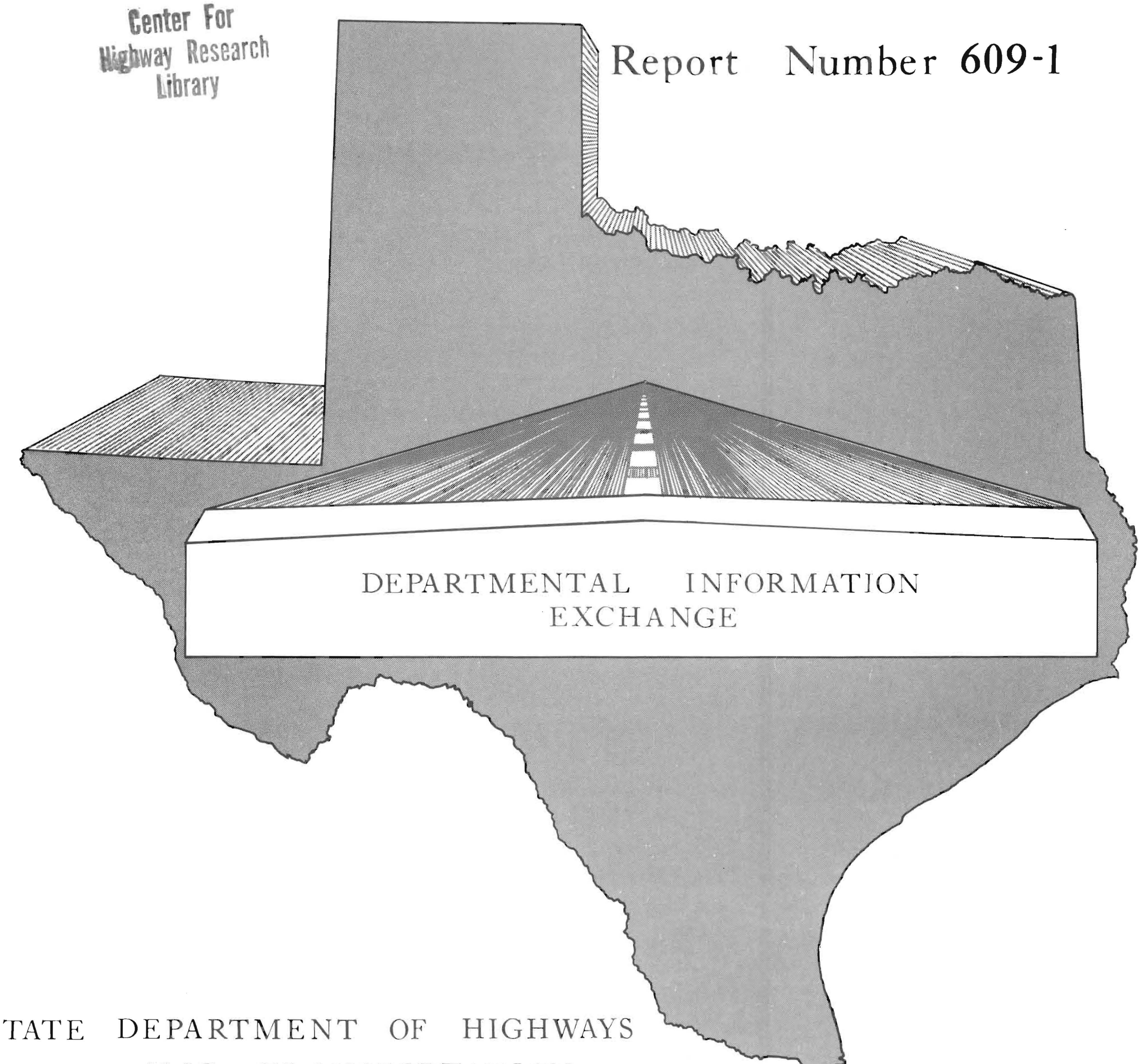
EXPERIMENTAL PROJECTS

TEST USING EXPANSIVE CEMENT IN CEMENT STABILIZED BASE TO ELIMINATE OR REDUCE CRACKING

Report Number 609-1



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

Test Using Expansive Cement in Cement Stabilized Base to Eliminate or Reduce Cracking

Report No. 609-1

A Narrative Report

by

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August 1975

Test Using Expansive Cement in Cement Stabilized Base To Eliminate Or Reduce Cracking

The purpose of this study was to determine the feasibility of using an expansive cement, TXI 4C Chem Comp, in lieu of the regular Type I Portland Cement in a cement stabilized gravel screenings base so as to eliminate or reduce cracks associated with this type of base construction. The test was carried out by field experimentation and observation.

The results of this test indicate that the use of expansive cement to stabilize gravel screening base material produced no appreciable reduction in the number or size of cracking in the base when the subgrade has a high clay content and that low temperatures could have a nullifying effect on the expansive cement. However, it was found that the frequency of cracking was reduced approximately 50% when gravel screening base material, stabilized with regular Type I Portland Cement, was placed over lime treated subgrade.

The test was carried out on a section of Project C976-3-27, FM 518, in the City of Friendswood, Galveston County. Although a test section was not provided for in the project contract, the contractor agreed to include a 550-foot test section, as well as two other control sections, in his work at no additional cost to the State. Texas Industries, Inc., Houston Division, which markets the expansive cement used on this test, furnished the Chem-Comp expansive cement to the contractor at the same price as regular Type I Cement. Mr. Leland Tatum, representative for Texas Industries, Inc., was present at the project site to offer advise and technical assistance during the placement of the expansive cement stabilized base. A test section had originally been planned

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for Project C976-3-26, FM 518 in League City; however, the contractor had elected to use sand-shell as the base material and since cracking has not been a problem with cement stabilized sand-shell base, the expansive cement test was not used on the project in League City.

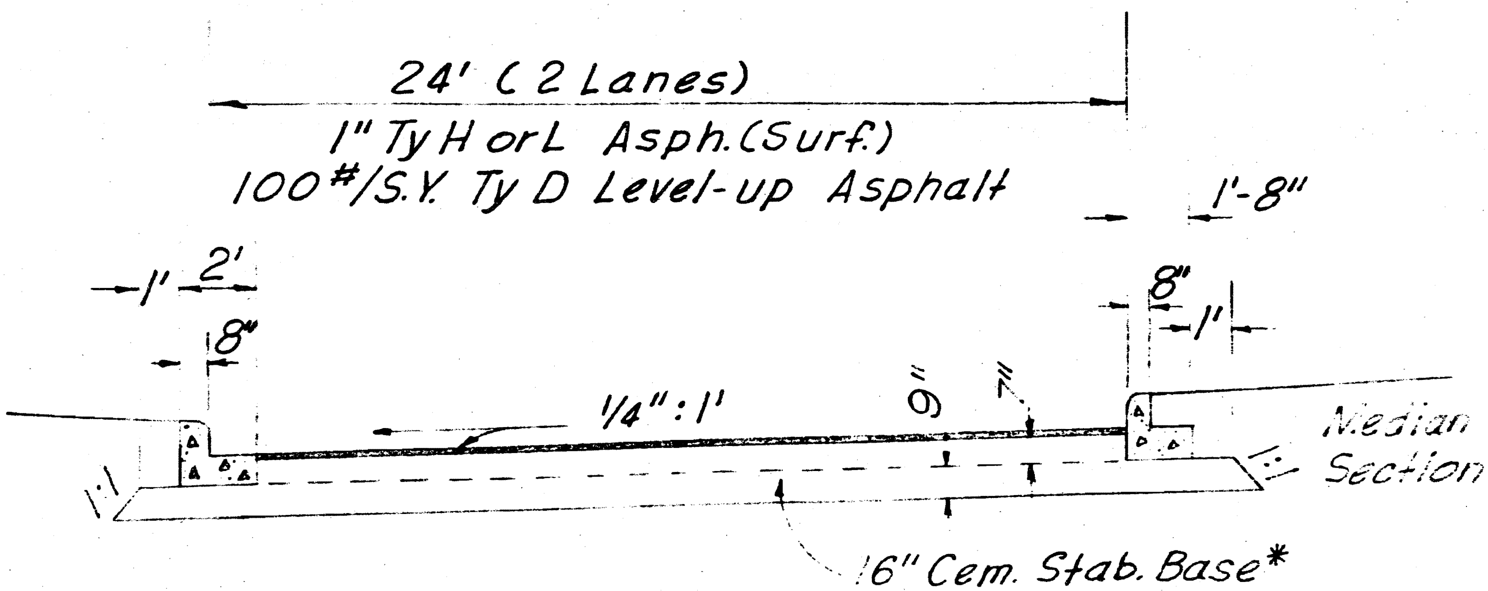
The project in Friendswood replaced the existing 2-lane open-ditch roadway with a 4-lane divided highway using a curb and gutter section with a 2-course 16-inch cement stabilized base and 2-inch asphaltic concrete overlay. After the project was approximately 43% complete, a 6-inch lime treatment was added to the subgrade by field change (see Exhibit B) to provide a working table for the contractor to complete the roadway during an extensive period of wet weather. The subgrade in the project in Friendswood is predominantly of the Lake Charles-Bernard Soil Series which consists of a gray to very dark gray firm clay surface, 12-36 inches thick, over gray, mottled with yellowish brown, very firm blocky clay. In wet weather the load bearing characteristics of this soil are greatly reduced making construction operations very difficult, and hence, the addition of the lime treatment became necessary.

The test consisted of replacing the standard Type I Portland Cement with an expansive cement TXI 4C Chem-Comp in a 550-foot section of cement stabilized gravel screenings base. For comparison, two other sections were constructed under controlled conditions with the base behavior being observed and recorded. (see Exhibit C). Base admixture (Exhibit BB) and construction methods remained the same for all sections with the exception of the cement type change in the test section. One control section was modified by the addition of a 6-inch lime treated subgrade(Exhibit B). The subgrade to be lime treated was prepared by grading it to the proposed grades, placing the lime on top of the untreated subgrade, and then mixing the lime and soil with a pulvi-mixer. After reaching the required consistency, the prepared mixture was compacted and reshaped to the finished grade. Non-treated subgrade was prepared simply by rolling and grading. The cement stabilized base was then hauled to the project and dumped on the finished subgrade. The cement was mixed with the gravel screenings base at a plant using a pug-mill type mixer After the base was placed on the subgrade, it was spread to the proper grade by a motor grader. Tamping and pneumatic tire rollers were then used to compact the base. Curing was accomplished by spraying the surface with water and keeping it damp for four days. After the 9-inch base course had cured, the concrete curb and gutter were constructed. The 7-inch base course was then placed, compacted, and cured in the same manner as the first course. A chronology of the base placement is included as Exhibit G. After the roadways had been constructed a record was made of the number and length of the cracks which had developed on the surface. The amount and size of the cracks appeared to become well established a few weeks after construction and a final record (see Exhibits D,E, and F) was made approximately one year after the roadways were completed. A "cracking density" was calculated for each section studied using the total length of cracks in that section divided by the total area of the section. Several photographs of the base placement and cracks were taken and are included as Exhibit H.

Analysis of the test results indicate that the use of the expansive cement TXI 4C Chem-Comp in the project in Friendswood had no apparent effect in preventing or reducing the cracking associated with cement stabilized gravel screenings bases The cracking density of .09 FT/SF and the size, width, and appearance of the cracks in the section using the expansive cement and untreated subgrade were approximately the same as those in the section using the regular cement and untreated subgrade. In the section using the lime treated subgrade, a significant difference was noted. The cracking density of .04 FT/SF was only about one-half as high as in the other two sections with untreated subgrade (see Exhibits D,E, and F) and most of the cracks were just hairline cracks Longitudinal cracks developed in both the section using the expansive cement and the section using the regular cement with untreated subgrade but none appeared in the section using the regular cement with a lime treated subgrade. Alan Carter, TXI Director of Technical Service, theorized that the extensive cracking in the second course of stabilized base using expansive cement might have been due to low early strength of the base because of the cold weather during curing of this course. He said the base might not have received strength and expansion because of lower hydration to offset the tensile stresses when drying shrinkage began. The test section using the expansive cement and the control section using regular cement experienced wet weather and low temperatures ranging from 51° to 37° during their curing period while the control section with the lime treated subgrade experienced only warm weather with intermittent rains during the month of July. This test was not extensive enough to obtain data sufficient to determine optimum conditions, or limits of conditions using expansive cement that would produce results beneficial to this type of operation.

It may be possible that the lime treated subgrade provided a more frictional surface than the untreated clay subgrade and may have served to more evenly distribute the tensile stresses caused by shrinkage as the base cured and thereby reduced the incidence of cracking.

The results of this test indicate that the use of expansive cement to stabilized gravel screening base material produced no appreciable reduction in the number or size of cracking in the base when the subgrade has a high clay content and that low temperatures could have a nullifying effect on the expansive cement. However, it was found that the frequency of cracking was reduced approximately 50% when gravel screening base material, stabilized with regular Type I Portland Cement, was placed over lime treated subgrade.



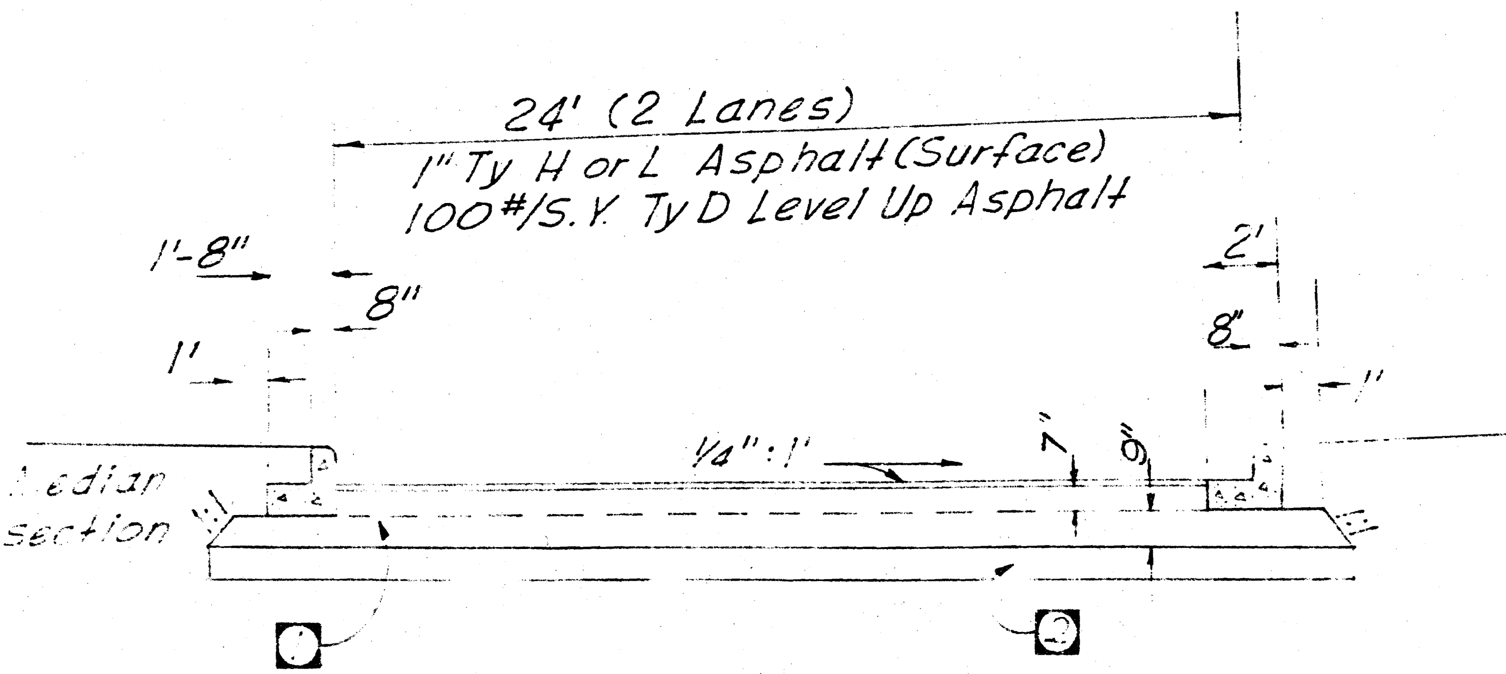
TYPICAL SECTION LT. ROADWAY

TEST SECTION: STA. 98+50 to 104+00 (Lt)
CONTROL SECTION: STA. 93+00 to 98+50 (Lt)

Scale: 1" = 5'

* Cem. Stab. Base Placed in 2 Courses. Dashed Line indicates Surface of 1st Layer.

EXHIBIT A



TYPICAL SECTION
RIGHT ROADWAY
WITH
LIME TREATED SUBGRADE

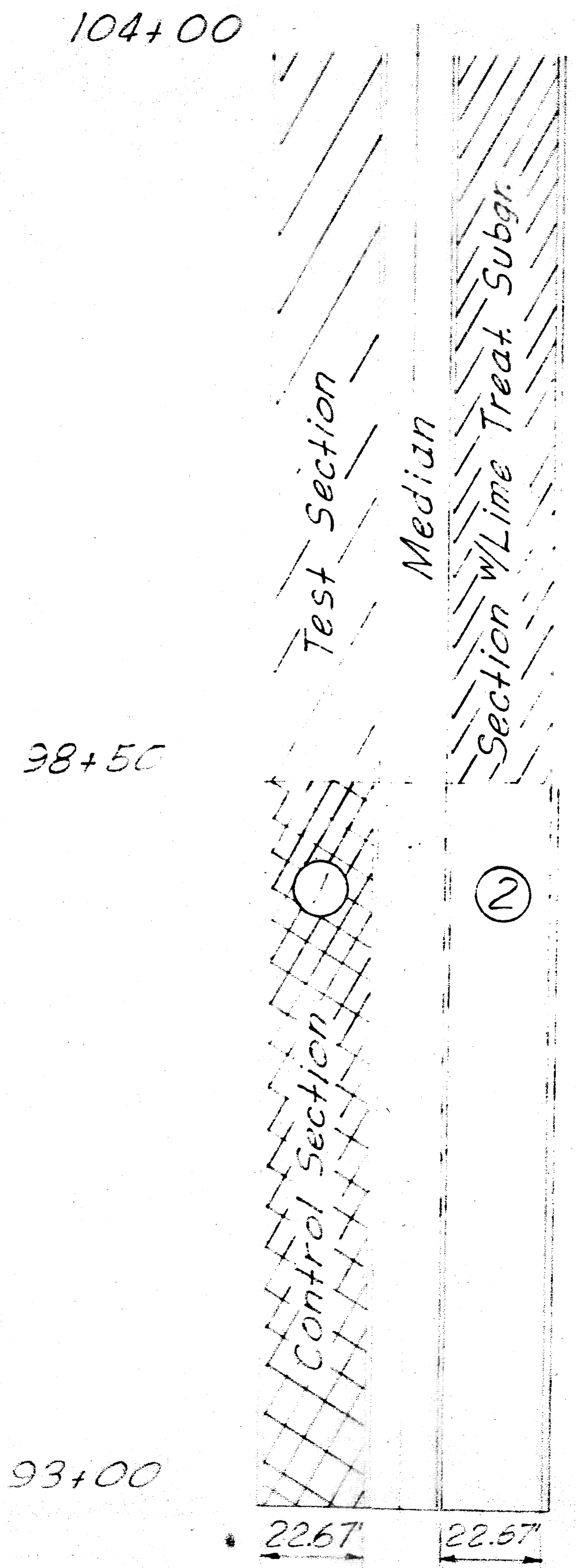
Sta. 98+50 to Sta. 104+00 (Rt.)

1 16" Cem. Stab. Base*
2 6" Lime Treat. Subgrade

Scale: 1"=5'

*Cem. Stab. Base Placed in 2 Courses. Dashed Line Shows Top of 1st Course.

EXHIBIT B



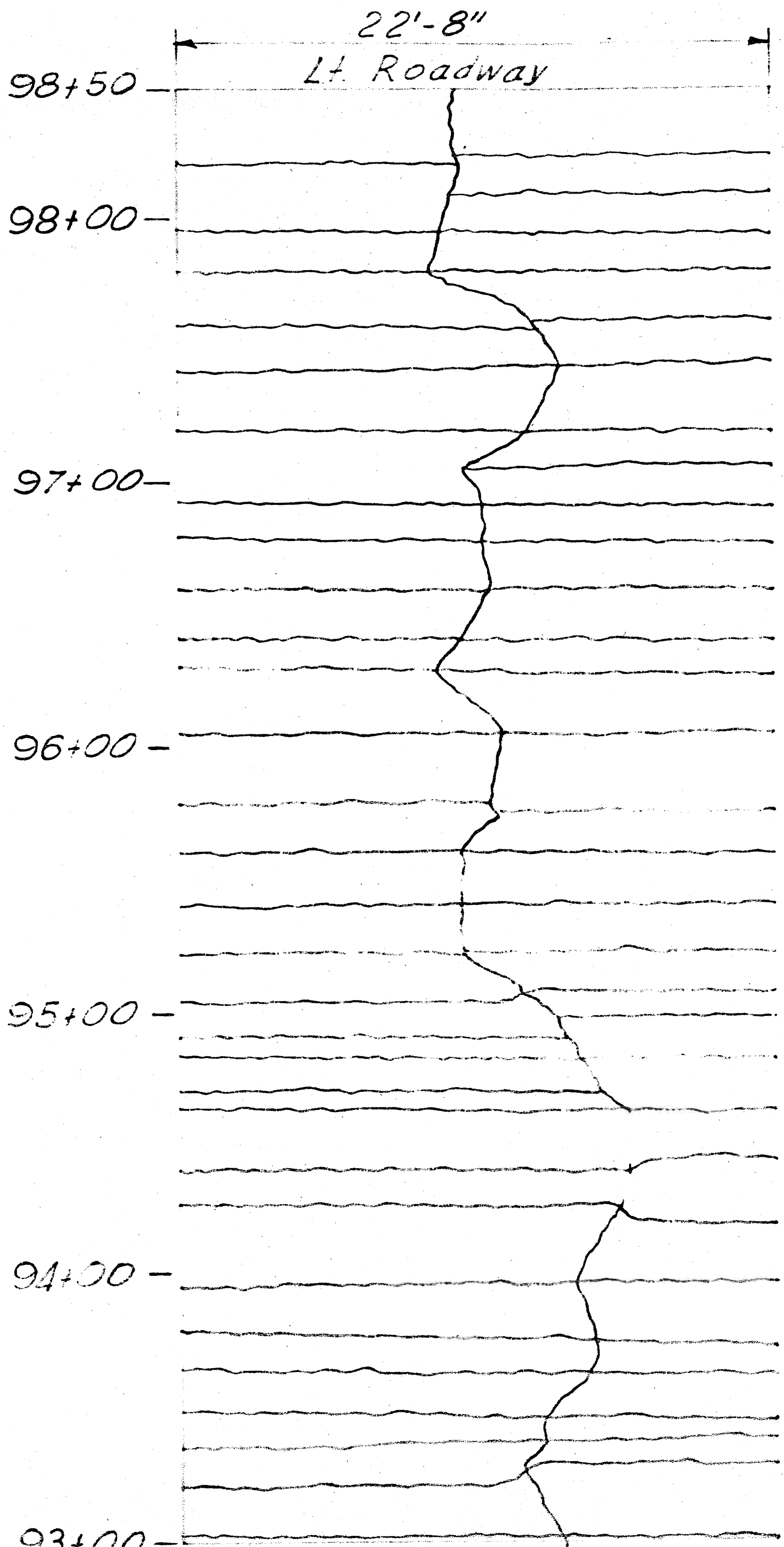
(1) Lt. Roadway
(2) Rt. Roadway

Intersections and Median Openings Not Shown

SKETCH SHOWING RELATIONSHIP BETWEEN TEST SECTIONS

Not to Scale

EXHIBIT C



Control Section Using Regular Cement with Cem Stab. Base

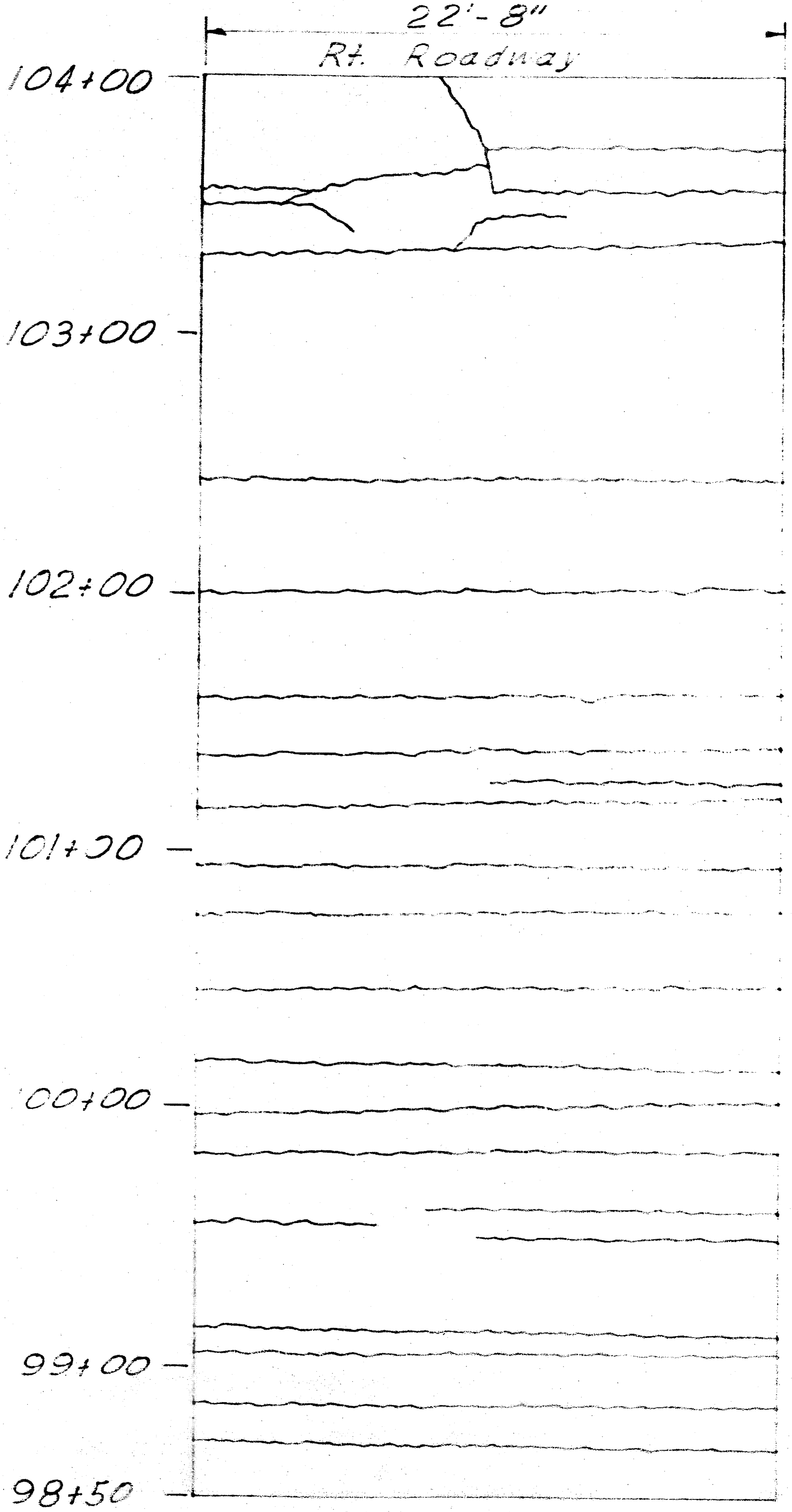
Total Length of Cracks = 1,224.6 Ft.

Total Area = 550 x 22.67 = 12,468 Sq. Ft.

Crack Density = .0982 Ft/Sq.Ft.

EXHIBIT D

Scale: 1" = 60' Long
1" = 6' Width



Control Section Using Regular Cement with Cem. Stab. Base & 6" Lime Treated Subgrade

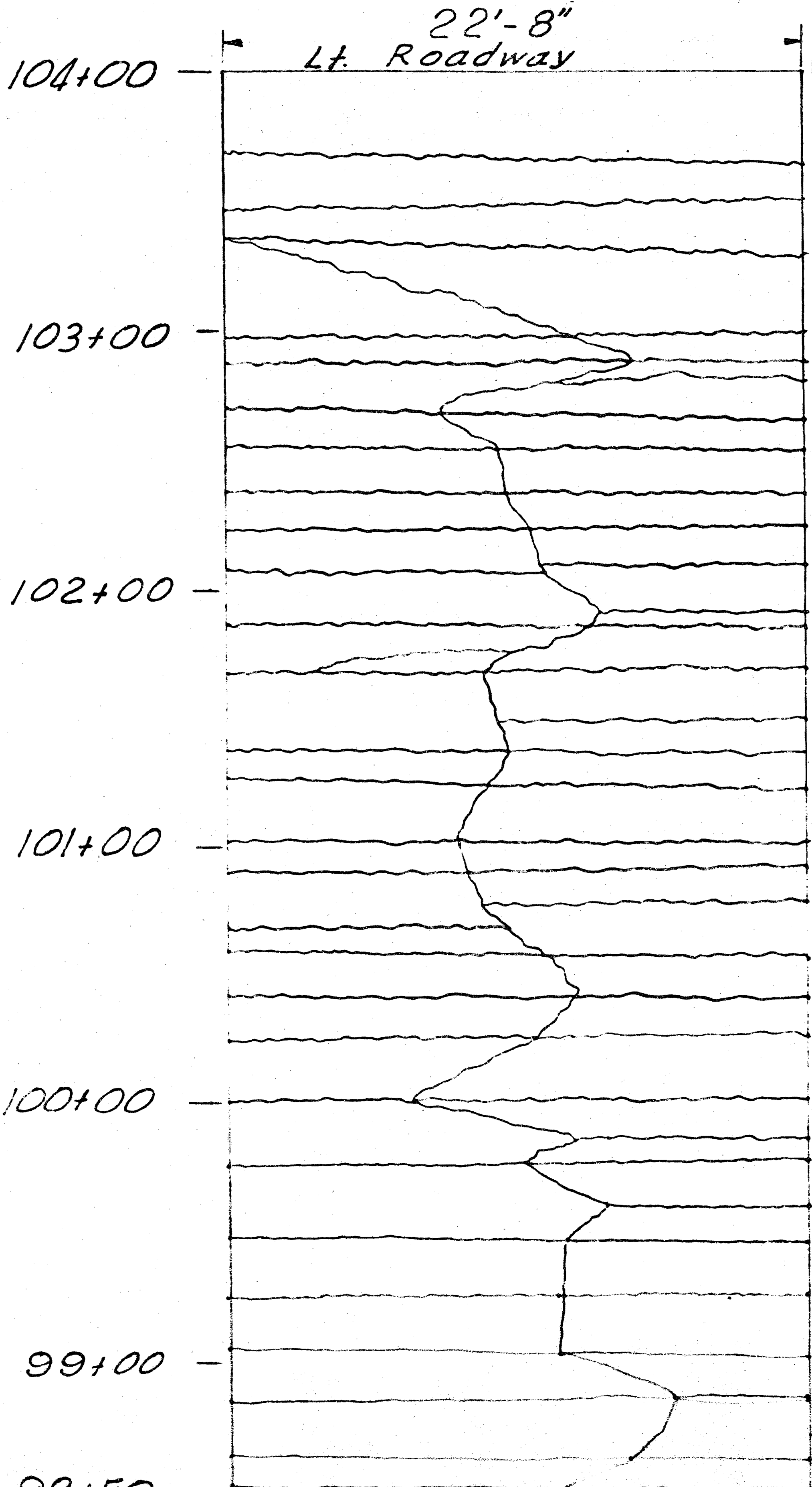
Total Length of Cracks = 505.20 Ft.

Total Area = 550 x 22.67 = 12,468 Sq Ft

Crack Density = .0405 Ft/Sq Ft.

EXHIBIT _ E

Scale: 1" = 60' Long
1" = 6' Width



Test Section Using TXI 4C Chem. Comp. Cement to Stabilize Base

Total Length of Cracks = 1182.2'

Total Area = 550' x 22.67' = 12,468.50 Sq.Ft.

Crack Density

$$\frac{1182.2}{12,468.5} = .0948 \text{ Ft/SF}$$

EXHIBIT F

Scale: 1" = 60' Long
1" = 6' Width

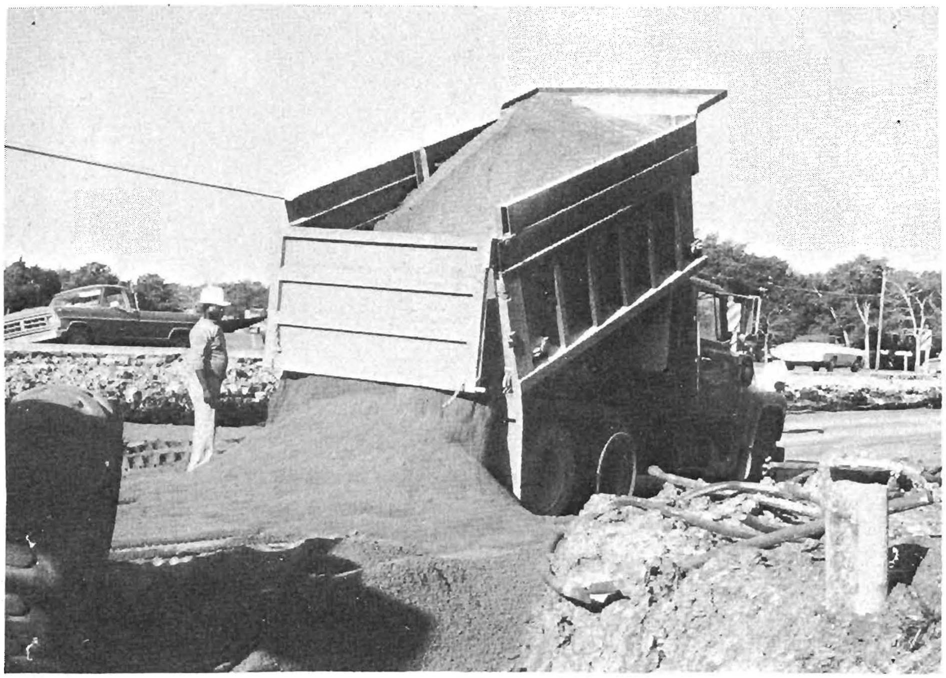
BASE PLACEMENT RECORD

11-14-73	Started placing 1st course of cement-stabilized base using expansive cement. Placed 200 foot section before stopping due to mechanical problems.
11-15-73	The remaining portion of the 550 foot test section was run. Also ran the 1st course of the 550 foot control section using regular cement
11-28-73 to 12-10-73	Placed curb and gutter on top of 1st course ofcement stabilized base on both test section and control section.
12-10-73	Began addition of lime treated subgrade.Project at this time was approximately 43% complete
1-9-74	Placed 2nd course of cement stabilized base on test section and control section.
6-5-74 to 6-7-74	Placed 1st course of cement stabilized base on top of lime treated subgrade from station 98+50 to 104·00(Rt.Roadway)
7-12-74 to 7-17-74	Placed curb and gutter on control section Sta. 98+50 to 104+00 (Rt.Roadway)
8-9-74	Placed 2nd course of cement stabilized base on right roadway, Sta. 98+50-104+00.

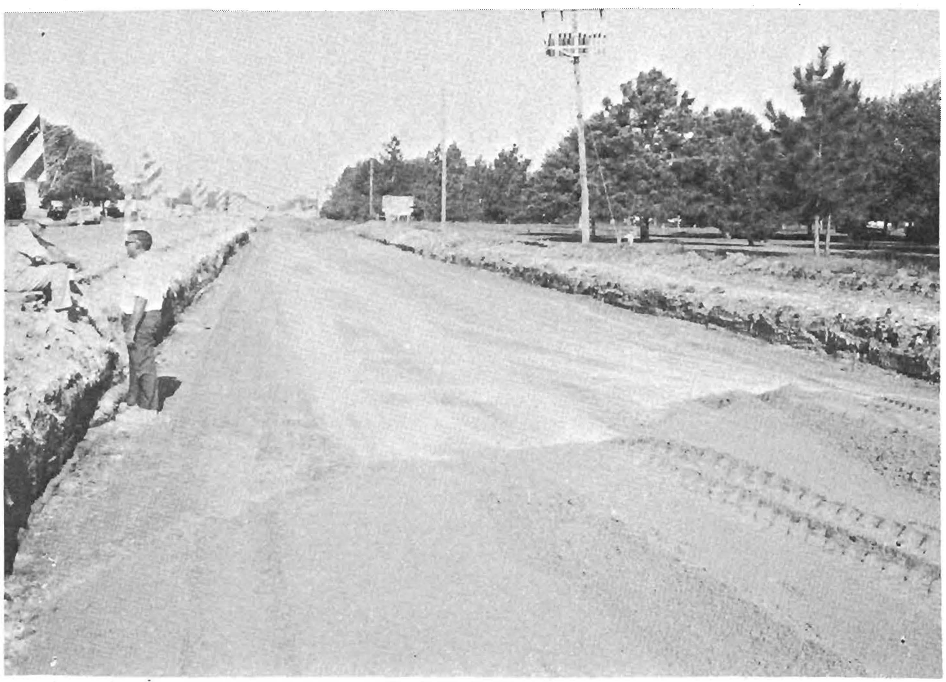
EXHIBIT G

PICTURES OF BASE PLACEMENT AND RESULTS

EXHIBIT H



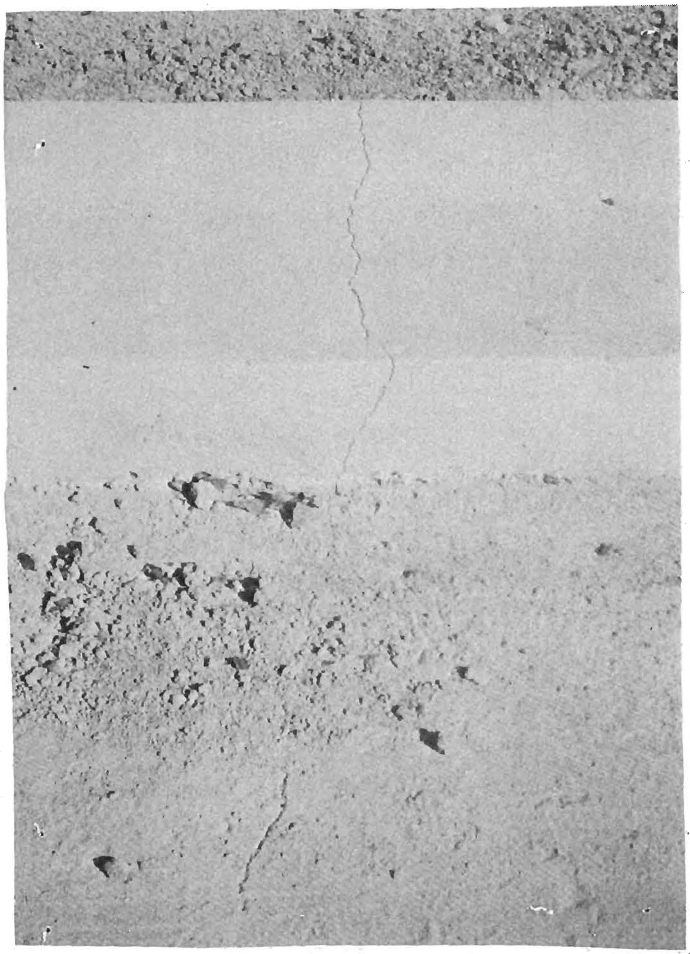
Placing cement stabilized gravel screenings base on untreated subgrade.(TXI 4C Chem Comp expansive cement test section)



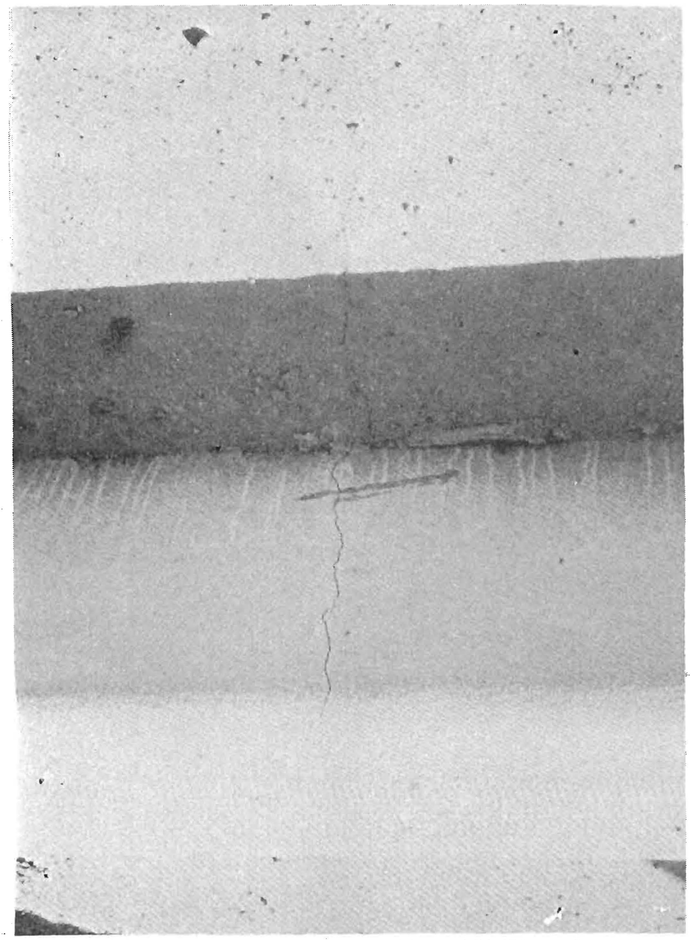
ChemComp expansive cement stabilized gravel screenings base on subgrade.

Grading and compacting cement stabilized base.

Curing 1st course of cement stabilized base

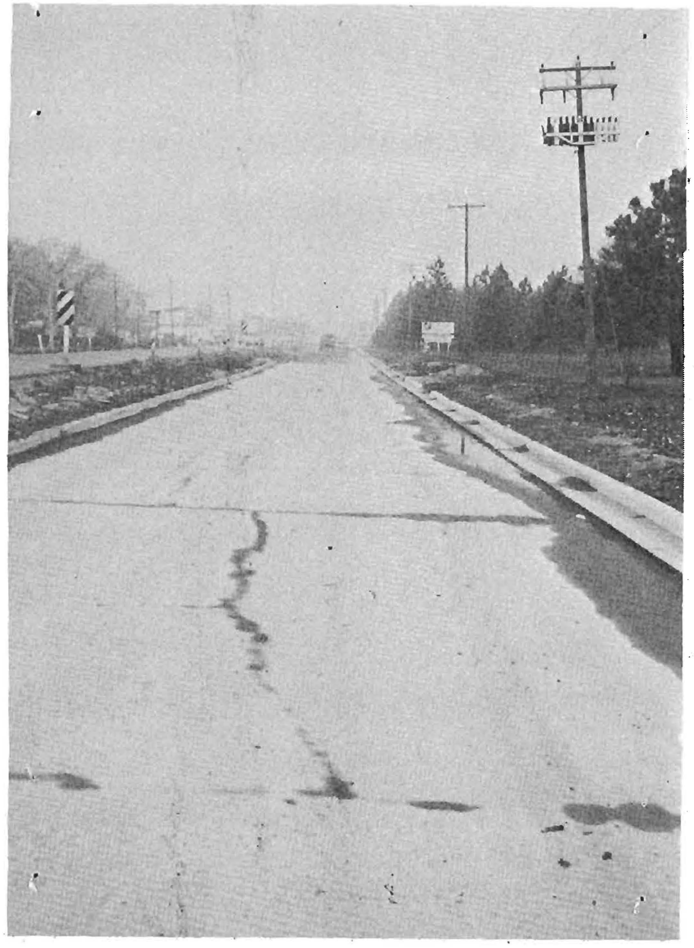


Crack through cement stabilized base (1st 9" course) with Type 1 Portland Cement



Crack through cement stabilized base (1st 9" course) with TXI 4C Chem Comp Expansive cement

Lateral and longitudinal cracks in second course
of expansive cement stabilized base.



Lateral and longitudinal cracks in second course of expansive cement stabilized base.

ITEM 274

CEMENT STABILIZED BASE

The cement stabilized base used on Project C976-3-27, FM 518, consisted (by weight) of 30% sand and 70% gravel screenings (processed gravel Grade 2) with the mixture meeting the following seive requirements.

Seive Size	Percent Retained
1-3/4"	0
No. 4	15-35
No. 40	55-85

The material passing the No. 40 seive was considered as "soil binder" and was required to meeting the following requirements when prepared in accordance with Test Method Tex-101-E Procedure

The Plasticity Index not to exceed 10

The Liquid Limit not to exceed 35

The cement factor used was 7% by dry weight of the mixture. The cement used was Type I Portland Cement conforming to the requirements of ASTM Designation C 150.

The optimum moisture for the mixture was approximately 4.5%. The optimum moisture content and desirable density were determined by Test Method Tex-114-E and checked in the field by Test Method Tex-115-E. The cement stabilized base was compacted to a density of not less than 95% of compaction Ratio, Test Method Tex-114-E.