SUMMARY REPORT 57—1F(S)

FORECASTING SERVICEABILITY LOSS OF FLEXIBLE PAVEMENTS

SUMMARY REPORT
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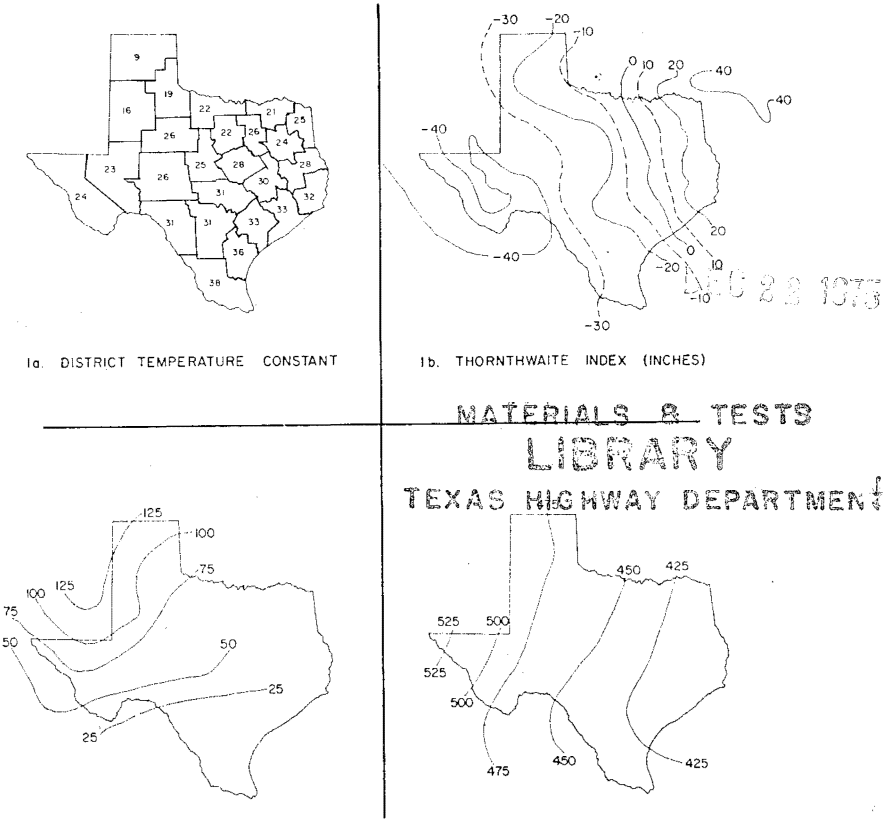

1a. DISTRICT TEMPERATURE CONSTANT

1b. THORNTHWAITE INDEX (INCHES)

1c. FREEZE THAW CYCLES PER YEAR

1d. MEAN DAILY SOLAR RADIATION (LANGLEYS/DAY)

Environmental Variables in Texas

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Forecasting Serviceability Loss of Flexible Pavements

by

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This report presents a methodology for (1) building more "rational" pavement performance models, (2) analyzing the sensitivity of these models, and (3) implementing these models at a reliability level that is specified by the user.

A "Two-Step Constrained Select Regression Procedure" was developed for the curve-fitting of pavement serviceability loss as a function of environmental effects, traffic conditions, aging effects, design variables, and construction material properties. It was observed that each pavement type required a separate performance equation. Three flexible pavement types were investigated in this study: (1) surface treatment pavement, (2) hot mix asphaltic concrete (HMAC) pavement without overlay construction, and (3) HMAC overlaid pavement. Pavement serviceability was analyzed based on the combined effects of many distress mechanisms such as: fatigue, swelling, shrinkage and thermal cracking.

The performance equations derived in this study fit the data collected in Texas Study 2-8-62-32 better than Scrivner's equation which is based on AASHO Road Test data and which is currently implemented in the Texas Flexible Pavement Design System, FPS-11. However, the Texas data were not collected in an experiment that was well-designed for regression analysis purposes, a sharp contrast with the AASHO Road Test.

A differential analysis method derived from the Taylor's series expansion was developed to examine the sensitivity of pavement serviceability in terms of each of the environment, traffic, time, design, and paving material variables. Also, the significance of each variable with respect to pavement performance can be examined using the differential analysis method.

Probabilistic design concepts were incorporated to indicate how to design reliable pavements which would provide satisfactory service to the user throughout the design life at designer-specified confidence levels. Equations to calculate the expected value and variance of pavement serviceabilities were derived from the Taylor's series expansion.

Description of Data

Pavement performance data which were collected on 133 Texas pavement sections are analyzed in this study. The 133 sections can be divided into three pavement types: (1) 45 surface treatment sections, (2) 61 HMAC pavement sections without overlay construction, and (3) 27 HMAC overlaid pavement sections. Using data from these sections, this study set out to develop a pavement performance equation for each pavement type.

The dependent variable in the statistical studies made was the serviceability loss. Independent variables chosen for this investigation were categorized as: (1) environmental factors (2) time, traffic and design variables, and (3) base course and subgrade properties. As far as possible, each of the dependent and independent variables was determined for each test site represented.

Serviceability Loss

The serviceability index of a new (or rehabilitated) pavement usually begins at a level somewhere between 4.0 and 5.0 and then decreases with time as a result of traffic and environmental influences. When the serviceability index has dropped to a minimum acceptable level, then some major maintenance effort must be applied to restore the riding quality. In this study, the initial serviceability index is assumed to be a value of 4.3 for HMAC surfaced pavements and 3.9 surface treatment pavements.

Three successive measurements of the serviceability index were made. The time between the first and second measurements averaged 2.1 years; the time between the second and third averaged 2.5 years. It was observed that serviceability index of 49% of HMAC sections and 64% of surface treatment sections increased as time passes. The gains in serviceability were due to the following reasons: (1) the time between successive measurements was too short to allow the development of significant trends, or (2) routine maintenance of the test sections prevented the development of significant trends, or (3) measurement errors masked the actual trends. In order to overcome the difficulty in applying these data for pavement performance analysis, the serviceability of the three measurements of each pavement section were averaged. The averaged serviceability index was thus used to calculate the serviceability loss.

Conclusions

Specific conclusions of this study are summarized herein.

1. A well-designed experiment is needed to provide adequate information for pavement performance analysis.

2. The two-step constrained select regression methodology, developed in the report, can be applied to approximate the true functional relationship of pavement performance information collected from experiments. This allows pavement life to be predicted based on the construction of alternatives, estimates of traffic, and environmental effects.

3. Pavement serviceability loss due to fatigue, swelling, shrinkage, and thermal cracking can be integrated into a simple performance equation which shows the effects that some of the important variables have on the performance of flexible pavements. A few of these effects are summarized below.

a. Fatigue damage is greater in those areas where the temperature is higher, and where there is more moisture supplied to the subgrade.

b. While load applications do contribute to fatigue damage, they are not as important as found in the AASHTO Road Test. This is possibly due to the relaxation of the asphalt concrete between loads or to the performance characteristics of the actual pavements used in Texas.

c. Swelling clay serviceability loss is greater where there is a larger percent of fines in the subgrade and where there is a greater moisture supply to the subgrade.

d. Shrinkage cracking of the base course is increased in the more arid areas and where the percent fines in the base course is greater. This kind of cracking is reduced by the addition of lime.

e. Thermal cracking is greater in the more arid areas, where there is a greater percent of fines in the base course, and where the number of freeze-thaw cycles is greater.

f. Fatigue distress becomes greater as the surface course becomes thicker up to a depth of around three inches.

4. Performance equations derived in the report fit the Texas data collected in Texas Study 2-8-62-32 better than the equation currently implemented in Texas Flexible Pavement Design System, FPS-11. Regression analyses of the data using the current FPS performance equation to predict serviceability loss resulted in R^2 values of around 0.02 to 0.1. The better fit of the newly developed performance equations is due to two factors:

a. A better physical explanation of the real data including more effects of the climate.

b. A larger number of variables used in the model.

5. Differential analysis can be applied to examine the sensitivity of pavement serviceability loss. A sensitivity study evaluates the significance of design, traffic and environmental variables.

6. Probabilistic design concepts can be used to design a reliable pavement which will provide satisfactory service to the user through its design service life at a designer-specified confidence limit.

7. Products of this study are not recommended for immediate implementation. More information is needed for confirmation of the models. However, the methodology developed and utilized in this report can be applied to future pavement performance studies.

Implementation Statement

Pavement performance equations presented in this report are not recommended for immediate implementation. This report outlines a research procedure for future pavement performance studies to be conducted in Study 2-8-75-207, "Flexible Pavement Evaluation and Rehabilitation," which has the ultimate goal of implementing more "rational" performance equations in the pavement design systems developed in Texas Study 2-8-69-32, "Extension of AASHO Road Test Results," and Study 1-8-69-123, "A System Analysis of Pavement Design and Research Implementation."

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

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