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Capacity of Cold-Formed Steel Warping-Restrained Members Subjected to Combined Axial Compressive Load and Bending

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Abstract : Cold-formed steel (CFS) elements are increasingly being used as main load-bearing components in the modern construction industry, including low- to mid-rise buildings. In typical multi-storey buildings, CFS structural members act as beam-column elements since they are exposed to combined axial compression and bending actions, both in moment-resisting frames and stud wall systems. Current design specifications, including the American Iron and Steel Institute (AISI S100) and the Australian/New Zealand Standard (AS/NZS 4600), neglect the beneficial effects of warping-restrained boundary conditions in the design of beam-column elements. Furthermore, while a non-linear relationship governs the interaction of axial compression and bending, the combined effect of these actions is taken into account through a simplified linear expression combining pure axial and flexural strengths. This paper aims to evaluate the reliability of the well-known Direct Strength Method (DSM) as well as design proposals found in the literature to provide a better understanding of the efficiency of the code-prescribed linear interaction equation in the strength predictions of CFS beam columns and the effects of warping-restrained boundary conditions on their behavior. To this end, the experimentally validated finite element (FE) models of CFS elements under compression and bending were developed in ABAQUS software, which accounts for both non-linear material properties and geometric imperfections. The validated models were then used for a comprehensive parametric study containing 270 FE models, covering a wide range of key design parameters, such as length (i.e., 0.5, 1.5, and 3 m), thickness (i.e., 1, 2, and 4 mm) and cross-sectional dimensions under ten different load eccentricity levels. The results of this parametric study demonstrated that using the DSM led to the most conservative strength predictions for beam-column members by up to 55%, depending on the element's length and thickness. This can be sourced by the errors associated with (i) the absence of warping-restrained boundary condition effects, (ii) equations for the calculations of buckling loads, and (iii) the linear interaction equation. While the influence of warping restraint is generally less than 6%, the code suggested interaction equation led to an average error of 4% to 22%, based on the element lengths. This paper highlights the need to provide more reliable design solutions for CFS beam-column elements for practical design purposes.

Keywords : beam-columns, cold-formed steel, finite element model, interaction equation, warping-restrained boundary conditions

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