Construction of 3-Span Cable-Stayed Composite Bridge
— Ikina Bridge —

3径間連続混合斜張橋の施工
— 生名橋 —

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* Kenichi KATA, P.E.Jp: Sumitomo Mitsui Construction Co., Ltd.
片　健一，技術士（建設部門）：三井住友建設（株）土木本部
** Kazuhiko OOKUBO: Sumitomo Mitsui Construction Co., Ltd.
大久保　和彦：三井住友建設（株）広島支店
*** Mitsuharu OKAMOTO: Ehime Prefectural Office
岡本　光晴：愛媛県　土木部
**** Yuji NINOMIYA: Ehime Prefectural Office
二宮　祐司：愛媛県　土木部
Contact: k-kata@smcon.co.jp

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Synopsis
Ikina Bridge is a 515m-long composite cable-stayed bridge with a main span of 315 meters and links the two islands of Ikina and Sajima (**Fig.1**). As the pier location is restricted by the geological condition, the main span length ration is larger than ordinary cable-stayed bridges. Accordingly, Ikina Bridge has a unique structure with a main span consisting of both steel girders and concrete girders to keep the balance of girder weight between main span and side span.
The tower is a reinforced concrete structure and has a separated type stay-cable anchorage system which effectively reduced construction costs.
The cantilever erection is adopted and the form traveler is used for concrete girder and the floating crane is used for steel girders. The form traveler is also used for erection of the connection girder to reduce the construction cost and term.

Structural Data
Structure: 3-span continuous cable-stayed bridge
Bridge Length : 515.0m
Span: 98m + 315m + 98m
Width: 10.8m(concrete girder), 8.7m(steel girder)
Tower Height: 62.6m
Owner: Ehime Prefectural Office
Designer: Chodai Co., Lid.
Contractor: Sumitomo Mitstui, Showa, Yokogawa JV
Construction Period: Jul. 2007 – Dec. 2010
Location: Ehime Prefecture, Japan

Fig.1 Ikina Bridge

1. Introduction
Ikina Bridge is the one part of the Kamijima Bridge project which is the plan to link the four islands consist Kamijima town by bridges. This bridge is a 515m-long composite cable-stayed bridge with a 315m-long main span. In order to reduce the construction cost, composite girder structure is adopted for super structure and main span is consists of concrete girder and 148m-long steel girder. And more, a separated type stay-cable anchorage system for reinforced concrete tower is adopted (**Fig.2**).
The cantilever erection is used both concrete girder and steel girder. And the form traveler is used for the connection girder erection.

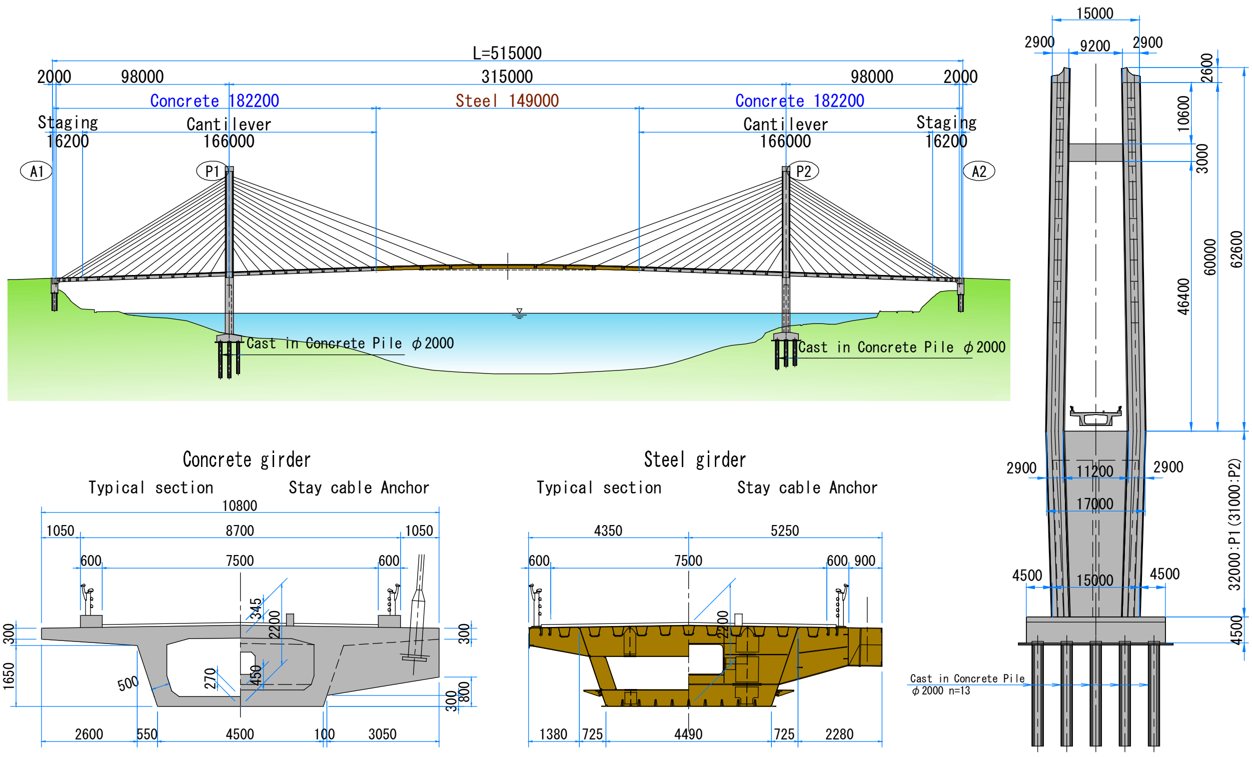

Fig.2 General view of Ikina Bridge

2. Construction Method

(1) Construction step

Construction step is shown in **Fig.3**. After the erection of the pier head, form traveler was assembled and the tower and concrete girder were simultaneously erected. The concrete girder was divided in 22 segments and erected using the balanced cantilever method. There are 2 vertical planes of stay cable and 11 cables were anchored every 2 segments.

After the side span construction using the staging support, the connection girder was erected at the head of center span.

Steel girder was divided 5 segments and erected by the cantilever method using the floating crane. Before the steel girder closure, in order to secure the expansion gap for closure erection "girder set back" and "girder set fore" was done at P1 side girder.

(2) Tower construction

The tower is H-shaped reinforced concrete structure. Each leg has a box section with outer dimension 4.9 m × 3.3 m and 62.6m-height above pier head. The legs are linked by cross-beam. 40MPa-strength concrete is used for the tower. The tower was built in 18 lifts from 2.7 m to 4.5 m using scaffolding. It has inclination toward vertical direction. Therefore, temporary cross beam was used during the erection.

The stay cable anchorage is located inside the tower. As the separated type stay-cable anchorage system is used in this bridge, these anchorages were fixed to the steel framework and GPS method was used to confirm

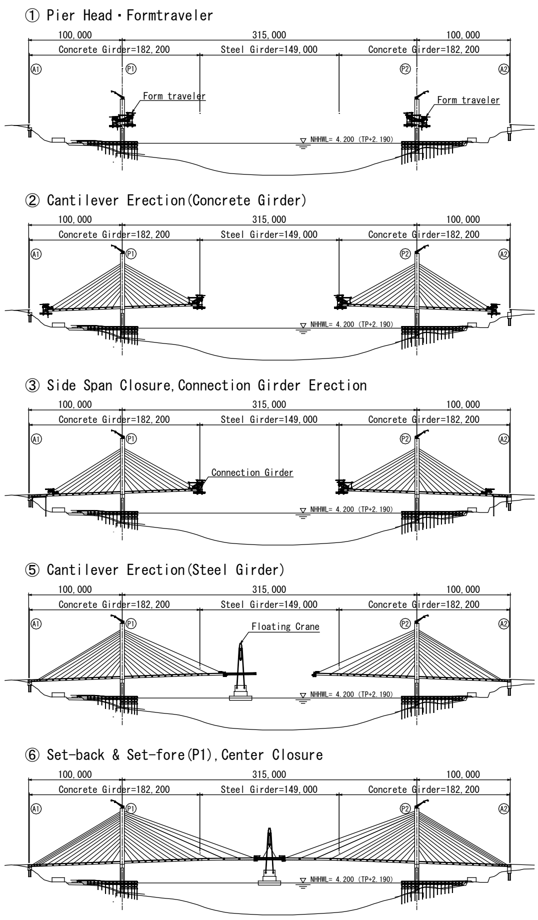

Fig.3 Construction step of Superstructure

the steel framework position and to keep the erection accuracy (**Fig.4**).
The tower has to be strengthened longitudinal and transverse direction against the stay cable anchorage force. Pre-grouted prestressing bar is used for this bridge in order to omit the grouting work such in high place.

(3) Concrete girder Construction

The concrete girder consists of 12m-long pier head and 22 cantilever segments and 16.2m-long side span edge. The length of cantilever segments is 4.0 m for typical type and 3 m for stay cable anchorage type (**Fig.5**).
The pier head was constructed using the staging supported by bracket. High strength steel bar was used for cantilever erection as internal prestressing steels.3.0m-long segment has cross beam and the cross beam is strengthened by prestressing steels.
16.2m-long side span edge was constructed by staging method. Expansive additive is used for pier head and side span concrete in order to avoid the thermal clacking. Inside the box girder of the side span, polyethylene coated external cables ware arranged.

(4) Connection girder Construction

Concrete girder and steel girder are connected by connection girder which has high strength steel bars inside (**Fig.6**). After side span closure, the connection girder was erected at the head of center span.
Connection girder was assembled at the girder factory and stuffing concrete was also constructed in same place. And then the girder was transported to the construction site by the barge.
This bridge is located above the sea lane and it is important to reduce the interference caused by the construction. So, using the form traveler of concrete girder erection was adopted. After the concrete girder erection, the winch was set to the form traveler on the center span and hoisted the connection girder from the barge directly (**Fig.7**). This method could reduce the interference for sea lane.

(5) Steel girder Construction

148m-long steel girder was divided 5 segments and erected by the cantilever method using the floating crane from both side (**Fig.8**). Maximum segment weight was 115 tons and the crane with 700 tons ability was used. Every segment except for center segment has 2 cable stay anchorages and 4 stay cables were anchored at the steel girder totally.

(6) Stay cable Construction

The stay cable system varies from 19 strands to 37 strands and the strand diameter is 15.6mm. The stay cable is erected strand by strand (**Fig.9**). The strand has 3 layers corrosion protection, galvanizing, grease and polyethylene coating. The tensioning force was introduced in 2 steps. In the first step, from 60 to 90% of designed tensioning force was introduced to the

Fig.4 Quality control using GPS method

Fig.5 Cantilever erection (concrete girder) onstruction at P2

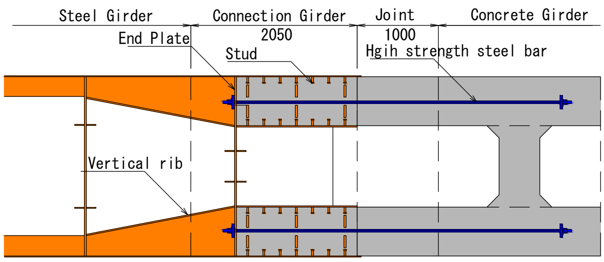

Fig.6 Structure of connection girder

Fig.7 Connection girder Erection

strands. First strand had load-cell and the introduced force of another strand was determined to suit the first strand's tensioning force. After all the strands were tensioned, the rest tensioning force was applied strand by strand again. This method could reduce tensioning force difference between strands.

(7) Center closure

This bridge has 315m-long center span and the girder length varied 4 cm in a day by temperature. Before the center closure, it was necessary to secure the expansion gap for closure erection. "Set back" jack was set at the P1 head and moved the P1 side girder to the abutment direction (**Fig.10**). Once the closure segment was set to the final position, the set back jack was released and the expansion gap was cancelled (called "Set fore").

Fig.8 Cantilever erection (steel girder)

3. Monitoring

Ikina Bridge is a composite structure and has small bending stiffness. During the erection, girder temperature, transformation and stress of tower and girder have been monitored in order to construct safely and accurately.

Fig.9 Stay cable construction

4. Conclusion

Ikina Bridge was completed in 2010 and now, fulfills an important role for promoting the industry and livehood of the area. It is hoped that this bridge will be treasured by the local people.

Fig.10 Set back Jack

References

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概　要

生名橋は，愛媛県越智郡上島町の生名島と佐島を結ぶ3径間連続鋼・コンクリート混合斜張橋である。橋長は515mで架橋位置の地盤条件により橋脚位置が制限され，中央支間長は315mを有する。中央径間と側径間の支間割りによる工費増加を避けるために，中央径間の中央部149mには鋼桁を採用して重量のバランスを確保し，建設費用の低減を達成している。

また，主塔はRC構造であり，建設コストを低減するために斜材定着構造には分離定着方式を採用しておりPC鋼棒にて補強している。

主桁の施工は，PC桁は移動作業車にて，鋼桁はFC船にて張出し架設工法で行い，接合桁の施工は移動作業車を用いた直下吊り架設工法にて行うことにより海上交通への影響を最小限とした。