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Autor: Sham, Robin

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An Innovative Technique for Fitting Trackwork Alignments Through the Railway Envelope of a Cable-stayed Bridge

Robin SHAM
Technical Director
Maunsell Ltd
United Kingdom

Robin Sham, born 1954, received his BSc in 1978 (Birmingham) and PhD (Structural Engineering) in 1989 (Imperial College). He is Technical Director responsible for Bridges & Special Structures and was Designer's Project Manager for the successful Kap Shui Mun Bridge & Ma Wan Viaduct Project in Hong Kong, opened in 1997.

Abstract

The Kap Shui Mun Bridge and Ma Wan Viaducts are 2-level structures which carry the expressway on the top deck and the airport railway in the central region of the lower deck. Emergency carriageways for use under typhoon conditions are provided on either side of the railway.

The innovative design concept aims at making possible what effectively is a tunnel in the air, to be constructed at an extraordinary rate, on time and within budget.

The cable-stayed structure has a main-span of 430m and a total length of 750m. Structural efficiency is enhanced by double steel-concrete composite action in the main span in that both the top and bottom flanges of the steel superstructure are formed in concrete.

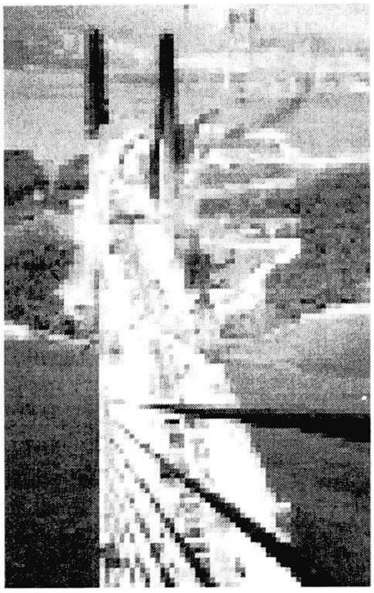

Fig 1 - Kap Shui Mun Bridge & Ma Wan Viaduct

The trackwork for the airport railway is contained in the central region of the lower deck of these bridges. The trackform design consists of precast, post-tensioned concrete trackslabs mounted on resilient bearings which are installed on transverse beams. The trackslabs are also restrained laterally through resilient bearings fixed to concrete corbels which are positioned on either side of the trackslab and cast into the bridge superstructure. The design constitutes a non-ballasted 'floating' trackslab system which isolates the trackform from the main bridge structure thereby minimising the generation of noise and vibration.

In order to meet an exceptionally tight programme, trackwork construction had to be concurrent with bridge construction. However, trackwork construction within the partially completed bridge superstructures would only be possible if design techniques could be developed to control the setting out of the trackwork under the most unusual conditions which existed.

With full co-operation from the contractor, Maunsell's Wriggle technique was applied to the trackwork reprofiling. The Wriggle technique originates from tunnel engineering and involves the determination of track alignments in three dimensions to fit through the surveyed tunnel. The technique was successfully used to fit a rail profile (vertical) and alignment (horizontal) through the as-constructed railway envelope in the lower deck. The track profile must satisfy the railway design criteria in terms of gradient and curvature. The alignment had to take account of the as-constructed shape of the railway furniture and emergency exit walkways. In all cases the minimum structure gauge must be maintained.

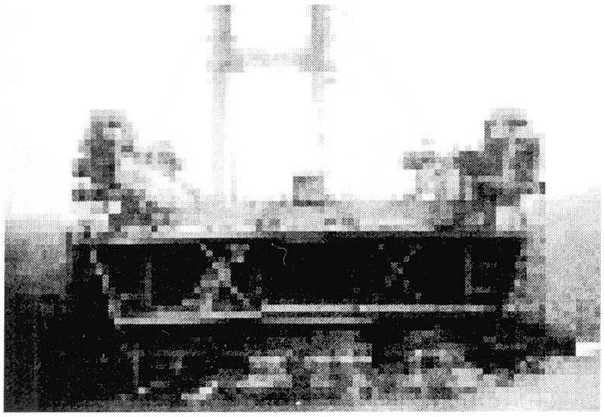

Fig 2 - A Cross-section of the Main Span

Unlike a tunnel, a long-span crossing is subject to transient as well as long-term movement. In particular the cable-stayed main span is susceptible to considerable movement between different survey operations carried out at different times of day. Due to the very tight programme of work the survey of the approach spans had to be carried out when temporary propping and falsework were still in place and the main span closure was yet to be completed. Similarly, as the construction of Ma Wan Viaducts progressed, the Wriggle exercise had to produce trackwork setting out data for the existing spans without the benefit of any survey results on spans which were yet to be built. The deflection predictions, on which the Wriggle exercise partly relied, were incrementally calibrated and adjusted, when it became possible to survey newly constructed spans.

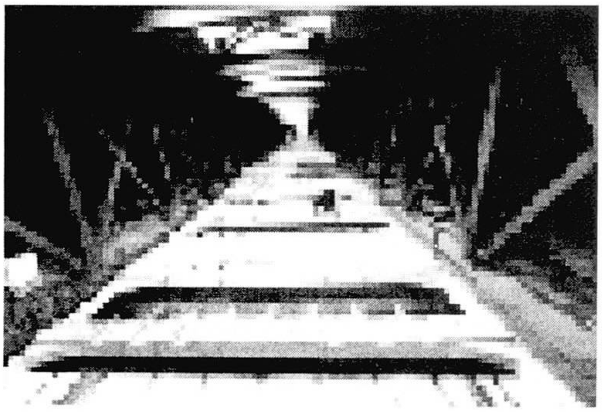

Fig 3 - Railway Envelope

The objective of the Wriggle exercise was to produce a smooth track alignment that provided the necessary clearances at pinch points and maintained minimum curvature requirements. The output from this exercise had to be supplied to the trackwork subcontractor at a staggering rate and in a form that was simple, accurate, and practical to use for setting out.

The logistics of the work associated with the railway envelope survey and track reprofiling were complicated by construction activities and the intense pressures from the construction programme. Despite these constraints, the work enabled on-site adjustments during construction to achieve compliance and was critical to the successful completion of the railway work.