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HIGHWAY RESEARCH REPORT

THE EFFECT OF TRUCK TRAFFIC ON NEWLY PLACED CEMENT TREATED BASES WHEN LEGAL LOAD LIMITS ARE EXCEEDED

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RESEARCH REPORT

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

January 1968
Exp. Auth. 643257

Mr. J. A. Legarra
State Highway Engineer
Sacramento, California

Dear Sir:

Submitted for your consideration is:

REPORT

OF

THE EFFECT OF TRUCK TRAFFIC

ON NEWLY PLACED CEMENT TREATED BASES

WHEN LEGAL LOAD LIMITS ARE EXCEEDED

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Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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FOREWORD

The Association of General Constructors has suggested that considerable savings in time and money could be realized if vehicles were allowed to carry heavier than legal loads over newly constructed thin cement treated bases (CTB). The loads would consist of Portland Cement Concrete (PCC) to be placed over the CTB and it is felt that savings would be reflected in lower bid prices for the PCC. Since it was not known whether this practice would damage the CTB, this research project, to study the feasibility of such an operation, was proposed by the Construction Department.

ACKNOWLEDGMENTS

The writers wish to acknowledge the cooperation of the Resident Engineers on the projects tested during this investigation, Mr. Everitt Raymond, Mr. Phillip Cuccia, and Mr. Merle Larrabee. Also, the cooperation of the contractor's superintendents, Mr. Jerry Pruit of Peter Kiewit Son's Construction Company and Mr. Glen Dedmon of Frederickson and Watson Construction Company, was greatly appreciated on the projects in which the complete testing sequence was carried out.

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REFERENCE: Zube, E., Gates, C., Shirley, E. and Munday, H., "The Effect of Truck Traffic on Newly Placed Cement Treated Bases When Legal Load Limits are Exceeded," State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report 643257 January, 1968.

ABSTRACT: The effect of extralegal loads (10% and 20% overloads) on newly constructed unsurfaced 0.33' thick CTB is reported. Benkelman beam deflections were measured before any traffic was allowed on the CTB and then intermittently as trucks with overloaded tandem axles traversed the CTB.

A moderate number of repetitions of the test loads caused no apparent damage to either of the two projects which were fully investigated. The deflections measured on four other projects were lower than on the projects which were fully investigated indicating they would be able to withstand even more of the overlegal loads. The effect of curing time on deflections for CTB's two to nine days old was negligible.

KEY WORDS: Cement treated bases, weight limits, pavement deflections, pavement distress

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INTRODUCTION

Portland cement concrete batch trucks are not normally permitted to travel over newly completed cement treated base (CTB) except to back into position in front of the paver. This practice results in a very small number of wheel loads passing over a given portion of the CTB. On some projects, where shoulder or median areas prohibit hauling, the contractor is allowed to haul on the cement treated layer provided he restricts the trucks to legal loads. In these cases, the number of wheel loads traversing a given portion of the CTB could amount to several hundred.

Literature on the effect of heavy truck traffic on semi-cured CTB does not appear to be available. Some previous work by this department was reviewed and it was determined that deflection measurements by means of the Benkelman beam have been used as the controlling criteria in projects of a similar nature.

Benkelman beam deflection measurements were made directly on the CTB (Class A) of Project 06-Ker-99 (old VI-Ker-4-F) on May 24, 1960, before and after PCC batch trucks were permitted to haul over it. The CTB was 0.33' thick and had an average seven day compressive strength of 1100 psi. The deflections averaged 0.016" before truck traffic and 0.019" after 240 passes of 3-axle dump trucks loaded with a gross load of 42,000 pounds (33,000 pounds tandem axle load). There was no visual evidence of damage from the heavy wheel loads and the increase in deflection was not considered to be significant. There were, however, two small areas with high deflections (.064" - .097") measured prior to truck traffic. These areas had block-cracked CTB and depressions in the tested areas appeared to have been caused by heavy wheel loads. It was necessary to completely rebuild these areas.

Based on the methods used in this earlier investigation, the following outline of work to be performed was then adopted:

A. Site Selection - The subgrade condition would represent the more resilient or weaker types. A project using the minimum thickness (0.33') of CTB would be selected since it would show adverse effects more readily and would be less likely to withstand many applications of heavier than legal loads.

B. Method of Evaluation - Deflection of the road would be measured by a Benkelman beam, (Figure 1) The load in the beam truck would be 15,000 pounds across the rear axle. Deflections would be measured prior to the application of the test loads and intermittently while these loads were being applied. Any substantial increase in deflection throughout the testing series

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would be considered as an indication of a weakening of the CTB. The test loads would be applied by typical 3-axle dump trucks, one loaded to the legal limit of 32,000 pounds on the tandem rear axles and one with a load equivalent to that produced by an eight cubic yard batch of PCC. Two stages of cure for the CTB would be evaluated; one section would be allowed to cure one day and the other three days.

On January 19, 1966, the first test series was performed on project 04-SM,SF-280,1 at Daly City. Due to the strong subgrade (R-value = 68+), deflections were not very high and showed no significant increase due to the extra-legal loading. Since this project did not represent a weak subgrade, a second project was felt to be necessary to adequately determine the destructive effect of extra-legal loads on unsurfaced CTB. Consequently, preliminary deflection measurements were made on Project 03-Sac-5 near Sacramento on March 3, 1966. The subgrade on this project had been lime treated and this treatment strengthened the clay basement soil to such an extent that this project was also considered unsuitable for inclusion in this research project.

On April 12, 1966, another complete test series was performed on Project 03-Gle-5,162 which bypasses the city of Willows. The subgrade on this project was only slightly weaker than that of the Daly City project and also produced no significant increase in deflection due to the extra-legal loads. Therefore, we continued to search for a project with a weak subgrade.

Preliminary deflection measurements were then made on Project 10-SJ-580,5 near Vernalis and 03-Col-5 at Arbuckle. The deflections of the CTB on these projects were well below that of the previously tested projects. As of today, we have been unable to locate a project with a weak subgrade even though the projects tested were generally chosen because their subgrade soils were of poor quality and had the potential of being highly resilient.

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CONCLUSIONS

A. After 340 to 400 applications of a 35,000 pound tandem axle load on CTB which had cured from 2 to 9 days, there was no visible evidence of distress in the CTB and the deflection levels did not increase significantly during either complete deflection testing program.

B. None of the six projects tested produced high deflection because the subgrades were relatively dry at the time the cement treated bases were placed. Consequently, the heavy loads did not cause excessive deflections of the CTB and no damage was notice.

C. Differences in curing time amounting to several days have no apparent effect on the deflection level of CTB. This conclusion applies to CTB which has cured one day or more.

D. The curing seal, consisting of MC-250 liquid asphalt was not picked up by the truck tires when it had been allowed to cure for five or more days. A small amount of the curing seal was picked up by the truck tires when the curing time was only one or two days.

E. California's PCC structural section design appears to be of such quality that the chance of encountering a highly resilient subgrade condition is unlikely.

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RECOMMENDATIONS

On projects where a relatively dry subgrade condition prevails, there should be no great harm in allowing over-legal loads on the freshly placed CTB. However, some safeguards should be used. The following guidelines are suggested:

A. Projects on which subgrade moisture control has been used to control subgrade expansion would be most apt to develop problems while using freshly placed CTB as a haul road. We hesitate to recommend using the CTB on a project of this type as a haul road for trucks carrying over-legal loads.

B. Overloads should be restricted to tandem axles and should not constitute more than 25% of the legal tandem axle-load.

C. The Engineer should maintain a close watch on the CTB condition. The use of over-legal loads should be stopped at any time the Engineer determines that damage is being done to the cement treated base.

D. The Contractor should either remove and replace or repair, at his expense and to the satisfaction of the Engineer, any damaged CTB or curing seal.

If these guidelines are followed, the chance of damage occurring to the CTB layer should be sufficiently diminished so as to make the risk negligible.

It is our feeling that this hauling over the CTB be restricted to a few jobs and the final go-ahead given only after a review substantiates that no damage has occurred.

The Pavement Section of the Materials and Research Department should be notified whenever overloads are permitted on the trial sections, in order to have an observer present, and if necessary, to make some deflection tests. During hauling operations, if cracking or other distress appears in the CTB or if deflection readings exceed .045", hauling of heavy loads should cease.

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DISCUSSION

As mentioned in the outline of work to be performed, it was hoped that a project having a highly resilient subgrade could be found in order to test the effect of extra heavy wheel loads under the worst probable conditions. When this study was first initiated the only going project which appeared anywhere near suitable for this study was Project 04-SM,SF-239,56,225-A, D1C,F,E,SF (New 04-SM,SF-280,1), at Daly City. This project had a very good subgrade soil consisting of a sandy material with an R-value of about 68. Due to the urgency of this study, the first test series was carried out at this location. The results of this test series can be considered as reflecting the better probable subgrade conditions under which heavier than legal loads could be allowed to haul over CTB without causing damage.

The structural section at the time of testing consisted of 0.50' of aggregate subbase with an R-value of 80± and 0.33' of Class "B" CTB with an average seven day compressive strength of 900 psi. MC-250 was used as the curing seal.

The PCC batch trucks hauling eight cubic yard batches were routed over a portion of the CTB to provide the applications of the greater than legal load. A truck and driver were hired on extra work to provide the legal load applications. Using the batch trucks to provide one of the test loads required a wait until the contractor, Peter Kiewit Son's, was paving before carrying out the testing program. Consequently, the effect of the extra heavy wheel loads was not put to test until the CTB was six days old in lane L-3 and nine days old in lane L-2. This differed from the planned ages of one and three days. Due to an overestimation by the contractor, the truck which was supposed to have carried the legal load was loaded to a 35,000 pound tandem axle load instead of 32,000 pounds. The concrete batch trucks were hauling eight cubic yard batches which produced a load of approximately 38,000 pounds on the tandem axles.

Because of the operating difficulties which often occur on the first day of slipform paving, only 75 batch trucks were available to be routed over the CTB test section. A sufficient number of repetitions (342) of the 35,000 pound tandem axle load was obtained, however.

Table I presents a summary of the test results for the Daly City project. These data show there was no significant increase in deflection after either 75 repetitions of the 38,000

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pound tandem axle load or 342 repetitions of the 35,000 pound axle load.

Considerable time was expended in an effort to locate a project with a weak subgrade for a second test series. Contract records were checked to locate jobs with poor quality subgrades and a thin structural section. Finding a project which not only met these requirements but which was also in the proper stage of construction was difficult.

Project 03-Sac-5-29.8/34.6, near the Sacramento Metropolitan Airport, with a structural section consisting of 0.67' PCC over 0.33' CTB covering 0.5' lime treated clay was considered a likely prospect. The lime treated layer, however, developed such strength that the maximum deflection measured on either the CTB or the lime treated clay, prior to the placement of the CTB, was only 0.030". Since this structural section appeared to be as strong or stronger than the structural section on the Daly City project, no further testing was performed and the search for a project with a weak subgrade continued.

Project 03-Gle-5,162 at Willows was chosen for the next complete test location. From the experience gained on the Daly City project, it was decided that a rented truck be used to apply the overlegal load rather than try to coordinate with the PCC batch trucks used during the contractor's paving operation. Also, the application of comparative legal loads was discontinued. The overlegal load used during the Willows test series consisted of a 35,000 pound tandem axle load while the maximum load used during the Daly City test series consisted of a 38,000 pound tandem axle load. As it turned out, these values were both for an eight cubic yard batch of mixed PCC. The difference arises from the fact that the typical truck used on the Daly City project had a tare weight which exceeded that of the truck used on the Willows project by 3,000 pounds and the truck used at Willows was slightly longer than those used at Daly City causing more of the load to be distributed onto the front axle. The structural section on the Willows project at the time of deflection testing consisted of 0.33' of Class "B" CTB with an average seven day compressive strength of 450 psi over 3'± of aggregate subbase with an average R-value of 60. The R-value of the basement soil was between five and ten. The structural section design called for only 1.00' of AS but the contractor elected to use AS material as imported borrow and this resulted in the 3'± thickness of AS at this test location.

Table 2 presents a summary of the test results for the Willows project. As in the case of the Daly City project, this

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data shows no significant increase in deflection after 400 applications of a 35,000 pound tandem axle load on CTB two days and five days old.

A small amount of the MC-250 curing seal was pulled off by the truck tires on the two day old CTB but no damage was done to the seal on the five day old CTB.

Project 10-SJ-580,5 at Vernalis, was the next to be checked. It had a clay basement soil with R-values as low as 6. The structural section on this project consisted of 0.33' of Class "A" CTB over 0.92' of Class 4 aggregate subbase. The subgrade on this project was quite dry when tested, however, and the deflections ranged from only 0.011" to 0.023". Since this was considerably lower than the deflections measured on the other projects no further testing was done.

The last project to be checked was Project 03-Col-5, at Arbuckle. Moisture control had been used on this project in order to limit the expansive properties of the clay subgrade. The structural section at the time of deflection testing consisted of 0.35' of Class "B" CTB over 0.5' of aggregate subbase. This appeared to be exactly what we had been looking for and we hoped to find high deflections on this project. As it turned out, however, the deflections ranged from 0.011" to 0.053" with all but four of 44 measurements below 0.026". Furthermore, the four deflections which were above 0.026" were in localized wet spots in the CTB which had not been adequately compacted due to the excess moisture. Since the localized areas of high deflection could not be considered representative and were too small for testing purposes, this project was also considered unsuitable as a location for a complete test series. If the CTB had been placed shortly after the subgrade had been compacted, this project would very likely have been highly resilient, but it had been exposed to the hot summer sun of the upper Sacramento Valley for several months before the CTB was placed. This allowed the subgrade to dry considerably and therefore greatly reduced its resilience.

It is apparent that few, if any, subgrades for cement treated bases are resilient. This is due to the fact that the structural design procedure requires substantial thicknesses of subbase over poor quality basement soils. Also, the moisture contents of the underlying soils are normally quite low at the time the CTB is placed. Therefore, it was decided that a further search for resilient subgrades would be unproductive. However, if a resilient subgrade comes to our attention, a supplemental study will be made.

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TABLE I

CTB DEFLECTION VERSUS LOAD REPETITION

04-SM,SF-280,1
(Daly City)

Station Lane	CTB Age Days	Tandem Axle Load Pounds	Benkelman Beam Deflection - Inches Number of Repetitions of Load								
			0	10	20	40	75	80	117	162	342
124+75 / L-3	6	35,000	0.020	0.024	0.024	0.025		0.026	0.025	0.026	0.024
124+75 / L-3	9	35,000	0.029	0.030	0.030	0.031		0.031	0.029	0.031	0.029
119+75 / L-3	6	38,000	0.026		0.028		0.027				
121+00 / L-2	9	38,000	0.033		0.031		0.035				

Notes: 1. CTB aggregate from PCA Centerville Pit in Lane L-2 and from PCA Brisbane Pit in Lane L-3. Both sources had seven day compressive strengths of about 900 psi.

2. Each deflection value is the average of three individual measurements.

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TABLE II

CTB DEFLECTION VERSUS LOAD REPETITION

03-Gle-5,162
(Willows)

Station Lane	CTB Age Days	Tandem Axle Load Pounds	Benkelman Beam Deflection - Inches						
			Number of Repetitions of Load						
			0	48	101	151	200	300	400
499+50	2	35,000	0.028	0.034	0.035	0.032	0.034	0.036	0.033
501+00	5	35,000	0.036	0.039	0.042	0.040	0.042	0.042	0.042

Note: All measurements taken in the southbound passing lane.

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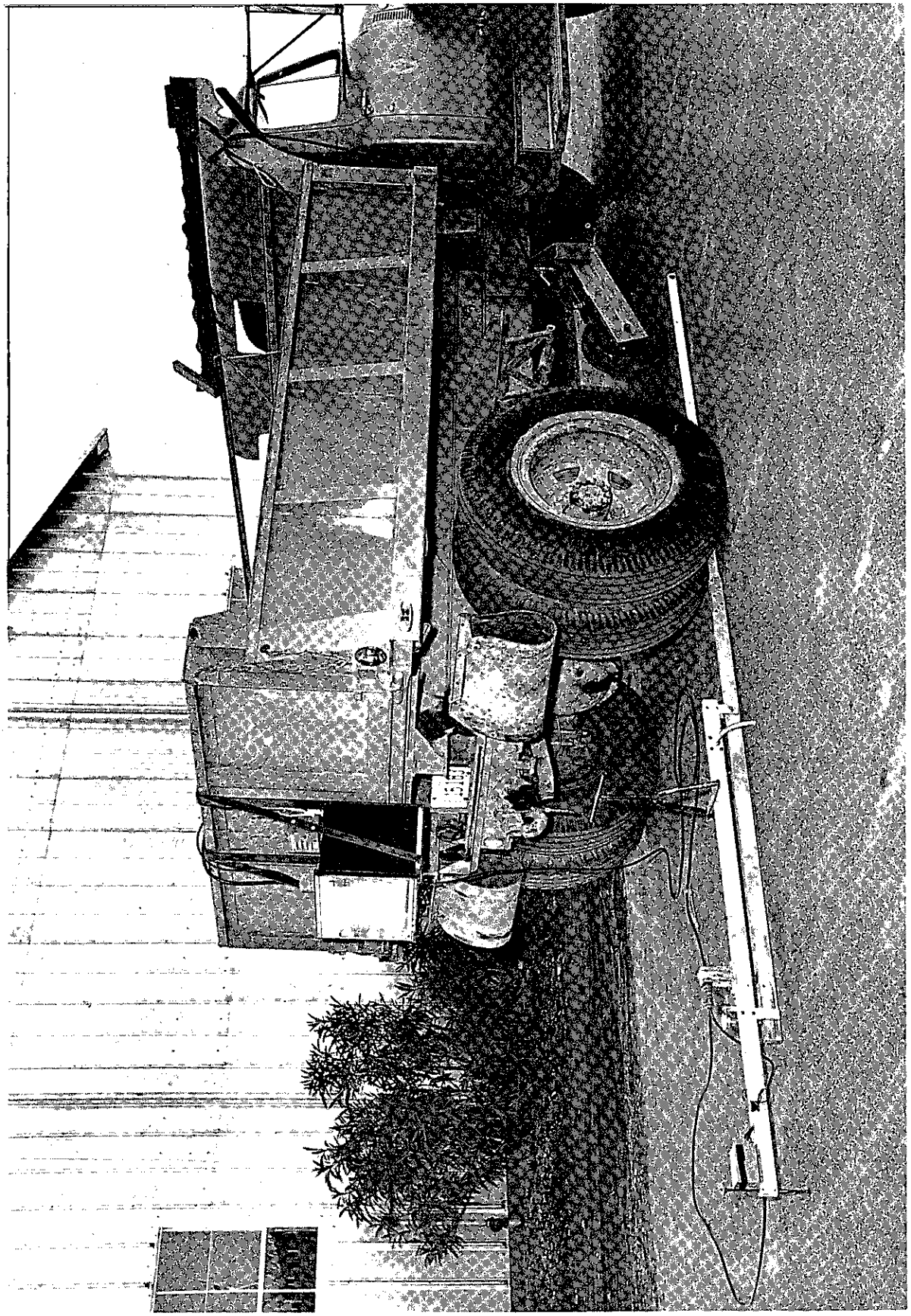
Figure 1



BENKELMAN BEAM WITH TEST TRUCK

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