A Symbol of Recovery from the Great East Japan Earthquake — Onahama Marine Bridge —

東日本大震災からの復興のシンボル — 小名浜マリンブリッジ —

 *
 **
 ***
 ****

* Shuhei ONO, P.E.Jp: SHIMIZU CORPORATION
小野　秀平，技術士（建設部門）：清水建設（株）
** Takashi SAKAMOTO, P.E.Jp: SHIMIZU CORPORATION
坂本　貴嗣，技術士（建設部門）：清水建設（株）
*** Nobuaki YOSHIURA, P.E.Jp: SHIMIZU CORPORATION
吉浦　伸明，技術士（総合技術監理部門，建設部門）：清水建設（株）
**** Kibo OKAMURA: Oriental Consultants Co., LTD.
岡村　希望，技術士（総合技術監理部門，建設部門）：（株）オリエンタルコンサルタンツ
Contact: ono@shimz.co.jp
Keywords: extradosed bridge, measures against salt damage, balanced cantilever erection
DOI: 10.11474/JPCI.NR.2022.113

Synopsis

The Onahama Marine Bridge, located in Iwaki, Fukushima, is a 5-span continuous prestressed concrete extradosed bridge that was planned as a harbor road to provide efficient access to the remote areas of the Port of Onahama. This bridge has a length of 510 m and a maximum span of 120 m, making it one of the largest bridges of this structural type in an international hub port in Japan (**Figs. 1** and **2**). Since the bridge is in a port area, salt damage prevention measures were taken, and plans and manuals for maintenance and future inspection were delivered. The local community recognizes this bridge as a demonstrable symbol of recovery from the damage caused by the Great East Japan Earthquake and the resulting tsunami.

Fig. 1 Completion view (side)

Structural Data

Structure: 5-span continuous prestressed concrete extradosed bridge
Bridge Length: 510.0 m
Span: 75.0 m + 3@120.0 m + 75.0 m
Width: 16.0 m
Tower Height: 11.0 m
Owner: Ministry of Land, Infrastructure, Transportation and Tourism
Designer: Oriental Consultants Co., Ltd.
Contractor: Shimizu-Kawada Joint Venture
Construction Period: Mar. 2010 – Mar. 2017
Location: Fukushima Prefecture, Japan

Fig. 2 Completion view (on bridge deck)

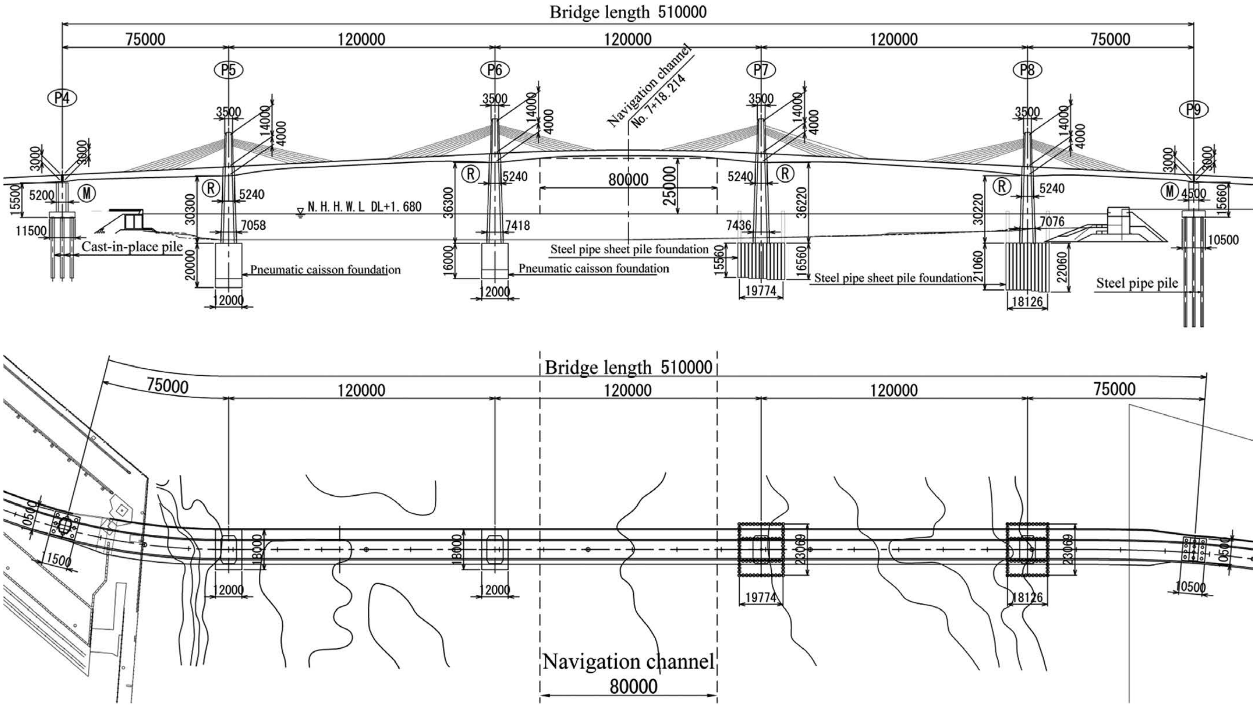

Fig. 3 General view of the Onahama Marine Bridge

1. Introduction

Located in the city of Iwaki in Fukushima, Japan, the Onahama Marine Bridge was completed in March 2017. The bridge was constructed as part of the road crossing Onahama port, with a length of 510 m and a maximum pier span of 120 m. The structural type of a 5-span continuous prestressed concrete extradosed bridge was selected based on economic and aesthetic perspectives. In addition, this bridge was designed as a multi-span rigid frame bridge for enhanced earthquake resistance and maintainability.

2. Overview of the Structure

An outline of the Onahama Marine Bridge is shown in **Fig. 3**, and its general section is shown in **Fig. 4**. The main girder is a 2-chamber box girder, and the exterior web is inclined with a thickness of 600 mm. The anchorages of the stay cables were installed inside the box girder for the aesthetic reason. Pneumatic caisson foundations for P5 and P6 and steel pipe sheet pile foundations for P7 and P8 were adopted based on a comparison of constructability and cost.

3. Design [1]

The bridge has a very symbolic and special design, which allows it to blend in with the panorama of sea and sky around it. In the main bridge section, the girder depth and the height of the main towers are kept low in order to avoid disrupting the scenery and view. The main tower, which has a trapezoidal cross section, changes its appearance depending on the viewing angle. The rhythmic triangular shape created by the main tower and the stay cables was selected considering the surrounding environment. The 2-column piers with V-shaped cutouts are extended vertically to become continuous with the main towers.

Since the bridge is located over the sea, salt damage prevention measures are very important. Therefore, the following measures were adopted: rigid connection between the superstructure and substructure without bearings, stay cables with multiple corrosion protection measures, anchorages of stay cables installed inside the box girder, and inner and outer tubes of anchorages that can drain infiltrated water.

The bridge was also designed in such a way that port administrators can carry out routine and emergency

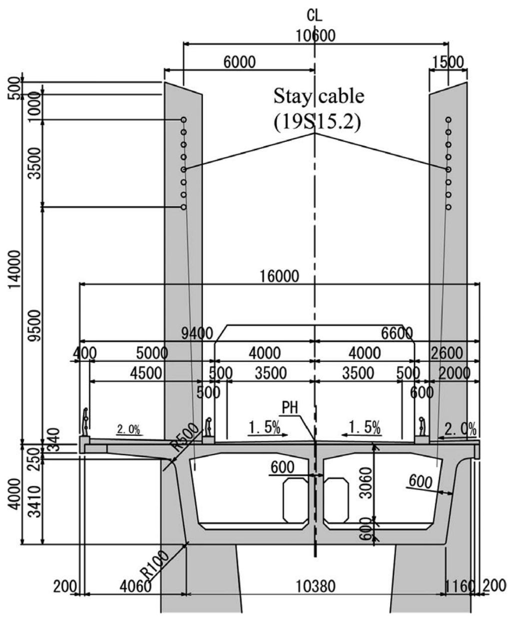

Fig. 4 General section

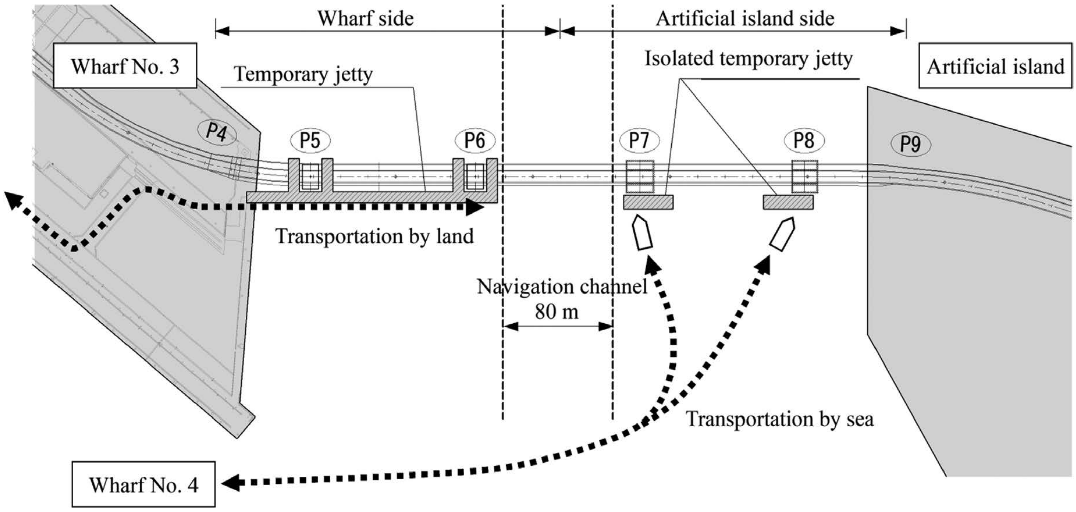

Fig. 5 Construction conditions

inspections reliably and efficiently. The provided inspection manual was formulated based on the characteristics of the bridge members and accessories for better quality of visual inspection.

4. Construction [2] [3]

(1) Pier Construction

Piers P5 and P6 were constructed using a temporary jetty installed parallel to the bridge. The temporary jetty was connected to the wharf; thus, land transportation was possible. On the other hand, piers P7 and P8 were constructed using a temporary jetty installed only around each pier. Therefore, it was necessary to supply ready-mixed concrete by sea transportation for piers P7 and P8. Concrete agitator trucks were transported by rampway barges, and concrete was cast using a pump truck mounted on a barge moored near the pier (**Fig. 5**). The pier concrete was considered as massive concrete with the risk of cracking due to thermal stress. Therefore, blast furnace slag cement achieving low heat and shrinkage reduction was used for the concrete of all the piers. In addition, the curing period was extended according to the outside temperature.

(2) Main Girder Construction

The main girder was constructed by balanced cantilever erection using form travellers (**Fig. 6**). There are 15 blocks in total, varying in length from 3.0 m to 3.5 m. Stay cable anchorages were installed from block 6 to 13. The average construction cycle of the blocks with stay cables was around 13 days.
A low-floor form traveller was used for the cantilever erection of the channel section because of space constraints between the channel and the girder. To ensure the safety of cargo ships and sightseeing boats navigating the channel, a TV sensor monitoring system was used as a safety measure for crane work above the channel. When the TV sensor monitoring system detected the approach of a ship to the channel, crane work was automatically stopped for the safety.
The central connection was constructed using form travellers as scaffolding. In addition, horizontal force adjustment work was conducted at each central closure of each span.

(3) Tower Construction

The main towers were constructed using scaffolding settled on the pier table. The base stage of the scaffolding was set at a slightly higher position such that it did not interfere with the traveller rail and the crane on the bridge deck. Concrete for the tower was cast by a pump truck in the range that the boom could reach, and by concrete buckets in areas higher than that.

Fig. 6 Balanced cantilever erection with travellers

Fig. 7 Installation of stay cables: wharf side (left); artificial island side (right)

(4) Stay Cable Construction

A semi-prefabricated resin-coated cable (19S15.2) was used for the stay cables, and penetration fixing was adopted for the saddle anchorages. Different methods were used for the wharf side and the artificial island side. On the wharf side, a tower crane (180 t.m.) was installed on the bridge deck of the pier table, and the stay cable materials were lifted by the crane and pulled in with a winch. On the artificial island side, a tower crane (120 t.m.) was installed on the temporary jetty, and the stay cable materials were pulled in with a winch using the scaffolding on the bridge deck (**Fig. 7**).

5. Horizontal Force Adjustment at Central Closures [4]

This bridge has a rigid frame structure with low piers compared to the fixed span length. Therefore, large bending moments were generated at the pier bases due to deformation caused by creep and drying shrinkage of the main girder. Therefore, it was necessary to improve the stress level at the pier bases, and as a solution, "horizontal reaction force adjustment" work was conducted at each central closure.

The features of this work on this bridge are that the cross section of the main girder is a 2-chamber box girder, and that the maximum horizontal load of 17,000 kN (one of the largest in Japan). the design load per loading point is 4000 kN. Using a steel reaction element fixed to the girder web element for horizontal loading is usually employed as a construction method for work of this scale, but the disadvantage of that method is that construction takes a long time.

As a solution, a method involving embedded anchorage devices for post-tensioning as a reinforcement material in the web member was devised, allowing horizontal force to be applied directly to the box girder section (**Fig. 8**). As a result, the construction process was reduced by about 2 weeks compared to the traditional method.

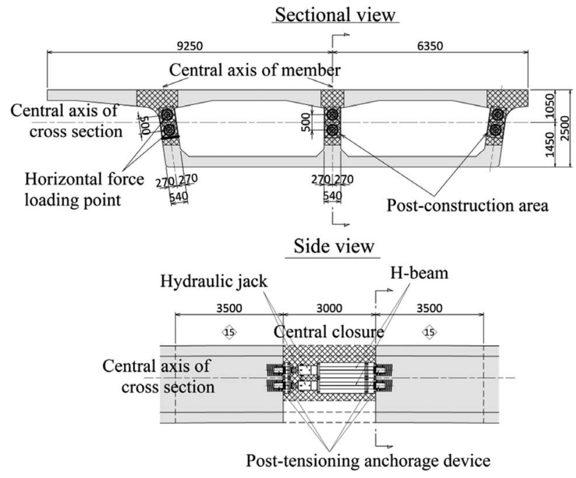

Fig. 8 Arrangement of forcing devices

6. Conclusion

Construction of the Onahama Marine Bridge was challenging because it happened at the same time as Great East Japan Earthquake reconstruction works, and it was difficult to procure materials and labor. The bridge was completed in March 2017, about seven years after the start of substructure construction and with the cooperation of all parties concerned and local residents. Over 6000 citizens participated in the completion commemorative walk held on April 23 of the same year. The bridge is expected to become a symbol of the region's recovery from the Great East Japan Earthquake.

This bridge won the Tanaka Award from the Japan Society of Civil Engineers and awards from the Japan Prestressed Concrete Institute and the Japan Concrete Institute.

References

[1] Manna, K., Okamura, K., Kuriyama, T., Onami, S.: *Design of the extra-dosed bridge as the symbol of Onahama port*, Journal of Prestressed Concrete, Vol. 57, No. 3, JPCI, Tokyo, pp. 28–33, May. 2015 (in Japanese).

[2] Ono, S., Matsunaga, H., Yoshida, N., Toshinami, T.: *Construction of superstructure (Onahama Marine Bridge)*, Concrete Journal, Vol. 56, No. 6, JCI, Tokyo, pp. 518–523, Jun. 2018 (in Japanese).

[3] Ono, S., Aoki, N., Mukaihara, S., Kitamura, Y., Sasaki, K., Hanami, H.: *Construction of Onahama Marine Bridge*, Bridge and Foundation Engineering, Vol. 51, No. 10, Kensetutosho, Tokyo, pp. 7–13, Oct. 2017 (in Japanese).

[4] Ono, S., Matsunaga, H., Toshinami, T.: *Rational reinforcement utilizing post-tensioning devises in Horizontal force adjustment for closure pour*, 39th IABSE Symposium, Vancouver, Canada, pp. 584–591, Sep. 2017.

概　要

小名浜マリンブリッジは，福島県の小名浜港 3 号埠頭（陸地側）と東港地区（人工島）を連結し，小名浜港後背地域と円滑に結ぶための臨港道路として計画された。橋梁の構造形式は，経済性と景観性に優れる 5 径間連続 PC エクストラドーズド橋である。

また，100年後も機能を発揮し続けるために，海上における長期耐久性対策（エポキシ樹脂塗装鉄筋の採用，斜材ケーブルの桁内定着など）が採用された。本橋の構造的な特徴や地域性を考慮した「点検マニュアル」が作成され，地域技術者との連携体制の構築，点検技術の向上や継承の取り組みなども行われている。

橋梁整備が開始された約 1 年後に東日本大震災が発生し，地域および小名浜港の復旧・復興とともに橋梁建設を本格化し，着工から約 7 年後の平成29年 3 月に橋梁の完成を迎えた。復興，そしてさらなる発展のシンボルとして期待されている。