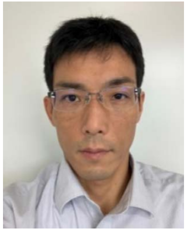
Replacement of RC Slabs with the Half Section Method
— Michitanidaini Bridge —

半断面施工による床版取替工事
— 道谷第二橋（上り線）—


*

**

***

****

* Tomoaki KAWABATA, P.E.Jp: P.S.Mitsubishi Construction Co., Ltd.
川畑　智亮，技術士（建設部門）：（株）ピーエス三菱
** Akira ENDO: West Nippon Expressway Co., Ltd.
遠藤　輝：西日本高速道路（株）
*** Daiki NAKAKO: West Nippon Expressway Co., Ltd.
仲子　大樹：西日本高速道路（株）
**** Yasuteru MITSUDA: P.S.Mitsubishi Construction Co., Ltd.
満田　恭輝：（株）ピーエス三菱
Contact: t-kawabata@psmic.co.jp

Keywords: construction of half sections, precast PC slab, construction machine, connecting joint
DOI: 10.11474/JPCI.NR.2022.149

Synopsis

The Michitanidaini Bridge (inbound lane) on the Chugoku Expressway is a 115-m-long 3-span continuous non-composite girder bridge that has been in service for 36 years (**Fig. 1**). The deteriorated reinforced concrete (RC) slabs caused by the intrusion of chloride ions were replaced with the precast prestressed concrete (PC) slabs, which was carried out under open traffic. Using general construction methods, require a full road closure of the inbound lane to replace the RC slabs, but because the inbound and outbound lanes were separated, this would have required closing a large traffic area. Also, being so close to the rest area or entrance and exit ramps, controlling the traffic flow near the construction site is very complicated and difficult. Therefore, to solve these problems, the authors developed a new technique for replacing the RC slabs under open traffic.

Structural Data

Structure: 3-span continuous steel non-composite girder bridge
Span: 38.0m + 38.0m + 38.0m
Width: 10.9m
Owner: West Nippon Expressway Co., Ltd.
Designer: P.S. Mitsubishi Construction Co., Ltd.
Contractor: P.S. Mitsubishi Construction Co., Ltd.
Construction Period: Oct. 2015 – Apr. 2017
Location: Yamaguchi Prefecture, Japan

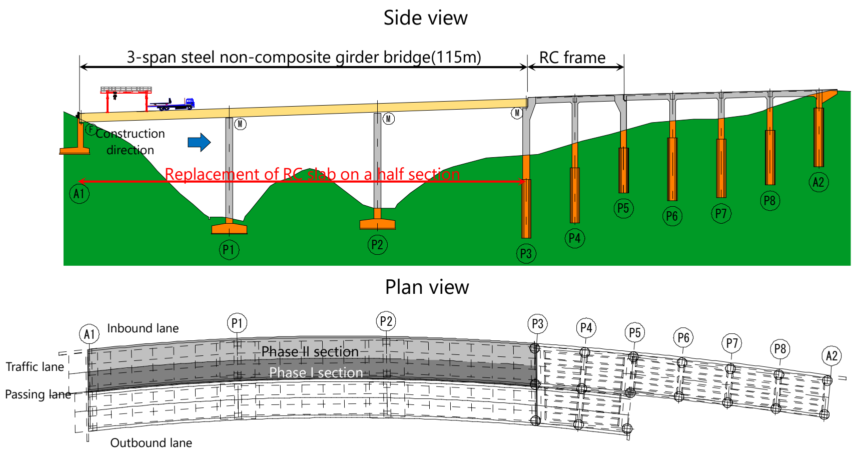


Fig. 1 General drawings of Michitanidaini bridge

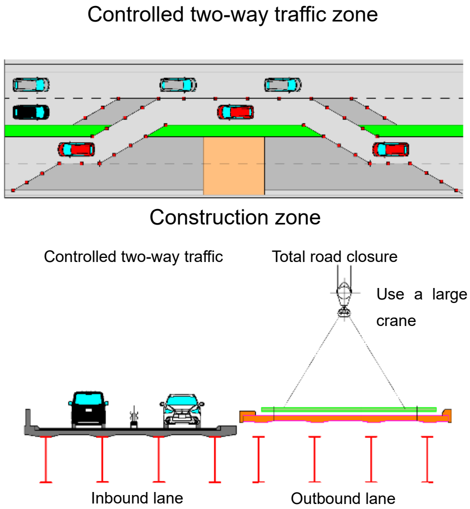


Fig. 2 Example of switching lanes

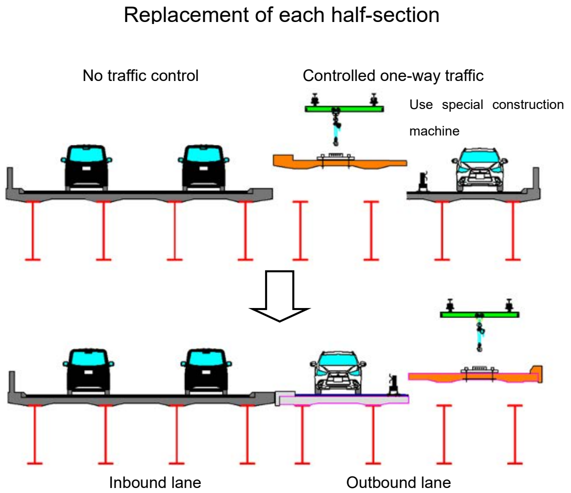


Fig. 3 Example of replacing each half-section

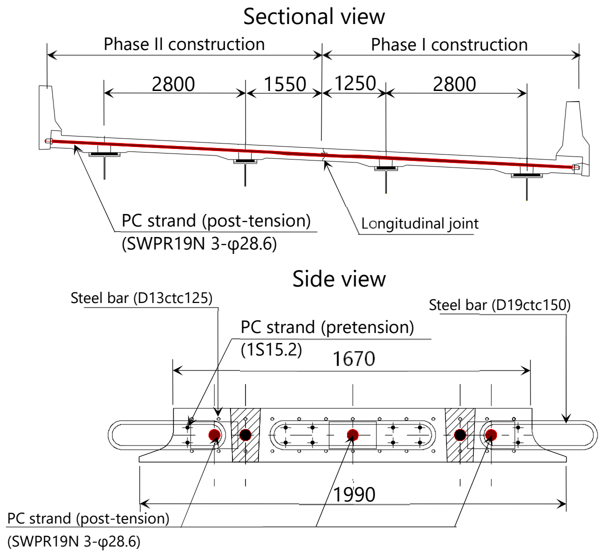


Fig. 4 Precast PC slab

1. Introduction

In Japan, a great concern is that most of the social infrastructure that was built during the country's period of rapid growth (1954–1972) has entered a phase of accelerated deterioration. Cases of severe damage to expressway bridges due to aging and environmental impacts are now gradually surfacing. The restoration and repair of those bridges are underway on a broad scale. For one such bridge—the Michitanidaini Bridge—the plan was to replace its current deck slabs entirely with precast PC slabs of high quality and superior durability. However, its inbound and outbound lanes were separated; thus, the authors would have had to close a large traffic area. Moreover, being so close to the rest area or entrance and exit ramps, controlling the traffic flow near the construction site is very complicated and difficult. To solve these problems, the authors therefore developed a new technique for replacing the RC slabs under open traffic.

2. Construction Methods

Generally, replacing deck slabs is done by full-width replacement as shown in **Fig. 2** after the road has been fully closed and an alternative route has been prepared. However, for a road with heavy traffic, it is impractical to conduct a full closure and provide an alternative route. Therefore, the option of replacement by half sections with a partial lane closure was proposed, as shown in **Fig. 3**[1]. The project [2][3][4] was divided into two parts, namely, phase I for replacement of the passing lane and phase II for replacement of the traffic lane. The scope of work of this project includes the replacement of the existing RC slabs from A1 to P3 of the inbound lane.

3. Design of Half-section PC slabs

(1) Summary of the Design

The RC slabs were to be replaced for each half section, which required a connecting joint in the bridge's longitudinal direction, along the central line of the width of the bridge. To solve this problem, the structure was designed such that the precast PC slabs on both sides were connected by means of post-tensioning PC strand after erection of the PC slabs (phase II). **Fig. 4** shows sectional and side views of a PC slab at the time of completion. The connecting joint was designed to be in a fully compressed state when the design load was applied. Assuming that the deck slabs must be replaced again or the connecting joint would be incurred damage, the PC slabs of phases I and II were designed as pretensioned components that can stand independently of each other.

(2) Introducing Prestressing force into the Connecting Joint

The connecting joint for the precast PC slab segments was designed according to the specified design technique for precast segments. To resist bending stress, a prestressing force was introduced to prevent tensile stress at the connecting joint under a designed load, and regarding shearing force, the structure

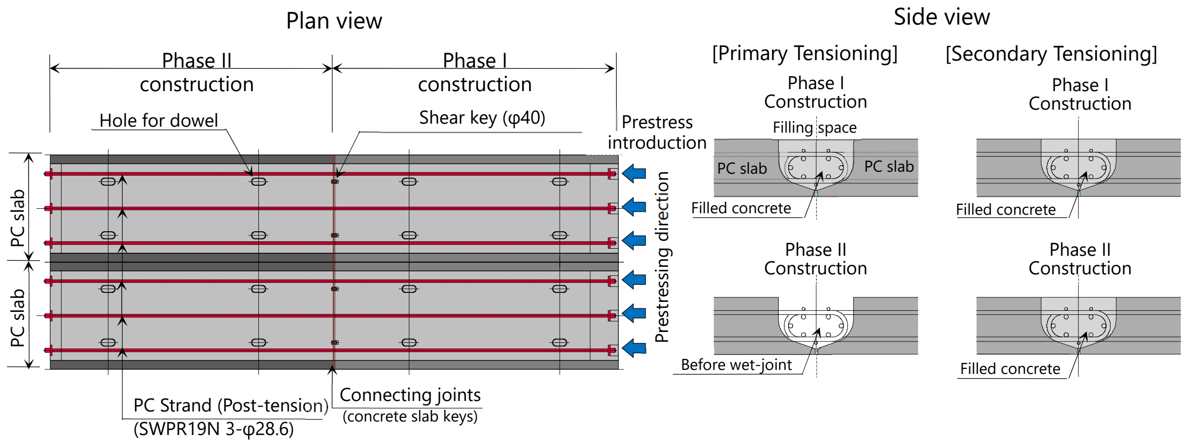


Fig. 5 Conditions of connecting joints at time of introducing prestress for each phase

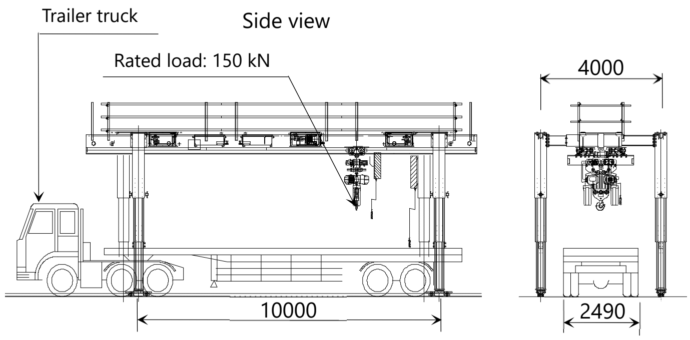


Fig. 6 Summary of the construction machine

Fig. 7 The construction machine being transported on a truck

was designed to allow such force to be transmitted through the concrete slab keys. Considering that (i) the slab segments had to be connected to each other through wet joints and (ii) a slab is a PC structure, the apprehension was that sufficient durability could not be ensured if the connecting joint was not prestressed. To alleviate this concern, the authors decided to introduce prestress also into the wet joints of the slab segments such that the structure was more durable. Prestress was introduced twice: the primary tensioning was done after placing the phase II slab segments, and the secondary tensioning was done after concrete placement of wet joints in phase II construction. At the time of primary tensioning, traffic was already open on the completed lane of phase I. **Fig. 5** shows the conditions of the connecting joint in each phase.

4. Structural Summary of the Construction Machine

A construction machine to operate in a half section must have the capacity of transporting, assembling, and dismantling within one lane, and a new type of construction machine was developed for this purpose. The machine had to be of a size that allowed it to be carried on a single trailer. In order to transport and erect slab segments within a half section (one lane), the machine had two hydraulic cylinders on each of its four legs, one operable in the horizontal direction and the other in the vertical direction. The machine could transport and erect slab segments independently without depending on a dedicated crane. The construction machine is shown schematically in **Fig. 6** and a view of transporting the machine is shown in **Fig. 7**.

5. Construction

(1) Phase I Construction

First, the pavement on the passing lane side was cut and removed, and then the deck slab was cut into sufficiently small pieces for removal. Following this step, the dedicated construction machine was transported to the site on a trailer, and it was assembled ready for independent operation without using a crane or other means. The existing deck slabs were separated from the steel girders using a hydraulic jack. After that, the existing slabs were removed and the new

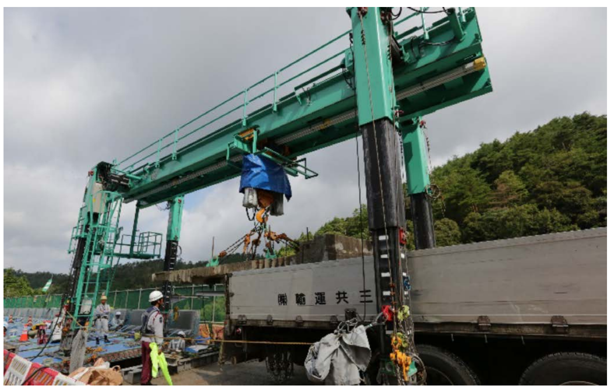


Fig. 8 Removal of existing slabs (phase I)

precast PC deck slabs were placed using the dedicated construction machine (**Fig. 8**). The deck slabs were placed in order at a rate of three slabs per day. The dedicated construction machine was then moved to the next segment, and the same steps were repeated until all the slabs in the passing lane had been replaced.

(2) Phase II Construction

For the phase II construction, the passing lane was open to traffic, and the deck slabs were replaced in the same way as in the phase I construction. Additional work to be conducted in this stage is to connect the new PC deck slabs to the passing lane. Shear keys were installed along the longitudinal joint for construction. Thus, the segments could be set accurately and construction completed quickly. On the connecting surface, a special epoxy resin-based adhesive with high elasticity was applied and the new deck slabs were placed by the construction machine (**Fig. 9**). Next, the connecting PC strand was inserted from the shoulder of the traffic lane manually for tensioning, which was done in two stages (**Fig. 10**).

Fig. 9 Construction of PC slabs (phase II)

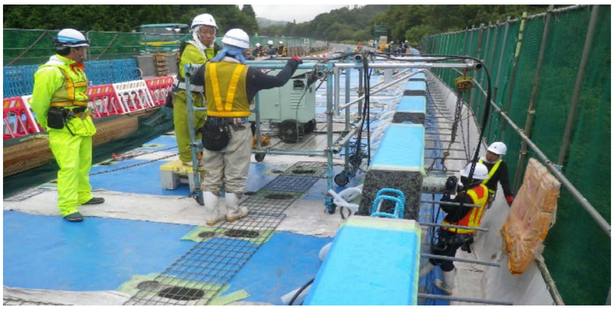


Fig. 10 Introducing the second tensioning (phase II)

6. Conclusion

This project, an expressway restoration project involving major renovation and repair plans, was aimed at replacing the RC slabs while keeping one of the two lanes open to traffic to reduce the social impact. Although a new approach different from total closure of both lanes in one direction, this replacement method could be completed as shown in the current project (**Fig. 11**). The authors' hope is that this report offers a valuable example for future expressway renovation projects.

Fig. 11 Completed project

References

[1] Morohashi, K., Mishima, K., Wada, Y., Aoki, K.: *Development of Exchange Technology of Deteriorated Reinforced Concrete Slabs*, fib Symposium 2016 Cape Town, South Africa.

[2] Honjo, K., Yamashita, Y., Kirikawa, K., Yamamura, S.: *Replacement of bridge deck slabs to attain a higher durability by half section replacement - Michitanidaini Bridge on Chugoku Expressway* -, 26th Symposium on Developments in Prestressed Concrete, 2017 (in Japanese).

[3] Shimizu, H. et al.: *Design and Construction Report of Slab Replacement on the Chugoku Expressway Michitani Second Bridge - Half by Half Section Slab Replacement Construction by One-lane Traffic Regulation* -, Journal of Prestressed Concrete, Vol. 59, No.2, JPCI, Tokyo, p.54-59, Mar. 2017 (in Japanese).

[4] Yamamura, S., Hisayuku, T., Yamashita, Y.: *Replacement of RC Slabs with Half Sections on the Michitanidaini Bridge to Increase Durability*, fib Symposium 2019 Krakow, Poland.

概　要

道谷第二橋は，供用開始から36年経過した橋長115m の鋼 3 径間連続非合成鈑桁橋であり，塩害等による既設 RC 床版の劣化から，片車線ごとにプレキャスト PC 床版へと取替えた工事である。本橋梁は上下線が分離していることから，従来の全面通行止め（対面通行規制）による床版取替工事では，交通規制区間が広範囲となる。また，施工箇所が SA・PA に隣接する場合は，車両の流入・流出が困難となる。本工事はこれを解決すべく開発された，片側車線規制により実施可能な半断面床版取替工事である。