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Pavement Deflection Measurement

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

May 26, 1964

Contra Costa County
Lab Auth 33174-S

Mr. Victor W. Sauer
Public Works Director
Contra Costa County
Hall of Records
Martinez, California

Dear Sir:

Submitted for your consideration is:

REPORT

of

DEFLECTION STUDY

of

VARIOUS ROADS IN

CONTRA COSTA COUNTY,

CALIFORNIA

64-35

Study made by ..... Pavement Section
Under general direction of ..... Ernest Zube
Work supervised by ..... R. Forsyth
Report prepared by ..... R. Forsyth
H. Munday

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

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Materials & Research Dept.

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# DEFLECTION STUDY OF VARIOUS ROADS IN CONTRA COSTA COUNTY

Presented herein are the results of a deflection survey for various roads in Contra Costa County. This study was requested by William A. Garrison, Contra Costa County Materials Testing Engineer, in a letter to J. L. Beaton dated March 2, 1964.

On the dates of April 13 through 16, 1964, deflection measurements were obtained with the traveling deflectometer and a 15,000 pound axle load on the following roads:

| Road Test Sequence | County Road Number | Road | Limits |
|---|---|---|---|
| A | 0461 | Third St. | Parr Blvd. to Grove Ave. |
| B | 0961 | San Pablo Dam Rd. | San Pablo, City Limits to May Rd. |
| C | 0961 | Camino Pablo | El Toynal to Freeway |
| D | 0961 | Moraga Way | Glorietta to Moraga |
| E | 3231 | Moraga Rd. | Donald to Via Campo Lindo |
| F | 3651 | Pleasant Hill Rd. | Freeway to Taylor Blvd. |
| G | 4151 | Ygnacio Valley Blvd. | C.L. Walnut Creek to C.L. Concord. |
| H | 4572 | Farm Bureau Rd. | Clayton Rd. to Willow Pass Rd. |
| I | 7711 | Walnut Blvd. | Camino Diablo to Marsh Creek Rd. |
| J | 9621 | Byron Highway | Washington St. to Alameda County Line |

The width of these roads varied from 20 to 64 feet and their structural sections consisted of 1-1/2 to 3 inches of asphalt concrete over 5 to 8-1/2 inches of aggregate base over 4-1/2 to 15 inches of aggregate subbase for all but one, Farm Bureau Road, which had no subbase. Portions of the Byron Highway structural section are over an old PCC pavement.

## Analysis of Data

The data resulting from this study are presented in tabular form by Table I. The criteria utilized for evaluation of pavement deflections originated as the result of a comprehensive deflection study which was made throughout the State from 1951 to 1955. The data represented readings from nearly 400 electronic gage units on 43 different projects under a 15,000 lb. single axle load. The report* on this work suggested limits (shown below) of the maximum

*Pavement Deflections and Fatigue Failures, F. N. Hveem, 1955.

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tolerable deflection to preclude "fatigue" cracking during the design life of the pavement. These limits varied in accordance with the type of structural section.

| Thickness | Type of Pavement | Maximum Deflection For Design Purposes (Tentative) |
|---|---|---|
| 6 in. | Cement Treated Base (Surfaced with Bit. Pavement) | 0.012" |
| 4 in. | Asphalt Concrete | 0.017" |
| 3 in. | Asphalt Concrete on Gravel Base | 0.020" |
| 2 in. | Asphalt Concrete on Gravel Base | 0.025" |

These values have been applied as guide criteria by the Materials and Research Department since 1955 for planning the reconstruction of existing roadways. To date, no additional evidence has been found which would cast serious doubt on the validity of these criteria insofar as California pavements are concerned.

More recent investigations have produced data on the deflection damping characteristics of the various structural elements or layers including gravel base, cement treated base, and asphaltic concrete. Utilizing this information, it is possible to estimate the thickness of surfacing or base required to reduce pavement deflections of a given roadway to tolerable limits.

The evaluated deflection level (Table I) is the 80 percentile value for each deflection measurement taken in a given section. This value is used as the basis for design since it reflects the deflection characteristics of the roadway as a whole rather than isolating possible causes of distress indicated by averages through cut, fill, cracked, and uncracked sections.

## Recommendations

Analysis of the data for the purpose of recommending a specific reconstruction for the road system was complicated by wide variations in deflection level of the various test sections for each street. In addition, there was no way for this department to properly evaluate the relative importance of any given street selected for tests or take into account economic considerations. The recommendations presented by Table II for reconstruction, therefore, are what would probably be considered for secondary state highways in order to increase the structural strength of the given roadway for an extended maintenance-free period.

In those areas where visual observation, level of deflection, and traffic volume indicated a major reconstruction, a digout with

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cement treatment was recommended in every case. The reason for this is the success of this technique throughout the State of California in effecting a substantial increase in the structural section strength while permitting only a minor increase in grade. This method also permits selective reconstruction; i.e., reconstruction of travel lanes only with subsequent blanketing of both passing and travel lanes. Should the county decide to use AC rather than cement treated base digouts, it is suggested that gravel equivalencies of AC surfacing be based upon the results of the AASHO road test; i.e., 1.9" for medium traffic and 2.5" for light traffic, as compared to 1.72" for cement treated base.

In several instances, where deflection level was relatively high and traffic index was sufficiently low, a 2" blanket was recommended if cracking had reached a stage where the existing surfacing had lost most of its structural integrity. In these cases, the new blanket could reasonably be expected to act independently of the old surfacing and thus provide greater flexibility or tolerate a higher level of deflection.

Concerning the repair of San Pablo Dam Road and reviewing the deflection data and recommendations from our letter report of October 13, 1961, it was noted that the original recommendation was for a 4-1/2" thick AC blanket or, as an alternative, the application of a seal coat to prevent surface water from entering the structural section. These two alternatives represent the divergent approaches of eliminating or reducing transient deflection and "living" with the condition by maintaining flexibility of the surfacing. This recommendation is therefore consistent with that of this report; i.e., the application of a 3/4" open grade AC surfacing which will, in effect, improve the appearance of the pavement. More extensive repair could be undertaken at a later date. The areas tested during this study, except for the trench backfill section, revealed minimal cracking even though the level of deflection exceeded the normal allowable limit for this structural section. The success of this roadway, therefore, is very likely due to a relatively low volume of traffic.

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TABLE I

DEFLECTION TEST DATA

| Run | Existing X-Sect. Inches AC | AB | AS | Lane | Deflection (Inches) Mean OWT | IWT | Evaluated (80% Level) | T.I. | Appearance |
|---|---|---|---|---|---|---|---|---|---|
| A-1 | 1-1/2 | 7 | 10 | SB | 0.012 | 0.013 | 0.015 | 7.5 | Some fine cracking |
| A-4 | " | " | " | NB | 0.018 | 0.017 | 0.020 | " | " " " |
| A-2 | 3 | 8-1/2 | 15 | SB | 0.025 | 0.025 | 0.029 | " | Cracked throughout |
| A-3 | " | " | " | NB | 0.034 | 0.035 | 0.041 | " | " " |
| B-1 | 2-1/2 | 6 | 9 | SBTL | 0.044 | 0.054 | 0.063 | 7.3 | Uncracked except for utility Trench backfill |
| B-2 | " | " | " | NBTL | 0.031 | 0.029 | 0.037 | " | Uncracked |
| B-3 | " | " | " | NBPL | 0.011 | 0.029 | 0.034 | " | " |
| C-1 | 3 | 7 | 9 | SBTL | 0.035 | 0.034 | 0.038 | 8.7 | Cracked & spalling |
| C-2 | " | " | " | " | 0.025 | 0.024 | 0.028 | " | Some cracking |
| C-3 | " | " | " | NBPL | 0.033 | 0.023 | 0.035 | " | Uncracked |
| D-1 | 1-1/2 | 6 | 11-14-1/4 | SB | 0.013 | 0.015 | 0.017 | 7.0 | Uncracked, New seal coat |
| D-2 | " | " | " | NB | 0.029 | 0.030 | 0.036 | " | Small cracked area New seal coat |
| D-3 | " | " | " | " | 0.042 | 0.032 | 0.048 | " | Cracked and pumping |
| E-1 | 3 | 7 | 6 | SB | 0.037 | 0.032 | 0.047 | 7.0 | Some cracking |
| E-2 | 2-1/2 | 7 | 6 | SBTL | 0.038 | 0.036 | 0.046 | " | Cracked throughout |
| E-3 | " | " | " | NBTL | 0.037 | 0.041 | 0.051 | " | Cracked throughout |
| E-4 | " | " | " | NBPL | 0.035 | 0.037 | 0.045 | " | Some cracking |

TABLE I (Cont'd)

| Run | Existing X-Sect. Inches | | | Lane | Deflection (Inches) Mean | | Evaluated (80% Level) | T.I. | Appearance |
|---|---|---|---|---|---|---|---|---|---|
| | AC | AB | AS | | OWT | IWT | | | |
| F-1 | 2-1/2 | 6 | 11-1/2 | NBTL | 0.029 | 0.023 | 0.035 | 7.5 | Slight cracking |
| F-2 | " | " | 10 | SBTL | 0.036 | 0.036 | 0.041 | 7.0 | Cracked throughout |
| F-3 | " | " | " | SBPL | 0.021 | 0.019 | 0.024 | " | Uncracked |
| F-4 | " | " | 11-1/2 | SBTL | 0.045 | 0.042 | 0.052 | 7.5 | Cracked throughout |
| G-1 | 2-1/2 | 6 | 14-1/2 | EBTL | 0.029 | 0.026 | 0.031 | 7.7 | Generally uncracked |
| G02 | " | " | " | WB | 0.025 | 0.023 | 0.029 | " | Cracked and pumping |
| H-1 | 1-1/2 | 5 | 0 | NB | 0.023 | 0.025 | 0.036 | 7.5 | About 1/2 cracked |
| H-2 | " | " | " | NB | 0.044 | 0.027 | 0.058 | " | " 2/3 " |
| I-1 | 1-1/2 | 6 | 4-1/2 | SB | 0.026 | 0.024 | 0.033 | 8.0 | About 1/4 cracked |
| I-2 | " | " | " | NB | 0.034 | 0.024 | 0.040 | " | Cracked throughout |
| J-1 | 3 | 5-6 | 6-8.5 | SB | 0.040 | 0.015 | 0.049 | 8.0 | OWT cracked throughout seal coat |
| J-2 | " | " | " | " | 0.028 | 0.003 | 0.036 | " | Same as J-1 |
| J-3 | " | " | " | " | 0.019 | 0.003 | 0.022 | " | About 1/3 cracked, OWT |
| J-4 | " | " | " | " | 0.014 | 0.006 | 0.016 | " | About 3/4 cracked |
| J-5 | " | " | " | NB | 0.017 | 0.007 | 0.020 | " | Uncracked |
| J-6 | " | " | " | NB | 0.014 | 0.002 | 0.023 | " | About 1/3 cracked, OWT |

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TABLE II

Recommendations for Reconstruction

| Road No. | Test Runs | Recommendation |
|---|---|---|
| 0461 Third Street (North Section) | A-1<br>A-4 | 1" AC Overlay |
| 0461 Third Street (South Section) | A-2<br>A-3 | 2" AC Overlay |
| 0961 (San Pablo Dam Road) | B-1<br>B-2<br>B-3 | It is recommended that the utility trench backfill section found predominantly in the Southbound travel lane be scarified to a depth of 10", accompanied by the removal of 2" of material. Cement should then be added in sufficient quantity to provide a Cl. "D" CTB with a compressive strength of 500 psi in 7 days. The digout should then be brought to grade with a 2" AC blanket. A 3/4" open graded AC should then be placed over the entire roadway. |

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TABLE II (Cont.)

| Road No. | Test Runs | Recommendation |
|---|---|---|
| 0961 (Camino Pablo) | C-1<br>C-2<br>C-3 | It is recommended that the travel lanes be scarified to a depth of 9", accompanied by the removal of 3" of material. A 6" Cl. "D" CTB should then be constructed as described for the San Pablo Dam Road. The digout should then be brought to grade with a 3" AC blanket. Both the travel and passing lanes should then be blanketed with a 3/4" open graded AC blanket. |
| 0961 (Moraga Way) | D-1<br>D-2<br>D-3 | 2" AC blanket |
| 3231 (Moraga Road) | E-1<br>E-2<br>E-3<br>E-4 | 2" AC blanket |



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TABLE II (Cont.)

| Road No. | Test Runs | Recommendation |
|---|---|---|
| 3651 (Pleasant Hill Road) | F-1<br>F-4 | It is recommended that travel lane areas of severe continuous distress, such as the area tested in Run F-4, be scarified to a depth of 6". Sufficient cement should then be added to form a Cl. "D" CTB with a minimum compressive strength of 500 psi in 7 days. The entire roadway should then be blanketed with a 2" AC surfacing. |
| 3651 (Taylor Blvd.) | F-2<br>F-3 | 2" AC blanket |
| 4151 (Ygnacio Valley Blvd) | G-1<br>G-2 | 2" AC blanket |
| 4572 (Farm Bureau Road) | H-1<br>H-2 | It is recommended that severely cracked sections, such as that included in Test Run H-2, be scarified to a depth of 6" and that a Cl. "D" CTB be constructed as described for Pleasant Hill Road. The entire roadway should then be blanketed with 2" of AC surfacing. |



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TABLE II (Cont.)

| Road No. | Test Runs | Recommendation |
|---|---|---|
| 7711 (Walnut Blvd.) | I-1<br>I-2 | 2" AC blanket |
| 9621 (Byron Highway) | J-1<br>J-2<br>J-3<br>J-4<br>J-5<br>J-6 | It is recommended that the outer wheel track sections directly adjacent to the existing PCC slab be scarified to a depth of 6". Sufficient cement should then be added for the construction of a Cl. "D" CTB similar to that described for the Pleasant Hill Road. The entire roadway should then be blanketed with 2" of AC surfacing. |



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