Effects of Hydrostatic Internal Pressure upon the Buckling of Hollow Sections subject to Axial Compression

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Abstract

A linear finite element buckling analysis of simply and fixed to roller supported structural steel circular and square hollow sections are presented in this investigation. The closed-end sections with perfect and imperfect cross-sections showed comparisons to the Euler buckling curve for both the axial force only and the axial force and internal pressure load cases. Section classification according to Eurocode 3 (Eurocode-3, 2005) revealed a data set including all 4 classes and an expanded class 4 set tending towards thin shell ratios. The circular hollow sections showed high reductions in strength with sine wave perturbations along the circumference, where six and four sinusoidal waves were the greatest reducers in strength. The internal pressure showed a steady increase in strength for all class 4 sections with no influence on class 1 to 3 sections. The mean buckling stress was greater than the yield stress of steel even with perturbation amplitudes outside the Eurocode limits. However, this was not true for square hollow sections. The perfect mesh was weaker than the perturbed mesh for all local and global buckling modes. Cross-sectional and global perturbation increased the mean buckling stress for all classes of square hollow sections. Class 1 to 3 sections all buckled above yield stress while all class 4 sections buckled before the material yield point. The internal pressure had a negligible increase in strength for all classes. However, a strength reduction was seen with a larger width to thickness and length to radius of gyration ratios when cross-sectional perturbation was considered. For both the square and circular sections, the out of straightness theoretical curves showed no benefit as all class 1 to 3 sections revealed buckling strengths greater than the Euler curve and the yield stress point.

Keywords: Circular hollow section; Square hollow section; Axial compressive buckling; Hydrostatic internal pressure; Buckling theory; Linear buckling; Finite-element method; Initial imperfection; Section classification