National Concrete Pavement Technology Center

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Impacts of Internally Cured Concrete Paving on Contraction Joint Spacing

Phase II: Field Implementation of Internally Cured Concrete for Iowa Pavement Systems

tech transfer summary

This study confirmed that internally cured (IC) concrete paving appears to be a viable and beneficial technique in reducing the potential for early-age pavement cracking—improving ride and increasing the longevity of relatively thin overlays—and the equivalent annual annuity results indicated a net savings over time with the use of IC technology in concrete.

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RESEARCH PROJECT TITLE
Impacts of Internally Cured Concrete Paving on Contraction Joint Spacing, Phase II

SPONSORS
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Goal/Problem Statement

The aim of this work was to investigate the impacts of internally cured (IC) concrete paving on warping in test pavements built in Iowa.

Objectives

The primary objective of this research was to perform a full-scale field demonstration using IC technology and to investigate its performance in rural roadways.

Background

Early-age cracking and permeability can strongly influence long-term performance of concrete structures and pavements. IC technology has been presented as a potential tool to improve concrete strength, durability, and resistance to early-age cracking.

Research Description/Overview

This study involved both laboratory investigations and field implementation of internally cured concrete for Iowa pavement systems. Two overlay construction projects were identified for the field demonstration. Samples of the mixtures were taken at the time of placement and sent to the laboratory for parallel testing with laboratory prepared mixtures.

Washington County Road W-61 overlay placement

Preparation of wiring for pavement sensors (top) and sensors mounted one inch and five and a half inches above the pavement base (bottom) before overlay paving on Washington County Road W-61

The sites selected were overlays under construction at County Road (CR) W-61/Riverside Road in Washington County, Iowa, and CR W-34 in Winneshiek County, Iowa. A number of sensors were embedded in the concrete slabs to monitor moisture and temperature over time. Periodic measurements were taken throughout the year to observe the dimensional stability of the slabs.

To better understand the effect of internal curing on curling (caused by temperature gradients) and warping (caused by moisture gradients) of portland cement concrete (PCC) pavements, field investigations were performed at four different locations in Washington and Winneshiek counties.

A stationary light detection and ranging (LiDAR) device was used to scan the slab surfaces under a variety of temperature and moisture conditions. The amount of movement was calculated for the selected slabs based on the point clouds acquired using LiDAR.

A number of runs were also conducted using AASHTOWare Pavement ME with the designed pavement details for all of the sections of interest to attempt to evaluate the structural performance of the IC and CC sections.

To assess the value proposition of using internal curing in concrete overlays, life-cycle cost analyses were conducted using reported costs from the projects. Because little structural benefit is expected from the IC mixtures, the assessment was based on a predicted reduction in maintenance costs of the sections due to improved permeability determined in the laboratory tests.

Key Findings

- The internal curing was found to improve the degree of hydration over time.
- Inclusion of lightweight fine aggregate (LWFA) did not affect maturity.
- The internal curing reduced temperature and moisture differentials in the system.
- Hence, warping and curling was reduced significantly.
- Permeability of the mixture containing LWFA was found to be improved—potentially increasing the longevity of the pavements.
- Structural design modeling using AASHTOWare Pavement ME did not reflect any differences given the low traffic loadings on these particular pavements.
- An LCCA analysis indicated there is a long-term financial benefit with the technique based on the reduced frequency of rehabilitation work and the extended predicted life.
- Reports from the construction sites indicated that storing and preconditioning the LWFA would be a challenge in larger applications, but otherwise no significant changes were observed.

Site Crew Feedback

- *We chose to use 0% moisture for the LWFA for the batch mix design. This proved to work very well, and the resulting slump and batch seemed to be no different from the control concrete.*
- *Getting the pile soaked and drained as required by the research team seemed easy to do given the size of our stockpile. Soaking and draining this material for projects on a larger scale may pose a bit of a challenge. Larger stockpiles will not make too much difference, but, if material needs to be hauled in during the project because of the large quantities that are needed, it could be a problem.*
- *Plant operations went very well. There were no issues or differences with how this material is handled or batched.*
- *The finish crew did not articulate any difference.*
- *We had occasional problems with the concrete paving machines vibrating cream to the top of the concrete in front of the paver, although this was happening occasionally prior to using the IC concrete.*

Implementation Readiness and Benefits

Based on the field and laboratory results, using LWFA improved the concrete hydration for about one month after placing. The biggest challenge appears to be related to obtaining and preconditioning the LWFA.

Significantly reduced warping and curling is a benefit as ride is improved and the risk of corner breaks is reduced. Based on this observation, it is likely that slab sizes can be extended for thinner sections, thus keeping saw-cuts out of the wheelpaths.

Both the net present value (NPV) and equivalent annual annuity (EAA) calculation results indicate a net savings over time with the use of IC technology.

In summary, the technique does appear to be of benefit for reducing the potential for early-age cracking, improving ride and increasing the longevity of relatively thin overlays. Assuming that the challenges of transportation and storage can be overcome, this is a viable technique to help improve the performance of such pavements.