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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

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Materials and Research Department

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FIRST REPORT
ON THE
EXPERIMENTAL CONCRETE PAVEMENT
CONSTRUCTED IN VENTURA COUNTY DURING OCTOBER, 1941
AS A PART OF THE
INVESTIGATION OF JOINT SPACING IN CONCRETE PAVEMENTS
CONDUCTED IN COOPERATION
WITH THE
PUBLIC ROADS ADMINISTRATION

VII-Ven-79-C Contract 27XC7-P F.A.P. 380-C(1)

Report by Thomas E. Stanton
Materials and Research Engineer

STATE OF CALIFORNIA DIVISION OF HIGHWAYS

44-02

State of California
Department of Public Works
Division of Highways
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REPORT BY THOS. E. STANTON
MATERIALS AND RESEARCH ENGINEER

May, 1944

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STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

FIRST REPORT ON THE EXPERIMENTAL CONCRETE PAVEMENT CONSTRUCTED IN VENTURA COUNTY DURING OCTOBER, 1941 AS A PART OF THE INVESTIGATION OF JOINT SPACING IN CONCRETE PAVEMENT CONDUCTED IN COOPERATION WITH THE PUBLIC ROADS ADMINISTRATION

VII-Ven-79-C CONTRACT 27XC7-P F.A.P. 380C(1)

May, 1944.

LOCATION AND GENERAL DESCRIPTION OF PROJECT

The concrete pavement project selected for the tests described in this report is located in the Santa Clara River Valley, Ventura County, about 20 miles inland from the Pacific Ocean on a section designated as VII-Ven,LA-79-C,A. The elevation is from 675 to 900 feet above sea level. The geography of the surrounding country is such that the project is subjected to wide ranges of climatic conditions, not only from season to season and from day to day but also during different portions of the same day.

The highway constructed under Contract 27XC7-P extends from the northeast end of the bridge over Piru Creek, to a short distance east of the Los Angeles County line. Concrete pavement was placed from Station 370+65 to the County Line at Station 665+68.69, with the exception of a small area near Station 597+25, where a branch of the Southern Pacific Railroad crosses the highway. The net length of concrete pavement is 29,859.97 feet (5.65+ miles).

There are duplicate sets of experimental sections; consisting of seven different types of construction and designated as Sections "1a" to "7a" and "1b" to "7b", respectively. In order to avoid a break in the middle of an experimental section at the railroad crossing near Station 597+25, the

positions of Sections 3b and 4b were reversed and the portion of the pavement between Station 596+51.5 and Station 598+24.7 was not included in the test sections. As constructed, the total length of the 14 test sections amounts to 29,676.7 ft. The locations and length of the different sections, their dates of construction, joint spacing and other physical characteristics are shown in Table 1.

The test pavement was designed, constructed and tested in accordance with the recommendations contained in the Public Roads Administration memorandum of May, 1940, entitled "Suggested Program of Observations for the Cooperative Investigation of Joint Spacing in Concrete Pavements." (Appendix A).

The test sections were constructed in October, 1941, but allowing time for initial cracking at the contraction joints as per request of the P.R.A. the first measurements were not made until February, 1942. As this is a relatively long time test this initial report was delayed until after the two-year measurements of February, 1944, were available.

OBJECT

The tests are designed to furnish information on the desirable spacing of transverse expansion joints in concrete pavements and the amount of expansion space required per unit of pavement length as well as a study of the efficiency of dummy contraction joints, with and without dowels or other devices for load transfer.

LABORATORY TESTS BY P. R. A. IN WASHINGTON, D.C.

It was considered impractical to make the measurements of the stress deformations in the concrete necessary for the determination of joint efficiency, upon pavements bearing traffic. It was, therefore, proposed to study the action of transverse dummy joints in full size pavement slabs that would not be subjected to traffic and that this part of the study would be carried on at the laboratory of the Public Roads Administration in Washington, D.C.

CALIFORNIA TESTS

1. Selection of Project

A review of the proposed highway on Route 79 in Ventura County between Piru Creek and L. A. County line disclosed that ample material of uniform quality was available for the construction of a blanket of selected subgrade material under a

Portland cement concrete pavement of suitable thickness for the purposes of the experiment and that grades and curvature were not of a nature to prejudice the results.

Therefore, no other concrete pavement job of sufficient magnitude and possessing the other attributes essential to the test being in immediate prospect closer to Sacramento, it was decided to conduct the experiment on the Ventura project.

2. Pavement Cross-Section

In the following discussion the term SECTION is used to denote a length of pavement of a certain design, SUBSECTION is used to denote a part of a section between two expansion joints while the term SLAB refers to an unbroken short unit of pavement between two contraction joints or between an expansion and a contraction joint.

With the exception of Sections 7a and 7b the pavement has a 9"-7"-9" cross section. Sections 7a and 7b are uniformly 8" thick.

3. Expansion Joints

All expansion joints were filled with 3/4" thick redwood strips. (See Table 20 for test data.)

4. Contraction Joints

Contraction joints were of the grooved dummy type and the spacing in the unreinforced sections was 15 feet. Spacing of contraction joints on the reinforced sections, Sections 6a and 6b, was 60 feet.

5. Reinforcement

Sections 6a and 6b were reinforced with wire mesh consisting of mats 10'-6" wide by 16 feet long with #4 gage transverse wires at 12" centers and #0 gage longitudinal wires at 6" centers except the outer four wires on each side which were #00 gage wires at 6" centers.

The remaining sections were unreinforced.

6. Description of Sections

For location and complete description of sections see Figs. 1 to 4 and Appendix A.

PROGRAM OF OBSERVATIONS AND TESTS

The program of observations and tests prepared by the Public Roads Administration (Appendix A) was followed. This program was augmented, however, by measurements of (1) Temperature gradient within the slab (Figs. 30, 31, and 32), (2) Modulus of elasticity of the Concrete (Appendix C), (3) Coefficient of subgrade friction (Appendix D), (4) Overall movement of one lane of Section 1b, (5) Subgrade factor "k" (Appendix E), and (6) Roughness measurements with the "Profilograph" (Appendix F).

GENERAL

Grading and other preliminary operations were begun in 1940 and continued to early September, 1941. Actual placing of concrete in the right or south lane began on September 20, 1941, and was completed on October 9. Paving of the left or north lane began October 10, and ended on October 29.

The Materials and Research Department made no special observations during the construction of the south lane nor were any of the gauge or level points installed in that lane. However, in accordance with the suggestions of the Surveys and Plans Department (Memorandum of September 10, 1940, Appendix A) facilities for the special tests previously referred to were installed in the south lane during construction. These special installations were as follows:

1. Thermocouples for use with Micromax temperature recorders were placed in the subgrade and in the pavement concrete at Station 656+90 during concreting operations. Temperatures within and below the slab were recorded during the hardening and curing of the concrete (Fig. 30) and at subsequent seasonal measurement periods (Figs. 31 and 32.)

2. Six detached pavement slabs, 15 ft. in length for determination of subgrade friction. These slabs were separated from the adjoining pavement at each end by 4" x 9" removable timbers, set on edge, and were located as follows:

   Sta. 468+61 to 468+76
   469+81 to 469+96
   471+01 to 471+16
   661+22 to 661+37
   661+67 to 661+82
   662+40 to 662+55

   See Appendix D for detail description of test results.

3. Concrete disks for determination of Westergaards "k" (subgrade factor). Twelve disks were installed between Sta. 406+82 and 410+12. See Appendix E for description of procedure and test results.

With the exception of the omission of the dowells and transverse bars at the dummy joints of Sections 1a to 4a and 1b to 4b of the north (left) lane, the structural details of both lanes were identical throughout (Figs. 1 to 4).

OBSERVATIONS AND TEST DATA

Throughout the paving of the north lane, representatives of the Materials and Research Department kept detailed records of construction procedure. Subsequent measurements have been made at periodical intervals as outlined in the P.R.A. memorandum (Appendix A) which outlined various observations and measurements to be made during and subsequent to construction. The various items are herein discussed in the order and identification in which they occur in that memorandum.

A. - PRELIMINARY DATA

1. Contract specifications, etc.
Not included with this report.

2. Plans. Complete plans are not included but copies of sheets showing the location of the project, arrangement of test sections and typical pavement sections are included as part of Appendix A, as well as in Figs. 1 to 4 of this report.

3. Soil Survey Data
The data requested under Item 3 of the June 1940 P.R.A. memorandum and the supplemental memorandum of August, 1940 will be found in the District Engineer's Final Report and in the Materials Report compiled by Mr. R. J. Allan, Materials Engineer, District VII (Appendix B). Additional data, compiled as routine soil survey procedure on highway construction in California is also included in Mr. Allan's report.

4. Source and Type of Materials
(a) Cement (Type II Low Alkali) from the Monolith Portland Cement Company Plant at Monolith, California, was used throughout. The cement was shipped to the job in sacks, by rail or truck. See Table 21 for tests of cement used in the project.

(b) Concrete Aggregates were furnished by the Consolidated Rock Company from the plant of the City Rock Company near Roscoe, San Fernando Valley, Los Angeles County, except for a small amount of blending sand which came from the Consolidated Rock Company's plant at Roscoe. See Tables 18 and 19 for aggregate tests.

The vendor (The City Rock Company) changed the screens in the plant in order to provide material graded to comply with the specifications for this project and samples taken from time to time indicated good uniformity. The fine aggregate, however, was close to the lower specification limit with respect to the amount passing the No. 30 sieve and a few samples were sl ightly below the limit. After the first few days of paving on the south lane a part of the concrete sand in each batch, equivalent to 5% by weight of the total aggregate batch, was replaced with a finer blending sand obtained from the Roscoe Plant of the Consolidated Rock Company.

(c) Water for mixing concrete, curing, etc., was hauled in tank trucks from an irrigation well on the nearby Newhall Ranch. A sample from this well was tested and found to be satisfactory for use in concrete.

(d) Steel Reinforcing Bars, Dowels, etc. were furnished by the Ceco Steel Products Corporation of Los Angeles. See Table 22 for tests.

(e) Corrugated Metal Culverts were furnished by the United Concrete Pipe Company of Los Angeles. All culverts were fabricated from pretested material.

(f) Redwood Expansion Joint Filler Strips were supplied by the Union Lumber Company of Fort Bragg, California. The joint material did not comply with the original contract specifications which required a maximum dry weight per cubic foot of not over 20 pounds and a co mpressive resistance of not more than 2000 pounds per square inch at half the original thickness.

As these original specifications were found impracticable they were changed after the contract was awarded to a maximum weight of 25 pounds per cu. ft. and 1500 pounds per sq. in. compressive resistance (see change order No. 45698). See Table 20 for tests on job samples.

(g) The Joint Seal Compound was a mixture of 20-30 airblown and SC-6 liquid asphalts. Tests showed a melting point of 154° F. and a penetration of 29 at 77° F., indicating a satisfactory material.

5. Forms for Concrete Test Specimens. 6"x6"x34" Beam Forms which had been used on X-Stan-4-A were hauled by truck to this project and used throughout the construction of the north lane. In each test section the end of one beam form was blocked off for a beam 6" x 6" x 20" for shipment to the laboratory of the P ublic Roads Administration. Details of fabrication, curing, etc., are discussed under Section C.

6. Daily Weather Reports Including Record of Temperature Rainfall, etc.

None of the local observation stations were near enough to the project to have similar climatic conditions. Therefore, arrangements were made to secure rainfall data (Tables 2 and 2a) from the Camulos Ranch rain gauge. This gauge is located on the south side of the project in the vicinity of Station 460. The rainfall data covers the period from 7 A.M. the preceding day to 7 A.M. the day the rainfall is recorded.

7. Thermometers

Temperature records were obtained by means of a 6-point "Micromax" recorder, supplemented by Weston all metal dial type thermometers. Detailed description of the Micromax and the thermometers, as well as of their use, will be fo und in Sections B and C.

Thermometers of the type described by the Public Roads Administration were provided, but were not used during the construction period except for occasional check purposes.

8. Mixtures, Slump, Yields, etc.

All mix data wil l be found in Table 16.

9. Construction Equipment

See Table 23.

10. Batching Procedure

The batching plant was erected near Sta. 550+00. The flow of aggregates into the weighing box was automatically controlled by an electrically operated Kron scale.

After the aggregates for each batch were proportioned in the weigh box, they were dropped into a batch hopper and carried by means of an inclined belt conveyor to a loading hopper, then dumped into the trucks for transportation to the mixer.

Cement for each batch was emptied by hand from the sacks into a cement hopper. As soon as about half of the aggregates were on the belt conveyor, the cement was allowed to flow from the cement hopper into the batch box. The cement blocked the flow of the balance of the aggregates until it was all on the belt, then the aggregate flow resumed.

The blending sand was proportioned by hand and dumped through a small hopper onto the other aggregates on the belt shortly before they reached the loading bin.

The use of more than one type of fine aggregate had not been anticipated when the plant was built and no provision had been made for more than one sand bin.

B. - DAILY OBSERVATIONS DURING CONSTRUCTION

1. Weather, Temperature, etc.

The data for the temperature charts (Figs. 30, 31, and 32) were obtained with a 6-point micromax recorder using Iron-Constantan thermocouples placed at the center of the pavement lane at elevations as follows: Point No. 1, in the subgrade 6 inches below the base of the concrete slab; Point No. 2, in the bottom 1 inch, Point No. 3, in the center, and Point No. 4, in the top 1 inch of the concrete slab, Point No. 5, air temperature, Point No. 6, wet bulb temperature. The wet bulb and air temperature were measured under a sun shield attached to the recorder box about 3 feet above the ground. The wet bulb temperature was secured by replacing the wet bulb thermometer of a Masons hygrometer with a thermocouple and depending on the natural circulation of the air for the evaporation of water from the hygrometer wick. The wet bulb temperatures are not plotted on the graphs, but were used to calculate per cent relative humidity.

Thermocouples in the first set were installed in the south lane at Station 656+90 at 1:00 P.M., October 9, 1941, and readings recorded for 48 hours (Fig. 32).

Thermocouples in the second set were installed in the north lane at Station 418+00 at 10:00 A.M. October 15, 1941 and readings again recorded for 48 hours (Fig. 32).

Thermocouples in the third set were installed in the north lane at Station 484+57 to record the pavement and air temperatures during the final pouring and curing operations (Figs. 30 and 31). It was originally planned to place a set of thermocouples in both the 9"-7"-9" and 8" uniform thickness slabs early in the morning to determine the effect of time of day on the temperature conditions of the pavement slab, but this was abandoned when the weather became unsettled with a substantial lessening of the differential in air temperature between night and day conditions. The Thermocouples at Station 484+57 are used for obtaining the temperatures when the daily, seasonal, and permanent readings are made (Fig. 31).

Sunshine with occasional clouds prevailed from October 10th to 18th during the pouring of test sections 1a to 6a and a portion of 7a.

Light rain and clouds with occasional sunshine prevailed from October 19 to October 25, during the pouring of test sections 7a, 1b, 2b, 3b, 4b, and a portion of 5b. No concrete was placed on October 26th and 27th.

Sunshine with occasional clouds again prevailed when the concrete was poured in test sections 5b, 6b, and 7b.

Table 2 shows rainfall data from September 1, to October 31, 1941. In addition, a partial record of temperature and humidity has been included in Tables 3 to 15 inclusive.

Considerable variation was noted in temperature, wind velocity and humidity on different parts of the project. A wet-dry bulb thermometer was installed under the overhang of the trailer water tank attached to the mixer and temperatures were recorded from time to time while the mixer was in operation. The air temperatures and the relative humidity values thus obtained are included in the "Daily Construction Records," (Tables 3 to 15).

2. Hours of Work With Stationing

A close record was kept of time at which concrete was mixed and placed at each station as well as of any delays, etc., at intermediate points. This record, as well as the record of the number of batches, volume of pavement slab, starting and quitting time for the mixer, the net operating time, etc., are shown in Tables 3 to 15. Figures 42 to 54 inclusive show the time of placing the concrete plotted graphically against the distance covered, so as to show at a glance the stationing, rate of progress, occurrence and duration of delays, etc.

3. Details of Concrete Mixes

The average combined gradings for each day's mix, weights per batch for each size of aggregate, etc., are shown in Table 16. The weight of water added at the mixer at each point where a change in amount occurred is shown in Tables 3 to 15.

As mentioned previously, a few of the daily control samples of the fine aggregate showed a grading slightly below the specification limits. In order to correct this deficiency, as well as in the hope of affecting a possible reduction in the amount of bleeding, approximately 250 pounds of blending sand (5% of total aggregate weight) was used to replace an equivalent amount of the concrete sand in each batch.

The change from 37% to 32% concrete sand plus 5% blending sand was first made on October 6th at Station 573+69 in the south lane. On October 9, the blending sand was omitted and replaced with regular concrete sand between Stations 641+73 and 652+00 after which the use of the blended sand was resumed. Except for the above changes in sand, only minor variations in the proportioning of the aggregates were made throughout the paving of both lanes. Daily quantities, slumps, yields, etc., are also shown in Tables 3 to 15.

4. Concrete Temperatures

As a supplement to the temperature records shown on Figures 30, 31, and 32 notations were made of the temperature of the freshly deposited concrete at various times during each day's work. Similar observations were made at the time of final floating. The placing and final float temperatures are shown on each of the Daily Construction Records (Tables 3 to 15).

In addition special thermometer wells, designed to accommodate the Weston dial type thermometers were installed in the fresh concrete, two feet from the left outside edge of the pavement at the following stations:

418+02	Concrete placed at	9:54 A.M.
434+57		7:25 " "
484+57		2:45 P.M.
485+29		6:10 A.M.
511+87		6:25 A.M.
545+62		12:15 P.M.
581+05		6:53 A.M.
629+00		6:30 A.M.

Each installation consisted of two thermometers, one indicating the temperature of the top 2 inches of the pavement, the other the temperature 4-1/2 inches to 6-1/2 inches below the surface. A record of the temperatures thus obtained will be found in Table 17.

5. Time Intervals Between P lacement, Finishing, Curing, Etc.

Records were kept of the time at which concrete was poured at each Section. Similar records were kept for successive operations. (Figures 42 to 54 inclusive).

The spreading and tamping of the fresh concrete followed the mixing time so closely (within 2 to 5 minutes) that no attempt has been made to show a graph for tamping time.

Additional data, including boundaries of test sections, location of test points, points at which test specimens were fabricated, the relative strength of test specimens, etc., are shown on the same charts.

6. Condition of Subgrade, Etc.

Detailed information on embankment subgrade and subbase conditions are reported by the District Engineer and by R. J. Allan, District Materials Engr. (Appendix B). The subgrade moisture and density data shown on the figures accompanying the Allan report have been summarized in Table 42.

(a) Embankment

The roadway excavation and natural soil in the fill foundations for the most part consisted of a loamy soil with varying amounts of sand and silt. This material was classified as A-4, A-6, and A-7 under the USPRA method of classification. The California bearing ratio varied from 3% to 40% at 0.1" penetration on the compacted and soaked material, with the greater portion of the material falling in the range of 3% to 5% bearing ratio.

The top 12 inches of the natural soil were compacted to at least 90% relative compaction, except for a few scattered locations as shown on the Standard Soil Profile Sheets, (Appendix B). In the few cases where an excess of moisture was present the relative compaction dropped slightly below 90%.

Subgrade density determinations consisted essentially in ascertaining the dry weight of the compacted material in a unit volume of the subgrade. They were made by excavating a hole, approximately 6" in diameter, in the compacted subgrade to the desired depth, collecting and weighing all the material removed from the hole, determining its dry weight and measuring the volume of the hole from which it was removed.

Clean, dry sand was used to determine the volume of the holes and the "sand-volume apparatus," developed by the Materials and Research Department and shown diagrammatically in Fig. 34, was employed to insure a uniform density for all determinations.

Because the subgrade consisted of clean sand and gravel, a flat steel plate with a 6" hole in the center was placed on the ground before excavation was started in order to prevent sloughing of the material around the top of the hole. This plate also furnished a firm base for the cone and prevented its edges from sinking into the sand (Fig. 33).

The hole was dug by hand and all the excavated material was placed in a container and its dry weight determined.

The sand volume apparatus, consisting of a "Measuring Cone" approximately 11" in diameter at the large end, an "Overflow Vessel" and a "Regulating Funnel," was placed over the hole as shown in the right hand sketch of Fig. 34.

A known weight of a sand of which the unit weight had been previously determined, was poured through the "Regulating Funnel" into the hole until it overflowed at the top of the "Measuring Cone." The overflow was replaced in the original container, the residue weighed and the weight of sand in the hole and the "cone" determined by difference. From this was deducted the previously determined weight required to fill the cone and the hole in the plate, the balance being the weight of the sand in the hole.

The ratio of dry weight of the soil removed from the hole to the weight of standard sand required to fill it, multiplied by the known unit weight of the sand, gave the unit dry weight of the soil in place. Fig. 33 shows the various stages of this operation.

The imported embankment material consisted of a gravelly sand mixture secured from a channel change in the Santa Clara River. This gravelly sand classified as A-2 under USPRA method of classification. The California bearing ratio ranged from a low of 30% to a high of 112% at 0.1" penetration, with an average of 57%. This material was placed in the embankment at a relative compaction of 90% or better.

The material in the top 6" of the subgrade was given special handling to insure a uniform material for the base immediately under the concrete pavement. This material was placed in 4 or more approximately equal windrows and mixed by blading from one side of the road to the other. Grading analyses of the samples taken across the roadway section, at various locations, prior to compaction, show a maximum variation of 2% on the 100 mesh screen and less than 10% variation on any of the coarser sizes. The relative compactions ranged from a low of 94% to a high of 102% with an average of 97%. This material had an average California bearing ratio of 57% at 0.1" penetration and had a USPRA A-2 classification.

The selected subgrade material contained some coarse particles grading up to 3 or 4 inches in diameter. These coarse particles tended to drag for a short distance under the cutting edge of the Lewis subgrader causing holes or grooves in the finished subgrade. These depressions filled with concrete when the pavement was placed and as a result the bottom of the concrete contains numerous small projections into the subgrade (Fig. 5).

7. Installation of Joints, Etc.

Table I shows the location of the expansion joints at each end of the various test sections and the spacing of the intervening expansion and dummy joints.

Three-quarter inch redwood boards were used in the expansion joints throughout the project and no instances of poor alignment or lack of support were noticed. A slight vertical displacement of the boards occurred in a few instances during the placing of concrete in the No. 6 sections.

All dowels in the test sections were painted and thoroughly greased and provided with caps. All the caps were in place when the concrete was poured.

The alignment, both vertical and horizontal of all expansion joint dowels was good but some trouble was experienced in keeping the dummy joint dowels of

Sections 5a, 5b, 6a, and 6b in proper alignment. However, by hand placing concrete around the dowel supports and by exercising special care in dumping the concrete from the hopper near the joints, most of the trouble was eliminated. In a few instances the transverse horizontal steel at these dummy joints was accidentally bent enough to be 1/4" to 1/2" out of line at the center of the lane, but the longitudinal alignment at the dowels was not affected. Measurements made after floating operations had been completed showed a few instances where the dummy joint dowels were as much as 1/8" (vertically) out of alignment with the surface of the pavement, but in most cases, they were within 1/16", or less, of the proper position.

8. Tie Bars

Although the pavement was constructed in two lanes of equal width no tie bars were used across the center joint. The steel side forms left a smooth surface on the inner edge of the concrete slab on the south lane throughout most of the project. All rough spots or honeycomb which did occur were plastered with cement mortar to a smooth finish before the concrete for the second, or north, lane was poured.

9. Depth of Dummy Joints

The depth of the groove for dummy joints was determined at frequent intervals for at least three points in a joint (near each edge and the center of the slab). Measurements were made after the concrete had begun to harden and before the groove was filled with asphalt. The depths varied from 2-1/8 inches to 2-5/8 inches and averaged approximately 2-1/2 inches.

10. Depth of Longitudinal Center Joint

The longitudinal center joint was a contact joint throughout the project (See "8" above). The use of the edging tools left a groove 3/4 inch to 1-1/2 inches deep. No regular series of depth measurements were made.

11. Appearance of Concrete, Etc.

The concrete was homogeneous in appearance throughout the job and its workability was good except for a few short intervals when a slight tendency towards harshness was noticeable.

The slump averaged 1-1/2 inches with an extreme range of 3/4 inch - minimum and 3 inches maximum. In most of the tests, however, the slump varied between 1-1/4 inches and 2 inches.

Neither an excess nor a deficiency of mortar was noticeable, and, although occasionally a small amount of pea gravel worked to the surface during finishing operations, no segregation was observed.

Some bleeding was noticeable throughout the job. At times it was barely perceptible but was generally pronounced although never excessive. No washing away of any cement was observed. There was very little, if any, difference in the amount of bleeding between the portions of the pavement where blending sand was used and those in which the unblended sand was used.

The time required for the hardening of the freshly placed concrete varied considerably with changes in temperature, humidity, etc.

As soon as the concrete had hardened enough to permit walking on the surface, the expansion and weakened place joints were filled with the asphaltic crack filler. Hence, the time required for initial hardening at any location may be determined from Figures 42 to 54, inclusive (except Figures 48, 49 and 51) by observing the time interval between the lines indicating the respective times of placing and joint filling. On October 20, 21, and 24th (Figures 48, 49, and 51) rain interfered with normal operations and made it necessary to fill the joints as soon as they were formed instead of waiting until initial hardening had occurred. Hence for each of the three days mentioned the joint filling times subsequent to noon are from 30 minutes to 4 hours earlier than the time of initial hardening.

The frequent changes in the amount of water added at the mixer to each batch (Tables 3 to 15) were made necessary by changes in the moisture content of the fine aggregate, by variations in the atmospheric temperature, by humidity, and by fluctuations in the direction and velocity of the wind.

The freshly mixed concrete was dumped from the traveling hopper of the mixer directly onto the subgrade, and immediately spread and screeded to the proper depth by a Blaw-Knox paving spreader. A Lakewood concrete tamper was operated immediately behind the spreader and the entire operation of placing, spreading and tamping was completed in a few minutes.

In the reinforced sections, 6a and 6b, the concrete for the lower 4-1/2" of the slab was spread by hand for a short distance ahead of the mixer, after which the steel mats were placed and then the upper half of the concrete was spread in the usual manner.

Exclusive of delays due to breakdowns, etc., the normal rate of pouring, as may be noted from Figures 42 to 54 was approximately 330 to 340 lineal feet of pavement (11 feet wide) per hour, averaging very close to one batch per minute, with a minimum mixing period of 45 seconds.

12. Finishing

Floating and finishing was done with a Johnson mechanical finisher. As a rule, from 100 to 500 feet of pavement was finished at a time.

The time intervals between placing and finishing the concrete, as may be noted for each day (Figures 42 to 54) varied from one to six hours, depending upon weather conditions and the behavior of the concrete.

On the last trip of the finishing machine over a given stretch of pavement, a strip of canvas was dragged behind the finisher to produce the desired surface texture.

Immediately behind the tamping machine, pieces of flat steel, 1/4" x 2" x 10'-11", were placed on edge in the fresh concrete at the location of each dummy joint so that the top of the steel was 1/4" to 3/8" below the surface of the concrete. As soon as the finishing machine had made its last pass, the steel was removed and the groove of the joint was finished with a dummy joint tool, consisting of a long handled wooden float 4" x 24" with a metal "T" across the center. The vertical leg of the "T" extended approximately 2-1/2" below the face of the float. The top edges of the joint were then finished with an ordinary 1/4" radius edging tool.

A similar float with a double center lip which fitted on each side of the redwood boards was used to form the grooves at expansion joints. A special double edging tool was used to finish the surface on each side of the expansion joint in one operation. The longitudinal edges were finished by means of 1/2" radius edging tools. All smooth horizontal surfaces left by the edging tools were brushed immediately after completion of the edging.

Occasionally the Johnson finisher worked a little mortar to the edge of the pavement but, as a rule, there was neither an excess nor a deficiency. In a few instances a little mortar from the edge had to be added to a rough spot in finishing a transverse joint.

After the concrete had hardened enough to permit walking upon it and the joints had been filled, a steel shod cutting float was pulled by hand across the surface of the slab to cut off any irregularities. The hardened steel cutting edge of the float was adjustable to maintain a true alignment (Fig. 10).

On October 20, 21, and 24th, rain interfered with normal finishing operations, expecially with respect to dummy joints and the use of the cut float.

Between Station 516+00 and 518+00 the dummy joints had been finished but not filled when the rain started. Some breakdown of the concrete edges at the joints occurred before the asphalt could be poured. Between Station 518+00 and the end of the day's work (11-20-41) at Station 527+60, all dummy joints were filled with asphalt immediately after they were formed, thereby avoiding most of the breakdown.

On October 21, rain again made it necessary to fill the joints from Station 536+00 to Station 555+20 immediately after they were grooved. These joints were cleaned out on the following day and refilled.

On the 24th a sudden and very heavy downpour occurred while the joints from Station 585+00 to 594+00 were open and considerable breakdown of the edges occurred. Between Stations 594+00 and 604+38 the steel was still in the concrete when the rain started and the joints were finished after the shower was over. However, the rain had washed sufficient free mortar from the surface to interfere to some extent with the proper finishing of the edges.

The fresh pavement surface was somewhat affected by the rainfall, especially between Stations 516+00 and 527+60, and between Stations 590+00 and 596+50. The latter portion had just been float finished when the hard shower of the 24th occurred and considerable of the surface mortar was washed away.

No bump cutting was done between Stations 511+40 and 555+20 because of the slow setting due to the rain on October 20 and 21st. An attempt to use the cut float on the day following the placing of the concrete was unsuccessful. On the 24th, the cut float removed only loose clean sand on the section between Stations 590+00 and 596+50.

Expansion joints were carefully installed and the redwood joint fillers were kept in good alignment. In a few instances, however, the boards moved vertically a little during the finishing of the concrete bringing the top of the board even with, or slightly above, the pavement surface. The joints with high boards were left unsealed until the concrete had cured, then the boards were trimmed to the proper depth and the joints sealed. It is probable, however, that concrete filled the space underneath the raised joint fillers. These imperfect expansion joints are located at the following points:

Station	498+17,	Section	6a
"	500+57	"	6a
"	641+72	"	6b

13. Curing Details

Curing was by an earth cover kept moist by sprinkling for eight days. The dirt was spread by hand immediately behind the bump cutting operations, as may be noted on Figures 42 to 54 except for those days on which rain retarded the hardening of the concrete. On those occasions the cover was applied the following morning but the pavement had been kept damp by rain all night.

The earth cover varied from 1/8 to 1 inch or more in thickness with an average of about 1/2 inch. It was moistened at frequent intervals by means of a water distributor equipped with an extension side spray bar. Applications were frequent enough to prevent complete drying of the cover at any time. At the end of the eight-day curing period the earth cover was removed with a motor grader.

14. Operation of Construction Equipment

The various items of construction equipment were operated in the customary manner. The operators were competent and skillful, especially the operator of the mixer. During the paving of the north lane, Mr. Johnson, who developed the Johnson finishing machine, was employed on the project as an assistant to the Resident Engineer and operated the finisher most of the time.

The same equipment, and, to a large extent, the same workmen were used throughout the paving operations. Delays due to breakdowns occurred occasionally but were not serious and seldom resulted in an extensive delay. The occurrence and extent of delays may be noted on Figures 42 to 54.

15. Removal of Forms and Condition of the Edges of the Concrete.

As a general rule, the side forms were removed about 24 hours after pouring the concrete. The outside or exposed edge of the north lane was good throughout with no honeycomb except for two small areas at Station 476+87 and at Station 487+45, respectively. From Station 370+75 to 401+00 frequent rough or honeycombed spots were noted on the inner (north) edge of the south lane. The hand placing of some concrete against the forms was started at 401+00 and only one or two small honeycomb spots were noted on the rest of the north edge of the south lane.

When, at the start of each morning's work, the tamping and finishing machines were moved back over the previous day's partially hardened concrete, the flanges of the outside wheels caused some damage to the top 2 inches of the outer edge of the concrete slab. This damage was not serious, usually amounting to a spalling of the top 2 inches of the edge for a width of 1/4 inch to 1/2 inch over the last 20 feet of each day's work. Other than the above, all edges were in excellent condition.

16. Joint Sealing Operation

All joints were sealed with an asphaltic joint sealing compound composed of 60% SC-6 and 40% air blown asphalt. The compound was heated until fluid, then poured by hand from cones into the joints.

Between Stations 536+00 and 555+20 the filling was imperfect because of the rain and all joints were cleaned and repoured the following day.

All sealing operations were carefully done. Some joint compound was removed by traffic during the construction period but all such spots were re-sealed by the contractor.

17. Pictures illustrating all construction phases of the project are included with this report (Figures 5 to 15.)

C - TEST SPECIMENS, ETC.

Test specimens were fabricated each day on which concrete was poured. Occasionally the test portions of two experimental sections were constructed on the same day and, on those occasions, a set of test specimens was made for each experimental section. As the first section of the north lane to be constructed (1a) required three construction days a set of test specimens was made each day. All other experimental sections have but one set of specimens each.

A set of specimens normally consisted of one beam 6" x 6" x 20", three beams 6" x 6" x 34", and three cylinders 6" x 12", all specimens of each set being fabricated at the same time. On Section 1a, no 6" x 6" x 20" beams were made on the first two days; the 6" x 6" x 20" beam for this test section being fabricated on the third day only.

The concrete for each set of test specimens was obtained from several batches immediately after they had been deposited on the roadbed in front of the spreading machine.

The test concrete was shovelled from the roadbed into a wheelbarrow and screened through a 1½" square mesh screen to remove the larger sizes of coarse aggregate. A portion of the sample was used for the slump test and the remainder was placed in the molds according to the respective standard methods for the fabrication of beams and cylinders.

One partial exception to the above procedure occurred in the case of Section 3b. In order to provide sufficient specimens for tests at various ages, additional beams and cylinders, 21 of each, were made when the job routine test specimens were fabricated. For this purpose one batch of concrete was dumped on the shoulder, instead of the pavement, and all specimens were made from the one batch.

At the end of 24 hours curing in the forms under wet burlap, the test beams were placed on the pavement slab at the point of fabrication, covering with wet sand or burlap, and given the same curing treatment as the concrete in the pavement. The 6" x 12" cylinders were cast in tin molds and sealed with tight fitting covers immediately after fabrication.

Identification numbers were stamped in each beam by means of steel dies as soon as the fresh concrete was hard enough to retain the impression of the die. Similar numbers were stamped in the bottoms of the 6" x 12" cylinder cans before they were filled.

At the designated times test specimens were disposed as follows:

(a) The 6" x 6" x 20" beams were shipped to the P.R.A., Washington, D.C. for the determination of volume change and modulus of elasticity. One of these beams was made for each test section, a total of 14 beams. At the end of the curing period, each beam was placed in a storage pile near the Resident Engineer's office until time for shipment. On November 18, 1941, the identification numbers were stenciled in black paint on the sides of the P.R.A. beams (Fig. 13) then the beams were packed (surrounded by sawdust) in individual wooden boxes and shipped, by freight, to the Public Roads Administration Laboratory, Arlington Experimental Farm, Rosslyn, Virginia.

(b) The 6" x 6" x 34" beams were cured as described above until they were from four to seven days old, then packed in wet sand in a truck and hauled to the Materials and Research Department at Sacramento.

(c) The 6" x 12" cylinders were shipped to Sacramento at the same time as the corresponding beams.

(d) In addition to the special test specimens mentioned above, the Resident Engineer fabricated the customary daily control specimens, two cylinders, and three beams, each day that concrete was poured. The cylinders were shipped to Sacramento for routine compression tests (10 day and 28 day.) One of the routine job control beams was broken in the field by means of a portable hydraulic beam testing machine (center point loading) at each of the following ages: 8, 14, and 28 days (See Table 25 for test results).

When the concrete in each of the experimental sections (north lane) was 21 days old, cores were cut for 28 day compressive strength tests. In most instances the cores were cut at the locations from which the concrete for test specimens had been obtained.

A similar set of cores was cut from the south lane in order to obtain a comparison of concrete strengths between the two lanes of the pavement. Some of these cores from the south lane were older than 28 days (29 to 38 days old) when tested. Corresponding sets of cores have since been cut from the two lanes when the pavement was two years old.

For tests of all specimens see Tables 24 to 27.

While the 28 day tests indicated a greater strength for the concrete without the blending sand, the two-year cores indicate that the pavement concrete in which the blending sand was used now equals or exceeds the compressive strength of unblended sand concrete.

The reason for the superiority of the concrete with the unblended sand at the early ages may be due in part to the higher temperatures prevailing during the first part of the construction and curing period.

The most plausible explanation however is the fact that the C_3S content of the cement averaged somewhat lower on the latter part of the project than the first part (Table 21).

3. Samples of Materials

In accordance with instructions, samples of the fine and coarse aggregates and of cement were shipped to Public Roads Administration Laboratory Washington, D.C. and to the Portland Cement Association in Chicago. The coarse aggregates were obtained from a composite of the daily screen test samples, while the fine aggregates and the cement are composites from the stockpiles of material used on the project. The coarse aggregates were screened to the sizes used in the job.

4. Measurement Points, Benchmarks, Temperature Wells, Etc.

Points for measurement of joint openings and closings, wells for measurement of slab temperatures, elevation points and permanent bench marks were installed as covered in the "Suggested Program of Observations for Cooperative Investigation of Joint Spacing in Concrete Pavements." (Appendix A).

Several sets of temperature wells for use with Weston Dial Type Thermometers were installed at the locations previously listed in Section "B". Each of these installations consisted of a brass plate anchored in the fresh concrete by means of two small rods. Two short 1/2 inch brass plugs were screwed into holes near the center of the plate and rods of approximately the same diameter as the stems of the Weston Thermometers were brazed into the plugs. One rod reached 2-1/4 inches below the surface and the other 6-1/4 inches below. The rods were greased when the assembly was set in the soft concrete. After the concrete had begun to harden the plugs were unscrewed and removed and thermometers inserted into the holes left by the rods. After the temperature observations were completed the plugs were replaced in order to maintain the wells in good condition for future use.

The location of the wells and concrete temperatures noted at each point are recorded in Table 17.

Complete records of the various details were kept in field books which are available for reference.

PERFORMANCE AND MEASUREMENTS SUBSEQUENT TO CONSTRUCTION

1. JOINT WIDTH MEASUREMENTS

Seasonal, daily and permanent joint measurements to date are shown in Tables 28 to 34 and Figs. 17 to 29.

The location of the joint width change measurement points and level points are likewise shown on the sketches at the base of Tables 28 to 34 as well as in Figs. 35 to 41.

A study of the figures is illuminating as it is possible to, at a glance, observe the pavement expansion and contraction fluxuations with the seasons as well as with the temperature variations.

All joint width changes are based on the original joint width measurements in February, 1942 and therefore show the expansion or shrinkage of the concrete from that datum.

(a) Seasonal Changes.

The maximum shrinkage of the concrete and hence largest joint opening at the weakened planes in 1943 occurred in November for all 116 weakened plane joints in the seven test sections. At the

time of the first measurements in 1942 the greatest shrinkage was in November for the great majority, 89 out of 116 joints. In only 15 cases was the shrinkage greater in February than in November.

Measurements at the same 116 contraction joints showed the greatest concrete expansion in May for 87 joints and in August for 14. The remaining 15 joints showed the same expansion in May as in August. On the other hand, the expansion joints measured the greatest expansion in August in 22 out of 23 cases, although the greatest shrinkage was in November as in the case of the weakened plane joints.

(b) Daily Changes

The greatest daily fluxuation occurred in reinforced Sec. 6b where the expansion joints were spaced 120 ft. with one intermediate weakened plane, the movement amounting to as much as 0.12" at the expansion joints and 0.07" at the weakened planes in August as compared with 0.06" and 0.04" for spacing of 120' with weakened planes every 15 feet in the unreinforced sections.

In the case of the 405 and 810' expansion joint spacing the daily fluxuation at the expansion joint was the same as with the 60' spacing (0.08") but only 0.04" at the weakened planes.

(c) Permanent Changes

The permanent changes at the weakened planes are negligible to date amounting in all cases to less than one one hundredths of an inch. The changes at the expansion joints have been somewhat greater although in no case over 0.03" subsequent to August, 1942. The permanent change from the original construction however is somewhat greater amounting to as much as 0.14" in the case of the 60' spaced expansion joints; 0.16" to 0.20" for the 120' spaced joints and 0.25" for the 405' and 810' spacing.

2. ELEVATION MEASUREMENTS

Levels were taken at the elevation points in October, 1941 and again in February, 1943.

Tables 35 to 41 and Figs. 35 to 41 show the relation of all elevation points in February, 1943 to the original elevations of October 1941.

For the most part there was little change during the first year and four months, the differential usually being substantially less than a tenth of an inch, notwithstanding the fact that fills up to as great as five to ten feet are included within the limits of the test points.

In a few cases, however, definite settlement has taken place; in one case (Sec. 2a) amounting to as much as 0.045' or over 0.5".

It is intended to take another set of level readings in August of this year (1944) when the construction will be approximately three years old.

3. CRACK SURVEY

A transverse crack developed in the north lane in experimental Section 3b at Sta. 617+25 before the pavement was opened to traffic in November, 1941. No further cracks had developed at the time of the last inspection in February, 1944 when the pavement had been in service for two years. The inspection at that date revealed an occasional occurrence of slight surface spalling of the south edge of the north lane along the contact with the south lane.

4. GENERAL CONDITION SURVEY

With the exception of the spalling (which is unimportant to date) the surface of the concrete, at the end of two years of service, showed practically no change from its appearance when first opened to traffic. All test sections were in excellent condition.

5. TEMPERATURE GRADIENT WITHIN THE SLAB

See Figures 30, 31, and 32.

6. MODULUS OF ELASTICITY OF CONCRETE

See Appendix C.

7. COEFFICIENT OF SUBGRADE FRICTION

See Appendix D.

8. OVERALL MOVEMENT OF ONE LANE OF SECTION 1b.

Concrete monuments for transit points were placed on each side of the pavement one foot below the ground surface, three feet out from the edge, and one foot back from each end of section 1b for use as reference points to determine overall movement at the ends of this one mile long test section. Copper tack transit points in lead were placed in the top of each monument and in the center of each pavement lane. These points were set in line January 14, 1942.

The following tabulation shows the increase in length at each end of each lane of Section 1b from January 14, 1942 to February 8, 1944.

Station	OVERALL CHANGE IN LENGTH SECTION 1b			
	W. End (Sta. 519+78.7)		E. End (Sta.568+27.9)	
	Right Lane	Left Lane	Right Lane	Left Lane
1-14-42	0	0	0	0
11-18-42	+.03"	+.17"	+.10"	+.08"
8-4-43	+.05"	+.20"	+.06"	+.12"
11-16-43	+.04"	+.20"	+.10"	+.12"
2-8-44	+.00"	+.20"	+.08"	+.08"

9. SUBGRADE FACTOR "k"

See Appendix E.

10. ROUGHNESS MEASUREMENTS

See Appendix F.

ACKNOWLEDGEMENT

The following members of the staff of the California Division of Highways and their assistants actively participated in this work in the field:

1. District Engineer Cortelyou
   District Construction Engineer A. N. George
   District Materials Engineer Rex Allan
   Resident Engineer E. L. Seitz

2. From headquarters at Sacramento,
   Assistant State Highway Engineer F. J. Grumm and
   Construction Engineer R. M. Gillis and their
   assistants, E. W. Withycombe, A. M. Nash and
   N. C. McCorkle.

3. The Materials and Research Department was represented
   by Senior Physical Testing Engineers O. J. Porter and
   F. N. Hveem and their assistants - J. E. Barton and
   J. L. Beatty.

The immediate direction of the investigational features of this project, including installing of all measurement points, the securing and recording of all test data, fabrication and test of all materials and specimens and the performance of the special field and laboratory tests relating to the determination of Subgrade k values, subgrade friction, concrete modulus of elasticity and temperature gradient and pavement roughness measurements and the compiling of reports thereon, was the responsibility of the Materials and Research Engineer.

Messrs. Barton and Beatty were primarily responsible for securing all field data relating to the concrete pavement and compiling and analyzing the data at Sacramento.

All work was done under the general direction of Director of Public Works C. H. Purcell and State Highway Engineer G. T. McCoy and in cooperation with the representatives of the Public Roads Administration.

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TABLE 1
SUMMARY OF TEST SECTIONS

VII-Ven-79-C F.A.P. 380-C (1) Research No. 00194 Contract 27XC7-P

Test Sect. No.	Located Between Stations	Length in Feet	Date of Construction		Expansion Joints		Dummy Joints			Cross Section Pavement Thickness	Rein-forcing Steel	Test Points Located Between
			North Lane	South Lane	Space Feet	No. of Dowels	Spac-	No. Dowels No. Lane	No. Dowels So. Lane			
1-A	370+75.2 **and** 423+54.3	5279.1	10/10/41 10/14/41 10/15/41	9/20/41 to 9/25/41	5280	9	15	0	4	9"-7"-9"	None	None
2-A	423+54.3 439+74.8	1620.5	10/15/41 10/16/41	9/25/41 9/26/41	810	9	15	0	4	9"-7"-9"	None	431+64.4 439+74.8
3-A	**439+74.8 468+16.1**	2834.6*	**10/16/41 10/17/41**	9/26/41 9/27/41 9/29/41	405	9	15	0	4	9"-7"-9"	None	**448+06.1 456+15.8**
4-A	468+16.1 480+16.8	1200.7	**10/17/41**	**9/29/41**	120	9	15	0	4	9"-7"-9"	None	470+56.4 476+56.4
5-A	480+16.8 493+37.3	1320.5	10/17/41 10/18/41	9/29/41 9/30/41	120	9	15	9	9	9"-7"-9"	None	484+97.3 490+97.2
6-A	493+37.3 506+57.8	1320.5	**10/18/41**	9/30/41 10/1/41	120	9	60	9	9	9"-7"-9"	Wire Mesh	None
7-A	506+57.8 519+77.7	1319.9	10/18/41 10/20/41	**10/1/41**	120	0	15	0	0	8"-8"-8"	None	None
1-B	519+77.7 **and** 568+28.9	5284.6*	10/20/41 10/21/41 10/22/41	10/1/41 10/2/41 10/3/41	5280	9	15	0	4	9"-7"-9"	None	543+49.1 551+30.2 **
2-B	568+28.9 584+49.0	1620.1	10/22/41 10/24/41	10/3/41 10/6/41	810	9	15	0	4	9"-7"-9"	None	None
4-B	584+49.0 596+51.5	1201.5*	10/24/41	10/6/41	120	9	15	0	4	9"-7"-9"	None	None
3-B	598+24.7 627+32.5	2835.6*	10/24/41 10/25/41	10/7/41 10/8/41	405	9	15	0	4	9"-7"-9"	None	None
5-B	627+32.5 639+32.5	1200.0	10/25/41 10/28/41	**10/8/41**	120	9	15	9	9	9"-7"-9"	None	None
6-B	639+32.5 652+50.1	1320.5*	**10/28/41**	10/8/41 10/9/41	120	9	60	9	9	9"-7"-9"	Wire Mesh	642+92.5 648+88.9
7-B	652+50.1 665+68.7	1318.6	10/28/41 10/29/41	**10/9/41**	120	0	15	0	0	8"-8"-8"	None	656+10.2 662+10.2

* See list of equations in stationing
** Also between Sta. 519+77.7 and 521+57.8 - Sta. 570+80.3 and 568+28.9*

TABLE 2

RAINFALL DURING PAVEMENT CONSTRUCTION PERIOD

VII-Ven-79-C F.A.P. 380-C (1) Res. 00194 Cont. 27XC7-P

Data compiled from records of the Camulos Ranch for a rain gauge located just south of the highway near Station 460. Observation period extends from 7:00 A.M. of previous day to 7:00 A.M. of the date shown.

September 1941					October 1941				
Day of Month	Rainfall In.	Pavement Placed * During Observ. Period			Day of Month	Rainfall In.	Pavement Placed * During Observ. Period		
		Lane	From	To			Lane	From	To
1					1		South	485+12	502+99
2					2		"	502+99	527+88
3					3		"	527+88	553+86
4					4		"	553+86	573+69
5					5				
6					6				
7					7		"	573+69	597+30
8					8		"	597+62	622+52
9					9		"	622+52	641+73
10					10		"	641+73	665+69
11					11		North	370+65	388+00
12					12	0.17			
13					13				
14					14				
15					15		North	388+00	407+49
16					16		"	407+49	431+20
17					17		"	431+20	459+47
18					18		"	459+47	484+97
19					19		"	484+97	511+40
20					20	0.08			
21					21	0.04	"	511+40	527+60
22					22	0.43	"	527+60	555+20
23					23	0.15	"	555+20	580+73
24	No Rainfall	South	370+65	386+95	24	0.19			
25		"	386+95	405+70	25	0.04	"	580+73	604+38
26		"	405+70	427+30	26		"	604+38	628+68
27		"	427+30	450+45	27	0.09			
28		"	450+45	459+92	28	0.14			
29					29			628+68	655+35
30		"	459+92	485+12	30		"	655+35	665+69
					31				

Note: The rainfall between 1:00 and 3:00 P.M. on 10/20/41 was much heavier at the location where concrete was being placed (Sta. 523 to 527) than it was in the vicinity of the rain gauge, approximately 1¼ miles away.

* Construction shown one day later than actual date of placement to conform to observation period noted above.

TABLE ~~13~~ 2A

SUPPLEMENTAL RAINFALL DATA

Sept. 1, 1941 to Feb. 8, 1944

VII-Ven,LA-79-C,A F.A.P. 380-c(1) Research .00194 Contract No. 27XC7-P

Rainfall in Inches for the 24-hr. Period Ending at 7:00 A.M. of the Date Shown

Year	Month	DAY 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total
1941	Sept.																																
	Oct.												.17								.08	.04	.43	.15	.19	.04		.09	.14				1.33
	Nov.																	.04													.41		.45
	Dec.				.37					.16	.50	.85	.01			.03		.05				.12			.02		.15		.52	1.84	.19	.01	4.82
		Total Sept. 1 to Dec. 31, Incl.																															6.60
1942	Jan.																						.21	.02		.01	.05						.29
	Feb.																						.80										.80
	Mar.											.30	.01			1.02																	1.33
	Apr.				.76	.04	.06				.17	.77		.01	.56	.10		.18				.02	.38										3.05
	May																																
	June																																
	July																																
	Aug.										.12																						.12
	Sept.																																
	Oct.												.04																	.78			.82
	Nov.				.11														.07														.18
	Dec.																								.33	.63							.96
		Total for 1942																															7.55
1943	Jan.																						6.40	6.37	.80		.42	.72			.25	1.15	16.11
	Feb.	.01							.17													.24	.80	.10	.76								2.08
	Mar.			.35	3.41	1.70	.35			.05	.11								.22				.10										6.29
	Apr.						.33																										.33
	May																																
	June																																
	July																																
	Aug.																																
	Sept.																																
	Oct.																																
	Nov.																			.20													.20
	Dec.						.37					3.10	.07							.83	.44	.31	1.23							.83	.13	.61	7.92
		Total for 1943																															32.93
1944	Jan.			.03		.01	.26																		.18						.46	.52	1.46
	Feb.				.65				.17		Data subsequent to Feb. 8, 1944 not yet available																						

Table ~~13~~ 2A

TABLE 3

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 10, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
			6:00			46	72								
1A	370+75	373+00	7:41					225	59.94	300	301	310			
"	373+00	375+00	8:26					200	51.14	256	252	305			
"	375+00	377+00	10:57	68	70	85	32	200	51.04	255	259	325			
"	377+00	379+00	11:36					200	51.58	258	259	320			
"	379+00	381+00	12:29			97	27	200	51.54	258	259	310	1-1/2		
"	381+00	383+00	1:15					200	51.87	259	259	315			
"	383+00	385+00	2:00	75	77			200	51.76	259	259	315	3/4		
"	385+00	388+00	3:10			92	32	300	79.18	396	371	315			

SUMMARY

Pavement constructed from Sta. 370+65 to Sta. 388+00

Total net length in feet 1740.17

" theoretical yardage 433.62

" actual yardage 448.06 (Pay quantity 447.72)

" number of batches 317

" theoretical sacks of cement 2240

" sacks of cement used 2219

Yield (sacks of cement per cu. yd.) 4.95

Total weight of steel 464.67 (Mat 446.54)

No. of expansion joint dowels 9

" " weakened plane dowels None

" " mats of wire mesh None

" " exp. joints without dowels None

" " square yards of subgrade 2128.7

Mixer operated from 6:07 A.M. to 3:10 P.M.

Net operating time 6 Hrs. 7 Min.

Reinforced Panel for Bridge Connection 370+65 to 370+75 Sect. 1-A Starts at Sta. 370+75

TABLE 4

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 14, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
1A	388+00	390+00	7:19					200	51.44	257	256	300			
"	390+00	392+00	8:15					200	51.44	257	251	295			
"	392+00	394+00	10:22	69	70			200	51.01	255	253	305	1"		
"	394+00	396+00	11:07					200	49.97	250	245	305			
"	396+00	398+00	11:42					200	49.80	248	241	310			
"	398+00	400+00	12:24					200	49.94	250	245	310	1"		
"	400+00	402+00	1:12	74	72			200	50.08	250	245	310			
"	402+00	404+00	1:50					200	49.86	249	240	315			
"	404+00	406+50	2:40					250	62.20	311	309	315			
"	406+50	407+49	3:05					99	24.00	120	116	315			

SUMMARY

Pavement constructed from Sta. 388+00 to Sta. 407+49

Total net length in feet 1946.55

" theoretical yardage 484.50

" actual yardage 489.74

" number of batches 343

" theoretical sacks of cement 2448

" sacks of cement used 2401

Yield (sacks of cement per cu. yd.) 4.90

Total weight of steel None

No. of expansion joint dowels None

" " weakened plane dowels "

" " mats of wire mesh "

" " exp. joints without dowels None

" " square yards of subgrade 2379.1

Mixer operated from 6:15 A.M. to 3:05 P.M.

Net operating time 6 Hrs. 12 Min.

TABLE 5

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 15, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
1A	407+49	409+00	7:09					151	37.77	189	194	310	1-1/4		
"	409+00	411+00	7:45	68	70	72	25	200	49.99	250	251	325		2-1/2	
"	411+00	413+00	8:21	67	70			200	49.76	248	244	325		2-1/4	
"	413+00	415+00	8:58			75	27	200	49.76	249	244	325		2-1/4	
"	415+00	417+00	9:37	69	71	82	20	200	49.94	250	243	315		2-3/8	
"	417+00	418+75	10:05					175	43.76	219	210	310		2-1/2	
"	418+75	421+00	12:11	70	71	85	20	225	56.24	281	280	325	1-1/2	2-1/2	
"	421+00	423+00	12:49			86	19	200	49.76	249	245	320		2-3/8	
"	423+00	423+55		73	71	87	19								
2A	423+55	425+00	1:22			88	20	200	49.90	249	243	320		2-1/4	
"	425+00	428+00	2:10	75	72			300	74.64	373	359	315		2-3/8	
"	428+00	430+00	2:45			90	19	200	49.76	249	252	320			
"	430+00	431+20	3:05	75	72	89	21	120	30.58	148	133	320			
			4:25			86	19								
			5:45			79	30								

SUMMARY

Pavement constructed from Sta. 407+49 to Sta. 431+20

Total net length in feet 2371 (2369.85)

" theoretical yardage 589.83

" actual yardage 590.86

" number of batches 414

" theoretical sacks of cement 2954

" sacks of cement used 2898

Yield (sacks of cement per cu. yd.) 4.91

Total weight of steel 18.13 lbs.

No. of expansion joint dowels 9

" " weakened plane dowels None

" " mats of wire mesh None

" " exp. joints without dowels None

" " square yards of subgrade 2896.6

Mixer operated from 6:07 A.M. to 3:12 P.M.

Net operating time 6 Hr. 56 Min.

TABLE 6

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 16, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
2A	431+20	433+00	6:40			58	53	180	44.78	224	229	318		2-1/4	
"	433+00	435+00	7:14	66	73	61	51	200	50.00	250	247	315	1-1/4	2-3/8	
"	435+00	437+00	7:50			63	49	200	49.92	249	238	320		2-3/8	
"	437+00	439+00	8:23	69	75			200	49.84	249	246	318	1-1/4	2-3/8	
"	439+00	439+75				74	38								
3A	439+75	441+00	8:57					193.2	48.65	244	242	330			Equation
"	441+00	443+00	9:30	71	78	82	30	200	50.73	253	247	335			440+31.87
"	443+00	444+93	10:01					193	48.58	243	231	335		2-3/8	=440+38.64
"	444+93	447+00	11:36			90	26	207	52.08	261	273	316	2	2-1/4	Lunch
"	447+00	449+00	12:08	76	82	91	24	200	50.21	251	246	315			
"	449+00	451+00	12:44					200	50.18	251	246	325			
"	451+00	453+00	1:18			91	24	200	50.00	250	250	325	1-1/4		
"	453+00	455+00	1:53	77	83	91	24	200	49.94	249	252	325			
"	455+00	457+00	2:26					200	50.14	251	249	317			
"	457+00	459+47	3:05	77	83	89	27	247	62.52	313	304	317			

SUMMARY

Pavement constructed from Sta. 431+20 to Sta. 459+47

Total net length in feet 2520.88

" theoretical yardage 702.12

" actual yardage 707.57

" number of batches 500

" theoretical sacks of cement 3538

" sacks of cement used 3500

Yield (sacks of cement per cu. yd.) 4.94

Total weight of steel 108.80#

No. of expansion joint dowels 54

" " weakened plane dowels None

" " mats of wire mesh None

" " exp. joints without dowels None

" " square yards of subgrade 3447.4

Mixer operated from 6:08 A.M. to 3:08 P.M.

Net operating time 8 Hrs., 8 Min.

TABLE 7

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 17, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
3A	459+47	461+00	6:31			57	61	153	38.86	195	208	320		2-1/4	
"	461+00	464+00	7:23	70	77			300	75.40	376	373	310		2-3/8	
"	464+00	466+00	8:04			60	51	200	50.25	251	259	318		2-3/8	
"	466+00	468+15				68	48								
4A	468+15	468+50	10:04					250	63.15	316	322	325		2-3/8	
"	468+50	470+00	10:29			80	36	150	37.46	187	175	325		2-1/4	
"	470+00	473+00	11:28	76	80			300	68.60	343	385	315	2"	2-3/8	
"	473+00	476+00	12:11			90	30	300	75.11	376	378	315		2-3/8	
"	476+00	478+00	12:46			89	27	200	50.96	255	252	320		2-1/2	
"	478+00	480+00	1:18					200	51.16	256	252	329			
"	480+00	480+17													
5A	480+17	482+00	1:59	78	75	88	28	200	50.53	253	246	325			
"	482+00	484+00	2:36			84	42	200	50.49	253	258	317			
"	484+00	484+97	2:54			82	40	97	24.53	122	112	317			

SUMMARY

Pavement constructed from Sta. 459+47 to Sta. 484+97		Total weight of steel	816#
Total net length in feet	2550.04	No. of expansion joint dowels	153
" theoretical yardage	634.69	" " weakened plane dowels	252
" actual yardage	636.52	" " mats of wire mesh	None
" number of batches	460	" " exp. joints without dowels	None
" theoretical sacks of cement	3183	" " square yards of subgrade	3116.6
" sacks of cement used	3220	Mixer operated from 6:31 A.M. to 2:54 P.M.	
Yield (sacks of cement per cu. yd.)	5.06	Net operating time 7 Hrs. 31 Min.	

TABLE 8

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 18, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
5A	484+97	487+00	6:41			52	76	203	51.50	258	262	315		2-3/8	
"	487+00	489+00	7:15	71	71			200	51.18	256	251	313	3	2-1/4	
"	489+00	491+00	7:49					200	51.05	255	253	308			
"	491+00	493+00	8:22			61	65	200	50.49	253	249	308		2-3/8	
"	493+00	493+37													
6A	493+37	496+97	9:30			72	50	397	100.38	503	501	317		2-1/2	
"	496+97	498+29	10:09	76	77			132	32.42	162	164	325		2-1/2	
"	498+24	506+57				79	42						3		
7A	506+57	508+00	2:07	78	76	81	46	971	246.79	1234	1223	333		2-3/8	Changed to
"	508+00	510+00	2:45			79	51	200	55.10	276	268	330			uniform 8"
"	510+00	511+40	3:14	78	76	76	56	140	38.88	194	189	330			section

SUMMARY

Pavement constructed from Sta.	484+97 to Sta. 511+40	Total weight of steel	1414.40
Total net length in feet	2640.13	No. of expansion joint dowels	162
" theoretical yardage	668.71	" " weakened plane dowels	540
" actual yardage	677.79	" " mats of wire mesh	88
" number of batches	480	" " exp. joints without dowels	4
" theoretical sacks of cement	3389	" " square yards of subgrade	3227.6
" sacks of cement used	3360	Mixer operated from 6:02 A.M. to 3:14 P.M.	
Yield (sacks of cement per cu. yd.)	4.95	Net operating time 7 Hrs. 54 Min.	

TABLE 9

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 20, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
7A	511+40	513+00	6:51	66	70	46	95	160	45.39	227	231	320		2-3/8	
"	513+00	516+50	8:00			50	88	350	98.88	494	490	315	1-3/4	2-3/8	
"	516+50	518+00	8:57					150	42.52	213	203	310			
"	518+00	519+77	9:37					177	49.13	248	264	305			
1B	519+77	521+20	9:58			59	69	143	36.91	182	170	305			
"	521+20	524+00	11:43	67	66		R	280	73.23	361	360	312			
"	524+00	526+00	12:17				A	200	51.31	257	259	298	1-1/4		Rain
"	526+00	527+60	12:47			59	I	160	41.23	206	193	298			"
							N								

SUMMARY

Pavement constructed from Sta.	511+40 to Sta. 527+60	Total weight of steel	None
Total net length in feet	1617.65	No. of expansion joint dowels	"
" theoretical yardage	422.67	" " weakened plane dowels	"
" actual yardage 437.60 (Pay Quantity 434.51)		" " mats of wire mesh	"
" number of batches	310	" " exp. joints without dowels	7
" theoretical sacks of cement	2188	" " square yards of subgrade	1977.1
" sacks of cement used	2170	Mixer operated from 6:14 A.M. to 12:47 P.M.	
Yield (sacks of cement per cu. yd.)	4.96	Net operating time 5 Hrs. 4 Min.	

TABLE 10

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 21, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
1B	527+60	529+00	6:35			52	93	140	35.88	179	185	300			
"	529+00	531+00	7:09					200	51.80	259	256	300			
"	531+00	533+00	7:42			54	94	200	51.68	259	252	300			
"	533+00	535+00	8:15					200	52.18	261	255	300			
"	535+00	537+00	8:49					200	52.02	260	256	298			
"	537+00	539+00	9:22			59	79	200	51.62	258	252	292			
"	539+00	540+65	9:50			62	75	165	42.02	210	210	292			
"	540+65	543+00	11:30					235	59.71	298	304	300			
"	543+00	545+00	12:01				R	200	50.33	252	256	300	1-1/4		Rain
"	545+00	547+00	12:35				A	200	50.65	253	245	308			"
"	547+00	549+00	1:07			61	I	200	50.16	251	252	304			"
"	549+00	551+00	1:40				N	200	49.92	250	252	300			"
"	551+00	554+00	2:32					300	75.54	378	378	296			"
"	554+00	555+20	3:07					120	30.98	155	154	296			"

SUMMARY

Pavement constructed from Sta.	527+60 to Sta. 555+20	Total weight of steel	None
Total net length in feet	2760 (2764.96)*	No. of expansion joint dowels	None
" theoretical yardage	688.16	" " weakened plane dowels	None
" actual yardage	704.49	" " mats of wire mesh	None
" number of batches	501	" " exp. joints without dowels	None
" theoretical sacks of cement	3522	" " square yards of subgrade	3379.3
" sacks of cement used	3507	Mixer operated from 6:07 A.M. to	3:07 P.M.
Yield (sacks of cement per cu. yd.)	4.98	Net operating time 7 Hrs. 46 Min.	

* Correction for curve

TABLE 11

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 22, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
1B	555+20	557+00	7:11	62	66	51	88	180	45.37	227	231	282		2-3/8	
"	557+00	559+00	7:48					200	50.97	255	252	280		2-3/8	
"	559+00	561+00	8:24			60	60	200	50.89	254	259	270		2-1/4	
"	561+00	564+00	9:16					300	80.50	402	392	280		2-3/8	
"	564+00	565+00	9:34					100	26.82	134	126	280			
"	565+00	568+28				64	57								
2B	568+28	569+00	11:15					400	100.79	504	497	272			
"	569+00	571+00	11:49	64	68			200	49.84	249	245	265			Equation
"	571+00	571+89													571+88.90
"	567+55	569+00	12:22					234	58.07	290	280	270	3/4		=567+55.54
"	569+00	571+50	1:11			68	48	250	62.20	311	311	287			
"	571+50	573+00	1:39					150	37.32	187	183	304			
"	573+00	576+00	2:32			67	51	300	74.64	373	381	283	2-1/4		
"	576+00	578+00	3:12					200	49.76	249	249	283			
"	578+00	580+00	3:45	66	66	65	50	200	51.46	257	255	277			
"	580+00	580+73	4:11					73	18.72	94	91	277			

SUMMARY

Pavement constructed from Sta. 555+20 to Sta. 580+73		Total weight of steel	36.66
Total net length in feet	2987.46	No. of expansion joint dowels	18
" theoretical yardage	743.58	" " weakened plane dowels	None
" actual yardage	757.35	" " mats of wire mesh	None
" number of batches	536	" " exp. joints without dowels	None
" theoretical sacks of cement	3787	" " square yards of subgrade	3551.4
" sacks of cement used	3752	Mixer operated from 6:32 A.M. to 4:11 P.M.	
Yield (sacks of cement per cu. yd.)	4.95	Net operating time 8 Hrs., 56 Min.	

TABLE 12

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 24, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
2B	580+73	583+00	7:31	61	72	52	94	227	58.46	292	291	254	1-3/4		
"	583+00	584+52													
4B	584+52	585+00	8:13			58	89	200	51.08	255	255	254		2-3/8	
"	585+00	587+00	8:47					200	50.96	255	259	242		2-3/8	
"	587+00	589+00	9:22	62	73			200	51.12	256	249	250		2-3/8	Equation
"	589+00	591+00	9:59					199	51.33	257	262	246			590+17.89=
"	591+00	591+50	10:06			64	70	50	12.88	66	63	250			590+18.93
"	591+50	593+00	11:02					150	38.66	191	196	254	1-3/4		
"	593+00	595+00	11:37					200	51.50	258	255	258			
"	595+00	598+00	12:40	67	68	68	68	281	74.04	370	372	270	1		19' out for
"	598+00	598+25													R.R.
3B	598+25	600+00	1:16			65	76	200	51.18	256	255	263			
"	600+00	602+00	1:55				R	200	50.72	253	255	267			Rain
"	602+00	604+38	2:45	67	67		A	238	60.02	300	305	267			"
							I								
							N								

SUMMARY

Pavement constructed from Sta.	580+73 to Sta. 604+38	Total weight of steel	251.73
Total net length in feet	2343.66	No. of expansion joint dowels	117
" theoretical yardage	581.18	" " weakened plane dowels	None
" actual yardage	601.95 (Pay Quantity 599.82)	" " mats of wire mesh	None
" number of batches	431	" " exp. joints without dowels	None
" theoretical sacks of cement	3010	" " square yards of subgrade	2863.5
" sacks of cement used	3017	Mixer operated from 6:43 A.M. to 2:45 P.M.	
Yield (sacks of cement per cu. yd.)	5.01	Net operating time 7 Hrs., 26 Min.	

TABLE 13

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 25, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
3B	604+38	607+00	6:52			48	100 ↑	262	66.07	330	331	258			
"	607+00	609+00	7:57			50	F	200	51.39	257	264	250			Equation
"	609+00	613+00	8:58	60	66		O	323	85.28	426	427	246			610+28.11=
"	613+00	615+00	9:54				G ↓	200	52.24	262	252	270			611+00.27
"	615+00	616+10	10:15			62	80	110	29.00	145	147	267	1-1/4"		
"	616+10	618+00	11:48					190	49.70	248	238	273			
"	618+00	620+00	12:31					200	52.55	263	273	263			
"	620+00	622+00	1:03			68	72	200	51.24	255	252	276			
"	622+00	625+00	1:57	68	70			300	76.50	383	385	270	1-1/2"		
"	625+00	627+00	2:32					200	53.10	265	252	275			
"	627+00	627+33													
5B	627+33	628+68	3:06	69	70	69	64	168	43.48	217	217	275			

SUMMARY

Pavement constructed from Sta. 604+38 to Sta. 628+68		Total weight of steel	272
Total net length in feet	2352.42 (See Equation)	No. of expansion joint dowels	63
" theoretical yardage	585.52	" " weakened plane dowels	72
" actual yardage	609.21 (Pay Quantity 604.34)	" " mats of wire mesh	None
" number of batches	434	" " exp. joints without dowels	None
" theoretical sacks of cement	3046	" " square yards of subgrade	2875.1
" sacks of cement used	3038	Mixer operated from 6:08 A.M. to 3:06 P.M.	
Yield (sacks of cement per cu. yd.)	4.98	Net operating time 7 Hrs., 13 Min.	

TABLE 14

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 28, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
5B	628+68	631+00	7:12			49	100	232	59.44	297	308	267			
"	631+00	633+00	7:51	60	63	52	93	200	52.18	261	259	270			
"	633+00	635+00	8:30					200	51.29	256	259	270			
"	635+00	637+00	9:07					200	51.94	260	263	270	1-1/2		
"	637+00	639+00	9:43	63	66	61	70	200	51.97	260	255	270			
"	639+00	639+35											1-3/4		Equation
6B	639+35	641+73	11:20					273	71.84	359	364	280			643+87.51=
"	641+73	645+30	12:33			65	58	360	93.73	469	469	292	2-1/4		643+84.62
"	645+30	648+90	1:43					360	94.30	471	469	283			
"	648+90	652+50		66	70										
7B	652+50	653+00	3:11			68	56	410	108.94	545	528	263			Changed to
"	653+00	655+35	4:01			65	62	235	64.35	322	319	263			uniform 8"
															Sect.

SUMMARY

Pavement constructed from Sta. 628+68 to Sta. 655+35		Total weight of steel	1686.40
Total net length in feet	2670.70 (See Equation	No. of expansion joint dowels	180
" theoretical yardage	671.20	" " weakened plane dowels	657
" actual yardage	699.98 (Pay Quantity 692.80)	" " mats of wire mesh	None
" number of batches	499	" " exp. joints without dowels	2
" theoretical sacks of cement	3500	" " square yards of subgrade	3264.4
" sacks of cement used	3493	Mixer operated from 6:19 A.M. to 4:01 P.M.	
Yield (sacks of cement per cu. yd.)	4.99	Net operating time 8 Hrs., 50 Min.	

TABLE 15

DAILY CONSTRUCTION RECORD

VII-Ven-79-C F.A.P. 380-C(1) Contract 27XC7P North Lane Date Placed Oct. 29, 1941

Test Sect. No.	Concrete Placed From Station	Concrete Placed To Station	Time	Conc. Temp. When Plcd.	Conc. Temp. Final Float	Obs. at Mixer Air Temp.	Obs. at Mixer % Rel. Humid.	Dist. in Feet	Theoretical Vol. Cu.Yd.	Theoretical Sacks Cem.	Act'l Cem. Used	Wt. Water Added	Slump in Inches	Aver. Depth Joint	Remarks
7B	655+35	657+00	6:51	60	63	44	86	165	45.25	227	231	275			
"	657+00	659+00	7:28					200	54.64	273	269	270		2-1/2	
"	659+00	662+00	8:24			56	78	300	82.10	410	410	270	1-1/4	2-3/8	
"	662+00	665+69	9:33	63	66	60	69	369	100.86	504	497	270	1-1/4	2-3/8	
	End of	Project													

SUMMARY

Pavement constructed from Sta. 655+35 to Sta. 665+68.69		Total weight of steel	None
Total net length in feet	1033.69	No. of expansion joint dowels	"
" theoretical yardage	280.75	" " weakened plane dowels	"
" actual yardage	282.85	" " mats of wire mesh	"
" number of batches	201	" " exp. joints without dowels	9
" theoretical sacks of cement	1414	" " square yards of subgrade	1263.4
" sacks of cement used	1407	Mixer operated from 6:09 A.M. to 9:33 P.M.	
Yield (sacks of cement per cu. yd.)	4.97	Net operating time 3 Hrs., 18 Min.	

TABLE 15

TABLE 16

BATCH WEIGHTS AND DAILY AVERAGES OF COMBINED AGGREGATE GRADINGS

VII-Ven-79-C F.A.P. 380-C(1) Research 00194 Contract 27XC7-P

North Lane Including Experimental Sections	Date (1941)	10/10	10/14	10/15	10/16	10/17	10/18	10/20	10/21	10/22	10/24	10/25	10/28	10/29		Spec.
% Passing each size	3"	100	100	100	100	100	100	100	100	100	100	100	100	100		100
	2½"	99	97	98.5	98	98	98.6	98	97.9	98	96.6	96.8	97	97		95-100
	2"	90	89	88	89	87	89.2	89.5	88.7	88.8	84.9	88.1	90.6	86.6		73-93
	1½"	76	75	75.7	77	76	75.9	76.5	76.6	76.3	75	76.2	76.4	75.4		60-85
	1"	60	63	62	63	62.1	63.1	61.7	62.3	63.4	63.4	63.5	61.3	62.2		47-73
	3/4"	53	55	55	55	54.7	55.2	54.5	54.7	55	54.7	55.2	54.5	54.8		42-65
	3/8"	41	43	43	43	42.6	42.8	42.5	41.6	42.3	43.4	41.2	42	42.3		35-50
	#4	36	37	37.2	37	36.9	37.1	37.1	36.7	36.7	36.3	36.4	36.7	36.5		30-40
	#8	32	31	32	31	31	31.4	30.9	30.9	30.8	30.3	30.6	30.6	30.5		22-34
	#16	26	25	25	25	24.2	24.4	24.8	24.6	24.5	23.9	24.8	24.2	24.1		17-27
	#30	17	16	16.4	16	15.9	15.6	16.1	15.7	15.8	15.2	15.7	15.7	15.5		11-18
	#50	9	8	9	9	7	7.9	8.4	8	8.4	7.8	7.9	7.8	8.0		4-9
	#100	3.2	2.2	3	3	2.6	2.5	2.7	2.6	2.9	2.3	2.5	2.5	2.7		0-3
	#200	0.1	0.6	1	0.3	0.4	0.4	0.7	0.6	0.9	0.7	0.6	0.7	0.8		0-2
Weights	Cement	658	658	658	658	658	658	658	658	658	658	658	658	658		
	F.Agg.	1867	1867	1840	1840	1803	1821	1821	1821	1821	1798	1798	1798	1798		
	3/4x4	859	859	850	845	828	836	836	836	836	826	826	826	826		
	1½x3/4	959	959	940	940	921	930	930	930	930	924	924	924	924		
	2½x1½	1362	1362	1335	1340	1313	1326	1326	1326	1326	1312	1312	1312	1312		

South Lane No Experimental Sections	Date (1941)	9/23	9/24	9/25	9/26	9/27	9/29	9/30	10/1	10/2	10/3	10/6	10/7	10/8	10/9	Spec.
% Passing each size	3"	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	2½"	97	98	96	99	98	97	99	98	96	98	99	97	99	97	95-100
	2"	89	87	88	88	88	88	87	86	88	87	90	86	86	89	73-93
	1½"	76	76	77	75	75	74	76	76	75	74	76	75	75	73	60-85
	1"	64	62	62	60	64	61	62	63	61	62	62	64	62	63	47-73
	3/4"	56	55	52	54	55	55	55	55	54	54	54	56	55	54	42-65
	3/8"	42	43	43	41	43	41	43	42	42	43	41	42	43	42	35-50
	#4	36	37	37	36	37	36	37	37	37	37	37	36	37	36	30-40
	#8	30	31	31	30	30	30	30	30	30	30	31	31	31	31	22-34
	#16	23	24	24	23	23	23	23	23	23	23	25	25	25	25	17-27
	#30	12	14	14	13	13	13	13	13	13	14	14	16	16	16	11-18
	#50	4	6	6	6	6	6	5	6	6	6	9	9	8	9	4-9
	#100	1	2	2	2	2	2	1	2	2	2	3	3	3	3.5	0-3
	#200	0	0	0	0	0	0	0	0	0	0.4	1	1	0.3	1.4	0-2
Weights	Cement	658	658	658	658	658	658	658	658	658	658	658	658	658	658	
	F.Agg.	1835	1850	1850	1831	1822	1822	1830	1860	1830	1830	1841	1830	1867	1867	
	3/4x4	911	851	851	842	838	838	840	850	840	840	850	842	859	859	
	1½x3/4	1002	950	950	941	935	935	940	950	940	940	940	940	959	959	
	2½x1½	1370	1350	1350	1336	1330	1330	1335	1360	1335	1335	1335	1335	1362	1362	

TABLE 17

CONCRETE PAVEMENT TEMPERATURES DURING EARLY STAGES OF CURING

VII-Ven-79-C F.A.P. 380-C (1) Research 00194 Cont. 27XC7-P

Age Hrs.	Sta. 418+02				Sta. 435+57				Sta. 484+57				Sta. 485+29			
	Time	Air	Top	Bot.	Time	Air	Top	Bot.	Time	Air	Top	Bot.	Time	Air	Top	Bot.
0	10/15/41 10 AM	84	70	70	10/16/41 7 AM	62	67	67	10/17/41 3 PM	84	78	78	10/18/41 6 AM	52	65	65
4	2 PM	89	78	72	11 AM	87							10 AM	74	74	66
5	3 PM	90	77	74	12 M	89	82	70					11 AM	79	76	67
6	4 PM	87	76	74	1 PM	91	82	72					12 M	80	76	70
7	5 PM	85	73	75	2 PM	91	82	74					1 PM	81	77	71
8	6 PM	78	71	75	3 PM	89	84	74					2 PM	79	79	73
9	7 PM				4 PM	88							3 PM	76	79	74
21	10/16 7 AM	61	56	61	10/17 4 AM				10/18 12 M	80	75	71	10/19 3 AM			
24	10 AM	85	70	64	7 AM	58	57	62	3 PM	76	75	73	6 AM			
27	1 PM	91	77	70	10 AM	80	70	64	6 PM		68	72	9 AM		63	65
30	4 PM	88			1 PM	89	81	71					12 M			
33	7 PM				4 PM	80	73	73					3 PM			
48	10/17 10 AM	80	72	66	10/18 7 AM	56			10/19 12 M		63	63	10/20 6 AM	46	50	56
51	1 PM	89	79	73	10 AM	76	73	66	3 PM				9 AM		54	55
54	4 PM	80	73	73	1 PM	81	80	71	6 PM				12 M	59	61	59
57	7 PM				4 PM	75	74	73					3 PM		60	60
72	18 10 AM	76	66	63	19 7 AM				20 12 M	59	63	59	21 6 AM	52	54	57
78	4 PM	75	74	72	1 PM				3 PM		60	60	12 M	61	60	59

Age Hrs.	Sta. 511+87				Sta. 545+62				Sta. 581+05				Sta. 629+00			
	Time	Air	Top	Bot.	Time	Air	Top	Bot.	Time	Air	Top	Bot.	Time	Air	Top	Bot.
0	10/20/41 6 AM	46	66	66	10/21/41 12 M	61	66	66	10/24/41 7 AM	52	61	61	10/28/41 6 AM	49	60	60
4	10 AM				4 PM				11AM	66	72	66	10 AM	62		
5	11 AM	59			5 PM				12 M	68	73	67	11 AM	64		
6	12 M	59	67	67	6 PM				1 PM	65	72	68	12 M	65		
7	1 PM		67	67					2 PM		70	68	1 PM	66		
8	2 PM		68	68					3 PM		68	68	2 PM	67		
9	3 PM		66	69					4 PM		65	68	3 PM	68	66	67
21	10/21 3 AM				10/22 9 AM	62	60	59	10/25 4 AM				10/29 3 AM			
24	6 AM	52	58	63	12 M	66	67	63	7 AM	49	55	59	6 AM	44	48	55
27	9 AM	59	60	63	3 PM	65	67	65	10 AM	62	60	59	9 AM	56	55	54
30	12 M	61	62	63	6 PM				1 PM	68	68	65	12 M		65	59
33	3 PM		62	65					4 PM	69	66	67	3 PM		65	62
48	10/22 6 AM	50	50	57	10/23 12 M				10/26 7 AM				10/30 6 AM			
51	9 AM	62	56	57	3 PM				10 AM				9 AM		58	56
54	12 M	66	61	61	6 PM				1 PM				12 M		61	59
57	3 PM	65	63	63					4 PM				3 PM		64	61
72	23 6 AM				24 12 M		63	61	27 7 AM				31 6 AM		47	51
78	12 M				6 PM				1 PM				12 M		62	60

TABLE 18

TESTS OF FINE AGGREGATES

USED IN THE CONCRETE PAVEMENT ON

VII-Ven,LA-79-C FAP 380-C (1) Research .00194 Contract No. 27XC7-P

Sample Number Field Sample No.		8659 50-1-A		8681 29	
Materials Sampled From Source Manufacturer Date Sampled Sampled By		Concrete Sand Stockpile City Rock Co. Pit, Tujunga Wash City Rock Co. 8-26-41 J. Fleharty		Blending Sand Stockpile Roscoe plant, Tujunga Wash Consolidated Rock Co. 9-30-41 E. H. Dewing	
Grading Analysis % Passing	Sieve Sizes #4 8 16 30 50 100 200 270 (Wash)	 100 87 68 43 21 6 2 1		 100 98 92 86 69 30 8 6	
Mortar Strength 1:2 by Volume (Compressive)	Age Ottawa Sand Job Sand Ratio (%)	7 Days 4170 4520 108.4	28 Days 5570 6503 113.2	7 Days	28Days
Soundness Test Na_2SO_4 Per cent loss		3.0		1.7	
Specific Gravity		2.69		2.69	
Colorimetric Test		Satisfactory		Satisfactory	

Petrological Classification

#8659 Granitic rock fragments, quartz and feldspars chiefly, with some biotite, hornblende, and magnetite in the fine sizes.

#8681 Granitic fragments, quartz, feldspars, with small amounts of mica, hornblende, and magnetite.

TABLE 19

TESTS OF COARSE AGGREGATES

USED IN THE CONCRETE PAVEMENT ON

VII-Ven,LA-79-C FAP 380-C(1) Research .00194 Contract No. 27XC7-P

Size		#1		#2	#3
Sample No.		60061	60062	60063	60064
Field Sample No.		101-A	102	201-A	301-A
Sampled From		Stockpile	Stockpile	Stockpile	Stockpile
Source		Tujunga Wash	Tujunga Wash	Tujunga Wash	Tujunga Wash
Manufacturer		City Rock Co.	City Rock Co.	City Rock Co.	City Rock Co.
Date Sampled		8-26-41	8-26-41	8-26-41	8-26-41
Sampled By		J. Fleharty	J. Fleharty	J. Fleharty	J. Fleharty
Grading Analysis % Passing	Size				
	3"	100	100		
	2½"	96	100		
	2"	61	77		
	1½"	17	21	100	
	1"	1	2	50	100
	3/4"	0	1	10	97
	3/8"		0	2	36
	#4			1	3
	#8				2
Soundness Test Na_2SO_4 % Loss				6.1	5.2
L.A. Rattler % Loss	100 Rev.	10.4	7.8	9.4	
	500 Rev.	40.0	35.8	39.2	
Specific Gravity		2.62	2.70	2.71	
Absorption		1.0	0.7	0.7	
Petrological Classification		Chiefly granitic rock and gneiss			

Samples of each type of aggregate were obtained from a special stockpile, built up by the manufacturer for this project (VII-Ven,LA-79-C,A).

TABLE 20

TESTS OF REDWOOD EXPANSION JOINT FILLER STRIPS

VII-Ven,LA-79-C,A FAP 380-C (1) Res. 00194 Contract 27XC7P

Inspection Certificate No.	16730	17184
Dated	9-21-41	10-24-41
Date of Inspection	7-15-41	7-15-41
No. of Pieces	225	11
Dimensions	1"x8"x12'-0"	1"x8"x12'-0"

Manufacturer Union Lumber Co., Fort Bragg, Calif.

TEST RESULTS

Specimen Number	Weight Lbs. per Cu. Ft. Oven Dry	Load in Lbs. per Sq. In. Required to Compress to 1/2 original thickness
1	22.48	1230
2	26.02	2690
3	20.05	954
4	23.70	1707
5	19.51	906
6	22.52	1070
7	20.40	1236
8	21.20	1320
9	23.55	1510
10	22.28	949
11	20.12	1292
12	24.10	1427
13	22.20	1655
14	21.08	1095
15	22.74	2086
Average	22.13	1408

The original specifications set up 20 lbs. per cu. ft. as the maximum ovendry weight and not more than 1000 lbs. per square inch compressive resistance at one half the original thickness. Under proposal for change #35698, dated September 8, 1941, these limits were changed to 25 lbs. per cu. ft. and 1500 lbs. per sq. in., respectively.

TABLE 21

TESTS ON CEMENT

USED IN THE CONCRETE PAVEMENT ON

VII-Ven,LA-79-C,A F.A.P. 380-C(1) Research 00194 Contract No. 27XC7-P

CHC No.			414	415	416	417	418	419	420	421	422	423	424	425	Spec. Limits M-60-38 Low Alkali
Laboratory No.			7401	7402	7403	7404	7405	7406	7407	7408	7409	7410	7411	7412	
Plant Bin No.			34	33	34	33	34	33	34	33	33	34	33	34	
Date Manufactured (1941)			9/7	9/20	9/21	9/26	9/29	10/3	10/7	10/9	10/14	10/17	10/18	10/22	
Physical Tests	Setting Time	Initial	3:00	2:30	2:15	1:30	1:45	3:15	1:35	3:30	3:20	1:30	2:40	2:30	> 0:45
		Final	5:30	3:40	3:55	3:45	4:00	--	4:20	--	5:35	5:00	--	--	<10:00
	Normal Consistency		25.0	23.5	24.0	24.0	24.0	25.0	23.0	24.0	23.0	23.0	24.0	24.0	
	Tensile Strength	3 days	280	285	370	280	345	340	325	290	280	255	250	210	
		28 days	415	475	475	440	425	425	420	425	435	415	430	410	> 350
	% Passing #325		90.4	90.3	88.7	90.9	92.0	89.9	88.2	92.2	88.6	91.6	90.1	90.8	
	Surface Area		1690	1605	1830	1645	1615	1610	1620	1795	1610	1945	1670	1610	> 1600
Oxide Analysis	SiO_2		22.2	21.3	21.0	22.5	21.1	22.2	21.9	22.3	22.3	23.5	23.2	24.0	> 21.0
	Al_2O_3		5.5	5.5	5.8	5.1	5.0	4.7	4.8	5.0	4.2	4.5	4.9	5.5	< 6.0
	Fe_2O_3		4.9	5.7	5.5	5.2	5.8	5.3	5.5	5.2	5.1	5.1	4.8	4.9	< 6.0
	CaO		63.3	63.0	63.6	63.3	63.6	63.9	63.7	64.7	64.0	63.5	62.9	62.8	
	MgO		1.2	1.2	1.3	1.1	1.5	1.4	1.3	1.4	1.2	1.2	1.2	1.2	< 5.0
	SO_3		1.5	1.8	1.7	1.5	1.8	1.4	1.4	1.4	1.3	1.3	1.7	1.3	< 2.0
	Ignition Loss		0.82	0.58	0.58	0.68	0.77	0.64	0.49	0.96	0.59	0.48	0.75	0.69	< 3.0
	Insoluble		0.72	0.47	0.26	0.26	0.31	0.34	0.14	0.46	0.24	0.21	0.45	0.28	< 0.75
Alkali	AS Na_2O		*0.38	**0.40	**0.51	*0.26	**0.36	0.31	0.32	0.31	0.30	0.27	0.27	0.42	< 0.60
	K_2O		0.18			0.14		0.27	0.26	0.13	0.15	0.13	0.15	0.27	
	Na_2O		0.26			0.17		0.13	0.15	0.22	0.20	0.18	0.17	0.24	
Compound Composition	C_4AF		15.0	17.0	17.0	16.0	18.0	16.0	17.0	16.0	16.0	16.0	15.0	15.0	< 8.0
	C_3A		6.0	5.0	6.0	5.0	3.0	3.0	3.0	4.0	3.0	3.0	5.0	6.0	
	$CaSO_4$		2.5	3.0	2.9	2.6	3.1	2.4	2.4	2.4	2.2	2.2	2.9	2.2	
	C_3S		46.0	47.0	50.0	43.0	54.0	51.0	50.0	53.0	44.0	42.0	33.0	32.0	
	C_2S		27.0	24.0	22.0	31.0	19.0	25.0	25.0	23.0	34.0	34.0	43.0	42.0	
	Al_2O_3/Fe_2O_3		1.1	0.97	1.1	1.0	0.86	0.89	0.87	0.96	0.82	0.88	1.0	1.1	0.7-2.0

Cement was furnished by the Monolith Portland Cement Co. from their plant at Monolith, Calif.
Project Specifications required the use of a Moderate Sulfate Resistant Cement, Type M-60-38, with a further provision that it be low alkali (less than 0.60% as Na_2O)

*Total alkalies as Na_2O when Na_2O and K_2O have been determined = % Na_2O + 0.6582 K_2O

**Total alkali calculated as Na_2O when total sulphates only are known = $\frac{\text{Wt. of Sulfates} \times 0.4364 \times 100}{\text{Wt. of sample}}$

TABLE 22

TESTS ON REINFORCING STEEL, DOWEL STEEL, AND WIRE MESH

USED IN THE CONCRETE PAVEMENT ON

VII-Ven,LA-79-C,A F.A.P. 380-C(1) Research 00194 Contract No. 27X07-P

Item	Shape	Lot No.	Date Shipped	Weight Lbs.	Heat No.
Reinforcing Steel	Square deformed	17128	7-31-41	11,835	15328
" "	" "	17128	7-31-41	23,318	2E63
" "	" "	5167	8-13-41	379	2E63
" "	" "	17142	8-28-41	924	3E124
Dowel Steel	Plain round	17128A	7-31-41	18,000	1E97
Wire Mesh	#0, #00, #4	17128A	7-31-41	44,704	----

TEST RESULTS

The following physical tests were witnessed by a representative of the Division of Highways at the Los Angeles Plant of the Bethlehem Steel Company. The results of chemical analyses were taken from the Steel Company's records.

Steel To Be Used For			Reinforcing Bars				Pavement Dowels	
Physical Tests	Heat No.		15328	2E63	3E124	Specif.	1E97	Specif.
	Test Cut From		½"Sq. Def.	½" Sq.Def.	½" Sq.Def.	Limits	3/4"Pl.Rd.	Limits
	Original Dimensions		.501x.500"	.500x.498"	.500x.525"	ASTM	.751 Diam.	ASTM
	Area in Square Inches		.2505	.2490	.2625	15-39	.4430	16-35
	Yield Point	Testing Machine	10830	10580	11490		24750	
		Lbs. per Sq. In.	43230	42490	43770	Min. 33,000	55870	Min. 50,000
	Ultimate Strength	Testing Machine	15440	14980	15570	55,000 to 75,000	40670	
		Lbs. per Sq. In.	61640	60160	59320		91800	Min. 80,000
	Elongation	Inches	2.10	2.25	2.30		1.60	
		Per Cent	26.2	28.1	28.7	24.0	20.0	18.0
	Fracture		½c	½c	½c		3/4c	
	Bend Test		OK	OK	OK		OK	
Chemical Analyses		Carbon		.15	.19		.43	
		Manganese		.40	.64		.48	.65
		Phosphorus		.011	.013	.10	.015	.05
		Sulphur		.043	.045		.064	.05
Date Tested			7-31-41	7-31-41	8-28-41		3-13-41	
Accepted or Rejected			Accepted	Accepted	Accepted		Accepted	

TABLE 23

CONSTRUCTION EQUIPMENT

VII-Ven,LA-79-C,A F.A.P. 380-C(1) Res. 00194 Contract 27XC7-P

Number	Item	Condition
	FOR SUBGRADE PREPARATION	
1	Caterpillar Tractor, R.D. 6	Good
1	Maintainer (Motor grader), Caterpillar #12 Diesel, equipped with a 12 ft. blade	Good
1	Lewis Subgrader, standard, 11 ft. width	Good
16,000	lin. ft. of steel side forms, "L" section, 9" high	Good
	FOR BATCHING AND PROPORTIONING CONCRETE AGGREGATES, CEMENT, ETC.	
1	Batching plant of frame construction, designed and built by the Contractor, and comprising elevated bins for aggregates, a weigh box, a batch hopper, scale housing, cement storage platform, etc.	Satisfactory for the purpose
1	Kron Springless Scale, manufactured by the Kron Co., Bridgeport, Conn., serial No. 23122, capacity 10,000 lbs., electrically operated for automatic control of discharge gates from storage bins.	Good
1	Belt conveyor, designed and built by Contractor. Powered by Hercules motor, Model XB5, Engine No. 689101. Somewhat troublesome in operation.	Fair
1	Generator, International-Palmer, gasoline-electric, model U6-20-3P-12, serial No. 201549, 25KVA, 220-440 volts, 20KW, 1200 RPM, 3 phase, 60 cycle	New
1	Clamshell crane, Northwest, 1-1/2 cu. yd. capacity, model no. 6, serial no. 4315	Fairly Good
	FOR MIXING, PLACING AND FINISHING CONCRETE	
1	Paving Mixer, Multi-Foote, model 34-E, serial No. 48022	Good, almost new
1	Paving Spreader, Blaw Knox, model OXC5, serial No. 3034	" " "
1	Concrete Tamper, Lakewood, Type C, serial No 32x001	Fairly good
1	Johnson Finisher, manufactured by Madsen Iron Works. Powered by Ford V-8 motor. Not the latest model.	Fairly good
1	Trailer Water Tank for use with Paver. 1500 gal. capacity	Good
1	Flat bed truck, Chevrolet, 1-1/2 ton capacity	Good
7	Dump trucks, Ford, 3 cu.yd. capacity. Each equipped with an extra gate in the dump body to permit the handling of two batches of concrete aggregates, etc. per trip	Fairly good
1	Walking edger 10" x 6" x 1/2"	Good
1	Walking edger 9" x 6" x 3/4"	"
1	Walking edger 9" x 7" x 3/4"	"
1	Walking edger 12" x 7" x 1-1/2"	"
2	Dummy joint tools, set in wood, 4" x 24", long handles	"
1	Cutting float, steel shod, wooden back, 16 ft. long	"
1	" " " " duraluminum back, 16 ft. long	"

TABLE 24

RESULTS OF TESTS ON SPECIAL BEAMS AND CYLINDERS AND ON CORES

FROM THE CONCRETE PLACED IN THE PAVEMENT OF THE NORTH LANE

VII-Ven,LA-79-C,A F.A.P. 380-(1) Research 00194 Contract No. 27XC7-P

Test Sect. No.	Date Concrete Placed (1941)	Beams and Cylinders: Spec. No.	Beams and Cylinders: From Station	Modulus of Elasticity Values Shown are for "E" x 10^{-6}: Sonic 10 Days: Cyl.	Sonic 10 Days: Beams	Sonic 28 Days: Cyl.	Sonic 28 Days: Beams	Compr. 28 Days Cyl.	Flexural Strength M. of R. Beams at 28 Da.	Compressive Strength in Lbs. per Sq.In.: 6"x12" Cyl. at 28 Da.	Beam Ends Average 28 Da.	Cores: From Station	Cores: 28 Days	Cores: 2 Years
1a	10/10	1A-1	385+00 to 385+10	4.15	4.11	4.68	4.63	3.27 ++	642	3320	4660	377+10	4080	6960
												376+90	4030	
												372+95	5380	
		1A-2		4.19	4.01	4.78	4.57	2.86	616	3400	4550	372+90	4760	
												384+95	4710	7065
		1A-3		4.17	4.03	4.87	4.48	3.20	572	3400	4700	385+05	4810	6750
		Average for Day		4.17	4.05	4.78	4.56	3.11	610	3370	4640		4630	6925
	10/14	1A-5	400+40 to 400+70	3.97	4.02	4.68	4.57	3.40	572	3740	4510	400+20	4690	
		1A-6		4.24	3.92	4.54	4.49	3.20	608	4030	4270	400+40	4760	6940
		1A-7		4.06	3.79	4.31	4.55	3.14	607	3810	4600	400+65	4810	
		Average for Day		4.09	3.91	4.51	4.54	3.25	596	3860	4460		4750	6940
	10/15	1A-9	419+00 to 419+50	4.16	4.00	4.63	4.72	3.14	568	3040	4670	419+10	4540	
		1A-10		4.04	4.07	4.51	4.72	2.62	626	3150	4930	419+30	3980	6125#
		1A-11		3.93	4.08	4.61	4.86	2.96	581	3180	5190	419+45	4240	7710
		Average for Day		4.04	4.05	4.58	4.77	2.91	592	3120	4930		4250	6920
	Average for Section 1a			4.10	4.00	4.62	4.62	3.09	600	3450	4680		4560	6925
2a	10/16	2A-1	438+25 to 438+75	4.17	4.18	4.88	4.83	3.08	598	3380	4640	438+30	4690	6390#
		2A-2		4.18	3.89	4.91	4.53	3.27	564	3600	4640	438+50	4310	7430
		2A-3		4.41	4.10	4.95	4.67	3.14	628	3740	4730	438+65	3660	7145
	Average for Section 2a			4.25	4.05	4.91	4.68	3.16	597	3570	4670		4220	6990
3a	10/16	3A-1	452+25 to 452+75	4.00	4.10	4.96	4.68	3.08	564	2800	4730	452+30	4400	7005
		3A-2		3.96	4.03	4.85	4.65	2.76	652	3060	4600	452+45	4390	7125
		3A-3		4.08	4.10	4.79	4.69	2.86	636	2980	4780	452+61	4030	7125
	Average for Section 3a			4.01	4.08	4.87	4.67	2.90	651	2950	4700		4270	7085
4a	10/17	4A-1	473+25 to 473+75	4.33	4.50	4.94	5.03	2.86	656	3130	4930	473+31	4700	8095
		4A-2		4.31	4.39	4.92	4.86	3.14	733	3280	4930	473+46	4290	8260
		4A-3		4.33	4.32	4.94	4.90	2.96	602	3540	4960	473+71	4590	7230
	Average for Section 4a			4.32	4.40	4.93	4.93	2.99	664	3320	4940		4530	7860
5a	10/18	5A-1	487+50 to 488+25	4.71	4.26	4.89	4.84	3.14	596	3360	5010	487+48	4660	6615
		5A-2		4.79	4.18	4.93	4.70	3.08	624	3580	4720	487+73	4290	8285
		5A-3		4.61	4.22	4.98	4.80	3.27	591	3750	4960	487+93	4330	7575
	Average for Section 5a			4.70	4.22	4.93	4.78	3.16	604	3560	4890		4430	7490
6a	10/10	6A-1	499+70 to 500+25	4.61	4.42	4.86	5.02	3.48	660	3520	4880	499+75	4470	7180
		6A-2		4.40	4.28	4.89	4.87	3.14	654	3590	4980	499+93	4420	7520
		6A-3		4.58	4.33	4.96	4.86	2.96	704	3410	4980	500+15	4450	6975
	Average for Section 6a			4.53	4.34	4.90	4.92	3.19	673	3510	4950		4450	7225
7a	10/20	7A-1	513+75 to 514+25	4.58	3.92	4.96	4.74	2.91	672	3290	4520	513+83	4130	6920
		7A-2		4.40	3.99	4.96	4.75	3.20	682	3340	4720	514+03	4220	7500
		7A-3		4.53	3.95	4.96	4.72	2.96	610	3380	4710	514+18	3680	7300
	Average for Section 7a			4.50	3.95	4.96	4.73	3.07	655	3340	4640		4080	7240
Aver. for Sections 1a to 7a, incl.				4.34	4.15	4.87	4.91	3.08	635	3630	4780		4360	7260
1b	10/21	1B-1	544+75 to 545+25	4.37	4.05	4.55	4.83	2.76	662	3350	4970	544+75	3870	7210
		1B-2		3.87	4.04	4.94	4.86	2.91	638	3260	4850	544+95	3790	7235
		1B-3		4.17	4.18	4.71	5.00	2.88	604	3130	4940	545+20	4110	7550
	Average for Section 1b			4.14	4.09	4.73	4.90	2.83	635	3250	4920		3920	7330
2b	10/22	2B-1	574+50 to 575+00	4.08	3.94	4.75	4.70	2.76	659	3000	4320	574+53	3890	6580
		2B-2		4.08	3.89	4.62	4.71	2.76	682	3060	4230	574+78	3910	7675
		2B-3		4.17	3.92	4.78	4.74	2.91	633	2880	4630	574+98	4410	7130
	Average for Section 2b			4.11	3.92	4.72	4.72	2.81	658	2980	4390		4070	7130
3b	10/25	3B-1	616+25	4.49	4.30	4.81	4.93	3.20	656	3520	4810	616+63	4380	7145
		3B-2		4.52	4.16	4.83	4.89	3.02	658	3620	4990	616+43	3970	6715
		3B-3		4.58	4.43	4.83	4.90	3.27	676	3460	4950	616+18	3760	7130
	Average for Section 3b			4.53	4.30	4.82	4.92	3.16	663	3530	4920		4040	6995
4b	10/24	4B-1	592+25 to 592+75	4.64	4.27	4.89	4.93	2.86	678	3280	4640	592+25	3560	7835
		4B-2		4.56	4.19	5.07	4.88	3.02	660	3340	4850	592+50	4430	7175
		4B-3		4.04	4.43	4.96	5.10	2.76	684	3250	5090	592+70	4370	6495
	Average for Section 4b			4.41	4.30	4.97	4.97	2.88	674	3290	4860		4120	7170
5b	10/28	5B-1	635+00 to 635+25	4.18	3.63	4.62	4.42	2.67	550	2720	4090	635+10	3580	6800
		5B-2		4.45	3.65	4.71	4.39	2.76	566	2660	4040	635+15	3680	7125
		5B-3		4.45	3.76	4.71	4.59	2.62	614	2520	4150	635+25	3590	6795
	Average for Section 5b			4.36	3.68	4.68	4.47	2.68	577	2630	4090		3620	6905
6b	10/28	6B-1	644+00 to 644+25	4.58	3.81	4.83	4.62	3.14	677	3290	4720	644+00	4790	6905
		6B-2		4.56	3.85	4.94	4.67	3.02	662	3360	4450	644+15	4780	6925
		6B-3		**	3.91	**	4.66	**	642	**	4490	644+25	4510	6905
	Average for Section 6b			4.57	3.86	4.88	4.65	3.08	660	3330	4550		4690	6910
7b	10/29	7B-1	661+00 to 661+25	4.28	3.88	5.12	4.65	3.14	591	3360	4570	661+08	4080	6515
		7B-2		4.37	3.86	4.87	4.63	3.08	643	3390	4490	661+24	3940	6235
		7B-3		4.35	3.80	4.85	4.50	3.02	660	3480	4370	661+31	3690	7130
	Average for Section 7b			4.33	3.85	4.95	4.63	3.08	631	3410	4480		3900	6625
Aver. for Sections 1b to 7b, incl.				4.35	4.00	4.82	4.89	2.93	643	3200	4600		4120	7010
Aver. for all Sections				4.35	4.08	4.85	4.90	3.01	639	3370	4690		4240	7135
Aver. Wt. per cu. ft.				Cylinders 150#, Beams 152#, Cores 154#.										

The beams and cylinders shown on this Table were fabricated by a representative of the Materials and Research Department and were made in accordance with the suggestions contained in the Public Roads Administration memorandum of May 1940.

* Specimens 1A-1, 1A-2, and 1A-3 were 14 days old when tested.

** Test Cylinder 6B-3 disappeared during the curing period.

\# Contained a large rock with a smooth, flat surface at an angle of approximately 45° with the axis of the core which may have reduced the breaking strength.

++ Modulus of Elasticity in Compression was determined at 1000 lbs. per square inch.

TABLE 25

RESULTS OF TESTS ON ROUTINE FIELD SPECIMENS AND ON CORES

FROM THE CONCRETE PLACED IN THE PAVEMENT OF BOTH LANES

VII-Ven,LA-79-C,A F.A.P. 380-C(1) Research 00194 Contract No. 27XC7-P

Test Section No.	Date Concrete Placed (1941)	Station	Fine Aggregate % Total Mix Conc. Sand	Fine Aggregate % Total Mix Blend. Sand	Flexural Strength Beams With Center Loading 8 Days	Flexural Strength Beams With Center Loading 14 Days	Flexural Strength Beams With Center Loading 28 Days	Compressive Strength Cylinders 6" x 12" 10 Days	Compressive Strength Cylinders 6" x 12" 28 Days	Compressive Strength Cores 28 Days Each	Compressive Strength Cores 28 Days Aver.	Compressive Strength Cores 2 Years Each	Compressive Strength Cores 2 Years Aver.
SOUTH LANE													
1a	9/23	377+50	37	0	604	758	789	2470	3550	5420 4570	4995		
	9/24	396+00	37	0	648	706	869	2840	4115	4760 4860	4810	6415 5905	6160
	9/25	413+10	37	0	583	745	873	2905	3955				
2a	9/26	437+00	37	0	681	651	842	2755	4135	4530 4970	4750	7020 6015	6515
3a	9/27	457+50	37	0				2020	3110	5560 5260	5410	6630 6365	6500
4a	9/29	471+90	37	0	760	614	792	3473	4330	5440 5680	5560	7290 6420	6855
5a	9/30	487+50	37	0						4870 5520	5195	7990 7500	7745
6a	9/30	495+90	37	0	728	603	788	2665	3615	5150 5080	5115	6690 6875	6785
7a	10/1	515+75	37	0	606	515	654	2920	4310	5540 5220	5380	6540 7125	6835
Average Sections 1a to 7a					660	656	801	2755	3890	5150	5150	6770	6770
1b	10/2	541+50	37	0	436	566	733	2330	3140	4680 4580	4630	6035 5795	5915
	10/3	565+00	37	0	610	694	631	2355	3505				
2b	10/6	584+45	32	5	459	457	591	2470	3670	4140 4460	4360	5445 6485	5965
3b	10/7	611+50	32	5	487	640	597	2355	3515	5130 4400	4765	5810 6570	6190
4b	10/6	592+25	32	5						5030 4765	4900	6250 6640	6445
5b	10/8	632+75	32	5	526	584	516	2850	3790	5420 6080	5750	7190 7630	7410
6b	10/9	644+50	37	0						4790 4780 4510	4695	6630 6690	6660
7b	10/9	652+85	32	5	470	601	553	1940	2850	3840 3780	3810	5400 6450	5925
Average Sections 1b to 7b					510	590	605	2385	3410	4690	4690	6360	6360
Average for South Lane					595	625	710	2595	3685	4930	4690	6565	6565
NORTH LANE													
1a	10/10	380+00	32	5	474	557	453	1770	2735	Individual Results on Table 24	4630	Individual Results on Table 24	6925
	10/14	400+25	32	5	599	549	641	2380	3300		4750		6940
	10/15	419+50	32	5	495	494	647	2420	3825		4250		6920
2a	10/15	438+50	32	5							4220		6990
3a	10/16	446+50	32	5	483	494	546	2135	3280		4270		7085
4a	10/17	474+50	32	5	578			1965	3060		4530		7860
5a	10/18	487+75	32	5							4430		7490
6a	10/18	499+95	32	5							4450		7225
7a	10/18	506+75	32	5	402	524	511	1855	3155		4080		7240
Average Sections 1a to 7a					497	517	546	2035	3195		4360		7260
1b	10/20	527+25	32	5	409	519	522	2100	3605		3920		7330
	10/21	547+75	32	5	487	409	578	2125	3420				
2b	10/22	569+25	32	5	446	439	566	1780	2075		4070		7130
3b	10/25	616+50	32	5	486		568				4040		6995
	10/25	624+75	32	5	419	402	572	1795	3040				
4b	10/24	596+25	32	5	466	442	563	1655	3160		4120		7170
5b	10/28	639+00	32	5	372	444	458	1695	3040		3620		6905
6b	10/28	644+15	32	5							4690		6910
7b	10/29	660+00	32	5	343	490		1910	3345		3900		6625
Average Sections 1b to 7b					421	443	541	1850	3210		4120		7010
Average for North Lane					459	480	543	1945	3205		4240		7135
Average Wt. cu. ft.								150			154		

The beams and cylinders shown on this table were fabricated by the Resident Engineer and his assistants as part of the routine construction control.

The flexural strengths were on 6"x6"x34" beams tested in the field on a portable machine with center point loading. All cylinders and cores were tested at Sacramento.

TABLE 26

AVERAGE CONCRETE TESTS SUMMARISED BY LANES

VII-Ven,LA-79-C FAP 380-C (1) Research 00194 Contract 27XC7-P

Test Section No.	Flexural Strength at 28 Days			Compressive Strength						
				Cyl. at 28 Days			Cores			
							28 Days		2 Years	
	North Lane		South Lane	North Lane		South Lane	North Lane	South Lane	North Lane	South Lane
	Special*	Field	Field	Special*	Field	Field				
1a	600	580	844	3450	3285	3875	4560	4905	6925	6160
2a	597		842	3570		4135	4220	4750	6990	6515
3a	651	546		2950	3280	3110	4270	5410	7085	6500
4a	664		792	3320	3060	4330	4530	5560	7860	6855
5a				3560			4430	5195	7490	7745
6a	673		788	3510		3615	4450	5115	7225	6785
7a	655	511	654	3340	3155	4310	4080	5380	7240	6835
1b	635	550	682	3250	3515	3320	3920	4630	7330	5915
2b	658	566	591	2980	3075	3670	4070	4300	7130	5965
3b	664	570	597	3530	3040	3515	4040	4765	6995	6190
4b	673	563		3290	3160		4120	4900	7170	6445
5b	577	458	516	2630	3040	3790	3620	5750	6905	7410
6b	660			3330			4690	4695	6910	6660
7b	631		553	3410	3345	2850	3900	3810	6625	5925
Average Sect. 1a - 7a	635	546	801	3530	3195	3890	4360	5150	7260	6770
Average Sect. 1b - 7b	643	541	605	3200	3210	3410	4120	4690	7010	6360
Average For Project	639	543	710	3370	3205	3685	4240	4930	7135	6565
Average Weight per cu. ft.				150#			154#			

*Tests shown in columns marked "special" were on specimens fabricated in the field by representatives of the Materials and Research Department and tested in Sacramento. The special beams were tested by "Third Point Loading." Field specimens tested by "Center Loading".

TABLE 27

COMPARISON OF TEST RESULTS ON SPECIMENS FROM CONCRETE WITH AND WITHOUT THE USE OF BLENDING SAND IN THE FINE AGGREGATE

VII-Ven,LA-79-C,A F.A.P. 380-C(1) Res. 00194 Cont. 27XC7-P

Flexural Strength Field Specimens		Compressive Strength				
		Cylinders			Cores	
8 Day	28 Day	10 Day Field	28 Day Field	28 Day Special	28 Day	2 Year
WITHOUT BLENDING SAND						
612	844	2740	3875		4905	6160
681	842	2755	4135		4750	6515
		2020	3110		5410	6500
760	792	3473	4330		5560	6855
					5195	7745
728	788	2665	3615		5115	6785
606	654	2920	4310		5380	6835
610	682	2340	3320		4630	5915
					4695	6660
Averages						
666	767	2700	3815		5070	6665
WITH BLENDING SAND						
459	591	2470	3670		4360	5965
487	597	2355	3515		4765	6190
					4900	6445
526	516	2850	3790		5750	7410
470	553	1940	2850		3810	5925
523	580	2190	3285	3450	4560	6925
				3570	4220	6990
483	546	2135	3280	2950	4270	7085
578		1965	3060	3320	4530	7860
				3560	4430	7490
				3510	4450	7225
402	511	1855	3155	3340	4080	7240
448	550	2115	3515	3250	3920	7330
446	566	1780	3075	2980	4070	7130
453	570	1795	3040	3530	4040	6995
466	563	1655	3160	3290	4120	7170
372	458	1695	3040	2630	3620	6905
				3330	4690	6910
343		1910	3345	3410	3900	6625
Averages						
461	550	2050	3255	3370	4340	6940

Tests shown in the column marked "Special" were on specimens fabricated in the field by representatives of the Materials and Research Dept. and tested in Sacramento.

TABLE 28

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 21, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 1b - NORTH LANE

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers																											
						1	3	5	7	9	11	13	15	19	23	27	31	35	39	43	47	51	55	59	63	67	69	71	73	75	77	79	81
2-18-42	119	3:05 PM	68	68	38	4.834*	4.945	4.855	5.251	5.152	4.776	4.795	5.053	5.066	5.085	5.050	5.030	5.058	5.055	5.016	5.015	5.030	5.040	5.038	5.056	5.050	4.905	4.855	4.745	4.802	5.082	4.876	4.834
5-26-42	210	3:25 PM	81	92	30	-.002	-.001	-.002	-.003	-.004	-.004	-.002	-.005	-.003	-.002	-.003	-.005	-.003	-.003	-.002	-.004	-.003	-.002	-.005	-.011	-.006	-.003	-.006	-.001	-.003	-.005	-.002	-.002
8-12-42	290	2:25 PM	93	105	34	+.006	+.003	+.001	-.001	-.002	-.003	-.002	-.010	-.003	-.004	-.004	-.005	-.004	-.005	-.004	-.004	-.003	-.002	-.006	-.010	-.006	-.007	-.007	-.001	-.003	-.010	+.001	+.002
11-17-42	388	11:00 AM	61	63	84	+.038	+.029	+.029	+.025	+.023	+.023	+.020	+.019	+.018	+.008	+.027	+.022	+.018	+.020	+.016	+.018	+.023	+.016	+.013	+.012	+.022	+.012	+.021	+.018	+.017	+.030	+.028	+.039
2-18-43	473	1:40 PM	81	71	24	+.021	+.016	+.009	+.004	+.005	+.005	-.001	.000	+.001	+.001	+.006	+.004	-.001	+.001	.000	-.001	+.003	+.002	+.006	-.013	+.002	.000	+.001	+.003	+.003	+.010	+.007	+.017
5-11-43	562	1:35 PM	87	98	36	+.012	+.002	.000	-.001	-.002	-.001	-.003	-.006	-.006	-.005	-.002	-.004	-.006	-.003	-.008	-.007	-.007	-.002	-.012	-.014	-.008	-.005	-.008	-.005	-.005	-.002	-.004	-.004
8- 4-43	647	2:35 PM	90	109	41	+.010	+.011	+.006	+.004	+.001	.000	+.003	-.005	-.003	-.009	-.002	-.006	-.010	-.005	-.004	-.006	+.004	.000	-.006	-.010	-.006	-.005	-.003	-.005	-.002	+.006	+.003	+.005
11-16-43	751	1:45 PM	73	64	29	+.042	+.038	+.035	+.033	+.028	+.029	+.023	+.021	+.018	+.014	+.026	+.020	+.022	+.018	+.014	+.017	+.025	+.017	+.012	+.006	+.024	+.016	+.018	+.002	+.021	+.037	+.033	+.050
2-8-44	836	2:30 PM	57	62	82	+.031	+.030	+.025	+.019	+.018	+.014	+.015	+.009	+.007	+.012	+.022	+.017	+.013	+.009	+.003	+.005	+.020	+.010	+.002	.000	+.013	+.011	+.008	-.001	+.008	+.025	+.020	+.036

* Original joint width measurements

DAILY

Date	Age Days	Starting Time		Air Temp.		Conc. Temp.		Rel. Hum.		Joint Numbers							
		AM	PM	AM	PM	AM	PM	AM	PM	1	7	13	39	43	69	75	81
2-19-42	120	8:05	3:40	34	70	45	70	81	22	-.014	-.025	-.025	-.036	-.025	-.028	-.025	-.030
5-27-42	211	6:40	2:50	48	62	72	92	76	26	-.038	-.036	-.027	-.028	-.028	-.027	-.033	-.043
8-13-42	291	7:15	2:40	61	90	79	100	89	36	-.031	-.027	-.025	-.022	-.024	-.020	-.027	-.040
11-17-42	388	8:25	2:25	58	62	62	65	100	84	-.004	-.005	-.004	-.006	-.005	-.004	-.003	-.006
2-18-43	473	8:40	3:30	45	85	55	76	93	22	-.019	-.026	-.021	-.024	-.018	-.017	-.019	-.029
5-11-43	562	7:15	3:30	55	88	69	104	65	40	-.057	-.028	-.024	-.024	-.023	-.025	-.031	-.045
8- 5-43	648	6:20	3:15	64	90	81	105	99	41	-.040	-.035	-.030	-.037	-.033	-.028	-.032	-.045
11-17-43	752	7:50	1:45	61	73	61	64	54	29	-.008	-.008	-.007	-.007	-.006	-.003	-.004	-.005
2-8-44	836	8:50	2:30	39	57	43	62	83	82	-.015	-.014	-.012	-.010	-.012	-.014	-.015	-.012

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers						
						38	39	40	41	42	43	44
8-13-42	290	2:40 PM	90	100	36	5.050*	5.050	5.023	5.061	5.048	5.012	5.036
8- 5-43	648	1:50 PM	90	106	40	+.003	.000	-.002	-.002	-.007	.000	+.001

* Original joint width measurements

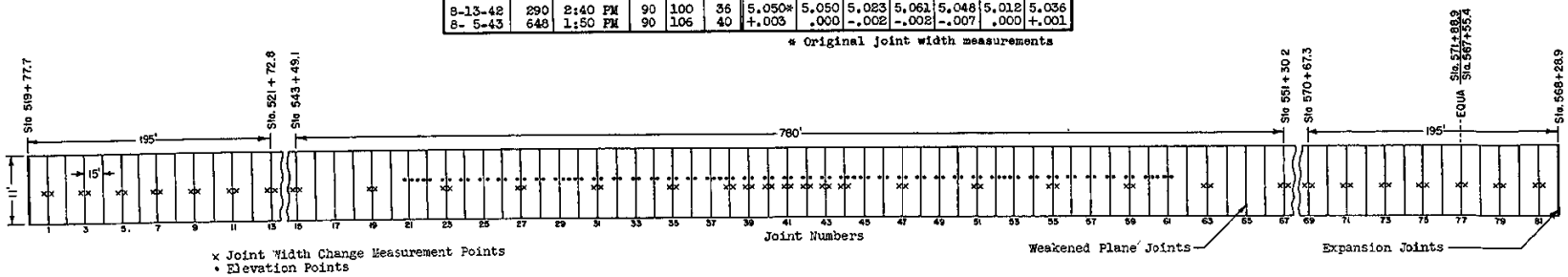


TABLE 29

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 16, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 2a - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 1	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	55
2-18-42	185	10:50 AM	58	50	94	5.018*	5.112	5.110	5.110	5.058	5.080	5.104	5.095	5.104	5.068	5.064	5.032	5.071	5.009	5.032	5.130	5.048	5.074	5.058	5.147	5.098	5.135	5.049	5.067	5.085	5.105	5.061	5.063	5.084
5-26-42	215	12:40 PM	76	86	38	-.140	-.015	-.020	-.022	-.015	-.025	-.019	-.018	-.020	-.018	-.022	-.019	-.016	-.017	-.019	-.016	-.022	-.014	-.026	-.017	-.019	-.012	-.021	-.015	-.018	-.015	-.016	-.009	-.154
8-12-42	295	1:05 PM	93	101	39	-.206	-.018	-.020	-.020	-.018	-.022	-.019	-.022	-.018	-.018	-.024	-.019	-.023	-.023	-.021	-.019	-.023	-.014	-.027	-.017	-.018	-.011	-.024	-.017	-.020	-.015	-.013	-.011	-.224
11-17-42	393	1:55 PM	71	67	57	-.163	+.005	+.021	-.014	+.001	-.005	-.004	+.002	-.013	-.001	-.006	-.002	-.006	-.006	-.006	+.007	-.006	-.008	+.002	-.001	-.002	+.005	-.007	-.001	+.005	+.003	+.005	+.016	-.165
2-19-43	485	11:25 AM	77	59	26	-.152	+.005	+.017	-.019	+.006	-.001	-.003	-.001	-.007	-.001	-.009	-.004	-.004	-.004	-.004	+.009	-.004	-.007	+.002	+.001	-.002	+.007	-.007	-.001	+.007	+.003	+.006	+.017	-.161
5-11-43	567	11:00 AM	88	84	40	-.195	-.005	-.013	-.020	-.012	-.023	-.019	-.023	-.020	-.018	-.019	-.017	-.014	-.015	-.016	-.014	-.011	-.016	-.022	-.015	-.018	-.009	-.019	-.014	-.010	-.010	-.011	-.003	-.188
8- 4-43	652	1:20 PM	90	104	45	-.241	-.004	-.013	-.017	-.011	-.020	-.016	-.025	-.020	-.018	-.019	-.017	-.013	-.013	-.018	-.014	-.012	-.011	-.023	-.016	-.015	-.009	-.018	-.014	-.010	-.015	-.011	-.004	-.250
11-16-43	766	12:40 PM	71	63	30	-.178	+.024	+.020	+.010	+.014	.000	+.008	+.010	+.005	+.013	-.001	+.011	+.011	+.016	+.012	+.017	+.002	+.004	+.013	+.013	+.010	+.018	+.003	+.013	+.020	+.018	+.022	+.025	-.184
2- 8-44	850	12:45 PM	63	58	74	-.185	+.010	-.001	-.005	+.007	-.009	-.004	+.001	-.010	-.006	-.010	+.001	+.001	-.002	.000	+.003	-.008	-.004	+.002	+.003	-.002	+.005	-.006	.000	+.011	+.003	+.009	+.017	-.184

* Original joint width measurements

DAILY

Date	Age Days	Starting Time AM	Starting Time PM	Air Temp. AM	Air Temp. PM	Conc. Temp. AM	Conc. Temp. PM	Rel. Hum. AM	Rel. Hum. PM	Joint Numbers 1	2	8	14	26	30	42	48	54	55
2-19-42	185	7:30	3:00	35	74	45	69	81	20	-.064	-.035	-.032	-.035	-.029	-.033	-.032	-.031	-.058	-.021
5-27-42	216	5:50	2:10	58	87	73	89	51	26	-.061	-.039	-.033	-.034	-.033	-.037	-.034	-.036	-.034	-.057
8-13-42	295	6:50	2:05	60	90	79	102	94	36	-.048	-.033	-.030	-.038	-.029	-.033	-.029	-.029	-.038	-.044
11-18-42	393	8:00	1:55	58	66	62	65	94	85	-.001	-.006	-.008	-.002	-.004	-.002	-.003	-.006	-.006	-.003
2-18-43	485	8:10	3:05	46	84	56	77	86	24	-.022	-.024	-.029	-.035	-.020	-.027	-.024	-.025	-.024	-.022
5-11-43	567	6:40	3:05	54	86	69	103	74	42	-.076	-.035	-.038	-.032	-.034	-.035	-.029	-.034	-.040	-.068
8- 5-43	653	6:00	2:50	60	90	82	108	94	41	-.072	-.041	-.014	-.037	-.036	-.037	-.038	-.036	-.036	-.066
11-17-43	767	7:30	12:40	62	71	61	63	50	30	-.002	-.005	-.008	-.007	-.003	-.003	-.006	-.005	-.008	-.002
2- 8-44	850	8:10	12:45	40	63	44	58	92	74	-.012	-.017	-.015	-.014	-.024	-.017	-.012	-.017	-.015	-.013

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 1	2	4	6	8	10	12	14	16	18	20	22	24	25	26	27	28	29	30	31	32
8-13-42	295	2:00 PM	90	102	36	4.808*	5.100	5.088	5.088	5.040	5.049	5.085	5.068	5.080	5.050	5.040	5.012	5.055	5.017	4.987	5.048	5.012	5.000	5.111	5.034	5.025
8- 5-43	653	1:30 PM	90	105	39	-.032	+.005	+.003	+.003	+.006	+.012	+.003	+.006	+.005	+.001	+.003	-.001	.000	+.004	+.009	-.007	+.004	+.004	+.004	+.002	+.005

* Original joint width measurements

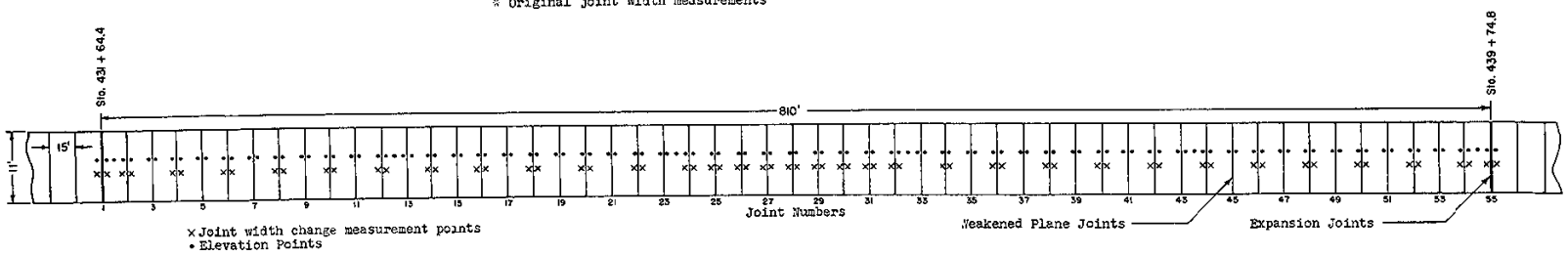


TABLE 30

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 16, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 3a - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 1	2	4	6	8	10	12	14	15	17	19	21	23	25	27	28	55
2-19-42	126	1:45 PM	72	64	38	5.100*	5.022	5.066	5.020	4.992	5.042	5.041	5.070	5.069	5.116	5.109	5.026	4.998	5.040	4.965	5.050	5.016
5-26-42	215	1:25 PM	76	89	38	-.160	-.004	-.014	-.006	-.006	-.007	-.011	-.006	-.006	-.011	-.007	-.006	-.010	-.010	-.002	-.180	-.166
8-12-42	295	1:35 PM	93	102	39	-.208	+.003	-.003	-.005	-.007	-.006	-.010	-.006	-.005	-.011	-.005	-.006	-.003	-.002	+.005	-.226	-.211
11-17-42	393	2:55 PM	68	68	46	-.140	+.038	+.020	+.010	+.008	+.005	+.004	+.005	+.010	+.008	+.008	+.009	+.010	+.019	+.035	-.172	-.152
2-19-43	485	11:50 AM	78	62	27	-.134	+.034	+.016	+.009	+.008	+.006	+.004	+.006	+.006	+.006	+.007	+.006	+.006	+.015	+.030	-.170	-.148
5-11-43	567	12:40 PM	86	95	42	-.208	.000	-.005	-.006	-.007	-.009	-.005	-.006	-.008	-.011	-.008	-.011	-.013	-.002	.000	-.232	-.211
8- 4-43	652	1:45 PM	90	106	47	-.233	+.007	.000	-.005	-.004	-.005	-.008	-.005	-.005	-.007	-.004	-.005	-.004	+.004	+.006	-.267	-.242
11-16-43	756	1:00 PM	71	63	27	-.150	+.048	+.032	+.026	+.021	+.020	+.013	+.011	+.021	+.016	+.019	+.019	+.017	+.031	+.043	-.198	-.168
2- 8-44	840	1:15 PM	63	59	69	-.157	+.035	+.017	+.012	+.009	+.006	+.003	+.003	+.011	+.006	+.007	+.004	+.007	+.016	+.021	-.206	-.171

* Original joint width measurements

DAILY

Date	Age Days	Starting Time AM	Starting Time PM	Air Temp. AM	Air Temp. PM	Conc. Temp. AM	Conc. Temp. PM	Rel. Hum. AM	Rel. Hum. PM	Joint Numbers 1	2	8	14	15	21	27	28
2-19-42	126	7:50	3:20	34	73	45	69	81	22	-.032	-.036	-.026	-.019	-.024	-.036	-.019	-.039
5-27-42	216	6:10	2:25	58	87	73	90	51	26	-.058	-.041	-.028	-.026	-.019	-.032	-.039	-.063
8-12-42	295	7:00	2:20	61	89	79	103	89	39	-.060	-.039	-.029	-.021	-.025	-.024	-.036	-.050
11-18-42	393	8:05	2:00	58	64	62	65	94	84	-.004	-.006	-.005	-.004	-.005	-.008	-.004	-.004
2-18-43	484	8:20	3:15	46	85	55	76	86	22	-.022	-.025	-.023	-.018	-.023	-.024	-.025	-.020
5-11-43	567	6:55	3:15	56	88	69	104	60	40	-.082	-.044	-.028	-.023	-.026	-.029	-.038	-.072
8- 5-43	653	6:10	3:00	60	90	82	108	93	41	-.082	-.046	-.034	-.033	-.033	-.033	-.045	-.075
11-17-43	757	7:35	1:00	62	71	61	63	50	27	-.005	-.008	-.007	-.009	-.007	-.007	-.004	-.003
2-8-44	840	8:25	1:15	40	63	43	59	83	69	-.022	-.018	-.016	-.022	-.013	-.018	-.014	-.016

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 11	12	13	14	15	16	17	18
8-13-42	296	2:20 PM	89	103	39	5.060*	5.028	5.030	5.064	5.063	5.030	5.109	5.010
8- 5-43	653	1:40 PM	90	105	40	+.002	+.005	+.004	+.001	-.002	+.002	-.004	+.003

* Original joint width measurements

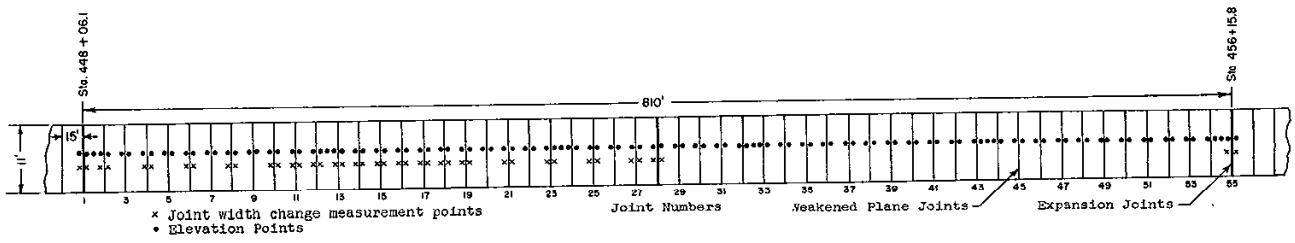


TABLE 31

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 17, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 4a - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers																	
						9	10	11	12	13	14	15	16	17	25	26	27	28	29	30	31	32	33
2-18-42	126	2:25 PM	68	67	34	5.028*	5.024	5.018	5.072	5.016	5.019	5.057	5.046	5.061	5.044	5.084	5.064	5.052	5.020	5.076	5.036	5.048	5.056
5-26-42	214	2:25 PM	80	90	35	-.131	-.003	-.003	-.003	-.001	-.003	-.007	-.001	-.097	-.101	-.002	-.004	-.006	-.004	-.006	-.002	.000	-.123
8-12-42	294	1:50 PM	94	104	39	-.161	+.007	+.005	+.001	+.004	+.002	+.003	+.003	-.118	-.132	+.003	+.002	+.002	-.001	+.003	+.004	+.006	-.156
11-17-42	392	2:45 PM	68	71	54	-.115	+.036	+.038	+.008	+.009	+.007	+.016	+.037	-.066	-.079	+.016	+.017	+.018	+.012	+.028	+.022	+.019	-.114
2-18-43	483	1:15 PM	80	67	23	-.112	+.036	+.025	+.003	+.005	+.003	+.008	+.028	-.071	-.080	+.008	+.013	+.016	+.008	+.024	+.017	+.012	-.112
5-11-43	566	1:00 PM	90	96	39	-.160	+.002	+.007	-.004	-.002	.000	+.003	+.001	-.107	-.123	-.001	.000	+.002	-.003	.000	+.002	+.002	-.153
8- 4-43	651	2:05 PM	90	107	47	-.182	+.015	+.017	+.003	+.005	+.007	+.012	+.013	-.129	-.146	+.006	+.007	+.008	+.003	+.008	+.003	+.011	-.177
11-16-43	755	1:15 PM	74	63	23	-.123	+.054	+.039	+.010	+.012	+.018	+.043	+.064	-.072	-.084	+.026	+.028	+.035	+.021	+.044	+.037	+.028	-.125
2- 8-44	849	1:00 PM	63	60	69	-.128	+.052	+.032	+.003	.000	+.005	+.019	+.030	-.075	-.094	+.014	+.021	+.018	+.015	+.033	+.024	+.016	-.130

* Original joint width measurements

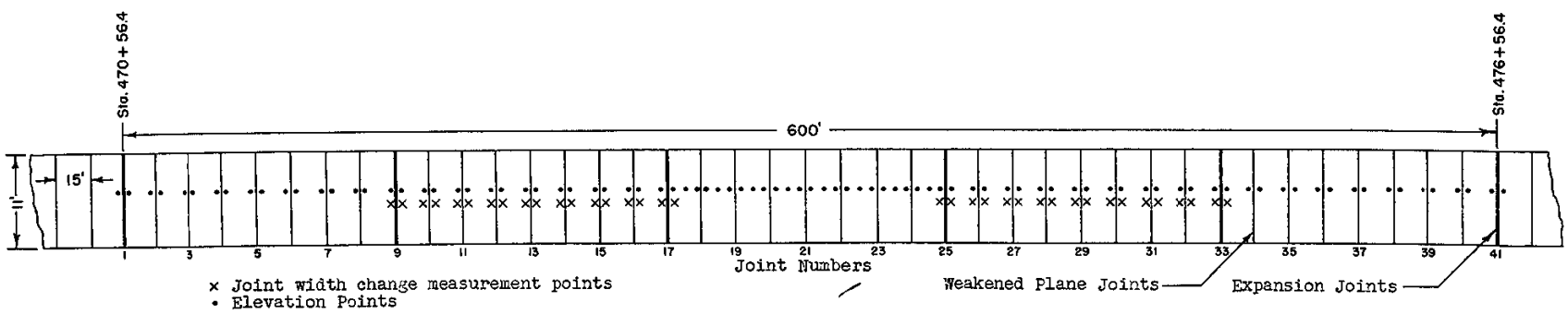


TABLE 32

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 18, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 5a - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 9	10	11	12	13	14	15	16	17	25	26	27	28	29	30	31	32	33
2-18-42	124	12:50 PM	67	52	41	5.024*	5.055	5.060	5.093	5.115	5.074	5.055	5.076	5.046	5.039	5.048	5.072	5.056	5.052	5.049	5.049	5.058	5.023
5-26-42	213	2:55 PM	81	91	38	-.137	+.001	-.003	-.012	-.012	-.006	-.003	-.008	-.090	-.132	-.009	-.008	-.006	-.006	-.003	-.002	-.005	-.143
8-12-42	293	2:10 PM	93	105	43	-.159	+.006	.000	-.009	-.010	-.003	+.001	-.003	-.109	-.151	-.004	.000	-.001	-.002	+.001	+.002	+.003	-.166
11-17-42	391	3:10 PM	68	71	56	-.102	+.030	+.017	+.009	+.005	+.010	+.019	+.011	-.061	-.095	+.015	+.013	+.011	+.020	+.017	+.012	+.018	-.112
2-19-43	483	1:30 PM	81	68	24	-.102	+.024	+.011	+.001	-.003	+.001	+.008	+.005	-.066	-.096	+.005	+.012	+.005	+.011	+.011	+.004	+.011	-.114
5-11-43	565	1:15 PM	87	97	36	-.150	+.006	-.003	-.010	-.015	-.008	.000	-.007	-.108	-.170	-.006	+.002	-.004	-.004	-.001	-.001	-.003	-.165
8- 4-43	650	2:20 PM	90	109	47	-.168	+.012	+.009	-.005	-.007	.000	+.006	+.001	-.129	-.167	+.002	+.004	+.002	+.002	+.003	+.006	+.007	-.183
11-16-43	754	1:35 PM	74	64	29	-.112	+.045	+.035	+.020	+.016	+.023	+.029	+.022	-.071	-.099	+.029	+.028	+.024	+.034	+.027	+.015	+.025	-.118
2- 8-44	838	2:20 PM	57	62	94	-.117	+.035	+.023	+.013	+.003	+.006	+.020	+.012	-.061	-.105	+.016	+.016	+.015	+.023	+.016	+.011	+.014	-.119

* Original joint width measurements

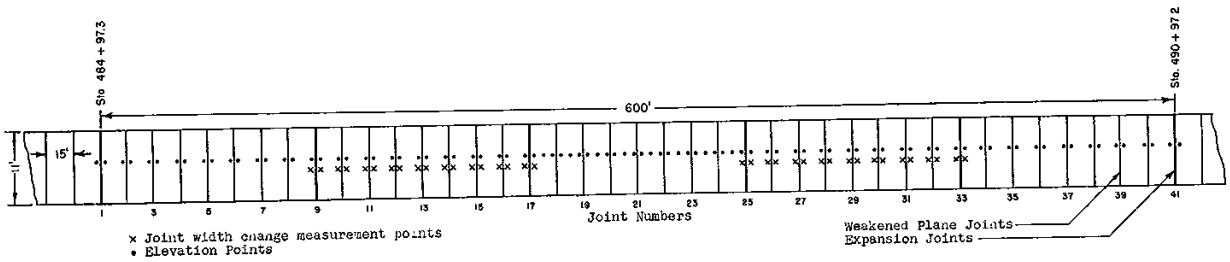
DAILY

Date	Age Days	Starting Time AM	Starting Time PM	Air Temp. AM	Air Temp. PM	Conc. Temp. AM	Conc. Temp. PM	Rel. Hum. AM	Rel. Hum. PM	Joint Numbers 9	10	11	12	13	14	15	16	17
5-27-42	214	6:25	2:35	59	86	73	90	52	28	-.057	-.037	-.038	-.040	-.038	-.036	-.033	-.037	-.048
8-13-42	294	7:05	2:35	61	91	79	103	89	33	-.041	-.028	-.030	-.029	-.030	-.029	-.028	-.033	-.044
11-18-42	392	8:15	2:15	57	63	62	65	100	84	-.008	-.009	-.004	-.005	-.005	-.008	-.002	-.006	-.004
2-19-43	483	8:30	3:20	45	83	55	76	93	23	-.025	-.021	-.027	-.025	-.022	-.019	-.023	-.025	-.023
5-11-43	565	7:05	3:25	56	87	69	104	65	39	-.054	-.035	-.039	-.034	-.032	-.032	-.029	-.032	-.056
8-5-43	651	6:20	3:10	60	90	82	108	92	41	-.061	-.038	-.041	-.038	-.037	-.034	-.035	-.035	-.057
11-17-43	755	7:45	1:35	61	74	61	64	58	29	-.007	-.005	-.007	-.007	-.009	-.003	-.006	-.008	-.005
2-8-44	838	2:20	8:35	39	57	43	62	92	94	-.018	-.013	-.017	-.012	-.015	-.016	-.012	-.015	-.020

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 9	10	11	12	13	14	15	16	17
8-12-42	293	2:35 PM	91	103	33	4.871*	5.062	5.060	5.085	5.105	5.070	5.056	5.069	4.934
8- 5-43	651	1:45 PM	90	106	40	-.012	+.005	+.004	+.003	+.003	+.005	+.005	+.007	-.014

* Original joint width measurements



× Joint width change measurement points
• Elevation Points

TABLE 33

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-79-C Between Piru Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Oct. 28, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 6b - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc T.	Rel. Hum.	Joint Numbers 1	2	3	4	5	6	7	8	9	10	11
2-18-42	112	4:35 PM	62	62	20	5.073*	5.113	5.077	5.085	5.071	5.063	5.080	5.101	5.075	5.076	5.053
5-27-42	204	12:30 PM	83	86	31	-.086	-.006	-.073	-.007	-.079	-.006	-.086	-.008	-.079	-.011	-.101
8-12-42	283	3:05 PM	93	108	39	-.128	-.005	-.108	-.008	-.107	-.007	-.123	-.005	-.115	-.008	-.123
11-18-42	381	11:50 AM	60	63	89	+.015	+.067	+.023	+.062	+.011	+.056	+.011	+.069	+.008	+.062	+.005
2-19-43	474	2:20 PM	82	72	22	-.038	+.034	-.025	+.008	-.035	+.009	-.035	+.019	-.034	+.012	-.041
5-11-43	555	11:20 AM	83	85	32	-.085	+.017	-.070	.000	-.076	-.003	-.072	-.003	-.070	-.002	-.079
8- 4-43	640	3:25 PM	90	110	47	-.135	+.020	-.116	-.001	-.113	-.002	-.125	-.001	-.120	-.002	-.130
11-16-43	754	2:25 PM	76	66	22	+.019	+.099	+.025	+.081	+.021	+.072	+.026	+.083	+.016	+.089	+.011
2- 8-44	838	4:25 PM	57	62	71	+.006	+.068	+.007	+.078	+.005	+.048	+.004	+.065	-.005	+.031	+.016

* Original joint width measurements

DAILY

Date	Age Days	Starting Time AM	Starting Time PM	Air Temp. AM	Air Temp. PM	Conc. Temp. AM	Conc. Temp. PM	Rel. Hum. AM	Rel. Hum. PM	Joint Numbers 3	4	5	6	7
2-19-42	113	8:30	4:05	31	72	45	71	89	28	-.094	-.072	-.083	-.073	-.066
5-27-42	204	6:50	3:10	60	83	72	92	58	31	-.112	-.064	-.111	-.062	-.121
8-12-42	283	7:35	3:05	62	90	79	105	89	32	-.092	-.054	-.088	-.053	-.095
11-18-42	381	8:40	2:40	57	62	62	65	100	89	-.008	-.011	-.011	-.010	-.012
2-18-43	473	8:55	2:20	47	82	55	72	86	22	-.050	-.051	-.053	-.050	-.052
5-11-43	555	7:30	3:55	56	90	69	105	65	41	-.108	-.063	-.108	-.094	-.118
8-5-43	641	6:35	3:45	64	90	81	108	92	41	-.110	-.074	-.111	-.069	-.122
11-17-43	755	8:05	2:25	59	76	61	66	57	22	-.013	-.016	-.012	-.015	-.018
2- 8-44	838	9:10	4:25	42	57	43	62	85	71	-.038	-.039	-.042	-.041	-.040

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 5	6	7
8-12-42	283	3:05 PM	93	108	39	4.964*	5.056	4.957
8- 5-43	641	2:00 PM	90	107	40	-.002	+.005	+.011

* Original joint width measurements

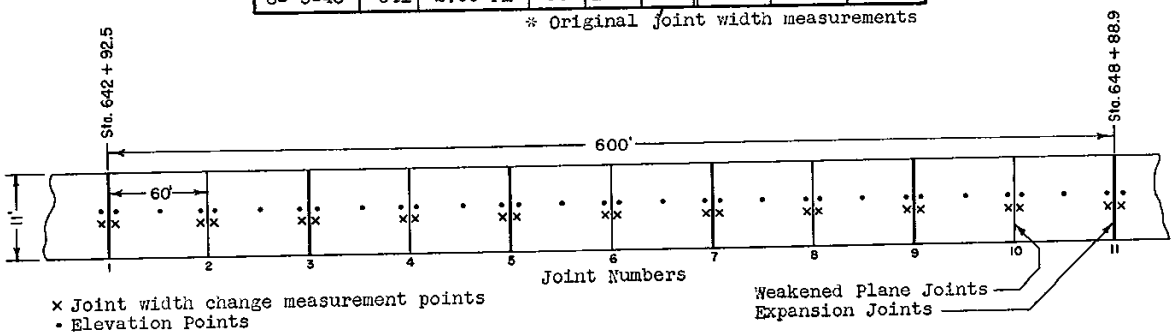


TABLE 34

EXPERIMENTAL CONCRETE PAVEMENT

VII-Ven-70-C Between Para Creek and Los Angeles Co. Line

Contract 27XC7-P - Constructed Octo. 29, 1941

CHANGES IN JOINT WIDTHS - INCHES

SECTION 7b - NORTH LANE

SEASONAL

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 9	10	11	12	13	14	15	16	17	25	26	27	28	29	30	31	32	33
2-19-42	112	2:20 PM	68	59	23	5.064*	5.079	5.045	5.036	5.061	5.095	5.092	5.060	5.032	5.020	5.057	5.084	5.024	5.028	5.018	5.068	5.041	5.036
5-27-42	203	1:15 PM	83	87	31	-.065	+.001	.000	.000	-.001	-.001	+.003	+.002	-.132	-.076	+.005	-.025	-.002	-.003	-.001	-.003	+.003	-.094
8-12-42	282	3:20 PM	92	108	38	-.090	+.004	+.004	+.003	+.001	+.005	+.007	+.008	-.192	-.104	+.006	.000	-.001	-.001	+.002	+.001	+.007	-.124
11-18-42	380	12:05 PM	60	63	94	-.030	+.033	+.033	+.028	+.027	+.029	+.033	+.036	-.105	-.039	+.034	+.026	+.026	+.023	+.018	+.024	+.036	-.050
2-18-43	472	2:30 PM	81	74	24	-.048	+.015	+.011	+.007	+.007	+.007	+.010	+.013	-.119	-.056	-.016	+.006	+.006	+.004	+.004	+.008	+.015	-.065
5-11-43	554	11:30 AM	84	87	39	-.071	+.007	+.005	+.004	+.003	+.002	.000	+.007	-.145	-.082	+.028	-.020	.000	.000	+.002	+.005	+.011	-.066
8-4-43	639	3:30 PM	90	110	47	-.096	+.010	+.010	+.007	+.008	+.008	+.007	+.011	-.200	-.149	+.011	+.005	+.004	-.001	+.005	+.006	+.015	-.127
11-16-43	743	2:40 PM	75	67	24	-.034	+.046	+.046	+.033	+.030	+.036	+.042	+.047	-.126	-.053	+.044	+.030	+.034	+.032	+.026	+.040	+.045	-.054
2-8-44	827	4:35 PM	57	62	82	-.041	+.033	+.033	+.020	+.014	+.017	+.028	+.030	-.127	-.052	+.038	+.016	+.021	+.020	+.018	+.036	+.034	-.064

* Original joint width measurements

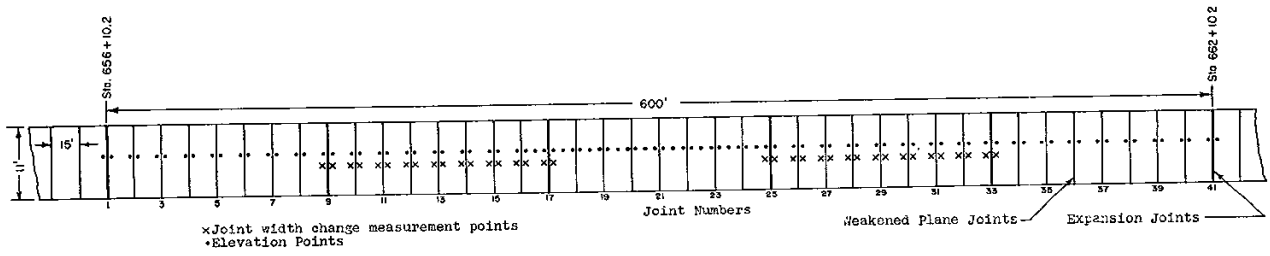
DAILY

Date	Age Days	Starting Time AM	Starting Time PM	Air Temp. AM	Air Temp. PM	Conc. Temp. AM	Conc. Temp. PM	Rel. Hum. AM	Rel. Hum. PM	Joint Numbers 9	10	11	12	13	14	15	16	17
2-19-42	113	8:40	2:20	32	68	44	68	79	23	-.031	-.025	-.031	-.027	-.030	-.026	-.017	-.022	-.033
5-27-42	204	7:05	3:15	55	83	72	92	59	28	-.045	-.032	-.034	-.035	-.032	-.036	-.034	-.035	-.065
8-13-42	283	7:40	3:10	63	90	79	105	89	32	-.046	-.021	-.027	-.028	-.036	-.025	-.027	-.027	-.048
11-18-42	381	8:45	2:45	58	63	62	65	94	84	-.004	-.006	-.005	-.007	-.005	-.005	-.007	-.009	-.003
2-18-43	473	9:00	2:30	49	81	54	74	86	24	-.022	-.018	-.021	-.016	-.017	-.018	-.020	-.021	-.019
5-12-43	555	7:35	4:00	60	87	69	105	58	47	-.032	-.032	-.030	-.029	-.026	-.030	-.029	-.027	-.064
8-5-43	640	6:40	3:45	64	90	81	108	90	41	-.057	-.039	-.038	-.034	-.031	-.037	-.036	-.037	-.065
11-17-43	744	8:10	2:40	61	75	61	67	54	24	-.006	-.006	-.004	-.006	-.007	-.004	-.008	-.006	-.006
2-8-44	827	9:20	4:35	45	57	43	62	86	82	-.013	-.010	-.011	-.008	-.019	-.010	-.015	-.012	-.010

PERMANENT

Date	Age Days	Starting Time	Air T.	Conc. T.	Rel. Hum.	Joint Numbers 9	10	11	12	13	14	15	16	17
8-12-42	282	3:10 PM	90	105	32	4.970*	5.089	5.050	5.037	5.052	5.100	5.100	5.068	4.850
8-5-43	640	2:05 PM	90	107	41	-.006	+.001	+.005	+.006	+.017	+.003	+.001	+.005	+.011

* Original joint width measurements



EXPERIMENTAL PAVEMENT LEVELS

Table 35

SECTION 1b

VII-Ven-79-C

Joint No.	Point A Elev.Ft. Oct.1941	Point A Diff.Ft. Feb.1943	Point B Elev.Ft. Oct.1941	Point B Diff.Ft. Feb.1943	Point C Elev.Ft. Oct.1941	Point C Diff.Ft. Feb.1943
21	754.089	-.005	754.091	-.006	754.148	-.005
22	754.210	-.002	754.211	-.001		
23	754.334	-.002	754.338	-.002		
24	754.458	-.004	754.461	-.004		
25	754.573	-.004	754.577	-.004		
26	754.698	-.005	754.694	-.004		
27	754.806	-.002	754.810	-.001		
28	754.927	-.004	754.930	-.004		
29	755.042	-.004	755.048	-.004	755.105	-.002
30	755.158	-.002	755.162	-.001		
31	755.291	+.002	755.291	+.003		
32	755.398	-.003	755.402	-.005		
33	755.513	-.004	755.517	-.002		
34	755.639	-.008	755.642	-.006		
35	755.743	-.008	755.746	-.007		
36	755.857	-.008	755.858	-.008		
37	755.967	-.007	755.970	-.006	756.035	-.007
38	756.098	-.005	756.099	-.005		
39	756.235	-.005	756.237	-.006		
40	756.353	-.004	756.356	-.004		
41	756.469	-.009	756.472	-.009		
42	756.592	-.016	756.594	-.017		
43	756.711	-.016	756.711	-.015		
44	756.830	-.011	756.833	-.010	756.891	-.009
45	756.944	-.003	756.944	-.003		
46	757.071	-.001	757.073	.000		
47	757.180	+.002	757.183	+.002		
48	757.297	+.001	757.299	+.002		
49	757.401	+.001	757.402	+.002		
50	757.500	+.004	757.502	+.004		
51	757.610	+.001	757.611	+.001		
52	757.719	+.001	757.720	+.001	757.770	+.001
53	757.823	-.001	757.822	.000		
54	757.923	.000	757.928	-.002		
55	758.017	-.002	758.020	-.001		
56	758.117	-.002	758.116	.000		
57	758.204	-.001	758.209	-.002		
58	758.312	-.006	758.314	-.007		
59	758.404	-.005	758.403	-.005		
60	758.488	-.002	758.490	-.004	758.536	-.007
61	758.583	-.003	758.586	-.004		

Temp. °F	Oct. 30, 1941 Air	Oct. 30, 1941 Concrete Top	Oct. 30, 1941 Concrete Center	Oct. 30, 1941 Concrete Bottom	Feb. 18, 1943 Air	Feb. 18, 1943 Concrete Top	Feb. 18, 1943 Concrete Center	Feb. 18, 1943 Concrete Bottom
Start	58	52	53	54	80	75	70	64
Finish	77	70	66	61	74	81	76	69

EXPERIMENTAL PAVEMENT LEVELS

Table 36

SECTION 2a

VII-Ven-79-C

Joint No.	Point A Elev. Ft. Oct. 1941	Point A Diff. Ft. Feb. 1943	Point B Elev. Ft. Oct. 1941	Point B Diff. Ft. Feb. 1943	Point C Elev. Ft. Oct. 1941	Point C Diff. Ft. Feb. 1943
1	687.886	-.045	687.886	-.043	687.837	-.047
2	687.796	-.042	687.792	-.042		
3	687.706	-.037	687.704	-.038		
4	687.627	-.032	687.626	-.033		
5	687.559	-.033	687.557	-.033		
6	687.512	-.035	687.509	-.034		
7	687.467	-.031	687.467	-.031		
8	687.440	-.030	687.438	-.030		
9	687.415	-.031	687.416	-.031		
10	687.403	-.029	687.404	-.030		
11	687.405	-.032	687.406	-.032		
12	687.405	-.034	687.407	-.036	687.412	-.039
13	687.410	-.039	687.412	-.039		
14	687.439	-.032	687.448	-.036		
15	687.481	-.033	687.484	-.033		
16	687.534	-.033	687.534	-.032		
17	687.580	-.027	687.583	-.026		
18	687.639	-.028	687.639	-.029		
19	687.703	-.032	687.705	-.032		
20	687.762	-.033	687.763	-.034		
21	687.847	-.036	687.846	-.035		
22	687.930	-.035	687.933	-.035		
23	688.040	-.036	688.040	-.035	688.093	-.035
24	688.149	-.032	688.153	-.029		
25	688.279	-.028	688.279	-.028		
26	688.411	-.022	688.418	-.023		
27	688.557	-.020	688.561	-.019		
28	688.709	-.018	688.714	-.017		
29	688.869	-.018	688.874	-.016		
30	689.039	-.017	689.042	-.014		
31	689.220	-.015	689.223	-.014		
32	689.413	-.015	689.415	-.015	689.526	-.018
33	689.619	-.017	689.625	-.017		
34	689.829	-.020	689.832	-.020		
35	690.052	-.016	690.061	-.016		
36	690.289	-.015	690.293	-.014		
37	690.530	-.015	690.539	-.017		
38	690.778	-.016	690.783	-.014		
39	691.043	-.015	690.049	-.016		
40	691.312	-.016	691.320	-.016		
41	691.588	-.017	691.593	-.015		
42	691.872	-.016	691.881	-.015		
43	692.181	-.015	692.189	-.016	692.332	-.017
44	692.492	-.017	692.501	-.017		
45	692.809	-.016	692.818	-.016		
46	693.157	-.015	693.167	-.014		
47	693.504	-.013	693.514	-.014		
48	693.859	-.010	693.869	-.011		
49	694.212	-.011	694.222	-.011		
50	694.580	-.010	694.590	-.011		
51	694.965	-.012	694.974	-.012		
52	695.351	-.012	695.360	-.011		
53	695.754	-.011	695.763	-.009		
54	696.159	-.011	696.173	-.012	696.379	-.015
55	696.577	-.013	696.582	-.010		

Temp. No.	Oct. 28, 1941 Air	Oct. 28, 1941 Concrete Top	Oct. 28, 1941 Concrete Center	Oct. 28, 1941 Concrete Bottom	Feb. 17, 1943 Air	Feb. 17, 1943 Concrete Top	Feb. 17, 1943 Concrete Center	Feb. 17, 1943 Concrete Bottom
Start	68	61	59	58	47	51	52	55
Finish	72	71	69	66	64	62	58	55

EXPERIMENTAL PAVEMENT LEVELS

Table 37

SECTION 3a

VII-Ven-79-C

Joint No.	Point A Elev. Ft. Oct. 1941	Point A Diff. Ft. Feb. 1943	Point B Elev. Ft. Oct. 1941	Point B Diff. Ft. Feb. 1943	Point C Elev. Ft. Oct. 1941	Point C Diff. Ft. Feb. 1943
1	717.447	+.006	717.455	+.005	717.594	+.003
2	717.727	+.004	717.737	+.003		
3	718.022	+.002	718.029	+.003		
4	718.303	+.001	718.309	+.002		
5	718.595	+.004	718.604	+.002		
6	718.871	+.002	718.877	+.002		
7	719.145	+.001	719.153	.000		
8	719.423	+.001	719.429	+.001		
9	719.682	+.002	719.691	+.001		
10	719.947	+.001	719.956	.000		
11	720.215	-.002	720.222	-.002		
12	720.470	.000	720.475	+.001	720.594	+.001
13	720.719	+.001	720.727	-.001		
14	720.967	.000	720.973	+.003		
15	721.220	.000	721.227	+.001		
16	721.459	+.002	721.463	+.005		
17	721.700	+.005	721.707	+.004		
18	721.939	+.004	721.947	+.004		
19	722.173	+.003	722.179	+.002		
20	722.403	+.004	722.409	+.003		
21	722.634	+.002	722.642	+.001		
22	722.855	+.002	722.862	+.001		
23	723.074	+.001	723.079	+.001	723.182	+.004
24	723.292	+.002	723.299	+.001		
25	723.507	-.001	723.513	+.001		
26	723.714	+.001	723.723	+.003		
27	723.931	.000	723.935	-.001		
28	724.130	-.002	724.133	-.001		
29	724.333	-.001	724.335	.000		
30	724.527	.000	724.533	.000		
31	724.706	+.002	724.714	.000		
32	724.905	+.003	724.912	+.001	725.004	-.001
33	725.101	+.001	725.105	+.001		
34	725.275	+.001	725.280	-.001		
35	725.456	-.001	725.462	-.001		
36	725.635	+.001	725.645	-.002		
37	725.813	.000	725.819	.000		
38	725.979	-.001	725.985	-.001		
39	726.134	-.003	726.138	-.002		
40	726.295	-.001	726.300	.000		
41	726.440	-.001	726.449	-.001		
42	726.596	+.001	726.602	-.001		
43	726.747	-.003	726.753	+.001	726.825	.000
44	726.896	+.002	726.900	+.002		
45	727.045	+.001	727.045	+.002		
46	727.184	+.003	727.189	+.003		
47	727.329	+.002	727.333	+.002		
48	727.467	+.002	727.470	+.002		
49	727.603	+.002	727.608	+.002		
50	727.736	+.002	727.739	+.001		
51	727.863	+.002	727.869	+.003		
52	727.989	+.003	727.996	+.002		
53	728.109	+.002	728.113	+.001		
54	728.234	.000	728.236	+.003	728.301	.000
55	728.365	+.004	728.370	+.001		

Temp. No.	Oct. 28 & 29, 1941 Air	Concrete Top	Concrete Center	Concrete Bottom	Feb. 17, 1943 Air	Concrete Top	Concrete Center	Concrete Bottom
Start	72	71	69	66	67	64	61	59
Oct. 28	69	72	72	69	Finish Joint 27			
Oct. 29	56	53	53	54	Start Joint 28			
Finish	71	60	58	57	69	78	74	67

EXPERIMENTAL PAVEMENT LEVELS

Table 38

SECTION 4a

VII-Ven-79-C

Joint No.	Point A Elev.Ft. Oct.1941	Point A Diff.Ft. Feb.1943	Point B Elev.Ft. Oct.1941	Point B Diff.Ft. Feb.1943	Point C Elev.Ft. Oct.1941	Point C Diff.Ft. Feb.1943
1	731.289	+.006	731.284	+.006		
2	731.143	+.011	731.139	+.010		
3	731.002	+.112	730.997	+.113		
4	730.852	+.014	730.847	+.015		
5	730.696	+.014	730.690	+.015		
6	730.527	+.017	730.525	+.016		
7	730.360	+.012	730.357	+.011		
8	730.194	+.011	730.182	+.012		
9	730.020	+.013	730.014	+.011		
10	729.836	+.015	729.834	+.012		
11	729.650	+.012	729.649	+.010		
12	729.469	-.005	729.463	-.004		
13	729.284	-.009	729.279	-.008		
14	729.094	-.006	729.090	-.007		
15	728.909	+.002	728.904	+.001		
16	728.705	+.007	728.705	+.007		
17	728.509	+.005	728.503	+.006	728.404	+.001
18	728.297	+.006	728.295	+.004	728.191	+.001
19	728.077	+.002	728.075	.000	727.967	-.003
20	727.855	-.001	727.852	.000	727.745	-.005
21	727.630	-.001	727.628	+.002	727.523	-.003
22	727.405	+.001	727.398	+.002	727.294	+.004
23	727.184	-.003	727.179	-.006	727.069	-.007
24	726.949	.000	726.938	-.002	726.828	-.007
25	726.710	+.001	726.699	+.002		
26	726.460	-.004	726.456	-.003		
27	726.215	-.001	726.210	-.003		
28	725.968	-.003	725.963	-.003		
29	725.720	-.003	725.708	-.002		
30	725.473	-.001	725.465	-.001		
31	725.221	-.005	725.216	-.005		
32	724.971	-.010	724.966	-.010		
33	724.725	-.010	724.717	-.011		
34	724.473	-.006	724.473	-.008		
35	724.237	+.001	724.231	.000		
36	723.977	+.001	723.972	.000		
37	723.732	-.004	723.729	-.005		
38	723.488	.000	723.484	-.003		
39	723.248	-.010	723.246	-.011		
40	723.021	-.014	723.019	-.016		
41	722.804	-.018	722.799	-.019		

Temp. °F	Oct. 29, 1941				Feb. 18, 1943			
		Concrete				Concrete		
	Air	Top	Center	Bottom	Air	Top	Center	Bottom
Start	71	60	58	57	47	54	54	57
Finish	78	74	71	66	54	57	56	57

EXPERIMENTAL PAVEMENT LEVELS

Table 39

SECTION 5a

VII-Ven-79-C

Joint No.	Point A Elev.Ft. Oct.1941	Point A Diff.Ft. Feb.1943	Point B Elev.Ft. Oct.1941	Point B Diff.Ft. Feb.1943	Point C Elev.Ft. Oct.1941	Point C Diff.Ft. Feb.1943
1	720.605	-.002	720.617	+.001		
2	720.752	+.007	720.760	+.005		
3	720.893	+.011	720.898	+.008		
4	721.066	+.008	721.070	+.008		
5	721.233	+.007	721.240	+.006		
6	721.413	+.010	721.421	+.008		
7	721.602	+.011	721.607	+.011		
8	721.780	+.010	721.786	+.010		
9	721.972	+.010	721.978	+.009		
10	722.173	+.007	722.180	+.005		
11	722.383	+.006	722.390	+.007		
12	722.599	+.006	722.604	+.006		
13	722.823	+.005	722.827	+.005		
14	723.055	-.002	723.060	.000		
15	723.299	-.001	723.304	+.001		
16	723.540	-.001	723.548	-.001		
17	723.785	-.002	723.795	-.003	723.909	-.002
18	724.028	-.001	724.035	-.002	724.156	-.003
19	724.280	-.002	724.287	-.001	724.410	-.003
20	724.535	-.003	724.542	.000	724.675	-.003
21	724.800	+.002	724.807	+.002	724.933	-.001
22	725.067	.000	725.072	+.002	725.203	-.001
23	725.335	-.003	725.340	.000	725.469	-.005
24	725.603	-.002	725.615	-.003	725.752	-.005
25	725.880	-.003	725.893	-.004		
26	726.171	-.005	726.178	-.006		
27	726.458	-.008	726.467	-.009		
28	726.736	-.014	726.746	-.016		
29	727.011	-.012	727.023	-.014		
30	727.286	-.014	727.296	-.014		
31	727.568	-.012	727.575	-.012		
32	727.847	-.014	727.856	-.014		
33	728.138	-.027	728.148	-.028		
34	728.418	-.018	728.427	-.019		
35	728.689	-.024	728.694	-.024		
36	728.959	-.030	728.962	-.029		
37	729.245	-.024	729.248	-.024		
38	729.516	-.017	729.525	-.018		
39	729.803	-.017	729.809	-.016		
40	730.079	-.014	730.089	-.014		
41	730.356	-.019	730.365	-.020		

Temp. °F	Oct. 29, 1941				Feb. 18, 1943			
		Concrete				Concrete		
	Air	Top	Center	Bottom	Air	Top	Center	Bottom
Start	76	74	72	67	69	64	61	59
Finish	71	73	72	68	78	73	67	64

EXPERIMENTAL PAVEMENT LEVELS

Table 40

SECTION 6b

VII-Ven-79-C

Joint No.	Point A Elev.Ft. Oct.1941	Point A Diff.Ft. Feb.1943	Point B Elev.Ft. Oct.1941	Point B Diff.Ft. Feb.1943	Point C Elev.Ft. Oct.1941	Point C Diff.Ft. Feb.1943
1	842.055	+.014	842.052	+.016	842.135	+.014
2	842.259	+.013	842.258	+.014	842.412	+.015
3	842.608	+.023	842.614	+.023	842.833	+.013
4	843.062	+.013	843.073	+.013	843.317	-.002
5	843.574	+.009	843.579	+.010	843.826	+.007
6	844.074	+.008	844.078	+.008	844.334	+.005
7	844.595	+.012	844.599	+.013	844.849	+.013
8	845.122	+.015	845.133	+.014	845.382	+.007
9	845.639	+.006	845.647	+.009	845.879	+.004
10	846.141	+.014	846.142	+.014	846.408	+.011
11	846.669	+.011	846.670	+.014		

Temp. °F	Oct. 30, 1941				Feb. 19, 1943			
	Air	Concrete			Air	Concrete		
		Top	Center	Bottom		Top	Center	Bottom
Start	78	74	70	64	53	55	56	57
Finish	80	77	74	67	60	56	56	57

EXPERIMENTAL PAVEMENT LEVELS

Table 41

SECTION 7b

VII-Ven-79-C

Joint No.	Point A Elev.Ft. Oct.1941	Point A Diff.Ft. Feb.1943	Point B Elev.Ft. Oct.1941	Point B Diff.Ft. Feb.1943	Point C Elev.Ft. Oct.1941	Point C Diff.Ft. Feb.1943
1	852.846	-.011	852.848	-.010		
2	852.973	-.010	852.973	-.010		
3	853.112	-.011	853.117	-.011		
4	853.242	-.002	853.247	-.002		
5	853.370	+.001	853.371	+.001		
6	853.493	+.007	853.498	+.007		
7	853.613	+.002	853.617	+.002		
8	853.749	-.004	853.750	-.004		
9	853.874	-.003	853.879	.000		
10	854.013	-.003	854.017	-.002		
11	854.146	-.004	854.148	-.004		
12	854.274	-.006	854.272	-.006		
13	854.402	-.004	854.409	-.006		
14	854.539	-.007	854.540	-.007		
15	854.659	-.007	854.670	-.007		
16	854.807	-.008	854.814	-.008		
17	854.936	-.010	854.941	-.007	854.999	-.009
18	855.064	-.007	855.072	-.007	855.128	-.009
19	855.189	-.004	855.194	-.006	855.262	-.009
20	855.323	-.005	855.329	-.007	855.378	-.008
21	855.446	-.008	855.449	-.010	855.511	-.013
22	855.574	-.011	855.574	-.012	855.631	-.014
23	855.691	-.013	855.702	-.012	855.755	-.012
24	855.818	-.012	855.823	-.010	855.890	-.013
25	855.934	-.012	855.946	-.009		
26	856.071	-.008	856.072	-.008		
27	856.198	-.008	856.208	-.009		
28	856.358	-.027	856.346	-.009		
29	856.466	-.008	856.475	-.009		
30	856.605	-.008	856.612	-.009		
31	856.731	-.004	856.737	-.003		
32	856.847	-.004	856.857	-.003		
33	856.985	-.004	856.990	-.003		
34	857.094	-.004	857.104	-.004		
35	857.211	-.004	857.219	-.004		
36	857.327	-.002	857.327	-.002		
37	857.424	-.003	857.429	-.004		
38	857.527	-.004	857.533	-.005		
39	857.633	-.005	857.636	-.003		
40	857.715	-.003	857.713	-.005		
41	857.803	-.008	857.805	-.004		

Temp. °F	Oct. 30, 1941				Feb. 19, 1943			
	Air	Concrete Top	Concrete Center	Concrete Bottom	Air	Concrete Top	Concrete Center	Concrete Bottom
Start	80	77	74	67	71	61	59	59
Finish	76	75	74	70	82	77	73	67

Table 42

RESULTS OF SUBGRADE DENSITY TESTS

VII-Ven,LA-79-C,A F.A.P. 330-C(1) Research 00194 Contract No. 27XC7-F

Test Sect. No.	North Lane						South Lane					
	Station	Sample No.	"A" 0" - 9"		"A & B" 0" - 18"		Station	Sample No.	"A" 0" - 9"		"A & B" 0" - 18"	
			% Moist.	Lbs/ Cu. Ft.	% Moist.	Lbs/ Cu. Ft.			% Moist.	Lbs/ Cu. Ft.	% Moist.	Lbs/ Cu. Ft.
1a	376+00	C444	2.8	130.0	3.8	130.4	376+00	C420	5.0	125.0	4.4	124.1
	388+00	C445	3.3	126.5	4.2	129.7						
	391+00	C446	4.1	122.4	3.9	127.0	391+00	C421	4.7	121.2	4.7	124.1
	407+00	C447	3.7	129.7	4.1	131.8	407+00	C422	3.7	120.6	4.7	126.3
							408+00	C423	4.0	123.4	3.8	129.0
							408+85	C424	4.0	119.5	4.2	129.1
							409+85	C425	4.8	120.3	4.5	124.7
	417+50	C448	5.5	129.3	4.6	128.4	417+50	C426	5.5	120.4	5.3	125.6
	Section Average		3.9	127.6	4.1	129.5			4.5	121.5	4.5	126.1
2a	424+00	C449	3.1	124.6	4.0	125.0						
	427+00	C450	4.0	120.6	4.6	123.2						
	430+00	C451	4.5	120.1	4.5	127.2						
	433+00	C452	4.2	135.6	4.5	129.0	433+00	C427	6.0	121.1	5.3	126.9
	436+00	C453	6.3	126.8	4.5	126.8						
	439+00	C454	6.9	128.4	7.3	128.8						
	Section Average		4.8	126.0	4.9	126.7			6.0	121.1	5.3	126.9
3a	442+00	C455	8.3	121.2	6.8	123.0						
	445+00	C456	4.1	126.1	4.9	128.1						
	446+50	C457	3.0	120.9	5.6	121.6	446+50	C428	5.9	127.7	4.9	134.1
	449+50	C458	4.4	122.6	4.8	131.3						
	452+50	C459	4.2	124.9	4.7	131.3						
	455+50	C460	4.2	126.9	4.1	132.5						
	461+00	C462	4.8	126.6	5.3	131.8	461+00	C429	6.8	126.3	6.7	130.8
	464+00	C463	3.8	117.1	4.6	123.1						
	467+00	C464	4.8	119.6	3.9	124.2						
	Section Average		4.6	122.9	5.0	127.4			6.4	127.0	5.8	132.5
4a	470+00	C465	4.8	123.1	4.7	127.0						
	472+30	C466	3.7	120.4	4.7	126.6						
	476+00	C467	4.7	126.3	4.3	129.9	476+00	C430	5.9	129.3	6.1	128.8
	479+00	C468	3.6	127.6	3.5	129.2						
	Section Average		4.2	124.4	4.3	128.2			5.9	129.3	6.1	128.8
5a	482+00	C469	5.8	121.3	4.8	132.4						
	485+00	C470	4.7	126.9	3.9	131.6						
	488+00	C471	4.1	129.4	3.9	131.2						
	491+00	C472	4.1	126.2	4.6	135.3	491+00	C431	5.4	126.8	5.4	131.2
	Section Average		4.7	126.0	4.3	132.6			5.4	126.8	5.4	131.2
6a	505+50	C473	6.5	116.5	6.2	118.8	505+50	C432	5.2	119.0	6.1	123.2
7a					No Samples							
Average Sections 1a to 7a			4.8	123.9	4.8	127.2			5.6	124.1	5.6	128.1
1b	520+50	C474	4.8	121.3	8.1	119.3	520+50	C433	4.9	123.8	9.0	121.5
	523+50	C475	4.8	122.2	8.6	121.3						
	526+50	C476	4.0	120.8	6.5	120.2						
	529+50	C477	6.1	127.0	6.4	124.6						
	532+50	C478	4.5	124.2	4.9	121.3						
	535+50	C479	4.8	123.2	5.6	124.5	535+50	C434	5.5	127.0	7.7	124.2
	538+50	C480	4.6	125.2	6.9	123.7						
	541+50	C481	4.6	120.6	5.8	125.3						
	544+50	C482	4.6	126.3	5.3	129.8						
	547+50	C483	5.5	126.4	5.8	132.1						
	551+00	C484	4.7	124.5	5.5	128.0	551+00	C435	8.3	120.2	7.1	131.3
	554+00	C485	4.9	127.6	5.8	126.3						
	557+00	C486	7.1	130.2	5.6	125.7						
	560+00	C487	5.7	121.2	6.3	132.2						
	563+00	C438	7.0	131.8	8.0	133.7						
	566+00	C489	7.8	127.6	7.2	132.3	566+00	C436	5.2	127.4	4.7	132.8
	Section Average		5.4	125.0	6.4	126.3			6.3	124.9	6.5	129.4
2b	569+00	C490	11.0	127.1	10.5	140.4						
	567+50*	C491	7.5	119.8	6.7	128.3	577+00	C437	3.3	124.3	4.6	128.7
	580+50	C492	7.7	123.1	6.0	130.7						
	Section Average		8.7	123.3	7.7	133.1			3.3	124.3	4.6	128.7
4b	592+00	C493	5.7	127.7	5.4	131.2	592+00	C438	4.6	125.1	4.3	127.4
3b	604+00	C494	6.7	122.7	5.8	127.7	604+00	C439	5.1	127.2	4.4	125.9
	618+50	C495	7.1	122.4	8.0	124.9	618+50	C440	6.9	124.6	6.0	125.6
	Section Average		6.9	122.6	6.9	126.3			6.0	125.9	5.2	125.8
5b	633+50	C704	7.2	114.5	8.8	121.4	635+50	C441	6.4	123.1	7.5	122.9
6b	641+00	C496	6.2	126.6	6.6	130.4						
	644+00	C497	6.8	133.0	5.9							
	647+00	C498	4.5	124.4	5.7	122.2	647+00	C442	5.4	125.4	5.8	125.8
	650+00	C499	6.4	118.1	4.9	132.3						
	Section Average		6.0	125.5	5.8	128.3			5.4	125.4	5.8	125.8
7b	653+00	C700	5.7	126.4	5.2	127.3						
	656+00	C701	5.2	122.8	5.9	131.8						
	659+00	C702	5.6	126.3	6.8	121.9						
	662+00	C703	5.2	124.0	6.5	128.1	662+00	C443	4.7	126.5	4.0	129.5
	665+00	C705	6.0	124.1	6.3	124.5						
	Section Average		5.5	124.7	6.1	126.7			4.7	126.5	4.0	129.5
Average Sections 1b to 7b			6.5	123.3	6.7	127.6			5.2	125.0	5.4	127.1
Average Entire Project			5.7	123.6	5.8	127.4			5.4	124.6	5.5	127.6

* Equation in stationing occurs near this point.

I N D E X

FIGURES	
1	Plan Showing Location of Test Project.
2.	Plan Showing Location of Test Sections.
3.	Typical Cross-Sections.
4.	Paving Details.
5 to 15.	Construction Pictures.
16.	Diagram of Concrete Strength Tests.
17 to 22.	Change in Joint Widths - Daily.
23 to 29	Change in Joint Widths - Seasonal.
30 to 32.	Temperature Records - Air - Concrete - Subgrade.
33.	Subgrade Compaction Test Procedure.
34.	Sand Volume Apparatus for Subgrade Density Determinations.
35 to 41.	Plan, Profile and Level Changes of Test Sections.
42 to 54.	Diagram Showing Time-Sequence of Construction Operations.

FIGURE 1

STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

PLAN AND PROFILE OF

STATE HIGHWAY

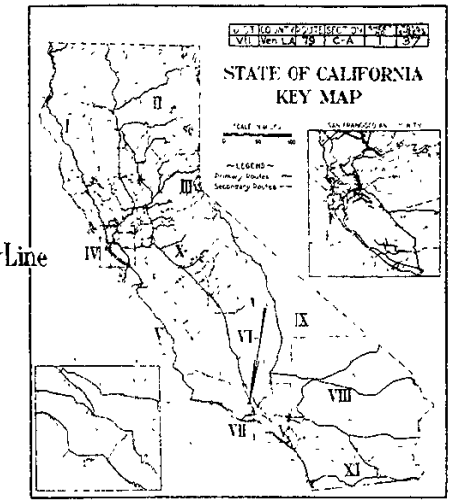
In Ventura and Los Angeles Counties, between Piru Creek and Los Angeles County Line

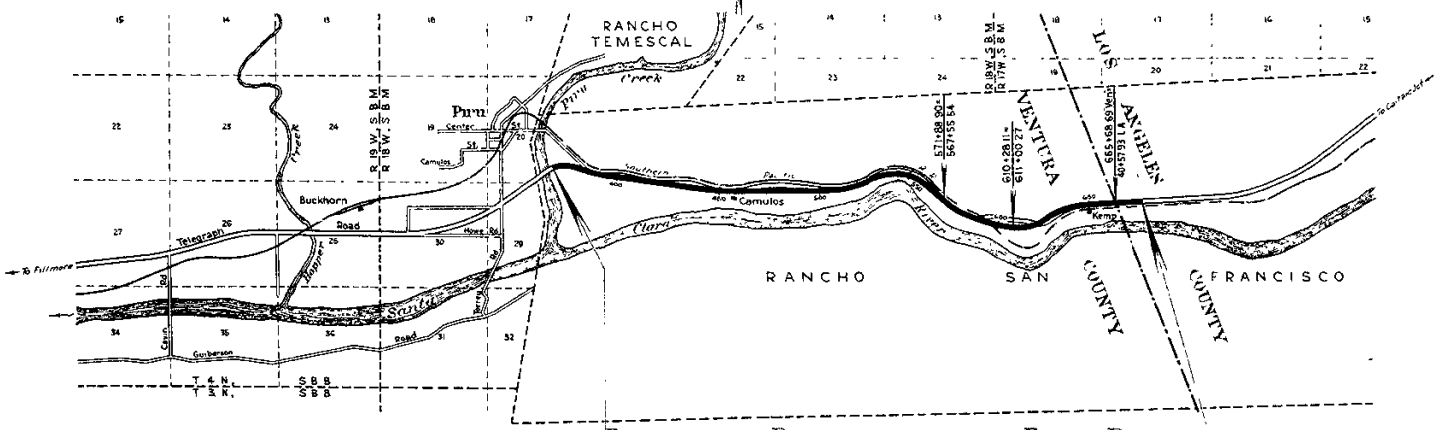
Scales {Plan - 1 In. = 50 Ft. / Profile Hor 1 In. - 50 Ft. Vert. 1 In. - 10 Ft.

being the detail plans of a portion of the route for the State highway adopted by the California Highway Commission August 30, 1940)

INDEX OF SHEETS

Sheet No. 1 Title Sheet
" " 2 Pavement Construction Diagram
" " 3 Typical Cross-section of Improvement
" " 4-5 Paving Details
" " 6-31 Plan & Profile
" " 32 Channel Change Details
" " 33-34 Special Structures
" " 35-37 Standard Structures
" " 1-96 Cross-sections





Beginning of Project
Station 370+65.00

End of Project
Station 44+57.95

CONVENTIONAL SIGNS

County Line
City or Town Limits
Township Line
Section Line
Grant Line
Fence
Guard Rail
Unfenced Property
Right of Way Line
Base or Survey Line
Traveled Way
Railway Tracks
Bank or Retaining Wall
Levee
Culverts
Drop Inlet
Trolley Pole
Power Pole
Power Tower
Telegraph or Telephone Pole
Marsh

Scale in Miles

Length of project - 30,259.99 feet - 5.73 miles

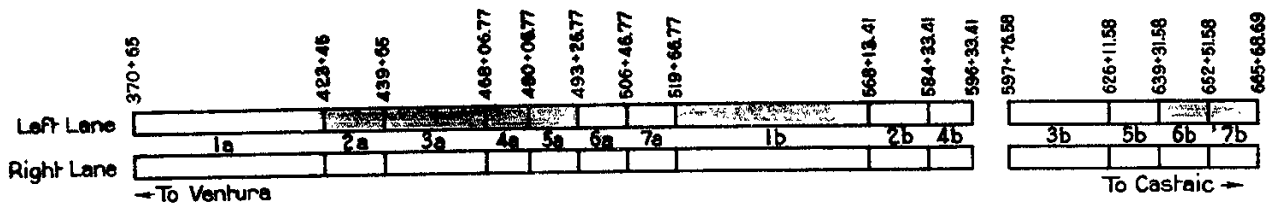
October 5, 1940
S. V. Cortelyou
October 7, 1940
C. H. PURCELL
State Highway Engineer
Frank W. Clark
Director of Public Works

Figure 1

FIGURE 2

Diagram and Table Showing Locations
of Various Types of Pavement Construction

DIAGRAM



Sections in which Joint & Level Measurement Points were placed

TABLE

Section	Length		Cross Section	Expansion Joints		Weakened Plane Joints			Reinforcement
	Left Lane	Right Lane		Spacing	Number of Dowels	Spacing	Number of Dowels		
							Left Lane	Right Lane	
1a	5280'	5280'	9"-7"-9"	5280'	9	15'	0	4	None
1b	5280'	5280'	9"-7"-9"	5280'	9	15'	0	4	"
2a	1620'	1620'	9"-7"-9"	810'	9	15'	0	4	"
2b	1620'	1620'	9"-7"-9"	810'	9	15'	0	4	"
3a	2835'	2835'	9"-7"-9"	405'	9	15'	0	4	"
3b	2835'	2835'	9"-7"-9"	405'	9	15'	0	4	"
4a	1200'	1200'	9"-7"-9"	120'	9	15'	0	4	"
4b	1200'	1200'	9"-7"-9"	120'	9	15'	0	4	"
5a	1320'	1320'	9"-7"-9"	120'	9	15'	9	9	"
5b	1320'	1320'	9"-7"-9"	120'	9	15'	9	9	None
6a	1320'	1320'	9"-7"-9"	120'	9	60'	9	9	Wire Mesh
6b	1320'	1320'	9"-7"-9"	120'	9	60'	9	9	Wire Mesh
7a	1320'	1320'	8" uniform	120'	0	15'	0	0	None
7b	1320'	1320'	8" uniform	120'	0	15'	0	0	None

FIGURE 3

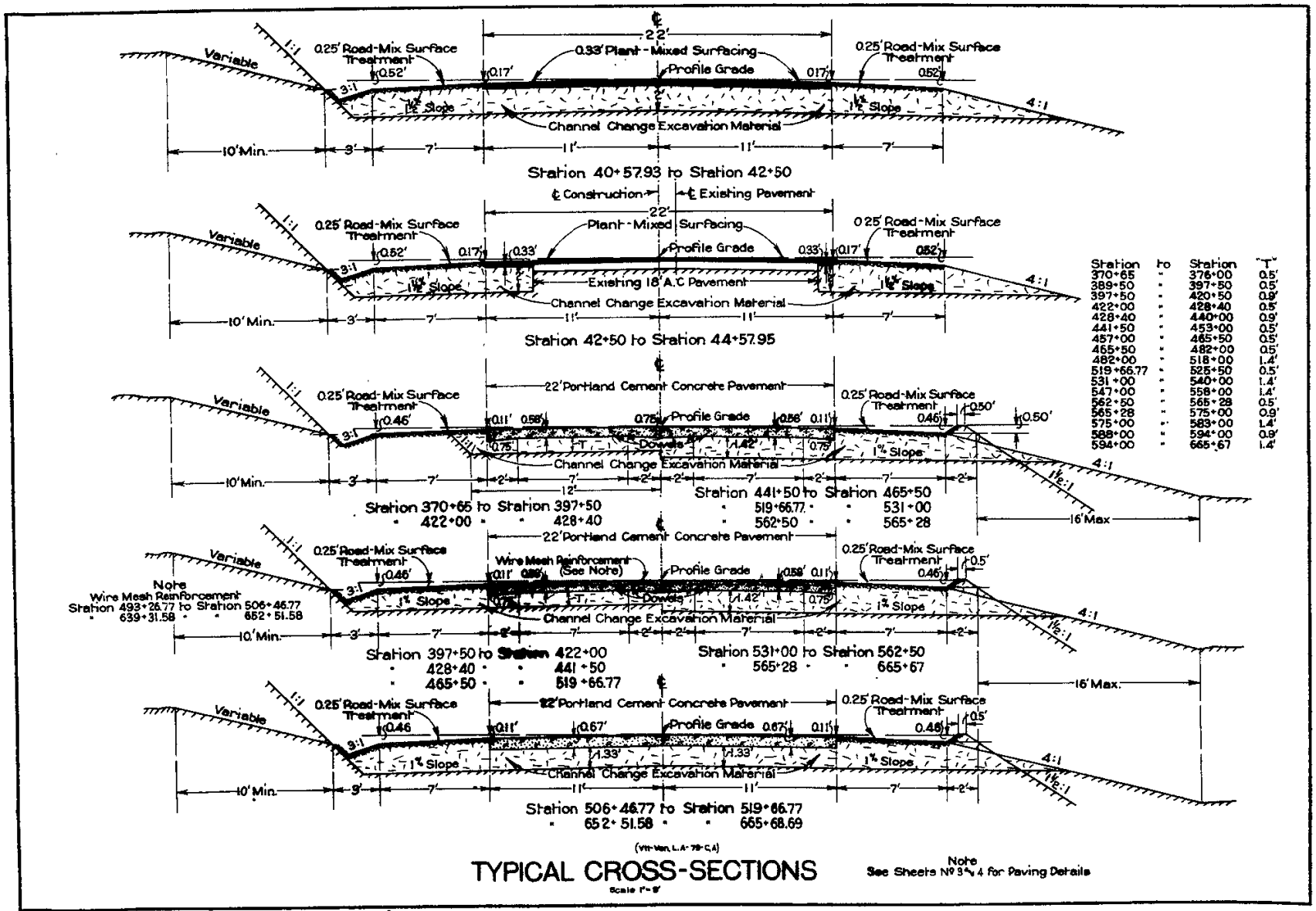
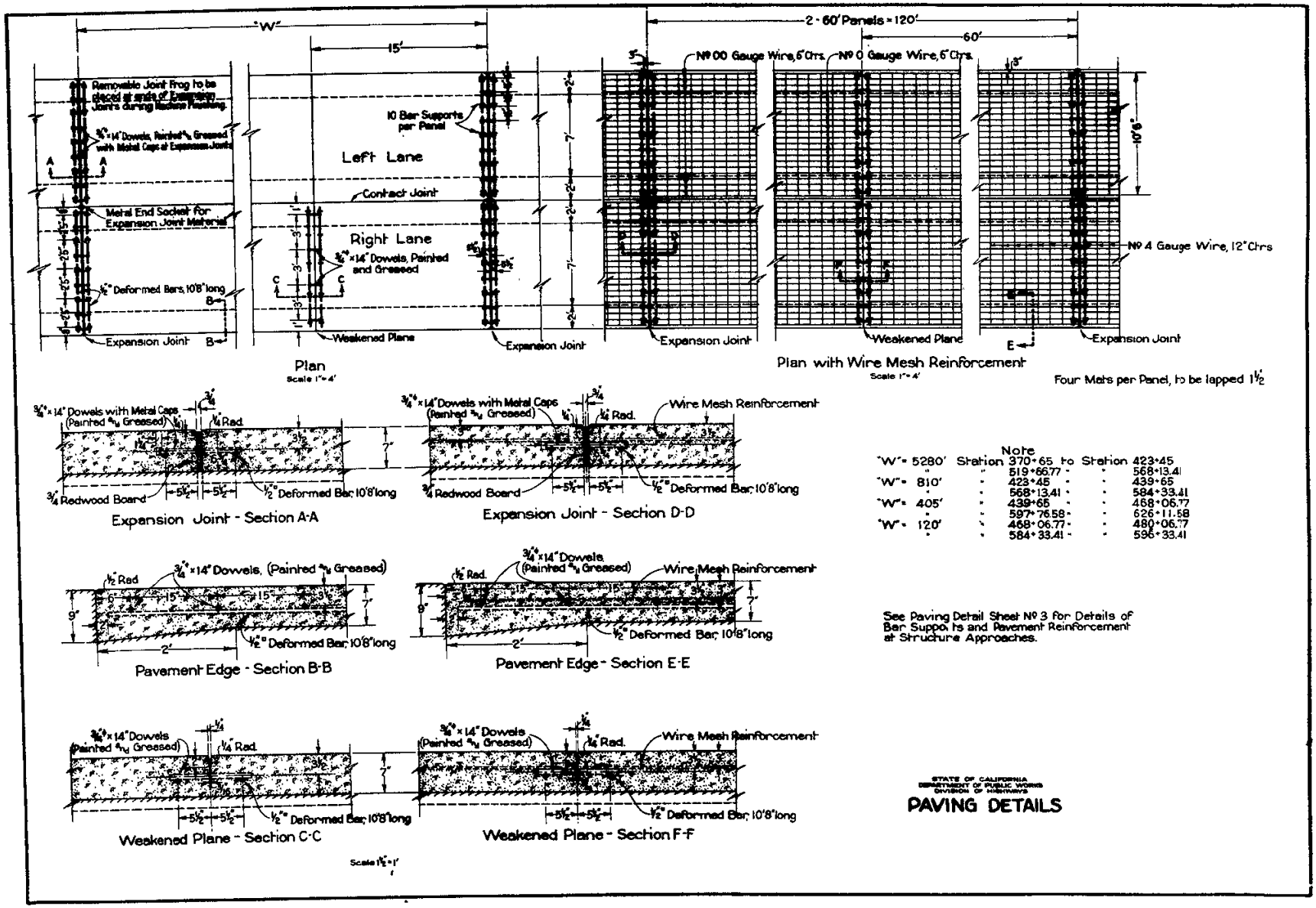


Figure 3

FIGURE 4



Note

"W" = 5280'	Station	370+65	to	Station	423+45
"	"	519+66.77	"	"	568+13.41
"W" = 810'	"	423+45	"	"	439+65
"	"	568+13.41	"	"	584+33.41
"W" = 405'	"	439+65	"	"	468+06.77
"	"	597+76.58	"	"	626+11.58
"W" = 120'	"	468+06.77	"	"	480+06.77
"	"	584+33.41	"	"	596+33.41

See Paving Detail Sheet Nº 3 for Details of Bar Supports and Pavement Reinforcement at Structure Approaches.

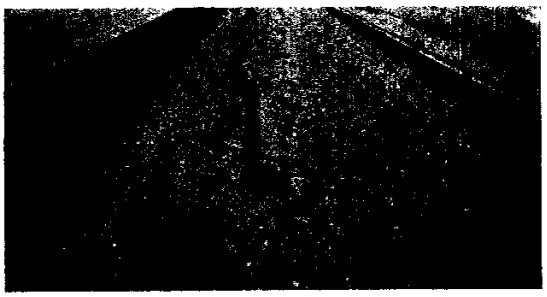
STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

PAVING DETAILS

Figure 4

TYPICAL CONDITIONS OF SUBGRADE

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P



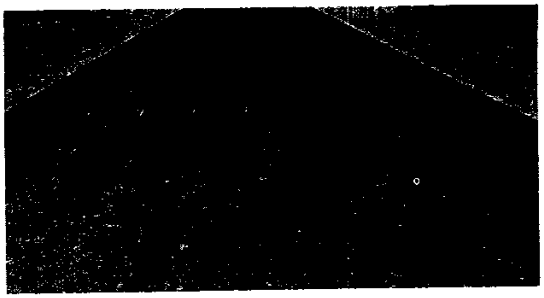
Typical Rough Subgrade

Roughness Caused by large rocks under Lewis subgrader

Station 514+50, Sect. 7a

Station 518+50 Sect. 7a

Note expansion joint filler,no dowels



Typical good subgrade with negligible roughness

Sta. 660+00 (Appr.) Sect. 7b

Note compaction test in progress

Sta. 485+97, Sect. 5A

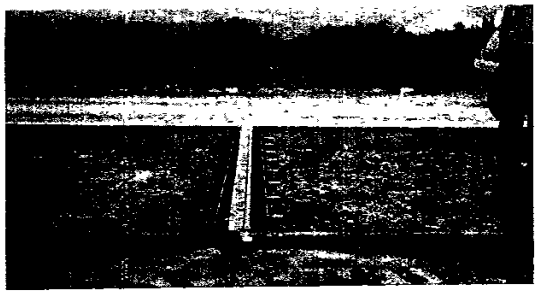
Note the reinforcing steel for weakened plane joints, also the expansion joint in the background.

Figure 6

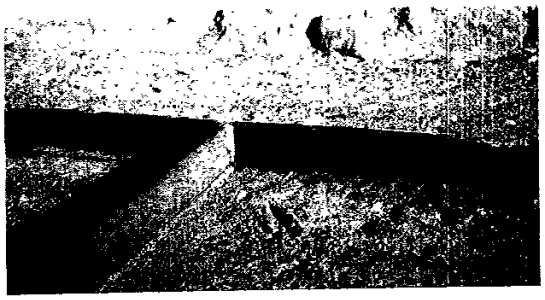
EXPANSION AND WEAKENED PLANE JOINTS

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

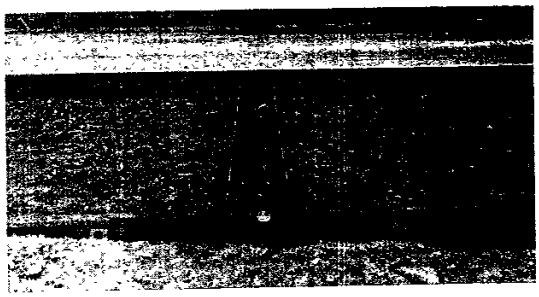
Expansion Joint Filler with Metal Pouring Guard in place



Expansion Joint Filler braced to form the joint at the end of a day's pour



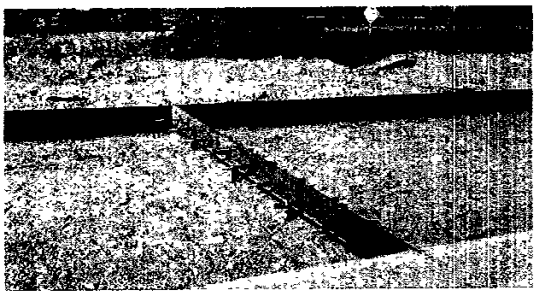
Redwood Expansion Joint Filler without dowels, Sects. 7a & 7b

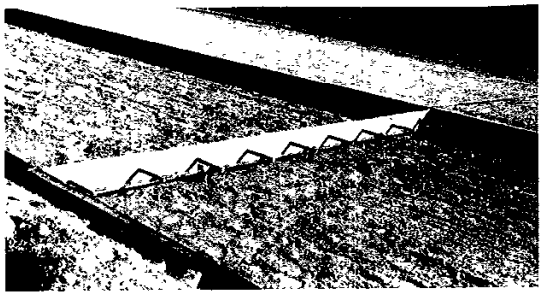


Dowels and Reinforcing Steel for Weakened Plane Joint, Sects. 5a & 5b

EXPANSION JOINT DETAILS

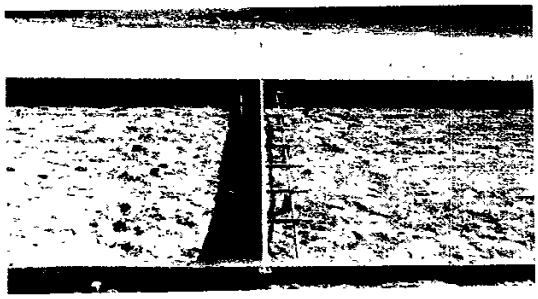
VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

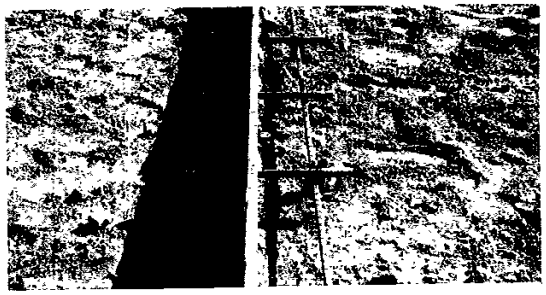




Expansion Joint at Station 483+77

Redwood Joint Filler and Dowel Steel in Place





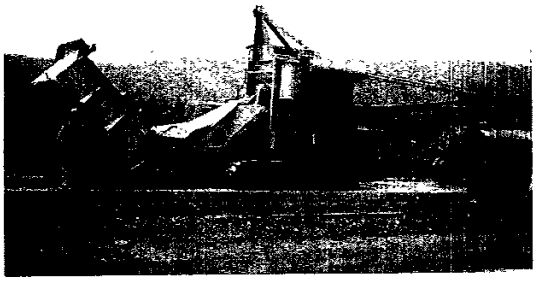
Expansion Joint at Station 483+77

Alignment and Details

Figure 8

MIXING AND PLACING CONCRETE

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P



Dumping a Batch of Aggregates and Cement into the Mixer Hopper

Mixing the Concrete
Spreading, Tamping and Preparing a Dummy Joint in the Background

Dumping Mixed Concrete on the Subgrade

Spreading and Tamping Concrete
Note the placing of some concrete by hand against the side forms.

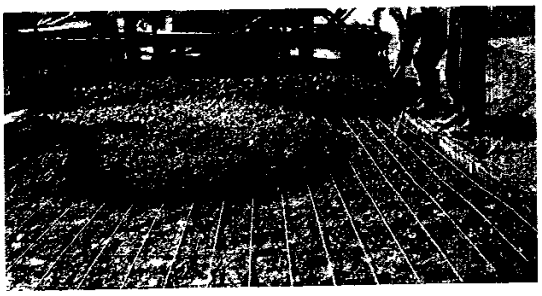
Figure 9

PLACING CONCRETE ON REINFORCED SECTIONS, 6a AND 6B

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

Placing Wire Mesh Reinforcement over Lower Layer of Concrete

Dumping Upper Layer of Concrete



Placing, Spreading and Tamping Concrete in Upper Layer

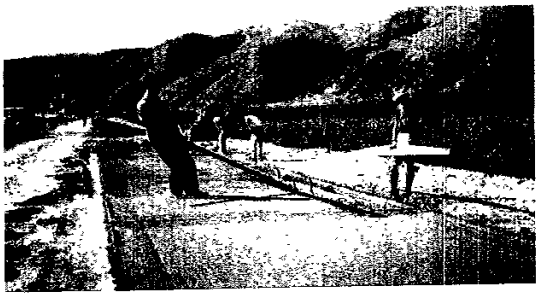
Figure 10

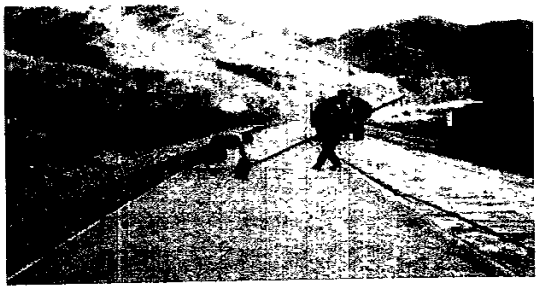
MECHANICAL FINISHING AND BUMP CUTTING

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

Mechanical Finisher (Johnson Float)
Preliminary Pass

Mechanical Finisher (Johnson Float)
Final Pass

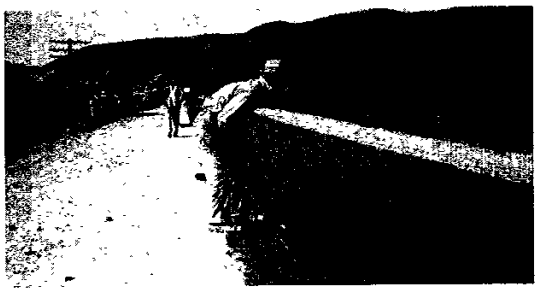




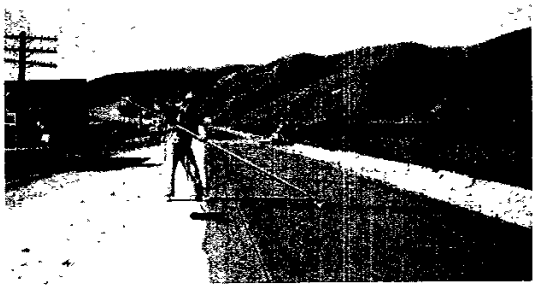
"Bump Cutting"

FINISHING JOINTS

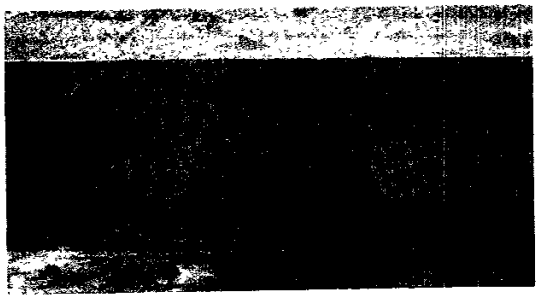
VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P



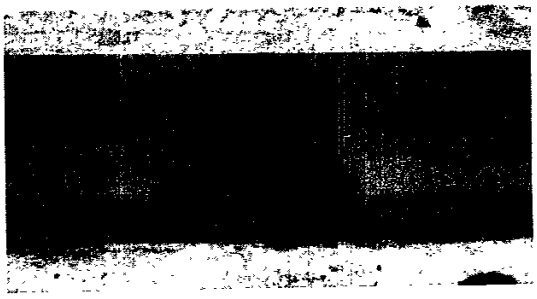
Removing Steel from Weakened Plane Joint



Floating an Expansion Joint



Finished Weakened Plane Joint "Dummy Joint"



Finished Expansion Joint

Figure 12

INSTALLATION OF GAUGE POINTS

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27X07-P

Template Used for Placing Chalk in Fresh Concrete at Gauge Points

Removing Chalk with Carbide Tipped Drill

Grouting Gauge Points in Place

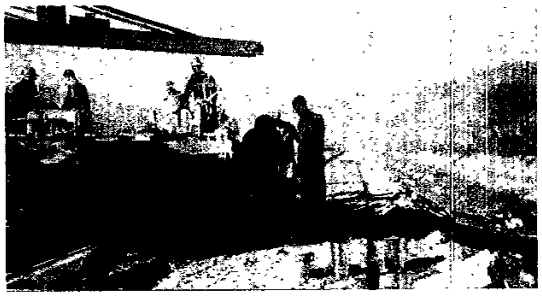
Figure 13

PREPARATION OF TEST SPECIMENS

AND

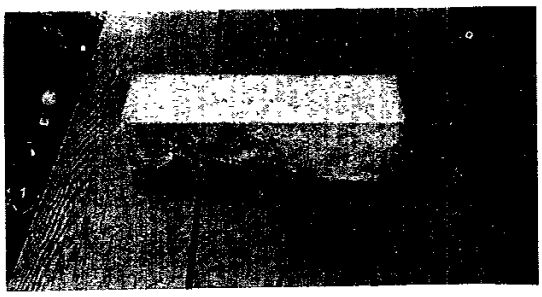
TYPICAL 6" x 6" x 20" BEAMS FOR P.R.A. LABORATORY

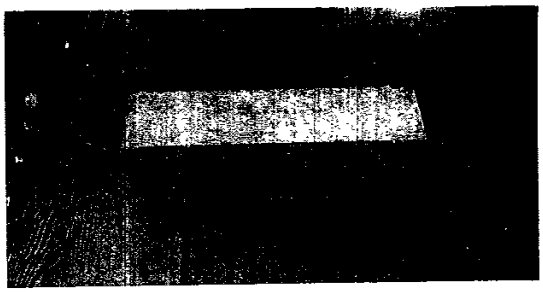
VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P



Screening Out Larger Sizes of Rock (Over 1-1/2" in size)

Sample of Concrete Ready for Fabrication of Test Specimens. Partition for 6" x 6" x 20" not yet in place in the form.



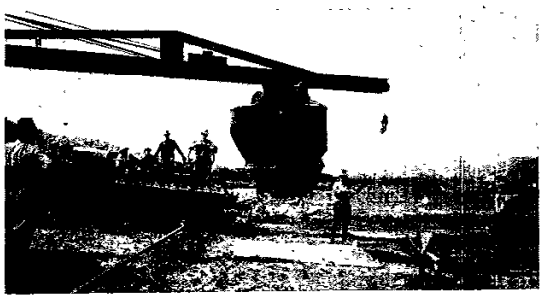


Typical 6" x 6" x 20" Beam Ready for Shipment to P. R. A. Laboratory for Volume Change Tests

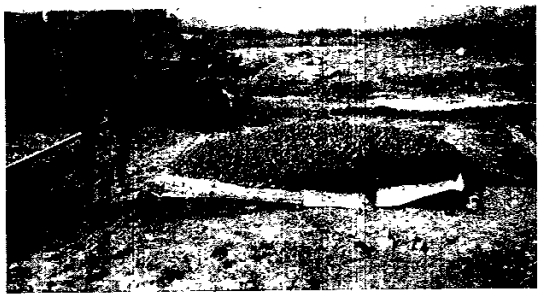
Figure 14

PREPARING SPECIAL SET OF TEST SPECIMENS

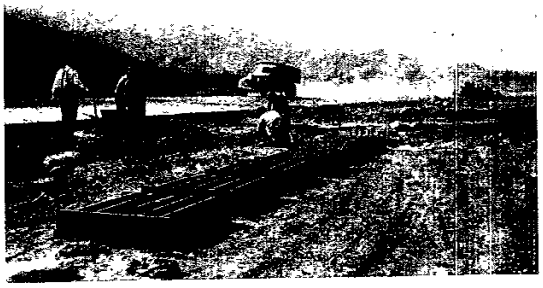
VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P



Dumping the Concrete



Concrete Dumped, Ready for Use



Slump Test

Fabricating Test Beams

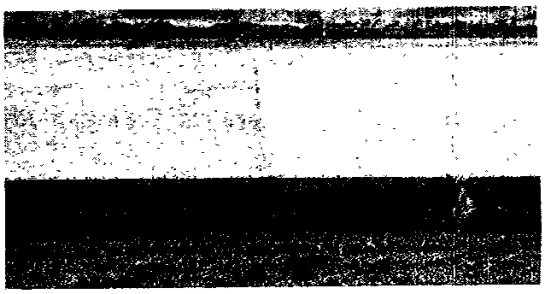
Note the partition for the 6"x6"x20" beam to be shipped to P.R.A. Laboratory

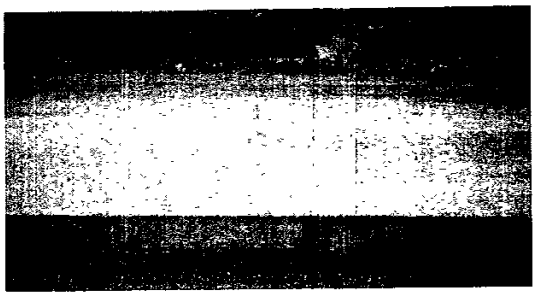
CRACKING AT WEAKENED PLANE JOINTS

AND

SPECIAL THERMOMETER INSTALLATIONS

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P





Typical Cracking at Weakened Plane Joints, South Lane

Sta. 561+95, Sect. 1b

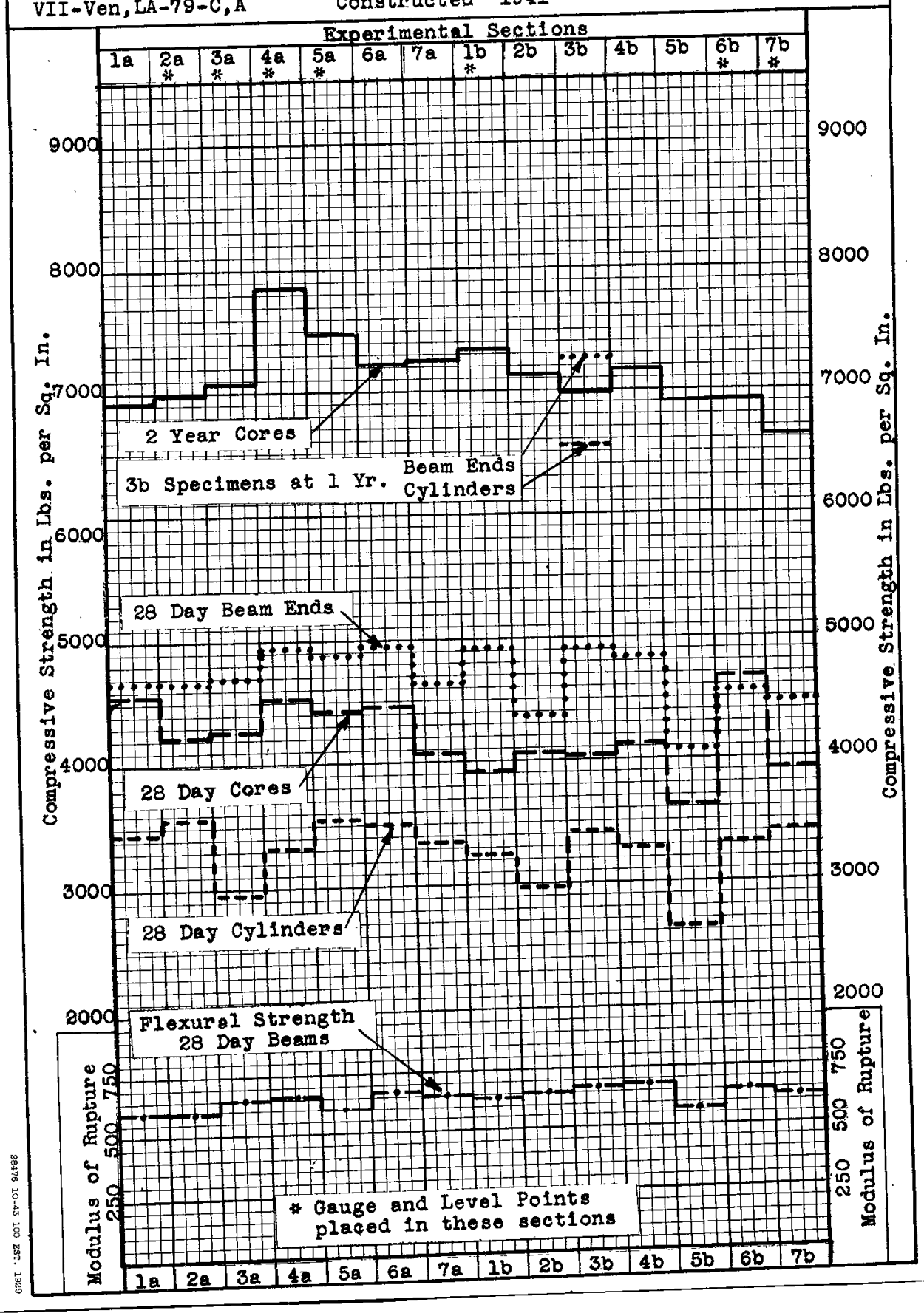
Sta. 564+95, Sect. 1b

Close-up of Crack shown above

Sta. 561+95

Weston Dial Type Thermometers Installed in Freshly Placed Concrete Pavement for Measurement of Temperature during hardening period.

AVERAGE COMPRESSIVE AND FLEXURAL STRENGTHS, CYLINDERS, CORES, BEAMS
VII-Ven,LA-79-C,A Constructed 1941 Cont. 27XC7-P



28476 10-43 100 EST. 1929

Fig. 17.

Sec. 1b.

Ventura County Experimental Concrete Pavement

Change in Joint Widths

DAILY

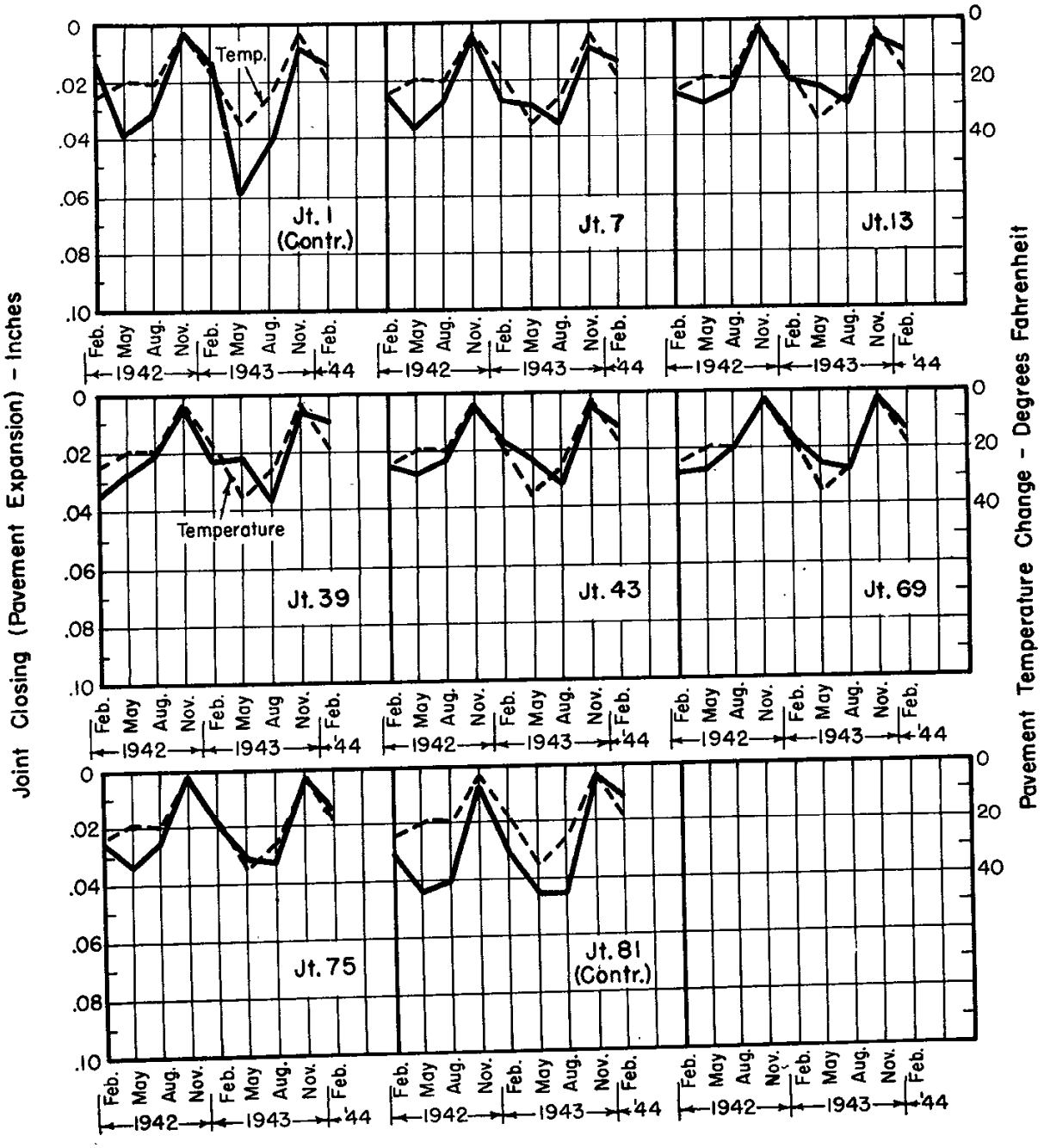


Fig. 18.
Sec. 2a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
DAILY

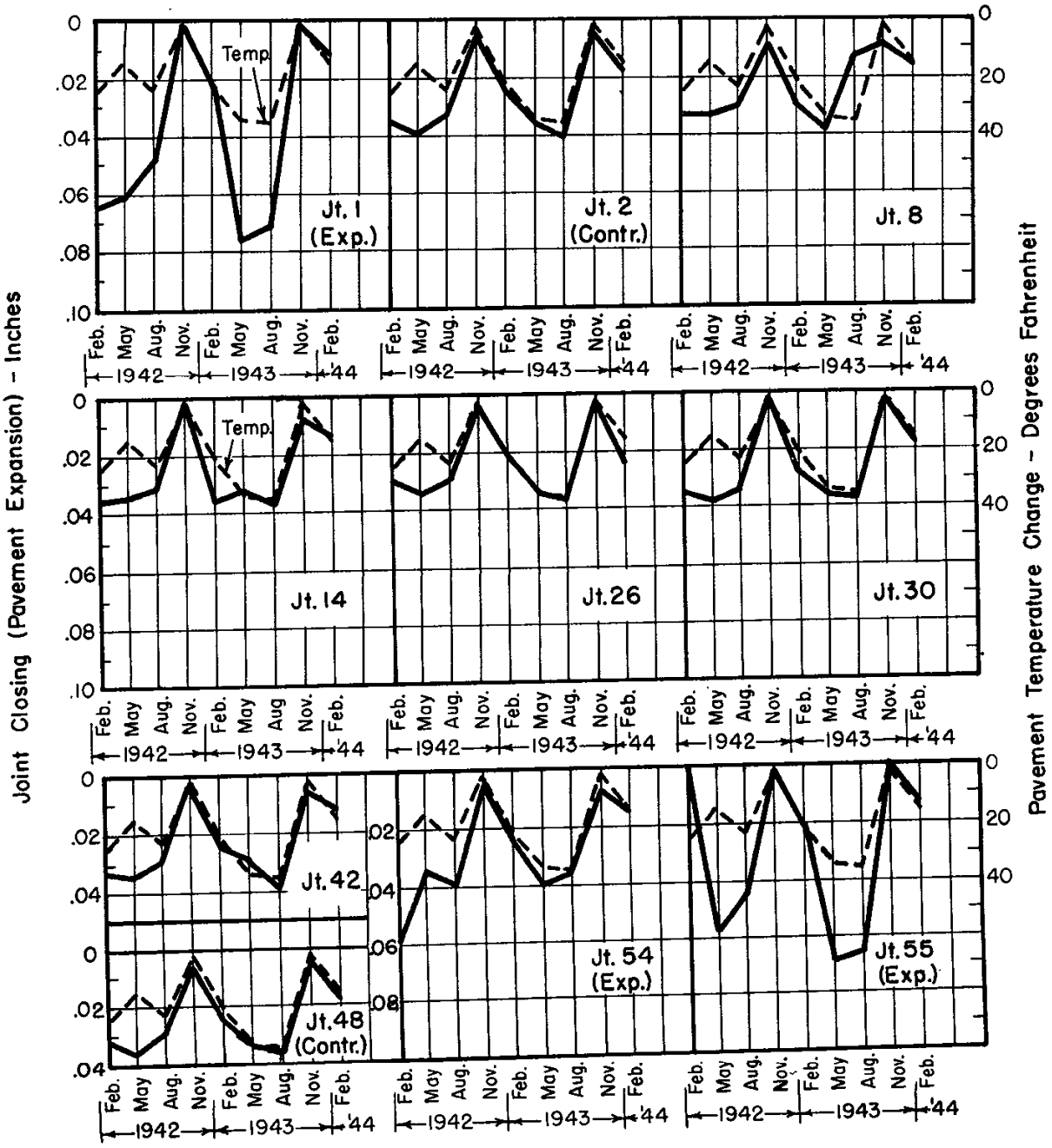


Fig. 19.
Sec. 3a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
DAILY

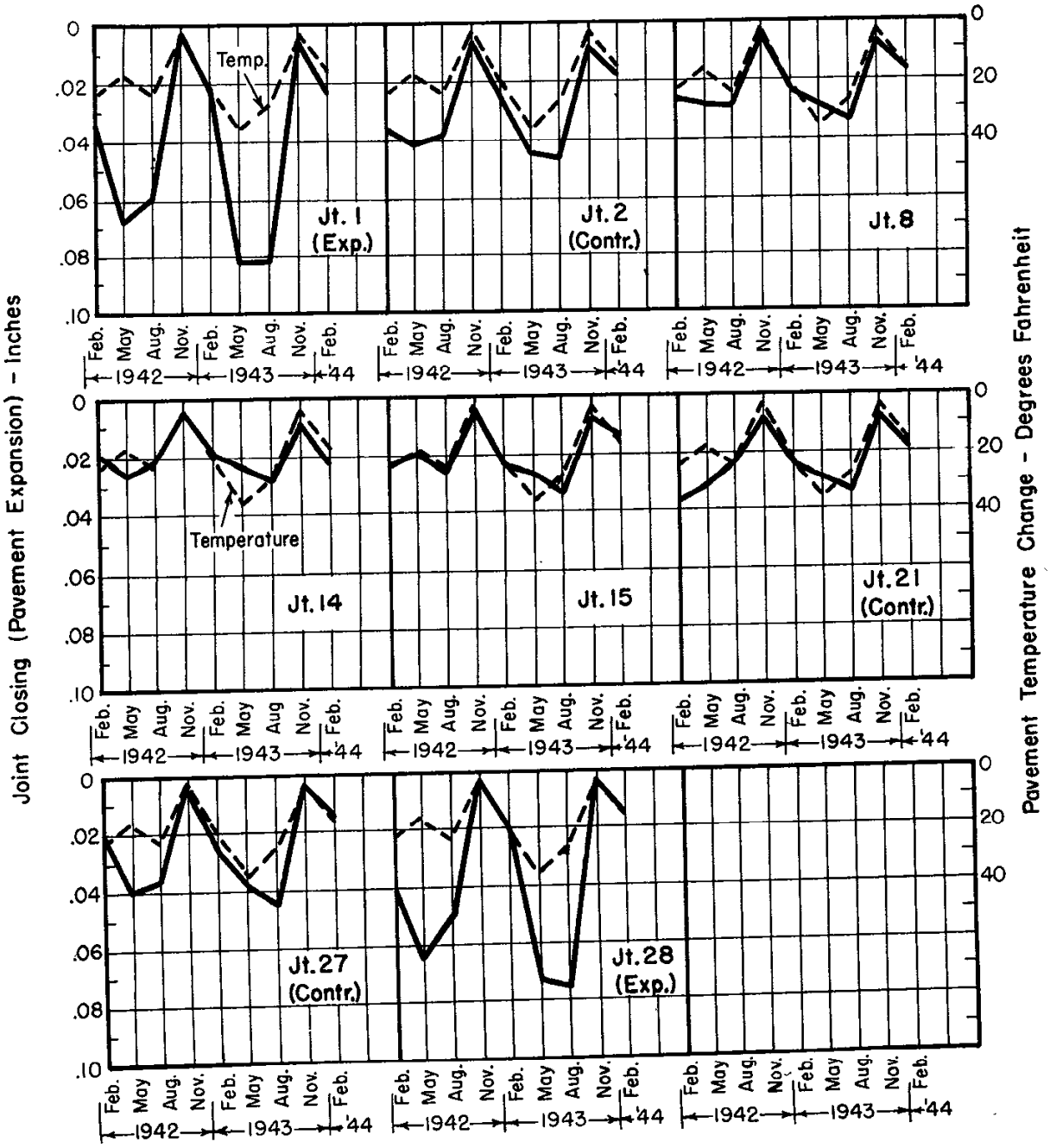


Fig. 20.
Sec. 5a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
DAILY

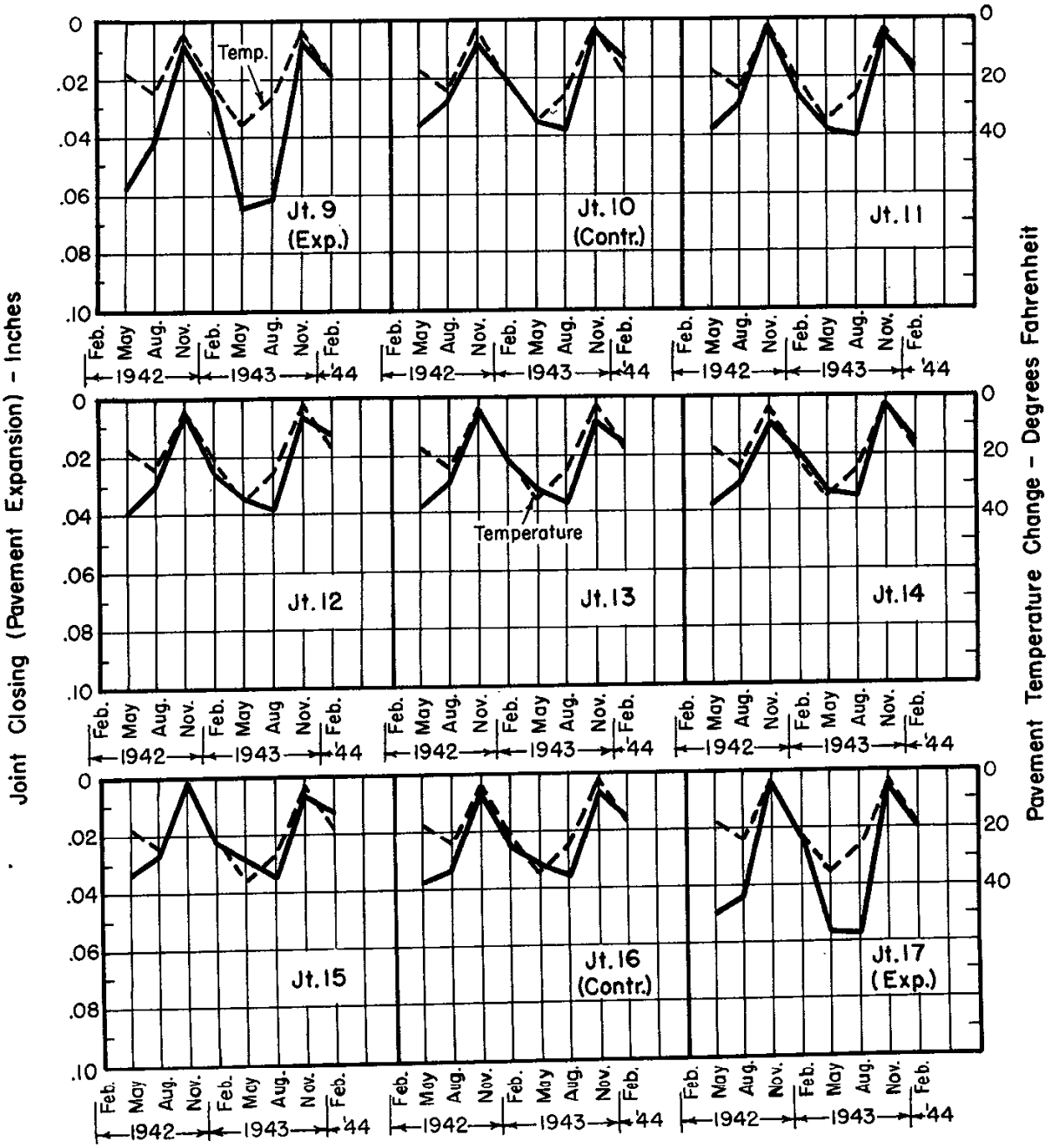


Fig. 21.
Sec. 6 b.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
DAILY

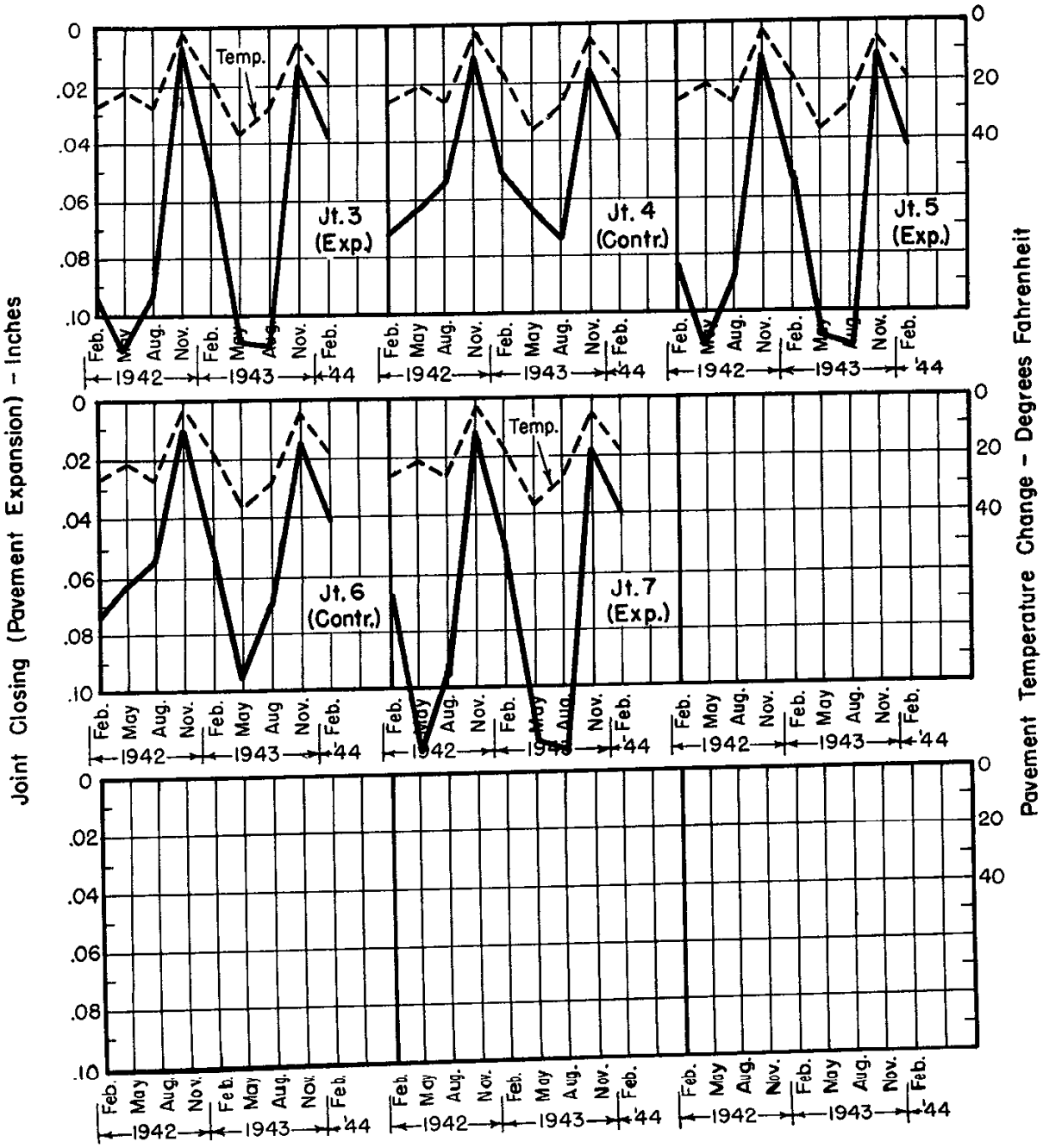


Fig. 22.
Sec. 7 b.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
DAILY

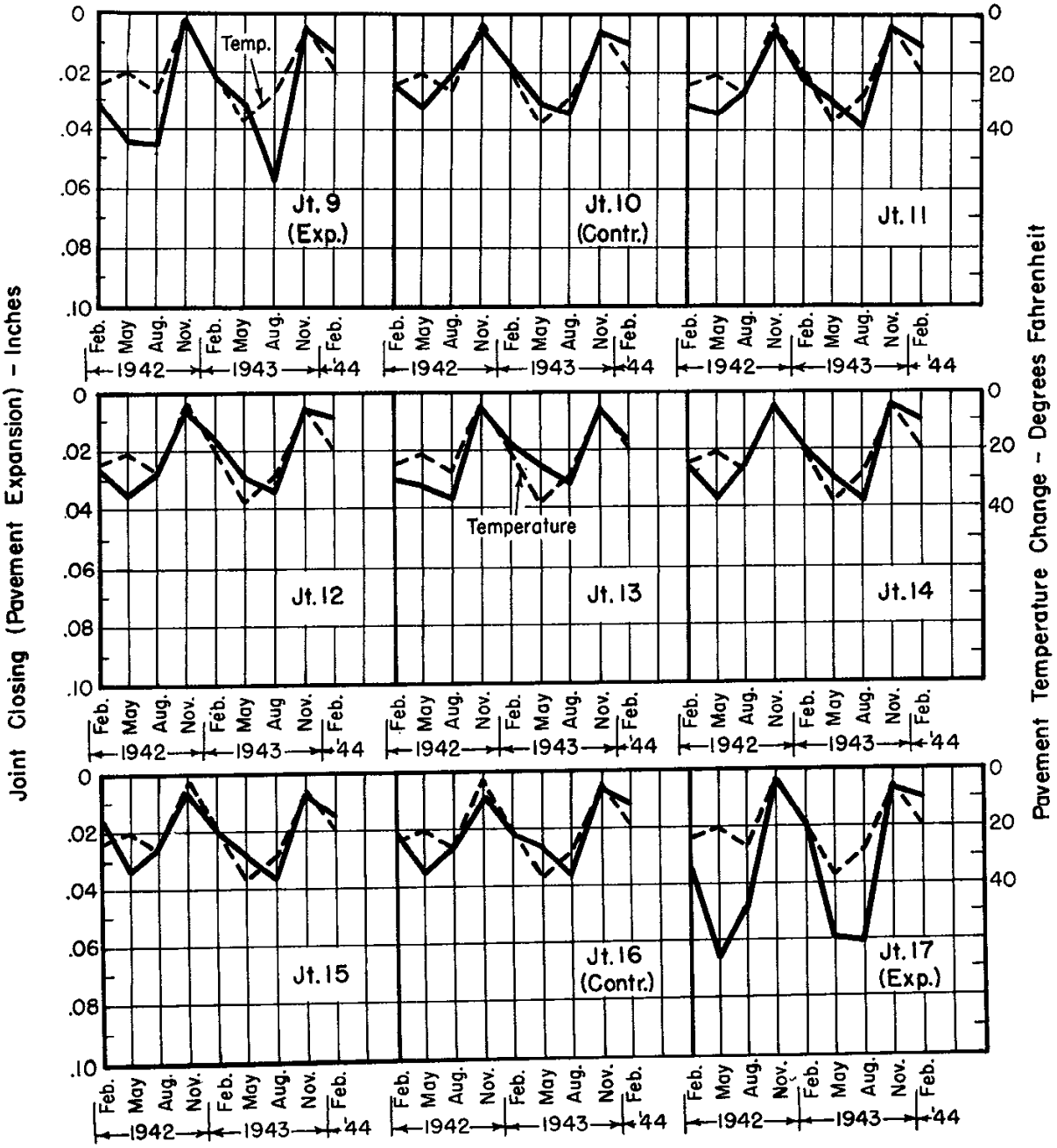


Fig. 23.

Sec. 1 b. (1)

Ventura County Experimental Concrete Pavement

Change in Joint Widths

SEASONAL

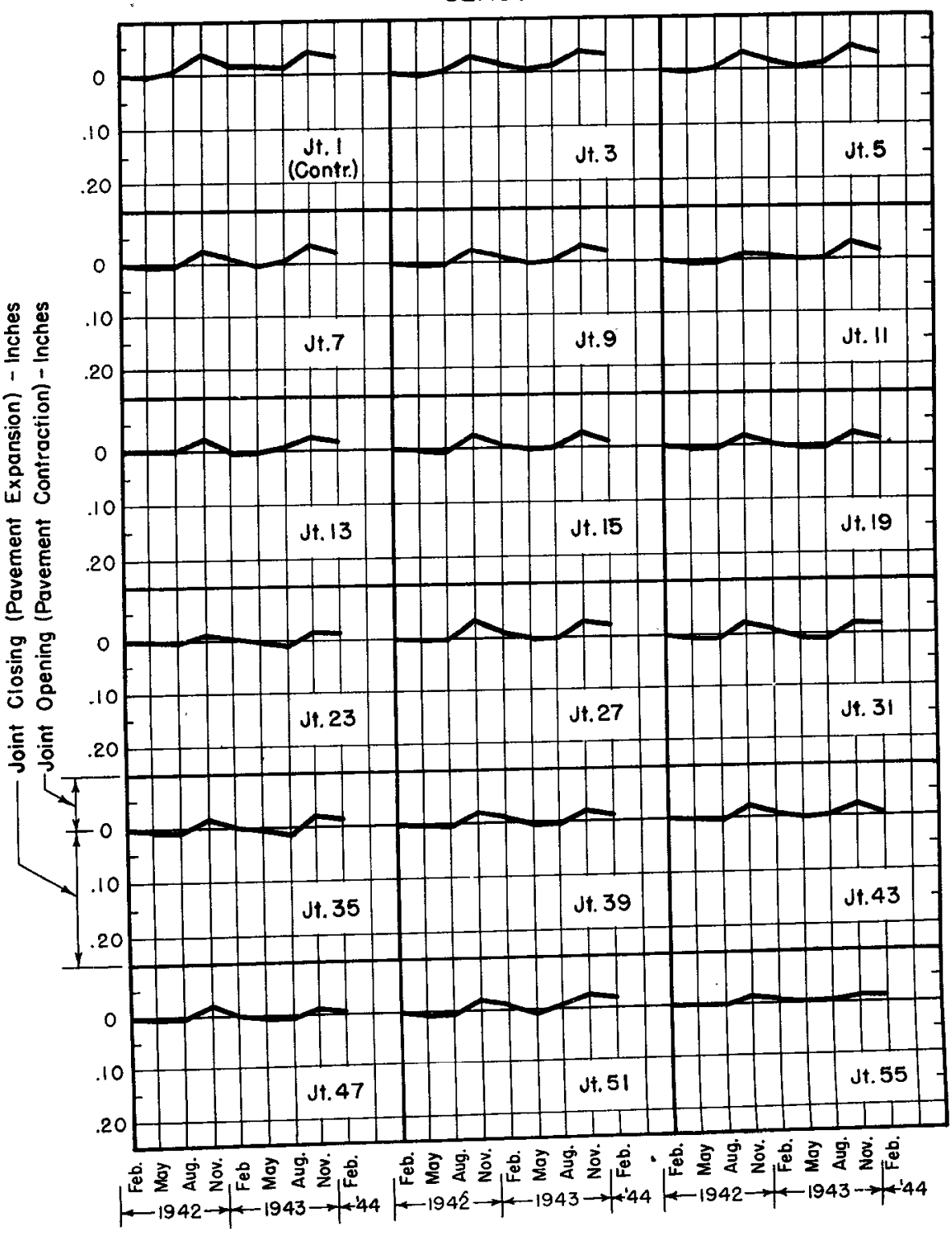


Fig. 23 a.

Sec. I b. (2)

Ventura County Experimental Concrete Pavement

Change in Joint Widths

SEASONAL

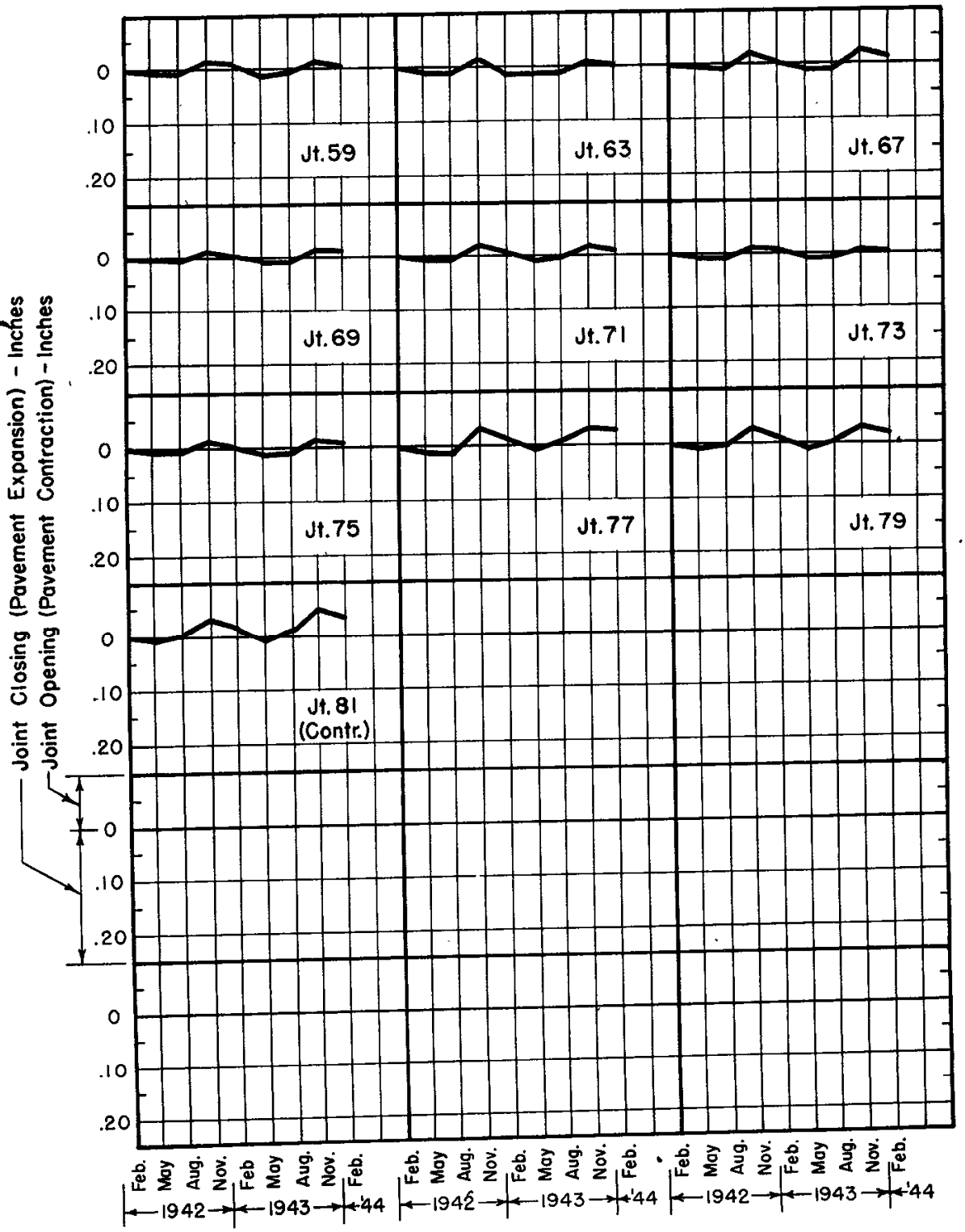


Fig. 24.
Sec. 2 a.(1).

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

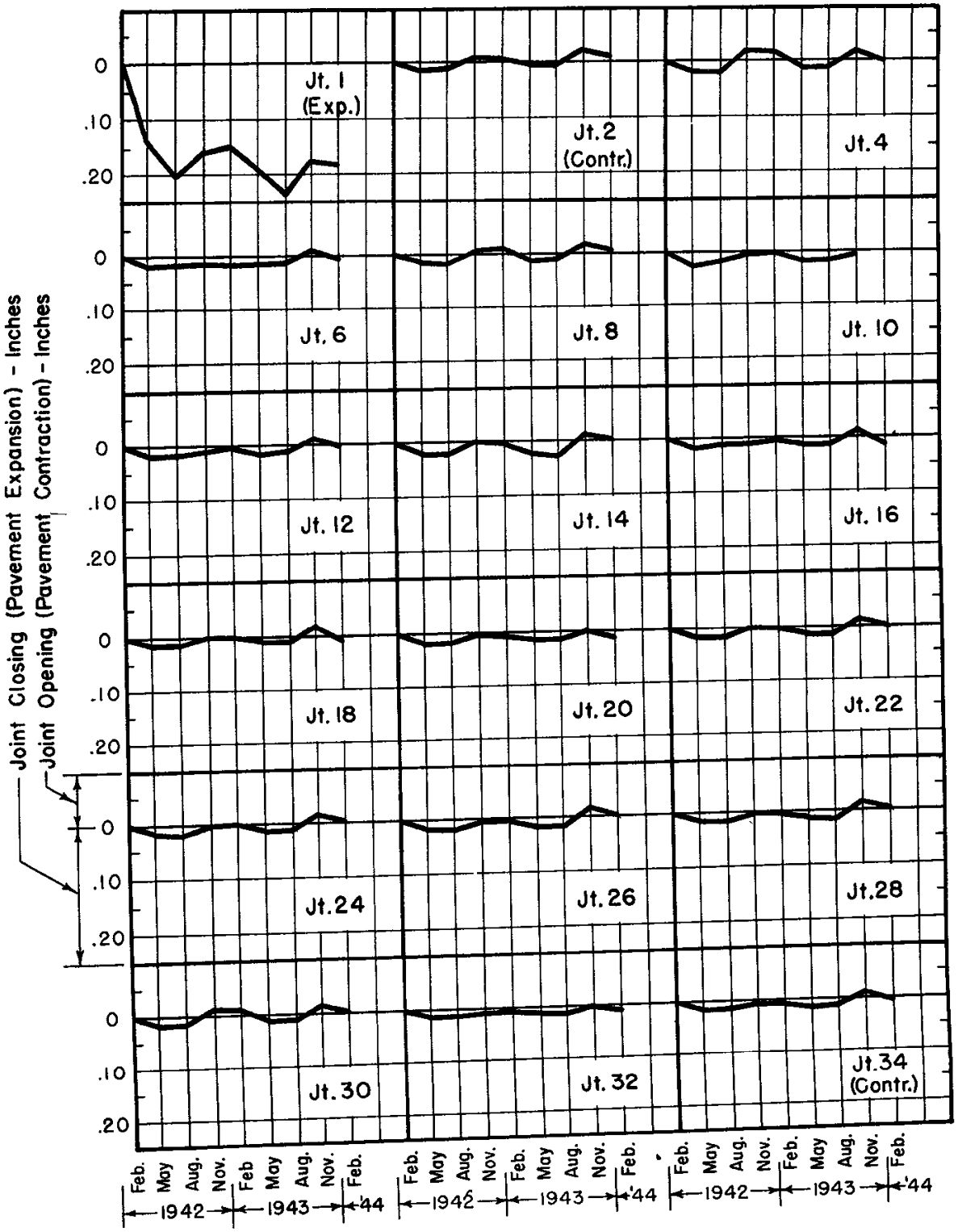


Fig. 24 a.
Sec. 2 a. (2).

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

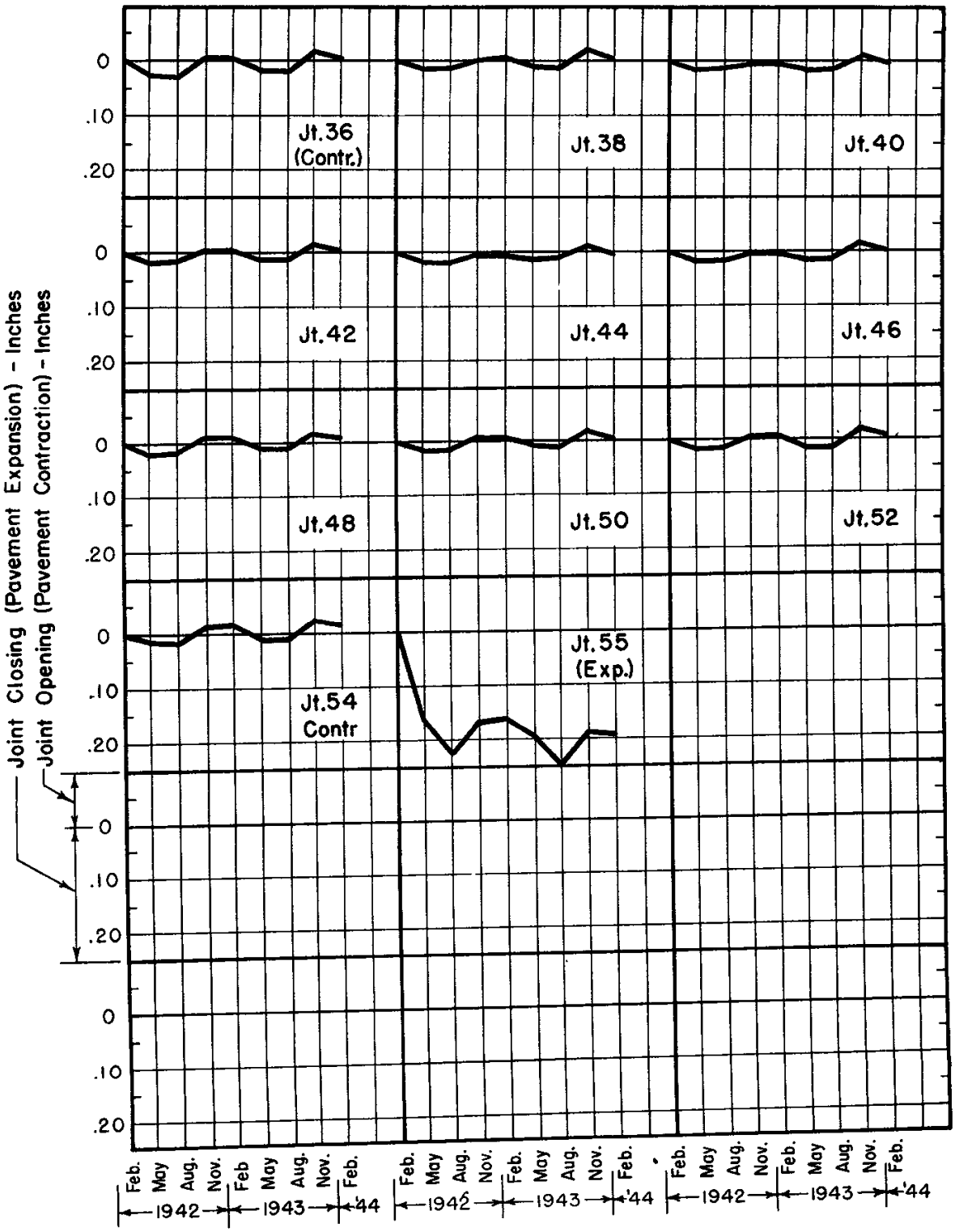


Fig. 25
Sec. 3a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

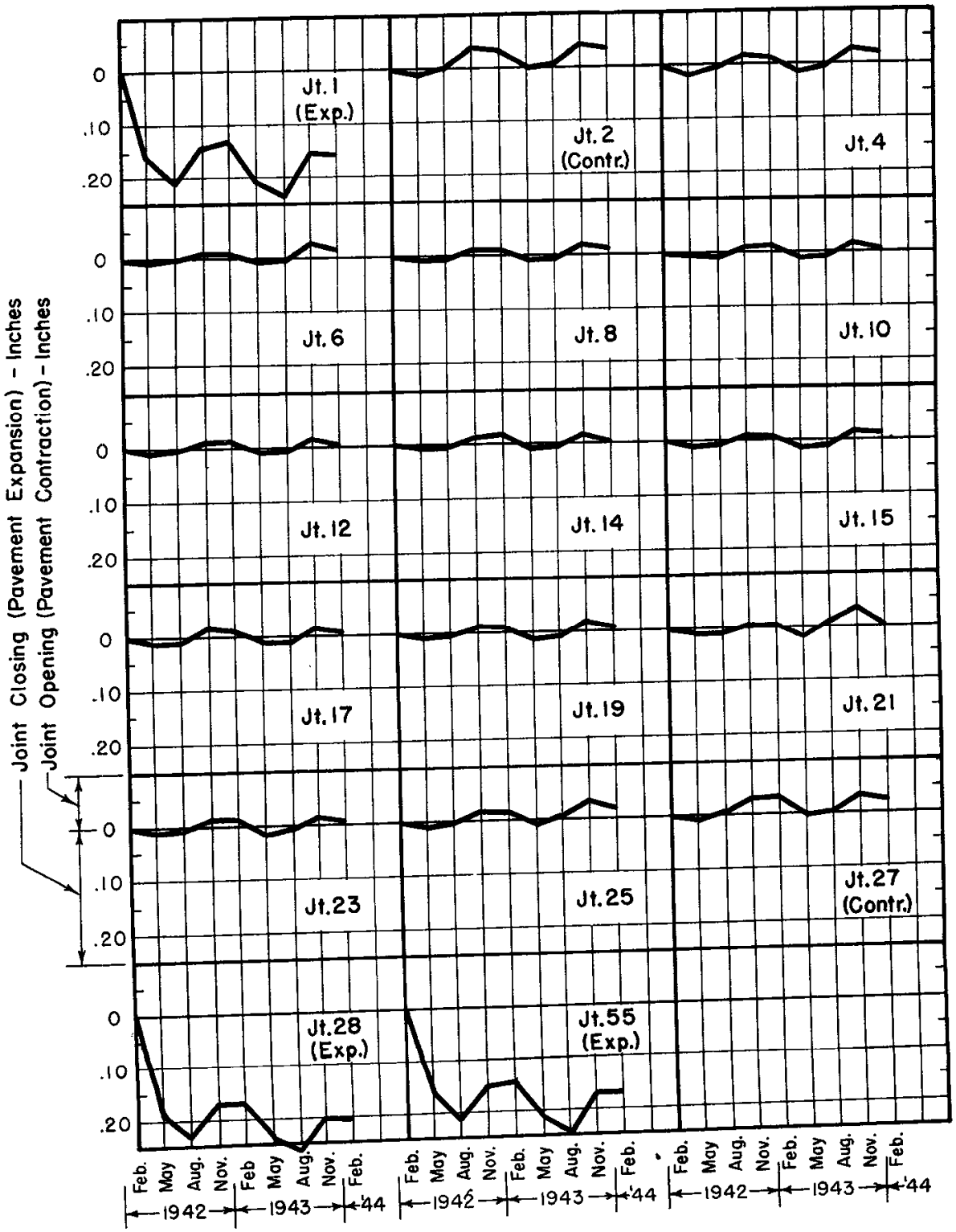


Fig. 26.
Sec. 4 a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

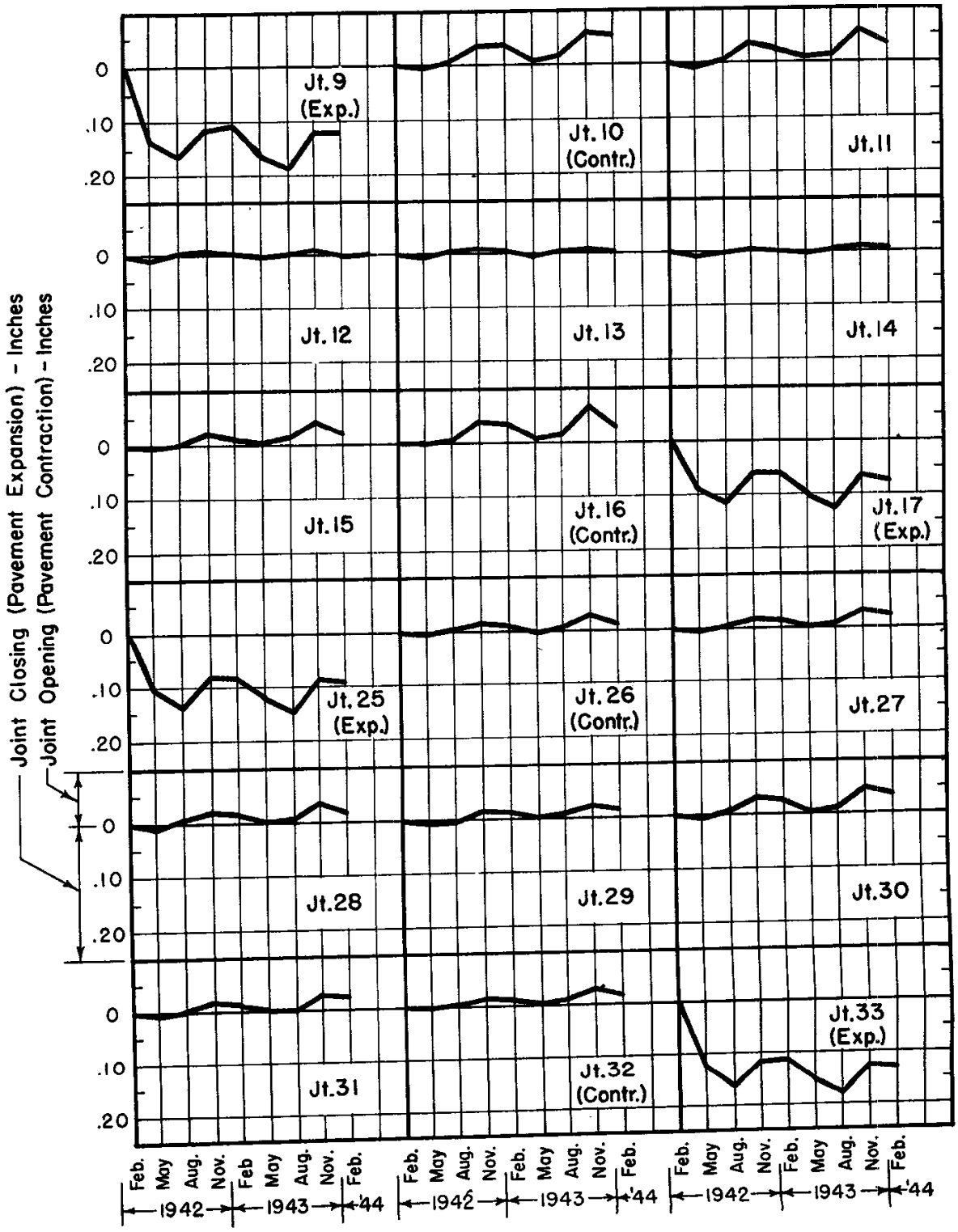


Fig. 27.
Sec. 5a.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

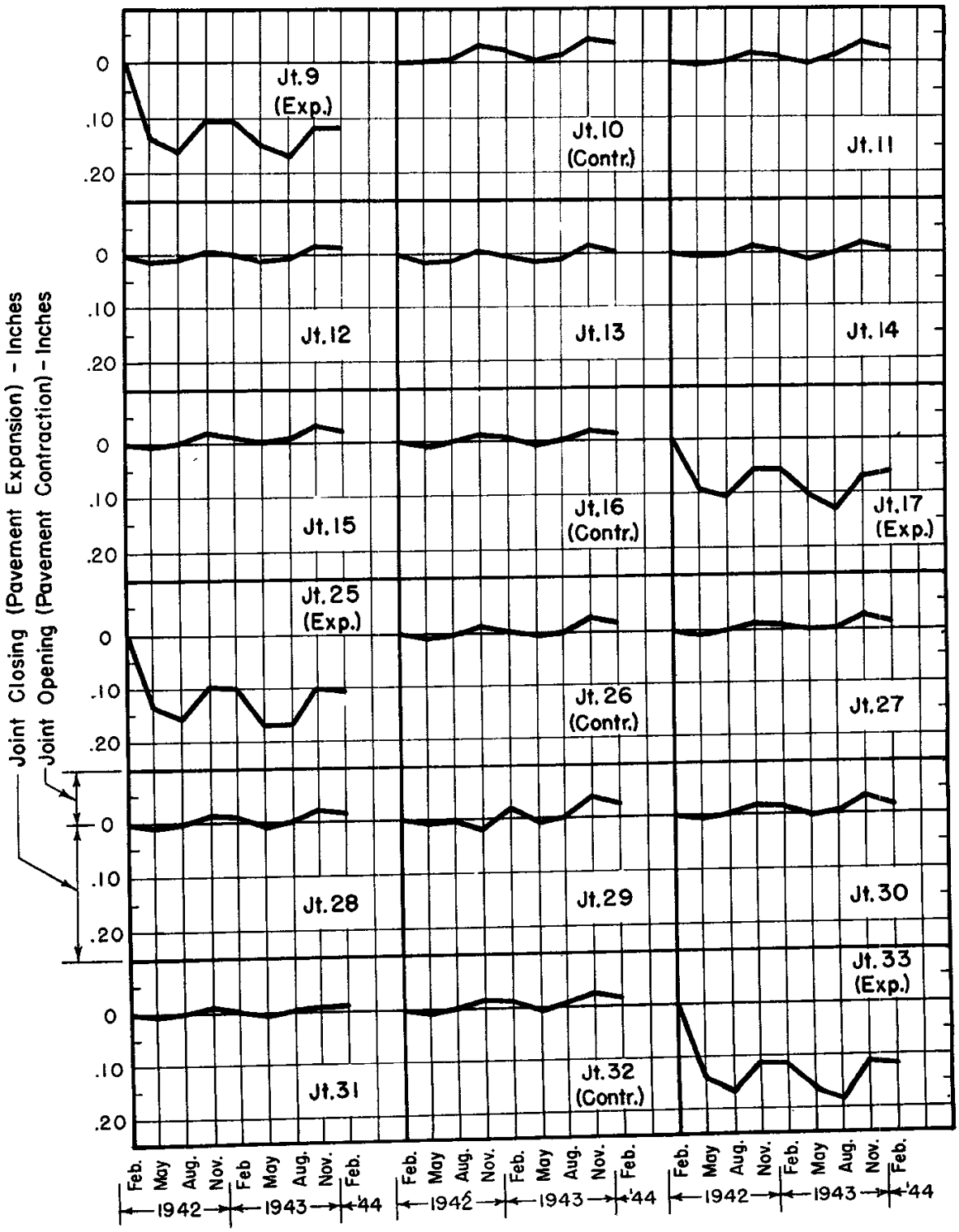


Fig. 28.
Sec. 6b.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL

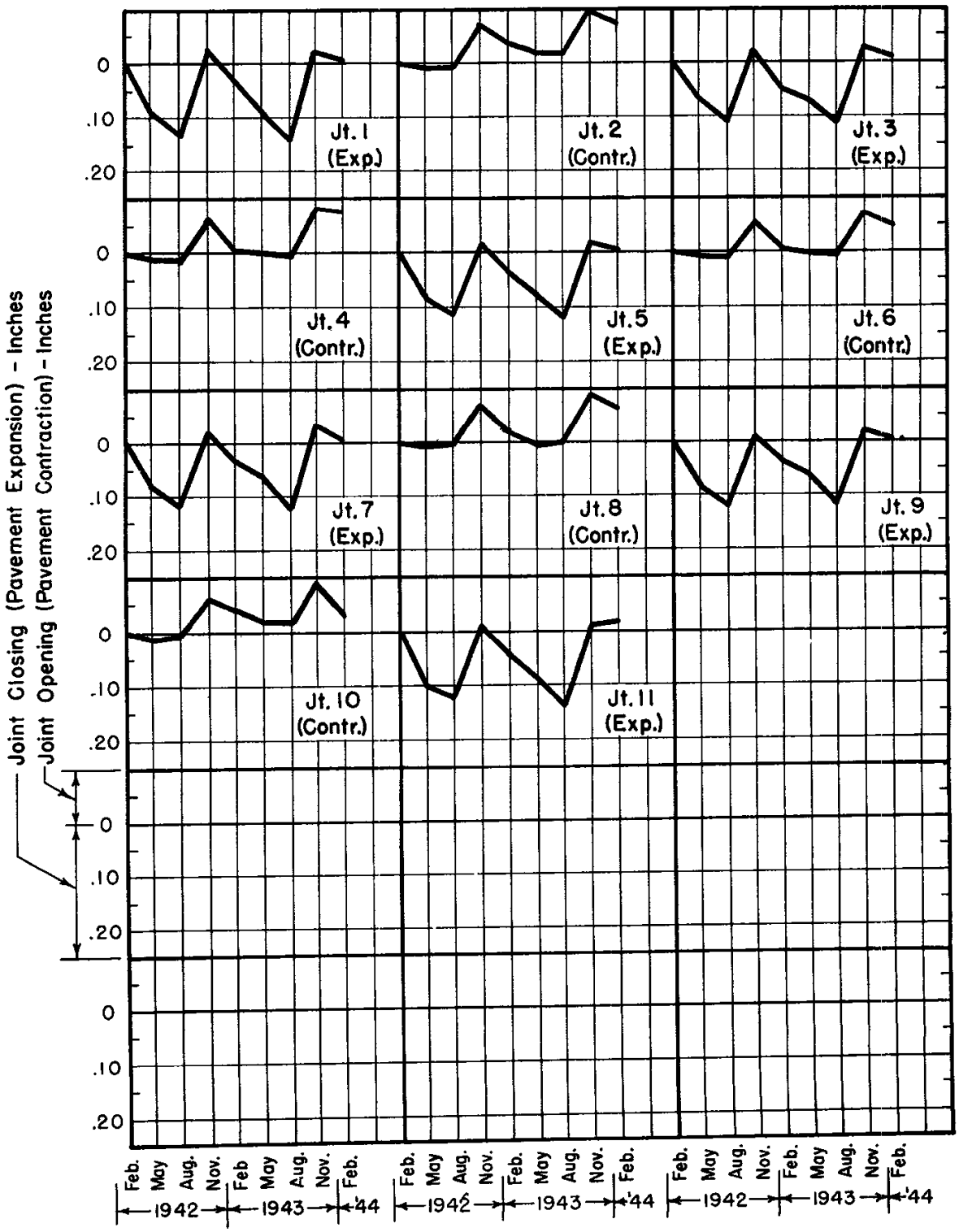
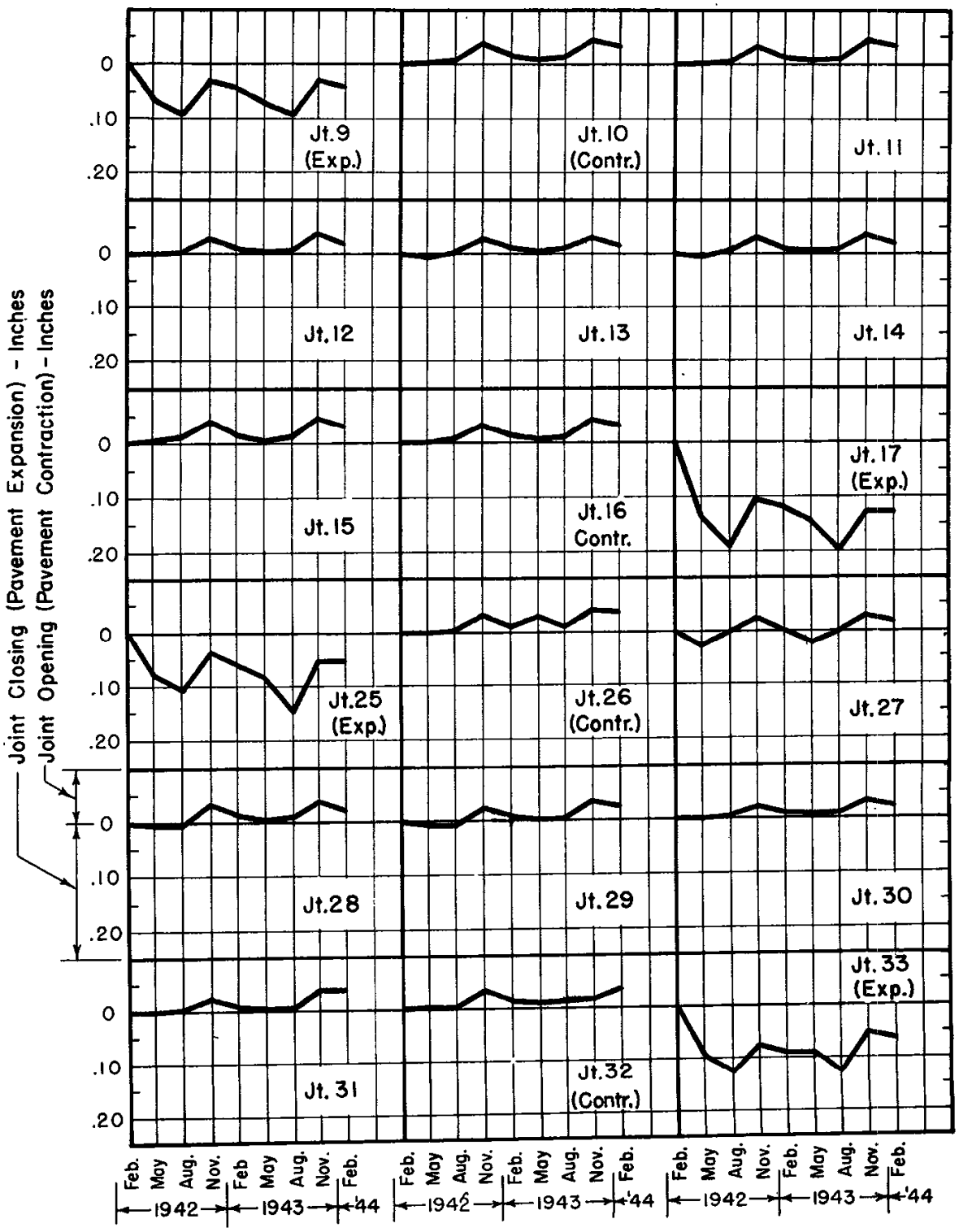


Fig. 29.
Sec. 7 b.

Ventura County Experimental Concrete Pavement
Change in Joint Widths
SEASONAL



Temperature Record from October 17 to 30, 1941

VII-Ven-79C Station 484 + 57

9"-7"-9" Slab Thickness

North Lane

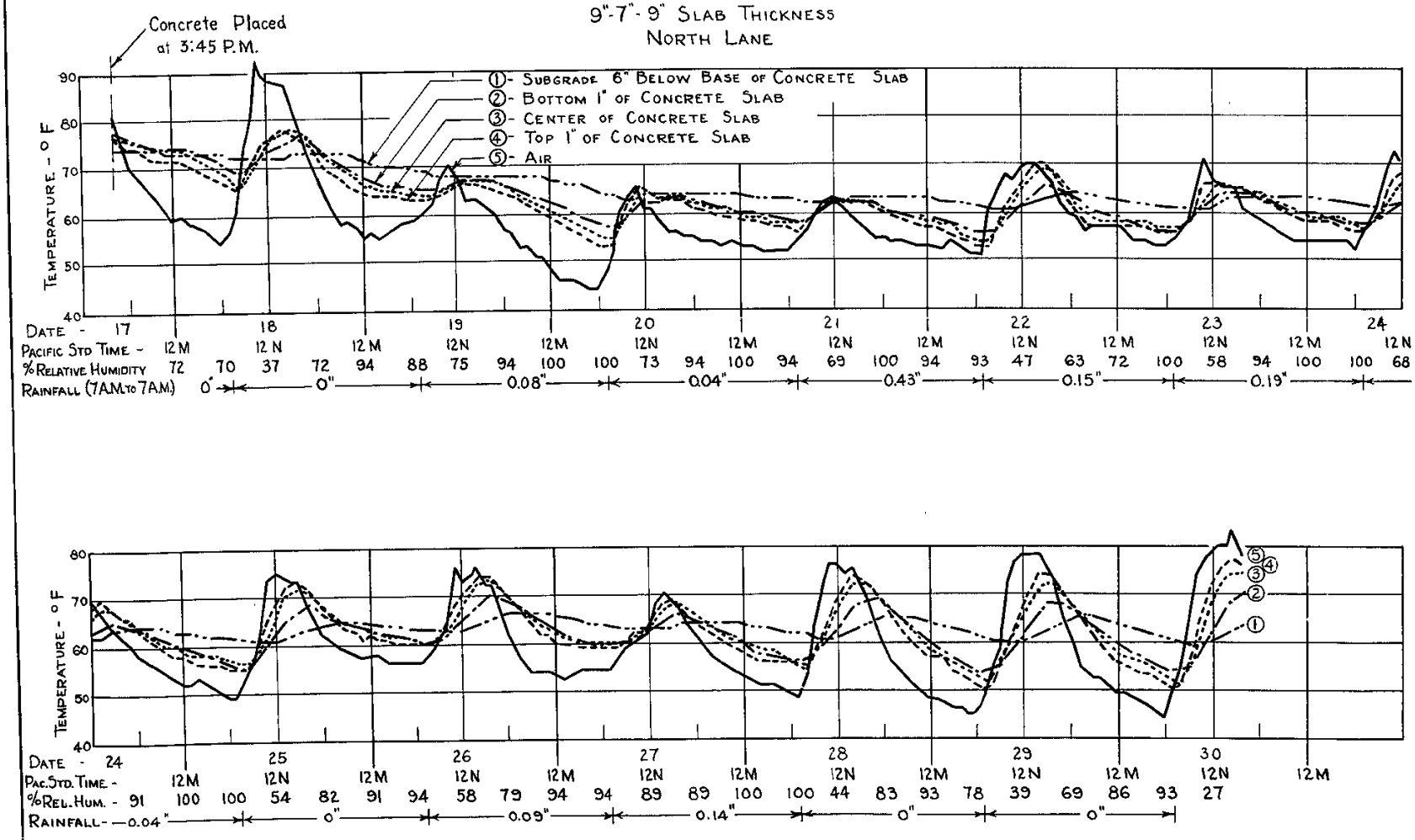
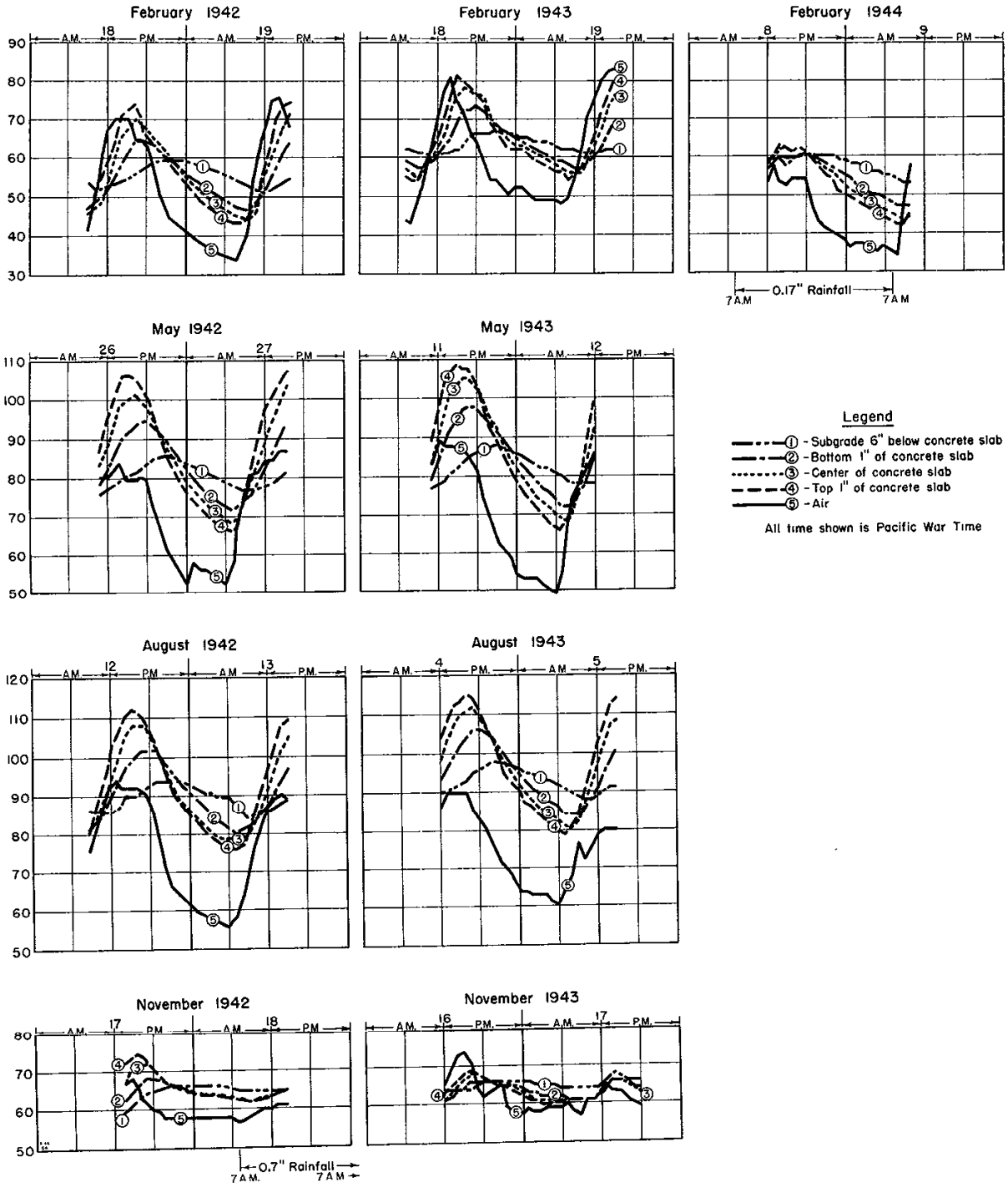


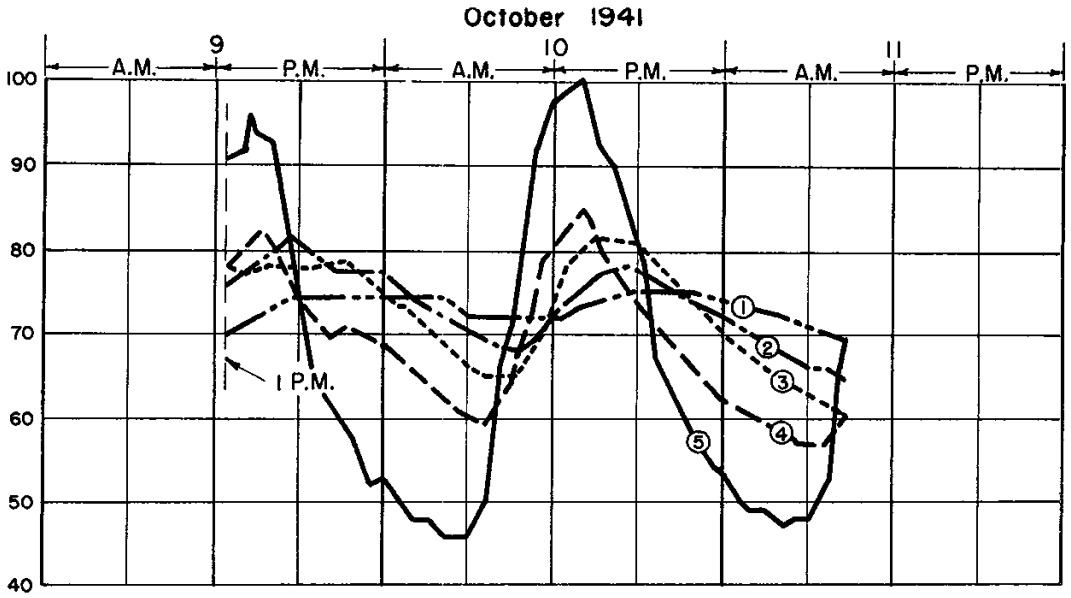
Fig. 30

Daily Temperature Records

VII-Ven-79-C Station 484 + 57
9"-7"-9" Slab Thickness
North Lane

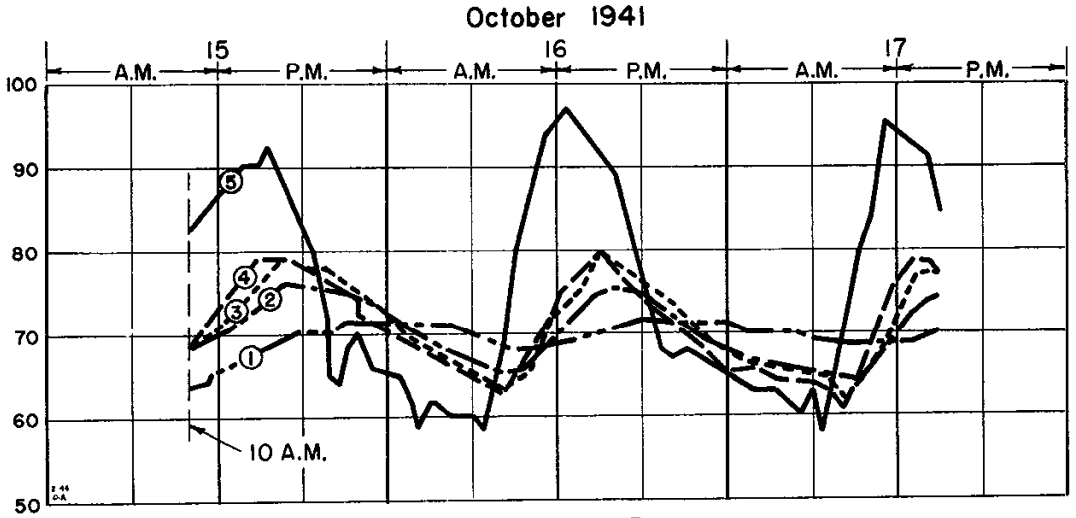


Daily Temperature Records
VII - Ven - 79 - C



SOUTH LANE

Station 656 + 90 8" Uniform Slab Thickness



NORTH LANE

Station 418 + 00 9"-7"-9" Slab Thickness

Legend

①-Subgrade 6" below concrete slab
②-Bottom 1" of concrete slab
③-Center of concrete slab
④-Top 1" of concrete slab
⑤-Air

Time shown is Pacific Standard Time

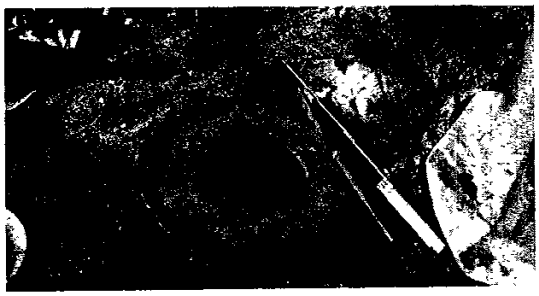
Figure 33

SUBGRADE COMPACTION TESTS

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

Loosening soil preparatory to removal

Placing loosened soil in container

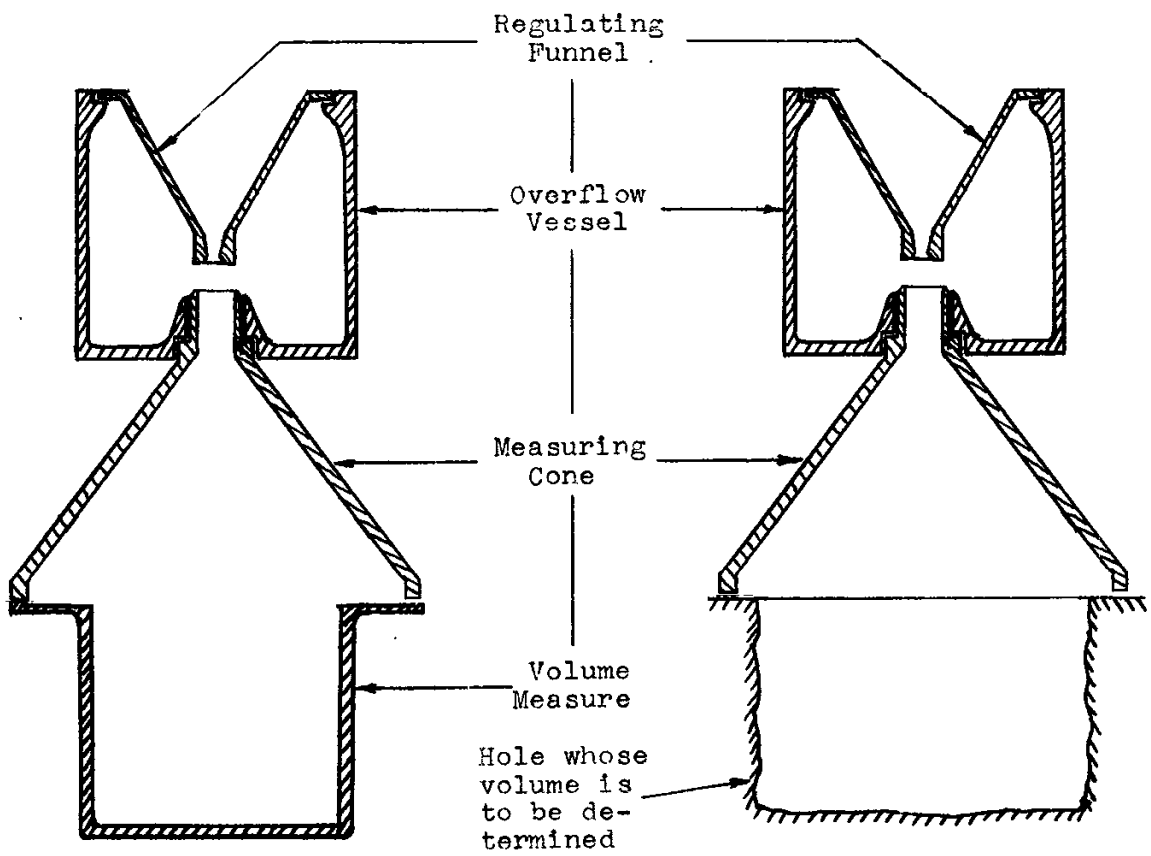


Completed hole after all loosened soil had been removed

Filling the hole and measuring cone with calibrated sand

FIGURE

SAND VOLUME APPARATUS

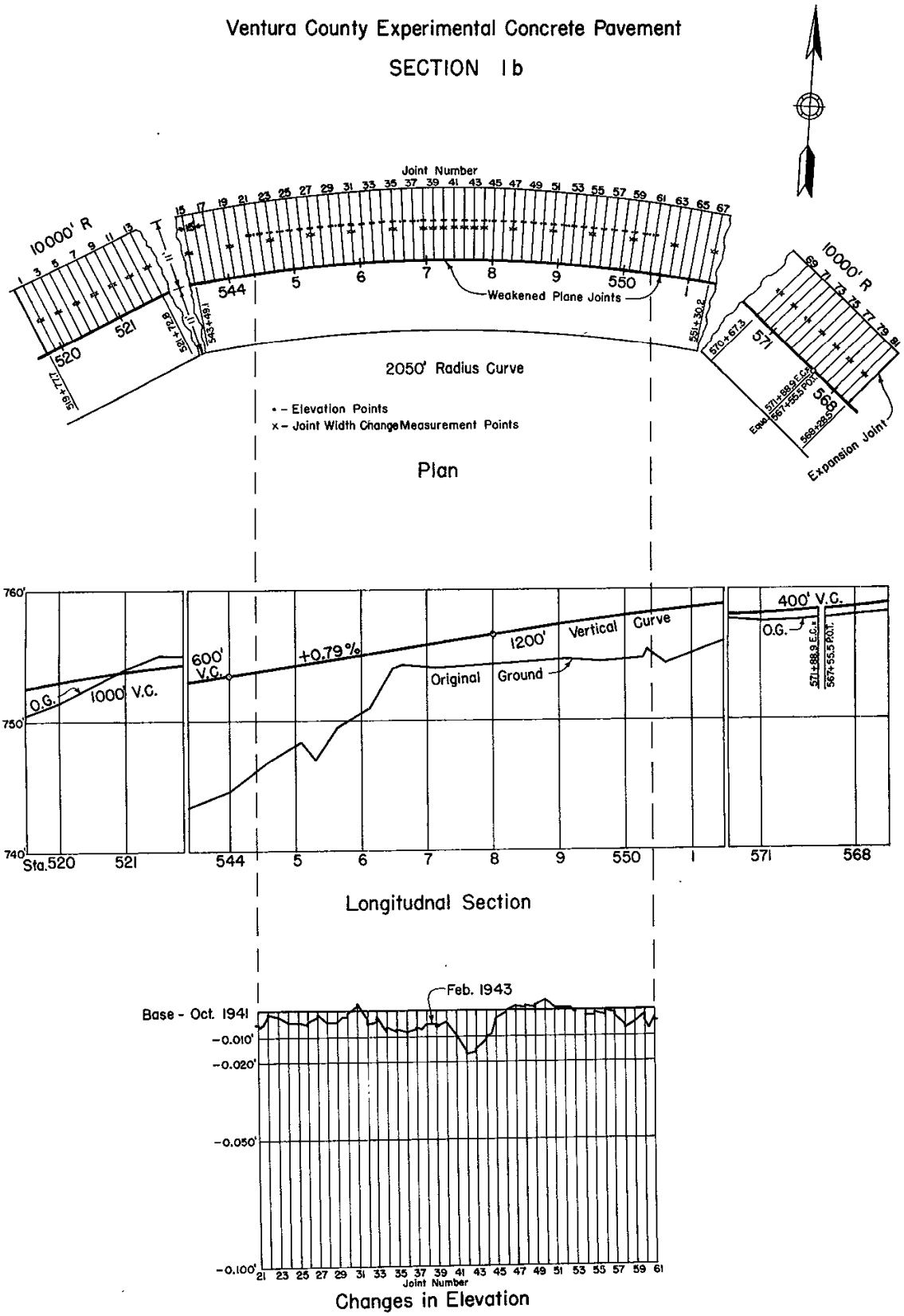


Apparatus set up for a calibration of sand to be used as standard for subsequent density determinations.

Apparatus set up for normal field use over a hole from which the soil has been removed and retained for drying and weighing.

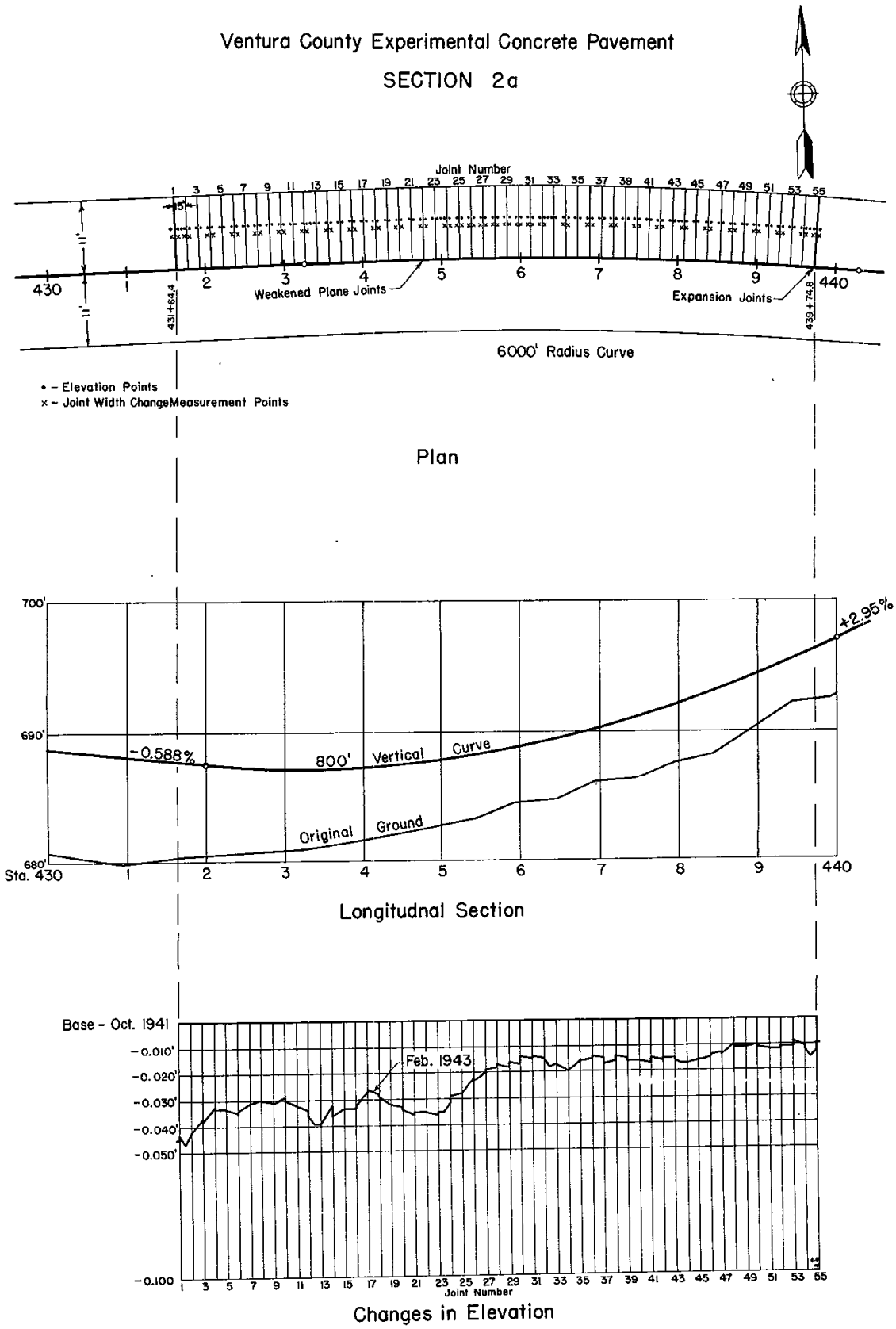
Ventura County Experimental Concrete Pavement

SECTION 1b



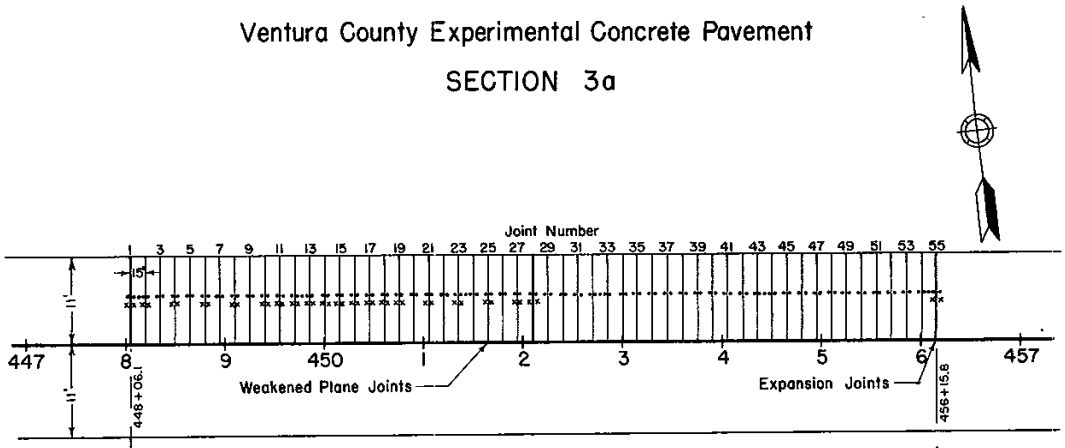
Ventura County Experimental Concrete Pavement

SECTION 2a



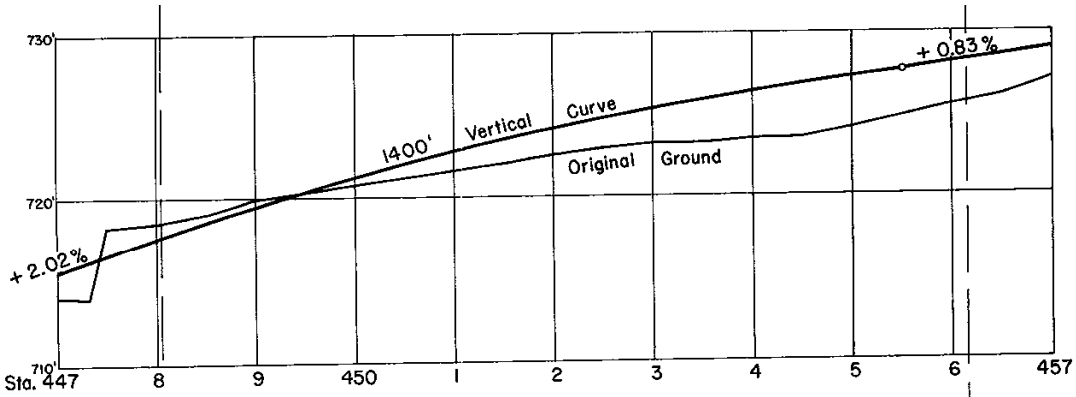
Ventura County Experimental Concrete Pavement

SECTION 3a

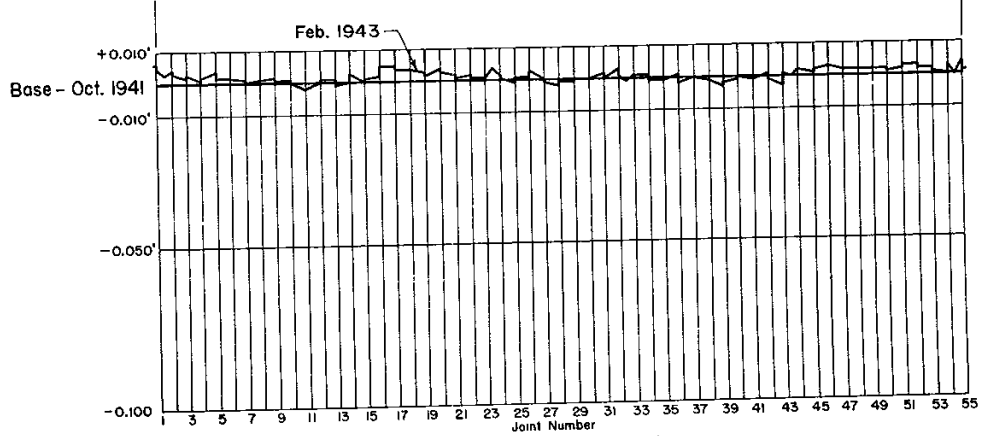


• - Elevation Points
x - Joint Width Change Measurement Points

Plan



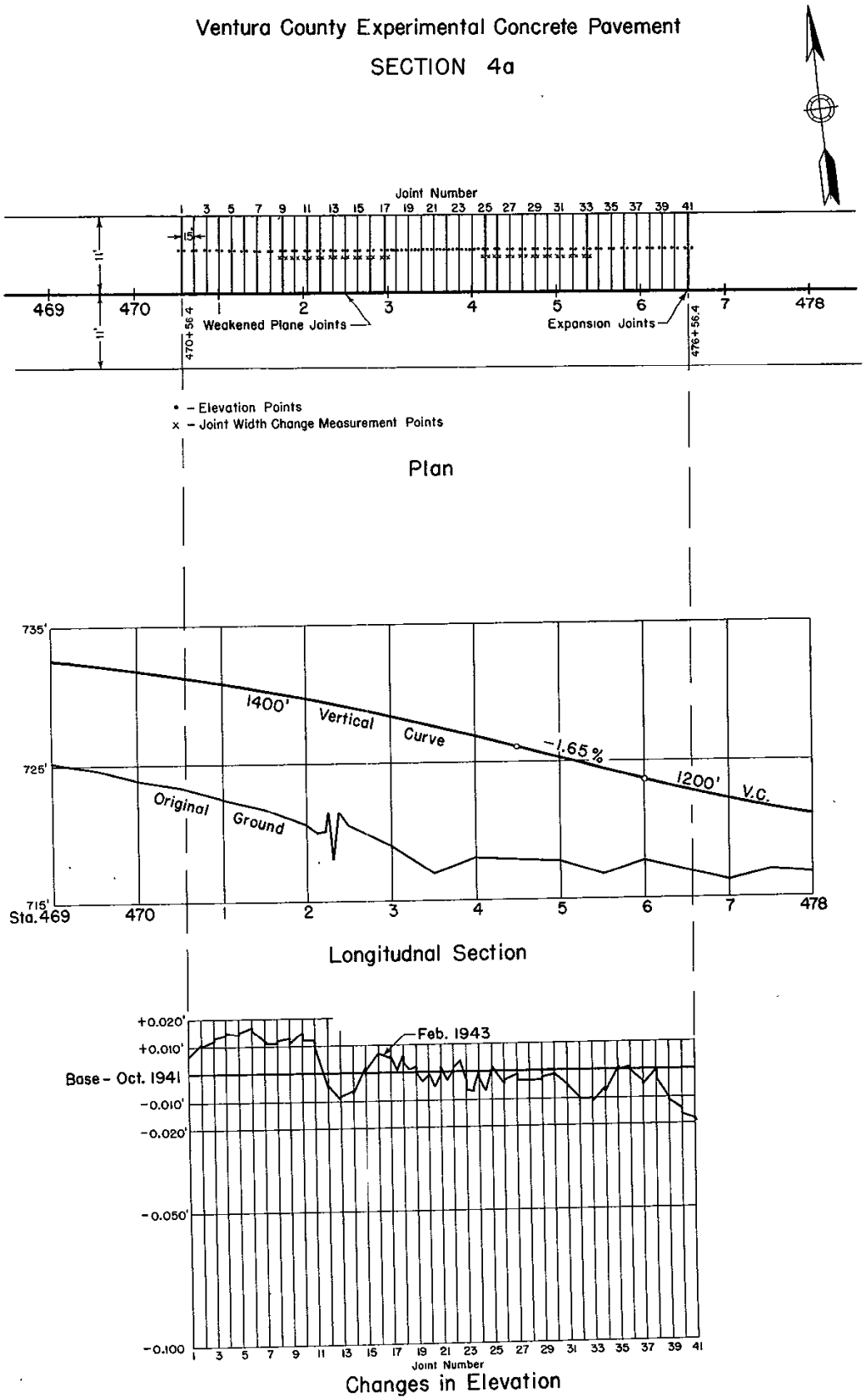
Longitudnal Section



Changes in Elevation

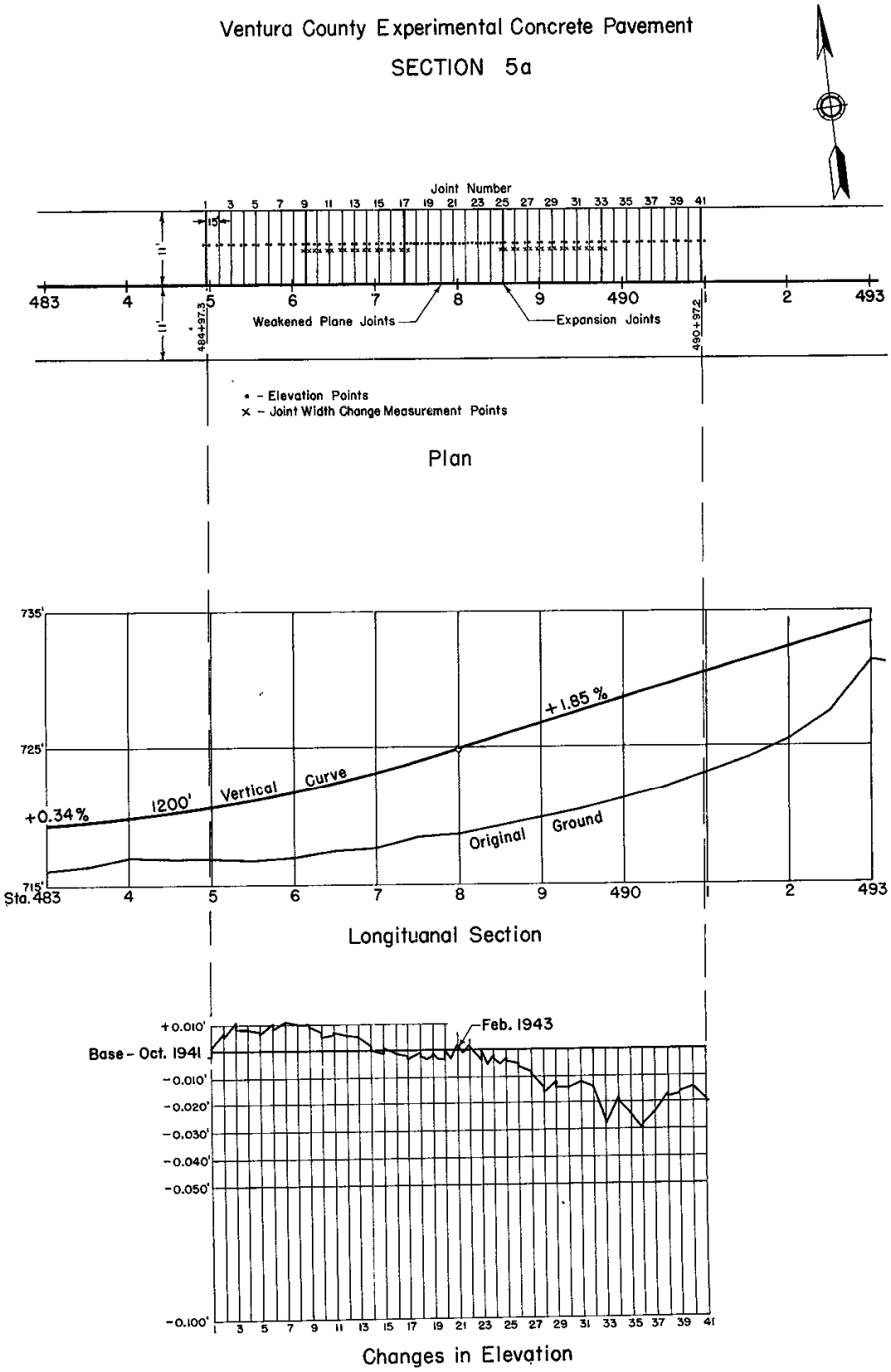
Ventura County Experimental Concrete Pavement

SECTION 4a



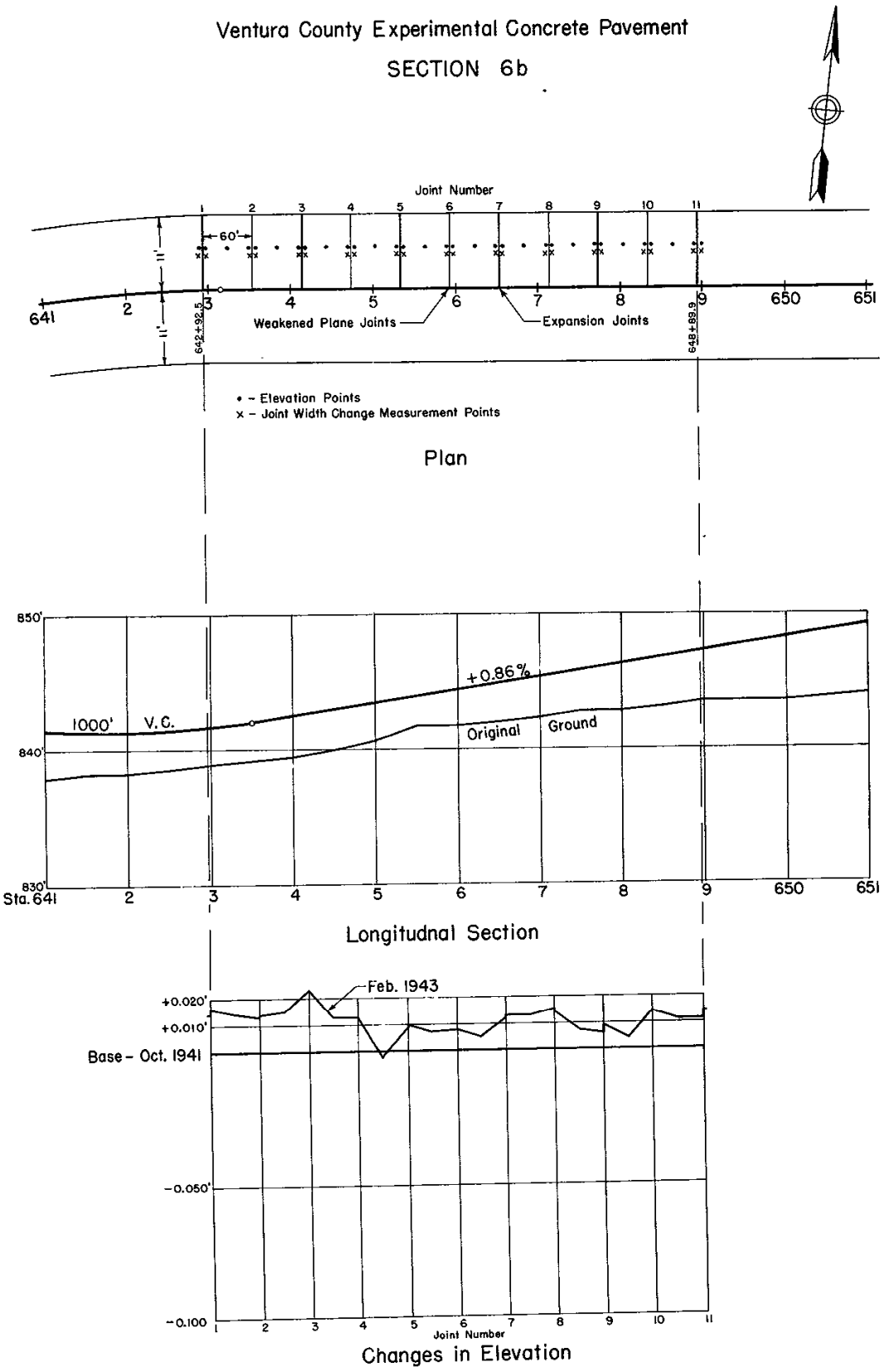
Ventura County Experimental Concrete Pavement

SECTION 5a



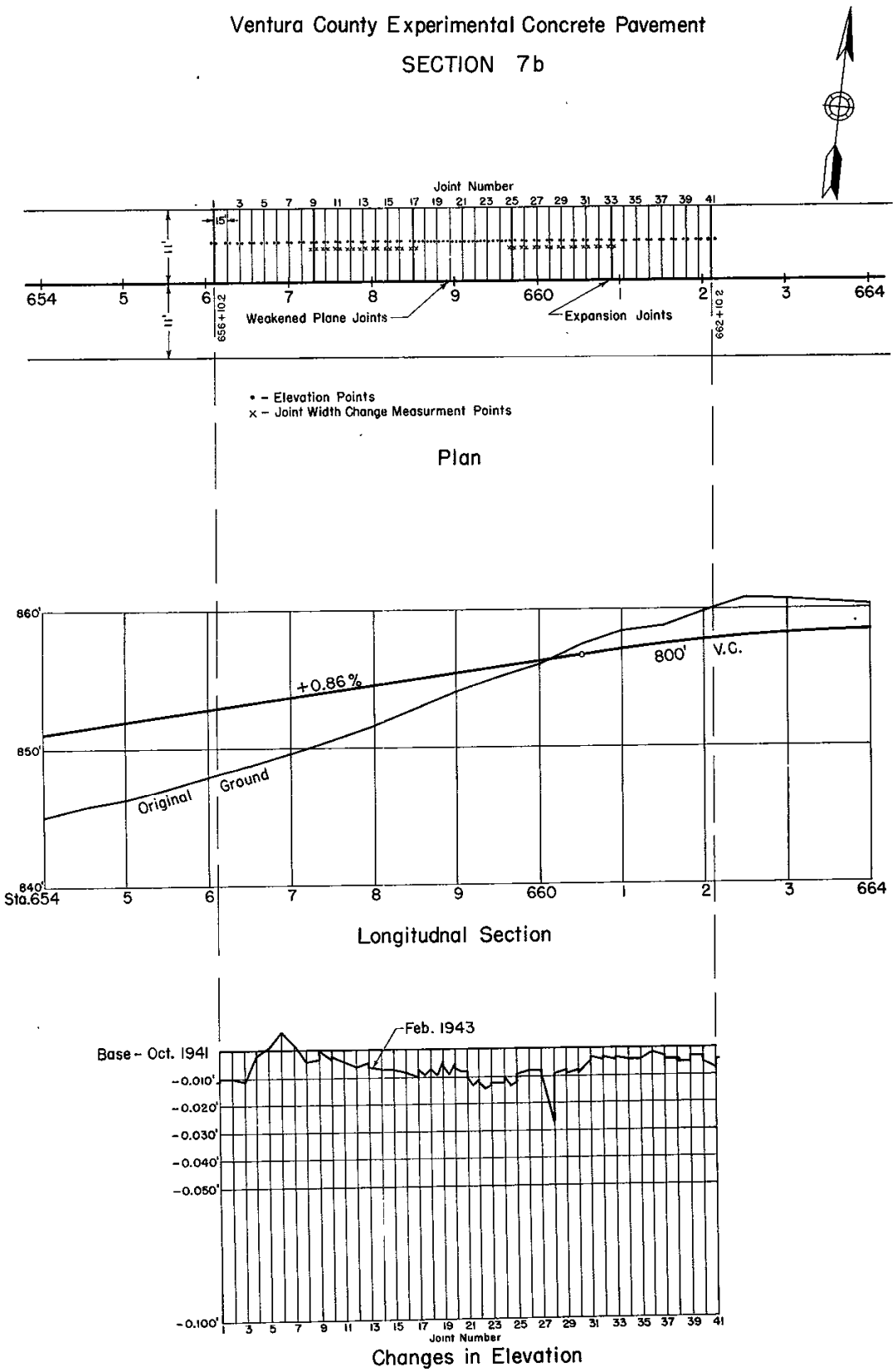
Ventura County Experimental Concrete Pavement

SECTION 6b



Ventura County Experimental Concrete Pavement

SECTION 7b



STATE OF CALIFORNIA

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

APPENDICES TO THE

FIRST REPORT ON THE EXPERIMENTAL CONCRETE PAVEMENT

CONSTRUCTED IN VENTURA COUNTY DURING OCTOBER, 1941.

VII-Ven-79-C Contract 27XC7-P FAP 380-C(1)

1. Appendix A:

   P.R.A. and California Division of Highways Memoranda Describing Project and Outlining Procedure and Tests.

2. Appendix B:

   Instructions and District Reports Covering Embankment and Subgrade Construction.

3. Appendix C:

   Special Modulus of Elasticity Determinations by Dynamic (Sonic) and Compressive (Stress-strain) methods.

4. Appendix D:

   Coefficient of Subgrade Friction.

5. Appendix E:

   Westergaards "K" or Subgrade Factor Determinations.

6. Appendix F:

   Roughness Measurements with Profilometer.

APPENDIX A

P.R.A. and California Division of Highways Memoranda Describing Project and Outlining Procedure and Tests.

M E M O R A N D U M

September 10, 1940

VII-Ven-79-C

Mr. T. E. Stanton:

Reference is made to the concrete pavement experiment proposed for construction between Piru Creek and the Los Angeles County Line on Road VII-Ven-79-C. Under date of September 10, 1940, you are being forwarded a proposed schedule of test and observational procedure submitted by the Public Roads Administration, wherein is set forth the various data which they believe should be accumulated with respect to the experimental installation.

In addition to the information listed by the Federal Roads Administration, it has been the opinion of this Department that certain supplemental information would be of extreme value in later correlation of the test results. We should like very much to have your reactions on this subject, as well as a rough estimate of the probable extra cost involved in obtaining this supplemental data.

Following is a list of the proposed supplemental procedure:

1. A 24-hour record of the temperature gradient within the slab, obtained during the early part of the curing interval and repeated upon several

selected days during the following year. (Note- it is our belief that the above information will make possible an accurate estimate of the probable internal stresses occuring in the pavement slabs during the early period of its life when it is most susceptible to the destructive effects of such stresses).

2. Accurate determination of the modulus of elasticity of the concrete produced on the project, obtained either from test cylinders or test beams at the ages of 7, 28, 90, 180 and 365 days. (Note: - We believe this information will get us important data upon the variations of the modulus of elasticity at various critical ages in the concrete's life.

3. Determination of the coefficient of subgrade friction under actual job conditions. (Note: - See Public Roads Vol. 16, No. 8, Oct. 1935, Pg. 156).

4. Determination of Westergaards "K", or subgrade factor. (Note: - This is a most important factor in Westergaards mathematical analysis of pavement stresses, and it would be very desirable to obtain data upon what the value is for this particular subgrade inasmuch as it will represent about average California conditions).

5. Determination of resistance to compression of the expansion joint filler material used. If it is decided to use a type likely to be effected by temperature, it should be tested for this property within the entire temperature range likely to be encountered in service.

With reference to Item No. 4, the determination of Westergaards factor "K" for the subgrade, we have been unable to find anywhere in the literature any suggested means for determining this factor prior to placing the concrete. However, two methods have been suggested, one by Mr. R. Robertson Rowe of the Bridge Department, and the other worked out by personnel in this office. Neither of these methods has been put to a practical test, and it is intended to present both of the methods for your examination and criticism in the hope that a

FIGURE 1-A

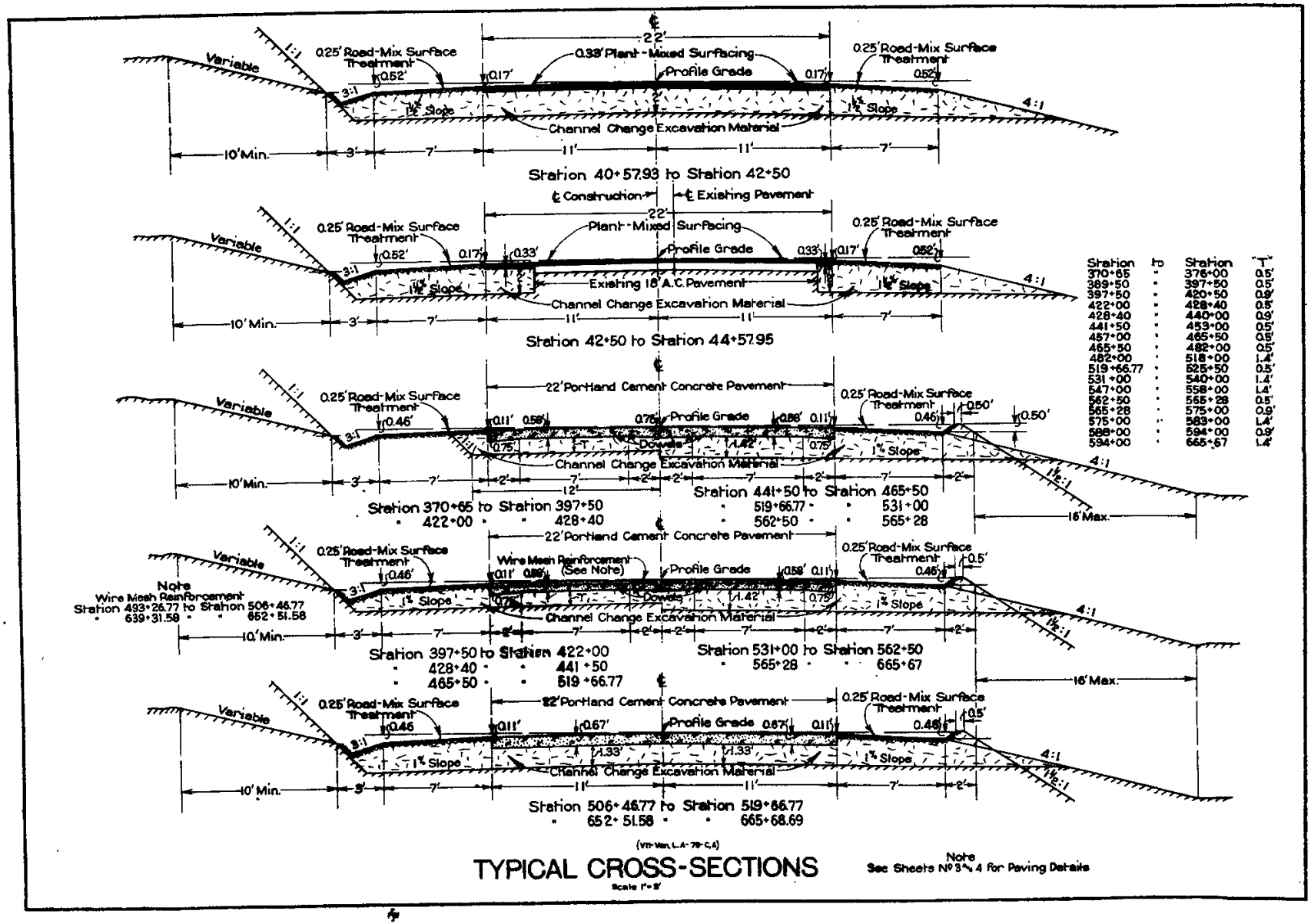


Figure 1-A

FIGURE 2-A

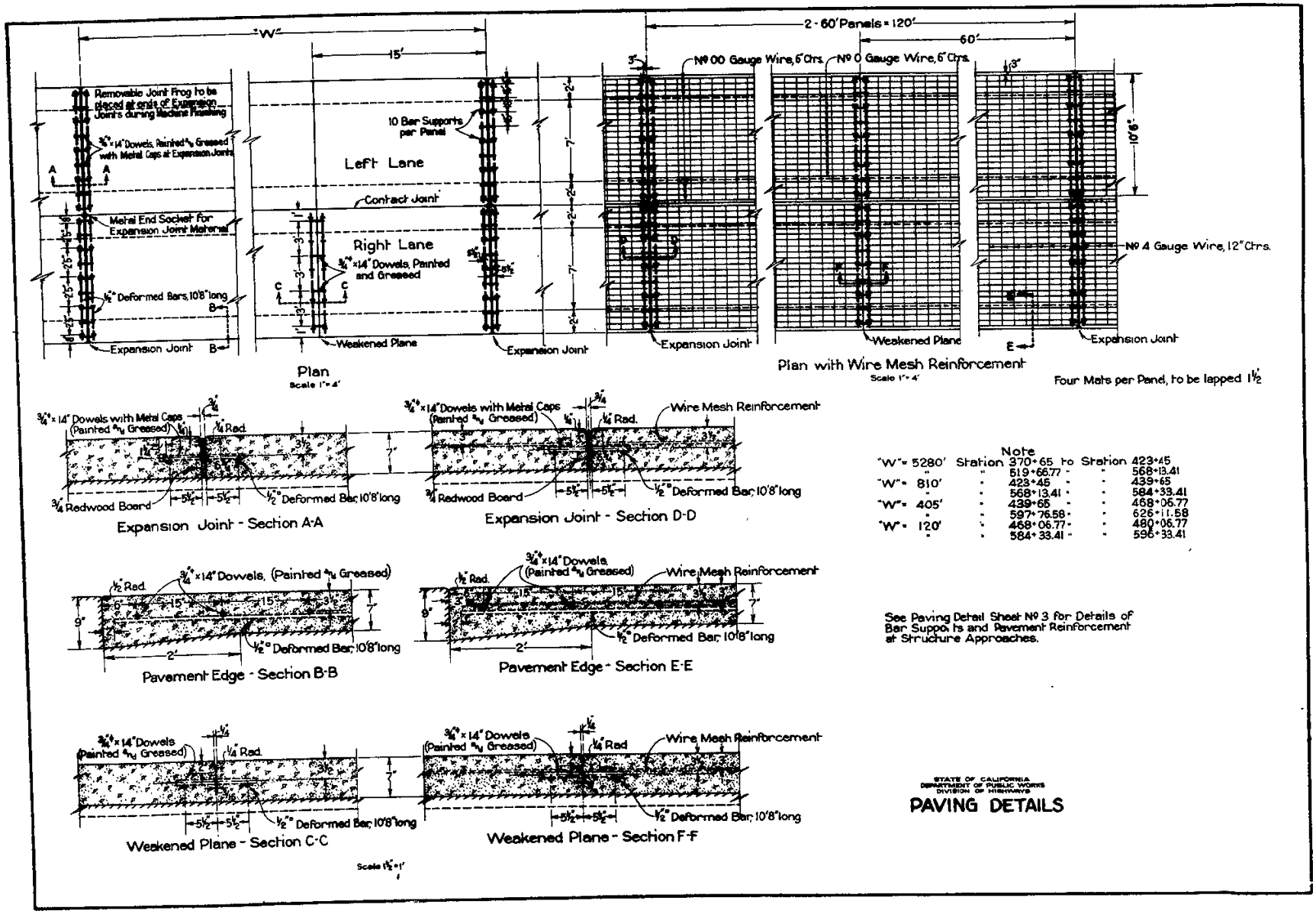
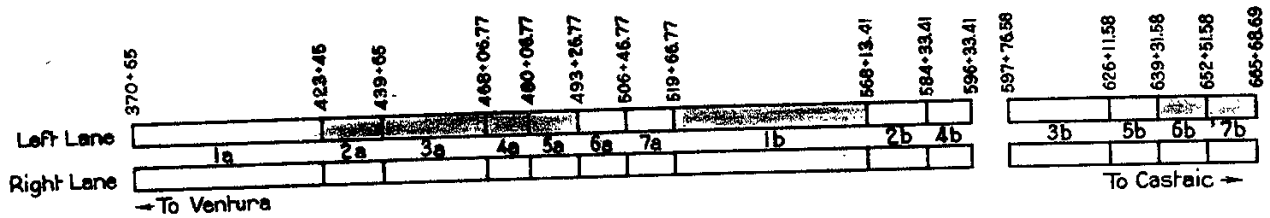


Figure 2-A

FIGURE 3A

Diagram and Table Showing Locations of Various Types of Pavement Construction

DIAGRAM



TABLE

Section	Length		Cross Section	Expansion Joints		Weakened Plane Joints			Reinforcement
	Left Lane	Right Lane		Spacing	Number of Dowels	Spacing	Number of Dowels		
							Left Lane	Right Lane	
1a	5280'	5280'	9"-7"-9"	5280'	9	15'	0	4	None
1b	5280'	5280'	9"-7"-9"	5280'	9	15'	0	4	"
2a	1620'	1620'	9"-7"-9"	810'	9	15'	0	4	"
2b	1620'	1620'	9"-7"-9"	810'	9	15'	0	4	"
3a	2835'	2835'	9"-7"-9"	405'	9	15'	0	4	"
3b	2835'	2835'	9"-7"-9"	405'	9	15'	0	4	"
4a	1200'	1200'	9"-7"-9"	120'	9	15'	0	4	"
4b	1200'	1200'	9"-7"-9"	120'	9	15'	0	4	"
5a	1320'	1320'	9"-7"-9"	120'	9	15'	9	9	"
5b	1320'	1320'	9"-7"-9"	120'	9	15'	9	9	None
6a	1320'	1320'	9"-7"-9"	120'	9	60'	9	9	Wire Mesh
6b	1320'	1320'	9"-7"-9"	120'	9	60'	9	9	Wire Mesh
7a	1320'	1320'	8" uniform	120'	0	15'	0	0	None
7b	1320'	1320'	8" uniform	120'	0	15'	0	0	None

simple and efficient means of obtaining this factor can be worked out for use on this project.

We believe the above supplementary tests are all pertinent to the problem being investigated, and, as stated above, we would be pleased to have your reaction with respect thereto.

(Signed) Fred Grumm
Engineer, Surveys and Plans

Sept. 10, 1940.

OUTLINE OF PROPOSED EXPERIMENTAL CONCRETE PAVEMENT CONSTRUCTION

ON

ROAD VII-VEN-79-C

BETWEEN PIRU CREEK AND LOS ANGELES CO. LINE

Object

The purpose of this proposed experimental work is to study the desirable spacing of transverse expansion joints in concrete pavements and the amount of expansion space required per unit of pavement length and to study the efficiency of dummy contraction joints with and without dowels or other devices for the transfer of load.

Procedure

Efficiency of Dummy Contraction Joints

It has been found to be impractical to make the measurements of the stress deformations in the concrete necessary to the determination of joint efficiency upon pavements bearing traffic. It is therefore proposed to study the action of transverse dummy joints in full size pavement slabs that will not be subjected to traffic.

This study will be carried on at the laboratories of the Public Roads Administration.

Detail of Proposed Experiment

1. Selection of Project.

A review of the proposed highway between Piru Creek and L. A. Co. line, Road VII-Ven-79-C, disclosed that ample material of uniform quality was available for the construction of a blanket under the pavement of suitable thickness for the purposes of the experiment and that grades and curvature were not of a nature to prejudice the results obtained.

No other concrete pavement job of sufficient magnitude and possessing the other attributes essential to the test being in immediate prospect, it was decided to conduct the experiment thereon.

2. Cross-Section

With the exception of Section *7a and 7b the proposed pavement will consist of two lanes each eleven feet in width and 9"-7"-9" in cross-section. (See Fig. 1 and 2). It is proposed to construct Sections *7a and 7b in two eleven foot lanes uniformly 8" in thickness.

3. Concrete.

The following characteristics of the concrete entering into the construction of the pavement are to be studied:

Modulus of Elasticity
Compressive Strength
Flexural Strength

These tests will be performed in such a sequence that their magnitudes may be plotted against time to provide a curve to aid in the analysis of the subsequent performance of the pavement.

It is proposed to include a rigid concrete specification in the special provisions to insure the utmost practical uniformity in the concrete entering into the pavement.

4. Expansion Joints

All expansion joints are to consist of 3/4" redwood boards, composed of redwood weighing not to exceed 20 lb. per cu. ft.

*In the following discussion the term SECTION is used to denote a length of pavement of a certain design; SUBSECTION is used to denote a part of a section between two expansion joints while the term SLAB refers to a unit of pavement length between two contraction joints or between an expansion and a contraction joint.

5. Contraction Joints

Contraction joints are to be of the grooved dummy type and the spacing in the unreinforced sections is to be 15 feet. Spacing of contraction joints on the reinforced sections, Section 6a and 6b, is to be 60 ft.

6. Reinforcement

Sections 6a and 6b are to be reinforced with wire mesh consisting of mats 10'-6" wide by 16 feet long with #4 gage transverse wires at 12" centers and #0 gage longitudinal wires at 6" centers except the outer four wires on each side which will be #00 gage wires at 6" centers. See Figure 2.

The remaining sections are not reinforced.

Description of Sections

See Figure 3 attached.

PROGRAM OF OBSERVATION

It is proposed to adopt the following Program of Observations prepared by the Public Roads Administration and to augment it with measurements of the temperature gradient within the slab, the modulus of elasticity of the concrete produced on the project, the coefficient of subgrade friction, the resistance to compression of the expansion joint material, the overall movement of one lane of Section 1b and if possible the value of the subgrade factor "k".

June, 1940

OBSERVATIONS AND MEASUREMENTS ON PROPOSED EXPERIMENTAL CONCRETE PAVEMENT CONSTRUCTION

This outline covers the suggested preliminary and daily observations during the construction of the experimental concrete pavement projects. Complete details for the measurement of seasonal changes and permanent changes in width of joints, elevation measurements and crack surveys are covered in a separate outline entitled: "Suggested Program of Observations for the Cooperative Investigation of Joint Spacing in Concrete Pavements" and in the drawings which accompany it.

PRELIMINARY AND DAILY OBSERVATIONS DURING CONSTRUCTION

A. Preliminary Data:

1. Obtain specifications, including special provisions and proposal for project with unit prices bid.
2. Obtain complete set of plans, showing all cross sections, place, profile pavement details and all sheets showing standard and special designs.
3. Get data from soil survey of site, tied into stationing on plan and profile sheets.
4. Get data on source and type of all materials, including cement, coarse aggregate, fine aggregate, joint materials, steel for dowels, tie bars, mesh reinforcement, etc., and also results of acceptance tests.
5. Arrange for forms for beams, facilities for curing, transporting and testing. See under "C" for -

instructions on number of beams to be made, how they are to be cured, shipped and tested.

6. Arrange to receive daily reports from nearest U. S. Weather Bureau Office. These to include record of temperatures, rainfall, etc.

7. Equip yourself with necessary thermometers, camera and accessories, record books, tape measures, folding scales and counters. At least two thermometers should be available with a spare to replace breakage.

8. Arrange to receive data on mixtures used, slump tests, yield tests and other data which the resident engineer or the regular inspectors on the job may have.

9. List and describe all construction equipment and report its condition.

B. Daily Observations:

1. Record full data on weather:

   Temperature

   Sunshine or clouds

   Wind direction and relative intensity

2. Record hours of work with stationing.

3. Record details of concrete mixture as received for resident engineer and inspector, with stationing of any major changes.

4. Take and record temperature of concrete at time of final finish. At that time concrete should be plastic enough to permit the insertion of a thermometer into the slab approximately one-half way to the subgrade.

A hole in the slab shall be made by means of a pin. If this is found impractical, the measurement shall be made earlier and the circumstances recorded. The practice in taking temperature readings should remain unchanged throughout the project. More detailed temperatures of the pavement slab during the hardening period should be taken at least three points on each project. Following the initial readings outlined above, subsequent temperatures shall be observed and recorded at periods of approximately three hours until the maximum temperature of the slab has been reached. One of these points should represent pavement placed during the morning, one near midday and one in the midafternoon.

5. Record time interval between placement of concrete, final finishing and initial curing.

6. Report conditions of subgrade, changes in type of soil, condition in respect to moisture content, and composition.

7. Observe closely installation of all joints, recording their stationing. Especially note whether they are properly aligned and supported and record stationing of any in which there is doubt as to accurate alignment and firm support. Observe and record pointing and greasing of dowels where used and use or omission of caps (sleeves to provide expansion space).

8. If road is built half at a time, observe and record straightening of tie bars. Was there breakage? Were bars satisfactorily straightened?

9. Where poured type dummy groove transverse joints are used, measure and record depths of dummy joint at three places. If premolded strip of bituminous felt or sheet metal is used, observe and record width of strip and depth of insertion.

10. Make same measurements and observations on longitudinal dummy center joint if used, measuring depth about every 10 feet.

11. Observe and record appearance of concrete, its workability, slump, excess or deficiency of mortar, tendency to segregate, tendency to bleed, time required to harden and any unusual features which may appear.

12. Observe and report details of finishing operations, including time interval after mixing of concrete. Observe and report on edging of the joints, the radius of the edger used, and whether there is an accumulation of mortar or if any concrete or mortar must be added to properly finish the joints.

13. Observe and report full details of curing, especially how soon it starts and how continuously the covering is kept wet. How long continued?

14. Report on operating of construction equipment and skill or lack of skill on part of workmen. Report any changes in equipment that may take place, describing new equipment.

15. Observe removal of forms and edges of concrete following removal. Record condition.

16. Observe and report on joint sealing operations, Materials used and care with which work is done.

17. Take sufficient pictures, properly identified, to illustrate all phases of the project.

C. Test Specimens, Plugs and Temperature Wells:

1. Specimens for volume change and modulus of elasticity. 1 beam 6" x 6" x 20" or longer from each section of the project (13 specimens from project with a normal number of sections listed in "Outline of Proposed Experimental Concrete Pavement Construction," dated February, 1940). These specimens shall be cured one day in the forms under wet burlap and for six days in wet sand or wet earth. The specimens shall be cast from concrete which is typical of that used throughout the section and shall be from the approximate center of the section. Each beam shall be marked with black paint indicating the section from which it was cast and the date cast. These beams, after curing, shall be held until all the beams of this type are ready for shipment when they shall all be shipped together, by freight, to the laboratory of the Public Roads Administration, Arlington Experiment Farm, Rosslyn, Virginia.

2. Three test beams 6" x 6" x 36" shall be cast each day. These beams shall be made and tested as prescribed in AASHO Method T-97-37 "Standard Method of

Making Flexure Tests of Concrete, Using a Simple Beam with Third Point Loading," except that the concrete shall be taken from that being used on the project. The beams for each day shall be made at about noon. They shall be cured one day in the forms under wet burlap and for six days in wet sand or wet earth. They shall be saturated before testing at 28 days. These beams will be tested in the laboratory of the State Highway Department and should be shipped to the Laboratory at the end of the 7-day field curing period, where they will be stored in a moist room or under moist curing in the laboratory until time of test. Each beam shall have marked upon it, in black paint, the date cast. Compression tests will be made on the broken ends of the same beams by the A.S.T.M. Standard Method of Test (A.S.T.M. Designation C 116-39).

3. Samples of Materials:

The following samples of materials shall be sent to the Laboratory of the Public Roads Administration, Arlington Experiment Farm, Rosslyn, Virginia, securely bagged and tagged to identify them with the project.

Cement	--	1 sack
Fine Aggregate	--	At least 50 pounds
Coarse Aggregate	--	At least 100 pounds

Great care shall be exercised to see that the samples submitted are truly representative of those used on the project. Special provisions on these experimental projects will require that materials from the same source be used throughout the job. If, in spite of these provisions, a change is made in the source of any of the materials, additional samples of the new materials will be submitted. If the coarse aggregate is divided into two or more sizes, a total of 100 pounds of the coarse aggregate shall be submitted in separate samples, in approximately the same proportion as used on the job. Samples, similar in every respect, shall also be sent to the Research Laboratory, Portland Cement Association, 33 West Grand Avenue, Chicago.

4. Points, bench marks, temperature wells, etc. Points for measurement of joint opening and closing, wells for measurement of temperature of slab, elevation points and permanent bench mark and schedule for measurements are covered in complete detail as outlined in the accompanying "Suggested Program of Observations for the Cooperative Investigation of Joint Spacing in Concrete Pavements" and accompanying drawings.

SUGGESTED PROGRAM OF OBSERVATIONS

COOPERATIVE INVESTIGATION OF JOINT SPACING

IN CONCRETE PAVEMENTS

As a part of this research it is desirable to make a further study of the structural efficiency of weakened plane joints as measured by the ability to control critical stresses caused by loads acting near the joints. It would be difficult and perhaps impracticable to make this study on pavements that are under traffic and for this reason it has been decided to make this part of the investigation at the laboratories of the Public Roads Administration. This particular study will comprise a determination of the efficiency of this type of joint by means of stress measurements made on full-size pavement slabs of concrete containing different sizes and types of aggregates and having various controlled widths of opening in the joints being tested. With the information obtained from these tests, it should be possible to make a reasonably accurate estimate of the efficiency of joints of the same type in service under field conditions, providing the changes in widths which occur in service are known.

The changes in widths that occur in the joints of concrete pavements may be of a daily, a seasonal or a permanent nature and the magnitude of the changes will depend upon both the spacing of the joints and upon the arrangement of the expansion and contraction joints as well as upon those factors that determine the volume change characteristics of the concrete itself. Therefore, in this suggested program of observations, measurements of the daily, seasonal and permanent changes in widths are schedules for a number of representative joints in the sections included in these experimental pavements.

In certain studies of the surface irregularities of concrete pavements that have been made, it has been noted that there is sometimes a tendency for short slabs to become slightly tilted on the subgrade, resulting in increased surface roughness at the joints. There is evidence to indicate that this tilting action in short pavement slabs may be controlled through the use of dowels at joints or by the action of aggregate interlock at cracks and weakened plane joints, if the cracks or weakened plane joints are maintained in a relatively tightly closed condition.

The effect of the use of very short slabs on the riding qualities of concrete pavements and the effects of the various other design details that might have an influence on the general smoothness of the pavement surface have never been thoroughly investigated. It is desirable that additional data be obtained and for this purpose a series of level measurements, to be made on certain representative parts of each section, has been included in the suggested program.

Instrumentation. The suggested method of measurement of the changes in the widths of the joints is shown in drawing No. 405. This method has been used by the Public Roads Administration and has proved to be simple and quite satisfactory. The gage points should be set in the longitudinal axis of the pavement. It is not possible to set these points satisfactorily in the green concrete at the time the pavement is being laid. The vernier calipers recommended for measuring the changes in widths of the joints read directly to one-thousandth of an inch.

A method of measuring the average temperature of a concrete pavement with a mercury thermometer is also shown on drawing No. 405. This method has been compared with a thermocouple installation and found to give an indication of the average temperature of a concrete pavement slab sufficiently accurate for the purposes of this investigation. The well in which the thermometer is placed should be at a distance of approximately 2 feet from the edges of the pavement. In the case of a thickened-edge pavement, it should be placed inside of the point at which the edge thickening begins. The type of thermometer shown on the drawing is recommended because it permits the scale to be read without removing the thermometer from the well. The thermometer should remain in the pavement for not less than 10 minutes after completing the installation, before a reading is made. The thermometer well should be in a clean and reasonably dry condition when used.

The elevation measurements may be made with a good engineers' level if sufficient number of substantial bench marks are placed along the right of way so that it will be unnecessary to carry the levels over long distances. A suggested bench mark installation is shown on drawing No. 405. The bench marks should be placed on undisturbed ground at the side of the road where they will not be disturbed. Short carriage bolts set in the pavement in the manner shown on drawing No. 405 are recommended for level points. The elevations should be measured to one-thousandth of a foot. This may be very tedious if the use of a target is attempted but it can be done with considerable rapidity if a spot level is placed on the leveling rod, so that the rod can be held vertically permitting elevations to be read to one-thousandth of a foot by interpolation. The spot level should be of good grade, such as Dietzen No. 6514, or the equivalent.

A schedule of the observations recommended for the different sections of a given project is described below. This schedule is considered to be the minimum that will give the desired information.

In the following discussion, the term SECTION is used to denote a length of pavement of a particular design, SUBSECTION is used to denote that part of a section between two expansion joints, while the term SLAB refers to a unit of pavement length between two contraction joints or between an expanions and a contraction joint.

Section 1. Measurements of the seasonal changes in widths of the joints should be made at the first contraction joint from each end of the section, at alternate joints thereafter for a distance of approximately 200 feet from each end and at every fourth joint for a distance of approximately 800 feet in the central part of the section. Measurements of the daily changes in widths of the joints on this section should be made at the first contraction joint from each end, at joints approximately 100 and 200 feet from each end and at two joints in the central part of the section. Measurements of the permanent changes in widths of the joints should be made at successive joints for a distance of approximately 100 feet in the central part of the section. Level measurements should be made on each side of each successive joint over a distance of approximately 600 feet in the central part of the section and at the center of six slabs within this area.

Section 2. A subsection, preferably the central one, should be selected. Measurements of the seasonal changes in the widths of the joints should be made at the expansion joint, at the first contraction joint on each end of the subsection and at alternate contraction joints over the remainder of the length of the subsection. Measurements of the daily changes in widths of the joints should be made at the expansion joint, at the first contraction joint on each end of the subsection, at joints approximately 100 and 200 feet from each end and at two joints in the central part of the subsection. Measurements of the permanent changes in widths of the joints should be made at the expansion joint and first contraction joint on one end of the subsection and at alternate joints thereafter to within 50 feet of the center of the subsection. From this point each successive joint, for a total distance of 100 feet, should be measured. Level measurements should be made on each side of each successive expansion and contraction joint over the full length of one subsection and at the center of each of the six slabs included within the subsection.

Section 3. Two subsections should be selected within the central portion of the section. Measurements of the seasonal changes in widths of the joints should be made at the three expansion joints, at the first contraction joint on each end of one subsection and at every second joint over the remainder of the length of this subsection. Measurements of the daily changes in widths of the joints should be made at the expansion joint and first contraction joint on each end of one subsection and at joints approximately 100 and 200 feet from each end of this same subsection. Measurements of the permanent changes in widths of the joints should be made at successive joints for a distance of approximately 100 feet in the central part of one subsection. Level measurements should be made on each side of each successive expansion and contraction joint over the full length of two subsections and at the center of each of the six slabs included within these two subsections.

Section 4. Five subsections should be selected in the central part of this section. Measurements of the seasonal changes in widths of the joints should be made at each successive expansion and contraction joint over the full length of two of these subsections. Level measurements should be made at each successive expansion and contraction joint over the full length of the five subsections and also at the center of each slab included in one subsection.

Section 5. The measurements of the seasonal changes in widths of the joints and the level measurements should be made on this section in the same manner as described for Section 4. Measurements of the daily and permanent changes in widths of the joints should be made at each successive expansion and contraction joint over the full length of one subsection.

Section 6. Five subsections should be selected in the central part of this section. Measurements of the seasonal changes in widths of the joints should be made at each successive expansion and contraction joint over the full length of these five subsections. Measurements of the daily changes in widths of the joints should be made at each successive expansion and contraction joint over the full length of two subsections, while measurements of the permanent changes in widths of the joints should be made at each joint over the entire length of one subsection. Level measurements should be made on each side of each expansion and contraction joint and at the center of each slab over the full length of the five subsections.

Section 7. The schedule for this section should be the same as that described for Section 5.

In this program, it is not intended that the observations should be duplicated on more than one lane of the pavement or on more than one section of the same type.

It is desirable that the portions of each section, selected for the measurements, be located on a relatively level part of the grade where the degree of horizontal curvature is a minimum and where the depth of embankment does not exceed approximately four feet. Uniform exposure to sunlight is desirable for those sections that are selected for the measurements.

The locations of the joints and of the points on the different sections of the pavement at which it is necessary to insert gage points and level points in the concrete, together with the recommended locations of the temperature wells and bench marks needed for this schedule of observations, are shown on drawing No. 406. It will be noted that only the joints within the selected areas where measurements are to be made are numbered on the drawings and that these numbers run consecutively. As shown on the legend, the small crosses at the joints

indicate the points at which points are to be placed for the measurements of the changes in width of the joints, while the small solid circles indicate the points at which the changes in elevation are to be measured. When referring to the level points in notes, those on the two sides of the joint should be distinguished by the letters A and B added to the joint number, while the points at the center of slabs should be designated by the letter C added to the number of the joint preceding it. The exact location of these points on the slabs and the method of numbering them is shown on the key plan at the bottom of the drawing.

The points for measuring the changes in widths of the joints and the elevations are shown in different lanes of the pavement on the drawing. This was done for clarity. There is no reason why both sets of points should not be placed in the same lane, provided they are separated by a sufficient distance to prevent interference.

As indicated on the drawing, a temperature well and bench mark should be placed in each section near the center of the area on which the readings are being made. As mentioned previously, these bench marks should be located on undisturbed ground at the side of the road at a point where there will be little likelihood of their being disturbed. It may be desirable in certain cases to use more than one bench mark to a section.

A list of the joints in each section at which measurements are to be made in the study of the seasonal, daily and permanent changes in widths and the points at which elevation data are to be obtained is given in table 1a.

It is estimated that it will require approximately three hours to make one complete set of measurements at those joints at which seasonal measurements of the changes in widths of the joints are to be made and approximately one hour each to make a set of measurements at the joints where the daily and the permanent changes are to be observed. It will probably require one or two days to make a complete set of level measurements but this is not a serious matter since only a few sets of these observations are scheduled.

MEASUREMENT OF THE SEASONAL CHANGES IN JOINT WIDTH

It is desirable that four sets of observations be made during the year to study the seasonal changes in width of the joints. The most suitable periods for these are: Winter -- January or February; Spring -- April or May; Summer -- July or August; Fall -- October or November.

The different sets of measurements of the seasonal changes in widths of the joints should be made on days that are typical of the season they represent and in a period of the day during which the temperature of the concrete remains fairly

constant for a sufficient length of time to complete the observations. The periods during which the pavement temperature is most stable are in the morning before the pavement is exposed to the sun and in the afternoon between 12:00 and 4:00 P.M. The four sets of seasonal measurements should each be made at the same period of the day.

MEASUREMENT OF THE DAILY CHANGES IN JOINT WIDTH

It is necessary to make two sets of measurements to determine the changes in widths of the joints which are caused by the daily temperature cycle. The number of joints at which these measurements are to be made has been reduced sufficiently to permit a set of observations to be completed on all of the sections before appreciable changes occur in the temperature of the concrete. The first set should be made in the morning before the pavement has been exposed to the sun. The second set should be made between 2:00 and 3:00 P.M. when the temperature of the concrete is at a maximum for the day.

The daily changes in the widths of the joints should be determined for each season of the year, within approximately one week of the time that the corresponding set of seasonal observations was made. In all cases the observations should be made on a clear day when the pavement is in a condition normal for the season of the year.

The average temperature of the concrete should be measured in each section at the time the measurements of the seasonal and daily changes in widths of the joints are being made.

MEASUREMENT OF PERMANENT CHANGES IN JOINT WIDTH

To measure the permanent changes in width of the joints, it is necessary to eliminate in some manner the differences in the lengths of the slabs that are caused by variations in the moisture and temperature condition of the pavement. The effect of moisture variations changes slowly in an annual cycle and may be eliminated by making the different sets of observations at approximately the same time each year. The differences in slab length caused by temperature variations cannot be eliminated entirely but every effort should be made to make the measurements on each section a t a time when the average pavement temperature is the same.

Only one set of measurements is required each year and the most suitable period is midsummer, between the first of July and the middle of August, when the joints tend to be closed during the hot part of the day. During this period the moisture condition of the pavement remains fairly constant except during and for a short time after rainfall.

The first set of measurements should be made approximately one year from the time the pavement was constructed. A clear day that has been preceded by at least one clear day during which the pavement has been exposed to the sun should be selected for the observations. The average temperature of each section should be determined at the time the measurements are being made on the section. Since it will be necessary to repeat these measurements in subsequent years at the same temperature that obtained when the first set was made, it is important that the first set be made on a day that is normal for the season.

Studies of the changes in widths of joints in concrete pavements made by the Public Roads Administration, over a long period of time, have shown that the magnitude of the seasonal and daily changes in widths do not vary from year to year except where cracking in the pavement has occurred. Permanent or residual changes in the widths of the joints may continue over a long period of time, however, under certain conditions. There appears to be no reason, therefore, for continuing the measurements of the daily and seasonal changes in widths of the joints for more than a year or two. The studies of the permanent changes in width of the joints should be continued for a period of several years, however.

LEVEL MEASUREMENTS

Since the first set of level observations is to serve as a base to indicate the normal elevations of the different points on the pavement, it is desirable that the observations should be made as soon as possible after the pavement was laid and before the subgrade is frozen or in an abnormal moisture condition.

The second set of elevation measurements should be made in the winter to determine how nearly the original alignment of the different sections of the pavement is maintained under winter conditions.

The third set of observations should be made after the pavement is several years old, at a time when the subgrade is in a normal summer condition.

CRACK SURVEYS

An intensive crack survey should be made when the pavement is from four to six weeks old to record any cracks which might have occurred during and following the curing period. After this, it is desirable that crack surveys should be made twice a year over a period of two or three years. These crack surveys should be made in the late spring before the beginning of the hot weather and in the fall before the beginning of the cold weather.

GENERAL CONDITION SURVEYS

A survey of the general condition of the pavement should be made once a year, preferably in the fall. In this survey special attention should be given to the condition of the joints.

Adequate information concerning the compressive and transverse bending strength of the concrete in these experimental pavements should be obtained. Laboratory tests on special specimens should be made to determine the elastic and volume change characteristics of the concrete used in each project.

SUMMARY OF TEST PROGRAM FOR THE FIRST YEAR AFTER THE CONSTRUCTION OF THE PAVEMENT

Seasonal Changes in Widths of Joints.

Four sets of measurements should be made to determine the magnitude of the seasonal changes in the widths of the joints.

Winter -- January or February
Spring -- April or May
Summer -- July or August
Fall -- October or November

Daily Changes in Widths of Joints.

Measurements should be made of the daily changes in the widths of the joints on selected days at each of the four seasons of the year.

Permanent Changes in Widths of Joints.

A set of measurements should be made at the various joints selected for studying the permanent changes in width. Since this set will be used as a basis for comparison with future data, the observations should be delayed until cracks have occurred at all the weakened plane joints. It is recommended that this set of measurements be made during the first summer following the construction of the pavement.

Elevation Measurements.

One set of level observations should be made to establish the original elevations of the selected points on the different sections of the pavement.

Crack Surveys.

Crack surveys should be made at the end of the curing period and in the late spring and fall.

General Condition Survey.

A survey should be made of the general condition of the pavement in the fall approximately one year after the laying of the pavement.

TABLE 1-a

SCHEDULE OF JOINTS AND POINTS AT WHICH MEASUREMENTS SHOULD BE MADE - CONTRACTION JOINT SPACING - 15 FEET

Changes in Joint Widths			
Sect. No.	Joint Numbers		
	Seasonal	Daily	Permanent
1	1, 3, 5, 7, 9, 11, 13, 15, 19, 23, 27, 31, 35, 39, 43, 47, 51, 55, 59, 63, 67, 69, 71, 73, 75 77, 79, 81	1, 7, 13, 39, 43, 69, 75, 81	38, 39, 40, 41, 42, 43, 44
	28	8	7
2	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 55	1, 2, 8, 14, 26, 30, 42, 48, 54, 55	1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32
	29	10	21
3	1, 2, 4, 6, 8, 10, 12, 14, 15, 17, 19, 21, 23, 25, 27, 28, 55	1, 2, 8, 14, 15, 21, 27, 28	11, 12, 13, 14, 15, 16, 17, 18
	17	8	8
4	9, 10, 11, 12, 13, 14, 15, 16, 17, 25, 26, 27, 28, 29, 30, 31, 32, 33		
	18	0	0
5	9, 10, 11, 12, 13, 14, 15, 16, 17, 25, 26, 27, 28, 29, 30, 31, 32, 33	9, 10, 11, 12, 13, 14, 15, 16, 17	9, 10, 11, 12, 13, 14, 15, 16, 17
	18	9	9
6	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	3, 4, 5, 6, 7	5, 6, 7
	11	5	3
7	9, 10, 11, 12, 13, 14 15, 16, 17, 25, 26, 27, 28, 29, 30, 31, 32, 33	9, 10, 11 12, 13, 14, 15, 16, 17	9, 10, 11, 12, 13, 14, 15, 16, 17
	18	9	9
Total	139	49	57

Changes in Elevations		
Section No.	Point Numbers	Number of Points
1	From 21A to 61B	88
2	From 1A to 55B	116
3	From 1A to 55B	116
4	From 1A to 41B	90
5	From 1A to 41B	90
6	From 1A to 11B	32
7	From 1A to 41B	90
Total		622

APPENDIX B

August 1940.

SOILS SURVEY AND MEASUREMENTS OF MOISTURE AND DENSITY IN FINISHED SUBGRADE ON PROPOSED EXPERIMENTAL CONCRETE PAVEMENT CONSTRUCTION.

These instructions, concerning the information on subgrade soils that is desired in connection with the construction of the experimental concrete pavements, are supplemental to the outline "Observations and Measurements on Proposed Experimental Concrete Pavement Construction" dated June, 1940.

In the above-mentioned outline, the soil survey of the site is listed in Paragraph 3 under "A. Preliminary Data." In making this survey it is suggested that A.A.S.H.O. Method T 86-36, "Standard Methods of Surveying and Sampling Soils for Use in Place on Subgrades for Highways" be followed in detail.

Paragraph 6 under "B. Daily Observations" describes in general terms the desired daily information regarding subgrade conditions. It will be desirable to make determinations of both moisture and density and the following procedure is suggested:

Subgrade soil density and moisture tests should be made at intervals of approximately 300 feet after the fine grading has been completed and immediately ahead of paving operations.

The samples may be taken with a 4-inch or 6-inch post auger unless the soil contains appreciable percentages of stone or gravel. In the latter case, a hole may be dug with a pick and shovel.

Two test holes should be bored at each location, the first one 9 inches in depth and the second one 18 inches. All of the soil from each hole should be saved in pans or other containers and handled in such manner as to prevent loss of soil and, to the extent practicable, loss of moisture. All the soil taken from each hole shall be weighed and the weight recorded. After weighing, the entire sample shall be thoroughly mixed and a representative sample taken for the determination of the moisture content. Each moisture sample shall be of sufficient size to nearly fill a 6- or 8- ounce ointment can. The soil shall be placed in the can, the lid shall be put on securely, and the joint between the lid and the can sealed with adhesive tape not less than 1/2 inch in width.

The object of this procedure is to avoid the loss of moisture from the soil in transit from the subgrade to the laboratory. Other methods which will accomplish the same purpose may be used.

After the soil has been weighed and the moisture sample taken, the volume of the hole for each of the depths shall be determined. This may be done by obtaining the weight of sand or heavy oil of known weight per cubic foot required to fill the hole and using these data to calculate the volume of the hole. The volume of bored holes may also be obtained by using a rubber bag, attached to a calibrated container and filled with water to the proper elevation for reading. The volume of the ribber in the hole must be taken into account when using this method.

After the moisture sample is received in the field or State Laboratory, the tape shall be removed and the sample, can and lid weighed as received and the weight recorded. The sample,

can and lid, shall then be dried in an oven at 105° C. to constant weight. The soil shall then be removed from the can and the weight of the can and lid recorded. From these data the percentage of moisture based on the basis of the weight of dry soil can be calculated.

Appendix B (Cont.)

GRADING PROBLEMS AND EMBANKMENT AND SUBGRADE CONSTRUCTION DETAILS AND SOIL TESTS.

Extracts from the Dist. Engr's. Final Report.

Roadway Excavation, Channel Change Excavation and Roadway Embankment

Roadway excavation between the beginning of the project (Sta. 370+65) and Sta. 622, also between Sta. 638 and the end of the project (Sta. 44+58) was comparatively light, consisting of shallow cuts through cultivated orchards and fields and along the existing travelled road. Embankment quantities within these sections exceeded excavation quantities. Excavation was made with tractor-drawn scrapers.

Excavation between Sta. 622 and Sta. 638 consisted of heavy cuts, ranging up to 100 feet in height, and comprised approximately one-half of the total roadway excavation. Portions of these cuts, sufficient to complete adjacent fills, were excavated with bulldozers and tractor-drawn scrapers. The balance, totalling approximately 30,000 cubic yards, was excavated with a power shovel and hauled in Euclid bottom dump "Trak-Truks" to complete roadway embankments between Sta. 465 and Sta. 597. The material encountered was silty clay loam and soft silty shale. No blasting was required for the shovel work and only a small amount of ripping was required for the tractor work.

The start of roadway excavation operations was delayed because of heavy rains beginning about the middle of January, 1941, and continuing at frequent intervals to the latter part of March. Only a small amount of pioneering work was done during this time and no embankments were placed. Scraper operations

were started March 24, and shovel operations were started March 27. By March 31 approximately 8,000 cu. yds. had been placed in embankments from Sta. 540 to Sta. 550, Sta. 594 to Sta. 597, and Sta. 628 to Sta. 630. Due to the high moisture content of the material proper compaction could not be obtained and the contractor elected to discontinue grading operations until weather and ground conditions were more favorable.

Rain and cloudy weather continued until the middle of April and the ground did not dry out sufficiently to permit grading until the middle of May. Work was resumed on May 14, but difficulties were encountered in obtaining satisfactory compaction in fill foundation areas. Excavation operations were not resumed until May 21. Again difficulties were encountered in compacting material from roadway excavation. Delays hampered grading operations until the middle of June. From that time on, operations proceeded without serious delay but progress was slow because of insufficient compacting equipment to handle maximum shovel and scraper production. The contractor had on the job only sufficient spreading and rolling equipment to handle production from either the power shovel or the scraper fleet. Rather than obtain additional rollers and tampers, the contractor elected to work the scrapers during a morning shift and the shovel during an afternoon shift, using the same rolling equipment for the morning and the afternoon shift. At times it was necessary to operate the rolling equipment a third shift to properly compact material that had been placed during the other two shifts.

The material encountered in fill foundation areas and in roadway excavation was, with a few exceptions, a poorly graded soil

having a high silt and clay content with properties that rendered it extremely difficult to secure a uniform moisture content. It was also found that these soils did not compact readily with equipment and methods in general use.

After repeated unsuccessful attempts on the part of the contractor to get uniform moisture content and satisfactory compaction, with methods he contended were prescribed by the provisions of the contract, demonstrations were carried out on several small areas to determine methods that would obtain desired results. It was found that uniform moisture content could be obtained only by adding water in small amounts and scarifying or cultivating after each addition of water during spreading operations and the further addition of water in small amounts during rolling operations. It was also demonstrated that with the material in the condition resulting from these operations not less than twenty passes, with the sheep-foot tampers being used, were required to obtain the specified relative compaction. This amount of rolling required twice the number of rollers specified as the minimum number of rollers under contract specifications.

By mutual consent, after conferencesbetween the contractor and district representatives, it was verbally agreed that the procedure of scarifying and rolling with double the minimum rolling equipment would be accepted as giving specified compaction. This procedure was followed on fills constructed with materials hauled in "Euclids" and, with a few exceptions, a relative compaction of 90% or over was obtained.

The contractor found that the method of scarifying and double rolling did not work out economically for scraper work and material excavated and hauled by scrapers was compacted by spreading in thinner layers and watering in small amounts during rolling operations in order to thoroughly mix the water in the soil. Proper routing of loaded and unloaded scrapers was insisted upon and after a proper routine had been established, satisfactory compaction was obtained.

Under Proposal for Change No. 47369 the contract specifications were modified to the extent that embankments could be placed on the natural ground of fill foundation areas after rolling for one hour with one roller unit for each 150 cu. yds. for one foot of depth and without further treatment of the natural ground. In a number of instances less than 90% relative compaction was obtained in natural soils. When the fill was less than three feet in height sufficient natural soil was removed to provide for a fill of three feet and the entire fill constructed of sandy material obtained from channel change excavation.

Roadway excavation quantities were insufficient to complete the required embankments and the deficiency in quantity was made up by importing material from channel change excavation. The most suitable material encountered in the channel change was reserved for selected material in the upper six inches of the subgrade; material slightly less suitable was used as a subgrade blanket beneath this six-inch layer. The least suitable material was used to complete the lower portions of the embankments.

Excavation was made with a Northwest crane on crawler tracks equipped with a fifty-foot boom and a 1½ Cu. Yd. dragline bucket. Hauling was done with Euclid bottom dump "Trak-Truks" of 13 Cu. Yd. capacity and 4½ Cu. Yd. dump trucks. Material was spread on the grade with bulldozers and power graders. Due to the sandy nature of the material, rollers or sheep-foot tampers were of little or no advantage. Their use was discontinued after it was demonstrated that relative compactions of 95% and higher were being obtained by watering and routing hauling equipment over all parts of the fill.

The portions of fills completed with channel change excavation and the thickness of subgrade blanket are shown on the Standard Soil Survey sheets attached to this report.

In lieu of placing and mixing selected material for the upper six-inch layer of the roadbed in four windrows as specified in the Special Provisions, the procedure of placing and mixing was modified by Proposal for Change No. 46921. Selected material was placed in four or more layers, each layer being spread uniformly before placing the next layer. After sufficient material had been placed in these layers in a compacted volume equal to the upper six inches of the roadbed, it was mixed by blading it across the roadbed in successive windrows with power graders. The size of the windrows being handled was increased and the work expedited by the use of tractors to tow the power graders. A constant check was kept on the screen analysis of materials in the borrow pit and on the grade to assure uniformity of material. Screen analyses of the blended material from samples

taken from the completed subgrade are shown on the Standard Soil Survey sheets attached to this report. They show that a very uniform material was obtained for the entire length of the project. All of the material placed in the upper six inches of the subgrade is classified as gravelly sand by grain size classification and as A-2 soil by U.S.P.R.A. classification.

Water Control & Compaction

Grading operations were started during the rainy season when surface soils were saturated from continuous rains and the moisture content was too high to permit maximum compaction. The specified relative compaction could not be obtained in the natural soil in fill foundation areas, and in the shallow cuts extending over the greater portion of the project excavation was not deep enough to reach the drier subsoils which would have permitted blending with the wet surface soils. After placing 5125 Cu. Yds. in the fill between Sta. 594 and Sta. 597 and 1825 Cu. Yds. in the fill between Sta. 628 and Sta. 630 of soil that contained 18% to 25% moisture grading operations were discontinued until more favorable weather conditions prevailed. The relative compaction in these fills was less than the 90% specified in the contract and the fills were removed and reconstructed.

Prior to June 1, 1941, relative compaction of natural soils in fill foundation areas and for materials placed in embankments was based on an optimum unit weight determined by means of the laboratory method of compaction as described in Section 6, article (d), Test No. 7, of the Standard Specifications.

Considerable difficulty was experienced in compacting embankments to the required 90% relative compaction if the moisture content did not slightly exceed the maximum allowable as indicated by the test data. It was found that greater unit weight could be more easily obtained in the embankment if the moisture content was slightly in excess of the optimum moisture content for maximum compaction as found by the laboratory method.

Comparative tests were made on typical soils throughout the project, using both the laboratory method and the field method described in Section 5.7112 of the Construction Manual, and results of these tests indicated that optimum unit weights by the field method averaged 2% to 3% less than that obtained by the laboratory method. Unit weights of materials in the embankments was 90% or more as compared to the optimum by the field method, but 2% to 3% less than 90% by the laboratory method.

On embankments of clayey soil, placed subsequent to June 1, 1941, relative compaction was determined by the field method of compaction and with a few exceptions satisfactory compaction was obtained. On clayey embankments placed prior to this time, relative compaction results were recalculated to make the records consistent.

The water contained in excavated material varied over a wide range within a given cut during a given day's operation. Much of the grading was done during the hot summer weather and evaporation of water on the grade was heavy and variable due to the necessity of applying water in small amounts and in numerous

applications to insure proper mixing and uniformity. Application of the proper amount of water required constant checking and the exercise of considerable judgment.

The moisture content of embankments made with silty clay soils from roadway excavation ranged from 12% to 18% with an average of approximately 15%. A great majority of the tests show a moisture content within 1% or 2% of the average. In the few instances where less than 90% relative compaction was obtained, the moisture content is low.

The moisture content in embankments made with the sandy gravel from channel change excavation, ranged from 5% to 9% with an average of approximately 8%. The moisture content was much higher than this at the time the material was being compacted but compaction samples were taken as much as a full day after the material had been placed and much of the water had drained out.

Since conclusions to be made from observations and test data are to be based on comparisons of the efficiency of the various joint spacings and dowel arrangements, uniformity of subgrade and pavement were of prime importance and every effort was made to secure this uniformity.

Uniformity of subgrade material was obtained by selecting and blending material for the upper six inches of the roadbed as previously described under Channel Change Excavation and Embankments. The material used was a gravelly sand with a comparatively low cementing value and did not compact readily under a sheepfoot tamper or conventional roller. However, under continued use by public traffic and the contractor's equipment

this material became well cemented and reached a very high density. When subgrade operations were started the roadbed had reached this condition of high density for the entire length of the project. The subgrade was scarified only three to four inches deep, or just sufficient to remove the coarser rock and provide for shaping the subgrade and still retain the density that had been obtained from traffic.

Samples taken from the subgrade immediately ahead of paving operations show densities ranging from 120 lbs. to 130 lbs. per cubic foot.

Appendix B (Cont.)

FINAL MATERIALS REPORT

Experimental Paving Project

VII-Ven,LA-79-C,A

Contract 27XC7-P

By R. J. Allan, District Materials Engineer

Feb. 6, 1942.

Instructions for the proposed construction, program of observations, soils survey, etc. were prepared by the Public Roads Administration. The instructions pertaining to the soil survey were dated August 1940.

Standard Soil Survey Sheets

On the attached soil survey sheets are shown two soil profiles. The upper profile is diagrammatic, showing the grade as a straight line and showing the details of the soils to depths of from 3 to 4' below the pavement. The lower profile shows the profile and grade line plotted to true elevations. This is on a smaller scale and shows only the samples and tests below the area covered in the detailed diagrammatic profile. These are mainly relative compaction tests.

The various layers of soil are shown on both profiles. In some cases where a part of the roadway was on fill and part in cut, the toe of the fill has been shown on the profile as a dotted line. The soils above this line are those of the fill rather than the original ground. This method has been used only where the fill represents the greater part of the soils under the pavement section. Numerous cross-sections are also shown on the soil survey sheets to clarify these cases where conditions could not be well shown on a profile.

Three types of samples are shown by different symbols indicated in the legend on the sheets. These types are as follows:

1. Moisture and Density Samples

These were taken in the top 9" and top 18" respectively of the subgrade as required by the outline of procedure of the U. S. Public Roads Administration dated August 1940. These samples are indicated by two solid lines approximately .05"

apart. Actually, each sample was taken in two parts by boring adjacent holes 9" and 18" in depth. In order to show these on the profile the two samples have been given one number and shown as "A" for the upper 9" and "A&B" for the full 18". The moistures and densities are shown at the side of the sample. The outline of procedure of the U. S. Public Roads Administration mentioned above, stated that these tests should be made at approximately 300' intervals immediately ahead of paving operations. In Mr. Stanton's letter of August 26 and his teletype of Oct. 10, this was interpretated to mean that these tests should be made at 300' intervals, only in portions of the north lane where reference points were to be set in the pavement, for measurements of expansion and changes in elevations. Between these sections the tests were made at approximately 1500' intervals; they were also made at 1500' intervals in the south lane throughout the job. Where these samples were taken at 300' intervals it was not possible in all cases to take them directly in front of the mixer because of the considerable time necessary for each test. Therefore some of the density determinations were made about 1500' ahead of the paving operations, but in these cases an additional sample was taken in the top 9" directly ahead of the mixer in order to determine the moisture content immediately before the concrete was placed.

2. Relative Compaction Tests.

These are shown in solid black lines with the moisture and density, in place, on the right side of the line and the relative compaction on the left. Because of the great number of these samples which were taken, there was not sufficient room on the sheets to tabulate test data and it was therefore decided to show them in the above described manner. A considerable number of relative compaction tests are not shown on the soil profile for the reason that they were in side hill fills which could not be shown. Other relative compaction tests were omitted because of lack of space to show them, as in the case fill between Stations 628 and 630.

3. Samples upon which complete tests were made.

These are shown by dotted lines approximately 0.1" apart. The detailed test data, including grading analysis, relative compaction, bearing value, liquid limit, plasticity index, and U.S.P.R.A. classification, are tabulated on the upper portion of the soil survey sheet. The bearing values at 0.1" penetration after soaking, the moisture and density in place, and the relative compaction, are also shown adjacent to the samples on the profile. These samples were taken at approximately 1500' intervals in each soil layer or at more frequent intervals where necessary to show changes in type or quality.

The following is a summary of the tests of various types which were made during the construction of this project:

Relative Compaction Tests	450+-
Grading Analysis on Channel Borrow:	
Preliminary	200
Control Tests	150
Moisture and Density Tests of Subgrade	170
Complete Soil Tests, including Grading Analysis, Relative Compaction, Bearing Value, Expansion, Liquid Limit, Plasticity Index, and U.S.P.R.A. classification	115
Aggregate Tests:	
Grading Analyses	115
Rattler Tests	19
Specific Gravity	21
Colorimetric	9

These aggregate tests do not include tests made at the Sacramento Laboratory or daily tests made by the Resident Engineer at the batching plant.

Compaction of Embankments.

The greater part of the roadway excavation and of the natural soils in the fill foundations consisted of silty clay loam which was very difficult to compact. Because of the excessively heavy rainfall during the winter of 1940-41 the moisture content of much of this material was above the amount at which 90% relative compaction could be secured. This added to the compaction difficulties since it was necessary in such cases to reduce the moisture content of the soil before it could be compacted. At certain locations it was impossible, because of capillary rise of underground water, to reduce the moisture content of the fill foundation material sufficiently to permit 90% relative compaction in the top foot as required by the Standard Specifications. In these locations the following procedure was authorized by Central Office:

If the fill was more than 3' in height, the original ground was rolled at the rate of one hour, with a standard 8' sheepsfoot roller, for each 150 cu. yds. of material in the top foot, this being the minimum amount of rolling permitted by the Standard Specifications. If, on the other hand, the fill was less than 3' in height, the top foot of the original ground was removed and replaced with sandy material from the channel borrow which could be compacted to a relative compaction of 90%.

In cases where particular difficulty was encountered in compacting clayey soils, even though the moisture content was such that 90% Relative Compaction was possible, if 90% Relative Compaction was not attained after double the minimum amount of rolling permitted by the Standard Specifications, the fills were accepted as being satisfactory. This procedure was authorized by Central Office. There were very few instances where 90% was not attained after double rolling.

The relative compaction tests made on the clayey material were based upon the compacted density of the material as obtained by the standard field method as authorized under Section 5.711 of the 1938 Construction Manual.

In general, relative compaction tests were made at approximately 1' to 2' vertical intervals in each fill and if the compaction was found to be less than 90%, except in the cases mentioned above, further rolling or, where necessary, scarifying and re-rolling were required. Since many of the tests were near the borderline and since the necessity for rescarifying and recompacting the material depended upon the results of the tests, great care was taken to secure accuracy in these results. In practically all cases three samples of the material were compacted by the field method in order to determine the optimum moisture and maximum density for each sample. All weighing operations and volume measurements were made with an accuracy which would insure an error of considerably less than 1% relative compaction.

The compaction tests shown on the soil survey sheet represent only a portion of the tests which were made. A great number of tests were void because the material was later recompacted, in which cases only the latest sample was shown on the soil survey sheet. Also, a number of tests were taken in side hill fills which do not show on the soil survey profile.

Subgrade

The success of the pavement experiment depends to a large extent on the uniformity of the subgrade. For this reason the special provisions required that the upper 6" of the subgrade material be blended to secure uniformity, by placing the material in four approximately equal windrows, blading the windrows together, and turning the material four times by blading from one side of the road to the other. This procedure was modified by a proposal for change to the extent that the materials were placed in four or more layers rather than in four windrows.

The material used for the subgrade was secured from the channel change which was constructed in the Santa Clara River. In order to determine the portion of the channel change which was most uniform in quality, approximately 200 tests were made on soil tube samples which were taken to depths of about 4' at various places within the limits of the proposed channel

excavation. During the excavation of this material and the placing of it on the roadbed, approximately 120 additional grading analyses were made to determine the distribution of the material in the various layers to give the greatest possible uniformity. After the layers had been mixed on the roadbed, 33 samples were taken transversely across the full width of the subgrade. The attached grading chart shows the exceptional uniformity of the subgrade as indicated by these 33 samples. The extreme limits of grading of the best 25 of these samples showed a variation of only 2% on the 100 mesh and not more than 10% on any of the coarser sizes. The grading analyses of the finished subgrade samples, shown on the soil survey sheet in this layer, show slightly finer grading and slightly greater variation in grading than the 33 tests which were taken prior to compaction of the subgrade. This difference was apparently due to breakdown of particles caused by compaction operations and to the considerable amount of traffic to which portions of this layer were subjected before the pavement was placed.

Concrete Aggregates

The concrete aggregates were secured from sources in the San Fernando Valley which usually show borderline results in the Rattler test. It was therefore decided to stockpile these aggregates and test each of the stockpiles before releasing them for use on the project. Special care was also taken to secure as uniform grading as possible at the plant.

Stockpiles were first tested at the Roscoe plant of the Consolidated Rock Products Company and some of these were used for concrete structures. Before paving operations started, however, the Consolidated Rock Company found that it would be impossible to supply sufficient aggregates for this project because of orders for National Defense work. They accordingly made arrangements with the City Rock Company to furnish all of the paving aggregates from their Sunland plant and arranged to reimburse the State, through the Constractor, for testing which had been done on the Roscoe aggregates.

The City Rock Company changed their plant screens in order to produce the State specification sizes and their product as a whole was very uniform in quality. The sand, however, was on the lower limit of the grading specifications on the 30 mesh sieve, occasional samples showing deficiency of 1 to 2% in material passing this sieve. After paving operations were under way, instructions were received from the Construction Department to use a blending sand in order to bring this size within the specification limits. The blending sand was secured from the Roscoe plant of the Consolidated Rock Company.

In the sampling of these aggregate stockpiles, samples were taken from as many as five different locations on the stockpile and were graded separately in order to indicate the variation to be expected. In order to secure more representative results on the grading of the coarse aggregates, the grading analyses were run on samples weighing from 200 to 500 lbs.

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MATERIALS AND RESEARCH DEPARTMENT

SEMI-LOG CHART FOR GRADING CURVES

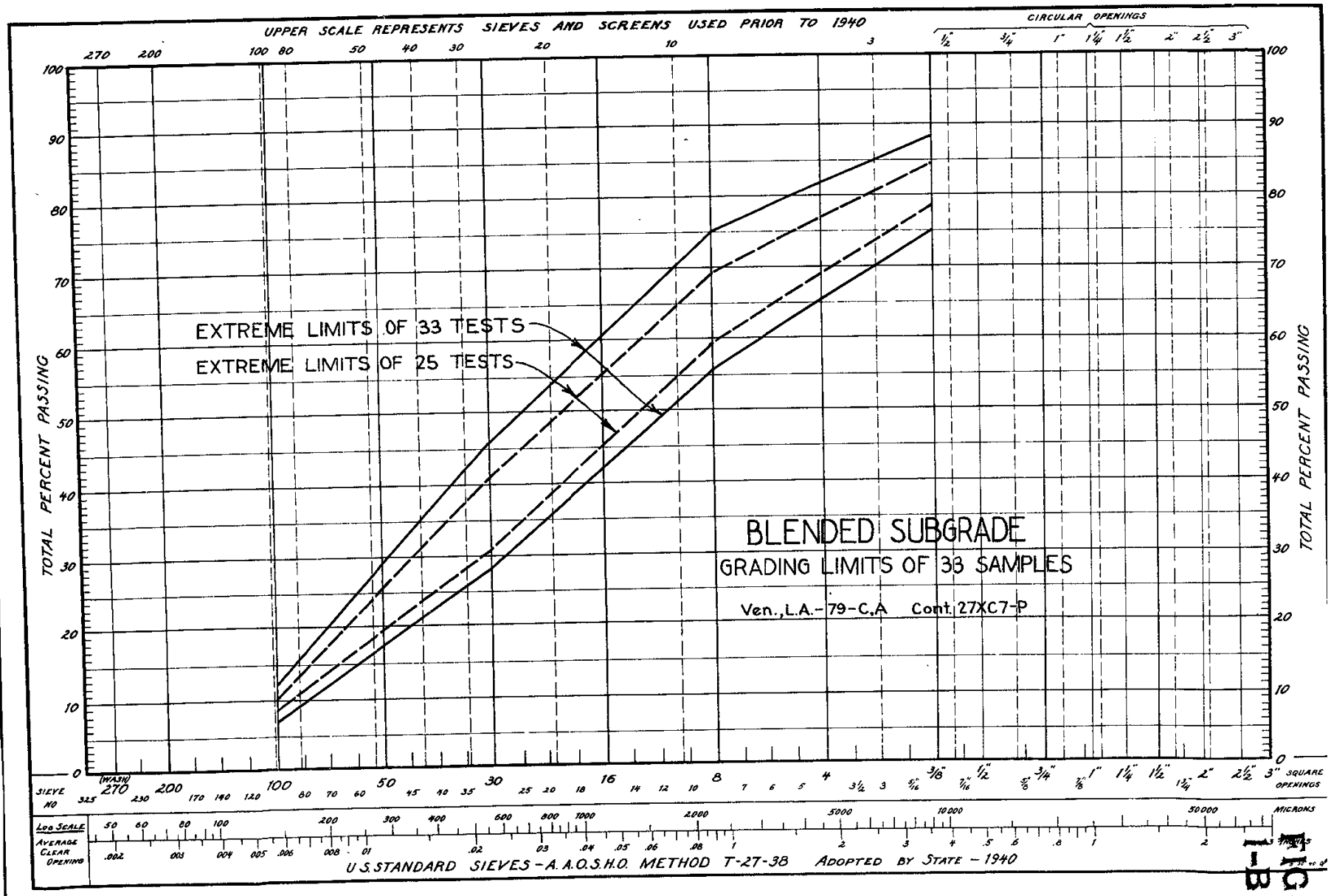

FIG. B

APPENDIX C

Ventura Experimental Pavement

Tests Comparing Dynamic (Sonic) and Compression Modulus of Elasticity, Modulus of Rupture and Compressive Strengths of Concrete from the Ventura Experimental Pavement.

SYNOPSIS

This discussion relates to tests designed primarily to compare modulus of elasticity determinations by the dynamic and compression methods.

Dynamic E tests were made on both 6"x6"x34" beams and 6"x12" cylinders; whereas, the secant stress-strain determinations were made on the cylinders only.

There was a close correlation at all ages (4 days to one year) between the dynamic E determinations on both beams and cylinders, but the secant E averaged considerably less than the dynamic.

The desirability of further studies is indicated to determine the relationship between the two methods.

As stated, the primary purpose of the tests described in this report was to determine the relation, if any, between the modulus of Elasticity by the Dynamic (Sonic) and Compression methods.

As far as possible, all factors related to mix and fabrications were kept constant. Thus all special test specimens (eighteen 6"x12" cylinders and eighteen 6"x6"x34" beams) were fabricated from the same batch of concrete mixed in the field in a standard paving mixer during regular paving operations. The water-cement ratio and slump were therefore constant, as well as the cement and aggregates.

Although the detail data relates to only one set of specimens and one set of circumstances, and therefore may not necessarily be susceptible of general application, they are of interest as indicative of results to be expected with similar combinations of materials and construction procedure and therefore have some value in supplementing previously published data.

Under the conditions of test described, the secant compressive modulus at 1000# was found to range from 62% of the dynamic modulus at 28 days to 75% or 76% at later periods. It was apparently possible to as accurately measure the dynamic modulus of the 6"x12" cylinder as of the 6"x6"x34" beams, although the frequency of the cylinders was of such an order as to be at or close to the measurable limit. The frequency of resonance of specimens 6 inches in diameter and less than 12 inches long was too high to be measured with satisfactory accuracy with the equipment available. Therefore, if it is desired to make dynamic E determinations on cylindrical specimens, it is necessary either for the length to be greater than twice the diameter, or to use equipment with adequate sensitivity in the high-frequency range. It is of interest to know, however, that where large numbers of 6"x12" cylinders are fabricated for compressive strength tests, it is practicable to make dynamic E determinations on this type specimen, provided the ratio of the diameter to length is not greater than 0.5.

The results of the tests on the three cylinders and three beams in each set tested to destruction at each of six test periods is evidence of the degree of uniformity as between the different specimens (Table I-C and Fig. 1-C).

The secant E at 1000 p.s.i. was determined on all unbroken specimens at each test period from 28 days on, and up to 2000 p.s.i. at 3 months, 6 months and one year. The results at the later period may, therefore, have been influenced by the earlier tests on the same specimens and this factor should be taken into consideration in evaluating these results and in any similar studies. However, the load application was continuous and there was immediate release as soon as the maximum load was reached. There was, therefore, little time for plastic flow to take place and the figures do not indicate any appreciable increase at later ages in the E_s of specimens similarly tested at earlier ages.

The secant E of the 6"x12" cylinders was found to be substantially the same at 1000 p.s.i. as at 25% of the compressive strength for all ages from 28 days on (Table II-C).

In making the dynamic E determinations, the correction factor T described by Obert and Duvall in their paper published by A.S.T.M. in 1941[1] was applied; T correction curve 4, Figure 1 being used. Curve 4, which applies directly to prisms, was used for 6"x12" cylinders by entering the chart at an abscissa value which is $2/\sqrt{3}$ times the actual ratio of diameter to length.

Figure 1-C of this report shows how closely the dynamic E of the cylinders (after correction) agreed with the similar determination on the beams.

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[1] Leonard Obert and Wilbur I. Duvall, "Discussion of Dynamic Methods of Testing Concrete with Suggestions for Standardization," Proceedings Am. Soc. Test. Mat'ls., Vol. 41, Pg. 1053 (1941).

Other Tests

Similar determinations were made at 28 days on specimens fabricated throughout the life of the project.

Forty-eight cylinders and beams fabricated during this period tested as follows at 28 days:

Dynamic E (6"x12") cylinders	4,800,000
" " (6"x6"x34") beams	4,900,000
Compressive E_s (1000#) Cyls.	3,000,000 = 62% Dynamic E.
Compressive Strength (Cyls)	3870 p.s.i.
" " (Cores)	4240 "
Modulus of Rupture	639 "

5.00 sacks of cement per cubic yard.

It is of interest to note the close agreement of all Dynamic and Compressive E determinations on these job specimens with similar determinations on the eighteen cylinder specimens from the single batch from which the special set of test specimens was fabricated.

As will be noted, the concrete on this project, which contained five sacks of cement per cubic yard, did not develop particularly high compressive strength at 28 days, but by three months well exceeded 5000 p.s.i. and by one year substantially exceeded 6000 p.s.i. The pavement core strengths (cores cut just prior to test) were as follows:

51 cores at 28 days tested 4240 p.s.i. in compression

48 " " 2 years " 7135 " " "

No cores were tested at one year and there were no cylinders available for test at two years.

Relation Between Dynamic E and Compression E_s

T. C. Powers[1], by averaging the stress-strain measurements on opposite sides of 6"x12" cylinders obtained initial tangent E values which checked fairly close with the dynamic E determinations made on companion 5"x5"x18" bars. At the same time, Powers shows a somewhat lower secant E at 1000 p.s.i. than the Dynamic E of an unloaded specimen. The results of the tests described in this paper check Powers' determinations.

While in the California series all "stress-strain" measurements were made on only one position of the specimens, which were then broken for compressive strength, subsequent tests at the four quarter points of 6"x12" cylinders from several recent concrete projects do not show on the average any great discrepancy between the measurements for the different positions of the compressometer.

Conclusion

The tests described herein indicate some definite relationship between dynamic and compressive E_s values. It appears that under conditions similar to those in the tests described in this report, the 28 days secant E at 1000 p.s.i. averages approximately 62 per cent of the Dynamic E at the same age.

Further studies indicate that this factor is influenced by type and quantity of cement as well as by the water-cement ratio, grading and type of aggregates, etc., for which reasons the desirability of further studies is apparent if any comparison of this nature has any value.

[1] T. C. Powers, "Measuring Young's Modulus of Elasticity by Means of Sonic Vibrations," Proceedings Am. Soc. Testing Materials, Vol. 38, Part II, Pg. 460 (1938).

TABLE

COMPARISON OF COMPRESSION, MODULUS OF RUPTURE, AND MODULUS OF ELASTICITY (COMPRESSION AND SONIC) TESTS ON 36 FIELD SPECIMENS OF CONCRETE FROM THE VENTURA TEST PROJECT

Specimens cast from concrete poured in North Lane near Station 616 + 25 on October 25, 1941.

All 36 specimens from the same batch of concrete.

Cylinders – 6" x 12" Beams – 6" x 6" x 34"

Age Test		4 DAYS						10 DAYS						28 DAYS					
		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength	
		Sonic		Comp.	M. of R	Cyl	Beam	Sonic		Comp.	M of R	Cyl	Beam	Sonic		Comp.	M of R	Cyl	Beam
Set No.	Spec. No.	Cyl	Beam	Cyl. 1000 p.s.i.	p.s.i.	p s i	Ends p.s.i.	Cyl	Beam	Cyl. 1000 p.s.i.	p s i	p s i	Ends p.s.i.	Cyl	Beam	Cyl. 1000 p.s.i.	p s i.	p s i	Ends p.s.i.
1	3B4	3.52	3.44	1.20	316	1230	2080												
	3B5	3.40	3.44	1.23	320	1230	2180												
	3B6	3.46	3.52	1.13	362	1180	2160												
	Avg.	3.46	3.47	1.19	333	1210	2140												
2	3B7	3.19	3.45					4.57	4.22	2.32	594	2040	3310						
	3B8	3.13	3.48					4.52	4.34	2.32	584	2080	3290						
	3B9	3.04	3.58					4.32	4.32	2.29	586	2020	3350						
	Avg.	3.12	3.50					4.47	4.29	2.31	588	2050	3320						
3	3B10	3.19	3.63					4.38	4.37					4.83	4.97	3.02	672	3630	5350
	3B11	3.21	3.53					4.47	4.38					4.91	5.03	3.14	684	3530	4970
	3B12	3.16	3.37					4.59	4.15					4.97	4.78	3.02	—	3660	5040
	Avg.	3.19	3.51					4.48	4.30					4.90	4.92	3.06	678	3610	5120
4	3B13	3.18	3.49					4.56	4.22					4.94	4.87	3.08			
	3B14	3.08	3.44					4.56	4.28					4.80	4.94	2.91			
	3B15	3.19	3.34					4.57	4.23					4.96	4.83	3.20			
	Avg.	3.15	3.42					4.56	4.24					4.90	4.91	3.06			
5	3B16	3.19	3.30					4.57	4.13					4.83	4.77	3.14			
	3B17	3.29	3.29					4.57	4.17					4.83	4.76	3.14			
	3B18	3.31	3.43					4.59	4.22					4.97	4.87	3.14			
	Avg.	3.26	3.34					4.58	4.17					4.88	4.80	3.14			
6	3B19	3.14	3.40					4.57	4.25					4.88	4.91	3.02			
	3B20	3.04	3.44					4.64	4.28					4.72	4.94	2.96			
	3B21	3.14	3.38					4.57	4.22					4.75	4.80	3.02			
	Avg.	3.11	3.41					4.59	4.25					4.78	4.88	3.00			
Grand Avg.		3.22	3.44	1.19	333	1210	2140	4.54	4.25	231	588	2050	3320	4.87	4.88	3.06	678	3610	5120

Age Test		3 MONTHS						6 MONTHS						1 YEAR					
		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength		Modulus of Elasticity Values shown are E x 10^-6			Flex. Str.	Compressive Strength	
		Sonic		Comp.	M of R	Cyl	Beam	Sonic		Comp.	M of R.	Cyl	Beam	Sonic		Comp.	M of R	Cyl.	Beam
Set No.	Spec. No.	Cyl.	Beam	Cyl. 1000 p.s.i.	p s i	p.s.i.	Ends p.s.i.	Cyl.	Beam	Cyl. 1000 p.s.i.	p s i	p.s.i.	Ends p.s.i.	Cyl.	Beam	Cyl. 1000 p.s.i.	M. of R p s i	Cyl. p s i	Beam Ends p.s.i.
1	3B4																		
	3B5																		
	3B6																		
	Avg.																		
2	3B7																		
	3B8																		
	3B9																		
	Avg.																		
3	3B10																		
	3B11																		
	3B12																		
	Avg.																		
4	3B13	5.56	5.60	3.64	752	5245	6530												
	3B14	5.36	5.60	4.21	808	5075	6790												
	3B15	5.23	5.62	3.81	832	5310	6680												
	Avg.	5.38	5.61	3.89	797	5210	6670												
5	3B16	4.96	5.48	3.56				5.90	6.00	4.44	878	5885	6220						
	3B17	4.98	5.60	4.32				6.09	5.98	4.44	856	6335	6470						
	3B18	5.25	5.60	4.10				6.09	6.02	4.85	844	5820	6480						
	Avg.	5.06	5.56	3.99				6.03	6.00	4.58	859	6010	6390						
6	3B19	5.03	5.63	4.10				6.05	6.10	4.45				6.12	6.38	4.57	791	6630	7450
	3B20	4.96	5.67	3.72				5.91	6.12	4.33				6.30	6.35	4.85	855	6280	7250
	3B21	4.96	5.50	3.91				5.94	6.10	4.22				6.20	6.34	4.57	778	6805	7140
	Avg.	4.98	5.60	3.91				5.97	6.11	4.33				6.21	6.36	4.66	808	6570	7280
Grand Avg.		5.14	5.59	3.93	797	5210	6670	6.00	6.05	4.46	859	6010	6390	6.21	6.36	4.66	808	6570	7280

Note – Sonic determinations were made by measuring fundamental frequency using "T" Correction Curve 4, Fig. 1, and the same equipment as shown in Fig 2, A S T M Proceedings, 1941, Pages 1055 and 1059.

TABLE II-C

COMPARISON OF DYNAMIC AND SECANT E

AT ALL PERIODS (6" x 12" CYLINDERS)

	Compressive E		Dynamic	Comp. E. / Dyn E.	Comp.Str.* p.s.i.
	at 25% Comp.Str.	at 1000 p.s.i.			
4 days	2,260,000	1,190,000	4,460,000	.34	1210
10 "	2,600,000	2,310,000	4,447,000	.52	2050
28 "	3,080,000	3,060,000	4,900,000	.62	3610
3 months	3,830,000	3,890,000	5,380,000	.72	5210
6 "	4,410,000	4,580,000	6,030,000	.76	6010
12 "	4,650,000	4,660,000	6,210,000	.75	6570

* 5 Sack Concrete.

TABLE III-C

Data Relating to Concrete Materials and Concrete Design and Construction, Ventura Test Project.

(a) Aggregates:

1. Fine - Granitic rock fragments, quartz and feldspars chiefly, with some biotite, hornblende and magnetite in the fine sizes. Specific Gravity 2.70.

2. Coarse - Chiefly granitic and gneiss. Specific Gravity 2.70.

(b) Cement:

Type II - 90.8% passing 325 mesh - Specific surface 1610.

C_3A 6.0% - C_3S 32.0%

The low C_3A and C_3S combined with the relatively low specific surface probably accounts for the comparatively low 28 day strength.

(c) Concrete:

Five sacks cement per cubic yard.

Water-cement ratio by weight 0.6. Slump 1½".

Concrete mix by weight: 1:2.73:3.66

The maximum size of coarse aggregate in the mix was 2½" to 3", but in fabricating test specimens, all particles over 1½" were removed.

Average Wt. Concrete: Cyls. 150#; beams 152#; Cores 154#.

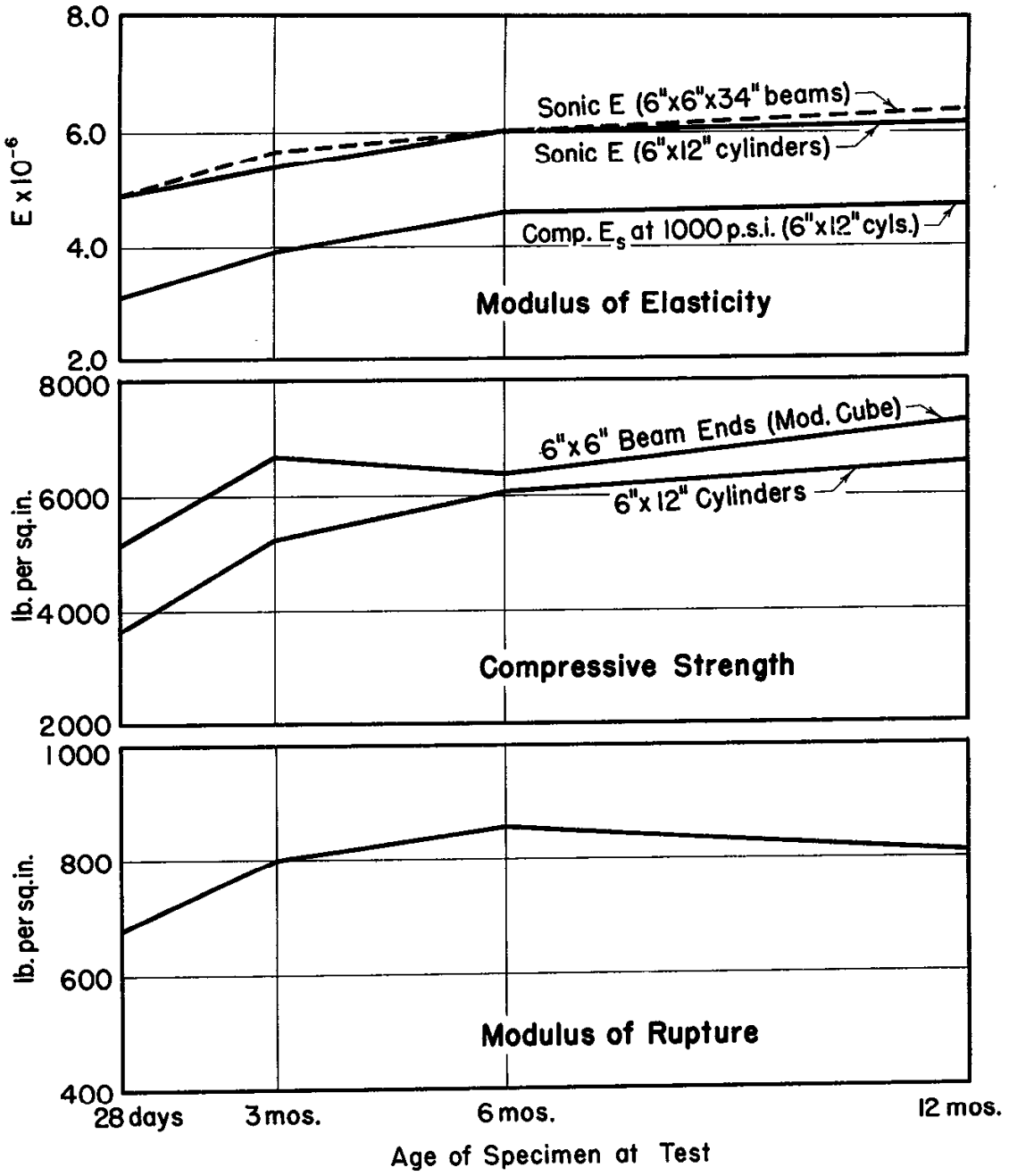


Fig. I-C. Comparison of Compressive Strength, Modulus of Rupture, and Modulus of Elasticity (Compressive and Sonic) Tests on Concrete from a Concrete Paving Project in Ventura County, California.

Tests made on a special set of 36 specimens (eighteen 6"x12" cylinders and eighteen 6"x6"x34" beams) from a single batch of concrete. See Table I for detail test data.

APPENDIX D

Subgrade Friction

Measurements of subgrade friction were made on full sized pavement slabs. The test slabs were separated from the adjoining slabs at each end by 4" x 10" redwood block spacers, placed during normal paving operations. These redwood spacers were subsequently removed, leaving a 4" clear opening at each end of the test slabs. The inside edge of the slab was in contact with the adjacent slab of the other lane and the outside edge was in contact with the shoulder material.

Thrusting force to move the slab was supplied by compressed air through a 4" "soft suction hose" placed in the 4" opening at the end of the slab and attached to a controlled variable pressure source. Wood shims were used to reduce the width of the opening to within the calibrated range of the hose. (Fig. 1-D).

The slab was first moved east slightly more than 0.10" by applying pressure through the hose at the west end of the slab. It was then moved west approximately 0.20" by applying pressure through the hose at the east end of the slab. The displacement was measured with Ames dials attached to adjacent slabs at the opposite end to which the pressure was applied. The slab was then moved alternately east and west in approximate 0.20" movements until the force required became constant. This preliminary series of displacement movements was made to put the subgrade in somewhat the same condition as might be expected under a pavement after a number of movements resulting from moisture and temperature cycles.

The slab was then displaced east and 0.05" from the original position so that any subsequent movements would lie well within the range covered by the preliminary movements. The subgrade friction test was started from this point. An increment of pressure sufficient to displace the slab approximately 0.010" eastward was applied slowly and held constant until all displacement had ceased. After recording this pressure and displacement an additional pressure increment was applied slowly for a total displacement of about 0.020" and held constant until all forward displacement had ceased. The pressure increments were repeated until a total displacement of about 0.050" was obtained. The pressure was then slowly decreased by the same units used to obtain the forward displacement. The pressure at each decrement was held constant until all movement had ceased and the recovery measured.

Pressure was then applied to move the slab in the reverse or west direction and displacement increments read as described for the east direction. Complete pressure and displacement measurements east and west were secured for successive slab displacements of approximately 0.05", 0.075" and 0.100". The increments of pressure were selected so that about 5 sets of intermediate readings were secured for each over all displacement in each direction. See Fig. 2-D for the pressure-displacements curves.

The subgrade friction on the full-sized concrete slabs increased for increased increments of displacement (Fig. 2-D). The average value of the thrusting force to move the 8" uniform thickness slab for a distance of 0.025 inches was about 40% of

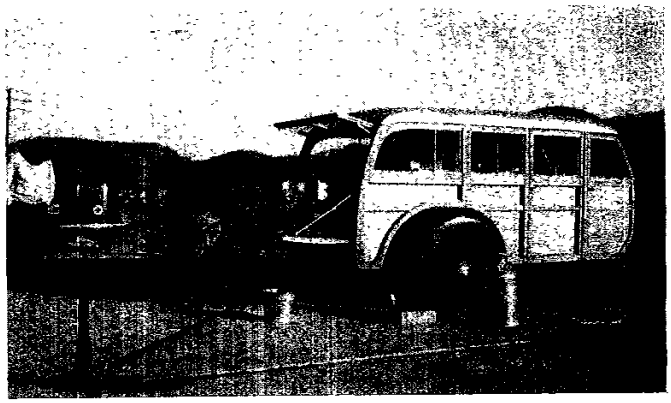
the slab weight. The average value for a movement of 0.050 inches increased to about 80% of slab weight and to about 110% of the slab weight for a movement of 0.10 inches.

The average thrusting force for the displacement of the 9"-7"-9" slab for a distance of 0.025 inches was about 45%. The average value for a movement of 0.050 inches increased to about 90% of slab weight and to about 130% of slab weight for a movement of 0.100 inches.

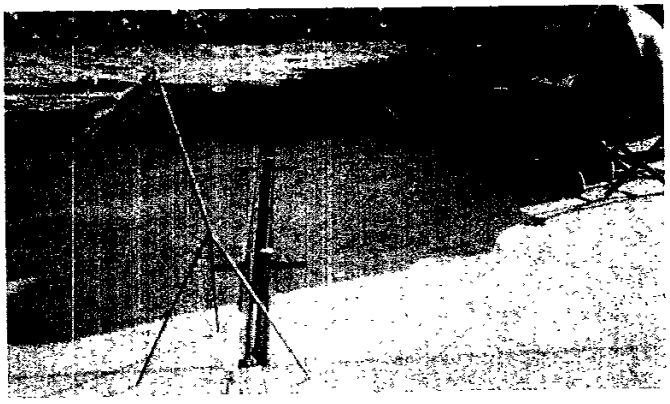
Figure 1-D

SUBGRADE FRICTION TESTS

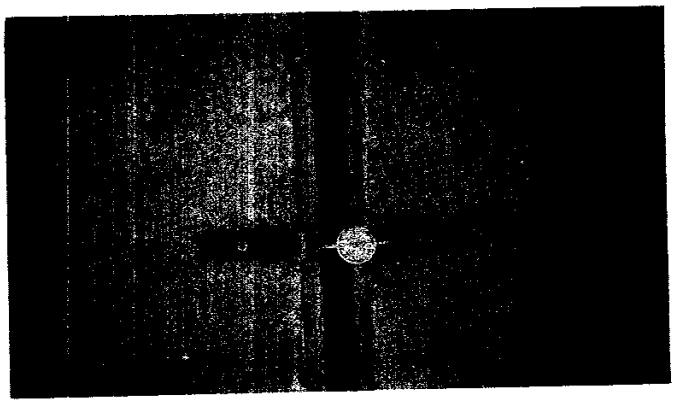
VII-Ven,LA-79-C,A Research 00194 Contract No. 27XC7-P



Slab under test



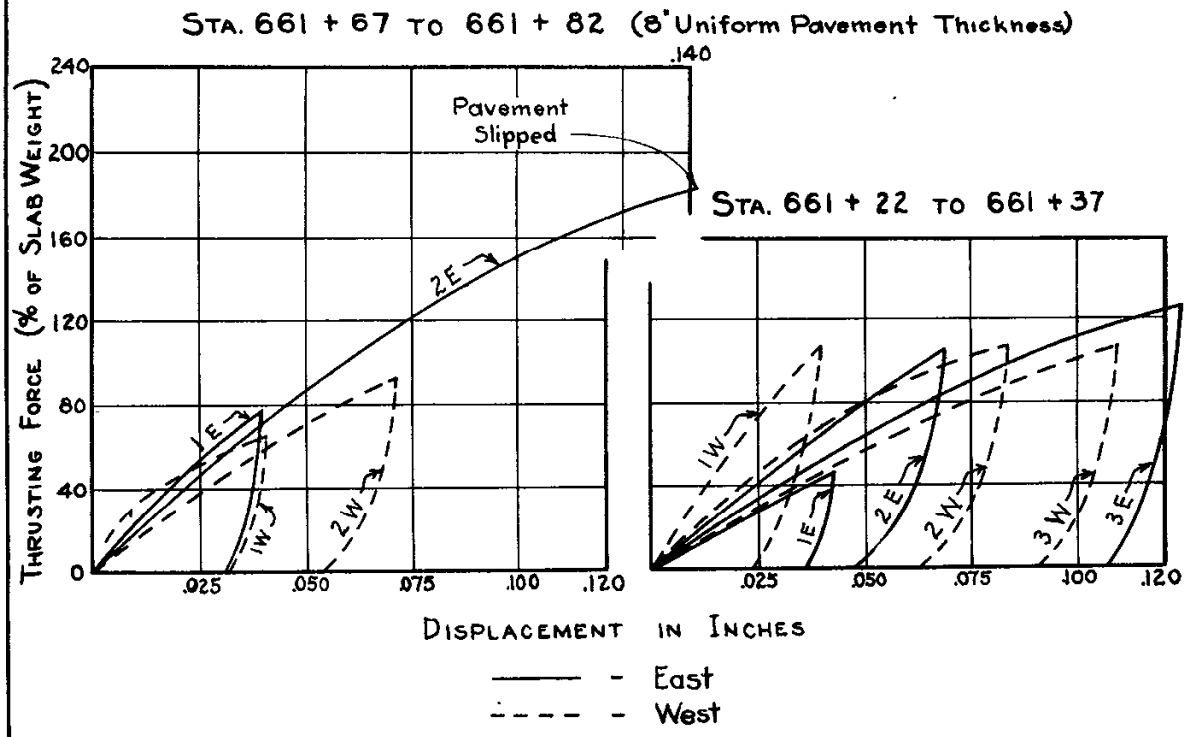
Ames Dials and Pressure Hose

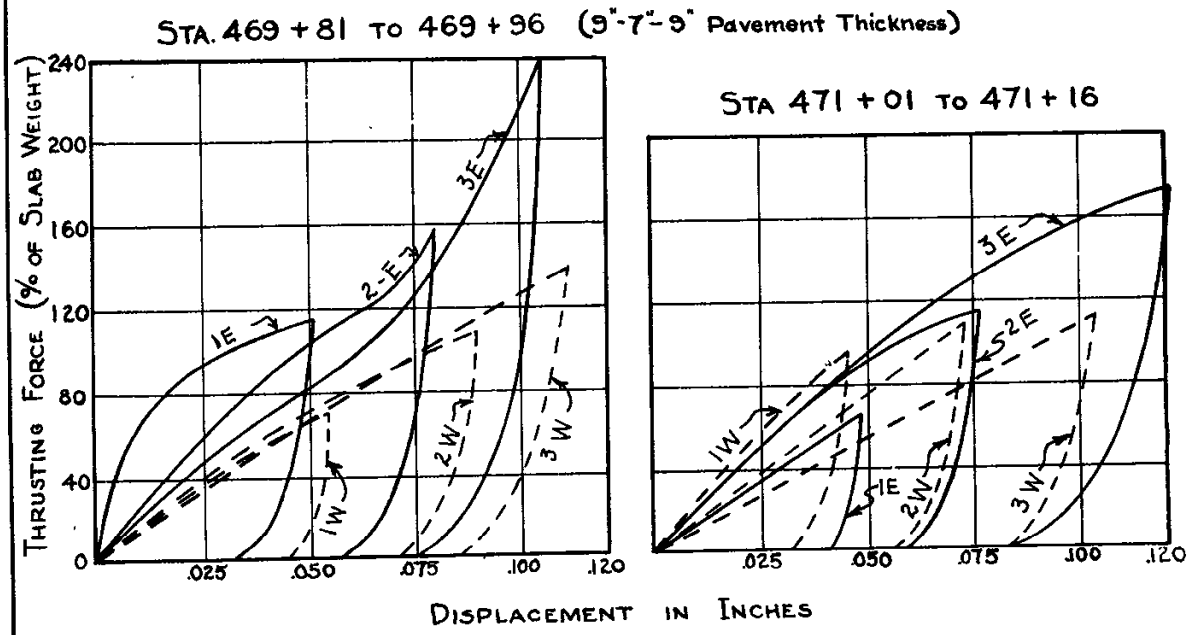


Close-up of Ames Dials and Pressure Hose

VII-Ven-79C

Force Displacement Curves





4-43

APPENDIX E

"k" (Westergaard) Determinations
On the Ventura Experimental Pavement

Measurements were made by four different methods to secure information concerning Westergaard's modulus of subgrade reaction "k."

(1) A diaphragm method and (2) a plunger method made on the subgrade after it had been prepared for the paving operations as outlined in Asst. State Highway Engineer Grumm's memorandum of October 10, 1940 (copy attached), (3) on full pavement thickness concrete discs of 12", 18", 24" and 36" diameter constructed on the subgrade during paving operations and (4) measurements of the deflection at the center of full sized concrete slabs (11' x 15').

1. DIAPHRAGM METHOD

For "k" determinations by the diaphragm method the finished subgrade was leveled off with a layer of sand approximately one-half inch thick. The diaphragm was then placed on this leveling course and carefully rotated to insure an intimate contact without bulging or sagging in the center, after which it was loaded with a sand supercharge to provide a unit weight equal to the unit weight of a 7" concrete slab. (Fig. 1-E).

A load, measured with a dynamometer, was applied to P (Figs. 1-E and 4-E) and held for 5 minutes at which time the movement of P was read on the Ames dials. An average of the readings on 3 dials was used to compensate for any eccentricity in loading. The load was then released for five minutes and the dials read again. These cycles of applying and releasing

the load were repeated until the difference in deformation between no load and full load increment remained constant for two or more applications of the load (Fig. 8-E). A second and larger load was then applied to P and the same cycle of readings recorded as for the first load. The successive loads were applied to P in increments up to a point at which the deflection of P approached the elastic limit of the diaphragm.

2. PLUNGER METHOD.

The procedure outlined in Grumm's memorandum was followed. Due to construction difficulties it was impossible to hold the weight of D (Fig. 2-E) to 10 lbs. and G to 0.4± pounds. These parts were counterbalanced as shown in Figure 5-E to bring the weights of the parts in contact with the subgrade to the desired value.

The subgrade was leveled off with a straight edge taking care to disturb it the least amount possible. The equipment was then set up using a loaded truck to anchor the hydraulic jack for applying pressure to R. A dynamometer instead of a spring scale was used to measure pressure P. A load of 1000 pounds was first applied slowly at R keeping P adjusted so that E remained stationary. This load was applied for 5 minutes and the value of M and P recorded. The load was then released slowly, still keeping E stationary, and left released for 5 minutes, again recording the value of M. The loading cycles were repeated until the difference between no load and load condition values of M remained constant for 2 or more applications of the load (Fig. 8-E).

3. CONCRETE DISCS

(a) Design. Circular forms made of 16 gauge galvanized iron 5½" high and 12", 18", 24" and 36" inside diameter were placed on the subgrade just prior to paving operations. The forms consisted of two concentric rings, the smaller ring having the required diameter of the concrete disc, and the larger ring being 4 inches greater in diameter, thus leaving a 2" clear space between the rings. A spider was placed in the smaller ring to hold the form to a circular shape while bituminous plant-mix was firmly tamped in the space between the two rings. The forms were placed on the subgrade with the top one and one-half inches below header grade. They were sufficiently rigid to maintain their shape while placing concrete by hand inside and around the forms just ahead of the concrete placing operations (Fig. 6-E) and allowing normal spreading and finishing operations to proceed without interruption. The concrete above the plant-mix was removed from between the rings and the edges finished with a trowel after the concrete had hardened to the finishing stage.

(b) Location. Twelve discs, three of each size, were cast in the south lane in the center of alternate 15' slabs, at the following locations:

	12" Diameter	18" Diameter	24" Diameter	36" Diameter
Station	406+81	407+11	407+41	407+71
"	408+01	408+31	408+61	409+91
"	409+21	409+51	409+81	410+11

(c) Test Procedure. The load was applied to the 12" diameter concrete disc by means of a hydraulic jack placed between the frame of a loaded truck and a 12" diameter x 7/8" thick steel plate resting on the concrete. This steel plate was set in a thin plaster of paris paste to insure full bearing between the plate and the concrete disc. Penetration was measured at the quarter points with four Ames dials attached to arms spaced equal distances from the center and resting on the adjacent concrete slab (Fig. 7-E).

The load was applied to the disc and hold for a period of 5 minutes. The dials were then read and the load released for 5 minutes after which the dials were reread to determine the elastic rebound. The loading cycles were repeated until the difference in the dial readings between the load and no load conditions remained the same for at least two loading cycles (Fig. 9-E).

The load was then increased and held for five minutes, the dials read and the load again released for 5 minutes. The load cycles were again repeated as for the first load increment until the difference in the dial readings between the load and no load conditions remained the same for at least 2 loading cycles.

The increments of loads were repeated until a load was reached equal to the capacity of the loading equipment.

The 18" diameter concrete discs were capped with 7/8" thick 18" diameter steel plates as described for the 12" diameter concrete disc. The 12" diameter steel plates were then centered over the 18" plates. The load cycles and penetration measurements (Fig. 10-E) were then made in the same manner as for the

12" diameter disc.

The 24" diameter discs were capped with a pyramid of 7/8" thick 24", 18" and 12" diameter steel plates. The load cycles and penetration measurements were then made (Fig. 11-E) in the same manner as described for the 12" diameter disc.

The same steel plate set-up was used for the tests on the 36" diameter concrete discs as on the 24" discs. This left a 6" ring of concrete on the outside of the pyramid of steel plates. The load cycles and penetration measurements were then made (Fig. 11-E) in the manner described for the 12" diameter disc.

4. DEFLECTION OF FULL SIZE SLABS.

3" pipe couplings fitted with a 3" pipe nipple were grouted into 6" core holes cut in the center of 15' slabs (Fig. 13-E). The couplings were placed in the alternate slabs between those containing the concrete discs. A hole extending 5½ feet below the top of the pavement was made with a soil sampler through the center of the pipe coupling. A 5-foot length of 1" thin wall conduit, to serve as a casing, was then pushed to the bottom of the sampler hole. A 6½-foot length of 1/2" pipe, topped with a 1/2" x 3/4" bushing and a 3/4" brass cap, was then driven through the conduit extending from approximately one inch above the base of the 3" pipe nipple to 1½ feet below the casing. A 3/4" brass cap was then drilled and tapped for a 1/4" thread.

The center of a 3" countersunk pipe cap was drilled and tapped for a standard 1/8" pipe thread. A collar threaded for 1/8" pipe thread was soldered to the case of a 1/10,000

inch Ames dial. The dial was attached to the pipe cap with a 4" length of 1/8" standard pipe. A short length of 1/4" threaded rod was screwed into the 3/4" cap on the reference rod and extending inside the 1/8" pipe* contacting the stem on the dial (Fig. 13-E). The dial attached to the pavement through the 3" coupling measured the vertical movement of the pavement and with reference to the rod anchored 5½ feet below the surface of the pavement.

The load was applied to the pavement slab adjacent to the couplings through a 12" diameter steel plate cushioned on the concrete with a 1/2" thick celotex gasket. The dial was read through a peephole cut in a piece of 7" pipe welded to the steel plate for supporting the hydraulic jack.

An I-beam frame was placed on the slab under test, and a water tank backed up to each end, with the rear wheels resting on the adjacent slabs. Jacks were placed between each corner of the I-beam frame and the frame on the tank trucks, with sufficient pressure being applied to these jacks to just keep the frame in contact with the pavement so that it would not shift when a load was applied through a hydraulic jack to the pavement slab under test.

DISCUSSION OF RESULTS

1. Diaphragm Method:

Westergaard's Modulus of subgrade reaction "k" calculated from data secured with the diaphragm method are shown in Table No. 1-E and Figure 8-E. The values shown as k(1) were

*A 1/8" standard pipe has an internal diameter of 0.269" or large enough to accomodate a quarter-inch rod.

calculated from data secured on the first application of load for each loading series. The values shown as k (2) are from data secured on the last application of load for each loading series.

The first series of loadings indicate values of k (1) less than half of the k (2) values. This may be due, at least in part, to rearrangement and consolidation in the sand leveling course. The value of k (1) and k (2) secured for the higher load values agree very closely. However, the results by this method are in general much higher than those obtained by the conventional method.

2. Plunger Method:

The k (1) values for the first load applied to the plunger are extremely low in comparison with the k (2) values. As in the diaphragm method this may be due, at least in part, to rearrangement and consolidation of the sand leveling course. This method also yields results which are somewhat higher than those obtained by the conventional method.

3. Concrete Discs:

"k" values obtained from the concrete discs are shown in Tables No. 2-E and Figures 9-E to 12-E, inclusive.

The average of the k (1) and k (2) values for all the loads for each diameter from Table No. 2-E are as follows:

	12" dia.	18" dia.	24" dia.	36" dia.
k (1)	2080	1580	1190	780
k (2)	2470	1860	1370	870

The k(1) values are somewhat lower than the k(2) values although the difference is not as pronounced as those obtained

with either the diaphragm or the plunger methods. This may be due, in part, to the fact that the discs were cast directly on the subgrade while the other methods required a sand leveling course.

The values of k(1) and k(2) varied approximately as the square root of the area involved in the test.

4. Full-size slabs:

"k" values based on the measured load deflection characteristics of a full-sized concrete slab were obtained by substituting in Westergaard's formula for Case 11 loading. Poissons ratio was taken at 0.16. The thickness of the slab was 7" and the compressive secant modulus of elasticity at 28 days 3,500,000 at 1000 p.s.i., as shown on Table No. 3-E.

Table 1-E

SUBGRADE "k" (WESTERGAARD)
Determined By
DIAPHRAGM AND PLUNGER METHODS

Station	Total Load	k(1)	k(2)	Total Load	k(1)	k(2)	Total Load	k(1)	k(2)
DIAPHRAGM METHOD									
407+71	100	1740	3900	170	7230	7230			
390+00	120	625	1840	300	3900	4650			
Average		1180	2870		5565	5940			
PLUNGER METHOD									
408+61	1000	390	3350	2000	1430	5580	4000	2080	2860
410+00	1000	630	3560	2000	1180	3140	4000	1530	4100
Average		510	3450		1310	4360		1810	3840

k(1) Slope of load deformation curve for first application of load.

k(2) Slope of load deformation curve for last application of load.

Table 2-E

SUBGRADE "k" (WESTERGAARD)

DETERMINED FROM DEFORMATION OF CONCRETE DISCS

Sta.	Load p.s.i.	k(1)	k(2)	Load p.s.i.	k(1)	k(2)	Load p.s.i.	k(1)	k(2)
12" Diameter									
406+81				40.4	1670	2380	84.2	1340	2550
408+01	8.6	2150	1720	36.0	3270	3600	79.8	2960	2960
409+21	12.6	1400	1800	40.0	2220	2500	83.7	1860	2330
Aver.	10.6	1780	1760	38.8	2390	2830	82.6	2050	2610
Grand Average all loads k(1) = 2080 k(2) = 2470									
18" Diameter									
407+11	16.9	1540	1880	36.3	1730	1910			
408+31	16.9	1410	1880	36.3	1730	2130			
409+51	18.1	1390	1650	37.5	1630	1700			
Aver.	17.3	1450	1600	36.7	1700	1910			
Grand Average all loads k(1) = 1580 k(2) = 1860									
24" Diameter									
407+41	20.2	1440	1440	42.0	1450	1620	64.1	1250	1390
408+61	20.5	1280	1470	42.4	1210	1460	64.6	1220	1340
409+81	20.8	1040	1300	42.7	1090	1220	64.8	670	1080
Aver.	20.5	1250	1400	42.4	1250	1430	64.5	1050	1270
Grand Average all loads k(1) = 1190 k(2) = 1370									
36" Diameter									
407+71	13.4	790	960	23.2	750	930	33.0	790	870
408+91	13.6	720	850	23.4	750	870	33.2	750	790
410+11	13.7	980	860	23.5	780	870	33.3	720	790
Aver.	13.6	830	890	23.4	760	890	33.2	750	820
Grand Average all loads k(1) = 780 k(2) = 870									

k(1) = Slope of load deformation curve for first application of load.

k(2) = Slope of load deformation curve for last application of load.

Table 3-E

SUBGRADE "k" (WESTERGAARD)

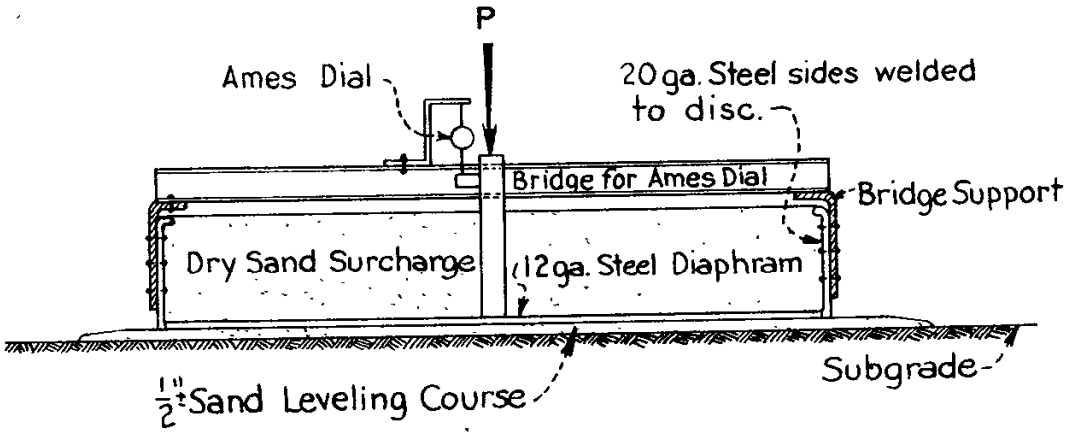
CENTER LOADING - FULL SIZE SLAB

Station	Total Load	"k" for *E_s=3.5x10^6	Total Load	"k" for E_s=3.5x10^6
408+16	7900	2640	10800	2270
408+76	"	1310	"	1230
409+36	"	1650	"	1730
409+96	"	1370	"	1370
Average		1750		1650

k(1) = k(2) for full size slab.

E_s = The compressive secant E at 28 days.

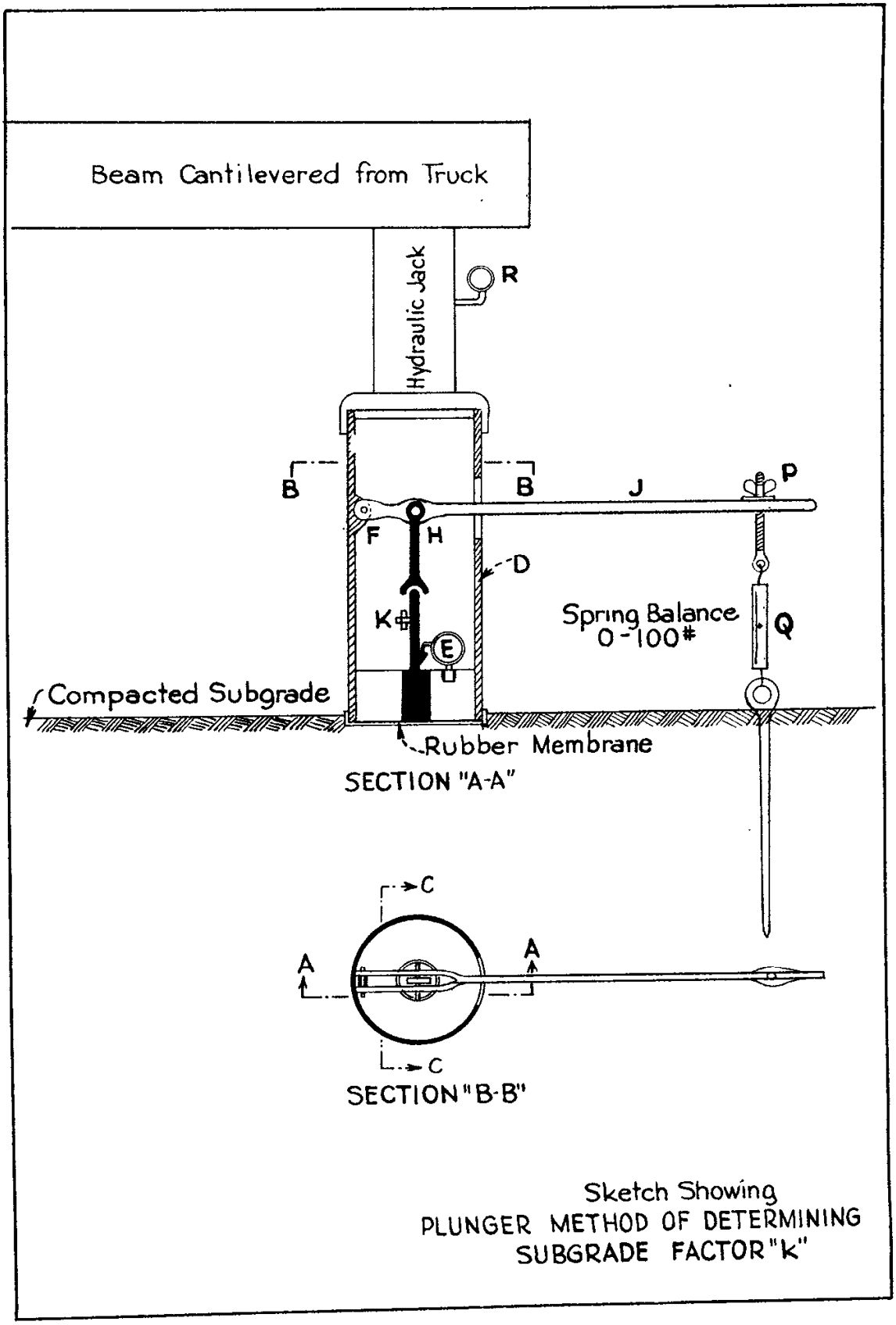
Fig. 1-E



NOTE:
Sand surcharge to provide
unit weight equal to 7" concrete slab

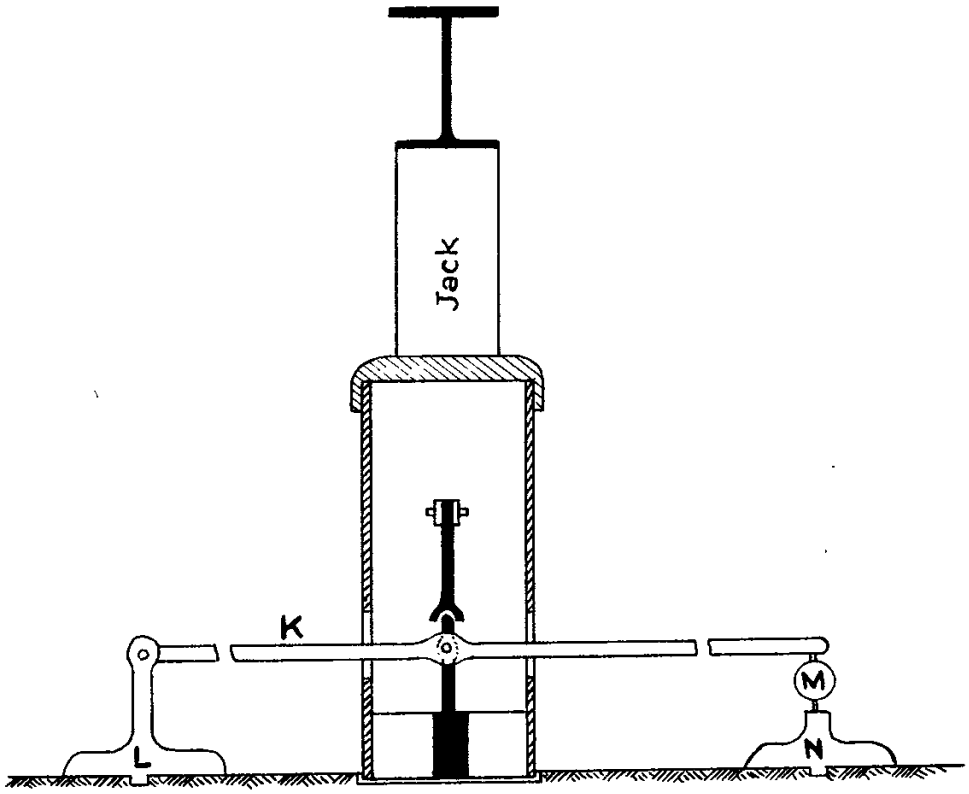
Sketch Showing
DIAPHRAM METHOD OF DETERMINING
SUBGRADE FACTOR "K"

Fig. 2-E



Sketch Showing
PLUNGER METHOD OF DETERMINING
SUBGRADE FACTOR "K"

Fig. 3-E



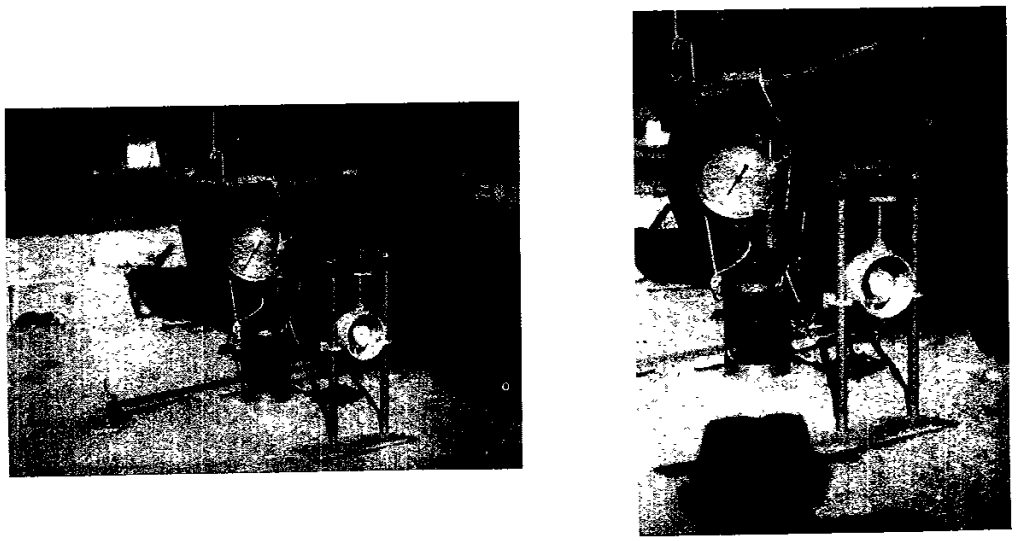
SECTION "CC"

Sketch Showing
PLUNGER METHOD OF DETERMINING
SUBGRADE FACTOR "k"

LOAD-DEFLECTION MEASUREMENTS

DIAPHRAGM METHOD

FIG. 4-E



PLUNGER METHOD

FIG. 5-E

CONSTRUCTION OF CONCRETE DISCS

Forms placed on subgrade.

Placing concrete around form.

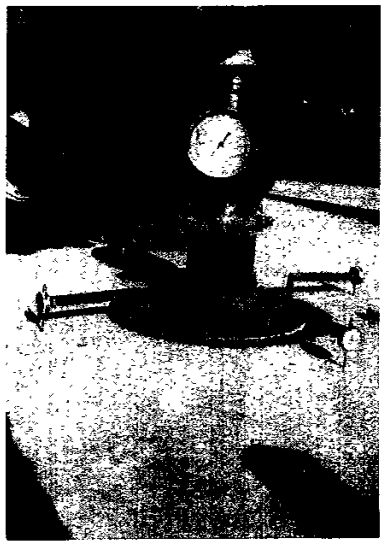
Blaw-Knox Spreader approaching form.

Concrete disc in finished concrete.

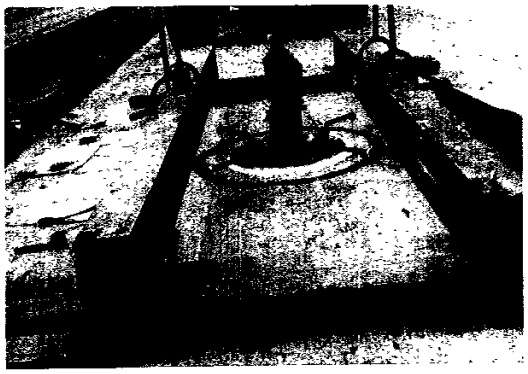
Fig6-E

LOAD-DEFLECTION MEASUREMENTS ON CONCRETE DISCS

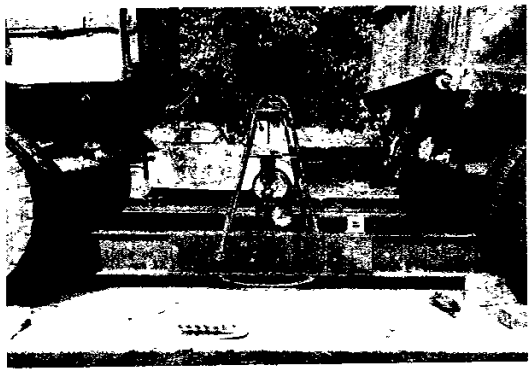
12" dia. Disc



18" dia. Disc



36" dia. Disc



Loading Frame

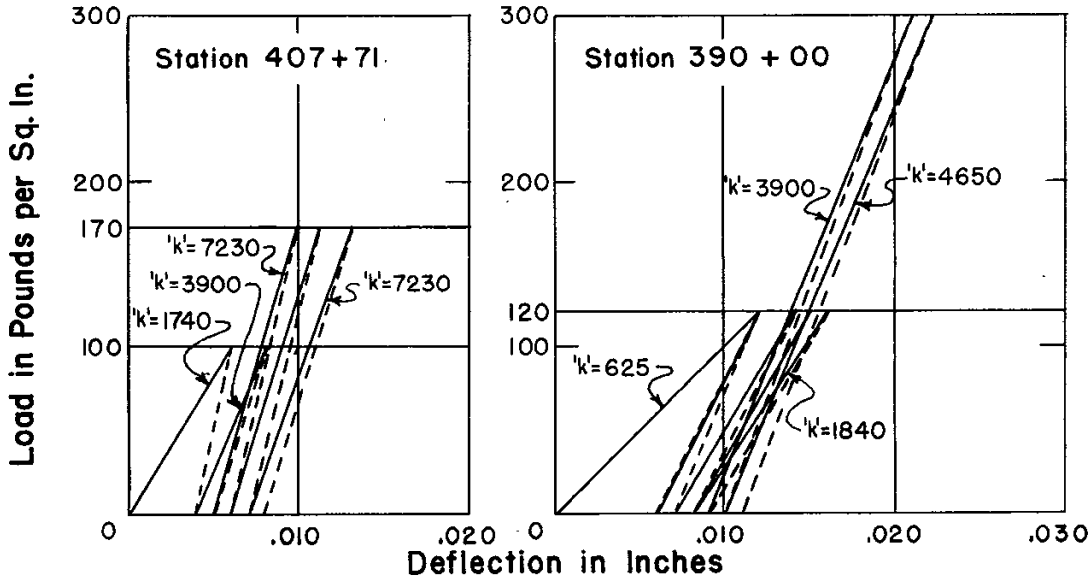
Fig. 7-E

Fig. 8-E

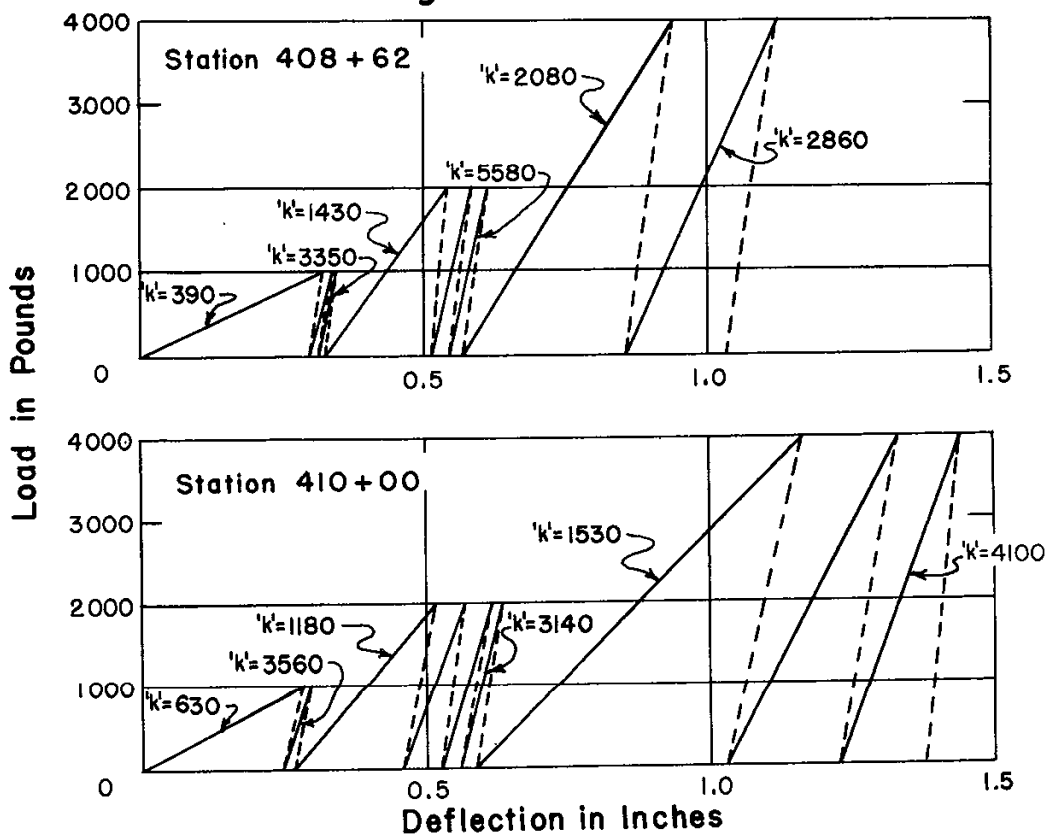
VII-Ven-79C

LOAD-DEFLECTION CURVES

Diaphragm Method



Plunger Method



4-43
OA

Fig. 9-E

VII-Ven-79 C

LOAD-DEFLECTION CURVES
12" Diameter Plate

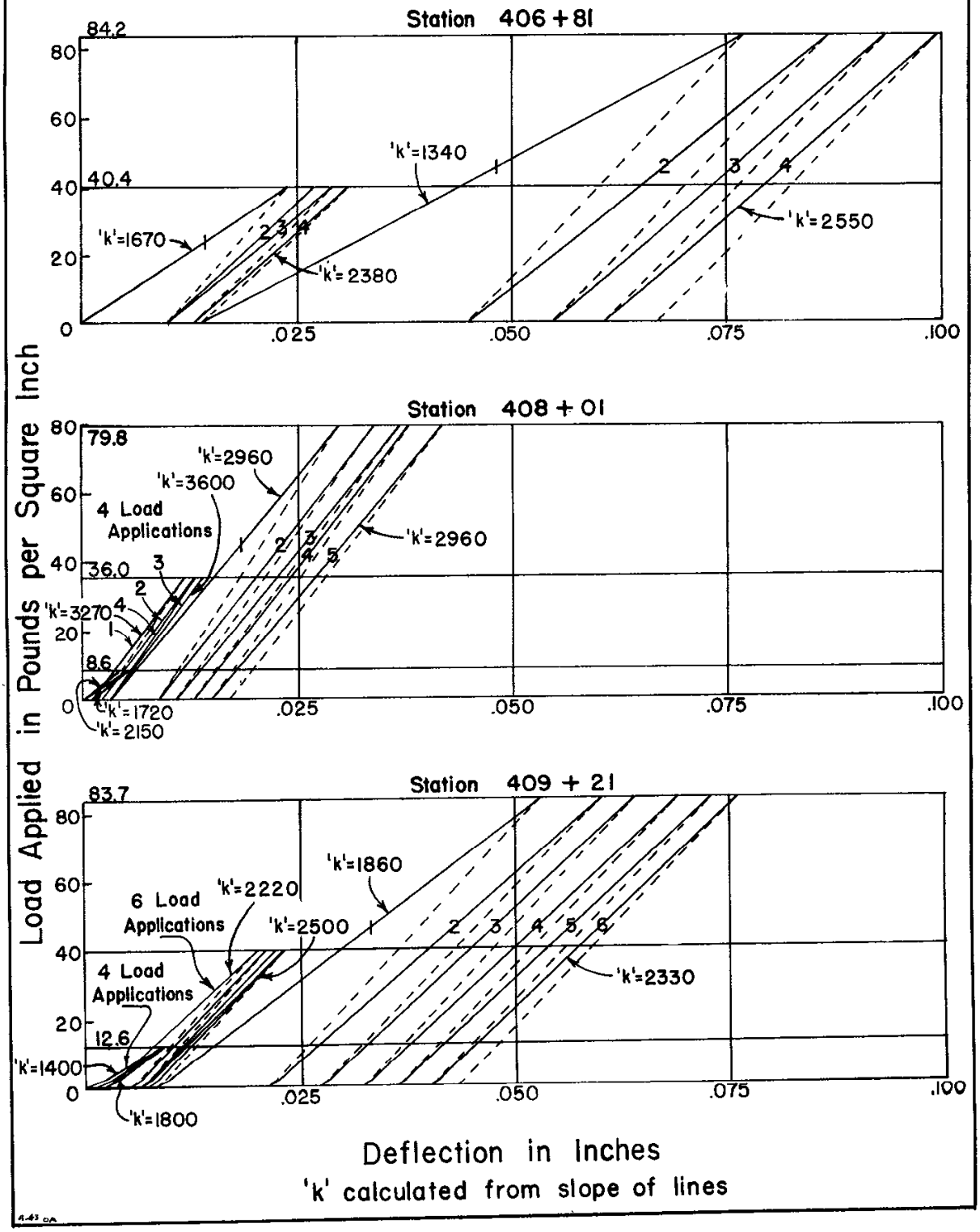
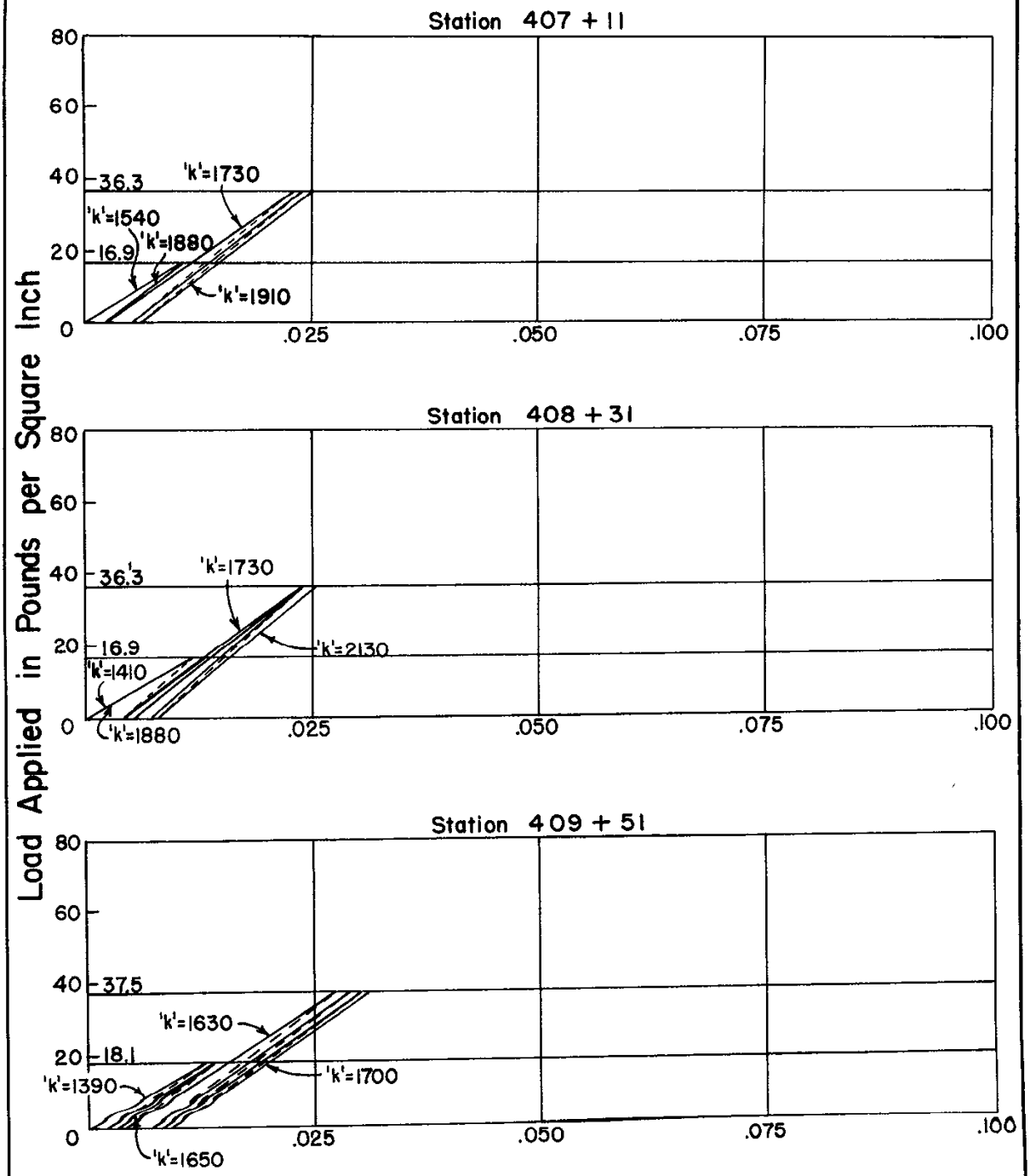


Fig. 10-E

VII-Ven-79 C

LOAD-DEFLECTION CURVES
18" Diameter Plate



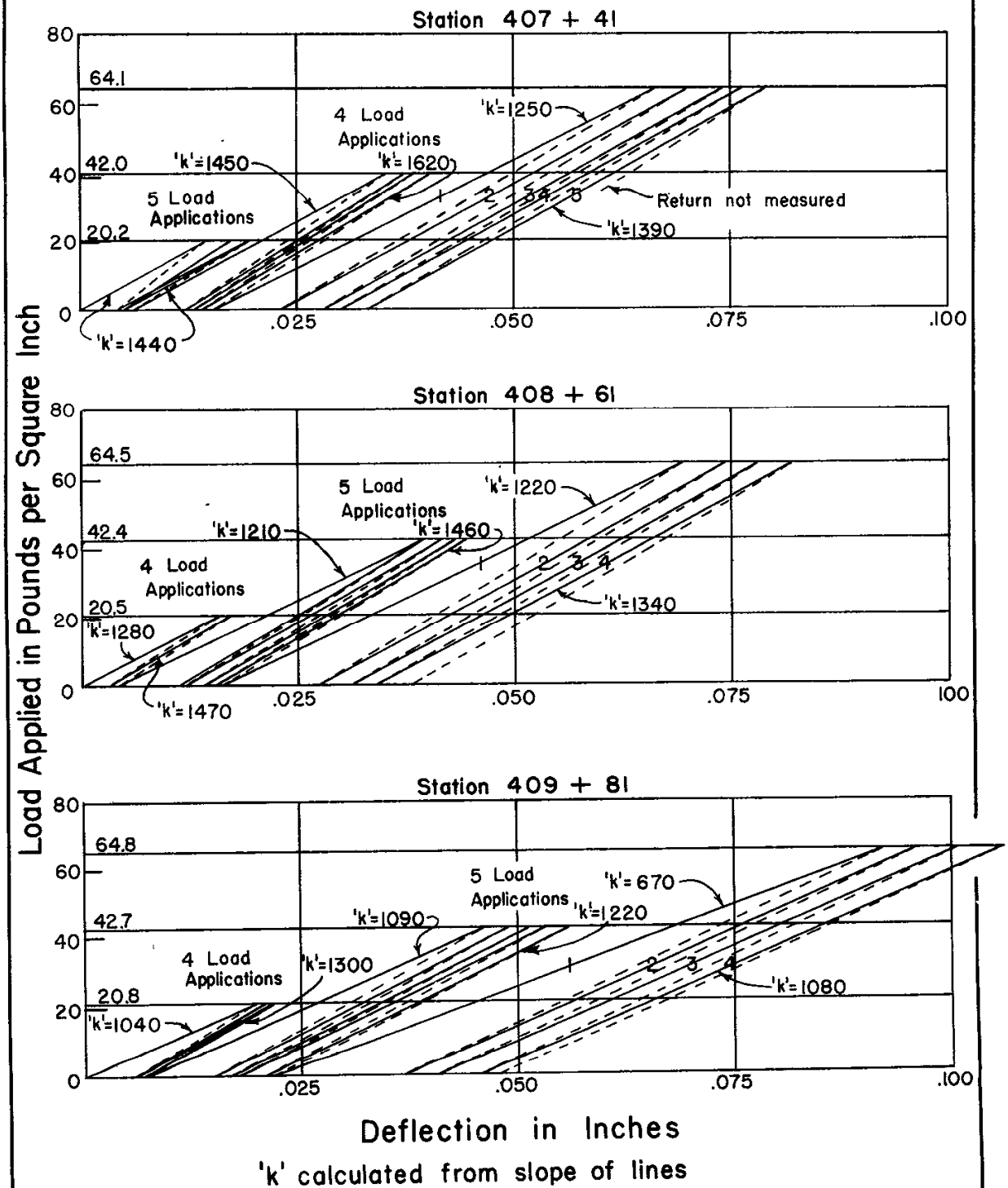
'k' calculated from slope of lines

4-43 S.A.

Fig.11-E

VII-Ven-79 C

LOAD-DEFLECTION CURVES
24" Diameter Plate

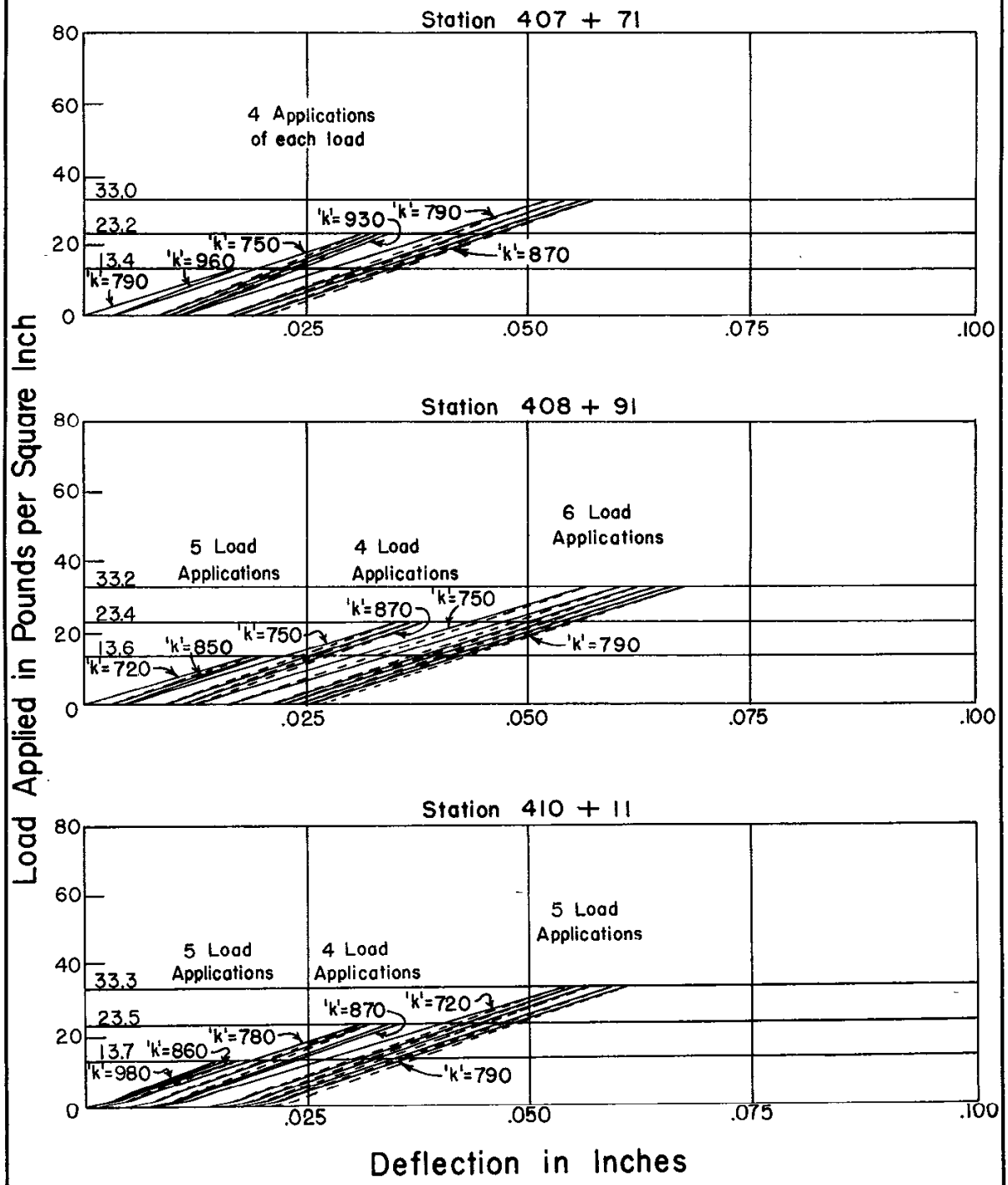


4-43

Fig. 12-E

VII-Ven-79 C

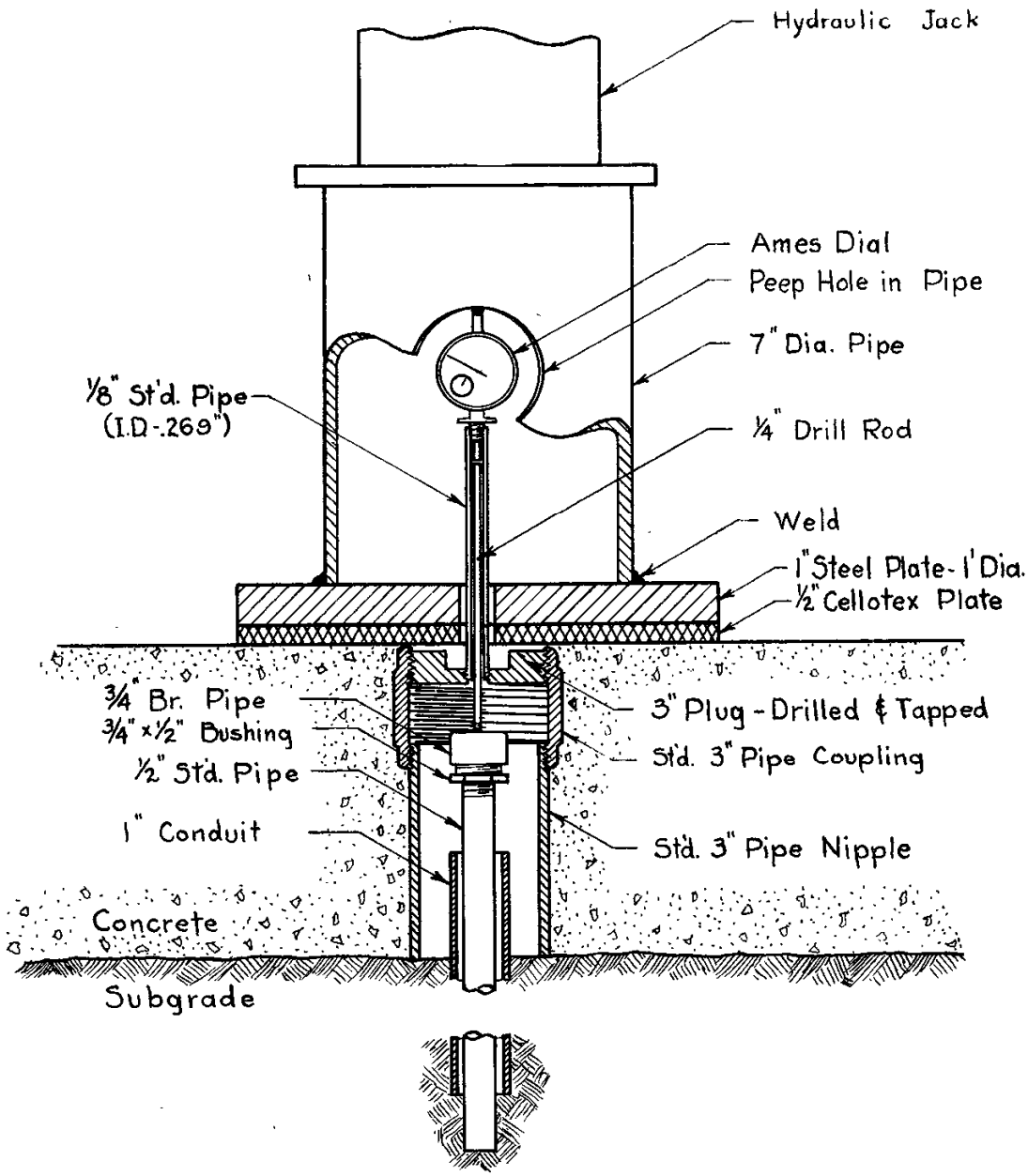
LOAD-DEFLECTION CURVES
36" Diameter Plate



'k' calculated from slope of lines

4-43 OA

VII-Ven-79C



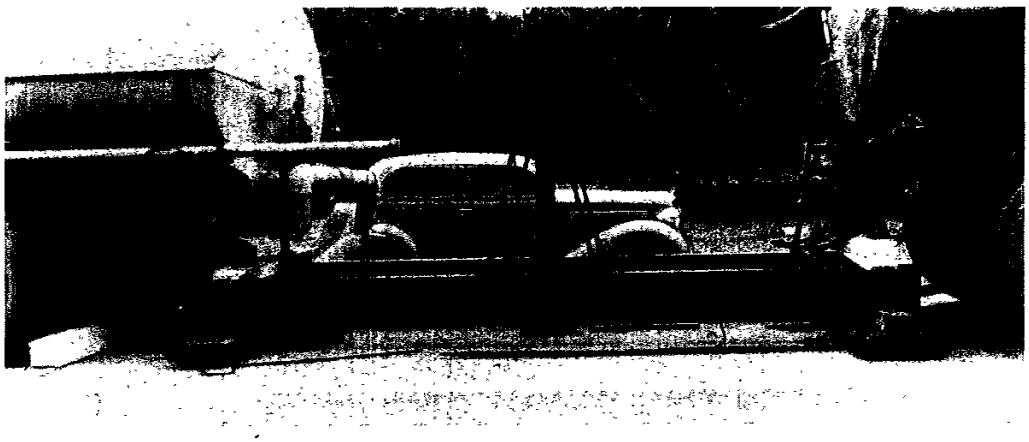
Schematic Diagram
of Apparatus for
Measuring Pavement Deflection

4-43
O.A

Fig. 14-E

LOAD-DEFLECTION MEASUREMENTS ON FULL SIZED SLABS

VII-Ven-79-C



Load applied to center of slab from trucks supported on adjacent slabs.

C O P Y

M E M O R A N D U M

200.461
September 3, 1941

Mr. Grumm:

Reference is made to the attached memorandum from Mr. Stanton relative to proposed methods of determining the subgrade factor "k" used in Westergaards formula for the design of Portland cement concrete pavements suggested for trial upon the experimental project between Piru Creek and the Los Angeles County Line, road VII-Ven-79-C.

The method recommended by Mr. Stanton consisting of the measurement of the penetration of circular discs into the subgrade under loads of varying magnitude has been followed in a number of instances in attempts to ascertain the factor "k". While this method has the advantage of being quite simple, I am somewhat doubtful that the desired data can be obtained in this manner.

Westergaard, in developing his formula, made the assumption that the subgrade acts as an elastic body. Since all subgrades are not the same he included in the formula a factor which he designated as "k" expressed in pounds per square inch per inch or lb/in^3.

Note that this is the same expression as for the modulus of elasticity of any solid. In other words the subgrade modulus "k" is merely the modulus of elasticity of the particular subgrade under consideration. Bearing this in mind the objection to the load-penetration method becomes more apparent i.e.

If a load is superimposed on a flat plane composed of an elastic substance a helmet shaped depression is developed and the modulus of elasticity of the substance is approximately equal to the weight of the load in lbs. divided by the volume of the depression in inches (see attached sketch). It is obvious that the area over which the load is imposed times the penetration bears no definite relationship to the helmet shaped depression produced and is therefore quite useless in determining the subgrade factor. Nonetheless, something of value may be learned from the load-penetration tests as proposed by Mr. Stanton and it is recommended that they be conducted as he suggests.

Also proposed are electric gage deflection measurements in the center of standard pavement slabs to be used in checking the subgrade factor procured by other methods.

Since it is intended to ascertain the modulus of elasticity of the concrete entering into the pavement, this method can be used to determine "k" with a fair degree of certainty within the range indicated from the various samples tested.

It is essential that some simple reliable method to determine the magnitude of "k" in the subgrades we are constructing be developed if our Portland cement concrete pavements are to be designed upon a rational basis. For this reason it is felt that the methods proposed by this department in the memorandum to Stanton of October 10, 1940 should be given a trial in spite of what appear to be practical difficulties in connection with their use. Both are theoretically capable of determining the modulus of elasticity of a truly elastic substance and practical difficulties have a way of often solving themselves when a method or device is put to actual test.

(Signed) N.C.M.

NCM:VD
cc: NCM
FJG

C O P Y

M E M O R A N D U M

August 27, 1941

SUBJECT: VII-Ven-79-C
Subgrade factor "k"

F. J. Grumm:

Referring to proposed determination of subgrade factor "k" on the concrete pavement experimental project between Piru Creek and the Los Angeles County Line on road VII-Ven-79-C, Contract No. 27XC7-P, FAP 380-C, considerable study of the literature on the subject has been made along with the two detailed methods of testing suggested in your memorandum of October 10, 1940.

The Division of Tests of the Public Roads Administration made a rather extensive series of tests in connection with their Arlington experimental work using bearing plates ranging from 2" to 84" in diameter. The loads required to obtain various increments of vertical displacement ranging from .005 to .05 of an inch were determined for most of the sizes of bearing plates ("Public Roads", October, 1935).

Mr. Frank Sheets of the Portland Cement Association recommended a load test on a 3' diameter bearing plate during the season of the year when the subgrade is in its weakest condition for determination of subgrade coefficient "k" and thickness of Portland Cement concrete pavement required (Engineering News Record, January 17, 1935).

It is our conclusion that it will be best to attempt to determine subgrade factor "k" by making load tests somewhat similar to those performed by the Public Roads Administration. It is specifically recommended that the load tests be made on circular bearing plates 12", 18", 24" and 36" in diameter and that the bearing disks be cast in the center of concrete slabs in the south lane during construction. It would appear desirable to provide for three repeat tests for each size of loaded area making a total of 12 installations. Each bearing plate can readily be poured as a separate part of the concrete pavement by installing two galvanized metal forms, the out one 4" larger in diameter than the inner one. The opening between the bearing slab and the surrounding concrete will be filled with bituminous material and sealed so that the load tests may be repeated at any subsequent period desired as the subgrade and subsoil takes up additional moisture through capillary or other action. Casting the test slab in this manner will automatically provide a normal pavement surcharge on the surrounding area.

It is also proposed that couplings for electric gauge deflection measurements be installed in the center of the standard pavement slabs between the load test slabs. Under this procedure, it will be possible to determine the center deflection of regular dimension slabs to compare with the load test data on circular segments of smaller area. Moisture content of the subgrade at the time the tests are made will be determined by sampling through the opening between the circular test slabs and the surrounding concrete.

While methods, 1 and 2, outlined in your memorandum of October 10, 1940, may be promising for the determination of subgrade factor "k" it appears that they both incorporate some objectionable features.

(1) So far as we know neither method has been previously used and, therefore, the results might not be recognized by the Public Roads Administration and other agencies unless they were checked against some other methods previously used.

(2) Both methods propose loading a relatively small area and in case of #2 without a surcharge comparable to the weight of a concrete slab over the surrounding ground.

(3) The plunger method, #2, proposes loading an area 5" to 6" in diameter. The reaction under this size of load area would be influenced largely by the material in the upper 6" of the subgrade whereas a concrete pavement slab under heavy truck equipment transmits the load to a much larger area, therefore, bringing into play the resistance of the subgrade and subsoil to a depth of 24" or more.

Even though it appears that valid objections might be raised regarding either method 1 or 2, I realize, of course, that sufficient work has not been done on this subject to substantiate any procedure of load test now in use in determining the necessary thickness of the concrete pavement and we have no objection to trying both of the methods, if you so desire. All load tests made on subgrade before or during construction have in common the one objection that they may not represent the action of the subgrade in its natural condition after it has become weakened by taking the moisture comparable to that which usually maintains 6 or 7 years after the pavement has been placed. The method of loading herein recommended is advantageous in that the deflection results can be repeated a few years subsequent to construction.

Please advise whether you concur with our recommendation regarding the loading tests and installation of couplings for deflection measurements in the center of the adjacent slabs.

T. E. Stanton
Materials & Research Engineer

OJP:mm

C O P Y

M E M O R A N D U M

October 10, 1940.

VII-Ven-79-C

Mr. T. E. Stanton:

Reference is made to our memorandum of September 10, 1940, relative to the concrete pavement experiment proposed for construction between Piru Creek and the Los Angeles County Line on Road VII-Ven-79-C.

Presented herewith for your consideration are the two suggested methods for the determination of the value of the subgrade factor "k" (Westergaard) prior to the construction of the pavement slab, referred to therein.

1. Diaphragm Method.

In a homogeneous slab, a concentrated load acting at a point a considerable distance from the edges has but slight influence beyond a distance of 8 times the radius of relative stiffness "l" from the point of loading.* From this it is reasoned that a circular diaphragm with a radius equal to 8 "l" is of sufficient size for the purpose of determining "k" by measurement of deflection. With the class of concrete and type of subgrade usually encountered in California, "l" averages approximately 30" and to be effective a test slab of concrete would have to be 40 feet in diameter.

With a given subgrade factor, the radius of relative stiffness "l" of a concrete slab seven inches thick and having modulus of elasticity of 4,000,000, is approximately fifteen times as great as the radius of relative stiffness

of a 12 gauge steel plate. It is therefore theoretically possible to construct a device for the determination of the subgrade factor "k" utilizing as its basic principle the ratio of load to deflection occurring in a relatively small steel diaphragm superimposed upon the subgrade.

A diaphragm such as shown on Figure 1 attached, thirty-six inches in diameter is large enough to record values of "k" of 100 lbs. per in.^{3} and over.

At any point in a slab located at any distance greater than 8"l" from the nearest edge,

$$k = \frac{12\,(1-U^2)\quad \left\{\frac{P}{8d}\right\}^2}{Eh^3}$$

Assuming the diaphragm to have the following characteristics:

Poissons ratio "u" = 0.25

Modulus of Elasticity "E" = 29,000,000

Thickness "h" = 0.0991 inches

the subgrade factor "k" = $\dfrac{P^2}{160{,}000 \quad d^2}$

Care should be exercised to see that the diaphragm is not loaded to such an extent that the resultant deformation exceeds its elastic limit.

2. Plunger Method

Tests have shown that pressure under bearing blocks or footings placed on compressible soils have parabolic distribution, the maximum pressure occurring at the center. The

*Computation of Stresses in Concrete Roads, H. N. Westergaard, Proceedings of the Fifth Annual Meeting of the Highway Research Board.

following described test utilizes this principle for the determination of "k".

Referring to Figure 2 and Figure 3.

D is a section of 5" pipe, capped at top and plugged at bottom, with cap and plug able to resist axial load equal to rear axle load - say 16,000 lbs. Bore plug to 1" ø and hone to 1-1/32" ø. Tap plug for Ames dial E. Cut pipe walls for 3 lever apertures and peephole by E. Weld pin lug F (for 1/4" pin).

G is a 1" (true) diameter plunger with shelf for Ames dial E, 1/8" pin for lower beam, and ball end at top of rod.

H is a thrust rod with socket at bottom and pin (1/4") at top.

J is the lever beam, pinned to fulcrum F and power H with force applied by turning wing nut P on machine screw, power being measured by spring balance Q and mechanical advantage (10). Hold down obtained by deformed eye-bolt.

K is the deflecting beam, fixed by ground weight L and 1/8" pin, actuated by movement of G, and deflecting doubly at Ames dial M on ground weight N. Left half of K should be heavier than right half, to avoid effect of pin play.

Jack is hydraulic, with calibrated gauge R, and 16,000 lbs. capacity.

Weight of D should be about 16 lbs., equivalent to pavement load. Also G should weigh 0.4 lbs.±.

Operation

Set up as shown and described.

Apply a small jack pressure, turning wing nut P to keep Ames dial E at initial setting. Read R, Q, and M.

With E constant, plunger and pipe have moved downward same distance (0.5M) with plunger pressure of 10 Q and average intensity $\frac{40}{\pi}$ Q.

Westergaard's k should be

$$k = \frac{\frac{40}{\pi} Q}{0.5\ M} = \frac{80\ Q}{\pi\ M}\ \text{lbs./in}^3$$

The effect of the compression of the surrounding ring will be to reduce (and perhaps nullify) (1) lateral movement below the plunger, (2) punching shear resistance of the soil, and (3) effect of Poisson's ratio.

To expedite set-up, a mat-template 42 x 30 could be made with holes and match marks for D, L, N, and Q.

Investigations conducted by A. T. Goldbeck and M. J. Bussard, U. S. Bureau of Public Roads and A. Bijls, relative to the supporting value of soil as influenced by the bearing area indicate that "k" would be approximately proportional to the square root of the area involved. This, together with the extreme delicacy of the deflection measurements from which "k" is determined introduces complications that may prove these methods impractical.

(Signed) Fred Grumm
Engineer, Surveys and Plans

C O P Y

M E M O R A N D U M

September 5, 1941

200.46

Mr. Stanton:

Reference is made to your memorandum of August 27, 1941, relative to proposed methods for the determination of the subgrade factor "k" used in the Westergaard formula for the design of Portland cement concrete pavements suggested for trial upon the experimental project between Piru Creek and the Los Angeles County Line, road VII-Ven-79-C.

As expressed in the attached memorandum by Mr. McCorkle, we are not convinced that the measurement of vertical displacements of circular discs under various loads can be utilized to correctly ascertain "k". However, as you point out in your memorandum, insufficient work has been done in this field to rule out investigation of any method promising a solution of the problem, and we therefore concur in your recommendation that load tests be made on circular bearing plates 12", 18", 24" and 36" in diameter in the manner outlined.

In view of the intention that modulus of elasticity determinations be made of the concrete entering into this pavement, your proposal to make electric gage deflections in the center of standard slabs is considered most excellent. Ordinarily this is not a particularly satisfactory means for determining "k" because of the important part the assumed modulus of elasticity of the concrete has in the formula for its solution.

On the Mer-4-A experiment, deflections were measured in the center of the slab to one-thousandth of an inch (0.001"). Later, when computations for "k" were attempted it was found that a much greater degree of accuracy is necessary if this method is to be used. For this purpose it is essential that the deflection measurement be accurate to one ten-thousandth of an inch (0.0001").

On the same experiment most of the deflection measurements were obtained when the load was imposed through truck wheels equidistant from the point. This procedure greatly complicates computations of "k" and it is therefor suggested that in the proposed experiment the deflection measurements be obtained at the point of the application of load. If possible, the slab should not be subjected to any other significant loading at the time the measurements are taken. Possibly a truck with sufficient wheel base to straddle the lane could be used to supply the load. The exercise of sufficient care in this work should provide us with a valuable yardstick with which to compare the results obtained by other proposed means.

It is recommended that the two methods proposed in my memorandum of October 10, 1940, be given a practical test to determine if they are feasible for the purpose intended.

(Signed) Fred Grumm
Engineer, Surveys and Plans

APPENDIX F

ROUGHNESS MEASUREMENTS WITH THE PROFILOGRAPH

An instrument, termed a "Profilograph," designed by Senior Physical Testing Engineer F. N. Hveem and built in the Materials and Research Department Machine Shop, was used to measure changes in profile and roughness of the concrete pavement at different times of the day and at different periods.

The "profilograph" is supported on 16 wheels, arranged in a staggered pattern so that the body of the machine moves, as nearly as possible, in an even plane which corresponds to the general plane of the pavement surface.

An additional wheel, free to move vertically, follows the contour of the pavement and, through a series of levers, etc., records the irregularities of the contour on a continuous graph. The respective horizontal and vertical scales on the graph are such as to make the actual contour of the pavement surface readily apparent.

By means of this instrument seasonal or daily changes in surface contour may be observed, recorded and compared. Typical examples of such graphs for portions of the Ventura experimental pavement are shown on Figures 2-F to 5-F, inclusive. These graphs illustrate very clearly the tendency of concrete slabs to curl upward at the joints under certain conditions of temperature and moisture content.

It is of interest to note the difference in curvature between morning and afternoon in warm weather and the decreased curvature in the damp cool weather of the rainy season.

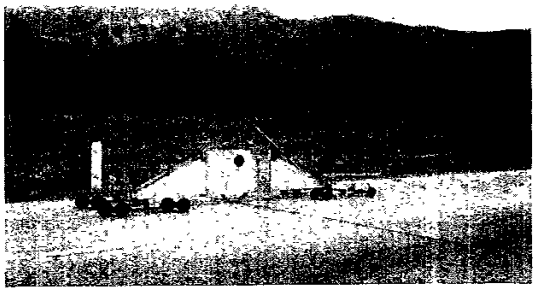
Such profilograph records afford an excellent visual demonstration of the features which affect the riding qualities of concrete surfaces as influenced by the temperatures and moisture contents of the pavement slabs as well as by construction deficiencies.

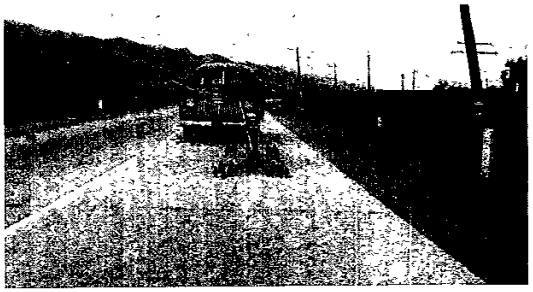
Complete profilograph records were made on all test sections but are not included with this report because of space requirements. The records are available, however, for comparative reports following future measurement periods.

Figure 1-F

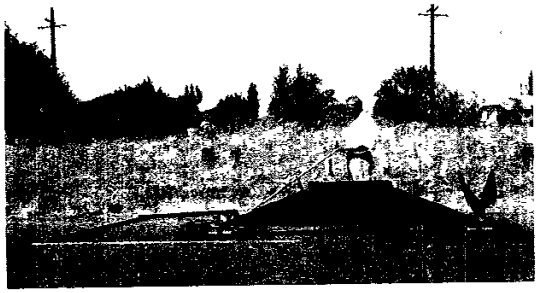
SPECIAL TEST EQUIPMENT

VII-Ven,LA-79-C,A F.A.P. 380-C (1) Research 00194 Contract No. 27XC7-P

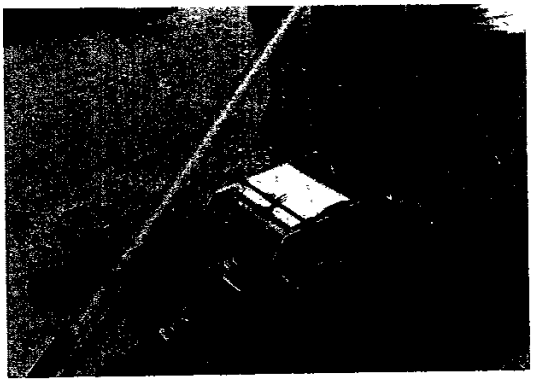




Profilograph



Profilograph in Operation



Close up of Recording Device on Profilograph
(Pens not in place)

FIGURE 2-F

Comparative Profilograph Records of Concrete Pavement

Test Section 3 B — VII - Ven - 79 C — Near center of North Lane

Scales

Horizontal - 1" = 25'

Vertical - 1" = ½"

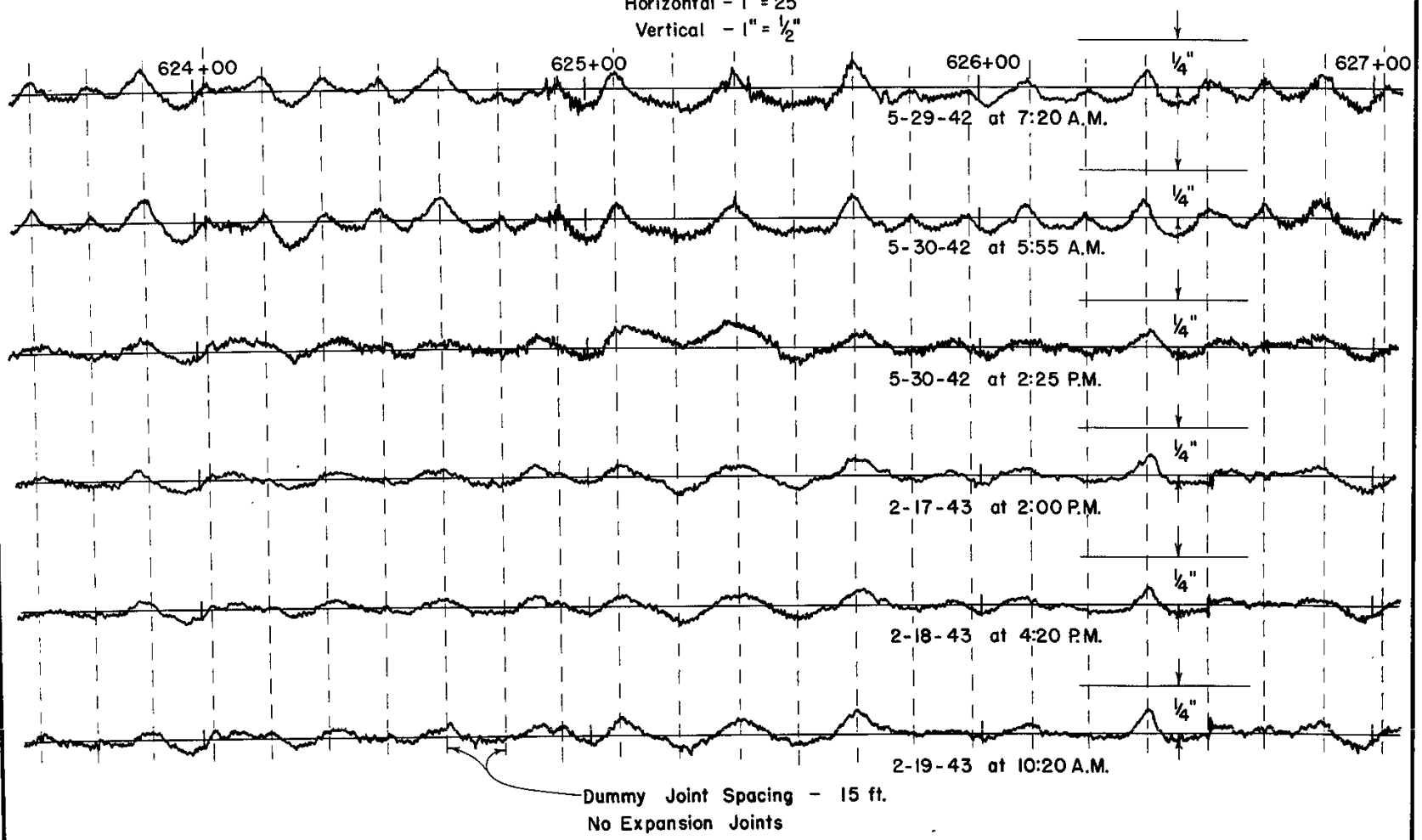


Fig. 2-F

FIGURE 3-F

Comparative Profilograph Records of Concrete Pavement

Test Section 6A — VII-Ven-79C — Near center of North Lane

Scales
Horizontal - 1" = 25'
Vertical - 1" = ½"

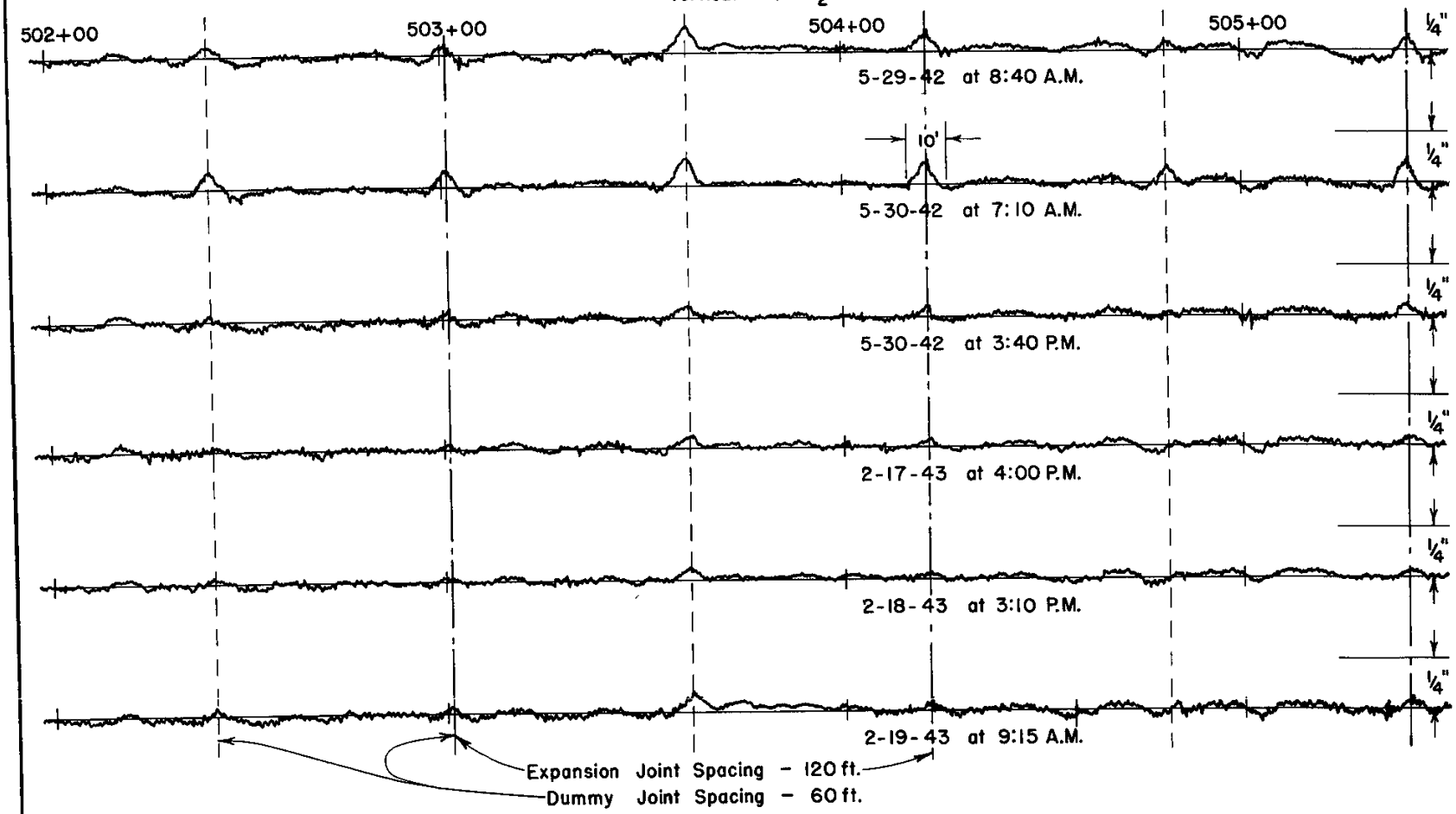


Fig. 3-F

FIGURE 4-F

Comparative Profilograph Records of Concrete Pavement

Test Section 1 B — VII - Ven - 79 C — Near center of North Lane

Scales

Horizontal - 1" = 25'

Vertical - 1" = ½"

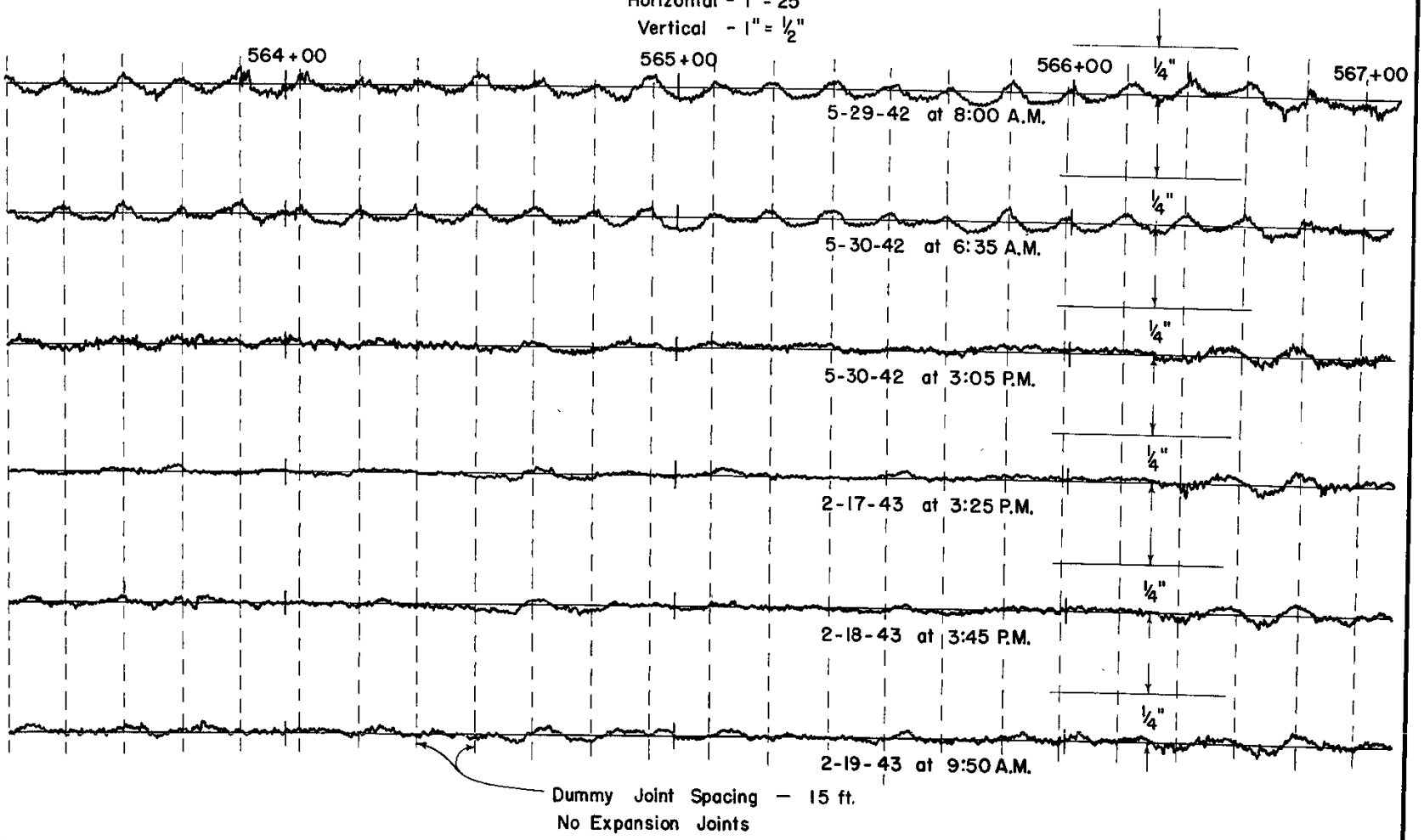


Fig. 4-I

FIGURE 5-F

Comparative Profilograph Records of Concrete Pavement

Test Section 5 B — VII-Ven-79 C — Near center of North Lane

Scales
Horizontal - 1" = 25'
Vertical - 1" = ½"

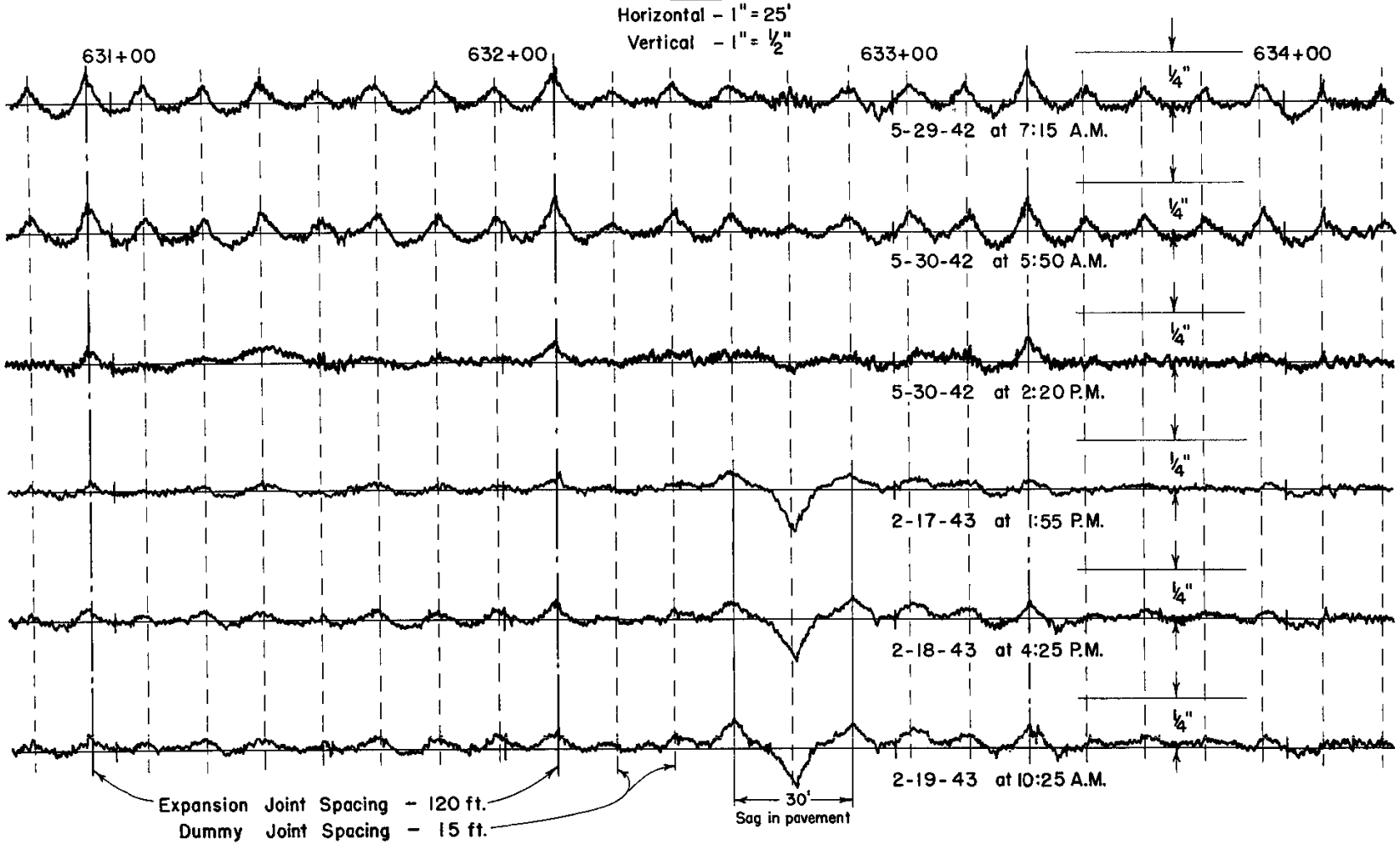


Fig. 5-F