Challenges in Erecting the West Kowloon Terminus Roof

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Summary

West Kowloon Terminus will be a landmark station at the Hong Kong end of the China high-speed rail system. The focus of the station will be a roof structure, formed from three triangulated steel trusses, curved both in plan and elevation, capped by composite concrete walkways which ultimately support significant superimposed dead loads in the form of landscaping, planters and trees. Significant parts of the building envelope is made of glass systems. The construction of this structure presents many challenges to the contractor's erection engineering team.

Keywords: Steel truss roof; steelwork erection; erection analysis; falsework system.

1. Introduction

1.1 Roof Description

The roof is composed of three triangulated steel trusses formed from circular hollow sections, supported by a series of fabricated steel columns, termed mega-columns. The trusses are curved in plan and elevation, and each truss is capped by a composite concrete deck, which will form the basis for walkways over the roof. The supporting mega-columns are also curved in elevation.

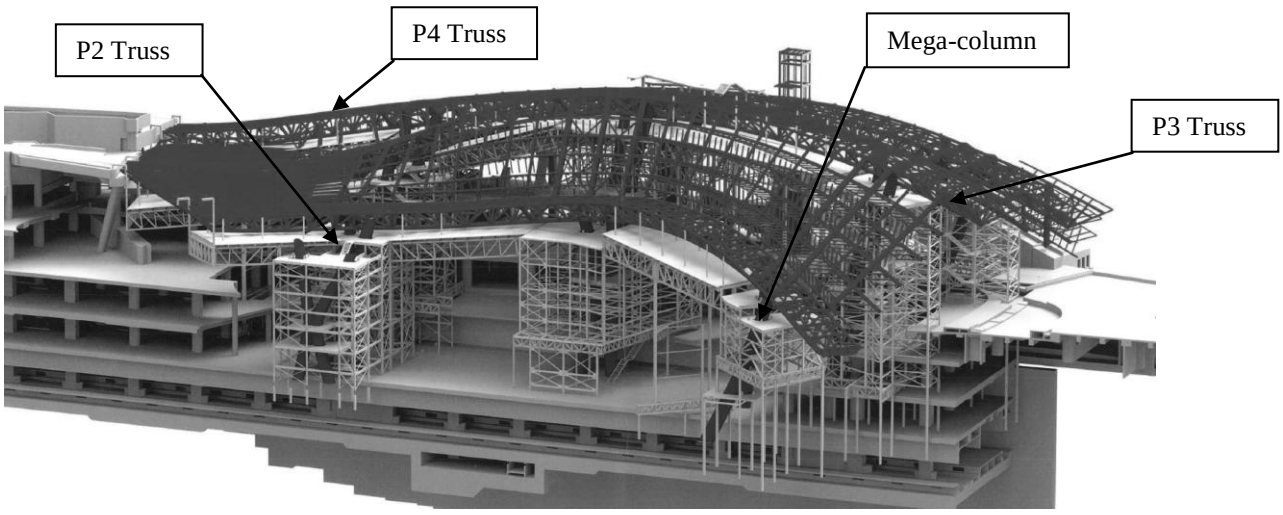

Fig. 1: Exploded View of the Station Roof and Temporary Works

The overall length of the steel roof is about 180m and the difference in elevation between the lowest mega-column baseplate and the crown of the middle (P3) truss is greater than 45m.

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2. Erection Sequence

The erection sequence for the roof has been developed to avoid any overstress under the transient loading conditions during erection and minimize the effects of locked-in stresses on the permanent structure, while ensuring the roof can be erected to a tight programme and in a cost effective manner. The roof is erected on elevated platforms supported by temporary trusses and towers. The assembly, and subsequent de-propping of the permanent trusses, is carried out systematically as a controlled process, ensuring the steelwork is not overstressed even when subjected to the onerous Hong Kong wind loading. On completion of the structural steelwork concrete slabs are cast along the top chords of the trusses to form a composite structure.

3. Erection Analysis and Geometry Control

Detailed analytical studies have been carried out on the structure for the various stages of erection, with the resulting member loads and movements being used to refine the erection sequence. Residual forces from the analysis are compared to the forces used in the permanent works design. The inclusion of concrete slabs requires the modelling of the time dependent properties of the concrete. The ultimate load effects have been determined during the construction stages, including the onerous effects of the typhoon wind loading, as well as the various temporary works and plant loads applied during construction.

According to the erection analysis, the unique geometry of the roof leads to large movements as the propping system is released. It has therefore been necessary to apply derived values of precamber to the structure to achieve the stipulated construction tolerances.

4. Temporary Works

The design of the temporary works has taken place in conjunction with the erection analysis and has required regular interaction with the erection analysis team. Essentially there are two key components to the temporary works: the supporting towers and the temporary trusses.

Temporary towers are constructed around the mega-columns and act both as lateral support during their erection and also a vertical support to the temporary trusses required to support the roof during assembly. The temporary trusses span between the temporary towers and act as a support system to the platforming upon which the the permanent V-trusses are erected. After the V-trusses have been de-propped, the working platforms, used for erecting the cladding and glazing, are suspended from the trusses.

5. Summary

The roof of the West Kowloon Terminus is complex due to its shape and geometry. As a consequence the erection and associated erection analysis are challenging and have required innovative solutions. The erection sequence for the roof has been developed with the aim of minimizing residual stresses in the steelwork structure while working within the constraints of tight construction programme. The erection analysis has closely modelled this sequence, highlighting areas where adjustment may be required.

At the time of writing the roof is under construction with completion due in 2014.

6. Acknowledgements

The Client for the project is the Mass Transit Railway (MTR), who appointed an AECOM-AEDAS JV as its designers, with Buro Happold as sub-consultant for the design of the roof. A Leighton-Gammon JV is the main contractor with Alfasi acting as its sub-contractor for the fabrication and erection of the roof. Aurecon has carried out the erection analysis and temporary works design for Alfasi.