Construction of the Bridge with the Highest Pier in Japan — Washimi Bridge —

日本一の橋脚高さを有する橋梁の建設 — 鷲見橋 —


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Synopsis
The Washimi Bridge (**Fig. 1**) is a 4-span continuous rigid frame partially prestressed concrete box girder bridge designed with corrugated steel webs on three high piers, the highest of which is 125 m high—the highest in Japan. Because the bridge is in a heavy snowfall region with severe weather conditions during construction, the SPER (Sumitomo Mitsui's Precast Form for Earthquake Resistance and Rapid Construction) method was adopted in order to utilize precast elements during construction of the bridge piers. To accelerate the construction of the superstructure, the Rap-Con (Rapid Construction of Corrugated Steel Webs) method was used.

Structural Data
Structure: 4-span continuous rigid frame bridge
Bridge Length: 459.0 m
Span: 107.0 m ＋ 139.0 m ＋ 134.0 m ＋ 79.0 m
Width: 10.950 m
Pier Heights: 67.5 m, 125.0 m, 67.5 m
Owner: Central Nippon Expressway Co., Ltd.
Designer: Japan Bridge & Structure Institute, Inc.,
Sumitomo Mitsui Construction Co., Ltd.
Contractor: Sumitomo Mitsui Construction Co., Ltd.
Construction Period: Jun. 2013 – Dec. 2018
Location: Gifu Prefecture, Japan

Fig. 1 Washimi Bridge

1. Introduction
The Washimi Bridge (Phase II) is an expressway bridge located in the central part of Japan in Gifu Prefecture. It was designed to run adjacent to an existing bridge (Phase I) spanning over a deep valley, using a four-span continuous rigid frame partially prestressed concrete box girder design with corrugated steel webs on three high piers, the highest of which is 125 m high—the highest in Japan. The general view of the bridge is shown in **Fig. 2**. Because the bridge is in a heavy snowfall region with severe weather conditions during construction, the SPER method was adopted in order to utilize precast elements during construction of the bridge piers. High-strength materials were used on the pier structure, namely, high strength concrete (design strength: 50 N/mm^2) and high-strength reinforcement

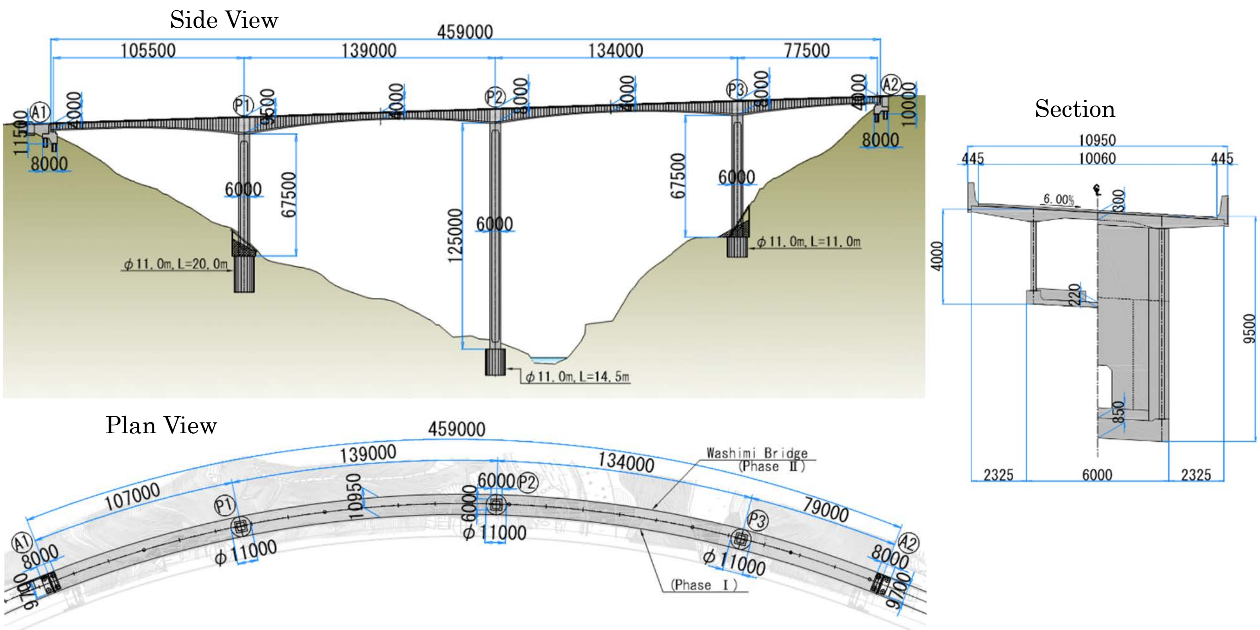

Fig. 2 The general view of Washimi Bridge

(yield strength: 685 N/mm^2). To accelerate the construction of the superstructure, the Rap-Con method was used. This method boosts construction efficiency by installing the form traveller on the corrugated steel panels and enabling construction to progress on several blocks simultaneously.

2. Pier Construction

For the construction of piers P1 and P2 with the SPER method, the precast members (**Fig. 3**) are manufactured at a plant, transported to the site, and erected with a crane after the main reinforcement assembly, and then the formwork for the concrete fill is set and concrete is placed inside. **Fig. 4** shows the lift plan for pier P2, while **Fig. 5** shows a schematic of the SPER method. On the first construction cycle, the 12.0-m height is divided into two lifts, and construction is carried out in the sequence of (1) scaffolding assembly, (2)

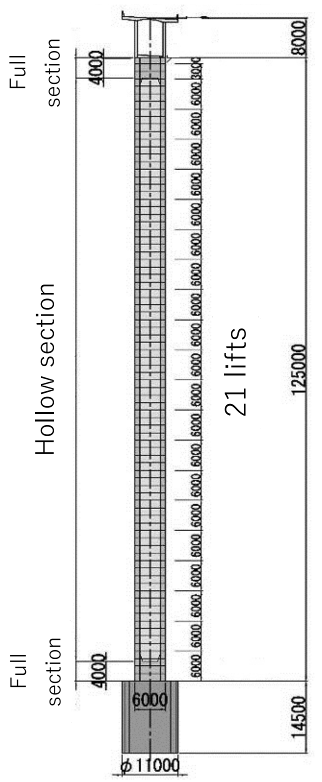

Fig. 4 Lift plan for pier P2

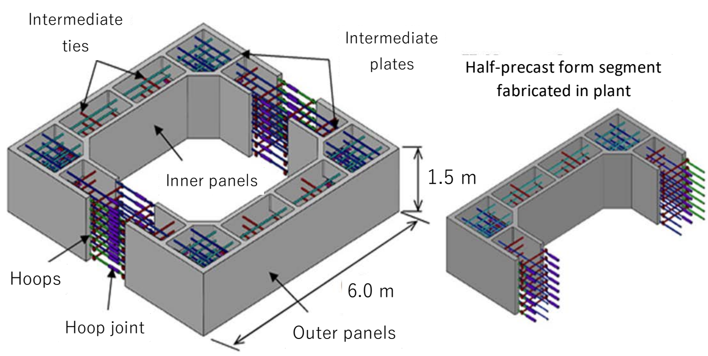

Fig. 3 Precast members in the SPER method

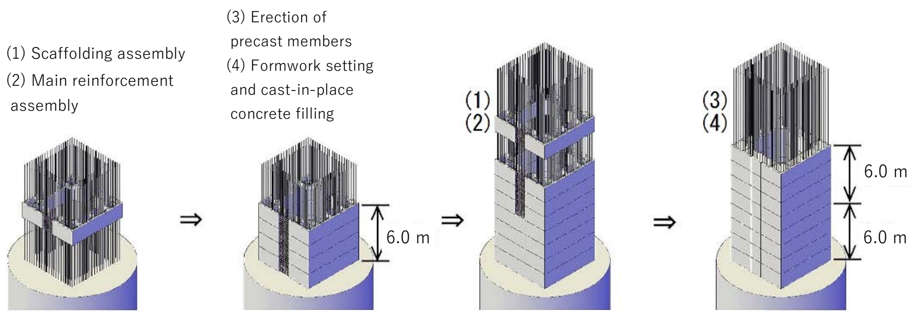

Fig. 5 Schematic diagram of the SPER method

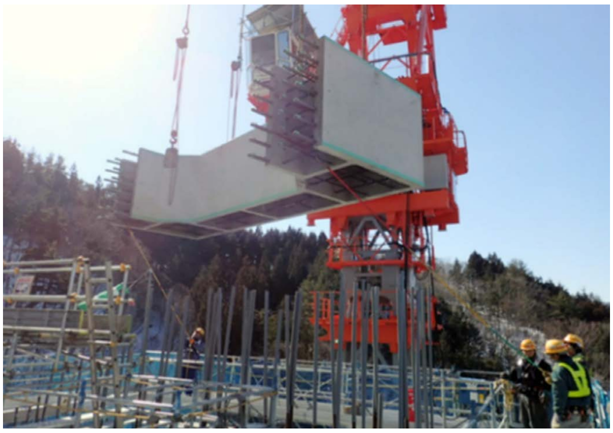

Fig. 6 Installing precast member

Fig. 8 Form traveller for P1 cantilever

main reinforcement assembly, (3) erection of precast members (**Fig. 6**), and (4) formwork setting and cast-in-place concrete filling. The first lift is erected by stacking precast members in four layers and then filling with concrete to a height of 6.0 m.

For the current project, the time required for one cycle (two lifts, 12.0 m) could be as short as 14 working days using the SPER method, achieving a reduction of up to 40% compared with 23 working days using conventional methods. Consequently, the construction period of the entire bridge pier including construction of the solid cross sections was shorten by 21% [1].

3. Superstructure Construction

In the Rap-Con method, the form traveller is supported by the corrugated steel panels, with the upper and lower flanges bolted together on splice plates at panel joints (**Fig. 7**). The high strength steel SM570 was used for the corrugated steel web supporting the form traveller for P1 cantilever (with each block cantilevering out 5.6 m), so as to withstand large external forces acting on flanges and splice plates of the web. Furthermore, a pitched roof was installed on the form traveller to prevent snow deposits and reduce the structural load on the corrugated steel web, which is designed on the assumption of no snow load during construction (**Fig. 8**).

The construction cycle time of both 4.8-m blocks at P2 and P3 cantilevers and 5.6-m blocks at P1 cantilever was reduced to 9 working days (excluding time for snow removal work in winter during the P1 cantilever construction) with the Rap-Con method.

A construction method with the form traveller was also used to shorten the construction period of the

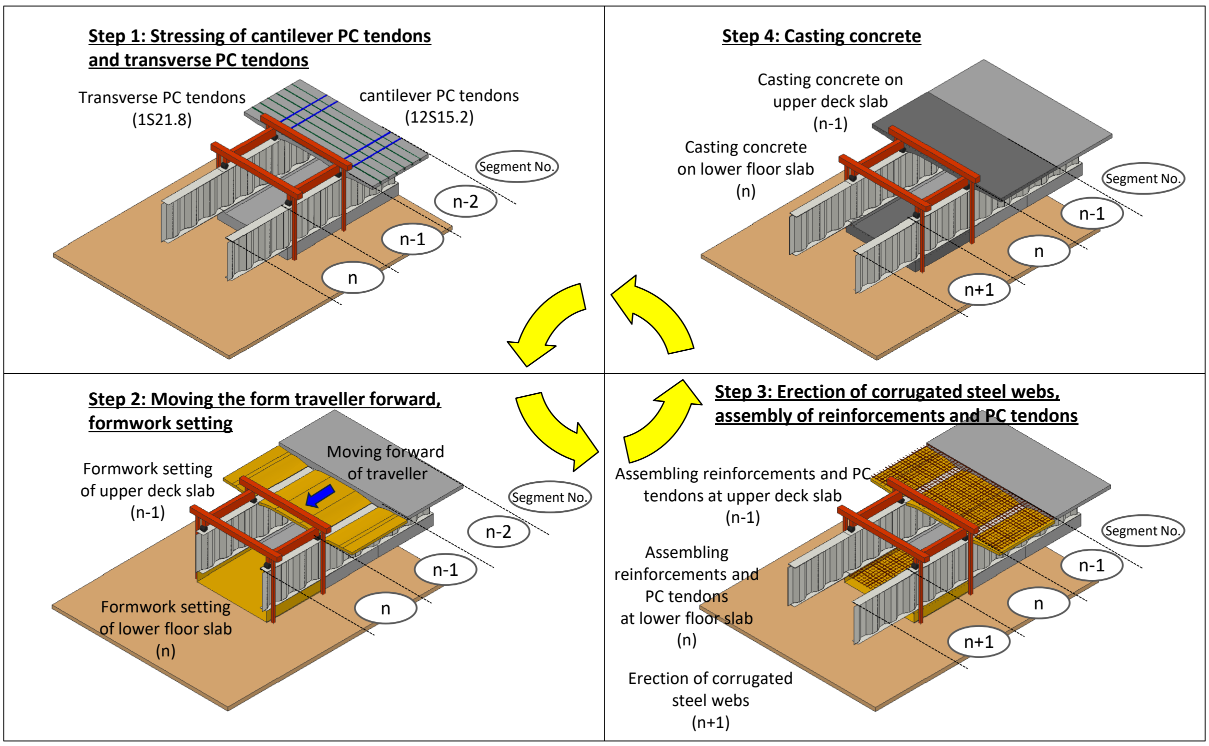

Fig. 7 Rap-Con method

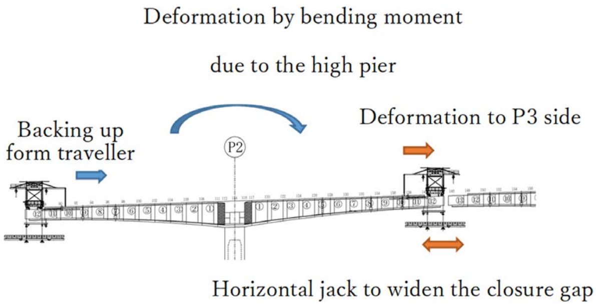

Fig. 9 P2-P3 Closure Process

Fig. 10 Horizontal jack to widen the closure

center closure. Because the superstructure construction was carried out in the sequence P3–P2–P1, the form traveller on the P2 cantilever was used for the P2–P3 closure, while the form traveller on the P1 cantilever was used for the P1–P2 closure. Cantilever construction at the high pier on P2 was completed in October 2017, and thus the form traveller on the P1 side—which would no longer be used—had to be dismantled before the start of the winter season. However, removing the form traveller from one side causes a load unbalance, potentially resulting in flexural deformation in the high pier. This flexural deformation of the pier toward the P3 side would cause the P2–P3 closure to narrow down and make it impossible for the closure panels to be positioned properly. Therefore, horizontal jacks on the concrete portions on the lower side of the corrugated steel panels were used to widen the closure gap and secure an erection space for the closure panels. This process is illustrated in **Fig. 9**, while the work in progress is shown in **Fig. 10** [2].

4. Conclusion

Accelerated construction of a new bridge with very high piers located adjacent to the existing bridge (**Fig. 11**) was achieved by adopting precast elements and other construction methods. Aside from shortening the construction period and saving labor, the construction method used on the Washimi Bridge helps to improve productivity and provides a wide range of benefits by improving safety with its shorter work periods, mitigating the impact (vibration and noise) on the surrounding environment and raising quality through plant production. The bridge was completed in December 2018 and is currently open for service. The authors hope that efforts in this project will help in the planning, design, and construction of similar bridges.

References

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Fig. 11 Washimi bridge (under construction)

概　要

鷲見橋（Ⅱ期線）は日本のほぼ中央である岐阜県に位置する自動車専用道路の橋梁である。供用中のⅠ期線に隣接した位置に計画され，深い谷地形を横架する橋梁であるため，３基の高橋脚を有するPRC4径間連続ラーメン波形鋼板ウェブ箱桁橋が採用された。中央の最も高いP2橋脚は日本一の高さ125mである。本橋梁地区は豪雪地域であり，厳しい気象条件の下での施工となるため，橋脚工にはプレキャスト部材を活用するSPER(Sumitomo-Mitsui Precast Earthquake resistance Rapid-construction) 工法を採用した。橋脚構造には，高強度コンクリート（設計基準強度：$50N/mm^2$）と高強度鉄筋（降伏強度：$685N/mm^2$）による高強度材料を適用した。上部工には，波形鋼板上に架設作業車を設置して，複数ブロックで同時に施工し効率化を図ることができるRap-Con 工法 (Rapid Construction on corrugated steel web method) を適用し，急速施工に取り組んだ。