

Construction of Viaduct Applying U-Shaped Girder Lifting Erection — Viaduct of Nasu-Dukuri Area —

U 桁リフティング架設工法を採用した高架橋の施工 — 茄子作地区高架橋 —



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* Akira MOROHASHI, P.E.Jp: Sumitomo Mitsui Construction Co., Ltd.

諸橋 明, 技術士 (建設部門) : 三井住友建設 (株)

** Shinsuke KAWANO, P.E.Jp: Sumitomo Mitsui Construction Co., Ltd.

河野 信介, 技術士 (建設部門) : 三井住友建設 (株)

*** Kei MURODA, P.E.Jp: Sumitomo Mitsui Construction Co., Ltd.

室田 敬, 技術士 (建設部門) : 三井住友建設 (株)

Contact: moroa@smcon.co.jp

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Synopsis

The Second Keihan Expressway in Japan, linking Kyoto and Osaka was constructed to bypass the existing road in order to ease the heavy traffic for the local residents. In the bridge construction of the expressway, rapid construction, environmental protection and improvement of safety as well as cost saving are required. To meet such requirements, unique segmental constructions which suit for the respective site condition were newly developed in the prestressed concrete viaducts of Nasu-dukuri area.

In Nasu-dukuri area, since relatively wide area was available at the construction site, U-shaped long prefabricated concrete girder was cast at the site, not in the way to combine conventional multi-divided precast segments, and the girder was lifted directly between piers with a lifting erection girder. The erection method is called “U-girder lifting erection method”.

Structural Data

Structure: 20-span continuous box-girder

Bridge Length: 790.0m

Span: 39.5m (average)

Width: 29.640m

Owner: Kinki Regional Development Bureau, MLIT

Designer: Sumitomo Mitsui Construction Co., Ltd

Contractor: Sumitomo Mitsui Construction Co., Ltd

Location: Osaka Prefecture, Japan

1. Introduction

The Second Keihan Expressway linking Kyoto and Osaka has been constructed as a bypass of the existing

national route (Fig. 1). Since the expressway passes the suburban residential area, accelerated construction and reduction of the environmental impact during construction as well as improving the safety etc. are required for the construction of the expressway.

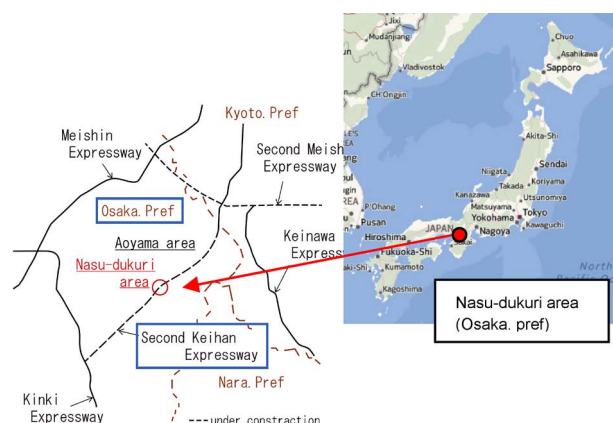


Fig. 1 The Second Keihan Expressway

In Nasu-dukuri Area, since some degrees of construction area could be used in the construction site, the areas were used as casting yard and a unique U-shaped precast girders were adopted. It was different from the conventional erection method that uses multi-number of small precast segments divided longitudinally. It was possible to have some casting yard along the viaduct and to transport the segment from the casting yard to the below area of the viaduct. The erection method was called “U-girder lifting

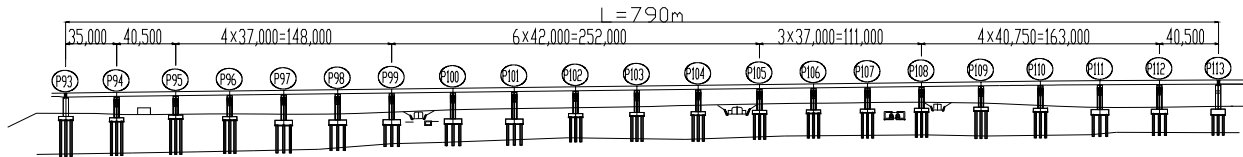


Fig. 2 General view

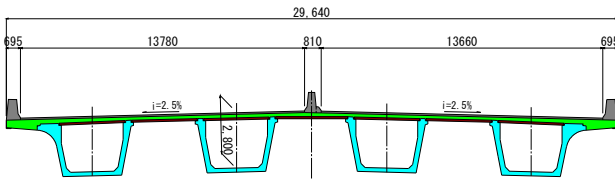


Fig. 3 Cross section

Table 1 Project summary and properties

Project	Nasu-dukuri Viaduct
Profile	20spans prestressed concrete viaduct
Period	Mar. 2007 - Mar. 2009
Length	790m
Spans	37m, 40.75m, 42m
Effective Width	13.780m, 13.660m
Alignment	R = 1950 - A = 650 - R = ∞
Vertical Alignment	1.240% - 0.300%
Horizontal Alignment	2.500%

erection method” in which site-fabricated U-shaped precast girders were used.

This viaduct, accelerated construction could be achieved by developing the conventional erection methods, which are suitable for their own construction conditions. It could shorten the erection cycle and could also save the construction cost.

This paper describes the new erection method.

2. Project Summary

(1) General Features

General view of the viaduct is shown in Fig. 2, and the cross section is shown in Fig. 3. The project summary and the structural properties are also shown in Table 1. The configurations of this bridge, such as width, total length, span length and the structural type are quite similar to the nearby viaducts. The design-built biddings were applied, and the construction methods were proposed by the contractor.

(2) Requirements for the Project

Following requirements were imposed throughout the construction periods.

- 1) Construction period is about two years. However, considering the time for the detail design and other preparation work, only 18 months were remained as the direct construction periods. Therefore, strong time reduction was required.

- 2) This viaduct is located in the quiet residential area. Therefore, the environmental impact had to be strongly reduced.

3. Construction of the Viaduct in Nasu-dukuri Area

(1) Outline of the Erection Method

In Nasu-dukuri, the contractor could use some areas as the construction yard at the site and precast girders were selected. After fabrication of the precast girder, the girder was transported to the erected span and lifted using erection girder. The U-shaped girder without upper slab was first applied in Furukawa viaduct on the New Meishin Expressway (2002). This erection method is called “U-girder lifting erection method”. The summary of structure is shown in Fig. 4.

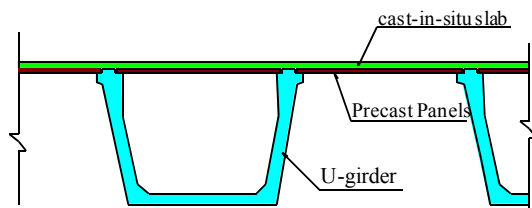


Fig. 4 Girders and slab structures

The procedures of the U-girder lifting erection are shown in Fig. 5. Maximum weight of a U-girder is 2,400kN, and the girder was lifted with the erection girder.

Since the precast girders were lifted near the supports of the erection girder on the piers, the bending moment acting on the erection girder could be quite small. Furthermore, applying the U-shaped girder without upper slab could also reduce the weight of the erection girder. As a result, the bending moment acting on the erection girder could be reduced up to 1/6 compared with the conventional span-by-span erection, and the erection girder could be lightened drastically (Figs. 5, 6 and Table 2).

The following effects to the surrounding area could be expected.

- 1) Noises and vibrations caused by the construction work can be reduced since the girders are fabricated at the fixed fabrication yard in the site.
- 2) No need to use the large trailers to pass the existing residential area for transporting the precast segments.

The standard construction cycle of the superstructures is shown in Table 3.

In Nasu-dukuri Area, no stockyard was built for the

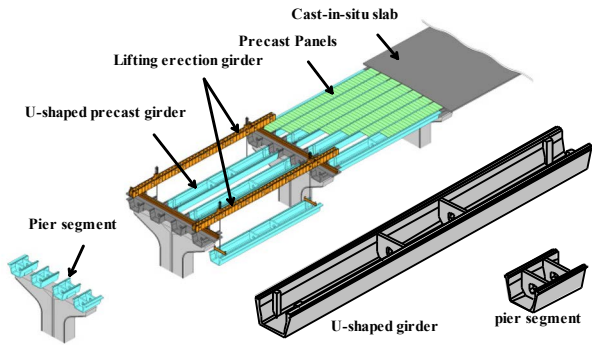


Fig. 5 Overview of the U-shaped girder lifting erection

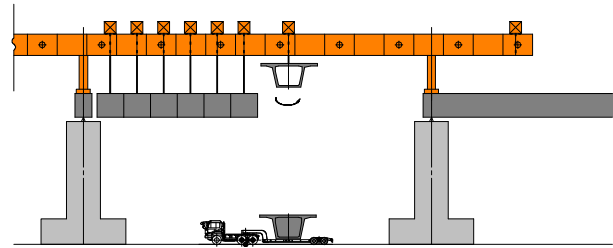


Fig. 6 Conventional span-by-span erection

Table 2 Erection methods and the bending moments of the erection girder

Erection Method	U-shaped girder lifting	Box girder lifting	Conventional span by span
Cross Section at Erection	U-girder 	Box girder 	Box girder
Max Bending Moment in Erection girder	4100 kNm 18%	6800 kNm 30%	23000 kNm 100%

U-girder. This could be achieved by that the casting cycle of four girders were set to be equal to their erection cycle. In order to achieve the fabrication and the erection cycles, four casting beds and two sets of lifting girders were used, respectively. Four girders per span could be erected in two weeks.

(2) Fabrication and Erection of the U-Girder

Considering the limited construction area and the way to transport the construction materials as well as the construction cycle work, four sets of casting bed were arranged in line longitudinally along the viaduct (Fig. 7).

The U-girders were transported from the casting bed to the erecting span with a large trailer (Fig. 8). Fig. 9 shows the erection of the U-girder. Since large tensile stresses occur near the lifting points inside the webs during lifting, the vertical prestressing and the additional reinforcement were arranged for the local stress. Prior to the fabrication, a mockup test was conducted to confirm the stress and the safety during erection.

After lifting the girder, the girder was moved horizontally and transversally to the designated location, following that the U-girder No.2 was lifted by another erection girder. The U-girder No.2 was then moved also horizontally and transversally (Fig. 10).

150 mm closure joints were placed at both ends of the girder and the pier segments. After placing concrete,

Table 3 Construction cycle of Nasu-dukuri viaduct erection

	1	2	3	4	5	6	7	8	9	10	11	12
U-girder1	T	E	J	P	S							
U-girder2		T	E	J	P	S						
U-girder3						T	E	J	P	S		
U-girder4							T	E	J	P	S	
erection girder	Er											Er

T: Transportation E: Erection J: joint concreting
P: Precast Panels S: Stressing Er: Erection Girder Equipment



Fig. 7 Casting yard

each girder was externally prestressed and then the lifting devices were released.

Segments No. 3 and No. 4 were also constructed as



Fig. 8 Transportation of the U-girder



Fig. 9 Erection of the U-girder



Fig. 10 Transversal movement of the girder

the same ways and the construction of one span was completed.

(3) Construction of Slab

For the construction of the slab, precast and prestressed panels were placed on the webs of the U-girder. These panels are used as structural components as well as for the formwork, and the re-bars were arranged on them. To reduce the thermal stress and the stress caused by the deformation of drying shrinkage and creep effects, expansive additive was used as well as additional reinforcement designed through the thermal stress analysis (Fig. 11, 12).



Fig. 11 Precast panels Fig. 12 Cast-in-situ slab

4. Afterword

It has been considered that the conventional span-by-span erection using conventional multi precast segments is suitable for the construction of the large-scaled continuous urban viaduct project for the cost saving, achieving the high quality and for the accelerated construction. However, in the urban viaduct projects, there might be some severe site conditions as mentioned. In such cases, the newly developed construction method adopted to the viaduct in Nasu-dukuri Area of the Second Keihan Expressway can be the good solutions. In this project, the rate of construction speed of 2,400m² per month were both achieved.

References

[1] Ikeda S., Ikeda H., Mizuguchi K., and Taira Y., : *Design and Construction of Furukawa Viaduct*, Proceeding of the 1st fib Congress, pp.21-28, Osaka, 2002.

概要

第二京阪道路茄子作地区 PC 上部工事は、橋長790mの専用部20径間連続箱桁橋や ON・OFF ランプ橋など4橋からなる橋梁工事である。大阪府枚方市～交野市の市街地に位置するため、品質確保と急速施工および周辺環境への負荷軽減を特に重要な評価点とした設計施工一括発注方式により、これらを同時に実現する新工法「U 桁リフティング架設工法」が採用された。

U 桁リフティング架設工法は、現場内の製作ヤードで、U 形断面プレキャストセグメント桁を製作し、場内運搬して橋体を架設、構築するものである。本工事では、1 径間分の U 桁をリフティングガーダーにて一括吊上げし、PC 板を敷設、場所打ちにより上床版を打設して主桁を構築し、4 室箱桁を 2 週間に 1 径間という施工速度を実現した。急速施工を目的とする従来のスパンバイスパン架設工法に比べ、架設ガーダーの曲げモーメントが低減可能となり、ガーダー重量の大幅な軽量化によりコスト縮減を実現した。