Construction and Outline of Stonecutters Bridge, Hong Kong — The Third Longest Cable-Stayed Bridge in the World —

世界第三位の中央支間を持つ斜張橋の概要と施工 — ストーンカッターズ橋 —


*


**

* Yuji KOBAYASHI, P.E.Jp: Yokogawa Bridge Corp.
小林　雄次，技術士（建設部門）:（株）横河ブリッジ
**Kaoru YAMANE: MAEDA CORPORATION
山根　薫 : 前田建設工業（株）
Contact: y.kobayashi@yokogawa-bridge.co.jp
Keywords: cable-stayed bridge, construction of towers, falsework system
DOI: 10.11474/JPCI.NR.2014.117

Synopsis
Stonecutters Bridge has a 1,018m long main span, which is third longest in the world as cable-stayed bridge. The bridge crosses the Ramber Channel between Stonecutters Island and Tsin Yi Island, and is a part of the new Route 8. The new Route 8 links the Hong Kong Airport to Western Kowloon and leads further to Shatin in New Territories. This paper focuses on the construction of the towers, the side span concrete works and erection of main span segments. Details of construction are covered by other papers [1] [4].

Structural Data
Structure: Cable-stayed bridge
Bridge Length: 1,596.0m
Span: 69.25m + 2@70m + 79.75m + 1,018m
79.75m + 2@70m + 69.25m

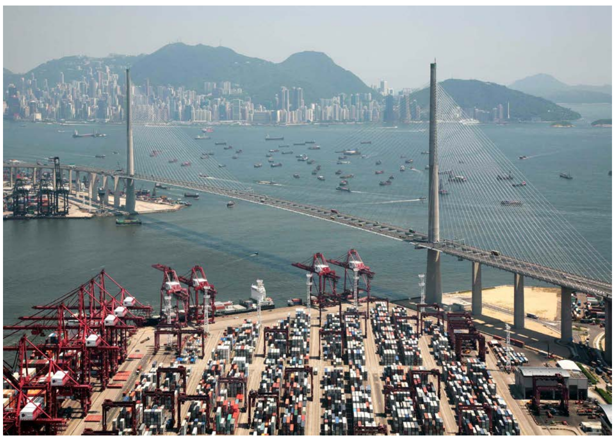
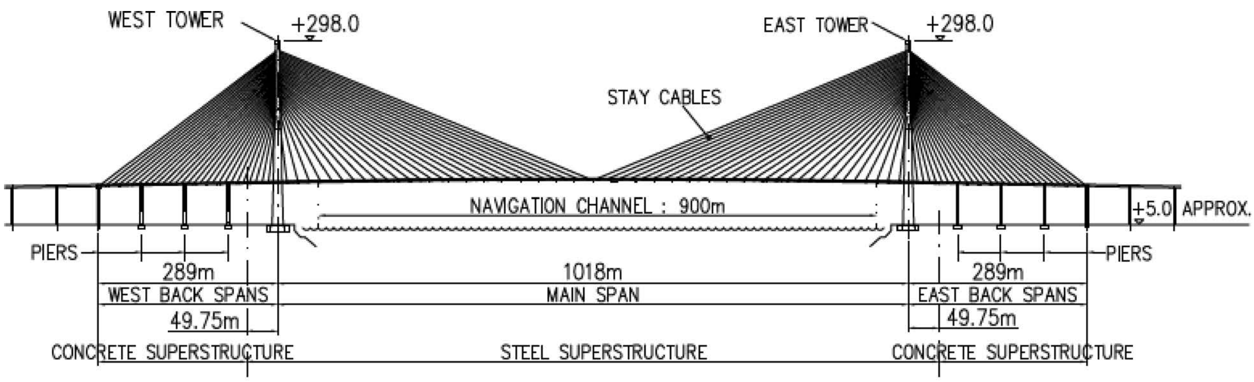


Fig. 1 View of Stonecutters Bridge

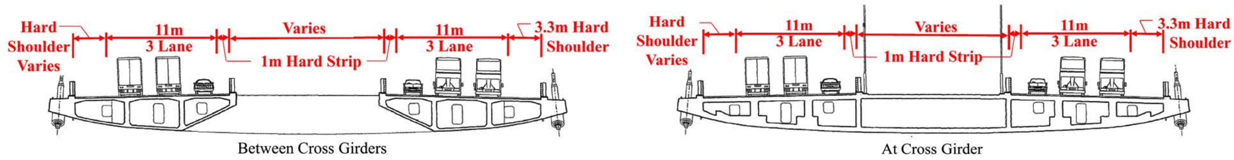
Width: 53.3m
Tower Height: 298mPD (The ground level is approximate 5mpD)
Owner: Highways Department of the Government of the Hong Kong Special Administrative Region
Detailed Design: Ove Arup & Partners Hong Kong Limited
Contractor : Maeda - Hitachi - Yokogawa - Hsin Chong Joint Venture
Construction Period: Apr. 2004 – Dec. 2009
Location: Hong Kong Special Administrative Region, China

1. Introduction
The profile of Stonecutters Bridge as seen in **Fig.1** and **Fig.2** is a new generation of long span cable-stayed bridges. The main span has a 53m wide twin steel box girder with orthotropic steel deck linked by cross girders giving excellent aerodynamic performance. This bridge has two monopole towers and concrete side spans monolithically connected to concrete piers. Quantities of concrete work are shown in **Table 1**.

2. Towers and Side spans
(1) Concrete Mix Design
The contractor undertook extensive concrete testing in order to establish a suitable mix designs to employ either pulverized fuel ash (PFA) or granulated ground blast-furnace slag (GGBS). Tests on the concrete including hydration heat, chloride resistance, compressive strength and flowability are conducted. The GGBS mix was used for the pile caps, and the PFA mix was used for the piers, decks and towers.



(1) elevation



(2) Typical cross section of concrete deck

Fig. 2 Stonecutters Bridge

Table 1 Quantities of concrete works

Location	Quantity
Bored Piles	27,000m^3
Piers	17,000m^3
Towers	57,000m^3
Back span decks	33,000m^3

Fig. 3 Self-climbing form system for Tower

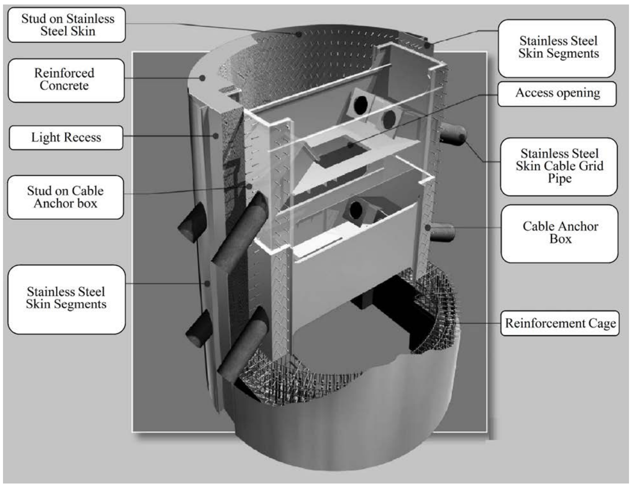


Fig. 4 Tower side Anchor for Stay Cable

(2) Construction of towers

The towers are mono-shaft structures with height of 298m above Principal Datum (mPD). There were two construction stages. The first stage is for the reinforced concrete structure from base to 175mPD. The second stage is for the composite structure of stainless steel skin and concrete from 175mPD to the top of towers.

The lower part of tower has a complex variable section. The section is oval shape of 24m x 18m at the bottom end. The shape changes from oval to a 14m diameter hollow circle at deck level. The shape of section changes to an 11m diameter circle at 175mPD.

The lower part of tower was constructed using a self-climbing form system (**Fig.3**). It contains all necessary access platforms for rebar fixing, formwork fixing and striking, concrete casting and curing plus the application of a concrete sealant. The concrete was placed by a skip with tower crane at 4m lifts.

The upper tower then becomes a composite structure with a stainless steel skin and inner steel anchor boxes for the stay cables. **Fig.4** shows a typical arrangement for the three component parts. Both the 50 steel anchor boxes for the cables and the duplex stainless steel skins were manufactured at the same yard in China and great care was taken to ensure the geometric accuracy. The trial assemblies of three sections of the combined units

Fig. 5 Erection of Stainless steel skin

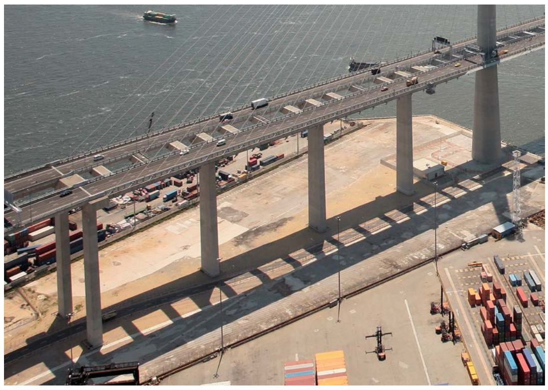


Fig. 6 View of Side spans

Fig. 7 Concrete Side span Falsework

Fig. 8 Falsework of concrete deck

to check the verticality ensured a good fit on site. The anchor boxes were painted with an MIO (Micaceous Iron Oxide) coating and the stainless steel skins were peened to give a dull non-reflective finish. The shells are shown in **Fig.5**.

(3) Construction of Side spans

Concrete deck was employed for 289m long side spans (**Fig.6**) as counterweights for the main span. Each side span is supported by four piers with 60-70m height. The monolithic side spans are post-tensioned in both transverse and longitudinal directions. Their geometry is very complex due to the grillage-type arrangement of the superstructure, the slender pier supports, the integration of stay cable anchorages and the complicated post-tensioning system. The total concrete volume for the East side span is about 20,000 m^3 (above pile caps) and somewhat more for the West side. A large scale falsework system shown in **Fig.7** was installed in order to support side spans until the stay cables were stressed. The falsework has three pairs of temporary towers in each span, which were made of 2m x 2m match cast precast concrete segment with shear keys at the joints. The concrete towers are connected by diagonal steel bracing members. The construction sequence is as follows.

- concrete casting for cross girders
- longitudinal deck

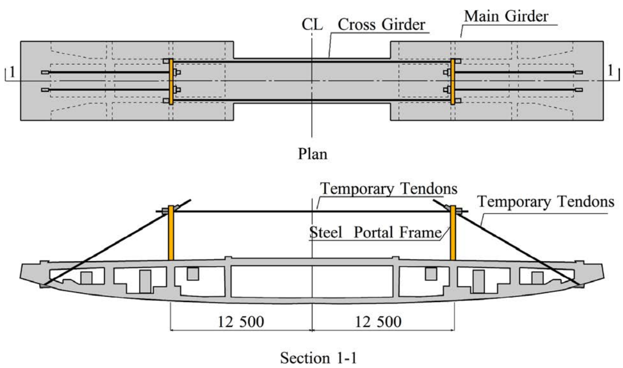


Fig. 9 The temporary prestress of concrete deck

- transverse post tensioning at intermediate stages (**Figs.8 and 9**).

The cross girders were poured first, followed by the longitudinal deck. The deck was completed in the center part of the each span before it was connected to the pier. Before connecting to the pier , the deck geometry was carefully checked. At this stage, the level corrections by jacking on the falsework towers was possible, but this was found unnecessary because the settlement predictions were very accurate. The longitudinal post-tensioning after all the connection of cross girders and piers gave continuity to the side spans. Details of the side span concrete decks are covered by other papers [1].

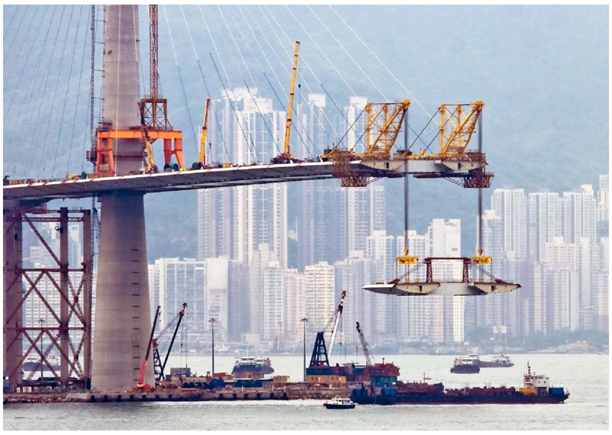


Fig. 10 Erection of main span segment

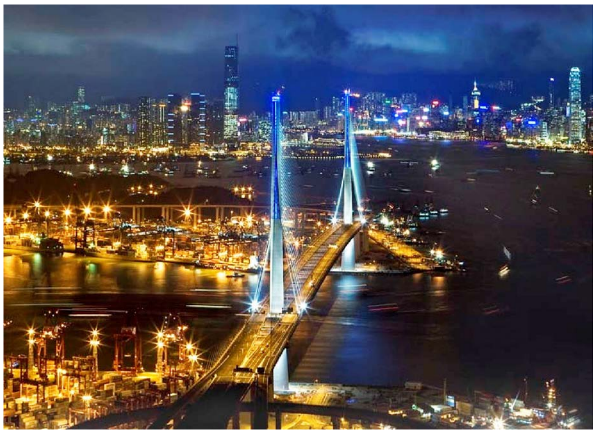


Fig. 11 Night view of Stonecutters bridge

3. Erection of the main span

Lifting operations were carried out on a 10 to 12-day cycle with the lifting alternating between the east and west side of the bridge. The lifting area was 200m by 200m and this was cordoned off by four guard boats. The barge was towed to the lifting area and positioned by GPS system and checked by surveyors. The lifting was carried out by lifting gantries positioned on the end of the deck. The minimal weight gantry design, i.e. 200t, reduced the deck deflection. The winches were linked to computer synchronized for load and level. They were chosen because they were faster and smoother than strand jacks. The lifting time for each 500t segment was within 40 minutes. The deck segment erection of main span is shown in **Fig.10**. Details of the election of the main span are covered by other papers[4].

Night view of Stonecutters bridge is shown in **Fig.11**.

References

[1] West .BW., Tapley M. J., Yamamoto S, Sham S. H. R.:*Challenges in Construction Stonecutters Bridge and Progress Update* ,Proceedings of 6th International Symposium on Steel Bridges, Prague, Czech Republic, 238-249, 2006

[2] Sham S. H. R.: *Construction Engineering for World's Longest Cable Stayed Bridges*, Proceedings of 24th Annual International Bridge Conference Pittsburgh, USA IBC 07-26, 2006

[3] West BW, Tapley MJ. : *Construction of Stonecutters Bridge* , Proceedings of 7th International Conference on Steel bridges, Guimaraes, Portugal

[4] Taku Hirai, Ir Rory O'Grady : *Erection of main span of Stonecutters Bridge, Hong Kong,* 8th Japanese German Bridge Symposium, 2009

概　要

ストーンカッターズ橋は，香港の新界北東地区からコンテナターミナル基地とランタオ島エアポートを結ぶ路線の一部となる長大橋梁であり，2009年12月に供用が開始された。橋長1,596m，中央径間長1,018m，主塔高さ298mの9径間連続複合斜張橋であり，斜張橋としては現在，世界第三位の中央径間長を誇る。側径間はPC構造，中央径間は鋼床版箱桁，主塔はRC構造であり，主桁は景観と耐風安定性向上の観点から，中央部で分離した箱桁をケーブル定着位置において剛性の高い横桁で連結する構造となっている。主塔は，高さ175mまではRC構造，175mより上は景観および防食の観点からステンレス鋼材とコンクリートの複合構造である。

本稿は，ストーンカッターズ橋の架設のうち，側径間のコンクリート桁建設，主塔建設，中央径間の架設の概要をまとめたものである。