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RESEARCH RESULTS DIGEST

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These **Digests** are issued in the interest of providing an early awareness of the research results emanating from projects in the NCHRP. By making these results known as they are developed, it is hoped that the potential users of the research findings will be encouraged toward their early implementation in operating practices. Persons wanting to pursue the project subject matter in greater depth may do so through contact with the Cooperative Research Programs Staff, Transportation Research Board, 2101 Constitution Ave., N.W., Washington, D.C. 20418.

Subject Areas: IIB Pavement Design, Management and Performance Responsible Senior Program Officer: Amir N. Hanna

On-Site Evaluation and Calibration Procedures for Weigh-In-Motion Systems

An NCHRP digest of the findings from the final report on NCHRP Project 3-39(2), "On-Site Evaluation and Calibration Procedures for Weigh-In-Motion Systems," conducted by Washington State University. Dr. T. Papagiannakis served as principal investigator.

INTRODUCTION

This digest presents guidance for the on-site evaluation and calibration of weigh-in-motion systems.

State highway agencies need accurate truck-weight data for use in planning, design, operations, maintenance, and management activities of both pavements and bridges. Weigh-in-motion (WIM) is the process in which the dynamic tire forces of a moving highway vehicle are measured and then used to estimate wheel, axle, and axle-group loads and gross vehicle weight. The accuracy of WIM-estimated loads is influenced by site condition, sensor reliability, and other factors.

Various WIM systems are available that collect truck data more efficiently than conventional weighing methods. A number of states are currently installing these systems and are sponsoring and conducting independent acceptance and validation procedures. However, widely accepted procedures do not exist for on-site evaluation and calibration of WIM systems. Such procedures need to be developed and validated by statistically designed field experiments so that WIM users can be confident that estimated weights will meet tolerances specified for various applications. Widely accepted procedures will also benefit manufacturers by establishing more consistent testing practices for their customers' use.

An initial phase of research was conducted under NCHRP Project 3-39, "Evaluation and Calibration Procedures for Weigh-in-Motion Systems," by Texas A&M Research Foundation. This research, completed in 1994, addressed many relevant issues but did not develop a program for on-site evaluation and calibration of WIM systems. To develop such a program, a second phase of research was conducted—and completed in 1995—under NCHRP Project 3-39(2) by Washington State University.

This digest provides a description of the work performed in the second phase of research. The material in this digest is extracted from the final report on NCHRP Project 3-39(2).

FINDINGS

As part of the project, procedures available for the evaluation and calibration of WIM systems were reviewed and the feasibility of two approaches for evaluating and calibrating these systems were examined. One approach involves a combination of test trucks and vehicle simulation models and the other uses automatic vehicle identification (AVI) equipment.

Test Truck-Vehicle Simulation Approaches

In this approach, a modified version of the vehicle simulation model, known as VESYM, that was developed in the late 1980s under a Federal Highway Administration's contract was used to estimate the dynamic axle loads exerted by test trucks at a WIM site. Three WIM systems—pressure cells, piezoelectric cables, and a bending plate—were evaluated in field experiments. Similar experiments were conducted at three sites each of which was equipped with a different WIM system. Each experiment included ten runs at each of four speeds (i.e., 50, 70, 90, and 110 km/h) by each of three truck types (i.e., 2-axle single unit, 3-axle single unit, and 5-axle semi-trailer). Pavement roughness profile was also measured at each site. The variation in WIM measurements for each speed averaged 3.8, 5.7, and 3.8 percent for the pressure cell, piezoelectric cable, and bending plate systems, respectively. This variation is an indication of the potential error of the systems in estimating the applied axle load.

The analysis performed in this project indicated that the use of simulation techniques does not provide accurate predictions of the discrete dynamic axle loads applied by test trucks on WIM sensors. However, simulation techniques provide a means for predicting the extent of errors anticipated at a WIM site due to pavement roughness. These simulations can be combined with data from either test trucks or the steering axle loads of traffic-stream, 5-axle semi-trailer trucks to calibrate WIM systems. The project's final report includes step-by-step procedures to help field personnel to implement these calibration methods.

AVI-Based Approaches

In this approach, AVI-equipped vehicles are monitored and the WIM measurements are compared to the static axle loads obtained at truck inspection sites. This approach was evaluated using the fixed AVI facilities of the Heavy Vehicle Electronic License Plate (HELP) program on Interstate 5 in Washington, Oregon, and California. WIM axle loads of individual AVI-equipped vehicles were measured during a 6-month period and were compared to the respective static loads.

The analysis performed in this project has confirmed the feasibility of evaluating and calibrating WIM systems by continuously monitoring AVI-equipped vehicles and correlating the results with data obtained from reference measurements devices at fixed AVI facilities. Also, the limited work performed in this project indicated the feasibility of using transportable AVI equipment for calibrating WIM systems.

CONCLUSIONS

The need to develop nationally recognized procedures for on-site evaluation and calibration of WIM systems has been recognized by state highway agencies and other organizations. The research performed under NCHRP Project 3-39(2) indicated that simulation techniques combined with data from test trucks or the steering axle loads of traffic-stream, 5-axle semi-trailer trucks can be used to establish WIM errors caused by pavement roughness. Further, WIM systems can be calibrated by correlating data from AVI-equipped vehicles to those obtained from reference measurement devices at fixed AVI facilities or transportable equipment.

FINAL REPORT

The agency final report, titled "On-Site Evaluation and Calibration Procedures for Weigh-In-Motion Systems," gives a detailed account of the project, findings, and conclusions, and includes the software for a modified vehicle simulation model used in the project. The report, which has been distributed to the 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, 2101 Constitution Avenue, N.W., Washington, D.C., 20418.

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