Project

Job name : Prague tower
Part : Part D
Author : John Smith
Date : 29.01.2018

Standard

Standard **EN 1995-1-1/Czech Rep.**.

Solid timber, basic load combination	: γ_M	= 1,300
Glued laminated timber, basic load combination	: γ_M	= 1,250
LVL, basic load combination	: γ_M	= 1,200
Plywood, basic load combination	: γ_M	= 1,200
OSB, basic load combination	: γ_M	= 1,200
Particleboard, basic load combination	: γ_M	= 1,300
Fibreboard, basic load combination	: γ_M	= 1,300
Accidental load combination	: γ_M	= 1,000

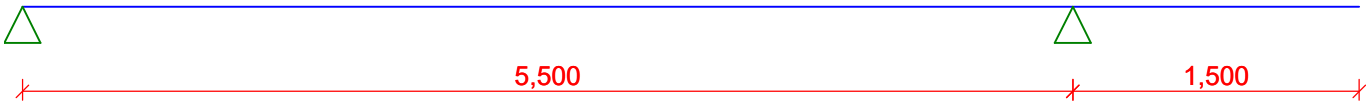
1 Beam 1

1.1 Input data

Length: 7,000 m
Service class: 2

1.1.1 Geometry

x [m]	Point kind	A/L [m]	I/L [m³]
0,000	hinged	-	-
5,500	hinged	-	-
7,000	free	-	-



Cross-section

Sector No.	Start [m]	End [m]	Section	Rotation [°]
1	0,000	7,000	Rectangular 180x300	0,0

Material

Name: S10 (C24) - coniferous
Timber type: solid
Calculation uses coefficient k_h for increasing tensile and bending strength.

1.1.2 Load

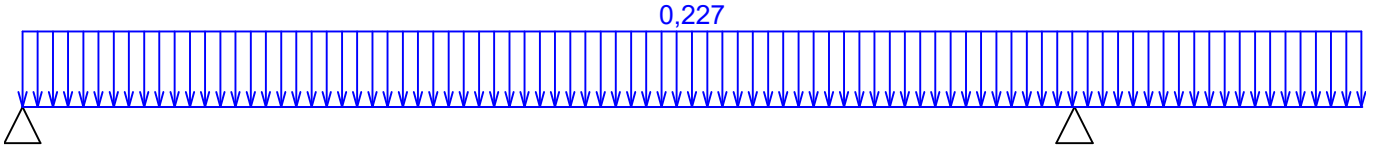
Load cases

no.	Name	Code	Type	γ_f ($\gamma_{f,inf}$)*	Factors for combinations				
					ξ	Categ.**	ψ_0	ψ_1	ψ_2
1	G1 Self-weight	Self weight	Permanent	1,35(0,90)	0,85	-	-	-	-
2	G2 Permanent load	Force	Permanent	1,35(0,90)	0,85	-	-	-	-

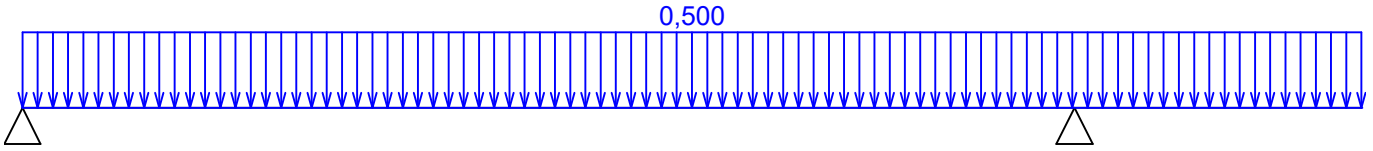
no.	Name	Code	Type	γ_f ($\gamma_{f,inf}$)*	Factors for combinations				
					ξ	Categ.**	ψ_0	ψ_1	ψ_2
3	Q3 Variable cat. A (1)	Force	Long-term variable	1,50	-	A	0,70	0,50	0,30
4	Q4 Variable cat. A (2)	Force	Long-term variable	1,50	-	A	0,70	0,50	0,30
5	Q5 Variable cat. A (3)	Force	Long-term variable	1,50	-	A	0,70	0,50	0,30

* $\gamma_{f,inf}$ for favourable dead loads
** Category of live loads according to table A1.1 in EN 1990

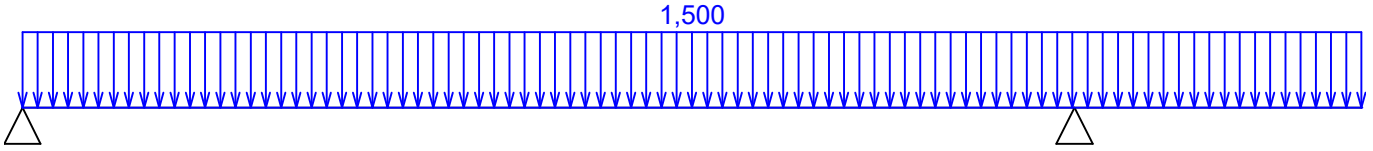
G1 Self-weight - load				
Type	Coor.x [m]	Length [m]	Size1	Size2
uniform	0,000	7,000	0,227kN/m	-



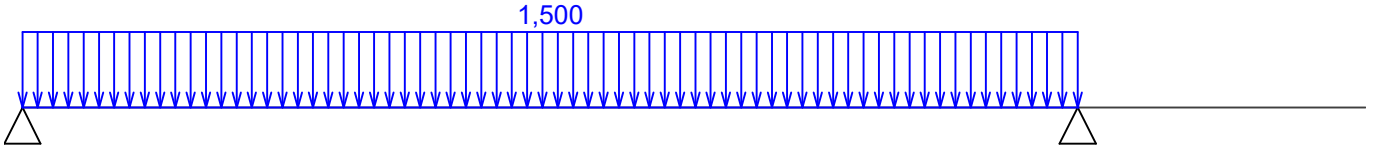
G2 Permanent load - load				
Type	Coor.x [m]	Length [m]	Size1	Size2
uniform	0,000	7,000	0,500kN/m	-



Q3 Variable cat. A (1) - load				
Type	Coor.x [m]	Length [m]	Size1	Size2
uniform	0,000	7,000	1,500kN/m	-



Q4 Variable cat. A (2) - load				
Type	Coor.x [m]	Length [m]	Size1	Size2
uniform	0,000	5,500	1,500kN/m	-



Q5 Variable cat. A (3) - load				
Type	Coor.x [m]	Length [m]	Size1	Size2
uniform	5,500	1,500	1,500kN/m	-

1.1.3 Combinations

Combinations

1.1.4 Combinations for 1st order calculation

Combination for check of ultimate limit state (ULS), 1st order

Number	Comb. name and type Composition
1	G1+G2; basic combination
	$\gamma_{f,sup,1}$*G1 + $\gamma_{f,sup,2}$*G2
2	Q5:G1+G2; basic combination
	$\gamma_{f,sup,1}$*G1 + $\gamma_{f,sup,2}$*G2 + $\gamma_{f,sup,5}$*Q5
3	Q4:G1+G2; basic combination
	$\gamma_{f,sup,1}$*G1 + $\gamma_{f,sup,2}$*G2 + $\gamma_{f,sup,4}$*Q4
4	Q3:G1+G2; basic combination
	$\gamma_{f,sup,1}$*G1 + $\gamma_{f,sup,2}$*G2 + $\gamma_{f,sup,3}$*Q3

Combination for check of serviceability limit state (SLS), 1st order

Number	Comb. name and type Composition
1	G1+G2; characteristic combination
	G1 + G2
2	Q5:G1+G2; characteristic combination
	G1 + G2 + Q5
3	Q4:G1+G2; characteristic combination
	G1 + G2 + Q4
4	Q3:G1+G2; characteristic combination
	G1 + G2 + Q3
5	G1+G2; final deformation combination
	(1+k_{def})*G1 + (1+k_{def})*G2
6	Q5:G1+G2; final deformation combination
	(1+k_{def})*G1 + (1+k_{def})*G2 + (1+$\psi_{2,5}$*k_{def})*Q5
7	Q4:G1+G2; final deformation combination
	(1+k_{def})*G1 + (1+k_{def})*G2 + (1+$\psi_{2,4}$*k_{def})*Q4
8	Q3:G1+G2; final deformation combination
	(1+k_{def})*G1 + (1+k_{def})*G2 + (1+$\psi_{2,3}$*k_{def})*Q3

Internal forces

Loads count: 12
G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	2,147	2,340	3,238	-
Min. value	-1,850	-0,818	1,850	-

Q5:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	2,454	1,627	5,794	-
Min. value	-3,340	-2,505	1,543	-

Q4:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	6,272	8,011	7,363	-
Min. value	-5,975	-0,818	5,975	-

Q3:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	6,579	7,170	9,919	-
Min. value	-5,668	-2,505	5,668	-

G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	3,865	4,212	5,828	-
Min. value	-3,330	-1,472	3,330	-

Q5:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	4,246	3,316	8,998	-
Min. value	-4,752	-3,564	2,950	-

Q4:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	8,980	11,244	10,943	-
Min. value	-8,445	-1,472	8,445	-

Q3:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	9,361	10,201	14,113	-
Min. value	-8,065	-3,564	8,065	-

G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	2,899	3,159	4,371	-
Min. value	-2,498	-1,104	2,498	-

Q5:G1+G2:

	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	3,359	2,106	8,206	-
Min. value	-4,847	-3,635	2,037	-

Q4:G1+G2:

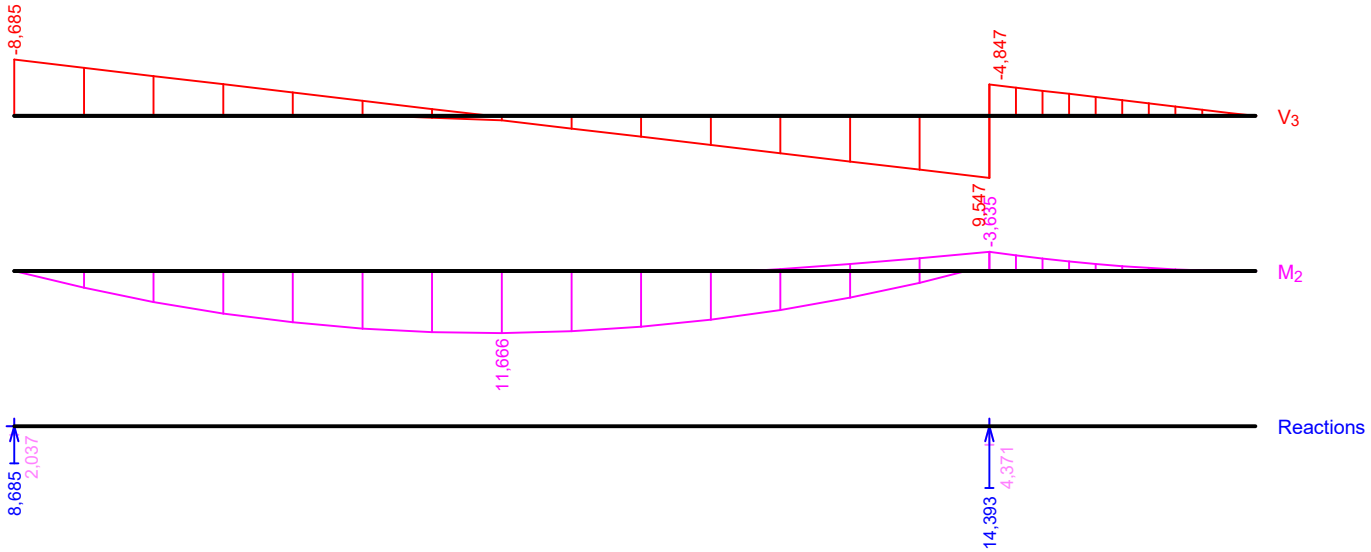
	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	9,086	11,666	10,558	-
Min. value	-8,685	-1,104	8,685	-

Q3:G1+G2:

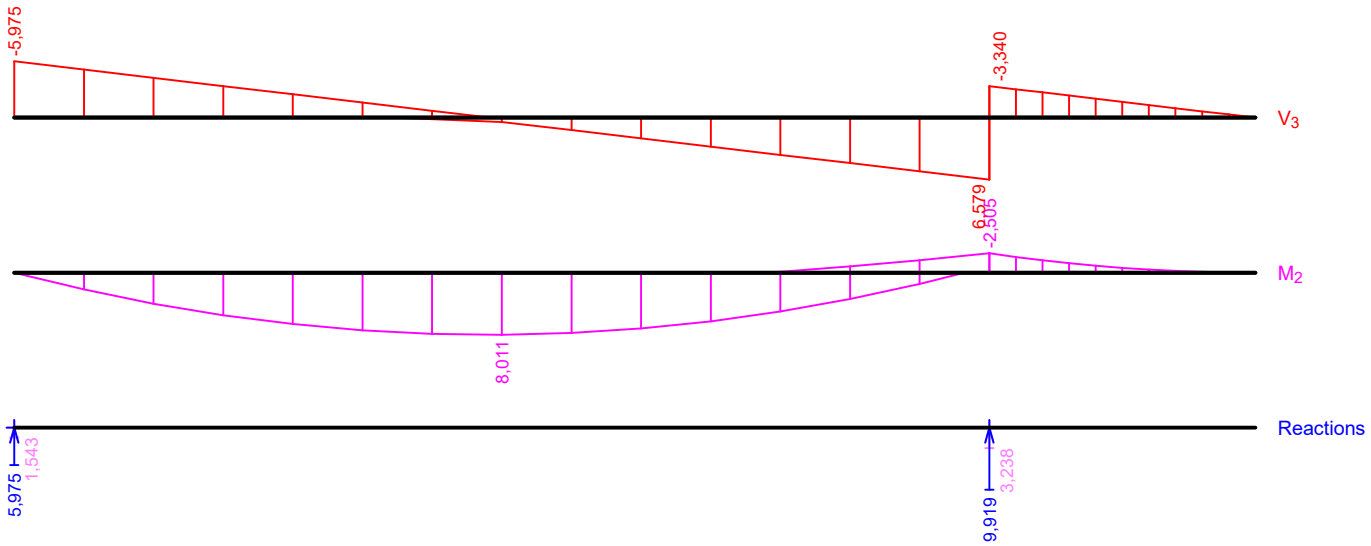
	V_3[kN]	M_2[kNm]	R_z[kN]	RO_x[kNm]
Max. value	9,547	10,404	14,393	-
Min. value	-8,225	-3,635	8,225	-

Envelopes

Envelope basic design (ULS)								
x [m]	Max M_2 [kNm]	Min M_2 [kNm]	Max V_3 [kN]	Min V_3 [kN]	Max R_z [kN]	Min R_z [kN]	Max RO_x [kNm]	Min RO_x [kNm]
0,000	0,000	0,000	-2,037	-8,685	8,685	2,037	-	-
0,393	3,157	0,723	-1,652	-7,415	-	-	-	-
0,786	5,817	1,295	-1,266	-6,145	-	-	-	-
1,179	7,981	1,716	-0,881	-4,875	-	-	-	-
1,571	9,644	1,986	-0,496	-3,609	-	-	-	-
1,964	10,815	2,106	-0,110	-2,339	-	-	-	-
2,357	11,489	2,074	0,275	-1,069	-	-	-	-
2,750	11,666	1,893	0,661	0,201	-	-	-	-
3,143	11,331	1,555	1,931	0,586	-	-	-	-
3,536	10,499	1,067	3,201	0,972	-	-	-	-
3,929	9,170	0,427	4,470	1,358	-	-	-	-
4,321	7,350	-0,361	5,737	1,742	-	-	-	-
4,714	5,029	-1,301	7,007	2,128	-	-	-	-
5,107	2,211	-2,393	8,277	2,513	-	-	-	-
5,500	-1,104L	-3,635L	9,547L	2,899L	14,393	4,371	-	-
5,500	-1,104R	-3,635R	-1,472R	-4,847R	-	-	-	-
5,650	-0,894	-2,944	-1,325	-4,362	-	-	-	-
5,800	-0,706	-2,326	-1,177	-3,877	-	-	-	-
5,950	-0,541	-1,781	-1,030	-3,393	-	-	-	-
6,100	-0,397	-1,309	-0,883	-2,908	-	-	-	-
6,250	-0,276	-0,909	-0,736	-2,423	-	-	-	-
6,400	-0,177	-0,582	-0,589	-1,939	-	-	-	-
6,550	-0,099	-0,327	-0,442	-1,454	-	-	-	-
6,700	-0,044	-0,145	-0,294	-0,969	-	-	-	-
6,850	-0,011	-0,036	-0,147	-0,485	-	-	-	-
7,000	0,000	0,000	0,000	0,000	-	-	-	-



Envelope characteristic (SLS)								
x [m]	Max M_2 [kNm]	Min M_2 [kNm]	Max V_3 [kN]	Min V_3 [kN]	Max R_z [kN]	Min R_z [kN]	Max RO_x [kNm]	Min RO_x [kNm]
0,000	0,000	0,000	-1,543	-5,975	5,975	1,543	-	-
0,393	2,172	0,549	-1,258	-5,100	-	-	-	-
0,786	4,001	0,986	-0,972	-4,225	-	-	-	-
1,179	5,488	1,311	-0,686	-3,350	-	-	-	-
1,571	6,630	1,525	-0,401	-2,477	-	-	-	-
1,964	7,433	1,627	-0,116	-1,602	-	-	-	-
2,357	7,893	1,617	0,170	-0,726	-	-	-	-
2,750	8,011	1,496	0,455	0,149	-	-	-	-
3,143	7,776	1,259	1,331	0,434	-	-	-	-
3,536	7,199	0,911	2,206	0,720	-	-	-	-
3,929	6,279	0,450	3,081	1,006	-	-	-	-
4,321	5,021	-0,120	3,954	1,290	-	-	-	-
4,714	3,417	-0,803	4,829	1,576	-	-	-	-
5,107	1,471	-1,598	5,704	1,862	-	-	-	-
5,500	-0,818L	-2,505L	6,579L	2,147L	9,919	3,238	-	-
5,500	-0,818R	-2,505R	-1,090R	-3,340R	-	-	-	-
5,650	-0,662	-2,029	-0,981	-3,006	-	-	-	-
5,800	-0,523	-1,603	-0,872	-2,672	-	-	-	-
5,950	-0,401	-1,228	-0,763	-2,338	-	-	-	-
6,100	-0,294	-0,902	-0,654	-2,004	-	-	-	-
6,250	-0,204	-0,626	-0,545	-1,670	-	-	-	-
6,400	-0,131	-0,401	-0,436	-1,336	-	-	-	-
6,550	-0,074	-0,225	-0,327	-1,002	-	-	-	-
6,700	-0,033	-0,100	-0,218	-0,668	-	-	-	-
6,850	-0,008	-0,025	-0,109	-0,334	-	-	-	-
7,000	0,000	0,000	0,000	0,000	-	-	-	-



Reactions extremes

Reactions extremes basic design (ULS)	
x [m]	Reaction
0,000	Max R_z = 8,685kN - Q4:G1+G2
0,000	Min R_z = 2,037kN - Q5:G1+G2
5,500	Max R_z = 14,393kN - Q3:G1+G2
5,500	Min R_z = 4,371kN - G1+G2

Reactions extremes characteristic (SLS)	
x [m]	Reaction
0,000	Max R_z = 5,975kN - Q4:G1+G2
0,000	Min R_z = 1,543kN - Q5:G1+G2
5,500	Max R_z = 9,919kN - Q3:G1+G2
5,500	Min R_z = 3,238kN - G1+G2

Lateral-torsional buckling

Buckling due to bending moment M_y:

Sector No.	Start [m]	End [m]	l_{z1} [m]	Beam and load type	Load position
1	0,000	7,000	7,000	beam with distributed load	on the top

1.2 Results

Intermediate results

Bending moment check:

Bending moment M_y = 3,158 kNm
Calculation of buckling from moment M_y:
Critical stress $\sigma_{m,crit}$ = 90,344 MPa
rel. slenderness $\lambda_{rel,m}$ = 0,515
buckling coefficient k_{crit} = 1,000
Coefficient for increasing characteristic strength in bending from M_y: $k_{h,My}$ = 1,000
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,600
Design strength in bending from moment M_y: $f_{m,y,d}$ = 11,077 MPa
Check in bottom left-hand cross-section corner:
W_y = 2,700E06 mm^3
W_z = -1,620E06 mm^3
$\sigma_{m,y,d}/(k_{crit}M_y*f_{m,y,d})$ = 0,106
0,106 < 1 Pass

Shear forces check:

Shear force V_z = 0,201 kN
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,600
Design strength in shear $f_{v,d}$ = 1,846 MPa
Crack effect coefficient k_{cr} = 0,670
Check in cross-section centre of gravity:
first moment of area S_y = 2,025E06 mm^3
Thickness t_y = 180,0 mm
stress $\tau_{Vz} = V_z*S_y/(I_y*k_{cr}*t_y)$ = 0,008 MPa
first moment of area S_z = 1,215E06 mm^3

thickness t_z = 300,0 mm
stress $\tau_{Vy} = V_y*S_z/(I_z*k_{cr}*t_z)$ = 0,000 MPa
$\sqrt{(\tau_{Vz}^2+\tau_{Vy}^2)}/f_{v,d}$ = 0,005
0,005 < 1 Pass
Slenderness for buckling perpendicular to z λ_z = 134,7
Slenderness for buckling perpendicular to y λ_y = 80,8
Critical slenderness λ = 134,7

Bending moment check:
Bending moment M_y = 1,893 kNm
Calculation of buckling from moment M_y:
Critical stress $\sigma_{m,crit}$ = 90,344 MPa
rel. slenderness $\lambda_{rel,m}$ = 0,515
buckling coefficient k_{crit} = 1,000
Coefficient for increasing characteristic strength in bending from M_y: $k_{h,My}$ = 1,000
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700
Design strength in bending from moment M_y: $f_{m,y,d}$ = 12,923 MPa
Check in bottom left-hand cross-section corner:
W_y = 2,700E06 mm^3
W_z = -1,620E06 mm^3
$\sigma_{m,y,d}/(k_{crit}M_y*f_{m,y,d})$ = 0,054
0,054 < 1 Pass

Shear forces check:
Shear force V_z = 0,661 kN
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700
Design strength in shear $f_{v,d}$ = 2,154 MPa
Crack effect coefficient k_{cr} = 0,670
Check in cross-section centre of gravity:
first moment of area S_y = 2,025E06 mm^3
Thickness t_y = 180,0 mm
stress $\tau_{Vz} = V_z*S_y/(I_y*k_{cr}*t_y)$ = 0,027 MPa
first moment of area S_z = 1,215E06 mm^3
thickness t_z = 300,0 mm
stress $\tau_{Vy} = V_y*S_z/(I_z*k_{cr}*t_z)$ = 0,000 MPa
$\sqrt{(\tau_{Vz}^2+\tau_{Vy}^2)}/f_{v,d}$ = 0,013
0,013 < 1 Pass
Slenderness for buckling perpendicular to z λ_z = 134,7
Slenderness for buckling perpendicular to y λ_y = 80,8
Critical slenderness λ = 134,7

Bending moment check:
Bending moment M_y = 11,666 kNm
Calculation of buckling from moment M_y:
Critical stress $\sigma_{m,crit}$ = 90,344 MPa
rel. slenderness $\lambda_{rel,m}$ = 0,515
buckling coefficient k_{crit} = 1,000
Coefficient for increasing characteristic strength in bending from M_y: $k_{h,My}$ = 1,000
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700

Design strength in bending from moment M_y: $f_{m,y,d}$ = 12,923 MPa
Check in bottom left-hand cross-section corner:
W_y = 2,700E06 mm^3
W_z = -1,620E06 mm^3
$\sigma_{m,y,d}/(k_{crit}M_y*f_{m,y,d})$ = 0,334
0,334 < 1 Pass

Shear forces check:
Shear force V_z = 0,201 kN
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700
Design strength in shear $f_{v,d}$ = 2,154 MPa
Crack effect coefficient k_{cr} = 0,670
Check in cross-section centre of gravity:
first moment of area S_y = 2,025E06 mm^3
Thickness t_y = 180,0 mm
stress $\tau_{Vz} = V_z*S_y/(I_y*k_{cr}*t_y)$ = 0,008 MPa
first moment of area S_z = 1,215E06 mm^3
thickness t_z = 300,0 mm
stress $\tau_{Vy} = V_y*S_z/(I_z*k_{cr}*t_z)$ = 0,000 MPa
$\sqrt{(\tau_{Vz}^2+\tau_{Vy}^2)}/f_{v,d}$ = 0,004
0,004 < 1 Pass
Slenderness for buckling perpendicular to z λ_z = 134,7
Slenderness for buckling perpendicular to y λ_y = 80,8
Critical slenderness λ = 134,7

Bending moment check:
Bending moment M_y = 10,400 kNm
Calculation of buckling from moment M_y:
Critical stress $\sigma_{m,crit}$ = 90,344 MPa
rel. slenderness $\lambda_{rel,m}$ = 0,515
buckling coefficient k_{crit} = 1,000
Coefficient for increasing characteristic strength in bending from M_y: $k_{h,My}$ = 1,000
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700
Design strength in bending from moment M_y: $f_{m,y,d}$ = 12,923 MPa
Check in bottom left-hand cross-section corner:
W_y = 2,700E06 mm^3
W_z = -1,620E06 mm^3
$\sigma_{m,y,d}/(k_{crit}M_y*f_{m,y,d})$ = 0,298
0,298 < 1 Pass

Shear forces check:
Shear force V_z = 0,661 kN
Material partial safety factor γ_M = 1,300
Modification coefficient k_{mod} = 0,700
Design strength in shear $f_{v,d}$ = 2,154 MPa
Crack effect coefficient k_{cr} = 0,670
Check in cross-section centre of gravity:
first moment of area S_y = 2,025E06 mm^3
Thickness t_y = 180,0 mm
stress $\tau_{Vz} = V_z*S_y/(I_y*k_{cr}*t_y)$ = 0,027 MPa
first moment of area S_z = 1,215E06 mm^3

thickness t_z = 300,0 mm
stress $\tau_{Vy} = V_y*S_z/(I_z*k_{cr}*t_z)$ = 0,000 MPa
$\sqrt{(\tau_{Vz}^2+\tau_{Vy}^2)}/f_{v,d}$ = 0,013
0,013 < 1 Pass
Slenderness for buckling perpendicular to z λ_z = 134,7
Slenderness for buckling perpendicular to y λ_y = 80,8
Critical slenderness λ = 134,7

Overall check

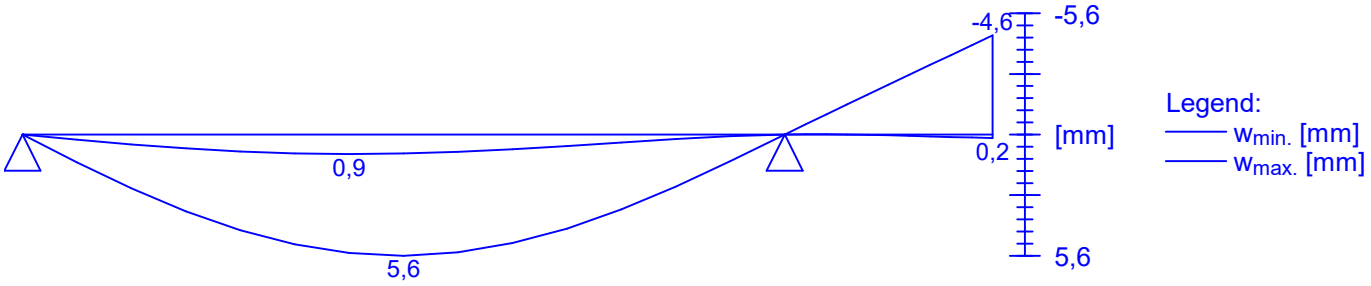
Decisive load: Q4:G1+G2
Internal forces: M_y = 11,666 kNm; V_z = 0,201 kN
Bending moment check:
Resistance: $M_{y,R}$ = 34,892 kNm
0,334 < 1 **Pass**

Shear forces check:
Resistance: V_R = 51,951 kN
0,004 < 1 **Pass**

Section ok

Deflection

Characteristic load states
Maximum deformation is 4,6mm at point x = 7,000m
Maximum allowed deformation is 3,000m / 300,0 = 10,0mm
4,6mm < 10,0mm □ **Pass**
Final load states
Maximum deformation is 6,3mm at point x = 7,000m
Maximum allowed deformation is 3,000m / 150,0 = 20,0mm
6,3mm < 20,0mm □ **Pass**
Member deflection PASS
characteristic (SLS)



final (SLS)