4-Span PC Extradosed Bridge Intersecting the River at 30 Degrees
— Kyushu Shinkansen Onogawa Bridge —

河川と30度で交差する４径間連続 PC エクストラドーズド橋
― 九州新幹線 大野川橋梁 ―

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Synopsis
Kyushu Shinkansen Onogawa Bridge is located in the northern section of the Kyushu Shinkansen Kagoshima Route, the high speed railway between Hakata station and Kagoshima-Chuo station. Because the bridge crosses the river at the angle of 30 degree and it is forbidden to layout pier in the bank for safety of the river, the spans in the river were set to 2@113 m. To reduce the stress in the girder at the central pier and to consider noise of train and landscape for the dense residential area, this bridge was planned as 4-span continuous PC extradosed bridge.

Structural Data
Structure: 4-span continuous PC extradosed bridge
Bridge Length: 286m
Span: 30m＋2@113m＋30m
Width: 12.4m
Owner: Japan Railway Construction, Transport and Technology Agency
Designer: Yachiyo Engineering Co., Ltd.
Contractor: Obayashi – Oriental Shiraishi – Mori JV
Construction Period : Nov. 2005 – Aug. 2009
Location: Kumamoto Prefecture, Japan

1. Introduction
Kyushu Shinkansen Onogawa Bridge is located in the northern section of the Kyushu Shinkansen Kagoshima Route. The northern section, between Hakata Station and Shin-Yatsushiro Station, is the secondly opened section of the Kyushu Shinkansen Kagoshima Route, the high speed railway between Hakata station and Kagoshima-Chuo station.
This bridge is 4-span continuous PC (presutressed concrete) extradosed bridge. The characteristic of the construction site is as follows;
- The bridge crosses the river at the angle of 30 degree.
- The river at the site is a tidal river, which can cause the salt attack.
- There is dense residential area in the right bank side of the river.

The outline of this bridge is shown in **Fig.1**.

2. Structural Design
(1) Design Requirement
River administrator required as follows;
- The length of span should be more than 23 m at the right angle to the direction of river flow (more than 50 m when cross angle is 30 degree).
- The ratio of total pier width for the width of river should be less than 8 %.
- The height of clearance under the bridge should be more than 4.5 m.

(2) Structural Planning
Because it is forbidden to layout pier in the bank for safety of the river, the spans in the river were set to 2@113 m. In addition, it is necessary to consider noise of train and landscape for the dense residential area. Generally, special measurement against noise

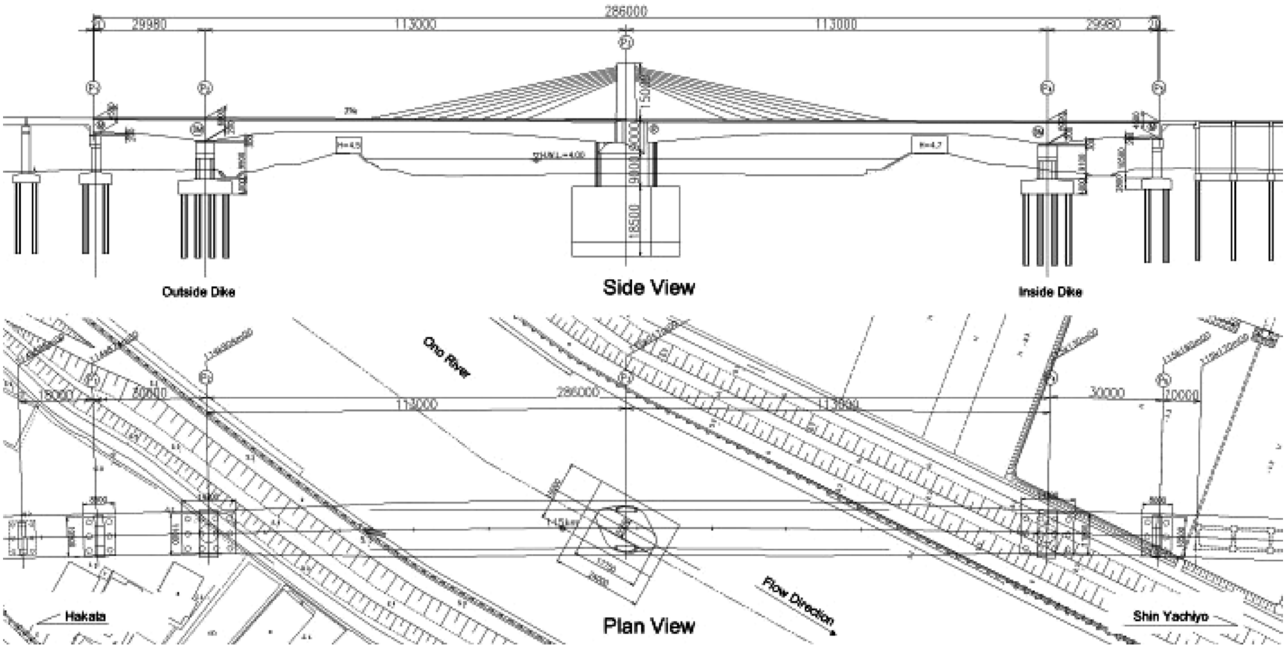


Fig.1 Overview of the bridge (unit: mm)

is required for steel bridge. Therefore PC extradosed bridge was planned because of economy, noise reduction and landscape.

As a result of study of 2-span continuous girder (113 m + 113 m), the stress in the girder at the central pier exceeded the limit. Finally, this bridge was planned as 4-span continuous PC extradosed bridge (30 m + 113 m + 113 m + 30 m) by integrating both side span girders to reduce the stress.

(3) Structural Characteristics

The characteristic of Onogawa Bridge is as follows.

1) The Shape of Central Pier

The shape of P3 pier cross-section is an oval, the long side of which is directed to the river flow direction. Because main girder and long side of the pier crosses at 30 degree, a corbel was adopted to the structure for the articulation of the girder and the pier. The shape of the corbel is made curved considering aesthetics (**Fig.2**).

2) Measure for Negative Reaction

Because the lengths of the side spans are much shorter than the main spans, it is required to consider negative reaction under live load. Counterweight concrete was added on the lower side of the cross girders (440 kN) (**Fig.3 a**) and inside of the box girder of the side spans (3,660 kN) (**Fig.3 b**) to prevent negative reaction

3) Measure for Salt Attack

The thickness of cover concrete is more than 100 mm as a measure for salt attack by tidal river.

3. Pylon and Stay Cable

(1) Pylon

The pylon continuously varies shape to the corbel and perpendicularly crosses the girder. The prefabricated saddles (**Fig.4**) of stay cables are placed in the pylon.

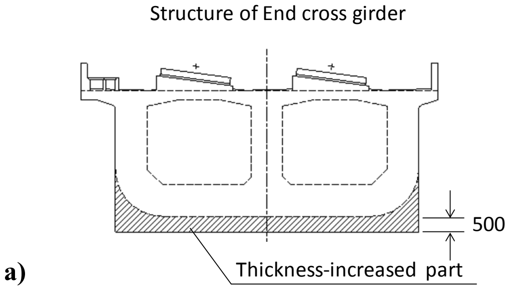
Fig.2 The shape of central pier

The saddle is consist of steel tubes within polyethylene pipes. The saddles enable the replacement of stay cables. The small amount of reinforcement around saddle contribute to improve the aesthetics and weight reduction to allow slim shape.

(2) Stay Cable

1) Design

Because this bridge crosses tidal river, stay cable



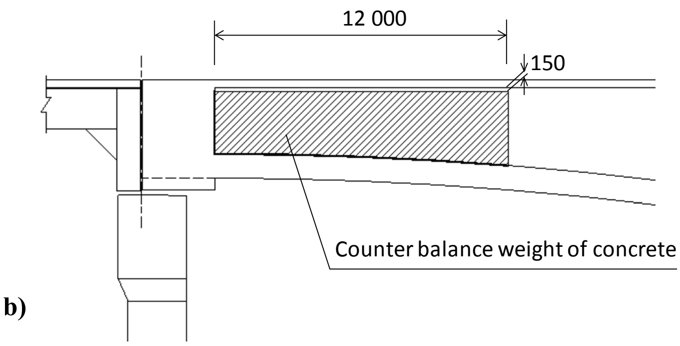


Fig.3 Measure for negative reaction (unit: mm)

anchors are placed in the box girder as a measure against salt damage. The stay cable strand is protected by triple layers, *i.e.* epoxy coating, cement grout and polyethylene (PE) pipes. The PE pipes with inner ribs were adopted to follow thermal expansion of strand and grout.

Because deflection of stayed deck, caused by excessive thermal expansion of stay cable, make it difficult to keep truck level suitable for high speed train[1], thermal insulation of the cable is planned. The grout was planned to be thicker than usual, with φ200 mm PE pipe. The light color paint was applied to the stay surface to prevent heating. The cross-section of the stay cable is shown in **Fig.5**.

The color of the stay is light orange, which stand for "Hinokuni" (former name of Kumamoto Pref. meaning land of fire), "Dekopon" (citrus fruit widely cultivated in Kumamoto Pref.) and "Shiranui" (meaning unknown fire, mysterious luminescence phenomenon in the sea near this bridge).

2) Wind Resistant Stability

Wind resistant stability of stay cable was examined on rain vibration. The stay cable with natural frequency of less than 3 Hz and Scruton number (Sc) of less than 60 are capable of being excessively vibrated by wind of velocity 6 m/s in rain. Dampers (logarithmic decrement δ = about 0.03) are generally installed to each cable as measure against rain vibration[2] [3].

Because 48 of 64 stay cables of this bridge have less natural frequency than 3 Hz and all have Sc 19.4 in analysis, dampers were planned for all the cables in consideration of uncertainty.

Although logarithmic decrement δ of stay cable is one of the significant parameter to examine Sc, the value of δ (0.005) was only assumed by experiences of bridges constructed in the past.

Therefore, to confirm natural frequency and logarithmic decrement of cables, vibration test (**Fig.6**) was carried out. The result indicated that natural frequencies (1.5 - 4.4 s) and logarithmic decrement δ (0.004 - 0.016) of stay cables were same level as expectation. The value of Sc was estimated at 16.3 without dampers. The value of Sc of all the cables was estimated more than 100 after the damper installation.

Fig.4 Prefabricated saddle of stay cables

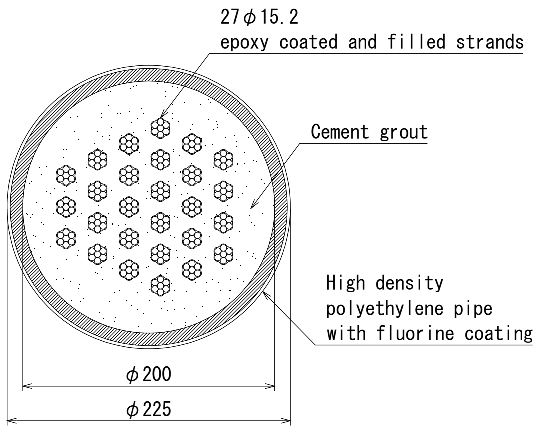


Fig.5 Cross section of stay cable

4. Erection of Girder

The main spans were erected by balanced cantilever method, whereas the side spans were erected with conventional falseworks. The side spans acted as the counter weight for cantilever erection. The construction procedures are shown in **Fig.7**.

5. Conclusion

As a result of overcoming severe conditions, this bridge was planned as 4-span continuous PC extradosed

bridge. It is quite unusual to adopt PC extradosed bridge for Shinkansen in Japan. Therefore this bridge will be a landmark of Kyushu Shinkansen and Uki City, Kumamoto Prefecture.
The northern section of the Kyushu Shinkansen Kagoshima Route including this bridge started operation in spring of 2011.

References

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Fig.6 Vibration test for stay cable

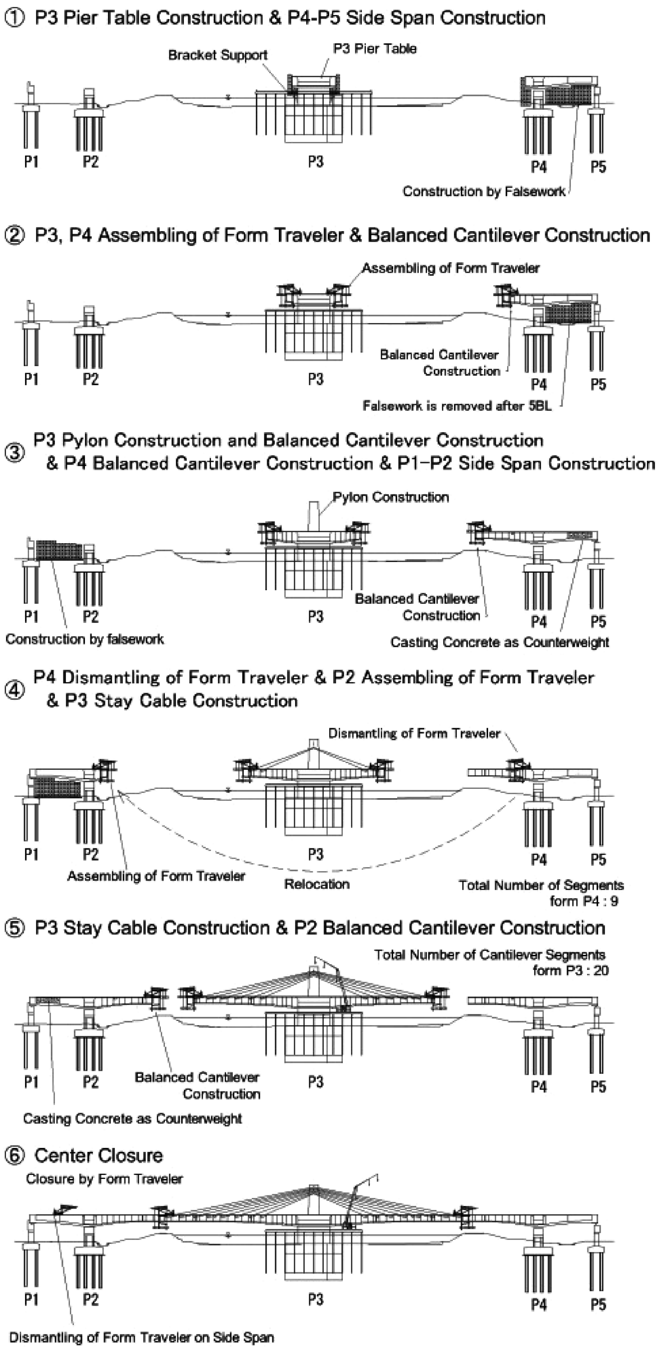

Fig.7 Erection step of girder

概　要

九州新幹線大野川橋りょうは，大野川と斜角30度で交差している。堤体内に橋脚を設けることができず，斜角が大きいことから，河川と交差する２径間は113m×2径間とし，中間橋脚付近の応力度を緩和するため，側径間を含む４径間連続 PC エクストラドーズド橋とした。

斜材は，PC 鋼より線をエポキシ樹脂被覆，セメントグラウト，高密度ポリエチレン保護管の三重防護とした。温度変化による斜材の伸縮が，高速走行する新幹線の軌道面の高低変位に影響を与えるため，グラウトの断熱効果に期待して高密度ポリエチレン管の径を通常よりも大きくするとともに，表面色を淡色として熱吸収を抑制した。耐風安定性に関しては，レインバイブレーションによる振動防止のためダンパを設置する計画としていたが，斜材の振動試験を行い，振動性状およびダンパの設置効果を確認した。