COMPARISION OF ANALYTICAL FORMULATIONS FOR THE FIRE RESISTANCE OF STEEL MEMBERS

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Abstract

This paper investigates the differences between different buckling formulations for the fire endurance of steel members, i.e. the one published in the Eurocode 3 part 1.2 [1], the recommendations made in the final report of the Buckling Curves in Case of Fire (BCCF) research project [2, 3] and the analytical equations proposed by Takagi and Deierlein [4]
A procedure for the calculation of fire resistance of steel members subjected to axial compression and bending has been developed as a result of the BCCF research. This formulation was later included in the Eurocode 3 part 1.2. It appeared that the equations published in the official version of Eurocode 3 part 1.2 [1] differ from the ones proposed in the original work [2-3, 5-7], see figure 1 and 2. Also Takagi and Deierlein [4] have published a new analytical formulation which has been extensively compared with the formulation for lateral torsional buckling currently available in the EC3 part 1.2.

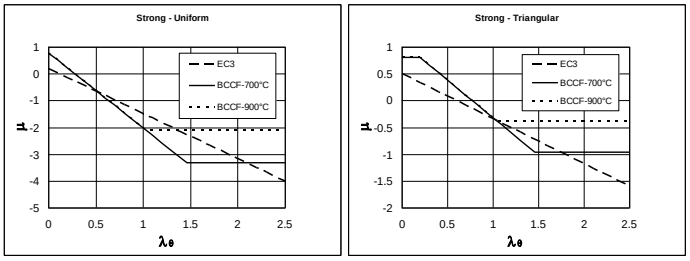

Fig. 1. $\mu_{y,\theta}$ as function of $\bar{\lambda}_\theta, y$

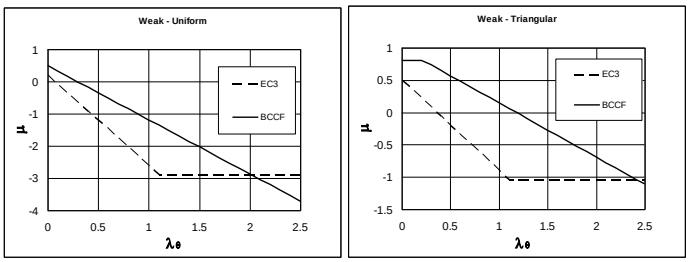

Fig. 2. $\mu_{z,\theta}$ as function of $\bar{\lambda}_\theta, z$

The objectives of this study are: to clarify the doubt concerning the safety level of the Eurocode 3 created by the modification of the formulae, to identify precisely the differences, to examine their consequences on the fire endurance of steel columns subjected to axial compression and bending and to assess the formulation proposed by Takagi and Deierlein [4].
An extensive comparison of the ultimate temperatures obtained with the different formulations has been performed for: 382 profiles in class 1 and 2, buckling about the strong and weak axis, reduced slenderness ($\bar{\lambda}_{20}$) from 0.2 to 2.4. The load cases considered were: M/N ratios of 0.05, 0.1, 0.5, 1.0, 3.0 and 5.0 multiplied by the radius of gyration about the buckling axis considered (i_y or i_z), and uniform and triangular bending moment distributions, corresponding to ψ = 1 and ψ = 0 respectively. A comparison of the failure temperatures

obtained between 400°C and 860°C has been performed. The outcomes of this comparison show that there is no dramatic difference in terms of ultimate temperatures when the column resists 500ºC or more. For a small number of cases a difference of up to 100ºC in the failure temperatures have been be observed but it has been shown that if the applied load is increased or decreased by 5% the same failure temperatures is obtained with both formulae (EC3 and BCCF). The ultimate temperatures predicted by the formulations have also been compared with experimental results from the database SCOFIDAT (figure 3). This comparison shows that there is no major difference between the EC3 and BCCF formulations for members subjected to axial compression and small and/or large bending moments.

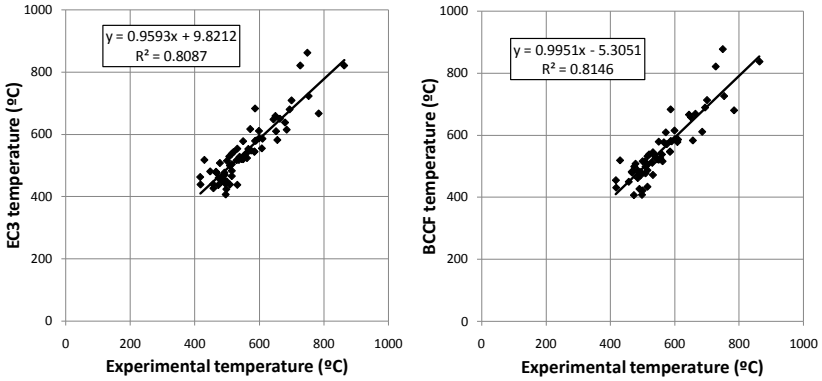

Fig. 3. Comparison of the EC3 and BCCF formulations with experimental results

As the comparison performed by Takagi and Deierlein, between their formulation and the one from the EC3 has shown good agreement, there is no doubt that this study, which will investigate other steel profiles, will have similar outcomes. This formulation will also be compared with the BCCF one and with the experimental results compiled in the database SCOFIDAT (141 experimental results).

This study concludes that minor differences between the EC3 and BCCF formulations can be observed and that it is generally equivalent to use either formulation. Both formulations (EC3 and BCCF) compared well when subject to combined bending and axial compression. Further conclusions regarding Takagi and Deierlein formulation will be included as soon as the final results will be available.

References:

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