Design and Construction of Butterfly Web Bridge -Akutagawa Bridge-

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Summary

Akutagawa Bridge (Figure 1) is a continuous rigid frame bridge located between Takatsuki junction and Kobe junction on New Meishin Expressway. This is the new application of concrete precast "Butterfly Web Bridge", which uses butterfly shaped panels fabricated in a factory. Compared to a conventional concrete box-girder structure, this unique structure enables the reduction in dead load of the superstructure by approximately 10%. And, a decrease in construction costs is expected through the reduction of both prestressing steel weight and size of bridge substructure.

Keywords: Prefabricated Panels; Fiber Reinforced Concrete; Light weight; Construction speed; Low maintenances; Reducing CO2 emissions

1. Introduction

The butterfly web structure uses butterfly-shaped panels in the web. With respect to shear force acting on the web, it behaves similarly to a double Warren truss structure (Figure 2). The material for the components of the web is concrete and tensile stress areas are reinforced with prestressing steels. The material for the components of the web is 80 MPa concrete and tensile stress areas are reinforced with prestressing single steels. Moreover, the 150 mm panel has no reinforcing steel but is reinforced by steel fibers. The web panel uses high-strength fiber reinforced concrete. It is a highly durable product because of its high quality since it is manufactured in a plant and without any reinforcement, which potentially reduces its maintenance requirements.

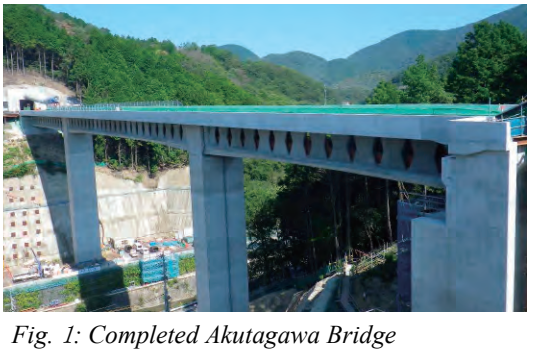

Fig. 1: Completed Akutagawa Bridge

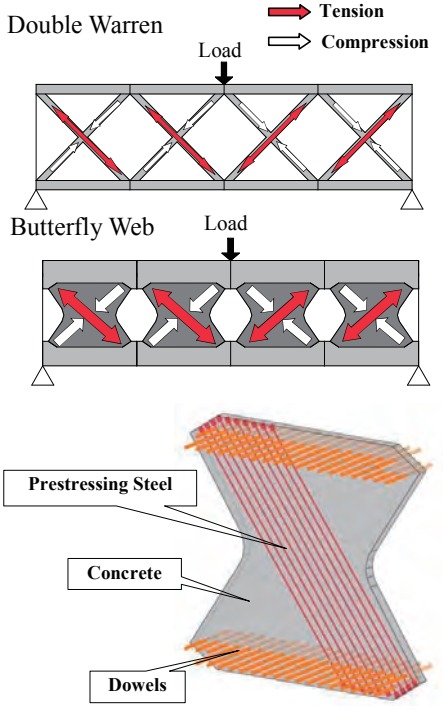

Fig. 2: Structural properties

2. Design

Comparison between an ordinary box girder and butterfly web is shown in Table 1. The cantilever method was used for main girder construction, where the decreased dead load of the webs allowed the establishment of a 6.0m-long construction unit, and the resulting decrease in the number of units led to a shortened construction process.

By using the butterfly web structure, the weight of the superstructure can be lessened and a smaller substructure can be achieved. A smaller footing can also be used with the smaller bridge pier cross section, which leads to around 20% reduction of the footing cross section. Based on these, the combined construction cost of the bridge pier and footing was reduced by as much as 15%.

Using of the butterfly web means that, this bridge uses less concrete for the structure than an ordinary concrete web box girder structure. Therefore, it reduces the Emission of CO2.

Table. 1: Comparison of the conventional box girder and the butterfly web structure

Concrete web	Butterfly web
(side view) Cantilever Erection Pier Head Cantilever Erection 2@4,0m 3@3,5m 2@3,0m 2@2,5m 12,0m 2@2,5m 2@3,0m 3@3,5m 2@4,0m 9L 8L 7L 6L 5L 4L 3L 2L 1L 4,0m 4,0m 4,0m 1R 2R 3R 4R 5R 6R 7R 8R 9R 5,0m (section) 10650 3000 5000 1500 6500 2250 200 10250 200	(side view) Cantilever Erection Pier Head Cantilever Erection 5@6,0m 8,5m 5@6,0m 5L 4L 3L 2L 1L 2,4m 2,4m 1R 2R 3R 4R 5R 4,0m 4,5m (section) 10650 4000 4500 2000 5500 2750 200 10250 200
Superstructure weight: 46,700kN (1,00) Block length: 2,5m～4,0m (9 blocks) Conctruction period: 90days (9blocks × 10days=90days)	Superstructure weight: 41,700kN (0,89) Block length: 6,0m (5 blocks) Conctruction period: 90days (5blocks × 11days=55days)

3. Construction

The cantilever construction used for the Akutagawa Bridge is shown in Figure 3. Each butterfly web panel weighs approximately 3.3 t, enabling construction of a main girder lighter than would be possible with an ordinary concrete web. Figure 4 shows panels being put into position inside a form traveller. The butterfly web panels are lifted to the bridge deck by crane after transportation to the site. The panels are positioned inside the form travellers, and then the concrete for the upper and lower deck slabs is placed to construct the main girder (Figure 4).

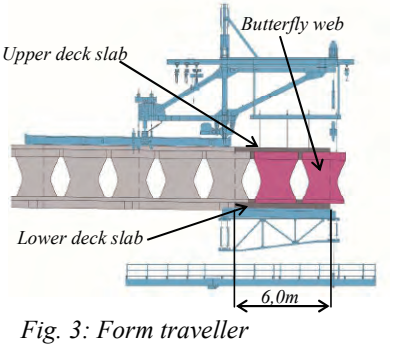

Fig. 3: Form traveller

4. Conclusion

In addition to enabling a lighter main girder, the butterfly web structure makes a substantial contribution to a shortened construction period due to advantages such as requiring a smaller number of construction block increments. Substructure can also be downsized because of the lighter superstructure, and as a result, the bridge has a smaller impact on the environment than if it were to be constructed using a conventional structure. Furthermore, maintenance is easier, because the web panels do not use reinforcing steel, and are high quality products produced in a fabrication plant. Consequently, this structure provides substantial reductions in both construction costs and maintenance costs.

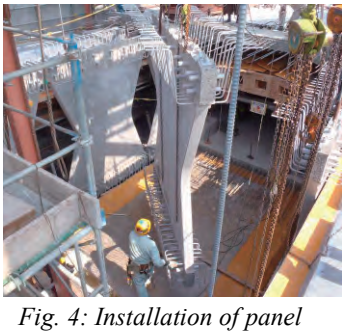

Fig. 4: Installation of panel