Structural Stability – Innovative and Aesthetic Design of Steel Bridges

Summary

Steel structures are lighter not only from the structural point of view but also from the aspect of aesthetics/landscape integration. To keep using steel in innovative steel and steel-concrete composite bridges, enhanced design rules and new criteria must be developed specifically for stiffened steel girders.

Stiffened plate girders, with either plane or curved steel panels, are increasingly used in the design of new bridges due to architectural and/or structural demands.

In fact, curved steel panels are being proposed for bridge decks more frequently. This is a more recent development that is due to its more economic use enabled by technical advances.

The design of all steel and steel-concrete composite long cable-stayed bridge decks also uses thin steel plates. Since these thin-walled plate girder or box girder decks are supported by inclined stay cables, which generate strong axial compressive stresses in addition to the usual beam shear and bending beam effects, their design provides a challenge to engineers. To avoid making conservative design assumptions that result in non-optimized stiffening configurations, larger steel amounts, and higher fabrication costs, the design should appropriately evaluate the stability behaviour of the elements under these combined stresses.

However, though these solutions have been adopted for many years now, design rules and design recommendations for these stiffened plated members are still scarce and basic knowledge needs to be developed at various levels.

Structural efficiency, that can produce saving of material and workmanship, will be achieved by optimizing buckling rules for curved and plane plates submitted to common compression, bending and shear (N, M, V) stress states. It is therefore important to develop such guidelines. The design guidelines should be developed also for high strength steel which will encourage designers to increase the use of high stress steels, the important trend for the coming years.

A direct benefit to the industry will be achieved by preparing the plane plate buckling rules for curved stiffened panels, including the stiffener design, in such format that will enable simple extension of Eurocode 3, namely its Part 1-5 (EN 1993-1-5 - Plated structural elements).

The behaviour of stiffened steel panels submitted to a general (N, M, V) stress state for the application in bridges depends on their stability behaviour and the influence of the material constitutive law. Given that, the usual design approach for steel members is to derive their ultimate (design) resistance based on the elastic stability behaviour, a great deal of effort needs to be dedicated to the evaluation of the buckling and post buckling behaviour of steel panels, to make these solutions structural efficient and economical.

Therefore, main objective of this research project is to develop solid knowledge on the structural behaviour of plane and curved stiffened steel panels for optimised applications in steel and steel-concrete composite bridges, allowing the extended use of steel in innovative and aesthetic designs.

The following objectives will be targeted:

- To identify the main bridge examples using curved steel stiffened plate girder panels and to define the main figures and parameters of these type of structures.
- To identify the key parameters of this type of structures by a parametrical numerical research based on numerical models.
- To perform numerical and experimental tests of stiffened plate girders submitted to N, M, V loadings.
- To evaluate the benefits and constrains of using high strength steel in bridge design.
- To extend the EN 1993-1-5 design methodology for stiffened plated girders under compression, bending, shear and combinations of these loadings.
- To develop enhanced design rules for transverse stiffeners considering the dual flange / web role.
- To optimize the number, shape, and distribution of longitudinally stiffened panels.

Project Reference

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Leading Institution

UC – University of Coimbra (Portugal)

Partners

University of Stuttgart (Germany), University of Ljubljana (Slovenia), GRID International (Portugal), ABES Pircher & Partner (Austria), ATKINS Global (United Kingdom)

CERIS Principal Investigador

José Oliveira Pedro (jose.oliveira.pedro@tecnico.ulisboa.pt)

CERIS Research Team

André Graça, Luís Vieira, Sérgio Nascimento

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Project Website

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