Investigation of Exterior Girder Rotation during Bridge Deck Construction

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Concrete deck of steel-concrete composite bridges in Iowa often extends beyond exterior girders. A combination of loads, such as weight of wet concrete, construction live load, and the installation of rails for finishing machine, is applied over the overhang portion of the bridge deck. In addition to the typical construction loads, the finishing machine is placed on the edges of the overhang portion of the bridge deck. A combination of formwork and overhang bracket is used to distribute all the loads uniformly on exterior girders during the construction of the bridge deck. The application of multiple loads introduces torsional loads on exterior girders, which can cause excessive rotation and increased stresses in girder components. Due to the placement of finishing machine over the overhang portion, exterior girders undergo additional deflections compared to interior girders. More importantly, if the weight of finishing machine varies significantly, eccentric loading can cause twist and unequal deflection across the bridge cross section. Bridges are not commonly designed to include such effects during the design phase. A combination of unaccounted effects can lead to the thinning of the bridge deck and subsequent consequences, which can be discovered only after the completion of construction. To address this issue, a set of field investigations and numerical simulations have been carried out on three representative bridges in Iowa. Full-scale finite-element models were developed and a comparative study was performed to investigate the effects of timber blocking and temporary bracing system employed in the construction of bridges within Iowa. For modeling exterior hangers, a realistic approach, which mimics the as-built condition of hangers, was employed in the development of numerical models. A parametric study was then performed to understand the effects of parameters, such as brace strength, skew angle, diaphragm spacing, girder spacing, thickness of girder flange, and span ratio. For the instrumented bridges, results predicted by the numerical models were in a good agreement with the field investigation. For straight bridges, a bracing system that included timber blocking along with temporary bracing was found to reduce the exterior girder rotations significantly. The outcome of this study directly contributes to improving the design and construction of bridge decks, especially for the bridges with high skewness.

Keywords: Bridge Deck; Exterior Girder Rotation; Construction Practices; Field Investigation