Background and Problem Statement

For wide bridges, the Iowa Department of Transportation (DOT) requires the use of longitudinal joints, in part, to minimize deck cracking. Cracking can be induced by transverse contractions due to temperature change, shrinkage, and/or live loads. Longitudinal deck joints are thought to provide a relief point and reduce the amount of shrinkage that must be accommodated.

However, longitudinal joints have been known to allow chloride-contaminated water to penetrate the bridge deck; minimizing longitudinal joints may significantly lessen this problem. Moreover, there is little agreement among state DOTs regarding the maximum width for a continuous deck, which can range from 60 to 120 ft.

Objectives

The primary objective of this project was to determine the effect of bridge width on bridge deck cracking. Other factors, such as bridge skew, girder spacing and type, abutment type, pier type, and number of bridge spans, were also studied.
Research Description

Analytical techniques including finite element analysis (FEA) were used to investigate the behavior of decks with various widths under typical loadings. Experimental field testing was also conducted, principally to help validate the analytical models.

One bridge was selected for both live-load and long-term testing, Bridge #605220 near Waterloo, Iowa. The data obtained from the field tests were used to calibrate a three-dimensional (3D) finite element model (FEM). Three different types of loading—live loading, thermal loading, and shrinkage loading—were applied to the model. The predicted crack pattern from the FEM was compared to the crack pattern from the bridge inspection results.

The validated model was then extrapolated in a parametric study to various other configurations—e.g., bridge skew, girder spacing and type, abutment type, pier type, and number of bridge spans—to study the influence of those parameters on cracking.

Additionally, to model potential solutions for reducing strain in the bridge deck, three solutions were preliminarily evaluated using the calibrated FEM:

1. Placing a temperature isolation pad between the soil and back side of the abutment to prevent heat transfer from the soil to the abutment
2. Adding an expansion joint within the abutment to reduce the strain in the deck
3. Increasing the amount of reinforcement steel in the deck

Key Findings

• Longitudinal and diagonal cracking in the deck of an integral abutment bridge is due to the restraint of the abutment and the temperature differences between the abutment and the deck. Shrinkage of the deck concrete, although not likely to induce cracking, may further exacerbate cracks developed from thermal effects.
• Based on the FEM study and a limited review of bridges in the Iowa DOT inventory, it appears that, regardless of bridge width, longitudinal and diagonal cracks are prevalent in integral abutment bridges but not as prevalent in bridges with stub abutments.
• The FEM parametric study results show that bridge width and skew have minimal effect on the strain in the bridge deck resulting from restrained thermal expansion.
• Pier type, girder type, girder spacing, and number of spans appear to have no influence on the level of restrained thermal expansion strain in the deck near the abutment.
• Based on the literature review results and this research, adding more transverse reinforcement steel in the deck near the abutment will not likely be effective in reducing the strain in the deck.