Strategies to Prevent Early Concrete Joint Distress

During the 1991 through 1993 construction seasons, a 15-mile section of jointed plain concrete was constructed on Interstate 90/94 near Wisconsin Dells. The section featured randomly spaced, skewed joints on slabs as long as 20 feet and a 12-inch layer of doweled portland cement concrete over a 4-inch layer of open-graded base course. In 1998 a WisDOT report on early distress at the site identified cracking in panels, especially at corners; loose chunks of concrete; and potholes where pulverized concrete was being pumped up to the surface after rainfalls.

What’s the Problem?

Expected life spans for concrete pavement are measured in decades, so serious damage after only five or six years is unusual. The types of distress that developed in this section were also unusual, particularly corner cracking, which is atypical for layers this thick. Examination of slabs removed during rehabilitation showed corroded dowels with epoxy coating worn away and delamination in the slabs at the dowel line, separating portions of the concrete into two layers.

An internal WisDOT technical group identified a number of factors that could have contributed to the pavement’s susceptibility to damage, including the use of open-graded base course, long panels and skewed joints in the pavement’s design. Clogged drains and poor concrete consolidation were also identified as potential contributors. WisDOT initiated this study to confirm the design and construction factors that likely contributed to the pavement distress.

Research Objectives and Methodology

This project pursued three primary objectives. Investigators sought to:

• Investigate distress through field observations and methods such as finite-element modeling.
• Identify maintenance or restoration activities to prevent or slow distress.
• Review WisDOT design standards and specifications and suggest changes as necessary to prevent distress.

To achieve these objectives, researchers took the following steps:

• Reviewed information provided by WisDOT, the Wisconsin Concrete Pavement Association and Marquette University, including photographs, deflection and profile data, and test results.
• In August 2006, observed rehabilitation of damaged pavement in the field and inspected removed slabs at a refuse yard.
• Employed finite-element methods to model pavement sensitivity to parameters that were considered likely contributors to distress, including slab length, joint skewness and strain gradients.
• Identified probable factors in poor pavement performance.
• Developed recommendations for maintenance and repair.
• Reviewed design standards and specifications, and recommended changes to prevent similar poor performance.

Results

Based on forensic investigation and modeling, researchers identified several factors that likely contributed to the distress. Analysis suggested that acute joint angles, curling and unstable base support led to weakness at slab corners, higher than normal deflections in the slabs, and high stress concentrations at the dowels and slab corners. Primary factors contributing to this distress included:

• Skewed joints, which increase corner stress, deflection, curling and warping effects, and dowel bearing stress during loading.
This brief summarizes Project 0092-05-05, “Analysis of Concrete Pavement Joints to Predict the Onset of Distress,” produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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