Buckling Resistance of Steel Curved Bridge Girder Webs

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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, while the web plates take increasing curvature. Linear elastic calculations show a rather surprising increase of the buckling resistance with curvature. Both, the GMNAnalysis and GMNIA confirm a slightly higher ultimate bending moment for curved webs. In particular GMNIA shows there is no critical sensitivity to imperfections, although two types have been considered and the amplitude was varied, well beyond the recommendations of EN 1993-1-6. Actually, the imperfection shape corresponding to the linear buckling mode results in more critical behaviour than a perfectly evident long wave pattern. Although the model being used includes a certain amount of shear force, an increase of shear might influence the results. This, together with testing on accurately scaled models is future steps in the research.

Keywords: Steel web plates, curved web, non-linear numerical simulation, types of imperfections, imperfection amplitude.

1. Introduction

Many bridge designs from recent years are characterised by a more solid and powerful form. As, during the past century, the lightness of structures has been explored thoroughly, excelling in outstanding suspension and cable stayed bridges, there might be a need to design again more strong sections and bridges. This is being demonstrated by structures as the Third Millenium bridge [1] the Hollands Diep bridge [2] and perhaps the bridge in Zemst [3]. However, some of these powerful structures have uncommon cross-sections instead of rectangular or trapezoidal elements. Both for creating torsion stiffness and variation in form, polygonal or curved sections are being used. The exact reasons for using these shapes are merely guessed, since mostly a distinct motivation is lacking.

However, the more solid character of both infrastructure of piers and abutments, as for superstructures, is being increased. Today, piers consisting of curved walls can be noticed, the smooth concrete surfaces being finished with utmost care. As the principle of integral bridges is adopted more often, the difference between infrastructure and bridge decks is becoming less noticeable. However, the alternative character of bridges is noticed more in superstructures, through a new interest in truss members and closed sections, especially in composite or steel construction. The latter show often folded plates or curved panels.

The curvature of panels of bridge girders introduces variable normal stresses, due to bending. However, because of the curvature, meridian stresses may be introduced, the magnitude of these being difficult to derive. It is also uncertain whether these stresses contribute to the carrying capacity or on the contrary have a disrupting effect. In addition, flat panels subjected to bending or compression have a relatively large carrying capacity, since the post-critical behaviour is stabilising the buckling effect. Fully curved panels, such as in cylindrical or conical shells, show large sensitivity to imperfections and their post-critical behaviour may be of definitely smaller load carrying capacity than perfect shells [3]. Panels in bridge sections belong to neither of these

https://doi.org/10.2749/222137912805111401
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