

## Concrete Pavement Buckling in Wisconsin

### Research Objectives

- Investigate buckling of concrete pavements in Wisconsin roadways
- Reveal the key mechanisms for buckling in Wisconsin with forensic studies
- Identify innovative methods to mitigate buckling incidents and associated costs

### Research Benefits

- This study led to the development of a set of key recommendations to address buckling in Wisconsin
- This project's key recommendations reveal possible changes to address buckling and can be applied to reduce buckling in the future

### Principal Investigator

**Shreenath Rao, Ph.D., P.E.**  
Applied Research Associates, Inc.  
[srao@ara.com](mailto:srao@ara.com)

### Project Manager

**Myungook Kang**  
WisDOT  
[myungook.kang@dot.wi.gov](mailto:myungook.kang@dot.wi.gov)

### Background

Buckling (also known as blowup) in Portland cement concrete (PCC) pavement is a localized upward movement or shattering of concrete slabs. Buckling typically starts with the cracking of a construction joint due to shrinkage: pavement contracts during cold winter months and expands during warm summer months. Over time, incompressibles infiltrate into the joints, causing high growth rate of yearly maximum compressive stress. The probability of buckling increases due to a variety of risk factors such as those that affect pavement's neutral temperature, the magnitude of temperature and increase in moisture, and the accumulation of compressive stresses over time.

Wisconsin has had over 100 blowups each year since 2019, with the rate of buckling generally increasing over the last decade. Most blowup incidents occurred in jointed plain concrete pavement (JPCP), with a few incidents occurring in resurfaced concrete pavement and continuously reinforced concrete pavements (CRCP).



*Blowup on Hwy 14 in Rock County*

The goal of this research study was to investigate buckling of concrete pavements, reveal key mechanisms and factors that impact buckling, and identify methods to reduce the risk of buckling.

### Methodology

To conduct this research, the team:

- Performed a thorough literature review
- Interviewed personnel from other highway agencies and industry representatives about their experiences with buckling in their jurisdiction
- Reviewed standards and specifications of six highway agencies neighboring Wisconsin
- Performed a field investigation and analyzed the data of eight buckling sites and three control sites in Wisconsin

*“This project allows WisDOT to identify the main reasons for buckling incidents and mitigate future incidents with feasible solutions. WisDOT takes full advantage of these findings to enhance our concrete pavement practices by updating design specifications and maintenance guidance.”*

*– Myungook (MK) Kang, WisDOT*

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- Simulated the risk of buckling using analytical modeling

## Results

The research indicated that buckling is a phenomenon that develops over time, with many potential contributing factors and mechanisms. Key factors that contribute to Wisconsin’s higher incidence of buckling relative to other midwestern and northeastern states, and much higher incidence of buckling relative to southern and northwestern states, include hot and humid summers with rainfall; concrete pavement operations performed during winter months, leaving joints unfilled or unsealed throughout the pavement’s life; using an unbound aggregate base course beneath the concrete slab; and using salt, sand and grit to treat snowy and icy roads. Additional durability issues stem from using less durable concrete mixes in the past that contribute to moisture and salt damage of the hardened concrete, and the use of asphalt patches to repair spalling.

Significant differences between Wisconsin practices and those of neighboring agencies with fewer occurrences and a smaller probability of buckled joints involve the design of joints and drainage, and in maintenance and rehabilitation treatments and practices. Most of the agencies whose practices the research team reviewed seal or fill their JPCP transverse joints; Wisconsin’s practice since 1990 has been to use a single saw cut for the JPCP transverse joint that is left unsealed or unfilled throughout the pavement’s life. The literature suggests that leaving the transverse joint unsealed or unfilled throughout the pavement’s life results in incompressibles collecting in the joints.

## Recommendations for implementation

To reduce the occurrences of buckling in Wisconsin, the research team recommends using a single saw cut and filling transverse joints with a low-modulus sealant; reviewing and updating cold weather practices; optimizing concrete mixtures for strength and durability; using concrete with lower CTE; repairing spalled joints with concrete full- or partial-depth patches as soon as practical; providing positive drainage in areas susceptible to water; using a stabilized base course; using wider paved shoulders and vegetation beyond shoulders; experimenting with forcing joints to activate; and using pressure relief expansion joints as a last resort. WisDOT will evaluate the impact of executing one or more of these recommendations in terms of initial costs, bid prices, life cycle costs, pavement maintenance and rehabilitation costs, etc., and analyze the costs in view of the benefits, such as reduced buckling and improved pavement performance.

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This brief summarizes Project 0092-20-02,  
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