Buckling Strength of Curved Bridge Girder Web Panels, including Residual Stress

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Summary

A numerical research is conducted about the effect of curvature of web plates of closed section bridge girders. An identical beam has been considered, its web plates taking increasing curvature. The introduction of residual stress into the models has been carried out through the use of internal force fields and corresponds well to the ECCS-predictions. However, deformations, due to the residual stresses have a different character for flat and curved web plates. The effects on the failure load caused by residual stress and by imperfections, both with nonlinear material and geometric analysis are calculated independently. These factors do not seem to have an overwhelming importance. However, if both factors are considered simultaneously, all values of the critical load are seriously lower than for any other type of analysis. Curved webs show a larger shear failure load than equivalent box sections with flat webs and it is a safe but conservative principle to identify the curved web to its flat equivalent of identical thickness

Keywords: Steel web plates, curved web, nonlinear numerical simulation, types of imperfections, imperfection amplitude, residual stress.

1. Introduction

In-plane curvature of bridge girder webs seems a rather dysfunctional arrangement, since the primary action of girder webs is the transfer of shear towards bearings and the shear connection of flanges. Flat, vertical webs constitute the most direct connection between flanges and are certainly capable of large shear resistance. However, there are various reasons for some recent designs with curved steel webs, such as larger torsion stiffness and the use of internal diaphragm vertical stiffeners.

During former numerical research, the bending, as well as the shear resistance of curved webs have been considered as a function of the web curvature. Concerning the bending resistance, numerous numerical simulations, including geometric and material nonlinear characteristics, as well as imperfections of various kinds, have shown that the web curvature increases the load-carrying capacity [1]. In addition, as the curvature increases, the web buckling pattern shifts upwards, closer to the connection with the upper flange.

Similar analysis has shown that the shear resistance of curved webs also increases with curvature and is not particularly sensitive to imperfections [2]. The combination of vertical meridian stresses and the increase of the developed length of the webs cause higher shear capacity. In addition, the web lateral deformation near to plasticity, modifies from a single wave at the web centre to double waves, shifting gradually towards the connection with the flanges. This is highly important in relation to the research that is being commented in this paper.

The aforementioned numerical simulations do not include the effect of residual stress, which may influence the failure load. The aim of the present research is to introduce residual stress due to the

https://doi.org/10.2749/222137814814027666
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