Development and Application of Precast Slabs Considering Rapid Replacing for Miyuki Bridge of Nishi-Meihan Expressway

西名阪道御幸大橋の床版取替工事の急速施工のための開発と施工


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Synopsis

In Japan there was more motorization than expected. Therefore, bridges which were designed according to old speculation were getting to degraded conditions because of fatigue. Especially serious damages were found on reinforced concrete slabs. After all, renewal of the slabs on steel bridges was constructed, though various retrofitting works were done. Miyuki Bridge (**Fig. 1**) of Nishi-Meihan Expressway that is more than 40 years old is focused. As lots of vehicles pass on the bridge per day and there is no other substitute expressway, the owner required to minimize influences to traffic. In actual retrofitting, the traffic control was decided to stop traffic only at night. This was the first case of replacing slabs in Japanese expressway under such circumstances. The execution was divided into three terms considering the traffic control.

At the first term, the bridge was a non-composite plate girder, and the type of replacing slabs were precast pre-stressed concrete (hereinafter, PC) slabs with loop connection. It took nine nights to replace 16 panels which were about 10m wide and 2.5m long.

The second construction was the replacement work for the slab on composite plate-girders. In this phase it was necessary to replace 14 panels in just five days. In order to replace the bridge deck, a precast type steel plate-composite deck was chosen[1].

A new connection of slabs for precast concrete was proposed in the third term. High early strength concrete is usually used in this joint and needs three hours to cure. To make rapid work, the special concrete which was enough strong to cure in one hour was used. Because of developed joint, it took six nights to replace 17 decks[2].

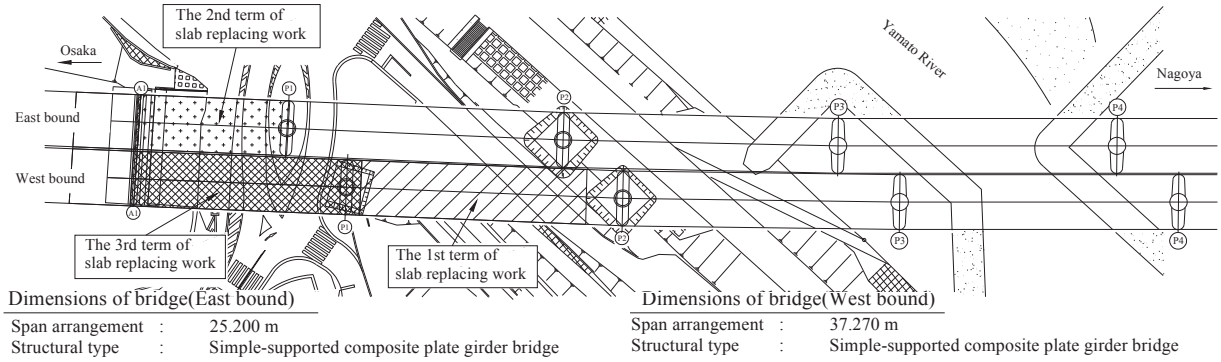
This paper reports the various tests of the proposed precast and the developed rapid slab replacement except the first work.

Structural Data

Structure: simple supported composite girder
Span: 37.27m (25.2m)
Width: 2@9.90m
Owner: West Nippon Expressway Co., Ltd.
Designer: Yokogawa Construction Co., Ltd. (I, III)
Kawada Industries, Inc. (II)
Contractor: Yokogawa Construction Co., Ltd. (I, III)
Kawada Industries, Inc. (II)
Construction Period: Oct. 2009 – May. 2012
Location: Nara Prefecture, Japan

1. Introduction

Miyuki Bridge was seriously damaged for pot-holes of pavement and cracking of the reinforced concrete slab have been found in recent years. These degraded condition caused the problem of noise and vibration to inhabitants in the neighborhood. Therefore, the owner decided the renewal of the slabs of this bridge. As over 60,000 vehicles pass on this bridge per day, the owner required to minimize influences to traffic and decided to stop traffic only at night during replacing the slabs.



Dimensions of bridge(East bound)
Span arrangement : 25.200 m
Structural type : Simple-supported composite plate girder bridge

Dimensions of bridge(West bound)
Span arrangement : 37.270 m
Structural type : Simple-supported composite plate girder bridge

Fig. 1 View of Miyuki Bridge

2. The second term of replacing slabs

(1) Precast composite slab

Precast composite slabs with a new joint structure (**Figs.2 and 3**) were adopted to the second term. They enabled shorter slab replacement time than PC slabs with conventional loop joints (in the first term) and also had equivalent durability to PC slabs. With this joint structure, nuts are equipped at the ends of the alternately arranged distributing reinforcing bars and the force in the distributing reinforcing bar is transmitted through the shear resistance of the transverse reinforcing bars and interfilling concrete. By adopting this form of joint, the interfilling width can be reduced to 240mm and construction time shortened.
A wheel load running test focusing on the joint structure was performed to ensure the fatigue durability in advance to the application to this bridge.

(2) Rapid slab replacement construction work plan

The slab replacement had to be carried out in the limited night hours when traffic was closed, however this bridge consisted of composite plate-girder and the slab and upper flange were fixed by densely-arranged horseshoe-shaped dowels. Therefore, it was impossible to carry out slab chipping, switch to new dowels and install a new slab within the limited time. In order to shorten the construction time during intensive construction days, cutting the main girder web and creating temporary joints were finished in advance. The slab, upper flange and materials on the upper edge of the web (hereafter "T-shaped materials") could be removed at the same time during the days of intensive construction allowing for the installation of a new slab and T-shaped materials (**Fig.4**).

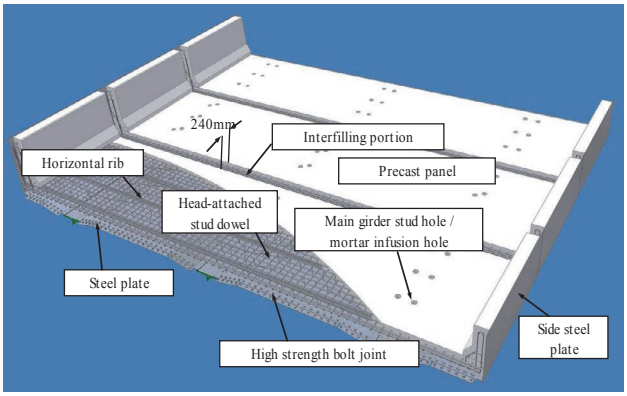


Fig. 2 Precast composite slab

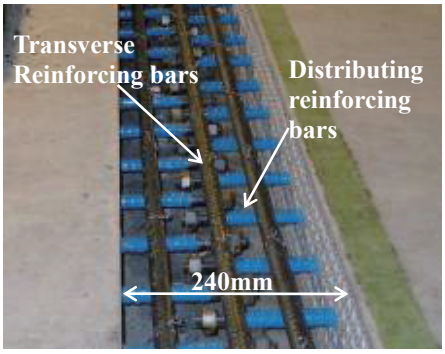


Fig. 3 Joint structure adopted to the second term

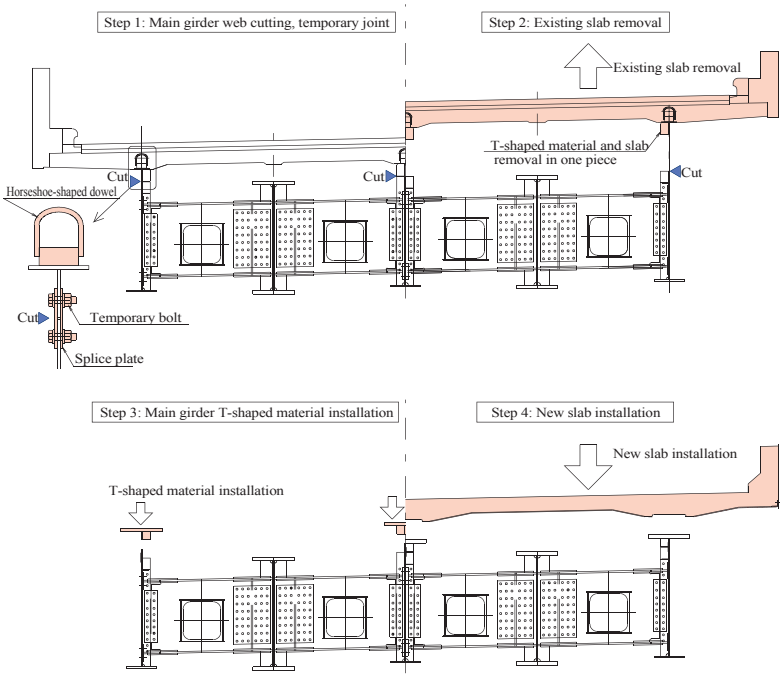


Fig. 4 Overview of slab replacement method

(3) Opening the bridge for traffic using an interfilling steel slab

As two to four slab panels were replaced per night during the intensive construction period, there was a temporary period where there was co-existing of existing slabs and new slabs. Accordingly, it was necessary to fill the gaps in the joint sections between both slabs in order to open a single lane to traffic during the day and this was done by using an interfilling steel plate as seen in **Fig.5**.

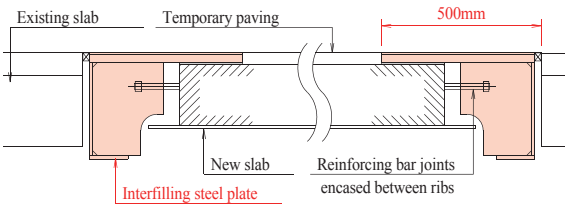


Fig.5 Interfilling steel plate deck overview

a) Slab cutting

b) Existing slab removal

c) T-shaped material

d) New slab installation

e) Jet concreting

f) Interfilling steel

g) Temporary paving

h) Completed paving

Fig.6 Stages of intensive construction work at second term

(4) Construction overview

Slab replacement was undertaken in the intensive construction period; however jacking-up of the main girder, cutting of the main girder web, and creation of temporary fished joints were carried out prior to the intensive construction period.

Two to four panels were replaced per night over a period of one week and bridge surface work such as paving was completed in the second week (**Fig.6**).

3. The third term of replacing slabs

(1) Outline

At the third term, there was a plan to replace 17 pieces of slab which is the same size of the first term. But, concrete barrier has been attached in the factory of precast concrete in considering of rapidity. The steel bridge with concrete slab is composite as the same as the second term. Therefore, the working procedure is almost same as the second term. There was necessity for the more rapid replacing of slabs to be accomplished in only six nights.

(2) Development of joint of precast slab

1) Outline of slit loop joint

A joint with loop shaped reinforcements for precast concrete slabs is popular in Japan. Especially, this joint is very often used in highway bridges. But, it takes

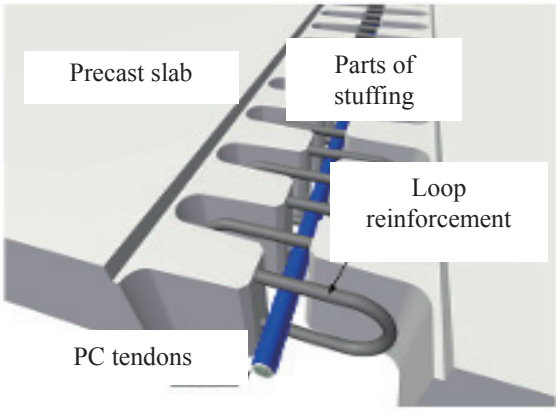


Fig.7 General view of slit loop joint

about 4 hours to work for reinforcement inserting and cure for high early strength concrete. To make better these points, the conventional loop joint was improved this time. The decrease of concrete volume for joints enabled to employ special concrete that only require one hour for curing from economical aspect. It is also advantage to mitigate the heat of hydration by special concrete. And it takes about half an hour to set PC tendons instead of reinforcing bars. The structure of this joint is shown in **Fig.7**. Under consideration of stuffing, the level of joint makes lower 30mm down to the top of the slab. This joint is called a slit loop joint.

2) Choice of material about stuffing between slabs

The requirements of stuffing between slabs for slit loop joint are as follows;

a. Material characteristics are same as precast concrete.
b. Material strength appears early as PC tendons are pre-stressed.
c. The heat hydration does not affect the joint performance so much.

To fulfill these conditions, ultra high early strength concrete was mixed with the coarse aggregates in the range of 10 from two millimeters. The amount of aggregate to mix was decided by the experiments. Consequently, the Young's modulus was improved compared with the mortal which has the same mix proportion. This ultra high early strength mortal with coarse aggregates was able to be stressed in one hour after the concreting. To put it concretely, compressive strength becomes over 30 N/mm^2 in one hour.

The proposed joint was tested by static and dynamic load in full-sized model. The dynamic load test is running wheel load test under consideration of fatigue. As a result, the proposed joint has enough fatigue durability and ultimate strength as expected.

(3) Application

1) Extraction themes from preceding executions

For references of experiences from the 1st and 2nd term, the persons concerned had meetings for themes. The temporary steel deck was improved from the point of view of control of vibration while replacing.

Grouting of precast slab to girder **Grouting to joint between slabs**

Fig.8 Construction works at 3rd term

2) Discipline on the figures and practical training

The owner, contractor and vendors together had exercised what they should do, how they worked on the figures and field, on the assumption of actual replacing work. Consequently, the persons concerned grasped the risk assessment and then got practical training on the works against high risk.

3) Execution

The working condition is almost same as the second term. The various situations of works are shown in **Fig.8**; they are different from the second term. To decrease noise from pavement, temporary pavement was surfaced on the temporary joint every day, and a temporary joint was divided into three pieces to adjust easily.

(4) Review

Although there is difference between structural characteristics, the work after replacing slab is almost same work. According to time table, it is clear that the work at the 3rd term with replacing for three slabs was faster than the work at the first term with replacing for two slabs. Finally, it was noticed that the mixer for this concrete needs more mixing ability to get more smooth work.

4. Conclusion

According to the series of those replacing, the following conclusion was acquired.

1) The procedure of replacing slabs on the highways with working at only night was established.
2) The quick change methods of composite girder and concrete slabs were developed.

References

[1] Mitsuda, T., Kihara, M., Yamada, H., Ryuto, M., Mizuno, H. and Hara, T. : *The replacing of slabs on the Miyuki Bridge at the 2nd term on Nishi-Meihan Expressway*, Bridges and foundations, Vol.,45, No.9, pp.15-20, September, 2011.(in Japanese)

[2] Mitsuda, T., Kihara, M., Kume, M., Mukandai, S., Yamaura, A. and Shirozu, A.: *The replacing of slabs on the Miyuki Bridge at the 3rd term on Nishi-Meihan Expressway,* Bridges and foundations, Vol.,46, No.2, pp.53-64, February, 2012. (in Japanese)

概　要

西名阪道御幸大橋は供用後約40年が経過し，床版や路面の劣化が進み，振動・騒音を惹起し，近隣に負担をかけていた。そこで，老朽化対策に加え環境対策として床版取替工事を行うこととした。施工条件は，夜間に施工し昼間は交通を解放する工法で，しかも短期間で行うことが求められた。

Ⅰ期工事では，仮設鋼床版を使用した昼間交通開放の技術を確立した。Ⅱ期工事では，仮設鋼床版のコンパクト化とともにプレキャスト合成床版の継手の改良を行い，1枚当たりの施工時間をⅠ期に対し6割に短縮した。Ⅲ期工事では，1時間で30Mpa以上の圧縮強度が出現するコンクリートを用いた新たなプレキャストPC床版の継手を開発し，Ⅰ期に比べ約2.2倍の施工速度での急速施工を実現した。