NUMERICAL ANALYSIS OF CELLULAR STEEL BEAMS FAILURE MODES IN FIRE CONDITIONS

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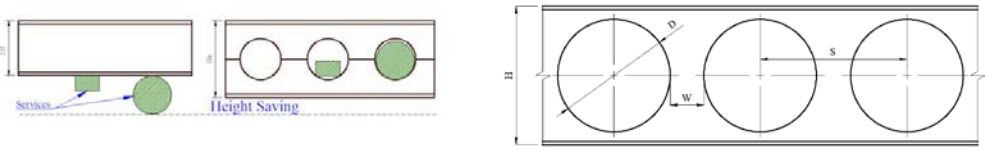
1. INTRODUCTION

Beams with long spans are increasingly used in the steel building constructions and usually are used with openings for technical equipment and ventilations systems cut in their web. These elements are structural steel beams that are deeper than normal rolled sections, with distributed circular openings, or other like squared or hexagonal, that are produced by cutting and welding hot rolled steel sections (Westok method). The split halves are then offset and welded together to form a deeper beam with full circular or hexagonal shaped web openings, which results in a beam approximately 40-60% deeper than its solid parent section, [1], see Figure 1. This method reduces the floor height and therefore the overall height of building.



a) b)

Figure 1 – a) Ceiling height saving from CB installation. b) Cellular beam geometric parameters.

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A cellular beam can have a bending resistance up to 2.5 times higher than its parent solid section and so improve the cost efficiency of a design. The cutting process and an application of cellular beams in buildings is illustrated in Figure 2.

Figure 2 - The cutting process of cellular beams. The use of cellular Beams in buildings, [2].

2. NUMERICAL ANALYSIS OF CELLULAR BEAMS

In fire conditions, a cellular beam at a design degree of utilisation, web post failure may occur before the section reaches the critical temperature obtained members in bending. This fact is mainly due to web height, and slenderness, and because the temperature of the web-post in a cellular beam increases at a faster rate compared to its equivalent (similar web size) solid beam. Beam failure may occur by local buckling instability of the web-post between the openings or by Vierendeel bending at the openings.

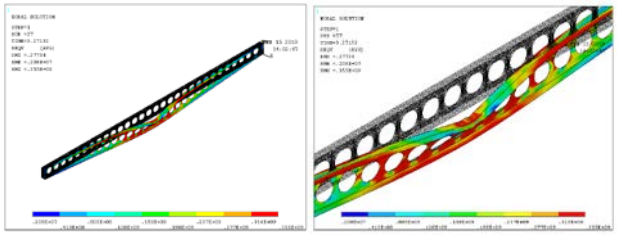

Figure 3 – Collapse mechanism of a 7 [m] span cellular beam, with a top uniform load.

This behaviour is analysed and evaluated by a numerical method, using the finite element method, considering geometrically and material nonlinear simulations, Figure 3. A parametric analysis is performed for different cellular beams, considering the variation of: i) different cross sections; ii) web post widths; iii) hole diameter to the section height ratios and (iv) distance between holes.

The numerical simulations should clearly define the cellular beams failure mode, either from the buckling of the web post, the Vierendeel bending or the flange compression at the hole section. A comparison of results is presented for the studied cases at ambient and elevated temperatures, considering the Eurocode new part EN1993-1-13, [3].

3. REFERENCES

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