The influence of diaphragm stiffening on welded tubular nodes in arch bridges

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Summary

A tubular arch bridge is prone to fatigue damage, particularly in the presence of varying traffic loads. The intersection of various tubes at the nodes of a tubular structure constitutes a radical transition of the geometry of the main tube. Due to geometric discontinuity, stress concentrations are introduced at the nodes. Because the nodes are welded, other stress concentrations add up to the former ones, particularly near the weld toe of the joints. By introducing internal diaphragms inside the main tube, the stresses in the weld toe can be reduced. This paper focuses on decreasing the hot spot stresses at the weld toe, as a function of the diaphragm location. By lowering the stresses at the weld toe, the fatigue resistance of the tubular arch bridge will be increased. To calculate these so-called hot spot stresses, accurate FE-models are being be assembled.

Keywords: Tubular arch bridges, welded tubular nodes, fatigue damage, diaphragm stiffening, hot spot stress, FE-models

1. Introduction

Bridges consisting of circular hollow sections are becoming increasingly popular. They are highly appreciated because of their aesthetic value. The use of tubes also offers structural advantages because they possess an equal bending stiffness, strength and resistance to buckling in all directions. High torsional stiffness and a high strength-to-weight ratio are also advantages of circular hollow sections. The welded nodes can be assembled thanks to new cutting, preparation and fabrication processes, making these bridges more feasible and competitive. Although they posses many advantages, tubular arch bridges are considered to be costly, mainly due to the use of welded nodes. These bridges comprise many welded tubular nodes, which are the most critical parts, because they reduce the fatigue strength of the bridge. Due to geometric discontinuity and the welding process, various stress concentrations are introduced at the nodes, making this type of bridge prone to fatigue damage due to the varying traffic loads. High peak values of stresses, so-called hot spot stresses, are reached near the weld toe of the nodes. If these stresses can be decreased, then the fatigue strength of the arch bridge will increase.

2. Nodes of tubular steel structures

Tubular trusses are frequently used for light structures, such as traffic signs, panels, footbridges and scaffoldings. The nodes of these trusses consist of secondary tubes who are welded on a primary tube. A force on the secondary tube acts partly perpendicular on the main tube. This results to in-plane bending of the hollow cross-sections, causing large secondary stress. The nodes are also not reinforced like nodes of classical truss beams that have heavier plates. Consequently these nodes are the weakest parts and determine the global strength of the structure. This also means that the tubes

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