Construction Engineering for Stonecutters Bridge: Concrete Backspans and Steel Deck Heavy Lift

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Summary

Stonecutters Bridge will be the second longest cable-stayed bridge in the world with a main span of 1018m. This paper describes the construction of the concrete backspans and the steel deck around the bridge towers. The construction of the concrete backspans was one of the most difficult aspects in the erection of the bridge. At a height of about 70m a geometrically complex grillage deck, monolithically connected to the piers was to be constructed. The concrete girders are constructed on a unique and purpose-designed falsework system, suited to the contractor's needs. Next, an 88m long portion of the steel deck to either side of the tower was to be erected on falsework but an alternative Heavy Lift scheme was developed, yielding economical, programme and quality advantages. This paper describes the development of the construction procedures, the design of the temporary works, the construction engineering aspects of adequacy checks and geometry control, and how the challenges of construction were harnessed.

Keywords: cable-stayed bridge, construction, concrete, steel, heavy lifting, geometry control.

1. Introduction

Stonecutters Bridge, to be completed in 2009, will be a new icon for Hong Kong. The bridge will link Stonecutters Island in West Kowloon with Tsing Yi Island and form part of a new Route 8.

Stonecutters Bridge is a high-level cable-stayed bridge with a main span of 1018m supported by 298m high single-shaft towers. The deck features a twin-box arrangement where the two longitudinal girders are interconnected by cross girders to form a grillage structure. The backspans are monolithic concrete structures with spans of around 70 meters. About 50m from the tower axis into the backspans the deck changes to steel. There are 8x28 parallel wire strand cables.

The contract for the construction was awarded to the Maeda-Hitachi-Yokogawa-Hsin Chong Joint Venture (JV) and Maunsell AECOM (Maunsell) is the JV's consultant for the construction engineering.

2. Concrete Backspan Construction

The concrete backspans are monolithic throughout and permanently post-tensioned in both transverse and longitudinal direction. 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 (PT) system.

The girders cannot support their own weight until the stay cables are installed and are thus constructed on a unique and purpose-designed falsework system, suited to the contractor's needs. The main supporting members are columns of match-fabricated pre-cast concrete elements, braced

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by steel truss members. The falsework supports a total of 30,000 tons of superstructure concrete per backspan and is designed for full typhoon loads. The deck was constructed in stages with the cross girders being cast first, followed by the longitudinal girders. Substantial falsework truss beams were used for this purpose. All connections were by prestressing bars to allow easy assembly and disassembly. Permanent and temporary post-tensioning was applied to the cross girders and longitudinal post-tensioning to the longitudinal girders.


Fig. 1: Falsework erection (left), staged casting of longitudinal girders (right)

3. Steel Deck Heavy Lift

Due to the grillage-type deck arrangement with the single pole towers located between the two longitudinal girders and the cross girders, the installation of the 88m long steel deck section around the tower was initially planned to be executed on a large ground-bearing falsework. In an endeavour to reduce the construction costs the Joint Venture formed an Alliance with VSL to develop an alternative Heavy Lift scheme. This method relied on the already constructed towers and the concrete backspan as lifting points and lifted the girders into position at 80m height in one 4000 ton lifting operation. Due to geometrical constraints transverse and longitudinal sliding operations by 6m and 2m respectively were also to be carried out at height. A guide system and intermediate restraint positions were provided for the lift and in the final lifted condition a fully typhoon-safe restraint system was installed. From the lifted longitudinal girders the cross girders were individually lifted and welded. Upon completion of the grillage the steel deck was stitched to the concrete deck with a closure pour, followed by cable installation and a release from the temporary lifting points.

Fig. 2: Steel Deck Heavy Lift

4. Construction Engineering

Maunsell provided extensive construction engineering services, comprising stage-by-stage analysis and structural adequacy checks of permanent works for all erection operations as well as Geometry Control analyses to ensure that at end of construction the bridge would meet the target geometry to within tight tolerances. A rigorous modelling approach that realistically represented the effects of all construction activities has been the basis of the project’s success.