Distortional-global interaction and DSM design of cold-formed steel beams under elevated temperatures

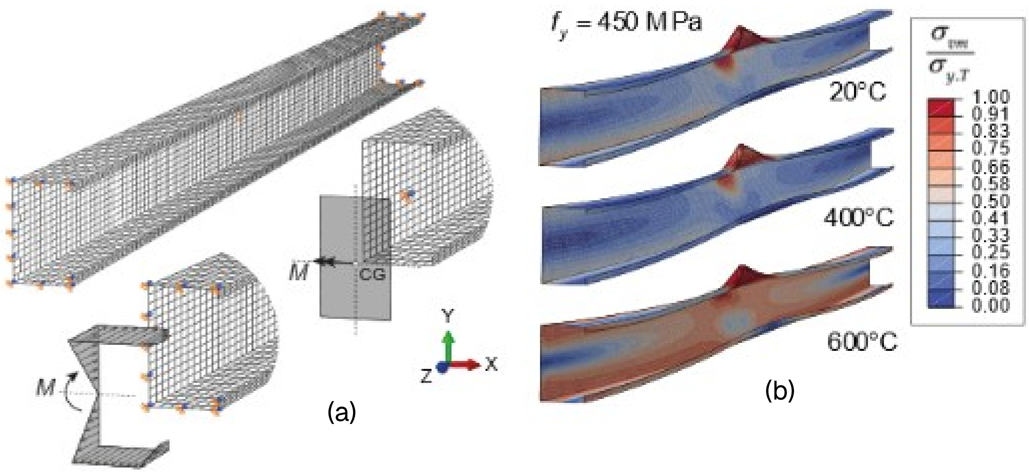
Summary

This thesis addresses the post-buckling behaviours, strength and design, based on the Direct Strength Method (DSM), of cold-formed steel beams affected by distortional-global mode interaction at elevated temperatures caused by fire conditions. Single-span simply supported beams with two end-cross-section warping boundary conditions (fully free or restrained warping) are analysed. The first step consists of identifying beam geometries (cross-section dimensions and lengths) susceptible to the occurrence of distortional-global (lateral-torsional) interaction, which requires performing educated "trial-and-error" buckling analysis sequences — the objective is to gather beam geometries associated with a reasonably wide range of global-to-distortional buckling load ratios. Next, the elastic and elastic-plastic post-buckling behaviours of selected beams are investigated, in order to characterise the distortional-global interaction at elevated temperatures — particular attention is paid to the identification of the most detrimental initial geometrical imperfection shape and to study the beam imperfection-sensitivity.

This investigation is carried out by means of geometrically and materially non-linear shell finite element analyses, using the code ABAQUS, adopting previously validated models that adopt the temperature-dependent steel constitutive law prescribed in the Australian/New Zealand standard AS/NZS 4600: 2018 — such analyses simulate the bending strength of columns under uniform and constant elevated temperatures (steady-state analyses). Next, the ABAQUS shell finite element models are used to perform an extensive parametric study, intended to gather failure load data concerning beams with (i) various geometries, ensuring different levels of distortional-global interaction, (ii) lateral-torsional initial geometric imperfections with prescribed amplitudes, (iii) several yield stresses (to cover wide slenderness ranges) and (iv) a fairly large number of elevated temperatures. Finally, the failure loads gathered are used to search for an efficient (safe, accurate and reliable) design approach, based on the Direct Strength Method, for the cold-formed steel beams dealt with in the thesis.

Keywords

Cold-formed steel (CFS) beams, Direct Strength Method (DSM), Distortional-global (D-G) interaction, Shell finite element (SFE) simulations, fire and elevated temperature behaviour.



(a) Numerical model: mesh, end support and loading conditions, and (b) beam deformed configurations and plastic strain contours at collapse for T= 20-400-600 °C.

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