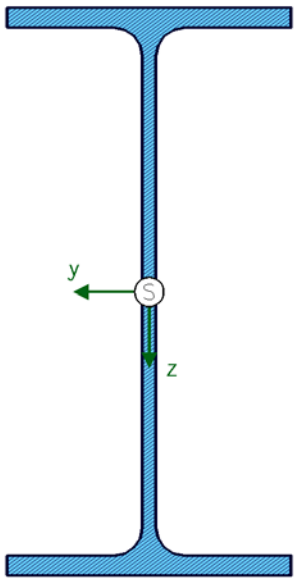
verification of stability EC 3-1-2 (12.10), NA: Deutschland 4H-EC3ST version: 12/2021-1b

1. input data

1.1. general information
verifications of stability in case of fire acc. to EN 1993-1-2
lateral torsional buckling with the method of fictitious bars for My

1.2. safety factor of material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00

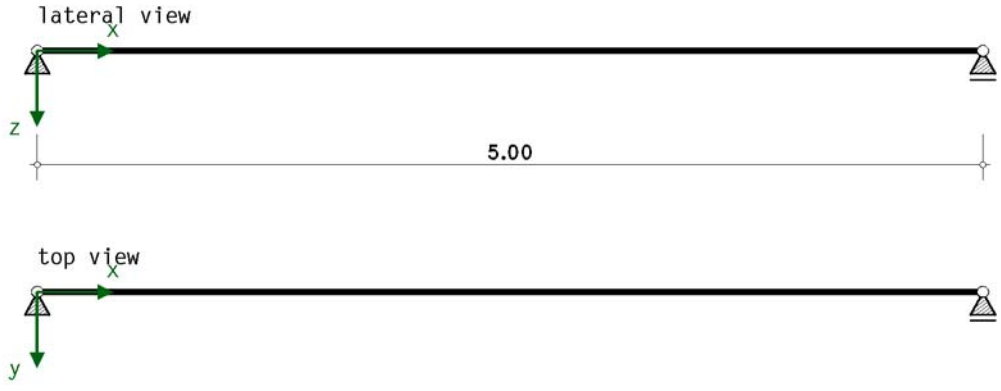
1.3. cross-section
material: S235 (St37) (E = 210000 N/mm^2, G = 80769 N/mm^2, $f_{y,k}$ = 235 N/mm^2)
section: IPE300
section scale 1:4.0



1.4. cross-section values (related to the centre of gravity S)
I_y = 8360.0 cm^4, I_z = 604.0 cm^4, I_ζ = 8360.0 cm^4, I_η = 604.0 cm^4, α = 0.0°
I_ω = 125900.0 cm^6, I_T = 20.2 cm^4
W_y = 557.0 cm^3, W_z = 80.5 cm^3, $W_{pl,y}$ = 628.0 cm^3, $W_{pl,z}$ = 125.0 cm^3
$z_{m,y}$ = 0.0 mm, $z_{m,z}$ = -0.0 mm, A = 53.8 cm^2

1.5. load application point (related to the center of the surrounding rectangle)
y_{load} = 0.0 mm (centroid)
z_{load} = -0.0 mm (shear center)

1.6. static system
all bearings with fork restraint, bar length 5.000 [m]
no intermediate bearing in z-direction, no intermediate bearing in y-direction



1.7. buckling coefficients

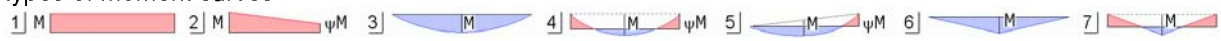
⊥ y-axis: β_y = 1.000, ⊥ z-axis: β_z = 1.000
warping restraint intensity β_0 = 1.000

1.8. design member forces (load combinations)

Lk	type	$M_{0y,d}$	ψ_y	$k_{c,y}$	ζ_y
	-y-	kNm	-	-	-
1	3	39.00	0.000	0.940	1.128

type (y): type of moment curves each direction; $M_{0y,d}$,ψ_y: reference values of moment curve; $k_{C,y}$,ζ_y: coefficients for calculation

types of moment curves



1.9. fire design

thermal action due to the standard curve, fire resistance time t = 10.7 min
emissivity of the cross-section surface of untreated steel steel
section all sides flamed
maximum density steel 7850.0 kg/m³, room temperature 20.0 °C
fire design at load level
adjustment factors of bending moments for uneven temperature distribution
across the cross section κ_1 = 1.00, along the beam κ_2 = 1.00

2. cross-section temperature

surface of the section exposed to fire A_m = 1160.0 mm²/mm
section factor of the unprotected component A_m/V = 1160.0 / 5381.2 ·10³ = 215.6 1/m
fire-stressed inner surface of the enclosing box A_b = 900.0 mm²/mm
section factor for the enclosing box A_b/V = 900.0 / 5381.2 ·10³ = 167.2 1/m
correction factor k_{sh} = (A_b/V) / (A_m/V) = 167.2 / 215.6 = 0.776, I-section: 0.9·k_{sh} = 0.698
cross-section temperature acc. to t = 10.7 min: **T_a = 518.6 °C**
reduction factors: $k_{y,fi}$ = 0.722, $k_{E,fi}$ = 0.546
material parameters: $f_{y,fi}$ = 169.8 N/mm², E_{fi} = 114674.7 N/mm²

3. verifications

3.1. classification of cross-section

3.1.1. load combination 1 ⇒ section class 1

no	c	t	c/t	ε	σ_1	σ_2	tab 5.2	α	ψ	k_σ	class
	mm	mm	-	-	N/mm²	N/mm²		-	-	-	-
1	56.5	10.7	5.28	0.850	67.48	67.48	single 1/1	---	---	---	1
2	56.5	10.7	5.28	0.850	67.48	67.48	single 1/1	---	---	---	1
3	248.6	7.1	35.01	0.850	57.99	-57.99	both 1/1	---	---	---	1
4	56.5	10.7	5.28	1.177	-67.48	-67.48	---	---	---	---	---
5	56.5	10.7	5.28	1.177	-67.48	-67.48	---	---	---	---	---

compressive stresses have a positive sign acc. to EC 3.
classification of cross-section in case of fire acc. to EC 3-1-2, 4.2.2.
the verifications are carried out in the smallest possible cross-section class 1

3.2. lateral torsional buckling for bending around y-axis

c^2 = 53427 mm², buckling curve 'fire' ⇒ α_{LT} = 0.65, N_{cr} = 273.44 kN

3.2.1. utilisations

event of fire: M_{Ed} = κ_1·κ_2·M_{Ed}

Lk	class	M_{cr}	λ_{LT}	f	Φ_{LT}	χ_{LT}	$\chi_{LT,mod}$	M_{Ed}	$M_{b,Rd}$	U
		kNm	-	-	-	m	m	kNm	kNm	-
1	1 ⇒ $W_{pl,y}$	71.30	1.223	1.000	1.645	0.364	0.364	39.00	38.83	**1.004**

max U = 1.004 > 1 not ok !!

4. final result

maximum utilisation U = 1.004 > 1 not ok !!

resistance not ensured !!

5. Selected Design Parameters of the National Annex

DIN EN 1993-1-1 (EC 3, Hochbau), NA Deutschland

chapter	value	definition
6.1(1)	permanent/transient situation	partial safety factors for structural steel
	γ_{M0} = 1.00	collapse of cross-section
	γ_{M1} = 1.10	instability
	γ_{M2} = 1.25	fracture cross-sections in tension
	accidental situation	partial safety factors for structural steel
	γ_{M0} = 1.00	collapse of cross-section
	γ_{M1} = 1.00	instability
	γ_{M2} = 1.25	fracture cross-sections in tension
6.3.2.2(2)	factor f to modify	lateral torsional buckling
	χ_{LT}	general case
6.3.2.3(1)	$\lambda_{LT,0}$ = 0.40	slenderness eqn. (6.75)
	β = 0.75	correction factor eqn. (6.75)
6.3.2.3(2)	coefficient k_c from tab. 6.6	calculation of the reduction factor χ_{LT}

DIN EN 1993-1-2 (EC 3, Brandfall), NA Deutschland

chapter	value	definition
2.3(1)	event of fire	partial safety factor for
	$\gamma_{M,fi}$ = 1.00	mechanical failure