Continuous PC Box Girder Bridge Used Movable Scaffolding
— Hokuriku Shinkansen Imamurashinden Viaduct —

移動式支保工架設による連続 PC 箱桁橋
— 北陸新幹線 今村新田高架橋 —


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Synopsis
Hokurikusinkansen Imamurasinden Viaduct consists of five 4-span and five 5-span continuous PC box girders. The shape of the girders and the piers were designed taking landscape into consideration.
For construction of this viaduct, movable scaffolding method was applied to 29 spans of 45 spans. The girder over the route 8, one of the most major highways in Japan, was also erected by movable scaffolding method with minimum regulation.

Structural Data
Structure: 4 and 5-span continuous PC box girder bridge
Bridge Length: 1 588.0m
Span: 2@35m + 3@32m, 2@32m + 3@37m, 2@32m + 3@37m, 35m + 3@37m, 4@37m, 3@37m + 2@35m, 3@35m + 37m, 3@37m + 35m, 5@35m, 5@35m
Width: 11.7-11.8m
Owner: Japan Railway Construction, Transport and Technology Agency
Designer: Yachiyo Engineering Co., Ltd.
Contractor: P.S. Mitsubishi - Wakachiku JV
Construction Period: Sept. 2008 - May 2011
Location: Niigata Prefecture, Japan

1. Introduction
Hokuriku Shinkansen Imamurashinden Viaduct is located between Nagano Station and Kanazawa Station. This viaduct has a total length of 1,588m consisting of five 4-span and five 5-span continuous PC (prestressed concrete) box girder. **Fig.1** shows an outline of this viaduct.
In the stage of erection planning, considering cost and period of erection, span-by-span movable scaffolding (MS) method with only one MS machine was applied to 29 spans of total 45 spans and ordinary frame timbering method was applied to other 16 spans, including the sites nearby the existing railway tracks. Recently, the railway viaducts erected by MS method are simple T-shaped girder-type viaducts such as Kyushu Shinkansen Daini Chikadou Viaduct[1] and Tohoku Shinkansen Daiichi Otomonai Viaduct[2]. It is quite unusual that PC continuous girder-type viaduct is erected by MS method.
This report describes design of this bridge and erection by MS method.

2. Planning of Bridge
(1) Structural Design
At the planning of layout of girders and piers, each distance of the piers was set 32-37 m continuously considering crossing roads and creeks, and landscape. For shinkansen viaduct, rigid-frame-type viaduct (span length is 10 m) is generally applied. In this site, considering the length of each span (32-37 m), PC girder-type viaduct was applied.
Because the construction site is nearby residential area, harmony of landscape and bridge was considered.

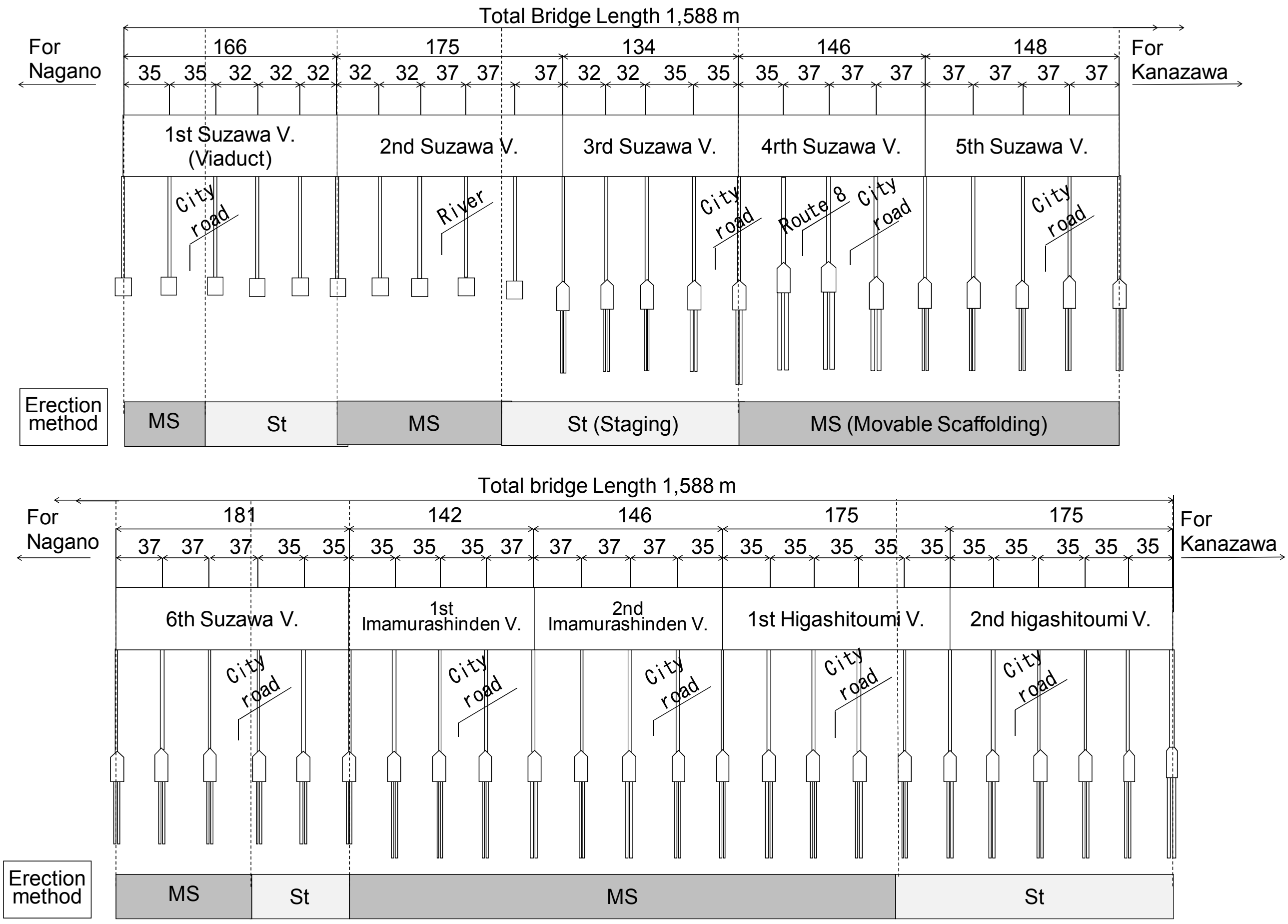

Fig.1 Bridge over view

About girder shape, straightness is emphasized by continuous multiple spans girder with uniform depth. In addition, skew web and large diameter chamfering was adopted. Cross-section of electric poll supporting beam was made trapezoid to reduce feeling of pressure. About shape of piers, reversed trapezoid shape with chamfering (R = 300 mm) was adopted instead of cantilever beams. Square drainage pipes were set in the grooves on the centers of piers (**Fig.2**).

Fig.2 Shape of girder and piers

(2) Erection Method

Three erection methods: MS method, frame timbering method, and launching method, were planned and compared. As a result of examination, MS method is adopted in the applicable sections. The reason is described as follows.

- It was estimated that the machine expenditure of MS method becomes economical if the number of girders erected by MS method is increased.
- The erection with ordinary frame timbering method over the road is required to set temporary pier on the road. However the interference for the traffic under girder was not permitted. Hence, the erection by MS method was employed for its non-traffic-interference merit.
- Because the construction site is near the Sea of Japan, severe environmental condition such as salt, wind and snow were expected in winter. By covering workshop on MS and transferred with MS, MS method is advantageous to improve environment under construction.
- For long viaduct, temporary facility of launching method becomes expensive because dismantling and assembling are necessary for movement to the next erection site.

3. Design of Bridge

(1) Point of Design

It was required that the height of track clearance of national route 8, one of the main highways, should not be less than 5.5 m under the girder of this bridge in operating period of shinkansen. Therefore, the depth of the main girder was controlled to 2.2 m. Depth / span ratio of girder is about 1/17.

This viaduct is in severe chloride attack condition because the site is nearby the shore of the Sea of Japan. So, full-prestressed concrete structure was applied to prevent cracks although partially prestressed concrete structure is standard structure of PC bridges for recently constructed shinkansen. Design cover thickness of concrete for steel is 70 mm (20 mm thicker than ordinary condition). In addition, epoxy coated steel reinforcement was applied to thin member whose cover concrete thickness is less than 70 mm.

(2) Point of Design for MS Method

1) Consideration of Construction Process

Construction joints of continuous girders were set 7.5 m (about 0.2 times of each span) from each supporting point considering small bending moment and cable connection.

Segment on intermediate piers were planned to be constructed by in situ concrete as pre-worked column heads before main girders were erected by MS method to support MS (**Fig.3**).

In longitudinal structural design, construction steps by MS method were considered. The weight of MS machine was considered as moving intensive load in each step.

2) Placing of prestressing cables

The continuous prestressing cables, set in girder erected by span-by-span MS method were connected by coupling tool.

At the girder in the last span, because the length of girder constructed in one step was too short (the shortest is 25.6 m), the prestressing force of some cables become short by the effect of anchor set loss (*ex.* 8 mm for 12 × φ12.7 mm anchorage). Additional six mono-strand cables (φ28.6mm) were put in lower slab to compensate the shortage of prestressing force. Placement of additional prestressing cables is shown in **Fig.4**.

4. Erection by MS method

(1) Outline of MS method

Construction cycle of MS method is shown **Table-1** and construction step is shown in **Fig.5**.

The MS machine in this site was supported by an erection girder, with forward erection nose, on R1 and R2 supports. Lateral and base forms can be divided and opened to dodge pier when MS machine moving to the next span (**Fig.6**).

(2) Erection over the Highway

Since the viaduct crosses over the national route 8, the road administrator required to secure the 4.5 m of track

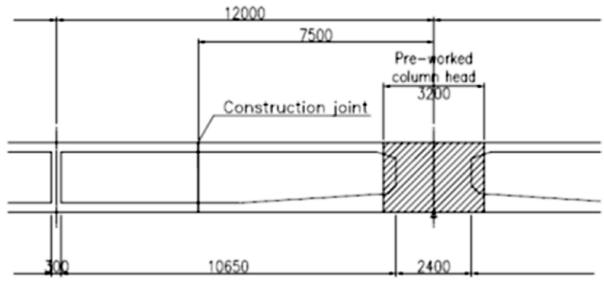

Fig.3 Intermediate supported point and construction joint

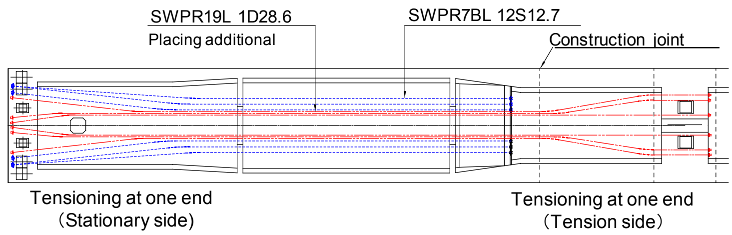

Fig.4 Placement of additional PC strand

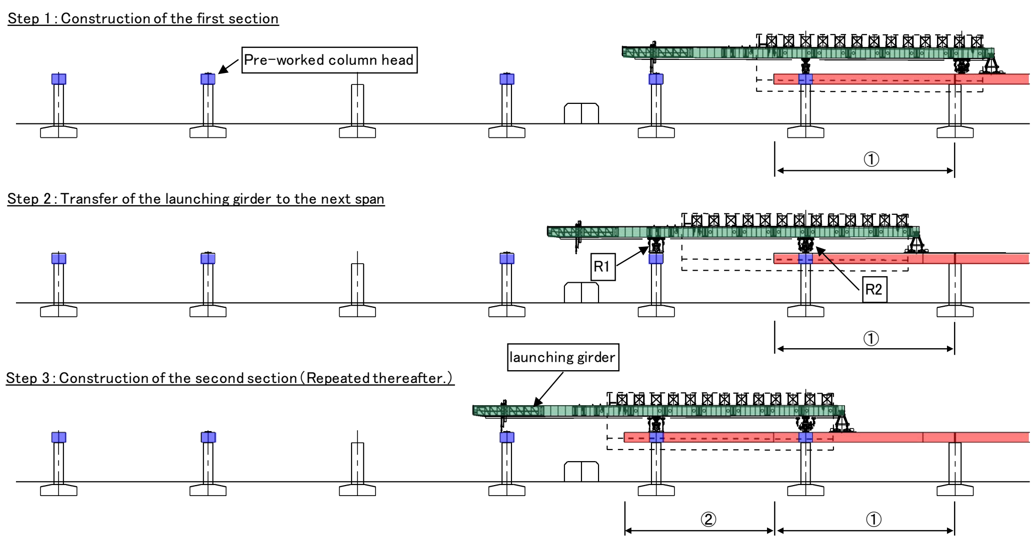

Fig.5 Construction step of MS method

Fig.6 Over view of MS machine

Fig.7 MS machine moving over the route 8

clearance under the MS.
When MS machine passing over route 8, minimum regulation was required. Route 8 was closed only when R1 temporary pier passing over. When MS machine was passing over route 8, one way alternation traffic was secured by closing the form to enable the traffic of one lane (**Fig.7**).

5. Conclusion

Erection by MS method enables to correspond to construction period and environmental condition and to minimize the closing of route 8, a major highway.
The operation of Hokuriku Sinkansen is scheduled to start in fiscal 2014.

References

[1] Terada, O., Nishi, T., Hirohata, K. Shimoyama, K.: *T-Shaped PC Girder Bridge used Various Erection Methods -Kyushu Shinkansen Daini Chikadou Viaduct-*, National Report –Recent Works of Prestressed Concrete Structure-, JPCEA, Tokyo, 2014 (submitted to)

[2] Ogawa, J.: *Design and Construction of PC Girder Erected by movable scaffolding*, The Journal of Japan Railway Civil Engineering Association, Vol.39, No.10, JRCEA, Tokyo, pp.847-849, Oct. 2001 (in Japanese)

Table-1 Standard construction Cycle (actual)

Processes	Descriptions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Formwork setup	Outer form setup						■											
	Inner form setup										■	■	■					
Reinforcement placing	Lower slab and web reinforcement assembly							■	■	■								
	Upper slab reinforcement assembly												■	■	■	■	■	■
Prestressing steel placing	Longitudinal cable assembly (12S12.7,12S15.2)								■	■	■							
	Transverse cable assembly (1S28.6)														■	■		
Concrete placing	Main girder concrete placing	■																■
Curing			■	■	■													
Tensioning	Longitudinal cable tensioning (12S12.7,12S15.2)				■													
	Transverse cable tensioning (1S28.6)				■													
Form removal and falsework release			■	■	■	■												
Falsework transfer and installation						■												

概　要

今村新田高架橋は，橋長1,588mの４径間５連，５径間５連なるPC連続箱桁橋である。交差条件と景観への配慮から，１径間32m～37mの等桁高多径間連続桁とし，下部工は傾きを一定勾配とした逆台形形状とした。同一形状のPC桁が連続し，施工延長が長いことから，経済性や工期の観点から，大型移動式支保工の導入を検討し，45径間中29径間を移動式支保工施工とした。

移動式支保工による施工は１サイクル17日間で行い，上屋を設置することによって冬期間の風雪による工程の遅延を防ぐことができた。

また，通常は移動式支保工を移動する際に下面の型枠・支保工を展開しているが，国道８号線上での架設では橋脚に支障する部分以外の型枠を閉じることにより，１車線分の通行を確保して通行止めを最小限とした。