Concrete Slab Replacement in Heavy Traffic Expressway — Mukaizano Bridge in the Kyushu Expressway —

重交通高速道路におけるコンクリート床版取替え — 九州自動車道・向佐野橋 —


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Synopsis

Mukaizano Bridge is located in a section of daily traffic with 100,000 vehicles in the Kyushu Expressway (**Fig.1**). From about 10 years after opened, degradation has spread in the reinforced concrete (RC) slab on the steel plate girder bridge. Therefore, renewal construction has been carried out to replace the entire RC slab with precast prestressed concrete (PCa PC) slab.

In Japan, looped splice joint is popular as a joint of PCa PC slab. But, to reduce the traffic control period and suit the site condition, End-band splice joint of Pca PC slab has been adopted in this project.

In addition, to improve durability and prevent exfoliation, ground granulated blast-furnace slag (BFS) and polypropylene fiber mixed concrete was used in the slab concrete.

Structural Data

Structure: Single-span RC hollow slab bridge,
4-span continuous steel plate girder bridge,
2-span continuous RC hollow slab bridge
Bridge Length: 210.05m
Span: 18.35m, 37.50m + 2@38.00m + 38.50m,
18.47m + 18.65m
Width: 32.00m
Owner: West Nippon Expressway Co., Ltd.
Designer & Contractor: Oriental Shiraishi Corp.
Renewal Construction Period: Jan. 2010 – May 2011
Location: Fukuoka Prefecture, Japan

Fig.1 Mukaizano Bridge

1. Introduction

Mukaizano Bridge in the Kyushu Expressway, which includes a steel plate girder bridge and a RC hollow slab bridge, was opened in 1975 (**Fig.2**). From about 10 years after opened, degradation has spread in the RC slab on the steel plate girder bridge, due to the low-quality of concrete, heavy traffic volume, using anti-freezing agent in winter, etc. Therefore, renewal construction has been carried out to replace the entire RC slab with PCa PC slab.

Since this bridge was located in a section of daily traffic with 100,000 vehicles, a traffic jam was predicted due to the decrease of the number of traffic lanes during replacing work of slab. Therefore, reduction of the traffic control period was required. Hereinafter, the summary of project is described.

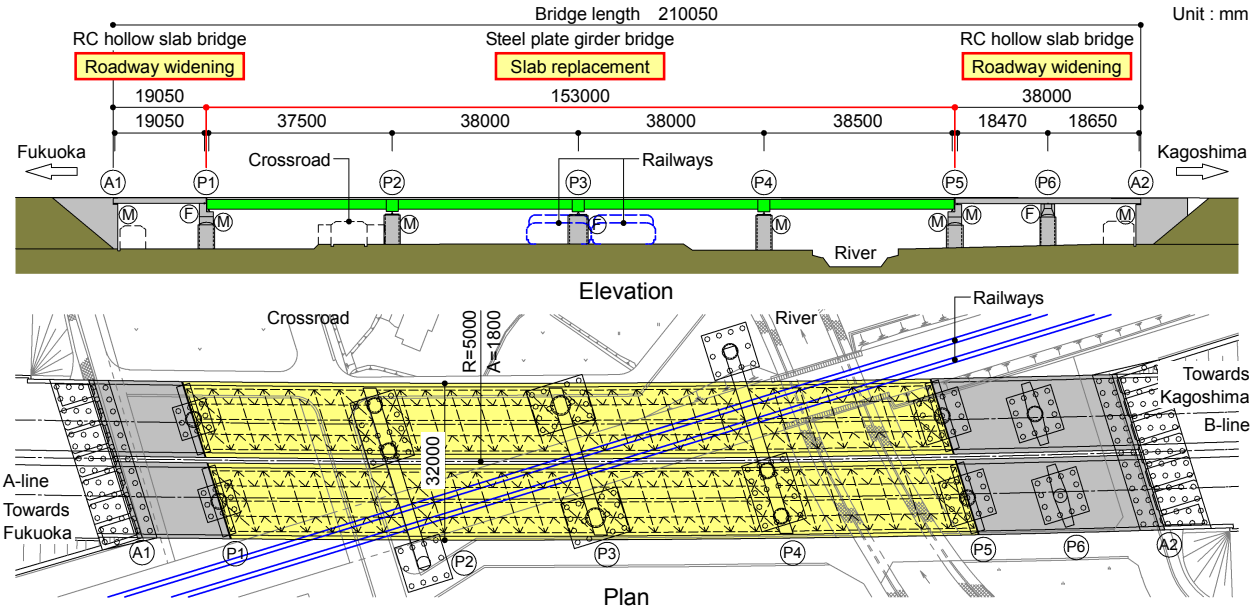


Fig.2 General view

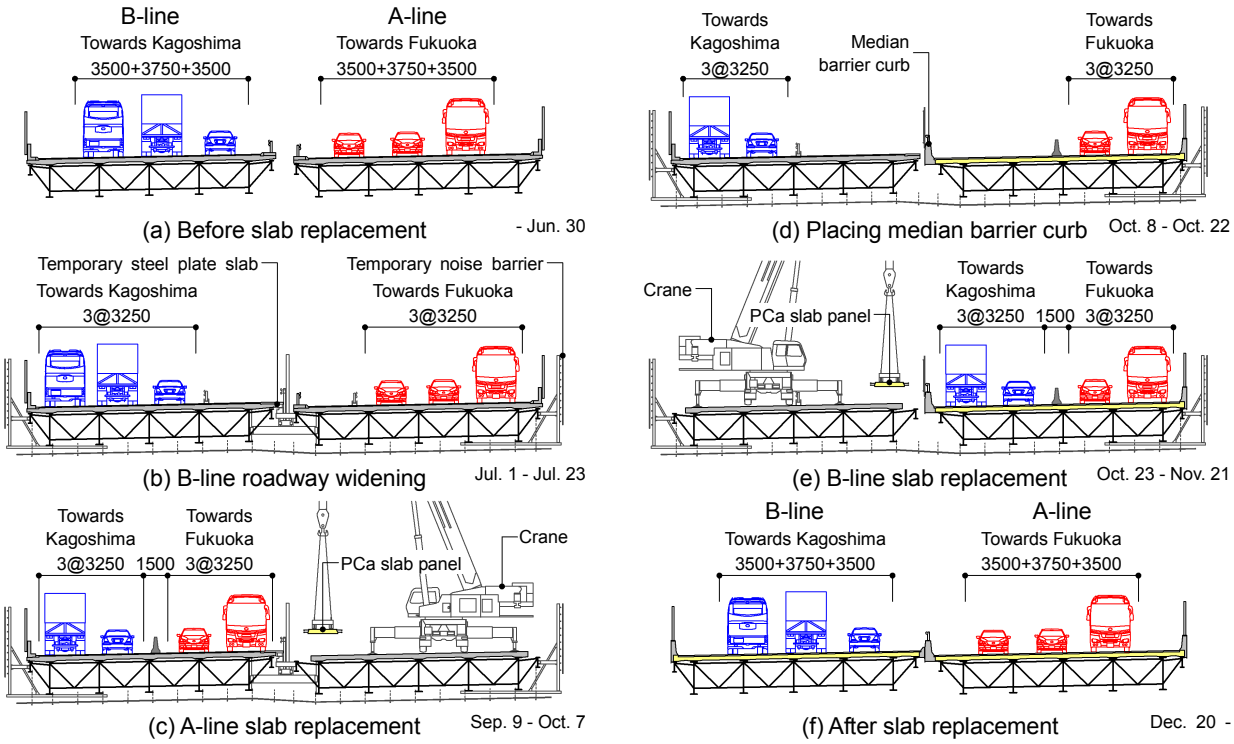


Fig.3 Slab replacement procedure

2. Slab Replacement Method

The slab replacement project at Mukaizano Bridge was carried out in the most heavy traffic expressway in Japan in the past. In addition, it was the largest slab replacement on the expressway of Japan.

The procedure of slab replacement is shown in **Fig.3**. The slab replacement was carried out with traffic restriction of each line. Because 6 traffic lanes in total decreased in 4 traffic lanes under traffic restriction, furthermore lane width decreased, a traffic jam was expected in a holiday and the commuter rush hour of morning and evening. Therefore, the slab replacement period was limited between the Summer and New Year vacation season, when the traffic is less. It was wished the slab replacement was over as soon as possible. On the other hand, the works with noise had limitation between 8:00 AM to 6:00 PM, because private houses are closed to the site. **Fig.4** shows B-line slab replacement under traffic restriction. The slab replacement of each line was completed in 30 days. **Fig.5** shows PCa slab panel erection using truck crane during nighttime.

Fig.4 Slab replacement under traffic restriction

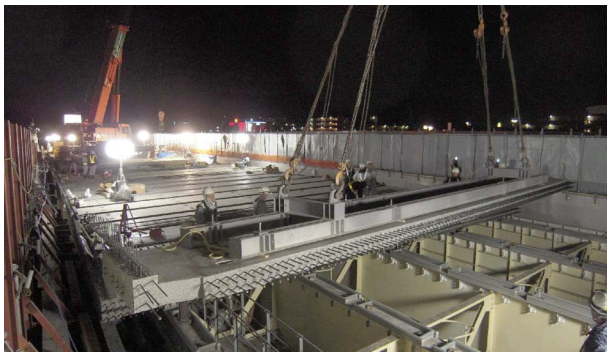
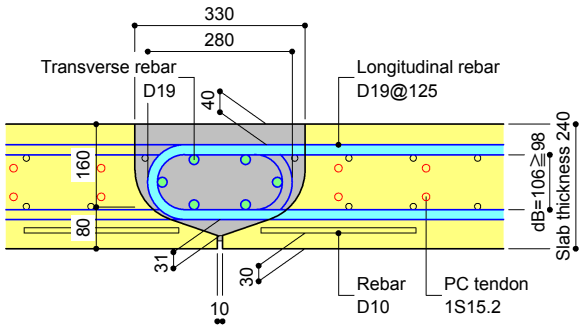
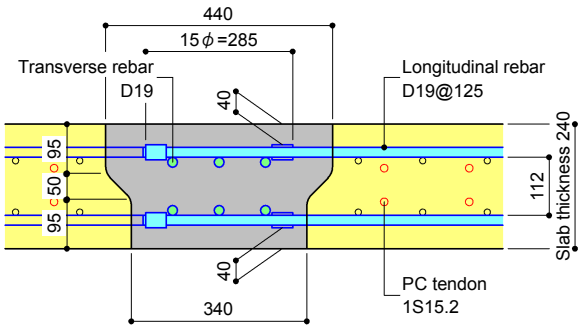


Fig.5 Erection of PCa slab panels



(a) Conventional looped splice joint, Japan



(b) End-band splice joint adopted in Mukaizano Bridge

Fig.6 Comparison of RC jointing method with PCa PC slab

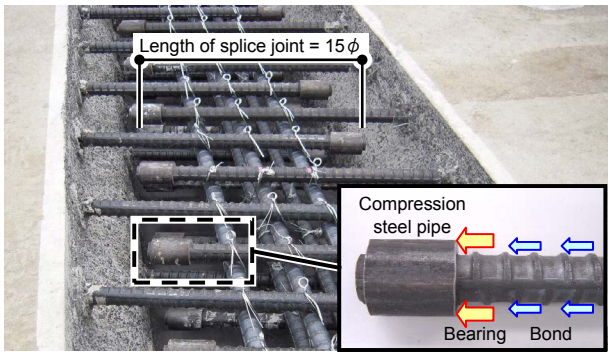


Fig.7 End-band splice joint

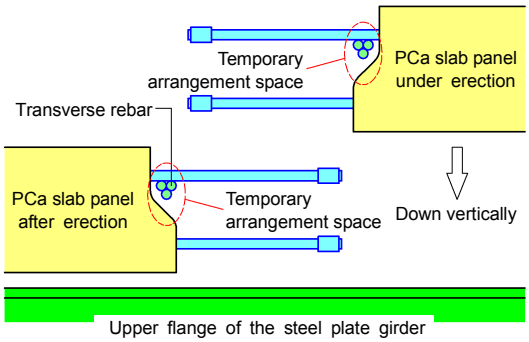


Fig.8 Installation of transverse rebars into joint

3. Joint of PCa PC Slab

(1) End-band Splice Joint

In order to obtain thinner slab thickness, reduce joint part length and improve workability of joint part, a new lap-splice joint of PCa PC slab was developed[1]. **Fig.6** shows conventional looped splice joint in Japan, and new lap-splice joint (called End-band splice joint). In the End-band splice joint, compression steel pipe on the tip of the rebar was used (**Fig.7**).

A major advantage of the End-band splice joint is related to the arrangement of rebars in transverse direction. In case of looped splice joint, transverse rebars have to be inserted in U-shaped bending rebars after the PCa slab panels are placed on the girders. Therefore, in case temporary noise barrier are fixed alongside the bridge under slab replacement (as shown in **Fig.3**), installing transverse rebars will be almost impossible without taking off temporary noise barrier. On the other hand, in case of the End-band splice joint, transverse rebars are able to put between End-band rebars sticking out from PCa slab panels before panels are erected on the girders (**Fig.8**), and the problems regarding use of looped splice joint are solved.

Another major advantage of End-band splice joint is to reduce slab thickness. However, slab thickness was not reduced in this project, because the bridge is located in a section of heavy traffic expressway.

(2) Wheel Loading Fatigue Test

Because of Mukaizano Bridge is located in heavy traffic volume, it was required to check fatigue durability of joint. Therefore, wheel loading fatigue test was carried out, under the same condition as in the test that have been made to conventional looped splice joint (**Fig.9**). The wheel loading fatigue test proved that the End-band splice joint have the same level fatigue durability in comparison with the looped splice joint[2].

Fig.9 Wheel loading fatigue test

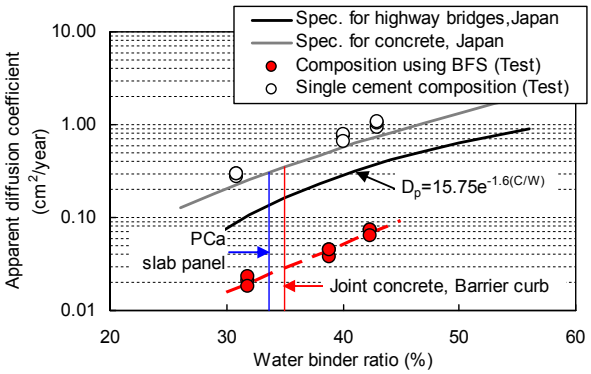


Fig.10 Chloride diffusion coefficient of concrete[3]

4. Improvement in Durability

In the section where Mukaizano Bridge is located, anti-freezing agent is sprayed in winter (about 10t/km/yer). Therefore, in order to reduce the ingress of chloride ions in the new concrete slab and concrete barrier curb, concrete in which 50% of the cement was replaced with BFS 6000 (specific surface area is 6000cm^2/g) was used for all the concrete. The apparent diffusion coefficient of composition using BFS was approximately one tenth of that obtained for the single cement composition (**Fig.10**)[3]. As well as ingress of chloride ions were reduced, alkali-silica reactions were reduced by using BFS. Furthermore, the CO_2 emissions associated with concrete manufacture can be reduced by about 43%.

In addition, from the fact that this bridge crosses over the road and the railways, polypropylene fiber (length of fiber is 30mm) was mixed in new concrete slab to prevent exfoliation (**Fig.11**). Mixing volume fraction of the fiber is 0.5Vol%.

5. Conclusion

This slab replacement project was carried out in the most heavy traffic expressway in Japan in the past. Therefore, new jointing method of PCa PC slab was adopted to reduce the traffic control period and suit the site condition. Also, the durability of the slab will be improved than conventional slabs on the bridge in Japan. At the end, the authors will be glad if this project is any help to the people concerned to slab replacement in the future.

Fig.11 Polypropylene fiber

References

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概　要

九州自動車道の向佐野橋は，鋼鈑桁橋および RC 中空床版橋で構成された橋である。本橋は1975年に供用を開始したが，鋼鈑桁橋の RC 床版の劣化進行が著しいことから，抜本的な補修対策としてプレキャスト PC 床版を用いた全面取替え工事を実施した。本工事は，日交通量約10万台の重交通高速道路で行われたことから，渋滞が生じる車線規制期間を短縮するとともに，高速道路利用者や周辺環境に配慮した施工方法を採用した。さらに，材料等の仕様は，耐久性の向上と環境負荷の低減に配慮した。

プレキャスト PC 床版の接合方法には，日本では一般的にループ継手を用いているが，本工事では，住宅地に近接するなどの施工上の制約から，エンドバンド継手を採用した。エンドバンド継手の採用にあたっては，輪荷重走行疲労試験を実施し，疲労耐久性がループ継手と同等であることを確認した。

また，プレキャスト PC 床版のコンクリートには，凍結防止剤の散布に対する耐久性の向上から高炉スラグ微粉末（粉末度6000）を混合し，さらに，剥落防止対策としてポリプロピレン繊維を混入した。