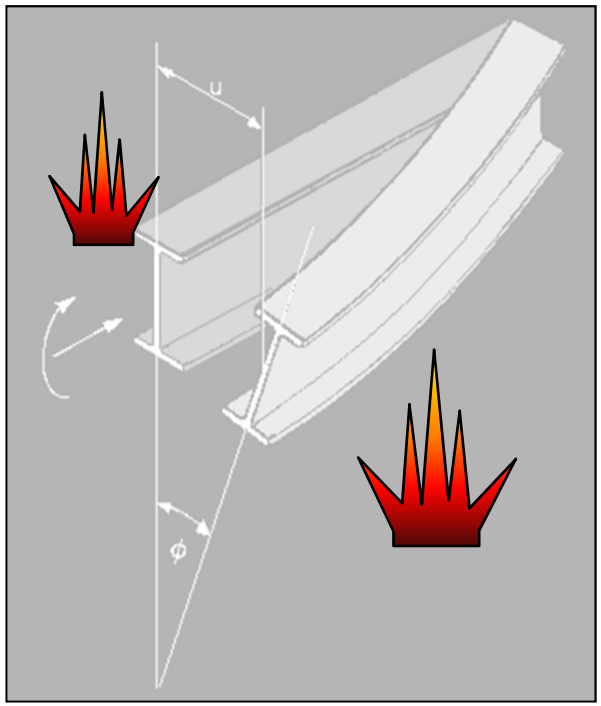
decivil universidade de aveiro departamento de engenharia civil

EN 1993-1-2: LATERAL-TORSIONAL BUCKLING RESISTANCE MOMENT IN CASE OF FIRE

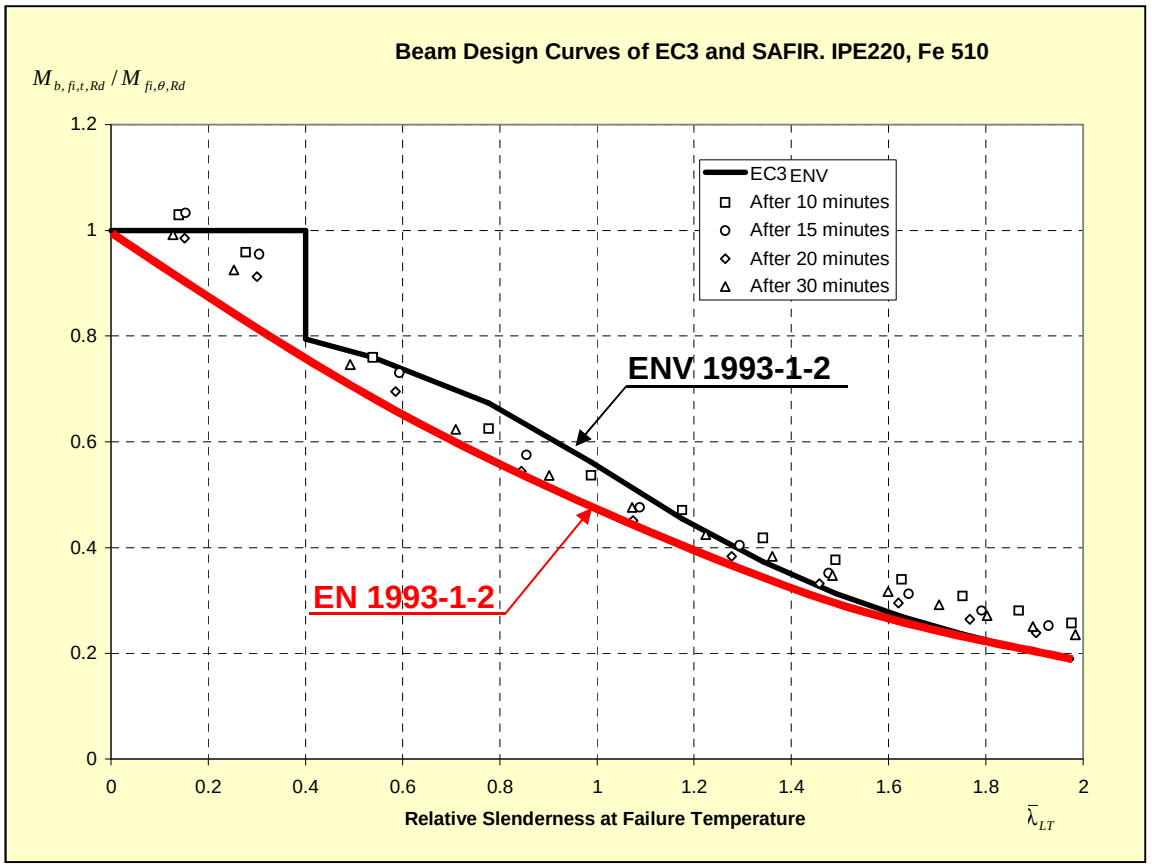
Paulo Vila Real; Nuno Lopes
LABEST - Universidade de Aveiro

Relevant dates

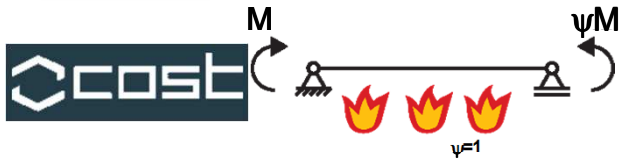


- **1998 – First proposal**
- **2000 – "1st preliminary draft" prEN 1993-1-2**
- **2004 – New proposal tanking into account the i) shape of the bending diagram**
- **2006 – Improvement of the proposal tanking into account the ii) the shape of the cross-section, iii) steel grade and iv) residual stress**
- **2012 – Simplified proposal approved at the Evolution Group of EN 1993-1-2 considering only the effect of bending diagrams.**

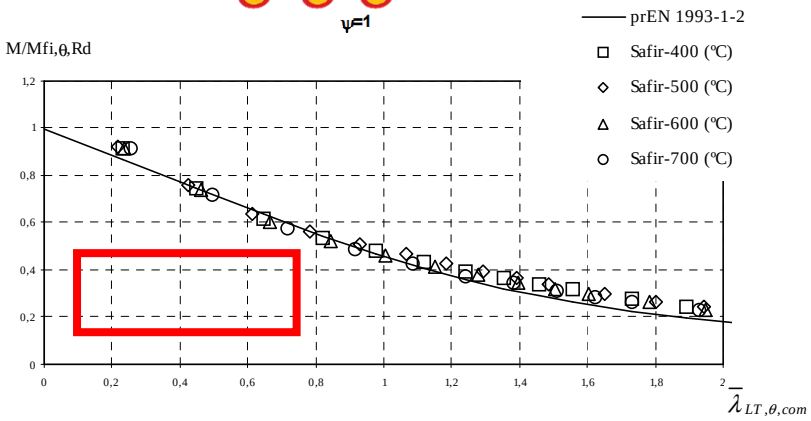
Unrestrained beams at high temperatures



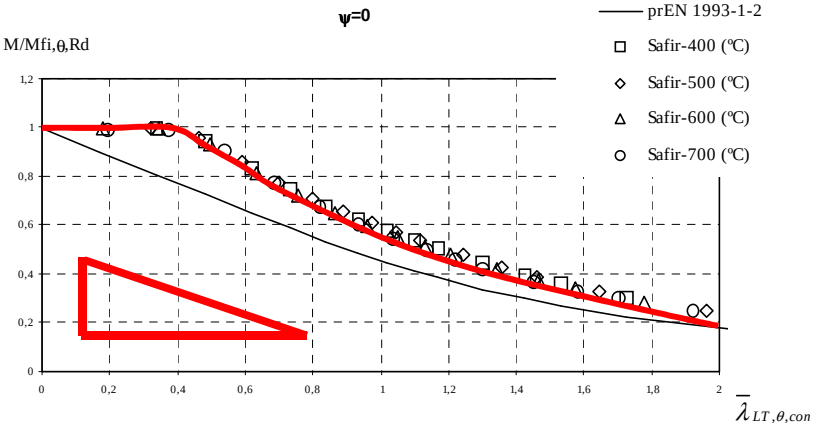
Unrestrained beams at high temperatures



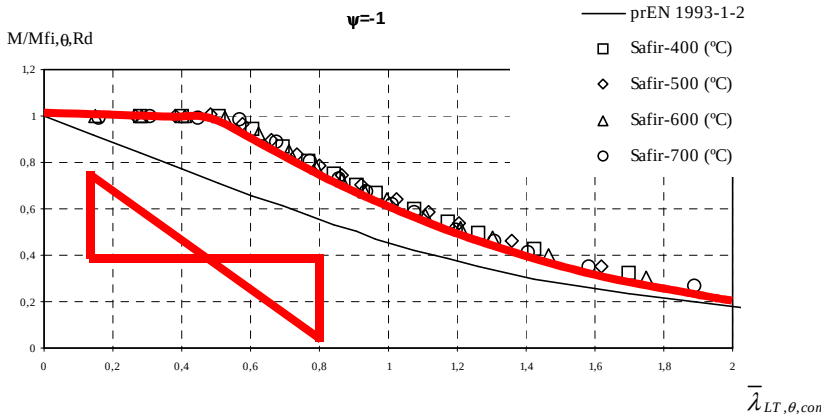
Influence of the bending diagrams



a) Ψ =*1*



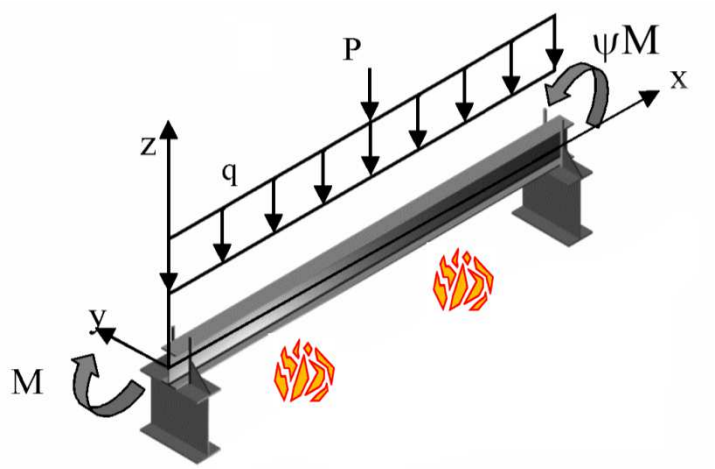
b) Ψ = *0*



c) Ψ = *-1*

Unrestrained beams at high temperatures

EC3 (EN 1993-1-2)



$$M_{b,fi,t,Rd} = \chi_{LT,fi} W_{pl,y} k_{y,\theta} \, f_y / \gamma_{M,fi}$$

$$\chi_{LT,fi} = \frac{1}{\phi_{LT,\theta,com} + \sqrt{\phi^2_{LT,\theta,com} - \bar{\lambda}^2_{LT,\theta,com}}} \quad \text{with} \quad \chi_{LT,fi} \le 1$$

$$\phi_{LT,\theta,com} = \frac{1}{2}\left(1 + \alpha \bar{\lambda}_{LT,\theta,com} + \bar{\lambda}^2_{LT,\theta,com}\right) \qquad \alpha = 0.65\sqrt{235 / f_y}$$

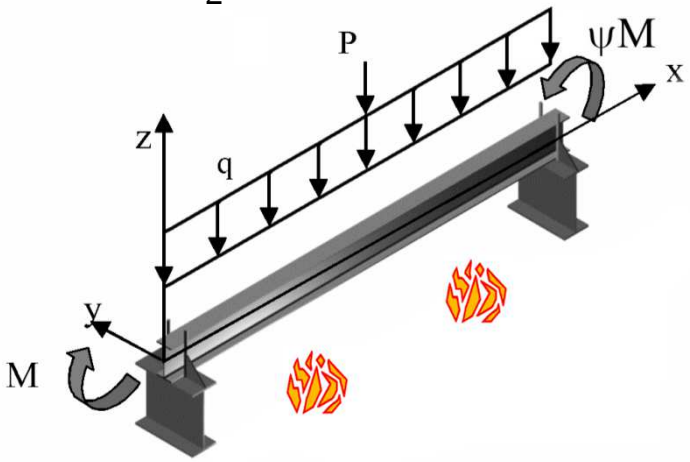
Unrestrained beams at high temperatures

"Full" proposal

$$M_{b,fi,t,Rd} = \chi_{LT,fi,\mathrm{mod}} W_{pl,y} k_{y,\theta} \, f_y / \gamma_{M,fi}$$

$$\chi_{LT,fi} = \frac{1}{\phi_{LT,\theta,com} + \sqrt{\phi^2_{LT,\theta,com} - \overline{\lambda}^2_{LT,\theta,com}}} \quad \text{with} \quad \chi_{LT,fi} \le 1$$

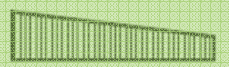
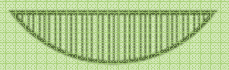
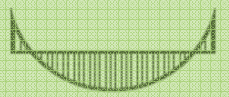
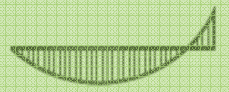
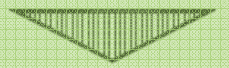
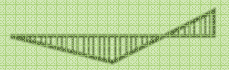
$$\phi_{LT,\theta,com} = \frac{1}{2}\left(1 + \alpha\overline{\lambda}_{LT,\theta,com} + \overline{\lambda}^2_{LT,\theta,com}\right)$$



$$\alpha = \eta\sqrt{235 / f_y}$$

$$\chi_{LT,fi,\mathrm{mod}} = \frac{\chi_{LT,fi}}{f} \quad \text{but} \quad \chi_{LT,fi,\mathrm{mod}} \le 1$$

$$f = 1 - 0.65(1 - k_c)$$

Moment distribution	k_c
M ψM  $-1 \le \psi \le 1$	$\frac{1}{1.33 - 0.33\psi}$ but $k_c \le 1$
	0.94
	0.90
	0.91
	0.86
	0.77
	0.82

Unrestrained beams at high temperatures
Imperfrction factor

Simplified proposal
Approved at the Evolution Group
EN 1993-1-2

$$M_{b,fi,t,Rd} = \chi_{LT,fi,\mathrm{mod}} W_{pl,y} k_{y,\theta} \, f_y / \gamma_{M,fi}$$

$$\chi_{LT,fi} = \frac{1}{\phi_{LT,\theta,com} + \sqrt{\phi^2_{LT,\theta,com} - \overline{\lambda}^2_{LT,\theta,com}}} \quad \text{with} \quad \chi_{LT,fi} \le 1$$

$$\phi_{LT,\theta,com} = \frac{1}{2}\left(1 + \alpha \overline{\lambda}_{LT,\theta,com} + \overline{\lambda}^2_{LT,\theta,com}\right)$$

$$\alpha = 0.65\sqrt{235 / f_y}$$

Geometry

Steel grade

Table 4.13 – Severity factor for the LTB of carbon steel elements in case of fire

Cross-section	limits	η S235, S275, S355, S420	η S460
Rolled I-section	$h/b \le 2$	0.65	0.70
	$h/b > 2$	0.75	0.80
Welded I-section	$h/b \le 2$	0.70	0.75
	$h/b > 2$	0.80	0.85
Other cross-sections		0.80	0.85

Residual stresses

Unrestrained beams at high temperatures
The effect of factor f

The factor f

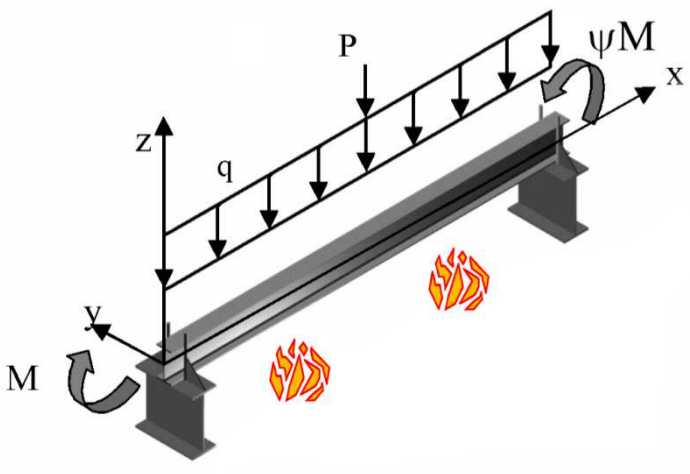
$$M_{b,fi,t,Rd} = \chi_{LT,fi,\mathrm{mod}} W_{pl,y} k_{y,\theta} \, f_y / \gamma_{M,fi}$$

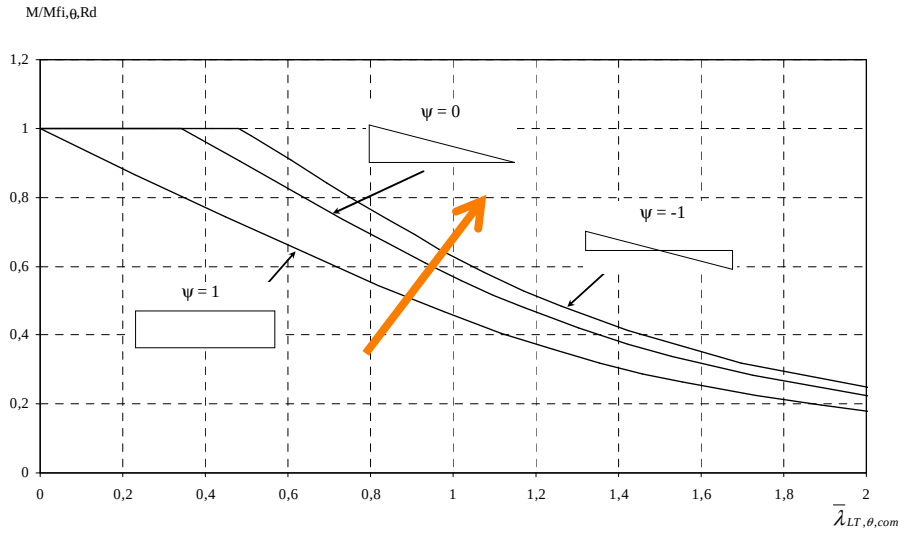
$$\chi_{LT,fi,\mathrm{mod}} = \frac{\chi_{LT,fi}}{f} \quad \text{but} \quad \chi_{LT,fi,\mathrm{mod}} \le 1$$

$$f = 1 - 0.65(1 - k_c)$$

$$\chi_{LT,fi} = \frac{1}{\phi_{LT,\theta,com} + \sqrt{\phi^2_{LT,\theta,com} - \overline{\lambda}^2_{LT,\theta,com}}} \quad \text{with} \quad \chi_{LT,fi} \le 1$$

$$\phi_{LT,\theta,com} = \frac{1}{2}\left(1 + \alpha\overline{\lambda}_{LT,\theta,com} + \overline{\lambda}^2_{LT,\theta,com}\right)$$





References:

VILA REAL, P. M. M.; LOPES, N.; SIMÕES DA SILVA, L.; FRANSSEN, J.-M. – "Parametric analisys of the Lateral-torsional buckling resistance of Steel beams in case of fire", Fire Safety Journal, ELSEVIER, ISSN: 0379-7112,Volume 42, Issues 6-7, Pages 416-424, September-October **2007**.

LOPES, N.; VILA REAL, P.; SIMÕES DA SILVA, L.; FRANSSEN, J.-M. "Lateral-torsional buckling on carbon steel and stainless steel beams with lateral loads plus end moments in case of fire", proceedings of the 6th International Conference on Structures in Fire SiF'10, pp. 67-74, ISBN 978-1-60595-027-3, East Lansing, United States of America, 2 to 4 of June of **2010**.

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Thank you for your attention

Paulo Vila Real; Nuno Lopes
LABEST - Universidade de Aveiro
pvreal@ua.pt