STRUCTURAL DESIGN OF UNSURFACED ROADWAYS AND AIRFIELDS

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ABRIDGMENT

•AN INVESTIGATION was conducted concerning the development of a structural design procedure using soil as a surfacing layer for roadway and airfield pavements. A review of the literature revealed limited pertinent testing that consisted of a total of 78 full-scale controlled tests conducted by the U.S. Army Engineer Waterways Experiment Station. The test items were generally 2-layer systems composed of a higher strength soil material overlying a weaker soil layer. These soils were of various types, thicknesses, and strengths (subgrade and cover). They were tested under various conditions of load, tire pressure, and tire size. Only failed items used in single-wheel load tests were considered in an analysis to develop equations for design of cover layers.

A multiple linear regression analysis was performed, and prediction equations were developed for thickness, coverage (service life), subgrade strength, load, and tire pressure in terms of the independent variables most affecting these values. These prediction equations are a method of presenting design criteria for unsurfaced roads and unsurfaced airfields based on the results of the full-scale testing.

The 5 independent variables of tire pressure, load, coverage, subgrade soil CBR, and cover soil CBR were tentatively selected as best defining thickness, the dependent variable. The 1 dependent variable and the 5 independent variables were put in a common logarithm form, and a linear correlation was developed in an equation form. The addition of more variables did not significantly increase the degree of correlation. Deleting any of the 5 variables decreased the degree of correlation and the increased standard error of estimate. An attempt to analyze the performance of different test items on the basis of material components revealed that there was no appreciable difference in the performance. Also, the correlation values were better when the type-of-material variable was deleted. The following equation is presented as best predicting thickness requirements:

$$\begin{aligned}\text{Log thickness} = & -1.02165 + 0.63624 \log \text{tire pressure} \\ & + 0.21484 \log \text{load} + 0.23937 \log \text{coverage} \\ & - 0.402813 \log \text{subgrade CBR} \\ & - 0.31404 \log \text{cover CBR}\end{aligned} \tag{1}$$

This correlation has a standard error of estimate of 2.5 in. and an R-value of 0.815; R^2 equals 0.665. A shape number relating tire dimensions and deflections, $b \cdot d(\delta)^{1/2}$, was used as an additional variable. In this form b is equal to width, d is equal to diameter, and δ is equal to deflection of tires. However, the addition of this variable did not improve the degree of correlation; therefore, it was not included. Also, deletion of the cover CBR variable weakened the correlation and increased the standard error of estimate; therefore, this variable was retained.

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A similar type of analysis was used for each of the other 4 variables with the following results:

$$\text{Log coverage} = 5.90386 - 1.73226 \log \text{tire pressure} - 1.75002 \log \text{load} + 1.21599 \log \text{subgrade CBR} + 1.10497 \log \text{cover CBR} + 0.851912 \log \text{shape number} + 2.64158 \log \text{thickness} \quad (2)$$

$$\text{Log subgrade CBR} = -1.57455 + 0.49026 \log \text{tire pressure} + 0.58114 \log \text{load} + 0.17190 \log \text{coverage} - 0.00123 \log \text{cover CBR} - 0.38251 \log \text{shape number} - 0.65471 \log \text{thickness} \quad (3)$$

$$\text{Log load} = 1.74026 + 0.20493 \log \text{tire pressure} - 0.07135 \log \text{coverage} + 0.16762 \log \text{subgrade CBR} + 0.07199 \log \text{cover CBR} + 0.74112 \log \text{shape number} + 0.20042 \log \text{thickness} \quad (4)$$

$$\text{Log tire pressure} = 1.47676 + 0.28537 \log \text{load} - 0.09836 \log \text{coverage} + 0.19691 \log \text{subgrade CBR} + 0.20471 \log \text{cover CBR} - 0.44815 \log \text{tire shape number} + 0.31440 \log \text{thickness} \quad (5)$$

The assumptions of a linear relationship are generally sound for the ranges of variables described from actual tests, but the true relationship may be far from linear for wider ranges. Specific reverification tests are needed in the lower and higher ranges of extrapolation where test data did not exist. Six additional tests in these ranges would confirm the findings and substantiate the assumption of linear relationship for the entire range of prediction.

Additional study is needed to better define the load-carrying capability of soils of large values of modulus of elasticity E in a 2-layer system. For identical subgrade conditions, this study revealed only very small actual reduction of thicknesses when increases of cover soil strength occurred. A series of tests is needed in which identical sections, with the exception of cover soil type and strength, are constructed, tested, and compared.

The 5 prediction equations for thickness, coverage, subgrade CBR, load, and tire pressure represent a method that previously was not available for the design of road shoulders and unsurfaced roads and airfields. The equations are the results of analysis of 78 full-scale test items.