

POSITION 3: EXAMPLE 3

1. Input parameters

1.1. General statements

results acc. to DIN EN 1993:2010, Germany

verification of classification of the cross-section (width to thickness ratio)

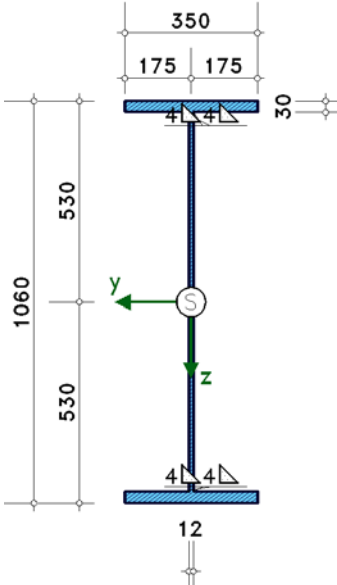
torsional-flexural buckling by the method of fictitious bars acc. to EN 1993-1-1 6.3.2 only M_y

1.2. Cross-section

material: S355 (St52)

designation: IPE500

section scale 1:200



1.3. Section properties (referring to centroid S)

$I_y = 657130 \text{ cm}^4$, $I_z = 21452 \text{ cm}^4$, $I_w = 56857609.4 \text{ cm}^6$, $I_t = 664.57 \text{ cm}^4$

$W_y = 12398.68 \text{ cm}^3$, $W_z = 1225.82 \text{ cm}^3$, $W_{p1,y} = 13997.70 \text{ cm}^3$, $W_{p1,z} = 1837.50 \text{ cm}^3$

$Z_{m,y} = 0 \text{ mm}$, $Z_{m,z} = 0 \text{ mm}$, $A = 33000 \text{ mm}^2$, cross-section is susceptible to torsional deformations

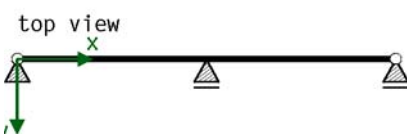
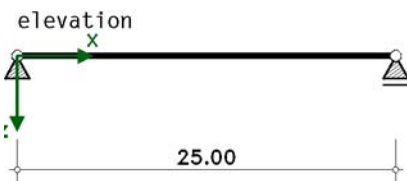
1.4. Load application point (referring to centroid S)

$Z_{\text{load}} = 0 \text{ mm}$ (centroid),

1.5. Structural system

all supports with fork conditions, beam length 25.000 [m]

no support in z-direction, 1 support in y-direction



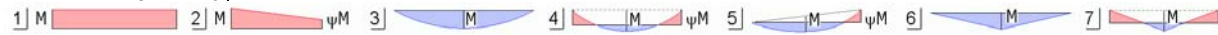
1.6. Buckling factors

about the y-axis: $\beta_z = 1.000$, about the z-axis: $\beta_y = 1.000$
warping restraint intensity $\beta_0 = 1.000$

1.7. Combinations of design internal forces

Nr	$M_{0y,d}$ kNm	type	ψ_y	$k_{c,y}$	ζ_y	A
1	1450.00	1	1.000	1.000	1.000	

moment diagram types



2. Verifications acc. to DIN EN 1993, Germany

DIN EN 1993-1-1 (EC 3)

chapter	value	definition
6.1(1)	permanent/transient sit. $\gamma_{M0} = 1.00$ $\gamma_{M1} = 1.10$ $\gamma_{M2} = 1.25$	partial factors for structural steel Cross-section failure instability
	accidental situation $\gamma_{M0} = 1.00$ $\gamma_{M1} = 1.00$ $\gamma_{M2} = 1.15$	partial factors for structural steel Cross-section failure instability fracture cross-sections in tension
6.3.2.2(2)	factor f for modifying of χ_{LT} : setting	buckling curve torsional-flexural buckling general case

2.1. Classification of cross-sections acc. to DIN EN 1993-1-1, 5.5.2

2.1.1. Load combination 1 \Rightarrow class of cross-section 3

Nr	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	1633.4	300.0	5.44	0.814	-1.14	-1.14	ones. 1/1	---	---	---	1
2	1633.4	300.0	5.44	0.814	-1.14	-1.14	ones. 1/1	---	---	---	1
3	9886.9	120.0	82.39	0.814	-1.14	1.14	double 1/3	---	---	---	3
4	1633.4	300.0	5.44	0.814	1.14	1.14	-----	---	---	---	---
5	1633.4	300.0	5.44	0.814	1.14	1.14	-----	---	---	---	---

verification is done in the predefined class of cross-section 3, $U = 0.817$

2.2. Torsional-flexural buckling acc. to DIN EN 1993-1-1 6.3.2 about the y-y-axis

$c^2 = 454221 \text{ mm}^2$, buckling curve d $\Rightarrow \alpha_{LT} = 0.76$, $N_{cr} = 2845.54 \text{ kN}$

2.2.1. Utilizations

Nr	M_{cr} kNm	λ_{LT}	f	Φ_{LT}	χ_{LT} -m	M_{Ed} kNm	$M_{b,Rd}$ kNm	U
1	1917.78	1.515	1.000	1.784	0.334	1450.00	1336.59	1.085

max $U = 1.085 > 1 \Rightarrow$ verification failed!
the total utilization is: $U = 1.085$