Lateral-torsional buckling of beams with corrugated webs subjected to fire

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Steel buildings stand on columns and beams, that are commonly composed of I-shaped profiles, which are build up with two horizontal plates – the flanges – and one vertical flat plate – the web –, connecting both flanges. Traditionally, the web plate represents 30 to 40% of the total weight of these elements, which the main structural purpose is to bear vertical loads (shear stresses), while the flanges are meant to resist the major external stresses. Therefore, aiming to strive material optimization, the majority of the section area should be used for the flanges instead of the web, which performs its function even with reduced thicknesses. However, by excessively reducing the web thickness, it can become susceptible to the phenomena of local buckling, compromising the stability of the whole structure.

To overcome this issue, instead of using a flat web panel (flat web beams – FWB, with thicknesses up to 40 mm), beams can be made with a waved-formed panel – the so-called corrugated web – with a much thinner thickness (in the range of 2-5 mm). Thus, web corrugated beams (WCB) are a recent structural solution, which major asset lies in taking advantage of the increase of rigidity on the web, leading to better resistance against local buckling and improved shear capacity resulting in higher loadbearing capacity.

Despite the increasing number of researches on the benefits in terms of resistance and material efficiency of WCB at normal temperature (20ºC), there is still a need for simplified formulae for predicting their behaviour in a fire situation (where steel structures are particularly vulnerable), in order to enable the designers to better exploit this structural system. Focusing on this aspect, the aim of this study was to develop simplified methods to predict the load-bearing capacity obtained numerically from simulations with finite element software.

The new proposals developed in this research of WCB introduces a new design philosophy for a fire situation, based on previous researches on FWB developed in the Civil Engineering Department of UA, closer to the principles of other structural systems, while at the same time, achieving more accurate, practical and cost-efficient solutions for engineers to use.

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FIGURE 1
Computer models of beams with sinusoidal and trapezoidal corrugated webs

FIGURE 2
Example of the new proposal (continuous lines) and comparison to the actual Eurocode 3's method (dashed lines) and to the obtained computer results (points).