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Portable Seismic Property Analyzer for Nondestructive Testing

Introduction. The use of nondestructive tests that are based upon wave propagation theory is increasing. As a diagnostic tool, the methods are used in detecting and locating defects within a material or at the interface of two adjacent materials. As a characterization tool, these methods typically rely on determining the modulus of different materials by measuring either the compression or shear wave velocity.

One of the advantages of wave propagation techniques is that fundamental material properties are measured. As such, similar modulus values are anticipated from field and laboratory tests as long as the material is tested under the same conditions (such as temperature for asphalt concrete, compaction and moisture content for base and subgrade materials). This unique feature of seismic methods in material characterization is of particular significance in implementing any mechanistic pavement design procedure and moving toward performance-based specifications for pavement design, construction, maintenance, and rehabilitation.

In the last ten to fifteen years, most agencies that have utilized wave propagation techniques have found them to be quite useful and, in many cases, superior to other alternatives. But, unfortunately, they have been used in limited projects. The main reasons for a lack of widespread use have been:

1. Lack of a device for rapidly conducting these tests,
2. Lack of a robust and user-friendly software for reducing the data, and
3. The need for a highly educated and skilled engineer to interpret the results.

Geomedia Research and Development (GRD) has developed portable, easy-to-use seismic nondestructive testing technology. The system aids in performing quality control during construction, allows the determination of the onset of deterioration, and helps monitor the effectiveness of maintenance treatments. This technology is deployed in the Portable Seismic Property Analyzer (PSPA), a hand-held device that focuses on pavement layer properties.

The device can be utilized on both rigid and flexible pavements. When used on rigid pavements, the PSPA can provide information with respect to the quality and thickness of concrete, the existence and/or the location of voids or delamination within concrete, and the existence of voids or the loss of support underneath the slab. For flexible pavements, the PSPA provides information about the quality of the asphaltic-concrete layer.

Description of Technology. The PSPA operates with a laptop computer (see Fig. 1). The computer is connected to the hand-carried transducer unit by a cable. Two accelerometers and a high-frequency source are deployed in the sensor unit. The receivers are connected to a data acquisition system in the electronics box. The collection and preliminary reduction of data at one point take less than 15 sec.

Three testing techniques are used in the operation of the PSPA. The records from the sensors are used in the ultrasonic surface wave method to determine the properties of the top pavement layer. For wavelengths shorter than the thickness of the upper layer, the velocity of propagation is independent of wavelength, assuming that the uppermost layer has uniform properties. As a result, an estimate of the thickness of the surface layer can be made by determining the wavelength below which the wave velocity is constant.

The PSPA also measures the velocity of high-frequency compression waves. These waves are the first to arrive at the receivers and are detected using an automated triggering algorithm. The compression wave velocity is used in calculating modulus.

In addition, the PSPA performs the impact echo tests that can potentially be used to detect the layer thickness, defects, voids, cracks and zones of deterioration.

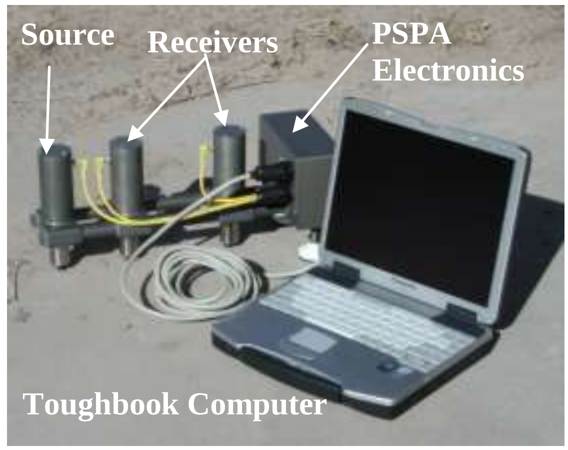

Figure 1. The PSPA System Components

Potential Uses of the PSPA. The quality control (QC) monitoring of portland cement concrete layers has historically been based on tests of poured cylinders and drilled cores. Due to differences in placement, compaction, and curing conditions, cylinders or cores may not be a good representation of the in-place properties. The PSPA can be used within hours on newly constructed pavements for QC.

With the trend by federal and state agencies to performance-based specifications and mechanistic pavement design, the need for measuring moduli of pavement layers during and after construction is rapidly growing. The QC of the asphaltic-concrete (AC) layer using the PSPA was the topic of Texas DoT Project 1735. The outcome of that study has demonstrated that the modulus of the ACP can be determined quite rapidly with the PSPA for QC purposes. Numerous studies in Texas, Canada and by the Army Corps of Engineers have shown close correlation between the seismic modulus and other concrete strength parameters such as compressive strength and modulus of rupture.

The PSPA can be configured to optimize measurements by adjusting the sensor spacing and allowing tests to be performed on top of prepared subgrade and base. Since the device allows for a layer-by-layer measurement and analysis, the quality of each layer can be individually assessed. Laboratory tests have also been developed so that a comprehensive test protocol can be implemented.

Seismic methods can be used to optimize the process of fast track construction, to determine the best time to saw cut and to decide when to open the forms. The predictive capabilities of the device have been studied and improved through extensive tests using the Texas Mobile Load Simulator.

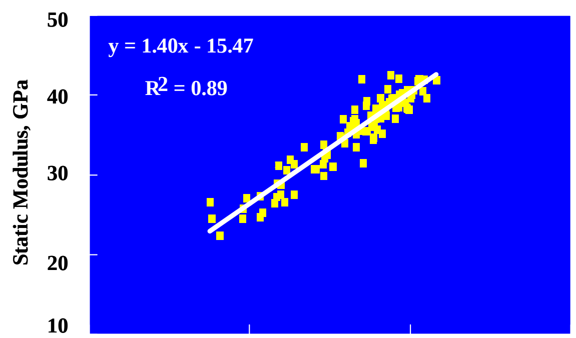

Figure 2. Correlation with Static Modulus

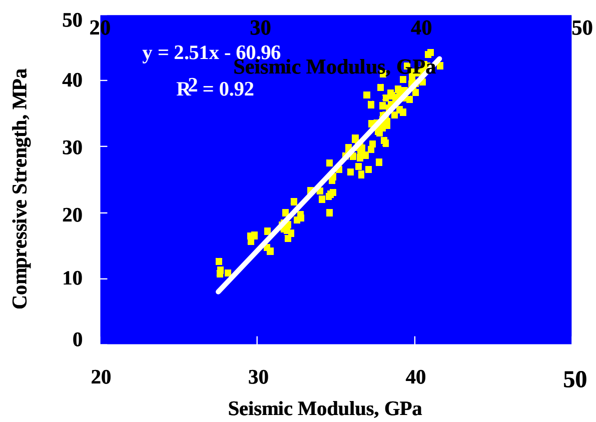

Figure 3. Correlation with Compressive Strength

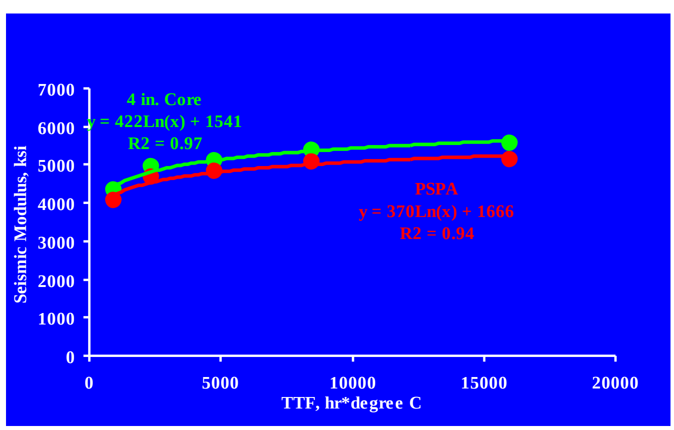

Figure 4. Correlation with Maturity from Core