Fire Design Methodology for Cold-Formed Steel C-Section Flexural Members

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Abstract

Fire design rules for cold-formed steel beams are commonly based on past research on hot-rolled steel beams. Hence this paper present a methodology for calculating the fire response of unrestrained cold-formed steel C-section flexural members, based on guidelines of Eurocode 3 Part 1.2 for fire design of steel beams and on results of experimental and numerical studies. European fire design rules were found to be unsafe or over-conservative, depending on their relative slenderness and serviceability load applied on the beams. Therefore, new formulae for lateral–torsional buckling of unrestrained cold-formed steel C-section flexural members, which approximate better their real behaviour in case of fire are proposed. Comparison with numerical moment capacities demonstrates the accuracy of the new design methodology.

Keywords: cold-formed, steel, beams, fire, finite element analyses, buckling, fire safety design.

1 Introduction

As cold-formed steel (CFS) members are usually classified as class 4 cross-sections, according to EN1993-1.1:2004 [1], and have much lower strength and stiffness than hot-rolled steel members, those members can fail in a variety of buckling modes including local, distortional, global buckling and their interactions [2-4]. This is why, the strength calculations of CFS members are carried out at several levels of complexity depending on the purpose of its use. For the standardised design of flexural members at ambient temperature the Effective Width Method (EWM) and the recently developed Direct Strength Method (DSM) [5] may be applied. The EWM, available in the EN 1993-1.3:2004 [6] and introduced by Von Kármán *et al.* in 1932 [7], performs a reduction of the plates that comprise a cross-section based on the stability of the individual plates for the prediction of the local and distortional buckling strength.

However, when it comes to fire, fire design rules for CFS members are commonly based on past research on hot-rolled steel members. There are inadequate fire design guidelines for this type of members [8, 9]. Engineers and architects face problems in using CFS members in structures because of lack of suitable design specifications for fire conditions [10]. There is an urgent need to investigate the behaviour of CFS members under fire conditions. As mentioned above, the simplified design methods presented in the EN 1993-1.2:2005 [11] can be used for CFS members according to its Annex E, but the area of the member cross-section must be replaced by the effective area and the section modulus by the effective section modulus, determined in accordance with EN 1993-1.3:2004 [6] and EN 1993-1.5:2006 [12], i.e. based on the material properties at 20°C. Besides, the design yield strength of steel should be taken as the 0.2

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