

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 $N+My+Mz$, interaction proof only with eqn. (6.61)

1.2. safety factor of material

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

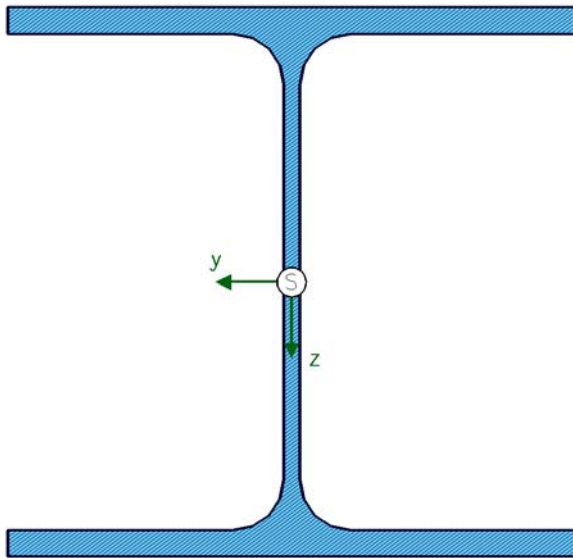
resistance of members in stability failure $\gamma_{M1} = 1.10$

1.3. cross-section

material: S355 (St52) ($E = 210000 \text{ N/mm}^2$, $G = 80769 \text{ N/mm}^2$, $f_{y,k} = 355 \text{ N/mm}^2$)

section: HE300A

section scale 1:4.0



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

$I_y = 18260.0 \text{ cm}^4$, $I_z = 6310.0 \text{ cm}^4$, $I_{yz} = 18260.0 \text{ cm}^4$, $I_{\eta} = 6310.0 \text{ cm}^4$, $\alpha = 0.0^\circ$

$I_{\omega} = 1200000.0 \text{ cm}^6$, $I_T = 85.6 \text{ cm}^4$

$W_y = 1260.0 \text{ cm}^3$, $W_z = 421.0 \text{ cm}^3$, $W_{pl,y} = 1383.0 \text{ cm}^3$, $W_{pl,z} = 642.0 \text{ cm}^3$

$z_{m,y} = -0.0 \text{ mm}$, $z_{m,z} = 0.0 \text{ mm}$, $A = 113.0 \text{ cm}^2$, cross-section is torsionally soft

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

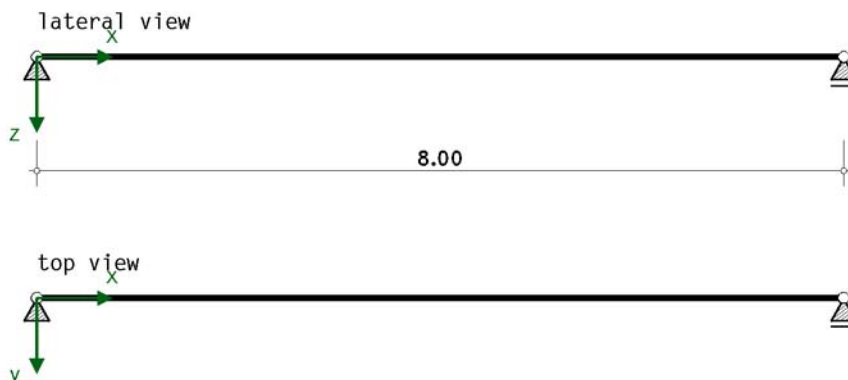
$y_{load} = 0.0 \text{ mm}$ (centroid)

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

1.6. static system

all bearings with fork restraint, bar length 8.000 [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	N _d kN	type - y -	M _{0y,d} kNm	ψ _y -	k _{c,y} -	ζ _y -	type - z -	M _{0z,d} kNm	ψ _z -	k _{c,z} -	ζ _z -
1	230.70	2	314.10	0.000	0.752	1.770	2	0.00	0.000	0.752	1.770

N_d: constant axial force in the bar; type (y), type (z): type of moment curves each direction; M_{0y,d}, ψ_y, M_{0z,d}, ψ_z: reference values of moment curve
k_{c,y}, ζ_y, k_{c,z}, ζ_z: coefficients for calculation

types of moment curves



2. verifications

2.1. classification of cross-section

2.1.1. load combination 1 ⇒ section class 3

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	118.8	14.0	8.48	0.814	257.80	257.80	single 1/3	---	---	---	3
2	118.8	14.0	8.48	0.814	257.80	257.80	single 1/3	---	---	---	3
3	208.0	8.5	24.47	0.814	199.31	-158.48	both 3/1	0.684	---	---	1
4	118.8	14.0	8.48	0.814	-216.97	-216.97	-----	---	---	---	---
5	118.8	14.0	8.48	0.814	-216.97	-216.97	-----	---	---	---	---

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

verifications are carried out in the **specified cross-section class 3**: $U_{eff} = 0.745 < 1$ **ok**

2.2. lateral torsional buckling

2.2.1. flexural buckling for normal force

$I_p = 24570 \text{ cm}^4$, $I_T = 86 \text{ cm}^4$, $i_p^2 = 21743 \text{ mm}^2$, $c^2 = 52851 \text{ mm}^2$, $i_m^2 = 21743 \text{ mm}^2$

flexural buckling around y-axis:

$i_y = 127.1 \text{ mm}$, $\beta_z = 1.00$ (⊥ z-axis), $L_{cr,z} = 8.000 \text{ m}$, $\lambda_1 = 76.409$

$\lambda_y = 0.824$, y-buckling curve b ⇒ $\alpha_y = 0.34$, $\Phi_y = 0.945$, $\chi_y = 0.710$, **N_{by,Rd} = 2588.37 kN**

flexural buckling around z-axis:

$i_z = 74.7 \text{ mm}$, $\beta_y = 1.00$ (⊥ y-axis), $L_{cr,y} = 8.000 \text{ m}$, $\lambda_1 = 76.409$

$\lambda_z = 1.401$, z-buckling curve c ⇒ $\alpha_z = 0.49$, $\Phi_z = 1.776$, $\chi_z = 0.349$, **N_{bz,Rd} = 1272.05 kN**

2.2.1.1. utilisations

Lk	N _d kN	U _y -	U _z -
1	230.70	0.089	0.181

2.2.2. lateral torsional buckling for bending around y-axis

$c^2 = 52851 \text{ mm}^2$, buckling curve b ⇒ $\alpha_{LT} = 0.34$, $N_{cr} = 2043.47 \text{ kN}$

2.2.2.1. utilisations

Lk	M _{cr} kNm	λ _{LT} -	f -	Φ _{LT} -	χ _{LT} m	χ _{LT,mod} m	M _{Ed} kNm	M _{b,Rd} kNm	U -
1	831.69	0.733	0.877	0.758	0.853	0.972	314.10	395.34	0.794

2.2.3. lateral torsional buckling for bending around z-axis

$c^2 = 52851 \text{ mm}^2$, buckling curve b ⇒ $\alpha_{LT} = 0.34$, $N_{cr} = 5913.44 \text{ kN}$

2.2.3.1. utilisations

Lk	M _{cr} kNm	λ _{LT} -	f -	Φ _{LT} -	χ _{LT} m	χ _{LT,mod} m	M _{Ed} kNm	M _{b,Rd} kNm	U -
1	2406.75	0.249	0.951	0.498	1.000	1.000	0.00	135.87	0.000

2.2.4. interaction

Lk	eqn.	C _{my} -	k _{yy} -	C _{mLT} -	k _{zy} -	C _{mz} -	k _{zz} -	k _{yz} -	U -
1	(6.61)	0.600	0.626	0.600	---	---	---	0.665	0.587
	(6.62)	---	---	0.600	0.974	0.600	0.665	---	0.955

max U = 0.955 < 1 **ok**

3. final result

maximum utilisation $U = 0.955 < 1$ **ok**

c/t-utilisation $U = 0.745 < 1$ **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