National Concrete Pavement Technology Center

Impact of Early-Age Behaviors on Pavement Smoothness

tech transfer summary

Knowledge of how pavement temperature variations affect pavement curvature is essential for understanding the effects on joint shifting, vertical slab movement, and overall pavement smoothness.

May 2006

RESEARCH PROJECT TITLE
Impact of Curling, Warping, and Other Early-Age Behavior on Concrete Pavement Smoothness: Early, Frequent, and Detailed (EFD) Study

SPONSORS
Federal Highway Administration (Project 16)

PRINCIPAL INVESTIGATOR
Halil Ceylan
Assistant Professor of Civil, Construction, & Environmental Engineering
Iowa State University
515-294-8051
hceylan@iastate.edu

MORE INFORMATION
www.cptechcenter.org

CP Tech Center
Iowa State University
2711 South Loop Drive, Suite 4700
Ames, IA 50010-8664
515-294-3230

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.

Objectives

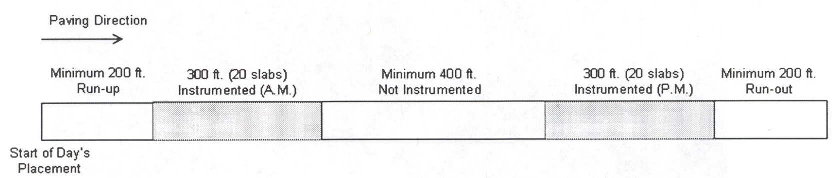
The purpose of this project is to obtain detailed information about factors affecting pavement smoothness during the critical time immediately following construction. These factors include curling, warping, and other early-age behaviors.

Problem Statement

Knowledge of the factors affecting pavement smoothness can be used to design and construct pavements in which curling, warping, and other early-age behaviors are minimized.

Research Description

During the Phase I evaluation, researchers conducted field and laboratory testing of the materials and construction process. A controlled field evaluation of three concrete pavement construction projects occurred on US 151 near Platteville, Wisconsin. Two test sections were selected to represent the entire pavement length. Both sections were on a relatively flat grade and void of horizontal curves. Extensive pavement profiling was performed during strategic times after placement.



Test section layout

- Since the collection of extensive early-age smoothness measurements are the central feature of this research, the project team completed extensive inclinometer profiling. A FACE Company Dipstick profiler was rented and used to measure pavement surface profiles in three patterns during diurnal cycles.
- Obtaining fundamental properties of the paving materials was a key component of this project and aided in the correlation between construction projects, as well as in providing a foundation for future tests on the test sections.

ctre Center for Transportation Research and Education

Iowa State University

Concrete mixture design

Component	Description	Batch weight
Portland cement	CEMEX - Type 1	395 lbs/yd3
GGBFS		
Fly ash	ISG - Type C (spec. grav. = 2.40)	170 lbs/yd3
Silica fume		
Coarse aggregate 1	Hartnett Quarry - limestone (spec. grav. = 2.607)	1,826 lbs/yd3
Coarse aggregate 2		
Fine aggregate 1	J&R Sand - natural (spec. grav. = 2.612)	1,220 lbs/yd3
Fine aggregate 2		
Water		203 lbs/yd3
Admixture 1	GRT Polychem VR - air entrainer	8.0 oz/yd3
Admixture 2	GRT Polychem 400NC - water reducer	17.0 oz/yd3
Water/cementitious materials ratio		**0.36**
Air content		**7.00%**

- Since most pavements exhibit diurnal changes in slab curvature, two test sections were instrumented to correspond to morning and afternoon construction. This diurnal testing of multiple sections provides a better understanding of the changes in slab curl that occur on a daily basis.
- The temperature gradient in the pavement slab is essential for understanding the correlation between changes in curvature and changes in the temperature gradient. Slab temperature data was logged at five-minute intervals throughout the field evaluation period.
- To aide in the characterization of slab curling and warping, it was necessary to characterize the movement of transverse and longitudinal joints. Shortly after construction, the project team attached stainless steel discs to the pavement surface to be used with DEMEC caliper measurements. Since these new concrete pavement joints had not begun to shift according to temperature changes, the project team referenced all relative joint movements to the initial reading taken at each location. To further aide in the analysis, the date, time, concrete age, and average concrete temperature were provided with each recording.
- In order to measure vertical slab movement, the project team installed linear variable distance transducers (LVDTs) at strategic locations in one slab within each test section. These measurements were used by the project team as a reference to the absolute slab movement resulting from pavement curling and warping.

Key Findings

The project team faced several issues at the first construction site:

- Time constraints and the relatively slow speed of the inclinometer profiler prevented the project team from obtaining the full range of data for the mid-afternoon diurnal period. This problem was alleviated in the Phase II instrumentation projects through rental of a faster profiler. The new profiler allowed the project team to collect profiles on all slabs within each test section for both the morning and afternoon diurnal cycles.
- In addition to the inadequacy of the profiler, the overall testing plan was too aggressive for temperature instrumentation. Since only minor variations existed between the three instrumentation locations in each test section, the project team installed temperature instrumentation at only one location per test section in the Phase II projects
- In Phase I, the project team was unable to install humidity sensors in the concrete test section due to concern that installation would affect the concrete surface and possibly the edge slump on the fresh concrete. However, the project team successfully installed humidity sensors in the Phase II construction projects.
- To facilitate additional modeling in the Phase II construction projects, the project team installed all LVDTs in adjacent slabs. The collected field data will be compared to the finite element modeling solutions in the next phase of the project. This change will help researchers understand the early age behavior of concrete pavement systems in more detail.

Implementation Benefits

By using the abundant data from this research and the mathematical models currently in development, researchers will gain a better understanding of the complex relationship between concrete pavement smoothness and concrete pavement curling, warping, and other early-age behavior.