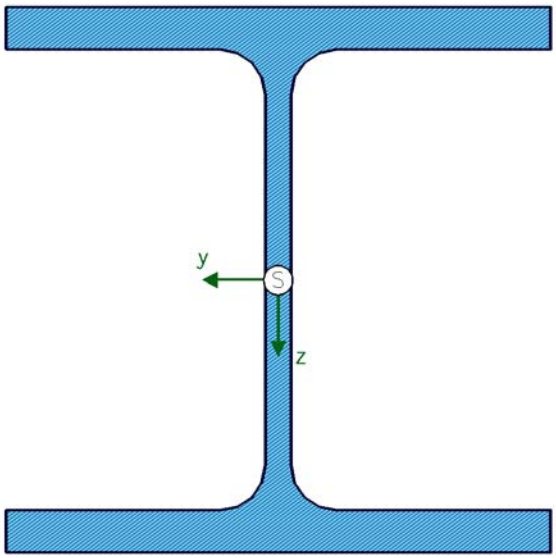
verification of stability EC 3-1-2 (12.10), NA: Deutschland 4H-EC3ST version: 12/2021-1b

1. input data

1.1. general information
verifications of stability in case of fire acc. to EN 1993-1-2
flexural buckling with the method of fictitious bars, no buckling direction

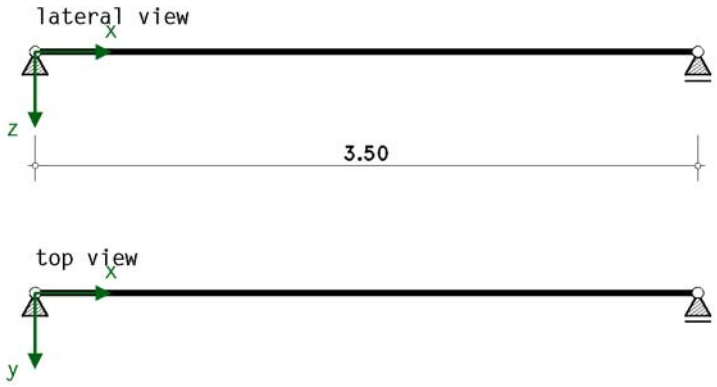
1.2. safety factor of material
resistance of cross-sections γ_{M0} = 1.00
resistance of members in stability failure γ_{M1} = 1.10
resistance of components in the event of fire $\gamma_{M,fi}$ = 1.00

1.3. cross-section
material: S275 (St44) (E = 210000 N/mm^2, G = 80769 N/mm^2, $f_{y,k}$ = 275 N/mm^2)
section: HE180B
section scale 1:2.5



1.4. cross-section values (related to the centre of gravity S)
I_y = 3830.0 cm^4, I_z = 1360.0 cm^4, I_ζ = 3830.0 cm^4, I_η = 1360.0 cm^4, α = 0.0°
I_ω = 93750.0 cm^6, I_T = 42.3 cm^4
W_y = 426.0 cm^3, W_z = 151.0 cm^3, $W_{pl,y}$ = 481.0 cm^3, $W_{pl,z}$ = 231.0 cm^3
$z_{m,y}$ = 0.0 mm, $z_{m,z}$ = -0.0 mm, A = 65.3 cm^2

1.5. static system
all bearings with fork restraint, bar length 3.500 [m]
no intermediate bearing in z-direction, no intermediate bearing in y-direction



1.6. buckling coefficients

⊥ y-axis: β_y = 0.500, ⊥ z-axis: β_z = 0.500
warping restraint intensity β_0 = 1.000

1.7. design member forces (load combinations)

Lk	N_d kN
1	495.00

N_d: constant axial force in the bar

1.8. fire design

thermal action due to the standard curve, fire resistance time t = 30.0 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 = 0.85

2. cross-section temperature

surface of the section exposed to fire A_m = 1037.2 mm²/mm
section factor of the unprotected component A_m/V = 1037.2 / 6525.1 ·10³ = 159.0 1/m
fire-stressed inner surface of the enclosing box A_b = 720.0 mm²/mm
section factor for the enclosing box A_b/V = 720.0 / 6525.1 ·10³ = 110.3 1/m
correction factor k_{sh} = (A_b/V) / (A_m/V) = 110.3 / 159.0 = 0.694, I-section: 0.9·k_{sh} = 0.625
cross-section temperature acc. to t = 30.0 min: **T_a = 766.3 °C**
reduction factors: $k_{y,fi}$ = 0.150, $k_{E,fi}$ = 0.103
material parameters: $f_{y,fi}$ = 41.4 N/mm², E_{fi} = 21728.1 N/mm²

3. verifications

3.1. classification of cross-section

3.1.1. load combination 1 ⇒ section class 1

no	c mm	t mm	c/t -	ε -	σ_1 N/mm²	σ_2 N/mm²	tab 5.2	α -	ψ -	k_σ -	class -
1	70.8	14.0	5.05	0.786	75.80	75.80	single 1/1	---	---	---	**1**
2	70.8	14.0	5.05	0.786	75.80	75.80	single 1/1	---	---	---	1
3	122.0	8.5	14.35	0.786	75.80	75.80	both 2/1	---	---	---	1
4	70.8	14.0	5.05	0.786	75.80	75.80	single 1/1	---	---	---	1
5	70.8	14.0	5.05	0.786	75.80	75.80	single 1/1	---	---	---	1

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. flexural buckling around z-axis

I_p = 5190 cm⁴, I_T = 42 cm⁴, i_p^2 = 7948 mm, c^2 = 5435 mm², i_m^2 = 7948 mm²
i_z = 45.6 mm, β_y = 0.50 (⊥ y-axis), $L_{cr,y}$ = 1.750 m, λ_1 = 72.006
λ_z = 0.533, z-buckling curve 'fire' ⇒ α_z = 0.60, Φ_z = 0.802, χ_z = 0.714, **$N_{bz,Rd}$ = 192.75 kN**

3.2.1. utilisations

Lk	N_d kN	U_z -
1	495.00	**2.568**

max U = 2.568 > 1 not ok !!

4. final result

maximum utilisation U = 2.568 > 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