Shear buckling resistance of non-uniform thickness bridge girder webs

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Summary

In very large steel bridge girders, the web often must be composed of more than one plate strip. As an alternative to longitudinal stiffeners of a slender web of uniform thickness, the bottom web plate strip my be designed as a vertical extension of the bottom flange – thicker than the upper web strip. A thicker bottom web strip enhances both the shear buckling resistance of the web and the bending moment resistance of the cross-section. The magnitude of these beneficial effects are adressed in this article. Moreover, the effect on the shear-bending resistance interaction is investigated. Non-linear finite element simulation is conducted and comparison to the predictions of the EC 3 is made.

Keywords: Bridge girders, shear buckling, shear-bending interaction, non-linear finite element simulation.

1. Introduction

In Swedish steel and composite bridges the post-critical behaviour of the web plates has been accounted for since some 20 years, and for other kinds of steel structures for 40 years. This means that the flanges can be fully utilized in bending, although this is not the case with the slender web plates connecting them. In other European countries this is not allowed, and this means that the web often have longitudinal stiffeners, which increase the critical stress for the web in bending, but also the total costs. Another aspect is that the web must be able to carry the vertical shear force, and this can lead to demands for either thicker webs or longitudinal stiffeners to increase the buckling coefficient, k_τ. Since the shear capacity increases much faster than the thickness of the web, it is however often advantageous to increase the web a few mm's, instead of introducing longitudinal stiffeners.

For very high girders, however, the web must often be composed of more than one plate strip. This gives an excellent opportunity to increase the thickness of the web part in compression, which will increase the shear capacity, and even more so the bending capacity of the steel cross section. If for example the lower 25% of a cross section at support is composed of a thicker plate, the bending stresses have decreased to 50% at the intersection to the thinner web plate. Furthermore, most of the extra material placed in the web can be excluded from the bottom flange. Although the material put in the flange has a somehow better cantilever arm in bending, the shear lag in a wide bottom flange to some extent can compensate for this.

2. Shear buckling of uniform thickness slender web plates

2.1 Resistance prediction of the EC3

The shear buckling resistance of an un-stiffened slender uniform thickness web is governed by the EC3 slenderness parameter, [1],

$$\bar{\lambda}_w = \sqrt{\frac{\tau_y}{\tau_{cr}}} = \sqrt{\frac{f_y}{\sqrt{3}\tau_{cr}}} = 0{,}76\sqrt{\frac{f_y}{\tau_{cr}}} \qquad (1)$$

https://doi.org/10.2749/222137810796025078
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