Design and Construction of Deck Slab Widening on Existing Bridges — Kirigataki Bridge on the Shin-Meishin Expressway —

既設橋における床版拡幅の設計・施工 ― 新名神高速道路　錐ヶ瀧橋 ―

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* Yuki KAMINAGA, P.E.Jp: Sumitomo Mitsui Construction Co., Ltd.
紙永　祐紀，技術士（建設部門）：三井住友建設（株）
** Tatsuya FUKUMOTO: Sumitomo Mitsui Construction Co., Ltd.
福本　達也：三井住友建設（株）
*** Yushi KITA: Central Nippon Expressway Co., Ltd.
喜多　雄士：中日本高速道路（株）
**** Michiru MURO: Central Nippon Expressway Co., Ltd.
室　充：中日本高速道路（株）
Contact: ykaminaga@smcon.ne.jp
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Synopsis

This project was conducted to widen the existing Kirigataki Bridge located within the Kameyama-Nishi Junction on the section of the Shin-Meishin Expressway between the Kameyama-Nishi and Shin-Yokkaichi Junctions. This project was requested to keep two lanes during construction for deck slab widening of long-span bridges located in a mountainous area. With these construction limitations, mobile overhanging platforms were used to carry out the works. This paper presents design and construction of deck slab widening on existing bridges conducted on existing bridges while in service.

Structural Data

Structure: Prestressed concrete continuous rigid-frame box-girder bridge
Widened Length:
Inbound lanes: 605 + 153 m
Outbound lanes: 57 + 81 m
Widened Width:
Inbound lanes: 0.45–4.10 m
Outbound lanes: 0.50–2.18 m
Owner: Central Nippon Expressway Co., Ltd.
Designer: Sumitomo Mitsui Co., Ltd.
Contractor: Sumitomo Mitsui Co., Ltd.
Construction Period: Jun. 2016 – Oct. 2019
Location: Mie Prefecture

1. General Overview

(1) Overview of the Project

The project was conducted to widen the Kirigataki Bridge built in 2004 on the Shin-Meishin Expressway. **Fig. 1** shows the overall layout of the project. Deck slabs were widened on the inbound and outbound lanes of the central and east bridges, for a total of four bridges. **Fig. 2** shows a general view of the bridges, while **Fig. 3** shows the main girder cross sections. The existing long-span bridges crossing a mountainous area are continuous prestressed concrete (PC) rigid frame box girder bridges with two chambers. The inbound lanes have a maximum span of 109 m and a maximum pier height of 64 m, while the outbound lanes have a maximum span of 90 m and a maximum pier height of 65 m. They were built with provisional widths and the design and construction carried out assuming bridge widening in the future. The cantilever slab section designed for widening was extended from the existing slab end and supported by struts to be installed in the inbound lanes, while it was simply extended from the existing slab end with no strut in the outbound lanes. Temporary safety barriers were installed to secure two service lanes, and after providing construction work areas on top of the bridges, the widening work was performed using construction platforms[1].

(2) Overview of Design and Construction

Because the widening work was carried out on the busy Shin-Meishin Expressway, two lanes had to be securely

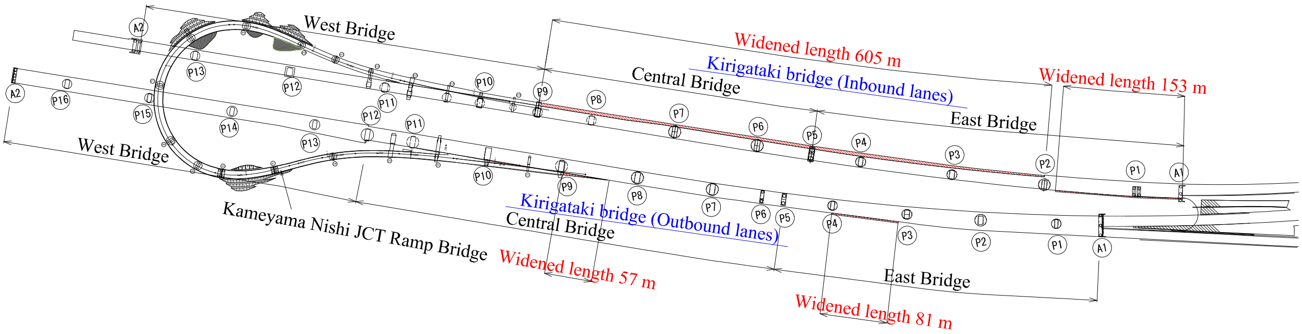

Fig. 1 Overall plan

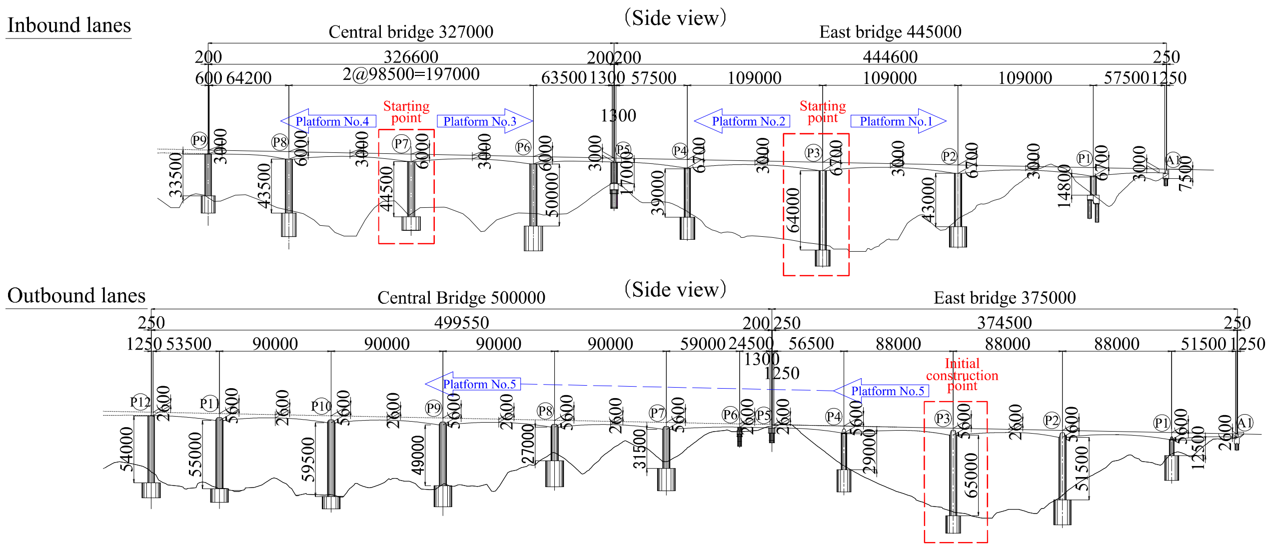

Fig. 2 General view

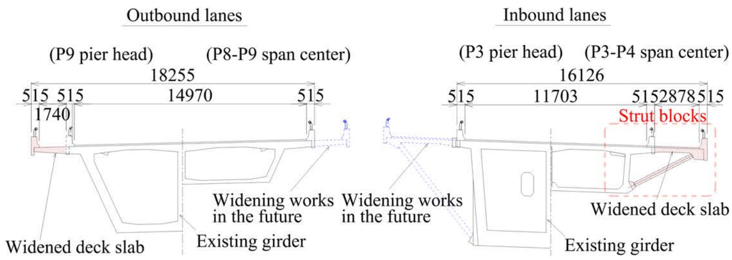

Fig. 3 Main girder cross sections

Fig. 4 Panoramic view of construction

opened for traffic throughout the construction. Area for construction use on top of the bridges was limited, especially on the narrower inbound lanes, therefore four mobile overhanging platforms were used to perform the deck slab widening work (**Fig. 4**). In addition, because pof the rugged terrain and mountainous location of the bridges, the starting point for construction were limited to piers P3 and P7 for the inbound lanes and pier P3 for the outbound lanes in order to mobilize the required construction materials and equipment. This paper presents the design and construction of the inbound lanes.

2. Design of Widened Deck Slabs

(1) Deck Slab Design

The cantilever length after widening the deck slabs of the inbound lanes is around 4.7 m at typical sections, with a maximum of about 6.0 m. The deck slabs were supported by struts to accommodate the large cantilever lengths. Strut blocks to hold struts in place were already present at 3.5-m intervals at the lower ends of the existing main girder sections.

Fig. 5 shows a detailed view of a widened deck slab section. Apart from the deck slab transverse tendons in the existing sections, additional transverse tendons (1S21.8) with 1.0-m intervals was designed. To

facilitate the placement of additional transverse tendons in the deck slabs, ducts were embedded in the existing deck slab sections.
These ducts made of polyethylene with an inner diameter of 38 mm were embedded for the post-tensioning of additional 1S21.8 tendons. The use of pre-grouted tendons has become common in recent years to achieve better grout reliability and durability. However, because of the fixed diameter of the embedded duct, epoxy coated and filled (ECF) prestressing strands were used with a nominal diameter of 21.8 mm. ECF strands were also used with a nominal diameter of 28.6 mm on the outbound lanes. Because the 19-wire ECF strands were used for the first time in this project, various tests were conducted to verify their performance.

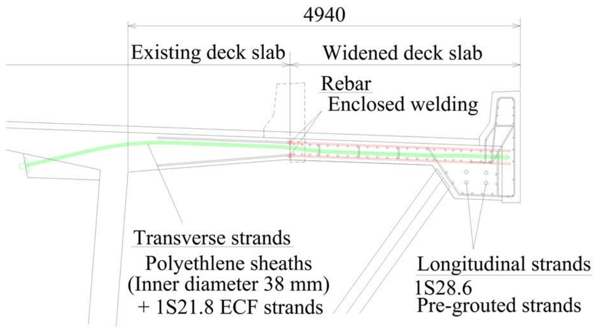

Fig. 5 Detailed view of widened deck slab section

(2) Design in the Longitudinal Direction for Existing Girder

Because more than 10 years had elapsed since the main girders of the existing bridge sections were constructed, the progress of concrete creep and drying shrinkage had already completed. In contrast, the deck slab widening sections were made of newly placed concrete. Consequently, the structure made of old and new concrete structural members required consideration of the age difference between those members. The old existing sections remain as PC structures, based on the design requirements at the time of their construction, with external tendons added to satisfy allowable values. To add external tendons that would take up increase of the dead load and the live load caused by widening the deck slabs on the main girders, anchoring devices were installed on crossbeams as well as deviator tubes on deviator sections.
The external tendons in the existing sections were grouted, with bare strands placed inside transparent ducts. The embedded external-tendon anchorage devices for deck slab widening were also made of similar products. However, it was impossible to use these embedded anchorages because production of the transparent ducts for this particular anchorage device had been discontinued. Instead, new anchoring members were installed on the outer side of the embedded anchoring devices (**Figs. 6** and **7**). These anchoring members use ultra-high-performance fiber reinforced cement (UHPFRC) to reduce their size and weight.

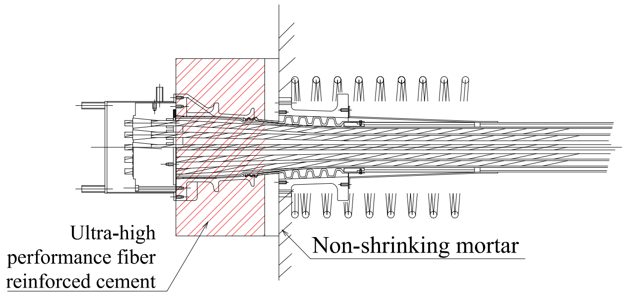

Fig. 6 Anchoring device (UHPFRC)

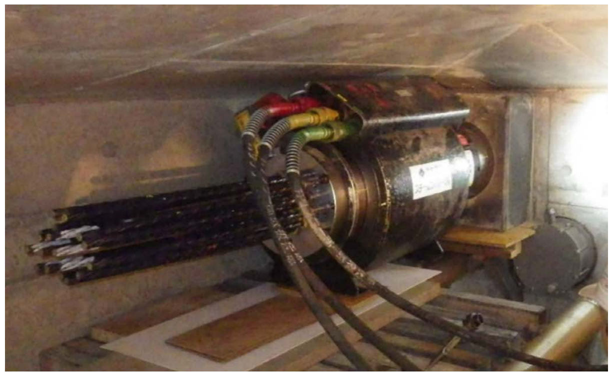

Fig. 7 Prestressing operation

3. Construction of Widened Deck Slabs

(1) Removal of Existing Bridge Barriers

The existing bridge barriers were removed before constructing the deck slabs. **Fig. 8** shows the special platform used for the removal work. Holes for using a wire saw and for lifting were core drilled into a barrier. Then, it was cut into 3-m blocks with a wire saw, lifted and removed using the special platform, transported by forklift to the pier acting as the initial construction point, and lowered from the deck slab.

Fig. 8 Removal of existing bridge barrier

(2) Removal of Existing Deck Slabs

Reinforcing bars in the widened deck slab sections were joined by enclosed welding. To perform enclosed welding on the deck slab rebars, it was necessary to remove the deck slab concrete up to the vicinity of the anchorage plates of the transverse tendons in the deck slabs. Deck slab concrete was removed using high pressure water jets sprayed from two nozzles to chip the concrete. The chipping depth was controlled by regulating the location of impact (**Fig. 9**).

Fig. 9 Removal of existing deck slab

(3) Construction of Widened Deck Slab Sections Using a Mobile Overhanging Platform

For the inbound lanes with small construction areas, the mobile overhanging platform shown in **Figs. 10** and **11** was used. To transport ready-mixed concrete, buckets were carried by forklift from the initial construction point to the rear of the construction platform and brought to construction area with the lifting device mounted on the platform.

The construction platform had to be able to support the overturning moments due to the weight of the formworks, scaffolding, and deck slab concrete. If the weight had been placed only in the transverse direction, then the arm would have been too short and the counterweight would have been too large, which would have affected the traffic lanes in service because the construction area was small on the inbound lanes. Therefore, the construction platform structure was extended in the longitudinal direction of the bridge with a counterweight provided at the rear for support (**Fig. 10**). Because the bearing points acting as supports were on top of the deck slabs, which cannot carry large reaction forces, a structure with multiple bearing points arranged on struts was used to disperse reaction forces.

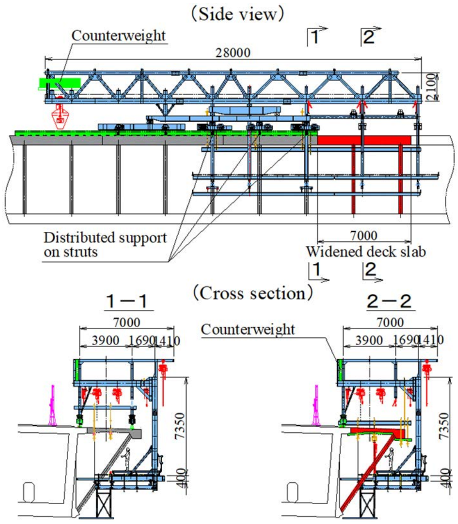

Fig. 10 Mobile overhanging platform

Fig. 11 Construction of widened deck slab section

4. Conclusion

This construction project was the first of its kind involving the widening of deck slabs on long-span bridges in a mountainous area while keeping them in service. Despite the various restrictions, the construction was completed successfully through design and construction innovations. The authors would like to express their gratitude to all those involved in the design and construction of this project for their guidance and assistance.

Reference

[1] Kaminaga, Y., Fukumoto, T., Kita, Y., Muro, M.: *Connecting a Floor Slab to an In-service Concrete Bridge for Bridge Widening. - Widening works of Kirigataki Bridge -*, Bridge and foundation Engineering, Vol.53, No.8, Kensetsutosho, Tokyo, pp. 67-70, Aug. 2019 (in Japanese)

概　要

本工事は新名神高速道路の亀山西 JCT ～新四日市 JCT 区間うち，亀山西 JCT 内に位置する既設橋である錐ヶ瀧橋を拡幅する工事である。重交通路線のため施工中も供用 2 車線を確保する必要があり，また橋面上の施工ヤードが狭く重機を配置できないため，専用の壁高欄撤去作業車と床版施工作業車を使用して施工を行った。また，架橋位置周辺の地形条件により資機材を搬入する施工起点が限定されたことから，各橋 1 箇所の中間橋脚から片押しで施工を行った。床版横締めには，内部充てん式エポキシ樹脂被覆 PC 鋼より線を使用し，グラウト充填不良による耐久性上のリスクを低減し，外ケーブルの追加配置では，超高性能繊維補強セメント系複合材料製の定着体を使用した。