

## Railway Viaduct Construction Contract Awarded to the Proposed Alternative Design and Construction

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### 1.0 Introduction

The Kowloon Canton Railway Corporation (KCRC) is constructing a new railway, known as West Rail in Hong Kong. At KCRC tender invitation, the Maeda-Chun Wo Joint Venture (MCWJV) have submitted tenders for the construction of two sections of viaduct totaling 10km in length, under the contracts designated as CC201 and CC211. MCWJV have proposed to construct these viaducts to a different design (the alternative design) which was developed as an alternative to the design previously developed by KCRC and shown on the tender drawings (the conforming design). MCWJV have engaged the design consultant Robert Benaim & Associates (Asia) Ltd (RBAA) as the designer of the proposed alternative design. The proposed alternative design was accepted by KCRC and awarded to MCWJV.

In this paper, the alternative design developed in order to win the competitive tender is introduced.

### 2.0 General considerations to the alternative design

In the tendering of the international competitive construction contract, an alternative tender based on the alternative design is admitted. However, only the submission of an alternative tender is not permitted, the tendering of the conforming is a condition for doing the alternative tender. This is because to keep the justice of the tender, and after the evaluation against the conforming tender, the alternative tender can be evaluated. "The Alternative" is the one that show how it is different to the conforming. Therefore, it is crucial to include the data of the design statement, drawings, quantity breakdown, specifications etc. in the tender submission.

The alternative should have the benefits to the Client such as;

- Improved quality/performance
- Reduced construction cost
- Reduced maintenance cost
- Reduced construction period

In addition to the above considerations, it is important that the alternative design should show the respect for the conforming design as far as possible. When the alternative design is adopted, the contractor bears the responsibility to the design. The contractor's designer needs to issue the design warranty.

### 3.0 Development of the Alternative Design Concept

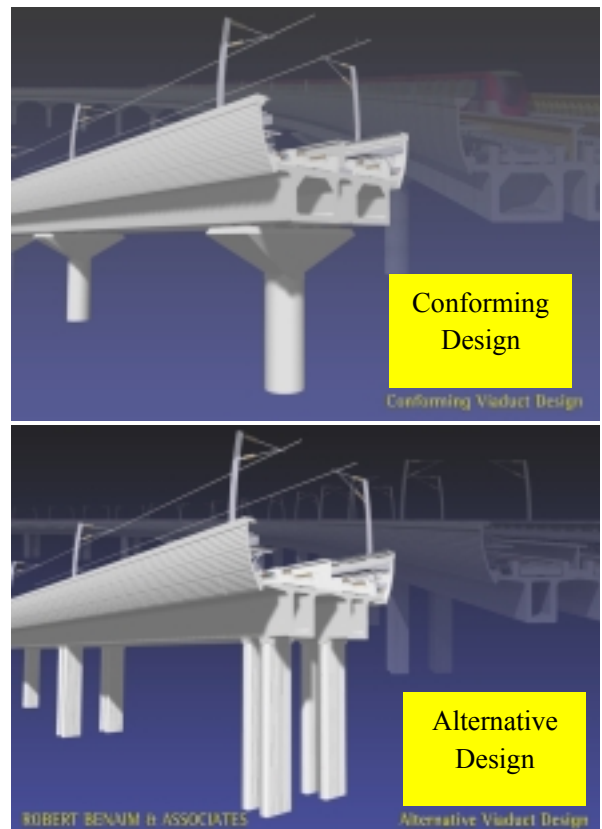
The West Rail project has to comply with the Hong Kong Noise Control Ordinance and Environmental Impact Assessment Ordinance of Hong Kong. In particular, the design must comply with the West Rail Environmental Permit issued by the Environment Protection Department (EPD).

For the viaducts, the key aspect of the Environmental Permit is noise impact on adjacent sensitive receivers. The development of the viaduct design (both the conforming design and the alternative design) has been influenced significantly by the need to minimize noise radiation from the viaduct structure as well as from the railway itself.

The aim of MCWJV and RBAA in developing the alternative design is to be able to offer to KCRC a viaduct design which, while not radiating any more noise than the conforming design, can be constructed more economically.

Key words: Alternative design, Conforming design, Competitive tender

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To achieve the objective of reduced construction cost, the principle strategy will be generally to find ways of using less materials to achieve equivalent performance, particularly in the viaduct deck. Reducing the mass of the viaduct deck reduces the foundation design loads and the prestressing, in addition to the direct reductions in concrete and reinforcement quantities.

#### 4.0 Assessment of the Structural-radiated Noise and the Structural Solution

At first sight of the conforming drawings, a greater mass of the concrete may be thought to allow absorption of greater noise energy, both because of the characteristics of the concrete itself and also because of the associated increase in stiffness.

Achievement of a viaduct design sufficiently quiet to meet the requirements of the Environmental Permit. It was realized early, however, that it is not just the mass itself but especially the careful disposition of the mass which is most effective in controlling noise radiation from the viaduct.

RBAA engaged Institute of Sound & Vibration Research to carry out studies, in which a number of potential alternative designs were considered and the most promising solutions were evaluated against the conforming design for relative noisiness.

A number of finite element (FE) models of the bridge have been used for solving particular sections of the overall noise problem. The solution is to make the narrow box girder monolithic with its supporting columns at each end. Each typical pier comprises a pair of double leaf columns, whose stiffness is carefully designed to accommodate flexural rotation of the bridge deck and effects of thermal, creep and shrinkage shortening, while still providing adequate strength and rigidity to resist applied loadings.

#### 5.0 Key Features of the Alternative Design

##### Aesthetic Appearance

Visually, the alternative and conforming viaduct decks are very similar. The only difference is the width of the box girder beams beneath each railway track. In the alternative design, the width of the box girders is 2000mm whereas in the conforming design is the width of the box girders is 3600mm.

The form of the typical piers of the alternative design is visually different from the typical piers of the conforming design. The typical piers of the alternative design comprise a pair of double leaf columns, which are visually both slender and elegant.

##### Superstructure Alignment, Span Lengths and Articulation

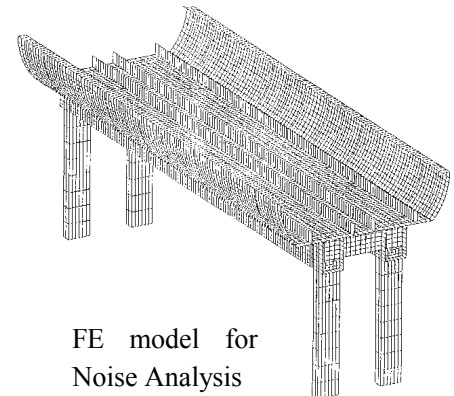
The horizontal and vertical alignment of the alternative design viaducts, and the provisions for rail cant, are identical to those of the conforming design.

##### Future Maintenance Considerations

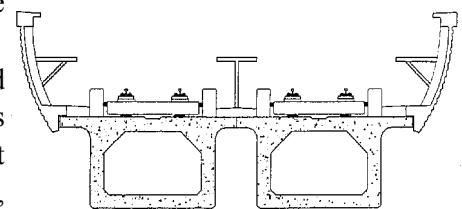
A major innovative feature of the alternative design is the elimination of all bridge deck bearings throughout the length of the contract. Bearings have traditionally been a source of maintenance issues and future expense, as their design life is only of the order of 25 years, so that they require replacement several times within the design life of the structure. However, with the alternative design, not only will KCRC benefit today from the saving in capital cost by the elimination of the bearings, but they will also not face the expense of bearing replacement in the future.

#### 6.0 Acknowledgement

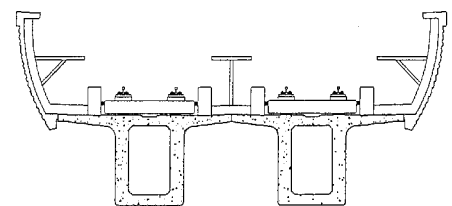
The development of alternative design have been described in the paper, which introduces the reduction of overall construction cost offering the equivalent performance. The experience in here would serve a good example when contractors would challenge the international competitive tender.



FE model for  
Noise Analysis



CONFORMING DECK X-SECTION



ALTERNATIVE DECK X-SECTION