

# JOINT TRANSPORTATION RESEARCH PROGRAM

**Principal Investigator:** William Jason Weiss, Purdue University, wjweiss@purdue.edu, 765.494-2215

**Program Office:** jtrp@purdue.edu, 765.494.6508, www.purdue.edu/jtrp

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

SPR-3200

2011

## Durability of Saw-Cut Joints in Plain Cement Concrete Pavements

### Introduction

The main objective of this study was to evaluate factors influencing the durability of the joints in portland cement concrete pavement in the state of Indiana.

The scope of the research included the evaluation of the absorption of water in concrete, the absorption of deicing solutions in concrete, the relationship between the degree of saturation and concrete deterioration, and the role of Soy Methyl Esters (SME) as a potential concrete sealant.

The aforementioned items were studied in conjunction with the observation of premature joint deterioration in concrete pavements. Previous work by the PI identified that deteriorating joints were observed to frequently have standing water and damaged joint sealant. This work was conducted to better understand the potential mechanisms responsible for joint deterioration, a series of mortars were tested that are consistent with the mortar fraction of concrete paving mixtures.

The first portion of the work examined the role of deicing salt solutions on the wetting and drying behavior of concrete elements. The second portion of the work examined the concept of the degree of fluid saturation and its relationship with freeze-thaw damage. The final portion of the work examined the potential use of penetrating concrete sealers (like soy methyl esters) to reduce water absorption and the corresponding freeze-thaw damage.

### Findings

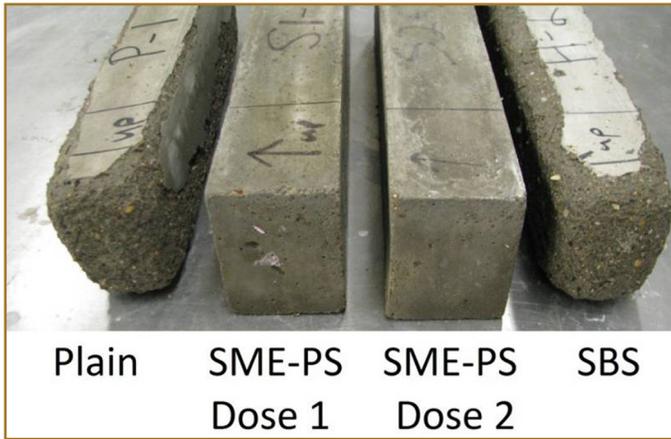
The following conclusions can be drawn:

- The rate of fluid absorption (i.e., deicing salt solutions) was related to the square root of ratio of surface tension and viscosity. Salt solutions have a slower rate of absorption than plain water.
- It was also observed that concrete previously exposed to deicing salts also exhibited an altered rate of water absorption. This implies that field concretes can exhibit altered absorption properties depending

- on previous exposure to salt solutions.
- It was observed that salts altered the equilibrium relative humidity of the solution. As such, concrete containing deicing solutions will not dry (i.e., reduce mass due to water loss) until the humidity is lower than the equilibrium relative humidity of the salt solution. This suggests that concrete in the presence of a salt solution may become preferentially saturated.
- The degree of saturation of the concrete was related to freeze-thaw damage. Specifically, mortars with different air contents were examined. Once this critical degree of saturation was reached freeze-thaw damage was inevitable. Acoustic emission measurements showed that the mortar began to deteriorate for samples where the degree of saturation exceeded 86% saturation. The damage occurred rapidly and took only a few cycles to show substantial degradation.
- The work suggests that absorption testing should be used to determine the degree of saturation which can be used to estimate the time to reach a critical degree of saturation.
- While entrained air was observed to slow the time to reach a critical degree of saturation, this critical degree of saturation could not be avoided.
- Penetrating concrete sealers (like soy methyl esters) reduce water absorption and the corresponding freeze-thaw damage. While absorption testing was able to show the benefits of sealers, differences were observed regarding the influence of sealer composition.



Photograph of field observation showing damage in pavement joints.



Freeze-Thaw samples after 280 cycles. Untreated (plain) samples and SBS treated samples show significant cover loss. SME-PS treated samples show no visual damage.

## Implementation Recommendations

The results of this investigation indicate that fluid ingress at the joints in plain jointed cement concrete pavements can lead to deterioration caused by freezing and thawing.

It is believed that the joints will contain an high salt concentration as the deicing solutions are held at the joints if they cannot drain. The results demonstrate that salt in the solution can alter the viscosity and can slow the rate of saturation. Despite a slower ingress, deicing solutions can also alter the drying rate limiting or preventing the amount of drying that can occur at the concrete joints.

Absorption tests on mortar without air entrainment reached a critical degree of saturation after only 4 to 5 months; however air entrained systems reached a critical degree of saturation after approximately 6 years. Soy Methyl Ester – Polystyrene blends (SME-PS) alter the rate of fluid absorption and reduce the potential for freeze-thaw damage.

It is recommended that the design of longitudinal and transverse joints in portland cement concrete pavements in Indiana be reconsidered. When considering only the durability of the concrete joint it appears that removing the conventional sealant and sealing the concrete with a penetrating sealer may extend the life of the joint. The redesign of the joint however also considers the potential for incompressible materials to enter the joint. Further the redesign of the joint requires that the subgrade is able to function properly with additional fluid that may come through the joint.

## References

Castro, J., Li, W., Pour-Ghaz, M., Tao, B., Sun, H., Weiss, W. J. *Durability of Saw-Cut Joints in Plain Cement Concrete Pavements*. Publication FHWA/IN/JTRP-2011/22. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011. DOI: 10.5703/1288284314649

View the full text of this technical report here: <http://dx.doi.org/10.5703/1288284314645>

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