Prestressed Concrete Composite Bridge over a Road, Railway, and River — Shiokawa Bridge on the Shin-Meishin Expressway —

道路，鉄道および河川を跨ぐ PC 複合橋 ― 新名神高速道路　塩川橋 ―


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Synopsis
As part of the Shin-Meishin Expressway, the Shiokawa Bridge is a partially prestressed concrete (PPC) bridge with a corrugated steel web box girder. The bridge is composed of two individual bridges, one for inbound traffic and the other for outbound traffic crossing over a heavy-traffic road, railway, and river (**Fig. 1**). These obstructions for the construction and the steep terrain at the bridge location made cantilever construction difficult. A cantilever construction method utilizing a permanent corrugated steel web was devised to shorten the construction period.

Fig. 1 Shiokawa Bridge

Structural Data
Structure:
Inbound Lane: 2-span continuous PPC rigid-frame box-girder bridge
Outbound Lane: 3-span continuous PPC rigid-frame box-girder bridge
Bridge Length:
Inbound Lane: 97.0 m
Outbound Lane: 233.5 m
Span:
Inbound Lane: 62.7 m + 30.7 m
Outbound Lane: 100.7 m + 92.5 m + 36.7 m
Width: 11.8 m
Owner: West Nippon Expressway Co., Ltd.
Designer: P.S. Mitsubishi Construction Co., Ltd.
Contractor: P.S. Mitsubishi Construction Co., Ltd.
Construction Period: July 2012 – Aug. 2017
Location: Hyogo Prefecture, Japan

1. Introduction
In Japan, new expressway construction projects are ongoing to realize a congestion-free and multiplex network, with the ultimate aim of stimulating economic growth and development. With a total length of 174 km, the Shin-Meishin Expressway is one of those major projects and is planned as an alternative route for the existing old Meishin Expressway that endures chronic heavy traffic congestion. Being one of the major expressway projects in Japan, some of its construction is still ongoing. As part of the Shin-Meishin Expressway, construction of the Shiokawa

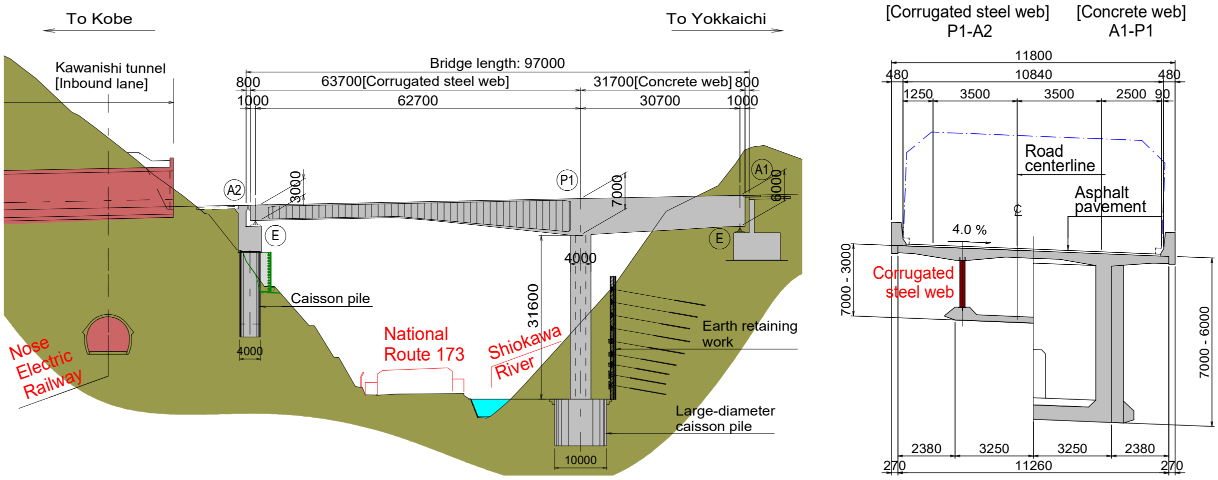

Fig. 2 Overall diagram and standard section of the superstructure of the inbound lane

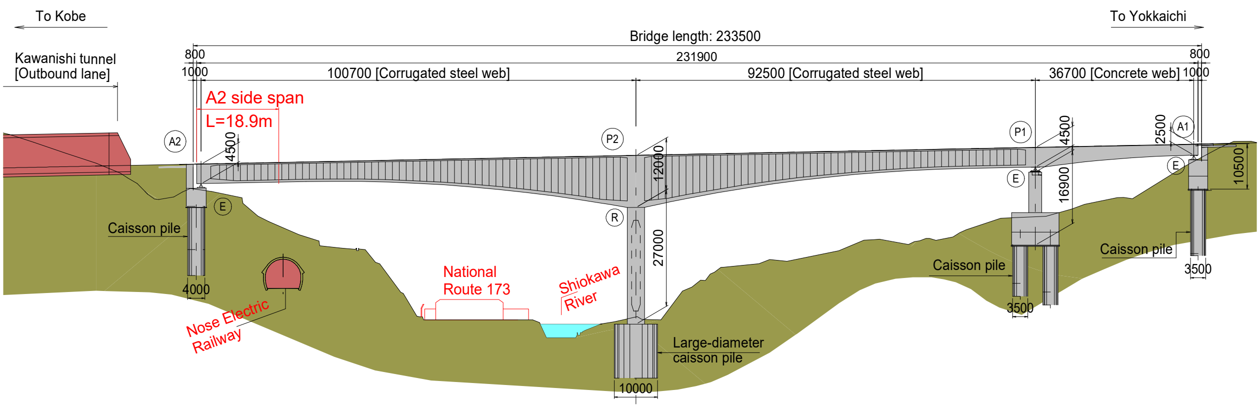

Fig. 3 Overall diagram of the outbound lane

Bridge began in 2012 and it was opened in December 2017. This bridge was constructed over National Route 173 with heavy traffic of about 40,000 vehicles per day, the Myoken Line of the Nose Electric Railway Co. Ltd, and the Shiokawa River in steep terrain.

2. Summary of the Construction Project

(1) Inbound Lane

Since the location of the substructure supporting a new inbound lane bridge is very limited, it has an unbalanced span arrangement of 30.7 m and 62.7 m for A1–P1 and P1–A2, respectively (**Fig. 2**). To deal with this span arrangement, the superstructure was designed with a heavier girder in A1–P1 and a lighter one in P1–A2. To reduce the girder weight in P1–A2, a corrugated steel web was adopted, while the girder in A1–P1 was designed with a concrete web. Also, the cantilever construction block (BL) was designed as 2.5 m and 3.2–4.8 m for A1–P1 and P1–A2, respectively. A general view of the inbound bridge is shown in **Fig. 2**. As the first cantilever stage, the cantilever construction started from P1 until 8BL on both sides, and ended by closing the side span of A1 side. In the second cantilever stage, the cantilever construction for 9BL to 11BL continued until the closure of the side span of A2 side.

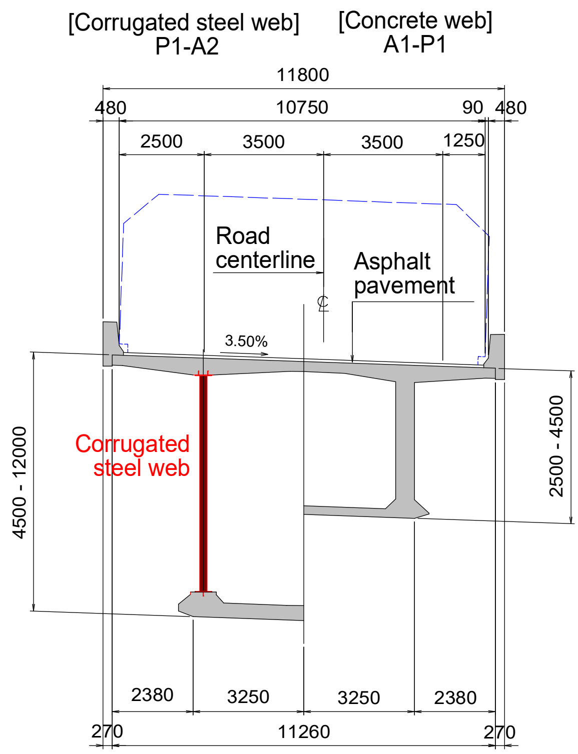

Fig. 4 Standard section of the superstructure of the outbound lane

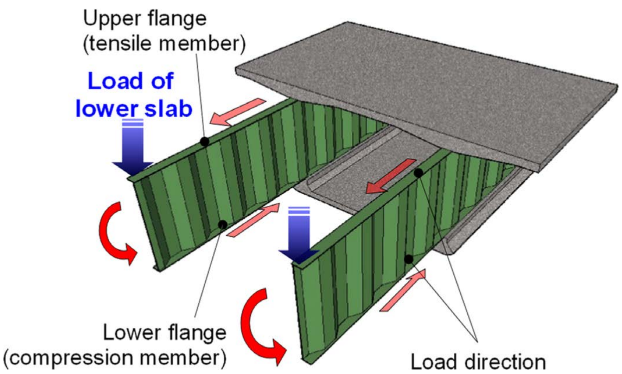

Fig. 5 Load-carrying mechanism lower slab

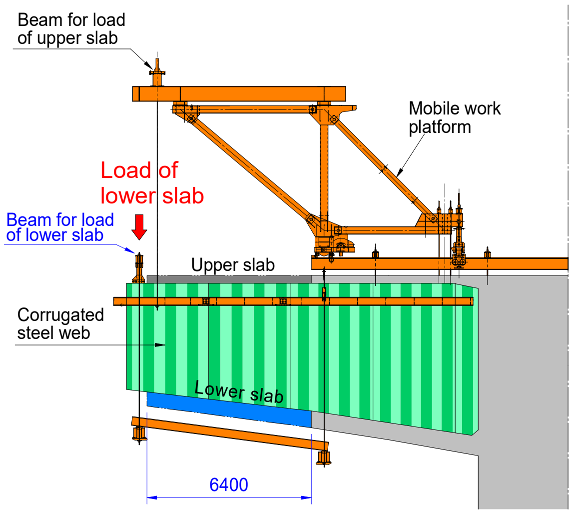

Fig. 6 Load-supporting mechanism of the lower slab concrete

(2) Outbound Lane

The bridge for the outbound lane also crosses over the national road, river, and railway between P2 and A2. Therefore, the span of 100.7 m between P2 and A2 was constructed by the cantilever construction method, and the span arrangement between P1 and A2 is almost symmetrical. To deal with the long cantilever length of 89.2 m from P2, a corrugated steel web was adopted again for P1–A2 to reduce the girder self-weight. The maximum girder height at the column crown is 12.0 m. This cantilever length of 89.2 m is one of the longest in prestressed concrete (PC) bridges in Japan having the same structural type with the same construction method[1]. An overall diagram and the standard section of the superstructure of the outbound lane are shown in **Fig. 3** and **Fig. 4**, respectively.

3. Design and Construction

(1) Shortening of Superstructure Construction Period by Extending the Cantilever Block Length

As mentioned, a corrugated steel web box girder between P1-A2 of the outbound lane bridge was constructed by the cantilever construction method. During cantilever construction work, a form traveller (FT) normally supports the weight of each new casting block, including the top and bottom slabs from the previously cast block. In this bridge, the pre-installed corrugated steel web was used as hanging falsework to carry the casting weight of the lower slab. As a result, the FT capacity was used more effectively, and the maximum length of a cantilever block could be extended from 3.5 m in the initial plan to 6.4 m. **Fig. 5** shows the load-carrying mechanism using the flanges for the corrugated steel web, and **Fig. 6** shows the load-supporting mechanism of the FT. Also, the number of blocks was reduced from 31 BLs to 13 BLs by extending the block length, which reduced the construction period by about 190 days.

(2) Construction of A2 abutments

1) Substructure Construction from Superstructure Tip

Normally, substructure works for pile and abutment are carried out prior to the superstructure construction. In this bridge, the substructure at the A2 side for both the inbound and outbound lane was planned to start after the breakthrough of the Kawanishi tunnel prior to the superstructure works. However, because of the construction schedule mismatch, the substructure construction for the A2 side was carried out from the tip of the cantilever. To conduct excavation work, a temporary platform was installed between the A2 location of the inbound and outbound lanes. The excavated soil was removed and transported through the outbound lane bridge as a temporary route (**Fig. 7**).

2) Displacement Measurement of the Superstructure

During the substructure construction, a 70 ton crane and concrete vehicles for mixing and pumping work placed additional construction loads on the cantilever tip in the outbound superstructure. Because these loads acted during the cantilever construction, their impact on the superstructure was investigated, even though the load level was limited compared with that of the FT. Although the stress level in the superstructure remained within its allowable limit, a concern was that there could be some impact on the elevation control. Therefore, a 24-hour three-dimensional automatic monitoring system was used to measure the girder displacement. **Fig. 8** and **Fig. 9** show the system layout at the site and the results from the system, respectively. As shown in **Fig. 9**, the elevation at the cantilever tip decreased by about 50 mm because of the construction load and the change in top slab temperature due to sunlight. Also, note that most of the deformation was recovered when all the machinery including the crane was stored at the pier top during the night or when was not in use. As shown by the measurement data,

Fig. 7 Transport route of excavated soil at A2 abutment

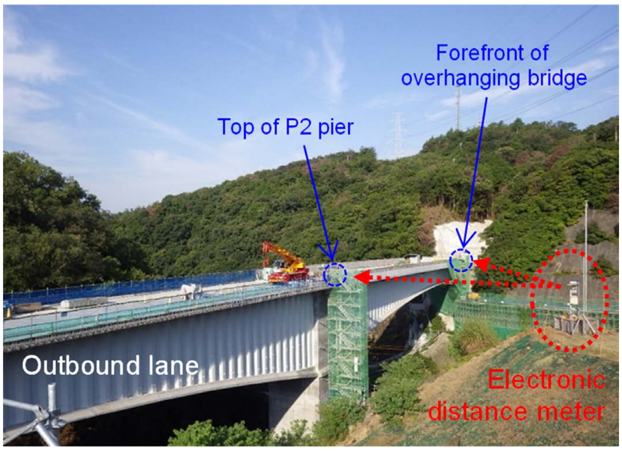

Fig. 8 Measurement of superstructure elevation

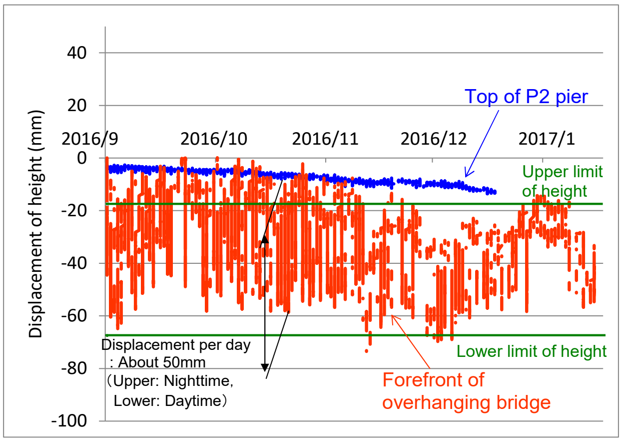

Fig. 9 Elevation change at the overhang tip superstructure heights

fortunately no unexpected phenomena arose during the construction.

4. Conclusion

Despite its challenging construction conditions, the Shiokawa Bridge was constructed successfully in 5 years, and it won the 2017 JPCI Award of the Japan Prestressed Concrete Institute.

Reference

[1] Kawanaka, R., Shimizu, H., Taguchi, Y., Miyamoto, K.: *Design and construction of the Shiokawa Bridge on the outbound lane of the Shin-Meishin Expressway*, Proceedings of the 25th Symposium on the Development of Prestressed Concrete, pp. 637-640, Oct. 2016 (in Japanese).

概　要

塩川橋は，新名神高速道路の一部として上下部工一式で発注された上下線分離の橋梁であり，箕面とどろみIC～川西IC間(兵庫県川西市東畦野)に位置する。本橋は急峻な地形条件に加え，国道，鉄道および河川を跨ぐ橋梁である。上り線は張出し架設工法を採用したが，前述の制約から支間長が2倍程度異なるため，施工時のアンバランスモーメント対策が課題であった。下り線は，張出し架設長が片側で89.2mと長かったため，波形鋼板ウェブを採用するなどの変更により，1ブロックの施工長を延長することで工程短縮を実現した。また，上下線とも終点側の橋台の施工は最大張出し状態の下り線上部工先端を利用して行う必要があり，工程短縮のために施工方法の変更などを行った。