Distress Prevention during Construction Stages of a Very Sharp Horizontally Curved Bridge

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Summary

A case study of construction stage analysis using finite element method (FEM) for an overpass bridge crossing Tiwanon Intersection in Thailand is presented. The bridge is a prestressed concrete box girder consisting of 7 continuous spans of 30+2x36+45+2x36+30 meters for a total length of 249 meters. Due to the limited rights of way, the bridge was geometrically designed to form a very sharp horizontal curve. FEM with 3D spline beams and nonlinear construction stage analysis showed that, if a uni-directional construction method along the sharp curve alignment was adopted, the torsional moment transferring from the superstructure would cause overstresses in the single bored piles (1.8 meters in diameter) under each main span pier. In order to prevent overstresses in those bored piles, a bi-directional construction method incorporating both cast-in-place and precast segments was proposed Full details and the achievement of the proposed method in the construction stages of this project are illustrated herein.

Keywords: sharp horizontally curved bridge; construction stage analysis; distress prevention during construction; post-tensioning sequences.

1. Introduction

The overpass bridge crossing Tiwanon Intersection in Thailand was selected to be cast-in-situ continuous box girder with the maximum span length of 45 meters. The bridge was designed to span continuously for 7 spans with the constant superstructure depth of 2.0 meters. The substructures and foundations of the bridge were designed using Y-shape pier supported by single bored piles with diameter of 1.8 meters for the 45 meters span and 1.5 meters for the shorter spans. The sharp horizontally curved alignment of the bridge required a minimum radius of curvature of 49.5 meters as illustrated in Fig. 1.

Fig. 1: Bridge arrangement and elevation

2. Structural analysis of construction stages

The proposed directions of construction considering in the design phase were two cases: (1) uni-directional construction and (2) bi-directional construction. In the uni-directional construction, the superstructure would be constructed span by span starting from one side to the other side along the horizontally curved alignment. Due to the span-by-span cast-in-situ continuous construction, the continuity tendons would be installed over the pier to approximately L/5 of the next span. For the bi-directional construction, the superstructure would be casted in-situ span by span continuously from both sides of the bridge as shown in Fig. 2. After three spans of superstructure were completely constructed from both sides, the precast box girder would be installed at the middle of the bridge using full moment splice connection.

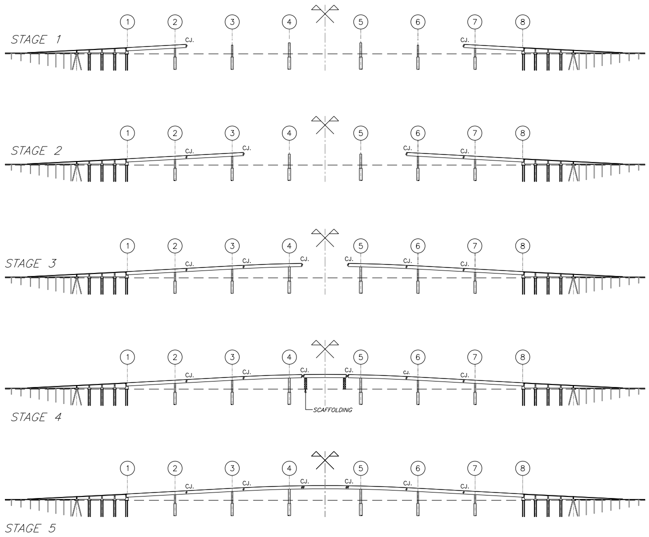

Fig. 2 Construction stages of the overpass bridge

To verify the bridge behavior, a finite element model as illustrated in Fig. 3 was created by using curved spline beam elements including the geometrical nonlinearity and time dependent effects in concrete and prestressing tendons. The time dependent material models in concrete and in prestressing strands were based on CEB-FIP Model Code (1990). The analysis of the bridge was performed in accordance with the proposed construction stages both in uni-directional and bi-directional methods.

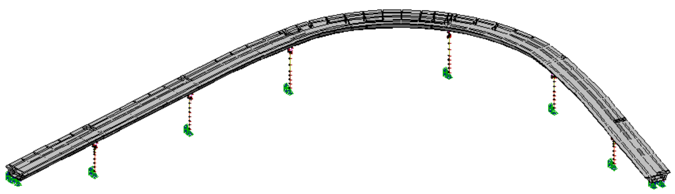

Fig. 3: Finite element model of the sharp horizontally curved box girder bridge

3. Results and conclusions

The analysis results clearly illustrated that the construction stages of any continuous bridge in a sharp horizontally curved alignment highly affected the internal forces redistribution in the superstructure and substructures. The finite element method based on bi-directional construction and the revised sequences of prestressing tendons showed the bending moment resulted from dead loads and secondary moments in bored piles reduced by 47% and 70% in piers 4 and 5 respectively when compared with the bending moments from uni-directional construction**.** By using bi-directional construction method, all the axial forces and moments resulting from all load combinations were less than the nominal capacity (Interaction Diagram) of all bored piles. Therefore, a bi-directional construction method incorporating both cast-in-place and precast segments was adopted for the construction of the overpass bridge in order to prevent distress. An example of overpass construction is shown in Fig. 4.

Figure 4 Construction of splice connection between overhang and the next internal span