Tied Arch Bridges with Optimized Arrangement of a Limited Number of Hangers

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Summary

Slender steel tied arch bridges are highly valued for their aesthetic appearance. However, the hangers are often experienced as a disturbing factor, as they decrease the transparency and lightness of the bridge. As demonstrated by the design of a new railway bridge, adjacent to historic Vierendeel-bridges, there may be interest in building tied arches with few hangers. A limited number of hangers, causes the arches to be subjected to patch loading, a far less favourable condition than is generally used. However, an optimum arrangement of sloping hangers can be found. This is obtained by distributing the hanger nodes in an even manner and concentrating the nodes on the lower chord near to the centre. The bending moments in the arch springs and at the nodes are becoming balanced. In addition, the buckling loads become more favourable in this type of arrangement. This optimisation is applied to the steel arch bridge at Mechelen, designed to comply with the existing Vierendeel-bridges, thus respecting part of the bridge heritage at this location.

Keywords: steel tied arch railway bridge; optimisation of hanger arrangement; historic bridges, Vierendeel-bridges.

1. Introduction

Tied arch bridges, consist of arches and a lower chord, connected by hangers, which may be arranged in various ways. In general, vertical hangers are used, although it has clearly been established that triangular arrangement is superior, both for the load carrying capacity as regarding deformations. However, certain combinations of live loads can introduce compression force in several hangers, or cause slackness of these. For instance, in network arches [1] [2] this is always the case and still remains the cause of questions about the fatigue resistance of these structures. Hence, the triangular arrangement requires sufficient stiffness of hangers and particular attention to the concept of the nodes. Combined alternatives have been considered, such as fan arranged hangers, with converging point either located below the lower chord or above the arch top.

Although the idea of arch bridges is highly valued, the hangers are often experienced as a disturbing factor, since they divide the area between the arch and the lower chord. In this sense, hangers decrease the transparency and lightness of the bridge, in particular if they are used in several vertical or sloping planes. Consequently, it may become interesting to limit the number of hangers and nodes. However, using a limited number of hangers modifies the effect of the arch from an almost distributed load to patch loading. The latter is an unfavourable condition for arch structures, since it introduces high bending moments and variable arch compression force. Hence, the effect of a limited number of hangers has to be closely assessed. In the following, a double-track railway bridge of 68.2 m span is being considered, since this is the structure which has been inspiring the present research. This structure is being commented in member 3.

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