MOISTURE AND COMPACTION CONTROL, AND DETERMINATION OF CEMENT CONTENT

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This report is a description of field tests performed and results obtained on a 24-mile soil-cement project located on State Route No. 15 in north-eastern Mississippi. The discussion includes field laboratory control of moisture and compaction and a method for determining the cement content of the soil-cement mixture. Data for each of these tests showing the results obtained are given in Table 7.

Roadway Density Prior to Stabilization: A roadbuilding machine was used to mix the soil and cement. This machine was designed to mix one-half of the roadway, and mixing was accomplished by lowering a cutting drum to the depth required to yield a six-inch stabilized base. The depth cut by the machine was adjustable and depended on the densities of the raw soil and the completed base.

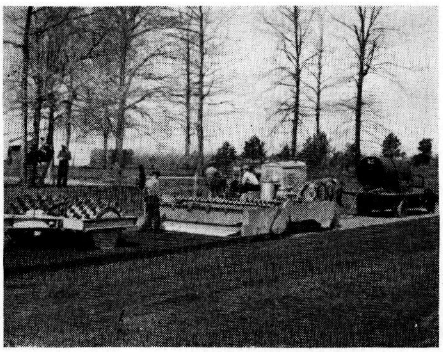

Figure 1. The roadbuilding machine mixing the soil-cement, with the truck tank ahead and the roller behind.

Prior to processing the soil the roadway was brought to plan grade and cross-section and the density of the material in the top six inches was determined at intervals of 1,000 ft., or less in event of a change in soil type. These density checks were made by drilling to the desired depth with a 4-in. auger. The soil removed was weighed and the moisture content determined. The volume of the hole was found by the sand method.

From the raw soil density and the density anticipated for the compacted processed material, the exact cutting-depth for the mixing machine was determined. The product of the desired depth in inches of compacted material and the ratio of the final desired density (less the cement included in the mixture which equaled 7.5 per cent of the dry weight of the soil-cement mixture) to the density of the raw roadway material determined the depth the machine should cut. See Table 1.

Figure 2. Determining the density and depth of the compacted soil-cement base

Optimum Moisture and Maximum Density: The soil-cement mixture was designed on average soil samples taken from the roadway prior to the awarding of the contract. This test work, consisting of moisture-density, wetting and drying, and freezing and thawing tests, was done independently by the department laboratory in Jackson, by the district laboratory in Tupelo, and by the Portland Cement Association. Based on these tests results it was decided to use 7 per cent by dry weight of the mixture which was equivalent to 9 per cent by volume or 0.405 bags per sq. yd. of 6 in. compacted depth. Soon after the construction began, chemical determinations revealed that in some areas the cement content was less than the designed value. To offset this condition the cement content was increased to 7.5 per cent by dry weight of the mixture which was equivalent to 9.56 per cent cement by volume or 0.430 bags per sq. yd. of 6 in. compacted depth.

For more accurate control during construction the grading of the soil was determined at intervals of 200 ft. The groups encountered are given in Table 8. From these gradings it was possible to segregate the soils into more specific types than used in the original design. Representative samples of these various types were submitted to the district laboratory and moisture-density curves of the soil-cement mixtures established. These curves were returned and posted in the field laboratory. Full information was available concerning the soil types to be encountered at each station before the paving operations began.

Field Check on Optimum Moisture During Mixing and Compacting Operations: The amount of water added to the soil-cement was, of course, the difference between the moisture content of the raw soil and that required in the compacted mix. With the data at hand, an inspector was stationed immediately behind the mixing machine to control the amount of water to be added. At frequent intervals samples were taken behind the machine and the percentage of moisture determined in order to insure the proper moisture content. As a result of preliminary laboratory tests on these particular soils an effort was made to maintain the moisture content of the processed material slightly below the optimum. On most soils, moisture should be maintained at the optimum or slightly above. When necessary during the progress of compaction water was added by means of gravity sprinklers mounted on trucks. This additional moisture was required especially during warm weather and when construction delay lengthened the time between the mixing and compacting operations.

Field Check on Optimum Moisture and Maximum Density Curve: In accordance with the variations of soil types additional moisture-density determinations were made on the moist processed

TABLE 1

EXAMPLES OF DETERMINATION OF DEPTH TO BE CUT

Station	Roadway density lb. per cu. ft.	Compacted soil-cement density anticipated lb. per cu. ft.	Depth to be cut in.	Depth obtained in.
777+00	128.0	116.0	$\frac{116-(0.075\text{x}116)}{128}$ x 6=5.0	6.0
785+00	120.0	116.0	$\frac{116-(0.075\text{x}116)}{120}$ x 6=5.4	5.85

material immediately behind the mixer. This was done at frequent intervals and the curves thus established served to keep the optimum moisture and maximum density accurately adjusted. Further, at intervals of approximately 500 ft. or closer if a change in soil type existed, samples of the moist processed material were taken prior to compaction and cylinders molded according to the Proctor Method. Generally these mixtures were molded without the addition of more water; however, in instances where evaporation occurred between the time of sampling and the time of molding, sufficient water was added to produce the designed moisture content. These specimens were properly labeled and sent to the district laboratory for curing and a durability test, which consisted of alternate wetting and drying cycles with brushing at the completion of each cycle. The loss due to brushing measured as a percentage of the dry weight of the specimen was recorded. The freezing and thawing durability test was not performed because earlier investigations of soil-cement mixtures in connection with this project revealed that the wetting and drying test was the more critical for this particular soil.

TABLE 2
EXAMPLE OF MOISTURE CONTROL

Station	Moisture content				
	Raw soil	Optimum soil-cement mixture	Desired	Behind mixer	At completion of compaction
	%	%	%	%	%
225+00	11.6	16	15	14.6	14 5
287+00	11 5	16	15	14.5	14.1

TABLE 3
DURABILITY OF SPECIMENS MOLDED IN THE FIELD LABORATORY
Wetting and Drying Test

Station	Moisture content	Density Proctor cylinder lb. per cu. ft.	Loss from brushing	Cement content		Density of compacted material lb. per cu. ft.
				By weight	By volume	
	%		%	%	%	
854+00	11.9	115.2	13.4	6.6	8.1	118.0
863+00	14.2	113.8	29.3	7.5	9.1	113.8
900+00	14.6	118.0	20.3	6.7	8.4	123.4
972+50	13.7	115.2	7.9	7.5	9.2	118.8
976+00	12.9	117.6	10.3	7.0	8.8	124.9
1061+00	13.6	116.2	11.5	7.2	8.9	116.0

For the purpose of additional information in correlating data, the cement content of each cylinder was determined by an analytical method described later.

Density and Depth Obtained in the Roadway: On completion of the compacting and finishing operations, the density and thickness of the completed work was determined. These checks were made at intervals of 200 ft. and at random points on the cross-section. Since the joints were compacted by hand, the density here was also determined. The method of checking the density of the completed base was the same as that used in connection with the raw roadway soil. Note that in the representative data in Table 4 the densities are shown at various depths of compaction. It should be noted that the top densities, which are most important, are lower than the densities toward the bottom.

acid solution, and digested on a hot plate for 15 min. After digestion, add water to make 200 cc. (Distilled water is used throughout the procedure.) Allow the solution to boil and set aside to cool. Next add 30 cc. of 1:1 ammonium hydroxide solution and bring again to the boiling point. The ammonium hydroxide neutralizes the excess acid and precipitates the iron and aluminum as hydroxides. Filter hot and wash repeatedly with

TABLE 4

REPRESENTATIVE DENSITY DATA

Station	Position	Depth in	Density lb. per cu. ft. dry wt.	Theoretical max. density lb. per cu. ft. dry wt	Percentage of theoretical max. density
799+00	Rt.	0–2	115.3	115 0	100.2
		2–4	119.8		104.1
		4–6	119 6		104 0
		Ave.	118 2		102 8
806+00	Rt.	0–2	116.3	116.0	100.2
		2–6	120 2		103 6
		Ave.	118 2		101 9
970+00	Lt.	0–6	115.5	114.0	101 3
	Rt.	0–6	116.1		101.8
1177+00	Lt.	0–3	109.0	114 0	95 6
		3–6	112.4		98 5
		Ave.	110.7		97 0
1204+00	Rt.	0–3	112.7	114.0	98 8
		3–6	119.3		104.6
		Ave.	116 0		101.7

Determination of the Cement Content of the Soil-Cement Mixture: A representative portion (approximately 15 lb.) of the processed material was taken from the roadway behind the mixing machine. A representative sample of raw soil was obtained at the same time and location together with a representative sample of cement. Tests were run on these samples.

First, about 200 g. of the soil-cement mixture are thoroughly dried and pulverized. A 5-g. sample of this is weighed and placed in a 250-cc. erlenmeyer flask, covered with 25 cc. of 1:1 hydrochloric

hot water. Collect the filtrate in a 500-cc. wide-mouth erlenmeyer flash and place on the hot plate. When the solution boils add 25-cc. of a saturated solution of ammonium oxalate. The filtrate thus treated should contain a slight excess of ammonium hydroxide. Calcium will precipitate as calcium oxalate, which should be filtered off and washed with a small quantity of hot water.

Wash the precipitate of calcium oxalate back into the original 500-cc. erlenmeyer flask, add water to make 200 cc., and dissolve with 25 cc. of 1:4 sulphuric acid. Bring the dissolved oxalate to the boiling point and titrate with a potassium permanganate solution of known normality. An approximately 0.3 N solution is best. From values thus obtained the calcium content may be computed. One cc. of a 0.1 N potassium permanganate solution is equivalent to 0.002004 g. of calcium.

Along with the processed material an analysis is made on a companion sample composed of an accurately weighed 5 g. portion of raw soil to which has been added enough cement to equal 7.5 per cent of the dry weight of the mixture. This is made by mixing 0.375 g. of cement with 4.625 g. of the soil. The soil and cement used are those obtained from construction operations as previously mentioned. This analysis furnishes a factor, the calcium-cement ratio, which is used in computing the grams of cement in the 5-g. sample of processed material analyzed. Determination of this factor is essential due to variations in the calcium content of the soil and of the cement, thus eliminating possible error in assuming a constant factor.

Prior to field laboratory work, the accuracy of this method was determined. Experimental data are tabulated in Table 5.

TABLE 5

No.	Wt. g.	Calcium-cement factor	Calcium g.	Cement g.	Cement recovered %	Cement placed %	Diff.	Efficiency of mixing and sampling %
1	5	0.4363	0 1527	0.3499	7 00	7.00	0 00	100.00
2	5	0 4363	0.1484	0.3401	6.80	7.00	−0.20	97.14
3	5	0.4363	0.1525	0.3494	6.99	7.00	−0.01	99.86
4	5	0.4363	0.1505	0.3449	6.90	7.00	−0.10	98.57
5	5	0.4363	0 1492	0.3420	6.84	7.00	−0.16	97.71
6	5	0.4363	0.1528	0 3502	7.00	7.00	0.00	100.00
7	5	0.4363	0.1475	0.3380	6 76	7.00	−0.24	96.57
8	5	0.4363	0.1293	0.2964	5.93	6 00	−0.07	98.83
9	5	0.4363	0.1483	0.3399	6 80	7.00	−0 20	97.14
10	10	0.4363	0.2954	0.6771	6.77	7.00	−0.23	96 71

NOTE: The average difference between the cement recovered and the cement placed is −0.12 and the average per cent efficiency of mixing and sampling is 98.25.

The above samples were taken from 2500 g. mixtures of sand-clay and portland cement. The soil was taken from the top six inches of the roadway on S. P. 15-1269 A. The factor was obtained by analysis of five gram mixtures containing 0.350 g. of cement and 4.650 g. of soil.

Sample No. 9 represents the primed portion of a cylinder molded according to the Proctor Method and primed with T-C 1 at 140°F.

SUMMARY

Moisture Density Control: In this report, which places emphasis on field laboratory tests for the control of construction operations, it is shown that it is possible to approach closely the desired results. In the first twelve miles of construction, it was found that the average moisture content of the raw soil was 11.6 per cent. The average moisture contained in the mix at the time of compaction was 13.2 per cent as compared to the predetermined optimum of 13.5 per cent. This is excellent moisture control. The average density obtained in the soil-cement base was 113.2 lb. per cu. ft. (dry weight) as compared to an average theoretical maximum of 115 lb. or 98.5 per cent of the theoretical value.

In the second twelve miles the average moisture content of the raw soil was again 11.6 per cent. In this section the

TABLE 6

REPRESENTATIVE CEMENT DETERMINATIONS

Processed material taken behind the mixing machine

Station	Design cement %	Depth of sample in.	Cement recovered %
51+00	7.5	0–1	5.8
		1–6	8.2
95+00	7.5	0–1	7.3
		1–6	7.9
743+00	7.5	0–3	7.5
		3–6	7.9
799+00	7.0	0–2	5.9
		2–3	7 2
		3–6	5.5
817+00	7.0	0–6	6.5
854+00	7.0	0–6	6.6
855+00	7.0	0–6	6.3
863+00	7.0	0–6	7.5
888+00	7.0	0–6	6.9
972+00	7.5	0–6	7.5
976+75	7.5	0–6	7 0
1008+00	7.5	0–6	7.3
1019+00	7.5	0–6	7.2
1027+00	7.5	0–6	6.9
1055+00	7.5	0–6	7.3
1061+00	7.5	0–6	7.2
1066+00	7.5	0–6	7 8
1222+00	7.5	0–6	7.0
1253+00	7.5	0–6	7.6

moisture contained during compaction averaged 14.3 per cent as compared to the predetermined optimum of 15.9 per cent. The data from the first twelve miles show that closer control than this can be obtained. The moisture content obtained on this second twelve miles is lower than is desirable for these mixtures. The average density obtained as a result of field compaction was 114 lb. as compared to the theoretical maximum density of 117 lb. or 97.5 per cent of the theoretical value.

It will be noted that the density control was quite close but varied, as was to be expected, with the accuracy of moisture control.

Determination of Cement Content: The method for determining the cement content of a soil-cement mixture was found to give accurate and informative results. From over 50 tests on soil-cement mixtures of known quantity of cement, the average results obtained were 98 per cent of the known quantity. That is to say, when a mixture containing 7 per cent cement by weight was analyzed, 6.86 per cent was reclaimed.

Since the calcium content varies with different soil types and also varies somewhat with different shipments of cement, for extreme accuracy it is essential that a test be made first to determine the calcium content of each. This, however, is best accomplished by mixing the soil and cement and determining the calcium content of the mixture. This is advisable with each soil type encountered and with each shipment of cement. On this 24-mile project the cement was shipped from one source and the calcium content was found to be fairly uniform. Some variation was found in the calcium content of the soil.

On a four-mile section where 7 per cent cement was specified in the design, 19 samples were tested and were found to contain an average of 6.8 per cent. An 8-mile section on which was specified 7.5 per cent cement, 25 samples were observed to have an average cement content of 7.2 per cent.

TABLE 7

SOIL-CEMENT FIELD TEST DATA

SUMMARY

S. P. 15-1269-A, C and D Chickasaw and Pontotoc Counties, Mississippi

Station	Moisture in raw roadway soil— %	Density of raw roadway soil— lbs. per cu. ft. (dry weight)	Moisture in processed material behind mixer %	Optimum moisture %	Theoretical maximum density— lbs. per cu. ft. (dry weight)	Density of compacted roadway material lbs. per cu. ft. (dry weight)	Depth of compacted roadway material in.	Soil type (See Table 8)
	1	2	3	4	5	6	7	8
27+00	....	.. ..	15.0	16.0	118	111.8	6.25	6
37+00	11.3	112.8	13.2	16.0	119	113.5	6.0	7
55+00	....	....	13 4	14.5	115	113 6	6.0	2
60+80	9.9	123.6	15.2	14.5	115	114.8	6 2	8
70+00	....	.....	12.8	14.5	115	107.9	6.2	8
79+00	....	.....	14.3	16.0	119	111.3	6.2	7
88+00	....	.. ..	15.0	16.0	118	118.5	6.0	6
97+00	....	.....	15.0	14.5	115	116 1	6.0	2
107+00	....	.....	15 0	14.5	115	103 9	5.7	2
117+00	....	.....	13.6	16.0	119	117.6	5.7	7
127+00	....	.. ..	14.5	14.5	115	111.0	5.9	2
137+00	....	.....	16 5	14.5	115	113.2	6.25	2
158+50	10.5	122.9	11 5	16 0	118	116.6	5.9	6
171+00	....	.....	16.5	16.0	119	127.0	5.0	7
181+00	....	.....	14 1	16 0	118	122.8	5 5	6
191+00	....	.....	15.3	16.0	119	110 1	6 0	7
201+00	....	.....	14 1	16.0	118	112 8	6 4	6
211+00	....	.....	13.4	16.0	119	111.7	6.0	7
221+00	11.6	124.8	14.5	16.0	118	113.6	6.4	6
231+00	9.6	127.0	13.5	16.0	118	112.5	7.5	6
255+00	....	.....	12.5	16.0	119	113.0	6.25	7
269+00	....	.. ..	12.0	16 0	119	118.0	6 25	7
287+00	....	.....	14.5	16.0	118	119 6	5.4	6
297+00	....	.....	14.6	16.0	119	115.7	6.75	7
317+00	....	.....	15.5	16.5	114	116.8	6.5	5
327+00	....	.....	13 5	16.0	118	115.1	6 4	6
337+00	10.7	129.1	15 5	16.0	119	114.2	6.4	7
349+00	13.1	128.1	14.2	16.0	118	110.8	7.5	6
359+00	13.4	123.0	14 1	16.5	114	112 1	6.4	5
369+00	....	.....	14.6	16 0	119	119.6	5.5	7
379+00	12.3	128.0	13.6	16.0	118	123.1	5.75	6
389+00	11 1	124 0	12 4	16.0	118	120 2	6.2	6
401+00	....	.....	13 0	16 0	118	111.5	6.25	6
411+00	....	.....	14.5	16.0	118	102 3	6.0	6
433+00	....	.....	13.9	16.0	118	109.1	6 2	6
463+00	....	.....	14.1	16.0	119	109.9	5.7	7
483+00	....	.....	14.6	16.0	118	116.6	4.5	6
503+00	....	.....	13.3	16.0	118	119.0	6.5	6
523+00	11.7	123 8	15 2	16.0	119	118.6	6 25	7
533+00	12.9	126.2	15.5	16.0	119	105.0	6.25	7
555+00	13.4	126.9	14 0	16.0	119	116.1	6.5	7
565+00	12 5	128.5	12.7	16.0	119	113.7	5.75	7
585+00	...	.....	16 0	16 0	118	115.1	5.75	6
595+00	12.7	122.5	13.0	16.0	118	109.7	6.9	6
603+00	12 5	124.2	16 8	16.0	118	121.6	5.9	6
613+00	12.5	124.9	16 0	16 0	118	118.1	5 5	6
622+00	11.3	128.8	15 2	16.5	114	117.3	5.9	5
633+00	....	.....	13.9	16.5	114	108.1	5.75	5

TABLE 7—*Continued*

Station	Moisture in raw roadway soil—%	Density of raw roadway soil—lbs. per cu. ft. (dry weight)	Moisture in processed material behind mixer %	Optimum moisture %	Theoretical maximum density—lbs. per cu. ft. (dry weight)	Density of compacted roadway material lbs. per cu. ft (dry weight)	Depth of compacted roadway material in.	Soil type (See Table 8)
	1	2	3	4	5	6	7	8
643+00	10.6	136.2	11.2	16.0	118	113.7	5.8	6
654+75	10.9	127.4	13.6	16.0	118	111 9	6 8	6
665+00	....	.....	13.0	14.5	115	105.1	5.2	2
685+00	12.4	124.1	13.1	14.0	116	108.8	5.25	1
695+00	12.9	117.1	14.1	14.5	115	103.1	5.75	2
705+00	....	.....	11.9	14.0	116	117 6	6.5	1
715+00	....	.....	12.5	14.0	116	112.4	6 75	1
733+00	.. .	.....	15.6	13.0	114	111.8	7 5	3
743+00	....	.. ..	12 4	13.0	114	108.8	6.75	3
753+00	....	.....	13.2	14.0	116	109.3	6.0	1
763+00	10.3	122.2	14.0	14.5	118	113 9	6.25	4
773+00	10.1	127.1	14.1	13.0	114	119.3	5.2	3
782+00	10.5	127.0	11.1	13.0	114	110.4	7.0	3
792+00	13 0	125.5	15.0	14.0	116	114.7	6.0	1
802+00	10 6	133.4	14.6	13.0	114	112.5	6.2	3
812+00	11.5	115.0	11.9	14 5	115	100.4	6.0	2
841+00	....	... .	12.8	13.0	114	104.5	6.6	3
850+00	....	.....	11.1	13.0	114	111.5	5 6	3
886+20	11.4	125.0	16.0	13.0	114	123.1	5.7	3
894+05	....	.....	14.5	14.5	115	114.3	6.5	2
904+00	....	.....	15 1	14.5	118	112 1	5.9	4
912+00	....	.....	15.2	13.0	114	117.1	6.0	3
939+00	....	.....	13.8	13.0	114	111.8	6 0	3
959+00	....	.....	13.2	13.0	114	121.0	6.1	3
967+00	....	.....	13.7	14.5	118	113.6	6.0	4
978+00	....	.....	12.8	14.0	116	117 5	5.75	1
988+00	....	.....	12.9	13.0	114	114.9	6.25	3
998+00	10.2	128.8	14.0	14.5	118	126.3	6.1	4
1008+00	11 1	120.7	12.1	13.0	114	119.7	6 0	3
1018+00	....	.....	13.5	13.0	114	116.1	5.75	3
1029+00	....	.....	14.4	14.0	116	117.5	6.6	1
1039+00	....	.....	13.0	14 0	116	110.5	6 1	1
1049+00	....	.....	11.6	13.0	114	117.4	5.75	3
1059+00	....	.....	12.5	14.0	116	107 7	6.0	1
1089+00	12.6	123.6	12.1	13.0	114	113.8	5.9	3
1109+90	....	.....	15.3	13.0	114	123.6	6 5	3
1121+00	....	.....	12.7	13.0	114	117.8	6.4	3
1131+00	....	.....	14.1	13.0	114	109 8	5.75	3
1151+00	11.6	126.0	12.9	14.5	118	114.2	6.0	4
1161+00	14.1	122.2	13 1	14.5	118	105.3	5.75	4
1181+00	10 1	119.8	13.5	14.0	116	106.8	6.1	1
1191+00	13.3	118.9	13.3	14.5	118	109.6	6.0	4
1210+00	11.9	118.0	11.7	13.0	114	114.9	6 0	3
1220+00	10.8	124.5	12 4	13.0	114	111.9	6.0	3
1240+00	11.8	123.0	14.5	13.0	114	120.8	6.1	3
1251+00	13.8	120 1	14.0	13.0	114	112.9	6 0	3
1260+00	....	.....	13.0	14.5	118	118.0	6.5	4
1270+00	....	.....	13.2	14.5	118	127.5	5.0	4
1280+00	....	.....	13.0	13.0	114	112.5	6 0	3

Moisture values recorded in column 3 were found from samples taken immediately after the mixing process and prior to compaction. Where these values were appreciably below the optimum (recorded in column 4), more water was generally added by sprinkling the section.

TABLE 8
SOIL GROUPS

Type No.	Retained No. 40 sieve	Coarse sand	Fine sand	Silt	Clay	Soil group and plasticity	Optimum moisture	Theoretical maximum density lb. per cu. ft.
	%	%	%	%	%		%	
1	30–40	65–80	6–12	6–14	10–14	A–1 and 2 F and P	14.0	116
2	25–35	65–80	10–16	8–14	14–25	A–2 VP to A–2 and 7 VP	14.5	115
3	30–40	65–80	6–12	3– 9	0–10	A–3 NP, A–1 to A–1 and 2 F	13.0	114
4	25–35	60–75	14–20	12–18	14–25	A–2 and 7 VP	14.5	118
5	40–50	75–80	8–10	6– 9	0– 5	A–1 to A–3 NP	16.5	114
6	40–45	75–80	7– 9	5– 9	6– 9	A–1 and 2 F and P	16.0	118
7	35–45	70–75	6–12	4– 8	10–13	A–1 and 2 P	16.0	119
8	0–15	35–50	25–45	8–12	10–16	A–1 and 2 P	14.5	115

NOTE: "F" Denotes "Friable"
"P" Denotes "Plastic"
"VP" Denotes "Very plastic"
"NP" Denotes "Non-plastic"

SINGLE MACHINE METHODS AND CONTROL OPERATIONS

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The Ohio Department of Highways built its first soil-cement road during the summer of 1939. This road was 6 in. in depth, 18 ft. wide, on a 30-ft. roadway. A bituminous surface treatment was included in the contract. The soil-cement pavement was constructed with 8 per cent cement, except for a length of 1,000 ft. with 10 per cent.

The contractor elected to use a roadbuilding machine for the cutting, pulverizing, mixing, and hydrating of the soil and cement, and instead of the plows, cultivators, harrows and discs usually used as separate units for the mixing operation.

PRELIMINARY LABORATORY INVESTIGATION

A preliminary soil survey was made to determine the different soil types which would be encountered. Durability tests were then run to determine the percentage of cement required for each type of soil. Moisture density tests were also made to determine the maximum dry weight and optimum moisture content of soil-cement mixtures for each soil type. Additional samples were taken at intervals of 500 ft. along the center-line from the top 6 in. of the road, to determine the relocation by the grading operations of the various soil types, so that the correct percentage of cement would be used at each location.

PROCESSING

The roadbuilding machine cut, pulverized, mixed, and applied the water in one operation. The sequence of the processing operations was as follows: Scarifying, blading, spreading the cement, mixing and hydrating the soil and cement with the roadbuilding machine, rolling with sheepsfoot rollers, shaping with a