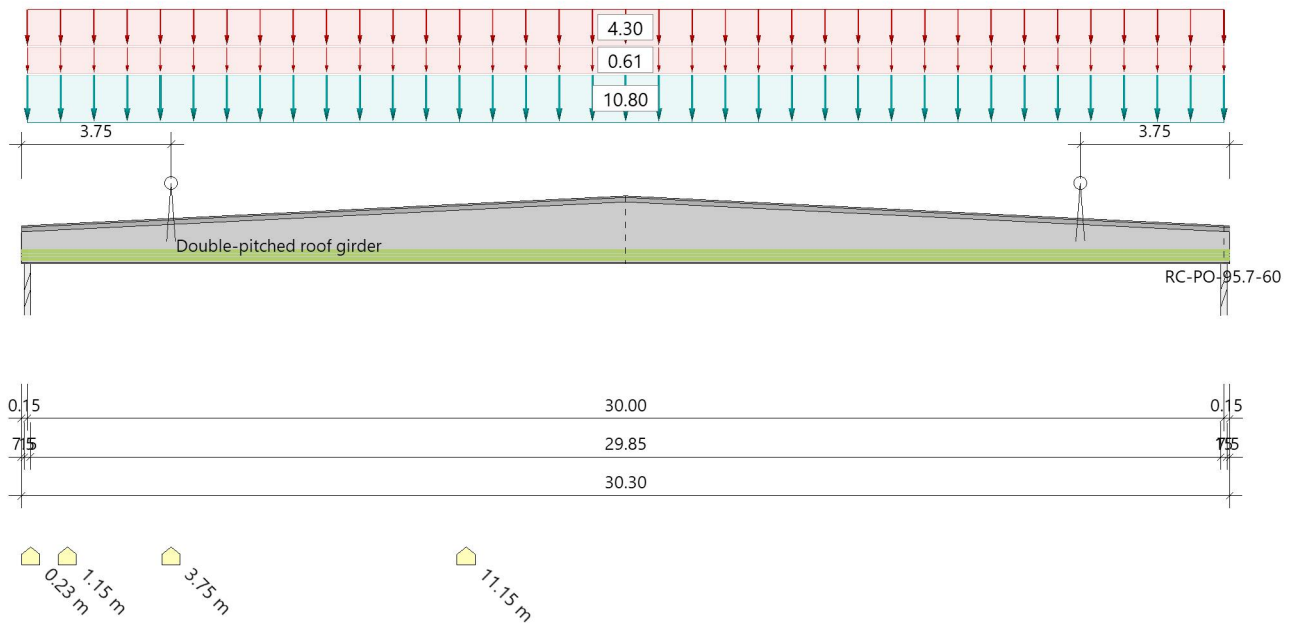


## Item: B8+\_FDB-Ref-BS1

Prestressed Concrete Girder B8+ (FRILO 2026-0-1)

### System

#### System image



#### System:

##### double-pitch roof

#### Basics:

Load combinatorics: NA to BS EN 1990/A1:2009-06 + EN 1990:2002/AC:2010  
ULS: Structural safety checks(STR)  
permanent/temporary design situation with equation 6.10 a,b

Design code: NA to BS EN 1992-1-1/A2:2015-07 + EN 1992-1-1:2004 /AC:2010  
Prestressing for pretensioning with heat treatment in stressing mould

#### System Geometry:

Total	L = 30.30 m	Effective	L1 = 30.00 m
Outstand left	L0 = 0.15 m	right	L2 = 0.15 m
Distance Ridge	L3 = 15.15 m		
Height beam :			
left	H1 = 95.0 cm	Ridge	H2 = 170.0 cm
right	H3 = 95.0 cm		
Relation eff.span to height of beam:			
	L1/H2 = 17.65		

Erection attachment, distance from the beginning resp. end of beam:

Hook	L8 = 3.75 m	right	L9 = 3.75 m
------	-------------	-------	-------------

**Cross-section Precast :**

Layer of cross-section from top to bottom			
Nr	Width [cm]	Distance [cm]	Remarks
1	60.0	0.0	
2	60.0	15.0	
3	19.0	23.2	Web begin
4	19.0	170.0	Web end
Top flange height over beam length constant			

**Material:**
**Prestressing steel**

Y1770S7 Strand 7 wires

$$\begin{aligned}
 d_d &= 4.1 \text{ mm} & d_p &= 12.3 \text{ mm} \\
 E_p &= 195000 \text{ N/mm}^2 & A_p &= 0.930 \text{ cm}^2 \\
 f_{p0.1k} &= 1520 \text{ N/mm}^2 & f_{pk} &= 1770 \text{ N/mm}^2 \\
 \epsilon_{uk} &= 35.0 \text{ ‰} & \epsilon_{ud} &= 31.5 \text{ ‰}
 \end{aligned}$$

Partial safety factor :

$$\gamma_s = 1.15$$

Coeff. prestress:

$$\begin{aligned}
 \text{charact. value} & \quad r_{sup} = 1.00 & r_{inf} &= 1.00 \\
 \text{Design value} & \quad \gamma_{p,max} = 1.10 & \gamma_{p,min} &= 0.90
 \end{aligned}$$

Proof of crack width

$$\text{Equ. diameter } d_{pv} = 7.20 \text{ mm} \quad \xi = 0.60 \text{ (Tab. 6.2)}$$

Relaxation class 2 (strands, wires, low relaxation)				
$\sigma_{p0}/f_{pk}$	10 h	200 h	1000 h	500000h
0.60	0.1	0.2	0.4	2.5
0.70	0.3	0.7	1.0	3.9
0.80	1.2	1.9	2.4	6.1
- Losses in % by 3.3.2 (6), example process				

Permitted stresses:

$$\begin{aligned}
 \text{in formwork} & \quad \sigma_p \leq 1368.0 \text{ N/mm}^2 \quad (0.90 * f_{p0.1k}) \\
 \text{after anchor. release} & \quad \sigma_p \leq 1292.0 \text{ N/mm}^2 \quad (0.85 * f_{p0.1k}) \\
 \text{char. Lc} & \quad \sigma_p \leq 1327.5 \text{ N/mm}^2 \quad (0.75 * f_{p0.1k})
 \end{aligned}$$

Transmission length

$$\begin{aligned}
 \eta_{p1} &= 3.20 & \alpha_2 &= 0.19 \\
 \alpha_1 &= 1.25 & \sigma_{pm0} &= 882 \text{ N/mm}^2 \\
 \text{PT: } f_{ctdt} &= 0.81 \text{ N/mm}^2 \\
 \text{good bond} & & \eta_1 &= 1.00 \\
 f_{bpt} &= 2.58 \text{ N/mm}^2 & l_{pt} &= 1.00 \text{ m}
 \end{aligned}$$

Dispersion length:

$$d = 0.91 \text{ m} \quad l_{disp} = 1.35 \text{ m}$$

**Reinforcing steel:**

	Longitudinal		Stirrup
	B500B		B500B
$E_s =$	200000 N/mm <sup>2</sup>	$E_s =$	200000 N/mm <sup>2</sup>
$f_{yk} =$	500 N/mm <sup>2</sup>	$f_{yk} =$	500 N/mm <sup>2</sup>
$f_{tk} =$	540 N/mm <sup>2</sup>	$f_{tk} =$	540 N/mm <sup>2</sup>
$\epsilon_{uk} =$	50.0 ‰	$\epsilon_{uk} =$	50.0 ‰
$\epsilon_{ud} =$	45.0 ‰	$\epsilon_{ud} =$	45.0 ‰

Partial safety factor :

$$\gamma_s = 1.15 \quad \gamma_s = 1.15$$

permitted stresses in SLS :

$$\sigma_s \leq 400 \text{ N/mm}^2 \quad \sigma_s \leq 400 \text{ N/mm}^2 \quad (0.80 * f_{yk})$$

**Requirements durability:**

	top	bottom
attack on concrete	X0	X0
reinforc. corrosion	XC1	XC1
min. concrete class	C 20/25	C 20/25
Stirrup	$d_{s,b} = 8 \text{ mm}$	
long. reinforcement	$d_{s,l} = 20 \text{ mm}$	$d_{s,l} = 16 \text{ mm}$
prestressed steel	$d_p = 12.3 \text{ mm}$ strand	
allowance in design	$\Delta C_{dev} = 5 \text{ mm} \quad *2$	$\Delta C_{dev} = 5 \text{ mm} \quad *2$
Stirrup	$C_{min,l} = 15 \text{ mm}$	$C_{min,l} = 15 \text{ mm}$
concrete coverage	$C_{nom,l} = 20 \text{ mm}$	$C_{nom,l} = 20 \text{ mm}$
longitudinal bars	$C_{min,m} = 20 \text{ mm} \quad *5$	$C_{min,m} = 16 \text{ mm} \quad *5$
concrete coverage	$C_{nom,m} = 28 \text{ mm} \quad *1$	$C_{nom,m} = 28 \text{ mm} \quad *1$
prestressing steel :	$C_{min,p} = 19 \text{ mm} \quad *5$	$C_{min,p} = 19 \text{ mm} \quad *5$
concrete coverage	$C_{nom,p} = 28 \text{ mm} \quad *1$	$C_{nom,p} = 28 \text{ mm} \quad *1$
laying dist. link	$C_{,l} = 20 \text{ mm}$	$C_{,l} = 20 \text{ mm}$
all. crack width	$w_{max} = 0.20 \text{ mm}$	$w_{max} = 0.20 \text{ mm}$
decompression	not req.	not req.
*1:with $c_{min,l}$		
*2: Quality Control		
*5: bond decisive		

**Concrete:**

Precast

	C 50/60
$f_{ck} =$	50.00 N/mm <sup>2</sup>
$\alpha_{cc} =$	0.85
$f_{ctk0.05} =$	2.85 N/mm <sup>2</sup>
$\alpha_{ct} =$	1.00
$\gamma =$	25.00 kN/m <sup>3</sup> Unit
$E_{cm} =$	37000 N/mm <sup>2</sup>
$\alpha_E =$	1.00 Coeff. E-module
$G_{cm} =$	14800 N/mm <sup>2</sup>

Partial safety factor :  
 $\gamma_c = 1.50$

permitted stresses in SLS :

char. $\sigma_c$	$\geq -30.00 \text{ N/mm}^2$
q.perm. $\sigma_c$	$\geq -22.50 \text{ N/mm}^2$
Removal the anchor $t = t_{0T}(sto) = 5.1 \text{ d}$	
$f_{cm}(t) =$	44.43 N/mm <sup>2</sup>
$f_{ck}(t) =$	36.43 N/mm <sup>2</sup>
linear creep $\sigma_c$	$\geq -16.39 \text{ N/mm}^2 \quad (k_2=0.45)$
maximum $\sigma_c$	$\geq -25.50 \text{ N/mm}^2 \quad (k_6=0.70)$

**Creep and shrinkage**

with heat treatment in stressing mould  
 $T_{t0} = 60 \text{ }^\circ\text{C}$  (until releasing the anchor)  
 $t_{eq} = 4533 \text{ h}$  (equivalent time difference for relaxation)  
 $t_{0T} = 5.1 \text{ d}$  (according to temperature adjusted concrete age)  
 Cement Strength class 42,5R;52,5  
 $\rho = 0.5$  (Aging coefficient)  
 Reference point for  $t_0$  is the start of the concreting of the precast

Creep	$t_0$ Days	RH %
Storage	1	70
Utilization precast	21	50

L.	Segment	Part- cross-section	$t_0$	$t$	$\alpha$	$t_{0,eff}$ B.9	$\beta_{t0}$ B.5	$\beta_H$ B.8	$\beta_{c(t,t_0)}$ B.7	$\phi_{RH}$ B.3	$\beta(f_{cm})$ B.4	$\phi(t,t_0)$ B.1
1	Storage	PcC	1.0	21.0	1	10.2	0.59	475.4	0.38	1.24	2.21	0.62
2	Utilization precast	PcC	21.0	26000.0	1	10.2	0.59	463.7	0.61	1.47	2.21	1.17

L.	A [cm <sup>2</sup> ]	U [cm]	h0 [cm]	$\beta_{ds}(t_0, t_s)$	$\beta_{ds}(t, t_s)$ 3.10	$\beta_{RH}$ B.12	$\epsilon_{cd,0}$ B.11	$\beta_{as}$ 3.13	$\epsilon_{ca}/10e6$ 3.12	$\epsilon_{cs}(t, t_0)$ [%]
1	4013.10	446.8	179.7	0.000	0.172	1.02	402.5	0.60	100.00	0.121
2	4013.10	446.8	179.7	0.172	0.996	1.36	536.0	1.00	100.00	0.430

**Loads:**
**Self weight**

Beam beginning  $g_{11} = 6.47$  kN/m  
 Ridge  $g_{12} = 10.03$  kN/m  
 Beam end  $g_{13} = 6.47$  kN/m

Total  $G = 250.1$  kN  
 Volume  $V = 10.00$  m<sup>3</sup>  
 Surf.  $A = 95.00$  m<sup>2</sup>

Units: Single load[kN] Single moment[kNm] line load[kN/m]												
span	type	gle	qle	Dist. a [m]	gri	qri	Length [m]	Fact	Act.	Sim.	Alt.	Pos.
1	1	0.00	0.61					1.00	9	0	0	
1	1	10.80	0.00					1.00	99	0	0	
1	1	0.00	4.30					1.00	10	0	0	

Load types: 1 = uniformly distr., 2 = single load at a, 3 = single moment at a  
 4 = trapezoidal load from a, 5 = triangle load over L

**Actions:**

Act.	$\gamma_Q$	$\psi_0$	$\psi_1$	$\psi_2$	Dep.	Cat.	Description
99	1.35	1.00	1.00	1.00	0	-	Permanent loads
9	1.50	0.60	0.20	0.00	0	W	Wind loads
10	1.50	0.50	0.20	0.00	0	S	Snow loads H < 1000 m

**Tendons:**

Dist(LE) > 3.5 cm axis horizontal > 3.7 cm vertical > 3.7 cm

lay. No.	num- ber	area A <sub>p</sub> [cm <sup>2</sup> ]	Dist.LE Y <sub>p</sub> [cm]	Prestressing $\sigma_p^{(0)}$ [N/mm <sup>2</sup> ]	<--- Isolations --->			type 
					Count	to x1 [m]	from x2 [m]	
1	3	2.79	8.5	1000	0			LE
2	3	2.79	12.3	1000	0			LE
3	3	2.79	16.1	1000	0			LE
4	3	2.79	19.9	1000	0			LE
5	3	2.79	23.7	1000	0			LE
6	3	2.79	27.5	1000	0			LE
7	3	2.79	31.3	1000	0			LE
8	1	0.93	35.1	1000	0			LE

x1 and x2 with respect to the left beginning from joint  
 LE= parallel lower edge, UE= parallel upper edge  
 The calculation of the losses due to creep, shrinkage and relaxation  
 following the method from Abelein

**Untensioned reinforcement:**

Layer No.	num- ber	diam. $\Phi_{s,l}$ [mm]	area A <sub>s</sub> [cm <sup>2</sup> ]	Dist.LE Y <sub>s</sub> [cm]	effective range		type 
					from xA [m]	to xE [m]	
1	2	16	4.02	3.6	0.00	30.30	LE
2	2	20	6.28	166.2	0.00	30.30	UE
3	2	20	6.28	155.0	0.00	30.30	UE

xA and xE with respect to the left beginning from joint  
 LE= parallel lower edge, UE= parallel upper edge

**Surface reinforcement acc.to Tab. NA.J.41 (B0 < D0) :**

Web (Z1/S3)  $As_s = 1.24$  cm<sup>2</sup>/m (UwkS <= XC4) (per side)  
 Top flange (Z3/S1)  $As_o = 0.00$  cm<sup>2</sup>/m (UwkS <= XC4)

### Settings for shear resistance check

Bearing width, distance bearing edge, effective height of the bearing line  
 left  $b_{Al} = 0.15 \text{ m}$   $a_l = 0.07 \text{ m}$   $d_{Al} = 0.92 \text{ m}$   
 right  $b_{Ar} = 0.15 \text{ m}$   $a_r = 0.07 \text{ m}$   $d_{Ar} = 0.92 \text{ m}$   
 For shear reinforcement not decisive ranges over support A and B:  
 $x_{aRe} = 0.99 \text{ m}$  direct bearing (width of bearing/2 + eff. height)  
 $x_{bLi} = 0.99 \text{ m}$  direct bearing (width of bearing/2 + eff. height)

### Check the limit deformation:

Total sagging  $f \leq L/250$  Increase deflection  $|df| \leq L/500$   
 Cantilever left  $f \leq 0.1 \text{ cm}$   $|df| \leq 0.1 \text{ cm}$   
 Span  $f \leq 12.0 \text{ cm}$   $|df| \leq 6.0 \text{ cm}$   
 Cantilever right  $f \leq 0.1 \text{ cm}$   $|df| \leq 0.1 \text{ cm}$   
 quasi- permanent combination and eff. char. prestress  
 Deflection due to shrinkage considered  
 Tension stiffening: Member rigidity, Characteristic combination

### RESULTS ( summary)

### Reaction forces (t = infinitely):

Units: all [kN] G:perm., Q:variable, V: Sum					
Support point	<-----char. value----->			<--ULS(PT)---->	
	G	min Q	max Q	min V	max V
A (left)	287.01	0.00	73.65	287.01	462.02
B (right)	287.01	0.00	73.65	287.01	462.02

### max. bending moment in erection state(char. value):

MF = = 2763.72 kNm at x = = 15.15 m

### Checks are not complied with:

Checkvalue		Extrem		Utilisation	x [m]
Resisting tens force bot	$\eta =$	0.86		1.16	0.15
Crack MinAs+AsDuc bottom	AsMin =	6.7	cm <sup>2</sup>	1.66	15.15
Prc.: Compressive stress t0 (storag	$\sigma_c =$	-27.31	N/mm <sup>2</sup>	1.07	3.75
Buckling installed state (Stiglat)	$\eta =$	1.69		1.19	

### Warning

Prc.: lin. creep t0 (storage)  $\sigma_c = -23.09 \text{ N/mm}^2$  x= 0.80 m  
 $\sigma_c < 0.45 \cdot f_{ck}(t) = -16.39 \text{ N/mm}^2$   
 \_disproportional creeping by increased creep modulus considered( $f_k = 1.32$ )

### Required shear reinforcement:

Column A:  $a_{sw} = 5.00 \text{ cm}^2/\text{m}$   
 Column B:  $a_{sw} = 5.00 \text{ cm}^2/\text{m}$

### Bursting reinforcement

left Laying length = 1.02 m  
 from x = 0.00 m  $A_s = 5.3 \text{ cm}^2$   
 right Laying length = 1.02 m  
 from x = 30.30 m  $A_s = 5.3 \text{ cm}^2$

### Check of anchorage

left: Tensile force resistance in anchoring area Util = 1.16  
 additional reinforcement necessary  
 right: Tensile force resistance in anchoring area Util = 1.16  
 additional reinforcement necessary

## Results

### Critical sections

### Overview crit. sections

Selected basic grid: 10 Sections

Checkvalue		Extrem		Utilisation	x [m]	
Flexural capacity bottom	$\eta =$	1.17		0.86	10.77	
Flexural capacity top	$\eta =$	6.65		0.15	3.75	
Resisting tens force bot	$\eta =$	0.86		1.16	0.15	!
Resisting tens force top	$\eta =$	6.65		0.15	3.75	
Prc.: Compressive stress t0 (storag	$\sigma_c =$	-27.31	N/mm <sup>2</sup>	1.07	3.75	!
Prc.: Compressive stress (char. comb.)	$\sigma_c =$	-22.83	N/mm <sup>2</sup>	0.76	3.75	
Stress in prestress.steel	$\sigma_p, C_c =$	1068.4	N/mm <sup>2</sup>	0.80	11.11	
Stress in rebars	$\sigma_s =$	142.7	N/mm <sup>2</sup>	0.36	10.81	
Crack MinAs+AsDuc bottom	AsMin =	6.7	cm <sup>2</sup>	1.66	15.15	!
Crack MinAs+AsDuc top	AsMin =	----	cm <sup>2</sup>	----	----	
Crack width bottom	wk =	0.08	mm	0.40	11.15	
Crack width top	wk =	0.15	mm	0.76	3.75	
Sagging top	fo =	-2.5	cm	0.20	16.83	
Sagging bottom	fu =	7.3	cm	0.61	13.47	
Incr.-deflection(Util)	df  =	6.0	cm	1.00	13.47	
Prc.:Shear reinf (web)	asw =	5.00	cm <sup>2</sup> /m	1.00	1.14	
Concrete strut capacity	$\eta =$	1.58		0.63	0.22	

---- Check not required

\*\*\*\* Check not fulfilled

Prc.: precast unit Add.: cast-in-place concrete addition

AsDuk:Ductility reinforcement

Linear creep limit, informative:		Extrem		Utilisation	x [m]
Prc.: lin. creep t0 (storage)	$\sigma_c =$	-23.09	N/mm <sup>2</sup>	1.41	0.80
Prc.: Compressive stress (quasi-perm. comb.)	$\sigma_c =$	-19.11	N/mm <sup>2</sup>	0.85	1.00

Tensile stress state I, informative:		Extrem		Utilisation	x [m]
Prc.: Tensile stress (construction)	$\sigma_t =$	9.52	N/mm <sup>2</sup>	2.34	10.14
Prc.: Tensile stress (construction)	$\sigma_t =$	3.01	N/mm <sup>2</sup>	1.19	0.80

## Internal forces ULS [kN,kNm]

x [m]	Design sit. permanent/transient				from prestressing ( formwork state)				
	Min My	Max My	Min Qz	Max Qz	Sto.tA Nv	Sto.tA Mv	Use.tE Nv	Use.tE Mv	PRE Deg
0.00	0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00
0.15	-0.10	-0.07	-1.3	-1.0	-300.0	-113.15	75.2	-16.91	2.41
0.15	-0.10	0.43	-1.3	460.8	-305.6	-115.28	72.7	-17.94	2.26
0.22	-0.21	32.11	-1.9	458.8	-481.2	-182.49	-12.7	-52.60	1.61
0.80	-2.82	293.41	-7.1	442.2	-1951.4	-771.31	-787.4	-359.95	1.66
1.00	-4.42	381.28	-8.9	436.5	-1956.7	-784.23	-1001.6	-467.11	2.00
1.14	-5.76	442.10	-10.2	432.4	-1956.7	-791.79	-1149.6	-543.73	2.35
1.35	-8.09	532.27	-12.1	426.4	-1956.7	-803.11	-1225.3	-591.58	2.30
1.36	-8.21	536.53	-12.2	426.1	-1956.7	-803.65	-1225.8	-592.43	2.28
3.37	-51.64	1334.23	-31.2	367.5	-1956.7	-911.27	-1317.2	-752.12	1.15
3.75	-64.22	1471.73	98.4	356.2	-1956.7	-931.47	-1327.8	-779.14	1.08
6.73	197.39	2400.70	75.4	266.8	-1956.7	-1088.60	-1386.4	-974.98	0.82
10.10	406.76	3125.02	46.9	162.5	-1956.7	-1263.95	-1416.4	-1164.27	0.75
11.15	451.89	3278.28	37.5	129.3	-1956.7	-1318.17	-1420.4	-1216.76	0.74
13.47	515.67	3492.30	15.8	54.9	-1956.7	-1437.39	-1423.1	-1322.50	0.76
15.15	529.64	3538.52	-0.7	0.7	-1956.7	-1523.27	-1420.7	-1390.67	0.79
16.83	515.67	3492.30	-54.9	-15.8	-1956.7	-1437.39	-1423.1	-1322.50	0.76
20.20	406.76	3125.02	-162.5	-46.9	-1956.7	-1263.95	-1416.4	-1164.27	0.75
23.57	197.39	2400.70	-266.8	-75.4	-1956.7	-1088.60	-1386.4	-974.98	0.82
26.55	-64.22	1471.73	-356.2	35.0	-1956.7	-931.47	-1327.8	-779.14	1.08
26.93	-51.64	1334.23	-367.5	31.2	-1956.7	-911.27	-1317.2	-752.12	1.15
28.94	-8.21	536.53	-426.1	12.2	-1956.7	-803.65	-1225.8	-592.43	2.28
28.95	-8.09	532.27	-426.4	12.1	-1956.7	-803.11	-1225.3	-591.58	2.30
30.15	-0.10	0.43	-460.8	1.3	-305.6	-115.28	72.7	-17.94	2.26
30.15	-0.10	-0.07	1.0	1.3	-300.0	-113.15	75.2	-16.91	2.41
30.30	0.00	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.00

**Internal forces SLS**

x [m]	<- char. Lc->		<- freq. Lc->		<q.- perm. Lc>	
	Min My	Max My	Min My	Max My	Min My	Max My
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.15	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
0.15	-0.07	0.32	-0.07	0.26	-0.07	0.24
0.22	-0.16	24.73	-0.16	20.81	-0.16	19.91
0.80	-2.09	226.11	-2.09	190.39	-2.09	182.18
1.00	-3.28	293.83	-3.28	247.44	-3.28	236.78
1.14	-4.26	340.71	-4.26	286.93	-4.26	274.59
1.35	-5.99	410.22	-5.99	345.50	-5.99	330.64
1.36	-6.08	413.50	-6.08	348.27	-6.08	333.29
3.37	-38.25	1028.49	-38.25	867.02	-38.25	829.94
3.75	-47.57	1134.52	-47.57	956.56	-47.57	915.69
6.73	214.04	1851.08	214.04	1562.52	214.04	1496.25
10.10	423.41	2410.09	423.41	2036.53	423.41	1950.74
11.15	468.54	2528.41	468.54	2137.06	468.54	2047.19
13.47	532.32	2693.69	532.32	2277.66	532.32	2182.13
15.15	546.29	2729.40	546.29	2308.09	546.29	2211.34
16.83	532.32	2693.69	532.32	2277.66	532.32	2182.13
20.20	423.41	2410.09	423.41	2036.53	423.41	1950.74
23.57	214.04	1851.08	214.04	1562.52	214.04	1496.25
26.55	-47.57	1134.52	-47.57	956.56	-47.57	915.69
26.93	-38.25	1028.49	-38.25	867.02	-38.25	829.94
28.94	-6.08	413.50	-6.08	348.27	-6.08	333.29
28.95	-5.99	410.22	-5.99	345.50	-5.99	330.64
30.15	-0.07	0.32	-0.07	0.26	-0.07	0.24
30.15	-0.07	-0.07	-0.07	-0.07	-0.07	-0.07
30.30	0.00	0.00	0.00	0.00	0.00	0.00

x[m]	<Flex. capacity->			<-----resisting tensile force----->				
	$\eta_{bo}$ =M <sub>Rd</sub> /M <sub>Ed</sub>	$\eta_{to}$ =M <sub>Rd</sub> /M <sub>Ed</sub>	$\eta_{bo}$ =T <sub>Rd</sub> /T <sub>Ed</sub>	$\sigma/\sigma_R$ [N/mm <sup>2</sup> ]	al [cm]	$\eta_{to}$ =T <sub>Rd</sub> /T <sub>Ed</sub>	$\sigma/\sigma_R$ [N/mm <sup>2</sup> ]	al [cm]
0.00	---	---	---	0.00#	---	---	0.00#	---
0.08	---	---	---	0.00#	---	439.95	0.00#	43.0
0.15	---	---	---	0.00#	---	345.29	0.00#	43.2
0.15	---	---	0.86	0.00#	103.7	343.30	0.00#	43.2
0.20	88.35	---	1.01	0.00#	103.9	292.53	0.00#	43.3
0.40	18.09	701.46	1.53	0.00#	105.1	136.97	0.00#	43.8
0.60	10.31	283.97	1.94	0.00#	106.2	75.00	3.09*!	44.3
0.80	7.27	118.79	2.25	0.00#	107.3	48.07	4.18*!	44.8
1.00	5.67	76.27	2.54	0.00#	108.4	36.35	4.22*!	45.3
1.20	4.71	53.22	2.54	1.59#	109.5	28.24	4.26*!	45.8
1.35	4.20	42.21	2.41	1.50#	110.3	23.78	4.29*!	46.1
1.36	4.17	41.60	2.40	1.49#	110.4	23.52	4.29*!	46.2
1.40	4.05	40.58	2.37	1.47#	110.6	23.02	4.30*!	46.3
1.60	3.58	32.19	2.23	1.11#	111.7	18.94	4.34*!	46.8
1.80	3.22	25.58	2.10	1.03#	112.8	15.48	4.38*!	47.3
1.85	3.14	24.24	2.07	1.01#	113.1	14.80	4.39*!	47.4
2.00	2.90	20.83	1.99	0.97#	114.0	13.09	4.43*!	47.8
3.37	1.92	8.16	1.63	5.93*!	121.6	7.67	4.83*!	51.1
3.75	1.79	6.65	1.56	7.51*!	123.7	6.65	4.97*!	96.0
6.73	1.30	---	1.26	15.14*!	88.6	---	0.02#	---
10.10	1.17	---	1.17	17.18*!	70.7	---	0.00#	---
11.15	1.17	---	1.17	16.94*!	73.3	---	0.00#	---
13.47	1.22	---	1.20	15.42*!	79.0	---	0.00#	---
16.83	1.22	---	1.21	15.42*!	79.0	---	0.00#	---
20.20	1.17	---	1.17	17.18*!	70.7	---	0.00#	---
23.57	1.30	---	1.26	15.14*!	88.6	---	0.02#	---
26.55	1.79	6.65	1.56	7.51*!	123.7	6.65	4.97*!	52.1
26.93	1.92	8.16	1.63	5.93*!	121.6	7.57	4.83*!	51.1
28.30	2.90	20.83	1.99	0.97#	114.0	13.09	4.43*!	47.8
28.45	3.14	24.24	2.07	1.01#	113.1	14.80	4.39*!	47.4
28.50	3.22	25.58	2.10	1.03#	112.8	15.48	4.38*!	47.3
28.70	3.58	32.19	2.23	1.11#	111.7	18.94	4.34*!	46.8
28.90	4.05	40.58	2.37	1.47#	110.6	23.02	4.30*!	46.3
28.94	4.17	41.60	2.40	1.49#	110.4	23.52	4.29*!	46.2

x[m]	<Flex. capacity>			<-----resisting tensile force----->				
	$\eta_{bo}$ =M <sub>Rd</sub> /M <sub>Ed</sub>	$\eta_{to}$ =M <sub>Rd</sub> /M <sub>Ed</sub>	$\eta_{bo}$ =T <sub>Rd</sub> /T <sub>Ed</sub>	$\sigma_I/\sigma_R$ [N/mm <sup>2</sup> ]	a <sub>I</sub> [cm]	$\eta_{to}$ =T <sub>Rd</sub> /T <sub>Ed</sub>	$\sigma_I/\sigma_R$ [N/mm <sup>2</sup> ]	a <sub>I</sub> [cm]
28.95	4.20	42.21	2.41	1.50#	110.3	23.78	4.29*!	46.1
29.10	4.71	53.22	2.54	1.59#	109.5	28.24	4.26*!	45.8
29.30	5.67	76.27	2.54	0.00#	108.4	36.35	4.22*!	45.3
29.50	7.27	118.79	2.25	0.00#	107.3	48.07	4.18*!	44.8
29.70	10.31	283.97	1.94	0.00#	106.2	75.00	3.09*!	44.3
29.90	18.09	701.46	1.53	0.00#	105.1	136.97	0.00#	43.8
30.10	88.35	---	1.01	0.00#	103.9	292.53	0.00#	43.3
30.15	---	---	0.86	0.00#	103.7	343.30	0.00#	43.2
30.15	---	---	---	0.00#	---	345.29	0.00#	43.2
30.22	---	---	---	0.00#	---	439.95	0.00#	43.0
30.30	---	---	---	0.00#	---	---	0.00#	---
---- Check not required **** Check not fulfilled #:Main tens.stress $\sigma_I$ #!: $\sigma_I > f_{ctk0.05}$ *:Edge tens. str. $\sigma_R$ #!: $\sigma_R > f_{ctk0.05}$								

**Shear resistance**

x [m]	V <sub>Ed</sub> [kN]	V <sub>Ed,red</sub> [kN]	cot $\Theta$	z [cm]	asw,Web [cm <sup>2</sup> /m]	$\eta$ =V <sub>Rd,max</sub> /V <sub>Ed</sub>
0.08	0.7	----	1.00	58.4	2.15	---
0.22	456.5	----	2.50*	68.9	5.00	1.58
0.23	455.9	----	2.50*	69.1	5.00	1.59
1.14	402.9	402.9	2.50	74.2	5.00	2.15
1.35	391.4	391.4	2.50	75.3	4.78	2.26
1.36	390.8	390.8	2.50	75.3	4.77	2.27
3.37	289.9	289.9	2.50	85.2	3.13	3.46
3.75	272.4	272.4	2.50	86.9	2.88	3.75
6.73	149.8	149.8	1.58	101.6	2.15	10.40
10.10	41.0	41.0	1.00	118.5	2.15	41.18
13.47	73.4	73.4	1.00	134.8	2.15	30.71
15.15	122.4	122.4	1.00	143.1	2.15	19.47
16.83	73.4	73.4	1.00	134.8	2.15	30.71
20.20	41.0	41.0	1.00	118.5	2.15	41.18
23.57	149.8	149.8	1.58	101.6	2.15	10.40
26.55	272.4	272.4	2.50	86.9	2.88	3.75
26.93	289.9	289.9	2.50	85.2	3.13	3.46
28.94	390.8	390.8	2.50	75.3	4.77	2.27
28.95	391.4	391.4	2.50	75.3	4.78	2.26
29.16	402.9	402.9	2.50	74.2	5.00	2.15
30.08	456.5	----	2.50*	68.9	5.00	1.58
30.22	0.7	----	1.00	58.4	2.15	---
---- Check not required **** Check not fulfilled *: Take over from last construction phase						

**Concrete stresses precast**

x [m]	$\sigma_{c,1}$ [N/mm <sup>2</sup> ]	$\sigma_{c,2}$ [N/mm <sup>2</sup> ]	$\sigma_{c,Cc}$ [N/mm <sup>2</sup> ]	$\sigma_{c,Qc}$ [N/mm <sup>2</sup> ]	$\sigma_{t,Cc}$ [N/mm <sup>2</sup> ]	$\sigma_{t,SC}$ [N/mm <sup>2</sup> ]
0.08	-1.56	-1.56	-0.82	-0.82	1.52	0.34
0.15	-3.76	-3.76	-2.87	-2.87	0.92	0.67
0.15	-3.83	-3.83	-2.94	-2.93	0.92	0.68
0.68	-18.93	-22.44	-16.91	-16.91	1.14	2.56
0.80	-23.09	-26.50	-15.49	-15.49	1.21	3.01
0.83	-23.02	-26.57	-15.35	-15.35	1.11	2.97
1.00	-21.70	-26.55	-19.11	-19.11	0.50	2.71
1.14	-21.28	-26.55	-19.80	-18.63	0.01	2.50
1.35	-20.67	-26.55	-21.05	-18.08	---	2.21
1.36	-20.64	-26.55	-21.06	-18.05	---	2.19
3.37	-16.00	-27.10	-22.61	-14.17	0.56	4.68
3.75	-15.31	-27.31	-22.83	-13.56	1.77	4.78
6.73	-11.52	-17.59	-16.23	-10.16	7.72	2.28
10.10	-9.48	-14.30	-15.81	-10.67	9.52	1.03
13.47	-8.85	-12.78	-14.49	-9.69	8.44	0.81



x [m]	$\sigma_{c,1}$ [N/mm <sup>2</sup> ]	$\sigma_{c,2}$ [N/mm <sup>2</sup> ]	$\sigma_{c,Cc}$ [N/mm <sup>2</sup> ]	$\sigma_{c,Qc}$ [N/mm <sup>2</sup> ]	$\sigma_{t,Cc}$ [N/mm <sup>2</sup> ]	$\sigma_{t,SC}$ [N/mm <sup>2</sup> ]
15.15	-8.88	-12.46	-13.01	-8.71	7.25	0.96
16.83	-8.85	-12.78	-14.49	-9.69	8.44	0.81
20.20	-9.48	-14.30	-15.81	-10.67	9.52	1.03
23.57	-11.52	-17.59	-16.23	-10.16	7.72	2.28
26.55	-15.31	-27.31	-22.83	-13.56	1.77	4.78
26.93	-16.00	-27.10	-22.61	-14.17	0.56	4.68
28.94	-20.64	-26.55	-21.06	-18.05	---	2.19
28.95	-20.67	-26.55	-21.05	-18.08	---	2.21
29.16	-21.28	-26.55	-19.80	-18.63	0.01	2.50
29.30	-21.70	-26.55	-19.11	-19.11	0.50	2.71
29.47	-23.02	-26.57	-15.35	-15.35	1.11	2.97
29.50	-23.09	-26.50	-15.49	-15.49	1.21	3.01
29.62	-18.93	-22.44	-16.91	-16.91	1.14	2.56
30.15	-3.83	-3.83	-2.94	-2.93	0.92	0.68
30.15	-3.76	-3.76	-2.87	-2.87	0.92	0.67
30.22	-1.56	-1.56	-0.82	-0.82	1.52	0.34

---- Check not required

\*\*\*\* Check not fulfilled

$\sigma_{c,1}$  : Compression and disproportional creeping check with early strength (storage)

$\sigma_{c,2}$  : Compressive stress check with early strength (erection)

$\sigma_{c,Cc}$  : Compression check Characteristic load combination

$\sigma_{c,Qc}$  : Disproportional creep check quasi-perm. load combination

$\sigma_{t,Cc}$  : Tensile stresses ,Installed state, Characteristic load combination (informative)

$\sigma_{t,SC}$  : Tensile stresses,State of construction (informative)

#### Check the limit deformation:

Total sagging	$f \leq L/250$	Increase deflection	$ df  \leq L/500$
Cantilever left	$f \leq 0.1 \text{ cm}$		$ df  \leq 0.1 \text{ cm}$
Span	$f \leq 12.0 \text{ cm}$		$ df  \leq 6.0 \text{ cm}$
Cantilever right	$f \leq 0.1 \text{ cm}$		$ df  \leq 0.1 \text{ cm}$

quasi- permanent combination and eff. char. prestress

Deflection due to shrinkage considered

Tension stiffening: Member rigidity, Characteristic combination

x [m]	Storage		Utilization		df  [cm]
	ftA [cm]	ftE [cm]	ftA [cm]	ftE [cm]	
0.00	0.0	0.1	-0.0	-0.1	-0.1
3.37	-0.9	-1.2	0.3	2.4	2.1
6.73	-1.4	-1.9	0.8	4.8	4.0
10.10	-1.7	-2.3	1.2	6.6	5.4
13.47	-1.8	-2.5	1.4	7.3	6.0
16.83	-1.8	-2.5	1.4	7.3	6.0
20.20	-1.7	-2.3	1.2	6.6	5.4
23.57	-1.4	-1.9	0.8	4.8	4.0
26.93	-0.9	-1.2	0.3	2.4	2.1
30.30	0.0	0.1	-0.0	-0.1	-0.1

$|df| = ftE(\text{service}) - ftA(\text{service})$

#### Selected section x = 11.00 m from left support

Internal force combinations from external loading

LAc: dominant variable action (leading action)

ULS-PT : permanent + transient design situation (fundam. combination)

SLS-Cc : characteristic combination

SLS-Fc : frequent combination

SLS-Qc : quasi-permanent combination

#### maximum moment : [kNm]

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	1240.12	918.59	918.59	918.59
Storage/Erection	649.18	468.54	468.54	468.54
Utilization	3278.28	2528.41	2137.06	2047.19
LAc	10	10	10	-

**Minimum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	918.56	918.59	918.59	918.59
Storage/Erection	451.89	468.54	468.54	468.54
Utilization	2047.16	2047.19	2047.19	2047.19
LAc	-	-	-	-

**maximum shear force:[kN]**

	ULS-PT
Storage	51.6
Storage/Erection	52.4
Utilization	129.3
LAc	10

**Effective Tendons ( prestressed formwork state for t = t0 (sto))**

Layer No.	No.	Area Ap [cm <sup>2</sup> ]	Distance f.bottom [cm]	Prestress		tens.force		Shorttime Relaxation [N/mm <sup>2</sup> ]
				max [N/mm <sup>2</sup> ]	min [N/mm <sup>2</sup> ]	max [kN]	min [kN]	
1	3	2.8	8.5	956.37	956.37	266.8	266.8	-4.63
2	3	2.8	12.3	956.37	956.37	266.8	266.8	-4.63
3	3	2.8	16.1	956.37	956.37	266.8	266.8	-4.63
4	3	2.8	19.9	956.37	956.37	266.8	266.8	-4.63
5	3	2.8	23.7	956.37	956.37	266.8	266.8	-4.63
6	3	2.8	27.5	956.37	956.37	266.8	266.8	-4.63
7	3	2.8	31.3	956.37	956.37	266.8	266.8	-4.63
8	1	0.9	35.1	956.37	956.37	88.9	88.9	-4.63

 $\Delta\sigma(Tt0) = -39 \text{ N/mm}^2$  due to heat treatment

**Untensioned reinforcement**

Layer	Number	Diameter [mm]	Area [cm <sup>2</sup> ]	LE [cm]
1	2	16	4.0	3.6
2	2	20	6.3	135.2
3	2	20	6.3	146.4

**Cross-section Precast :**

Layer of cross-section from top to bottom			
Nr	Width [cm]	Distance [cm]	Remarks
1	60.0	0.0	
2	60.0	15.0	
3	19.0	23.2	Web begin
4	19.0	150.2	Web end

**Cross-section Values**

	brutto			ideal		
	A <sub>c</sub> [cm <sup>2</sup> ]	z <sub>u</sub> [cm]	I <sub>c</sub> [cm <sup>4</sup> ]	A <sub>i</sub> [cm <sup>2</sup> ]	z <sub>i</sub> [cm]	I <sub>i</sub> [cm <sup>4</sup> ]
Precast cross-section	3636.9	89.2	8019344	3797.3	88.0	8768771

**Internal forces from prestress (mean values, prestressed formwork state)**

Creep period	N <sub>pm</sub> <sup>(0)</sup>		M <sub>pm</sub> <sup>(0)</sup>	
	tB [kN]	tE [kN]	tB [kNm]	tE [kNm]
Storage	-1956.7	-1793.6	-1318.17	-1254.74
Utilization	-1793.6	-1420.4	-1254.74	-1216.76

tA=Begin, tE=End creep period

Prestress steel relaxation			
Lay. No.	Storage $\Delta\sigma_{p,r1}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,r2}$ [N/mm <sup>2</sup> ]	
1	-0.10	-13.00	
2	-0.10	-12.94	
3	-0.11	-12.89	
4	-0.11	-12.84	
5	-0.11	-12.79	
6	-0.11	-12.73	
7	-0.11	-12.68	
8	-0.11	-12.63	

Prestr. steel, losses due to creeping, shrinking and relaxation:			
Lay. No.	Storage $\Delta\sigma_{p,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,csr2}^{(0)}$ [N/mm <sup>2</sup> ]	
1	-50.61	-75.05	
2	-50.09	-77.17	
3	-49.57	-79.29	
4	-49.05	-81.41	
5	-48.54	-83.53	
6	-48.02	-85.65	
7	-47.50	-87.77	
8	-46.98	-89.89	

Stress in rebars due to creeping,shrinking and relaxation:			
Lay. No.	Storage $\Delta\sigma_{s,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{s,csr2}^{(0)}$ [N/mm <sup>2</sup> ]	
1	-52.51	-63.45	
2	-34.06	-140.25	
3	-32.50	-146.79	

**Bending with Normal Force ULS**

L.	Creep period	Cross-section	Tens-zone	z [cm]	M <sub>Rd</sub> [kNm]	M <sub>Ed</sub> [kNm]	η (>1.0)	
1	tB Storage	P	top	119.4	634.58	M <sub>Ed</sub> < 0	n/a	#1
2	tE Storage	P	below	123.7	3829.99	1240.12	3.09	
3	tB Storage/Erection	P	top	119.4	634.58	M <sub>Ed</sub> < 0	n/a	#1
4	tE Storage/Erection	P	below	123.7	3829.99	649.18	5.90	
5	tE Utilization	P	top	125.0	781.51	M <sub>Ed</sub> < 0	n/a	
6	tE Utilization	P	below	123.4	3843.82	3278.28	1.17	

 #1:  $f_{ck}(t) = 0.73 \cdot f_{ck}$ 

Interim results : Ultimate elongation and internal forces										
L.	ε <sub>c</sub> [‰]	ε <sub>s</sub> [‰]	x [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	Z <sub>p</sub> [kN]	Z <sub>s</sub> [kN]	D <sub>c</sub> [kN]	D <sub>p</sub> [kN]	D <sub>s</sub> [kN]
1	3.500	5.500	56.9	0.0	12.6	0.0	549.1	1807.6	-1441.6	166.9
2	3.500	21.900	20.2	20.5	4.0	2962.2	180.5	2730.3	0.0	380.1
3	3.500	5.500	56.9	0.0	12.6	0.0	549.1	1807.6	-1441.6	166.9
4	3.500	21.900	20.2	20.5	4.0	2962.2	180.5	2730.3	0.0	380.1
5	3.500	9.500	39.4	0.0	12.6	0.0	551.9	1717.7	-1308.2	163.9
6	3.500	22.700	19.6	20.5	4.0	2967.4	180.7	2660.2	0.0	468.0

### Shear resistance

Design value shear force						
L.	Creep period	Combination	$V_{Ed,0}$ [kN]	$M_{Ed}$ [kNm]	$dV$ [kN]	due to
1	tB Storage	QMax	51.6	1240.10	-49.6	Vccd
2	tE Storage	QMax	51.6	1240.10	-49.6	Vccd
3	tB Storage/Erection	QMax	52.4	637.93	-25.5	Vccd
4	tE Storage/Erection	QMax	52.4	637.93	-25.5	Vccd
5	tB Utilization	MMax	129.3	3278.28	-131.5	Vccd
6	tE Utilization	MMax	129.3	3278.28	-131.5	Vccd

Effective cross-section									
L.	Cross-section	Tens-zone	$b_w$ [cm]	$d$ [cm]	$z$ [cm]	$A_c$ [cm <sup>2</sup> ]	$A_{sl}$ [cm <sup>2</sup> ]	$\sigma_{cp}$ [N/mm <sup>2</sup> ]	$V_{Rdc}$ [kN]
1	P	below	19.0	146.6	123.7	3636.9	24.5	4.84	347.6
2	P	below	19.0	146.6	123.7	3636.9	24.5	4.44	347.0
3	P	below	19.0	146.6	123.7	3636.9	24.5	4.84	347.6
4	P	below	19.0	146.6	123.7	3636.9	24.5	4.44	347.0
5	P	below	19.0	146.6	123.4	3636.9	24.5	4.44	347.0
6	P	below	19.0	146.6	123.4	3636.9	24.5	3.52	308.4

Shear design $v1= 0.480$									
L.	$V_{Ed}$ [kN]	$V_{Ed,red}$ [kN]	$a_{cw}$	$\cot \Theta$	$a_{sw}$ [cm <sup>2</sup> /m]	Note	$a_l$ [cm]	$V_{Rd,max}$ [kN]	
1	2.0	2.0	1.199	1.000	1.83	Min	73.3	1754.2	#1
2	2.0	2.0	1.133	1.000	2.15	Min	73.3	2130.3	
3	26.8	26.8	1.199	1.000	1.83	Min	73.3	1754.2	#1
4	26.8	26.8	1.133	1.000	2.15	Min	73.3	2130.3	
5	2.2	2.2	1.133	1.000	2.15	Min	73.3	2125.8	
6	2.2	2.2	1.105	1.000	2.15	Min	73.3	2073.9	
#1: $f_{ck}(t) = 0.73 \cdot f_{ck}$									

### Check of crack width limit in SLS

perm. crack width:  $w_k < 0.20$  mm, Frequent load combination

L.	Creep period	Cross-section	Tens-zone	$r_{sup}$ $r_{inf}$	$\max. \sigma_s$ [N/mm <sup>2</sup> ]	$s_{r,max}$ [mm]	$\epsilon_{sm} - \epsilon_{cm}$ [‰]	$w_k$ [mm]
1	tB Storage	P	top	1.00	CS completely compressed no cracks	128.75	205.71	0.386
2	tE Storage	P	below	1.00				
3	tB Storage/Erection	P	top	1.00				
4	tE Storage/Erection	P	below	1.00				
5	tE Utilization	P	top	1.00				
6	tE Utilization	P	below	1.00				0.08

Internal forces and elongation							
L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. σ [N/mm <sup>2</sup> ]	XOI [cm]	ϕ <sub>eff</sub>	ε <sub>c</sub> [‰]	XOII [cm]
1	-1956.7	-399.59	-2.32	201.0	1.78	-0.775	80.1
2	-1793.6	-336.16	-8.10	211.2			
3	-1956.7	-849.64	0.88	141.1			
4	-1793.6	-786.20	-12.61	140.6			
5	-1420.4	830.43	-9.64	101.7			
6	-1420.4	920.30	5.49	97.9			
XOI: Pressure zone height in state I    XOII: Pressure zone height in state II							

L.	$h_{c,ef}$ [cm]	$A_{ceff}$ [cm <sup>2</sup> ]	$\xi_1$	$A_p$ [cm <sup>2</sup> ]	$A_s$ [cm <sup>2</sup> ]	$\rho_{p,ef}$ [%]	$\rho_{tot}$ [%]	k1	k2	k3	c [cm]	k4
6	23.4	444.1	1.15	11.2	4.0	4.257	3.418	1.38	0.50	3.40	2.8	0.425

Crack forces and strains (State II)							
L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. $\sigma$ [N/mm <sup>2</sup> ]	X <sub>0I</sub> [cm]	$\phi_{eff}$	$\epsilon_c$ [‰]	X <sub>0II</sub> [cm]
6	-1420.4	778.83	4.07	104.4			
X <sub>0I</sub> : Pressure zone height in state I X <sub>0II</sub> : Pressure zone height in state II							

**Minimum reinforcement for crack control:**

L.	Creep period	Cross-section	Tens-zone	r <sub>sup</sub> r <sub>inf</sub>	$\sigma_t$ [N/mm <sup>2</sup> ]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
1	tB Storage	P	top	1.00	-1.89	< 4.07	not req.
2	tE Storage	P	below	1.00	-8.10	< 4.07	not req.
3	tB Storage/Erection	P	top	1.00	1.31	< 4.07	not req.
4	tE Storage/Erection	P	below	1.00	-12.61	< 4.07	not req.
5	tE Utilization	P	top	1.00	-9.37	< 4.07	not req.
6	tE Utilization	P	below	1.00	9.42	<= 0 cm <sup>2</sup>	

L.	D [mm]	x0IZ [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	ξ <sub>1</sub>	Web				Flange			
					k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]
6	16	45.8	5.6	1.15	0.65	0.29	871.0	4.3	--no flange--			
x0IZ: tensile zone in state I due to cracking forces												

**Ductility reinforcement in precompressed tensile zone:**

b [cm <sup>3</sup> ]	f <sub>ctm</sub> [N/mm <sup>2</sup> ]	Z <sub>s</sub> [cm]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
19	4.07	146.6	5.9	4.0

**Stress checks SLS**

Concrete edge stresses in state I due to prestress, creep, shrinkage and relaxation			
L.	due to	$\sigma_R$ Precast	
		top [N/mm <sup>2</sup> ]	bottom [N/mm <sup>2</sup> ]
1	Prestr. release anchorage	4.20	-18.38
2	csr storage	-0.02	1.07
3	csr utilisation	0.71	1.36

Tab. Compr stresses of concrete						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	$\sigma_c$ Precast		
				C <sub>c</sub> ,P <sub>k</sub> [N/mm <sup>2</sup> ]	Q <sub>c</sub> ,P <sub>k</sub> [N/mm <sup>2</sup> ]	
1	tB Storage	P	--	-9.16	-9.16	
2	tE Storage	P	--	-8.10	-8.10	
3	tB Storage/Erection	P	--	-13.68		
4	tE Storage/Erection	P	--	-12.61		
5	tB Utilization	P	+-	-15.68	-10.57	
6	tE Utilization	P	+-	-14.19	-9.53	

Tab. Steel- and Concrete tension stress						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	$\sigma_p$ C <sub>c</sub> ,P <sub>m</sub> [N/mm <sup>2</sup> ]	$\sigma_s$ C <sub>c</sub> ,P <sub>k</sub> [N/mm <sup>2</sup> ]	$\sigma_t$ C <sub>c</sub> ,P <sub>k</sub> [N/mm <sup>2</sup> ]
1	tB Storage	P	+-	916.52	< 0	ZII
2	tE Storage	P	+-	873.82	< 0	ZII
3	tB Storage/Erection	P	---	902.22	2.75	0.88
4	tE Storage/Erection	P	+-	859.53	< 0	0.86
5	tB Utilization	P	++	1067.66	124.02	ZII
6	tE Utilization	P	++	1068.31	142.41	ZII

 P<sub>k</sub>= Prestres char. value, P<sub>m</sub>= prestress mean value, StII: State II

**Selected section x = 1.00 m from left support**

Internal force combinations from external loading

LAc: dominant variable action (leading action)

ULS-PT : permanent + transient design situation (fundam. combination)

SLS-Cc : characteristic combination

SLS-Fc : frequent combination

SLS-Qc : quasi-permanent combination

**maximum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	162.93	120.67	120.67	120.67
Storage/Erection	-4.34	-4.34	-4.34	-4.34
Utilization	446.42	344.04	289.74	277.27
LAc	10	10	10	-

**Minimum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	120.65	120.67	120.67	120.67
Storage/Erection	-5.86	-4.34	-4.34	-4.34
Utilization	277.25	277.27	277.27	277.27
LAc	-	-	-	-

**maximum shear force:[kN]**

	ULS-PT
Storage	158.5
Storage/Erection	-10.3
Utilization	432.1
LAc	10

**Effective Tendons ( prestressed formwork state for t = t0 (sto))**

Layer No.	No.	Area Ap [cm <sup>2</sup> ]	Distance f.bottom [cm]	Prestress		tens.force		Shorttime Relaxation [N/mm <sup>2</sup> ]
				max [N/mm <sup>2</sup> ]	min [N/mm <sup>2</sup> ]	max [kN]	min [kN]	
1	3	2.8	8.5	956.37	912.14	266.8	254.5	-4.63
2	3	2.8	12.3	956.37	912.14	266.8	254.5	-4.63
3	3	2.8	16.1	956.37	912.14	266.8	254.5	-4.63
4	3	2.8	19.9	956.37	912.14	266.8	254.5	-4.63
5	3	2.8	23.7	956.37	912.14	266.8	254.5	-4.63
6	3	2.8	27.5	956.37	912.14	266.8	254.5	-4.63
7	3	2.8	31.3	956.37	912.14	266.8	254.5	-4.63
8	1	0.9	35.1	956.37	912.14	88.9	84.8	-4.63

 $\Delta\sigma(Tt0) = -39 \text{ N/mm}^2$  due to heat treatment

**Untensioned reinforcement**

Layer	Number	Diameter [mm]	Area [cm <sup>2</sup> ]	LE [cm]
1	2	16	4.0	3.6
2	2	20	6.3	85.7
3	2	20	6.3	96.9

**Cross-section Precast :**

Layer of cross-section from top to bottom				
Nr	Width [cm]	Distance [cm]	Remarks	
1	60.0	0.0	Web begin Web end	
2	60.0	15.0		
3	19.0	23.2		
4	19.0	100.7		

**Cross-section Values**

	brutto			ideal		
	$A_c$ [cm <sup>2</sup> ]	$z_u$ [cm]	$I_c$ [cm <sup>4</sup> ]	$A_i$ [cm <sup>2</sup> ]	$z_i$ [cm]	$I_i$ [cm <sup>4</sup> ]
Precast cross-section	2696.3	62.2	2560641	2856.7	61.1	2848818

**Internal forces from prestress (mean values, prestressed formwork state)**

Creep period	$N_{pm}^{(0)}$		$M_{pm}^{(0)}$		$\phi F_{ak}$ Prc
	tB [kN]	tE [kN]	tB [kNm]	tE [kNm]	
Storage	-1956.7	-1637.6	-792.33	-674.94	1.22
Utilization	-1717.0	-1160.2	-707.67	-549.27	1.00

tA=Begin, tE=End creep period

 $\phi F_{ak}$ : Increase factor creep modulus (non-linear creep:> 1.0)

Prestress steel relaxation		
Lay. No.	Storage $\Delta\sigma_{p,r1}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,r2}$ [N/mm <sup>2</sup> ]
1	-0.08	-8.50
2	-0.08	-8.68
3	-0.09	-8.87
4	-0.09	-9.06
5	-0.09	-9.25
6	-0.09	-9.45
7	-0.09	-9.65
8	-0.10	-9.85

Prestr. steel, losses due to creeping, shrinking and relaxation:		
Lay. No.	Storage $\Delta\sigma_{p,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,csr2}^{(0)}$ [N/mm <sup>2</sup> ]
1	-93.48	-163.58
2	-90.24	-160.74
3	-86.99	-157.90
4	-83.75	-155.07
5	-80.51	-152.23
6	-77.27	-149.40
7	-74.03	-146.57
8	-70.79	-143.74

Stress in rebars due to creeping,shrinking and relaxation:		
Lay. No.	Storage $\Delta\sigma_{s,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{s,csr2}^{(0)}$ [N/mm <sup>2</sup> ]
1	-100.10	-164.76
2	-28.24	-98.51
3	-18.44	-89.47

**Bending with Normal Force ULS**

L.	Creep period	Cross-section	Tens-zone	z [cm]	$M_{Rd}$ [kNm]	$M_{Ed}$ [kNm]	$\eta$ (>1.0)	
1	tB Storage	P	top	70.5	339.08	$M_{Ed} < 0$	n/a	#1
2	tE Storage	P	below	74.4	2207.63	162.93	13.55	
3	tB Storage/Erection	P	top	70.5	339.08	5.86	57.88	#1
4	tE Storage/Erection	P	below	74.4	2207.63	$M_{Ed} < 0$	n/a	
5	tB Utilization	P	top	75.1	496.04	$M_{Ed} < 0$	n/a	
6	tE Utilization	P	below	74.3	2193.79	446.42	4.91	

 #1:  $f_{ck}(t) = 0.73 \cdot f_{ck}$

**Interim results : Ultimate elongation and internal forces**

L.	$\epsilon_c$ [%]	$\epsilon_s$ [%]	x [cm]	$A_p$ [cm <sup>2</sup> ]	$A_s$ [cm <sup>2</sup> ]	$Z_p$ [kN]	$Z_s$ [kN]	Dc [kN]	Dp [kN]	Ds [kN]
1	3.500	2.500	56.5	0.0	12.6	0.0	500.3	1794.5	-1443.3	166.9
2	3.500	13.900	19.5	20.5	4.0	2828.8	178.1	2654.0	0.0	365.7
3	3.500	2.500	56.5	0.0	12.6	0.0	500.3	1794.5	-1443.3	166.9
4	3.500	13.900	19.5	20.5	4.0	2828.8	178.1	2654.0	0.0	365.7
5	3.500	4.900	40.4	0.0	12.6	0.0	548.3	1759.4	-1403.1	163.9
6	3.500	14.700	18.7	20.5	4.0	2828.0	178.2	2551.6	0.0	419.9

**Shear resistance**
**Design value shear force**

L.	Creep period	Combination	$V_{Ed,0}$ [kN]	$M_{Ed}$ [kNm]	dV [kN]	due to
1	tB Storage	QMax	158.5	162.91	-10.8	Vccd
2	tE Storage	QMax	158.5	162.91	-10.8	Vccd
3	tB Storage/Erection	QMax	-10.3	-5.86	0.0	-----
4	tE Storage/Erection	QMax	-10.3	-5.86	0.0	-----
5	tB Utilization	QMax	432.1	446.40	-29.8	Vccd
6	tE Utilization	QMax	432.1	446.40	-29.8	Vccd

**Effective cross-section**

L.	Cross-section	Tens-zone	$b_w$ [cm]	d [cm]	z [cm]	$A_c$ [cm <sup>2</sup> ]	$A_{sl}$ [cm <sup>2</sup> ]	$\sigma_{cp}$ [N/mm <sup>2</sup> ]	$V_{Rdc}$ [kN]
1	P	below	19.0	97.1	74.4	2696.3	24.5	4.86	251.6
2	P	below	19.0	97.1	74.4	2696.3	24.5	5.47	281.6
3	P	top	19.0	91.3	70.5	2696.3	12.6	4.86	217.3
4	P	top	19.0	91.3	70.5	2696.3	12.6	5.47	243.3
5	P	below	19.0	97.1	74.3	2696.3	24.5	5.73	288.9
6	P	below	19.0	97.1	74.3	2696.3	24.5	3.87	237.5

**Shear design  $v_1 = 0.480$** 

L.	$V_{Ed}$ [kN]	$V_{Ed,red}$ [kN]	$a_{cw}$	cot $\Theta$	$a_{sw}$ [cm <sup>2</sup> /m]	Note	aI [cm]	$V_{Rd,max}$ [kN]	
1	147.7	147.7	1.250	2.487	1.83	Min	92.6	761.6	#1
2	147.7	147.7	1.164	2.123	2.15	Min	79.0	1015.3	
3	10.3	10.3	1.250	1.000	1.83	Min	45.6	1042.2	#1
4	10.3	10.3	1.164	1.000	2.15	Min	45.6	1247.5	
5	402.4	402.4	1.172	2.500	4.98	Var	92.8	912.3	
6	402.4	402.4	1.116	2.500	4.98	Var	92.8	868.9	

 #1:  $f_{ck}(t) = 0.73 \cdot f_{ck}$ 
**Check of crack width limit in SLS**

 perm. crack width:  $w_k < 0.20$  mm, Frequent load combination

L.	Creep period	Cross-section	Tens-zone	$r_{sup}$ $r_{inf}$	$\max. \sigma_s$ [N/mm <sup>2</sup> ]	$s_{r,max}$ [mm]	$\epsilon_{sm} - \epsilon_{cm}$ [%]	$w_k$ [mm]
1	tB Storage	P	top	1.00	no cracks			
2	tE Storage	P	below	1.00	CS completely compressed			
3	tB Storage/Erection	P	top	1.00	56.15	431.24	0.168	0.07
4	tE Storage/Erection	P	below	1.00	CS completely compressed			
5	tB Utilization	P	top	1.00	CS completely compressed			
6	tE Utilization	P	below	1.00	CS completely compressed			



Internal forces and elongation							
L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. σ [N/mm <sup>2</sup> ]	XOI [cm]	ϕ <sub>eff</sub>	ε <sub>c</sub> [‰]	XOII [cm]
1	-1956.7	-671.66	2.49	90.1	0.00	-0.718	69.6
2	-1637.6	-554.27	-17.62	90.5			
3	-1956.7	-796.67	4.23	85.6			
4	-1637.6	-679.28	-20.30	85.1			
5	-1717.0	-430.40	-0.03	100.9			
6	-1160.2	-259.53	-9.63	105.7			
XOI: Pressure zone height in state I    XOII: Pressure zone height in state II							

L.	h <sub>c,ef</sub> [cm]	A <sub>ceff</sub> [cm <sup>2</sup> ]	$\xi_1$	A <sub>p</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	$\rho_{p,ef}$ [%]	$\rho_{tot}$ [%]	k1	k2	k3	c [cm]	k4
3	10.4	621.0	1.29	0.0	6.3	1.012	1.012	0.80	0.50	3.40	2.8	0.425

Crack forces and strains (State II)							
L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. $\sigma$ [N/mm <sup>2</sup> ]	XOI [cm]	$\phi_{eff}$	$\epsilon_c$ [‰]	XOII [cm]
3	-1956.7	-785.48	4.07	85.9			
XOI: Pressure zone height in state I XOII: Pressure zone height in state II							

**Minimum reinforcement for crack control:**

L.	Creep period	Cross-section	Tens-zone	r <sub>sup</sub> r <sub>inf</sub>	$\sigma_t$ [N/mm <sup>2</sup> ]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
1	tB Storage	P	top	1.00	3.61	< 4.07	not req.
2	tE Storage	P	below	1.00	-17.62	< 4.07	not req.
3	tB Storage/Erection	P	top	1.00	5.34	<= 0 cm2	
4	tE Storage/Erection	P	below	1.00	-20.30	< 4.07	not req.
5	tB Utilization	P	top	1.00	1.92	< 4.07	not req.
6	tE Utilization	P	below	1.00	-8.46	< 4.07	not req.

L.	D [mm]	xOIz [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	$\xi_1$	Web				Flange			
					k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]
3	20	14.8	0.0	0.00	0.65	0.00	280.6	-nan(ind)	0.97	0.53	498.5	4.8
xOIz: tensile zone in state I due to cracking forces												

**Ductility reinforcement in precompressed tensile zone:**

b [cm <sup>3</sup> ]	f <sub>ctm</sub> [N/mm <sup>2</sup> ]	Z <sub>s</sub> [cm]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
19	4.07	97.1	3.9	4.0

**Stress checks SLS**

Concrete edge stresses in state I due to prestress, creep, shrinkage and relaxation			
L.	due to	OR Precast	
		top [N/mm <sup>2</sup> ]	bottom [N/mm <sup>2</sup> ]
1	Prestr. release anchorage	4.17	-23.84
2	csr storage	-0.34	2.65
3	csr utilisation	-0.08	4.58

**Tab. Compr stresses of concrete**

L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>c</sub> Precast		
				Cc,Pk [N/mm²]	Qc,Pk [N/mm²]	
1	tB Storage	P	--	-21.25	-21.25	#1
2	tE Storage	P	--	-18.60	-18.60	
3	tB Storage/Erection	P	--	-26.55*		
4	tE Storage/Erection	P	--	-19.98		
5	tB Utilization	P	--	-15.24	-15.24	
6	tE Utilization	P	--	-10.66	-10.66	

 #1: due to σ<sub>c</sub> > 0.45\* f<sub>ck</sub>(t) increased creep modulus

**Tab. Steel- and Concrete tension stress**

L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>p</sub>	σ <sub>s</sub>	σ <sub>t</sub>
				Cc,Pm [N/mm <sup>2</sup> ]	Cc,Pk [N/mm <sup>2</sup> ]	Cc,Pk [N/mm <sup>2</sup> ]
1	tB Storage	P	---	887.99	8.61	2.49
2	tE Storage	P	+-	781.46	< 0	2.15
3	tB Storage/Erection	P	---	900.14	56.15	ZII
4	tE Storage/Erection	P	---	764.91	48.14	ZII
5	tB Utilization	P	++	836.43	< 0	ZII
6	tE Utilization	P	++	664.02	< 0	ZII

Pk= Prestres char. value, Pm= prestress mean value, StII: State II

**Selected section x = 3.60 m from left support**

Internal force combinations from external loading

LAc: dominant variable action (leading action)

ULS-PT : permanent + transient design situation (fundam. combination)

SLS-Cc : characteristic combination

SLS-Fc : frequent combination

SLS-Qc : quasi-permanent combination

**maximum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	543.37	402.48	402.48	402.48
Storage/Erection	-47.57	-47.57	-47.57	-47.57
Utilization	1471.73	1134.52	956.56	915.69
LAc	10	10	10	-

**Minimum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	402.45	402.48	402.48	402.48
Storage/Erection	-64.22	-47.57	-47.57	-47.57
Utilization	915.67	915.69	915.69	915.69
LAc	-	-	-	-

**maximum shear force:[kN]**

	ULS-PT
Storage	133.8
Storage/Erection	134.5
Utilization	356.2
LAc	10

**Effective Tendons ( prestressed formwork state for t = t<sub>0</sub> (sto))**

Layer No.	No.	Area A <sub>p</sub> [cm <sup>2</sup> ]	Distance f.bottom [cm]	Prestress		tens.force		Shorttime Relaxation [N/mm <sup>2</sup> ]
				max [N/mm <sup>2</sup> ]	min [N/mm <sup>2</sup> ]	max [kN]	min [kN]	
1	3	2.8	8.5	956.37	956.37	266.8	266.8	-4.63
2	3	2.8	12.3	956.37	956.37	266.8	266.8	-4.63
3	3	2.8	16.1	956.37	956.37	266.8	266.8	-4.63
4	3	2.8	19.9	956.37	956.37	266.8	266.8	-4.63
5	3	2.8	23.7	956.37	956.37	266.8	266.8	-4.63

Layer No.	No.	Area Ap [cm <sup>2</sup> ]	Distance f.bottom [cm]	Prestress		tens.force		Shorttime Relaxation [N/mm <sup>2</sup> ]
				max [N/mm <sup>2</sup> ]	min [N/mm <sup>2</sup> ]	max [kN]	min [kN]	
6	3	2.8	27.5	956.37	956.37	266.8	266.8	-4.63
7	3	2.8	31.3	956.37	956.37	266.8	266.8	-4.63
8	1	0.9	35.1	956.37	956.37	88.9	88.9	-4.63
$\Delta\sigma(Tt0) = -39 \text{ N/mm}^2$ due to heat treatment								

**Untensioned reinforcement**

Layer	Number	Diameter [mm]	Area [cm <sup>2</sup> ]	LE [cm]
1	2	16	4.0	3.6
2	2	20	6.3	98.6
3	2	20	6.3	109.8

**Cross-section Precast :**

Layer of cross-section from top to bottom				
Nr	Width [cm]	Distance [cm]	Remarks	
1	60.0	0.0	Web begin Web end	
2	60.0	15.0		
3	19.0	23.2		
4	19.0	113.6		

**Cross-section Values**

	brutto			ideal		
	A <sub>c</sub> [cm <sup>2</sup> ]	z <sub>u</sub> [cm]	I <sub>c</sub> [cm <sup>4</sup> ]	A <sub>i</sub> [cm <sup>2</sup> ]	z <sub>i</sub> [cm]	I <sub>i</sub> [cm <sup>4</sup> ]
Precast cross-section	2940.8	69.3	3618822	3101.3	68.2	4006279

**Internal forces from prestress (mean values, prestressed formwork state)**

Creep period	N <sub>pm</sub> <sup>(0)</sup>		M <sub>pm</sub> <sup>(0)</sup>	
	tB [kN]	tE [kN]	tB [kNm]	tE [kNm]
Storage	-1956.7	-1763.7	-931.47	-864.86
Utilization	-1763.7	-1327.8	-864.86	-779.14
tA=Begin, tE=End creep period				

Prestress steel relaxation		
Lay. No.	Storage $\Delta\sigma_{p,r1}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,r2}$ [N/mm <sup>2</sup> ]
1	-0.09	-10.88
2	-0.09	-10.92
3	-0.09	-10.97
4	-0.10	-11.01
5	-0.10	-11.06
6	-0.10	-11.11
7	-0.10	-11.15
8	-0.10	-11.20

**Prestr. steel, losses due to creeping, shrinking and relaxation:**

Lay. No.	Storage $\Delta\sigma_{p,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,csr2}^{(0)}$ [N/mm <sup>2</sup> ]
1	-67.25	-114.61
2	-65.72	-115.19
3	-64.19	-115.77
4	-62.66	-116.36
5	-61.13	-116.94
6	-59.60	-117.52

## Prestr. steel, losses due to creeping, shrinking and relaxation:

Lay. No.	Storage $\Delta\sigma_{p,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,csr2}^{(0)}$ [N/mm <sup>2</sup> ]
7	-58.07	-118.11
8	-56.54	-118.69

## Stress in rebars due to creeping, shrinking and relaxation:

Lay. No.	Storage $\Delta\sigma_{s,csr1}^{(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{s,csr2}^{(0)}$ [N/mm <sup>2</sup> ]
1	-70.93	-107.90
2	-31.67	-121.91
3	-27.04	-123.56

## Bending with Normal Force ULS

L.	Creep period	Cross-section	Tens-zone	z [cm]	M <sub>Rd</sub> [kNm]	M <sub>Ed</sub> [kNm]	η (>1.0)	
1	tB Storage	P	top	82.3	426.83	M <sub>Ed</sub> < 0	n/a	#1
2	tE Storage	P	below	87.4	2610.30	543.37	4.80	
3	tB Storage/Erection	P	top	82.3	426.83	64.22	6.65	#1
4	tE Storage/Erection	P	below	87.4	2610.30	M <sub>Ed</sub> < 0	n/a	
5	tE Utilization	P	top	89.0	588.56	M <sub>Ed</sub> < 0	n/a	
6	tE Utilization	P	below	86.9	2637.16	1471.73	1.79	

#1: f<sub>ck</sub>(t) = 0.73 \* f<sub>ck</sub>

## Interim results : Ultimate elongation and internal forces

L.	ε <sub>c</sub> [%]	ε <sub>s</sub> [‰]	x [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	Z <sub>p</sub> [kN]	Z <sub>s</sub> [kN]	D <sub>c</sub> [kN]	D <sub>p</sub> [kN]	D <sub>s</sub> [kN]
1	3.500	3.100	58.2	0.0	12.6	0.0	546.9	1848.1	-1436.5	166.9
2	3.500	16.300	19.4	20.5	4.0	2871.2	178.9	2643.2	0.0	366.7
3	3.500	3.100	58.2	0.0	12.6	0.0	546.9	1848.1	-1436.5	166.9
4	3.500	16.300	19.4	20.5	4.0	2871.2	178.9	2643.2	0.0	366.7
5	3.500	6.700	37.7	0.0	12.6	0.0	549.4	1641.4	-1223.8	164.0
6	3.500	16.300	19.4	20.5	4.0	2862.7	178.7	2643.2	0.0	451.2

## Shear resistance

## Design value shear force

L.	Creep period	Combination	V <sub>Ed,0</sub> [kN]	M <sub>Ed</sub> [kNm]	dV [kN]	due to
1	tB Storage	QMax	133.8	543.35	-30.8	V <sub>ccd</sub>
2	tE Storage	QMax	133.8	543.35	-30.8	V <sub>ccd</sub>
3	tB Storage/Erection	QMax	134.5	-64.22	0.0	-----
4	tE Storage/Erection	QMax	134.5	-64.22	0.0	-----
5	tB Utilization	QMax	356.2	1471.72	-83.8	V <sub>ccd</sub>
6	tE Utilization	QMax	356.2	1471.72	-83.8	V <sub>ccd</sub>

## Effective cross-section

L.	Cross-section	Tens-zone	b <sub>w</sub> [cm]	d [cm]	z [cm]	A <sub>c</sub> [cm <sup>2</sup> ]	A <sub>sl</sub> [cm <sup>2</sup> ]	σ <sub>cp</sub> [N/mm <sup>2</sup> ]	V <sub>Rdc</sub> [kN]
1	P	below	19.0	110.0	87.4	2940.8	24.5	4.86	277.2
2	P	below	19.0	110.0	87.4	2940.8	24.5	5.40	308.1
3	P	top	19.0	104.2	82.3	2940.8	12.6	4.86	241.5
4	P	top	19.0	104.2	82.3	2940.8	12.6	5.40	268.4
5	P	below	19.0	110.0	86.9	2940.8	24.5	5.40	308.1
6	P	below	19.0	110.0	86.9	2940.8	24.5	4.06	266.3

x0IZ: tensile zone in state I due to cracking forces

**Ductility reinforcement in precompressed tensile zone:**

b [cm <sup>3</sup> ]	f <sub>ctm</sub> [N/mm <sup>2</sup> ]	Zs [cm]	req. As [cm <sup>2</sup> ]	exist. As [cm <sup>2</sup> ]
19	4.07	110.0	4.4	4.0

**Stress checks SLS**

Concrete edge stresses in state I due to prestress, creep, shrinkage and relaxation				
L.	due to	σ <sub>R</sub> Precast		
		top [N/mm <sup>2</sup> ]	bottom [N/mm <sup>2</sup> ]	
1	Prestr. release anchorage	4.24	-22.16	
2	csr storage	-0.13	1.76	
3	csr utilisation	0.43	2.86	

Tab. Compr stresses of concrete						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>c</sub> Precast		
				Cc,Pk [N/mm <sup>2</sup> ]	Qc,Pk [N/mm <sup>2</sup> ]	
1	tB Storage	P	--	-15.31	-15.31	
2	tE Storage	P	--	-13.56	-13.56	
3	tB Storage/Erection	P	--	-27.31*		
4	tE Storage/Erection	P	--	-22.83		
5	tB Utilization	P	+-	-8.74	-6.26	
6	tE Utilization	P	+-	-8.31	-5.83	

Tab. Steel- and Concrete tension stress						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>p</sub> Cc,Pm [N/mm <sup>2</sup> ]	σ <sub>s</sub> Cc,Pk [N/mm <sup>2</sup> ]	σ <sub>t</sub> Cc,Pk [N/mm <sup>2</sup> ]
1	tB Storage	P	+-	900.09	< 0	ZII
2	tE Storage	P	+-	849.73	< 0	ZII
3	tB Storage/Erection	P	---	899.12	87.38	ZII
4	tE Storage/Erection	P	---	820.77	84.68	ZII
5	tB Utilization	P	++	881.60	< 0	ZII
6	tE Utilization	P	+++	779.85	< 0	1.77

Pk= Prestres char. value, Pm= prestress mean value, StII: State II

**Selected section x = 0.08 m from left support**

Internal force combinations from external loading

LAC: dominant variable action (leading action)

ULS-PT : permanent + transient design situation (fundam. combination)

SLS-Cc : characteristic combination

SLS-Fc : frequent combination

SLS-Qc : quasi-permanent combination

**maximum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	13.29	9.83	9.83	9.83
Storage/Erection	-0.17	-0.17	-0.17	-0.17
Utilization	36.70	28.27	23.78	22.75
LAc	10	10	10	-

**Minimum moment : [kNm]**

	ULS-PT	SLS-Cc	SLS-Fc	SLS-Qc
Storage	9.80	9.83	9.83	9.83
Storage/Erection	-0.23	-0.17	-0.17	-0.17
Utilization	22.73	22.75	22.75	22.75
LAc	-	-	-	-

**maximum shear force:[kN]**

	ULS-PT
Storage	166.7
Storage/Erection	-2.0
Utilization	458.5
LAc	10

**Effective Tendons ( prestressed formwork state for t = t0 (sto))**

Layer No.	No.	Area Ap [cm²]	Distance f.bottom [cm]	Prestress		tens.force		Shorttime Relaxation [N/mm²]
				max [N/mm²]	min [N/mm²]	max [kN]	min [kN]	
1	3	2.8	8.5	247.68	152.10	69.1	42.4	-0.05
2	3	2.8	12.3	247.68	152.10	69.1	42.4	-0.05
3	3	2.8	16.1	247.68	152.10	69.1	42.4	-0.05
4	3	2.8	19.9	247.68	152.10	69.1	42.4	-0.05
5	3	2.8	23.7	247.68	152.10	69.1	42.4	-0.05
6	3	2.8	27.5	247.68	152.10	69.1	42.4	-0.05
7	3	2.8	31.3	247.68	152.10	69.1	42.4	-0.05
8	1	0.9	35.1	247.68	152.10	23.0	14.1	-0.05

 $\Delta\sigma(Tt0) = -39 \text{ N/mm}^2$  due to heat treatment

**Untensioned reinforcement**

Layer	Number	Diameter [mm]	Area [cm²]	LE [cm]
1	2	16	4.0	3.6
2	2	20	6.3	81.1
3	2	20	6.3	92.3

**Cross-section Precast :**

Layer of cross-section from top to bottom			
Nr	Width [cm]	Distance [cm]	Remarks
1	60.0	0.0	
2	60.0	15.0	
3	19.0	23.2	Web begin
4	19.0	96.1	Web end

**Cross-section Values**

	brutto			ideal		
	Ac [cm²]	zu [cm]	lc [cm⁴]	Ai [cm²]	zi [cm]	li [cm⁴]
Precast cross-section	2609.7	59.6	2239971	2770.2	58.5	2496523

**Internal forces from prestress (mean values, prestressed formwork state)**

Creep period	N <sub>pm</sub> <sup>(0)</sup>		M <sub>pm</sub> <sup>(0)</sup>	
	tB [kN]	tE [kN]	tB [kNm]	tE [kNm]
Storage	-506.7	-240.7	-192.30	-101.51
Utilization	-391.9	-25.8	-165.30	-57.77

tA=Begin, tE=End creep period

Prestress steel relaxation		
Lay. No.	Storage $\Delta\sigma_{p,r1}$ [N/mm²]	Utilization $\Delta\sigma_{p,r2}$ [N/mm²]
1	-0.00	-0.50
2	-0.00	-0.51
3	-0.00	-0.52
4	-0.00	-0.53
5	-0.00	-0.53
6	-0.00	-0.54

Prestress steel relaxation		
Lay. No.	Storage $\Delta\sigma_{p,r1}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,r2}$ [N/mm <sup>2</sup> ]
7	-0.00	-0.55
8	-0.00	-0.55

Prestr. steel, losses due to creeping, shrinking and relaxation:		
Lay. No.	Storage $\Delta\sigma_{p,csr1(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{p,csr2(0)}$ [N/mm <sup>2</sup> ]
1	-36.33	-102.24
2	-35.67	-101.24
3	-35.02	-100.25
4	-34.37	-99.25
5	-33.71	-98.26
6	-33.06	-97.26
7	-32.41	-96.27
8	-31.75	-95.27

Stress in rebars due to creeping,shrinking and relaxation:		
Lay. No.	Storage $\Delta\sigma_{s,csr1(0)}$ [N/mm <sup>2</sup> ]	Utilization $\Delta\sigma_{s,csr2(0)}$ [N/mm <sup>2</sup> ]
1	-38.12	-105.77
2	-24.44	-84.82
3	-22.46	-81.80

**Bending with Normal Force ULS**

L.	Creep period	Cross-section	Tens-zone	z [cm]	M <sub>Rd</sub> [kNm]	M <sub>Ed</sub> [kNm]	η (>1.0)	
1	tB Storage	P	top	66.6	504.73	M <sub>Ed</sub> < 0	n/a	#1
2	tE Storage	P	below	69.0	2032.94	13.29	152.91	
3	tB Storage/Erection	P	top	66.6	504.73	0.23	2177.81	#1
4	tE Storage/Erection	P	below	69.0	2032.94	M <sub>Ed</sub> < 0	n/a	
5	tB Utilization	P	top	60.7	542.47	M <sub>Ed</sub> < 0	n/a	
6	tE Utilization	P	below	69.1	2017.85	36.70	54.98	

#1: fck(t)= 0.73 \* fck

Interim results : Ultimate elongation and internal forces										
L.	ε <sub>c</sub> [%o]	ε <sub>s</sub> [%o]	x [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	Z <sub>p</sub> [kN]	Z <sub>s</sub> [kN]	D <sub>c</sub> [kN]	D <sub>p</sub> [kN]	D <sub>s</sub> [kN]
1	3.500	10.300	23.4	9.3	12.6	338.5	553.0	743.6	-35.3	166.8
2	3.500	13.500	19.1	20.5	4.0	2769.6	178.1	2597.6	0.0	355.4
3	3.500	10.300	23.4	9.3	12.6	338.5	553.0	743.6	-35.3	166.8
4	3.500	13.500	19.1	20.5	4.0	2769.6	178.1	2597.6	0.0	355.4
5	3.500	12.500	20.2	9.3	12.6	433.0	554.8	880.3	-56.0	163.7
6	3.500	14.300	18.2	20.5	4.0	2772.7	178.2	2492.6	0.0	399.4

**Shear resistance**

Design value shear force						
L.	Creep period	Combination	V <sub>Ed,0</sub> [kN]	M <sub>Ed</sub> [kNm]	dV [kN]	due to
1	tB Storage	QMax	166.7	13.27	-1.0	V <sub>ccd</sub>
2	tE Storage	QMax	166.7	13.27	-1.0	V <sub>ccd</sub>
3	tB Storage/Erection	QMax	-2.0	-0.23	0.0	-----
4	tE Storage/Erection	QMax	-2.0	-0.23	0.0	-----
5	tB Utilization	QMax	458.5	36.68	-2.6	V <sub>ccd</sub>
6	tE Utilization	QMax	458.5	36.68	-2.6	V <sub>ccd</sub>



Effective cross-section									
L.	Cross-section	Tens-zone	b <sub>w</sub> [cm]	d [cm]	z [cm]	A <sub>c</sub> [cm <sup>2</sup> ]	A <sub>sl</sub> [cm <sup>2</sup> ]	σ <sub>cp</sub> [N/mm <sup>2</sup> ]	V <sub>Rdc</sub> [kN]
1	P	below	19.0	92.5	69.0	2609.7	24.5	1.75	160.5
2	P	below	19.0	92.5	69.0	2609.7	24.5	0.83	149.0
3	P	top	19.0	86.7	66.6	2609.7	12.6	1.75	131.9
4	P	top	19.0	86.7	66.6	2609.7	12.6	0.83	119.0
5	P	below	19.0	92.5	69.1	2609.7	24.5	1.35	162.8
6	P	below	19.0	92.5	69.1	2609.7	24.5	0.09	129.5

Shear design v1= 0.480

Check V<sub>Rd,s</sub> not requ., asw und CotΘ from the last construction phase

L.	V <sub>Ed</sub> [kN]	V <sub>Ed,red</sub> [kN]	a <sub>cw</sub>	cot Θ	asw [cm <sup>2</sup> /m]	Note	a <sub>l</sub> [cm]	V <sub>Rd,max</sub> [kN]	
1	165.8	165.8	1.072	2.492	1.83	Var	86.2	604.5	#1
2	165.8	165.8	1.025	2.127	2.15	Var	86.2	827.6	
3	2.0	2.0	1.072	1.000	1.83	Min	43.4	844.4	#1
4	2.0	2.0	1.025	1.000	2.15	Min	43.4	1037.7	
5	455.9	455.9	1.041	2.500	5.00	Var	86.4	753.7	
6	455.9	455.9	1.003	2.500	5.00	Var	86.4	726.3	

#1: f<sub>ck</sub>(t)= 0.73 \* f<sub>ck</sub>

### Check of crack width limit in SLS

perm. crack width: w<sub>k</sub> < 0.20 mm, Frequent load combination

L.	Creep period	Cross-section	Tens-zone	r <sub>sup</sub> r <sub>inf</sub>	max. σ <sub>s</sub> [N/mm <sup>2</sup> ]	S <sub>r,max</sub> [mm]	ε <sub>sm</sub> -ε <sub>cm</sub> [‰]	w <sub>k</sub> [mm]
1	tB Storage	P	top	1.00	no cracks			
2	tE Storage	P	below	1.00	CS completely compressed			
3	tB Storage/Erection	P	top	1.00	no cracks			
4	tE Storage/Erection	P	below	1.00	CS completely compressed			
5	tB Utilization	P	top	1.00	no cracks			
6	tE Utilization	P	below	1.00	CS completely compressed			

### Internal forces and elongation

L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. σ [N/mm <sup>2</sup> ]	X <sub>0I</sub> [cm]	φ <sub>eff</sub>	ε <sub>c</sub> [‰]	X <sub>0II</sub> [cm]
1	-506.7	-182.47	0.92	83.6			
2	-240.7	-91.68	-3.02	82.2			
3	-506.7	-192.47	1.07	82.3			
4	-240.7	-101.68	-3.25	79.9			
5	-391.9	-142.54	0.73	83.3			
6	-25.8	-33.99	-0.89	65.4			

X<sub>0I</sub>: Pressure zone height in state I X<sub>0II</sub>: Pressure zone height in state II

L.	h <sub>c,ef</sub> [cm]	A <sub>ceff</sub> [cm <sup>2</sup> ]	ξ <sub>1</sub>	A <sub>p</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	ρ <sub>p,ef</sub> [%]	ρ <sub>tot</sub> [%]	k <sub>1</sub>	k <sub>2</sub>	k <sub>3</sub>	c [cm]	k <sub>4</sub>
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### Crack forces and strains (State II)

L.	N <sub>ges</sub> [kN]	M <sub>ges</sub> [kNm]	State I		State II		
			max. σ [N/mm <sup>2</sup> ]	X <sub>0I</sub> [cm]	φ <sub>eff</sub>	ε <sub>c</sub> [‰]	X <sub>0II</sub> [cm]

X<sub>0I</sub>: Pressure zone height in state I X<sub>0II</sub>: Pressure zone height in state II

### Minimum reinforcement for crack control:

L.	Creep period	Cross-section	Tens-zone	r <sub>sup</sub> r <sub>inf</sub>	σ <sub>t</sub> [N/mm <sup>2</sup> ]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
1	tB Storage	P	top	1.00	1.88	< 4.07	not req.
2	tE Storage	P	below	1.00	-3.02	< 4.07	not req.
3	tB Storage/Erection	P	top	1.00	2.03	< 4.07	not req.
4	tE Storage/Erection	P	below	1.00	-3.25	< 4.07	not req.
5	tB Utilization	P	top	1.00	2.05	< 4.07	not req.
6	tE Utilization	P	below	1.00	-0.78	< 4.07	not req.

L.	D [mm]	x0IZ [cm]	A <sub>p</sub> [cm <sup>2</sup> ]	ξ <sub>1</sub>	Web				Flange			
					k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]	k	k <sub>c</sub>	A <sub>ct</sub> [cm <sup>2</sup> ]	A <sub>s</sub> [cm <sup>2</sup> ]
x0IZ: tensile zone in state I due to cracking forces												

**Ductility reinforcement in precompressed tensile zone:**

b [cm <sup>3</sup> ]	f <sub>ctm</sub> [N/mm <sup>2</sup> ]	Z <sub>s</sub> [cm]	req. A <sub>s</sub> [cm <sup>2</sup> ]	exist. A <sub>s</sub> [cm <sup>2</sup> ]
19	4.07	92.5	3.7	4.0

**Stress checks SLS**

Concrete edge stresses in state I due to prestress, creep, shrinkage and relaxation			
L.	due to	σ <sub>R</sub> Precast	
		top [N/mm <sup>2</sup> ]	bottom [N/mm <sup>2</sup> ]
1	Prestr. release anchorage	1.07	-6.34
2	csr storage	0.01	1.05
3	csr utilisation	0.19	2.93

Tab. Compr stresses of concrete						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>c</sub> Precast		
				Cc,Pk [N/mm <sup>2</sup> ]	Qc,Pk [N/mm <sup>2</sup> ]	
1	tB Storage	P	--	-6.11	-6.11	
2	tE Storage	P	--	-5.06	-5.06	
3	tB Storage/Erection	P	--	-6.34		
4	tE Storage/Erection	P	--	-5.29		
5	tB Utilization	P	--	-4.76	-4.76	
6	tE Utilization	P	--	-1.82	-1.82	

Tab. Steel- and Concrete tension stress						
L.	Creep period	Cross-section	M <sub>Ed</sub> + = Max - = Min	σ <sub>p</sub> Cc,Pm [N/mm <sup>2</sup> ]	σ <sub>s</sub> Cc,Pk [N/mm <sup>2</sup> ]	σ <sub>t</sub> Cc,Pk [N/mm <sup>2</sup> ]
1	tB Storage	P	---	229.01	3.47	0.92
2	tE Storage	P	+-	105.20	< 0	0.93
3	tB Storage/Erection	P	---	228.51	4.20	1.07
4	tE Storage/Erection	P	+-	104.70	< 0	1.08
5	tB Utilization	P	++	201.69	< 0	0.73
6	tE Utilization	P	++	21.02	< 0	0.92

Pk= Prestres char. value, Pm= prestress mean value, Still: State II

**Lateral buckling (Stiglat)**

Safety in installed state  $\eta = 1.69 < 2.00$   
 Design buckling moment:  $M_{kipp} = 4657.51 \text{ kNm}$   
 existing moment :  $M_{Ed} = 2763.72 \text{ kNm}$  without prestress  
 Combination of characteristic values

Interim values acc. to 'Beton- und Stahlbetonbau' 1985, H. 9,10,11

$E_{cm} = 37000 \text{ N/mm}^2$        $G_{cm} = 14800 \text{ N/mm}^2$       It, Iy averaged  
 $I_t = 208188 \text{ cm}^4$        $I_y = 394505 \text{ cm}^4$       acc.to Rafla  
 $I_x = 11379011 \text{ cm}^4$        $A_k = 4664.5 \text{ MN}^2\text{cm}^4$       (It 60% as C.II)  
 $h_c = 1.58 \text{ m}$        $\beta_1 = 0.000$        $\beta_2 = 0.003$   
 $k_1 = 3.540$        $k_2 = 1.000$        $k_3 = 0.920$   
 $M_k = 7415.48 \text{ kNm}$        $W_{x0} = 123859 \text{ cm}^3$        $x = 10.10 \text{ m}$   
 $\sigma_B = 52.87 \text{ N/mm}^2$        $\sigma_T = 33.21 \text{ N/mm}^2$        $\lambda_v = 83.1$   
 (σT acc. eq.62calculated !)

a potentially nessecary reinforcement for torsion is not determined in the program

**Lateral buckling check in erection state (acc. to Stiglat)**

Height of left attachment point about LE beam  
 left Hmh = 114.0 cm      right Hmh = 114.0 cm

**Erection with lifting beam**

Lateral buckling safety  $\eta = 4.29 > 2.50$   
 Design buckling moment:  $M_{kipp} = 2343.70 \text{ kNm}$   
 existing moment :  $M_{Ed} = 546.29 \text{ kNm}$  without prestress

Interim values acc. to 'Beton- und Stahlbetonbau' 1985, H. 9,10,11

$\beta_4 = 0.000$   $\delta = 0.000$   $\gamma = 1.000$   
 $f = 0.331 \text{ m}$   $A_k = 4664.5 \text{ MN}^2\text{cm}^4$   $p = 0.752$   
 $j(\alpha) = 0.095$   $\alpha = 1.478$   $q_{kl} = 47.76 \text{ kN/m}$   
 $W_{xo} = 148769 \text{ cm}^3$   $M_k = 2700.05 \text{ kNm}$   $x = 16.83 \text{ m}$   
 $\sigma_B = 18.15 \text{ N/mm}^2$   $\sigma_T = 15.75 \text{ N/mm}^2$   $\lambda_v = 141.8$

**Anchorage by bond ( over the left bearing)**

$\eta_{P2} = 1.20$   
 good bond  $\eta_1 = 1.00$   
 $l_{pt2} = 1.20 \text{ m}$   $f_{bpd} = 2.28 \text{ N/mm}^2$   
 Distance first bending crack  
 below  $l_{r,u} = 3.37 \text{ m}$

**Resisting tens force bot**

x [m]	$Z_p$ [kN]	$Z_s$ [kN]	$T_{Ed}$ [kN]	$\eta = (Z_p + Z_s) / T_{Ed}$	Util
0.20	523.2	178.1	691.7	1.01	0.99
0.40	1046.5	178.0	799.3	1.53	0.65
0.60	1569.7	178.0	901.1	1.94	0.52
0.80	2093.0	178.0	1007.5	2.25	0.44
1.00	2616.2	178.1	1101.6	2.54	0.39
1.20	2831.2	178.2	1185.0	2.54	0.39
1.40	2832.3	178.2	1268.4	2.37	0.42
1.60	2833.2	178.2	1351.7	2.23	0.45
1.80	2834.1	178.2	1435.1	2.10	0.48
1.85	2834.3	178.2	1456.0	2.07	0.48
2.00	2845.5	178.4	1518.5	1.99	0.50

$Z_p$ : resisting tensile force by the prestressed steel

$Z_s$ : resisting tensile force by the rebars

$T_{Ed}$ : tensile force to be anchored

No. Lay.	Dist.LE [cm]	XA [m]	$\sigma_p$ [N/mm <sup>2</sup> ]	Eq.	$l_{bpd}$ [m]	$x_k$ [m]	$\Sigma Z_p$ [kN]	$\Sigma Z_s$ [kN]	$T_{Ed}$ [kN]	add. As [cm <sup>2</sup> ]	
1	8.5	0.00	619.00	8.21	2.15						(PT)
2	12.3	0.00	629.03	8.21	2.14						(PT)
3	16.1	0.00	639.06	8.21	2.13						(PT)
4	19.9	0.00	649.09	8.21	2.12						(PT)
5	23.7	0.00	659.11	8.21	2.11						(PT)
6	27.5	0.00	669.13	8.21	2.10						(PT)
7	31.3	0.00	679.15	8.21	2.09						(PT)
8	35.1	0.00	689.17	8.21	2.08						(PT)

XA: Beginning of the anchoring area of the steel layer (dist. from the corresp. binder side)

Eq. 8.21.1: Anchorage area uncracked,  $\sigma_p$  acc.to fig. 8.17DE (b)

Eq. 8.21.1: Anchorage area cracked,  $\sigma_p$  acc.to fig. 8.17DE (b)

$x_k$ : decisive section in the anchoring area of the layer (distance from the beginning of the binder)

add. As: Additional sagging reinforcement required for anchorage

**Anchorage by bond ( over the right bearing)**

$\eta_{P2} = 1.20$   
 good bond  $\eta_1 = 1.00$   
 $l_{pt2} = 1.20 \text{ m}$   $f_{bpd} = 2.28 \text{ N/mm}^2$   
 Distance first bending crack  
 below  $l_{r,u} = 3.37 \text{ m}$

**Resisting tens force bot**

x [m]	Z <sub>p</sub> [kN]	Z <sub>s</sub> [kN]	T <sub>Ed</sub> [kN]	$\eta = \frac{Z_p + Z_s}{T_{Ed}}$	Util
28.30	2845.5	178.4	1518.5	1.99	0.50
28.45	2834.3	178.2	1456.0	2.07	0.48
28.50	2834.1	178.2	1435.1	2.10	0.48
28.70	2833.2	178.2	1351.7	2.23	0.45
28.90	2832.3	178.2	1268.4	2.37	0.42
29.10	2831.2	178.2	1185.0	2.54	0.39
29.30	2616.2	178.1	1101.6	2.54	0.39
29.50	2093.0	178.0	1007.5	2.25	0.44
29.70	1569.7	178.0	901.1	1.94	0.52
29.90	1046.5	178.0	799.3	1.53	0.65
30.10	523.2	178.1	691.7	1.01	0.99

 Z<sub>p</sub>: resisting tensile force by the prestressed steel

 Z<sub>s</sub>: resisting tensile force by the rebars

 T<sub>Ed</sub>: tensile force to be anchored

No. Lay.	Dist.LE [cm]	XA [m]	$\sigma_p$ [N/mm <sup>2</sup> ]	Eq.	l <sub>bpd</sub> [m]	xk [m]	$\Sigma Z_p$ [kN]	$\Sigma Z_s$ [kN]	T <sub>Ed</sub> [kN]	add. As [cm <sup>2</sup> ]	
1	8.5	0.00	619.00	8.21	2.15						(PT)
2	12.3	0.00	629.03	8.21	2.14						(PT)
3	16.1	0.00	639.06	8.21	2.13						(PT)
4	19.9	0.00	649.09	8.21	2.12						(PT)
5	23.7	0.00	659.11	8.21	2.11						(PT)
6	27.5	0.00	669.13	8.21	2.10						(PT)
7	31.3	0.00	679.15	8.21	2.09						(PT)
8	35.1	0.00	689.17	8.21	2.08						(PT)

XA: Beginning of the anchoring area of the steel layer (dist. from the corresp. binder side)

 Eq. 8.21.1: Anchorage area uncracked,  $\sigma_p$  acc.to fig. 8.17DE (b)

 Eq. 8.21.1: Anchorage area cracked,  $\sigma_p$  acc.to fig. 8.17DE (b)

xk: decisive section in the anchoring area of the layer (distance from the beginning of the binder)

add. As: Additional sagging reinforcement required for anchorage

**Bursting Reinforcement at beginning of beam**

$$\gamma_{p,unfav} = 1.20 \quad l_{disp} = 1.35 \text{ m}$$

Initiation zone			Section over the last effective position of tension. member						
No.	from [m]	to [m]	Dist.LE [cm]	N <sub>c</sub> [kN]	N <sub>p</sub> [kN]	T <sub>p</sub> [kN]	Factor Interpolation	req. As [cm <sup>2</sup> ]	
1	0.00	1.35	36.1	-1286.3	1762.0	475.8	0.406	5.3	

The bursting reinforcement must be arranged in zone of reduced dispersion length.

 red. dispersion length indented wire w.o. strand 3/4\*I<sub>disp</sub>=1.02 m

**Bursting Reinforcement at end of beam**

$$\gamma_{p,unfav} = 1.20 \quad l_{disp} = 1.35 \text{ m}$$

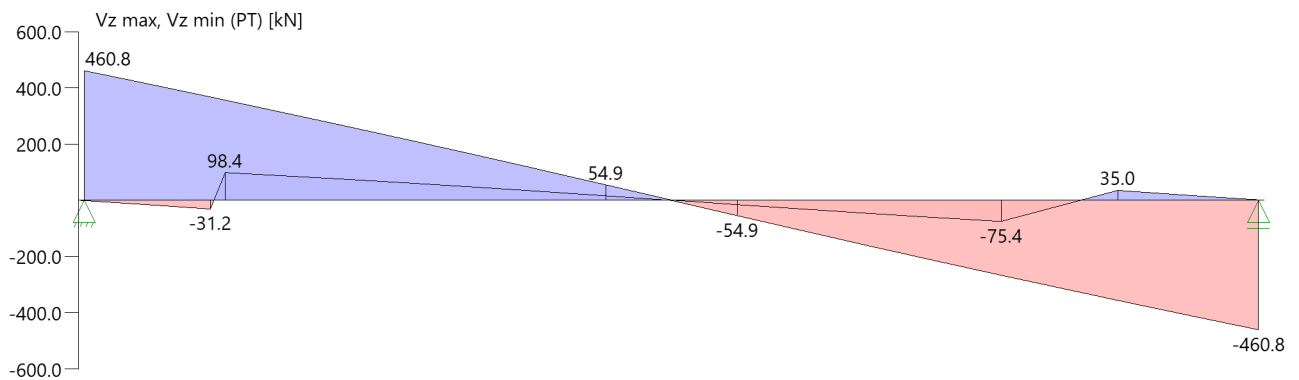
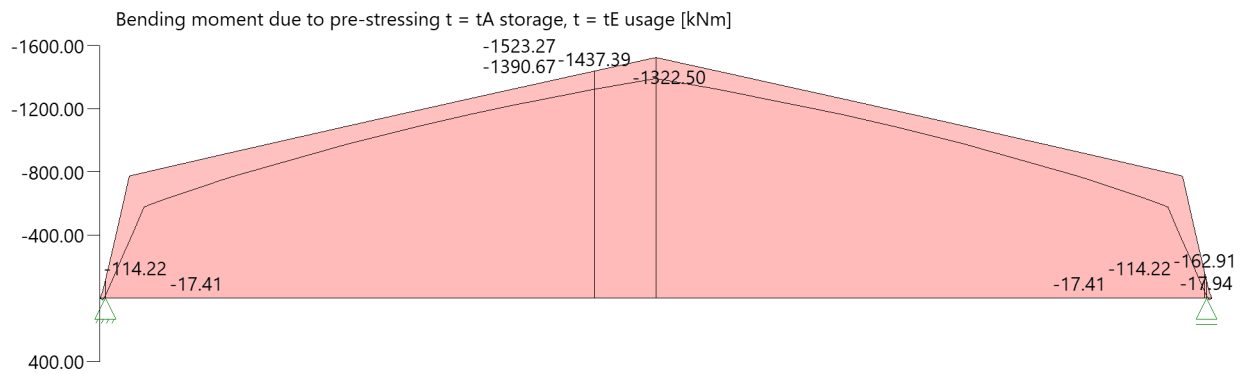
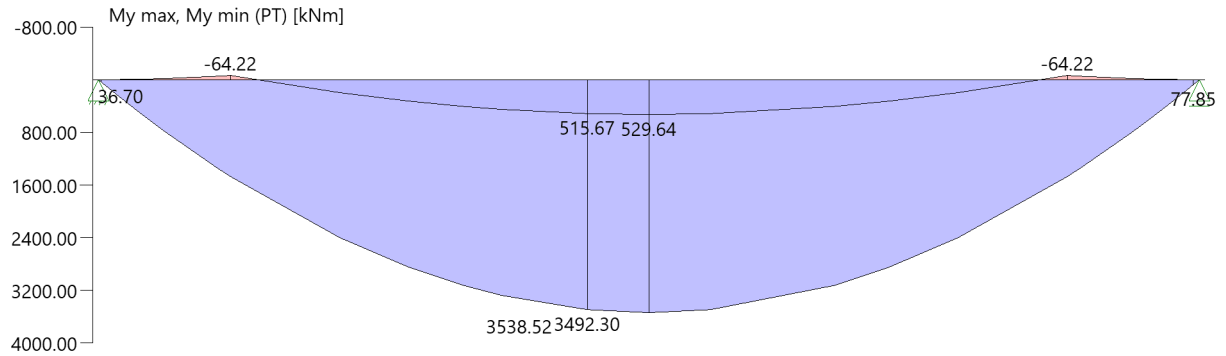
Initiation zone			Section over the last effective position of tension. member						
No.	from [m]	to [m]	Dist.LE [cm]	N <sub>c</sub> [kN]	N <sub>p</sub> [kN]	T <sub>p</sub> [kN]	Factor Interpolation	req. As [cm <sup>2</sup> ]	
1	30.30	28.95	36.1	-1286.3	1762.0	475.8	0.406	5.3	

The bursting reinforcement must be arranged in zone of reduced dispersion length.

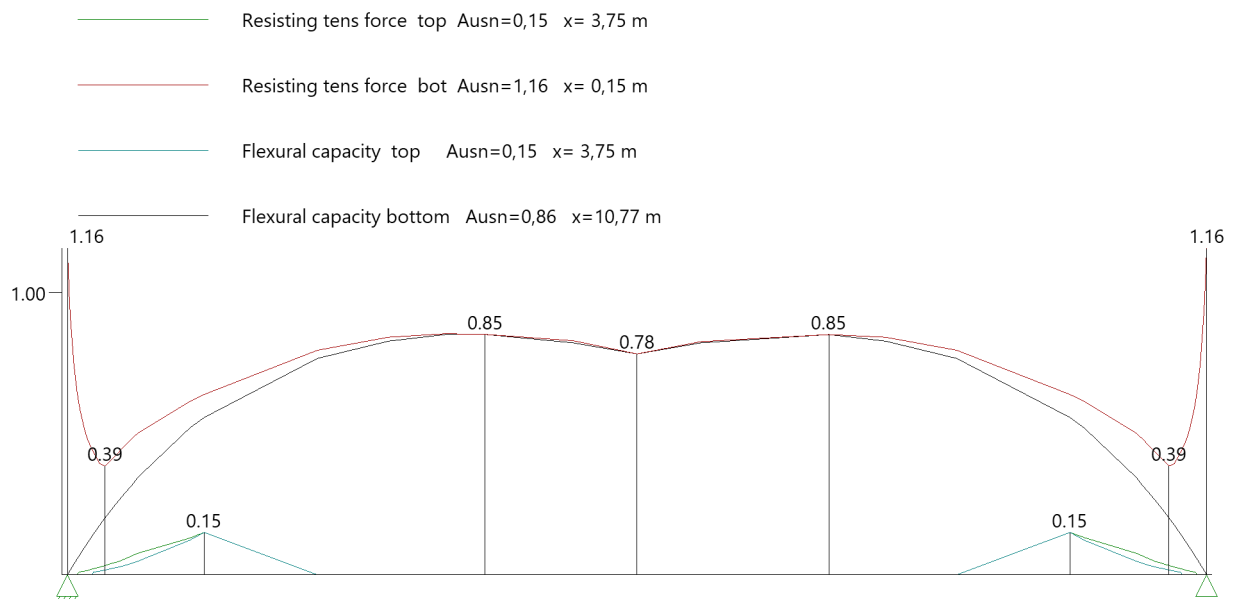
 red. dispersion length indented wire w.o. strand 3/4\*I<sub>disp</sub>=1.02 m

## Result graphics

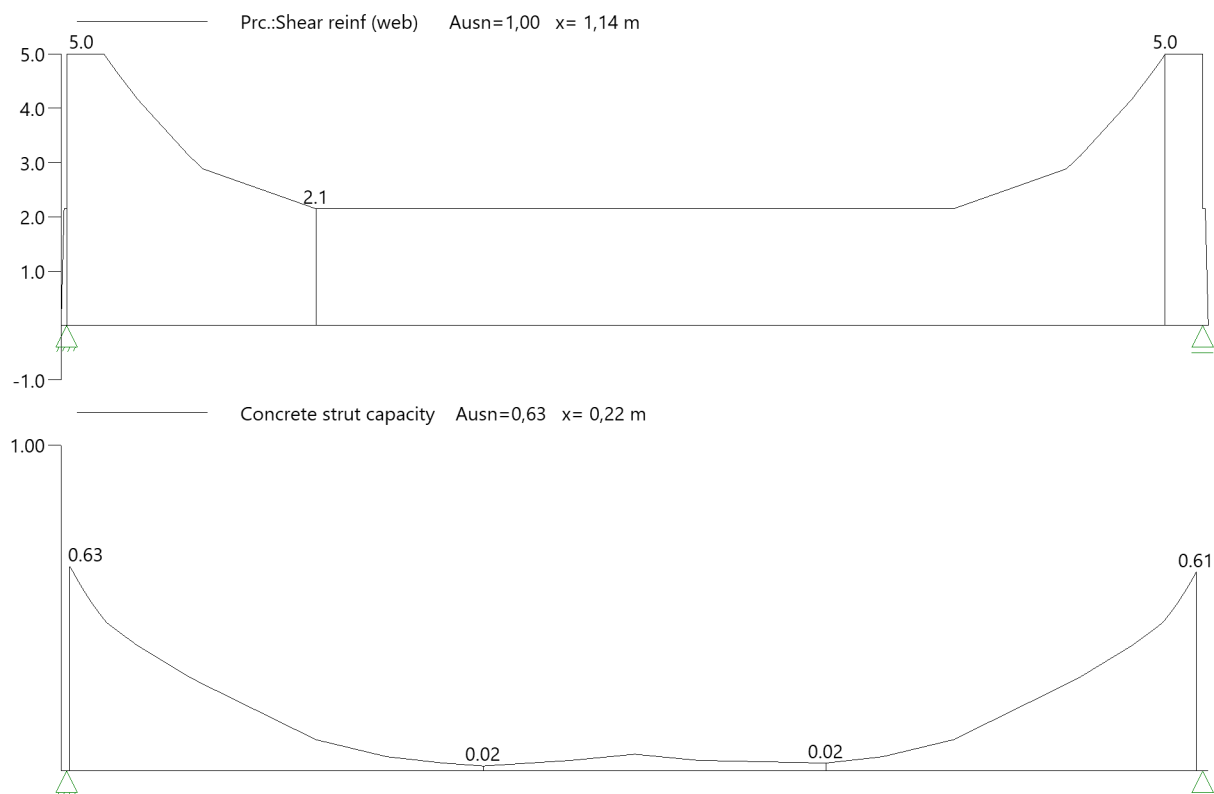
### Internal forces



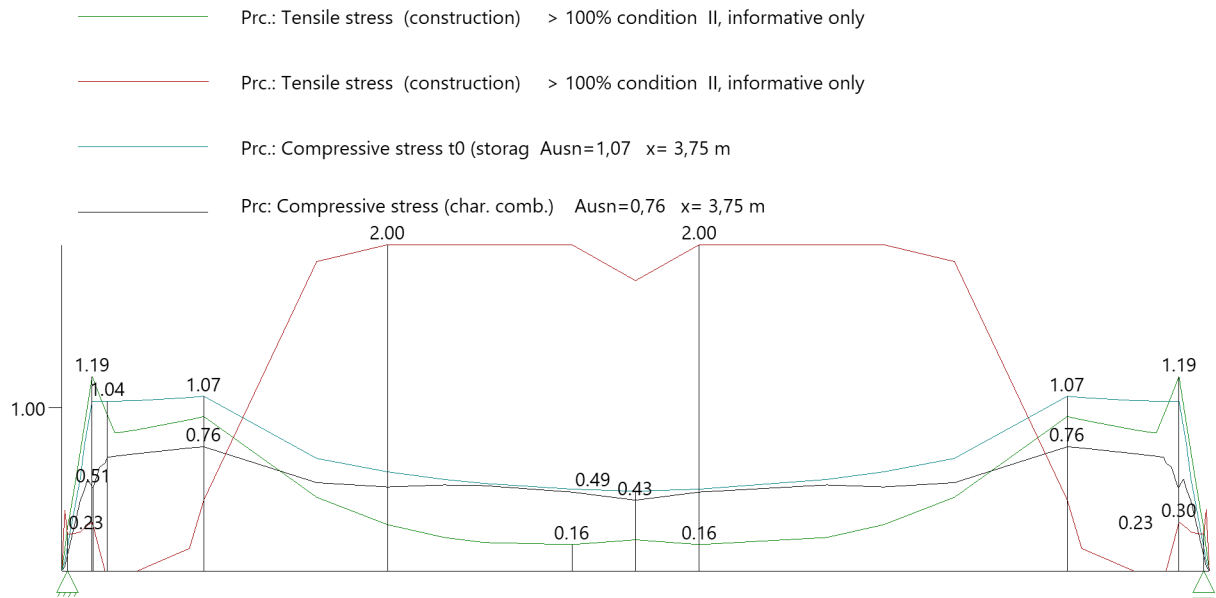
## Bearing Capacity



## Shear Reinforcement



## Concrete stress precast concrete



## Deflections

