National Concrete Pavement Technology Center

CP Tech Center

Real-Time Pavement Thickness Measurement

tech transfer summary

A device that measures concrete pavement thickness in real time can eliminate the need for core sampling in quality assurance activities.

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RESEARCH PROJECT TITLE
Using Scanning Lasers for Real-Time Pavement Thickness Measurement

SPONSORS
Iowa Highway Research Board (TR-538)
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The mission of the National Concrete Pavement Technology Center is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, tech transfer, and technology implementation.

ctre Center for Transportation Research and Education

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Objectives

- Investigate and test new methods that can determine pavement thickness in real-time, including laser scanning, ultrasonic sensors, and electromagnetic eddy current sensors.
- Develop the algorithms that process real-time scanning data to create an accurate 3D pavement model that can determine pavement thickness at any point.

Problem Statement

In the quality assurance process for concrete pavement in Iowa, the current technique for measuring pavement thickness is to take core samples of the pavement every 2,000 square yards. Payment methods for concrete paving contractors typically involve averaging the lengths of the cores from the new roadway and comparing this average to the design thickness. However, core sampling is a labor-intensive process, and gathering samples at this interval may not catch all deficiencies. Moreover, due to limited budgets and reduced inspection staff, state departments of transportation (DOTs) are in need of innovative and efficient approaches to quality assurance for concrete pavements.

Technology/Technique Description

The proposed configuration of the laser scanning system consists of two 2D scanning lasers mounted to the paver, one on the front to measure subgrade profile and the other on the back to measure pavement surface profile. A computer mounted on the paver uses coordinate data and slope readings to determine paver coordinates in three dimensions, and accelerometers mounted on the lasers record vibrations to correct vibration-induced errors in the scanned profile. To determine pavement thickness, the rear pavement surface scan is overlaid with the corresponding scan of the subbase from the forward laser.

The research team captured thickness data from three paving projects using a commercially available, survey-grade scanning laser—the HDS3000 from Leica Geosystems. Three scans were taken: a subbase scan, a concrete scan between the paver and the curing cart, and a concrete scan after the curing cart. The data were then processed using Cyclone, a software tool provided by Leica Geosystems, which reduced the number of data points, filtered background noise, and measured thickness. A data processing technique called "ordinary kriging" was also used to measure pavement thickness and profile.

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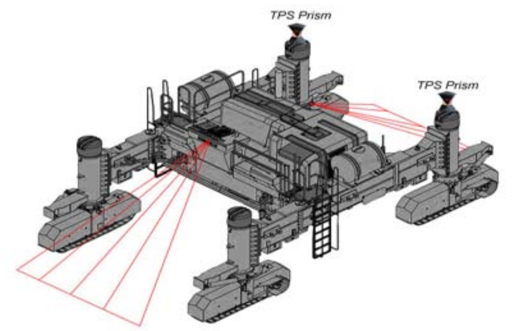
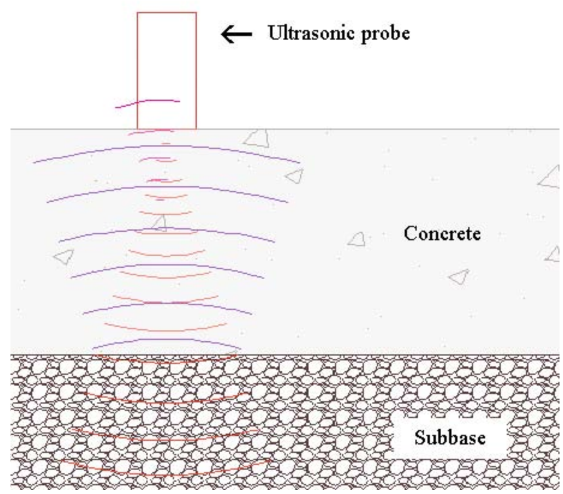
In addition to laser scanning, ultrasonic and electromagnetic eddy current sensors were tested in the laboratory for their ability to measure concrete pavement thickness. Ultrasonic scanning measures the time it takes for sound waves to penetrate through the wet concrete, reflect off the base, and return to the receiver. Pavement thickness is derived from this data. The eddy current method uses a coil with changing electrical current to detect a metal plate situated on top of the base. Because the concrete pavement is invisible to the sensor, the sensor measures the distance between itself and the metal plate resting on the base layer.



Anticipated plan for the laser scanning profiler

Key Findings

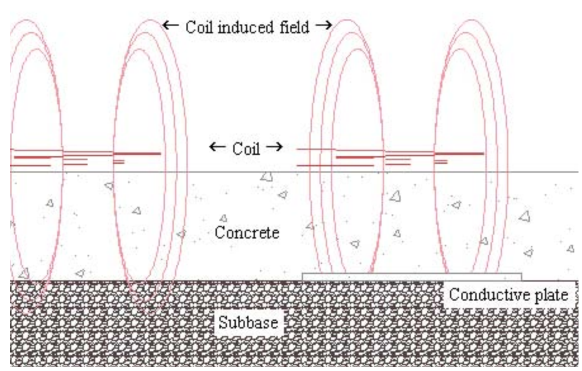
- Two approaches are viable for measuring concrete pavement thickness during the paving operation: laser scanning and electromagnetic eddy current sensors.
- Laser scanning has proved to be a reliable technique in terms of its ability to provide virtual core thickness and its low variability.
- Laser scanning involves tight coordinate control, which is possible using current technology (e.g., robotic total stations and a combination of GPS and stringline).
- The eddy current approach would likely involve placing small metal plates randomly on the base. A row of electromagnetic sensors would then be mounted on the back of the paver to measure concrete pavement thickness at any location along its width.
- Electromagnetic sensors are more economical than laser scanning and can be implemented in a handheld device or fixed behind the paver.



Using ultrasound to measure pavement thickness

Implementation Benefits

- A device that measures pavement thickness in real time will eliminate the need for state DOTs to assess thickness by taking cores.
- This device can also be considered for in-process paver control, since real-time pavement depths will be calculated. Such a real-time method may eliminate the need for the owner or contractor to measure depth during paving.
- Scanning lasers may be used to determine concrete yield quantities and perhaps smoothness.



Electromagnetic eddy current testing

Implementation Readiness

- Research is still required to develop a prototype laser scanning system that integrates data from two scanners. Coordinate control will also be required, which can use a total station approach or GPS for x-y control and the stringline for accurate elevation readings.
- The eddy current approach is closer to field implementation than the laser scanning approach. An IHRB subcommittee therefore recommended that the research team pursue the electromagnetic technique.