Relating stress concentrations in triangular steel bridge piers to simple beam models

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Abstract

Triangular piers integrate both support surface for bearings and lateral stiffness to resist horizontal force. It is generally known that in the triangle's corner large stress concentrations may appear. Therefore curved transitions are provided at these locations. To determine these stress concentrations the use of highly dense FE-models and indeed also engineering judgement, is needed. The latter applies to most software packages. On the other hand, one might consider to use simple beam elements, the axes coinciding with the real pier axes. In doing this, the stress concentrations will be missed and unsafe design is the result. The main aim of the research is to compare the results of an equivalent beam model to elaborate shell element models, which include the necessary transition curves. For each type of external force and rounding parameters the stress concentration factor for the undisturbed cross-sections is established. The work is presently in progress and the first results show definitely plausible factors. However, for small stress magnitude, the results are less convincing.

Keywords: steel triangular piers, stress concentration, variable radius of rounding, FE-models, load combinations, simulation accuracy.

1 Introduction

Triangular piers became rather popular for long viaducts, from the 90's on, up to date. There are many examples as the viaducts of Battice, Herve, José and Ruyff (Fig. 1) [1]built in Belgium for the high-speed line Liège-Cologne. However, most of these piers are concrete, the steel alternative being rare. A similar concrete example is found in the viaduct of La Savoureuse in the Eastern part of France [2].

However, the need for rapid construction increases the popularity among designers to consider steel triangular piers [3]. The latter show considerable horizontal resistance to braking and acceleration loads. In buildings they are sometimes valued for their cool and smooth shape, as can be seen in Fig. 2. The latter example are columns outside a steel contractor's new plant, supporting the office building. The triangular form is also inspired by the lateral force from rolling cranes in the adjacent workshop.

While designing these triangular columns, it was striking that the loads were almost similar to bridge superstructure loads. Hence, these structures might very well be similar to piers for a viaduct of around 25 m span. The details from this design may be used as an excellent example to explore what are the stresses and especially stress concentration in the steel structure. Determining the stresses in the piers requires the use of detailed FE-models. Any other type of analysis will not detect the stress concentrations and the design will be obsolete. What is more, the stress conditions outside of the concentration areas of the FE-model for Fig. 2, compared to a simple triangular beam model with