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INFLUENCE OF WATER DEPTHS ON FRICTION PROPERTIES OF VARIOUS PAVEMENT TYPES

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Influence of Water Depths on Friction Properties of Various Pavement Types

by

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Reported herein are the results of the final phase THD Study 2-8-69-138. This phase of the study is concerned with determination of the effects of various water depths (obtained with a rain simulator) on the friction properties of various pavement textures at different levels of vehicular speeds and tire-tread depths, tire pressures and tire types. Equations relating these variables are also developed and the relative effects of the variables determined. Tabular and figurative methods are utilized to present the results.

Background information and pertinent past research pertaining to effects of water depth on pavement friction are given.

Sixteen different types of surfaces were tested including full scale prototypes and regular pavements built under normal contracts. The prototype surfaces, located at the Texas A&M Research Annex, are 600 feet long by 24 feet wide. Friction tests were conducted on each surface at several water depths for various combinations of tire type, tire-tread depth, tire pressure, and vehicle speed. Multiple regression analyses were used to assess the effects of the variables on friction properties of the different surfaces. A series of twenty-five tables included in the report represents the summarized data of the study.

Pavement water depth was found to affect skid numbers at 60-mph significantly. For a tire-tread depth of 0.31 in. and a texture of 0.033 in., increasing the water depth from 0.58 to 2.22 mm decreased the 60-mph skid numbers by as much as 36 percent. Increases in tire-tread depth and surface texture increased skid numbers; whereas, increases in vehicle speed decreased skid numbers.

Study Objectives

The objectives of this research were:

1. To examine the effects of various water depths on the friction properties of various surface textures at different levels of vehicular speeds and tire-tread depths;

2. To develop equations relating water depth, surface texture, vehicular speed, and tire-tread depth to friction number; and

3. To recommend means by which the findings and conclusions contained herein can be implemented by the highway engineer in determining proper geometric designs and paving materials commensurate with acceptable pavement friction characteristics and service demands.

Conclusions

1. Vehicle speed, tire type, tire-tread depth, tire pressure, surface texture, and water depth were found to affect skid numbers in the following manners. The equations selected as the final model, based on R^2, the physical constraints, simplicity of expression and inclusion of all four independent variables, namely, MPH, TD, WD, and TXD are given below.

$$SN = 135.121\ X_4 + 563.655\ X_5$$

$$= \frac{135}{MPH^{0.72}}\ TD^{0.06} + \frac{4.18\ TXD^{0.05}}{(25.4WD + 2.5)^{0.08}}$$

where

SN = skid number at corresponding speed;
MPH = vehicle speed (mph);
TXD = average surface-texture depth (in.);
WD = water depth above top of texture (in.).

Other data groups are regressed using the same procedures. Final models for each data group are shown below. Plots of these models are included in the main report.

Select Regression (Pads 1, 3, 4, 5, 6, 7, 8,)

ASTM Tire, 32 psi

$$SN = \frac{135}{MPH^{0.72}}\ TD^{0.06} + \frac{4.18\ TXD^{0.05}}{(25.4WD + 2.5)^{0.08}} \qquad \text{Equation 1.}$$

Commercial Tires, 32 psi

$$SN = \frac{186}{MPH^{0.83}}\ \frac{TD^{0.07}\ TXD^{0.01}}{(25.4WD + 2.5)^{0.16}} + 2.49 \qquad \text{Equation 2.}$$

($N = 735$, $R^2 = 0.933$, SE = 9.47, DF = 2/733, F = 5131)

ASTM Tire, 24 psi

$$SM = \frac{154}{MPH^{0.77}}\ TD^{0.05} + \frac{4.71\ TXD^{0.09}}{(25.4WD + 2.5)^{0.09}} \qquad \text{Equation 3.}$$

($N = 228$, $R^2 = 0.942$, SE = 10.32, DF = 2/226, F = 1825)

Commercial Tires, 24 psi

$$SN = \frac{234}{MPH^{0.86}}\ \frac{TD^{0.06}\ TXD^{0.07}}{(25.4WD + 2.5)^{0.13}} + 2.49 \qquad \text{Equation 4.}$$

($N = 732$, $R^2 = 0.937$, SE = 8.79, DF = 2/730, F = 5441)

1. Other equations were developed specifically for low friction surfaces and portland cement concrete finishes. These are presented in the main report.

2. Increases in water depths beyond that required to inundate the surface asperities were not found to affect skid number significantly at 20 and 40 mph speeds; however, significant decreases in skid numbers with increases in water depths were found when only skid numbers at 60 mph were used in the analysis. This is not meant to imply that the absence or presence of a water film has no influence on friction numbers at any speed, since these results are based on data taken only after the surface was wetted.

3. Surface texture and skid numbers were positively related. The effect was very pronounced at the lower texture values where slight increases in macro-texture (with a given microtexture) produced large increases in skid numbers.

4. Tire-tread depth and skid numbers were also positively related, particularly at the lower tread depths. The effect became less evident at tread depths greater than 0.20-inch.

5. Vehicle speed had a very significant effect on skid numbers. Higher speeds were associated with lower skid numbers. The reader is referred to Tables 3-1 through 3-25 and Figures 3-1 through 3-48 in the full report for more information on findings of the study.

6. Detailed plots of a portion of the findings are contained in Figures 3-49 through 3-60 of the main report.

7. Within the variations of the types of tire treads studied tread pattern appeared to have only a minor influence on the factors under study.

8. Tread depth exercised a strong influence on the skid number. The magnitude of the effect varied as expected with water depth, speed, and amount of macrotexture.

The findings and conclusions contained herein will be useful to the highway engineer in determining proper geometric designs and paving materials commensurate with acceptable pavement friction characteristics and service demands. Suggestions for further research are also included.

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

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