INTERACTION AXIAL FORCE – BENDING MOMENT DIAGRAMS FOR STEEL SECTIONS EMBEDDED ON WALLS

Antonio Moura Correia
ISISE – Institute for Sustainability and Innovation on Structural Engineering
Polytechnic Institute of Coimbra

João Paulo Correia Rodrigues
ISISE – Institute for Sustainability and Innovation on Structural Engineering
Faculty of Sciences and Technology of the University of Coimbra

Paulo Vila Real
LABEST – Laboratory for the Concrete Technology and Structural Behavior
University of Aveiro

FCTUC FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE DE COIMBRA

Eurocode EN 1993-1-2

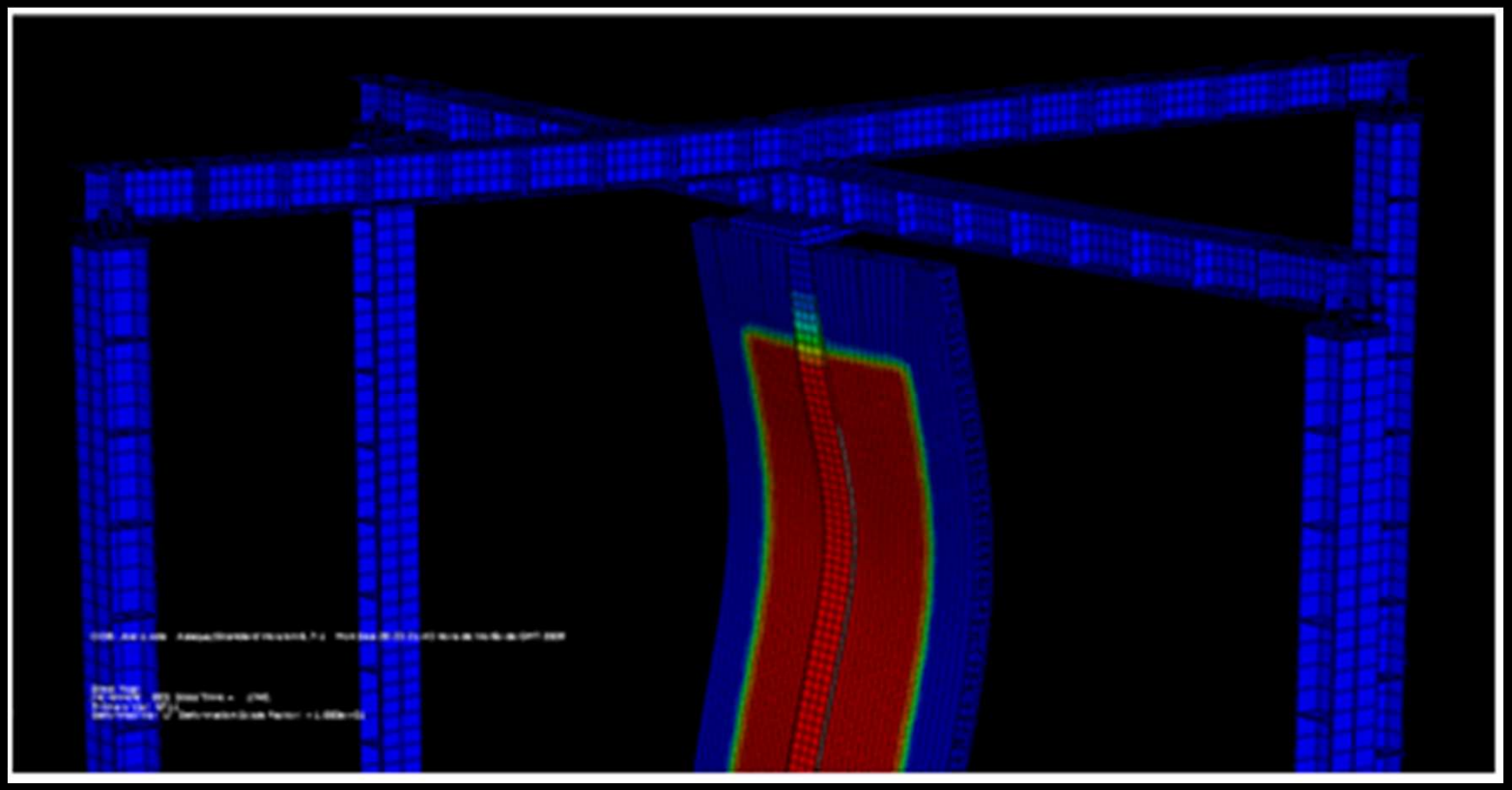
Reasons for improvement

The EN 1993-1-2, does not consider the combined effect of axial force and bending moment, in structural elements, when the temperature distribution is not uniform within the cross-section, in the design resistance of the cross-section.

Proposed changes

The proposal consists of interaction diagrams for H steel sections, with non-uniform temperature distribution, when in contact with walls. The contact with the walls provides huge thermal gradients, which vary with the orientation of the web of the profile, in relation to the walls.

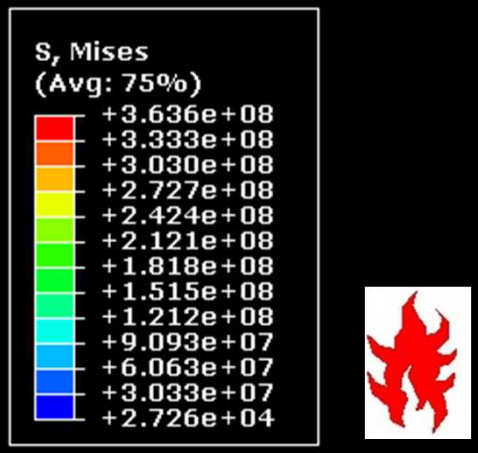
THERMAL BOWING – Lateral Deflection of a Column during FIRE TEST

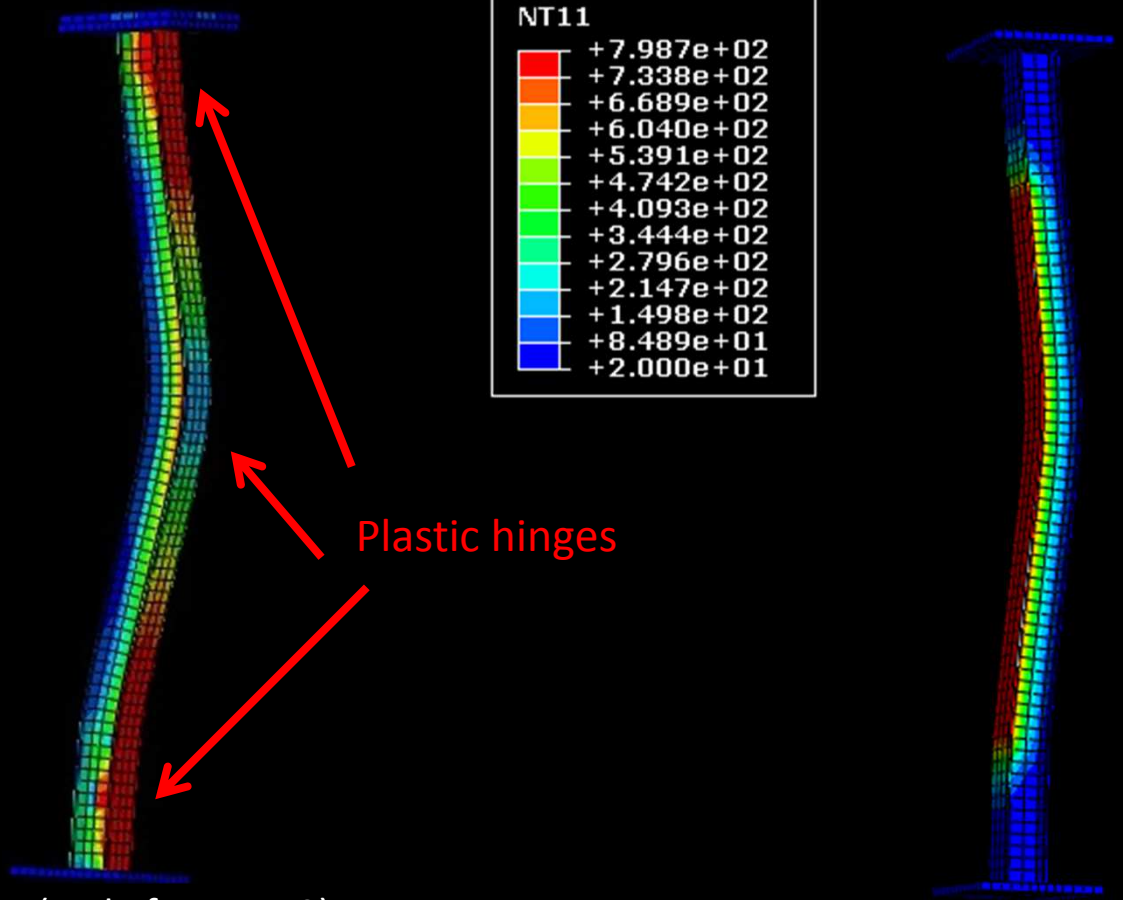


INTERACTION AXIAL FORCE-BENDING MOMENT DIAGRAMS FOR STEEL SECTIONS EMBEDDED ON WALLS

António Correia, João Paulo Rodrigues, Paulo Vila Real

Results – Von Mises stresses and temperatures





Von Mises stresses (scale factor = 2)

Temperatures

(t=24min)

Institute for Sustainability and Innovation in Structural Engineering

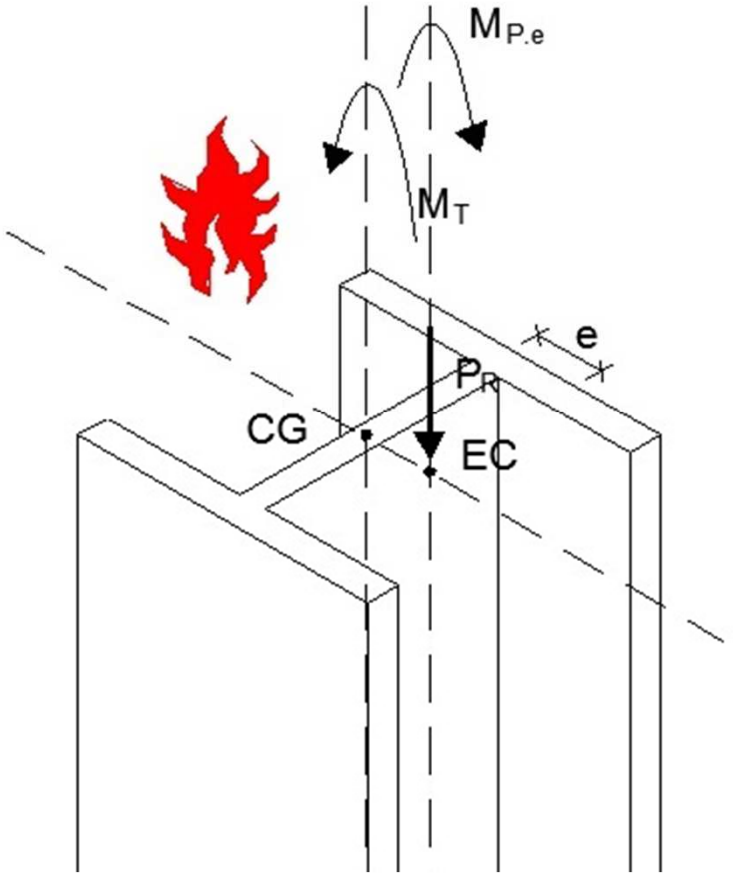
FCTUC
Faculdade de Ciências e Tecnologia
Universidade de Coimbra

Behaviour of an unevenly heated column

The left half-flanges will undergo greater thermal expansion.

Due to the restraint to rotation, a "thermal moment" M_T is generated.

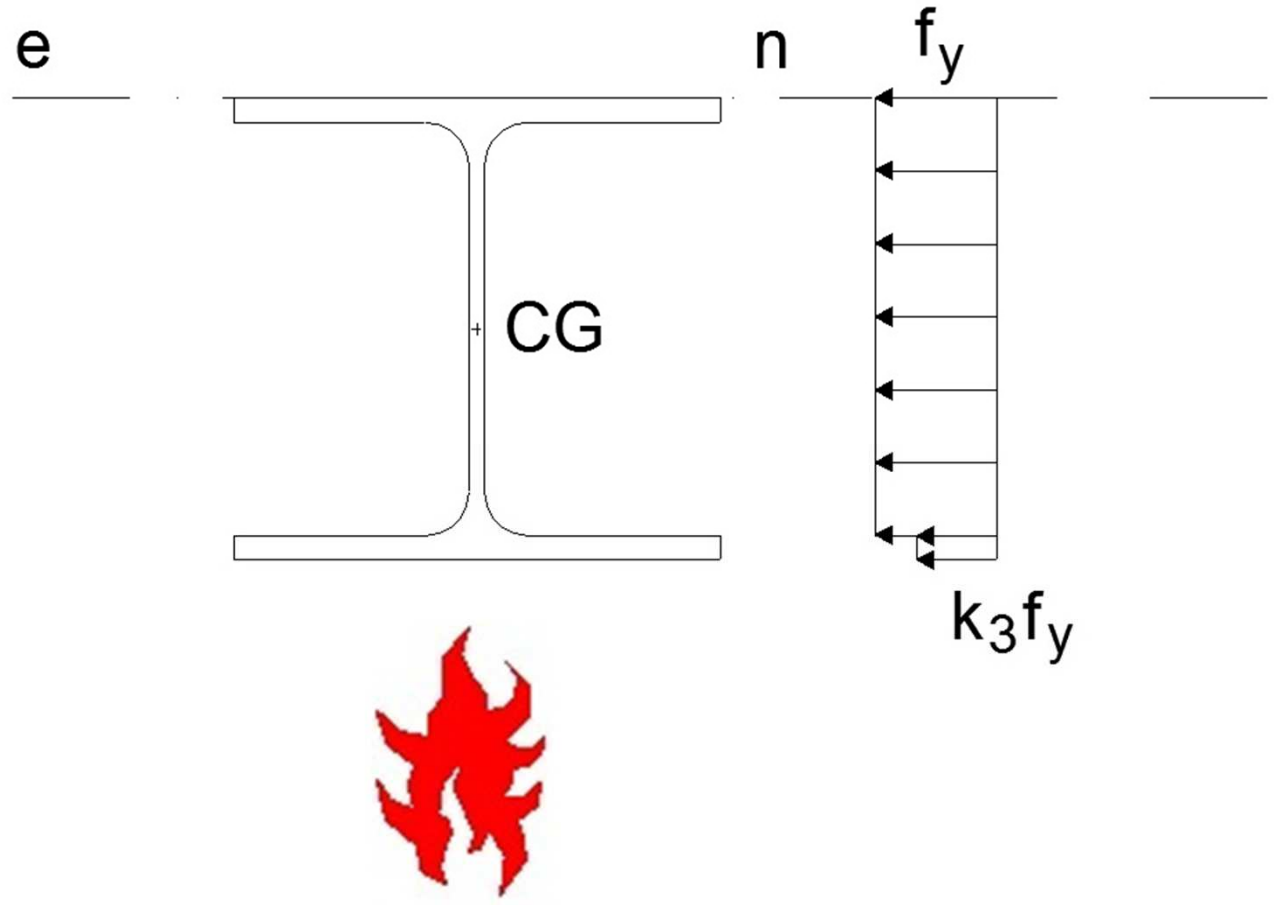
When the temperatures increase, the effective centroid migrates towards the cooler flange.



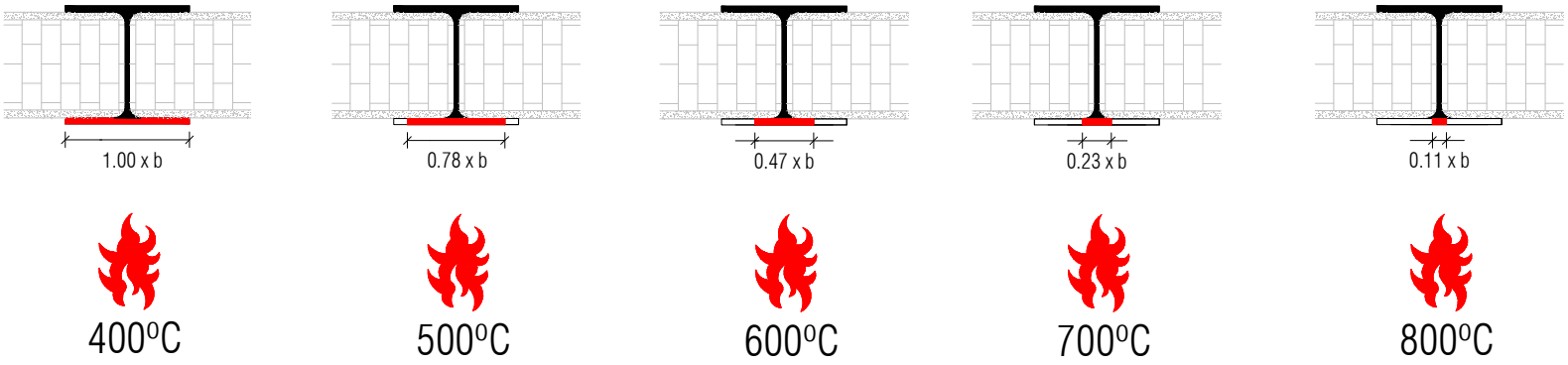
The position of the resultant of the axial stresses P_R (which is located at the effective centroid) moves according to the changes of the section's material properties.

The movement of P_R generates an adittional moment about the Geometric Centroid CG (M_{Pxe}).

Stress diagrams for non-uniform heated steel column with web perpendicular to the walls – thermal gradient along the web



Reduced cross-section - columns with the web perpendicular to the walls (thermal gradient along the web)

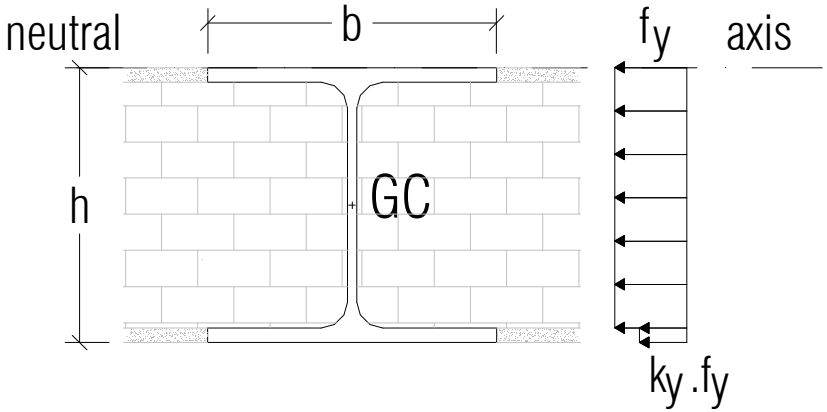


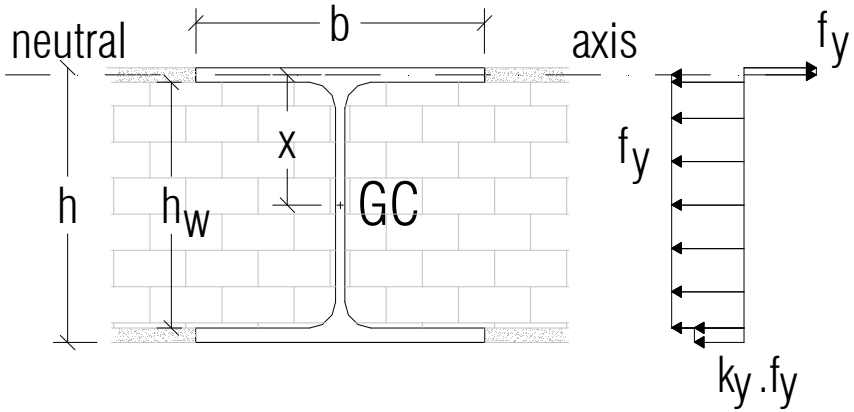
The plastic resistance of the column may be calculated considering a reduced area of the heated flange. The yield stress is uniform along this area.

Reduction factors of the effective yield strength relative to yield strength at 20ºC, as a function of the temperature (EN 1993-1-2-2005).

Temperature (ºC)	20-400	500	600	700	800	900	1000
$k_{y,\theta}$	1	0.78	0.47	0.23	0.11	0.06	0.04

Reduced yield stress - columns with the web perpendicular to the walls (thermal gradient along the web)



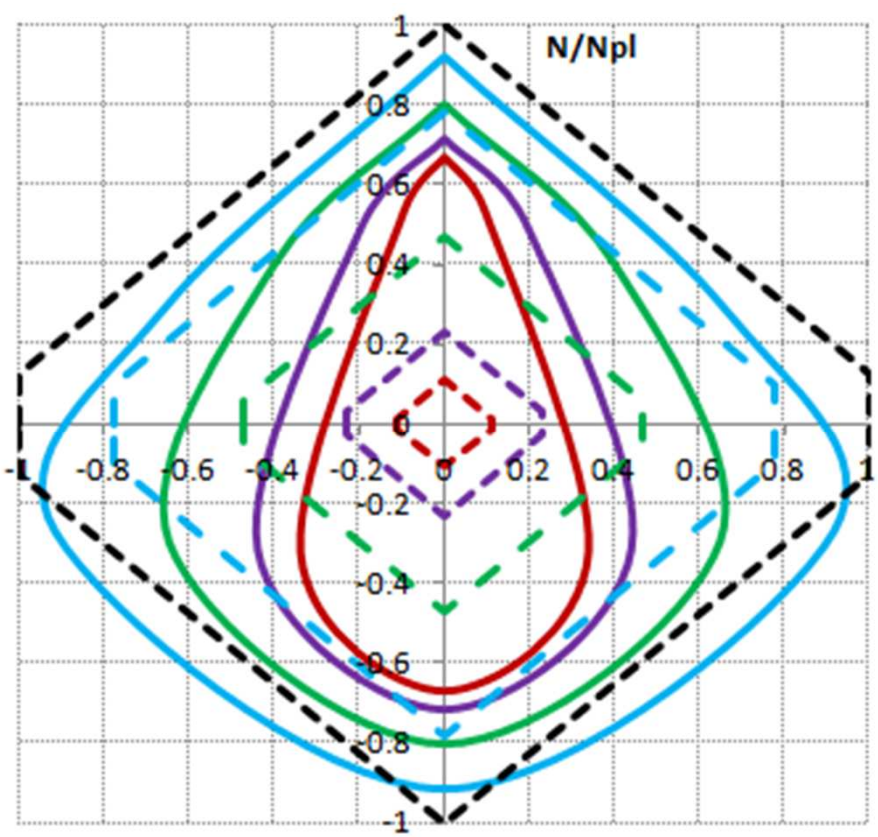


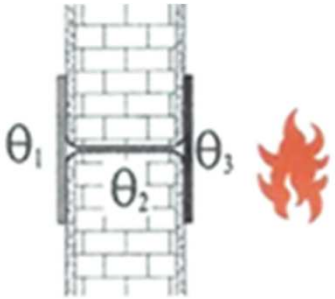
Pure compression

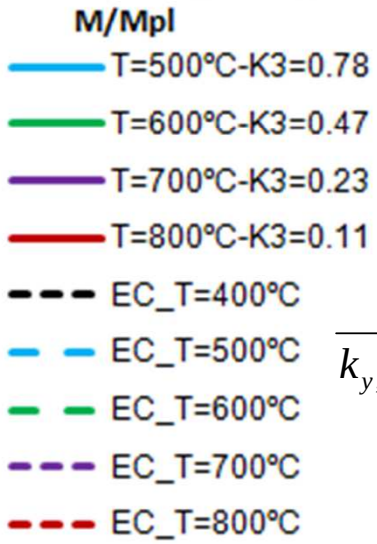
M/M_{pl} is maximum and N/N_{pl} =0

Proposal

Plastic Axial Force-Bending Moment interaction diagrams for steel beam-columns at elevated temperatures – web perpendicular to the walls, considering uniform temperature, and considering the unevenlly heated section

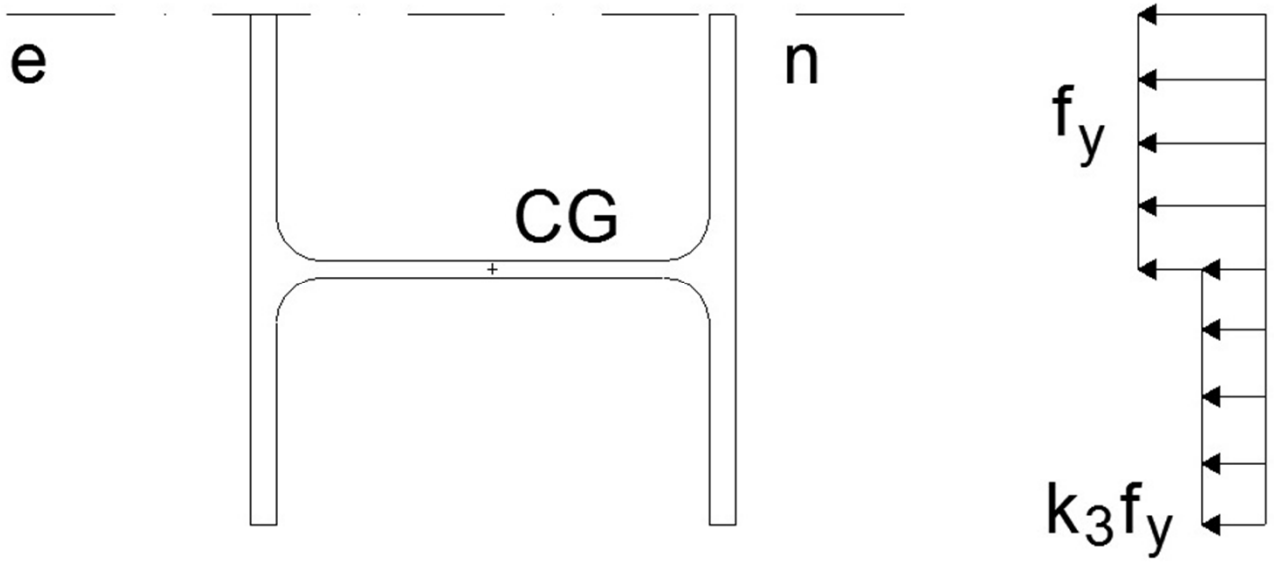




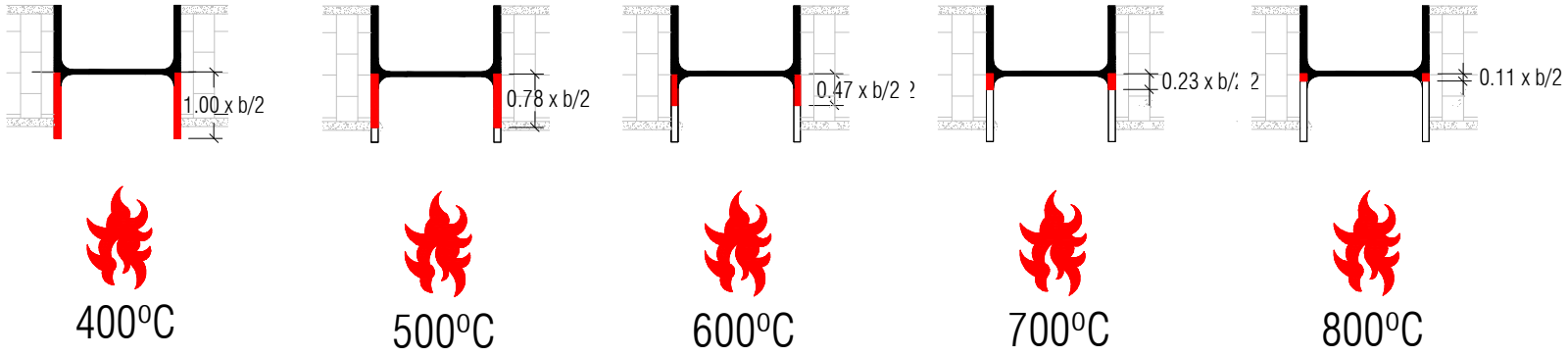


$$\frac{N}{k_{y,\theta}N_{pl}} = 1 - \frac{M}{k_{y,\theta}M_{pl}}\left(1 - 0.5a\right)$$

Stress diagrams for non-uniform heated steel column with web parallel to the walls – thermal gradient along the flange



Reduced cross-section - columns with the web parallel to the walls (thermal gradient along the flanges)

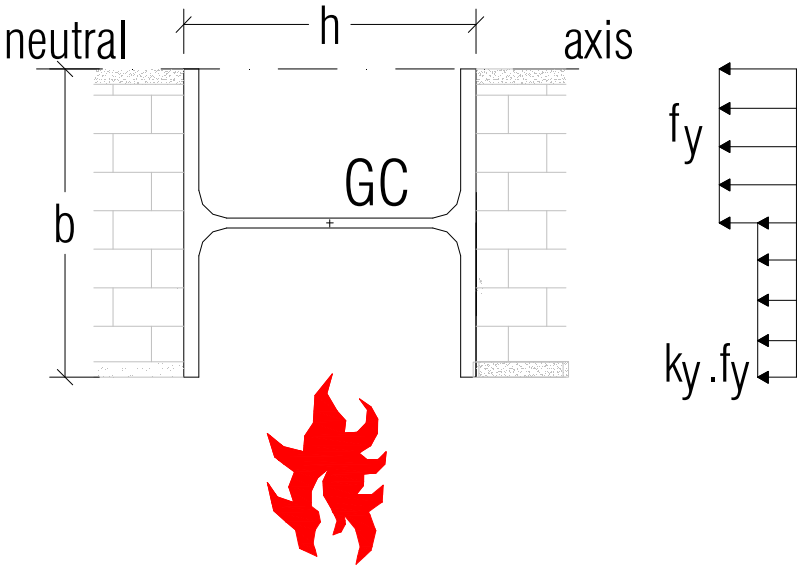


The plastic resistance of the column may be calculated considering a reduced area of the heated flange. The yield stress is uniform along the flanges. Contribution of the web may be neglected.

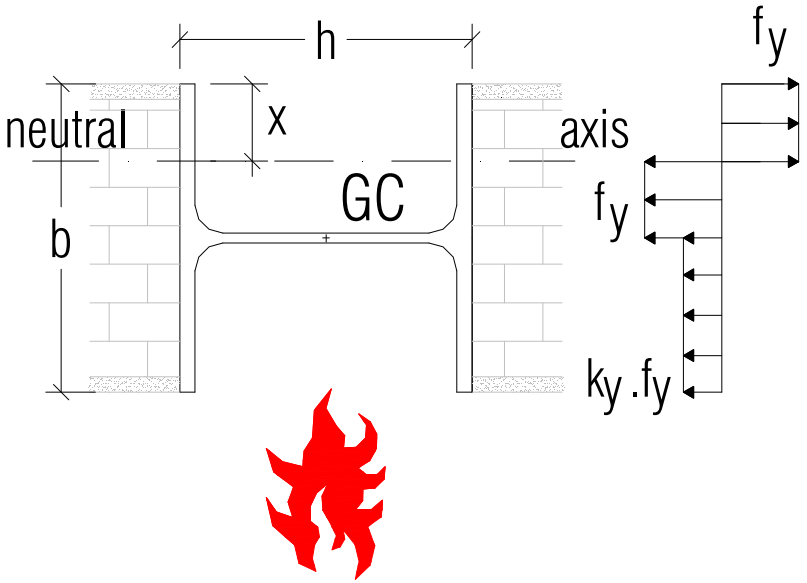
Reduction factors of the effective yield strength relative to yield strength at 20ºC, as a function of the temperature

Temperature (ºC)	20-400	500	600	700	800	900	1000
$k_{y,\theta}$	1	0.78	0.47	0.23	0.11	0.06	0.04

Reduced yield stress - columns with the web parallel to the walls (thermal gradient along the flanges)



$M/M_{pl}=0$ and N/N_{pl} is maximum

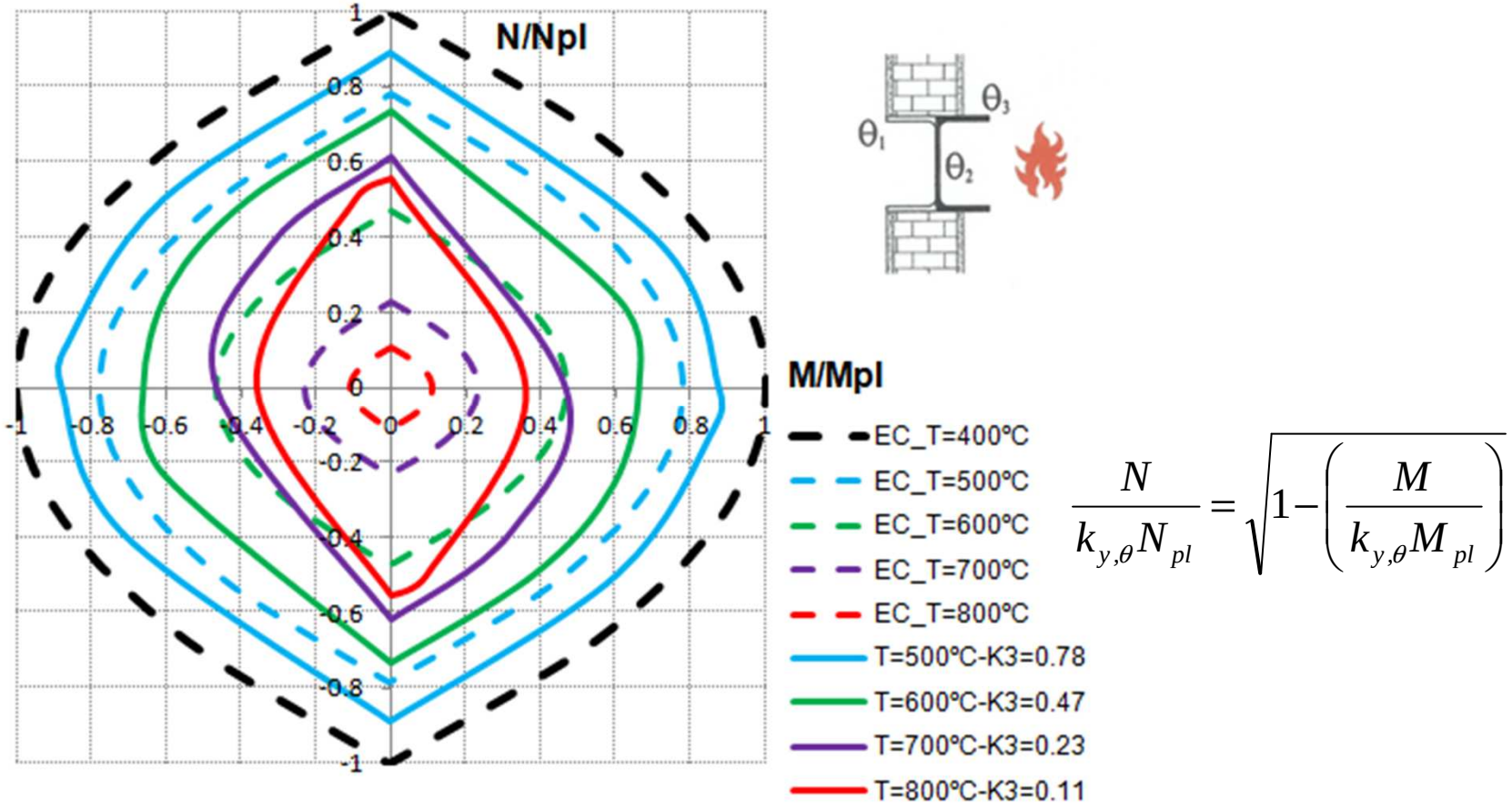


M/M_{pl} is maximum and $N/N_{pl}=0$

António Correia, João Paulo Rodrigues, Paulo Vila Real

Proposal

Plastic Axial Force-Bending Moment interaction diagrams for steel beam-columns at elevated temperatures – web parallel to the walls, considering uniform temperature, and considering the unevenlly heated section



$$\frac{N}{k_{y,\theta}N_{pl}} = \sqrt{1-\left(\frac{M}{k_{y,\theta}M_{pl}}\right)}$$

Conclusions

Concerning the design of steel columns in contact with wall, considering uniform temperature by EN 1993-1-2 (2005)

It was concluded that the formulation of this document is always conservative, than the consideration of the gradients with the real temperatures within the cross section.