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HIGHWAY FRICTION MEASUREMENTS WITH MU-METER AND LOCKED WHEEL TRAILER

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Highway Friction Measurements With Mu-Meter and Locked Wheel Trailer

by

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This summary report describes one phase of Research Study No. 2-8-69-138 entitled "Vehicle-Pavement Interaction Study." Other reports published under this research study include: No. 138-1, Microtexture Measurements on Pavements Surfaces; and No. 138-2, Macrotexture, Friction, Cross Slope and Wheel Track Depression Measurements on 41 Typical Texas Highway Pavements.

Introduction

Friction properties of pavement surfaces have become factors of major importance to the over-all traffic safety problem. Friction measurements of the tire-pavement combination are considered highly acceptable for evaluating the skid-resistant properties and thus safety of pavement surfaces, and are essential to the determination of what occurs at the tire-pavement interface under different environmental conditions. Research by numerous investigators has shown that experimental studies under actual field conditions are a necessary supplement to theoretical analyses and laboratory investigations. It is for this reason that the work reported in this study is field oriented.

Previous attempts have been made to characterize the skid-resistant properties of pavement surfaces in qualitative manners such as surface macrotexture, drainage characteristics of the road surface and aggregate size, shape, microtexture, and mineralogy. The majority of these are not convenient survey measures nor has the relative magnitude of their influences been universally accepted; thus, characterizations at present are mainly dependent on implicit information from friction tests.

Friction Testing Procedures and Conditions

Friction tests at 20, 40, 60, and 80 mph, on wet and dry surfaces using smooth and treaded tires, with 10 and 24 psi tire inflation pressures were taken in the slip mode with a Mu-Meter and in the skid mode the Texas Highway Department research skid trailer. The Mu-Meter is a continuous-recording friction-measuring trailer which determines the frictional characteristics of treadless tires operating in the cornering slip mode. It measures the cornering-force friction coefficient generated between the test surface and the pneumatic tires on two running wheels which are set at a fixed $7\frac{1}{2}$-degree toe-out (yaw) angle to the line of drag. The trailer, used by the Texas Highway Department Research Section of D-8, conforms substantially to ASTM Designation E 274-65T (Skid Resistance of Pavements Using a Two-Wheel Trailer). It utilizes the E-17 circumferentially grooved, treaded tires inflated to 24 psi. The locked wheel sliding skid mode drag forces are measured with strain gages.

Fifteen pavement surfaces including: 1) 9 hot mix asphalt concrete, 2) 2 portland cement concrete, 3) 3 surface treatments, and 4) 1 flushed seal were tested. Surfaces were chosen so as to exhibit widely different friction levels, friction-velocity gradients, drainage capabilities, mineralogical properties, and textural classifications. The surfaces were classified as to the mineralogy, size and shape of the coarse aggregate contained therein. Pavement macrotexture tests were conducted by volumetric and mechanical roughness detector methods.

Documented research indicates that the drainage capability of a given surface, as determined from skid tests, varies considerably with respect to test velocity, water film thickness, tire tread depth, and inflation pressure. Forty mile-per-hour test velocity, approximately 0.020-inch water film thickness, and E-17 circumferentially grooved, treaded tires inflated to 24 psi are normally used as a basis for reporting and comparing pavement skid resistance. These "standard conditions" were also used in this study in an attempt to better evaluate their relative effects on the slip and skid modes. Additionally, other variations were incorporated into the study to gain a better insight into the overall problems.

Two series of 20, 40, 60, and 80 mph friction tests were conducted with each instrument, under differing conditions, at four locations on each surface. On several surfaces 80 mph tests were not attempted because of poor roadway geometrics or high traffic densities. Instead, tests at top speeds of less than 80 mph were taken on these surfaces. Reported slip and skid numbers, for a given test method on each surface represent average values for four locations tested on that particular surface.

Reported Findings

Comparisons and relationships between various friction parameters as obtained with both instruments were made. Effects of macrotexture on the friction parameters were also analyzed. Statistical analyses and typical plots are given.

A listing of the equipment, test conditions and variables which were introduced under controlled conditions for the tests is given in Figure 1. Average friction-velocity summary comparisons are also contained in Figure 1.

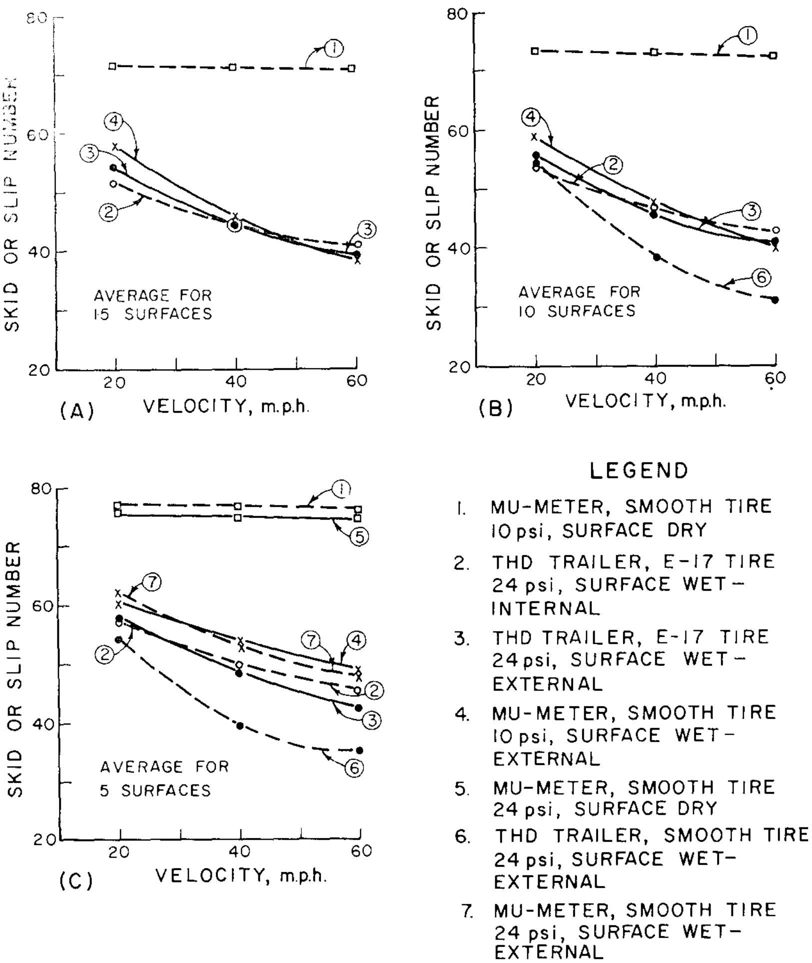

Figure 1. Average friction-velocity comparisons for different test conditions.

Conclusions

Based on the test procedures, the environmental conditions and the equipment utilized in these studies the following tentative conclusions appear warranted.

1. The skid trailer and the Mu-Meter correlate quite well provided both instruments are equipped with smooth (treadless) tires and are operated on pavement surfaces wetted alike. Correlation coefficients of 0.94, 0.92, and 0.96 were obtained at 20, 40, and 60 mph, respectively.

2. When the Mu-Meter with smooth tires is compared with the trailer equipped with ASTM E-17 treaded tires, the correlation coefficients dropped to 0.86, 0.80, and 0.75 at 20, 40, and 60 mph, respectively. The decrease in the correlation coefficient with increased speed is attributed to the relative difference in the drainage capabilities of the smooth versus the treaded tires.

3. For the water film thickness (approximately 0.020 inches) used in these studies friction values obtained on highly textured surfaces with either smooth or ASTM treaded tires do not differ appreciably. This statement further assumes that the microtexture of that part of the surface contacting the tire rubber is essentially the same.

4. Internal versus external pavement wetting processes for the skid trailer exhibited correlation coefficient of 0.92, 0.93, and 0.93 at speeds of 20, 40, and 60 mph, respectively. In some instances the efficiency of the internal watering system was reduced at high speeds due to splash and wind effects.

5. The Mu-Meter gave high values on all clean dry surfaces at speeds from 20 to 80 mph; however, the correlations between values obtained on pavements in the wet and dry condition were quite poor.

6. At a fixed gross load tire pressure had little influence on Mu-Meter values obtained from tests on wet pavements.

7. Pointing up the relative drainage capabilities of the E-17 (treaded) and smooth tires, a good correlation (correlation coefficient of 0.92) was found to exist between the percentage gradients of the Mu-Meter and the trailer when both were equipped with smooth tires.

8. Macrotexture and 40 mph trailer skid values showed little correlation. A somewhat better correlation was found to exist between Mu-Meter results and macrotexture (correlation coefficient equal to 0.56).

Recommendations for Implementation

In the United States the majority of state highway departments, federal agencies, etc. rely almost exclusively on coefficient of friction values derived from skid mode friction tests for purposes of evaluating various pavement surface types and other factors in relation to their relative effect on the achievement of adequate contact forces between wet pavement surfaces and vehicle tires.

Different friction levels exist for variable, but normal operating modes of a tire; i.e., rolling and slipping during braking, driving and cornering. For research purposes it is desirable to utilize both the slip and skid mode so as to better evaluate the relative slipperiness of given pavement surface types under different operating conditions. These data should prove useful in the selection of surface types and roadway geometrics compatible with service demands and point up the desirability of tailoring the pavement surface design to the operator-vehicle needs. The critical nature of the cornering operation appears to warrant a closer look at the pertinent facets of the slip mode of operation, particularly for vehicles with essentially smooth tires.

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