

JOINT TRANSPORTATION RESEARCH PROGRAM

Principal Investigator: Tommy Nantung, Indiana Department of Transportation, tnantung@indot.in.gov, 765.463-1521

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

Sponsor: Indiana Department of Transportation, 765.463.1521

SPR-2642

2011

High Performance Concrete Pavement in Indiana

Introduction

Until the early 1990s, curling and warping of Portland cement concrete pavement did not concern pavement engineers in many transportation agencies. Since beginning construction of the interstate system in the United States in the late 1950s through the late 1980s, the performance of Portland cement concrete pavement has been associated with properties of concrete as a pavement material. In those years developed standards and design guidelines emphasized better concrete materials and construction control. At the time, combining curling and loading stresses was quite controversial due to the nature of the load-carrying capacity of concrete pavement and the occurrence of types of loads. Arguments developed that the types of loads (traffic and curling) rarely occurred at the same time of day. The concrete pavement design principle did not include the effects of curling and warping of concrete pavement as determining design factors in pavement performance.

This research project was initiated as a response from the INDOT Pavement Steering Committee related to the joint spacing of Jointed Plain Concrete Pavement in Indiana. There was an initiative in the Committee to reduce the joint spacing from 18 feet to 15 feet as a way to reduce premature concrete pavement deterioration. There was an indication that some newly paved JPCP had transverse cracks even before the pavement section was opened to traffic.

Findings

Higher deflections in the concrete slab did not always mean higher stresses. Likewise, lower deflections in the slabs did not always mean lower stresses. Boundary con-

ditions surrounding the slabs affected the slabs behavior on curling.

In the case of transverse joints with dowel bars as thick and as closer apart (with a 1.5-inch diameter dowel bar and 12-inch spacing) compared to the concrete pavement without dowel bars, looking only to the deflections on the surface of the slab will not yield correct information about the state of stress in the slabs. Lower surface deflections in this study will mean higher stress concentrations around the jointed transverse edges of slabs. In the longitudinal joints, the slabs are tied with 0.7-inch deformed steel bars with a spacing of two feet. Therefore, the restraint from the tie bars was significantly lower than that of the dowel bars, which would account for the lack of significant differences in the deflections and tilting of the slabs in transverse directions.

The followings are more detail findings from the study:

1. The temperature profile in concrete, inch by inch, depends only on seasonal changes in temperature.
2. The diurnal changes in air temperature influence the temperature profile of a concrete slab only about half-way through the thickness of the concrete pavement. Unless there is a sudden and drastic change in temperature, the temperature difference between the middle and the bottom portion of the slab is negligible.
3. The temperature profile of concrete's responses for diurnal temperature changes is not a linear profile from bottom to top as was previously assumed. Rather, it is an exponential form with a drastic change toward the surface of the concrete pavement.
4. Drastic changes in temperature in the concrete slab occur mostly during the winter and late spring or early summer seasons. These drastic changes in temperature will determine the maximum and minimum stresses in concrete pavement.

- Built-in curling did occur as predicted by previous researchers.
- The state of stress due to temperature curling in the concrete slabs depends significantly on the boundary conditions of the edges of the slabs.
- The maximum and minimum stresses in concrete slabs occurred when there was a drastic, sudden change in the air temperature.
- Shorter joint spacing gives an advantage in reducing the stresses in concrete slabs, especially stresses in the longitudinal direction that can influence the occurrence of transverse cracks. Thinner concrete slabs in combination with shorter joint spacing will significantly reduce stresses in slabs.
- It is impractical to control built-in curling in concrete pavement by attempting to place the fresh concrete in a timely way to avoid the end of the final setting of cement hydration coinciding with the hottest temperature of the day.

- Propose to the INDOT Pavement Steering Committee that they adopt shorter joint spacing for concrete pavement in excess of 12 inches in thickness.
- Propose to the INDOT Portland Cement Concrete Pavement Technical Committee that they support reducing the amount of cement in the concrete mix in order to reduce the temperature of the concrete during the final setting of the cement hydration. However, the concrete strength should be in accordance to the 700 psi requirement in the INDOT MEPDG design.

References

Nantung, T., High Performance Concrete Pavement in Indiana. Publication FHWA/IN/JTRP-2011/20. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2011. DOI: 10.5703/1288284314644

View the full text of this technical report here:
<http://dx.doi.org/10.5703/1288284314644>

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

		Perfectly built slab at zero temperature gradient	Slab built at positive temperature gradient
Zero gradient	6:00 AM		
Curling down			
Positive gradient	12:00 PM		
Curling up			
Zero gradient	6:00 PM		
Curling up			
Negative gradient	12:00 AM		
Curling down			
Zero gradient	6:00 AM		

Built-in curling of slabs based on temperature gradient.

Implementation Recommendations

The following implementation suggestions are proposed for INDOT to be implemented in the pavement design procedures:

- Propose to the INDOT Pavement Steering Committee that they reduce the thickness of the concrete pavement as much as possible by maximizing the pavement support layers underneath the concrete pavement layer.

