New Phra Nang Klao Bridge
The Longest Prestressed Concrete Box Girder Span Bridge in Thailand

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Summary

New Phra Nang Klao Bridge is located in Nonthaburi province of Thailand and was constructed adjacent to the existing bridge. The bridge, carrying six traffic lanes crossing the Chao Phraya River, is recognized as the prestressed concrete box girder bridge with the longest main span in Thailand. The main span of 229 meters is constructed by balanced cantilever method. Due to the geometric constraint, the alignment needs to be horizontally curved toward the upstream of the existing bridge. Thus, this introduces high torsion in the box girder superstructure and transverse bending in the piers. If a symmetrical pile arrangement is adopted, the downstream piles will sustain considerably larger axial compression forces than the upstream piles. To overcome this issue, an analysis by finite element method (FEM) was performed and showed that the unsymmetrical pile arrangement, which corresponds to the torsion direction in the box girder, will result in a rather uniform axial load distribution on piles both during the construction and after the bridge was completely constructed. The unsymmetrical pile arrangement was proved to be effective and can reduce the size of foundation and the number of piles. The analysis also indicated using double-wall piers instead of single stocky column can decrease the magnitude of axial loads in the piles due to its lower flexural stiffness.

Keywords: horizontally curved bridge; balanced cantilever construction; unsymmetrical pile arrangement; uniform axial loads on piles; double-wall piers.

1. Introduction

Both approaches of the New Phra Nang Klao Bridge are diverted and elevated from the existing road and incorporates a horizontally curved alignment toward the upstream as going toward the Chao Phraya River (Fig. 1). The horizontal curve was introduced due to the limited right of way at the approach span and the existing Phra Nang Klao Bridge. The new bridge consists of a 229 meters long main span and two side spans of 130 meters long each. The bridge was founded on the groups of 2.0 meters diameter bored piles, each approximately 60 meters long. The total width of the two-cell box girder is 27.6 meters carries six traffic lanes and its depth varies from 12.5 meters at the river piers to 2.5 meters at midspan.

Fig. 1: New Phra Nang Klao Bridge crossing the Chao Phraya River

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2. Structural analysis

To analyse the behavior and response of the horizontally curved box girder during and after the construction, a finite element model as shown in Fig. 2 was created by using beam elements which incorporate both material and geometrical nonlinearity factors and time dependent effects such as creep and shrinkage in concrete and prestressing tendons. To capture all significant responses during the construction, a complete step-by-step construction stage analysis of a free cantilever standing of superstructure was performed by finite element method (FEM).

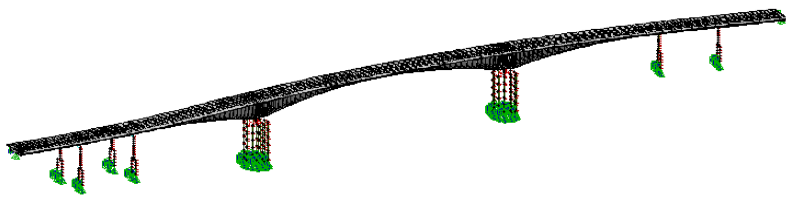

Fig. 2: Structural model of New Phra Nang Klao Bridge

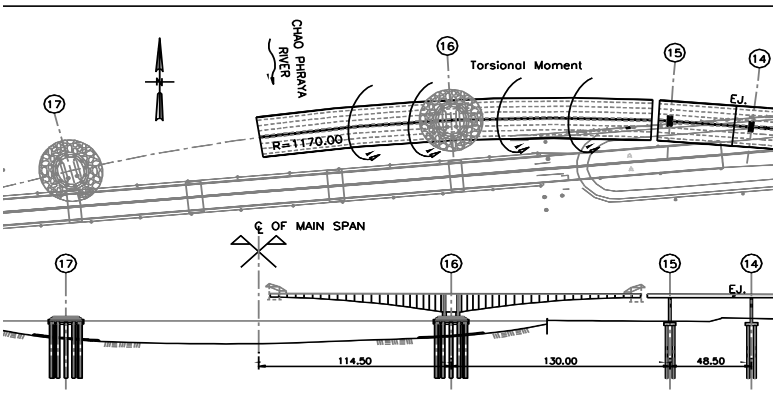

Fig. 3: Torsional moment in superstructure during construction

3. Conclusion

The curved alignment of the bridge introduces high torsion in the box girder as well as transverse bending in the piers as shown in Fig. 3. By assuming rigid foundation, the calculation indicates the downstream piles would experience larger compressive forces while the upstream piles would sustain larger uplift forces from torsion. In solving the issue, revising pile arrangement as shown in Fig. 4 was introduced. Two piles were added and positioned eccentrically relative to the pile group to accommodate the eccentric dead load due to the horizontal curve of the superstructure.

In addition, rigid connection between the superstructure and the very stiff pier would result in higher compressive forces in the piles due to its large lateral flexural stiffness. Double-wall piers, as shown in Fig. 5, were chosen for the main span substructures of New Phra Nang Klao Bridge since they can increase structural stability both for the unbalancing and torsional moments during the construction. This was because double-wall piers have longer moment arms for resisting moment than a single column. Furthermore, the double-wall piers would also induce less axial compressive forces on piles due to their less flexural stiffness.

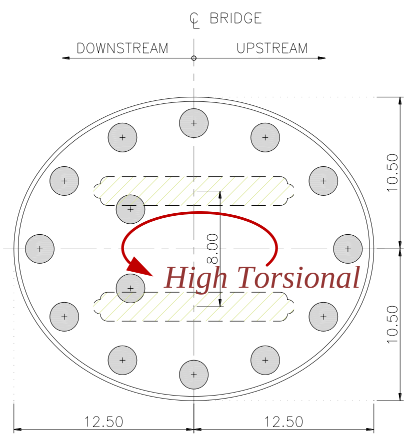

Fig. 4: Unsymmetrical pile arrangement to accommodate torsional moment

Fig. 5: Double-wall pier