

RESILIENT MODULUS TESTING FOR PAVEMENT COMPONENTS

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Editors: Gary N. Durham
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*Gary N. Durham, W. Allen Marr, and
Willard L. DeGroff, editors*

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Foreword

The Symposium on Resilient Modulus Testing for Pavement Components was held in Salt Lake City, Utah on 27–28 June 2002. ASTM International Committee D18 on Soil and Rock and Subcommittee D18.09 on Cyclic and Dynamic Properties of Soils served as sponsors. Symposium chairmen and co-editors of this publication were Gary N. Durham, Durham Ge-Enterprises, Stone Mountain, Georgia; W. Allen Marr, Geocomp Incorporated, Boxborough, Massachusetts; and Willard L. DeGroff, Fugro South, Houston, Texas.

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Overview

Resilient Modulus indicates the stiffness of a soil under controlled confinement conditions and repeated loading. The test is intended to simulate the stress conditions that occur in the base and subgrade of a pavement system. Resilient Modulus has been adopted by the U.S. Federal Highway Administration as the primary performance parameter for pavement design.

The current standards for resilient modulus testing (AASHTO T292-00 and T307-99 for soils and ASTM D 4123 for asphalt) do not yield consistent and reproducible results. Differences in test equipment, instrumentation, sample preparation, end conditions of the specimens, and data processing apparently have considerable effects on the value of resilient modulus obtained from the test. These problems have been the topic of many papers over the past thirty years; however, a consensus has not developed on how to improve the testing standard to overcome them. These conditions prompted ASTM Subcommittee D18 to organize and hold a symposium to examine the benefits and problems with resilient modulus testing. The symposium was held June 27–28, 2002 in Salt Lake City, Utah. It consisted of presentations of their findings by each author, followed by question and answer sessions. The symposium concluded with a roundtable discussion of the current status of the resilient modulus test and ways in which the test can be improved. This ASTM Special Technical Publication presents the papers prepared for that symposium. We were fortunate to receive good quality papers covering a variety of topics from test equipment to use of the results in design.

On the test method, Groeger, Rada, Schmalzer, and Lopez discuss the differences between AASHTO T307-99 and Long Term Pavement Performance Protocol P46 and the reasons for those differences. They recommend ways to improve the T307-99 standard. Boudreau examines the repeatability of the test by testing replicated test specimens under the same conditions. He obtained values with a coefficient of variation of resilient modulus less than 5 % under these very controlled conditions. Groeger, Rada, and Lopez discuss the background of test startup and quality control procedures developed in the FHWA LTPP Protocol P46 to obtain repeatable, reliable, high quality resilient modulus data. Tanyu, Kim, Edil, and Benson compared laboratory tests to measure resilient modulus by AASHTO T294 with large-scale tests in a pit. They measured laboratory values up to ten times higher than the field values and they attribute the differences to disparities in sample size, strain amplitudes, and boundary conditions between the two test types. Rada, Groeger, Schmalzer, and Lopez review the LTPP test program and summarize what has been learned from the last 14 years of the program with regard to test protocol, laboratory startup, and quality control procedures.

Considering the test equipment, Bejarano, Heath, and Harvey describe the use of off-the-shelf components to build a PID controller for a servo-hydraulic system to perform the resilient modulus test. Boudreau and Wang demonstrate how many details of the test cell can affect the measurement of resilient modulus. Marr, Hankour, and Werden describe a fully automated computer controlled testing system for performing Resilient Modulus tests. They use a PID adaptive controller to improve the quality of the test and reduce the labor required to run the test. They also discuss some of the difficulties and technical details for running a Resilient Modulus test according to current test specifications.

Test results are considered by Li and Qubain who show the effect of water content of the soil specimens on resilient modulus for three subgrade soils. Butalia, Huang, Kim, and Croft examine the effect of water content and pore water pressure buildup on the resilient modulus

of unsaturated and saturated cohesive soils. Bandara and Rowe develop resilient modulus relationships for typical subgrade soils used in Florida for use in design. Trindale, Carvalho, Silva, de Lima, and Barbosa examine empirical relationships among CBR, unconfined compressive strength, Young's modulus, and resilient modulus for soils and soil-cement mixtures. Titi, Herath, and Mohammad investigate the use of miniature cone penetration tests to get a correlation with resilient modulus for cohesive soils and describe a method to use the cone penetration results on road rehabilitation projects in Louisiana. Iasbik, de Lima, Carvalho, Silva, Minette, and Barbosa examine the effect of polypropylene fibers on resilient modulus of two soils. Konrad and Robert describe the results of a comprehensive laboratory investigation into the resilient modulus properties of unbound aggregate used in base courses.

The importance of resilient modulus in design is addressed by Nazarian, Abdallah, Meshkani, and Ke, who demonstrate with different pavement design models the importance of the value of resilient modulus on required pavement thickness and show its importance in obtaining a reliable measurement of resilient modulus for mechanistic pavement design. Nazarian, Yan, and Williams examine different pavement analysis algorithms and material models to show the effect of resilient modulus on mechanistic pavement design. They show that inaccuracies in the analysis algorithms and in the testing procedures have an important effect on the design. Boudreau proposes a constitutive model and iterative layered elastic methodology to interpret laboratory test results for resilient modulus as used in the AASHTO Design Guide for Pavement Structures.

The closing panel discussion concluded that the resilient modulus test is a valid and useful test when run properly. More work must be done to standardize the test equipment, the instrumentation, the specimen preparation procedures, and the loading requirements to improve the reproducibility and reliability among laboratories. Further work is also needed to clarify and quantify how to make the test more closely represent actual field conditions.

We thank those who prepared these papers, the reviewers who provided anonymous peer reviews, and those who participated in the symposium. We hope this STP encourages more work to improve the testing standard and the value of the Resilient Modulus test.

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