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Rational Approach to Analysis and Construction of Curved Composite Box Girders in Bridges

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Abstract : Horizontally curved steel-concrete composite box girders are extensively used in highway bridges. They consist of reinforced concrete deck on top of prefabricated steel box section beam which exhibits a high torsional rigidity to resist torsional effects induced by the curved structural geometry. This type of structural system is often constructed in two stages. The composite section will take the tension mainly by the steel box and, the compression by the concrete deck. The steel girders are delivered in large pre-fabricated U-shaped sections that are designed for ease of construction. They are then erected on site and overlaid by cast-in-place reinforced concrete deck. The functionality of the composite section is not achieved until the closed section is formed by fully cured concrete. Since this kind of composite section is built in two stages, the erection of the open steel box presents some challenges to contractors. When the reinforced concrete slab is cast-in-place, special care should be taken on bracings that can prevent the open U-shaped steel box from global and local buckling. In the case of multiple steel boxes, the design detailing should pay enough attention to the installation requirement of the bracings connecting adjacent steel boxes to prevent the global buckling. The slope in transverse direction and grade in longitudinal direction will result in some local deformation of the steel boxes that affect the connection of the bracings. During the design phase, it is common for engineers to model the curved composite box girder using one-dimensional beam elements. This is adequate to analyze the global behavior, however, it is unable to capture the local deformation which affects the installation of the field bracing connection. The presence of the local deformation may become a critical component to control the construction tolerance, and overlooking this deformation will produce inadequate structural details that eventually cause misalignment in field and erection failure. This paper will briefly describe the construction issues we encountered in real structures, investigate the difference between beam element modeling and shell/solid element modeling, and their impact on the different construction stages. P-delta effect due to the slope and curvature of the composite box girder is analyzed, and the secondary deformation is compared to the first-order response and evaluated for its impact on installation of lateral bracings. The paper will discuss the rational approach to prepare construction documents and recommendations are made on the communications between engineers, erectors, and fabricators to smooth out construction process.

Keywords : buckling, curved composite box girder, stage construction, structural detailing
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