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LOCKED-WHEEL PAVEMENT SKID TESTER CORRELATION AND CALIBRATION TECHNIQUES

An NCHRP staff digest of the essential findings from the interim report on NCHRP Project 1-12(2), "Locked-Wheel Pavement Skid Tester Correlation and Calibration Techniques," by W. E. Meyer, R. R. Hegmon, and T. D. Gillespie, The Pennsylvania State University, University Park, Pennsylvania.

THE PROBLEM AND ITS SOLUTION

The skid resistance of wet pavements is one of the critical factors in automotive traffic safety. The majority of highway departments in the United States measures pavement skid resistance with a locked-wheel pavement skid tester. This method is standardized by ASTM Method E-274-70. Adherence to this standard is, however, not sufficient guarantee of repeatable results by any one tester or good correlation between different testers. Any measurement must accept a degree of uncertainty, caused by imperfections of the measuring devices and procedures. A skid tester is a complex measuring device containing many components, each contributing to the uncertainty in the measured quantity. The acceptable degree of inaccuracy, or error, is usually a compromise between the desired accuracy and the effort of improving the measuring system. In the past, the error in skid testing clearly has been too large. The problem, therefore, is to determine the causes of error and to find means of reducing them.

Discrepancies in test results may be caused by variations of one or more of the many factors involved in skid testing. Some of these factors can be controlled within limits; others are not as readily subject to control and their effects should be recognized and accounted for in some manner. Reliability in skid resistance measurement is a prerequisite to specifying minimum skid resistance requirements for the nation's highways and to upgrading pavements that do not meet requirements.

The objective of NCHRP Project 1-12(2) is the development and verification of methods for improving the ability to measure pavement skid resistance when using locked-wheel skid testers. Tentative recommendations for reducing variations in skid resistance measurements have resulted from the first phase of the project on the basis of a research program that involved (1) meetings with many skid tester users to discuss the problems and obtain all available information; (2) field and laboratory tests to investigate specific effects of test variables; and (3) the development and operation of a simulation model of a skid tester primarily for the investigation of dynamic effects. The tentative recommendations are to be verified and/or modified in a second and final phase of the study through a correlation program involving skid testers from several highway departments. In the meantime, current and prospective skid tester users should consider their use on a trial basis.

FINDINGS

Initial contacts were made with 54 agencies known to be operating locked-wheel pavement skid testers to collect all possible information about the test equipment and to obtain test data for further analysis. A mathematical model of a locked-wheel skid tester was prepared for a computer analysis of the influence of the various parameters on measurements as affected by operator, data-evaluation techniques, lateral position, speed, and temperature. A small skid-test comparative study involving six testers was conducted in cooperation with the National Bureau of Standards. With completion of the first phase of the research, all major factors known to influence skid resistance measurement have been evaluated and recommendations have been prepared for reducing the effect of each factor during skid testing.

It was found that inadequate procedures are the primary cause for poor repeatability in skid resistance measurement and are responsible for discrepancies between the results from different skid testers. Skid tester correlation can be improved by tightening controls, mainly on speed and lateral positioning.

Major equipment characteristics were not identified as having a significant effect on skid tester performance and no major structural changes are recommended. Support equipment such as watering system, speed measuring system, and instrumentation should be of high quality to reduce errors. A summary of the recommendations is as follows:

1. Speed should be maintained within ± 1 mph. This requires a fifth wheel for accurate speed measurement. A speed deviation indicator is recommended.

2. With the E-249-66 test tire, a 10°F temperature increase causes a drop of approximately 4% in skid resistance. Temperature corrections are needed when comparing data taken at significantly different temperatures. Such corrections require convenient and accurate temperature measurement of either the pavement or the tire.

3. A nominal water film thickness of 0.02 inch provides consistent wetting on nearly all pavements, but a standard watering method is recommended for best correlation between testers.

4. Straying off the wheel track causes relatively large differences. Drivers must be made aware of this large potential error source and trained to minimize it.

5. The test tire causes variability that does not show up in calibration. When changing tires, an effort must be made to determine systematic change between the new and old tires. When correlating testers, new tires of the same production batch should be used and checked for uniformity.

6. Wheel load errors cause a directly proportional skid resistance error. Wheel load determination within ±1% accuracy is recommended.

7. Strain gage sensors require high amplification. High-quality components are essential.

8. Combined use of torque arm and platform calibration is recommended; the former as check of the measuring system, the latter to compensate for tire effects on system response.

9. An evaluation of the recorded friction trace over a 1.5-second interval starting 0.5 second after lock-up is recommended. Total system response must have a bandwidth of 0 to 10 cycles per second minimum to prevent loss of signal.

APPLICATIONS

Variance in skid test measurements results from the interaction of many factors. To determine acceptable error limits, it is necessary to investigate separately each factor and form a judgment on the relative weight of its effect on the measured skid resistance. The statistical analysis made during this study should be of particular value to highway departments developing inventory-type skid testing programs.

The variance, or error band, depends on the quality of the skid tester, including support system, operator experience, and consistency of testing procedures. For rational planning of skid testing it is necessary to know: (1) the expected variance for the type of tests planned, and (2) the number of tests that will give a mean skid resistance with a desired accuracy. The expected variance of a skid tester can be estimated from either a sufficient number of old test data sets or a special test conducted for this purpose. In both cases the estimate should be based on several hundred tests. If more than one operator is normally used on the tester, the variance should also be determined with more than one operator. When a value for the standard deviation has been established, the number of tests for a desired accuracy of specified levels of confidence and probability can be determined.

Figure 37, derived from Guenther*, gives the number of tests as a function of tester standard deviation and confidence interval length for confidence coefficient of 0.90, and probability of 0.90. Standard deviations of a score of skid testers under different conditions of testing and at several speeds were calculated and found to be within the range covered in the graph. Analysis of skid resistance data revealed a normal distribution of all single spot and section data.

To demonstrate the use of the graph, assume that the standard deviation is found to be 2. To find the required sample size for an interval of six skid numbers (i.e., true mean ±3 SN) read up from 6 on the horizontal axis to the curve S.D.=2, then across to the vertical axis to a sample size of 4.4. Rounding off upward, the required sample size is 5.

The confidence coefficient (0.90) and probability (0.90) used in the construction of these curves were selected because they appeared to yield practical sample sizes. In some circumstances, however, it might be desirable to use different values. Raising the confidence coefficient to 0.95 would result in in-

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*Grant, E. L., *Concepts of Statistical Influence.* McGraw-Hill (1959) p. 292.

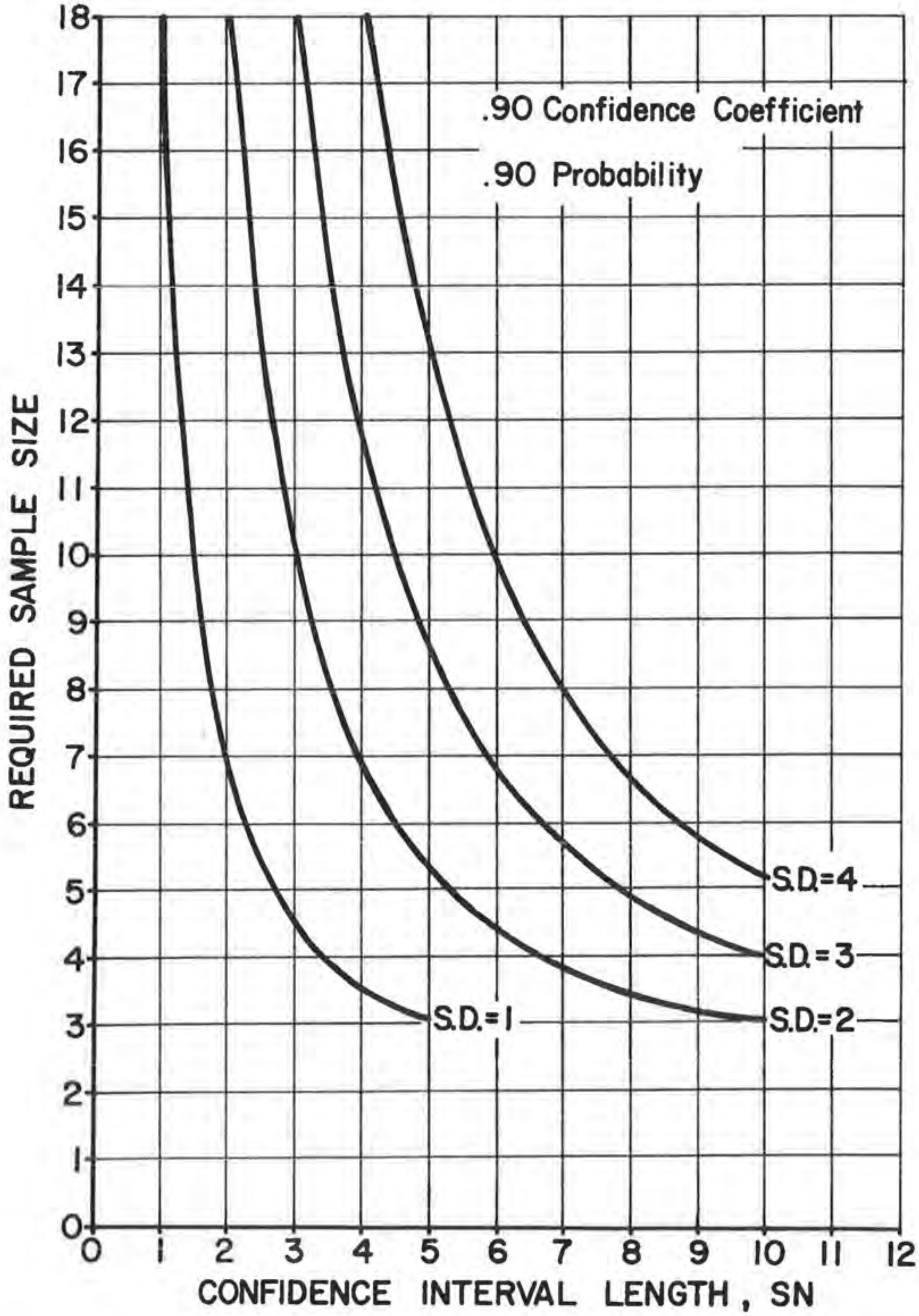

Fig. 37 Chart for Determining Sample Size Required for a Desired Accuracy, as a Function of Known Tester Standard Deviation.

creasing the required sample size by a factor of about 1.5. The use of lower probabilities would result in decreasing the sample size.

To test the effectiveness of the recommended measures, a Skid Tester Correlation Program will be held at the facilities of the Transportation and Traffic Safety Center of The Pennsylvania State University in August 1972. A number of skid testers--representative of different makes, types of suspension, and transducers--will be invited to participate. Regional representation will be considered in the selection to encourage subsequent regional cooperation in improving skid tester performance.

The results of these correlation meetings will serve as basis for formulating more specific recommendations and as guidelines for adopting standard equipment and procedures. In the interim period, skid tester owners and prospective buyers are encouraged to use the present recommendations and form a judgment on their effectiveness.