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16. ABSTRACT
This study is an evaluation of the effects of overloads on newly constructed cement treated bases (CTB) that are utilized as haul roads during Portland cement treated bases (CTB) that are utilized as haul roads during Portland cement concrete (PCC) paving. Ten wheel dump trucks were used during transporting of 8 cubic yard batch of plastic PCC. Single axle loads up to 20 kips were permitted on a trial basis. A net loss or gain in strength or a weakening of the CTB as a result of overload hauling was determined using surface deflection measurements both before and after the hauling operations. Condition surveys were also performed to evaluate surface damage and cracking. Equivalent 5,000 pound wheel loads were determined from axle weights and daily truck counts. These data were collected on four paving projects. It was concluded that overloads up to 20 kips per axle are not detrimental to newly paced CTB when the average haul period is from 3 to 6 days.

Recommendations covering overload hauling are suggested for incorporation in a tentative specification.

17. KEYWORDS
Cement treated bases, condition survey, deflection, hauling, overloads, construction practice

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OF PUBLIC WORKS
DIVISION OF HIGHWAYS
AND RESEARCH DEPARTMENT
FOLSOM BLVD., SACRAMENTO 95819

March 1972

Final Report
M&R No. 633107
FHWA No. D-5-39

Mr. Robert J. Datel
State Highway Engineer

Dear Sir:

Submitted herewith is the final research report titled:

OVERLOADS ON EXPOSED CEMENT

TREATED BASES

George B. Sherman
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Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

REFERENCE: Sherman, George B., Matthews, James A., and Hannon, Joseph B., "Overloads on Exposed Cement Treated Bases," State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 633107, March 1972.

ABSTRACT: This study is an evaluation of the effects of overloads on newly constructed cement treated bases (CTB) that are utilized as haul roads during portland cement concrete (PCC) paving. Ten wheel dump trucks were used during transporting of 8 cubic yard batches of plastic PCC. Single axle loads up to 20 kips were permitted on a trial basis. A net loss or gain in strength or a weakening of the CTB as a result of overload hauling was determined using surface deflection measurements both before and after the hauling operations. Condition surveys were also performed to evaluate surface damage and cracking. Equivalent 5,000 pound wheel loads were determined from axle weights and daily truck counts. These data were collected on four paving projects. It was concluded that overloads up to 20 kips per axle are not detrimental to newly placed CTB when the average haul period is from 3 to 6 days.

Recommendations covering overload hauling are suggested for incorporation in a tentative specification.

KEY WORDS: cement treated bases, condition survey, deflection, hauling, overloads, construction practice.

ACKNOWLEDGMENTS

This study was conducted by the Materials and Research Department in cooperation with the Construction Department of the California Division of Highways. Credit should be shared with the personnel involved with data collection and testing, in particular Mr. Roy Bushey, Mr. Al Rybicki, and Mr. Wesley Dwyer.

The authors also wish to express their appreciation to the Construction Departments of Districts 04, 07, 09, and 11 and to the Resident Engineers for their cooperation on the four projects involved. We would also like to thank the Owl Paving Company and J. W. Vickrey, Inc. for their cooperation. Appreciation is also expressed to the California Highway Patrol for their loan of portable scales.

The research work reported herein was accomplished under Highway Planning and Research Project D-5-39 as a Type B Study in cooperation with the U. S. Department of Transporation, Federal Highway Administration. The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Federal Highway Administration.

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INTRODUCTION

In the construction of multilane freeways, there is a trend to utilize heavier than legal loads in transporting portland cement concrete (PCC) for pavement construction. The most modern technique involves batching and mixing the ingredients in a central plant and hauling the plastic PCC to the paving site in dump trucks. Generally, the project haul roads are rough and undulating and cause considerable wear on the hauling vehicles. If newly constructed cement treated bases (CTB) could be utilized as haul roads, this could reduce wear and tear on the hauling vehicles, as well as reduce the number of trucks necessary for continuous production. It has been suggested that considerable savings in time and money could be realized from this operation, both to the State and to the Contractor. This would promote lower competitive bidding and also improve construction safety.

Yamanouchi and Ishido[1] discuss the possibility of accelerating road construction by omitting the initial curing period and opening a soil-cement base to general traffic directly after compaction. Present California Standard Specifications permit construction traffic to travel over newly placed cement treated bases, when loads are not in excess of the legal load of 18 kips per axle. These specifications prohibit most PCC hauling operations because paving concrete is usually mixed in 8 cubic yard batches that produce single axle loads of about 20 kips.

A revised specification on weight limitations was put into effect during the 1970-71 construction season. On a trial basis, this permitted up to 20 kips per axle on newly placed cement treated base. It allowed trucks loaded with plastic PCC for paving to travel on exposed cement treated bases and exceed the present maximum legal load of 18 kips on a single axle. Loads exceeding 18 kips on a single axle and 32 kips on a tandem axle are considered overloads.

This research study was conducted to evaluate the effects of the overload hauling operation. An earlier study[2] made by the California Division of Highways investigated the effects of overload hauling on six different CTB projects. The method of evaluation consisted of obtaining Benkelman beam deflection measurements on newly placed CTB prior to any hauling. Subsequent measurements were then made following various wheel load applications. Any substantial increase in deflection was to be considered an indication of a weakening of the CTB. However, after 340 to 400 applications of 35,000 pound tandem axle loads, no significant increase in deflection was noted and no visual evidence of distress was observed. The test periods, however, were limited to one day hauling operations.

It was recommended as a result of the earlier study to allow hauling of loads in excess of the legal load on CTB on a trial basis and restrict the overloads to 25 percent above the legal tandem axle load. It was the intent of the present study which is reported herein to expand these findings by additional research. This study could also serve to justify the use of the above-mentioned revised specification on weight limitations which permits up to 20,000 pound axle loads on newly placed cement treated bases.

CONCLUSIONS

1. Overloads up to 20 kips per axle, are not detrimental to newly placed CTB when the average haul period is from 3 to 6 days. For the conditions encountered in this study, it appears that an accumulative load limit between (8 and 13) $X10^4$ equivalent 5,000 pound wheel loads could be carried on an exposed CTB before imposing load restrictions.

2. Overloads up to 20 kips per axle cause no detrimental increase in deflection level of CTB during the 3 to 6 day haul period when loading is within the limits defined in conclusion 1.

3. Isolated longitudinal cracking may develop in CTB after 4 days of overload hauling but does not necessarily reduce structural integrity. Relatively long or continuous longitudinal cracking in or adjacent to wheel paths of the haul vehicles at any time would indicate that overload hauling should be stopped.

4. Normal construction traffic could fatigue newly placed CTB under wet subgrade conditions and overloads should, therefore, not be allowed for the first 7 days following CTB placement.

5. On two of the projects studied, some transverse cracking developed in the test section during the period of overload hauling. The observed crack pattern was transverse cracking with an interval of from 20 to 25 feet on the average and would normally be thought of as shrinkage associated rather than load related. Overload hauling may accelerate the development of transverse shrinkage cracks, but did not appear to be detrimental under the conditions encountered on these projects. Measurements before and after hauling did not show detrimental increases in deflections; hence, it is believed that the cement treated base retained its structural integrity.

6. Overload hauling produces some loss of CTB curing seal that may require replacement.

7. As insurance against future loss of PCC load carrying capacity, overload hauling on CTB should be restricted to the No. 1 median lanes.

RECOMMENDATIONS

1. Overloads should be permitted on a trial basis and should be stopped, if block cracking develops. Particular attention should be given when the haul period exceeds the normal 3 to 6 days encountered in this study.

2. Overloads should not be allowed on CTB during the first 7 days of the curing period.

3. Restrict overload hauling to the No. 1 median lanes only.

4. Limit maximum loading to 20,000 pounds per axle.

5. All loose material should be broomed off the CTB surface following the final haul and the curing seal should be replaced in spalled areas prior to PCC placement.

IMPLEMENTATION

Preliminary recommendations from this study were furnished to our Headquarters Construction Department and have been incorporated in the following Standard Special Provisions:

1. SSP 27.01 dated 9-7-71, "Road-Mixed Cement Treated Base."

2. SSP 27.02 dated 9-7-71, "Plant-Mixed Cement Treated Base."

3. SSP 27.03 dated 9-7-71, "Road-Mixed and Plant-Mixed Cement Treated Bases."

The following are standard paragraphs which have been included in the above:

After cement treated base has cured for 7 days, trucks loaded with portland cement concrete for paving may travel on the completed cement treated base with axle loads not exceeding 20,000 pounds per axle. Such overload hauling shall be limited to the lane immediately adjacent to the median, in each direction.

If block cracking occurs, the Engineer may reduce said axle loads to the maximum specified in Section 7-1.02, "Weight Limitations," of the Standard Specifications. The Contractor shall not be entitled to any additional compensation nor extension of contract time by reason of such load reduction.

Before placing portland cement concrete paving over the cement treated base, any damage resulting from hauling shall be repaired, all loose material shall be broomed off the cement treated base surface, and any damaged curing seal shall be repaired by the Contractor at his expense, all as directed by the Engineer.

The implementation of these Standard Special Provisions could possibly result in lower bid prices for portland cement concrete pavement. The annual cost savings from this operation cannot be estimated at this time.

EVALUATION PROCEDURE

Four paving projects were investigated during this study to determine the effect of hauling overloads. A net loss or gain in strength or a weakening of the CTB as a result of overload operations was determined using surface deflection measurements both before and after the hauling operation. This was used as the main criteria for evaluation. These measurements were obtained with the California Traveling Deflectometer (Figure 1) carrying an 18 kip loading on the rear axle. The deflection data was statistically analyzed using the t-statistic by testing the hypothesis that the mean deflection levels of the loaded No. 1 lane and the No. 2 or No. 4 unloaded lanes were equal. If a significant difference existed at the 95 percent confidence level, the hypothesis was then rejected. The alternate hypothesis that the mean deflection levels were different, was then accepted. This same analysis was used on test areas receiving no truck traffic.

Condition studies which included photographs and crack surveys were also made to evaluate surface damage and cracking. Equivalent 5,000 pound wheel loadings were also determined from axle weights and daily truck counts.

Portable MD400 California Highway Patrol scales (Figure 2) were used to weigh both loaded and unloaded trucks, picked at random during one hour haul periods (Figure 3).

Test sections were selected to represent loaded, unloaded and no-load conditions. Loaded trucks traveled to the paving operation over the No. 1 lanes nearest the median and returned to the plant unloaded over the No. 2 and No. 4 truck lanes (Figure 4).

Final evaluation was based on deflection measurements, surface condition and wheel loadings.

DATA COLLECTION AND ANALYSES

The four projects included in this study are presented below with representative data collection and analyses.

07-Ora-91-R13.4/R18.9

This project is an eight-lane divided freeway located in the Santa Ana Canyon east of Anaheim. A 4,000 ft. area was selected for testing in the westbound lanes between Station 450 and Station 490. Ten wheel dump trucks loaded with 8 cubic yards of PCC traveled to the paving operation over the No. 1 lane (nearest median) for a period of three days and returned unloaded over the No. 4 lane (near outer shoulder). The age of the CTB at the beginning of the haul period was 15 days in the No. 1 lane and 20 days in the No. 4 lane.

A total of 1,295 loads passed over the test area. Average loaded and unloaded axle weights were determined from 6 loaded trucks and 4 unloaded trucks picked at random during a one hour haul period.

The average weight of the heaviest loaded axle was 20.2 kips which was only slightly in excess of the maximum specified axle load. The overloads produced a total of 40,780 equivalent 5,000 pound wheel loads over the test area during the three day period.

Deflection measurements were obtained on the CTB of lanes 1 and 4, prior to hauling and following the first and second day of hauling. Refer to Table 1. Construction operations prevented measurement of deflections on the final day of haul just prior to PCC paving. Condition surveys and photographs were taken following each day of hauling. After three days of hauling some loss of MC-250 curing seal was observed. Only transverse cracks developed and the total amount was about the same after 2 days for the unloaded test haul (lane No. 4) as for the loaded (lane No. 1). Refer to Table 2.

After 3 days of hauling, the amount of transverse cracking had increased from 25.8 to 61.0 linear feet per station in the loaded lane. The cracking in the unloaded section remained unchanged at 26.6 linear feet per station after the third day of hauling. In this comparison, it was necessary to adjust these values to represent the uncovered test lane lengths following each haul period. These data suggest that overload hauling may have accelerated the development of normal shrinkage associated transverse cracks. However, the majority of these cracks were hairline and not considered detrimental. An attempt was made to secure CTB cores for further evaluation but crumbling resulted and this was abandoned. The field data from this project are presented graphically on Figure 5.

Tests for significance at the 95 percent level (Table 3) indicate a difference in mean deflection magnitude between the right wheel track measurement of the No. 1 loaded lane and the No. 4 unloaded lane prior to hauling. The unloaded No. 4 lane produced the higher deflection magnitude of 0.012 inch versus 0.011 inch for the No. 1 loaded lane. However, no significant difference in deflection level existed between these lanes after two days of overload hauling.

A significant difference was noted between measurements made prior to hauling and those obtained after two days of hauling for both the loaded (No. 1) and unloaded (No. 4) lanes. During the haul period the deflection magnitude increased by 15 and 27 percent per wheel track in the No. 1 lane and 22 and 25 percent in the No. 4 lane. In terms of deflection, this increase was about 0.002 to 0.003 of an inch. These data suggest about the same relative deflection change regardless of truck loading. In final analysis it can be concluded that overload hauling did not produce a detrimental increase in deflection level of the CTB on this project.

<u>11-SD-805-3.5/7.3</u>

This project is an eight-lane divided freeway located in Chula Vista, south of San Diego. The length of this facility is 3.8 miles. Three test areas were selected for study in the southbound lanes between Station 230 and Station 270. Ten wheel dump trucks loaded with plastic PCC traveled over the No. 1 lane (nearest median) and the return trip unloaded was over the No. 4 lane. A portion of the No. 3 lane served as a no-load section. On the first day of the operation 179 8-1/2 cubic yard batches were hauled. This was later reduced to 8 cubic yard batches because of problems with the batching operation. The age of the CTB at the start of the PCC haul period was 19 days in the No. 1 lane and 13 days in the No. 3 and No. 4 lanes.

The average weight of the heaviest loaded axle carrying 8-1/2 cubic yards was 22.0 kips which was in excess of the maximum specified axle load. This loading was reduced to 19.7 kips with 8 cubic yards.

A total of 3,401 loaded trucks passed over the test section in 6 days of hauling. This was equal to 129,000 equivalent 5,000 pound wheel loads. Field data was collected in the same manner on this project as that collected on the 07-Ora-91 job. Data are presented graphically in Figure 6.

The deflection results are shown in Table 4. Statistical analysis of deflection data for significant difference (Table 5) indicates the mean wheel track deflection levels of the No. 1 loaded lane prior to hauling are significantly higher than the mean levels of the No. 4 unloaded lane by 10 and 20 percent prior to hauling.

No significant difference existed between right wheel track measurements in these lanes after 5 days of hauling. The left wheel track deflection of the unloaded lane No. 4 remained the same after 5 days of haul and the left wheel track measurement in the No. 1 loaded section increased by an additional 6 percent. This increase was considered statistically significant at the 95 percent level; however, the deflection magnitude increased by less than 0.002 of an inch. This deflection increase was not considered detrimental to the CTB. An increase of the same magnitude was also produced by the right wheel track of the No. 4 unloaded test lane after 5 days of hauling.

The deflection level of the unload test area in the No. 3 lane was significantly different than both the loaded No. 1 and unloaded No. 4 lanes after 5 days of hauling. It was also of higher magnitude by about 0.001 to 0.002 inches. In final analyses, it can be concluded that no detrimental increase in deflection was produced by overload hauling.

Condition surveys suggest that overload hauling may accelerate the development of transverse shrinkage cracks since about four times as much transverse cracking developed in the loaded test section as in the unloaded test section (Table 6). However, the total cracking was approximately equal for the same CTB ages. Also, the transverse cracking was only hairline and not considered detrimental. Longitudinal cracking also appeared after three days of hauling in the loaded test section and after four days haul in the unloaded test section. Some short transverse cracks did appear in conjunction with longitudinal cracking in the loaded test section after four days of hauling but did not progress further. No loss in structural integrity was indicated by deflection measurement.

<u>09-Ker-SBd-58-135.0/1.5</u>

This project is a four-lane divided freeway located near Boron in the high desert east of Mojave. The test areas on this project were in the eastbound lanes between Stations 530 and 560. The loaded haul was made over the No. 1 lane nearest the median and no hauling was done over the No. 2 lane.

The age of the CTB at the time of the initial haul was 12 days. However, CTB construction problems occurred later because of cold weather and delayed the PCC paving operation by about 2 weeks.

The average weight of the heaviest loaded axle carrying an 8 cubic yard batch was determined from portable scale weights to be 18.1 kips. A total of 2,438 loaded ten wheel dump trucks passed over the test section during 5-1/2 days of hauling. This was equal to 62,700 equivalent 5,000 pound wheel loads. The resulting deflection levels are shown on Table 7. No new cracking developed in the test areas during the hauling period. However, a few isolated areas of "alligator" cracking were present prior to the hauling period and were delineated by high deflection.

This project experienced a rainstorm following the CTB placement and a combination of saturated subgrade and construction traffic could have contributed to the "alligator" cracking problem. Field data are presented graphically on Figure 7.

Nuclear densities were obtained on the CTB in the test areas of the No. 1 and No. 2 lanes at random after 4 days of overload hauling. These measurements were taken by state project personnel to determine if overload hauling produces additional densification. These test data are presented in Table 8. Results suggest no significant difference between the density of the No. 1 lane, subject to overload hauling, and the No. 2 lane subject to no hauling.

Tests for significant difference in mean deflection levels are presented in Table 9. The left wheel track of the No. 2 no-load section was found to be significantly higher than the No. 1 loaded lane by 22 percent prior to hauling. There was no significant difference between the right wheel track mean deflection levels. After 5-1/2 days of hauling there was still a significant difference between the left wheel track mean deflection level of the No. 1 and No. 2 lanes. The no-load section (lane 2) was still 13 percent higher than the No. 1 loaded lane at the same CTB age. Also, after 5-1/2 days of hauling the left wheel track of the No. 1 loaded section produced no increase in deflection. The right wheel track deflection levels of the No. 1 and No. 2 lanes both decreased by 8 percent and produced the same deflection magnitude after 5-1/2 days of overload hauling.

This analyses indicated that overload hauling produced no significant increase in deflection level on this project.

<u>04-CC-4,84-27.3/30.6, 9.3/11.4</u>

This project is a four- and six-lane divided freeway located near the city of Antioch.

Test locations were selected near the contractor's batch plant on the Route 4 portion of this facility. Two separate test areas were selected in the westbound lanes between Stations 19 and 30 and Stations 47 and 57. A delay of nearly two months occurred between the time of CTB completion and placement of the PCC pavement. This resulted because the contractor shifted his CTB equipment to another contract and additional delays resulted from heavy rains. The loaded haul was made over the No. 1 median lane and the return unloaded was made over the No. 2 lane. The age of the CTB at the beginning of the haul was 59 days.

Ten wheel dump trucks were utilized for the hauling operation. The average weight of the heaviest loaded axle was determined by scale weight as 19.6 kips with an 8 cubic yard PCC load. A total of 1,452 batches were hauled during a 3-1/2 day test period. This resulted in a total of 45,500 equivalent 5,000 pound wheel loads, passing over the test areas in the No. 1 lane.

Deflection measurements are presented in Table 10. The test areas in the southbound lanes between Stations 47+00 and 53+00 were eliminated from further analyses because of changes in PCC hauling patterns and construction progress. Field data are presented on Figure 8.

Statistical analyses of deflection data (Table 11) indicated that the No. 1 loaded lane between Stations 18+00 and 30+00 produced a significantly higher deflection level than the No. 2 unloaded section prior to hauling. However, the No. 2 lane produced a significantly higher deflection following the haul period. The unloaded No. 2 lane deflections increased in the wheel tracks by 38 and 93 percent. The right wheel track of the No. 1 lane increased by 13 percent which was equivalent to slightly over 0.001 inch. The left wheel track deflection decreased by 6 percent. Overall analyses suggests no detrimental increase in deflection level as a result of overload hauling. Also, no cracks developed in the CTB during the overload hauling in lane No. 1. However, a few longitudinal and transverse cracks were evident in the unloaded No. 2 lane (Table 12).

All Projects

Figures 9 through 18 present the CTB conditions before and after overload hauling on all projects except 04-CC-4,84 where representative photographs were not available.

Surface spalling and loss of curing seal was evident on all projects tested. This was true for both loaded and unloaded test areas.

Although there were some significant increases in deflection level produced by overload hauling, there were also significant deflection increases produced in the unloaded test areas. The magnitudes of these increases were generally equivalent for both loaded and unloaded test areas. It is, therefore, concluded that overload hauling did not contribute to these deflection increases. The final levels of deflection were not considered detrimental.

Structural section information on layer thicknesses, densities and compressive strengths from field control testing are presented on Table 13.

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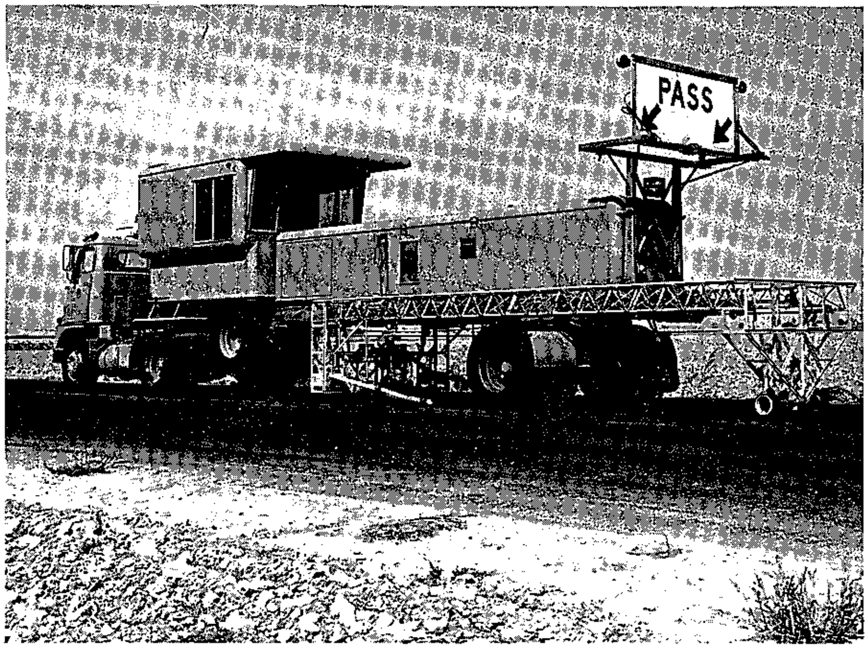
1. Yamanouchi, T. and Ishido, M., "Laboratory and In-Situ Experiments on the Problem of Immediate Opening of Soil-Cement Base to General Traffic," Proceedings of the Fourth Australia-New Zealand Conference on Soil Mechanics and Foundation Engineering, 1963.

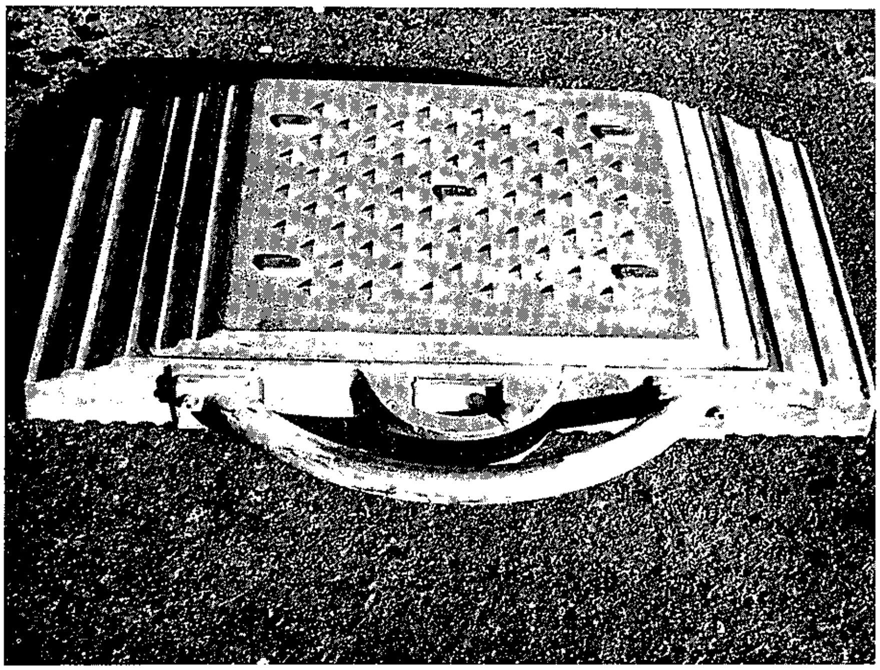
2. Zube, E., Gates, C. G., Shirley, E. C., and Munday, H. A., "The Effect of Truck Traffic on Newly Placed Cement Treated Bases When Legal Load Limits Are Exceeded," State of California, Division of Highways, Materials and Research Department, Final Report, 643257, February 1968.

Figure 1



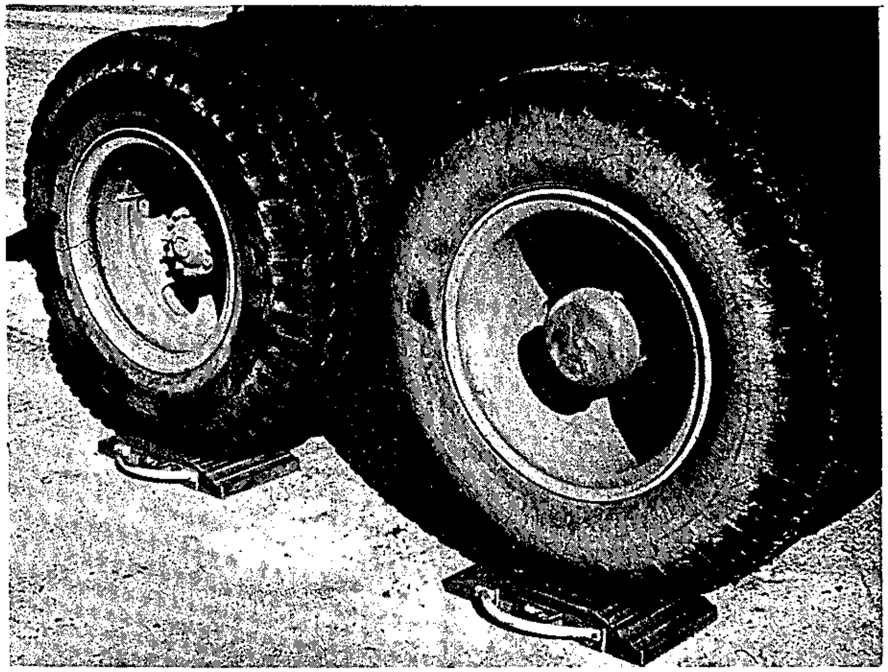
CALIFORNIA TRAVELING
DEFLECTOMETER

Figure 2



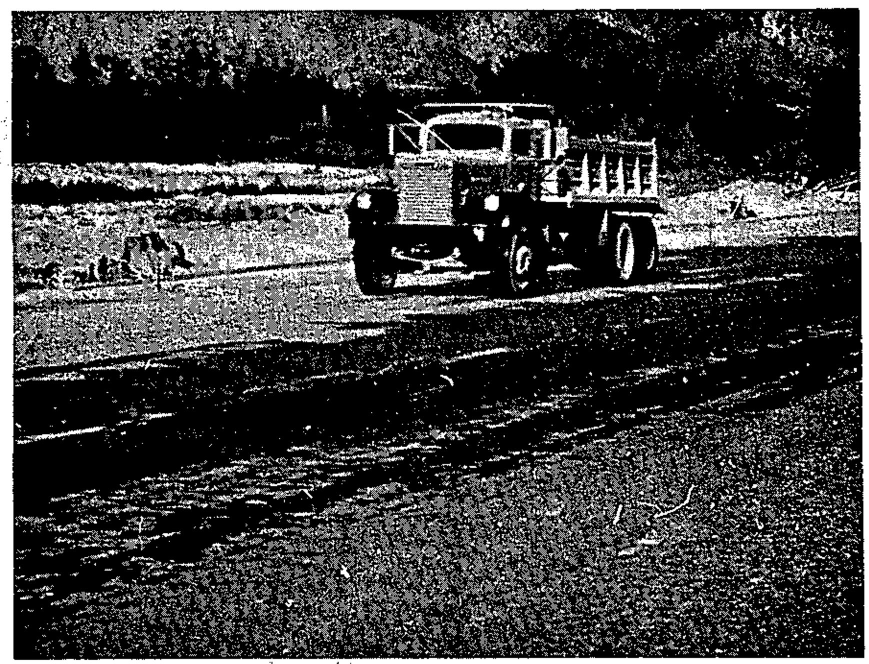
PORTABLE MD400 CHP SCALES

Figure 3



WEIGHING LOADED BATCH TRUCK
USING PORTABLE SCALES

Figure 4



UNLOADED BATCH TRUCK
RETURNING TO PLANT

TABLE 1
DEFLECTION TEST DATA
PROJECT 07-Ora-91-R13.4/R18.9

Test Area	Loading Criteria	CTB Age (Days)	Deflection ($x10^{-3}$ inches) Mean *LWT	Mean *RWT	Standard Deviation *LWT	Standard Deviation *RWT
A.) WBL #1 Sta.450+00 to 490+00						
1) Prior to hauling (Sta. 450+00 to 490+00)	Loaded	10	10	11	3.2	3.4
2) After 1st day of haul (Sta. 450+00 to 490+00)	"	16	12	14	3.4	3.8
3) " 2nd " " " (Sta. 450+00 to 478+50)	"	17	12	14	3.1	3.7
B.) WBL #4 Sta. 490+00 to 450+00						
1) Prior to hauling (Sta. 490+00 to 450+00)	Unloaded	15	10	12	3.4	3.5
2) After 1st day of haul (Sta. 490+00 to 460+00)	"	21	12	14	3.2	4.8
3) " 2nd " " " (Sta. 475+00 to 460+00)	"	22	12	15	3.6	5.2

*LWT = Left wheel track of Traveling Deflectometer

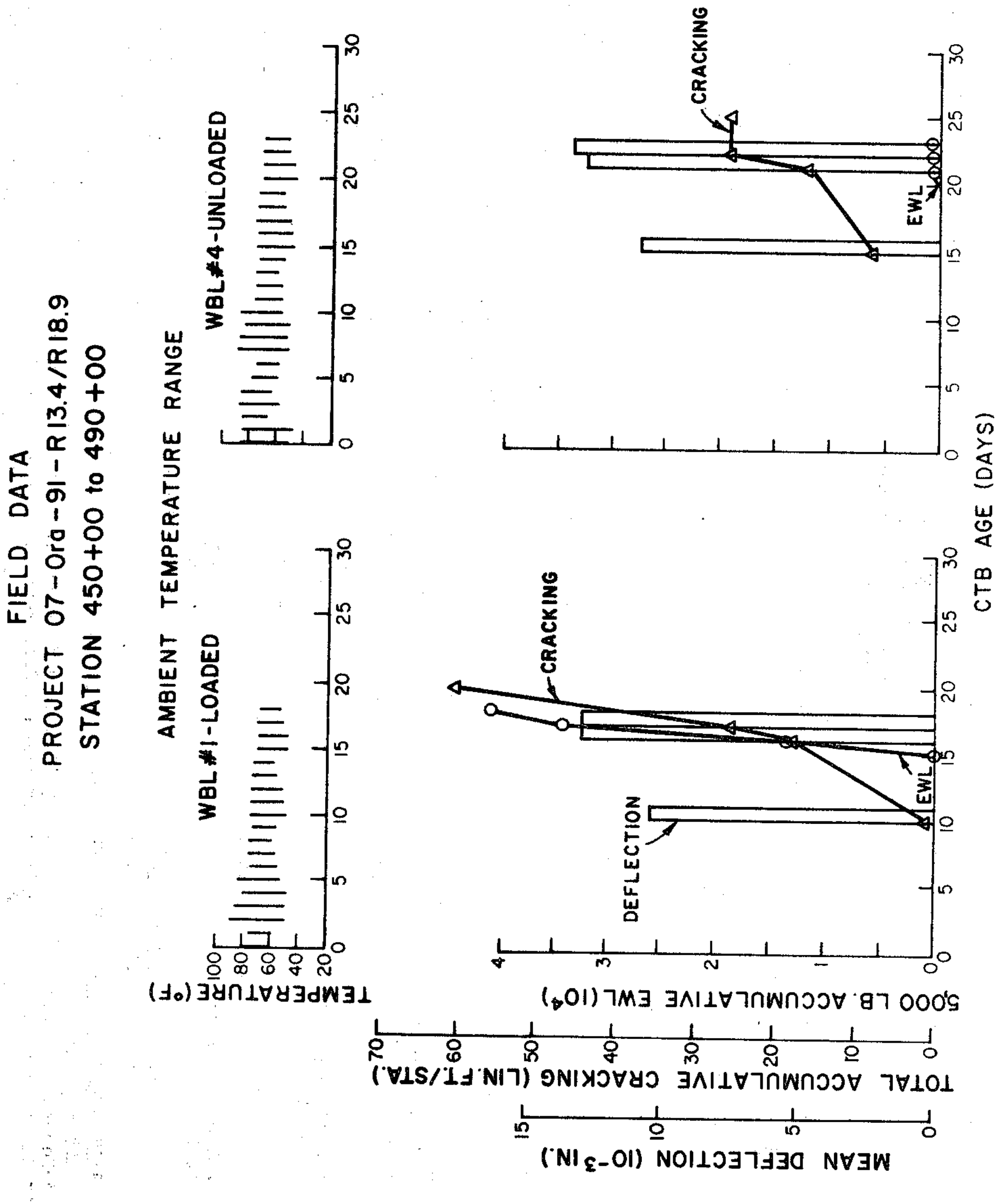
*RWT = Right wheel track of Traveling Deflectometer

TABLE 2
CRACK SURVEY
PROJECT 07-Ora-91-R13.4/R18.9

Test Location	CTB Age (Days)	Transverse Total Cracking Lin.Ft.	Transverse Total Cracking Lin.Ft./Sta.	Transverse Adjusted* Lin.Ft./Sta.	Longitudinal Cracking
A.) WBL #1 (Loaded Trucks)					
1.) Prior to hauling (Sta. 450+00 to 490+00)	10	15	0.4	0.9	None
2.) After 1st day of haul (Sta. 450+00 to 490+00)	16	720	18.0	18.5	"
3.) After 2nd day of haul (Sta. 450+00 to 480+00)	17	985	32.8	25.8	"
4.) After 3rd day of haul (Sta. 450+00 to 467+00)	20	1037	61.0	61.0	"
B.) WBL #4 (Unload Trucks)					
1.) Prior to hauling (Sta. 457+50 to 490+00)	15	92	2.8	7.4	None
2.) After 1st day of haul (Sta. 457+50 to 490+00)	21	589	18.1	16.2	"
3.) After 2nd day of haul (Sta. 457+50 to 480+00)	22	953	42.3	26.6	"
4.) After 3rd day of haul (Sta. 457+50 to 467+00)	25	252	26.6	26.6	"

*Adjusted to fit test areas subjected to 3 days of hauling.

Figure 5



FIELD DATA
PROJECT 07-Ora-91-R13.4/R18.9
STATION 450+00 to 490+00
AMBIENT TEMPERATURE RANGE
WBL #1-LOADED
WBL #4-UNLOADED
TEMPERATURE (°F)
DEFLECTION
CRACKING
EWL
5,000 LB. ACCUMULATIVE EWL (10⁴)
TOTAL ACCUMULATIVE CRACKING (LIN.FT./STA.)
MEAN DEFLECTION (10⁻³ IN.)
CTB AGE (DAYS)

TABLE 3
STATISTICAL TESTS FOR
SIGNIFICANT DIFFERENCE
PROJECT 07-ORA-91-R13.4/R18.9

QUESTION Is there a significant difference in mean deflection at a confidence level of 95%?

HYPOTHESES $H_o: \overline{X}_1 = \overline{X}_2$ $H_1: \overline{X}_1 \neq \overline{X}_2$

CONCLUSION Yes: Reject H_o and Accept H_1

No: Accept H_o

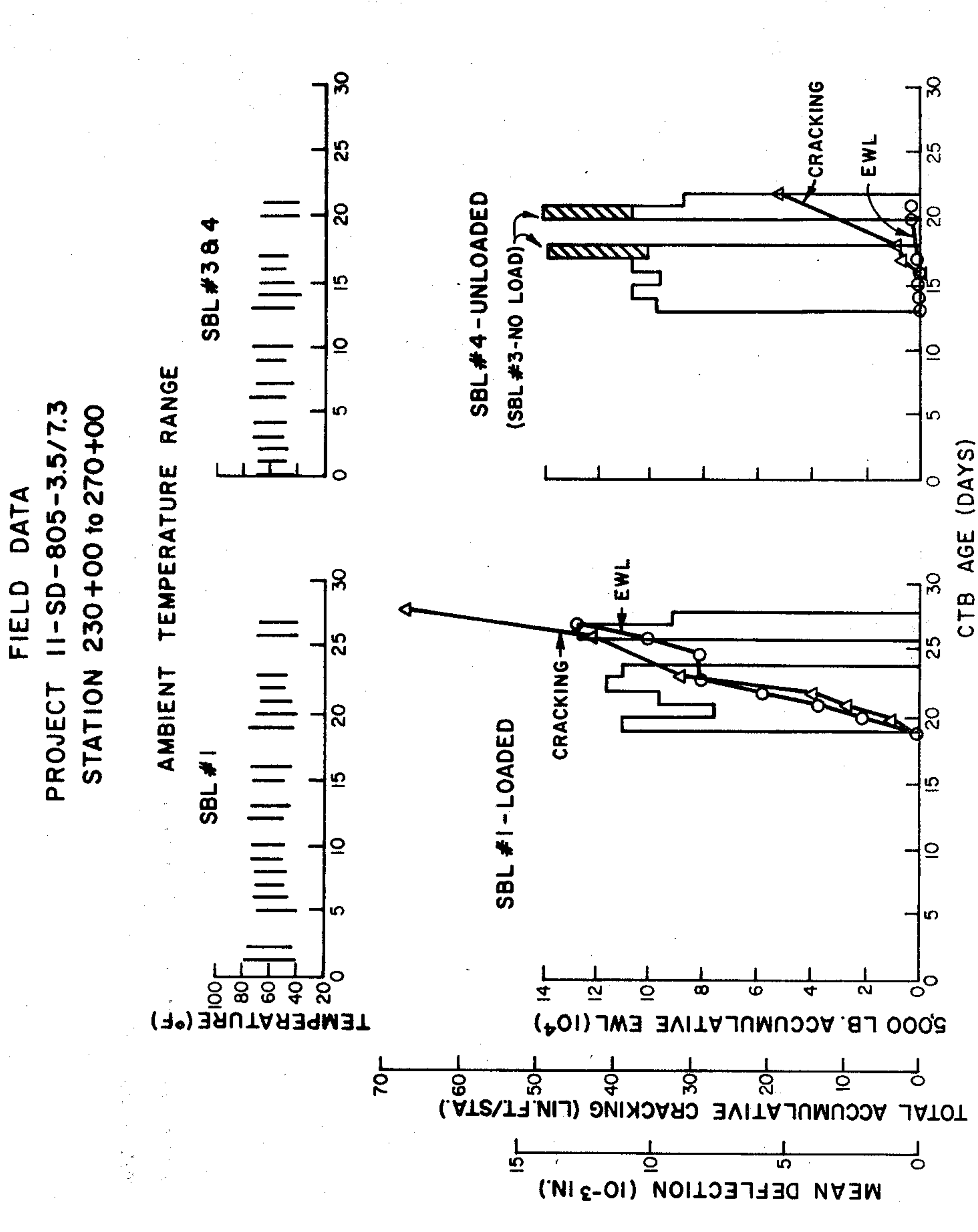
SAMPLE 1				SAMPLE 2				
		Deflection (10^{-3} Inches)				Deflection (10^{-3} Inches)		
Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Significant Difference
Sta. 450 to 490 WBL No. 1 prior to hauling				Sta. 450 to 490 WBL No. 4 prior to hauling				
LWT*	241	10.4	3.2	LWT	231	10.1	3.4	No **
RWT	241	10.9	3.4	RWT	231	11.9	3.5	Yes (Negative)
WBL No. 1 after 2 days of over-load hauling				WBL No. 4 after 2 days of unloaded haul				
LWT	159	12.0	3.1	LWT	85	12.3	3.6	No
RWT	159	13.8	3.7	RWT	85	14.9	5.2	No
WBL No. 1 prior to hauling				WBL No. 1 after 2 days of over-load hauling				***
LWT	241	10.4	3.2	LWT	159	12.0	3.1	Yes (Increase)
RWT	241	10.9	3.4	RWT	159	13.8	3.7	Yes (Increase)
WBL No. 4 prior to hauling				WBL No. 4 after 2 days of unloaded haul				
LWT	231	10.1	3.4	LWT	85	12.3	3.6	Yes (Increase)
RWT	231	11.9	3.5	RWT	85	14.9	5.3	Yes (Increase)

*LWT = Left wheel track of Traveling Deflectometer
RWT = Right " " " " "

**Negative or positive defines significant difference between different load conditions.

***Increase or decrease defines significant difference in the same load conditions.

Figure 6



FIELD DATA
PROJECT 11-SD-805-3.5/7.3
STATION 230+00 to 270+00
AMBIENT TEMPERATURE RANGE
SBL #1
SBL #3 & 4
TEMPERATURE (°F)
SBL #1 - LOADED
SBL #4 - UNLOADED
(SBL #3 - NO LOAD)
CRACKING
EWL
CTB AGE (DAYS)
5,000 LB. ACCUMULATIVE EWL (10^4)
TOTAL ACCUMULATIVE CRACKING (LIN.FT./STA.)
MEAN DEFLECTION (10^{-3} IN.)

TABLE 4
DEFLECTION TEST DATA
PROJECT 11-SD-805-3.5/7.3

Test Area	Loading Criteria	CTB Age (Days)	Deflection ($x10^{-3}$ inches) Mean *LWT	Mean *RWT	Standard Deviation *LWT	Standard Deviation *RWT
A.) SBL #1, Sta.230+00 to 270+00						
1) Prior to hauling (Sta.230+00 to 270+00)	Loaded	19	11	11	5.5	7.5
2) After 1st day of haul (Sta. 230+00 to 252+00)	"	20	8	7	2.9	3.0
3) " 2nd " " " (Sta.270+00 to 230+00)	"	21	9	10	5.3	6.6
4) " 3rd " " " (Sta.270+00 to 230+00)	"	22	11	12	6.0	6.3
5) " 4th " " " (Sta.270+00 to 230+00)	"	23	10	12	5.4	6.3
6) " 5th " " " " " " " " "	"	26	12	13	5.6	6.4
7) " 6th " " " (Sta.239+00 to 230+00)	"	27	9	9	2.4	3.2
B.) SBL #4, Sta. 269+00 to 230+00						
1) Prior to hauling (Sta. 269+00 to 230+00)	Unloaded	13	10	9	5.1	5.8
2) After 1st day of haul (Sta. 235+00 to 230+00)	"	14	12	10	3.3	4.8
3) " 2nd " " " (Sta. 269+00 to 230+00)	"	15	9	10	4.9	5.1
4) " 3rd " " " " " " " " "	"	16	10	11	4.8	6.0
5) " 4th " " " " " " " " "	"	17	10	10	4.2	5.9
6) " 5th " " " " " " " " "	"	20	10	11	5.2	5.9
7) " 6th " " " (Sta. 236+00 to 230+00)	"	21	9	8	3.7	3.6
C.) SBL #3, Sta.269+00 to 257+00						
1) After 4th day	No load	17	13	14	4.4	5.4
2) " 5th day	" "	20	13	15	4.2	4.9

*LWT = Left wheel track of Traveling Deflectometer

*RWT = Right wheel track of Traveling Deflectometer

TABLE 5
STATISTICAL TESTS FOR
SIGNIFICANT DIFFERENCE
PROJECT 11-SD-805-3.5/7.3

QUESTION Is there a significant difference in mean deflection at a confidence level of 95%?

HYPOTHESES $H_o: \overline{X}_1 = \overline{X}_2$ $H_1: \overline{X}_1 \neq \overline{X}_2$

CONCLUSION Yes: Reject H_o and Accept H_1

No: Accept H_o

	SAMPLE 1				SAMPLE 2			
		Deflection (10^{-3} Inches)				Deflection (10^{-3} Inches)		
Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Significant Difference
Sta. 230 to 270 SBL No. 1 prior to hauling				Sta. 230 to 270 SBL No. 4 prior to hauling				
LWT*	232	10.9	5.5	LWT	220	9.9	5.1	Yes (Positive)**
RWT	228	11.3	7.5	RWT	215	9.4	5.8	Yes (Positive)
SBL No. 1 after 5 days of over-load hauling				SBL No. 4 after 5 days of unloaded haul				
LWT	217	12.5	6.4	LWT	223	9.9	5.2	Yes (Positive)
RWT	201	11.8	5.6	RWT	204	11.3	5.9	No
SBL No. 1 prior to hauling				SBL NO. 1 after 5 days of over-load hauling				
LWT	232	10.9	5.5	LWT	217	12.5	6.4	Yes (Increase)***
RWT	228	11.3	7.5	RWT	210	11.8	5.6	No
SBL No. 4 prior to hauling				SBL No. 4 after 5 days of unloaded haul				
LWT	220	9.9	5.1	LWT	223	9.9	5.2	No
RWT	215	9.4	5.8	RWT	204	11.3	5.9	Yes (Increase)

TABLE 5 (continued)

	SAMPLE 1				SAMPLE 2			
		Deflection (10^{-3} Inches)				Deflection (10^{-3} Inches)		
Test Area Information	Sample Size (n)	Mean ($\bar{X}$)	Std. Dev. (S)	Test Area Information	Sample Size (n)	Mean ($\bar{X}$)	Std. Dev. (S)	Significant Difference
SBL No. 3 no load				SBL No. 1 after 5 days of over-load hauling				
LWT	67	13.4	4.2	LWT	217	12.5	6.4	No
RWT	67	15.4	4.9	RWT	201	11.8	5.6	Yes (Positive)
SBL No. 3 no load				SBL No. 4 after 5 days of unloaded haul				
LWT	67	13.4	4.2	LWT	223	9.9	5.2	Yes (Positive)
RWT	67	15.4	4.9	RWT	204	11.3	5.9	Yes (Positive)
SBL No. 3 no load (age 17 days)				SBL No. 3 no load (age 20 days)				
LWT	66	13.3	4.4	LWT	67	13.4	4.2	No
RWT	63	13.8	5.4	RWT	67	15.4	4.9	No

*LWT = Left wheel track of Traveling Deflectometer
RWT = Right " " " "
**Negative or positive defines significant difference between different load conditions.
***Increase or decrease defines significant difference in the same load conditions.

TABLE 6
CRACK SURVEY
PROJECT 11-SD-805-3.5/7.3

Test Location	CTB Age (Days)	Transverse Total Cracking		Longitudinal Total Cracking	
		Lin.Ft.	Lin.Ft./Sta.	Lin.Ft.	Lin.Ft./Sta.
A.) SBL #1 (Loaded Trucks)					
1) Prior to hauling (Sta.230+00 to 270+00)	19	6	0.2	None	None
2) After 1st day of haul " " "	20	153	3.8	None	None
3) " 2nd " " " " " "	21	385	9.6	None	None
4) " 3rd " " " " " "	22	538	13.5	5	0.1
5) " 4th " " " " " "	23	1036	25.9	190	4.8
6) " 5th " " " " " "	26	1402	35.1	243	6.1
7) " 6th " " (Sta.230+00 to 250+00)	27	1194	59.7	243	6.1
B.) SBL #4 (Unloaded Trucks)					
1) Prior to hauling (Sta. 230+00 to 270+00)	13	None	None	None	None
2) After 1st day of haul " " "	14	None	None	None	None
3) " 2nd " " " " " "	15	None	None	None	None
4) " 3rd " " " " " "	16	None	None	None	None
5) " 4th " " " " " "	17	54	1.4	36	0.9
6) " 5th " " " " " "	20	58	1.5	36	0.9
7) " 6th " " " " " "	21	315	15.7	50	1.3
C.) SBL #3 (No Trucks)					
1) After 5th day (Sta. 257+00 to 269+00)	20	36	3.0	None	None

TABLE 7
DEFLECTION TEST DATA
PROJECT 09-Ker,SBd-58-135.0/1.5

Test Area	Loading Criteria	CTB Age (Days)	Deflection ($x\ 10^{-3}$ inches) Mean *LWT	Mean *RWT	Standard Deviation *LWT	Standard Deviation *RWT
A.) EBL #1, Sta. 530+00 to 552+00						
1) Prior to hauling (Sta. 530+00 to 552+00)	Loaded	7	17	16	6.6	4.5
2) After 1st day of haul (Sta. 530+00 to 552+00)	"	13	15	14	4.5	3.0
3) After 5-1/2 days of haul (Sta.530+00 to 552+00)	"	27	17	15	4.2	3.5
B.) EBL #2, Sta. 552+00 to 530+00						
1) Prior to hauling (Sta. 552+00 to 530+00)	No loads	7	20	16	8.8	4.4
2) After 5-1/2 days of haul (Sta. 552+00 to 530+00)	"	27	19	15	3.5	3.3

*LWT = Left wheel track of Traveling Deflectometer

*RWT = Right wheel track of Traveling Deflectometer

Figure 7

NOTE: NO CRACKS WERE OBSERVED IN THE CTB BY AGE 28 DAYS.

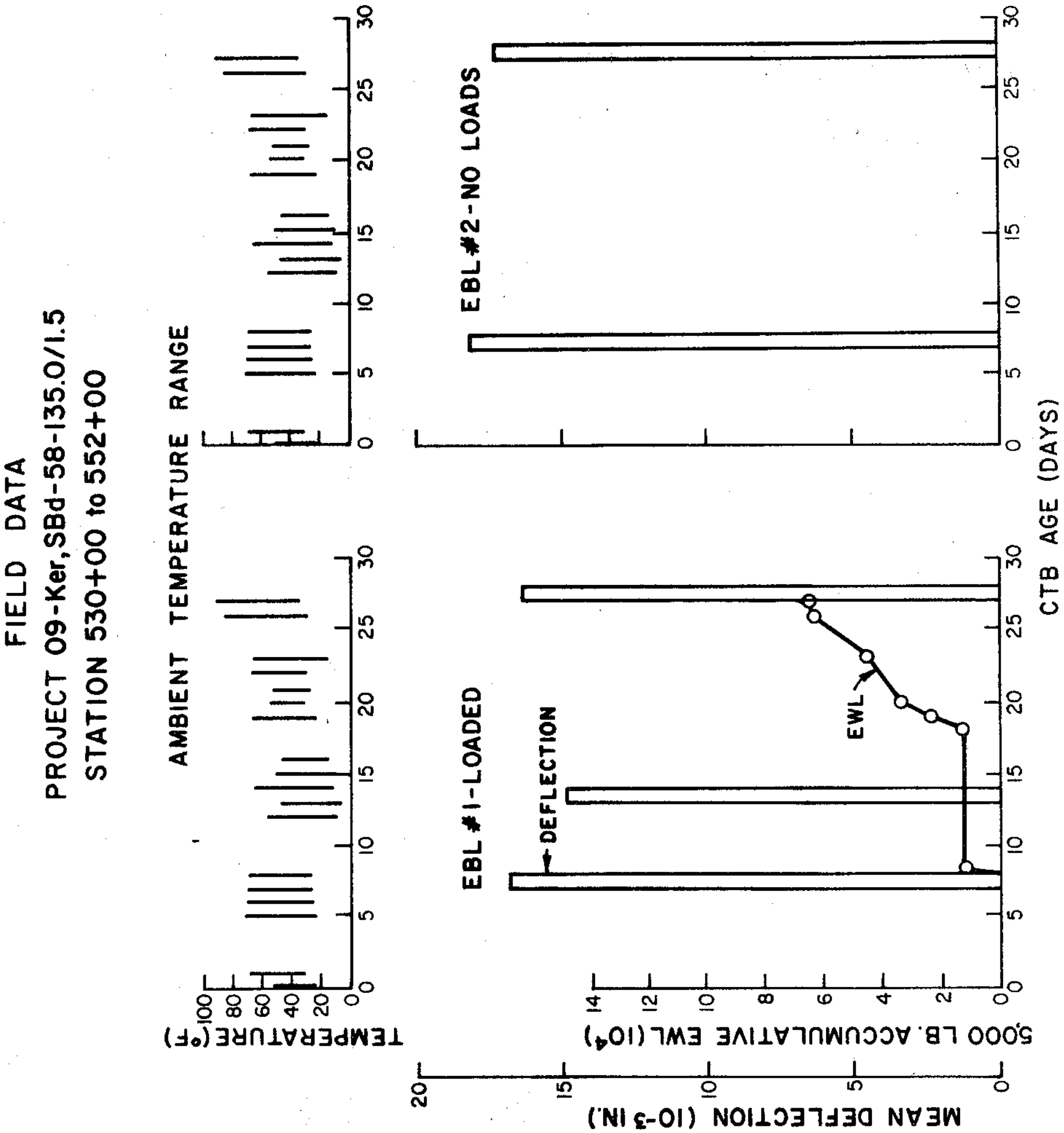


TABLE 8
SIGNIFICANCE TEST FOR
DIFFERENCES IN NUCLEAR DENSITIES

If Significant Difference exists at $\alpha = 5\%$,
Reject H_o: $\overline{X}_1 = \overline{X}_2$

Accept H_1: $\overline{X}_1 \neq \overline{X}_2$

Project and Location 09-Ker,SBd-58-135.0/1.5	Number of Tests	Nuclear Density* (lbs./ft.^{3}) Mean ($\overline{X}$)	Standard Deviation	Range	t-Statistic	Significant at 95%
1.) Sta. 530+00 to 560+00, EBL No. 1 (Overload condition)	18	125.8	3.3	119.5 to 129.6	1.56	No
2.) Sta. 530+00 to 560+00, EBL No. 2 (No load condition)	18	124.1	3.1	120.5 to 130.1		

*After 4 days of overload hauling.

CONCLUSION

Accept H_o: $\overline{X}_1 = \overline{X}_2$

TABLE 9

STATISTICAL TESTS FOR SIGNIFICANT DIFFERENCE

PROJECT 09-Ker,SBd-58-135.0/1.5

QUESTION · Is there a significant difference in mean deflection at a confidence level of 95%?

HYPOTHESES $H_o: \overline{X}_1 = \overline{X}_2$ $H_1: \overline{X}_1 \neq \overline{X}_2$

CONCLUSION Yes: Reject H_o and Accept H_1

No: Accept H_o

	SAMPLE 1				SAMPLE 2			
		Deflection (10^{-3} Inches)				Deflection (10^{-3} Inches)		
Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Significant Difference
Sta. 530 to 552 EBL No. 1 prior to hauling				Sta. 530 to 552 EBL No. 2 prior to hauling (age 7 days)				**
LWT*	122	16.6	6.6	LWT	106	20.2	8.8	Yes (Negative)
RWT	122	16.1	4.5	RWT	108	15.8	4.4	No
EBL No. 1 after 5-1/2 days of overload hauling				EBL No. 2 No loads (age 27 days)				
LWT	119	16.6	4.2	LWT	104	18.8	3.5	Yes (Negative)
RWT	119	14.8	3.5	RWT	103	14.5	3.3	No
EBL No. 1 prior to hauling				EBL NO. 1 after 5-1/2 days of overload hauling				
LWT	122	16.6	6.6	LWT	119	16.6	4.2	No ***
RWT	122	16.1	4.5	RWT	119	14.8	3.5	Yes (Decrease)
EBL No. 2 No loads (age 7 days)				EBL No. 2 No loads (age 27 days)				
LWT	106	20.2	8.8	LWT	104	18.8	3.5	No
RWT	108	15.8	4.4	RWT	103	14.5	3.3	Yes (Decrease)

*LWT = Left wheel track of Traveling Deflectometer

RWT = Right " " " " "

**Negative or positive defines significant difference between different load conditions.

***Increase or decrease defines significant difference in the same load conditions.

TABLE 10
DEFLECTION TEST DATA
PROJECT 04-CC-4,84-27.3/30.6,
9.3/11.4

Test Area	Loading Criteria	CTB Age (Days)	Deflection ($x 10^{-3}$ inches) Mean *LWT	Mean *RWT	Standard Deviation *LWT	Standard Deviation *RWT
A.) SBL #1, Sta. 30+00 to 18+00						
1) Prior to hauling (Sta. 30+00 to 18+00)	Loaded	21	9	9	2.1	2.9
2) After 4th day of haul (Sta. 30+00 to 18+00)	"	65	9	10	3.9	3.4
B.) SBL #1, Sta. 53+00 to 47+00						
1) Prior to hauling (Sta. 53+00 to 47+00)	"	21	10	9	6.0	5.2
2) After 4th day of haul (Sta. 53+00 to 47+00)	"	64	12	10	4.5	2.3
C.) SBL #2, Sta. 30+00 to 18+00						
1) Prior to hauling (Sta. 30+00 to 18+00)	Unloaded	21	8	8	3.8	2.3
2) After 4th day of haul (Sta. 30+00 to 18+00)	"	65	11	15	3.2	4.4
D.) SBL #2, Sta. 53+00 to 47+00						
1) Prior to hauling (Sta. 53+00 to 47+00)	"	21	10	7	3.2	2.5
2) After 4th day of haul (Sta. 53+00 to 47+00)	"	64	10	15	3.1	7.5

*LWT = Left wheel track of Traveling Deflectometer

*RWT = Right wheel track of Traveling Deflectometer

PROJECT 04-CC-4, 84-27.3/30.6, 9.3/11.4
STATION 18+00 TO 30+00

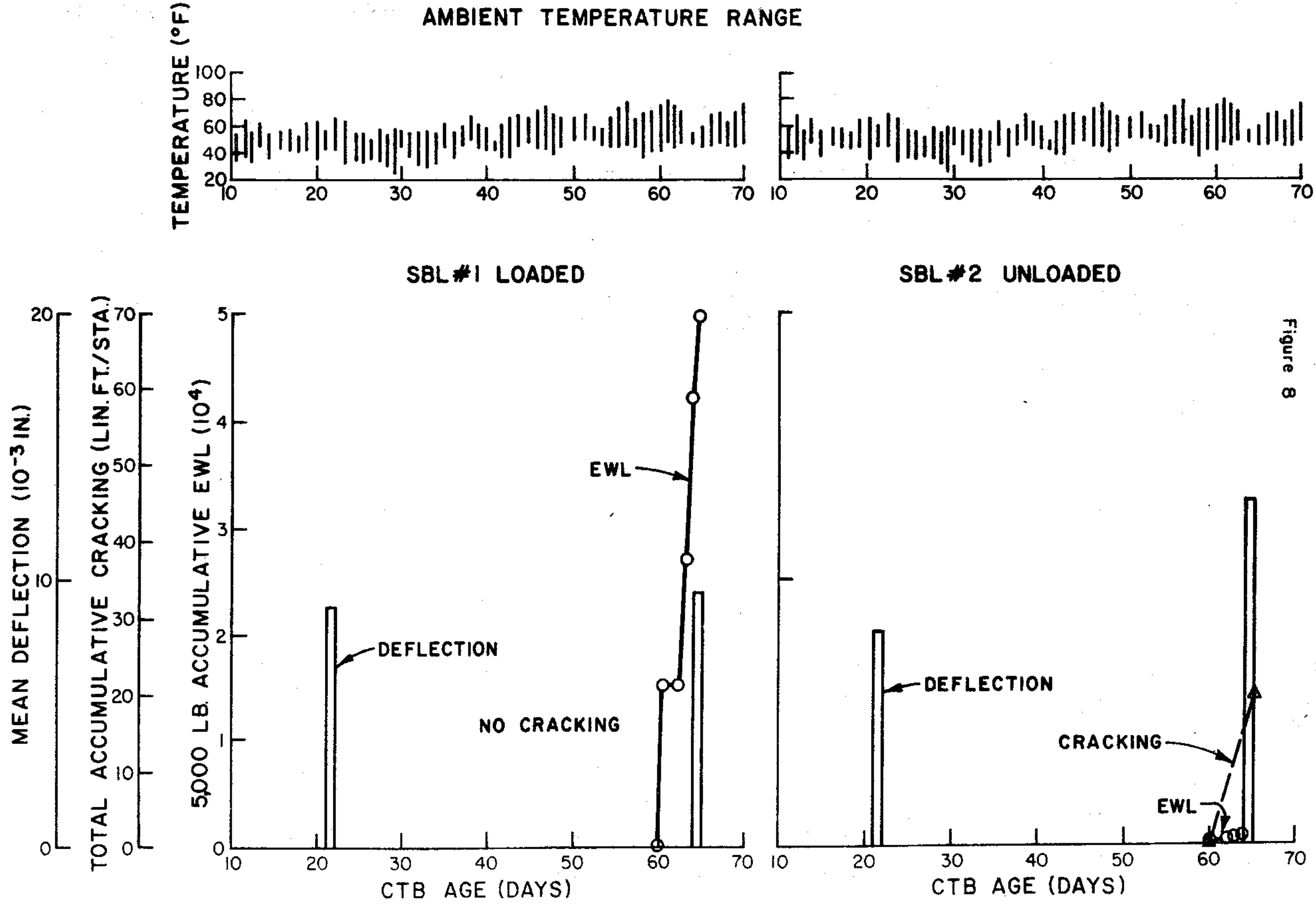


Figure 8

TABLE 11
STATISTICAL TESTS FOR SIGNIFICANT DIFFERENCE
PROJECT 04-CC-4,84-27.3/30.6,9.3/11.4

QUESTION: Is there a significant difference in mean deflection at a confidence level of 95%?

HYPOTHESES: $H_o: \overline{X}_1 = \overline{X}_2$ $H_1: \overline{X}_1 \neq \overline{X}_2$

CONCLUSION: Yes: Reject H_o and Accept H_1

No: Accept H_o

SAMPLE 1		Deflection (10^{-3} Inches)		SAMPLE 2		Deflection (10^{-3} Inches)		
Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Test Area Information	Sample Size (n)	Mean ($\overline{X}$)	Std. Dev. (S)	Significant Difference
Sta. 18 to 30 SBL No. 1 prior to hauling (age 21 days)				Sta. 18 to 30 SBL No. 2 prior to hauling (age 21 days)				**
LWT	64	9.0	2.1	LWT	68	7.5	3.8	Yes (Positive)
RWT	65	9.2	2.9	RWT	68	8.0	2.3	Yes (Positive)
SBL No. 1 after 4 days of over-load hauling				SBL No. 2 after 4 days of unloaded haul				
LWT	57	8.5	3.9	LWT	65	11.0	3.1	Yes (Negative)
RWT	58	10.4	3.4	RWT	63	15.4	4.4	Yes (Negative)
SBL No. 1 prior to hauling				SBL No. 1 after 4 days of overload hauling				
LWT	64	9.0	2.1	LWT	57	8.5	3.9	No ***
RWT	65	9.2	2.9	RWT	58	10.4	3.4	Yes (Increase)
SBL No. 2 prior to hauling (age 21 days)				SBL No. 2 after 4 days of unloaded haul				
LWT	68	7.5	3.8	LWT	65	11.0	3.1	Yes (Increase)
RWT	68	8.0	2.3	RWT	63	15.4	4.4	Yes (Increase)

*LWT = Left wheel track of Traveling Deflectometer
RWT = Right " " " " "

**Negative or positive defines significant difference between different load conditions.

***Increase or decrease defines significant difference in the same load conditions.

TABLE 12
CRACK SURVEY
PROJECT 04-CC-4,84-27.3/30.6,9.3/11.4

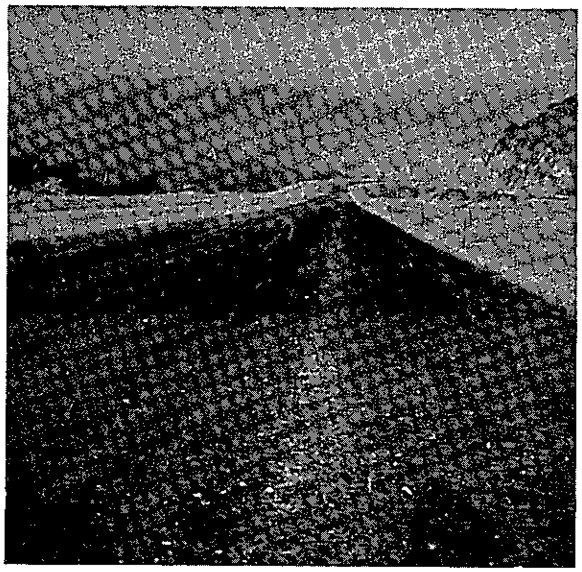
	Test Location	CTB Age (Days)	Transverse Total Cracking Lin.Ft.	Transverse Total Cracking Lin.Ft./Sta.	Longitudinal Total Cracking Lin.Ft.	Longitudinal Total Cracking Lin.Ft./Sta.
A.)	SBL #1, Sta. 30+00 to 18+00(Loaded Trucks)					
	1.) Prior to hauling	21	None	None	None	None
	2.) After 4th day of haul	65	"	"	"	"
B.)	SBL #2, Sta. 30+00 to 18+00(Unloaded Trucks)					
	1.) Prior to hauling	21	None	None	None	None
	2.) " " "	44	"	"	"	"
	3.) After 4th day of haul	65	20	1.7	200	16.7

TABLE 13
STRUCTURAL SECTION INFORMATION

Project	Structural Section Subject to Overloads	CTB Test Results (Field Lab) Dry Density ($lb./ft.^3$)	Compressive Strength (psi)	Cement Content (%)	Moisture Content (%)
1.) 07-Ora-91-R13.4/R18.9 (Sta.450+00 to 490+00 WB)	0.45'Cl.A CTB(Lane No.1) 0.60'Cl.3 AB	134	759(8)*	4.5	8.4
	0.45'Cl.A CTB(Lane No.4) 0.50'Cl.3 AB	"	"	"	"
2.) 11-SD-805-3.5/7.3 (Sta.230+00 to 270+00 SB)	0.45'Cl.A CTB(Lane No. 1) 0.90'Cl.4 AS	137.4	925(7)	3.2	8.4
	0.45'Cl.A CTB(Lane No.3&4) 0.85'Cl.4 AS	"	"	"	"
3.) 09-Ker,SBd-58-135.0/1.5 (Sta.530+00 to 560+00 EB)	0.35'Cl.A CTB 0.50'Cl.4 AS	132.4	1082(7)	4.6	7.8
4.) 04-CC-4,84-27.3/30.6,9.3/11.4 (Sta. 18+00 to 30+00 & Sta. 47+00 to 53+00 SB)	0.45'Cl.A CTB 0.50'Cl.4 AS 1.00' Select Material	145.3	1587(7)	5.0	8.3

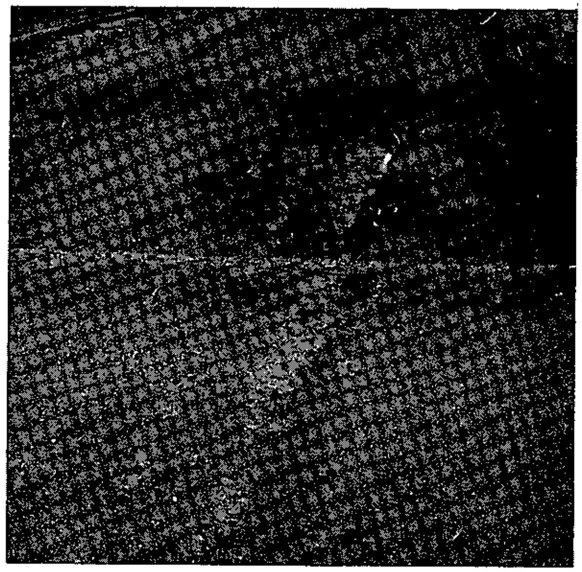
*Age in days

Figure 9



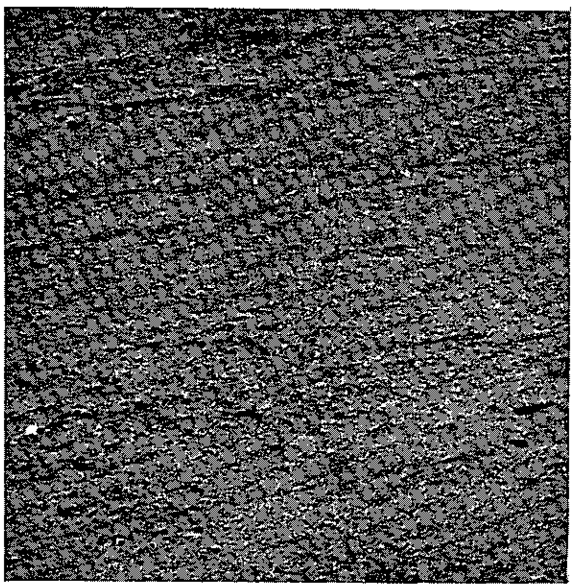
LOOKING EAST AT STA. 474+60 IN WESTBOUND LANE NO. 1 PRIOR TO HAULING.

Figure 10



STA. 461+70 WESTBOUND LANE NO. 1 AFTER 2 DAYS OF OVERLOAD HAULING.

Figure 11



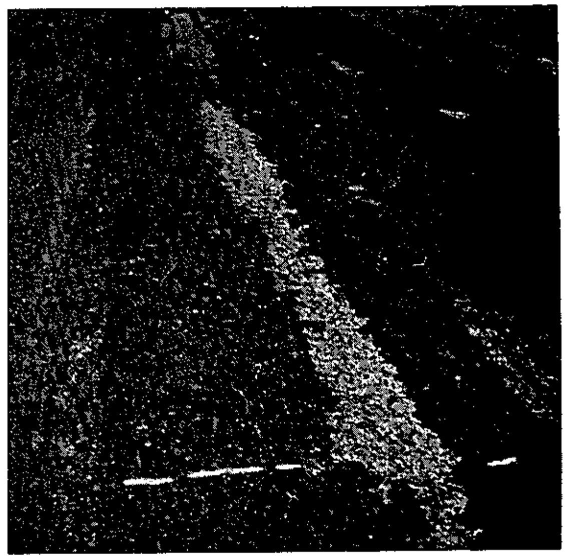
TYPICAL TRANSVERSE CRACK AFTER 3 DAYS OF OVERLOAD HAULING.

VISUAL CONDITION
PROJECT 11-SD-805-3.5/7.3

Figure 12

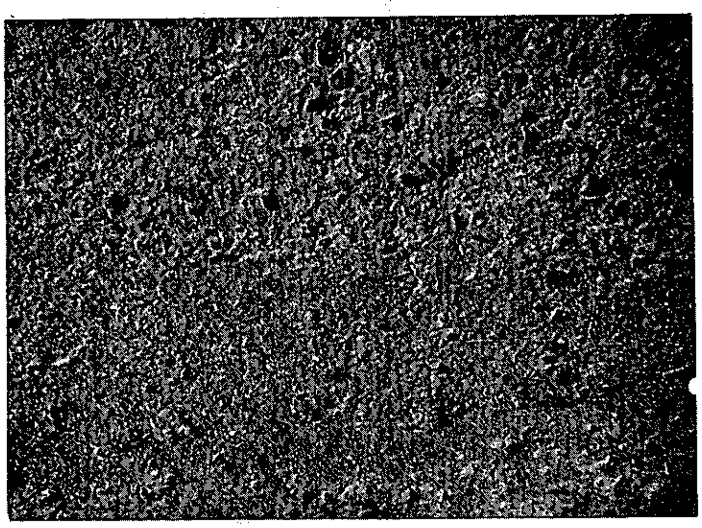
STA. 235+60 SOUTHBOUND LANE NO. 1 PRIOR TO HAULING.

Figure 13



STA. 233+75 SOUTHBOUND LANE NO. 1 AFTER 6 DAYS OF OVERLOAD HAULING.

Figure 14



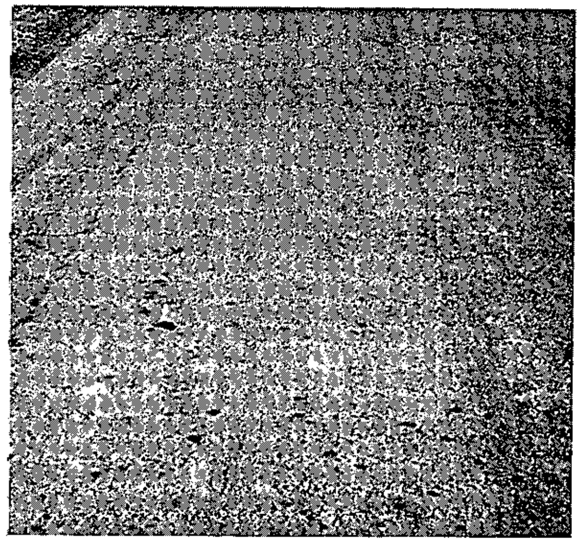
TYPICAL TRANSVERSE CRACK AFTER 6 DAYS OF OVERLOAD HAULING.

VISUAL CONDITION
PROJECT 09-KER,SBd-58-135.0/1.5

Figure 15

STA. 530 EASTBOUND LANES PRIOR TO HAULING.

Figure 16



STA. 530 EASTBOUND LANE NO. 1 AFTER 6 DAYS OF OVERLOAD HAULING.

Figure 17

STA. 540 EASTBOUND LANES PRIOR TO HAULING.

Figure 18

STA. 546+70 EASTBOUND LANE NO. 1 AFTER 6 DAYS OF OVERLOAD HAULING.