PUTTING RESEARCH TO WORK

BRIEF

Perpetual Pavement: Monitoring Performance in Real Time

Recent innovations in pavement design and construction in Wisconsin are leading to roads that last longer, are less costly to maintain, and involve less traffic disruption when maintenance is required. One such innovation is "perpetual pavement"—hot-mix asphalt pavement that holds the promise of a pavement life of up to 75 years, compared with the 20-year design life of a traditional HMA pavement. This is accomplished using multiple layers: a bottom layer to provide fatigue resistance, and intermediate and upper layers to resist top-down cracking and rutting caused by traffic loading.

Every 15 to 20 years, as the surface layer is distressed by traffic and weather, it can be replaced overnight without the need to reconstruct the entire pavement. This represents an enormous savings in time, money and motorist inconvenience.

What's the Problem?

Careful field testing is needed to ensure that in-service perpetual pavements are performing according to design specifications. Valuable performance data can be gathered through instrumentation: placing sensors in and around the pavement to directly monitor the live responses of pavements to traffic, construction and the environment. As the largest transportation project ever undertaken by the state of Wisconsin, the Marquette Interchange reconstruction project in Milwaukee presented an ideal opportunity for researchers to add sensors to a pavement at the time of construction, allowing them to monitor pavement performance in a heavily trafficked urban corridor.

Research Objectives

In this initial phase of the project, researchers aimed to successfully design and implement a complete sensor array in a section of HMA perpetual pavement. These sensors will collect data on traffic loads, pavement response and environmental conditions, and transmit the data wirelessly, in real time, to a data server housed at nearby Marquette University.

To enable a comprehensive mechanistic-empirical pavement appraisal, researchers also sought to document materials characteristics of the pavement section.

Methodology

Researchers selected the location for the test section, identified appropriate sensors, and designed a plan for implementing them:

- An array of piezoelectric strips in the surface of the pavement to measure vehicle loading, speed and position.
- Strain gauges beneath the bottom asphalt layer and pressure plates within the base course and subgrade to relay the response of the pavement to loading.
- Temperature and moisture probes in each HMA layer and at various depths within the subgrade.
- Sensors to record weather conditions: ambient temperature, relative humidity, wind speed, precipitation and solar exposure.
- A video camera to record real-time truck traffic in coordination with pavement monitors.

Researchers coordinated sensor installation with contractor crews so as not to disrupt the construction effort. Careful physical installation of the sensors in the pavement structure was critical: If a large number of pavement sensors had failed to survive the installation, the entire project could have been compromised. After installing the sensors, researchers set up a roadside electronic cabinet to collect the data and wirelessly transmit it to a database at Marquette.

Investigator

"As we and others analyze this stream of performance data, we'll learn to design better, longer-lived pavements, and ultimately save taxpayer dollars."

–James Crovetti
Marquette University
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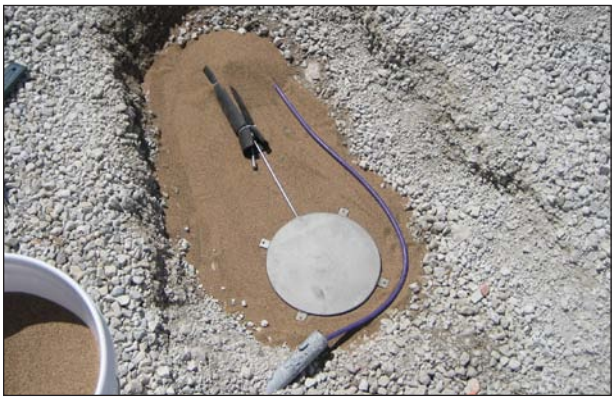

By embedding earth pressure cells like this one and asphalt strain gauges within the various layers of pavement, investigators can now monitor the stress and strain response of the pavement to traffic loads.

In addition, investigators collected numerous samples of the pavement, subgrade and base course to document the materials characteristics that are important as inputs to mechanistic-empirical design.

Results

Data collection is now under way, with information steadily accumulating in the project database. The installation of the pavement sensors was a success: immediately after paving, all but two strain sensors were working perfectly, and all of the other equipment installed is fully operational.

Implementation and Benefits

The data generated by this research will be used to estimate the fatigue life of the perpetual HMA pavement and to modify WisDOT's pavement design procedures as necessary to help ensure the most efficient use of taxpayer dollars. In particular, this instrumentation project will provide valuable insight that will help engineers adapt pavement design to local conditions.

This research will generate an exceptionally thorough set of real-world pavement performance data. By summer 2008, live and archived data will be available over the Internet to researchers around the world.

Further Research

The second phase of this project has begun: the collection, storage and analysis of 12 to 18 months of data. Investigators are devising a protocol for efficiently storing field data sets and developing automated data processing algorithms to produce meaningful summary values for mechanistic-empirical pavement analysis. Investigators will use this data to validate or refine general models used in M-E design. In addition, researchers will develop a Web site to allow other researchers to access the data.

Flexible Pavements TOC Chair

"This research project represents one of the most thorough pavement instrumentation and data collection efforts ever undertaken."

–Len Makowski
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