Terasako Bridge

1. Introduction

Terasako Bridge (***Figures 1***, ***2,*** and ***3***) is a 712.5 meter-long ten-span continuous prestressed concrete box-girder bridge located between Hyuga Interchange and Tsuno Interchange on the Higashi-Kyusyu expressway in Miyazaki Prefecture.

This is the first application of concrete precast “Butterfly Web” panels, which are fabricated in a butterfly shape. Compared to a conventional concrete box-girder structure, this unique structure reduces the dead load of the superstructure by approximately 10%. Moreover, by reducing both the prestressing steel weight and the number of bearing supports, construction costs can be lowered.

The cantilever method was used for the main girder, where the decreased dead load of the webs allowed for a 6 meter-long construction unit. The resulting decrease in the number of units shortened the construction process.

Figure 1. Terasako Bridge

Stractural Data

Structural type: 10-span continuous prestressed concrete butterfly web bridge

Bridge Length: 712.5 m

Span: 58.6 m + 87.5 m +7@73.5 m + 49.2 m

Effective width: 9.26 m to 9.46 m

Owner: West Nippon Expressway Co., Ltd.

Designer: Sumitomo Mitsui Construction Co., Ltd.

Contractor: Sumitomo Mitsui Construction Co., Ltd.

Construction Period: Aug. 2010 – Aug. 2013

Location: Miyazaki Prefecture, Japan.

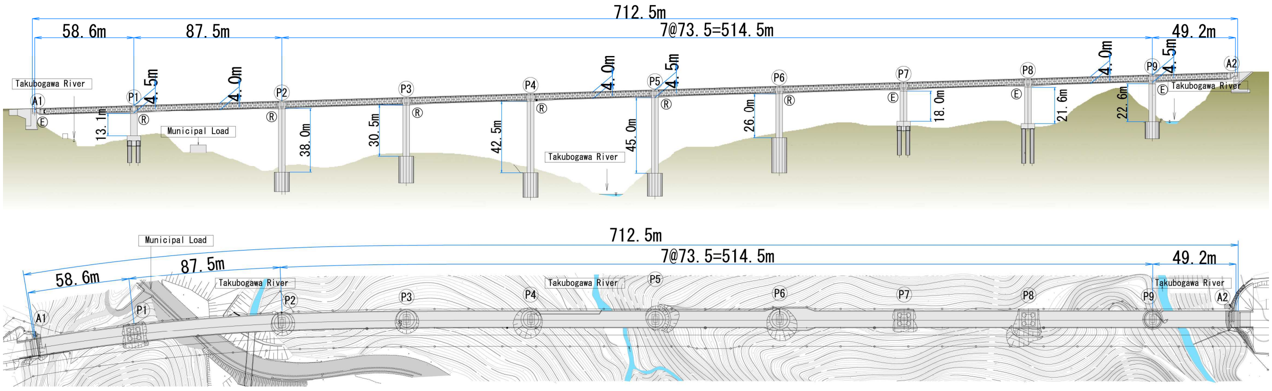


Figure 2. General view of Terasako Bridge

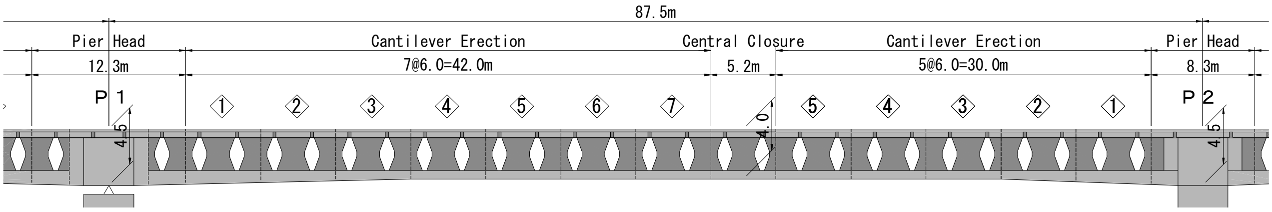


Figure 3. Side view, maximum length span

2. Design of Terasako Bridge

(1) Butterfly Web

The butterfly web structure uses butterfly-shaped panels in the web. With respect to a shear force acting on the web, it behaves similarly to a double Warren truss structure. (***Figure 4***) The butterfly web comprises precast panels fabricated off-site at a plant using high strength fiber reinforced concrete with a specified design strength of 80 MPa. Steel fibers are used to enhance the shear capacity. (***Figure 5***)

Inside the panels, prestressing steel members are placed so that they align with the orientation of the tension acting on the panels. Prestressing is used as the pretensioning method. The prestressing steel components are 15.2 mm diameter strands. There is no reinforcing steel, which makes the panels easy to work with and simplifies maintenance.

Based on the main girder height and the size of the indentations that form the butterfly shape, the butterfly web panels are 2.9 m long and installed at

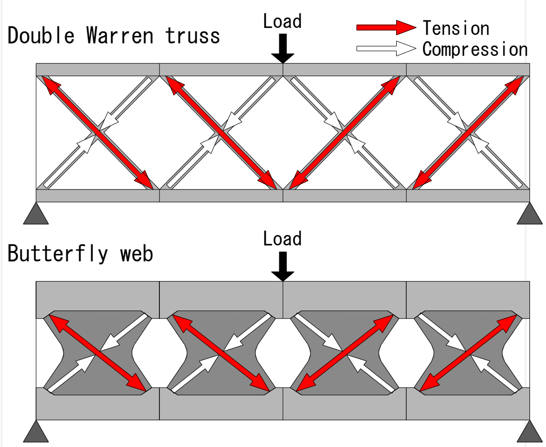


Figure 4. Structural behavior

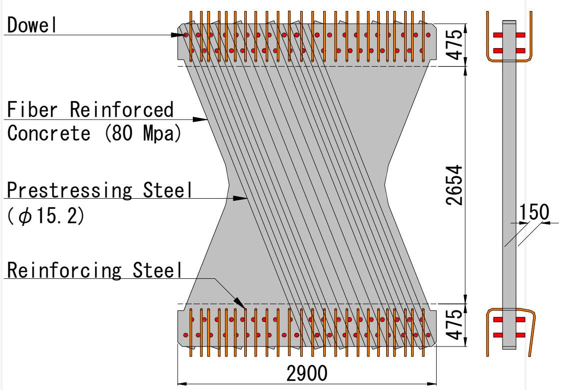


Figure 5. Detail of butterfly web

3.0 m intervals. As described above, in terms of resistance to shear force, the behavior of a butterfly web is similar to that of a double Warren truss. Consequently, the shear force is broken down into compressive and tensile forces, which are transmitted separately. The area of tensile stress is reinforced by prestressing steel, with the amount of steel varying to ensure no tensile stress intensity under a dead load and no cracking under the design load.

The web panels are 150 mm thick, a thickness sufficient to provide the necessary amount of prestressing steel, as described , and resist the compressive force acting on the compression side under an ultimate load.

(2) Main girder

The butterfly web panels that comprise the web are discontinuous in the longitudinal direction of the bridge, and the panels are relatively thin. Thus, the web is less rigid than an ordinary concrete web with a box section. Consequently, greater unit bending stress occurs in the web due to dead weight and vehicle loads. For this reason, transverse reinforcing ribs are installed at a 3.0 m pitch. (***Figure 6***)

3.Construction of Terasako Bridge

(1) Butterfly web

The butterfly web panels are fabricated at a plant located 270 km from the bridge construction site. They are then transported to the site by truck. The bridge requires a total of 444 web panels, although the external shape and thickness are standardized. Since a prestressing force is applied early in the fabrication stage, steam curing is used to accelerate strengthening. The prefabrication process for the panel is shown in ***Figure*** *7*.

(2) Cantilever construction

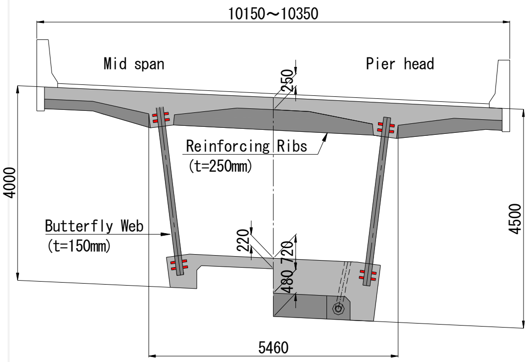


Figure 6. Main girder section

Figure.7. Arrangement of prestressing

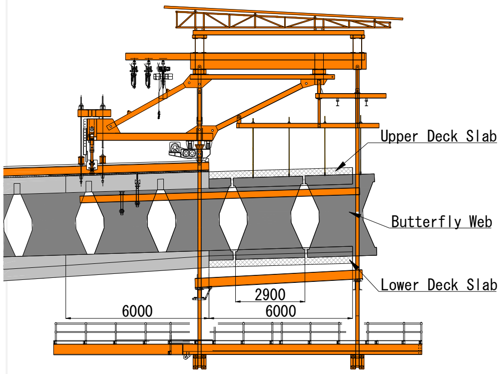


Figure 8. Form traveler

Figure 9. Cantilever construction

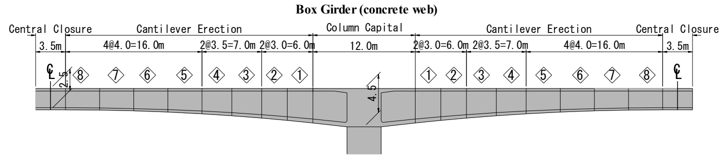
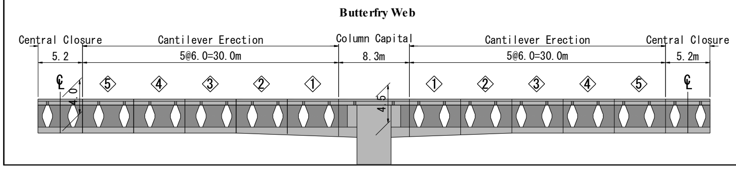
Side view & Section	Weigt (superstructure)	Prestressing steel	Block length
Box Girder (concrete web) 	153000kN (1.00)	287t (1.00)	3.0～4.0m 8blocks
Butterfry Web 	138800kN (0.91)	233t (0.81)	6.0m 5blocks

Table 1. Comparison of box girder and butterfly web

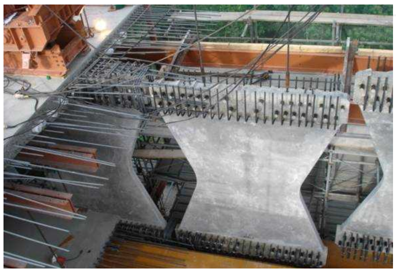


Figure 10. Panels inside a form

Figure 11. Center Closure

The cantilever construction method used for the Terasako Bridge is shown in ***Figures 8*** and ***9***. Each butterfly web panel weighs approximately 3.3 tons, resulting in a main girder that is lighter than would be possible with a conventional concrete web. Consequently, a construction block length of 6.0 m could be used, which is equivalent to the length of two butterfly web panels on each side of the bridge. As a result, only 5 segments were required for a cantilever span, whereas a conventional concrete box girder would require 8 segments (***Table 1***). With fewer segments required, the construction period was substantially shortened. In addition, since the butterfly web panels are not continuous in the longitudinal direction, there is no need to join adjacent web elements, which enhances work efficiency. The butterfly web panels are lifted to the bridge deck by crane after transportation to the site and then moved to the cantilevered deck ends where the form travelers are located. Inside the form travelers, the panels are picked up and positioned, and then the concrete for the upper and lower deck slabs is placed to construct the main girder. ***Figure 10*** shows panels being put into position inside a form traveler. The central closure is shown in ***Figure 11***. It is executed using a form traveler, and then the external cables are tensioned.

4. Conclusion

In addition to providing a lighter main girder, the butterfly web structure substantially reduces construction time because it requires a smaller number of construction segment increments. Piers and footings can also be scaled down because of the lighter superstructure. As a result, the bridge has a smaller impact on the environment than a bridge with a conventional structure. Furthermore, maintenance is easier because the web panels do not use reinforcing steel and are high quality products produced in a plant using industrial fabrication processes. Consequently, this structure provides substantial reductions in both construction and maintenance costs.