Corrugated Steel Web Bridge with the World's Longest Center Span
— Yatogawa Bridge —

世界最長の中央径間を有する波形ウェブ連続箱桁橋
— 谷津川橋 —

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Synopsis

Yatogawa Bridge, constructed in Susono City, Shizuoka Prefecture, Japan, is located between Numazu Service Area and Gotemba Junction of New Tomei Expressway. The inbound and outbound lanes are structurally separated and both are 5-span continuous corrugated steel web box girder bridges. The inbound lane is 383.5m long with the longest span at 135.0m and the outbound lane is 406.0m long with the longest span at 131.5m. As a continuous corrugated steel web box girder bridge, the 135m long center span is the world's longest. **Fig. 1** and **Fig. 2** show the view of completed bridge and of under-erection respectively.

Structural Data

Structure: 5-span continuous corrugated steel web box girder bridge
Bridge Length: 383.5m (Inbound)
406.0m (Outbound)
Span: 43.8m + 91.0m + 135.0m + 74.0m + 37.3m (Inbound)
34.8m + 81.0m + 131.5m + 95.5m + 60.8m (Outbound)
Width: 16.5m
Pier Height: 44m
Owner: Central Nippon Expressway Co., Ltd.
Designer and Contractor:
DPS Bridge Works Co., Ltd. (Inbound)
Kawada Construction Co., Ltd. (Outbound)
Construction Period: Mar. 2007 – Mar. 2011 (including the period of detailed design and construction of the superstructure)
Location: Shizuoka Prefecture, Japan

Fig. 1 Completed Yatogawa Bridge

Fig. 2 Yatogawa Bridge under erection

1. Features

The features of Yatogawa Bridge are summarized in 7 topics as follows:

(1) Continuous girder structure

The bridge was designed to be a continuous girder structure supported by the seismic isolation bearings (super-high damping rubber bearings) for the main purpose of reducing the entire construction cost and reducing the seismic load on the piers during earthquakes. With respect to the superstructure of the inbound lane, this bridge has the world's longest span length as a continuous corrugated steel web box girder bridge.

With a spectacular view of Mt. Fuji in its background (**Fig. 1**), also with its 135m long span and 45m tall piers, it was desirably contemplated that this bridge should project a free and gorgeous image associated with the wide-spreading edge line of Mt. Fuji. On the basis of this image, studies were conducted on the quadratic curve, linear curve and meridian regarding the shape of lower slab portion, and as a result rather elaborate quadratic curve analysis was adopted for the transition of girder height in light of scenic attraction. Linear curve transition analysis was employed in Akabuchi Bridge and Nakaisshikikawa Bridge since the type of those bridges was that of lower flanges installed to the corrugated web plates.

In addition, the struts, referred to in below (3), made of reinforced concrete (hereinafter referred to as "RC") and supporting the cantilevered deck slab, are of precast products fabricated in the plant for improvement of their installation accuracy, and with their converted lengths and angles, attached to designed locations of the lower slab.

As a result of diligent studies on the strut locations and structural details, the total weight of the superstructure remarkably decreased in comparison with other bridges that have the same effective widths, allowing the bridge to boost its more refined structure. The total weight decreased to 65% of Okitsugawa Bridge composed of a single hollow girder completed in the early stage of New Tomei Expressway construction, to 75% of Shibakawa Viaduct composed of concrete slabs and webs with steel struts, and to 90% of Akabuchigawa Bridge composed of corrugated steel web plates, precast panels and precast ribs.

As another feature of this bridge, the use of seismic isolation bearings enabled the piers' cross sectional area to decrease by 20% than the case of not using such bearings (**Fig. 4**).

(2) "Edge beam" structure

The floor slab is supported by the struts attached between the edge beam and the lower slab. Since the bending moment occurs toward the longitudinal direction as well, pre-grout prestressed concrete cable (hereinafter referred to as "PC cable") was installed inside the edge beam (**Fig. 5**). The PC cable inside the edge beam also helps to prevent the joint displacement of cantilevered floor slab caused by the effect of shear lag. [1]

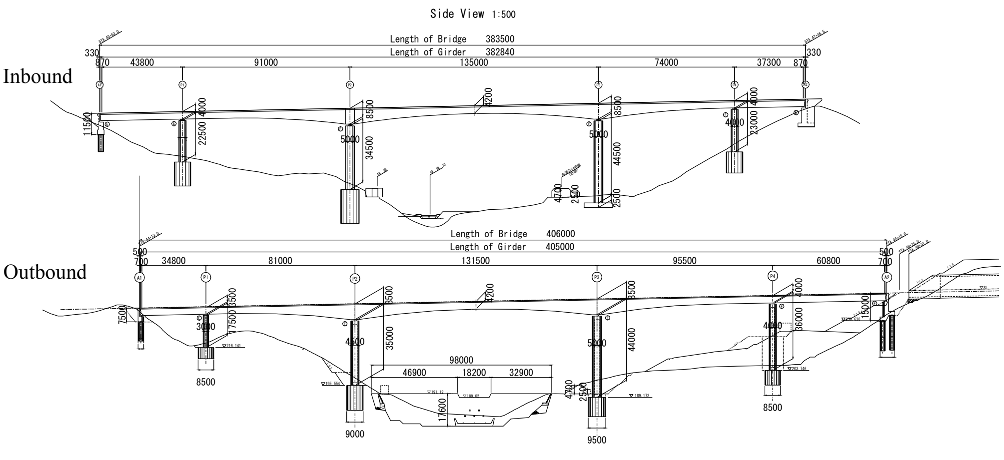

Fig. 3 Elevation and plan of Yatogawa Bridge

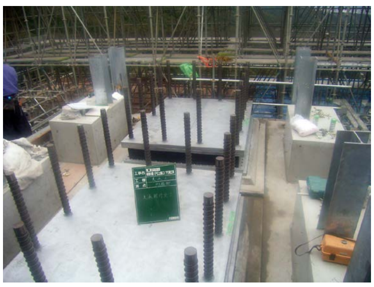

Fig. 4 Installation of special rubber bearings

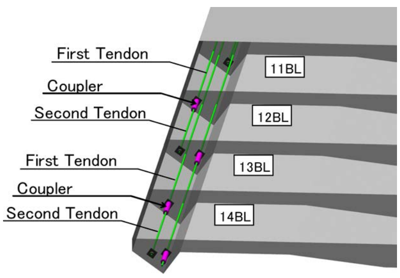

Fig. 5 PC cable location at edge beam

Fig. 6 RC struts

While the PC cable inside the edge beam was fixed by dead anchors for the inbound lane, it was fixed by couplers for the outbound lane as the analyses proved more optimal number of the cable and the effectiveness of stress transfer around the fixing portion.

(3) Precast RC struts

The structure of supporting the cantilevered deck slab by struts realized the narrower main box girder. This not only reduced the weight of the girder itself but downsized the substructure as well, thereby enabled the reduction of ground excavation (**Fig. 6**).

RC struts are more often used in these days, while steel pipes and/or FRP pipes were used in the early construction stage of New Tomei Expressway. However, as any performance requirement for such RC struts was not specified, their required yield strength and quality control method were also not determined. Under such circumstance, certain specifications were established by conducting bending strength tests in accordance with the JIS standards, and a proposal of design and quality control method for the RC struts were prepared. Upon certification of such specifications by the owner, those RC struts were fabricated in JIS-accredited plants in light of quality control and fabrication accuracy (**Fig. 7**).

(4) Epoxy resin-coated PC cable

Epoxy resin-coated PC steel cable was used for the structure of the inbound lane (**Fig. 8**). Compared to the normal grout type external cable, the employment of epoxy-coated strands for non-grout external cable brings about the following advantages:

1) Labor-saving and shortening of construction period by elimination of grouting work
2) Elimination of connection and installation work of longer protective tubes
3) Reduction of cable's dead weight
4) Easier cable inspection under public use
5) Practicable anticorrosion throughout fabrication, storage, erection and under-public-use stages

(5) Galvanized multi-PC cable

A galvanized multi-PC cable, fabricated in the plant, was used in the structure of outbound lane with the aim of further improvement of anticorrosion property and workability (**Fig. 9**). There were following merits by employing the galvanized multi-PC cable instead of using the normal grout type external cable:

1) Labor-saving and shortening of construction period by one-time cable setting and elimination of grouting work
2) Elimination of connection and installation work of longer protective tubes
3) Reduction of cable's dead weight
4) Double anticorrosion effect by galvanizing of the strands and polyethylene casing of such galvanized strands
5) Easier cable inspection on the bridge in public use

In addition, the galvanized multi-PC strands are mantled by polyethylene tube as its external casing. In order to observe the degree of decreased galvanizing, some sample cables are placed inside the box girder to check their degree of corrosion (**Fig. 10**).

(6) Super low viscosity grout

For the outbound lane, super low viscosity grout admixture was used for anticorrosion of the internal cable. As this admixture causes much lower viscosity to the grout than any other conventional ones, the grout

Fig. 7 Steel bar arrangement of RC struts

Fig. 8 Epoxy resin-coated PC cable

Fig. 9 Galvanized multi-PC cable

Fig. 10 Sample cables inside box girder

Fig. 11 Grout injection test

smoothly runs into any narrow interstices and long span sheath pipes, therefore reduces the occurrences of blockage. Such low viscosity also realizes the long-distance pressure filling without moving grouting devices, thus improves the efficiency of pressure filling and allows a stable compressive strength for the grout.
Before adopting the super low viscosity grout, certain material examinations were conducted at the manufacturer's plant to verify the slump flow, free volume and amount of bleeding. Then, an actual grout injection test with a full-scale model was conducted to observe the property of the grout and the degree of filling (**Fig. 11**). As the result of those examinations and tests, it was affirmed that even an injection of 60m distance was practicable since the measured maximum injection pressure of the super low viscosity type was 0.1MPa in contrast to 13MPa of a high viscosity type when a maximum injection distance was set at 58m. With these results gained in the material examinations and injection tests, an operation manual of the super low viscosity grout was prepared. The degree of grout filling was verified by nondestructive testing.

(7) Large-scale form traveler

On the outbound lane, a large-scale form traveler (4,000kN·m capacity) was employed for the cantilever erection of main girders including corrugated steel web plate installation (**Fig. 12** and **13**).
The traveler has a higher lifting range (structure height) and this makes easier erection and placement of corrugated steel web plates and strut members (**Fig. 14**).
With such large-scaled capacity, every distance between struts was uniformly set at rather longer 4.0m regardless of the girder height, and consequently each erection cycle was shortened. In result, the number of cantilevered segments decreased from 16 to 14, leading to the reduction of construction period by 40 days per a single pier and by 80 days in the entire outbound lane construction.

Fig. 12 Erection of corrugated steel web plate

2. Conclusion

The Yatogawa Bridge adopted various innovations and new technologies developed during the construction of New Tomei Expressway. As the result, the bridge has the world's longest span length as a continuous corrugated steel web box girder bridge. It would be informative and helpful if this report is referred to in other similar constructions in the future. The bridge was successfully completed in March 2011 without any accident or problem throughout the construction period and awarded a prize as one of the best bridges of the year by Japan Prestressed Concrete Institute. Another photo of the completed bridge is attached below (**Fig. 15**).

References

[1] Imai, H., Inaba, N., Yabuki, T., Tategami, H.: *Construction of Yatogawa Bridge –Corrugated Steel Web Bridge that has the Longest Center Span in the World-*, Journal of Prestressed Concrete, Japan, Vol.53, No.5, pp.20-27, Sep.2011(in Japanese)

Fig. 13 Large-scale form traveler

Fig. 14 Installation of RC struts

Fig. 15 Completed Bridge

概　要

谷津川橋は，新東名高速道路の沼津 SA ～御殿場 JCT 間に位置する波形鋼板ウェブとストラット付き床版を有する複合 PC 橋である。橋梁の規模は，上り線は最大支間135.0m の 5 径間連続箱桁橋であり，下り線は最大支間131.5m の 5 径間連続箱桁橋である。上り線の中央支間長は，連続桁形式の波形鋼板ウェブ橋とした橋梁では世界最長となる。本橋の施工に際しては，経済性，品質の向上，施工性，景観性に関する検討を行っており，上り線を先行施工し，あと施工である下り線でさらなる改善を行っている。本稿は，これらの検討事項に関する詳細について報告するものである。