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Determination of Insitu Material Properties of Asphalt Concrete Pavement Layers from Nondestructive Tests

This digest summarizes the findings from the final report on NCHRP Project 10-44A, "Determination of Insitu Material Properties of Asphalt Concrete Pavement Layers," conducted by Applied Research Associates, Inc. It was prepared by Dr. Amir N. Hanna, NCHRP Senior Program Officer, from the contractor's final report authored by Dr. Athar Saeed and Dr. Jim W. Hall, Jr., who served as principal investigator.

INTRODUCTION

This digest describes the findings of the research conducted under NCHRP Project 10-44A on the determination of insitu material properties of asphalt concrete (AC) pavement layers and presents tentative findings about the suitability of currently available nondestructive testing (NDT) methods for determining relevant material properties.

Because of the effects of temperature, moisture, and traffic on pavement materials, knowledge of the insitu material properties of pavement layers is essential for evaluating the effective structural capacity of the pavement and selecting an appropriate rehabilitation strategy. Destructive and nondestructive tests are used for field testing and evaluating pavement layers. Although many highway agencies frequently use deflection-testing techniques for pavement evaluation, experience has shown that these techniques may not provide an accurate characterization of the insitu material properties of the AC pavement layers. Therefore, there is a need to evaluate existing methods and to identify suitable methods for determining the insitu material properties of AC pavement layers commonly used in pavement evaluation (i.e., resilient modulus and thickness) to help with the selection and design of appropriate rehabilitation strategies. NCHRP Project 10-44A was conducted to address this need.

An initial phase of the research was conducted under NCHRP Project 10-44, "Nondestructive Testing to Determine Insitu Material Properties of Pavement Layers," by Brent Rauhut Engineering of Austin, Texas. This research, completed in 1997, included a review of the state of practices relevant to the use of NDT for determining insitu material properties of pavement layers and limited field testing to evaluate the operational characteristics of selected NDT methods. The review determined that deflection testing was commonly used for determining elastic layer moduli, and ground penetrating radar (GPR) was commonly used for determining layer thickness. An evaluation of NDT methods revealed that none of the available methods or devices is capable of measuring both material properties and layer thickness. For example, estimates of layer stiffness can be obtained from falling weight deflectometer (FWD) tests, and estimates of thickness can be obtained from GPR measurements. However, estimates of thickness cannot be obtained from FWD tests, and estimates of layer stiffness or strength cannot be obtained from GPR measurements.

A second phase of research was conducted under NCHRP Project 10-44A, "Determination of Insitu Material Properties of Asphalt Concrete Pavement Layers," by Applied Research Associates, Inc. Completed in October 2001, the research included an evaluation of field test methods used to (1) measure the insitu resilient modulus and thickness of the AC layers used in flexible pavements and resurfacing of rigid pavements and (2) identify methods that are well suited for this purpose. This digest provides a summary of the work performed in this research. The materials in this digest are extracted from the project's final report.

FINDINGS

The research focused on evaluating NDT methods used for measuring the insitu resilient modulus and thickness of AC layers. The research also included limited field and laboratory tests to compare the results obtained using selected devices to the results obtained in the laboratory from tests conducted on core samples.

Evaluation of NDT Devices

NDT devices evaluated in the project included FWD, seismic pavement analyzer (SPA), GPR, and dynamic cone penetrometer (DCP). FWD can be used to provide estimates of AC modulus values, and GPR and DCP can be used to provide estimates of AC thickness. However, SPA can be used to provide estimates of both layer stiffness and thickness. A subjective evaluation of these methods was made to identify strategies involving combinations of devices suitable for estimating both thickness and stiffness. This evaluation considered several features of these methods, including accuracy, mobility, speed of test, ease of data processing, need for skilled operators, disruption to traffic, initial cost, maintenance cost, labor cost, and reliability. Using this evaluation, five strategies were identified as having potential for appropriately estimating both thickness and stiffness and were selected for evaluation in field tests. These strategies involved use of one, two, or three measuring devices, as follows:

- Strategy 1—a combination of FWD and GPR;
- Strategy 2—a combination of FWD, GRP, and DCP;
- Strategy 3—a combination of FWD and SPA;
- Strategy 4—SPA; and
- Strategy 5—a combination of SPA and GPR.

Strategy 1 provides estimates of the thickness by GPR and stiffness by FWD. Strategy 2 provides estimates of thickness by GPR and DCP and stiffness by FWD. Strategy 3 provides estimates of thickness by SPA and stiffness by FWD and SPA. Strategy 4 provides estimates of both thickness and stiffness by SPA. Strategy 5 provides estimates of thickness by SPA and GPR and estimates of stiffness by SPA.

Field evaluations were conducted at 10 test sites representing ranges of climates (hot and cold), AC thickness (thin and thick), pavement age (new and old), and pavement type (unresurfaced flexible and rigid pavement resurfaced with an AC overlay). The field evaluation included the following items:

- FWD deflection measurements,
- SPA (both full size and portable) tests,
- GPR thickness measurements, and
- DCP thickness measurements.

Also, a visual distress survey of each site was made prior to the tests, temperature of the AC layers was measured during the tests, and core samples were extracted from each test site for use in laboratory tests. Laboratory tests were conducted on 47 core samples to determine AC layer stiffness using two different procedures. Resilient modulus values were first determined using ASTM method D 4123 and then using ASTM method C 597.

Summary of Findings

Based on the results obtained from the field and laboratory tests, the following findings were made:

- FWD and GPR provide the best combination of technologies for measuring AC thickness and stiffness.
- Comparable AC modulus values are obtained from FWD and SPA measurements.
- No relationships were found between the insitu moduli determined from FWD or SPA tests and dynamic modulus determined from laboratory tests.
- Seismic technology offers some advantages over deflection-based measuring methods. Nevertheless, the SPA technology has some limitations and disadvantages, such as unsuitability for testing composite pavements, unproven equipment reliability, and need for high skills relevant to data reduction and analysis.
- GPR technology lacks the ability to differentiate between layers of AC and layers of asphalt-treated materials in thickness estimation.
- Research is needed to advance GPR technology and enable differentiation between pavement layers of similar materials.

CONCLUSIONS

State highway engineers have recognized the need to identify suitable methods for determining the insitu material properties of AC pavement layers commonly used in pavement evaluation to help with the selection and design of appropriate rehabilitation strategies. This research presented the results of field and laboratory investigations designed to address this need. However, because of the limited scope of the investigations, only preliminary findings regarding the suitability of available NDT methods for determining desired materials properties could be made. Further evaluation of these findings is needed to ensure their validity for a wide range of pavement structures and climatic conditions. Also, a research and development effort may be warranted to enhance existing technologies' ability to estimate material properties and layer thickness.

FINAL REPORT

The agency's final report, titled "Determination of In Situ Material Properties of Asphalt Concrete Pavement Layers," gives a detailed account of the project, findings, and conclusions. The report, which was distributed to NCHRP sponsors (i.e., the state departments of transportation), is available for loan on request to the National Cooperative Highway Research Program, Transportation Research Board, 500 Fifth Street, N.W., Washington, DC 20001.