

1. input data

1.1. general information

verifications of stability acc. to EN 1993-1-1

c/t-verification (classification of cross-section)

lateral torsional buckling with the method of fictitious bars for M_y

1.2. safety factor of material

resistance of cross-sections $\gamma_{M0} = 1.00$

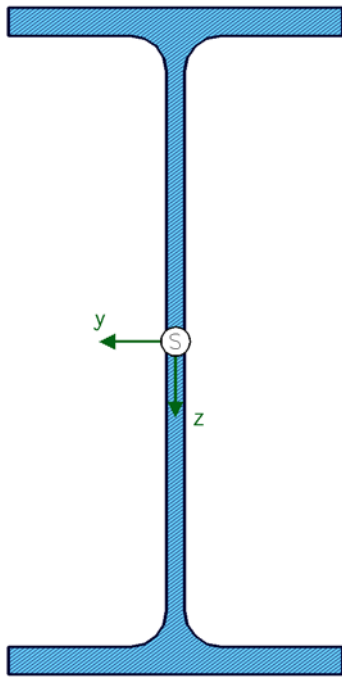
resistance of members in stability failure $\gamma_{M1} = 1.10$

1.3. cross-section

material: S235 (St37) ($E = 210000 \text{ N/mm}^2$, $G = 80769 \text{ N/mm}^2$, $f_{y,k} = 235 \text{ N/mm}^2$)

section: IPE220

section scale 1:2.5



1.4. cross-section values (related to the centre of gravity S)

$I_y = 2770.0 \text{ cm}^4$, $I_z = 205.0 \text{ cm}^4$, $I_{yz} = 2770.0 \text{ cm}^4$, $I_{\eta} = 205.0 \text{ cm}^4$, $\alpha = 0.0^\circ$

$I_{\omega} = 22670.0 \text{ cm}^6$, $I_T = 9.1 \text{ cm}^4$

$W_y = 252.0 \text{ cm}^3$, $W_z = 37.3 \text{ cm}^3$, $W_{pl,y} = 285.0 \text{ cm}^3$, $W_{pl,z} = 58.0 \text{ cm}^3$

$z_{m,y} = -0.0 \text{ mm}$, $z_{m,z} = -0.0 \text{ mm}$, $A = 33.4 \text{ cm}^2$

1.5. load application point (related to the center of the surrounding rectangle)

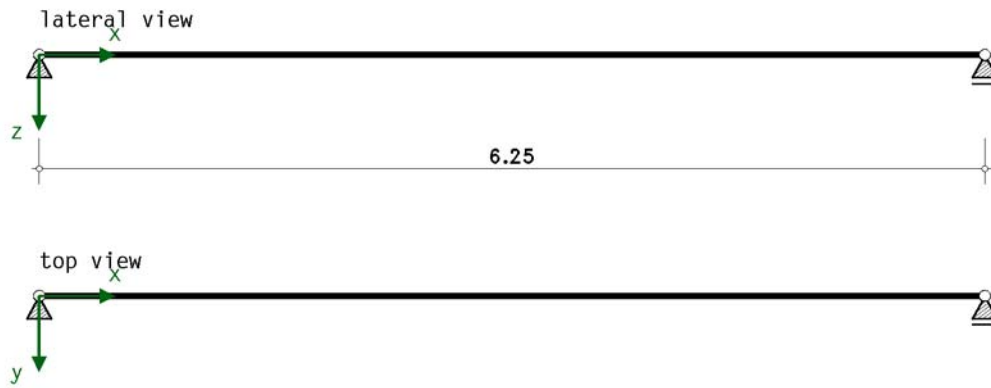
$y_{load} = 0.0 \text{ mm}$ (centroid)

$z_{load} = -110.0 \text{ mm}$ (upper edge of cross-section)

1.6. static system

all bearings with fork restraint, bar length 6.250 [m]

no intermediate bearing in z-direction, no intermediate bearing in y-direction



1.7. buckling coefficients

⊥ y-axis: $\beta_y = 1.000$, ⊥ z-axis: $\beta_z = 1.000$

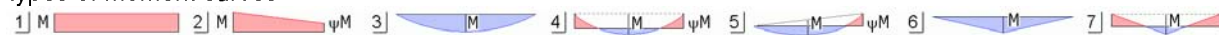
warping restraint intensity $\beta_0 = 1.000$

1.8. design member forces (load combinations)

Lk	type -y-	$M_{0y,d}$ kNm	ψ_y -	$k_{c,y}$ -	ζ_y -
1	5	26.70	0.588	0.910	1.630
2	5	26.70	1.000	0.910	2.222

type (y): type of moment curves each direction; $M_{0y,d}, \psi_y$: reference values of moment curve; $k_{c,y}, \zeta_y$: coefficients for calculation

types of moment curves



2. verifications

2.1. classification of cross-section

2.1.1. load combination 1 ⇒ section class 1

no	c mm	t mm	c/t -	ϵ -	σ_1 N/mm ²	σ_2 N/mm ²	tab 5.2	α -	ψ -	k_σ -	class -
1	40.0	9.2	4.35	1.000	73.92	73.92	single 1/1	---	---	---	1
2	40.0	9.2	4.35	1.000	73.92	73.92	single 1/1	---	---	---	1
3	177.6	5.9	30.10	1.000	62.28	-62.28	both 1/1	---	---	---	1
4	40.0	9.2	4.35	1.000	-73.92	-73.92	-----	---	---	---	---
5	40.0	9.2	4.35	1.000	-73.92	-73.92	-----	---	---	---	---

2.1.2. load combination 2 ⇒ section class 1

no	c mm	t mm	c/t -	ϵ -	σ_1 N/mm ²	σ_2 N/mm ²	tab 5.2	α -	ψ -	k_σ -	class -
1	40.0	9.2	4.35	1.000	101.59	101.59	single 1/1	---	---	---	1
2	40.0	9.2	4.35	1.000	101.59	101.59	single 1/1	---	---	---	1
3	177.6	5.9	30.10	1.000	85.59	-85.59	both 1/1	---	---	---	1
4	40.0	9.2	4.35	1.000	-101.59	-101.59	-----	---	---	---	---
5	40.0	9.2	4.35	1.000	-101.59	-101.59	-----	---	---	---	---

compressive stresses have a positive sign acc. to EC 3.

verifications are carried out in the specified cross-section class 2: $U_{c/t} = 0.435 < 1$ ok

2.2. lateral torsional buckling for bending around y-axis

$c^2 = 78632 \text{ mm}^2$, buckling curve b ⇒ $\alpha_{LT} = 0.34$, $N_{cr} = 108.77 \text{ kN}$

2.2.1. utilisations

Lk	M_{cr} kNm	λ_{LT} -	f -	Φ_{LT} -	χ_{LT} m	$\chi_{LT,mod}$ m	M_{Ed} kNm	$M_{b,Rd}$ kNm	U -
1	28.08	1.544	1.000	1.589	0.409	0.409	19.43	24.89	0.781
2	48.15	1.179	0.968	1.154	0.591	0.611	26.70	37.19	0.718

max U = 0.781 < 1 ok

3. final result

maximum utilisation $U = 0.781 < 1$ **ok**

c/t-utilisation $U = 0.435 < 1$ **ok**

verification succeeded

4. 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
	$\gamma_{M0} = 1.00$	collapse of cross-section
	$\gamma_{M1} = 1.10$	instability
	$\gamma_{M2} = 1.25$	fracture cross-sections in tension
	accidental situation	partial safety factors for structural steel
	$\gamma_{M0} = 1.00$	collapse of cross-section
	$\gamma_{M1} = 1.00$	instability
	$\gamma_{M2} = 1.25$	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)
	$\beta = 0.75$	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