Project Summary Report 4909-S
Project 0-4909: Precision of Test Method Tex-531-C
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PROJECT SUMMARY REPORT

# PRECISION OF THE MOISTURE SUSCEPTIBILITY TEST METHOD TEX-531-C

## What We Did...

Test Method Tex-531-C is the primary method used for determining moisture damage susceptibility of hot mix in Texas. Before the results of this research project became available, there were no known precision statements for this test method. Such a precision statement is required for reliable assessment of the moisture susceptibility of the mixture. Through a 10-month research project, the precision, repeatability, and reproducibility of this test method were investigated by conducting an experiment that involved a number of laboratories.

The project began in August 1999 and was completed in June 2000. The investigation included two limestone aggregates and one gravel aggregate from TxDOT approved hot mix designs. The limestone aggregates were treated with lime, as specified in the mix design, and the gravel aggregate was treated with a liquid antistripping agent. The mixtures with limestone aggregates had PG 64-22 binders while the gravel aggregate was mixed with a PG 70-22 binder according to the design procedure. Nine laboratories participated in the round-robin testing. On the average, the single-operator standard deviation of tensile strength for dry specimens was found to be 15 psi and that for moisture-conditioned specimens to be 12 psi. The reproducibility standard deviation of the tensile-strength ratio between different laboratories was found to be 10 percent on the average. The average coefficient of variation of the tensile-strength ratio was found to be approximately 8 percent for specimens compacted in one laboratory and tested in different laboratories. The average coefficient of variation of the tensile-strength ratio was found to be approximately 12 percent for specimens both compacted and tested in different laboratories. The differences noticed in the results from different laboratories could be influenced by many factors such as variability in compaction, conditioning, and indirect tensile testing. It is important to minimize the variability in these influencing factors in order to improve the precision of the test method.

### Precision and Accuracy

The focus of this project has been the precision of Test Method Tex-531-C, given that precision is required for reliable assessments of a mixture's moisture susceptibility. In general, to have confidence in a test's results, one must have confidence that the test is both repeatable and reproducible. (The related terms are subsequently explained.) The quality of a test is determined by the accuracy and precision of its measurements. Accuracy is measured in terms of the proximity of average measured values to the true values.

Precision is measured in terms of the variability of the measured values. In other words, when a test method is applied to a large portion of a material (i.e., the test is repeated for different specimens from this large portion of the material), the results will not have the same value. A measure of the degree of agreement among test results describes the precision of the test method for that material. Greater variability among the test results is an indication of lesser precision. Various statistical measures and basic statistical principles provide a practical and convenient way to describe the precision of a testing procedure.

### Repeatability and Reproducibility

These two terms deal with the variability of test results obtained under specific laboratory conditions. The repeatability of a test within a single laboratory refers to the variability among the test results obtained by one tester within that laboratory. The tests are performed by a single operator in the shortest practical period of time with a specific set of equipment using test specimens taken at random from a single quantity of material.

The reproducibility of a test among laboratories is determined from the results achieved by multiple testers performing tests in their respective laboratories. In other words, reproducibility deals with the variability among different single test results obtained in different laboratories, each of which has applied the test method to test specimens taken at random from a single quantity of material.

Repeatability and reproducibility are not sufficient but are essential elements for a test to be considered reliable. Two other important abilities a test must exhibit to be considered reliable are the ability to distinguish between poor and good performers, and the ability to provide meaningful results. If there are problems with repeatability and reproducibility in a testing procedure, necessary steps must be taken to improve the test.

The repeatability limit is presented by value r, which is the value below which the absolute difference between two single results obtained under repeatability conditions may be expected to lie with a probability of 95 percent.

The reproducibility limit is presented by value R, defined as the value below which the absolute difference between two single measurements obtained under reproducibility conditions may be expected to lie with a probability of 95 percent.

### Experiment Design

The researchers conducted laboratory tests to determine the precision of two aspects of the test procedure:

- the repeatability of the test procedure within a laboratory
- the reproducibility of the test procedure among laboratories

For each case, a series of specimens were prepared and shipped to the testing laboratories. For the among-laboratories study, two types of specimens were prepared at the central laboratory (at The University of Texas at Austin) and sent to the other laboratories. The first set of specimens included the compacted specimens. The receiving laboratory participated in conditioning and testing these specimens. The second set of specimens consisted of aggregate batches and the asphalt binder. In this case, the receiving laboratory participated in mixing and compaction as well as in testing the specimens. For the latter case, each laboratory received two batches of aggregate weighing 7,000 grams (15.5 lb) each. These two batches were used to prepare the compacted test specimens and the loose specimens for determination of maximum theoretical specific gravity.

All of the specimen sets were tested according to Test Method Tex-531-C. This procedure requires testing both conditioned and dry specimens in the indirect tensile test. A total of 480 compacted specimens were prepared for the study. In addition, sixty batches of aggregates, each 7,000 grams (15.5 lb), were prepared and shipped to the participating laboratories along with the asphalt binders, lime, and antistripping agents. All of the selected laboratories were qualified to participate in the interlaboratory study. They all had proper laboratory facilities and testing equipment, and all had competent operators. Moreover, the participants were all familiar with the test method and they all had a reputation for performing reliable testing.

## What We Found...

The results indicated that the procedure has sufficient repeatability for all materials and reasonable reproducibility for the material treated with the liquid antistripping agent. However, for the two materials with lime treatment, some improvement is needed with respect to reproducibility, considering the variability in results obtained from different laboratories. The differences noticed in the results obtained from different laboratories could be the result of many factors, such as variability in compaction, conditioning, and indirect tensile testing. It is important to minimize the variability in these influencing factors in order to improve the precision of the test method. Better control of treatment with lime and liquid antistripping agents will also probably improve reproducibility of results. The following specific conclusions are drawn based on the results of the research:

The values for repeatability standard deviation ($\underline{S}_r$) were 0.06, 0.07, and 0.05 for the three materials tested in this study, respectively (i.e., for B, C, and W.) The corresponding repeatability coefficients of variation were 7, 9, and 6 percent, respectively. The repeatability limits were 0.16, 0.20, and 0.14.

The reproducibility criteria were determined for two types of specimens:

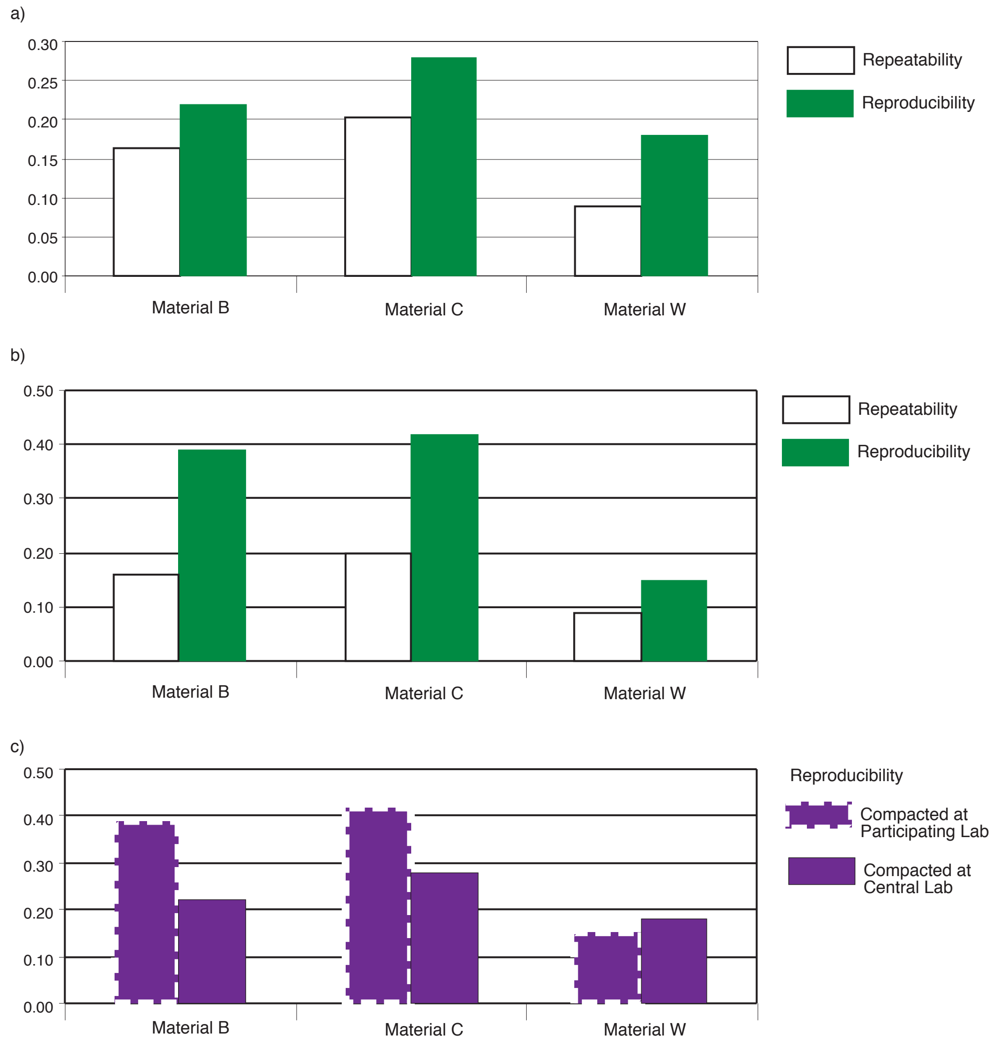
- Group I: specimens compacted and tested at the participating laboratories
- Group II: specimens compacted at the central laboratory and tested at the participating laboratories

For group I, the values for the reproducibility coefficients of variation for the three materials were 18, 14, and 5 percent, respectively. The values for reproducibility standard deviation ($\underline{S}_R$) were 0.13, 0.12, and 0.06, and the 95 percent reproducibility limits were 0.37, 0.33, and 0.17.

For group II, the values for the reproducibility coefficient of variation for the three materials were 7, 9, and 6 percent, respectively. The values for reproducibility standard deviation ($\underline{S}_R$) were 0.08, 0.10, and 0.07, and the 95 percent reproducibility limits were 0.22, 0.28, and 0.20.

The repeatability standard deviation $\underline{S}_r$ and repeatability standard deviation $\underline{S}_R$ are indicative of slight variability for all materials, implying that within a single laboratory results are comparable for multiple tests of the same material.

There is higher variability in results for the materials that have been both compacted and tested in the participating laboratories, compared to those materials that have been compacted at the central laboratory and tested at the participating laboratory.




Summary of Limits for Repeatability and Reproducibility

a) All specimens compacted at the central laboratory

b) Specimens compacted at the participating laboratories

c) Comparison of reproducibility limits

*Figure One: Summary of limits for repeatability r and reproducibility R*

## The Researchers Recommend...

The reproducibility standard deviation $S_R$ is always greater than the repeatability standard deviation $S_r$; therefore, the reproducibility limit R is always greater than the repeatability limit r. However, the results for $S_R$ and R for materials B and C from the case in which these materials were compacted in the participating laboratories are somewhat larger than expected. One can reduce $S_R$ and R by minimizing the differences among different laboratories because the test is sufficiently repeatable. Efforts should be made to ensure that the laboratories use comparable equipment and practices. The variability in results obtained from different laboratories could be a consequence of many factors, including differences in mixing and compaction, conditioning, and testing. The test procedure should be improved through better control of influencing factors to reduce this variability.

### Implementation

The results assist TxDOT in regard to evaluating the test procedure and the steps needed to improve reliability of the procedure. The procedure must be improved in order to increase the reproducibility of the method. Improved precision will make engineers' assessments of material quality with regard to moisture susceptibility more reliable. The researchers recommend that TxDOT investigate the possibility of providing training to personnel to ensure that the testing procedure is followed as uniformly and as closely as possible among different laboratories.

## For More Details...

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TxDOT Project Director: Maghsoud Tahmoressi, P.E.

The research is documented in the following reports:

4909-1 *Precision of the Moisture Susceptibility Test Method TEX-531-C: Research Report* May 2002

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3126, email: ctrlib@uts.cc.utexas.edu

## TxDOT Implementation Status
## December 2003

The recommendations of this study have been implemented in TxDOT. As a result of them, TxDOT has decided to discontinue the use of the Tex-531-C for determining moisture damage susceptibility of hot mix in Texas.

For more information contact: Dr. German Claros, P.E., Research and Technology Implementation Office, (512) 465-7403, gclaros@dot.state.tx.us

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