General Design of Hollow RC Sections under Combined Actions

Motivation

The design of large reinforced concrete (RC) hollow sections is recurrent in medium to large sized bridge projects.

Hollow sections are consistently considered the preferred solution for substructure members (piers, towers or columns) and for bridge decks (e.g. pre-stressed box girders) due to its efficiency and the large material savings associated with it.

One of the main challenges with contemporary bridge design is the increasing difficulty in immediate identification of critical loading scenarios or locations. In fact, as code requirements evolve one needs to account for a growing number of load combinations in the design. In addition, as aesthetic considerations become more predominant, the shapes of structural members becomes more complex.

This challenge is augmented primarily at substructure members, which tend to be exposed to a combination of concurrent force effects (axial load, biaxial flexure, biaxial shear and torsion).

Traditional design techniques (e.g. Eurocode, AASHTO) treat the verification of structural adequacy for normal stresses (due to axial load and flexure) independently from that for shear stresses (due to shear and torsion).

Objective

The objective is therefore to develop a practical and easy-to-use tool for designers, which addresses the challenges described above for an arbitrary hollow reinforced concrete section. If successful this tool may add significant value to the design process of bridge projects or others in which there are concrete members with hollow sections

The verification of the structural adequacy shall make use of the reinforcement formulas, see Annex F of Eurocode 1992-1:2004. These enable the simultaneous consideration of normal and shear stresses and conform with the Lower Bound Theorem of Plasticity, i.e. yield a safe design.

The main challenge of this project is to build an automatic procedure allowing for a reasonable static admissible stress field on a hollow reinforced concrete section subjected to any combination of axial, shear, flexural and torsional demands. This has been attempted before by Professor L.C. Hoang's group at University of Southern Denmark, though the work developed did not result on general, expedite solutions which can benefit designers.

As the structural verification is based on the so called lower bound approach, if necessary, the kinematic conditions (compatibility) can be relaxed to allow for a reliable automation.