The Superstructure Design of The Uchimaki Viaduct

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1. Introduction

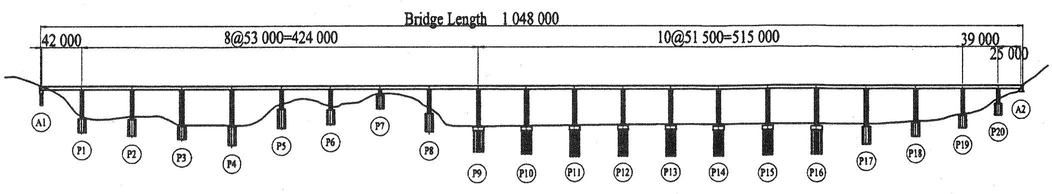
The Uchimaki Viaduct is a multiple span continuous box girder bridge that will be constructed in Shizuoka City for the New Tomei Expressway. The wing slab is supported by diagonal struts, which reduces the self weight and bottom slab width, and therefore allows the cross section of the pier columns to be reduced.

Table 1: Bridge Configuration

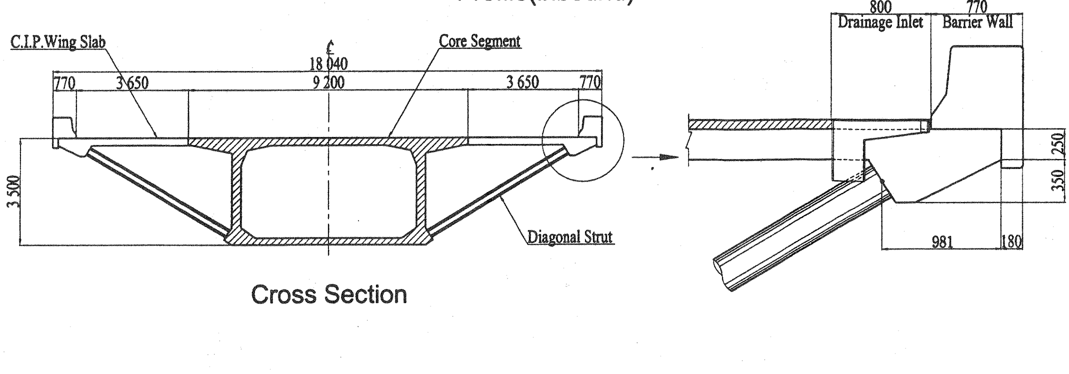
Bridge length	1,048m (inbound), 1,024m (outbound)
Width	Effective width: 16.50m Main girder width: 17.68m Total width: 18.04m
Structural type	21-span continuous prestressed concrete box girder bridge (both inbound and outbound)
Span length	42.0m+8@53.0m+10@51.5m+39.0m+25.0m (inbound) 28.0m+18@51.5m+41.0m+25.0m (outbound)
Girder type	Single cell box girder, girder height: 3.5m

Since the bridge length is over 1km in each direction, and 36 of 42 spans are standardized into approximately 50m, span-by-span erection with precast segments is applied to the superstructure. Although precast segments are utilized, central rectangular part of the girder section is fabricated as precast member (hereafter referred to as the 'core segment') which does not include the wing slab, instead of as an ordinary whole cross section, in order to obviate the need for large-scale erection facilities or casting and storage yards. The wing slab is cast-in-place with a traveling form.

This paper outlines the superstructure design of the Uchimaki Viaduct.



Profile(inbound)



Cross Section

Figure 1: General View

2. Outline of the Structure

The configuration of the Uchimaki Viaduct is shown in Table 1.

2.1 Core Segment Width

Under the following conditions, the joint between the precast core segment and the cast-in-situ wing slab is determined to be 4.6m from the centerline of the girder section.

1) In consideration of the traffic lanes, the joint should have the least possibility of direct wheel loading.

2) The bending moment under permanent load should be close to zero at the joint.

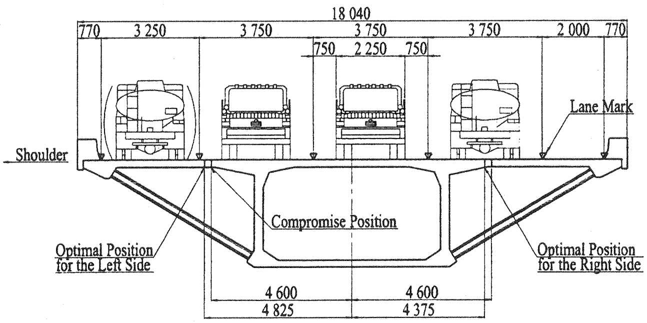


Figure 2: Traffic Lanes

Under condition 1, the optimal joint positions are 4,825mm to the left and 4,375mm to the right from the girder center line as shown in Figure 2. Based on condition 2, the bending moment of the deck slab under permanent load is very small near both the optimal joint positions obtained under condition 1. Considering the above factors, the mean value of 4,825mm and 4,375mm is taken as a compromise joint position for the two sides. Therefore, the core segment width is decided as 9,200mm.

3. Strut Layout

To decide the supporting point by the strut in the transverse direction, the relation between the supporting point and the bending moment of the deck slab is obtained through a 3-D FEM analysis (Figure 3). The result shows that positive and negative moments on the wing slab will roughly balance when the strut is placed 1.0m inward from the outer edge of the deck slab. This means that the wing slab should be supported at 1.0m inward from the outer edge of the deck slab to minimize reinforcements in the wing slab. In consideration of the result from the FEM analysis, together with the installation of drainage inlets, the strut is actually placed 981mm inward from the outer edge of the deck slab (Figure 1).

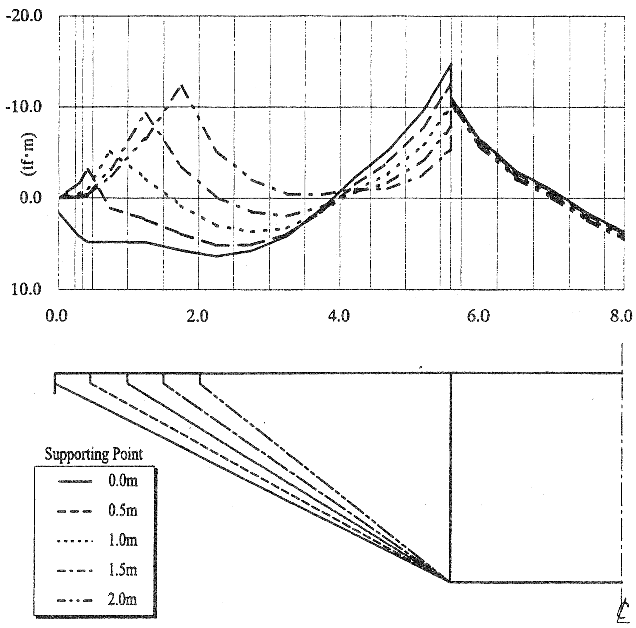


Figure 3: Relation between Supporting Point and Bending Moment Distribution

In the longitudinal direction, one strut is placed in each segment. Therefore, the distance between the adjacent struts is equivalent to the segment length, which is around 3.0m.

4. Transverse Design

A precondition for the transverse design is the use of pre-grouted tendons. The deck slab on the core segment should be prestressed before the erection, because trailer trucks loaded with segments will be driven over the core segments. Therefore, the transverse tendons need to be separated into primary and secondary ones. The primary tendons are tensioned after fabrication of the core segment, and the secondary tendons are tensioned after the wing slabs are placed. Although the primary and secondary tendons could be connected by means of couplers, the presence of couplers at the joint would greatly reduce the concrete cross section. As a result, ducts in which pre-grouted tendons with sheath can be inserted are made in the core segment beforehand, and then the secondary tendons are drawn into the core segments and anchored inside the box girder (Figure 4).

1S21.8 pre-grouted tendons are to be distributed at 625mm intervals, when the deck slab is designed under the following conditions. 1) The deck slab is a partially prestressed concrete member, and extreme fiber tensile stress under service load conbination is to be limited to less than the tensile strength of concrete. 2) The sectional forces caused by the wheel load are determined through 3-D FEM analysis.

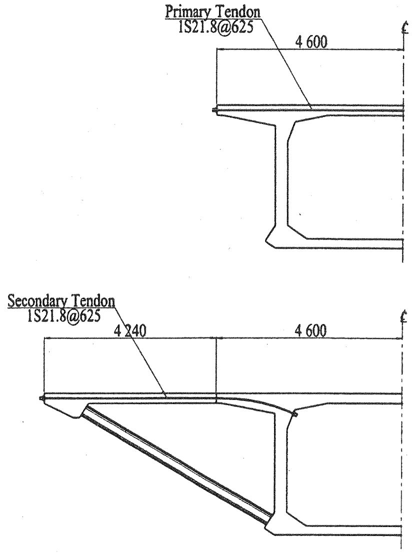


Figure 4: Transverse Tendon Layout

5. Edge Beam Design

The edge beam is a continuous beam-shaped member placed in the longitudinal direction where the strut is connected to the wing slab. The relatively high flexural rigidity of the edge beam prevents the concentration of bending moment at the wing slab and axial force at the strut, which are caused by the wheel load.

The edge beam is defined as a partially prestressed concrete member, and tensile stress at the bottom fiber is to be limited by the allowable crack width. The stress distribution under wheel load is analyzed through 3-D FEM, assuming that 3-1S28.6 pre-grouted tendons will be arranged in the edge beam cross section. The results show a tensile stress of 4.0N/mm^2 at the bottom fiber of the edge beam, and 2-D25 and 8-D22 re-bars are required to satisfy the allowable crack width (0.005c) (Figure 5).

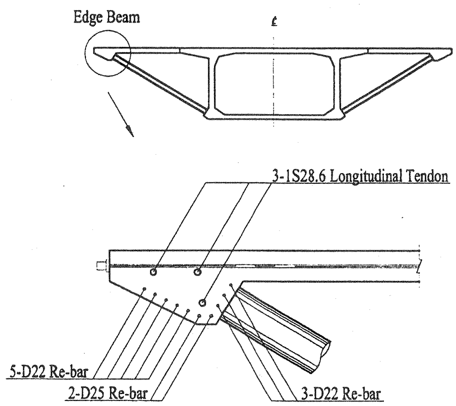


Figure 5: Longitudinal Reinforcement in the Edge Beam

6. Longitudinal Design

External tendons are basically utilized for all longitudinal tendons. A standard span (S=51.5m) will require 14-27S15.2 tendons. Among them, eight tendons will be tensioned after erection of the core segments, and the remaining six tendons will be tensioned after the wing slab is placed. The longitudinal tendon layout in a standard span is shown in Figure 6.

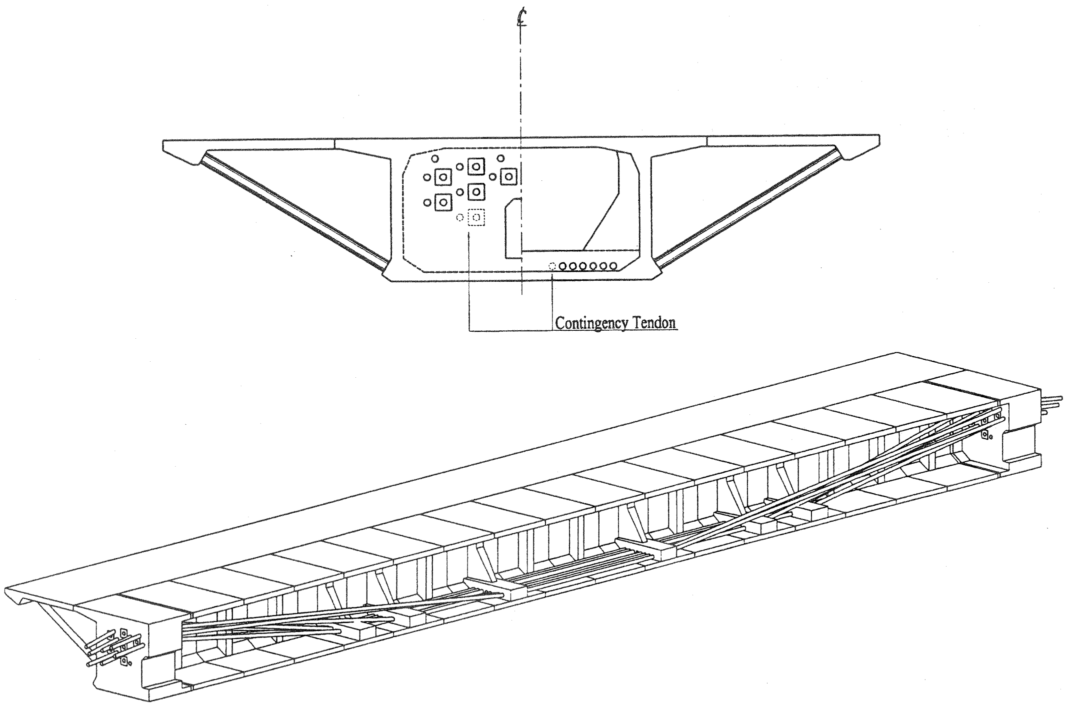


Figure 6: Longitudinal Tendon Layout

7. Concluding Remark

This report outlined the superstructure design at the present stage, especially core segment width, strut layout, transverse design, edge beam design and longitudinal design. Detailed results of the design and various experimental studies performed through the designing process will be reported in the future.

8. Acknowledgements

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Reference

1) Inokuma, Y. and Honma, A. (1998): "Study of a PC Box-Girder Using Corrugated Steel Webs and Cantilever Deck Slab Supported by Inclined Struts," Journal of Prestressed Concrete Vol. 40, No. 5, Sept.-Oct. 1998, Tokyo, Japan