Large Cantilever Erection on Tall and Slender Pier Column
— Kawashimogawa Bridge —

小断面・高橋脚上での大規模張出し架設
— 川下川橋 —

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Synopsis
Kawashimogawa Bridge is a highway bridge built as a part of New Meishin Expressway. The superstructure is 3-span continuous box girder (**Fig. 1**). The main pier column is 95m tall that is one of the tallest pier columns in Japan. Even though the main pier column is very tall, the cross section is minimized by applying high-strength re-bars as well as high-strength concrete.
The cantilever erection in each direction is 110m long that is one of the longest cantilever erection lengths without cable-support in Japan. Since the cantilever erection was carried out on the very flexible main pier, inclination of the pier column and the foundation were monitored. At the end of the cantilever erection, remained inclination was corrected by drawing the box girder horizontally.

Structural Data
Bridge Length: 300.0m
Bridge Width: 24.14m
Traffic Width: 10.50m + 10.50m
Structure: 3-span continuous box girder
Spans: 120m + 143m + 37m
Main Pier Height: 95m
Girder Type: Variable depth two-cell box girder
Owner: West Nippon Expressway Co., Ltd.
Design and Construction: Kajima Corporation & P.S. Mitsubishi Construction Co., Ltd.
Construction Period: Dec. 2008 – Jun. 2013
Location: Hyogo Prefecture, Japan

Fig. 1 Kawashimogawa Bridge

1. Introduction
Kawashimogawa Bridge was planned as a part of New Meishin Expressway. Kawashimogawa Bridge had to span a deep and steep ravine, which is over 100m deep and is about 300m wide. Furthermore, a fault fracture zone exists under the western slope of the ravine. Meanwhile, this bridge accommodates four traffic lanes at first, and later will be widened to accommodate six traffic lanes. Since this project was very challenging as mentioned above, the owner called for design–build proposals and selected a successful bidder. As the result, a three-span continuous concrete box girder bridge with 95m-tall pier column was selected[1] (**Fig. 2**). The cantilever erection length is 110m, which is one

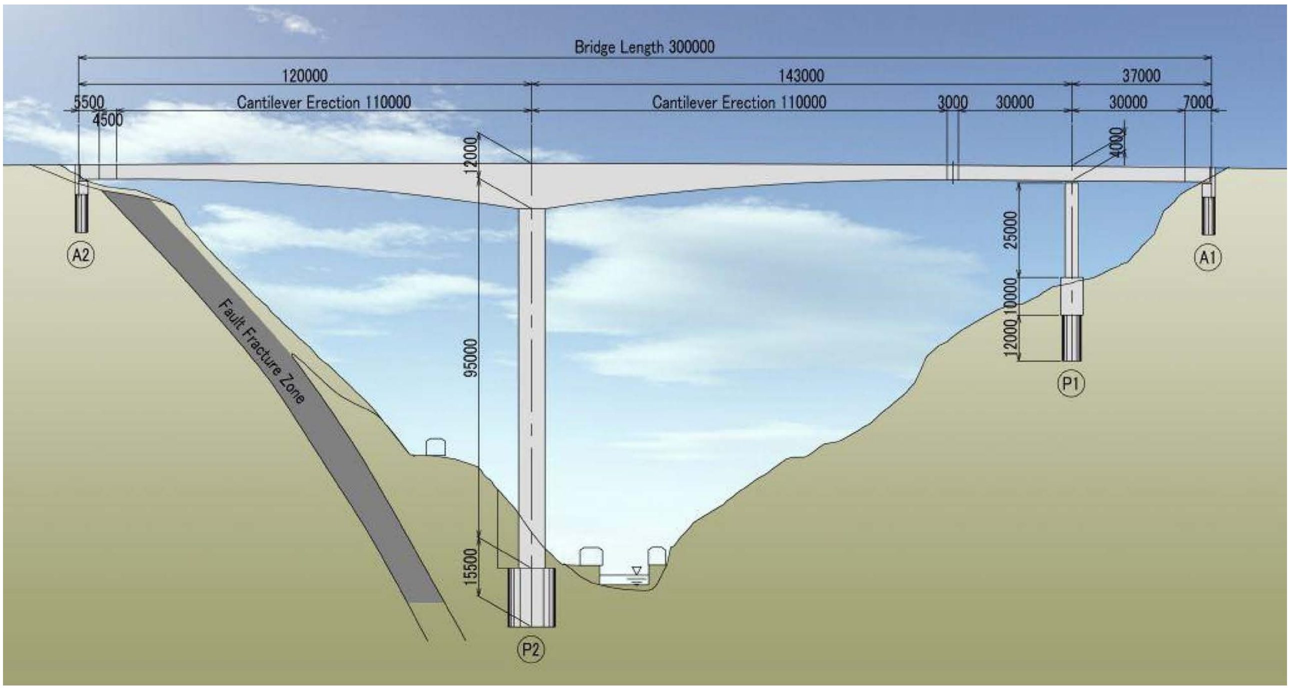


Fig. 2 General view (unit: millimeter)

of the longest erections in Japan.

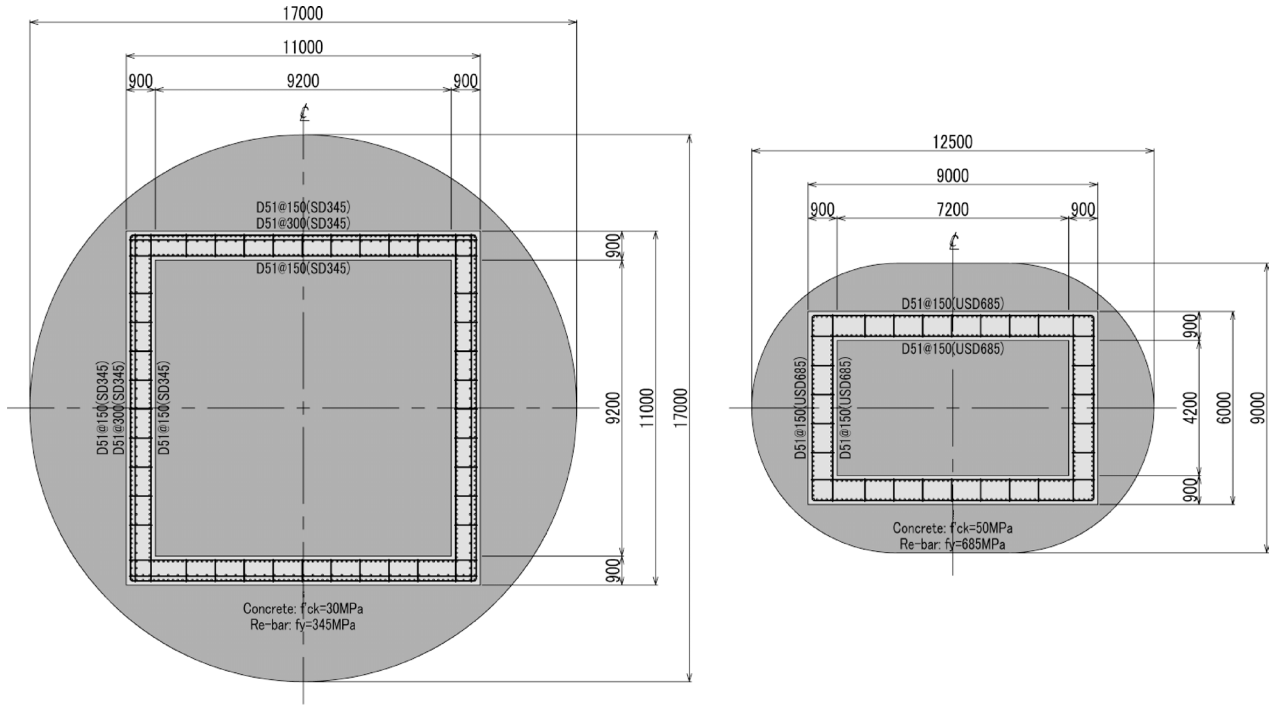
This paper briefly describes the structural characteristics of Kawashimogawa Bridge. Then, the characteristics of geometry control of Kawashimogawa Bridge project are introduced. A special recovery measure, which applied to this project in order to correct inclination of the pier column, is explained.

2. Structural characteristics

The superstructure of Kawashimogawa Bridge is supported by four substructures, which are two abutments at both ends of the girder, 95m-tall main pier column and 25m-tall subsidiary pier column.

(1) Substructure

High-strength concrete (f'_{ck}= 50MPa) and high-strength re-bars (f_y= 685MPa) are applied to the main pier column. The design of Kawashimogawa Bridge achieves substantial reductions in cross-sectional area of the main pier as well as the foundation, compared



Conventional Materials **High-Strength Materials**

Fig. 3 Cross section of main pier column and foundation (unit: millimeter)

with a combination of conventional materials (**Fig. 3**). Furthermore, since the smaller cross section of the pier column results in lower stiffness, the natural vibration period of the structure becomes longer. As a result, response acceleration due to seismic motions is considerably reduced and seismic resistance is enhanced.

(2) Superstructure

The superstructure, which has a total width of 24.14 m to accommodate eastbound and westbound traffics, is composed of a two-cell box girder with inclined exterior webs. Because the cantilever erection length is one of the longest in Japan, high-strength concrete (f'_{ck}= 50MPa) is applied to the superstructure. The girder depth is varied. The girder at the top of the main pier is 12m deep, and it becomes gradually shallower until 4m at each cantilever end (**Fig. 4**).

Future widening will be achieved to construct strutted wing slabs. In order to install the struts, longitudinally continuous projections are provided along the lower edges of the box girders.

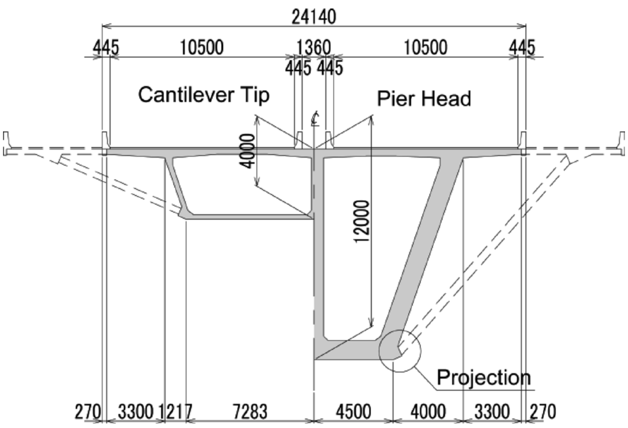


Fig. 4 Cross section of box girder (unit: millimeter)

Fig. 5 Cantilever erection

3. Geometry control

(1) Monitoring

Because of the large cantilever erection, elevation of the deck slab is very sensitive to the inclination of the pier column (**Fig. 5**). Although the elevation of the deck slab is much influenced from the inclination of the pier column, the pier column of Kawashimogawa Bridge is very tall and slender. Therefore, the geometry especially elevation of the deck slab had to be carefully controlled[2].

Inclination of the main pier was monitored in the longitudinal and transverse directions during the cantilever erection. A pair of inclinometers was installed in the box girder at the top of the main pier. Inclination of the foundation was also monitored in the both directions. Another pair of inclinometers was installed at the top of the foundation (**Fig. 6**).

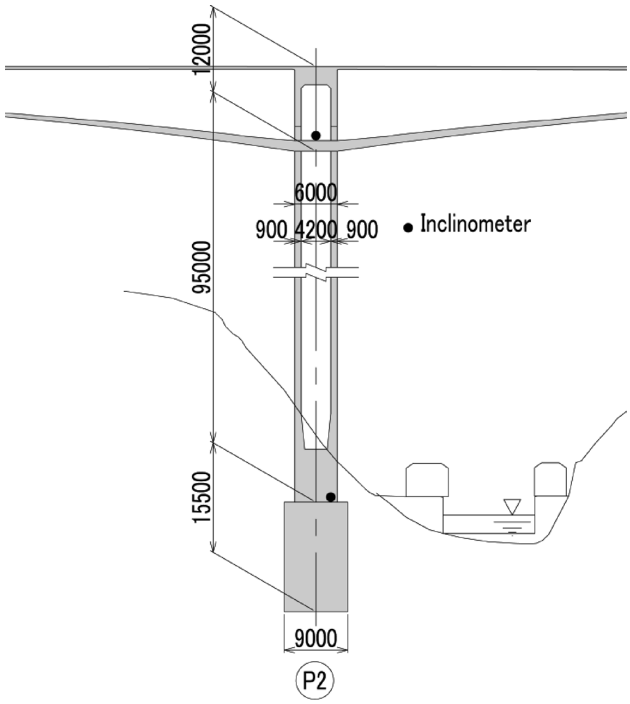


Fig. 6 Location of inclinometers (unit: millimeter)

(2) Correction of inclination of main pier

While the girder deflections were in good agreement with the predicted values, the main pier started inclining to the abutment A1 side without any known cause when the 2/3 of cantilever erection was completed. Even though the girder deflections were controlled precisely, the elevation of the top slab started deviating as inclination of the main pier became larger.

When the cantilever erection from the main pier column was completed, longitudinal inclination of the main pier was remaining. The inclination angles were 0.07degree and 0.01degree at the top and bottom of the main pier respectively. The horizontal deviation at the top of the main pier was 32mm, and the vertical deviation at the cantilever tips were +54mm and -62mm respectively (**Fig. 7**). It was decided that the remained inclination of the pier column was corrected by horizontal loading as a recovery measure. The horizontal load to the top of the main pier was imposed by drawing the box girder from the abutment A2. Temporary post tensioning bars were used to draw the box girder. Four 32mm diameter temporary post tensioning bars were installed between diaphragm in the 32nd segment and parapet of the abutment A2 (**Fig. 8**, **Fig. 9**). Tensioning force was applied to the post tensioning bars from the abutment side by hydraulic jacks. Vertical displacements at the cantilever tips and horizontal displacement at the top of the main pier were surveyed while drawing the girder. When 440kN tensioning force was applied, the both cantilever tips came back to ideal elevation.

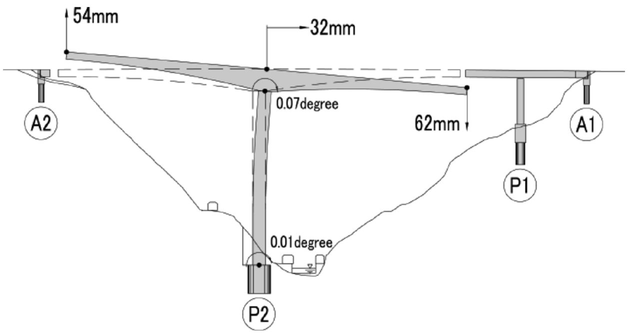


Fig. 7 Deviation caused by inclination of main pier

Fig. 8 Temporary PT bars (before tensioning)

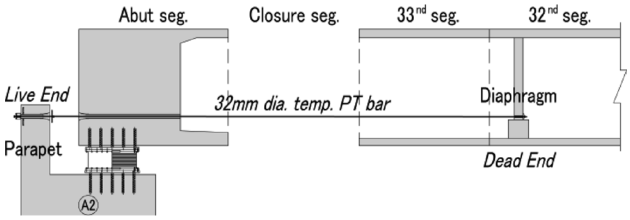


Fig. 9 Configuration of recovery measure

4. Conclusion

Kawashimogawa Bridge was constructed as a part of New Meishin Expressway. Kawashimogawa Bridge had to span a deep and steep ravine.

The bridge is a 3-span continuous box girder bridge with tall and slender pier column. High-strength re-bars are applied to the 95m-tall pier column in order to reduce the cross section. A variable depth 2-cell box girder is applied to the wide superstructure.

The inclination of the pier column was monitored through the cantilever erection with inclinometers, because elevation of the deck slab is very sensitive to the inclination of the pier column, and the pier column is very flexible.

Inclination of the pier column was corrected by horizontal loading. The horizontal load to the top of the pier was imposed by drawing the box girder with temporary post tensioning bars.

References

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概　要

川下川橋は，新名神高速道路の一部として，非常に急峻な谷間を横断する箇所に計画された。本橋の工事は，上下部一体・設計施工一括方式で発注され，高橋脚を有する 3 径間連続ラーメン箱桁橋が採用された。本橋の橋脚高さ95m と張出し架設長さ110m は，共に日本最大規模である。本橋の橋脚には，高強度コンクリートと高強度鉄筋を組み合わせた構造が適用され，通常材料の組合せに比べて，大幅な断面の縮小を実現している。上下線合計で 4 車線に対応する上部構造には，斜ウェブを有する 2 室箱桁断面を適用し，将来の拡幅にはストラットに支持された張出し床版の施工が計画されている。

張出し架設長が長い本橋の床版出来形は，橋脚の傾斜に大きく左右されるうえ，橋脚が非常に柔軟であるため，張出し架設中に橋脚の傾斜を傾斜計で常時計測した。計測の結果，張出し架設中に橋脚が傾斜し始め，張出し終了時にも傾斜が残留したため，箱桁を水平に牽引して橋脚の傾斜を修正した。