DEVELOPMENT OF A DEVICE FOR ANALYSIS OF PORTLAND CEMENT CONCRETE AND COMPOSITE PAVEMENTS

Pooled Fund Project

Problem Statement
June 2006

PROJECT TITLE

Development of a Device for Analysis of Portland Cement Concrete and Composite Pavements: Phase I – Feasibility Study

PROBLEM STATEMENT

Determination of the structural condition of Portland cement concrete (PCC) and composite (hot-mix asphalt plus Portland cement concrete) pavements is a difficult and cumbersome task with commercially available equipment. Most of the time the only network level measurement on these types of pavements is ride quality which is usually measured with a high-speed profilometer device. All other assessments are based on visual surveys or static devices at discrete, and relatively widely dispersed, locations and therefore may not fully represent the condition of longer lengths of pavements.

Increasingly, State Departments of Transportation and other highway owners are looking for network-level measurements of pavement structural condition to assist in planning, programming and executing repairs and renovations. With the currently available technologies, obtaining the needed measurements over a large network of highways is very costly and difficult to accomplish. Further, these static devices require lane closures causing disruption to the traveling public and exposing field personnel to dangerous working conditions.

As will be discussed more fully subsequently, the Iowa Department of Transportation will serve as the lead state for the execution of the pooled fund study described herein. The Iowa Department of Transportation, through the CP Tech Center at Iowa State University, will therefore handle all administrative duties associated with the work. The CP Tech Center will also serve as the lead research institution for the project.

PROJECT GOALS

The long-term goal of this effort is to develop a device that will measure, at highway speeds, pavement structural condition which is known to impact the performance of PCC and composite pavements. Such a system needs to be able to process the collected measurements into an immediately usable form in near real-time. It is believed that the recent improvements in computers, laser measuring devices, and similar technologies will make the development of such a system possible. The goal of the work specifically described herein is to, in fact, determine if the required technologies exist and to what extent a market exists for such a device.

BACKGROUND

Analysis of pavement distress and structural condition is a key component of all pavement management systems and provides a method to schedule rehabilitation and maintenance activities to minimize life-cycle costs for these facilities. In the analysis of existing PCC or composite pavements, the properties normally associated with structural condition include load transfer, cracking, and faulting. The current state-of-the-practice consists of obtaining cracking information by visual observation or using electronic image recognition methods. Visual observation is the most common method but it requires significant training to ensure consistency and accuracy and often subjects observers to traffic hazards. Electronic image recognition is a relatively new technology but has significant limitations. Measuring load transfer across joints is normally done using a Falling Weight Deflectometer (FWD) by loading one side of joint and reading deflection measurements from one or more sensors on each side. The method works but it is slow, requires lane closures, and exposes the FWD operators to traffic hazards. Faulting is usually measured using manual devices operated within the traffic lane – again, exposing those making the measurements to traffic hazards. In all cases, these state-of-the-practice methods require lane closures and may create traffic delays.

At the network level, it is difficult to secure enough data about structural condition to be statistically significant. Pavement conditions change frequently due to irregularities in geology, materials used, and construction techniques. As a result, management systems frequently conduct analyses with insufficient structural information or without consideration of the structural conditions of the existing pavements.

RESEARCH PLAN (PROJECT DESCRIPTION)

The proposed research project will investigate the feasibility and practicality of developing a device for measuring the structural condition of PCC and composite pavements. There are two tasks in this project:

I. Technical Feasibility Study

A detailed study will be conducted to determine the feasibility of developing a device to detect and measure, at highway speeds, pavement structural condition which is known to impact the performance of PCC and composite pavements. This task will identify typical failure mechanisms for both rigid and composite pavements, the metrics that identify those or pending failure mechanisms, current methods used to quantify pavement damage and the quality and precision of those methods, and available technology that could immediately be used or could be adapted to measure these critical pavement distresses on a network level. The study will first identify all nondestructive and high speed technologies capable of measuring the metrics associated with structural condition. Identified technologies will be evaluated based upon their likely success. One or more technologies for each metric will be further evaluated and a conceptual system design and alternatives will be developed. For the developed system any known problems and issues (e.g., patents) will be identified. In addition, a preliminary cost estimate and anticipated timeframe required to develop and build such a prototype will be made. Technologies

analyzed in this task will be evaluated on their ability to produce measurements of similar quality and precision as the stationary devices and manual methods currently in use.

To accomplish this task, the following subtasks will be completed:

Task IA – Technical Advisory Committee meeting
A Technical Advisory Committee (TAC) will be formed as described subsequently. The TAC will be initially charged with defining the following:

1. Current descriptions of the structural integrity of PCC and composite pavements as well as failure mechanisms for PCC and composite pavements.
2. The metrics that identify the structural integrity and failure mechanisms.
3. Current state-of-the-practice, including:
    a. Precision.
    b. Accuracy.
4. Other information that, if available, would be useful for network level pavement management.

Task IB – Survey of available technologies
A global search for currently available technologies that could either be immediately used or easily adapted will be conducted. This search will include a review of technical papers and commercial literature related to the metrics identified during task IA.

Task IC – Review of available technologies
The identified technologies will be reviewed for their apparent ability to meet the project requirements in terms of precision, accuracy, and speed of metric measurement. The most promising technologies will be identified for further technical evaluation.

Task ID – Detailed technology review
The most promising technologies identified in Task IC will be further reviewed. It is anticipated that this review will include a fundamental evaluation of the technology methodology and, when possible, demonstrations may be conducted.

Task IE – Conceptual system design
Based upon the results of Tasks IA through ID a conceptual system will be developed. Where possible, alternatives will be identified and costs and associated implementation timelines will be estimated.

II. Utilization Study

This task will examine the usefulness of the proposed device, compare existing devices, and determine whether a market exists for it. A market study will be conducted to determine the probability that this kind of data collection device, if developed, would be useful and desirable within the highway community. Such a market study will most likely be conducted via a survey of State departments of Transportation and other interested entities. As it is known that people often do not realize the full value of

something that does not yet exist, the research team will "pre-test" the survey and be cognizant of that potential.

TECHNICAL ADVISORY COMMITTEE

A TAC will be formed from entities participating in the project. The TAC will help formulate specific work plans and will provide guidance and oversight regarding the execution of the research. In addition, the TAC will be asked to participate formally in the process by aiding the research team in identifying typical PCC and composite pavement deterioration modes and to define the current state-of-the-practice. As such, the TAC will consist of State DOT representatives and other researchers who have studied pavement failure modes.

It is anticipated at this time that the first TAC meeting will be held on September 6, 2006, in order to facilitate expeditious execution of the research plan. Travel expenses for State DOT representatives will be covered by each State's financial participation in the project. For details, please contact Tom Cackler, CP Tech Director, 515-294-3230, tcackler@iastate.edu.

FUTURE WORK

It is anticipated that there will be subsequent phases of work following the one describe herein. Although it is difficult to anticipate exactly what additional work will be needed (will be determined based upon the results of this work), it is anticipated that future work will include: laboratory testing of measurement technologies, construction of a prototype system, field evaluation of the prototype, and development of an implementation plan.

RESEARCH FACILITIES

This project will be conducted through the National Concrete Pavement Technology Center (CP Tech Center). The Center was founded in 2000 as the Center for Portland Cement Concrete Pavement Technology (PCC Center) through the support of the Iowa Department of Transportation and the Iowa Concrete Paving Association. In 2005, the center evolved into the National Concrete Pavement Technology Center with the support of the American Concrete Pavement Association. The CP Tech Center works with partners to improve pavement design, mix and materials, construction, and maintenance to produce durable, cost-effective concrete pavements.

The CP Tech Center's main offices are located at the Center for Transportation Research and Education in the Iowa State University Research Park, roughly three miles from both the ISU campus and the Iowa DOT's headquarters in Ames, Iowa. The facility offers the following features:

- Videoconference classroom
- Large conference room accommodating 15–25 people
- Smaller conference room
- State-of-the-art computing hardware and software, including desktop publishing capabilities and a T1 connection to the university's communications backbone
- Transportation technology transfer library

- Office space for visiting and affiliate faculty

Laboratory facilities for research are available in the PCC Pavement and Materials Research Laboratory on the Iowa State University, collocated with the Department of Civil, Construction and Environmental Engineering in Town Engineering Building. The 2,500 square-foot lab is fully equipped with state-of-the-art laboratory equipment. The lab helps researchers discover practical solutions to the challenges faced by the concrete paving community and provides students with opportunities for hands-on research experience. In addition, the Center has a 44-foot-long trailer that has been custom built and fully outfitted with equipment capable of performing a comprehensive suite of tests for concrete pavement applications on a remote project site.

ESTIMATED PROJECT DURATION

The total project is expected to take 12 months to complete.

BUDGET AND SPONSORSHIP

Proposed Project Funding

The total project budget is estimated at $80,000 to $100,000. A partnership for funding this research is proposed between state DOTs and the FHWA. With additional participation it is anticipated that a further and more in depth search for and evaluation of technologies could be made.

Sponsorship Goals

State DOT(s) (1 to 5 @ $5,000 per state)	$5,000 to $25,000
Federal Highway Administration	$75,000
Total Budget	**$80,000 to $100,000**

Summary of Requirements for Project Sponsors

- Financial support
- TAC participation
- State DOTs are also asked to work with principal investigators and provide pavements for testing in subsequent work.

DELIVERABLES

The following products will be submitted as indicated:

1. Electronic quarterly reports following lead state guidelines.
2. Quarterly reports to be published via the pooled fund website.
3. Final report and tech brief that document the results of the entire study.

PROJECT ADMINISTRATION

The Iowa DOT, through the CP Tech Center at Iowa State University, will serve as the lead state and handle administrative duties for the project. Each participating entity may provide an individual to serve on the technical advisory committee that will provide direction to the project. The TAC will organize the specifics of the cooperative work tasks and oversee the accomplishment of these tasks. The CP Tech Center, under direction of the TAC, will provide administrative management and be the lead research institution on the project.

CONTACT FOR FURTHER INFORMATION

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