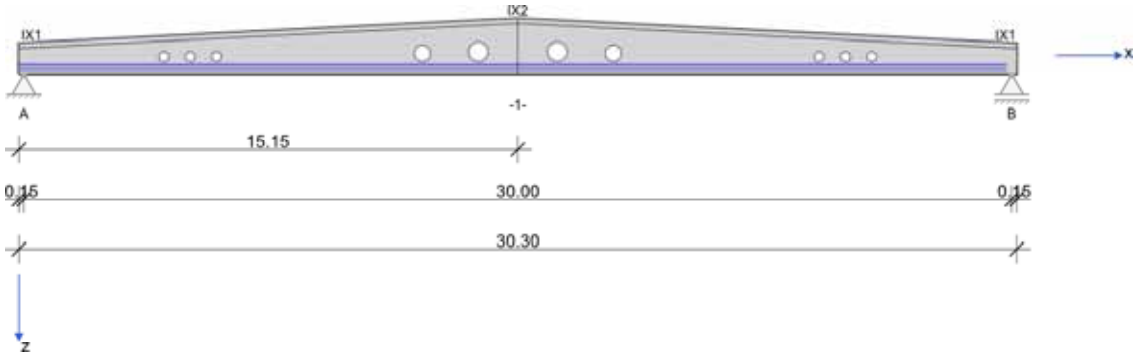
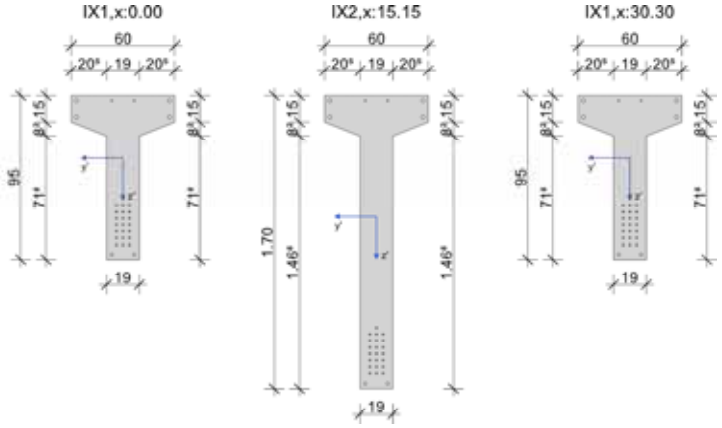
RIB Software SE	FERMO V19.0 Build-No. 12022019	Type: Precast beam
File: FDB-Beispiel.Ferx		

System information



Standards:	DIN EN 1992-1-1		Design	
Calculation:	effective widths are being considered			
Building type:	General building construction		Prestressing:	pretensioning
Design situation:	permanent			
Exposure class:	Top XC1	Bottom XC1		
Fire resistance class:	R60		Flame application:	4-sided

Cross-section geometry



Precast member

Geometry - pre-cast member

Cross-section	b_w [cm]	h_w [cm]	b_o [cm]	d_o [cm]	b_u [cm]	d_b [cm]	A_c [cm²]	I_y [cm⁴]	z_s [cm]
IX1	19.0	95.0	60.0	15.0	19.0		2588.1	2163995	36.1
IX2	19.0	170.0	60.0	15.0	19.0		4013.1	11379011	70.3

Length	Cross-section run, left				Cross-section run, right			
[m]	QA	$L_{v,le}$[m]	$Q_{v,Li1}$	$Q_{v,Li2}$	$Q_{v,Re2}$	$Q_{v,Re1}$	$L_{v,ri}$[m]	QE
30.30	IX1	15.15	IX2	IX2				IX1

Recesses

No.	a to the origin [m]	Type	Distance from BE [cm]	∅ or b_x [cm]	h_z [cm]	$d_{1.ao}$ [cm]	$d_{1.au}$ [cm]
1	4.400	Circle	40.0	30.0	0.0	4.0	4.0
2	5.200	Circle	40.0	30.0	0.0	4.0	4.0
3	6.000	Circle	40.0	30.0	0.0	4.0	4.0
4	12.250	Circle	40.0	50.0	0.0	4.0	4.0
5	13.950	Circle	40.0	60.0	0.0	4.0	4.0
6	16.350	Circle	40.0	60.0	0.0	4.0	4.0
7	18.050	Circle	40.0	50.0	0.0	4.0	4.0
8	24.300	Circle	40.0	30.0	0.0	4.0	4.0
9	25.100	Circle	40.0	30.0	0.0	4.0	4.0
10	25.900	Circle	40.0	30.0	0.0	4.0	4.0

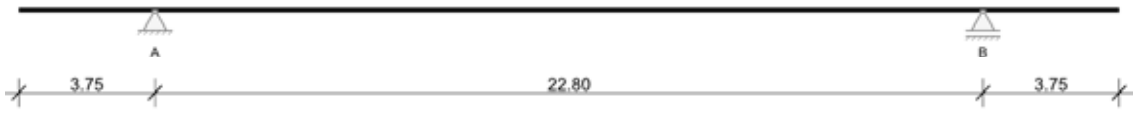
Material

Timeline

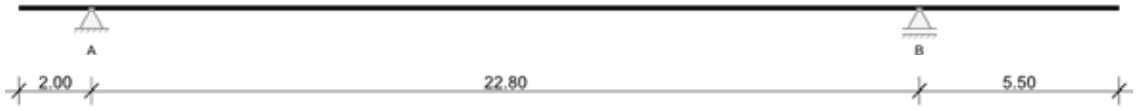
Timeline in days	Analysis	Precast member	$f_{cm}(t)$ [N/mm²]	Support condition
Dead load / Prestressing 1	yes	-	44.00	Factory support
Transport	yes	10	-	Transportation support
Assembly	yes	11	-	Mounting support
Finishing loads / Live loads	yes	21	-	Final support
too	yes	36500	-	Final support

Support conditions

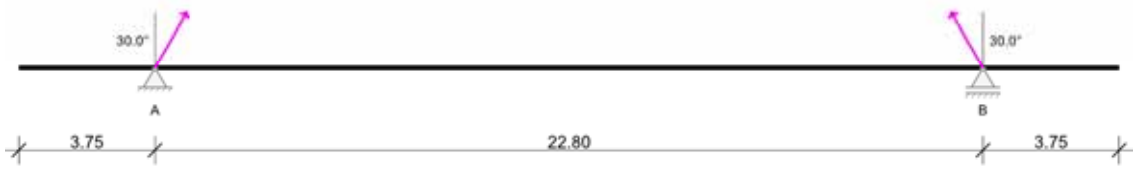
Factory support:



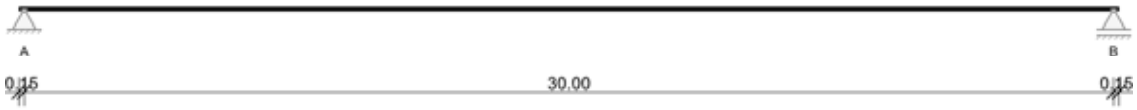
Transportation support:



Mounting support:



Final support:



Reinforcement specification

Longitudinal reinforcement

Reinforcement, top		Reinforcement, bottom	
TE - in-situ concrete TE - precast member BE - top flange*	TE - in-situ concrete slab TE - pre-cast member BE - pre-cast member top flange	TE - bottom flange* BE - precast member	TE bottom flange precast member BE - pre-cast member
e	Bar spacing relating to the symmetry axis	xa-xe	Laying area
)*	Reinforcement layers are being considered, but not increased in the design		
Reinforcement layers with the same reference are combined in the neutral axis of the layers			

Posi.	Amount	ϕs [mm]	As [cm²]	e [cm]	z [cm]	z from refer.	xa [m]	xe [m]
1	2	10	1.57	13.0	3.0	OK Fertigteil	0.000	30.300
2	2	20	6.28	54.0	3.0	OK Fertigteil	0.000	30.300
3	2	20	6.28	54.0	3.0	UK Obergurt	0.000	30.300
4	2	16	4.02	13.0	3.0	UK Fertigteil	0.000	30.300

Prestressing reinforcement

pre-tensioning

Type	Prestressing steel material	ζ	Ratio of bond strength - prestressing steel / reinforcement
A_p	Prestressing steel area per tendon	z_p	vertical tendon eccentricity from TE
ΣA_p	Sum of prestressing steel area per layer	left / right	Stripping lengths from the left / right
$\varnothing_p$	Prestressing steel nominal diameter	P_{max}	max. prestressing force per tendon
e	Horizontal tendon spacing	σ_{pmax}	max. prestressing stress per tendon
		0.0 %	Short-term relaxation for heat treatment

Posi.	Type	A_p	ΣA_p	$\varnothing_p$	ζ	e	z_p	P_{max}	σ_{pmax}	Stripping

		n_p	[cm²]	[cm²]	[mm]		[cm]	[cm]	[kN]	[N/mm²]	n_p	left	right
a	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	86.5	93.4	1000	0	0.000	0.000
b	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	82.7	93.4	1000	0	0.000	0.000
c	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	78.9	93.4	1000	0	0.000	0.000
d	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	75.1	93.4	1000	0	0.000	0.000
e	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	71.3	93.4	1000	0	0.000	0.000
f	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	67.5	93.4	1000	0	0.000	0.000
g	ST1570/1770	3	0.93	2.80	12.5	0.60	3.8	63.7	93.4	1000	0	0.000	0.000
h	ST1570/1770	1	0.93	0.93	12.5	0.60	3.8	59.9	93.4	1000	0	0.000	0.000

Loading

Load cases

LC	Type of action	γ_{sup}	γ_{inf}	ψ_0	ψ_1	ψ_2	Name
0	Dead load (monolithic)	1.35	1.00	1.00	1.00	1.00	Eigengewicht Träger
1	Permanent load	1.35	1.00	1.00	1.00	1.00	Ausbau
2	Snow load	1.50	0.00	0.50	0.20	0.00	Schnee
3	Wind load	1.50	0.00	0.60	0.20	0.00	Wind Ez z
4	Wind load (Construction state)	1.50	0.00	0.60	0.20	0.00	Wind Bz y
5	Prestressing (precast segment)	1.00	1.00	1.00	1.00	1.00	Spannbett

Load case 0 (Dead load - precast member):

x_a [m]	x_e [m]	q_{za} [kN/m]	q_{ze} [kN/m]
0.000	4.250	6.47	7.47
4.250	4.550	6.06	6.13
4.550	5.050	7.54	7.66
5.050	5.350	6.25	6.32
5.350	5.850	7.73	7.85
5.850	6.150	6.44	6.51
6.150	12.000	7.92	9.29
12.000	12.500	6.95	7.06
12.500	13.650	9.41	9.68
13.650	14.250	6.86	7.00
14.250	15.150	9.82	10.03
15.150	16.050	10.03	9.82
16.050	16.650	7.00	6.86
16.650	17.800	9.68	9.41
17.800	18.300	7.06	6.95
18.300	24.150	9.29	7.92
24.150	24.450	6.51	6.44
24.450	24.950	7.85	7.73
24.950	25.250	6.32	6.25
25.250	25.750	7.66	7.54
25.750	26.050	6.13	6.06
26.050	30.300	7.47	6.47

Load case 1 (Ausbau):

Type	Reference	LR	a to the origin [m]	q_L/m_L [kN,kNm]	q_R/m_R [kN,kNm]	e_y [cm]	e_z [cm]	e_z Reference	Length [m]	b_L [m]	b_R [m]
Line load	Girder	z	0.000	10.80	10.80		0.0	Ok	30.300		

Load case 2 (Schnee):

Type	Reference	LR	a to the origin [m]	q_L/m_L [kN,kNm]	q_R/m_R [kN,kNm]	e_y [cm]	e_z [cm]	e_z Reference	Length [m]	b_L [m]	b_R [m]
Line load	Girder	z	0.000	4.30	4.30		0.0	Ok	30.300		

Load case 3 (Wind Ez z):

Type	Reference	LR	a to the origin [m]	q_L/m_L [kN,kNm]	q_R/m_R [kN,kNm]	e_y [cm]	e_z [cm]	e_z Reference	Length [m]	b_L [m]	b_R [m]
Line load	Girder	z	0.000	0.61	0.61		0.0	Ok	30.300		

Load case 4 (Wind Bz y):

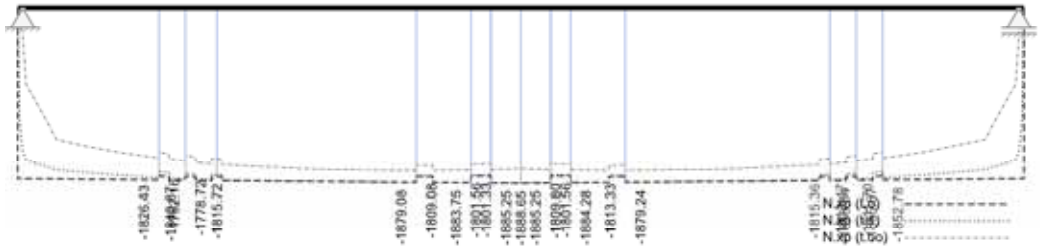
Type	Reference	LR	a to the origin [m]	q_L/m_L [kN,kNm]	q_R/m_R [kN,kNm]	e_y [cm]	e_z [cm]	e_z Reference	Length [m]	b_L [m]	b_R [m]
Line load	Girder	y	0.000	0.33	0.33		0.0	Neutral axis	30.300		

Results

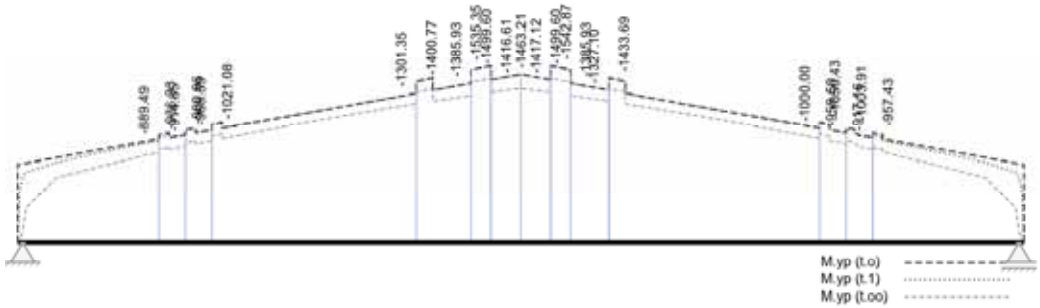
Prestressing

Prestressing stress resultants (time-dependent)

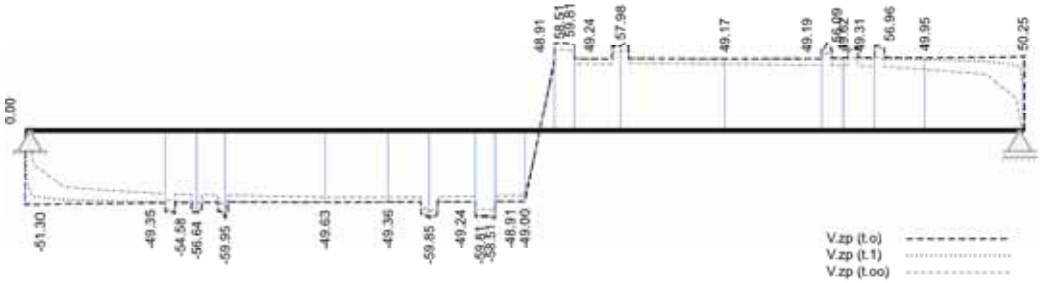
Normal forces Nx [kN]



Bending moments My [kNm]



Shear forces Vz [kN]



Support forces

Support - final state		A				B			
LC No. / Name	EXTR	A_x [kN]	A_z [kN]	M_x [kNm]	M_y [kNm]	B_x [kN]	B_z [kN]	M_x [kNm]	M_y [kNm]
0		0.00	120.88	0.00	0.00	0.00	120.88	0.00	0.00
1		0.00	163.62	0.00	0.00	0.00	163.62	0.00	0.00
2		0.00	65.14	0.00	0.00	0.00	65.14	0.00	0.00
3		0.00	9.24	0.00	0.00	0.00	9.24	0.00	0.00
Sum G		0.00	284.50	0.00	0.00	0.00	284.50	0.00	0.00
Wind	max Az	0.00	9.24	0.00	0.00	0.00	9.24	0.00	0.00
Snow	max Az	0.00	65.14	0.00	0.00	0.00	65.14	0.00	0.00
EQU	min Az	0.00	256.05	0.00	0.00	0.00	256.05	0.00	0.00
GK	max Az	0.00	490.11	0.00	0.00	0.00	490.11	0.00	0.00
GK	min Az	0.00	284.50	0.00	0.00	0.00	284.50	0.00	0.00

Stress resultants

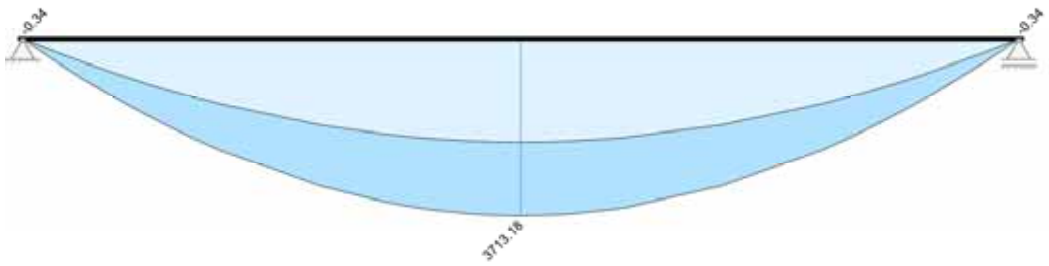
Span stress resultants, summary

Span	max M_{yEd} [kNm]	min M_{yEd} [kNm]	max V_{zEd} [kN]	max M_{tEd} [kNm]	max N_{xEd} [kN]	min N_{xEd} [kN]
	3713.18	-0.34	485.56	0.00	0.00	0.00

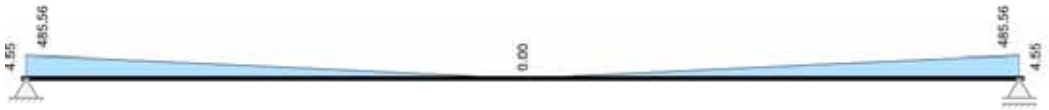
Design

Combination stress resultants

Basic combination M_{yd} [kNm]



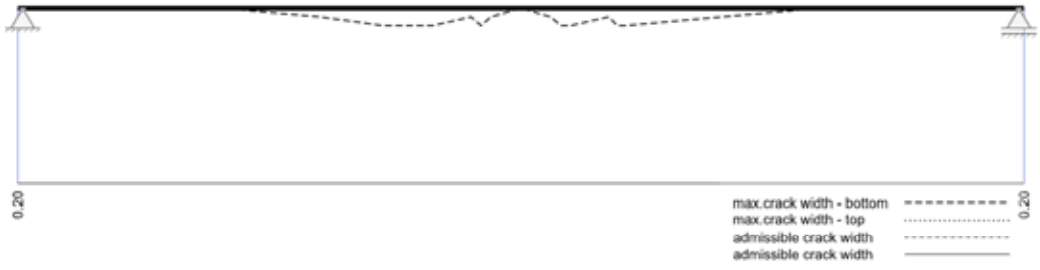
Basic combination $|V_{zd}|$ [kN]



Limitation of the crack widths

Method	direct calculation of the crack widths for individual and terminated cracking		
admissible crack widthw_k Crack width point in timet_A Type of restraint Design CoA N_{Ed},M_{yEd} x_cII $\sigma_{s,eff}$II $A_{ct,eff}$ ρ_{eff}	0.20 mm 28 d Lastbeanspruchung frequent Design stress resultants without P_{dir} Compression zone height II - imperviousness effective steel stress II effective tension zone area effective reinforcement ratio	Concrete tensile strength$f_{ct,eff}$ Prestressing r_{inf}/r_{sup} $d_{s,wo}$,$d_{s,fo}$ $d_{s,wu}$,$d_{s,fu}$ $A_{s,wo}$,$A_{s,fo}$ $A_{s,wu}$,$A_{s,fu}$ $w_{k,o}$,$w_{k,u}$ ...,max/min	3.95 N/mm² Variance factor 0.95/1.05 Limit diameter web / flange - top Limit diameter web / flange - bottom req. crack reinforcement web / flange - top req. crack reinforcement web / flange - bottom max calculative crack widths eq. 7.8 Values related to max/min Coa
+ mod. steel stresses due to differing bond behavior effective values belong to the calculative crack width w_k			

Crack widths [mm]

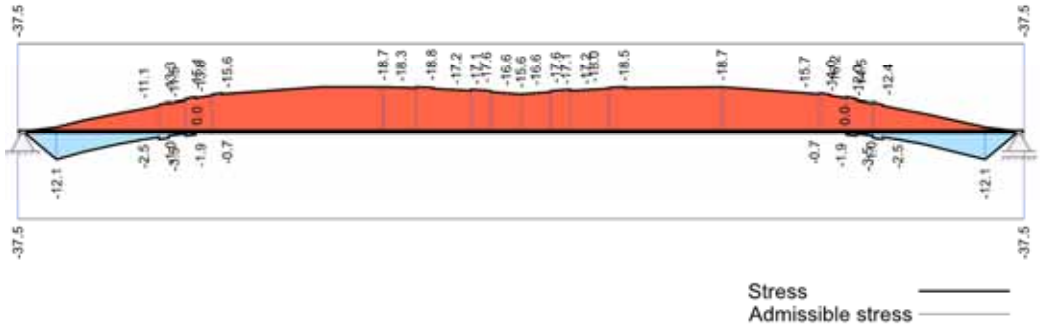


Limitation of the stresses

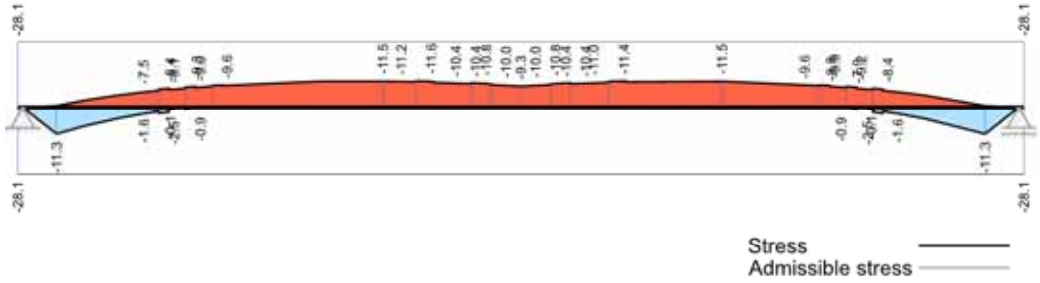
rare combination	Concrete Reinforcing steel	0,60 f_{ck}(t=21) = 0,60 f_{ck}(t=21) = 0,60 f_{ck}(t=36500) = 0,80 f_{yk} =	-28.94 N/mm² -28.94 /-28.94 N/mm² -37.47 /-37.47 N/mm² 400.00 N/mm²	E_{cm} = 37300 N/mm² top / bottom top / bottom
quasi-permament combination	Concrete Prestressing steel	0,45 f_{ck}(t=21) = 0,45 f_{ck}(t=21) = 0,45 f_{ck}(t=36500) = 0,65 f_{pk} =	-21.70 N/mm² -21.70 /-21.70 N/mm² -28.10 /-28.10 N/mm² 1150.50 N/mm²	f_{ctm} = 4.10 N/mm² top / bottom top / bottom

σ_{pm0} (t0)	Prestressing steel	0,85 f_{p01k} (t0) = 0,75 f_{pk} (t0) =	1275.00 N/mm² 1327.50 N/mm²
$\sigma_{c,qperm} > 0,45\ f_{ck}(t)$	non-linear creep is automatically considered according to 3.1.4		

Concrete compressive strength - rare combination, t_∞ [N/mm²]



Concrete compressive strength - quasi-permanent combination, t_∞ [N/mm²]



Buckling stability in the ultimate limit state

Buckling stability geometrical and physical non-linear acc. to 5.8.6 with applying the pre-deformation acc. to 5.9 (load step method) as combined loading from biaxial bending, shear force with torsion

Geometric imperfection	$L_{eff}/300$ =	10.0 cm	Stiffnesses condition I	()'	uncracked, elastic
Obliquity		0.00 %	Stiffnesses condition II	()"	cracked
exis. top flange width	b_{Gurt} =	60.0 cm	red. Torsionssteifigkeit GI_T'	70%	Micro cracking
Tension stiffening in concrete	f_{ctm} =	4.1 N/mm²	red. Torsionssteifigkeit GI_T"	20%	$M_{T,cr}$ exceeded
Dynamic coefficient - transport	φ =	1.30	Creep + shrinkage	considered	
Safety factor - prestressing	$\gamma_{p,fav}$ =	0.83			

Load case combinations

LCC	Limit load factor	rel.	Time [d]	Combinations
1	1.50		10	LF0*1.15*1.30+LF4*1.15*1.30+LF5*0.83 (Transport)
2	1.50		11	LF0*1.15*1.30+LF4*1.15*1.30+LF5*0.83 (Montage)
3	1.08	*	21	LF0*1.35+LF1*1.35+LF2*1.50+LF3*0.90+LF5*0.83
4	1.09		36500	LF0*1.35+LF1*1.35+LF2*1.50+LF3*0.90+LF5*0.83

Shear design from buckling analysis

Shear force and torsion bearing capacity for 1,0-fold limit load with non-linear stress resultants acc. to 6.2 / 6.3

A	Support axis	Ar	Support edge
Ar±d	Distance d from the support edge	j	Design of the shear joint is decisive
m	Minimum shear force reinforcement	S,O,U	Web, top chord, bottom chord
a_{sw}	Stirrups (shear force + torsion) - double shear	A_{sTL}	Longitudinal torsion reinforcement distributed onto partial cirumference

x [m]	Attr	V_{Ed} [kN]		M_{Td} [kNm]	A_k [cm²]	V_{Rdc} [kN]	θ [Grad]	z_i [cm]	V_{Rdmax} [kN]	T_{Rdmax} [kNm]	VT_{Ed} / VT_{Rd}	a_{smin} [cm²/m]	a_{sw} [cm²/m]		A_{sTL} [cm²]
0.000		0.0	S O U	0.0 0.0	1068 872	63.9	45.0	82.8	1857.2	123.6 86.4	0.00	2.49	2.49 0.00	m	0.00 0.00
0.050	Ar	3.4	S O U	0.0 0.0	1071 872	63.9	45.0	83.6	1875.2	123.9 86.4	0.00	2.49	2.49 0.00	m	0.00 0.00
0.150	A	11.7	S O U	0.0 0.0	1077 872	193.5	45.0	84.1	1886.4	124.6 86.4	0.00	2.49	5.42 0.00		0.00 0.00
0.150	A	483.9	S O U	19.9 18.4	1077 872	193.5	30.5	84.1	1648.7	124.6 86.4	0.11	2.49	9.68 4.87		4.33 3.02
0.250	Ar	476.8	S	20.0	1083	193.5	31.6	70.7	1415.9	125.3	0.14	2.49	9.67		4.34

			O U	18.4	872					86.4			4.85		3.01
1.167	Ar+d	415.5	S O U	20.7 17.7	1137 872	193.5	26.6	88.1	1581.2	131.6 86.4	0.09	2.49	9.61 4.66		4.47 2.90
2.000		334.9	S O U	21.2 17.0	1187 872	185.7	23.8	91.6	1518.0	137.3 86.4	0.07	2.49	7.82 4.50		4.56 2.80
3.030		283.4	S O U	21.7 16.3	1248 872	195.0	20.8	95.9	1429.4	144.4 86.4	0.06	2.49	6.59 4.29		4.64 2.67
3.750		249.5	S O U	21.9 15.7	1291 872	213.3	18.4	95.1	1229.8	149.3 86.4	0.06	2.49	6.23 4.14	m	4.67 2.57
4.250		226.7	S O U	22.0 15.3	1320 872	220.5	18.4	97.5	1267.0	152.8 86.4	0.05	2.49	5.92 4.02	m	4.68 2.50
4.250		222.6	S O U	22.0 15.3	1320 872	246.2	18.4	97.8	1271.4	152.8 86.4	0.05	2.49	3.83 4.02	m	4.68 2.50
4.400		216.1	S O U	22.0 15.1	1329 872	248.7	18.4	98.6	1284.3	153.8 86.4	0.05	2.49	3.81 3.99	m	4.68 2.48
4.550		208.7	S O U	22.0 15.0	1338 872	251.3	18.4	91.6	1195.8	154.8 86.4	0.05	2.49	3.78 3.95	m	4.67 2.46
4.550		214.0	S O U	22.0 15.0	1338 872	224.9	18.4	91.6	1195.0	154.8 86.4	0.05	2.49	3.78 3.95	m	4.67 2.46
5.050		192.1	S O U	22.0 14.5	1368 872	232.8	18.4	94.1	1238.0	158.3 86.4	0.04	2.49	3.70 3.83	m	4.66 2.38
5.050		187.1	S O U	22.0 14.5	1368 872	260.1	18.4	94.1	1239.4	158.3 86.4	0.04	2.49	3.70 3.83	m	4.66 2.38
5.200		180.9	S O U	22.0 14.4	1377 872	262.8	18.4	94.8	1252.5	159.3 86.4	0.04	2.49	3.67 3.79	m	4.65 2.36
5.350		175.2	S O U	21.9 14.2	1386 872	265.5	18.4	95.5	1266.0	160.3 86.4	0.04	2.49	3.64 3.76	m	4.64 2.33
5.350		180.1	S O U	21.9 14.2	1386 872	237.7	18.4	95.5	1264.3	160.3 86.4	0.04	2.49	3.64 3.76	m	4.64 2.33
5.850		159.0	S O U	21.8 13.7	1416 872	246.7	18.4	98.0	1314.3	163.8 86.4	0.03	2.49	3.54 3.62	m	4.60 2.25
5.850		154.2	S O U	21.8 13.7	1416 872	275.6	18.4	98.0	1317.0	163.8 86.4	0.03	2.49	3.54 3.62	m	4.60 2.25
6.000		148.2	S O U	21.7 13.6	1424 872	278.8	18.4	98.7	1332.8	164.8 86.4	0.03	2.49	3.50 3.58	m	4.58 2.23
6.000		144.7	S O U	21.7 13.6	1424 872	279.6	18.4	98.7	1335.2	164.8 86.4	0.03	2.49	3.50 3.58	m	4.58 2.23
6.060		142.1	S O U	21.7 13.5	1428 872	281.0	18.4	99.0	1342.3	165.2 86.4	0.03	2.49	3.49 3.57	m	4.57 2.22
6.060		145.1	S O U	21.7 13.5	1428 872	280.3	18.4	99.0	1340.1	165.2 86.4	0.03	2.49	3.49 3.57	m	4.57 2.22
6.150		141.5	S O U	21.6 13.4	1433 872	282.4	18.4	99.4	1349.9	165.8 86.4	0.03	2.49	3.47 3.54	m	4.56 2.20
6.150		147.5	S O U	21.6 13.4	1433 872	252.4	18.4	99.4	1345.5	165.8 86.4	0.03	2.49	3.47 3.54	m	4.56 2.20
9.090		34.1	S O U	18.4 9.9	1608 872	397.6	18.4	113.9	2143.0	186.0 86.4	0.01	2.49	2.64 2.60	m	3.85 1.62
9.090		34.4	S O U	18.4 9.8	1608 872	396.1	18.4	113.9	2134.6	186.0 86.4	0.01	2.49	2.64 2.60	m	3.85 1.61
11.000		37.3	S O U	14.4 7.0	1721 872	255.0	18.4	123.3	1659.4	199.2 86.4	0.01	2.49	2.49 1.86	m	2.98 1.15
12.000		71.2	S O U	11.6 5.4	1781 872	259.1	18.4	128.2	1725.4	206.0 86.4	0.00	2.49	2.49 1.44	m	2.40 0.89
12.000		79.0	S O U	11.6 5.4	1781 872	305.4	18.4	128.2	1725.4	206.0 86.4	0.01	2.49	2.49 1.44	m	2.40 0.89
12.120		82.7	S O U	11.2 5.2	1788 872	306.5	18.4	128.8	1733.4	206.9 86.4	0.00	2.49	2.49 1.38	m	2.32 0.86
12.250		88.8	S O U	10.8 5.0	1796 872	307.0	18.4	129.4	1741.5	207.8 86.4	0.01	2.49	2.49 1.32	m	2.23 0.82
12.500		94.4	S O U	9.9 4.6	1811 872	307.7	18.4	130.7	1759.0	209.5 86.4	0.00	2.49	2.49 1.21	m	2.06 0.75
12.500		86.0	S O U	9.9 4.6	1811 872	261.1	18.4	130.7	1759.0	209.5 86.4	0.00	2.49	2.49 1.21	m	2.06 0.75
13.650		119.2	S O	6.0 2.6	1879 872	252.7	18.4	136.3	1834.4	217.4 86.4	0.01	2.49	2.49 0.70	m	1.24 0.43

			U												
13.650		127.8	S O U	6.0 2.6	1879 872	308.0	18.4	136.4	1835.7	217.4 86.4	0.01	2.49	2.49 0.70	m	1.24 0.43
13.950		136.3	S O U	4.8 2.1	1897 872	308.2	18.4	137.8	1854.6	219.4 86.4	0.01	2.49	2.49 0.55	m	0.00 0.34
14.250		145.9	S O U	3.6 1.5	1915 872	308.5	18.4	139.3	1874.7	221.5 86.4	0.01	2.49	2.49 0.41	m	0.00 0.25
14.250		135.8	S O U	3.6 1.5	1915 872	254.5	18.4	139.3	1874.7	221.5 86.4	0.01	2.49	2.49 0.41	m	0.00 0.25
15.150		74.4	S O U	0.0	1968	256.9	45.0	143.7	3223.3	227.7	0.00	2.49	2.49	m	0.00
15.150		164.2	S O U	0.0	1968	256.9	43.5	143.7	3218.8	227.7	0.00	2.49	2.49	m	0.00
16.050		135.8	S O U	3.6 1.5	1915 872	254.5	18.4	139.3	1874.7	221.5 86.4	0.01	2.49	2.49 0.41	m	0.00 0.25
16.050		145.9	S O U	3.6 1.5	1915 872	308.5	18.4	139.3	1874.7	221.5 86.4	0.01	2.49	2.49 0.41	m	0.00 0.25
16.350		137.5	S O U	4.8 2.1	1897 872	308.2	18.4	137.8	1854.6	219.4 86.4	0.01	2.49	2.49 0.55	m	0.00 0.34
16.650		127.8	S O U	6.0 2.6	1879 872	308.0	18.4	136.4	1835.7	217.4 86.4	0.01	2.49	2.49 0.70	m	1.24 0.43
16.650		119.2	S O U	6.0 2.6	1879 872	252.7	18.4	136.3	1834.4	217.4 86.4	0.01	2.49	2.49 0.70	m	1.24 0.43
17.800		86.1	S O U	9.9 4.6	1811 872	261.1	18.4	130.7	1759.0	209.5 86.4	0.00	2.49	2.49 1.21	m	2.06 0.75
17.800		94.3	S O U	9.9 4.6	1811 872	307.7	18.4	130.7	1759.0	209.5 86.4	0.00	2.49	2.49 1.21	m	2.06 0.75
18.050		86.9	S O U	10.8 5.0	1796 872	307.0	18.4	129.4	1741.5	207.8 86.4	0.00	2.49	2.49 1.32	m	2.23 0.82
18.180		84.9	S O U	11.2 5.2	1788 872	306.5	18.4	128.8	1733.4	206.9 86.4	0.01	2.49	2.49 1.38	m	2.32 0.86
18.300		79.0	S O U	11.6 5.4	1781 872	305.4	18.4	128.2	1725.4	206.0 86.4	0.01	2.49	2.49 1.44	m	2.40 0.89
18.300		71.2	S O U	11.6 5.4	1781 872	259.1	18.4	128.2	1725.4	206.0 86.4	0.00	2.49	2.49 1.44	m	2.40 0.89
21.210		34.5	S O U	18.4 9.8	1608 872	396.1	18.4	113.9	2134.7	186.0 86.4	0.01	2.49	2.63 2.60	m	3.85 1.61
21.210		34.0	S O U	18.4 9.8	1608 872	397.7	18.4	113.9	2143.7	186.0 86.4	0.01	2.49	2.63 2.60	m	3.84 1.61
24.150		147.5	S O U	21.6 13.4	1433 872	252.4	18.4	108.7	1471.5	165.8 86.4	0.03	2.49	3.47 3.54	m	4.56 2.20
24.150		141.5	S O U	21.6 13.4	1433 872	282.4	18.4	109.6	1488.4	165.8 86.4	0.03	2.49	3.47 3.54	m	4.56 2.20
24.240		145.0	S O U	21.7 13.5	1428 872	280.4	18.4	109.2	1478.3	165.2 86.4	0.03	2.49	3.49 3.57	m	4.57 2.22
24.240		142.1	S O U	21.7 13.5	1428 872	281.1	18.4	109.2	1480.6	165.2 86.4	0.03	2.49	3.49 3.57	m	4.57 2.22
24.300		144.7	S O U	21.7 13.6	1424 872	279.6	18.4	108.9	1473.3	164.8 86.4	0.03	2.49	3.50 3.58	m	4.58 2.23
24.300		148.2	S O U	21.7 13.6	1424 872	278.8	18.4	108.9	1470.6	164.8 86.4	0.03	2.49	3.50 3.58	m	4.58 2.23
24.450		154.2	S O U	21.8 13.7	1416 872	275.6	18.4	108.3	1455.5	163.8 86.4	0.03	2.49	3.54 3.63	m	4.60 2.25
24.450		159.0	S O U	21.8 13.7	1416 872	246.7	18.4	107.4	1440.4	163.8 86.4	0.03	2.49	3.54 3.63	m	4.60 2.25
24.800		173.7	S O U	21.9 14.1	1395 872	240.3	18.4	105.9	1407.0	161.4 86.4	0.03	2.49	3.61 3.72	m	4.63 2.31
24.950		179.2	S O U	21.9 14.2	1386 872	237.8	18.4	105.3	1394.3	160.3 86.4	0.04	2.49	3.64 3.76	m	4.64 2.33
24.950		175.0	S O U	21.9 14.2	1386 872	265.6	18.4	106.1	1406.6	160.3 86.4	0.03	2.49	3.64 3.76	m	4.64 2.33
25.100		181.2	S O U	22.0 14.4	1377 872	262.7	18.4	105.5	1393.8	159.3 86.4	0.04	2.49	3.67 3.80	m	4.65 2.36
25.250		187.1	S O U	22.0 14.5	1368 872	260.0	18.4	104.9	1381.6	158.3 86.4	0.04	2.49	3.70 3.83	m	4.66 2.38

25.250		192.0	S O U	22.0 14.5	1368 872	232.8	18.4	104.0	1368.3	158.3 86.4	0.04	2.49	3.70 3.83	m	4.66 2.38
25.750		214.0	S O U	22.0 15.0	1338 872	225.0	18.4	101.9	1329.4	154.8 86.4	0.05	2.49	3.79 3.96	m	4.68 2.46
25.750		207.8	S O U	22.0 15.0	1338 872	251.4	18.4	102.7	1340.9	154.8 86.4	0.04	2.49	3.79 3.96	m	4.68 2.46
25.900		214.2	S O U	22.0 15.1	1329 872	248.8	18.4	102.1	1330.2	153.8 86.4	0.05	2.49	3.81 3.99	m	4.68 2.48
26.050		222.6	S O U	22.0 15.3	1320 872	246.2	18.4	101.5	1319.5	152.8 86.4	0.05	2.49	3.84 4.03	m	4.68 2.50
26.050		226.6	S O U	22.0 15.3	1320 872	220.5	18.4	100.6	1307.3	152.8 86.4	0.05	2.49	5.86 4.03	m	4.68 2.50
26.550		249.5	S O U	21.9 15.7	1291 872	213.3	18.4	98.5	1273.8	149.3 86.4	0.06	2.49	6.15 4.14	m	4.67 2.57
27.270		283.7	S O U	21.7 16.3	1248 872	195.0	20.8	95.9	1430.2	144.4 86.4	0.06	2.49	6.59 4.29		4.64 2.67
27.270		283.3	S O U	21.7 16.3	1248 872	195.0	20.8	95.9	1429.0	144.4 86.4	0.06	2.49	6.59 4.29		4.64 2.67
29.133	Ar-d	415.8	S O U	20.7 17.7	1137 872	193.6	26.6	88.1	1581.4	131.6 86.4	0.09	2.49	9.61 4.66		4.47 2.90
30.050	Ar	475.9	S O U	20.0 18.4	1083 872	193.6	31.5	70.7	1413.6	125.3 86.4	0.14	2.49	9.67 4.85		4.35 3.01
30.150	A	484.1	S O U	19.9 18.5	1077 872	193.6	30.5	84.1	1649.4	124.6 86.4	0.11	2.49	9.68 4.87		4.33 3.02
30.150	A	10.6	S O U	0.0 0.0	1077 872	193.6	45.0	84.1	1886.4	124.6 86.4	0.00	2.49	5.42 0.00		0.00 0.00
30.250	Ar	3.1	S O U	0.0 0.0	1071 872	63.9	45.0	83.6	1875.2	123.9 86.4	0.00	2.49	2.49 0.00	m	0.00 0.00
30.300		0.0	S O U	0.0 0.0	1068 872	63.9	45.0	82.8	1857.2	123.6 86.4	0.00	2.49	2.49 0.00	m	0.00 0.00

Maximum utilization: 1.00 Pos.= 0.250 m Analysis fulfilled.

Tabular fire protection

Analysis for beams mainly under compression acc. to table 5.5 as well as one-way spanning slabs acc. to table 5.8			
System	structural determinate	$\theta_{s,cr}$; $\theta_{p,cr}$	critical temperature - reinforcing / prestressing steel
Fire resistance class	R60	b_w	min beam height - neutral axis - cross-section
Flame application	quadrilateral	$h_{w,min}$	min beam height
As,prov / As,req	Automatically	b_{min}	min beam height - neutral axis - reinforcement
Web class	WC	a_{min}	min axis distance of neutral axis to tension reinforcement
μ_{fi}	$M_{Ed,fi}/M_{Ed}$	a_{sd}	min lateral axis distance of reinforcement
		*	Minimum cross-section not observed

x [m]	μ_{fi}	$\theta_{s,cr}$ [°C]	$\theta_{p,cr}$ [°C]	b_w [cm]		$h_{w,min}$ [cm]		b_{min} [cm]		a_{min} [cm]	a_{sd} [cm]	a [cm]		Util-zation
				exis.	req.	exis.	req.	exis.	req.	exis.	exis.	req.		
0.050	0.59	500.0	0.0	19.0	10.0	95.3	20.0	19.0	19.0	3.0	4.1	3.1		1.04
1.167	0.58	646.0	544.7	19.0	10.0	100.8	20.0	19.0	19.0	21.9	2.7	1.7		1.00
2.000	0.58	621.6	512.2	19.0	10.0	104.9	20.0	19.0	19.0	21.8	2.9	1.9		1.00
3.030	0.58	597.1	479.4	19.0	10.0	110.0	20.0	19.0	19.0	21.7	3.1	2.1		1.00
3.750	0.58	530.9	391.2	19.0	10.0	113.6	20.0	19.0	19.0	21.7	3.9	2.9		1.00
4.250	0.58	530.8	391.1	19.0	10.0	116.0	20.0	19.0	19.0	21.7	3.9	2.9		1.00
4.250	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9		1.05
4.400	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9		1.05
4.550	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9		1.05
4.550	0.58	530.8	391.1	19.0	10.0	117.5	20.0	19.0	19.0	21.7	3.9	2.9		1.00
5.050	0.58	530.8	391.0	19.0	10.0	120.0	20.0	19.0	19.0	21.6	3.9	2.9		1.00
5.050	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
5.200	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
5.350	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
5.350	0.58	530.8	391.0	19.0	10.0	121.5	20.0	19.0	19.0	21.6	3.9	2.9		1.00
5.850	0.58	530.7	390.9	19.0	10.0	124.0	20.0	19.0	19.0	21.6	3.9	2.9		1.00
5.850	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
6.000	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
6.060	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
6.150	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
6.150	0.58	530.7	390.9	19.0	10.0	125.5	20.0	19.0	19.0	21.6	3.9	2.9		1.00
9.090	0.58	530.5	390.6	19.0	10.0	140.0	20.0	19.0	19.0	21.6	3.9	2.9		1.00
11.000	0.58	530.4	390.6	19.0	10.0	149.5	20.0	19.0	19.0	21.6	3.9	2.9		1.00
12.000	0.58	530.4	390.5	19.0	10.0	154.4	20.0	19.0	19.0	21.6	3.9	2.9		1.00
12.000	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05
12.120	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9		1.05

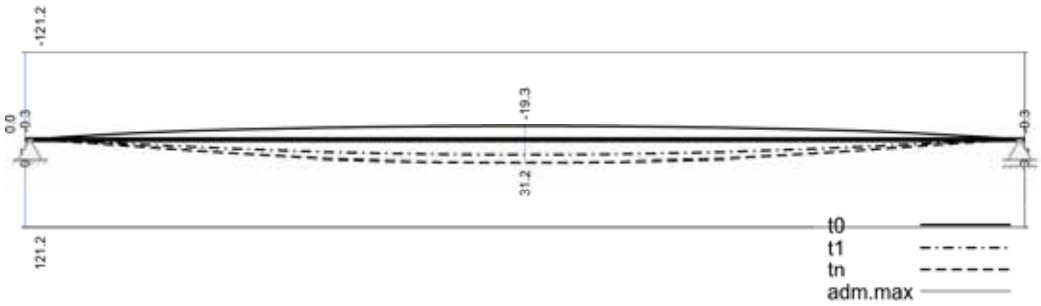
12.250	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
12.500	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
12.500	0.58	530.4	390.5	19.0	10.0	156.9	20.0	19.0	19.0	21.6	3.9	2.9	1.00
13.650	0.58	530.4	390.5	19.0	10.0	162.6	20.0	19.0	19.0	21.6	3.9	2.9	1.00
13.650	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
13.950	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
14.250	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
14.250	0.58	530.4	390.5	19.0	10.0	165.5	20.0	19.0	19.0	21.6	3.9	2.9	1.00
15.150	0.58	530.3	390.5	19.0	10.0	170.0	20.0	19.0	19.0	21.6	3.9	2.9	1.00
16.050	0.58	530.4	390.5	19.0	10.0	165.5	20.0	19.0	19.0	21.6	3.9	2.9	1.00
16.050	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
16.350	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
16.650	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
16.650	0.58	530.4	390.5	19.0	10.0	162.6	20.0	19.0	19.0	21.6	3.9	2.9	1.00
17.800	0.58	530.4	390.5	19.0	10.0	156.9	20.0	19.0	19.0	21.6	3.9	2.9	1.00
17.800	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
18.050	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
18.180	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
18.300	0.58	530.4	390.5	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
18.300	0.58	530.4	390.5	19.0	10.0	154.4	20.0	19.0	19.0	21.6	3.9	2.9	1.00
21.210	0.58	530.5	390.6	19.0	10.0	140.0	20.0	19.0	19.0	21.6	3.9	2.9	1.00
24.150	0.58	530.7	390.9	19.0	10.0	125.5	20.0	19.0	19.0	21.6	3.9	2.9	1.00
24.150	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
24.240	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
24.300	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
24.450	0.58	530.7	390.9	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
24.450	0.58	530.7	390.9	19.0	10.0	124.0	20.0	19.0	19.0	21.6	3.9	2.9	1.00
24.800	0.58	530.7	391.0	19.0	10.0	122.2	20.0	19.0	19.0	21.6	3.9	2.9	1.00
24.950	0.58	530.8	391.0	19.0	10.0	121.5	20.0	19.0	19.0	21.6	3.9	2.9	1.00
24.950	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
25.100	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
25.250	0.58	530.8	391.0	19.0	10.0	40.0	20.0	19.0	19.0	21.6	3.9	2.9	1.05
25.250	0.58	530.8	391.0	19.0	10.0	120.0	20.0	19.0	19.0	21.6	3.9	2.9	1.00
25.750	0.58	530.8	391.1	19.0	10.0	117.5	20.0	19.0	19.0	21.7	3.9	2.9	1.00
25.750	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9	1.05
25.900	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9	1.05
26.050	0.58	530.8	391.1	19.0	10.0	40.0	20.0	19.0	19.0	21.7	3.9	2.9	1.05
26.050	0.58	530.8	391.1	19.0	10.0	116.0	20.0	19.0	19.0	21.7	3.9	2.9	1.00
26.550	0.58	530.9	391.2	19.0	10.0	113.6	20.0	19.0	19.0	21.7	3.9	2.9	1.00
27.270	0.58	597.1	479.4	19.0	10.0	110.0	20.0	19.0	19.0	21.7	3.1	2.1	1.00
29.133	0.58	646.0	544.7	19.0	10.0	100.8	20.0	19.0	19.0	21.9	2.7	1.7	1.00
30.250	0.59	500.0	0.0	19.0	10.0	95.3	20.0	19.0	19.0	3.0	4.1	3.1	1.04

Maximum utilization: 1.05 Pos.= 4.100 m Analysis not fulfilled.

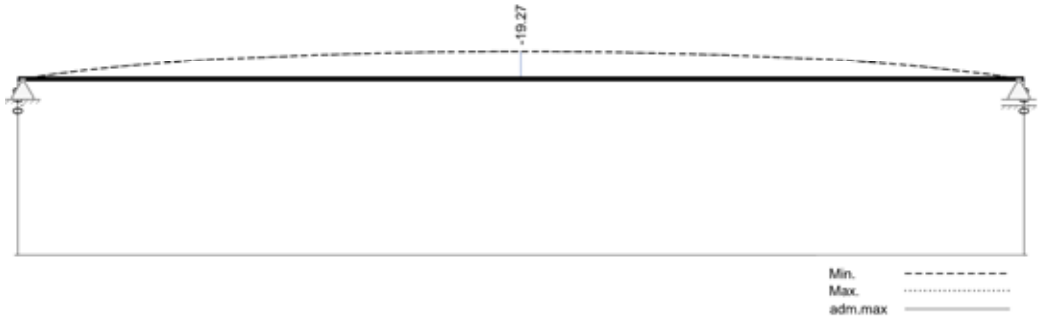
Limitation of the deflection

Method	Deformations condition II according to Krüger-Mertzsch		
Point in time Creep coefficient Shrinkage value	t_1 = 21 d φ = 0.00 ε_{cs} = 0.0e-05	t_∞ = 36500 d φ = 0.00 ε_{cs} = 0.0e-05	E_{cm} = 37300 N/mm² f_{ctm} = 4.10 N/mm²
Calculation of the sagging / deflection is carried for quasi-permanent CoA and required As-values			
l_{eff}/250 l_{eff}/500 l_{eff}/100	admissible deflection - span admissible deflection - span (t_∞ - t_1) admissible deflection - lever arm		

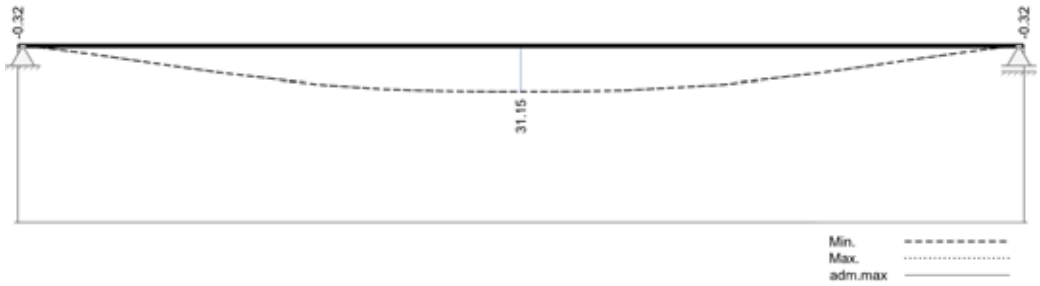
Deflection in condition II [mm]



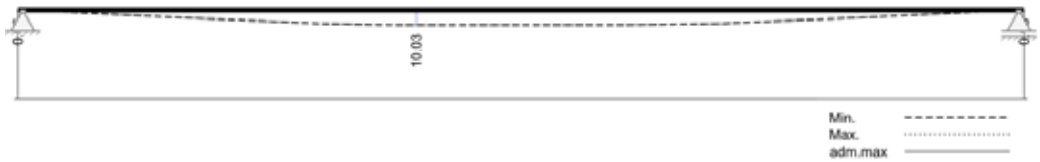
Deflection t1 in condition II [mm]



Deflection t∞ in condition II [mm]



Deflection Δt in condition II [mm]



Design - recess

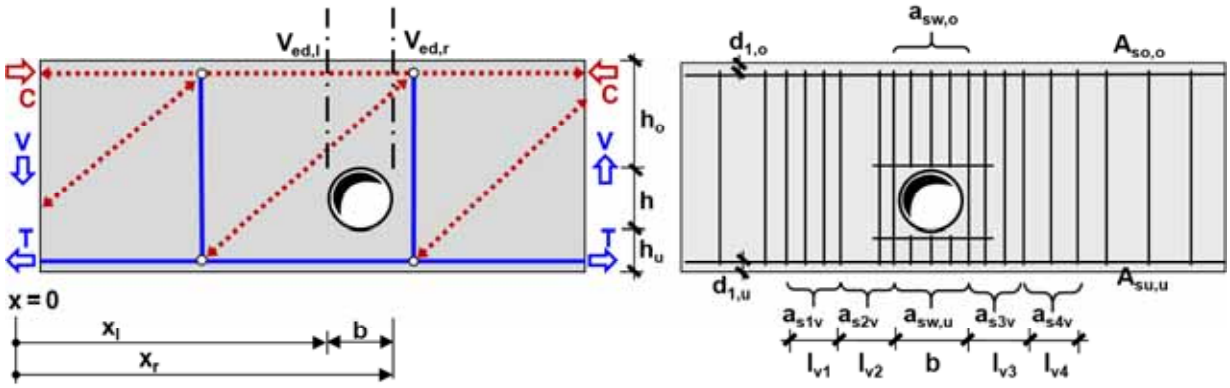
Method: Strut and tie model according to DAfStb Heft 459

$M_{Ed,li}$,$N_{Ed,li}$,$V_{Ed,li}$ Flange t $A_{so,o}$ A_{s3h},$A_{su,o}$,A_{s4h} a_{swo} l_o,l_u l_v	Design stress resultants - left Top flange Reinforcement TE top flange Reinforcement BE top flange Shear force reinforcement due to V_{Edo} horizontal distances from the edge of the opening Area of the suspension reinforcement	$M_{Ed,re}$,$N_{Ed,re}$,$V_{Ed,re}$ Flange b $A_{su,u}$ A_{s1h},$A_{so,u}$,A_{s2h} a_{swu} a_{s1v},a_{s2v} a_{s3v},a_{s4v}	Design stress resultants - right Bottom flange Reinforcement BE bottom flange Reinforcement TE bottom flange Shear force reinforcement due to V_{Edu} Suspension reinforcement, left Suspension reinforcement, right

Dimensions

No.	xl [m]	xr [m]	b [cm]	h [cm]	h_o [cm]	h_u [cm]	b_w [cm]	z_i [cm]	z_o [cm]	z_u [cm]	$d_{1,o}$ [cm]	$d_{1a,o}$ [cm]	$d_{1a,u}$ [cm]	$d_{1,u}$ [cm]
1	4.25	4.55	30.0	30.0	46.8	40.0	19.0	96.9	38.8	31.0	3.0	4.0	4.0	3.0
2	5.05	5.35	30.0	30.0	50.7	40.0	19.0	99.5	42.7	31.0	3.0	4.0	4.0	3.0
3	5.85	6.15	30.0	30.0	54.7	40.0	19.0	102.0	45.6	32.0	3.0	4.0	4.0	3.0
4	12.00	12.50	50.0	50.0	65.6	40.0	19.0	148.8	55.5	32.0	3.0	4.0	4.0	3.0
5	13.65	14.25	60.0	60.0	64.1	40.0	19.0	137.8	54.1	32.0	3.0	4.0	4.0	3.0
6	16.05	16.65	60.0	60.0	64.1	40.0	19.0	155.0	54.1	32.0	3.0	4.0	4.0	3.0
7	17.80	18.30	50.0	50.0	65.6	40.0	19.0	146.4	55.5	32.0	3.0	4.0	4.0	3.0
8	24.15	24.45	30.0	30.0	54.7	40.0	19.0	116.6	45.6	32.0	3.0	4.0	4.0	3.0
9	24.95	25.25	30.0	30.0	50.7	40.0	19.0	113.0	41.7	32.0	3.0	4.0	4.0	3.0
10	25.75	26.05	30.0	30.0	46.8	40.0	19.0	109.5	37.8	32.0	3.0	4.0	4.0	3.0

General drawing 'Small opening' Heft 459, fig. 3.2,3.3



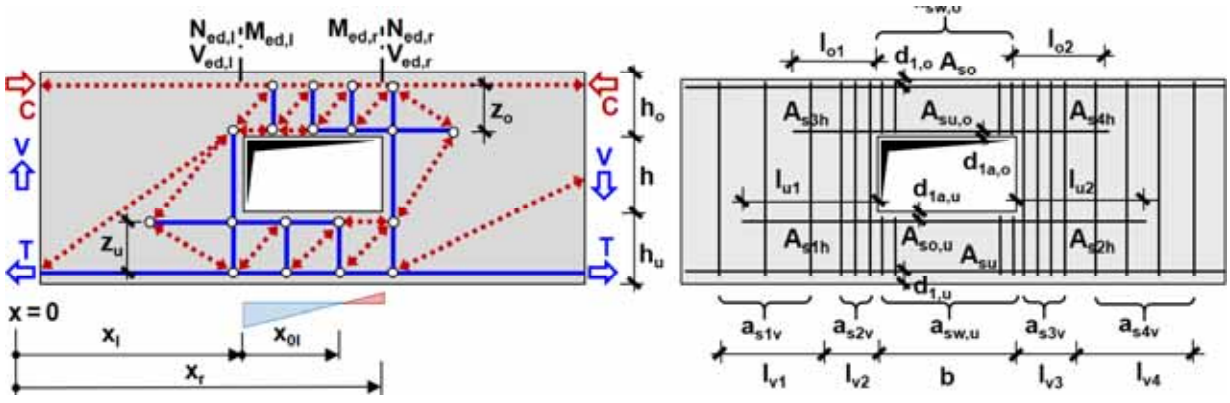
Longitudinal reinforcement 'Small openings'

					Top flange	Bottom flange	Strut			
No.	xl [m]	xr [m]	$V_{Ed,l}$ [kN]	$V_{Ed,r}$ [kN]	$A_{so,o}$ [cm²]	$A_{su,u}$ [cm²]	d_c [cm]	θ [°]	σ_c [N/mm²]	zul σ_c [N/mm²]
1	4.25	4.55	310.1	301.2	1.57	4.02	5.4	46.0	21.0	21.3
4	12.00	12.50	51.1	35.6	1.57	4.02	1.5	56.0	20.5	21.3
5	13.65	14.25	-30.5	-41.2	1.57	4.02	1.3	43.0	20.6	21.3
6	16.05	16.65	41.2	30.5	1.57	4.02	1.3	43.0	20.6	21.3
7	17.80	18.30	-35.6	-51.1	1.57	4.02	1.5	56.0	20.5	21.3
10	25.75	26.05	-301.2	-310.1	1.57	4.02	5.4	46.0	21.0	21.3

Suspension and shear force reinforcement 'Small openings'(Factor for shear force in the compression chord = 0.80)

No.	xl [m]	xr [m]	a_{swo} [cm²/m]	a_{swu} [cm²/m]	l_{v1} [cm]	A_{s1v} [cm²]	l_{v2} [cm]	A_{s2v} [cm²]	l_{v3} [cm]	A_{s3v} [cm²]	l_{v4} [cm]	A_{s4v} [cm²]
1	4.25	4.55	7.17	2.49	13.7	7.13	48.2		13.7	6.93		
4	12.00	12.50	2.49	2.49	3.6	1.18	48.9		3.6	0.82		
5	13.65	14.25	2.49	2.49			3.8	0.70	89.2		3.8	0.95
6	16.05	16.65	2.49	2.49	3.8	0.95	89.2		3.8	0.70		
7	17.80	18.30	2.49	2.49			3.6	0.82	48.9		3.6	1.18
10	25.75	26.05	7.15	2.49			13.7	6.93	48.2		13.7	7.13

General drawing 'Large opening' Heft 459, fig. 4.31,4.32



Design stress resultants - cross-section (inner lever arm zi from the bending design)

No.	xl [m]	xr [m]	Comb.	$M_{Ed,li}$ [kNm]	$N_{Ed,li}$ [kN]	$V_{Ed,li}$ [kN]	$M_{Ed,re}$ [kNm]	$N_{Ed,re}$ [kN]	$V_{Ed,re}$ [kN]
2	5.05	5.35	max My	1130.5	-1596.3	283.7	1229.2	-1596.3	274.7
3	5.85	6.15	max My	1330.1	-1626.8	258.3	1421.3	-1626.8	249.2
8	24.15	24.45	max My	1421.3	-1626.8	-249.2	1330.1	-1626.8	-258.3
9	24.95	25.25	max My	1229.3	-1596.4	-275.0	1130.6	-1596.4	-284.0

Design stress resultants - chord (Factor for shear force in the compression chord = 0.80)

No.	xl [m]	xr [m]	Comb.	Flange	V_{Rdmax} [kN]	$M_{Ed,li}$ [kNm]	$N_{Ed,li}$ [kN]	$V_{Ed,li}$ [kN]	$V_{Ed,li}$/ V_{Rdmax}	$M_{Ed,re}$ [kNm]	$N_{Ed,re}$ [kN]	$V_{Ed,re}$ [kN]	$V_{Ed,re}$/ V_{Rdmax}
2	5.05	5.35	max My max My	o u	709.8 638.8	0.0 0.0	-1568.7 508.4	227.0 56.7	0.32 0.09	65.9 16.5	-1568.7 508.4	219.7 54.9	0.31 0.09
3	5.85	6.15	max My max My	o u	760.6 664.4	0.0 0.0	-1741.0 645.4	206.6 51.7	0.27 0.08	59.8 15.0	-1741.0 645.4	199.3 49.8	0.26 0.08
8	24.15	24.45	max My max My	o u	760.2 664.4	59.8 15.0	-1754.0 658.3	-199.3 -49.8	0.26 0.08	0.0 0.0	-1754.0 658.3	-206.6 -51.7	0.27 0.08
9	24.95	25.25	max My max My	o u	709.3 638.5	66.0 16.5	-1581.8 521.7	-220.0 -55.0	0.31 0.09	0.0 0.0	-1581.8 521.7	-227.2 -56.8	0.32 0.09

Longitudinal reinforcement 'Large openings'

			Top flange						Bottom flange					
No	xl	xr	$A_{so,o}$	A_{s3h}	l_{o1}	$A_{su,o}$	A_{s4h}	l_{o2}	$A_{su,u}$	A_{s1h}	l_{u1}	$A_{so,u}$	A_{s2h}	l_{u2}

.	[m]	[m]	[cm²]	[cm²]	[cm]	[cm²]	[cm²]	[cm]	[cm²]	[cm²]	[cm]	[cm²]	[cm²]	[cm]
2	5.05	5.35	1.57			0.00			4.02	7.39	96.4	0.00	6.30	96.4
3	5.85	6.15	1.57			0.00			4.02			0.00		
8	24.15	24.45	1.57			0.00			4.02			0.00		
9	24.95	25.25	1.57			0.00			4.02	6.46	96.4	0.00	7.56	96.4

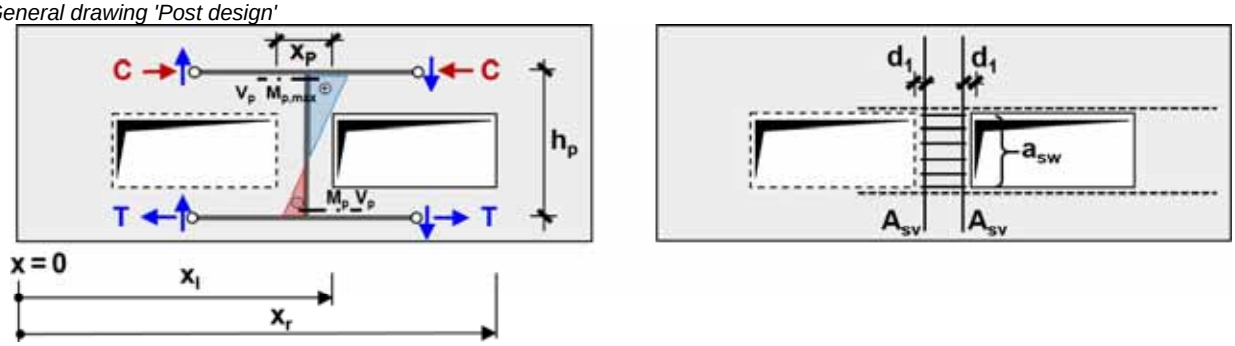
Suspension and shear reinforcement 'Large openings'

No.	xl [m]	xr [m]	a_{swo} [cm²/m]	a_{swu} [cm²/m]	l_{v1} [cm]	A_{s1v} [cm²]	l_{v2} [cm]	A_{s2v} [cm²]	l_{v3} [cm]	A_{s3v} [cm²]	l_{v4} [cm]	A_{s4v} [cm²]
2	5.05	5.35	5.74	2.49								
3	5.85	6.15	4.64	2.49					10.5	5.73		
8	24.15	24.45	4.63	2.49								
9	24.95	25.25	5.74	2.49								

Post design

Method	Post method for 0.10 h ≤ x_p ≤ 0.80 h		
x_p A_{sv}	Post width between adjacent openings Bending reinforcement vertical on both sides	V_p,M_p a_{sw}	Design stress resultants Shear force reinforcement - horizontal

General drawing 'Post design'



			left post						right post					
No.	xl [m]	xr [m]	x_p [cm]	V_p [kN]	M_p [kNm]	A_{sv} [cm²]	a_{sw} [cm²/m]	V_{Rdmax} [kN]	x_p [cm]	V_p [kN]	M_p [kNm]	A_{sv} [cm²]	a_{sw} [cm²/m]	V_{Rdmax} [kN]
2	5.05	5.35	50.00	200.9	181.6	10.13	6.41	761.1	50.00	194.5	175.8	9.78	6.10	754.4
3	5.85	6.15	50.00	102.0	83.3	4.42	2.49	645.9						
8	24.15	24.45							50.00	99.3	83.3	4.42	2.49	658.1
9	24.95	25.25	50.00	194.7	176.0	9.79	6.11	754.6	50.00	201.1	181.8	10.14	6.42	761.3

Maximum utilization: 0.38 Pos.= 25.900 m Analysis fulfilled.

Design - tensile splitting

Method	Calculation of the tensile splitting reinforcement for pretensioned prestressing
Transmission length	l_{disp}
Prestressing force	Z_p = 1.35 · max. prestressing force
Shear force	T = (Z_p+N_u+N_p) ≥ (Z_p+N_o+N_p), section directly above the tendon layers
Factor k	is interpolated between 1/3 and 1/2 corresponding to the height of the prestressing
Tensile splitting reinforcement	A_{sw} = k·T / f_{yd} distribute onto 0.75 l_{disp}

Transmission [m]			Concrete force parts [kN]				vertical tensile splitting reinforcement [cm²]		
from x	to x	l_{disp}	N_o	N_u	N_p	Z_p	T	k	A_{sw}
0.00	0.96	0.96	-743.9	-594.0	-1436.1	2774.0	743.9	0.41	6.94
29.34	30.30	0.96	-743.9	-594.0	-1436.1	2774.0	743.9	0.41	6.94

Anchorage analyses for pretensioning

Prestressing time t =5 days

max σ_o,max σ_u	max. edge stress in the ULS (cond.I)	*	= max σ > $f_{ct,0.05}$ = 2.87 N/mm²
F_{Ed}I	M_{Ed}/z	F_{Ed}II	M_{Ed}/z + 0.5·V_{Ed}·(cotΘ-cotα)
F_{Ed}	dec. for tensile force covarage	F_{pd}	Prestressing steel force
F_{sd}	Reinforcement force (F_{Ed}-F_{pd}	$A_{s,req}$	Reinforcement additions
x_{Riss}	Start of the cracked area	x_{Vers}	x_{Riss} with offset value of the M_{Ed}/z-curve
l_{pt1}	Length of transmission area (0,80·l_{pt})	l_r	Length of uncracked area
l_{pt2}	Length of transmission area (1,20·l_{pt})	x_{As}	decisive design position
l_{bpd}	Length of anchorage area		

Stresses and tensile forces

x [m]	max σ_o [N/mm²]	max σ_u [N/mm²]	F_{Ed}I [kN]	F_{Ed}II [kN]	F_{Ed} [kN]	F_{pd} [kN]	F_{sd} [kN]	x_{Riss} [m]	x_{Vers} [m]
0.000	0.00	0.00	0.0	0.0	0.0	0.0	0.0		
0.050	0.23	0.00	0.0	0.7	0.0	26.9	0.0		
0.150	0.68	-0.64	-0.1	412.2	-0.1	80.6	0.0		

0.250	0.94	-1.75		89.3	481.7	89.3	134.4	0.0		
1.167	2.53	-7.11		642.4	1096.8	642.4	1354.2	0.0		
2.000	1.42	-0.71		1077.3	1563.2	1563.2	2680.2	0.0	2.59	1.67
27.270	0.32	5.50	*	1520.2	2041.7	2041.7	2680.2	0.0	27.66	28.73
29.133	2.53	-7.11		642.3	1096.8	642.3	1354.2	0.0		
30.050	0.94	-1.75		89.3	481.7	89.3	134.4	0.0		
30.150	0.68	-0.64		-0.1	412.2	-0.1	80.6	0.0		
30.250	0.23	0.00		0.0	0.7	0.0	26.9	0.0		
30.300	0.00	0.00		0.0	0.0	0.0	0.0	0.0		

Transmission and anchorage lengths

$f_{ctm}(t)$ = 3.12 N/mm² α_1 = 1.00	$f_{ctd}(t)$ = 1.37 N/mm² η_{p1} = 2.85	f_{bpt} = 3.92 N/mm² η_{p2} = 1.40	f_{ctm} = 4.10 N/mm² η_1 = 1.00	f_{ctd} = 1.81 N/mm²	f_{bpd} = 2.53 N/mm²
Case a: Case b: Case c:	No cracking in the anchorage area No cracking in the transmission length Cracking within the transmission length			Tendon layer -n Tendon layer -i	unstripped part stripped part

Tendon layer		x_{Anf} [m]	x_{End} [m]	l_{pt1} [m]	l_{pt2} [m]	Case Sta	Case End	d_p [mm]	α_2	σ_{pm0} [N/mm²]	σ_{pmn} [N/mm²]	σ_{pd} [N/mm²]
a	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	98.7	1304.3
b	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	117.8	1304.3
c	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	135.8	1304.3
d	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	152.8	1304.3
e	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	168.8	1304.3
f	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	183.9	1304.3
g	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	396.3	1304.3
h	-i	0.00	30.30	0.48	0.73	a	a	12.5	0.19	1000.0	423.1	1304.3

Transmission area			Prest.	Condition (IIZ = cracked)				
x_{Anf} [m]	x_{lpt2} [m]	x_{lbpd} [m]	Z_p [kN]	Start	l_{pt2}	l_{bpd}	x_{Riss} [m]	x_{Vers} [m]
0.00	0.73	1.86	2054.8	ID	ID	ID		
30.30	29.57	28.44	2054.8	ID	ID	ID		

Tensile force coverage

x_{Anf} [m]	x_{lpt2} [m]	x_{As} [m]	l_r [m]	F_{Ed}I [kN]	F_{Ed}II [kN]	F_{Ed} [kN]	F_{pd} [kN]	F_{sd} [kN]	$A_{s,req}$ [cm²]
0.00	0.73	1.86		1003.7	1484.3	1407.4	2680.2	0.0	0.00
30.30	29.57	28.44		968.4	1447.7	1162.1	2680.2	0.0	0.00

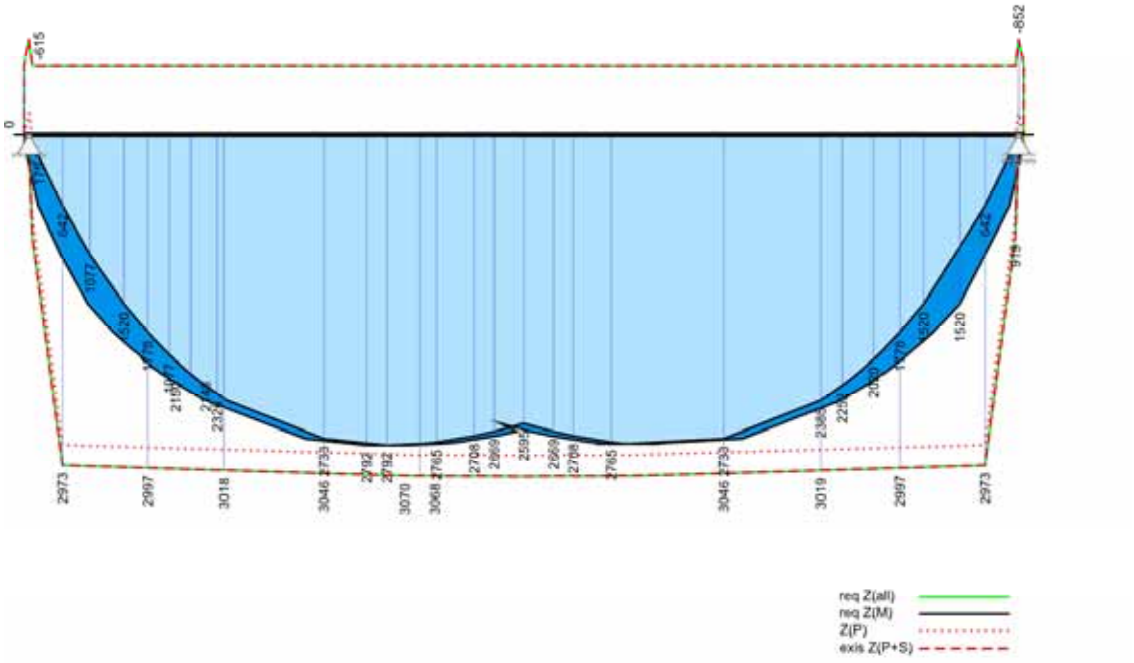
Summary

Analysis summary

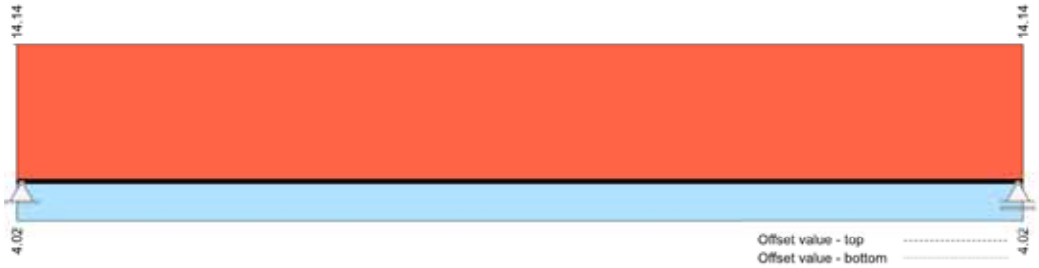
Structural analysis of continuous beam with linear eleastic stress resultant calculation					
Design according to DIN EN 1992-1-1		General building construction		Design is carried out normative	
ULS	Analysis	SLS	Analysis	FLS	Analysis
Announcement behavior	yes	Decompression	w/o ana.	Fatigue - bending	w/o ana.
Bending bearing capacity	fulfilled	Limitation of the crack width	fulfilled	Fatigue - shear force	w/o ana.
Shear loading capacity	fulfilled	Limitation of the stresses	fulfilled		
Shear joint loading capacity	w/o ana.	Limitation of the deformations	fulfilled		
Structural fire protection	not fulfilled				
Buckling stability	fulfilled				
Notches	w/o ana.				
Recesses	fulfilled				

Reinforcement

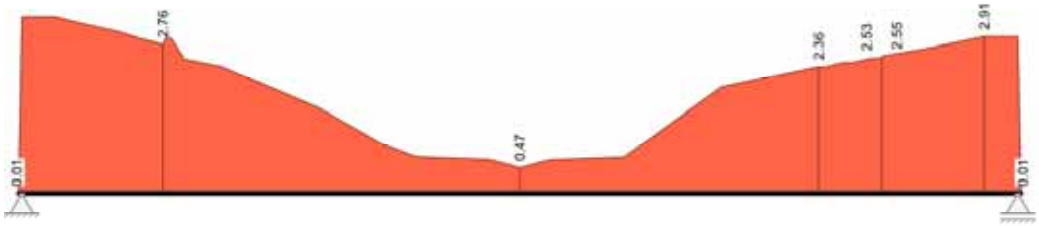
Tensile force coverage [kN]



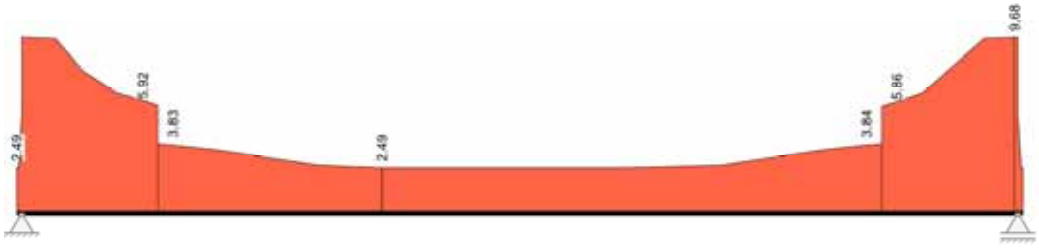
Required longitudinal reinforcement [cm²]



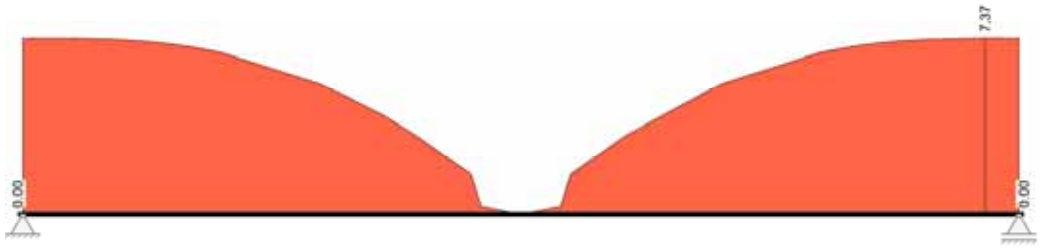
Required flange connecting reinforcement [cm²/m]



Required stirrups - web [cm²/m]



Additionally required torsion reinforcement [cm²]



Material consumption

Material		Volume [m³]	Weight [kg]
Concrete - precast member	C50/60	10.331	25828
Concrete - in-situ concrete slab	B500S	0.090	707
Reinforcing steel	ST1570/1770	0.062	489
Prestressing steel - stressing bed			
Prestressing steel - post-tensioning			

Theoretical material consumption of the design results without structural reinforcement, additions and lap lengths.