



# Performance Study of Longitudinal Cracking on Widened Pavements

PUTTING RESEARCH TO WORK

# BRIEF

The Wisconsin Department of Transportation (WisDOT) has little information on what to base the performance evaluation of widened Portland Cement Concrete (PCC) pavements. A broad perspective is needed to evaluate performance of concrete pavement width alternatives for cost effectiveness. A thorough investigation of all concrete width alternatives, including those employed in other states and in Wisconsin, as well as an analysis of their cost effectiveness and applicability for Wisconsin is needed to help guide WisDOT, and possibly other highway agencies, with a scientific understanding of the relationships between the performance and costs of concrete pavement width alternatives. Such an understanding will validate concrete pavement cross-section design, construction and maintenance practices and better predict concrete pavement performance.

## What is the problem?

Many widened PCC pavements are approaching 20 years of service life, and some are experiencing longitudinal cracking in the slabs. While the current pavement section was a success in reducing edge cracking and shoulder maintenance, it may have made the pavement more susceptible to other forms of distress. WisDOT commissioned this study to evaluate the performance of these pavements to determine if there has been an increase in longitudinal cracking in concrete pavement due to the use of wider concrete slabs (i.e., 14 feet or greater).

## Research Objective

The objectives of this research project are to:

- Evaluate and statistically compare the performance of concrete pavements with wider panels (14 feet wide or greater) to the performance of concrete pavements with standard width panels (12 to 13 feet wide).
- Determine the maximum allowable pavement width as a function of pavement thickness in order to achieve optimal concrete pavement performance.

## Methodology

The researchers conducted the following tasks to achieve the research objectives:

- A review of literature on the causes and treatment practices for longitudinal cracking in jointed plain concrete pavement (JPCP).
- An online survey of six Midwestern states (Iowa, Ohio, Michigan, Wisconsin, Illinois, and Minnesota) on panel width practices and how they impact longitudinal cracking. The information

### Investigators

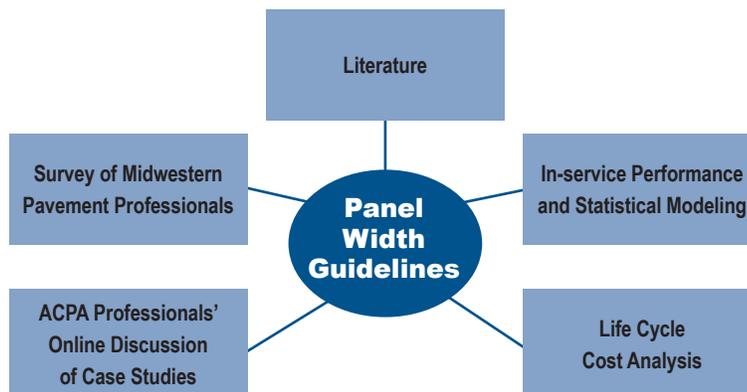


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Panel Width Guidelines Development Framework (ACPA: American Concrete Pavement Association)

sought pertained to cross-section practices including criteria for determining panel widths on rural highways, commonly used panel widths, the frequency of longitudinal cracking occurrence and probable causes of cracking from construction practice and design features.

- Data collection and statistical analysis of the in-service performance. A total of 1,008 concrete segments within the state, averaging 1.14 miles in length, were analyzed to directly determine which factors cause longitudinal cracking and to statistically compare the performance of wider concrete panels (14 and 15 feet) to standard width panels (12 and 13 feet).
- Life cycle cost analysis (LCCA) was performed to quantify the costs and benefits associated with each panel width over its life cycle.

## Results

The researchers found that:

- Approximately 60% of 1.14-mi. pavement segments in the state had longitudinal cracking. Approximately 56% of these segments with 14-ft. wide panels experienced longitudinal cracking compared to 81% of 12-ft. wide panels and 84% of 15-ft. wide panels.
- The significant factors explaining the presence or absence of longitudinal cracking included width-to-thickness ratio, joint spacing, longitudinal jointing method, tining orientation, dowel bar installation, traffic level, age and region.
- The significant factors explaining the length and/or severity of longitudinal cracking included offset of crack, pavement thickness, width-to-thickness ratio, joint spacing, transverse joint orientation (skewed or normal), rumble strips, base gradation (dense or open), dowel bar installation, Average Annual Daily Truck Traffic (AADTT), age and region.
- A majority of longitudinal cracking across all panel widths is between wheel paths or in the right wheel path compared to pavement edges.
- For 14-ft. panels, a one-inch thickness increase from 9 inches (i.e. width-to-thickness ratio,  $w/t=1.6$ ) to 10 inches ( $w/t=1.4$ ) reduced the number of cracks by 25 percent. Conversely, if the  $w/t$  ratio is raised from 1.4 to 1.6, the average cracking length within a pavement segment increases by 45% for the 14-ft. panels. If the  $w/t$  ratio is raised from 1.5 to 1.7 in 15-ft. panels, the average cracking length within a pavement segment increases by 18%.
- The 12-ft. panel has the lowest overall rehabilitation and net present worth cost per 1.14-mi. segment but the highest maintenance cost among 9-in. and 10-in. thick pavements.
- The 15-ft. panel has the largest rehabilitation cost per 1.14-mi. segment; the rehabilitation cost is approximately 1.7 times that of the 12-ft. panels and 1.1 times that of the 14-ft. panels.
- For all panel widths, a one-inch increment in thickness from 9 in. to 10 in. results in a reduction in the mean observed crack length per 1.14-mi. segment by 70-80 ft. at incremental costs ranging from approximately \$25,000 to \$28,500.

## Recommendations

Researchers developed and recommended the following guidelines for panel width practices to achieve the optimal concrete pavement performance:

- Specify a standard panel width of 14 ft. to limit cracking severity and extent.
- For the specified 14-ft. panel, a width-to-thickness ratio of 1.2 (12-in. thickness) to 1.5 (9.5-in. thickness) must accompany it to minimize cracking severity and extent.
- Better performance is expected with the 14-ft. panel when used in conjunction with a normal joint orientation, untreated aggregate base, transverse joint spacing of 15 ft. and longitudinal tining.
- Cracking can occur at various locations across the pavement including wheel paths, edges and between wheel paths. With the exception of the left edge, cracking extent at all locations in 14-ft. panels can be reduced through the use of 15-ft. transverse joint spacing in conjunction with normal joint application, PCC rumble strip installation and open graded base. However, for mid-panel cracking, the width-to-thickness ratio is another factor to consider.

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*This brief summarizes Project 0092-12-05,  
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