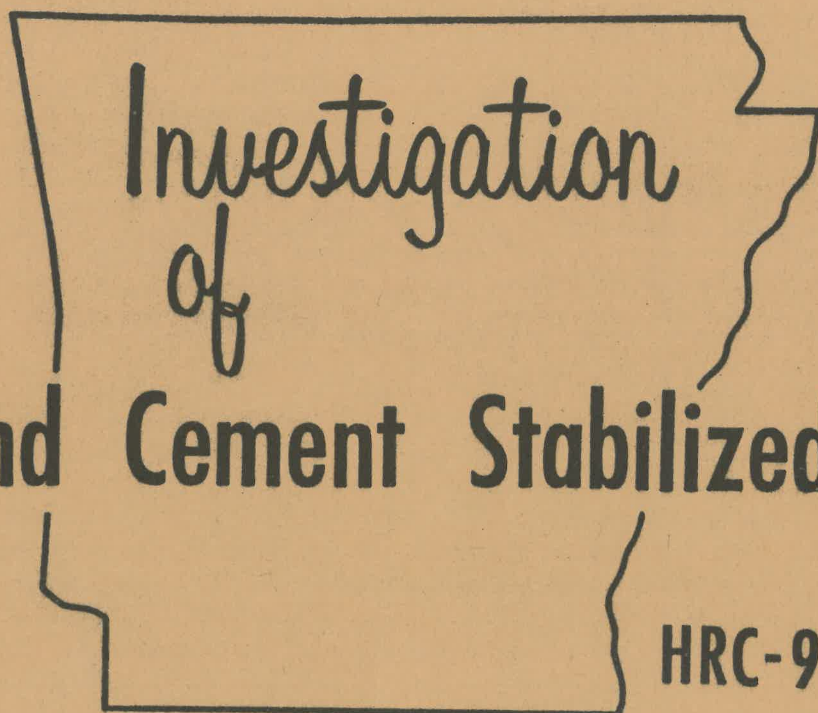

Investigation of Portland Cement Stabilized Bases

HRC-9

PREPARED BY

ARKANSAS STATE HIGHWAY DEPARTMENT
DIVISION OF PLANNING AND RESEARCH
IN COOPERATION WITH
U. S. DEPARTMENT OF COMMERCE
BUREAU OF PUBLIC ROADS

INVESTIGATION OF THE PERFORMANCE UNDER TRAFFIC OF EIGHT ROADWAYS CONSTRUCTED WITH PORTLAND CEMENT STABILIZED BASES

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M. J. HENSLEY
OCTOBER 1966

FOREWORD

The purpose of this project is to observe and record the in-service performance of eight short segments of secondary highways at scattered locations in the southern, southeastern, and eastern parts of the State. Each of the sections of roadway was constructed under similar designs with a Portland Cement stabilized base and a double bituminous surface treatment; however, they are located in widely separated parts of the State and have served under different traffic, maintenance, and climatic conditions.

AUTHORITY

Highway Research Project No. 9 (HRC-9), HPS-HPR-1(21), I456, was established April 19, 1963, by approval of a detailed workplan under a joint agreement between the Arkansas State Highway Department, Planning and Research Division, and the U.S. Department of Commerce, Bureau of Public Roads.

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INTRODUCTION

This project was conceived due to the fact that our natural sources of base materials are rapidly decreasing over a wide section of the State. With increased attention on job control and specification material, it becomes more difficult to locate quality and quantity sources for base course material. For these reasons, our attention has been focused on the evaluation of eight such stabilized roadway bases in scattered locations throughout the State. These sections have a uniform stabilized thickness; however, the material stabilized has varying engineering characteristics and physical properties from job to job. The sections also are subjected to varying climatic and maintenance conditions.

These eight sections were to be evaluated under traffic in accordance with the performance of each as determined by the maintenance required, cracking and patching observed, and accumulated damage as determined by the CHLOE Profilometer. A pattern, if any existed, in the cracking of such stabilized bases was to be developed. This was requested by the Bureau of Public Roads in the letter of approval for the project. Benkelman Beam deflection tests were to be performed on the pavements initially and periodically throughout the study. The density and moisture content were to be taken annually on the base, subbase, and subgrade of each section.

All maintenance costs for these sections were to be tabulated separately for the evaluation. This proved impossible, because the maintenance is kept by route-and-section, and each job was only a fraction of a section; therefore, no cost estimate was available on the individual jobs under observation.

The Benkelman Beam deflection tests were never incorporated into the project; however, the writer feels that such tests would not add appreciably to the performance survey.

Although this project has not lasted as long as the intent of the proposal, the writer feels that some conclusions can be made on the data presented herein.

Section I. REVIEW OF JOB RECORDS

The records were obtained from the job files at the Materials and Tests Division, and the following information for each job was obtained:

A. Soil Survey.

B. Mechanical Analysis of the Soil Pits, with AASHO Classification.

C. Record Samples from Roadway, with Mechanical Analysis and AASHO Classification.

D. Resident Engineer's Daily Reports.

E. Soil Cement Stabilization Durability Tests and Compressive Strength Tests.

F. Seal Coat Test Reports.

G. Optimum Density and Moisture Results.

The jobs included in this study are listed in Table 1.1.

Table 1.1

Job No.	Rt. & Sec.	County	Length (Miles)	Date of Completion
11683	132-2	Crittenden	4.774	Fall 1962
11691	242-0	Phillips	3.795	Fall 1962
2615	33-1	Arkansas	3.588	Summer 1962
2630	142-1	Chicot	5.006	Summer 1962
2631	35-7	Drew	5.530	Summer 1962
2637	35-6 & 7	Drew & Cleveland	6.289	Spring 1963
3599	53-3	Nevada	7.679	Summer 1962
7586	160-3	Columbia	5.783	Summer 1962

All of these jobs used a minimum of six inches of stabilized material. On jobs where more material was used, the additional material would be classified as subbase. On some of the jobs, the plans called for nine inches of material, with a minimum of six inches stabilized; in these instances, there were usually about seven inches stabilized, as will be reflected in the field data.

Table 1.2 shows the optimum moisture and density and planned thickness for the base material, along with the recommended percent of cement by volume.

Where tests were not performed on the recommended cement content, interpolation from the percentages that were run was made to determine the density and moisture, as shown in Table 1.2.

Table 1.2

DESIGN DATA FROM RECORDS
OF
MATERIALS AND TESTS DIVISION

HRC-9

Job No.	Soil Cement			Raw Soil Density		Planned Thickness	
	Density	O.M.	% Cement	Density	O.M.	Base	Subbase
11683	122.2	12.0	11.5	114.3	13.0	6	3/0
11691	112.0	13.0	10.0	105.0	15.0	6	3/0
2615	109.5	13.0	10.0	104.6	15.0	6	3
2637	135.3	6.8	5.0	133.6	7.0	6	1
2631	122.2	10.2	8.0	114.7	11.9	6	1
2630	117.7	10.2	10.0	108.2	13.4	6	4/2
3559	128.0	7.0	8.5	112.5-127.0	9.4-12.3	6/3*	3/0
7586	110.0	11.0	9.0	103.5	15.9	6	4/2

* 3 inches of gravel over existing base

Section II. INSPECTION OF THE ROADS IN GENERAL

The field work was set up to begin in January of 1964. The first general inspection was made on the 28th, 29th, and 30th of that month by the project staff, in company with the District Engineer or, in his absence, the Resident Engineer. This inspection covered such items as: drainage, shoulder condition, traffic riding on and off of the pavement in the curves, cracking, and general surface conditions.

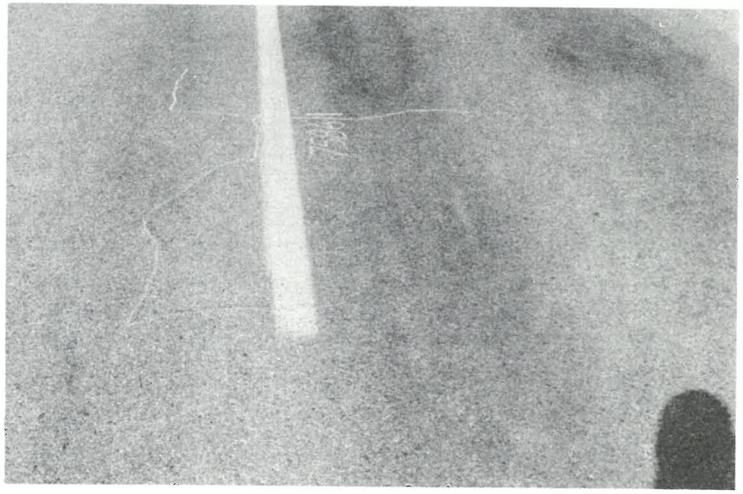
On this inspection, it was noted that six of the eight jobs had extensive cracking, with transverse cracks varying from 6 to 20 feet. On some sections, longitudinal cracking existed in the outside wheelpath. In cases where the longitudinal cracks were not consistent throughout the job, nor for any great distance, they were classified as vertical shear planes. This assumption is substantiated by appearance of localized rutting. On the jobs where longitudinal cracking existed in the outer wheelpath, the shoulders were observed to be very loose and of relatively unstable material.

It is the writer's opinion that had these jobs had more lateral resistance or support against such failures, the base material would not have sheared. The material that is often used in the stabilized bases approaches a cohesiveless condition and thus cannot be confined easily. The finished roadway is usually 28 feet wide, with the center 21 feet stabilized; this leaves 3½ feet at a depth of seven or eight inches to compact for the finished shoulder. It was observed that much damage has been done to the surface edges and shoulders by traffic riding on and off, as can be seen in the figure on page 8.

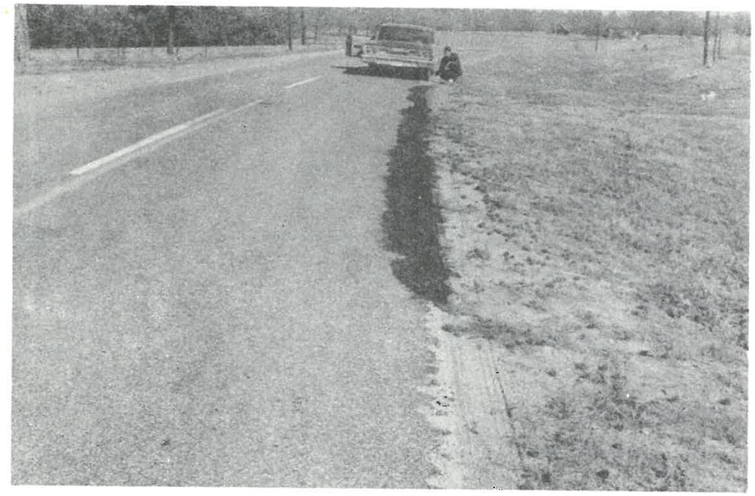
In the first general inspection, the jobs were found to be in very good overall condition. No extensive base failures were found; however, there was edge patching, as evidenced by the results discussed in the preceding, and surface patches as a result of surface slippage.

The second general inspection was made in March of 1966. Six of the eight jobs had been resealed prior to this inspection. Jobs 2637 and 11683 were the two that had not been resealed. These Jobs are shown on pages 13 and 14 . Job 7586 had been spot-sealed, as shown in the photo on page 12.

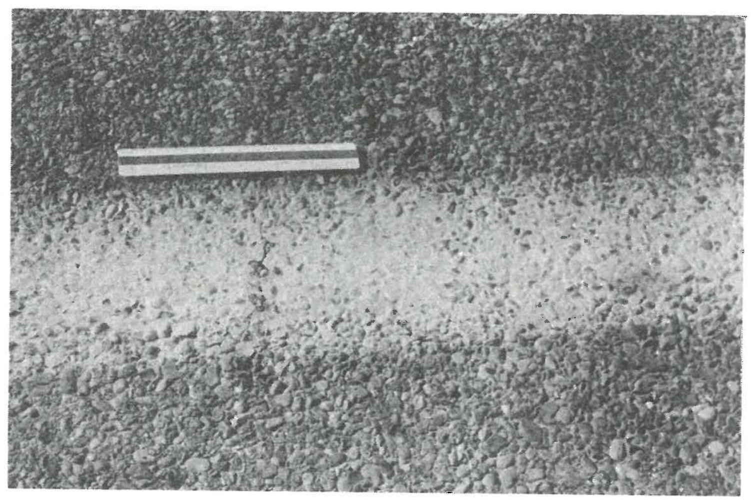
INSPECTION NO. 1



Job 7586 Irregular Cracking at Centerline

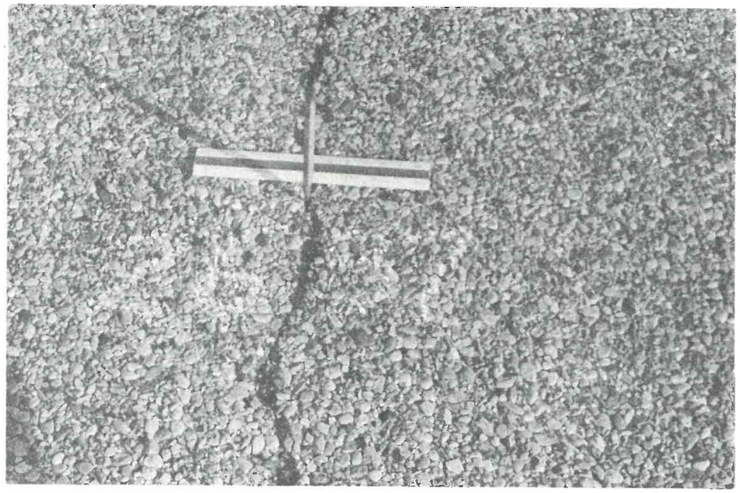


Job 7586 Edge Patching on Inside of Curve

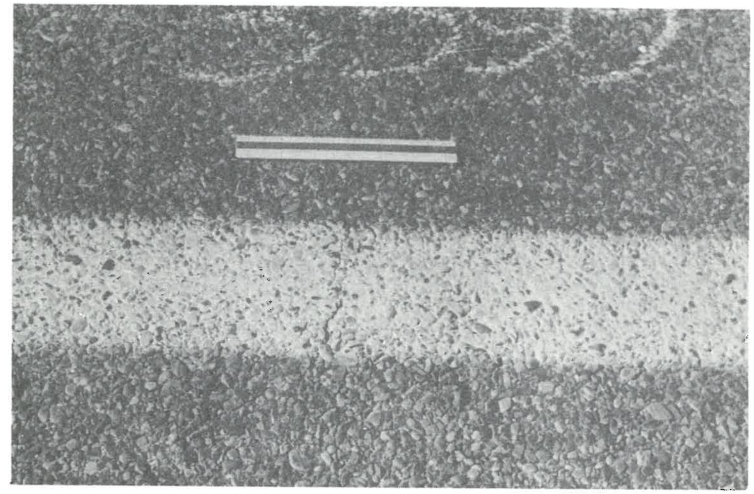


Job 7586 Minor Transverse Crack at Centerline

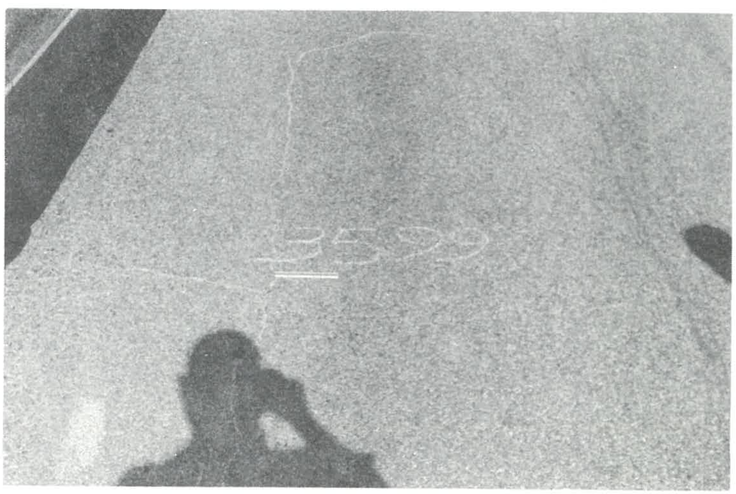
INSPECTION NO. 1



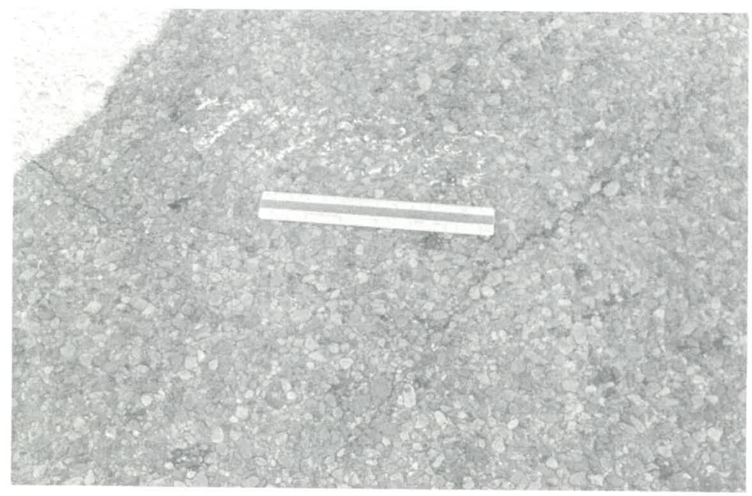
Job 2637 Transverse Crack



Job 3599 Minor Transverse Crack

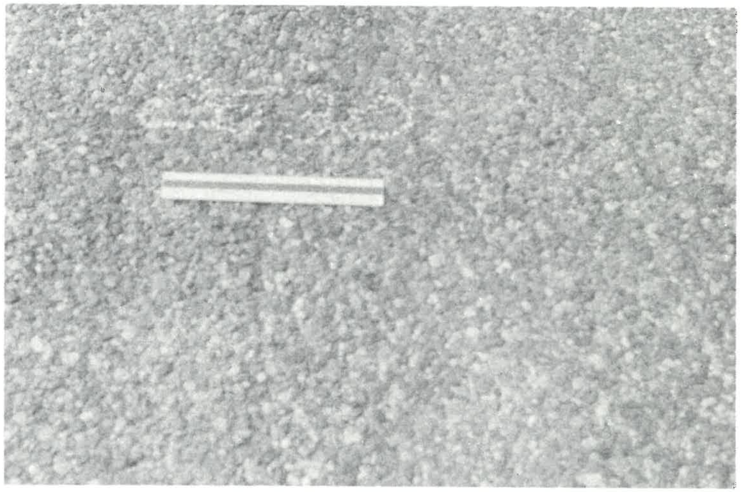


Job 3599 Minor Cracking



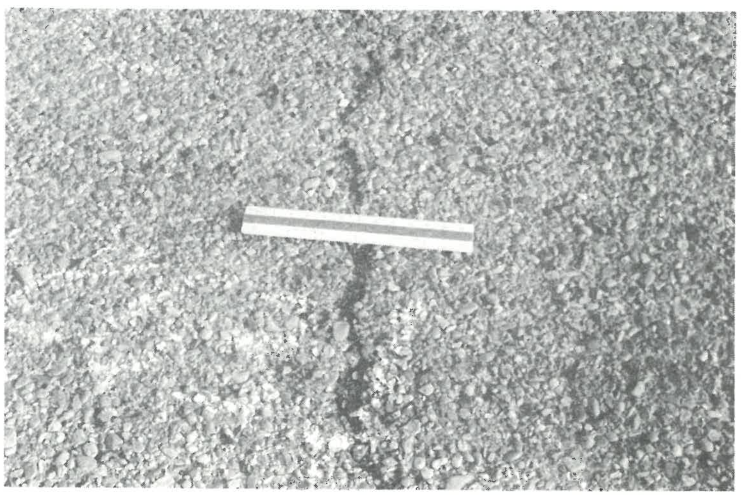
Job 7586 Minor Cracking at Centerline

INSPECTION NO. 1



Job 2630 Transverse Crack

Job 2631 Transverse Crack Pattern of 6' to 12'

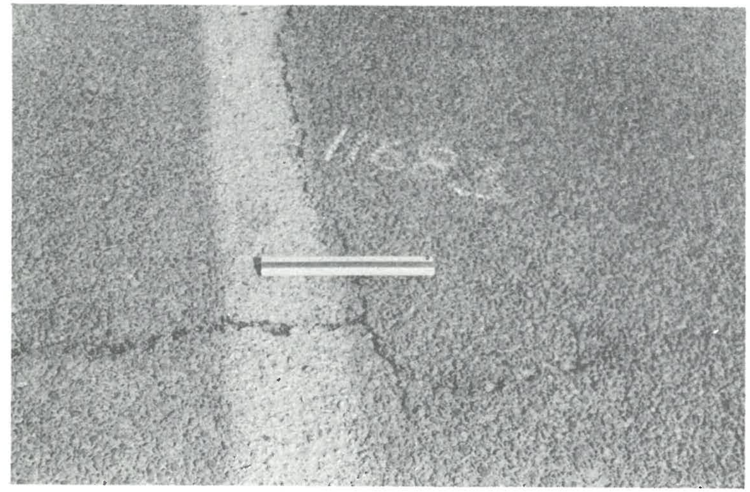


Job 2631 Transverse Crack

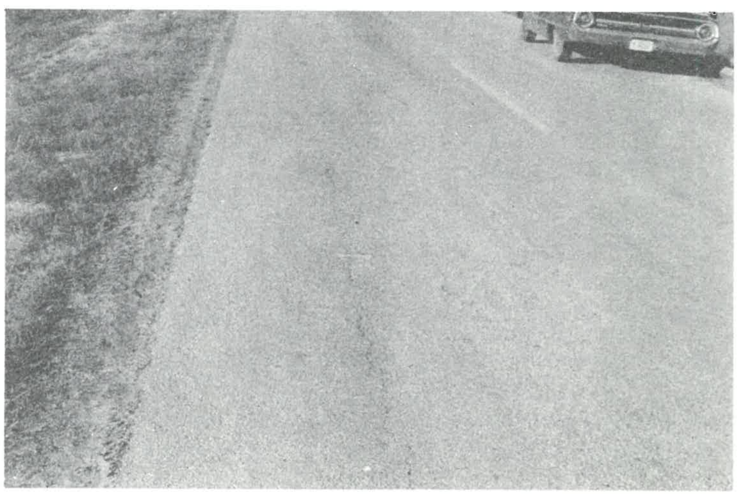
Job 2631 Logitudinal and Transverse Cracks

INSPECTION NO. 1

Job 11683 Longitudinal Crack Center of Lane



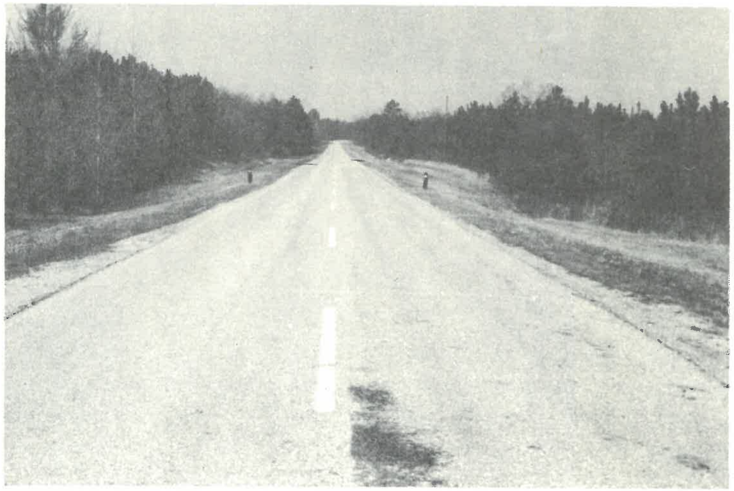
Job 11683 Longitudinal & Transverse Cracks at Centerline



Job 2615 Longitudinal Crack

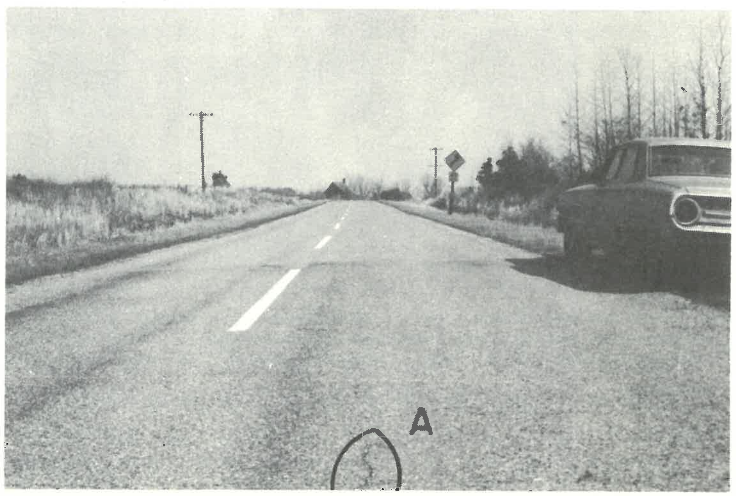
Job 2615 Longitudinal Crack

INSPECTION NO. 2



Job 2631 after Resealing

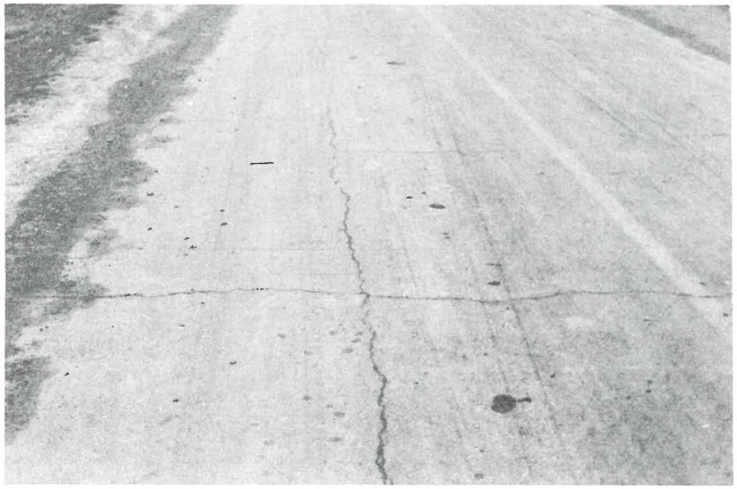
Job 2631 after Resealing



Job 7586 Shows a Change in Texture with Cracking

Job 7586 Shows a Change in Texture with Cracking

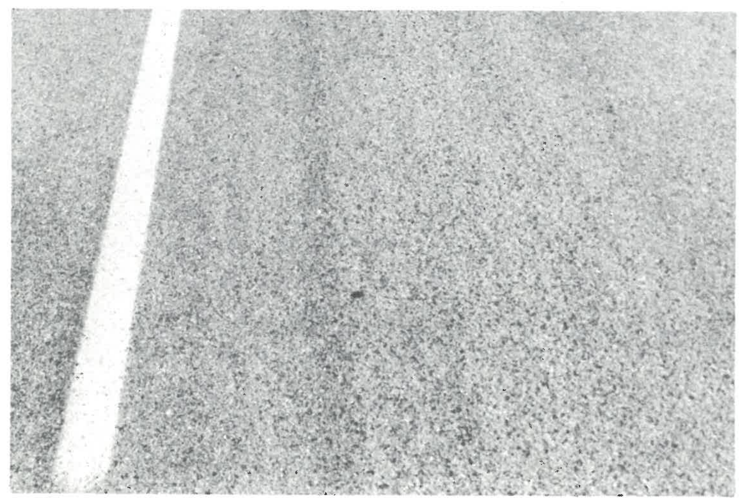
INSPECTION NO. 2



Job 11683 Longitudinal & Transverse Cracks

Job 11683 Longitudinal & Transverse Cracks

Job 2615 after Resealing



Job 2615 after Resealing

INSPECTION NO. 2

Job 2631 Shows Scaling after Resealing

Job 2631 Shows Scaling after Resealing

Job 2637 Shows Crack Pattern

Job 2637 Shows Crack Pattern

Section III. PRESENTATION OF FIELD DATA

In May of 1964, detailed field investigation began on all the jobs. The data collected is presented in Table 3.1. The cement content shown in this Table is that which was recommended; no analysis of the cores was made to check this content. The densities shown in Table 3.1 on the subbase may not represent an exact figure for that material, due to the limited thickness of the material. As mentioned earlier in the report, nine inches of the material were placed on most of the jobs, and on some jobs more was used; when three inches or less of the material existed, the density test was disregarded and the subgrade density was taken.

Three cores were attempted on all the jobs for compression tests. Some of the cores sheared while being drilled; this is recorded in Table 3.1. The first were six-inch cores drilled with water. Such a large percentage of the cores were breaking using this method that an alternate method was chosen. This method incorporated the use of an air compressor mounted in the back of the drill truck, and the cuttings were blown out instead of being washed out. It is the writer's opinion that this method works much better; however, considerably more time is required for the core drilling. Also, when the air was used to drill the core, an eight-inch cutter was used, which added to the rigidity of the core.

The densities were made using the sand cone method. A twelve-inch core was removed from the base course, and again air was used in order not to destroy the moisture content of the twelve-inch core nor the underlying material, on which moisture and density tests were to be performed . When the twelve-inch core was removed from the hole, it was broken up, and a representative sample was taken for the moisture test on the speedy moisture meter.

The twelve-inch hole was carefully cleaned out with a large spoon to an undisturbed level, and then the sand cone test was performed. A four-inch hand auger was used to drill into the subgrade for a moisture sample, again to be run on the speedy moisture meter. The cores were measured, along with the thickness of the surface material, and recorded as shown in Table 3.1.

When the cores were returned to the laboratory for strength tests, more of the cores were broken in the preparation of the compression tests, as shown in Table 3.1, along with the results of the strength tests.

PORTLAND CEMENT STABILIZED BASES
TABLE 3.1

Cores drilled: 4-29, 5-1-64
Weather: Clear & Hot

Core-Job No.	Log Mile	Density lbs/ft.^{3} Subbase	Density lbs/ft.^{3} Subgrade	Mositure Content % Base	Mositure Content % Subbase	Mositure Content % Subgrade	Cement Content Base %	Thickness Core (inches)	Thickness Surface (inches)	Compression Stress (PSI)
1-3599	7.0	102.9		2.0	6.1	7.9	8.5%	6 1/8	1/2	- - - -
2-3599	4.0	101.5		7.0	12.1	13.0	8.5%	7 3/8	5/8	____
3-7586	4.3	112.4		4.1	11.4	11.7	9.0%	8 3/4	1/2	____
4-7586	0.4	107.5		4.3	15.2	15.6	9.0%	6 1/4	5/8	- - - -
5-7586	3.1	119.1		9.5	10.6	12.9	9.0%	6 5/8	1/2	- - - -
6-2630	0.8	114.4		8.7	8.5	19.7	10.0%	7 5/8	5/8	1920
7-2630	2.9	107.9		13.3	12.0	19.8	10.0%	6 5/8	5/8	1302
8-2630	4.8	114.9		6.3	7.8	16.1	10.0%	6	5/8	____
9-2631	4.9	114.9		7.0	12.0	7.0	8.0%	6	5/8	473
10-2631	3.1	112.8		10.7	11.2	Gravel Subbase Old Road	8.0%	5 1/2	5/8	- - - -
11-2631	1.3	115.7		10.4	11.1	10.2	8.0%	6 3/4	5/8	- - - -
12-2637	5.7	138.2		7.7	8.0	14.5	5.0%	6	3/8	____
13-2637	3.9	121.4	X	7.0	6.9	9.2	5.0%	6	1/2	- - - -
14-2637	1.2	129.8	X	7.0	10.5	22.4	5.0%	5 3/4	3/8	____
15-2615	3.0	89.1	X	13.8	16.7	22.5	10.0%	6 1/2	5/8	1550

TABLE 3.1 CONTINUED

16-2615	1.9	No Subbase	X	18.5	19.0	17.8	10.0%	6 3/4	5/8	- - - -
17-2615	0.5	83.0	X	20.0	18.0	19.2	10.0%	6	5/8	- - - -
18-11691	2.5	X	88.3	11.4	16.5	21.0	10.0%	7 1/8	5/8	______
19-11691	1.1	X	90.7	7.8	8.3	17.3	10.0%	7	5/8	831
20-11691	0.5	X	86.6	12.2	16.0	17.7	10.0%	6 7/8	5/8	- - - -
21-11683	3.8	111.2		7.1	7.7	10.5	11.5%	6	5/8	1571
22-11683	2.7	111.2		8.0	12.0	13.1	11.5%	6 1/2	5/8	1826
23-11683	1.4	109.1		9.2	15.8	22.0	11.5%	6 3/8	5/8	1430

______ Core was broken in drilling process

- - - - Core was broken in preparation of lab test

In November 1964, the eight sections of roadway were profilometered, using the CHLOE profilometer. While this survey was being made, attempts were made to establish the initial serviceability index for each job. This was accomplished by talking to the Resident Engineers, et al., who were familiar with the finished surface of roadway they had built, and comparing this information to jobs presently being profilometered. Most of these jobs were constructed under traffic and, as a result, some built-in roughness was measured with the CHLOE that would not otherwise be detected.

Annual traffic surveys were made through June 30, 1965. Since most of the jobs were completed in the summer of 1962, all data was collected on a fiscal-year basis. The jobs were profilometered again in July of 1965.

The profilometer data and the traffic data are shown in Table 3.2. The traffic data is shown in terms of equivalent 18-Kip loads.

Considerable difficulty was experienced with the CHLOE during this period of testing; however, all data collected appears to be good.

Although no profilometer data was obtained in 1966 after the jobs had been resealed, it was estimated that the PSI would be raised 0.90± from the PSI of 1965. This amount would restore most of the jobs to a PSI approximately equal to that at the time the job was constructed.

TABLE 3.2
TRAFFIC AND PRESENT SERVICEABILITY INDEX (PSI)

	ROUTE &	SUMMATION TRAFFIC EQUIV. 18^K LOADS			PSI		
JOB NO.	SECTION	1964	1965	1966	1962*	1964	1965
11683	38-8	44,200	66,300	87,350	3.90	3.20	2.94
11691	242-0	134,370	201,550	261,720	3.60	2.86	2.79
2615	33-1	20,800	31,200	42,400	3.50	2.68	2.50
2630	142-1	42,040	63,060	78,100	3.90	3.72	3.72
2631	35-7	66,509	99,760	135,960	3.60	2.71	2.51
2637	35-6&7	89,270	133,900	171,600	3.60	2.64	2.47
3599	53-3	75,100	112,650	144,425	3.90	3.00	2.98
7586	160-3	85,100	127,650	169,900	3.60	2.82	2.75

*Estimated

SUMMATION OF STUDY

1. No repetative crack pattern existed.

2. Surface slippage was minor on these eight roadways.

3. Edge-raveling was common to these eight roadways, mostly due to traffic riding off and on the pavement surface.

4. Different maintenance practices on these roadways had little effect on the PSI.

5. The moisture content of the base was lower than optimum, as determined in the laboratory by AASHO T-99-57.

6. The moisture content of the subbase (unstabilized base material) was higher than the optimum, as determined in the laboratory.

7. Based on the performance to date, no further research is needed on the performance of this type roadway.