CENTER FOR TRANSPORTATION INFRASTRUCTURE SYSTEMS
THE UNIVERSITY OF TEXAS AT EL PASO

Project Summary Report 0-1735-S
Project 0-1735: Development of Structural Field Testing of Flexible Pavement Layers
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PROJECT SUMMARY REPORT

Quality Management of Flexible Pavement Layers with Seismic Methods

The primary strength parameters that affect the performance of a flexible pavement section are the moduli of different layers. Current mechanistic-empirical procedures for structural design of flexible pavements consider these parameters. However, the construction specifications are not based on these engineering parameters. To successfully implement any mechanistic pavement design procedure and to move toward performance-based specifications, it is essential to develop tools that can measure the modulus of each layer.

As shown here, the key to the success of a performance-based construction specification is to strike a balance between the level of sophistication in the design method, lab testing for material selection and field testing for quality control. Simplified lab and field tests that can be performed rapidly by field personnel are introduced.

The primary goal of this project was to provide a concept, which, in a rational manner, combines the results from laboratory and field tests with those used for quality control during construction. Simplified laboratory tests that are compatible with the field tests are suggested. All these tests have several features in common. They can be performed rapidly (less than two minutes), they are inexpensive, and their data reduction processes are simple.

Performing the simplified laboratory and field tests on pavement materials will allow districts to develop a database that can be used to smoothly unify the design procedures and construction quality control. The proposed protocol has several obvious advantages:

- This is the only technology that can measure modulus in lab and field.
- This is the only available process that can potentially provide consistent and seamless performance-based specifications
- This is a methodology that can replace QA/QC based on nuclear technology.

Figure 1 – Portable Seismic Pavement Analyzer

Figure 2 – Free-Free Resonant Column Device

What We Did …

One of the major goals of the project is to develop field tests that are compatible with laboratory results. Two lab procedures are proposed in this study.

In the ***free-free resonant column (FFRC)*** tests (see Figure 2), the specimen is placed on a pedestal. An accelerometer is securely placed on one end of the specimen, and the other end is impacted with an instrumented hammer. The signal from the accelerometer are used to determine Young's modulus of a specimen.

The ***ultrasonic lab device*** (see Figure 2) is useful for testing AC specimens. A transmitting and a receiving transducer are securely placed on the opposite faces of the specimen. The internal clock of the device automatically displays a traveltime that can be converted to Young's modulus.

Field tests are performed with a device called the Portable Seismic Pavement Analyzer (PSPA, see Figure 1). The PSPA consists of two transducers and a source packaged into a hand-portable system. The device is operable from a computer. As a part of this project, the PSPA hardware and software were modified so that it can function on the base and prepared subgrade materials. Some users refer to the new system as DSPA ("Dirt" SPA). The source and receivers are adjustable so that the system can be easily optimized for different layer thickness.

The advantages of the PSPA and DSPA, aside from its automated nature, are several. They directly measure modulus without any need for backcalculation. The measurements are layer specific, and the results are not impacted by the properties of the underlying layer. The measured moduli are similar to those measured in the lab under the same compaction and environmental conditions.

Based on these tests, we have also put together a five-step protocol.

Step 1: Selecting Most Suitable Material. The traditional parameters related to constructability and durability such as the angularity and hardness of aggregates and percent allowable fines, should still be considered to select the material.

Step 2: Selecting Most Suitable Modulus. The modulus has to be related to one of the primary construction parameters. For base materials the modulus can be related to moisture content and for ACP, to the compaction effort (i.e. air void content). The same specimens used to develop moisture density curve can be used for determining the moisture-modulus curve. For the AC materials, after the job mix formula is deter-

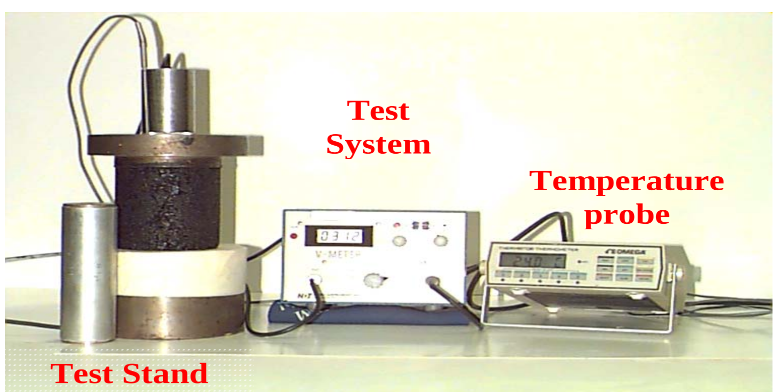

Figure 3 – Ultrasonic Lab Device

mined, several specimens with higher and lower than the design air void content can be prepared and tested. *Step 3: Simulating Seasonal Variation in Modulus.* One of the major input parameters in many pavement design procedures for base and subgrade materials is the seasonal variation in moisture and for the ACP the variation in modulus with temperature. Means of quantifying the variation in modulus with the seasonal parameters are provided in this protocol. *Step 4: Determining Desirable Modulus of Material.* Based on the results from Steps 2 and 3, a decision on the desirable modulus for the selected water content (for base and subgrade) and air void (for AC layer) is made. Such seismic moduli should be translated to a design modulus. This step is necessary because seismic moduli are linear elastic moduli. A software package named *Seismic Modulus Analysis and Reduction Tool (SMART)* has been developed for this purpose. Design modulus is dependent on the thickness of the structure and the nonlinear behavior of each layer. For the AC layer, the most desirable way of calculating the design modulus is to develop the master curve based on the recommendations of AASHTO 2002 Design Guide. *Step 5: Field Quality Control.* Field quality control is then carried out using the portable devices at regular intervals or at any point that the construction inspector suspects segregation, lack or excess moisture, or any other constructed related anomalies. Similar to the statistical-based acceptance criteria used for moisture-density measurements, the field moduli should be greater than the representative seismic modulus (not design modulus) determined in the previous steps.

What We Found …

The focus of the last two years of the project has been towards improving the test protocols and relating the results to field performance indicators in close collaboration with TxDOT. So far we have applied the protocol to a number of controlled distressed and intact sites. We have found that the lab tests are well suited to delineate well- and poor-performing materials. A good correlation between the seismic values and the angle of internal friction of the granular materials has been established, as shown in Figure 4. A methodology has also been developed to relate the resilient modulus to seismic modulus. The field equipment is quite repeatable and easy to use.

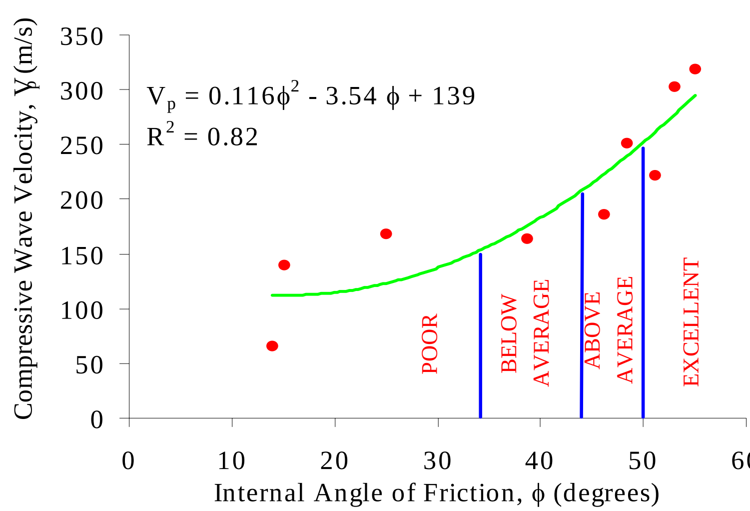

Figure 4 – Variation in Angle of Internal Friction with Wave Velocity

The Researchers Recommend …

The project is currently approved for implementation in four districts. Based on the feedback from these districts, the protocols and devices will be finalized.

For More Details…

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The research is documented in the following report:
1735-1 *Specifications for Tools Used in Structural Field Testing of Flexible Pavement Layers*
1735-2 *Quality Management of Asphalt-Concrete Using Wave Propagation Techniques*
1735-3 *Quality Management of Flexible Pavement Layers with Seismic Methods*

To obtain copies of a report: Center for Transportation Infrastructure Systems**,**
(915) 747-6925, email ctis@utep.edu**.**

TxDOT Implementation Status
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The equipment and procedures developed by this project are being implemented by IPR 5-1735. This implementation is on a pilot basis. The experience gained during the implementation project will factor into the decision of wider implementation.

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