

# JOINT TRANSPORTATION RESEARCH PROGRAM

**Principal Investigator:** Nancy M. Whiting, Purdue University, [nwhiting@nas.edu](mailto:nwhiting@nas.edu), 202.334.2956

**Program Office:** [jtrp@purdue.edu](mailto:jtrp@purdue.edu), 765.494.6508, [www.purdue.edu/jtrp](http://www.purdue.edu/jtrp)

**Sponsor:** Indiana Department of Transportation, 765.463.1521

SPR-3506

2016

## Concrete Pavement Joint Deterioration

### Introduction

Concrete pavements are an important part of our national infrastructure. In recent years the number of reported joints deteriorating prematurely in concrete pavements around Indiana has increased. Changes over the past 45 years in INDOT specifications, pavement materials and design, construction practices, and deicing materials were examined and related to the durability of concrete at the joints of existing pavements.

Cores were retrieved and examined from the joints and mid-panel of 11 pavement sections that represented different materials, ages, construction, deicer exposure, and levels of deterioration, from non-deteriorated concrete to concrete with severe deterioration at the joints.

### Findings

Several variables were identified that influence the durability of concrete at the joints: use of fly ash, joint sealer type, saw cut configurations, water-to-cementitious ratio (w/cm), 7-day flexural strength acceptance criteria, minimum cement content, tie bar spacing and size, target percentage air, and minimum percentage air before failure.

The physical properties and chemistry of cements have changed over the years. The fineness has increased for INDOT cements as well as cements used across the country.

- The amount of  $C_3S$  has increased, while the amount of  $C_2S$  has decreased.
- Since 1954, the 1-day through 28-day strengths have all increased; the 1-day and 3-day strengths have increased the most dramatically, resulting in increased early-age rate of strength gains.
- The 7-day strength values have been the most consistent across all cements examined since 1990.
- The increase in both fineness and  $C_3S$  have con-

tributed to the dramatic increase in 1-day and 3-day strengths but also can contribute to higher amounts of CH in the concrete.

- The sulfates also have increased to counteract set problems that can occur with finer cements and more readily available aluminates.

A survey of concrete pavements across Indiana revealed that no pavements less than 40 years old from the two southern districts showed this distress, except in more recently placed patches. These districts not only experience a less harsh freeze-thaw (FT) environment but also use lower amounts of deicers. Other evidence from field and laboratory analysis of existing concrete pavements includes the following:

- The pavement base drained well at the mid-panel of most pavements but was reduced at the joints for over half the pavements, with the most severe joint deterioration associated with the slowest drainage.
- None of the concrete had a measured air void system that met all the criteria recommended for FT durable concrete, but the air void systems were better at the mid-panel than at the joints. Infilling and lining of the entrained air voids with ettringite and some Friedel's salt was more common near the joints and could account for the reduced air void system. The FT testing did not correlate directly with the air void parameters, but generally mid-panel samples did test as more durable than joints.
- The presence of unhydrated cement grains suggested that the concrete at the joint face was not always fully cured.
- One pavement section that did not have fly ash had worse deterioration than the panels nearby that had fly ash.
- Calcium hydroxide was more noticeable in the concrete from joints with severe deterioration.

In summary, this study identified that one or more of the following variables likely influenced the durability of the concrete at the joints examined: the drainability of the base at the joints, original air void system, reduced air void parameters due to lining and infilling of the air voids with secondary minerals, compromised hydration of the concrete at the joint face, increased moisture at the joint.

## Implementation

---

Steps to consider that could reduce the potential for concrete to deteriorate at the joint include the following:

- *Fly ash* or other SCM that provides additional silica as part of the cementitious mixture can help convert CH into CSH, which is especially critical if the cement has a higher  $C_3S:C_2S$  ratio—common in modern cements. Many modern cements are more susceptible to higher heats of hydration. SCMs that reduce the heat of hydration are especially valuable when concrete is placed during high ambient temperatures.
- *Sealing* of joints without a backer rod may reduce the amount of moisture held at the joint face that contributes to the concrete reaching the critical saturation level that renders it susceptible to FT damage. Treating the joint face with a silane or other penetrating waterproof sealer soon after sawing may improve the curing of the concrete at the joint face, making the concrete more durable, and may reduce the potential of the concrete to become critically saturated throughout the life of the joint.
- The *air void system* is commonly reduced in older

pavements. Adopting practices that give an excellent original air void system is valuable, encouraging spacing factors and specific surface that are much better than marginal. These parameters are critical to long-term durability of concrete exposed to a harsh FT environment and deicers. A balance between optimal air for long-term durability and meeting early strengths requirements needs to be considered.

- Ensuring the hydraulic conductivity of the base is adequate, especially at the joints, and remains good throughout the life of the pavement.

In existing pavements, steps that reduce the amount of moisture at the joint will likely reduce the potential for or rate of concrete deterioration at the joint. Practices recommended by other researchers that are applicable include removing the backer rod and sealing the joint face with a silane, siloxane, or other penetrating waterproofing sealer.

## Recommended Citation for Report

---

Whiting, N. M., Panchmatia, P., & Olek, J. (2016). *Concrete pavement joint deterioration* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2016/02). West Lafayette, IN: Purdue University. <http://dx.doi.org/10.5703/1288284316225>

View the full text of this publication here: <http://dx.doi.org/10.5703/1288284316225>

Published reports of the Joint Transportation Research Program are available at <http://docs.lib.purdue.edu/jtrp/>.

