The effect of undue transverse welding on the fatigue resistance of hanger connections for steel tied arch bridges

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Abstract

Steel arches are mostly built as rectangular hollow box sections. Most types of connection of hangers to steel tied arch bridges require the introduction of stiffeners, enabling to transfer the hanger force to the hollow box arch section's webs. However, the hanger force coincides with the arch axis plane, whereas the webs are located in 2 vertical planes at a distance of half of the arch width from the axis. In a particular case the plates, connecting the hangers to the arch lower flange were also welded to the arch box section's lower flange. This introduces unwanted transverse bending of this flange. The research aims at assessing the fatigue resistance for this multiaxial stress condition, first by applying nominal stress evaluation and subsequently by determining the hot spot stress situation. To overcome the fact that these methods apply to unidirectional stress, the critical plane method was used as it renders the most reliable result and demonstrates the insufficient fatigue resistance for a particular case. Subsequently, the results have been generalized in a single diagram in which the horizontal axis displays the stress variation parallel to the arch axis, due to compression and bending, versus the normal stress perpendicular to the former and due to the hanger force being introduced.

Keywords: steel tied arch, arch to hanger connection, biaxial stress, fatigue resistance, hot spot stress, modified critical plane method.

1 Connecting hangers to arch box sections

Steel arch bridges and especially tied arches, have become a preferential way to cross subjacent roads and other infrastructure for spans from 40 to 200 m. Also it is common to use rectangular hollow box sections for the arch itself. As for the hangers, often plain rods are used, their ends being articulated in the arch plane sense. This latter tries to avoid introducing bending in the hanger rods. The connection can be seen in Fig. 1a. The hanger end is connected to a single widening plate, containing a hole for the hinge pen, the wider longitudinal plate dispersing the hanger force.

The connection essentially is meant to transfer the hanger force as shear to the arch box member. This shear force is developed in the arch box webs, located on both sides of the hollow section, as shown in Fig. 1b. Hence, both these forces are not coplanar, and diaphragms in the arch box section are needed for transferring the hanger force from one plane to the other. As a consequence, the diaphragms are subjected to bending in a plane perpendicular to the arch plane. It seems logical that the arch box lower flange should be connected to the diaphragms in order to constitute reversed T-section and to develop higher bending resistance. This would also apply to the hinge plate, penetrating through the lower box flange. However, all of these details are introducing