Florida Department of Transportation Research

Phase and Widening Construction of Steel Bridges

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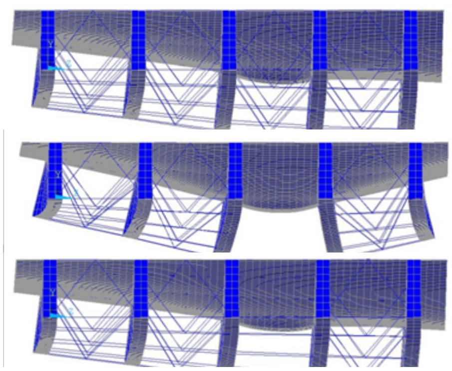
Maintaining traffic flow for bridge widening and replacement projects often requires bridges to be constructed in phases so that traffic can travel on one portion of the bridge while another portion is being constructed. The bridge portions are then connected with cross frames and deck closure pours. The adjacent deck elevations of the phases must align along the length of the bridge so the resulting driving surface is smooth, uniform and durable. Although they can perform satisfactorily, phase-constructed steel I-girder bridges have presented some challenges. Differing finish grade elevations in the closure region, which close the gaps between the phases, can occur due to camber tolerances and differences between predicted and actual dead load deflections. The misalignment can also be due to sources such as creep and shrinkage deflections because the phases are constructed independently at different times.



Deformed cross sections with and without cross frames.

The integrity of concrete and development of reinforcement in closure pours between steel I-girder construction phases can be difficult to establish. Due to the inherent flexibility of steel I-girders, the portion of the bridge carrying traffic can deflect and vibrate from live load while the closure pour concrete is going from a fluid to plastic to hardened state. Prior to the concrete having fully cured, movement can cause cracking in the closure pour and separation between the steel reinforcement and concrete, causing poor rideability, reduced service life, and unpredictable load distribution.

In this project, Florida International University researchers sought to determine the role and influence of cross-frames between construction phases on the performance of phased constructed steel I-girder bridges with cast-in-place concrete decks. Two cross-framing alternatives were investigated: 1) elimination of cross-frames between the phases, and 2) elimination of diagonal members only, leaving only horizontal struts. Two sample FDOT bridge projects were used to study the effect of the two cross-framing alternatives. Finite element models were the basis of the parametric study, aimed at examining the influence of various factors—girder spacing, deck thickness, girder depth, phase configuration (number of girders in the phases), and cross-frame spacing—on live load distribution and transverse stresses in the bridge deck. Researchers concluded that eliminating cross frames in the closure region increases live load distribution and requires significant demand increases for the girders and deck. Elimination of cross frames in a single bay of the cross section increases the strain in the deck and may reduce the service life of the bridge. Alternative closure region cross-frame concepts were presented based on the results of the parametric study. A cross frame connection concept was presented that can accommodate camber tolerances and potential differences between predicted and actual deflections.

The researchers also reviewed literature for field and laboratory investigations of traffic-induced deflection and vibration effects on casting the deck closure. Previous field studies relied on visual inspection of closure pours in some widening projects to evaluate the performance of closure pours. Previous laboratory studies attempted to simulate traffic-induced deflection and vibration on early age concrete and observe any adverse effects on reinforcement bond strength and concrete quality and performance. Based on the literature review, the researchers suggest establishing a live load deflection limit as a strategy to mitigate deflection effects for deck closures containing a standard lap splice. Other deflection and vibration mitigation strategies were also presented for phase construction closure regions.

The project findings provide a more precise understanding of cross-frame influence on the closure region of phase-constructed steel I-girder bridges. Alternative cross-frame concepts and mitigation strategies for deflection and vibration can lead to improved construction methods and longer service life of phase-constructed steel I-girder bridges.

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