SUMMARY REPORT 136-6F(S)

AN ANALYSIS OF DYNAMIC DISPLACEMENTS MEASURED WITHIN PAVEMENT STRUCTURES

SUMMARY REPORT
of
Research Report Number 136-6F

Cooperative Research Program of the
Texas Transportation Institute and the Texas Highway Department
In Cooperation with the
U. S. Department of Transportation, Federal Highway Administration

August, 1973

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

An Analysis of Dynamic Displacements Measured Within Pavement Structures

by

Frank H. Scrivner and William M. Moore

A basic purpose of this study was to provide new experimental evidence of the manner in which strains induced by dynamic surface loads are distributed throughout flexible pavement structures. Since strains in heterogenous materials cannot be measured accurately, while displacements can (at least under cyclic loading), it was decided to measure the latter in the expectation that a mathematical model for the displacements could be found, and the model could be easily converted to strains by well known procedures. Accordingly, measurements were made on 30 specially designed test sections at the Texas A&M University Research Annex. Cyclic loading (8 cps, 1000 lbs. peak-to-peak) was supplied by a Dynaflect.

Measured Data

Nearly 7300 measurements of vertical and horizontal displacements, half of which were replicate measurements to be used in defining experimental error, were made and have been compiled in Appendix B, a separate volume of this report. With regard to these data the following can be said:

a. Vertical motions at all points were downward as the load was increased, and had an average replication (or experimental) error of 15% of the mean displacement. This error is considered small and tends to support the reliability of the vertical displacement data.

b. At shallow depths in the pavement structure (about 3 inches for the thinnest pavements, up to 5 or 6 times that depth for the thickest pavements) points tended to move horizontally toward the load; at greater depths they moved horizontally away from the load. The average replication error was 32% of the mean value of the amplitude. Thus the horizontal (or radial) displacement measurements appear to be less reliable than the vertical measurements.

c. Contour maps of a number of the sections suggested the existence of a horizontal line (or "neutral axis") in the vicinity of which radial displacements were near zero, and vertical displacements were near maximum, at least up to about 100 inches measured horizontally from the load.

d. Some of the data suggested that the sum of the three normal strains (the dilatation, or bulk strain) was negligible, compared to the largest of the three strains.

Application of Neutral Axis Concept

A commonly used formula for locating the depth to the neutral axis of a composite beam was employed as a regression model for an analysis of the appropriate data (layer thicknesses, material types, apparent depths to the neutral axis) from the 30 test sections. This analysis yielded ratios of the elastic moduli of the six types of materials used in bases, subbases and embankments, to the modulus of the asphaltic concrete material. The modular ratios appeared to be ordered reasonably, but their values should be checked by independent means.

Model for Displacements

The model adopted for displacements (which was so structured that the bulk strain was zero, and the depth to the neutral axis appeared in the model) contained four constants to be determined by regression on the data. When fitted to the vertical displacements section-by-section good fits were obtained, the value of the squared correlation coefficient, R^2, ranging from .94 to .99, but when fitted to the vertical displacement data from all 30 sections simultaneously, large prediction errors were encountered. When fitted to the radial (horizontal) displacement data section-by-section lower values of R^2 resulted, and the values of the four constants obtained were different for each section from the values previously found from the vertical displacement data for the same section.

Conclusions and Recommendations

Since the displacement vector model could not be extrapolated from one test section to the next, it obviously cannot be extrapolated to real highway sections, and therefore is not suitable, in its present form, for use as a practical design tool. The basic data, however, are considered unique in the field of pavement research, and deserve further study. It is recommended that such a study be pursued to a satisfactory conclusion.

Implementation Statement

The analysis reported herein resulted in a displacement vector model that only partially met the requirements of a practical pavement design tool. The basic data, available in Appendix B, should be analyzed further prior to implementation.

The published version of this report may be obtained by addressing your request as follows:

Mr. Phillip L. Wilson, Engineer-Director
Planning and Research Division, D-10R
P. O. Box 5051—VFW Building
Austin, Texas 78763
(Phone 512 475-7346)