compare our 47 variables. The coefficient of

TABLE 12

COEFFICIENT OF CORRELATIONS ABOVE ±0.500
(All 89 Cards)

Variable	Correlation	Variable	Correlation	Variable	Correlation
1/2[1]	-0.610	23/25	+0.609	35/36	+0.955
1/3	+0.940	23/26	+0.653	35/38	-0.576
1/11	+0.546	23/27	-0.603	35/39	-0.587
2/3	-0.535	25/26	+0.952	35/40	-0.527
2/11	-0.660	25/27	-0.552	35/41	-0.763
4/5	+0.933	26/27	-0.604	35/42	-0.695
4/7	+0.871	27/28	-0.647	35/46	+0.554
4/10	+0.725	28/29	+0.695	35/47	+0.540
5/7	+0.858	32/31	+0.907	38/31	-0.621
5/10	+0.768	32/33	+0.886	38/33	-0.677
6/7	-0.541	32/34	+0.738	38/34	-0.553
6/9	+0.624	32/35	+0.796	38/36	-0.553
7/10	+0.807	32/36	+0.818	38/37	+0.909
13/14	+0.724	32/37	-0.595	38/39	+0.771
15/16	+0.649	32/38	-0.693	38/41	+0.586
15/17	+0.591	32/39	-0.686	41/31	-0.571
16/17	+0.538	32/41	-0.595	41/33	-0.594
18/20	+0.829	32/42	-0.516	41/34	-0.726
20/26	+0.502	32/46	+0.503	41/36	-0.708
20/27	-0.530	32/47	+0.523	41/37	+0.561
21/23	+0.558	35/31	+0.726	41/38	+0.586
21/25	+0.641	35/32	+0.796	41/39	+0.610
21/26	+0.670	35/33	+0.769	41/40	+0.725
21/27	-0.643	35/34	+0.928	41/42	+0.879

[1] - Read as coefficient of correlation of Variable One with Variable Two is -0.610.

TABLE 13

MEAN, STANDARD DEVIATIONS, AND COEFFICIENT OF VARIATIONS
($\bar{x}$) ($\bar{\sigma}$) (V)

Variable No.	Units	89 cards (all)			18 cards (poor)	28 cards (good)
		$\bar{x}$	$\bar{\sigma}$	V_t	V_p	V_g
1	pcf	102.7	7.7	7.5	6.8	7.2
2	%	17.3	3.8	21.9	17.9	20.2
3	%	85.6	6.4	7.5	6.5	8.3
4	%	30.4	7.2	23.7	18.4	14.1
5	-	7.8	7.0	89.7	58.2	78.2
6	%	19.8	2.9	14.6	8.9	10.3
7	%	23.2	18.8	81.0	49.4	66.8
8	%	93.2	10.8	11.6	3.6	18.5
9	%	61.3	10.8	17.6	9.1	24.4
10	%	25.6	7.4	28.9	16.7	27.2
11	psi	31.4	11.9	37.9	33.0	24.6
12	-	6.6	6.7	101.5	74.6	85.7
13	pcf	124.2	8.5	6.8	6.9	5.9
14	%	92.0	4.8	5.2	5.1	5.0
15	-	19.3	2.8	14.5	9.5	13.5
16	-	3.2	3.8	118.8	93.6	176.0
17	%	18.0	4.9	27.2	23.9	29.7
18	inch	6.9	2.2	31.9	26.4	35.8
19	inch	2.09	0.36	17.2	15.4	15.5
20	inch	9.4	2.2	23.4	19.2	22.7
21	inch	94.7	25.8	27.2	11.4	20.8
22	inch	47.9	18.0	37.6	17.6	47.9
23	inch	321.9	80.0	24.9	19.7	25.0
24	-	1169.0	679.0	58.1	58.0	58.3
25	-	82.4	13.7	16.6	12.2	7.4
26	-	75.2	15.9	21.1	19.9	11.2
27	year	7.7	2.0	25.9	17.8	39.7
28	.01 mm	26.8	7.2	26.9	16.7	28.5
29	cm	12.2	11.8	96.7	65.2	91.1
30	°F	58.8	23.9	40.6	54.4	21.3
31	inch	0.037	0.020	54.1	40.0	30.4
32	inch	0.026	0.017	65.4	55.9	37.5
33	inch	0.015	0.013	86.7	47.6	62.5
34	inch	0.046	0.023	50.0	37.3	34.4
35	inch	0.034	0.019	55.9	42.6	31.7
36	inch	0.022	0.016	72.7	51.5	42.9
37	in/in	3057.0	2370.0	77.5	93.3	66.9
38	in/in	1648.0	979.0	59.4	64.6	49.9
39	in/in	972.0	480.0	49.4	42.5	38.7
40	in/in	1832.0	1527.0	83.4	57.9	72.6
41	in/in	1106.0	524.0	47.4	38.1	40.2
42	in/in	744.0	374.0	50.3	37.2	45.3
43	inch	38.3	7.1	18.5	15.2	18.1
44	inch	18.4	6.4	34.8	26.3	28.4
45	inch	39.3	8.9	22.6	21.2	27.3
46	inch	28.0	4.7	16.8	15.1	17.5
47	inch	19.8	4.8	24.2	20.8	20.0

variation for the 47 variables obtained in "runs" 1, 9, and 10, are presented in Table 13.

Variables which had a difference of 10 or less in their V's from "poor" to "good" were discarded. Also variables which had a numerical V of less than 10 were discarded. This value of 10 percent was an arbitrary number selected to produce the critical variables for further study. The remaining 18 variables were then assumed to be most significant and should be studied further. These 18 variables are: 2, 3, 4, 5, 7, 8, 9, 14, 15, 16, 18, 19, 20, 24, 27, 29, 35, and 41 (see Table 11 for their identification).

Two approaches to analysis of these 18 variables are reported. First, the IBM 650 computer was utilized to obtain multiple-regression equations, giving the best-fitted line for the variables analyzed. Second, a graphical solution was made, relating the variables to an arbitrary "performance rating." The graphical solution was reduced to equations in order to save space in this report.

<u>Regression Analysis</u>

By regression analysis, using the IBM 650 computer, it is possible to determine the linear equation of best fit for different combinations of variables. Table 14 lists the variables associated with the letters in the following equations. Table 14 further contains the values by job of: (o) total EWL; (p) EWL/lane/day; and (r) pavement age. The following equation for 16 independent variables and one dependent variable was determined.

TABLE 14

A. SUMMARY OF VARIABLES USED IN REGRESSION EQUATIONS WITH LETTER AND NUMBER CODE

Variable Number	Designation	Units	Letter ID used in Equations
2	subgrade inplace moisture	%	a
3	" percent compaction	%	b
4	" liquid limit	%	c
5	" plasticity index	%	d
7	" volumetric shrinkage	%	e
8	" % passing No. 200	%	f
9	" % silt	%	g
14	base percent compaction	%	h
15	" liquid limit	%	j
16	" plasticity index	%	k
18	" thickness	inch	l
19	pavement thickness	inch	m
20	total structure thickness	inch	n
24	total EWL/lane	no.	o
24a	EWL/lane/day	no.	p
27	pavement age to 10-1-60	years	r
29	asphalt ductility	cm	s
35	average OWP deflection	inch	t
41	average OWP RATIO	in/in	u

B. VALUES FOR AGE (variable 27) AND EWL (variable 24)

Variable Identification		Job A	C	F	Ia	J	M
24	Total EWL/lane (x1000)	474.00	1054.00	417.00	2222.00	1993.00	1114.00
24a	EWL/lane/day	139.00	307.00	165.00	769.00	851.00	917.00
27	pavement age	9.33	9.42	6.92	7.92	6.42	3.33

Equation No. 1

$$\text{OWP Deflection} \quad (t) = + 0.514\,a - 0.095\,b - 1.023\,c + 0.189\,d + 0.260\,e + 0.323\,f - 0.349\,g + 0.277\,h - 0.798\,j + 0.260\,k + 1.713\,l - 0.555\,m - 6.084\,n + 0.00855\,o - 0.225\,r + 0.010\,s + 73.9$$

This equation (No. 1) has a multiple coefficient of correlation of 0.590. It is noted that some of the terms in this equation are negligible, and that some of the variables are not really independent of each other. A second equation (No. 2) was determined, using the multiple-regression analysis with fewer variables. This equation with 6 independent variables and one dependent variable has a multiple coefficient of correlation of 0.570. This equation is:

Equation No. 2

$$\text{OWP Deflection} \quad (t) = + 1.008\,a - 0.176\,c - 0.126\,g - 0.448\,j - 4.360\,n + 0.00802\,O + 70.1$$

The same 6 independent variables were rerun, using the outer wheel path ratio as the dependent variable. This equation is:

Equation No. 3

$$\text{OWP Ratio} \quad (u) = - 3.422\,a + 0.112\,c + 0.881\,g + 1.362\,j + 11.331\,n - 0.0088\,o - 12.3$$

This equation for ratio in terms of 6 independent variables has a multiple coefficient of correlation of 0.514.

Values for the 18 variables, from 77 sample stations, are presented in Appendix B. It is noted that the values obtained from

Equations 1 and 2 should be divided by 1000 to obtain the correct deflection. Further, it is noted that the values obtained from Equation 3 should be multiplied by 10 to obtain the correct ratio. The following equation (No. 4) has been developed to present the relationship between Deflection (t) and Ratio (u).

Equation No. 4

$$(t)\ (u) = 187.5\ t + 4.23\ u + 18530$$

$.05\ u = 187.5(.05) + 4.23u + 18$

<u>Graphical Solution</u>

$-4.18u = 7 + 18,5 \quad 4,c$

It was necessary to perform a graphical solution for this problem of highway performance because of the interaction between the many variables affecting performance. The regression equations 1, 2, and 3 are the best mathematical solution (linear) of the variables involved. But we still cannot say what pavement performance is equal to, because of the low multiple coefficients of correlation associated with these equations. It could be said that with a certain "Deflection" or "Ratio" the performance is equal to a certain quantity. However, we can only relate our dependent variable (either deflection or ratio) to the other variables at a low confidence level. Therefore what we are attempting to do in this graphical analysis is to change the "weight" of the "critical" variables until we obtain an equation (or graph) that predicts pavement performance in terms of the measured quantities.

The "critical" variables were grouped by their natural classification, and the ones having the better coefficients of correlation (from the Beaton program) were selected for evaluation of cause and effect. Three groups resulting from this are:

A. Subgrade factors - (X)

Composed of liquid limit, plasticity index, inplace moisture content, and volumetric shrinkage.

B. Pavement and base factors - (Y)

Composed of pavement thickness, asphalt ductility, pavement age, and total structure thickness.

C. Traffic effect factor - (Z)

Composed of 5000-pound EWL per lane per day, pavement age, and outer wheel path ratio (or deflection).

Two variables that were expected to appear in the above grouping were subgrade percent compaction and base percent compaction. In the data obtained (see Table 13), these two variables had a coefficient of variation of 7.7 percent and 5.2 percent, respectively. They were therefore eliminated from consideration in this analysis. Other variables, such as shrinkage limit, had a sufficiently high coefficient of variation to be considered but it was necessary to obtain independent variables, and in this case volumetric shrinkage had a higher variation and also higher coefficients of correlation with other variables. These two variables are interrelated, and either one or the other could have been selected for further analysis. Each variable included in the "grouping" resulted from a similar consolidation.

Four nomographs were determined by trial and error to fit the data obtained from this study of roads in the Loess Terrace Soil area of eastern Arkansas. By regression analysis, using the IBM 650 computer, four equations were determined to replace the four nomographs.

These equations are:

Equation No. 5

$$\text{Subgrade factor } (X) = -\,3.321\,a + 0.081\,c - 0.665\,d - 0.985\,e + 135.3$$

Equation No. 6

$$\text{Pavement and base factor } (Y) = +\,1.190\,m + 6.198\,n - 2.535\,r + 0.164\,s - 1.7$$

Equation No. 7

$$\text{Traffic effect factor } (Z) = +\,0.011\,p - 0.952\,r + 0.0336\,u + 5.2$$

Equation No. 8

$$\text{Performance Rating } (R) = +\,0.076\,X + 0.207\,Y + 0.629\,Z + 7.6$$

These four equations may be combined into one, as follows:

Equation No. 9

$$R = -\,0.253\,a + 0.006\,c - 0.051\,d - 0.075\,e + 0.246\,m + 1.283\,n + 0.007\,p - 1.124\,r + 0.034\,s + 0.0211\,u + 20.8$$

Table 14 lists the variables associated with the letters in the above equations. In the above equations for R, X, Y, and Z, it is noted that their value will range from 0 to 100, and that a value for R of 100 is a perfect performance rating. It is further noted that the multiple coefficient of correlation for this 10-variable equation is 0.994, which is as to be expected when we make our equation fit the data. Equation No. 9 may be replaced with the following 6-variable equation, which has a multiple coefficient of correlation of 0.986.

Equation No. 10

$$R = -0.353 - 0.069\,e + 1.149\,n + 0.007\,p$$
$$- 1.250\,r + 0.0212\,u + 25.0$$

Values for X, Y, Z, and R, for 77 sample stations, are presented in Appendix B. It is noted that these values in Appendix B were obtained from the nomographs and may vary slightly when determined by the equations.

Performance Rating

Each location where samples were taken on the study roads has been evaluated to determine its performance rating. Comparison of this performance rating (R) and the previously discussed condition rating (page 8), is given in Table 15. The mean performance rating for the 77 sample stations presented in Appendix B is 45.9 with a 15.3 standard deviation. For a normal distribution, 68 percent of the R values fall between 30.6 and 61.2, while the range of 15.3 to 76.5 includes 95 percent of the R values. The purpose of this discussion is to present the reasons a sample station has a high or low R value. Table 16 gives the mean and standard deviations for the subgrade factors (X), pavement and base factors (Y), traffic-effect factors (Z), and the performance rating (R).

The sample stations with R values falling outside the middle 68 percent are summarized in Table 17. The R value for sample A-5 (meaning Job A, Station 5) is 31 and falls below the 36.5 lower limit

TABLE 15

COMPARISON OF CONDITION RATING AND PERFORMANCE RATING

Description	Condition Rating	Performance Rating
Excellent	95 - 100	66 - 92
Good	90 - 95	59 - 65
Fair	80 - 90	49 - 59
Average	70 - 80	42 - 48
Poor	55 - 70	30 - 41
Failure	less than 55	0 - 29

COMPARISON OF PERFORMANCE RATING AND OWP DEFLECTION

Performance Rating	OWP Deflection Range
91 - 100	0 - 0.007 inch
81 - 90	0.008 - 0.010 inch
71 - 80	0.011 - 0.014 inch
61 - 70	0.015 - 0.018 inch
51 - 60	0.019 - 0.024 inch
41 - 50	0.025 - 0.036 inch
31 - 40	0.037 - 0.058 inch
21 - 30	greater than 0.058 inch

TABLE 16

MEANS AND STANDARD DEVIATIONS BY JOBS FOR SUBGRADE FACTOR, PAVEMENT AND BASE FACTOR, TRAFFIC EFFECT FACTOR AND PERFORMANCE RATING (from Graphs)

Item	Job						
	A	C	F	Ia	J	M	ALL
No. Samples	15	16	12	12	10	12	77
Mean, $\bar{x}$							
Subgrade, X	59.5	45.9	60.3	57.3	53.3	60.7	55.9
Pave. and Base, Y	33.3	28.9	38.7	34.2	53.5	64.4	40.8
Traffic, Z	43.5	30.1	29.7	36.2	49.5	48.4	39.0
Perf. Rating, R	46.4	36.0	38.9	41.9	54.0	62.5	45.9
Std. Deviation σ							
Subgrade, X	16.8	15.2	20.4	19.4	17.4	25.9	19.9
Pave. and Base, Y	11.0	6.4	9.6	17.6	9.0	35.6	21.5
Traffic, Z	14.9	19.3	7.5	18.0	17.9	21.7	18.8
Perf. Rating, R	9.9	12.9	6.6	12.9	12.4	15.0	15.3

TABLE 17

SAMPLE STATIONS WITH A PERFORMANCE RATING - R - OUTSIDE THE MIDDLE 68 PERCENT OF DATA WITH POSSIBLE CAUSE

No.	Location	Performance Rating Low	Performance Rating High	Remarks
1	A-5	26		very low x
2	A-15		65	very high z
3	A-33		71	very high x, extremely high z
4	C-17	22		low y, low z
5	C-26		56	high x, very high z
6	C-38		55	high x, high y, high z
7	C-44		62	very high z
8	F-20	23		very low x, low y, very low z
9	I_a-2		59	high x, high z
10	I_a-14		72	very low x, high y, extremely high z
11	I_a-36	28		very low y, very low z
12	J-1	35		very low x, low y, low z
13	J-8		79	extremely high z
14	J-20		68	very high x, high z
15	M-4	39		very low x
16	M-12		95	extremely high y, extremely high z
17	M-14_a		85	extremely high z

NOTES: low = below 84% of Job, very low = below 84% of ALL Jobs, extremely low = below 95% of ALL Jobs

high = above 84% of Job, very high = above 84% of ALL Jobs, extremely high = above 95% of ALL Jobs for the mid-68 percent. This low value for R is attributed to a poor subgrade, which has a plasticity index of 20, and a 45 percent volumetric shrinkage. By comparing with complete data given in Appendix B, each sample station can so be evaluated for cause. The performance rating may also be compared with the outer wheel path deflection, as shown in Table 15.

FIGURE A-1 JOB A

FED. ROAD DIV. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	F-217(7)		1	3
JOB NO.		1248		1	3

Specifications Adopted By State Highway Commission March 1, 1940 With Special Provisions As Follows:-

DIVISION	PART
I	1
II	2
II	5
II	9
IV	

SPECIAL PROVISIONS

NUMBER		SHEETS
	Required Contract Provisions	7
2-1	Revision Of Article 2 11 (Approved 2-8-41)	2
2-2	Equipment List Required	1
*2-4	State License for Contractors	1
4-1	Revision of Article 4.9	1
7-7	Public Convenience and Safety	1
8-3	Special Provision Pertaining to the Required Contract Provisions for Federal Aid Projects	2
9-5	Partial Payments	1
205-18	Revision of Section 205	3
501-12	Revision of Section 501 - Prime Coat Application	3
510-13	Medium Curing Cut-Back Asphalts	1
622	Dense Graded Asphaltic Hot Mix Surface Course	11
625	Plant and Equipment for Hot Plant Mix Bituminous Surface Courses	8
510-14	Rapid Curing Cut-Back Asphalts	1
3-8	Termination Of Contract	1
	Source Of Gravel Base Course Material & Mineral Aggregate	1

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

VANNDALE - NORTH SURFACING

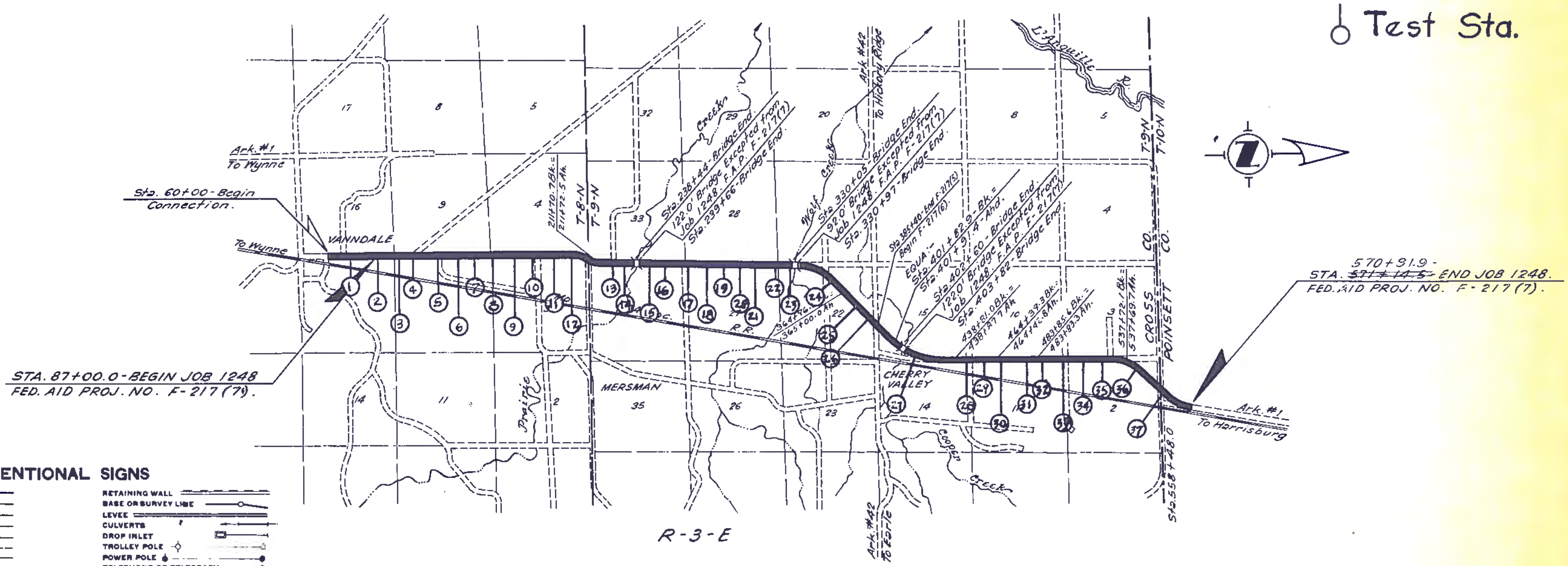
CROSS & POINSETT COUNTIES

ROUTE 1 SECTION 14 & 15

Fed. Aid Proj. No. F-217(7).

LEGEND:

Test Sta.



CONVENTIONAL SIGNS

STATE LINE
COUNTY LINE
CITY OR VILLAGE
TOWNSHIP LINE
SECTION LINE
GRANT LINE
FENCE LINE
UNFENCED PROPERTY
RIGHT OF WAY LINE
TRAVELED WAY
RAILROADS
RETAINING WALL
BASE OR SURVEY LINE
LEVEE
CULVERTS
DROP INLET
TROLLEY POLE
POWER POLE
TELEPHONE OR TELEGRAPH
MARSH
HEDGE
BUILDINGS

FED. ROAD DIV. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK	S-296(7)			
JOB NO.		1252		1	68

INDEX OF SHEETS

FIGURE A-2 JOB B

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

WALDENBURG ~ WEST

JACKSON & POINSETT COUNTIES

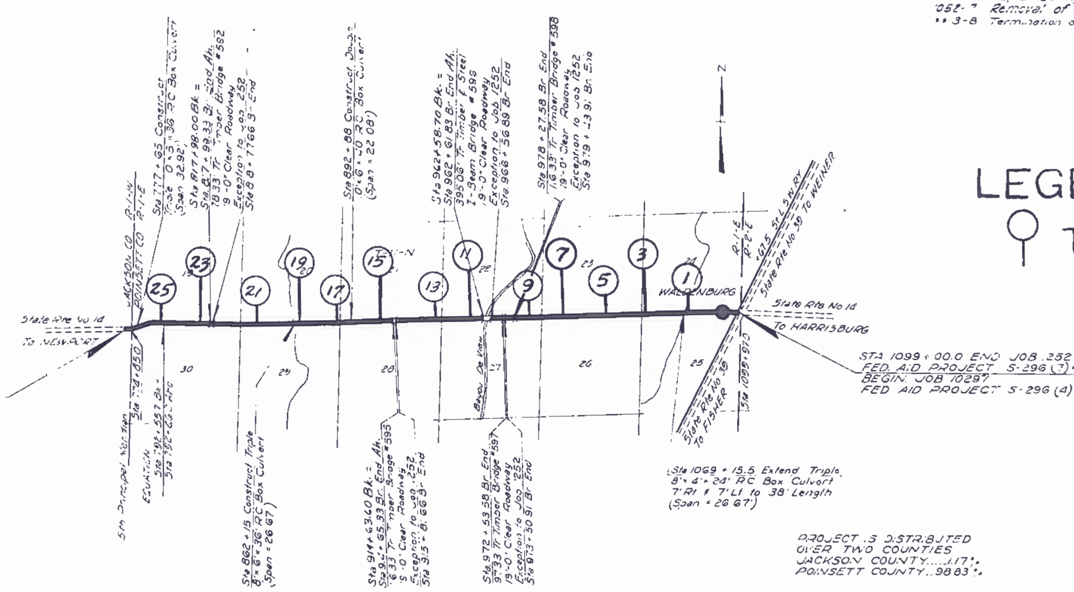
ROUTE 14 SECTION 12 & 13

FEDERAL AID PROJECT S-296(7)

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940 WITH SPECIAL PROVISIONS AS FOLLOWS:

DIVISION	PART
I	1
II	1
II	2
II	5
II	9
IV	

NUMBER	SPECIAL PROVISIONS	SHEETS
	Required Contract Provisions	7
2-1	Revision of Article 2.11 (Appr 2-8-41)	2
2-2	Equipment List Required	1
2-4	State License for Contractors	1
** 4-1	Revision of Article 4.9	1
7-7	Public Convenience and Safety	1
8-3	Special Provision Pertaining to the Required Contract Provisions for Federal Aid Projects	2
9-5	Partial Payments	1
101-5	Revision of Section 101	1
107-5	Overhaul	1
115-4	Removing Canopies and Porches	1
125	Special Compaction of Earthwork	3
126	Embankment Material	3
127	Selected Material	3
205-18	Revision of Section 205	3
501-7	Prime Coat Application	1
* 510-13	Medium Curing Cut-Back Asphalts	1
622	Dense Graded Asphaltic Hot-Mix Surface Course	14
625	Plant and Equipment for Hot Plant Mix Bituminous Surface Courses (3-14-50)	9
902-5	Revision of Section 902 - Reinforcing Steel	1
906-9	Spelter Coated Corrugated Metal Arch Culverts	3
927-1	Railroad - Highway Grade Crossing Signs	2
1054-1	Moving and Resetting Gasoline Pumps	1
JOB 1252	Sources of Embankment Material & Selected Material	2
* 510-14	Rapid Curing Cut-Back Asphalts	1
1052-7	Removal of Existing Bridge Structures	1
** 3-8	Termination of Contract	1



LEGEND:

Test Sta.

CONVENTIONAL SIGNS

STATE LINE	RETAINING WALL
COUNTY LINE	BASE OR SURVEY LINE
CITY OR VILLAGE	LEVEE
TOWNSHIP LINE	CULVERTS
SECTION LINE	DROP INLET
GRANT LINE	TROLLEY POLE
FENCE LINE	POWER POLE
UNFENCED PROPERTY	TELEPHONE OR TELEGRAPH
RIGHT OF WAY LINE	MARSH
TRAVELED WAY	HEDGE
RAILROADS	BUILDINGS

FIGURE A-3 JOB C

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	F-296(5)			
JOB NO.		10297			

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

WALDENBURG – HARRISBURG

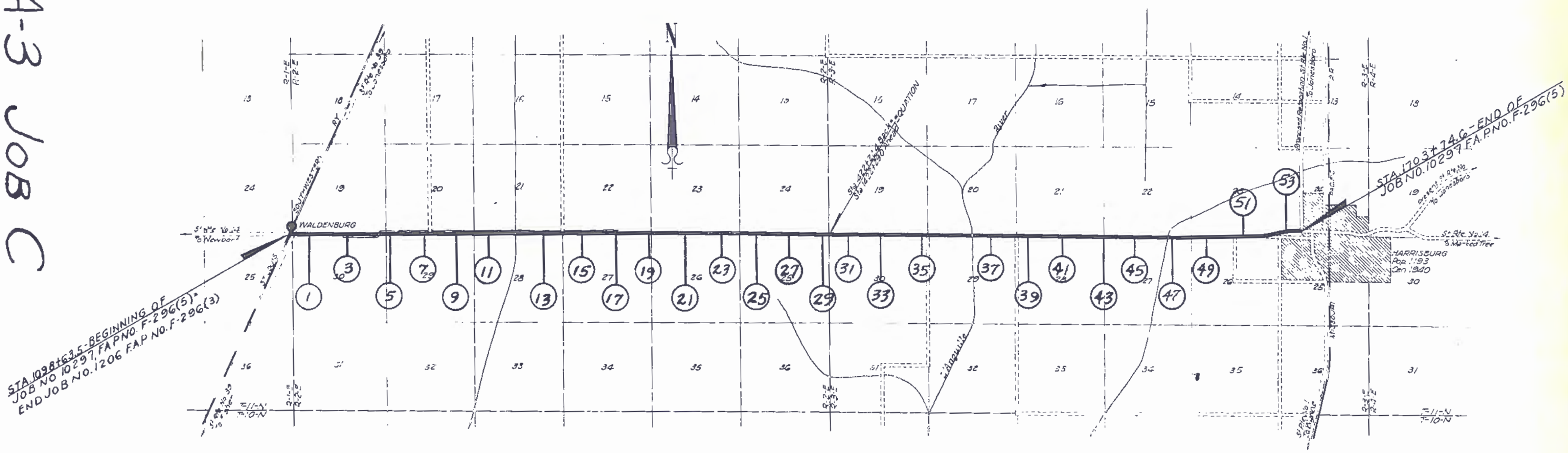
POINSETT COUNTY

ROUTE 14 SECTION 13

F.A.P. NO. F-296(5)

LEGEND:

Test Sta.



CONVENTIONAL SIGNS

STATE LINE
COUNTY LINE
CITY OR VILLAGE
TOWNSHIP LINE
SECTION LINE
GRANT LINE
FENCE LINE
UNFENCED PROPERTY
RIGHT OF WAY LINE
TRAVELED WAY
RAILROADS
RETAINING WALL
BASE OR SURVEY LINE
LEVEE
CULVERTS
DROP INLET
TROLLEY POLE
POWER POLE
TELEPHONE OR TELEGRAPH
MARSH
HEDGE
BUILDINGS

FIGURE A-4 JOB E

FED. ROAD DIV. NO.	STATE	FED. AID PROJECT	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK	S 4.0(2)			
JOB NO		0418			64

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY
WALDENBURG-CROSS CO. LINE

POINSETT COUNTY

ROUTE 39 SECTION 5

FEDERAL AID PROJECT S-410(2)

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940, WITH SPECIAL PROVISIONS AS FOLLOWS:

DIVISION — PART

NUMBER	SPECIAL PROVISIONS	SHEETS
	Required Contract Provisions	
2-1	Revision of Article 2.11 (Appr. 8-8-41)	2
2-2	Equipment List Required	
2-4	State License for Contractors	
5-8	Termination of Contract	
6-1	Revision of Article 4.9	
7-7	Public Convenience and Safety	
8-3	Special Provision Pertaining to the Required Contract Provisions for Federal Aid Projects	2
9-5	Partial Payments	
101-5	Revision of Section 101	
101-6	Clearing Right of Way	
103-1	Cleaning Culverts	
107-5	Overhaul	
107-7	Overhaul	
119-3	Revision of Section 119	
125	Special Compaction of Earthwork	3
126-1	Embankment Material	2
127	Selected Material	2
205-18	Revision of Section 205	3
504-8	Tandem Rollers	1
504-9	Revision of Article 504.6	
510-13	Medium Curing Cut-Back Asphalts	
510-14	Rapid Curing Cut-Back Asphalts	1
510-19	Mineral Aggregate	
511	Prime Coat Application	3
550-2	Furnishing Mineral Aggregate	
902-5	Revision of Section 902 - Reinforcing Steel	
906-5	Spelter Coated Corrugated Metal Arch Culverts	3
927-1	Railroad Highway Grade Crossing Signs	2
951-1	Removing & Resetting F.A.P. Markers	
952-1	Engineer's Field Laboratory	
Job 10418	Cutting Back Building - Right Sta. 192+46	
Job 10418	Source of Selected Material	
Job 10418	Sketch Map	

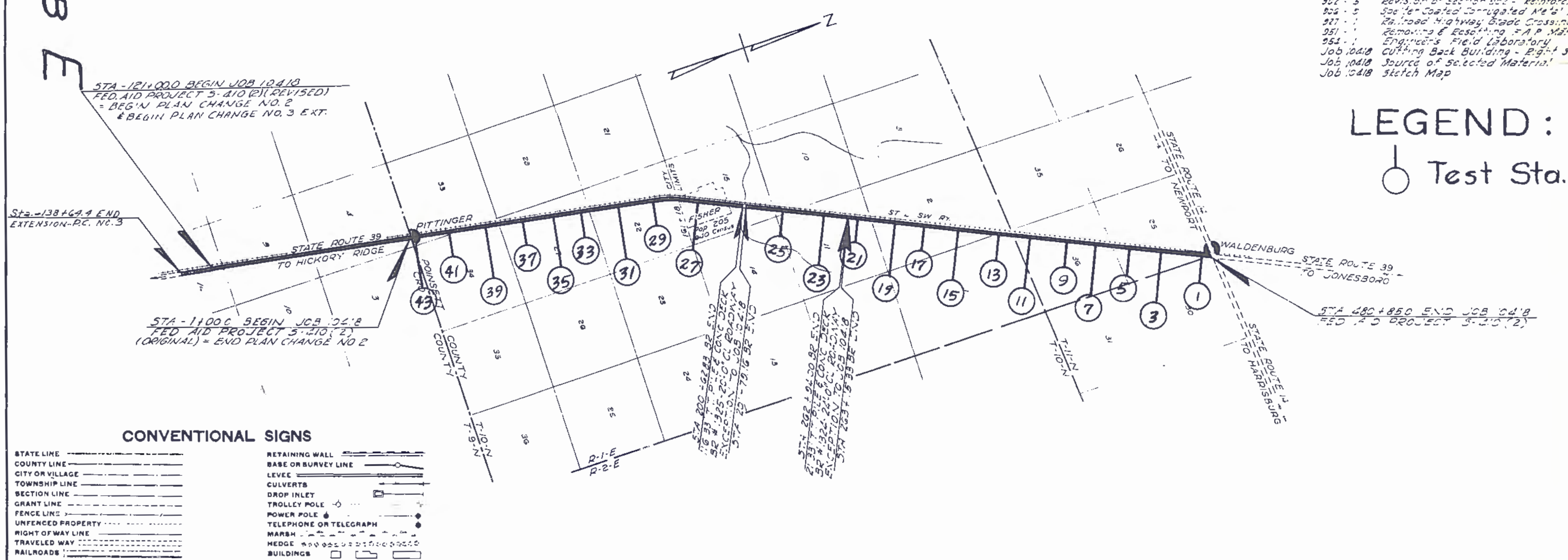


FIGURE A-5 JOB F

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	F-031-2(3)			
JOB NO.		10479		1	4

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1948, WITH SPECIAL PROVISIONS AS FOLLOWS:

DIVISION I PART IX

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

HARRISBURG-SOUTH SURFACING

POINSETT COUNTY

ROUTE 1 SECTION 15

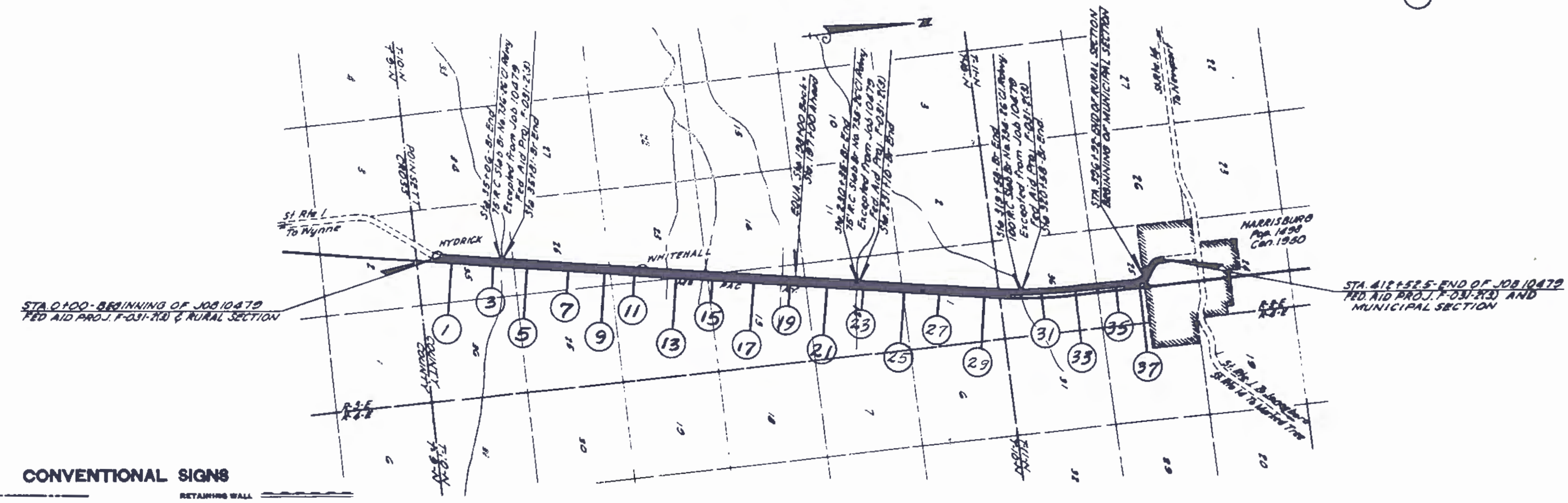
FED. AID PROJ. F-031-2(3)

F

NUMBER	SPECIAL PROVISIONS	SHEETS
7-9	Required Contract Provisions For Federal Aid Projects	9
2-1	Competency of Bidders	2
2-2	Equipment List Required	1
2-4	State License For Contractors	1
3-8	Termination of Contract	1
4-1	Revision of Article 4.9	1
6-1	Furnishing Materials From Bars, Pits or Quarries	2
7-10	Public Convenience and Safety	1
8-3	Employment of Labor For Federal Aid Projects	1
9-5	Partial Payments	1
9-9	Federal Excise Tax on Freight Shipments	1
109-1	Subgrade	2
202-1	Gravel Base Course	2
501-13	Prime and Tack Coats	3
510-5C	Materials and Equipment For Bituminous Surface Courses	6
622	Dense Graded Asphaltic Hot Mix Surface Course	11
625	Plant and Equipment For Hot Plant Mix Bituminous Surface Courses	8
Job 10479	Source of Gravel Base Course and Mineral Aggregate	1
Job 10479	Sketch Map	1

LEGEND:

Test Sta.



FED. ROAD DIV. NO.	STATE	FED. AID PROJECT NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	S 216 (2)			38
JOB NO.		11436			62

Specifications Adopted By State Highway Commission March 1930 With Special Provisions As Follow

DIVISION	PART
I	
II	
IV	1
V	8A, 8B
VII	9, 10

STATE OF ARKANSAS
STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY
MONROE CO. LINE — HILLEMANN

WOODRUFF COUNTY

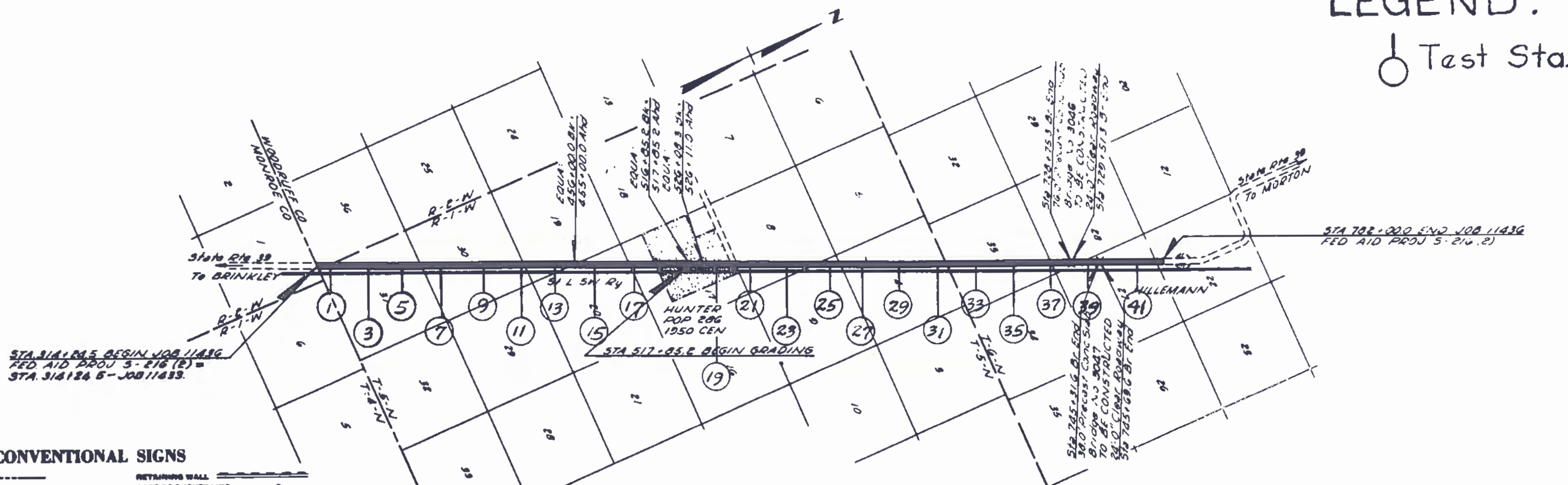
ROUTE 39 SECTION 7

FED. AID PROJ. S-216(2)

NUMBER	SPECIAL PROVISION
7-11	Required Contract Provisions For Federal Aid Secondary Projects
2-1	Competency Of Bidders
2-2	Equipment List Required
2-4	State License For Contractors
3-9	Award Of Contract
4-1	Final Clearing Up Of Right-Of-Way
6-1	Furnishing Materials From Bars, Pits Or Quarries
7-10	Public Convenience And Safety
8-2	Employment Of Labor
9-5	Partial Payments
9-7	Common Carrier Rates
9-9	Federal Excise Tax On Freight Shipments
101-5	Revision Of Section 101
107-6	Overhaul
110-	Subgrade
126-1	Special Compaction Of Earthwork
126-2	Embankment Material
127	Selected Material
PART 2	Aggregate Base And Surface Courses
PART 5	Bituminous Surface Courses
802-2	Precast Concrete Products
803-5	Revision Of Art 803 21 Bar Reinf. (20,000# Design)
804-3	Revision Of Section 804 Concrete Piling
805-3	Steel Plate Guard Rail Rev 12-28-49
850-1	Engineers Field Office
853-1	Machine Mixing
902-5	Revision Of Section 902 - Paint Steel
909-9	Spelter Coated Corrugated Metal Arch Culverts
925-7	Revision Of Article 925 20(a) Rev 3 20-50
1052-9	Removal Of Existing Bridges And Maintenance Of Traffic

LEGEND:

Test Sta.



CONVENTIONAL SIGNS

STATE LINE
COUNTY LINE
CITY OR VILLAGE
TOWNSHIP LINE
SECTION LINE
GRANT LINE
FENCE LINE
UNFENCED PROPERTY
RIGHT OF WAY LINE
TRAVELED WAY
RAILROADS
RETAINING WALL
BASE OR SURVEY LINE
LEVEE
CULVERTS
DROP INLET
TROLLEY POLE
POWER POLE
TELEPHONE OR TELEGRAPH
MARSH
HEDGE
BUILDINGS

FIGURE A-6 JOB H

FIGURE A-7 JOB I

FED. ROAD DIV. NO.	STATE	FED. AID PROJ.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK	[illegible]		1	5 / 6
JOB NO.		11442		1	6

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED

STATE HIGHWAY

MARVELL-WALNUT CORNER SURFACING

PHILLIPS COUNTY

ROUTE 20 SECTION 2

FED. AID PROJECTS F-54(3) & F-137(14)

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940, WITH SPECIAL PROVISIONS AS FOLLOWS

DIVISION

FAP F-54(3)	FAP F-137(14)	JOB 11442
I	I	I
	II	II
	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

PART

FAP F-54(3)	FAP F-137(14)	JOB 11442
	1	1
	9	9

NUMBER	SPECIAL PROVISIONS	FAP F-54(3) SHEETS	FAP F-137(14) SHEETS	JOB 11442 SHEETS
	Required Contract Provisions	7	7	7
2-1	Competency of Bidders	2	2	2
2-2	Equipment List Required	1	1	1
2-4	State License for Contractors	1	1	1
5-8	Termination of Contract	1	1	1
4-1	Revision of Article 49	1	1	1
7-7	Public Convenience & Safety	1	1	1
8-3	Special Provision Pertaining to the Required Contract Provisions for Federal Aid Projects	2	2	2
9-5	Partial Payments	1	1	1
9-9	Federal Excise Tax on Freight Shipments	1	1	1
101-5	Revision of Section 101		1	1
118-1	Reconstructing Wells		1	1
205-18	Revision of Section 205	3	3	3
313-1	Asphaltic Concrete Hot Mix Base Course		17	17
511-1	Prime Coat Application		4	4
512	Prime Coat Application & Preparation of Base	4	4	4
624	Asphaltic Concrete Hot Mix Surface Course	9	9	9
625	Plant & Equipment for Hot Plant Mix Bituminous Surface Courses	8	8	8
251-1	Removing & Resetting F.A.P. Markers		1	1
107-5	Overhaul	1	1	1

LEGEND:

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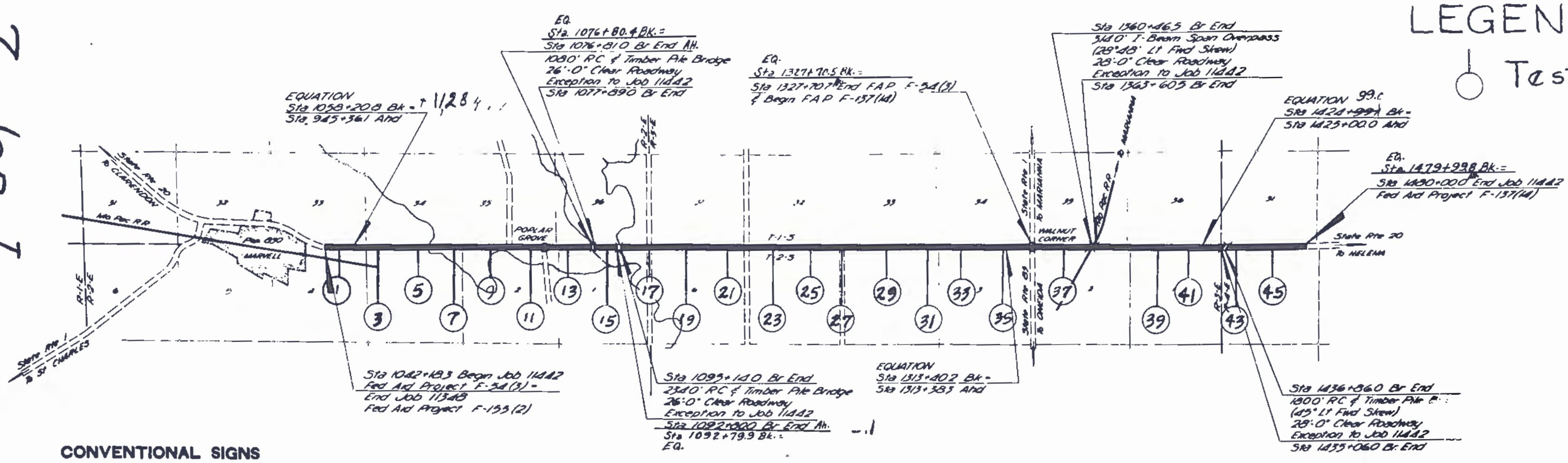


CONVENTIONAL SIGNS

STATE LINE	RETAINING WALL
COUNTY LINE	BASE OR SURVEY LINE
CITY OR VILLAGE	LEVEE
TOWNSHIP LINE	CULVERTS
SECTION LINE	DROP INLET
GRANT LINE	TROLLEY POLE
FENCE LINE	POWER POLE
UNFENCED PROPERTY	TELEPHONE OR TELEGRAPH
RIGHT OF WAY LINE	MARSH
TRAVELED WAY	HEDGE
RAILROADS	BUILDINGS

FIGURE A-8

Job J

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

WALNUT CORNER—NORTH

PHILLIPS & LEE

COUNTY

ROUTE 1 SECTION 8 & 9

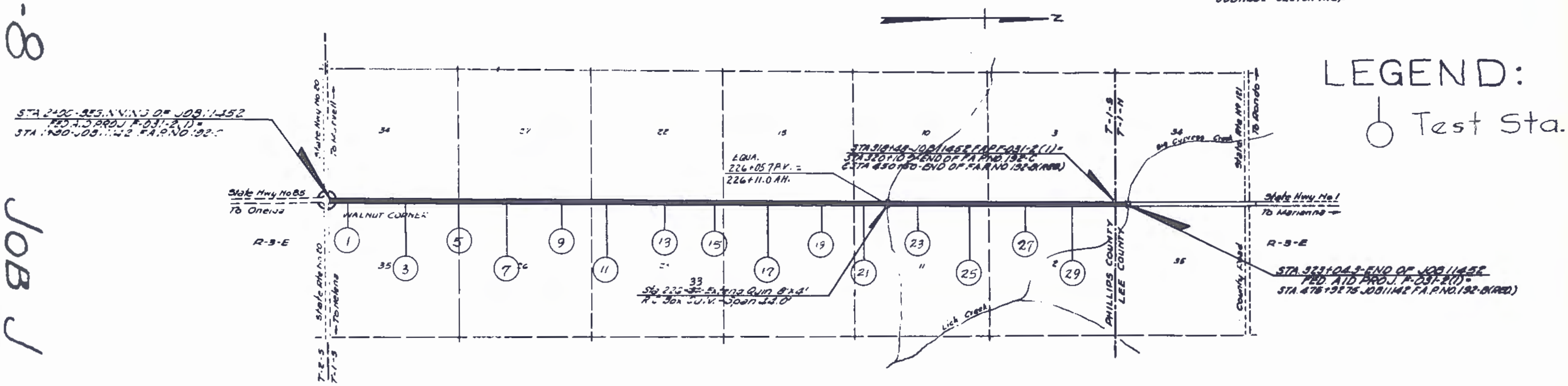
FED. AID PROJ. F-031-2 (1)

6	ARK.	F-031-2			
JOB NO.		11452		1	60

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1960 WITH SPECIAL PROVISIONS AS FOLLOWS:

DIVISION	PART
I	
II	1
V	9
X	10
XI	

NUMBER	SPECIAL PROVISIONS	SHEETS
7-9	Required Contract Provisions For Federal Projects	9
2-1	Competency of Bidders	2
2-2	Equipment List Required	1
2-4	State License For Contractors	1
3-8	Termination of Contract	1
4-1	Revision of Article 4.9	1
6-1	Furnishing Materials From Bars, Pits or Quarries	2
7-10	Public Convenience and Safety	1
8-3	Employment of Labor For Federal Aid Projects	1
9-5	Partial Payments	1
9-9	Federal Excise Tax on Freight Shipments	1
101-6	Revision of Section 101	1
107-6	Overhaul	1
109-1	Subgrade	2
125	Special Compaction of Earthwork	3
126	Embankment Material	2
127	Selected Material	2
202-1	Gravel Base Course	2
501-13	Prime and Tack Coats	3
510-30	Materials and Equipment For Bituminous Surface Courses	6
524	Asphaltic Concrete Hot Mix Surface Course	6
625	Plant and Equipment For Hot Plant Mix Bituminous Surface Courses	6
902-5	Revision of Section 902-Reinforcing Steel	1
906-9	Spelter Coated Corrugated Metal Arch Culverts	3
951-1	Removing and Resetting F.A.P. Markers	1
951-2	Removing and Resetting Right Of Way Markers	1
JOB 11452	Removing and Replacing Gravel Base Course and Bituminous Surfacing	2
JOB 11452	Source of Embankment Material	1
JOB 11452	Source of Selected Material	1
JOB 11452	Sketch Map	1



This Project is distributed Over Two Counties: Phillips County — 58.58%, Lee County — 41.42%.

CONVENTIONAL SIGNS

FIGURE A-9 JOB K

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	S-207(2)		1	4
JOB NO.		11458		1	4

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940 WITH SPECIAL PROVISIONS AS FOLLOWS:

DIVISION I, IV — PART

NUMBER	SPECIAL PROVISIONS	PAGES
7-9	Required Contract Provisions for Federal Aid Projects	4
2-1	Competency of Bidders	2
2-2	Equipment List Required	1
2-4	State License for Contractors	1
4-1	Final Clearing of Right-of-Way	1
6-1	Furnishing Materials from Bars, Pits or Quarries	2
7-10	Public Convenience and Safety	1
8-2	Employment of Labor	1
9-5	Partial Payments	1
9-7	Common Carrier Rates	1
9-9	Federal Excise Tax on Freight Shipments	1
109-1	Subgrade	2
202-1	Gravel Base Course	2
501-13	Prime and Tack Coats	3
503-9	Bituminous Surface Treatment	3
510-30	Materials and Equipment for Bituminous Surface Courses	5

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED

STATE HIGHWAY

WHEATLEY — MORO

SURFACING

ST. FRANCIS & LEE COUNTY

ROUTE 78 SECTION 1 & 2

FED. AID PROJ. S-207 (2)

LEGEND:

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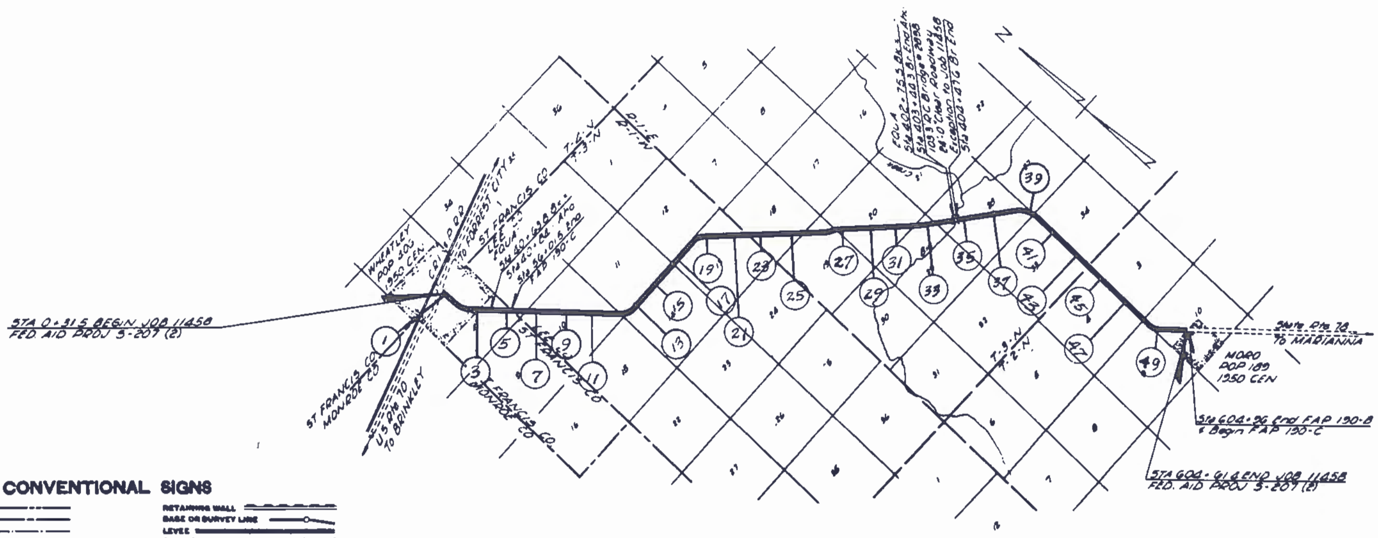


CONVENTIONAL SIGNS

STATE LINE
COUNTY LINE
CITY OR VILLAGE
TOWNSHIP LINE
SECTION LINE
GRANT LINE
FENCE LINE
UNFENCED PROPERTY
RIGHT OF WAY LINE
TRAVELED WAY
RAILROADS
RETAINING WALL
BASE OR SURVEY LINE
LEVEE
CULVERTS
DROP INLET
TROLLEY POLE
POWER POLE
TELEPHONE OR TELEGRAPH
MARSH
HEDGE
BUILDINGS

This Project is Distributed Over Two Counties
St Francis County 9.23%
Lee County 90.77%

A-9

FED ROAD DIST NO	STATE	FED AID PROJ No	FISCAL YEAR	SHEET No	TOTAL SHEETS
6	ARK.	S-216(1)			
JOB NO.		11465		1	16

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED

STATE HIGHWAY

JCT. HWY. 17–WOODRUFF CO. LINE

SURFACING

MONROE COUNTY

ROUTE 39 SECTION 7

FEDERAL AID PROJECT S-216(1)

FIGURE A-10

JOB L

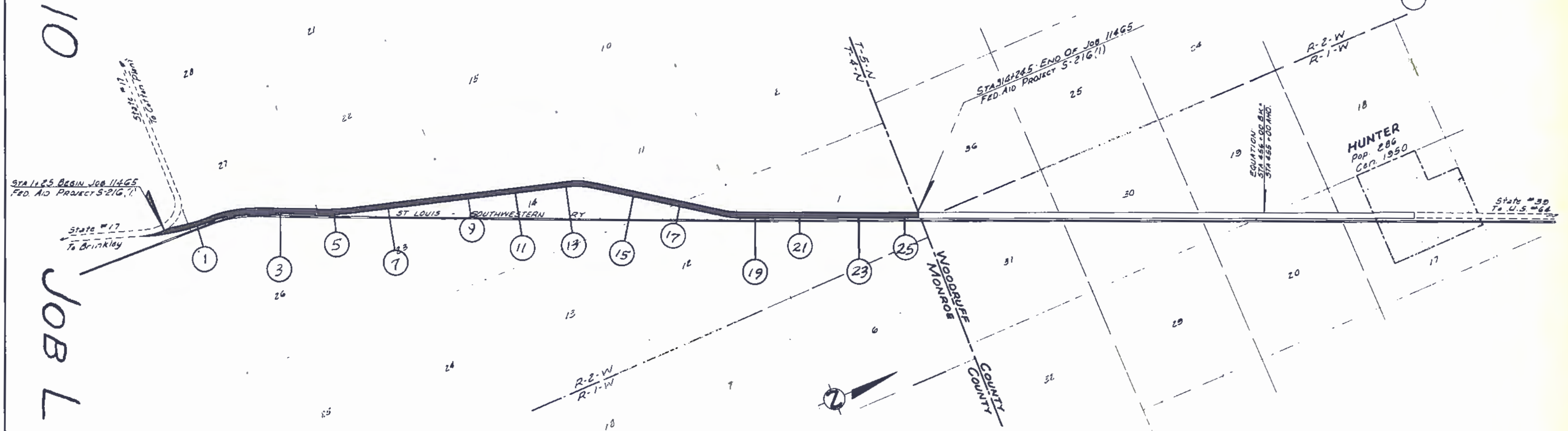
SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940, WITH SPECIAL PROVISIONS:

DIVISION	PART
I	
II	9
III	

NUMBER	SPECIAL PROVISIONS	PAGES
7-9	Required Contract Provisions For Federal Aid Projects	9
2-1	Competency of Bidders	2
2-2	Equipment List Required	1
2-4	State License For Contractors	1
4-1	Revision of Article 4.9	1
6-1	Furnishing Materials From Bars, Pits or Quarries	2
7-10	Public Convenience and Safety	1
8-3	Employment of Labor For Federal Aid Projects	1
9-5	Partial Payments	1
9-9	Federal Excise Tax on Freight Shipments	1
109-1	Subgrade	2
202-1	Gravel Base Course	2
501-13	Prime and Tack Coats	3
503-9	Bituminous Surface Treatment	3
510-30	Materials and Equipment For Bituminous Surface Courses	6
951	Right of Way Markers And Project Marker Posts	1

LEGEND:

Test Sta.



CONVENTIONAL SIGNS

- STATE LINE
- COUNTY LINE
- CITY OR VILLAGE
- TOWNSHIP LINE
- SECTION LINE
- GRANT LINE
- FENCE LINE
- UNFENCED PROPERTY
- RIGHT OF WAY LINE
- TRAVELED WAY
- RAILROADS
- RETAINING WALL
- BASE OR SURVEY LINE
- LEVEE
- CULVERTS
- DROP INLET
- TROLLEY POLE
- POWER POLE
- TELEPHONE OR TELEGRAPH
- MARSH
- HEDGE
- BUILDINGS

FIGURE A-11 JOB M

FED. ROAD DIST. NO.	STATE	PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK.	F-031-2 (4)			
JOB NO.		11489		1	32

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

PHILLIPS CO. LINE-MARIANNA

LEE COUNTY

ROUTE 1 SECTION 9

FED. AID PROJ. F-031-2 (4)

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION [illegible] WITH SPECIAL PROVISIONS AS FOLLOWS

DIVISION PART

NUMBER

7-9	Required Contract Provisions For Federal Aid Projects
[illegible]	[illegible]
[illegible]	Equipment List Required
2-4	State License For Contractors
[illegible]	Award of Contract
[illegible]	Furnishing Materials From Borrow Pits or Quarries
7-12	Public Convenience and Safety
[illegible]	Employment of Labor
9-5	Partial Payments
9-7	[illegible] Carrier Rates
9-9	Federal Excise Tax on Freight Shipments
[illegible]	Revision of Section 101
[illegible]	Overhaul
[illegible]	Subgrade
[illegible]	Special Compaction of Earthwork
127	Selected Material
[illegible]	Aggregate Base and Surface Courses
[illegible]	Bituminous Surface Courses
[illegible]	Hot Mix Bituminous Base and Surface Courses
[illegible]	Steel Rail Guard
[illegible]	Concrete Reconstructures
[illegible]	Revision of Section 903 - Reinforcing Steel
[illegible]	Spelter Coated Corrugated Metal Arch Culverts
[illegible]	Revision of Article 925 [illegible]
[illegible]	Removing and Resetting [illegible] Markers
[illegible]	Removing and Resetting Right-of-Way Markers
Job 11489	Removing and Replacing Gravel Base Course & Bituminous Surfacing
[illegible]	[illegible]
8-7	Liquidated Damages
9-10	Method of Measurement

LEGEND:

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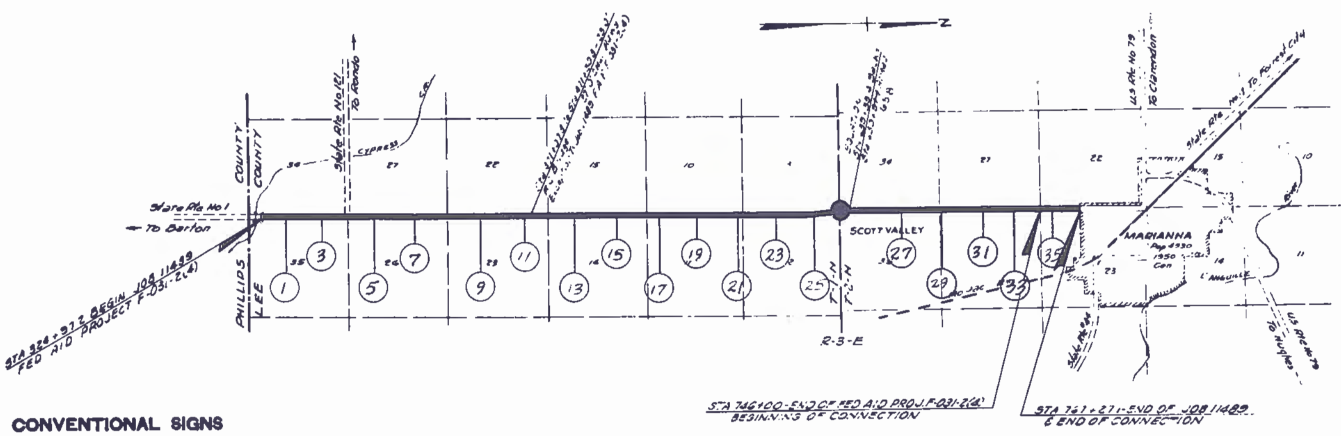

CONVENTIONAL SIGNS

STATE LINE	RETAINING WALL
COUNTY LINE	BASE OR SURVEY LINE
CITY OR VILLAGE	LEVEE
TOWNSHIP LINE	CULVERTS
SECTION LINE	DROP INLET
GRANT LINE	TROLLEY POLE
FENCE LINE	POWER POLE
UNFENCED PROPERTY	TELEPHONE OR TELEGRAPH
RIGHT OF WAY LINE	MARSH
TRAVELED WAY	HEDGE
RAILROADS	BUILDINGS

A-11

FED. ROAD DIST. NO.	STATE	FED. AID PROJ. NO.	FISCAL YEAR	SHEET NO.	TOTAL SHEETS
6	ARK	S 216(3)		1	3
JOB NO.		11580			

SPECIFICATIONS ADOPTED BY STATE HIGHWAY COMMISSION MARCH 1, 1940 WITH SPECIAL PROVISIONS AS FOLLOWS

DIVISION PART
I - - - - 1
IV

STATE OF ARKANSAS

STATE HIGHWAY COMMISSION

PLAN AND PROFILE OF PROPOSED
STATE HIGHWAY
HILLEMANN —— MORTON
SURFACING
WOODRUFF COUNTY

ROUTE 39 SECTION 7

FEDERAL AID PROJECT S-216(3)

FIGURE A-12 JOB N

NUMBER SPECIAL PROVISIONS

- 7-11 Required Contract Provisions For Federal Aid Secondary Projects
- 2-1 Competency of Bidders
- 2-2 Equipment List Required
- 2-4 State License For Contractors
- 3-9 Award of Contract
- 6-1 Furnishing Materials From Bars, Pits or Quarries
- 7-10 Public Convenience and Safety
- 8-2 Employment of Labor
- 8-7 Liquidated Damages
- 9-5 Partial Payments
- 9-7 Common Carrier Rates
- 9-9 Federal Excise Tax on Freight Shipments
- 9-10 Method of Measurement
- 110 Subgrade
- Part 2 Aggregate Base and Surface Courses
- Part 5 Bituminous Surface Courses
- " 8-9 Legal Holidays

LEGEND:
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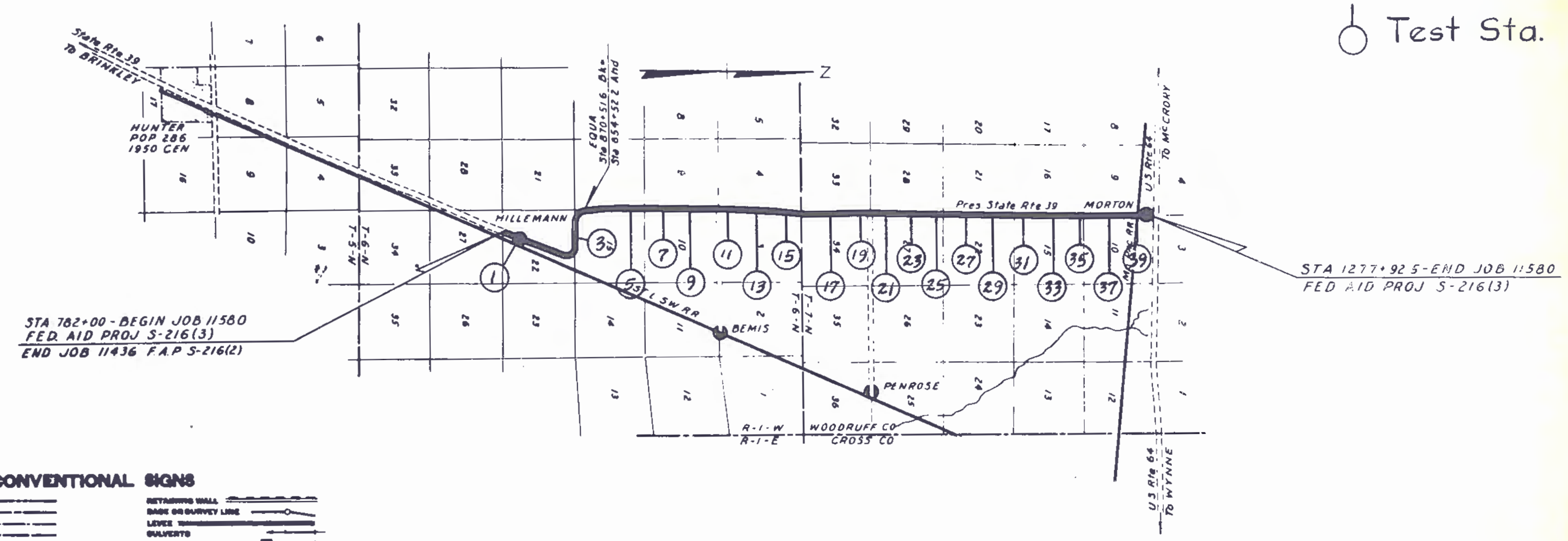

CONVENTIONAL SIGNS

APPENDIX B

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			A-3	A-5	A-7	A-9	A-11	A-13	A-15	A-17
			16	19	15	14	11	19	15	17
2	a	Subg. Inpl.-Moist.	18	16	17	18	15	20	17	13
3	b	Subg.-% Comp.	88	89	86	87	97	83	97	92
4	c	Subg. - LL	27	39	32	29	27	29	30	26
5	d	Subg. - PI	5	20	19	7	4	8	9	7
			22	19	13	22	23	21	21	14
7	e	Subg. - VS	6	45	24	13	5	13	25	16
8	f	Subg.-% Pass 200	94	93	95	96	97	92	93	95
9	g	Subg.-% Silt	73	58	65	70	73	69	61	67
			21	35	30	26	27	23	32	28
14	h	Base-% Comp.	96	92	99	99	92	98	88	91
15	j	Base - LL	16	16	18	18	18	17	19	19
16	k	Base - PI	0	0	0	0	0	0	0	3
18	l	Base - Thick	6	6	6	4	5	5	7	8
19	m	Pave. Thick.	2.0	1.9	2.1	2.4	2.0	2.0	2.1	2.0
20	n	Tot. Struct. Thick.	8.0	7.9	8.1	6.4	7.0	7.0	9.1	10.0
29	s	AC duct.	5	5	5	5	5	7	~~6~~	4
35	t	OWP defl. (x 10^{+3})	20	46	18	24	29	24	12	32
41	u	OWP ratio	1720	870	1770	1370	1210	1430	2120	1060
--	X	Subg. factor	71	22	44	62	72	54	53	75
--	Y	Pave.-Base factor	28	26	28	18	21	21	35	36
--	Z	Traffic factor	58	26	43	45	39	47	73	33
--	R	Perf. rating	55	31	44	44	42	46	65	41
		Condition Rating	84/75	82/70	91/80	88/72	95/83	87/65	91/75	94/91

Avg / Vmin

NOTE:

1 - Variable Number (See Table 14 for listing of variables).

2 - Letter identification of variable used in equations.

3 - See Table 14 for abbreviation used in identification.

4 - Location by Job and Station, i.e., A-3 = Job A, Station 3.

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			A-19	A-21	A-23	A-25	A-27	A-33	A-35	C-2
			23	11	12	28	16	16	16	
2	a	Subg. Inpl.-Moist.	21	17	15	25	18	14	19	27
3	b	Subg.-% Comp.	78	93	92	76	88	88	86	77
4	c	Subg. - LL	29	33	27	27	25	26	30	28
5	d	Subg. - PI	12	10	5	6	5	4	8	6
			17	23	22	21	20	27	22	[illegible]
7	e	Subg. - VS	15	14	3	12	3	10	16	22
8	f	Subg.-% Pass 200	96	98	98	96	94	94	95	98
9	g	Subg.-% Silt	65	68	77	68	76	68	63	66
			31	30	21	28	18	26	32	
14	h	Base-% Comp.	99	96	96	96	96	96	98	95
15	j	Base - LL	17	19	17	17	21	23	22	17
16	k	Base - PI	1	0	0	2	5	5	4	4
18	l	Base - Thick	11	9	5	8	8	8	6	7
19	m	Pave. Thick.	2.1	2.0	2.8	2.5	2.5	2.3	2.4	2.3
20	n	Tot. Struct. Thick.	13.1	11.0	7.8	10.5	10.5	10.3	8.4	9.3
29	s	AC duct.	5	2	3	5	7	5	5	31
35	t	OWP defl. (x 10^{+3})	22	25	26	18	32	20	27	52
41	u	OWP ratio	1180	1120	890	1230	1070	2370	1290	700
--	X	Subg. factor	45	63	85	39	75	79	54	28
--	Y	Pave.-Base factor	60	42	27	44	45	39	30	40
--	Z	Traffic factor	36	35	27	40	31	78	42	22
--	R	Perf. rating	46	43	37	45	42	71	44	31
			[illegible]							
			92/90	89/82	89/80	90/85	85/73	86/79	88/84	66/50

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] C-5	C-8	C-11	C-14	C-17	C-20	C-23	C-26
2	a	Subg. Inpl.-Moist.	19	18	20	18	20	23	18	14
3	b	Subg.-% Comp.	88	86	83	91	73	80	84	93
4	c	Subg. - LL	24	26	28	26	30	25	26	26
5	d	Subg. - PI	2	7	7	5	9	0	4	4
			22	19	21	21	21	25	12	22
7	e	Subg. - VS	16	18	26	20	30	15	16	21
8	f	Subg.-% Pass 200	97	97	99	99	99	99	98	99
9	g	Subg.-% Silt	64	59	55	66	63	51	70	63
14	h	Base-% Comp.	95	91	99	95	99	89	88	98
15	j	Base - LL	19	20	17	19	19	21	32	30
16	k	Base - PI	5	3	0	3	3	5	15	15
18	l	Base - Thick	6	6	6	4	4	5	4	6
19	m	Pave. Thick.	2.1	2.4	2.3	2.4	2.3	1.9	2.5	2.0
20	n	Tot. Struct. Thick.	8.1	8.4	8.3	6.4	6.3	6.9	6.5	8.0
29	s	AC duct.	5	8	14	14	30	41	10	5
35	t	OWP defl.(x 10^{+3})	62	56	95	70	91	45	49	13
41	u	OWP ratio	500	650	370	490	400	660	610	1700
--	X	Subg. factor	58	54	38	54	33	46	59	67
--	Y	Pave.-Base factor	28	30	32	19	21	26	19	27
--	Z	Traffic factor	15	20	10	14	11	21	19	60
--	R	Perf. rating	27	31	23	24	22	30	28	56
			62/57	59/53	63/55	66/60	67/60	64/58	66/57	67/62

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			C-29	C-32	C-35	C-38	C-41	C-44	C-48	F-2
2	a	Subg. Inpl.-Moist.	17	14	12	16	17	13	16	16
3	b	Subg.-% Comp.	91	85	95	89	91	90	88	90
4	c	Subg. - LL	26	48	45	26	43	40	28	35
5	d	Subg. - PI	4	24	23	2	23	20	6	13
			22	24	22	24	20	20	22	22
7	e	Subg. - VS	18	67	54	19	53	43	24	26
8	f	Subg.-% Pass 200	98	99	98	97	99	99	98	97
9	g	Subg.-% Silt	64	55	60	68	67	58	66	65
14	h	Base-% Comp.	84	94	90	94	84	95	92	85
15	j	Base - LL	20	19	24	19	23	20	24	18
16	k	Base - PI	2	5	10	5	7	5	9	6
18	l	Base - Thick	7	5	5	7	7	7	7	5
19	m	Pave. Thick.	2.1	2.2	2.2	2.2	2.3	2.3	1.8	1.5
20	n	Tot. Struct. Thick.	9.1	7.2	7.2	9.2	9.3	9.3	8.8	6.5
29	s	AC duct.	10	7	5	16	5	5	12	5
35	t	OWP defl. (x 10^{+3})	24	14	67	18	39	16	23	31
41	u	OWP ratio	1020	1580	430	1570	690	1980	1120	770
--	X	Subg. factor	60	29	36	64	18	35	56	49
--	Y	Pave.-Base factor	35	23	22	37	35	35	33	23
--	Z	Traffic factor	35	56	12	55	22	71	38	25
--	R	Perf. rating	41	50	23	55	30	62	43	32
			67/65	68/65	64/60	69/65	67/57	72/68	68/57	80/63

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

			Location[4]							
Col. I[1]	Col. II[2]	Identification[3]	F-5	F-8	F-11	F-14	F-17	F-20	F-23	F-26
2	a	Subg. Inpl.-Moist.	18	22	16	18	19	15	16	11
3	b	Subg.-% Comp.	88	78	85	84	80	84	89	94
4	c	Subg. - LL	26	40	28	26	25	47	25	22
5	d	Subg. - PI	3	16	6	5	2	20	0	3
7	e	Subg. - VS	12	30	22	14	18	49	10	16
8	f	Subg.-% Pass 200	95	98	89	97	96	98	98	84
9	g	Subg.-% Silt	66	62	57	53	67	59	68	53
14	h	Base-% Comp.	87	94	92	92	95	87	98	92
15	j	Base - LL	18	18	18	18	18	16	16	18
16	k	Base - PI	6	7	7	7	7	6	6	7
18	l	Base - Thick	6	8	6	7	8	4	9	7
19	m	Pave. Thick.	1.8	2.3	2.0	1.9	2.1	1.8	2.2	2.3
20	n	Tot. Struct. Thick.	7.8	10.3	8.0	8.9	10.1	5.8	11.2	9.3
29	s	AC duct.	6	6	8	6	2	6	5	8
35	t	OWP defl.(x 10^{+3})	26	39	30	41	25	55	27	26
41	u	OWP ratio	1050	720	1030	590	1040	510	890	1020
--	X	Subg. factor	66	23	58	62	55	28	77	84
--	Y	Pave.-Base factor	32	48	34	40	46	20	54	43
--	Z	Traffic factor	36	23	35	18	36	15	30	35
--	R	Perf. rating	42	34	41	32	44	23	43	45
			69/55	62/53	72/57	64/53	76/63	69/57	60/55	73/59

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] F-29	F-32	F-35	I-2	I-5	I-8	I-11	I-14
2	a	Subg. Inpl.-Moist.	8	19	11	15	14	19	19	19
3	b	Subg.-% Comp.	97	85	97	91	80	79	86	89
4	c	Subg. - LL	25	27	28	27	30	26	28	35
5	d	Subg. - PI	3	5	3	3	7	0	3	12
			22	22	25	24	23	26	25	[illegible]
7	e	Subg. - VS	8	19	24	11	17	12	15	35
8	f	Subg.-% Pass 200	73	97	85	97	98	99	98	99
9	g	Subg.-% Silt	47	67	57	66	69	63	68	66
14	h	Base-% Comp.	92	92	97	93	88	82	91	91
15	j	Base - LL	18	16	16	19	17	18	20	20
16	k	Base - PI	7	4	4	0	2	0	4	2
18	l	Base - Thick	8	7	7	8	9	6	5	10
19	m	Pave. Thick.	2.1	1.8	1.7	2.1	2.1	1.7	1.8	1.7
20	n	Tot. Struct. Thick.	10.1	8.8	8.7	10.1	11.1	7.7	6.8	11.7
29	s	AC duct.	9	3	6	30	14	5	24	33
35	t	OWP defl.(x 10^{+3})	24	22	24	25	49	24	36	15
41	u	OWP ratio	940	1050	1050	1470	770	1250	850	2060
--	X	Subg. factor	95	52	75	77	71	64	59	28
--	Y	Pave.-Base factor	48	38	38	49	52	29	26	59
--	Z	Traffic factor	32	36	36	57	30	48	33	80
--	R	Perf. rating	45	42	44	59	43	49	38	72
			66/60	75/[illegible]	76/63	95/84	94/83	95/89	95/88	91/81

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] I-17	I-20	I-24	I-27	I-29	I-33	I-36
2	a	Subg. Inpl.-Moist.	21	13	15	19	20	12	16
3	b	Subg.-% Comp.	92	96	82	86	85	99	92
4	c	Subg. - LL	31	26	29	27	44	33	27
5	d	Subg. - PI	6	4	6	4	17	6	4
			25	22	23	25	27	27	23
7	e	Subg. - VS	19	15	17	12	44	27	12
8	f	Subg.-% Pass 200	99	99	99	93	99	99	99
9	g	Subg.-% Silt	69	70	70	63	64	70	71
14	h	Base-% Comp.	90	86	99	86	85	84	88
15	j	Base - LL	19	23	20	20	21	20	20
16	k	Base - PI	1	8	0	0	0	6	0
18	l	Base - Thick	12	4	4	7	5	5	4
19	m	Pave. Thick.	1.9	2.2	1.9	1.4	1.2	1.5	1.6
20	n	Tot. Struct. Thick.	13.9	6.2	5.9	8.4	6.2	6.5	5.6
29	s	AC duct.	12	8	5	4	19	8	3
35	t	OWP defl. $(\times 10^{+3})$	30	65	52	94	26	54	84
41	u	OWP ratio	970	550	640	380	1150	590	440
--	X	Subg. factor	45	78	68	61	12	53	72
--	Y	Pave.-Base factor	69	20	17	33	21	21	15
--	Z	Traffic factor	38	22	25	15	45	23	18
--	R	Perf. rating	49	32	32	29	41	31	28
			94/88	81/70	97/95	83/70	92/77	85/61	72/60

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			J-1	J-4	J-8	J-10	J-13	J-17	J-20	J-23
2	a	Subg. Inpl.-Moist.	22	23	12	17	15	20	16	21
3	b	Subg.-% Comp.	75	75	80	88	82	80	88	83
4	c	Subg. - LL	36	31	30	32	32	25	16	34
5	d	Subg. - PI	14	7	6	7	8	0	0	10
			22	24	24	25	24	25	16	24
7	e	Subg. - VS	30	17	26	29	27	11	8	30
8	f	Subg.-% Pass 200	99	96	97	76	97	95	53	88
9	g	Subg.-% Silt	67	69	67	57	61	75	30	54
14	h	Base-% Comp.	87	93	90	94	92	91	94	92
15	j	Base - LL	20	21	18	20	24	20	19	20
16	k	Base - PI	3	0	0	0	8	0	2	2
18	l	Base - Thick	7	7	4	6	6	5	5	4
19	m	Pave. Thick.	1.8	1.9	2.0	2.2	2.1	2.0	1.8	1.8
20	n	Tot. Struct. Thick.	8.8	8.9	6.0	8.2	8.1	7.0	6.8	5.8
29	s	AC duct.	8	5	4	9	7	40	26	20
35	t	OWP defl. $(x\ 10^{+3})$	51	39	14	30	21	41	16	22
41	u	OWP ratio	620	920	2200	1000	1470	770	1720	1230
--	X	Subg. factor	24	40	68	46	55	62	77	29
--	Y	Pave.-Base factor	40	53	54	50	49	64	56	42
--	Z	Traffic factor	27	38	87	42	59	32	69	50
--	R	Perf. rating	35	46	79	48	59	46	68	50
			97/97	98/97	98/97	98/97	98/97	97/92	98/97	98/97

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] J-26	J-28	M-1	M-4	M-8	M-12	M-14A	M-17
2	a	Subg. Inpl.-Moist.	15	12	18	24	19	18	12	12
3	b	Subg.-% Comp.	91	83	85	81	81	84	89	89
4	c	Subg. - LL	22	24	35	31	27	26	26	26
5	d	Subg. - PI	6	0	12	9	0	1	3	0
			16	24	23	22	27	25	22	26
7	e	Subg. - VS	24	18	49	26	12	8	12	15
8	f	Subg.-% Pass 200	90	66	94	99	93	99	99	76
9	g	Subg.-% Silt	58	38	60	65	70	67	65	52
14	h	Base-% Comp.	90	92	92	91	94	91	94	96
15	j	Base - LL	21	20	19	20	18	18	18	18
16	k	Base - PI	0	0	4	4	0	0	2	0
18	l	Base - Thick	5	4	12	5	8	16	8	10
19	m	Pave. Thick.	1.6	1.9	2.4	1.8	2.0	1.9	2.1	2.2
20	n	Tot. Struct. Thick.	6.6	5.9	14.4	6.8	10.0	17.9	10.1	12.2
29	s	AC duct.	15	14	67	21	8	7	24	39
35	t	OWP defl.(x 10^{+3})	22	41	28	53	42	7	14	31
41	u	OWP ratio	1410	800	840	680	720	2200	2200	960
--	X	Subg. factor	58	80	21	25	64	72	86	85
--	Y	Pave.-Base factor	72	55	90	38	56	100	59	72
--	Z	Traffic factor	57	34	41	35	37	97	93	46
--	R	Perf. rating	63	46	54	39	47	95	85	58
			97/94	94/91	98/97	98/97	98/97	98/97	98/97	98/97

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] M-20	M-23	M-26	M-29	M-34	M-37
2	a	Subg. Inpl.-Moist	17	11	17	18	23	13
3	b	Subg.-% Comp.	82	74	81	79	64	78
4	c	Subg. - LL	27	27	28	36	33	27
5	d	Subg. - PI	6	0	4	14	7	0
			21	27	24	22	26	27
7	e	Subg. - VS	22	12	9	32	26	2
8	f	Subg.-% Pass 200	94	48	92	98	99	35
9	g	Subg.-% Silt	64	18	59	58	65	20
14	h	Base-% Comp.	89	95	77	90	88	98
15	j	Base - LL	17	17	18	18	18	18
16	k	Base - PI	1	0	0	0	1	0
18	l	Base - Thick	9	12	10	10	9	10
19	m	Pave. Thick.	3.1	2.6	2.3	1.9	2.6	1.9
20	n	Tot. Struct. Thick.	12.1	14.6	12.3	11.9	11.6	11.9
29	s	AC duct.	24	36	10	13	32	33
35	t	OWP defl.(x 10^{+3})	19	15	16	20	25	25
41	u	OWP ratio	1190	1350	980	1510	920	1100
--	X	Subg. factor	54	90	72	35	29	95
--	Y	Pave.-Base factor	73	89	71	72	71	72
--	Z	Traffic factor	55	61	47	67	44	51
--	R	Perf. rating	63	71	57	67	57	62
			98/90	98/97	98/97	98/9[illegible]	98/[illegible]	98/[illegible]7

SUPPLEMENT TO

REVISED COMPREHENSIVE REPORT OF

THE PERFORMANCE OF FLEXIBLE BASES AND PAVEMENTS

IN

LOESS TERRACE SOIL AREA

Project No. 4

Joint Highway Research Program

Civil Engineering Department

University of Arkansas

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INTRODUCTION

This supplement will discuss the findings and make recommendations for each Job by sample stations. Each Job will be considered separately and the sample stations will be compared with others on the same Job. A final summary will make comparisons of all the jobs.

It will be observed that a combination of small variations in several variables may show a weakness whereas a small change in any one of these variables would not have any effect on the final result. In other cases the combination of variables tend to balance each other.

GENERAL COMMENTS

Table 11 on Page 47 of the Revised Comprehensive Report shows the 47 variables that were found to effect the performance of flexible bases in the Loess Terrace Soil Area. Some of these variables were of secondary nature. It was possible to reduce these variables to a total of 16 that had important bearing on the performance of the pavements. These 16 variables were divided into three groups for the purpose of developing equations. These three groups are subgrade factor, pavement and base factor, and traffic factor. The variables included in each of these factors are shown on page 55 of the Revised Comprehensive Report. These three factors were then combined to produce a performance rating. This performance rating does not agree with the visual condition survey in a few locations because the defects causing the low performance rating have not produced signs of distress in the pavement at this time. These variables and the factors for each sample station are shown in Appendix B of the Revised Comprehensive Report.

SUMMARY AND RECOMMENDATIONS

All of the failures or weak sections of the Jobs in this list can be traced to one or more of the following things: Wet subgrade, loose subgrade, loose base, thin base, and low fatigue strength of the base material. In some cases it was evident that only one of these items caused the failure, but in many cases it was a combination of weaknesses in two or more of these items that caused the unsatisfactory performance of the pavement. It is evident from a study of the summary by stations that wide stabilized shoulders provided support to the outer wheel path and are always desirable. Previous road tests have proved that paved shoulders also helped.

The cracking of the pavement contributed materially to failures in some cases. This might be considered as a secondary cause of failure, because water entered the base and subgrade through these cracks causing failure.

The quality of the base material on these jobs was not the best. Much of the base on Job C and Job F proved to be plastic. Studies in recent years show that there is a continuous increase in the deformation of gravel bases with an increase in the number of wheel load applications. There is a very definite fatigue strength for the base. This is not as evident in crushed stone bases as it is in gravel bases. The lack of granular interlock and low internal friction causes the gravel bases to loosen and move laterally with an increase in the number of application of load. There was only one job in this study that had a crushed stone base. This was Job K, which is one of the secondary roads. This base has shown unusually good stability and strength, even though it has only a thin surface treatment to protect it. The quality of the base and pavement structure of this job compares very favorably with the best of the jobs having the high type pavement structure. There are not enough data available on crushed stone bases in this study to permit a more accurate comparison of the results. It is anticipated that crushed stone bases will be encountered in other areas where this study is to be conducted, so that a final analysis and comparison of the different types of bases will be possible.

The results of this study indicate that the minimum base thickness should be seven inches and the surface should be a minimum of two inches of high quality asphaltic concrete. A subbase of four to six inches is needed where there is a possibility that the subgrade will be wet. The shoulders should be a minimum of eight feet wide and stabilized. It is desirable that the ditches be deep enough to provide drainage for the base and subgrade. The danger of infiltration of the subgrade into the base material is always present and should be provided for in cases where the base does not have the proper gradation to prevent this.

There are many instances on these jobs where the pavement was saved by high density in the subgrade or base. In other cases a good quality subgrade was ruined by being loose. The top twelve inches of a subgrade should be compacted to a modified AASHO density of above 90 percent. A density of 95 percent of modified AASHO maximum should be achieved in the base material.

There is one instance where sealing of the pavement prolonged the life of pavement very materially. The pavement should be sealed as soon as cracks begin to appear on the surface.

All of these jobs were chosen on the Loess Terrace Soil Area, so that the quality of the subgrade would not vary greatly from job to job. This has proved successful on this project. This study indicates that more than 95 percent of the soil encountered in the Loess Terrace Soil Area is classified as A-4. It was anticipated in planning this job that the quality of the subgrade would not be variable and that this variable would be encountered when more than one Soil Area had been covered in later phases of this study.

Report shows
75% A-4
25% A-6

It was originally planned that the cost of maintenance of these jobs would be included in the work, but it was soon found that there is not enough detailed information on cost to justify a continuation of this part of the study. In many cases the cost of maintenance was shown only by Route and Section number. There was no indication as to whether the cost was chargeable to drainage, to structures, to mowing and general cleanup, or to the pavement and base. The maintenance cost developed on this basis would not be of value to this study.

There is no summary and comments of the condition and performance of the roads for the low type pavements. The conditions were so variable on these projects and they depreciated so rapidly that it was felt that any comparisons would not be valid to continue beyond these particular jobs. In most cases the ditches were shallow and full of water. The subgrade in many cases was extremely wet. The thickness in the base varied widely from job to job. In some cases there was only two or three inches of base on the job. An examination of the base indicated that compaction was very poor at the time it was constructed. There was evidence of the bituminous prime coat penetrating a distance of two inches into the base material even where the gradation of the base was such that it should have been much denser.

A combination of the studies of these low type pavement roads along with the visual observation of maintenance required give a very definite indication that the demands on the pavement structure for these roads are as high as for those high type roads that are classified as primary roads. It is realized that secondary roads are built with a very limited amount of money but a considerable saving would accrue to the State if the pavement structure on the low type pavement roads could be constructed to higher standards, even to the standards of the primary system. The alignment and grade of these low type pavement roads could still be constructed to secondary standards giving some saving in cost.

JOB A

Job A is in Cross County on State Highway No. 1 and extends from Vanndale north to the Poinsett County line. This Job is on the Westside of Crowley's Ridge and parallels it. The distance from the Ridge is about one-fourth mile. The drainage on this project is excellent. No water stands in the ditches. The ditches are fairly deep, thus providing good drainage for the base and subgrade.

The surfacing on this Job was 9.33 years old and consists of approximately two inches of asphaltic concrete. The first inspection of this Job revealed many isolated cracks in the pavement. These cracks were in each case a single crack extending for the entire width of the traffic lane and often for the entire width of the pavement, and varied in spacing from about 15 feet up to 30 or 40 feet. In some cases there was a distance of several hundred feet without cracks. Longitudinal cracks were also observed at the center line and near the center of each traffic lane. Tests on the asphalt cement extracted from this pavement showed that the ductility varied from 0 to 7 centimeters. The penetration varied from 13 to 29 with an average of 23.

A seal coat has been placed on this pavement recently and visual observations indicate most of the isolated cracks have been sealed. This seal coat will add materially to the life of the pavement.

STATION 3

The performance rating for this station is above the average for the Job and is considered as good. This is due to a good subgrade and compact base. The base is slightly thin.

STATION 5

This station has a very low performance rating. The subgrade has a P.I. of 20 and volumetric shrinkage of 45. The combined thickness of the base and pavement is only eight inches. The low performance rating and high deflection is due to the thin base and pavement on a poor subgrade.

STATION 7

The performance at this station is about average, even though the subgrade is of poor qualtiy. The density of the base and average moisture content of the subgrade saves the pavement.

STATION 9

The performance at this station is average for the Job. This average performance is possible despite a base thickness of four inches because the subgrade is a high quality and the subgrade is a high quality and the base has a density of 99 percent.

STATION 11

The performance of the pavement at this station is slightly below average, because of a thin and loose base. Low moisture content and a dense subgrade of high quality makes it possible for the road to carry the traffic.

STATION 13

Performance at this station is about average for the entire Job. The subgrade is of good quality, but the density is very low. The pavement at this station is saved by a good quality subgrade and high density in the base.

STATION 15

The performance of the pavement at this station is high because of a very good subgrade. The density of the base is low.

STATION 17

The performance of the pavement at this station is below average for the entire Job. The deflection is high and the deflection ratio is low.

STATION 19

The performance of the pavement at this location is average, due to a thick base that is compacted to 99 percent. The subgrade is loose and wet.

STATION 21

Performance of the pavement at this location is about average because of an average quality subgrade that is compacted to 93 percent and to a base thickness of nine inches, compacted to 96 percent.

STATION 23

The performance of the pavement at this station is low because of a thin base. Failure is only prevented by a good quality subgrade. The traffic factor was low due to the thin base.

STATION 25

Pavement performance at this station was above average. A good base saved a very poor subgrade.

STATION 27

The performance at this station was average. The subgrade was of good quality, but not very dense. The base was good except for a P.I. of 5.

STATION 33

The performance rating of this station was very high primarily due to a good but loose subgrade and eight inches of dense base.

STATION 35

The performance rating of this station was average. The subgrade was good, but a little wet and loose. The base was thin but very dense.

SUMMARY FOR JOB A

The performance of Job A is average for the six Jobs discussed here. This performance rating is also considered average on the basis of visual condition rating. The subgrade was variable but in most cases it had a low P.I. and low volumetric shrinkage. The density was deficient at some locations, the base density in most cases was satisfactory, and generally the base on this job is above average of all the Jobs under study.

Some of the reduction in performance rating is undoubtedly due to the isolated cracks that have occurred in the pavement. On the other hand, the seal coat that has been placed on the pavement has saved this job from a much worse rating.

The total thickness of nine inches for the pavement and base structure appears to be adequate for this job if the subgrade is compacted above 90 percent and the base is of good quality and well compacted. The failures on this Job were caused by a loose subgrade, a thin base, or a loose base, or a combination of these three factors. The shoulders of the road are adequate to protect the outer wheel path.

JOB C

All three rating factors for this Job were the lowest of the six Jobs discussed here. Drainage on this project is poor and the ditches hold water year around. The shoulders are very narrow and steep.

The pavement on Job C was in poor condition at the time this study started and deteriorated very rapidly during the course of the study. There were many patches and some areas have been completely resurfaced. It was not unusual to find locations where a second and sometimes a third patch had been put on the same place. In comparing this project with some of the better projects the entire length of this job would be considered as having a very poor performance rating. There were longitudinal and transverse cracks in the pavement. Rainwater had entered the base and subgrade through these cracks to the extent that failures of the entire pavement had occurred.

The results of the tests on the pavement itself were very erratic because of the many patches. Often patches were included in the samples of the pavement. Where it was possible to definitely identify the pavement as being of the original job, the ductility of the asphalt cement varied from about zero to five.

STATION 2

The performance at this station is below the average for this job, primarily due to the high moisture content and low density of the subgrade. The moisture content was some

10 percent above optimum and density was only 77 percent of maximum. A good base helped the performance.

STATION 5

The performance rating at this station is low primarily because of the high deflection in the outer wheel path. There is no support from the shoulder. The subgrade is fair. The base is thin.

STATION 8

The performance at this station is slightly below the average for the job. The subgrade is good, but not very dense. The base is not thick enough to help on a loose subgrade and narrow shoulders.

STATION 11

The performance at this station is very low. The deflection ratio for this station was only 370 with the outer path deflection being 0.095 inches. The base is 6 inches thick with 2.3 inches of pavement. The base density is 99 percent. The subgrade is excellent except for low density. A cracked pavement caused the high deflection.

STATION 14

The performance is considerably below the average for this job. This low performance is primarily due to a thin base, thus a low deflection ratio. The subgrade material is good and has good density.

STATION 17

The performance at this station is low due to a combination of factors. The density of the subgrade is only 73 percent. The base is only four inches thick, this causes the deflection in the outer wheel path to be very high.

STATION 20

The subgrade is about average with a 23 percent moisture content and an 80 percent density. The base is thin and loose. The performance at this station is slightly below the average because of the thin base and loose subgrade.

STATION 23

The poor performance here is due to a very poor and thin base. The subgrade density is low. The deflection is high and the radius of the deflection is very low, primarily due to the very thin base and low density in the base and subgrade.

STATION 26

The high performance rating of this station is due to a good subgrade and base. These factors combined produce the high performance rating.

STATION 29

A good subgrade and seven inches of base combined to produce a performance rating that is above the average of this job. The base has only 84 percent density.

STATION 32

The performance rating at this station is considerably above the average for the job. This high performance rating is primarily due to a low deflection and high deflection ratio.

The subgrade is poor, P.I. 24, volumetric shrinkage is 67 with only 85 percent density. The base is 5 inches thick with 2.2 inches of pavement. Local patching has produced a low deflection under the wheel.

STATION 35

The poor performance at this station is primarily due to the thin loose base. The base is only five inches thick and has a density of 90 percent and a P.I. of 10. The dry compact subgrade prevented a lower rating.

STATION 38

The good performance rating of this station is due primarily to a high deflection ratio. The base is seven inches thick and has a density of 94 percent. The subgrade is good, but the density is only 89 percent.

STATION 41

The low performance at this station is due to a combination of low density in the base and a plastic subgrade. The subgrade is of poor quality, having a P.I. of 23 and volumetric shrinkage of 56.

STATION 44

The performance at this station is the highest of any of this job. This high performance is due to a combination of low moisture content and high density in the subgrade plus a compact base.

STATION 48

The performance on this station is above the average for this job. This is due to a good subgrade with a low moisture content.

SUMMARY FOR JOB C

The causes of low performance on the job were often not clearly defined because of the condition of the pavement. Much of the pavement in the outer wheel path had been patched and repatched to the extent that the pavement was several inches thicker that at the center of the traffic lane where the samples were taken. There were several cases where high deflections were due to cracking of the pavement in the outer wheel path.

The major causes of failure of this job was the very narrow and steep shoulders along with the cracks in the pavement which admitted moisture to the subgrade, softening it, especially in the outer wheel path. Two important lessons can be learned from this project: First, the shoulders must be wide enough and stable enough to support the outer edge of the pavement and secondly, the surface must be sealed to prevent moisture from entering the base and subgrade.

JOB F

This Job is on the north end of Job A. It is on the west side of and parallels Crowley's Ridge. The north end of the Job (high station numbers) is on the lower slope of the Ridge. The surfacing of the Job shows the same type of cracking as Job A, but Job F was not sealed, and many of the cracks admitted enough water to the subgrade that the subgrade has completely failed. Most of the outer wheel path has required patching and in some cases completely resurfacing for considerable distances. The performance of the entire pavement is considered poor. The subgrade factor for this Job is one of the two highest of any of the projects studied, because the P.I. of the subgrade is consistently low except for one station and the volumetric shrinkage is low in most cases. The density of the subgrade is low, and only at one station does the moisture content exceed 20 percent. The base material is of poorer quality than that found on many of the jobs. The P.I. of the base is consistently 6 or 7 and the density of the base is generally below that of many of the jobs. The traffic factor is consistently low. The direct cause of the low deflection ratio is the low density of the base and subgrade, and the high P.I. of the base.

The performance rating of this project is poor.

STATION 2

The performance rating at this station is below the average for this job. The low performance rating is due to a thin base and pavement, and only 85 percent density of the base.

STATION 5

The performance at this station is average for the entire job. The subgrade is good, but the base is poor. The base has a density of only 87 percent and a P.I. of 6.

STATION 8

The performance rating of this station is below average primarily due to poor subgrade conditions. The moisture content of the subgrade is 22 percent and the density is 78 percent. The base is good at the station, except for a P.I. of 7.

STATION 11

The performance at this station is about average for this job. The subgrade has a P.I. of 6 and the volumetric shrinkage of 22, but the density is only 85 percent. The quality and the base thickness are the poor qualities of this station.

STATION 14

The performance of this station is average for this job. A high deflection and low deflection ratio is caused by a low density of the subgrade, and cracks in the pavement.

STATION 17

The performance rating here is above average for this project. The deflection ratio is fairly good and the deflection is low. The worst condition is the low subgrade density.

STATION 20

This station has the lowest performance rating of any station on this Job. This low performance is due to a combination of high P.I. subgrade with low density and only 4 inches of base under 1.8 inches of pavement. This thin base and high P.I. subgrade has caused high deflection and a very low deflection ratio.

STATION 23

Performance rating at this station is above average for this Job. The subgrade is fairly good. The cracking has produced a low deflection ratio.

STATION 26

Performance for this station is above the average. The high rating is primarily due to an excellent subgrade.

STATION 29

The performance rating at this station is average, it is held down by a poor base. The P.I. of the base is 7, and the density is 92 percent. The high density of good subgrade material and low moisture content was all that saved this station from failure.

STATION 32

The performance rating of this station is average for this job. The subgrade has low density, 85 percent, but is of good material.

STATION 35

The subgrade is good at this station with a moisture content of 11 percent and a density of 97 percent. The base is satisfactory. The deflection ratio is 1050, which is acceptable.

SUMMARY FOR JOB F

The prime reasons for failures of this job is the low density of the subgrade combined with a poor quality of base material. A minimum thickness of pavement and base should be nine inches. The density of the base is low and the density of the subgrade is very low. The low to non-existent ductility of the asphalt cement in the surface has contributed materially to the failure of this job.

JOB I_a

The age of this Job is 7.92 years. The surface of the pavement is in good condition having very few cracks, none of the cracking that characterizes Jobs A, C, and F. The shoulders are of average width and in fair condition. The drainage of this project is fairly good, and rarely is there any water standing in the ditches.

STATION 2

The performance rating at this station is fair to good because it has an excellent subgrade with a density of 91 percent and eight inches of base with a density of 93 percent.

STATION 5

The performance rating is only average for this Job. This is due to low density of the subgrade and base. The combination of these two allow a high deflection.

STATION 8

The performance at this station is fair to average. The subgrade and the base were loose. The base was thin.

STATION 11

The performance rating at this station is rated as poor because of a thin loose base. A good subgrade material has only 86 percent density.

STATION 14

The performance at this station is rated as excellent, primarily due to a 10 inch thick base. The subgrade is mediocre, having a P.I. of 12 and a density of 89 percent.

STATION 17

This station has a performance rating of fair. The moisture content of the subgrade is high. The pavement base factor is very high, because there is 12 inches of base under 2 inches of pavement.

STATION 20

This station has a poor performance rating because of a thin loose base with a P.I. of 8. The high deflection is due to the poor base.

STATION 24

The performance rating at this station is poor because of a thin base and loose subgrade. The base is only four inches thick.

STATION 27

The poor rating of this station is due to a damp subgrade with a density of 86 percent. The high deflection is due to a crack in the pavement.

STATION 29

The performance rating at this station is considered to be about average for the Job. The subgrade is poor. It has a density of only 85 percent and a P.I. of 17. The base is thin and loose. The samples are probably not representative of the exact location where the deflection was taken.

STATION 33

This station has a low performance rating because of a thin base and pavement. The base is five inches thick and the pavement 1.5 inches thick. The base has a density of only 84 percent. The deflection at this location is very high.

STATION 36

The pavement at this location is considered to be in a failure condition due to a very thin pavement and base. The base has a density of 88 percent.

SUMMARY FOR JOB I_a

The factors governing the performance rating of the Job were very erratic. The standard deviation in every case was high. The quality of the subgrade and the base were generally good, only in two cases did the P.I. of the subgrade exceed 7, but the density in many cases was low. The thickness of the base varied from 4 to 12 inches and the thickness of the pavement was less than 1.5 inches in two cases.

The poor performance rating of this Job is due to a combination of a low density of the subgrade and low combined thickness of the base and pavement. The base had a low density. It appears that the minimum total pavement structure for the soil and moisture conditions of this Job would be a minimum of nine inches. The subgrade must be compacted to good density, the base compacted to a minimum of 95 percent.

JOB J

This Job has the second highest performance rating of any of the the Jobs. The traffic factor rating is the highest, and the pavement and base factor rank second highest of any of the Jobs. The shoulders on this Job are wide and gravel stabilized. The drainage is good, and there is no water standing in the ditches. The subgrade moisture content varies between 12 percent and 23 percent.

STATION 1

The performance rating for this station is poor due to a subgrade that has a moisture content of 22 percent and a density of only 75 percent. The base is seven inches thick and has a density of 78 percent.

STATION 4

This station has a low performance rating because the subgrade is wet and loose.

STATION 8

This station has an excellent performance rating. It is the center of a paved intersection. The low moisture content of the subgrade and the subbase make the performance good.

STATION 10

This station has a performance rating of average to fair. The combination of subbase and average to good subgrade provide a high deflection ratio.

STATION 13

The performance at this station is fair to good. The low moisture content of the subgrade and a subbase substitutes for low densities.

STATION 17

This station has a below average performance rating. The moisture content of the subgrade is high and the density is low. The subbase is all that saves this station from complete failure.

STATION 20

This station rates as excellent due to a fair subgrade with a low moisture content and five inches of subbase.

STATION 23

The performance rating is fair. The subgrade is in poor condition. The base is only four inches thick and has a density of only 92 percent. Four inches of subbase save this pavement.

STATION 26

The performance at this station is average. The subgrade has a fair to good density and a low moisture content.

STATION 28

This station has a performance rating below average, because of a loose subgrade and a thin base.

SUMMARY FOR JOB J

The subgrade material is fairly good and where the moisture content is low it has considerable stability, even though the density of the subgrade is very deficient. The quality of the base material is satisfactory, but is lacking in density. The subbase saves this Job. The design would prove adequate if a better density could be maintained. The present moisture content of the subgrade is not high.

The ductility and penetration of the asphalt cement are low in places but not to the danger point. A seal coat will greatly extend its life when cracks begin to appear.

JOB M

This is the youngest of the Jobs studied. The performance of the subgrade, pavement, base, and the overall performance of this pavement structure is the highest of any of them. The traffic factor was the second highest of any of the jobs, however, it should be observed that the deviation for all of the four factors is high, ranging from 15 on performance to 22 on pavement and base factor. The shoulders on this road are wide, about ten feet, and have been stabilized with granular material. The drainage is good on this job, except that the roadside ditches are shallow when compared to other jobs.

The ductility of the asphalt cement in most cases is above 20 and the average penetration is about 35.

STATION 1

The performance of this station is rated below average. The subgrade is loose and of poor quality. The base is thick but loose.

STATION 4

The performance at this station was considered poor, because of a wet loose subgrade and thin base. The base density is low.

STATION 8

The performance rating is below average, primarily due to a wet subgrade and low density.

STATION 12

The performance at this station was excellent due to to 16 inches of base.

STATION 14 A

Station 14 A is opposite a small pond in which the water level was only about two feet below the crown of the road and about 20 feet from the shoulder. The performance at this station is rated as excellent, the subgrade was dry and of good quality. The base was adequate.

STATION 17

Performance was only fair at this station. The samples of subgrade and base are considered excellent. There was a variation between the location of the sample and the deflection point.

STATION 20

The performance rating is considered average to fair at this location. The density of the base and subgrade were low. A thick pavement and base saves this station.

STATION 23

The performance at this station is above average because of a thick dense base. The subgrade is dry but loose.

STATION 26

The quality of the subgrade is good, but density is low. The base and pavement are thick but the base is very loose. The performance rating is poor.

STATION 29

This station has an average performance rating because of a thick base. The density of the subgrade and base are low.

STATION 34

A very poor subgrade with a high moisture content and very low density. The base was loose.

STATION 37

This station has an average performance rating. The subgrade density is only 78 percent. The base is thick and dense.

SUMMARY FOR JOB M

The quality of the subgrade on this Job is good, except for stations 1 and 29, but the density is low in many cases, varying from 64 percent to a maximum of 89 percent. The P.I. of the subgrade is low. The base is generally thick but the density is erratic varying from a low of 77 percent to a high of 98 percent. The total thickness of the pavement structure varies from 17.9 inches down to 6.8 inches. The paving structure thickness is more than adequate for this subgrade, if the subgrade and base were both compacted to a better density.

TABLE 11

IBM 650 CODE - VARIABLES PUNCHED INTO CARDS

1. Card One			2. Card Two		
No.	Digit	Designation	No.	Digit	Designation
1	11-13	Subgrade, inplace density	31	11-12	High △ IWP
2	14-15	" inplace moisture	32	13-14	Average △ IWP
3	16-17	" percent compaction	33	15-16	Low △ IWP
4	18-19	" liquid limit	34	17-18	High △ OWP
5	20-21	" plasticity index	35	19-20	Average △ OWP
6	22-23	" shrinkage limit	36	21-22	Low △ OWP
7	24-26	" volumetric shrinkage	37	23-25	Ratio IWP - High
8	27-28	" % passing No. 200	38	26-28	Ratio IWP - Average
9	29-30	" % silt	39	29-31	Ratio IWP - Low
10	31-32	" % clay	40	32-34	Ratio OWP - High
11	33-34	" unconfined strength	41	35-37	Ratio OWP - Average
12	35-36	" Agricultural name	42	38-40	Ratio OWP - Low
13	37-39	Base, inplace density	43	41-42	Radius IWP - High
14	40-41	" percent compaction	44	43-44	Radius IWP - Low
15	42-43	" liquid limit	45	45-46	Radius OWP - High
16	44-45	" plasticity index	46	47-48	Radius OWP - Average
17	46-47	" % clay (-No. 40 only)	47	49-50	Radius OWP - Low
18	48-49	" thickness			
19	50-51	Pavement thickness			
20	52-54	Total structure thickness			
21	55-57	shoulder width			
22	58-60	ditch depth			
23	61-63	distance OWP △ to ditchline			
24	64-67	total EWL/lane (5000 lb)			
25	68-69	condition rating - average			
26	70-71	condition rating - minimum			
27	72-74	pavement age to 10/61			
28	75-76	asphalt penetration			
29	77-78	asphalt ductility			
30	79-80	asphalt softening point			

effect. Three groups resulting from this are:

A. Subgrade factors - (X)

Composed of liquid limit, plasticity index, inplace moisture content, and volumetric shrinkage.

B. Pavement and base factors - (Y)

Composed of pavement thickness, asphalt ductility, pavement age, and total structure thickness.

C. Traffic effect factor - (Z)

Composed of 5000-pound EWL per lane per day, pavement age, and outer wheel path ratio (or deflection).

Two variables that were expected to appear in the above grouping were subgrade percent compaction and base percent compaction. In the data obtained (see Table 13), these two variables had a coefficient of variation of 7.7 percent and 5.2 percent, respectively. They were therefore eliminated from consideration in this analysis. Other variables, such as shrinkage limit, had a sufficiently high coefficient of variation to be considered but it was necessary to obtain independent variables, and in this case volumetric shrinkage had a higher variation and also higher coefficients of correlation with other variables. These two variables are interrelated, and either one or the other could have been selected for further analysis. Each variable included in the "grouping" resulted from a similar consolidation.

Four nomographs were determined by trial and error to fit the data obtained from this study of roads in the Loess Terrace Soil area of eastern Arkansas. By regression analysis, using the IBM 650 computer, four equations were determined to replace the four nomographs.

TABLE 16

MEANS AND STANDARD DEVIATIONS BY JOBS FOR SUBGRADE FACTOR, PAVEMENT AND BASE FACTOR, TRAFFIC EFFECT FACTOR AND PERFORMANCE RATING (from Graphs)

Item	Job						
	A	C	F	Ia	J	M	ALL
No. Samples	15	16	12	12	10	12	77
Mean, $\bar{x}$							
Subgrade, X	59.5	45.9	60.3	57.3	53.3	60.7	55.9
Pave. and Base, Y	33.3	28.9	38.7	34.2	53.5	64.4	40.8
Traffic, Z	43.5	30.1	29.7	36.2	49.5	48.4	39.0
Perf. Rating, R	46.4	36.0	38.9	41.9	54.0	62.5	45.9
Std. Deviation σ							
Subgrade, X	16.8	15.2	20.4	19.4	17.4	25.9	19.9
Pave. and Base, Y	11.0	6.4	9.6	17.6	9.0	35.6	21.5
Traffic, Z	14.9	19.3	7.5	18.0	17.9	21.7	18.8
Perf. Rating, R	9.9	12.9	6.6	12.9	12.4	15.0	15.3

APPENDIX B

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] A-3	A-5	A-7	A-9	A-11	A-13	A-15	A-17
2	a	Subg. Inpl.-Moist.	18	16	17	18	15	20	17	13
3	b	Subg.-% Comp.	88	89	86	87	97	83	97	92
4	c	Subg. - LL	27	39	32	29	27	29	30	26
5	d	Subg. - PI	5	20	19	7	4	8	9	7
7	e	Subg. - VS	6	45	24	13	5	13	25	16
8	f	Subg.-% Pass 200	94	93	95	96	97	92	93	95
9	g	Subg.-% Silt	73	58	65	70	73	69	61	67
14	h	Base-% Comp.	96	92	99	99	92	98	88	91
15	j	Base - LL	16	16	18	18	18	17	19	19
16	k	Base - PI	0	0	0	0	0	0	0	3
18	l	Base - Thick	6	6	6	4	5	5	7	8
19	m	Pave. Thick.	2.0	1.9	2.1	2.4	2.0	2.0	2.1	2.0
20	n	Tot. Struct. Thick.	8.0	7.9	8.1	6.4	7.0	7.0	9.1	10.0
29	s	AC duct.	5	5	5	5	5	7	6	4
35	t	OWP defl.(x 10^{+3})	20	46	18	24	29	24	12	32
41	u	OWP ratio	1720	870	1770	1370	1210	1430	2120	1060
--	X	Subg. factor	71	22	44	62	72	54	53	75
--	Y	Pave.-Base factor	28	26	28	18	21	21	35	36
--	Z	Traffic factor	58	26	43	45	39	47	73	33
--	R	Perf. rating	55	31	44	44	42	46	65	41

NOTE:

[1] - Variable Number (See Table 14 for listing of variables).

[2] - Letter identification of variable used in equations.

[3] - See Table 14 for abbreviation used in identification.

[4] - Location by Job and Station, i.e., A-3 = Job A, Station 3.

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			A-19	A-21	A-23	A-25	A-27	A-33	A-35	C-2
2	a	Subg. Inpl.-Moist.	21	17	15	25	18	14	19	27
3	b	Subg.-% Comp.	78	93	92	76	88	88	86	77
4	c	Subg. - LL	29	33	27	27	25	26	30	28
5	d	Subg. - PI	12	10	5	6	5	4	8	6
7	e	Subg. - VS	15	14	3	12	3	10	16	22
8	f	Subg.-% Pass 200	96	98	98	96	94	94	95	98
9	g	Subg.-% Silt	65	68	77	68	76	68	63	66
14	h	Base-% Comp.	99	96	96	96	96	96	98	95
15	j	Base - LL	17	19	17	17	21	23	22	17
16	k	Base - PI	1	0	0	2	5	5	4	4
18	l	Base - Thick	11	9	5	8	8	8	6	7
19	m	Pave. Thick.	2.1	2.0	2.8	2.5	2.5	2.3	2.4	2.3
20	n	Tot. Struct. Thick.	13.1	11.0	7.8	10.5	10.5	10.3	8.4	9.3
29	s	AC duct.	5	2	3	5	7	5	5	31
35	t	OWP defl.(x 10^{+3})	22	25	26	18	32	20	27	52
41	u	OWP ratio	1180	1120	890	1230	1070	2370	1290	700
--	X	Subg. factor	45	63	85	39	75	79	54	28
--	Y	Pave.-Base factor	60	42	27	44	45	39	30	40
--	Z	Traffic factor	36	35	27	40	31	78	42	22
--	R	Perf. rating	46	43	37	45	42	71	44	31

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			C-5	C-8	C-11	C-14	C-17	C-20	C-23	C-26
2	a	Subg. Inpl.-Moist.	19	18	20	18	20	23	18	14
3	b	Subg.-% Comp.	88	86	83	91	73	80	84	93
4	c	Subg. - LL	24	26	28	26	30	25	26	26
5	d	Subg. - PI	2	7	7	5	9	0	4	4
7	e	Subg. - VS	16	18	26	20	30	15	16	21
8	f	Subg.-% Pass 200	97	97	99	99	99	99	98	99
9	g	Subg.-% Silt	64	59	55	66	63	51	70	63
14	h	Base-% Comp.	95	91	99	95	99	89	88	98
15	j	Base - LL	19	20	17	19	19	21	32	30
16	k	Base - PI	5	3	0	3	3	5	15	15
18	l	Base - Thick	6	6	6	4	4	5	4	6
19	m	Pave. Thick.	2.1	2.4	2.3	2.4	2.3	1.9	2.5	2.0
20	n	Tot. Struct. Thick.	8.1	8.4	8.3	6.4	6.3	6.9	6.5	8.0
29	s	AC duct.	5	8	14	14	30	41	10	5
35	t	OWP defl.(x 10^{+3})	62	56	95	70	91	45	49	13
41	u	OWP ratio	500	650	370	490	400	660	610	1700
--	X	Subg. factor	58	54	38	54	33	46	59	67
--	Y	Pave.-Base factor	28	30	32	19	21	26	19	27
--	Z	Traffic factor	15	20	10	14	11	21	19	60
--	R	Perf. rating	27	31	23	24	22	30	28	56

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] C-29	C-32	C-35	C-38	C-41	C-44	C-48	F-2
2	a	Subg. Inpl.-Moist.	17	14	12	16	17	13	16	16
3	b	Subg.-% Comp.	91	85	95	89	91	90	88	90
4	c	Subg. - LL	26	48	45	26	43	40	28	35
5	d	Subg. - PI	4	24	23	2	23	20	6	13
7	e	Subg. - VS	18	67	54	19	53	43	24	26
8	f	Subg.-% Pass 200	98	99	98	97	99	99	98	97
9	g	Subg.-% Silt	64	55	60	68	67	58	66	65
14	h	Base-% Comp.	84	94	90	94	84	95	92	85
15	j	Base - LL	20	19	24	19	23	20	24	18
16	k	Base - PI	2	5	10	5	7	5	9	6
18	l	Base - Thick	7	5	5	7	7	7	7	5
19	m	Pave. Thick.	2.1	2.2	2.2	2.2	2.3	2.3	1.8	1.5
20	n	Tot. Struct. Thick.	9.1	7.2	7.2	9.2	9.3	9.3	8.8	6.5
29	s	AC duct.	10	7	5	16	5	5	12	5
35	t	OWP defl. (x 10^{+3})	24	14	67	18	39	16	23	31
41	u	OWP ratio	1020	1580	430	1570	690	1980	1120	770
--	X	Subg. factor	60	29	36	64	18	35	56	49
--	Y	Pave.-Base factor	35	23	22	37	35	35	33	23
--	Z	Traffic factor	35	56	12	55	22	71	38	25
--	R	Perf. rating	41	50	23	55	30	62	43	32

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			F-5	F-8	F-11	F-14	F-17	F-20	F-23	F-26
2	a	Subg. Inpl.-Moist.	18	22	16	18	19	15	16	11
3	b	Subg.-% Comp.	88	78	85	84	80	84	89	94
4	c	Subg. - LL	26	40	28	26	25	47	25	22
5	d	Subg. - PI	3	16	6	5	2	20	0	3
7	e	Subg. - VS	12	30	22	14	18	49	10	16
8	f	Subg.-% Pass 200	95	98	89	97	96	98	98	84
9	g	Subg.-% Silt	66	62	57	53	67	59	68	53
14	h	Base-% Comp.	87	94	92	92	95	87	98	92
15	j	Base - LL	18	18	18	18	18	16	16	18
16	k	Base - PI	6	7	7	7	7	6	6	7
18	l	Base - Thick	6	8	6	7	8	4	9	7
19	m	Pave. Thick.	1.8	2.3	2.0	1.9	2.1	1.8	2.2	2.3
20	n	Tot. Struct. Thick.	7.8	10.3	8.0	8.9	10.1	5.8	11.2	9.3
29	s	AC duct.	6	6	8	6	2	6	5	8
35	t	OWP defl.(x 10^{+3})	26	39	30	41	25	55	27	26
41	u	OWP ratio	1050	720	1030	590	1040	510	890	1020
--	X	Subg. factor	66	23	58	62	55	28	77	84
--	Y	Pave.-Base factor	32	48	34	40	46	20	54	43
--	Z	Traffic factor	36	23	35	18	36	15	30	35
--	R	Perf. rating	42	34	41	32	44	23	43	45

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]							
			F-29	F-32	F-35	I-2	I-5	I-8	I-11	I-14
2	a	Subg. Inpl.-Moist.	8	19	11	15	14	19	19	19
3	b	Subg.-% Comp.	97	85	97	91	80	79	86	89
4	c	Subg. - LL	25	27	28	27	30	26	28	35
5	d	Subg. - PI	3	5	3	3	7	0	3	12
7	e	Subg. - VS	8	19	24	11	17	12	15	35
8	f	Subg.-% Pass 200	73	97	85	97	98	99	98	99
9	g	Subg.-% Silt	47	67	57	66	69	63	68	66
14	h	Base-% Comp.	92	92	97	93	88	82	91	91
15	j	Base - LL	18	16	16	19	17	18	20	20
16	k	Base - PI	7	4	4	0	2	0	4	2
18	l	Base - Thick	8	7	7	8	9	6	5	10
19	m	Pave. Thick.	2.1	1.8	1.7	2.1	2.1	1.7	1.8	1.7
20	n	Tot. Struct. Thick.	10.1	8.8	8.7	10.1	11.1	7.7	6.8	11.7
29	s	AC duct.	9	3	6	30	14	5	24	33
35	t	OWP defl.(x 10^{+3})	24	22	24	25	49	24	36	15
41	u	OWP ratio	940	1050	1050	1470	770	1250	850	2060
--	X	Subg. factor	95	52	75	77	71	64	59	28
--	Y	Pave.-Base factor	48	38	38	49	52	29	26	59
--	Z	Traffic factor	32	36	36	57	30	48	33	80
--	R	Perf. rating	45	42	44	59	43	49	38	72

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] I-17	I-20	I-24	I-27	I-29	I-33	I-36
2	a	Subg. Inpl.-Moist.	21	13	15	19	20	12	16
3	b	Subg.-% Comp.	92	96	82	86	85	99	92
4	c	Subg. - LL	31	26	29	27	44	33	27
5	d	Subg. - PI	6	4	6	4	17	6	4
7	e	Subg. - VS	19	15	17	12	44	27	12
8	f	Subg.-% Pass 200	99	99	99	93	99	99	99
9	g	Subg.-% Silt	69	70	70	63	64	70	71
14	h	Base-% Comp.	90	86	99	86	85	84	88
15	j	Base - LL	19	23	20	20	21	20	20
16	k	Base - PI	1	8	0	0	0	6	0
18	l	Base - Thick	12	4	4	7	5	5	4
19	m	Pave. Thick.	1.9	2.2	1.9	1.4	1.2	1.5	1.6
20	n	Tot. Struct. Thick.	13.9	6.2	5.9	8.4	6.2	6.5	5.6
29	s	AC duct.	12	8	5	4	19	8	3
35	t	OWP defl.(x 10^{+3})	30	65	52	94	26	54	84
41	u	OWP ratio	970	550	640	380	1150	590	440
--	X	Subg. factor	45	78	68	61	12	53	72
--	Y	Pave.-Base factor	69	20	17	33	21	21	15
--	Z	Traffic factor	38	22	25	15	45	23	18
--	R	Perf. rating	49	32	32	29	41	31	28

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] J-1	J-4	J-8	J-10	J-13	J-17	J-20	J-23
2	a	Subg. Inpl.-Moist.	22	23	12	17	15	20	16	21
3	b	Subg.-% Comp.	75	75	80	88	82	80	88	83
4	c	Subg. - LL	36	31	30	32	32	25	16	34
5	d	Subg. - PI	14	7	6	7	8	0	0	10
7	e	Subg. - VS	30	17	26	29	27	11	8	30
8	f	Subg.-% Pass 200	99	96	97	76	97	95	53	88
9	g	Subg.-% Silt	67	69	67	57	61	75	30	54
14	h	Base-% Comp.	87	93	90	94	92	91	94	92
15	j	Base - LL	20	21	18	20	24	20	19	20
16	k	Base - PI	3	0	0	0	8	0	2	2
18	l	Base - Thick	7	7	4	6	6	5	5	4
19	m	Pave. Thick.	1.8	1.9	2.0	2.2	2.1	2.0	1.8	1.8
20	n	Tot. Struct. Thick.	8.8	8.9	6.0	8.2	8.1	7.0	6.8	5.8
29	s	AC duct.	8	5	4	9	7	40	26	20
35	t	OWP defl.(x 10^{+3})	51	39	14	30	21	41	16	22
41	u	OWP ratio	620	920	2200	1000	1470	770	1720	1230
--	X	Subg. factor	24	40	68	46	55	62	77	29
--	Y	Pave.-Base factor	40	53	54	50	49	64	56	42
--	Z	Traffic factor	27	38	87	42	59	32	69	50
--	R	Perf. rating	35	46	79	48	59	46	68	50

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4] J-26	J-28	M-1	M-4	M-8	M-12	M-14A	M-17
2	a	Subg. Inpl.-Moist.	15	12	18	24	19	18	12	12
3	b	Subg.-% Comp.	91	83	85	81	81	84	89	89
4	c	Subg. - LL	22	24	35	31	27	26	26	26
5	d	Subg. - PI	6	0	12	9	0	1	3	0
7	e	Subg. - VS	24	18	49	26	12	8	12	15
8	f	Subg.-% Pass 200	90	66	94	99	93	99	99	76
9	g	Subg.-% Silt	58	38	60	65	70	67	65	52
14	h	Base-% Comp.	90	92	92	91	94	91	94	96
15	j	Base - LL	21	20	19	20	18	18	18	18
16	k	Base - PI	0	0	4	4	0	0	2	0
18	l	Base - Thick	5	4	12	5	8	16	8	10
19	m	Pave. Thick.	1.6	1.9	2.4	1.8	2.0	1.9	2.1	2.2
20	n	Tot. Struct. Thick.	6.6	5.9	14.4	6.8	10.0	17.9	10.1	12.2
29	s	AC duct.	15	14	67	21	8	7	24	39
35	t	OWP defl.(x 10^{+3})	22	41	28	53	42	7	14	31
41	u	OWP ratio	1410	800	840	680	720	2200	2200	960
--	X	Subg. factor	58	80	21	25	64	72	86	85
--	Y	Pave.-Base factor	72	55	90	38	56	100	59	72
--	Z	Traffic factor	57	34	41	35	37	97	93	46
--	R	Perf. rating	63	46	54	39	47	95	85	58

APPENDIX B (continued)

SUMMARY OF DATA BY STATION

Col. I[1]	Col. II[2]	Identification[3]	Location[4]					
			M-20	M-23	M-26	M-29	M-34	M-37
2	a	Subg. Inpl.-Moist	17	11	17	18	23	13
3	b	Subg.-% Comp.	82	74	81	79	64	78
4	c	Subg. - LL	27	27	28	36	33	27
5	d	Subg. - PI	6	0	4	14	7	0
7	e	Subg. - VS	22	12	9	32	26	2
8	f	Subg.-% Pass 200	94	48	92	98	99	35
9	g	Subg.-% Silt	64	18	59	58	65	20
14	h	Base-% Comp.	89	95	77	90	88	98
15	j	Base - LL	17	17	18	18	18	18
16	k	Base - PI	1	0	0	0	1	0
18	l	Base - Thick	9	12	10	10	9	10
19	m	Pave. Thick.	3.1	2.6	2.3	1.9	2.6	1.9
20	n	Tot. Struct. Thick.	12.1	14.6	12.3	11.9	11.6	11.9
29	s	AC duct.	24	36	10	13	32	33
35	t	OWP defl.(x 10^{+3})	19	15	16	20	25	25
41	u	OWP ratio	1190	1350	980	1510	920	1100
--	X	Subg. factor	54	90	72	35	29	95
--	Y	Pave.-Base factor	73	89	71	72	71	72
--	Z	Traffic factor	55	61	47	67	44	51
--	R	Perf. rating	63	71	57	67	57	62