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# HIGHWAY RESEARCH REPORT

# RECENT EXPERIMENTAL PCC PAVEMENTS IN CALIFORNIA

## INTERIM REPORT

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RONALD REAGAN, *Governor*

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DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819

June 1973
M&R No. 5180-1-73-01
Fed. No. D-5-31

Mr. R. J. Datel
State Highway Engineer

Dear Sir:

Submitted for your consideration, is an interim report entitled:

RECENT EXPERIMENTAL PCC PAVEMENTS

IN CALIFORNIA

Study made by . . . . . . . . . . Concrete Section

Under direction of . . . . . . . . . D. L. Spellman
Supervised by . . . . . . . . . . . J. H. Woodstrom
Report Prepared by . . . . . . . . . P. E. Mason
and
B. F. Neal

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

Attachment

ACKNOWLEDGMENTS

This project was performed in cooperation with the U. S. Department of Transportation, Federal Highway Administration, Agreement No. D-5-31.

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the State of California, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

The authors wish to thank all those who assisted with this project, especially P. Wagner of Headquarters Design, L. Spickelmire of Headquarters Construction, C. Roderick, Resident Engineer, M. McDonald, Office Engineer, and D. Howard, Materials and Research.

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# RECENT EXPERIMENTAL PCC PAVEMENTS IN CALIFORNIA

## INTRODUCTION

Approximately 30% of the lane miles of California's highway system is constructed of portland cement concrete (PCC). These roads carry an extremely large percentage of the total traffic, with some sections of urban freeways having average daily traffic counts in excess of 230,000 vehicles. While the pavements are designed to provide a service life of from 20 to 30 years, a considerable number require remedial treatment before this service life is reached.

Typically, California pavements are unreinforced, 0.70 or 0.75-ft. in thickness, and placed over 0.45-ft. cement treated base which is at least one foot wider on each side than the pavement. Longitudinal joints between 12-ft. lanes are usually insert type weakened plane joints formed by plastic tape placed in the fresh concrete. Transverse weakened plane joints are located at repeated intervals of 13, 19, 18, and 12 feet, and skewed counterclockwise 2 feet in 12. These joints may be constructed either by plastic tape inserted in the fresh concrete or by sawing the hardened concrete. Sealing of joints is usually not specified except in some of the areas of higher elevation where pavement sanding and salting is expected. Tie bars, or dowels, across either the longitudinal or transverse joints are not specified.

Most of the problems with PCC pavements in California are associated with the transverse joints. Uneven volume changes result in curled or warped slabs. Faulting or step-off at the joints also occurs and creates roughness. These defects can lead to cracking of the slabs and structural failure. Also, blowups may occur when the slab ends become overstressed. All these factors lead to the conclusion that changes in design or construction techniques are desirable. Developing a trouble-free pavement system in keeping with economic considerations is a continual goal of highway engineers.

The objective of the research project reported here is to explore various means of providing improved serviceability of PCC pavements in California. The steel industry[1,2] has reported that when properly constructed, continuously reinforced concrete pavements (CRCP) will provide superior traffic service. A trial section of CRCP was constructed in California in 1949[3,4] and is now performing satisfactorily as part of the interstate highway system. Since other states [4-10] have also reported improved performance, though to varying degrees, the predominant experimental feature selected for this study was CRCP. Four other experimental designs were also selected in an effort to find alternatives to steel reinforcement to eliminate or minimize pavement defects.

To determine the feasibility for future work of this nature and to compare alternatives, all costs of construction of the five experimental sections were collected. They are compared to the typical California unreinforced pavement. Studies by McKnight[11] and United States Steel[12] have shown costs for other parts of the United States.

## CONCLUSIONS

The following conclusions concerning construction of the experimental pavements under described conditions, are warranted.

1. All reinforced sections cost more (by at least 58%) to construct than any of the alternative designs.

2. Of the three types of reinforcement, welded wire fabric was the most difficult to place properly, and had the highest unit cost.

3. Sled type mesh depressors can catch and move the mats longitudinally, adversely affecting the planned lap distance. This occurred at times even though the number of ties at splices were considered adequate to prevent translation.

4. Difficulty in adjusting the tubes used to support and guide the longitudinal steel through the placer-spreader resulted in a large portion of the steel being placed below planned depth.

5. The construction rate was slower for reinforced pavement than for nonreinforced (an average of 432 ft./hr. vs 779 ft./hr.).

6. Average crack spacing of the reinforced pavements after 15 months was about 4 ft. for the sections with welded wire fabric, and for those with both longitudinal and transverse steel. For the sections without transverse reinforcement, average crack spacing was about 6 ft., but was 8 ft. in the southbound lanes and 4.5 ft. in the northbound lanes. (There is no readily apparent explanation for the large difference in crack patterns at this time.)

7. In sections with short joint spacing (8, 11, 7, 5 ft.), the average joint opening is about one-half that of the standard spacing (13, 19, 18, 12 ft.).

8. In sections with short joint spacing, about 95% of the sawed joints cracked without having to be induced by application of a heavy "cracking" load.

9. The cost of constructing pavement with short spacing was only about 2% more than that with standard joint spacing.

10. Joint openings in nonreinforced sections were highly variable at early ages, but became more uniform after being open to traffic for a year.

11. A lean concrete base can be mixed in a central mixing plant and placed with a slipform paver in the same manner as the pavement.

12. The cost of 4-sack concrete base was about 60% greater than standard cement treated base.

## PROJECT DETAILS

### Test Site

The project selected for construction of the experimental pavements is located in San Joaquin County, east of the town of Tracy. It consists of two 12-ft. lanes in each direction built to freeway standards and is a part of Interstate 5. The experimental sections are in the middle 9.4 miles of the 14.2-mile project. The roadway is substantially on tangent alignment and has a fairly level grade except at bridges. It passes through cultivated fields and orchards with predominantly clayey native soil. Rainfall averages between 10 and 15 inches per year with approximately 80% occurring between November and March. Temperatures range from lows of 20°F to highs of 115°F with fog prevailing during much of the winter and spring months.

### Roadbed Design (Control Section)

The performance of all experimental sections will be compared to "control" sections which are a typical California unreinforced concrete pavement design.

The structural design thicknesses for the various layers in the control sections were: 0.70-ft. PCC, over 0.45-ft. Class A cement treated base (CTB), over 1.00-ft. Class 4 aggregate subbase (AS), Type A, over 1.00-ft. Class 4 AS Type B over the imported borrow embankment. The shoulder consists of 0.25-ft. asphalt concrete over 0.50-ft. aggregate base over the AS. (The major difference between Type A and Type B AS is in the resistance value (R-value) requirement; Type A must have a minimum of 55, and Type B, 15.)

While there are no strength specifications for CTB or the concrete used in pavements, there are aggregate qualification tests to establish minimum cement contents based on strength attainment of laboratory specimens. For CTB, specimens must reach a compressive strength of 750 psi in 7 days, and for concrete, the design flexural strength of 550 psi in 28 days. From tests made with job aggregates, the minimum cement contents were established; for CTB, 4.0% cement by weight of the dry aggregate, and for concrete, 5.5 sacks per cubic yard. Except for experimental sections 3 and 5, these cement contents were used throughout the project.

## Experimental Features

The predominant experimental feature of the project is continuously reinforced pavement. Three different types of reinforcement were used - longitudinal bars only, longitudinal and transverse bars, and deformed welded wire fabric. The other experimental features are: higher cement content concrete, extra thick pavement, transverse weakened plane joints at approximately one-half the normal spacing, and pavement placed over lean concrete base (LCB). Except for the lean concrete base section, all pavements were placed over CTB. Each feature was incorporated into both the northbound and southbound lanes to provide fair comparisons in case of unequal traffic. (See Figures 1 - 8 for layout and typical cross-sections of the various experimental pavements.)

### CRCP (Experimental Sections 1-A, 1-B, and 1-C)

The thickness designated for CRCP was 0.70-ft., the same as that used for the control. Longitudinal reinforcement was 0.56% of the theoretical cross-sectional area, to be located 0.25 to 0.35-ft. from the top surface. Where longitudinal bars only were used (1-A), the reinforcement consisted of 44 No. 5 round deformed bars spaced at 6-1/2 inches in the 24-ft. slab width. For Section 1-B, longitudinal reinforcement was the same as in 1-A, but transversely, No. 4 bars spaced at 60 inches longitudinally were added. Transverse bars were set to the proper grade by placing on metal chairs, with longitudinal bars tied on top.

The welded wire fabric (1-C) was in the form of mats (approximately 8x40-ft. in size) with D-19 longitudinal bars spaced at 4 inches welded to D-6 transverse wires spaced at 16 inches. The specified minimum yield strength for the longitudinal reinforcing bars was 60,000 psi, and for the wire, 70,000 psi.

Tests indicate the actual yields were approximately 65,000 and 85,000 psi respectively.

A longitudinal insert type weakened plane joint was formed between the 12-ft. lanes, but there were no transverse weakened plane joints in the CRCP sections. Where contact joints were necessary, such as at the end of a day's paving, additional steel was used to provide twice the normal reinforcement.

### Short Joint Spacing (Experimental Section No. 2)

The current practice in California is to place transverse weakened plane joints in unreinforced pavement at repetitive intervals of 13, 19, 18, and 12 feet, and skewed 2 feet in 12 counterclockwise. For this experimental section, intervals of 8, 11, 7, and 5 ft. were used, and the same skew maintained. These distances were established as the least likely to cause rhythmic vehicle motion. Provided these joints could all be made to crack through the slab, the resultant tighter cracks should provide better aggregate interlock and load transfer as well as higher resistance to intrusion of foreign material.

### Higher Cement Content (Experimental Section No. 3)

For this section, the cement content of the pavement was increased to 7.5 sacks per cubic yard as compared to the control section with 5.5 sacks. The purpose was to provide higher concrete strength, thereby reducing the bending stress ratios (ratio of stress induced by loading to flexural strength of concrete), and increasing fatigue life. The greater stiffness of the higher strength slabs was also expected to reduce load deflections and tendencies to pump.

### Extra Thickness Pavement (Experimental Section No. 4)

This section of pavement was built to a thickness of 0.95-ft. compared to the 0.70-ft. used for the remainder of the project. Decreased deflection and resultant pumping action beneath the slab is expected. It was designed to be a "no fatigue" section since calculated stress ratios even at highest loadings would not greatly exceed 0.5.

### Lean Concrete Base (Experimental Section No. 5)

Lean concrete base (LCB) was placed 0.45-ft. thick, using a 4-sack concrete mix. Transverse weakened plane joints were cut at intervals of 30-ft. to relieve tensile stresses and prevent random cracking. A resin base type concrete curing compound was applied in the same manner as used for curing concrete pavement.

Since LCB, as constructed on this project, is more rigid than regular cement treated base and has greater erosion resistance, it is expected to be more effective in reducing the tendency of joints to fault. It has been shown that erosion of the surface of CTB provides one source of material which builds up under one side of joints and causes faulting[13,14]. It has also been shown that joint effectiveness (load transfer efficiency) improves with an increase in foundation bearing value[15].

## CONSTRUCTION DETAILS

The CRCP was placed during the period May 19 through June 9, 1971. The other sections were placed July 2 through July 21, 1971, with a labor strike stopping construction July 12 through 16. Paving rates are shown in Table 1. In addition to the regular inspection, observers were present during the paving operation collecting data on paving rate, weather, joint movement, end movement of CRCP, crack formation, and construction costs.

### Concrete Plant

An Erie-Strayer portable concrete batch plant with twin 12-cubic yard tilt drum mixers was set up near the middle of the project. Aggregate from a commercial source about 5 miles from the project was stockpiled at the plant. Automatic batching was controlled by an operator at an electronic console mounted in a trailer. Either end or belly dump trucks were used in hauling the concrete to the grade, depending on the experimental section being placed. The number of trucks in use at a given time was dependent on the length of haul and occasionally on truck availability.

### Base

The Contractor, Gordon H. Ball, Inc., at his option, elected to use plant-mixed CTB in lieu of road-mixed CTB. An automatic batch plant was erected near the jobsite and used for mixing. The CTB was hauled to the roadway in bottom dump trucks and spread and brought to grade by a slipform paver. Line and grade control was provided by guide wires and electronic devices. Some compaction was obtained with a vibratory screed attached to the paver. Final compaction was achieved with a vibratory steel wheel roller, followed by a pneumatic tired roller. (See Figures 9, 10, and 11.) With this procedure, no trimming or excessive manipulation of the CTB took place, and it is believed that the surface of this layer will be more durable and erosion resistant than that of CTB normally placed.

The lean concrete base in Experimental Section 5 was produced in a concrete batch plant and placed with a slipform paver. (See Figures 12, 13, and 14.) A nylon broom towed behind the paver added some texture. Few problems developed with this base operation. In a few locations, hand finishing had to be employed to remove irregularities, and occasionally shrinkage cracks occurred (see Figure 15). These were probably due to a combination of factors, such as excessive working of the surface, rapid drying conditions, and loss of water to the untreated subbase. The cracks are not considered to be harmful to the LCB surface durability.

## Paving

In the unreinforced sections, the paving train consisted of the slipform paver, a pipe float, burlap drag, curing machine, followed later by a saw for cutting the transverse weakened plane joints. In the reinforced sections, a placer-spreader machine with a side delivery attachment was added to place the concrete to approximate grade. The slipform paver provided vibration and strikeoff to final grade, followed by the float, drag, and curing rig.

Paving started in the section with longitudinal steel only (no transverse steel). (See Figures 16, 17, and 18). The bars were placed on the base in approximate final location and the 20-inch laps were tied at staggered intervals across the roadbed. Pushed along on skids in the front of the placer-spreader was a frame holding forty-four 2-1/4-inch diameter metal tubes with flared ends. Bars were fed through the tubes for proper positioning in the fresh concrete. Occasionally a lap splice would catch on a metal tube resulting in a brief paving delay while a bent rebar was replaced. A few minor problems arose in the use of side delivery equipment for the concrete, but these were gradually overcome. Considerable difficulty was experienced in adjusting the metal tubes to obtain proper placement of the rebars in the concrete. Much of this section has steel well below the planned depth.

Where transverse bars were used, they were clipped to metal chairs and spaced at 60-inch intervals. Longitudinal bars were then placed on top at the proper spacing and tied to the transverse steel (see Figures 19, 20, and 21). The staggered longitudinal laps were also tied except at intervals of about 1500 feet where laps were left untied until just before paving to allow for expansion. However, on one bridge approach grade, thermal expansion of the steel caused the chairs to tip over for the entire 1500 feet. The repositioning of the chairs and steel required considerable effort by the Contractor, but the problem was fully corrected with no damage to the involved section.

The welded wire fabric was prefabricated into 40-ft. long mats. Three mats were used for the 24-ft. pavement width, one of which was 7'-10" wide and two were 8'-9" wide. Concrete was deposited directly on the base and brought to approximate grade by the placer-spreader machine. The mats were then placed on the fresh concrete by a crane and laps (16-inch longitudinal and 8-inch transverse) tied by iron workers. The longitudinal laps were staggered about 4 feet across the roadway (see Figures 22, 23, 24, and 25). A mesh depressor attached to the front of the slipform paver forced the fabric into the concrete to the proper depth with vibrating vertical baffles (see Figure 26). The depressor rode on pneumatic tires and had a hydraulic system to control the height of the baffles. It was noted during construction that occasionally the depressor caught on mats breaking splices and bending the steel. This created delays while the mats were replaced and retied. As described later, several failures occurred at lap splices.

A series of lug type terminal anchors were designed for use before each bridge approach in the CRCP sections. The lugs were intended to restrain the movements of the slab ends to approximately the same degree that the major portion of the pavement is restrained, and prevent excessive pressure on structure abutments due to thermal expansion[16] and the growth phenomenon[4]. A lug series consisted of five 3-ft. deep by 2-ft. wide trenches excavated across the CTB 17 feet apart beginning 16 feet from the bridge approach slab. The lugs were reinforced with stirrups and continuous bars. One group of lugs was filled with concrete prior to paving (these were made with a key formed on top), and the rest were filled with concrete during the paving operation (see Figures 27 and 28).

The end of the CRCP where it reaches the bridge approach slab rests upon half of a 2'-3" wide sleeper slab. Between the pavement slab and sleeper slab are two layers of 30-lb. roofing felt with graphite between them. The sleeper slab extended beneath the bridge approach slab also and was connected to it by reinforcement. A 1-1/4-in. sealed expansion joint was placed between the CRCP and bridge approach slab (see Figure 29). Theoretically, the lugs will restrain most of the longitudinal movement that might occur in the pavement and the 1-1/4-in. expansion joint will be more than adequate to accomodate the movement expected at the free end of the pavement.

## OBSERVATIONS AND MEASUREMENTS

### Weather

The range of temperatures during the paving operation is shown in Table 2. Daily variations of 30 to 50 degrees were conducive to early thermal cracking. Wind was normally calm in the morning and around 10 miles per hour in the afternoon although on three days, it was over 15 miles per hour. Relative humidity generally ranged from 55% in the morning to 35% in the afternoon. A small amount of rain which fell on one day did not interrupt the paving operations.

### Construction Costs

Collection of cost data was done in cooperation with the Contractor. A summary of the cost comparisons is shown in Table 3. Only the base and pavement data were collected for this comparison. Because of special construction considerations, the costs of the standard reinforced concrete bridge approach slabs (approximately 10-1/2 feet) are not incorporated into the cost comparison data. Costs involved in setting up the base and concrete plants are also omitted. Indirect costs, such as those involved in maintaining haul roads for batch trucks, are included. Overtime salaries were reduced to straight time for comparison purposes and included fringe benefits payable by the Contractor. A surcharge of 30% for Contractor's overhead and profit was added to the computed unit cost of all base and pavement sections.

The unit cost of CTB includes charges for aggregate, cement, plant operation, hauling to the grade, placing, rolling, and sealing. Unit cost of LCB includes charges for aggregate and hauling to the batch plant, cement, batch plant operation, hauling to the grade, paving, finishing, curing, and sawing transverse weakened plane joints, including men and equipment.

Unit costs of the concrete pavement include charges for aggregate and hauling to the batch plant, cement, batch plant operation, hauling concrete to the grade, paving, finishing, curing, and sawing transverse weakened plane joints (where applicable), including men and equipment. In the CRCP sections, charges for excavating terminal anchor lugs are included as well as the costs of reinforcement, material, shipping, and placing.

The base for cost comparisons is the control portion of the project within experimental limits. Since some of the experimental sections were at the longest haul distance, average haul lengths were used in cost computations, both for unreinforced and reinforced sections.

## CRCP Crack Surveys

Mapping of cracks started the day following construction and was repeated as often as time permitted during the first few weeks. A survey of all the reinforced sections was made just before opening to public traffic when the average pavement age was about five months. The latest survey was made after being open to traffic for approximately one year. Mapping of cracks during this last survey was limited to the travel lane and was made on typical 1000-ft. lengths of each CRCP type with one exception -- only 400-ft. of undisturbed pavement was available in the northbound welded wire fabric section where a number of repairs were made. Average slab length, or the average distance between cracks, for three types of reinforcement up to age 15 months, is shown in Table 4. Reduction in slab length over a period of time is shown in Table 5.

Many cracks did not extend across both lanes of pavement. This resulted in the calculated average slab length being longer in the passing lane than in the travel lane.

According to a study made at Purdue University[9], slab length is a function of reinforcement depth. In the experimental sections where longitudinal bars only were used, much of the steel was placed below design depth and the result was considerably longer slab lengths. As expected, such cracks are of slightly greater width.

Not indicated in Table 4 is the fact that pavement placed early in the day tended to have shorter slab lengths than that placed later in the day. Concrete placed early in the day is subjected to more solar radiation and generally is warmer when final set occurs than that placed later in the day. Thermal contraction is therefore greater for concrete placed in the morning and is considered to be the reason for the observed cracking pattern.

The cracking over the lug areas was not considered typical and was omitted from the calculation of average slab length. Areas adjacent to large cracks which occurred in the wire mesh section (see "Pavement Failure") were also omitted.

## End Movement of CRCP

Pavement gauge plugs and external reference points were placed to measure longitudinal end movement of the CRCP. Although the reference points were set in concrete along the right of way and thought to be safe, most were destroyed by a motor grader during cleanup work. The few measurements that were made are shown in Table 6. At the Deuel Overhead location, the contractor elected to make a contact joint about 120 feet from the bridge, and the remaining portion, including the anchor lugs, was not placed until 41 days later. A check on this free end 17 days after placement showed no movement.

Unfortunately, further measurements of these end movements cannot be made. It is believed, however, that the lug type terminal anchors will supply sufficient restraint to the force induced by "growth" and thermal expansion to prevent appreciable movement.

## Transverse Joint Movement (Unreinforced Sections)

To study movement at cracks induced by transverse weakened plane joints, sets of two gauge plugs were placed in the fresh concrete about 10 inches apart. (See Figures 30, 31, 32, and 33.) Later in the day, a saw cut 0.17-ft. deep was made between them. Twenty pairs of plugs were placed -- 10 in the control section and 10 in the short joint section. The plugs have threaded tops and screw-on caps to keep out foreign material. Measurements are made with a shop fabricated strain gauge to the nearest .001-inch. Results of measurements are shown in Tables 7 and 8. Although the amount of movement from one joint to another is not uniform, average joint width in the short spacing is about half that in the standard spacing. The total change in equivalent lengths of pavement is about the same, however.

Within a week after paving, cracks had formed at approximately 90% of the planned joints in both the sections with normal spacing and those with short joint spacing.

Two or three of the joints being measured do not appear to be "working" although the same joints in the adjacent lane were observed to be cracked within a week.

## Roughness Measurements

To determine roughness of the various pavements, profilograms were obtained with a California truck-mounted profilograph and rideability was measured with a PCA type Road Meter. Results of these measurements up to age 16 months are shown in Table 9. Specifications require that the profile index of new PCC pavements not exceed 7 inches per mile. There is no specification limit for the Road Meter.

All of the experimental pavements were considered to be relatively smooth at an average age of approximately six months. Profile indices indicate significant increases in roughness of some sections at 16 months, especially in the northbound control section and the pavement with higher cement content. Profilograms show that many slabs in these sections have curled, creating greater roughness. Figure 34 depicts typical profiles of both curled and noncurled pavements.

On new PCC pavements, constructed in California, Road Meter results usually vary from 300 to 700 counts per mile depending on the type of roughness built in, including texturing. At age six months, the rideability of all sections was generally satisfactory. At 16 months there is a significant increase in roughness in most sections. Due to limitations of equipment, initial Road Meter results were averaged for the four shorter experimental pavements. A new dual-control console has simplified obtaining individual readings of contiguous short sections.

## Deflections

A Dynaflect* was used to obtain deflection readings of the subgrade, AS (Types A and B), CTB, LCB, and the CRCP, and to

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*The Dynaflect is an electro-mechanical device for measuring dynamic deflections generated by an oscillatory load. M&R Report "Evaluation of the Lane-Wells Dynaflect", No. 633297, October 1968.

check on uniformity of compaction, or rigidity. The values do not appear to have significant meaning at this time, but in case of any unusual performance of the pavement test sections, the readings can be reviewed.

## Materials Tests

Typical results of tests on the various materials used in the embankment, subbase, and base are shown in Table 10. In a few areas, the Type A AS failed to meet R-value requirements. However, by treating the material with lime and recompacting, the contractor was able to meet specification limits.

Results of tests on fresh concrete used in the pavement and base are shown in Table 11. Cement content of fresh concrete was determined by a titration test method which is being developed for possible mixer performance and field control testing.

Cores were obtained from the base and pavement sections. Data from core tests are shown in Table 12. Although it was originally anticipated that depth of steel might be determined by use of a Pachometer, the amount of concrete cover was too great. Over 100 cores were cut from the CRCP sections to check on the steel depth and thickness of concrete.

## PAVEMENT FAILURE

Shortly before the pavement was to be opened to traffic, wide transverse cracks started appearing in the two sections reinforced with welded wire fabric. Cracks were wide enough to be seen when driving by at high speed and the length was noted to be that of mat widths. Preliminary investigation revealed insufficient lap splice. A survey of both sections was made and 57 wide crack locations were found and marked for repair. At 10 locations, three cracks were present over the 24-ft. wide pavement at 4-ft. staggered mat intervals, nine locations had two cracks, and 38 locations had a crack across only one of the three mats of reinforcement (see Figure 35). Excavation at crack locations revealed laps measuring from 10-1/2 inches to a maximum gap of 16 inches. (A minimum lap of 16 inches was specified.)

Repair work consisted of saw cutting around each crack in an approximate 8-ft. by 6-ft. pattern, the 6-ft. length providing space for placement and lapping of additional reinforcement. Concrete was removed for the full depth of the slab, No. 5 bars were tied to the existing mesh (see Figure 36), and fresh concrete was placed.

The cost of these repairs was approximately $29,000, which is not included in the cost comparison. All of the repaired areas are performing satisfactorily at this time and only one new wide crack has been found since opening to traffic.

Removing concrete in the repair areas also provided an opportunity to check depth of steel placement. Most of the mat was within design tolerances, but at some transverse laps, the edges had curled upward, even to the extent of being exposed at the surface in one instance. The reason for this is not known since supposedly equal pressure was applied by the depressor at all points.

## FUTURE PLANNED WORK

The following work is planned at intervals deemed necessary to properly evaluate performance of the experimental pavement sections:

1. Mapping of cracks in selected typical areas of the CRCP sections.
2. Measure joint movement in both control and short joint spacing sections.
3. Make faulting measurements at established points on the unreinforced pavements.
4. Make traffic counts and/or loadometer surveys.
5. Obtain maintenance costs for individual sections.
6. Measure roughness either by Profilograph, Road Meter, or both.

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6. Sternberg, Fred "Experimental Continuously Reinforced Concrete Pavement Study, Rte. I-84, Southington" Connecticut State Highway Department, June 1969.

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TABLE 1

PAVING RATES (Feet per Hour)*

| | Continuously Reinforced Concrete Pavement | | | | | | |
|---|---|---|---|---|---|---|---|
| | Longitudinal Only | | Longitudinal with Transverse Bars | | Welded Wire Fabric | | Total |
| | Daily Range | Avg. | Daily Range | Avg. | Daily Range | Avg. | Average |
| S.B. | 93-373 | 315 | 458-569 | 517 | 183-491 | 395 | 406 |
| N.B. | ** | 616 | 282-535 | 460 | 132-464 | 401 | 452 |
| Totals | 10,292 ft. / 25 hours | =412 | 19,320 ft. / 40 hours | =483 | 18,941 ft. / 47.5 hours | = 399 | 48,553 ft. / 112.5 hrs. = 432 |

| | Unreinforced PCC Pavement | | | | | | |
|---|---|---|---|---|---|---|---|
| | Higher Cement Content | | Extra Thick Concrete | | All Other Sections | | Total |
| | Daily Range | Avg. | Daily Range | Avg. | Daily Range | Avg. | Average |
| S.B. | ** | 770 | ** | 589 | 315-1081 | 787 | 763 |
| N.B. | 230-697 | 527 | ** | 456 | 732-1129 | 1021 | 799 |
| Totals | 5976 ft. / 9.5 hrs. | = 629 | 5089 ft. / 10 hrs. | = 509 | 37,983 ft. / 43.5 hrs. | = 873 | 49,048 ft. / 63 hours = 779 |

* Actual paving time only, 24 feet wide
** One day or less

TABLE 2

WEATHER SUMMARY

| Date | Stations Paved, (Approx.) | Sky Conditions | Temp. Range, °F AM | Temp. Range, °F PM | Wind, MPH AM | Wind, MPH PM | Rel.Hum.,% AM | Rel.Hum.,% PM |
|---|---|---|---|---|---|---|---|---|
| 1971 | | | | | | | | |
| 5-19 | 407-409 SB | Clear | 51 | 81 | Calm | Calm | -- | -- |
| 5-20 | 409-427 SB | Clear | 50 | 73 | Slight | Calm | -- | -- |
| 5-21 | 427-460 SB | Clear | 48 | 69 | Slight | High | -- | -- |
| 5-22,23 | ---------- | ----- | 52 | 90 | ------ | ------ | -- | -- |
| 5-24 | 460-495 SB | Clear | 51 | 88 | Calm | 13 | -- | -- |
| 5-25 | 495-543 SB | Clear | 54 | 88 | 18 | 35 | -- | -- |
| 5-26 | 543-548 SB | Scattered clds. | 47 | 72 | Calm | Slight | -- | -- |
| 5-27 | 548-588 SB | Clds, shower in PM | 50 | 62 | Calm | 11 | -- | -- |
| 5-28 | 588-624 SB | Clds, rain aft. 15:15 | 51 | 68 | Calm | Calm | -- | -- |
| 5-29,30,31 | ---------- | Scattered clds. | 45 | 72 | ------ | ------ | -- | -- |
| 6-1 | 400-351 NB | Clear | 48 | 68 | Calm | 10 | -- | -- |
| 6-2 | 351-313 NB | Clear | 49 | 82 | Calm | 13 | 42 | 30 |
| 6-3 | 313-259 NB | Clear | 49 | 80 | Calm | 7 | 58 | 37 |
| 6-4 | 259-234 NB | Clear | 48 | 85 | Calm | 7 | 67 | 36 |
| 6-5,6 | ---------- | Clear | 55 | 90 | ------ | Windy | -- | -- |
| 6-7 | 234-208 NB | Clear | 52 | 76 | Calm | 10 | 60 | 30 |
| 6-8 | 208-171 NB | Clear | 54 | 88 | Calm | 7 | -- | 33 |
| 6-9 | 171-123 NB | Cloudy | 51 | 80 | Calm | 15 | -- | 38 |
| 6-10 | ---------- | Clear | 56 | 81 | Calm | 7 | 50 | 42 |
| 6-11 | ---------- | Clear | 54 | 88 | Calm | 4 | -- | 39 |
| 7-2 | 626-596 NB | Clear | 56 | 88 | ------ | 13 | -- | 41 |
| 7-3,4,5 | ---------- | Clear | -- | 93 | ------ | ------ | -- | -- |
| 7-6 | 596-545 NB | Clear | 54 | 90 | ------ | ------ | -- | -- |
| 7-7 | 545-461 NB | Clear | 57 | 83 | ------ | ------ | -- | -- |
| 7-8 | 461-406 NB | | | | | | | |
| | 402-299 SB | Clear | 57 | 92 | 5 | 10 | 41 | 32 |
| 7-9 | 299-238 SB | Clear | 65 | 83 | 4 | ------ | 49 | -- |
| 7-10,11 | ---------- | Clear | -- | 87 | ------ | ------ | -- | -- |
| 7-19 | 238-217 SB | Clear | 64 | 100 | ------ | 7 | -- | 31 |
| 7-20 | 217-173 SB | Clear | 69 | 100 | 2 | ------ | 41 | -- |
| 7-21 | 173-122 SB | Clear | 66 | 99 | ------ | 13 | -- | -- |
| 7-22 | ---------- | Clear | 60 | 100 | ------ | ------ | -- | -- |
| 7-23 | ---------- | Clear | 62 | 93 | ------ | ------ | -- | -- |

TABLE 3

COST COMPARISON

| | | AREA, SQ. YD. | COST/SQ. YD. | % OF CONTROL |
|---|---|---|---|---|
| BASE | C T B | 269,520 | $1.51 | 100% |
| | L C B | 15,170 | 2.39 | 159 |
| PCC PAVEMENT | Large Control Area | 85,390 | 3.99 | 100 |
| | Short Joint Spacing | 16,170 | 4.08 | 102 |
| | High Cement Content | 16,130 | 4.56 | 114 |
| | Extra Thickness | 13,570 | 5.37 | 134 |
| CRCP | Continuous Bars Only | 27,700 | 6.32 | 158 |
| | Continuous & Transverse Bars | 51,520 | 6.35 | 159 |
| | Welded Wire Fabric | 51,250 | 7.30 | 183 |

Pavement portion includes materials, mixing, hauling, placing, curing, sawing, reinforcement and anchor lugs. The cost data is the best estimate with the figures available including 30% for overhead and profit.

TABLE 4

CRCP SLAB LENGTH SUMMARY

| AGE | | 5 MONTHS | | | | 15 MONTHS |
|---|---|---|---|---|---|---|
| Type | | Average Depth to ℄ Reinf. | Passing Lane | Travel Lane | Average | Travel* Lane |
| Longitudinal Bars Only | NB | 0.46 ft. | 6.9 ft | 5.9 ft | 6.4 ft | 4.5 ft |
| | SB | 0.47 | 9.3 | 8.7 | 9.0 | 8.0 |
| | Avg | 0.46 | 8.1 | 7.3 | 7.7 | 6.2 |
| Longitudinal Bars with Transverse | NB | 0.33 | 4.1 | 3.9 | 4.0 | 3.7 |
| | SB | 0.34 | 5.1 | 5.2 | 5.2 | 4.0 |
| | Avg | 0.34 | 4.6 | 4.6 | 4.6 | 3.8 |
| Welded Wire Fabric | NB | 0.33 | 5.1 | 5.1 | 5.1 | 4.1 |
| | SB | 0.32 | 3.8 | 3.8 | 3.8 | 3.3 |
| | Avg | 0.33 | 4.4 | 4.4 | 4.4 | 3.7 |

* Typical 1000-foot sections only

TABLE 5

CRACKING vs TIME
CRCP SLAB LENGTHS IN FEET*

| Age | Longitudinal Only | | Longitudinal With Transverse | | Welded Wire Fabric | |
|---|---|---|---|---|---|---|
| | S. B. | N. B. | S. B. | N. B. | S. B. | N. B. |
| Days | | | | | | |
| 1 | 1000 | --- | 1000 | --- | 1000 | --- |
| 2 | --- | --- | 29 | --- | 1000 | 80 |
| 3 | 24 | 30 | 20 | --- | --- | --- |
| 4 | 20 | --- | 19 | 13 | 100 | --- |
| 5 | 14.7 | --- | 17 | --- | 56 | 12 |
| 6 | 14.5 | --- | --- | 9.8 | --- | --- |
| 7 | --- | 15 | --- | 9.7 | --- | 10 |
| 14 | 14.1 | --- | 10 | --- | --- | --- |
| 20 | --- | --- | --- | --- | 9.1 | --- |
| Months | | | | | | |
| 1 | --- | 8.7 | --- | 8.2 | --- | 8.7 |
| 2 | 13.5 | --- | 9.1 | --- | 6.4 | --- |
| 5 | 11.1 | 5.7 | 5.1 | 3.8 | 3.5 | 5.6 |
| 15 | 8.0 | 4.5 | 4.0 | 3.7 | 3.3 | 4.1 |

*Typical 1000-foot sections only

TABLE 6

MOVEMENT OF END OF CRCP

| Location | Age of Pvmt., Days | Movement Inches | Remarks |
|---|---|---|---|
| SOUTHBOUND: | | | |
| Deuel OH South side | 17 | ----- | Measurement taken on pvmt. free end, anchor lugs placed later with pvmt. plug |
| Rte. 5/33 Sep. North side | 5<br>26 | + .12<br>+ .05 | Anchor lugs placed separately, prior to pavement placing operations |
| NORTHBOUND: | | | |
| Rte. 5/33 Sep. South side | -- | ----- | Anchor lugs placed later by hand with pavement plug |
| Rte. 5/132 Sep. North side | -- | ----- | Anchor lugs placed monolithically with pavement by paver |
| Rte. 5/132 Sep. South side | -- | ----- | Same as above |
| Delta Mendota Canal North side | -- | ----- | Anchor lugs placed monolithically with pavement by paver |
| Delta Mendota Canal South side | -- | ----- | Same as above |
| California Aqueduct Br. North side | 41 | - .25 | Anchor lugs were placed monolithically with pavement by paver |
| California Aqueduct Br. South side | 38 | + .10 | Anchor lugs placed with plug 2 days after paving. Measurements on the plug. |
| Hospital Creek Bridge North side | 38 | - .08 | Anchor lugs were placed with plug 2 days after paving. Measurements on the plug. |

+ = Expansion

- = Contraction

TABLE 7

TRANSVERSE JOINT MOVEMENT
(Unreinforced, Standard Spacing)
Change in Width from Original, 0.001-Inch

| Slab Length, Feet | 13 | 12 | 18 | 19 | 13 | 12 | 18 | 19 | 13 | 12 | 18 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gauge No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Air Temp. | Avg. |
| Date 1971: | | | | | | | | | | | | |
| 7-9 | +1 | 0 | +29 | +1 | +1 | +10 | 0 | +40 | +1 | +10 | 76° | +10 |
| 7-19 | +4 | +25 | +42 | +32 | +1 | +47 | +26 | +45 | +1 | +28 | 72° | +25 |
| 7-19 | 0 | +6 | +6 | +10 | -1 | +14 | +8 | +10 | -1 | +5 | 90° | +6 |
| 7-20 | +4 | +26 | +39 | +33 | +1 | +46 | +28 | +43 | +3 | +30 | 73° | +26 |
| 11-22 | +44 | +45 | +78 | | +17 | +46 | +66 | +85 | +27 | +27 | 50° | +50 |
| 1972: | | | | | | | | | | | | |
| 1-5 | +44 | +40 | +70 | +123 | +14 | +35 | +60 | +86 | +24 | +15 | 50° | +51 |
| 4-1 | +43 | +43 | +57 | | +19 | +36 | +51 | +56 | | +21 | 64° | +41 |
| 6-13 | +26 | +35 | +33 | | +23 | +32 | +38 | +10 | | +21 | 90° | +27 |
| 8-24 | +35 | +52 | +48 | +56 | +34 | +50 | +55 | +29 | +37 | +35 | 82° | +43 |
| 9-21 | +69 | +68 | +90 | +96 | +42 | +68 | +87 | +73 | +49 | +55 | 67° | +70 |
| 9-21 | +51 | +51 | +60 | +64 | +38 | +55 | +60 | +40 | +39 | +37 | 83° | +50 |

TABLE 8

TRANSVERSE JOINT MOVEMENT
(Unreinforced, Short Spacing)

Change in Width from Original, 0.001-inch

| Slab Length, Feet | 8 | 5 | 7 | 11 | 8 | 5 | 7 | 11 | 8 | 5 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|

| Gauge No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Air Temp. | Avg. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | | | | | | | | | | | | |
| 1971: 7-9 | 0 | 0 | +2 | +3 | 0 | -1 | +3 | +2 | 0 | +6 | 76° | +1 |
| 7-19 | -1 | -1 | +18 | +18 | 0 | 0 | +23 | +13 | -2 | +27 | 72° | +9 |
| 7-19 | 0 | -1 | +2 | -1 | 0 | 0 | +2 | -1 | +1 | +7 | 90° | +1 |
| 7-20 | 0 | -1 | +20 | +19 | +1 | +1 | +24 | +14 | +1 | +28 | 73° | +10 |
| 11-22 | -1 | +8 | +37 | | +23 | | +39 | +28 | -3 | +90 | 50° | +38 |
| 1972: 1-5 | -1 | +8 | +32 | +35 | +25 | 0 | +32 | +18 | +2 | +102 | 50° | +25 |
| 4-1 | 0 | | +21 | +23 | +25 | | +26 | +14 | 0 | +73 | 64° | +21 |
| 6-13 | 0 | | +16 | +16 | +28 | | +19 | | 0 | +28 | 90° | +16 |
| 8-24 | -1 | +24 | +24 | +12 | +39 | -3 | +32 | +24 | 0 | +36 | 82° | +19 |
| 9-21 | +1 | +34 | +43 | +47 | +57 | +2 | +58 | +57 | +4 | +77 | 67° | +38 |
| 9-21 | -3 | +24 | +27 | +12 | +41 | -3 | +35 | +24 | 0 | +41 | 83° | +20 |

TABLE 9

ROUGHNESS OF EXPERIMENTAL SECTIONS

| | | Profile Index Inches/Mile | | Road Meter Σ Counts/Mile | |
|---|---|---|---|---|---|
| | | Age | | Age | |
| | | 6 Mos. | 16 Mos. | 6 Mos. | 16 Mos. |
| Control | SB | 7 | 8 | 515 | 690 |
| | NB | 5 | 10 | 570 | 825 |
| 1A Longitudinal Bars Only | SB | 6 | 6 | 765 | 1070 |
| | NB | 3 | 2 | 530 | 645 |
| 1B Transverse and Longitudinal Bars | SB | 3 | 2 | 495 | 575 |
| | NB | 2 | 2 | 500 | 625 |
| 1C Welded Wire Fabric | SB | 4 | 4 | 540 | 690 |
| | NB | 6 | 7 | 590 | 695 |
| 2 Short Joint Spacing | SB | 5 | 6 | 540* | 730 |
| | NB | 2 | 5 | 525* | 695 |
| 3 Higher Cement Content | SB | 6 | 9 | 540* | 890 |
| | NB | 3 | 8 | 525* | 730 |
| 4 Extra Thickness Pavement | SB | 7 | 6 | 540* | 835 |
| | NB | 4 | 6 | 525* | 690 |
| 5 0.70' Pavement over 4-sack PCC Base | SB | 6 | 6 | 540* | 635 |
| | NB | 5 | 6 | 525* | 905 |

*Average of all four sections.

TABLE 10

ROADWAY MATERIALS TEST

| Material | Sand Equivalent | | | R-Value* | | | Relative Compaction | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | Range | Average | No. of Samples | Range | Average | No. of Samples | Average | No. of Samples | |
| Imported Borrow | 11-34 | 18.3 | 12 | 18-82 | 34.8 | 12 | --- | -- | |
| Class 4AS | | | | | | | | | |
| Type B | 10-28 | 20.0 | 27 | 19-70 | 48.3 | 27 | --- | -- | |
| Type A | 17-30 | 23.0 | 76 | 55-86 | 66.6 | 77 | --- | -- | |
| Class A CTB | 26-35 | 31.8 | 4 | ----- | ---- | -- | 97.7 | 19 | Avg. 7-da. compres-sive strength, 921 psi |
| Class 2AB 3/4" | 30-55 | 40.8 | 25 | 83-86 | 84.9 | 15 | 97.6 | 7 | Shoulder areas |

* Resistance according to Test Method No. Calif. 301.

TABLE 11

TESTS ON FRESH CONCRETE (AVERAGE)

| Type | Cement Content | | Slump, Ins. | Air Content Percent | Compressive Strength, psi | | Flexural Strength ** | |
|---|---|---|---|---|---|---|---|---|
| | Design | Actual* | | | 14 da. | 28 da. | 7 days | 14 days |
| Laboratory | 5.5 | | 2.2 | 3.2 | 3760 | ------ | ------ | 605 |
| Control Pvmt. | 5.5 | 5.4 | 2.1 | 3.0 | | 3850 | 670 | |
| CRCP Pvmt. | 5.5 | 5.1 | 2.2 | 3.9 | 2975 | | 655 | |
| High Strength | 7.5 | 7.1 | 2.0 | 2.5 | | 4505 | 810 | |
| LCB | 4.0 | 4.0 | 2.5 | 2.8 | | 3050 | 580 | |

* From titration tests

** Laboratory tests - third point loading
Field Tests - center point

TABLE 12

PAVEMENT CORE SUMMARY

| | | | Pavement Thickness | | Compressive Strength* 90 Days | | Depth to C/L Reinforcement | |
|---|---|---|---|---|---|---|---|---|
| | | | S. B. | N. B. | S. B. | N. B. | S. B. | N. B. |
| Unreinforced PCC Pavement | Extra Thick (.95') | Avg. | 0.98' | 0.98' | 4664 psi | 4748 psi | ---- | ---- |
| | | Range | 0.96-0.99 | 0.96-0.99 | 4450-4770 | 4040-5220 | | |
| | High Cement Content (7.5 Sks./cu.yd.) | Avg. | 0.70' | 0.73' | 6545 psi | 6748 psi | ---- | ---- |
| | | Range | 0.67-0.72 | 0.70-0.78 | 6060-6920 | 6000-7590 | | |
| | LCB, Short Joint and Control | Avg. | 0.73' | 0.74' | 5316 psi | 5394 psi | ---- | ---- |
| | | Range | 0.69-0.78 | 0.69-0.83 | 3880-6000 | 4560-6190 | | |
| CRCP | Longitudinal Reinf. only | Avg. | 0.73' | 0.74' | 5236 psi | 5253 psi | 0.47' | 0.46' |
| | | Range | 0.69-0.76 | 0.71-0.77 | 4440-5920 | 4700-5880 | .32-.56 | .35-.40 |
| | Longitudinal and Transverse | Avg. | 0.72' | 0.72' | 5927 psi | 5139 psi | 0.34' | 0.33' |
| | | Range | 0.68-0.79 | 0.67-0.76 | 5260-6640 | 4520-5480 | .29-.41 | .23-.40 |
| | Welded Wire Fabric | Avg. | 0.72' | 0.74' | None | None | 0.32' | 0.33' |
| | | Range | 0.68-0.75 | 0.69-0.79 | | | .25-.40 | .16-.46 |

*Compressive strength adjusted to $\frac{L}{D} = 2$

Figure 1

Control Section
Standard Spaced
Transverse Joints
See Figure 2

Longitudinal Bars Only
CRCP (1A)
See Figure 3

Longitudinal & Transverse Bars
CRCP (1B)
See Figure 4

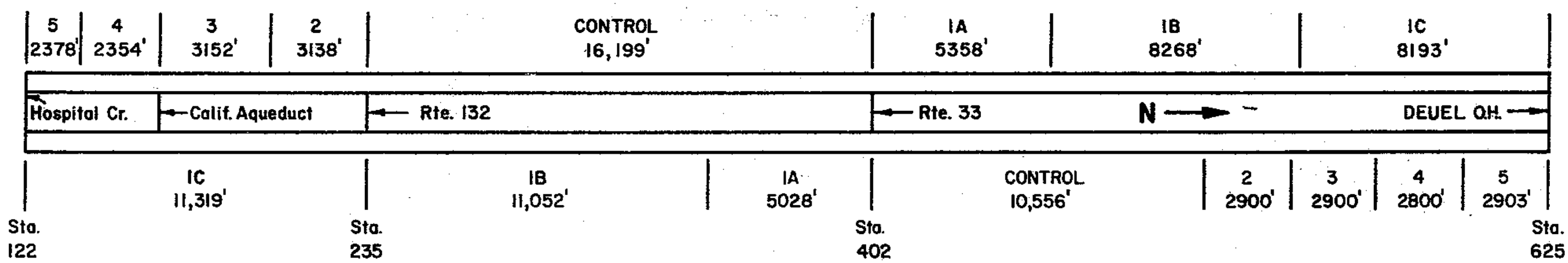
Welded Wire Fabric
CRCP (1C)
See Figure 5

Short Joint Spacing (2)
Transverse Joints at
8', 11', 7', 5', and Repeat
See Figure 2

Higher Cement Content (3)
Increase Cement to 7.5
Sks./C.Y. from 5.5 Sks.
See Figure 6

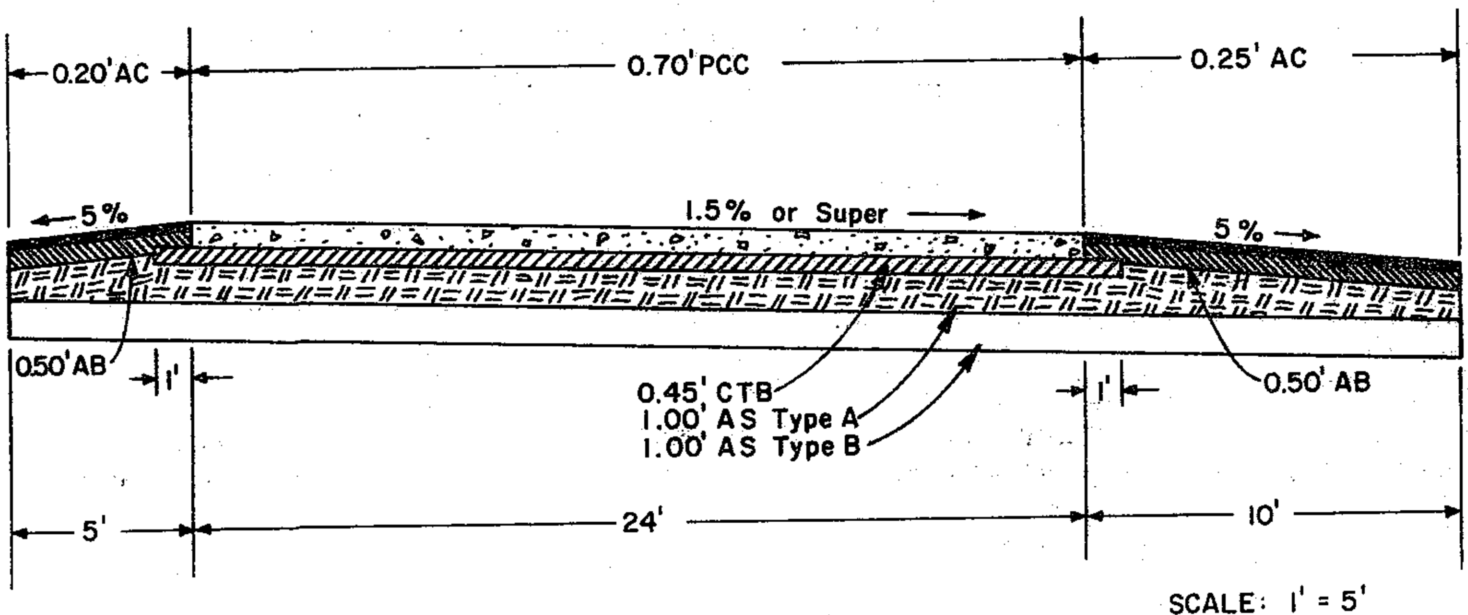
Extra Thickness (4)
From 0.70' to 0.95'
See Figure 7

Lean Concrete Base (5)
See Figure 8




LAYOUT OF TEST SECTIONS

Figure 2

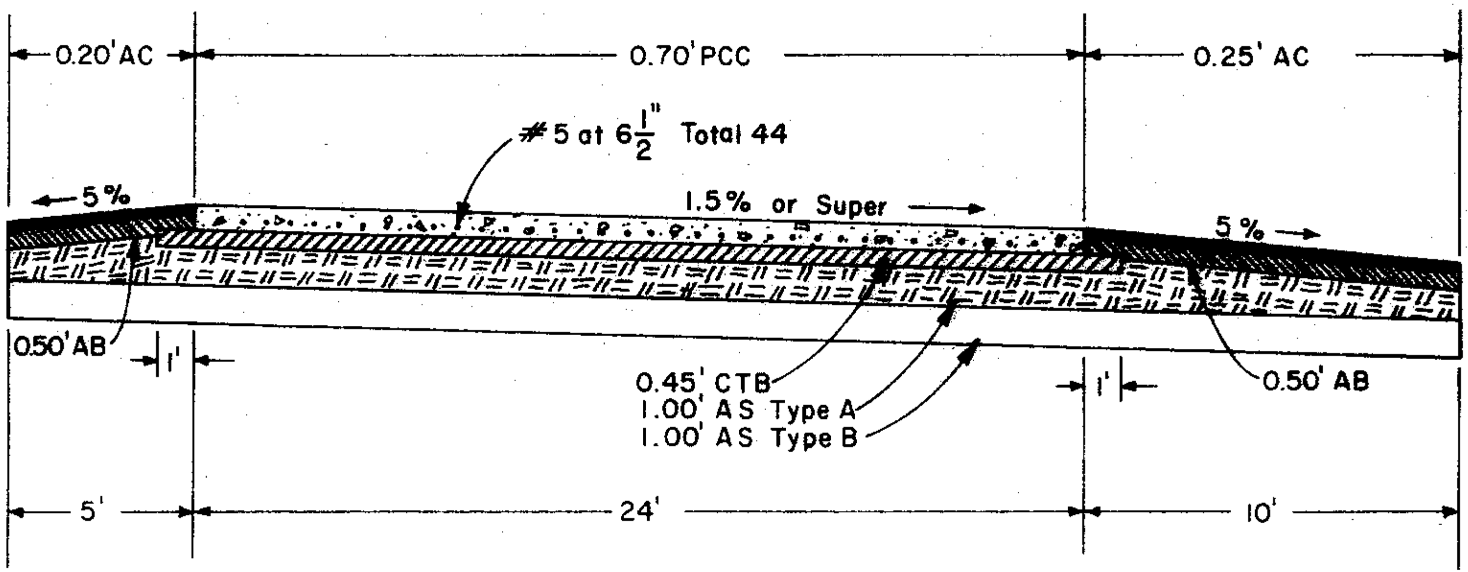



TYPICAL HALF SECTION
CONTROL AND SHORT JOINT SPACING

SYMBOLS & ABBREVIATIONS

| | |
|---|---|
| PCC | Portland Cement Concrete. 5 1/2 Sacks per CY |
| AC | Asphalt Concrete – Type B |
| CTB | Cement Treated Base – Class A. |
| AB | Aggregate Base – Class 2. |
| AS | Aggregate Subbase – Class 4. |

Figure 3

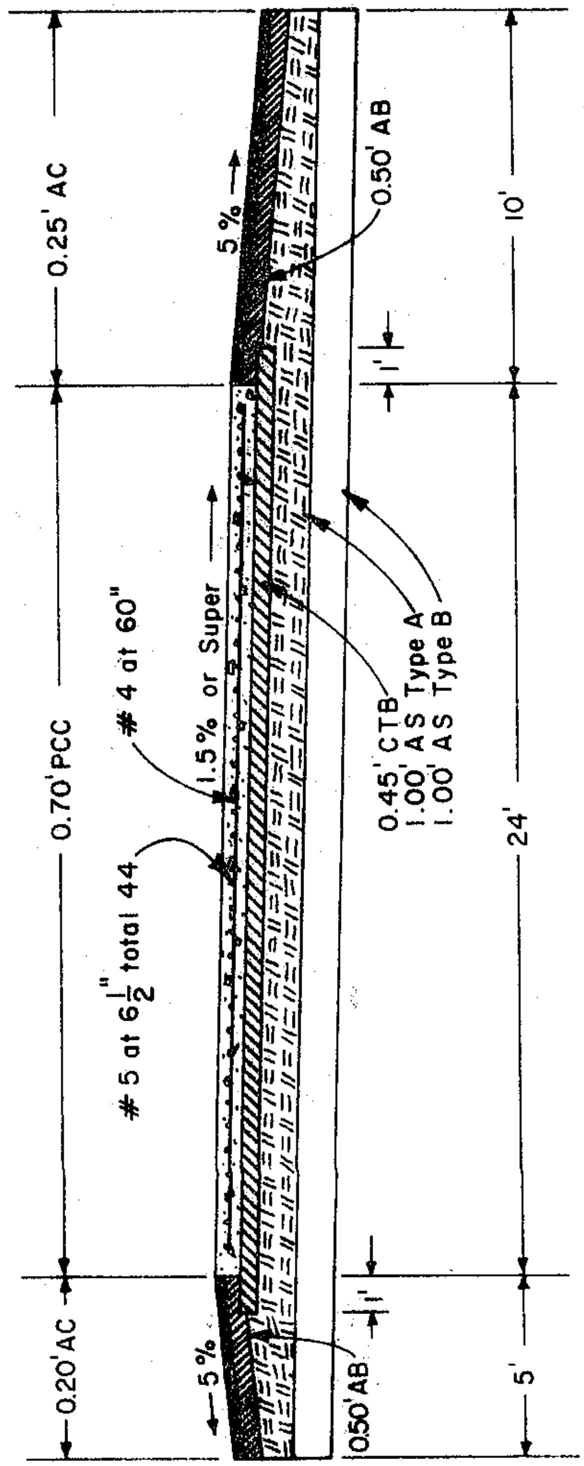



TYPICAL HALF SECTION
REINFORCED: LONGITUDINAL BARS ONLY

**SYMBOLS & ABBREVIATIONS**

PCC Portland Cement Concrete. 5 1/2 Sacks per CY
AC Asphalt Concrete – Type B
CTB Cement Treated Base – Class A.
AB Aggregate Base – Class 2.
AS Aggregate Subbase – Class 4.

Figure 4




SCALE: 1' = 5'

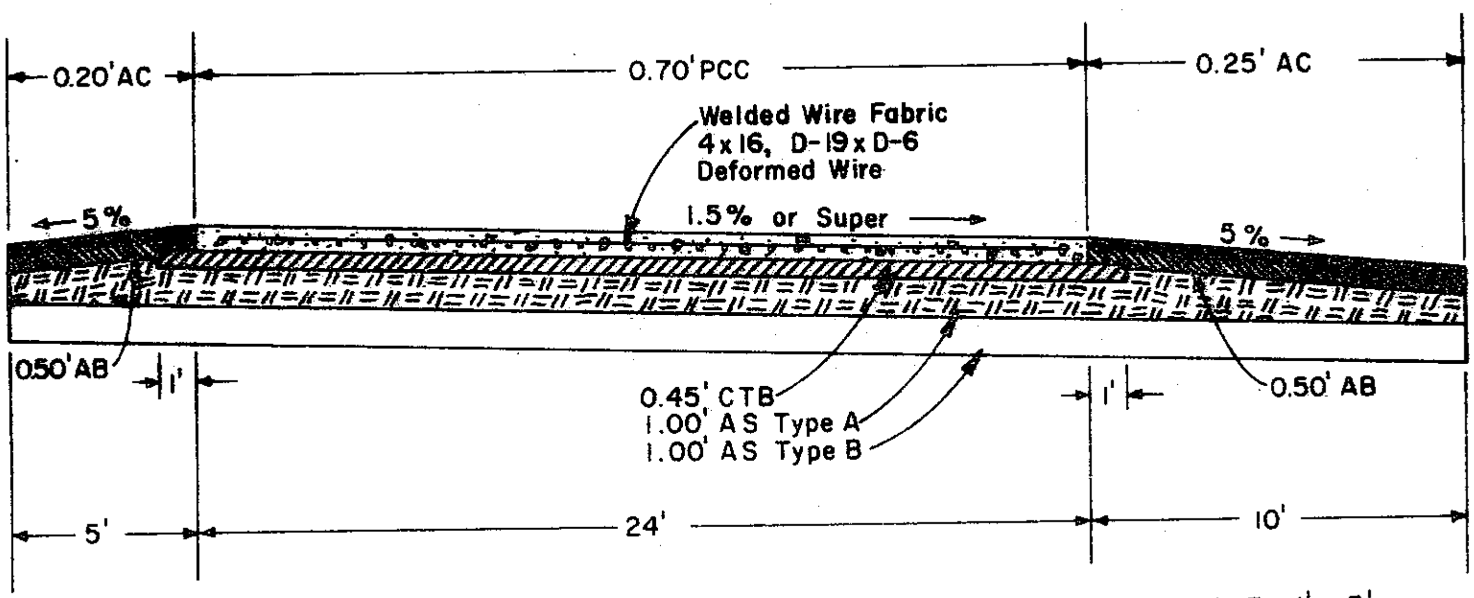
TYPICAL HALF SECTION

REINFORCED: LONGITUDINAL AND TRANSVERSE BARS

SYMBOLS & ABBREVIATIONS

PCC Portland Cement Concrete. 5 1/2 Sacks per CY
AC Asphalt Concrete - Type B
CTB Cement Treated Base - Class A.
AB Aggregate Base - Class 2.
AS Aggregate Subbase - Class 4.

Figure 5

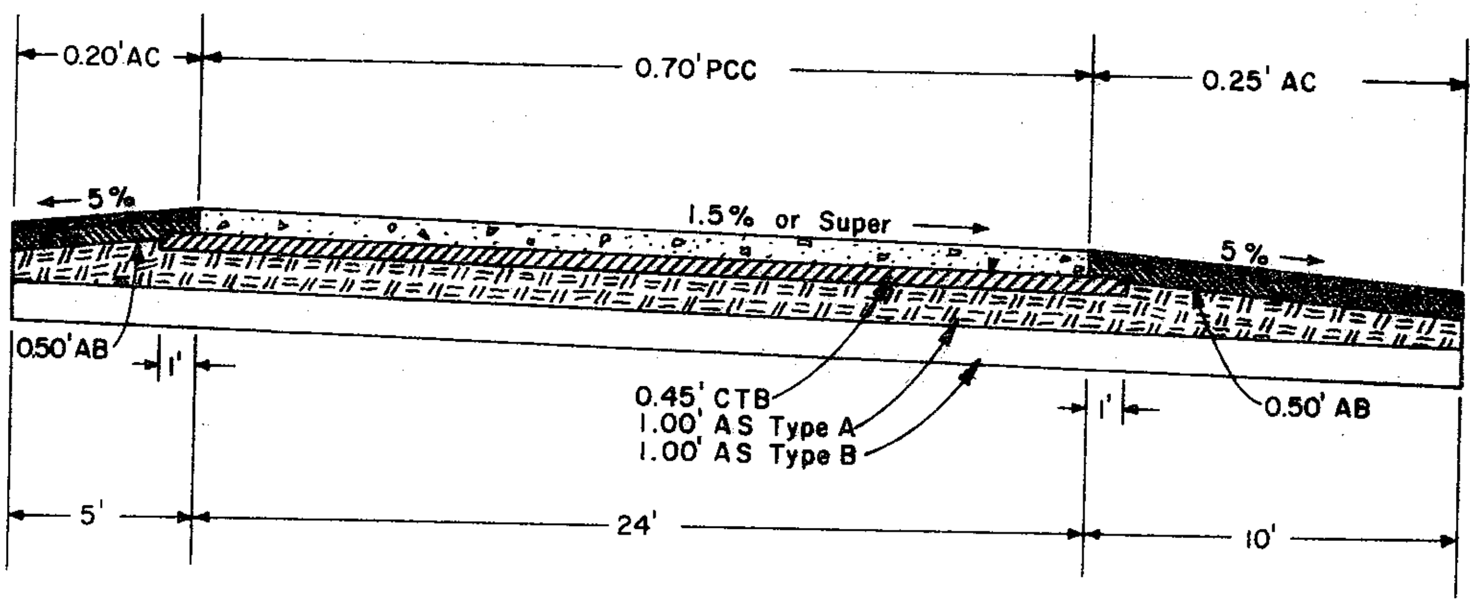



TYPICAL HALF SECTION
REINFORCED: WELDED WIRE FABRIC

SYMBOLS & ABBREVIATIONS

PCC Portland Cement Concrete. 5 1/2 Sacks per CY
AC Asphalt Concrete – Type B
CTB Cement Treated Base – Class A.
AB Aggregate Base – Class 2.
AS Aggregate Subbase – Class 4.

Figure 6



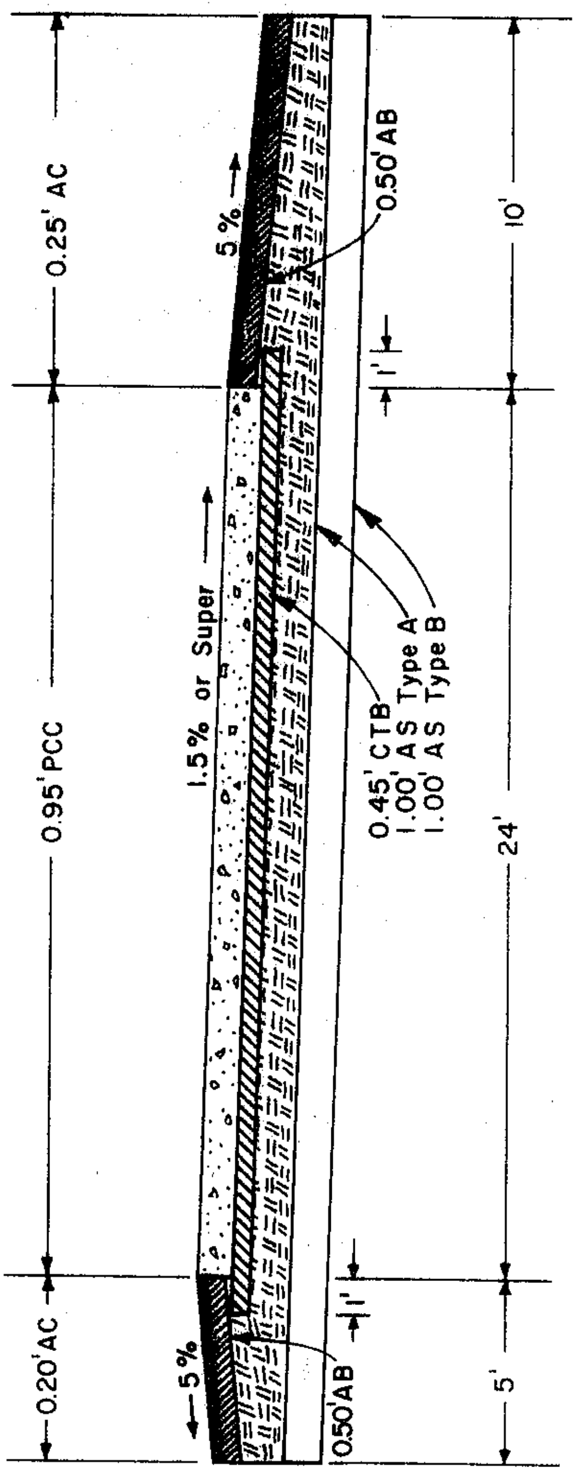

SCALE: 1' = 5'

TYPICAL HALF SECTION
HIGHER CEMENT CONTENT

**SYMBOLS & ABBREVIATIONS**

PCC Portland Cement Concrete. 7 1/2 Sacks per CY
AC Asphalt Concrete – Type B
CTB Cement Treated Base – Class A.
AB Aggregate Base – Class 2.
AS Aggregate Subbase – Class 4.

Figure 7



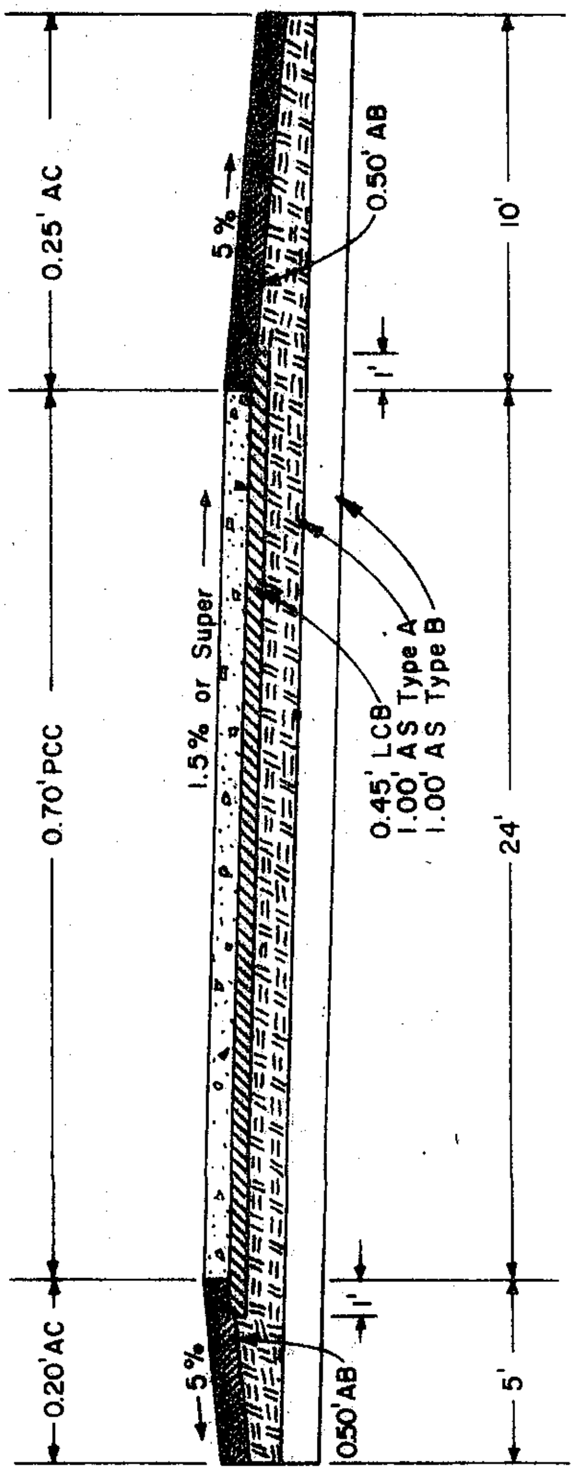

SCALE: 1' = 5'

TYPICAL HALF SECTION
EXTRA THICKNESS PAVEMENT

**SYMBOLS & ABBREVIATIONS**

PCC Portland Cement Concrete. 5 1/2 Sacks per CY
AC Asphalt Concrete - Type B
CTB Cement Treated Base - Class A.
AB Aggregate Base - Class 2.
AS Aggregate Subbase - Class 4.

Figure 8




SCALE: 1' = 5'

TYPICAL HALF SECTION
LEAN CONCRETE BASE

**SYMBOLS & ABBREVIATIONS**

PCC Portland Cement Concrete. 5 1/2 Sacks per CY
AC Asphalt Concrete – Type B
CTB Cement Treated Base – Class A.
AB Aggregate Base – Class 2.
AS Aggregate Subbase – Class 4.
LCB Lean Concrete Base, 4 Sacks per CY

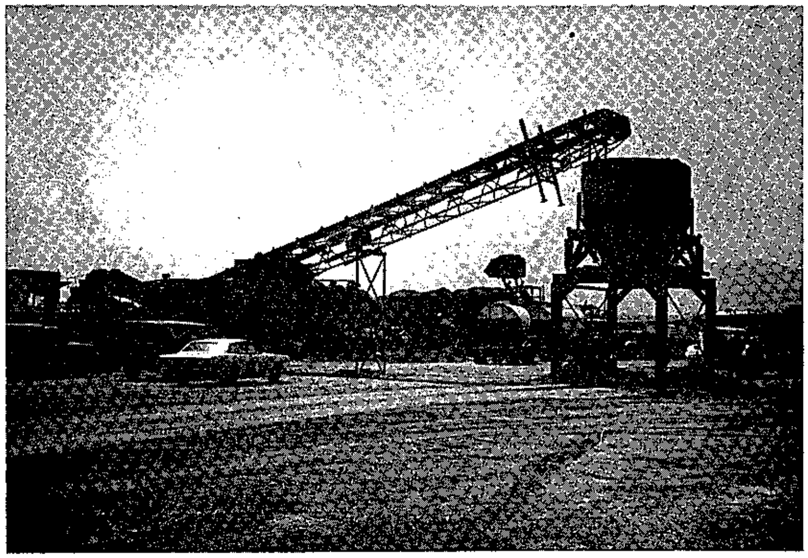


Figure 9

Plant

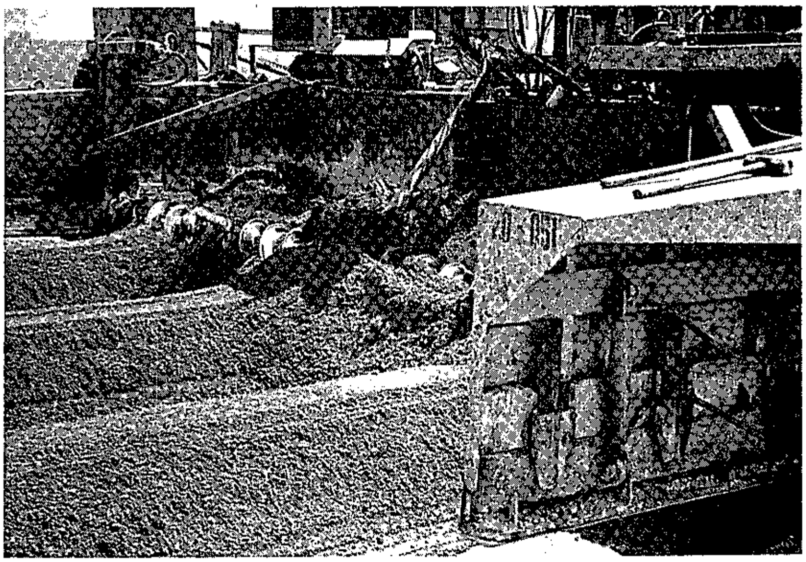


Figure 10

In windrows
at paver

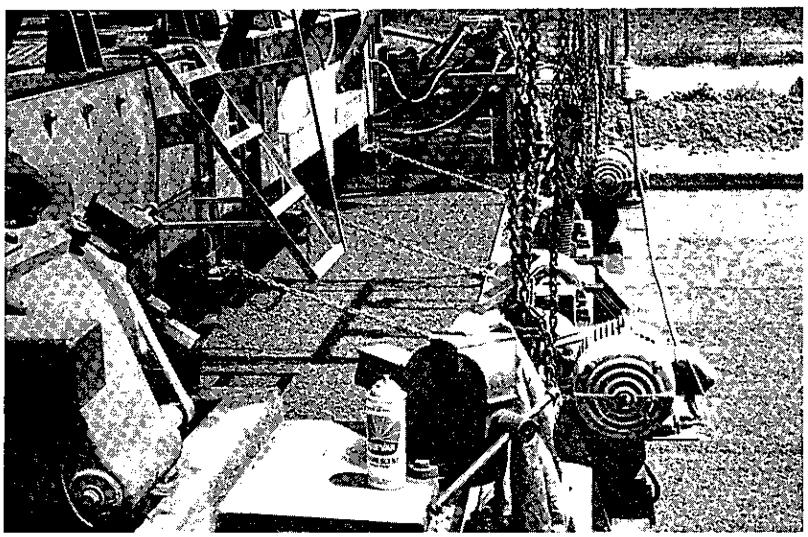


Figure 11

Behind paver

CEMENT TREATED BASE

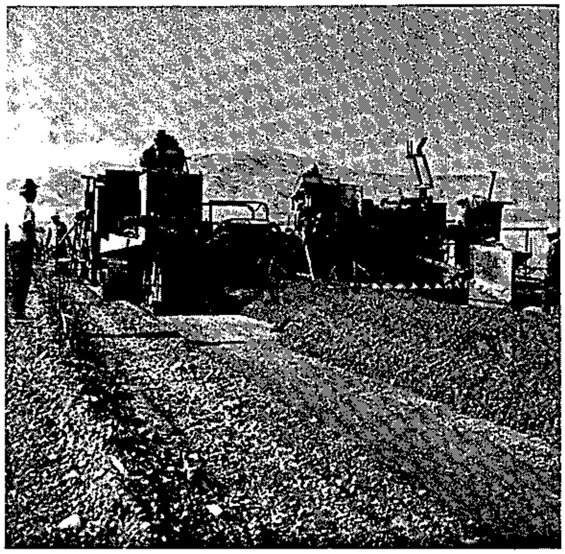


Figure 12 In front of paver.

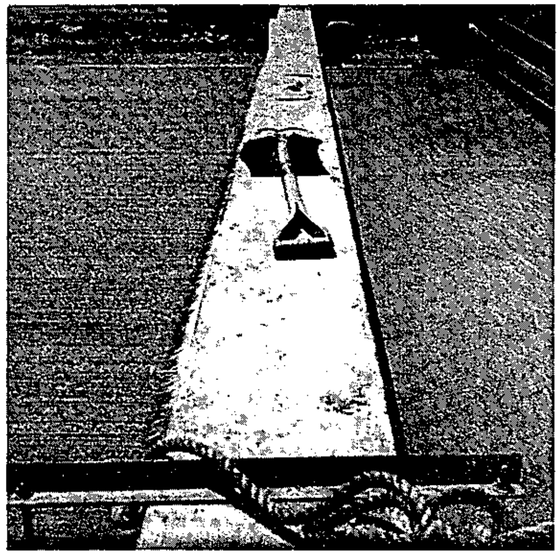


Figure 13 After paver.

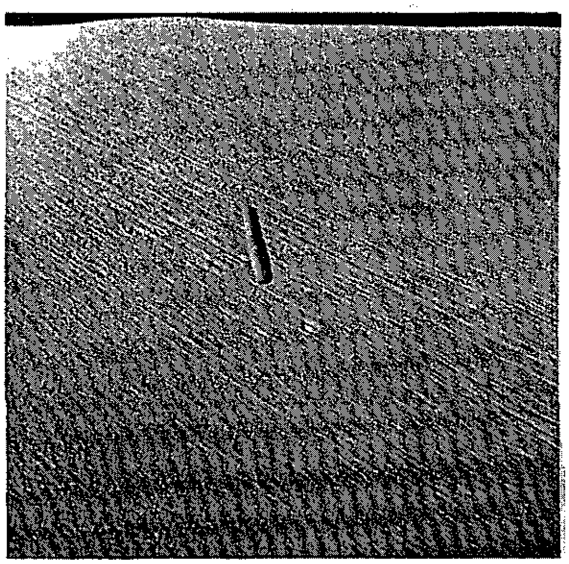


Figure 14 Texture.

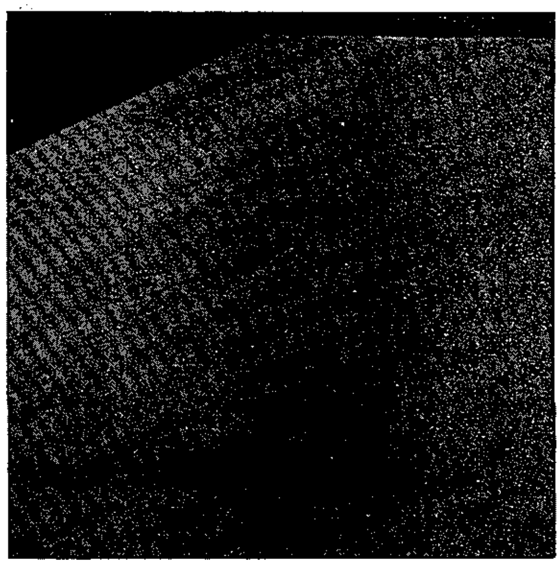


Figure 15 Shrinkage cracks.

LEAN CONCRETE BASE

Figure 16

On CTB

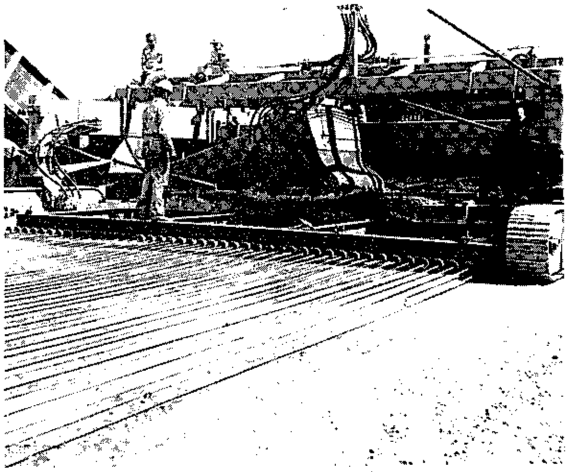


Figure 17

Going through tubes
at Placer-Spreader

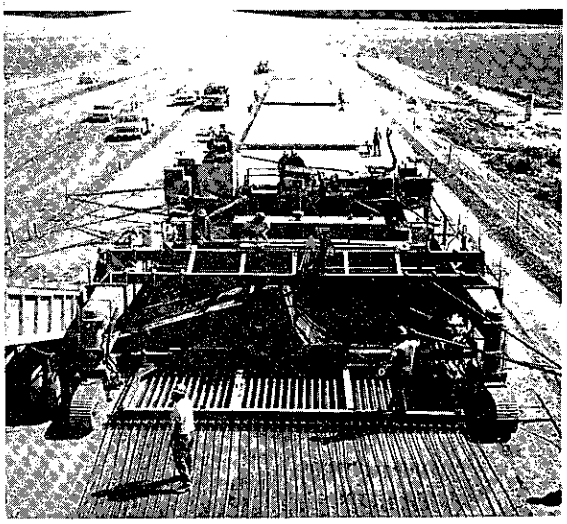


Figure 18

Paving train

LONGITUDINAL BARS ONLY, CRCP

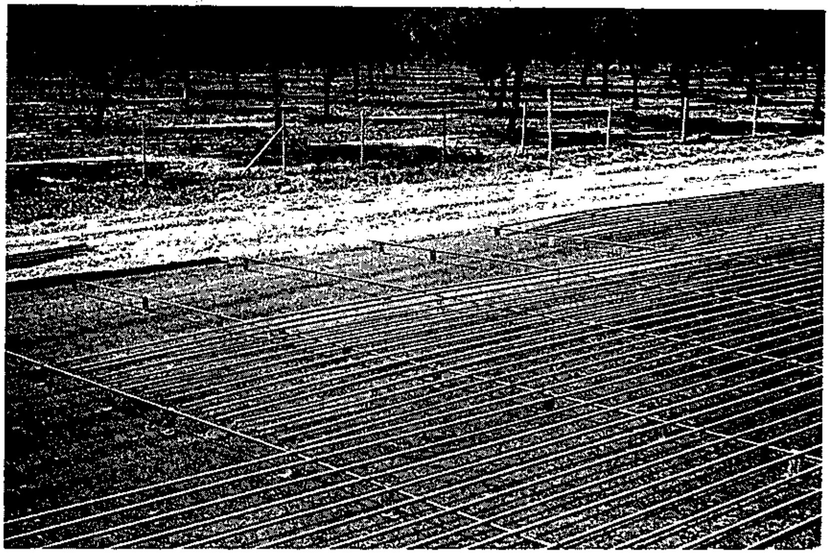


Figure 19 Placing on chairs

Figure 20

Longitudinal reinforcing bars tied to transverse bars

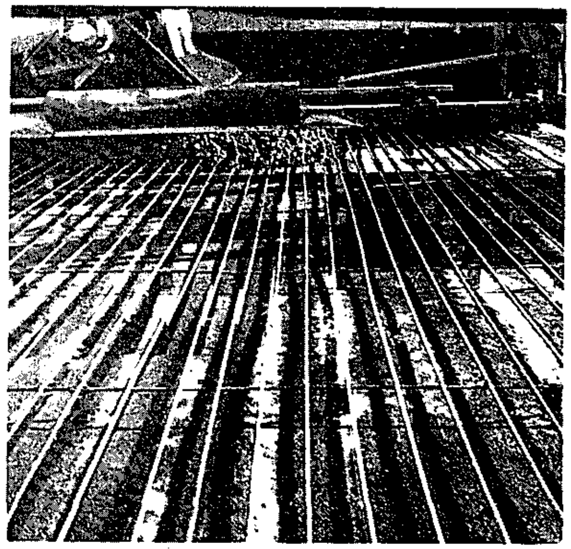


Figure 21 Placer-Spreader

LONGITUDINAL BARS WITH TRANSVERSE BARS, CRCP

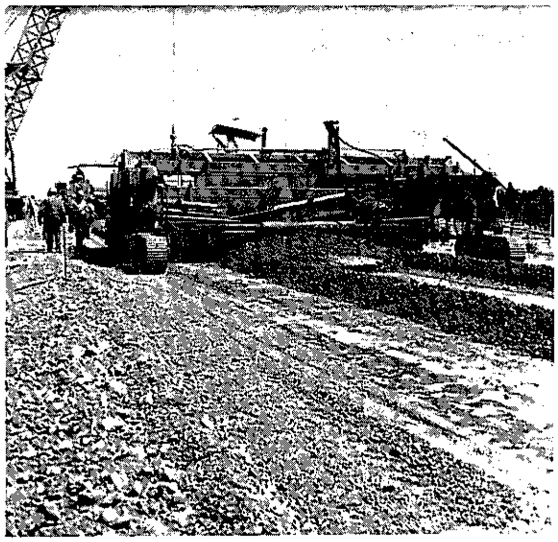


Figure 22

Concrete on CTB before Placer-Spreader

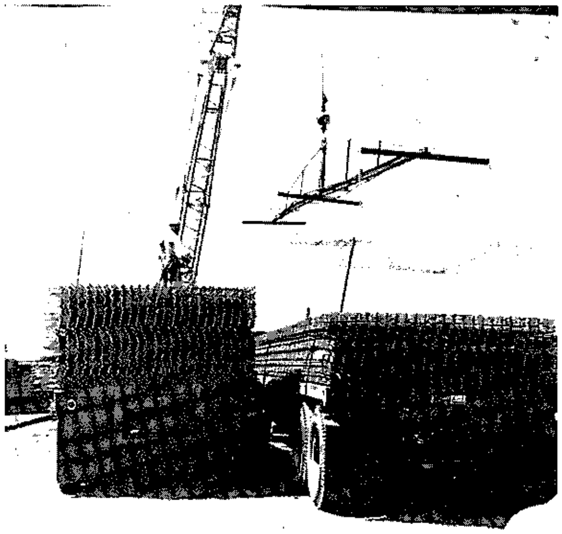


Figure 23

Fabric mats on trailers

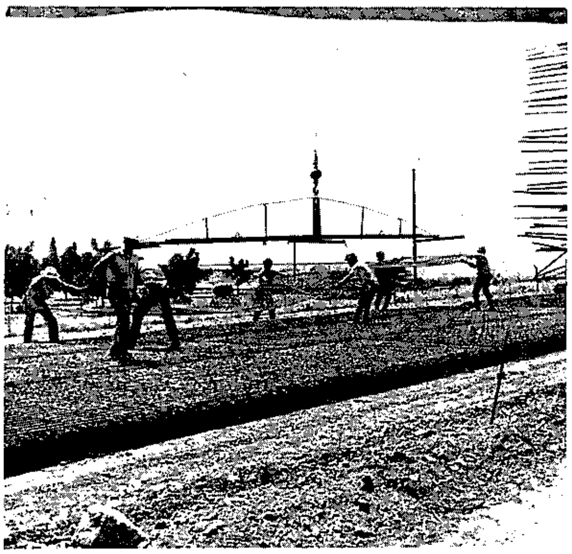


Figure 24

Mats placed onto concrete

DEFORMED WELDED WIRE FABRIC, CRCP

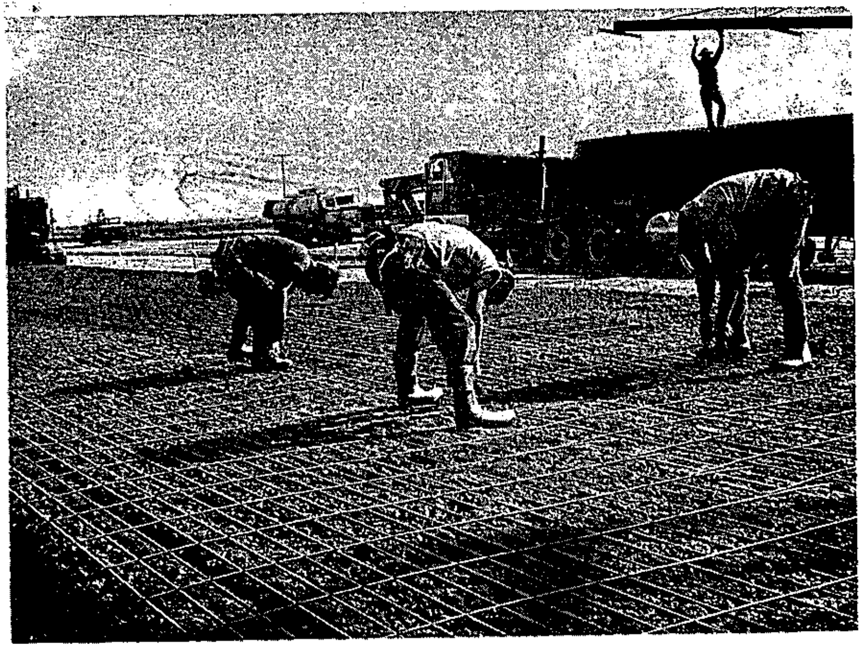


Figure 25

Laps being tied

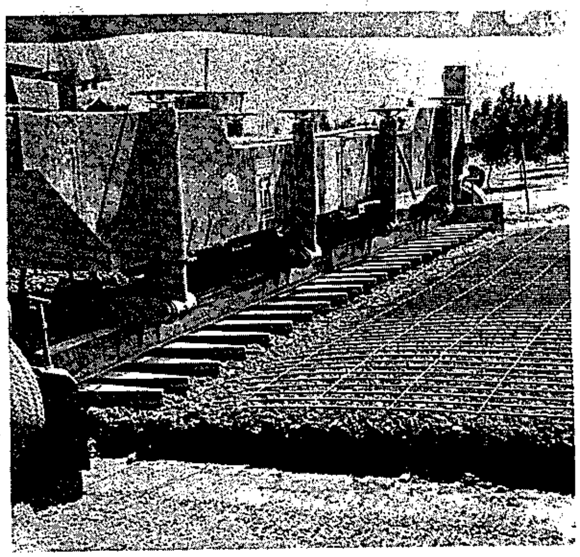


Figure 26

Mats being depressed into concrete

DEFORMED WELDED WIRE FABRIC, CRCP

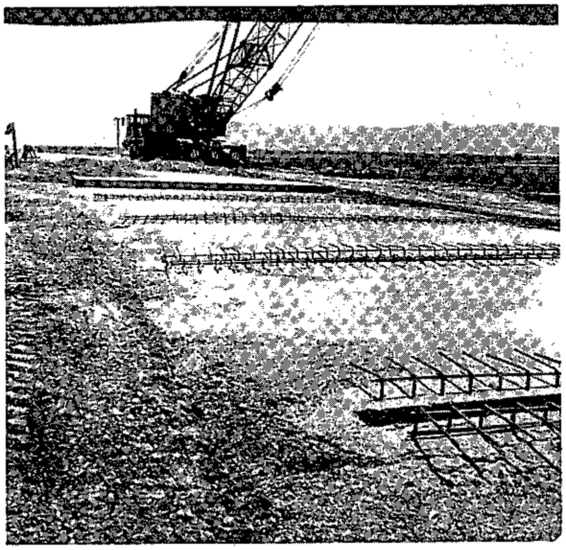


Figure 27

Lug type terminal anchor

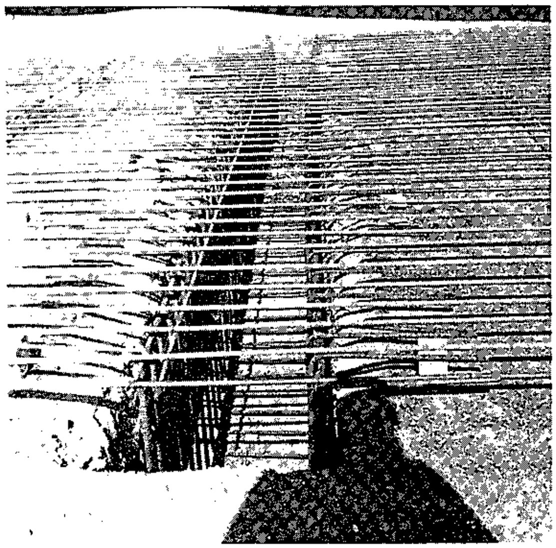


Figure 28

Reinforcement for terminal anchor lug

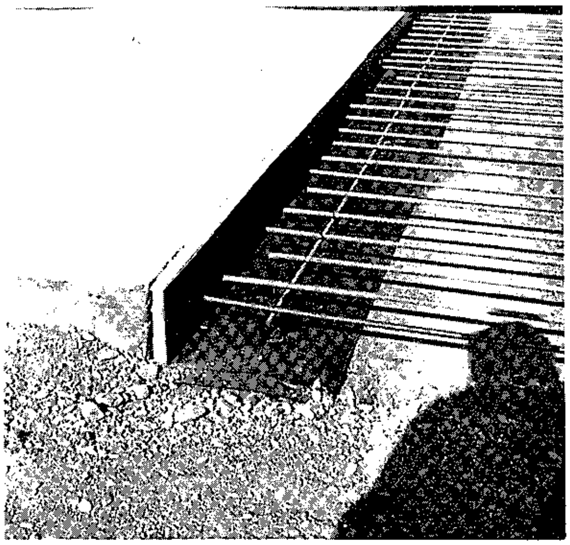


Figure 29

End of CRCP reinforcement at bridge approach slab

TERMINAL ANCHOR FOR CRCP

Figure 30

Gauge plugs attached to holder

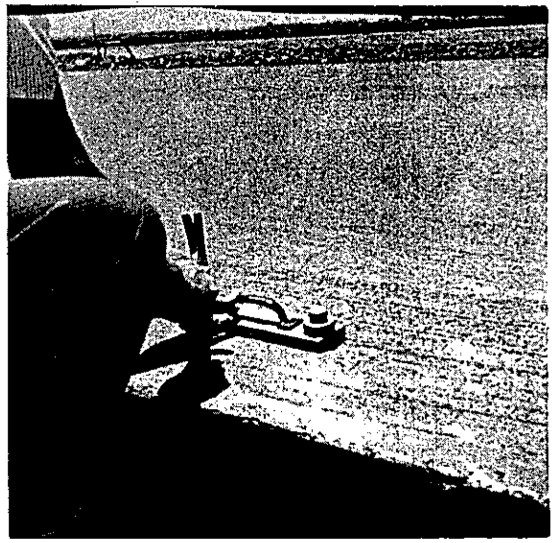


Figure 31

Inserting plugs into fresh concrete

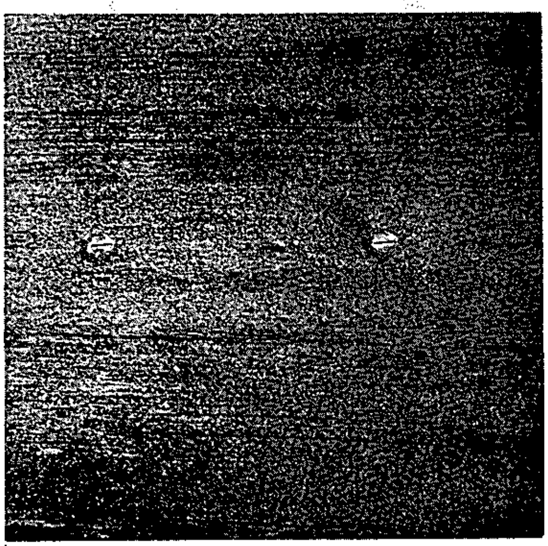


Figure 32

Gauge plugs in place

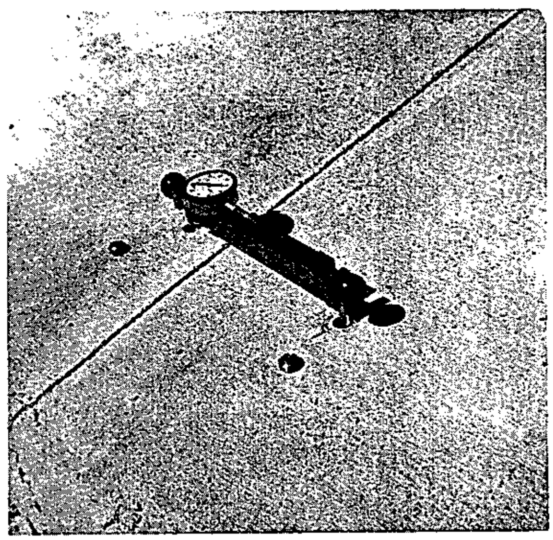


Figure 33

Strain gauge in plugs across weakened plane joint

TRANSVERSE JOINT MOVEMENT

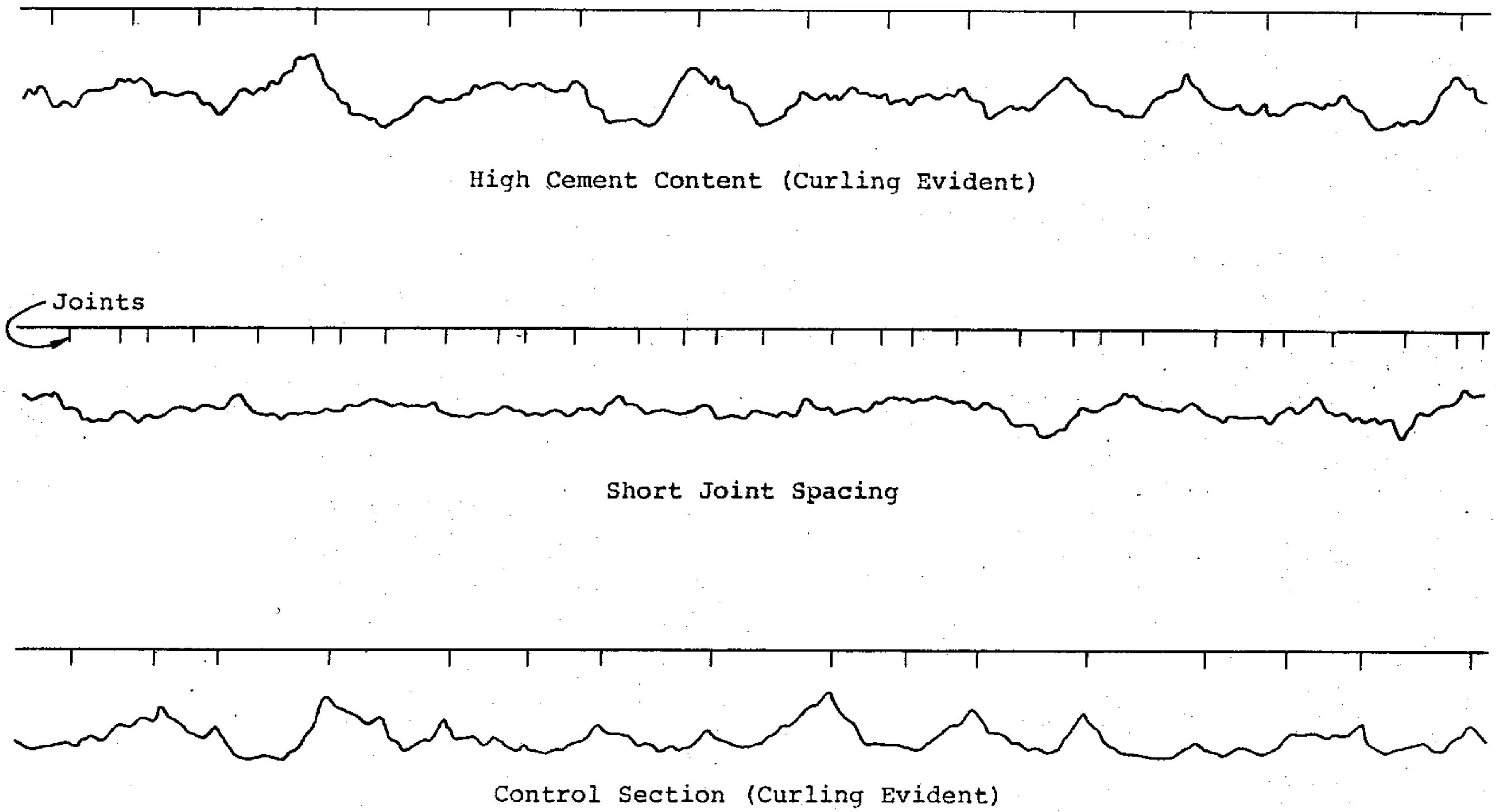



Figure 34

TYPICAL PROFILOGRAMS (16 MONTHS)

Figure 35

Large cracks in CRCP

Figure 36

Pavement excavated at cracks and reinforcement added

PAVEMENT FAILURE