Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements

phase I summary

PROJECT NUMBER
Transportation Pooled Fund Study
TPF-5(066)

PUBLICATION DATE
September 2004

SPONSORS
Federal Highway Administration (FHWA)
17 state highway agencies
American Concrete Pavement Association (ACPA)
State/regional paving associations

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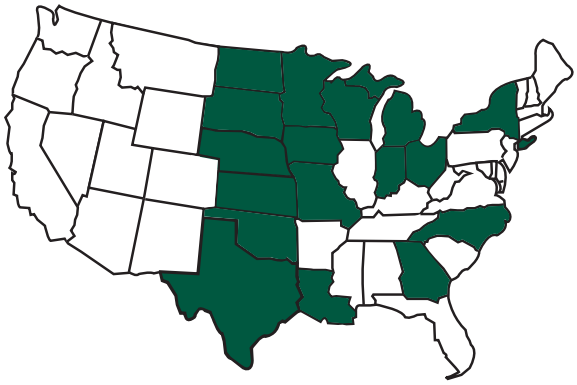
Project Objectives

- Evaluate conventional and new technologies and procedures for testing concrete and concrete materials to prevent material and construction problems that could lead to premature concrete pavement distress.
- Develop a suite of tests that provides a comprehensive method of ensuring long-term pavement performance.



Project Partnerships

Pooled Fund Sponsorship

The MCO project is a transportation pooled fund study sponsored by the FHWA, 17 state highway agencies, ACPA, and state/regional concrete paving associations.

Project Team

The Iowa Department of Transportation serves as the lead state for the project. The PCC Center at Iowa State University is responsible for the management and execution of the project. The FHWA provides significant contribution as both technical and administrative advisor.

Advisory Committees

A technical advisory committee composed of representatives from participating states, industry, and the FHWA provides direction to the project. An executive committee functions as the project's board of directors.

Problem Statement

The chemistry of today's concrete mixture designs is complicated by many variables, including multiple sources of aggregate and cements and a plethora of sometimes incompatible mineral and chemical admixtures. Adding to the complexity are construction variables such as weather, mix delivery times, finishing practices, and pavement opening schedules.

Mixture materials, mix design, and pavement construction are not isolated steps in the concrete paving process. Each affects and is affected by the other in ways that determine overall pavement quality and long-term performance.

Equipment and procedures commonly used to test concrete materials and concrete pavements have not changed in decades, leaving serious gaps in our ability to understand and control the factors that determine concrete durability. The concrete paving community needs tests that will adequately characterize the materials, predict interactions, and monitor the properties of the concrete.

Project Phases

The five-year Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements (MCO) project is divided into three major phases. Phase I (2003–2004), summarized here, compiled practical, easy-to-use testing procedures for identification and monitoring of material and concrete properties to ensure durable pavement.

Phase II (2004–2006) will demonstrate, evaluate, and refine best practices and lab and field tests proposed in the Phase I suite of tests. A field-oriented manual that includes a description of recommended tests and troubleshooting guidance will be prepared. Phase III (2006–2007) will refine and finalize lab and field tests based on shadow project test data.

Data Collection

The MCO project research team contacted each participating state to gather information related to concrete and concrete material tests. Three types of information were gathered:

1. State Research. State research relating to concrete mix properties and PCC paving practices was gathered from the participating states and compiled into one useful document. Great effort was also made to find simple, practical research that state highway agencies conduct but that doesn't usually get reported.
2. State Practices. A detailed inventory of participating states' technologies and procedures for mix design, materials control, concrete testing, and field control was gathered. This information provided a baseline for proposed testing recommendations and helped identify practices with potential for success in other states.
3. Problem Projects. Participating states identified past projects exhibiting some form of early pavement deterioration. Details about these projects provided researchers with specific, real-world examples of problems and the opportunity to assess the causes of concrete pavement distress to ensure that the proposed testing identifies the problems.

Visits to Participating States

The project monitor visited each of the participating states between fall 2003 and summer 2004. A half-day meeting was held with each participating state's personnel involved with research, materials, and construction.

The visits served the following purposes:

- Present an overview and update of the project to the participating states.

- Solicit details on past projects exhibiting premature pavement distress.
- Collect information on current state technologies and practices for materials and construction testing.
- Gather related state research, especially unpublished research.

In addition, several state visits involved a field trip to a nearby project. The meeting and site visits provided the research team with critical information and insights into the concerns and priorities of each state.

Suite of Tests

A preliminary suite of tests to ensure long-term pavement performance was developed. The goal was to include tests that provide useful information and results that are easy to interpret, and that can be reasonably performed routinely in terms of time, expertise, training, and cost.

The tests examine concrete pavement properties in five focal areas determined to be most critical to the long life and durability of concrete pavements: (1) workability, (2) strength development, (3) air system, (4) permeability, and (5) shrinkage. For each of these areas, tests were identified as existent and adequate, existent but needing further development, or nonexistent and needing to be developed. The tests were considered for relevance at three stages in the concrete paving process: mix design, preconstruction verification, and construction quality control.

A pilot project in Iowa was used to evaluate the suite of tests in fall 2003. This served as a trial run for evaluating the tests and helped the research team refine the suite of tests to a feasible number and scope.

Shadow Projects

Under Phase II of the study, shadow construction projects are being conducted in each participating state to evaluate the preliminary suite of tests. These field projects will also demonstrate the testing technologies and procedures using local materials. As the shadow projects are conducted, the suite of tests will be further refined or enhanced.

Tests of Concrete Properties in Five Focal Areas at Three Stages

	Mix Design	Preconstruction Mix Verification	Construction Quality Control
1. Workability			
2. Strength Development			
3. Air System			
4. Permeability			
5. Shrinkage			

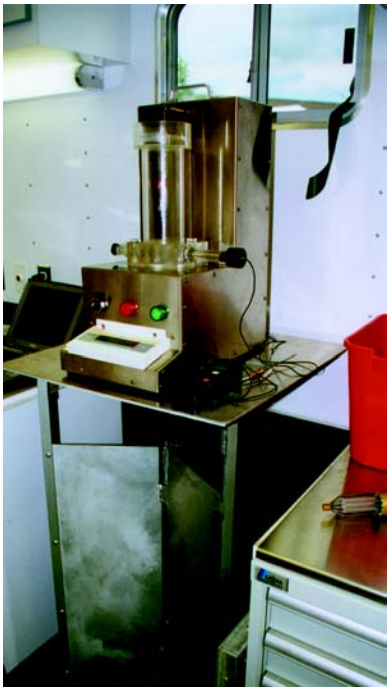
Mobile Concrete Research Lab

Mobile Concrete Research Lab

A 44-foot-long trailer was designed and equipped as a mobile concrete testing laboratory to facilitate the shadow projects. Funding for the Mobile Concrete Research Lab was provided by the American Concrete Paving Association, state/regional concrete paving associations, and Iowa State University. The MCO project is the first of many research projects that will benefit from the new facility.

The mobile lab's air void analyzer (AVA) provides an important new method of measuring the volume, size, and distribution of air voids in concrete in the field. The AVA is a sensitive machine that has been considered accurate only in buildings, thus limiting its use in field control. Because vibrations, such as those caused by wind, can dramatically skew the AVA's results, the trailer was designed with a portal in the floor to accommodate the AVA. When the lab is parked, the base of the AVA rests on the ground through the hole and is surrounded by a weather shield so that it is protected but not touching the trailer.

The lab's data collection capabilities are further enhanced by the lab's weather station and global positioning system (GPS). The lab records detailed weather data and GPS coordinates from the beginning of testing at a project site until the testing is complete. This information will greatly increase the accuracy and meaningfulness and of the test data and analysis produced by the MCO project.



Air void analyzer (AVA)

Weather station

Technology Transfer

MCO project interim findings have been communicated with a variety of audiences through numerous events, publications, and the project website (www.pcccenter.iastate.edu/mco/).

In addition, the results of the project are being compiled in a user-friendly field manual. The goal of the research team is to have this manual ready for distribution in 2005.