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Stainless steel beam-columns interaction curves in case of fire with and without lateral torsional buckling

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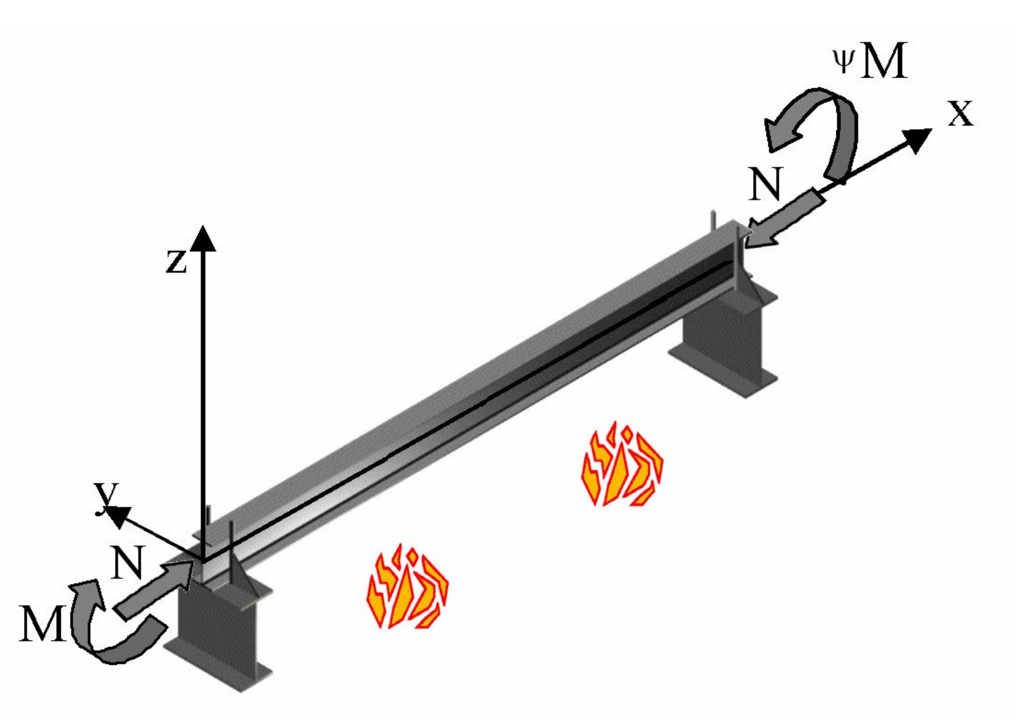
INTRODUCTION

➢The EN 1993-1-4 "Supplementary rules for stainless steels" gives design rules for stainless steel structural elements at room temperature, and only makes mention to its fire resistance by referring to the fire part of the Eurocode 3 (EC3), EN 1993-1-2, stating that stainless steel structural members subjected to high temperatures must be designed with the same formulae as those used for carbon steel members. However, as these two materials have different constitutive laws, it can be expected that different formulae for the calculation of member stability should be used for fire design.

➢In previous works, new proposals, which are considered here, for the flexural buckling of stainless steel columns and LTB of stainless steel beams were made.

➢It is the purpose of this work to evaluate the accuracy and safety of the currently prescribed design rules in EC3: Part 1.2 for the evaluation of the resistance of stainless steel beam-columns with and without lateral-torsional buckling (LTB). In this evaluation the new carbon steel beam-column formulae at room temperature were also tested, after being adapted to deal with stainless steel in fire situation.

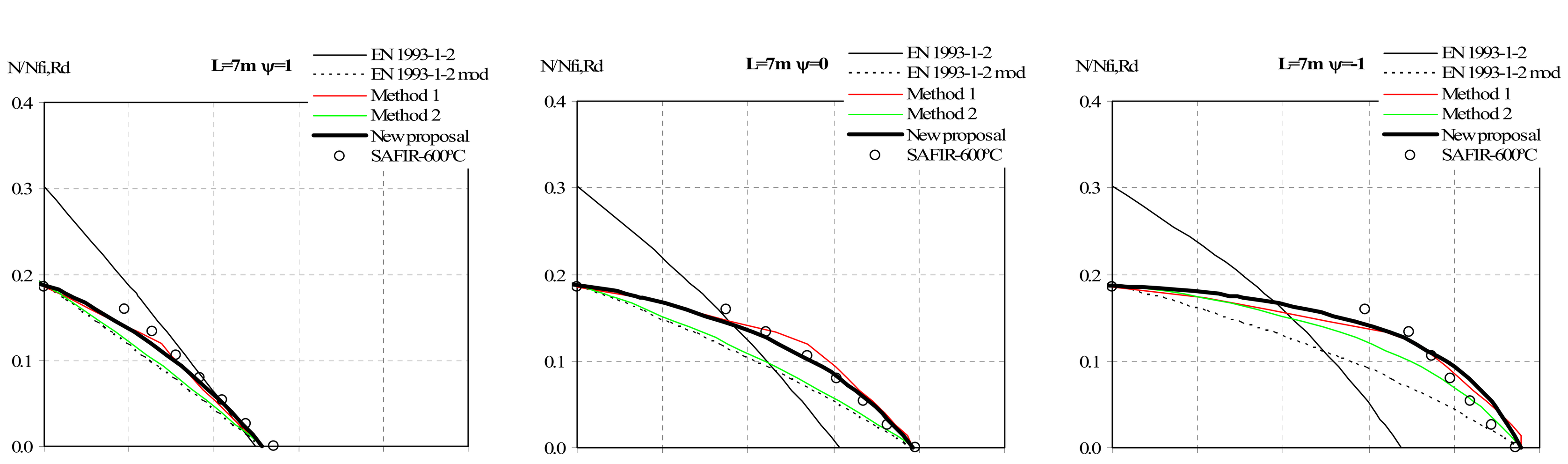


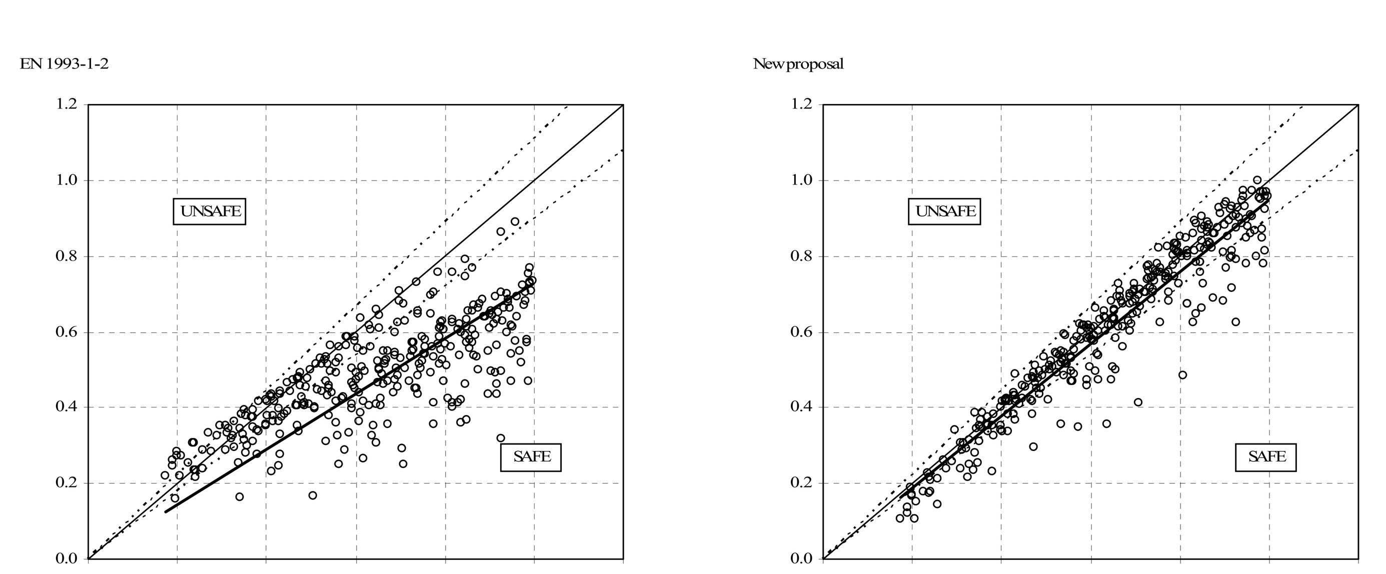
BEAM-COLUMNS WITH LTB

➢Formulated interaction curves "New proposal"

$$\frac{N_{fi,Ed}}{\chi_{z,fi} A \frac{k_{y,\theta} f_y}{\gamma_{M,fi}}} + K_{LT,fi} \frac{M_{y,fi,Ed}}{\chi_{LT} W_{pl,y} \frac{k_{y,\theta} f_y}{\gamma_{M,fi}}} \leq 1 \qquad K_{LT,fi} = 1 - \frac{\mu_{LT,\theta} N_{fi,Ed}}{\chi_{z,fi} A k_{y,\theta} \frac{f_y}{\gamma_{M,fi}}} \quad \text{with} \quad K_{LT,fi} \leq 1$$

$$\mu_{LT,\theta} = \left(-0.14\beta_{M,LT} + 0.11\right)\overline{\lambda}_{z,\theta} + 0.50\beta_{M,LT} - 0.09 \leq 0.8$$





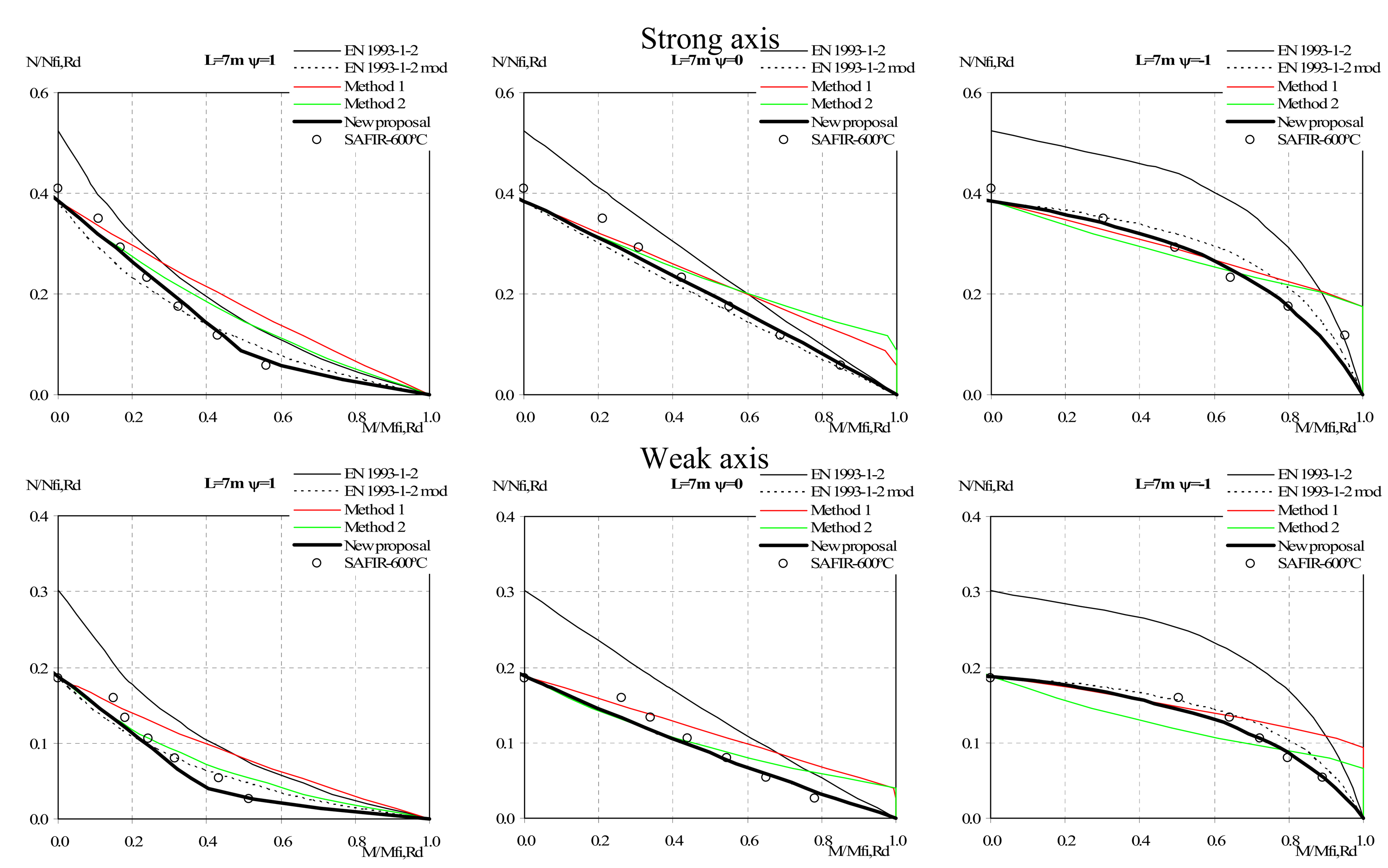
BEAM-COLUMN WITHOUT LTB

➢The five interaction curves in the graphics are obtained from:
- ➢part 1-2 of EC3 "EN 1993-1-2";
- ➢part 1-2 of EC3 with the new proposal for columns "EN 1993-1-2 mod";
- ➢part 1-1 of EC3 for carbon steel beam-columns "Method 1"and "Method 2";
- ➢and the formulated interaction curves "New proposal".

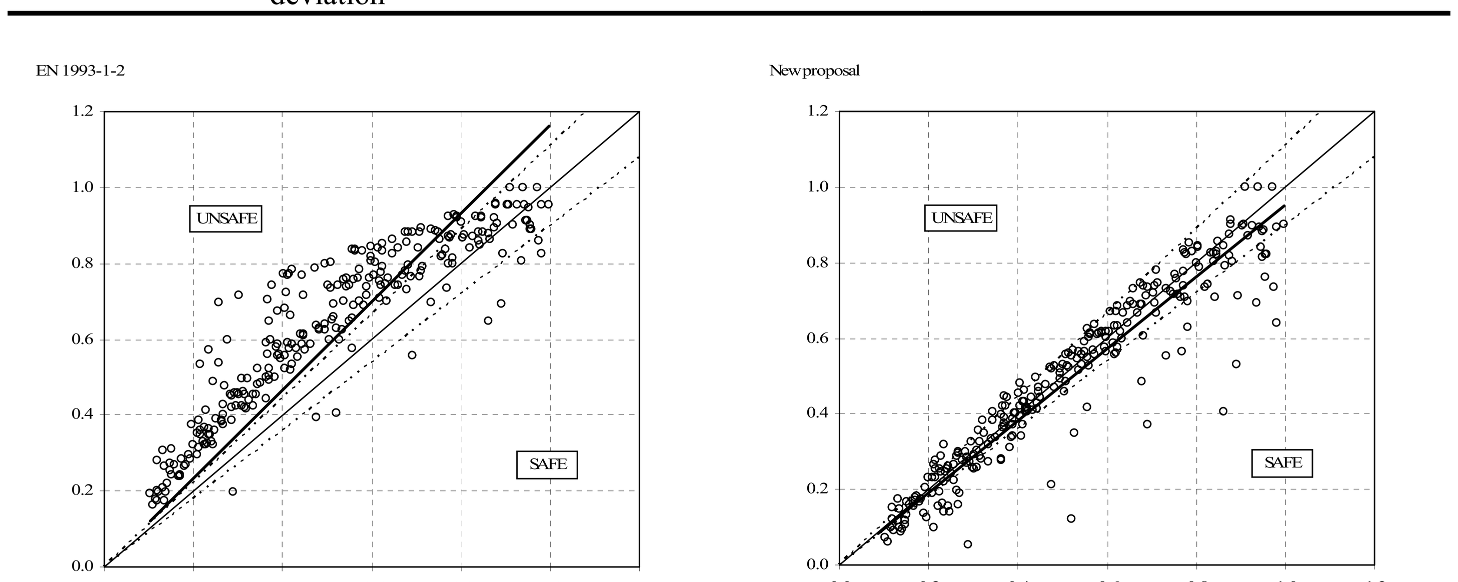
$$\frac{N_{fi,Ed}}{\chi_{i,fi} A k_{y,\theta} \frac{f_{y,\theta}}{\gamma_{M,fi}}} + K_{i,fi} \frac{M_{i,fi,Ed}}{W_{pl,i} \frac{f_{y,\theta}}{\gamma_{M,fi}}} \leq 1 \qquad K_{i,fi} = 1 - \frac{\mu_{i,\theta} N_{fi,Ed}}{\chi_{i,fi} A k_{y,\theta} \frac{f_y}{\gamma_{M,fi}}} \quad \text{with} \quad K_{i,fi} \leq 0.8\overline{\lambda}_{i,\theta} + 0.9$$

$$\mu_{y,\theta} = \left(4.33\beta_{M,y} - 8.56\right)\overline{\lambda}_{y,\theta} + 0.33\beta_{M,y} + 0.11 \leq 0.7$$

$$\mu_{z,\theta} = \left(3.03\beta_{M,z} - 6.33\right)\overline{\lambda}_{z,\theta} + 1.93\beta_{M,z} - 2.45 \leq 0.7$$



		EN 1993-1-2	EN 1993-1-2 mod	Method 1	Method 2	New proposal
Strong axis	Average value	1.355	1.017	1.185	1.122	0.961
	Standard deviation	0.312	0.218	0.320	0.272	0.162
Weak axis	Average value	1.342	0.973	1.188	0.951	0.903
	Standard deviation	0.281	0.195	0.270	0.261	0.154



CONCLUSIONS

➢In this work, new approaches for evaluating the safety of stainless steel elements subjected to axial compression and bending in the fire situation were presented. These approaches address the influence of global buckling phenomena (flexural buckling and LTB).

➢The studies on stainless steel beam-columns concluded that the direct adaptation of the new carbon steel interaction curves to stainless steel in case of fire didn't give good results. As a consequence, new interaction curves for the design of stainless steel beam-columns with and without LTB, and at high temperatures, were proposed, providing safe and economic approximations to the obtained numerical results.

➢The studies presented in this paper were made in different stainless steel grades. Due to the fact that they have different stress-strain relationships at high temperatures, it was necessary to account for this influence, mainly in the duplex grade.