An Extradosed Bridge with a Center Span of 155 m over a National Highway — Hosotsubo Bridge —

国道を跨ぐ支間長155m のエクストラドーズド橋 — 北陸新幹線　細坪架道橋 —


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Synopsis

The Hosotsubo Bridge is a 339-m, 3-span continuous prestressed concrete (PC) extradosed bridge between Kagaonsen Station and Awaraonsen Station on the Hokuriku Shinkansen that crosses over National Highway No. 8 in Kaga City, Ishikawa Prefecture.
National Highway No. 8 is built on an embankment atop soft ground, which prompted concern that installing the foundations of the overpass in the embankment would result in deformation during earthquakes that could damage the embankment. Additionally, to satisfy the allowable deflection requirements for safe Shinkansen operation, a 339 m long 3-span continuous PC extradosed bridge with a center span of 155 m and side spans of 92 m was selected among other different types of bridges.

Structural Data

Structure: 3-span continuous PC extradosed bridge
Bridge Length: 339.0 m
Span: 92.0 m + 155.0 m + 92.0 m
Width: 13.76–14.56 m
Tower Height: 17.5 m
Box-girder Height: 4.3–7.0 m
Construction Period: Feb. 2017 – Nov. 2021
Location: Ishikawa Prefecture, Japan

1. Introduction

The Hosotsubo Bridge is a 3-span continuous PC extradosed bridge with a center span of 155 m, the longest span of PC extradosed railway bridges in Japan. The most significant challenge was to expedite the handover of the bridge—and thus the launch of Shinkansen operation—by shortening the overall construction schedule. Additionally, the methods for assembling and dismantling the form travellers were revised because the original plan for temporary traffic restrictions of the national highway to dismantle those form travellers was dropped.
This paper explains the above efforts as well as examples of steps taken to shorten the construction schedule.

Fig. 1 Hosotsubo Bridge

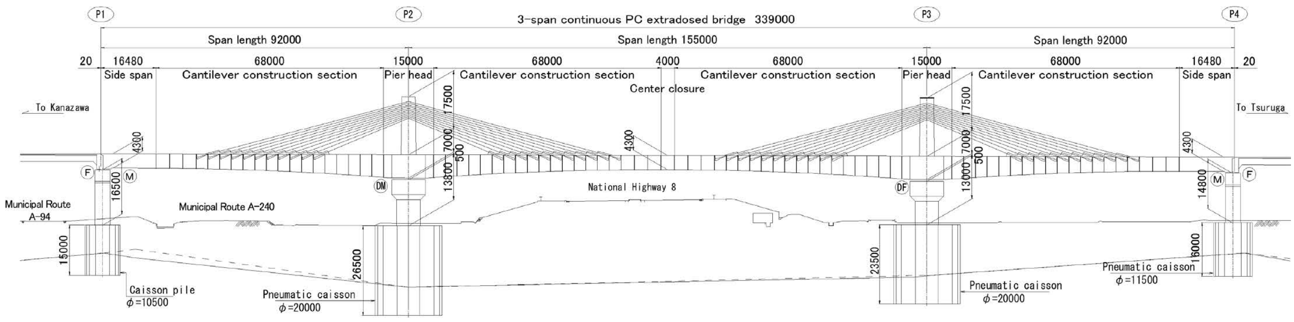

Fig. 2 Overview of Hosotsubo Bridge

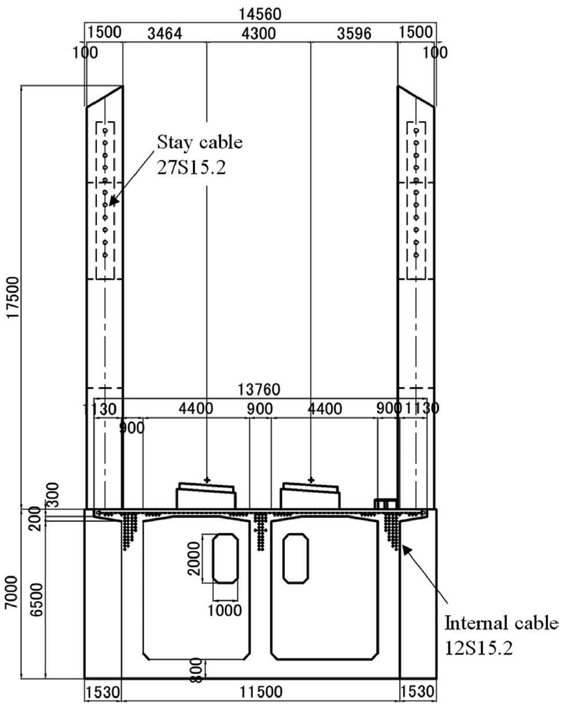

Fig. 3 Main girder (pier cap) cross-section view

2. Design

(1) Structural Type

Given the bridge's maximum span length of 155 m, it was necessary to limit the amount of long-term deflection due to temperature changes and creep. With respect to the girder height and number of cable stays, it was necessary to increase rigidity to limit deflection, however, increasing girder height for rigidity would also increase the girder weight and deflection. Therefore, stay cables were necessary to limit deflection. The balance between the increase of girder rigidity and weight was compared, resulting in a girder height of 7.0 m at the pier caps and 4.3 m at the girder ends and span centers, and 11 stays for the stay cables were determined for this bridge (**Figs. 2–3**).

3. Construction of the Main Girder

(1) Construction of Pier Cap

The double-line bearing structure of the bridge's pier caps required six bearings and four damper stoppers, resulting in congested arrangement of rebars and anchors. Additionally, given that D51 rebars would be used as the main reinforcement of the main towers, interfering of these rebars with other rebars as well as sheaths for internal cantilever cables was another concern. Therefore, a 3D CAD model was created and interference was checked prior to construction (**Fig. 4**). Bracket supports are normally used for pier cap construction, but for this bridge, the lower platforms of the form travellers were assembled in advance to serve as working areas for the pier cap formwork and falsework (**Fig. 5**). This construction method

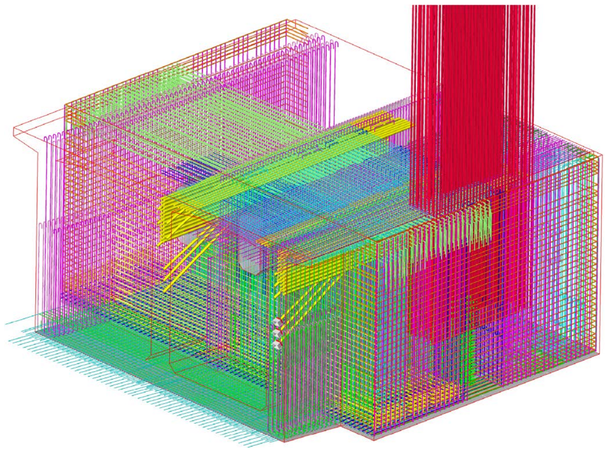

Fig. 4 Rebar verification using a 3D CAD model

Fig. 5 Pier cap falsework using the form traveller members

shortened the time to assemble the form travellers after constructing the pier caps. Also, it created enough working space and prevent objects to be fallen down to the side municipal roads during pier cap construction.

(2) Balanced Cantilever Construction

The cantilever construction of the bridge was carried out above National Highway No. 8. Thus, it was necessary to secure sufficient clearance between the highway and the bridge includes form traveller. Accordingly, a clearance measurement system was installed on the lower platform of the form travellers to continually monitor the distance between the platform and the highway (**Fig. 6**).

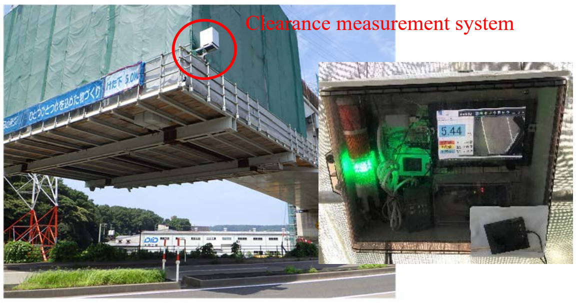

Fig. 6 Clearance measurement system

On this bridge, there are stay cable blisters from blocks 6 to 16; thus, the cycle process was longer for these blocks than for standard blocks. Steel formwork was used for the stay cable blisters to shorten the process. The shape and position of the blisters are the same for all blocks. Therefore, using steel formwork reduced the time and work for fabricating and installing the formwork. Conversely, given the expected difficulty of assembling some of the rebars when the reinforcement of the blisters was enclosed by steel formwork, the side sections were designed to be easily removable to facilitate rebar assembly (**Fig. 7**).

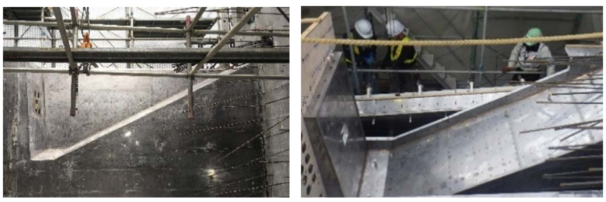

Fig. 7 Steel formwork at a stay cable blister

4. Construction of Stay Cables

(1) Outline

The stay cables of the bridge are suspended from both sides of the towers and anchored in blisters located at the outsides of the outer webs of the main girder. The stay cables pass through the saddles of the main towers and are arranged at the main girder on the origin and terminal sides. The stay cables have a three-layer corrosion-resistant structure, with epoxy resin-coated PC steel strands jacketed in a fiber-reinforced plastic (FRP) protective pipe and grout.

(2) Connecting and Erecting the Protective Pipe

White FRP was selected as the material of the protective pipe for the stay cables to reduce the temperature changes of the steel. As for the method of connection and erection, each 5.5-m length of pipe was connected to the next on the bridge deck and hoisted into position using a winch. After attaching a length of pipe to the previous length on a scaffolding built for the task, a sling and pulley were used to suspend the pipe from a pilot wire, and a hoisting device was used to hung up the pipe into position for the next length of pipe to be attached and erected. This sequence was repeated until all lengths of pipe were connected (**Fig. 8**).

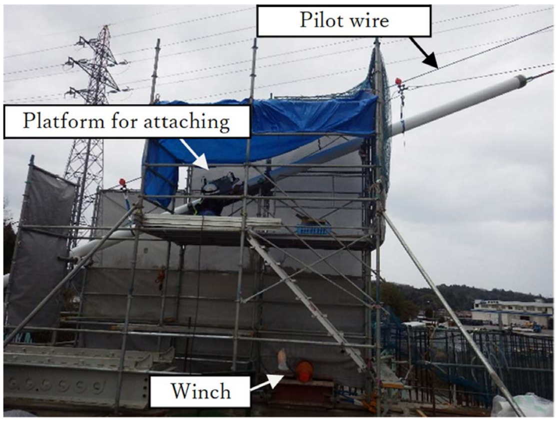

Fig. 8 Scaffolding for connecting protective pipe

(3) Stay Cable Tensioning

Stay cable tensioning was performed by setting up tensioning jacks on temporary rail suspended from the stay cable blister (**Fig. 9**). The tensioning was performed simultaneously using four jacks to prevent torsion of the main girder. Additionally, to minimize deviations in the timing of the tensioning due to pump operation, an improved method was used in which a single pump simultaneously operates two tensioning jacks.

Fig. 9 Tensioning jack setting condition

5. Dismantling the Form Travellers

As described previously, for this bridge, it was necessary to dismantle the form travellers away from the national highway. Therefore, the upper beams of the form traveller were designed to be movable in the vertical upward direction allowing the form traveller to be retracted toward the towers (away from the highway).

Fig. 10 shows the process for dismantling a modified form traveller. Although raising the upper beams made it possible for the form traveller to be retracted toward the towers up until block 9, it was still difficult to position the crane to dismantle the heavy main frame in that position. Therefore, the bottom platform was dismantled, and the main frame was moved farther back until it was within the operating radius of the crane for dismantling. To facilitate this, the form travellers were designed so that the ends of the upper beams that interfered with the stay cables were fixed with bolts, and removed after dismantling the bottom platform (**Figs. 11–12**).

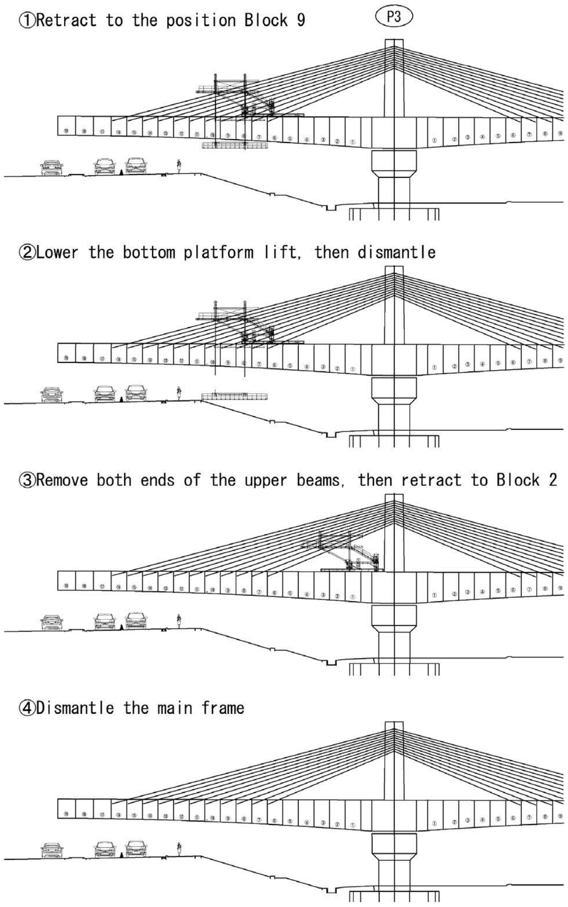

Fig. 10 Procedure for dismantling a form traveller

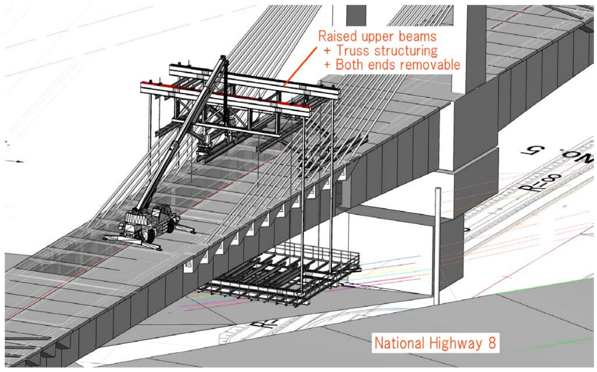

Fig. 11 Dismantling the bottom platform

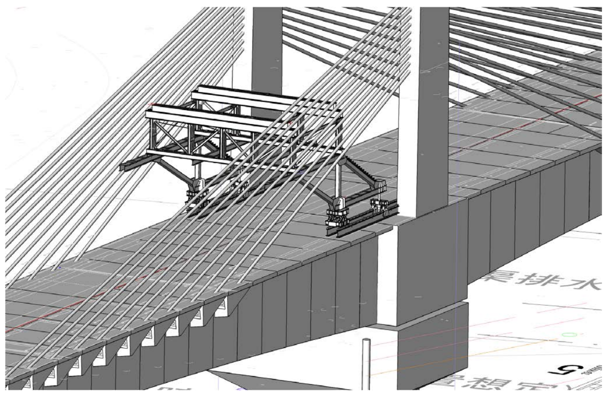

Fig. 12 Dismantling the main frame

6. Conclusion

The 155 m center span of the Hosotsubo Bridge is the longest of all railway bridges in Japan. Although working conditions were very strict —cantilever construction over live traffic on a national highway— the workarounds described in this paper enabled on-time handover of the completed railway bridge.

概　要

細坪架道橋は，北陸新幹線の加賀温泉駅～芦原温泉駅間に位置し，石川県加賀市内の国道 8 号と上空で交差する橋長339m の 3 径間連続 PC エクストラドーズド橋である。

本橋と交差する国道 8 号との離隔や新幹線の走行安全性を考慮した許容たわみ量を満足するように径間長および橋梁形式を検討した結果，橋長339m，中央支間長155m，側径間長92m の 3 径間連続 PC エクストラドーズド橋が採用された。中央支間長155m は鉄道橋における PC エクストラドーズド橋としては国内最長である。

新幹線開業に向けて，全体工期を短縮し，橋面の早期引渡しを実現することが最大の課題であったため，様々な工期短縮への取組みを行った。