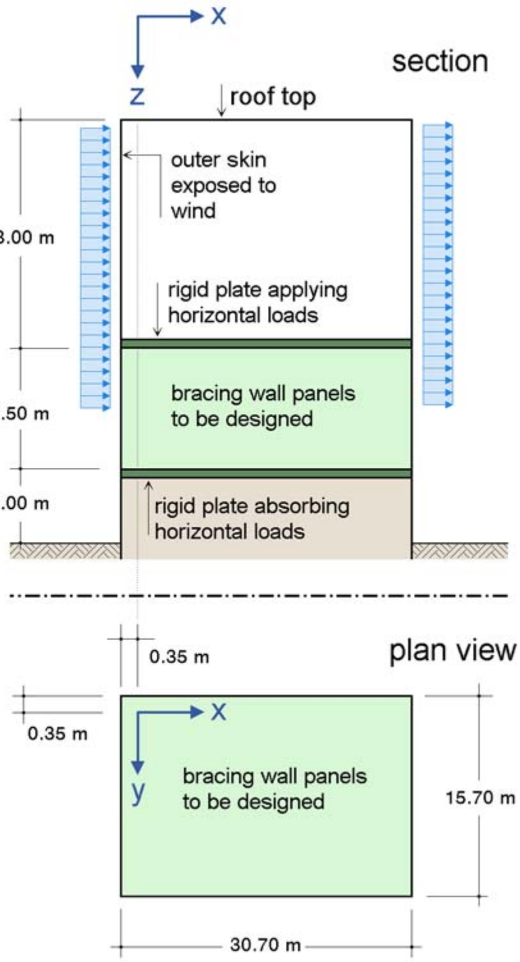
1. building model

1.1. system

principle sketch



roof shape: flat roof

estimation of the slab stiffness

to absorb the bending moments:	30 %
to absorb the vertical loads:	0 %
consideration of the warping force:	0 %

The stiffnesses of the wall plates against a horizontal zontale plate load are determined from:

concrete walls and masonry:

- ☑ bending deformation
- ☑ shear deformation

1.2. underlying standards

The calculation is based on **Eurocode** in conjunction with the national application document for **Deutschland**, the parameters of which are given in the annex to this document

short	long-term	reference
EC0	EN 1990:2010	load factors, superposition rules
EC1	EN 1991-1-4:2010	wind load calculation
EC2	EN 1992-1-1:2011	reinforced concrete verifications

for the theory of the formulas used, see: http://www.pcae.de/main/allgemeines/nachrichten/aussteifungen.pdf

2. wind loads

2.1. basic data

wind zone	2
height above NN	112 m
q_{ref}	0.39 kN/m²
soil roughness profile:	inland

$q(z) = 1.5\ q_{ref}$ *für* $z < 7\,m$

$q(z) = 1.7\ q_{ref} \left(\frac{z}{10}\right)^{0.37}$ *für* $7\,m < z < 50\,m$ $\Rightarrow$ $q(0) = 0.58$ kN/m²

$q(z) = 2.1\ q_{ref} \left(\frac{z}{10}\right)^{0.24}$ *für* $50\,m < z < 300\,m$ $q(h) = 0.88$ kN/m²

2.2. wind from the left

Calculation acc. to EC1-1-4 (5.2): integration of pressure coefficients

eights:		lengths:	char. values:
centre wall plates:	hu = 1.750 m	b = 15.700 m	h/d = 0.70 ≤ 5
total height:	h = 21.500 m	d = 30.700 m	

wind on vertical walls

external pressure coefficient acc. to EC1-1-4 Tab 7.1:
pressure (area D): $c_{pe,10(D)} = +0.76$; $q_D = c_{pe,10(D)}\ q(\zeta)$
suction (area E): $c_{pe,10(E)} = -0.42$; $q_E = c_{pe,10(E)}\ q(h)$

ζ runs upwards from the OK area; $\Delta R = 0.5\ (bu+bo)\ \Delta h\ q(\zeta)\ (q_D-q_E)$

from ζu	to ζo	Δh	bu	bo	$q(\zeta)$	q_D	q_E	ΔR	ζm	ΔM_0
m	m	m	m	m	kN/m²	kN/m²	kN/m²	kN	m	kNm
1.75	15.70	13.95	15.70	15.70	0.78	0.60	-0.37	211.38	8.72	1844.29
15.70	21.50	5.80	15.70	15.70	0.88	0.67	-0.37	94.57	18.60	1759.08

$R_{walls} = \Sigma(\Delta R) =$ **305.95 kN**
$M_{0,walls} = \Sigma(\Delta M_0) =$ **3603.38 kNm**

no horizontal load component from wind on roof area.
$R_{roof\ area} = M_{0,roof\ area} =$ **0**

sum					
	resulting horizontal force:	R_{total}	$= R_{walls} + R_{roof\ area}$	=	305.95 kN
	resulting moment:	$M_{0,total}$	$= M_{0,walls} + M_{0,roof\ area}$	=	3603.38 kNm
	effective height:	h_0	$= M_{0,total} / R_{total}$	=	11.78 m
	height (top wall plate):	h_W		=	3.50 m
	effective moment:	M_{total}	$= (h_0 - h_W)\ R_{total}$	=	2532.53 kNm

2.3. wind from the front

Calculation acc. to EC1-1-4 (5.2): integration of pressure coefficients

eights:			lengths:		char. values:
centre wall plates:	hu =	1.750 m	b =	30.700 m	$h/d = 1.37 \leq 5$
total height:	h =	21.500 m	d =	15.700 m	

wind on vertical walls

external pressure coefficient acc. to EC1-1-4 Tab 7.1:
pressure (area D): $c_{pe,10(D)} = +0.80$; $q_D = c_{pe,10(D)}\ q(\zeta)$
suction (area E): $c_{pe,10(E)} = -0.50$; $q_E = c_{pe,10(E)}\ q(h)$

ζ runs upwards from the OK area; $\Delta R = 0.5\ (bu+bo)\ \Delta h\ q(\zeta)\ (q_D - q_E)$

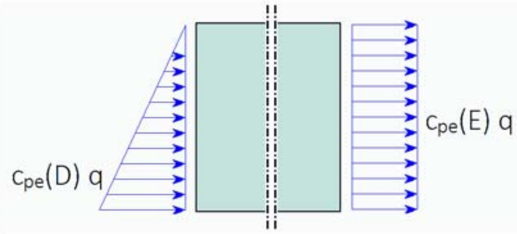
from ζu	to ζo	Δh	bu	bo	$q(\zeta)$	q_D	q_E	ΔR	ζm	ΔM_0
m	m	m	m	m	kN/m²	kN/m²	kN/m²	kN	m	kNm
1.75	21.50	19.75	30.70	30.70	0.88	0.70	-0.44	693.69	11.63	8064.13

$R_{walls} = \Sigma(\Delta R) =$ **693.69 kN**
$M_{0,walls} = \Sigma(\Delta M_0) =$ **8064.13 kNm**

no horizontal load component from wind on roof area.
$R_{roof\ area} = M_{0,roof\ area} = 0$

sum				
	resulting horizontal force:	R_{total}	$= R_{walls} + R_{roof\ area}$	= 693.69 kN
	resulting moment:	$M_{0,total}$	$= M_{0,walls} + M_{0,roof\ area}$	= 8064.13 kNm
	effective height:	h_0	$= M_{0,total} / R_{total}$	= 11.63 m
	height (top wall plate):	h_W		= 3.50 m
	effective moment:	M_{total}	$= (h_0 - h_W)\ R_{total}$	= 5636.22 kNm

2.4. compilation



According to EN 1991-1-4 par. 7.1.2, the eccentrically applied forces may be reduced by factor

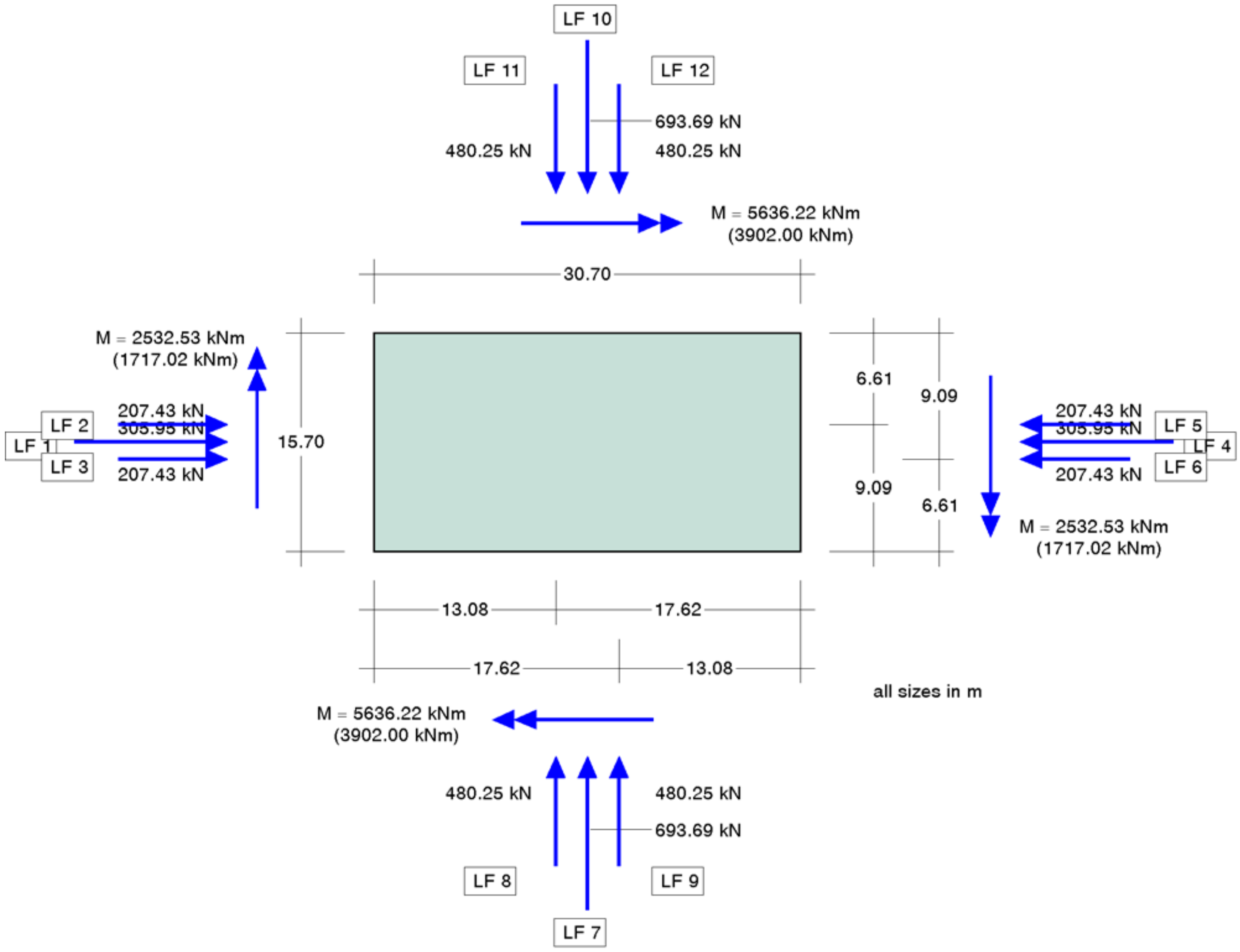
$$f_{red} = \frac{\frac{1}{2} c_{pe}(D) - c_{pe}(E)}{c_{pe}(D) - c_{pe}(E)}$$ as shown in the adjacent sketch.

wind from	h/d	$c_{pe}(D)$	$c_{pe}(E)$	f_{red}	R	R_{red}	M	M_{red}
-	-	-	-	-	kN	kN	kNm	kNm
left	0.700	0.76	-0.42	0.6780	305.95	207.43	2532.53	1717.02
right	0.700	0.76	-0.42	0.6780	305.95	207.43	2532.53	1717.02
front	1.369	0.80	-0.50	0.6923	693.69	480.25	5636.22	3902.00
back	1.369	0.80	-0.50	0.6923	693.69	480.25	5636.22	3902.00

The eccentricity is calculated acc. to EN 1991-1-4 par. 7.1.2
(b = reference length)

$$e = \frac{c_{pe}(D)}{6\ c_{pe}(D) - 12\ c_{pe}(E)}\ b \quad \Rightarrow ex = 2.27\ m, \quad ey = 1.24\ m$$

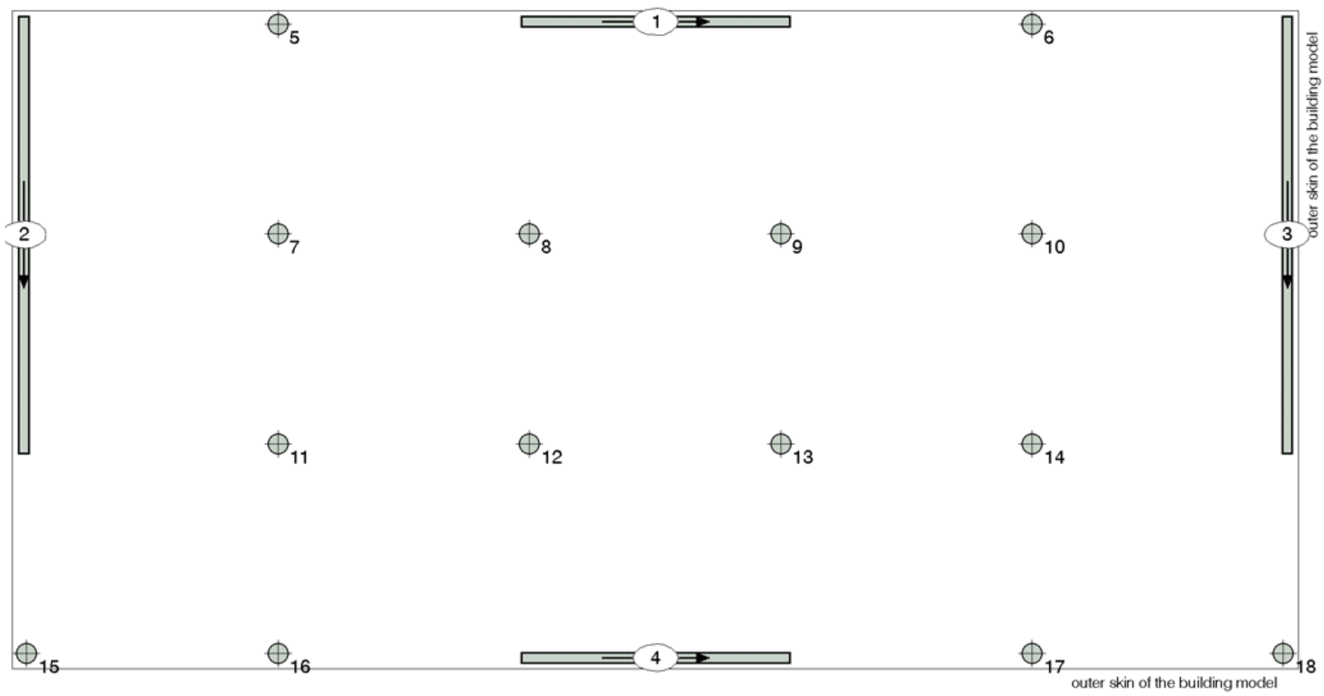
with the eccentricities acc. to EC1-1-4 par. 7.1.2 result 12 alternative wind load cases



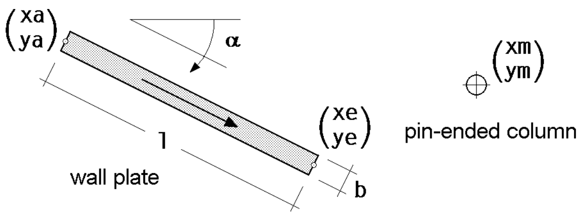
3. wall plates

3.1. protocol of the wall plates and columns

graphic display



protocol of the wall plates



Nr.	type	xa	ya	xe	ye	l	b	α
-	-	m	m	m	m	m	m	°
1	reinf.concwall	11.80	-0.08	18.20	-0.08	6.40	0.240	0.00
2	reinf.concwall	-0.08	-0.20	-0.08	10.20	10.40	0.240	90.00
3	reinf.concwall	30.08	-0.20	30.08	10.20	10.40	0.240	90.00
4	reinf.concwall	11.80	15.08	18.20	15.08	6.40	0.240	0.00

protocol of the pin-ended columns

Nr.	type	xm	ym	Nr.	type	xm	ym
-	-	m	m	-	-	m	m
5	reinf.conccolumn	6.00	0.00	12	reinf.conccolumn	12.00	10.00
6	reinf.conccolumn	24.00	0.00	13	reinf.conccolumn	18.00	10.00
7	reinf.conccolumn	6.00	5.00	14	reinf.conccolumn	24.00	10.00
8	reinf.conccolumn	12.00	5.00	15	reinf.conccolumn	0.00	15.00
9	reinf.conccolumn	18.00	5.00	16	reinf.conccolumn	6.00	15.00
10	reinf.conccolumn	24.00	5.00	17	reinf.conccolumn	24.00	15.00
11	reinf.conccolumn	6.00	10.00	18	reinf.conccolumn	30.00	15.00

3.2. calculated stiffnesses

C is the spring stiffness against a horizontal head displacement in the plate direction.

Nr.	C	EI	EA	G
-	kN/m	kNm²	kN	kg
1	3656273.45	157086913.95	46021556.82	13440.00
2	7489277.13	674062402.22	74785029.83	21840.00
3	7489277.13	674062402.22	74785029.83	21840.00
4	3656273.45	157086913.95	46021556.82	13440.00
---	---	---	---	---
5	0.00	0.00	4793912.17	0.00
6	0.00	0.00	4793912.17	0.00
7	0.00	0.00	4793912.17	0.00
8	0.00	0.00	4793912.17	0.00
9	0.00	0.00	4793912.17	0.00
10	0.00	0.00	4793912.17	0.00
11	0.00	0.00	4793912.17	0.00
12	0.00	0.00	4793912.17	0.00
13	0.00	0.00	4793912.17	0.00
14	0.00	0.00	4793912.17	0.00
15	0.00	0.00	4793912.17	0.00
16	0.00	0.00	4793912.17	0.00
17	0.00	0.00	4793912.17	0.00
18	0.00	0.00	4793912.17	0.00

3.3. concrete walls

structure of concrete walls

explanations: max ρ = maximum (arithmetic) reinforcement ratio

Nr.	lengt	heig	thick	centre distances horizontal	centre distances vertical	main reinforcem. horizontal	main reinforcem. vertical	max ρ	anchor forces
-	m	m	cm	cm	cm	cm²	cm²	%	
1	6.400	3.500	24.0	3.0	4.0	0.00	0.00	8.0	no
2	10.400	3.500	24.0	3.0	4.0	0.00	0.00	8.0	no
3	10.400	3.500	24.0	3.0	4.0	0.00	0.00	8.0	no
4	6.400	3.500	24.0	3.0	4.0	0.00	0.00	8.0	no

material and verification options for concrete walls acc. to EC 2 (design)

explanations: BSt_l: reinforcing steel grade of the longitudinal reinforcement (BSt 500 = BSt 500 A)
column **(M)**: minimum reinforcement for walls
column **(Q)**: transverse reinforcement - minimum share of the main reinforcement; column **(S)**: main compressive stress verification verify with $\sigma_{1d} \leq \sigma_{Rd}$ = fak σ_{Rd} · f
description of materials see 'material characteristics of concrete walls'

Nr.	concrete	BSt_l	(M)	(Q)	(S)	fak σ_{Rd}
1	C20/25	B500	B2	0.20	ys	1.00
2	C20/25	B500	B2	0.20	ys	1.00
3	C20/25	B500	B2	0.20	ys	1.00
4	C20/25	B500	B2	0.20	ys	1.00

verification options for concrete walls acc. to EC 2 (crack verification)

initial crack formation from bending or centric constraint (tensile restraint) for direct (self-induced) or indirect (outside induced) loading.
creep-,shrinkage influences are taken into account via a modification of the concrete stress-strain diagram with the coefficients $\varphi_{\infty,t0}$ and $\varepsilon_{cs,\infty}$.

Nr.	Ø of distrib. long.rein in mm horiz.	Ø of distrib. long.rein in mm vert.	bond property	crackwidth w_k in mm	cracks from load	init.crack formati from
1	8	8	good	0.30	ys	centr.const(direct)
2	8	8	good	0.30	ys	centr.const(direct)
3	8	8	good	0.30	ys	centr.const(direct)
4	8	8	good	0.30	ys	centr.const(direct)

material characteristics for concrete walls acc. to EC 2

explanations: ρ_c: concrete maximum density; BSt_l: reinforcing steel grade of the longitudinal reinforcement (BSt 500 = BSt 500 A)
concrete material data: f_{ck}: cylinder compressive strength; α_c: reduction coefficient (Gl. 3.15); ε_{c2}, ε_{c2u}: strains;
n_c: exponent for the description of the stress-strain line (Gl. 3.17); E_{cm}: mean modulus of elasticity (secant modulus)
f_{ctm}: mean value of the centric tensile strength; for deformation calculations: final creep coefficient $\varphi_{\infty,t0}$; final shrinkage strain $\varepsilon_{cs,\infty}$
reinforcement material data: f_{yk}: elastic limit; f_{tk}: tensile strength; ε_{su}: strain at failure; E_s: elastic modulus

Nr.	concr.	ρ_c	BSt_l	f_{ck}	α_c	ε_{c2}	ε_{c2u}	n_c	E_{cm}	f_{ctm}	$\varphi_{\infty,t0}$	ε_{cs}	f_{yk}	f_{tk}	ε_{su}	E_s
		kg/m3		MN/m2		‰	‰		MN/m2	MN/m2		‰	MN/m2	MN/m2	‰	MN/m2
1	C20/25	2200	B500	20.0	0.000	-2.0	-3.5	2.00	29962.0	2.21	---	---	500.0	525.0	25.0	200000.0
2	C20/25	2200	B500	20.0	0.000	-2.0	-3.5	2.00	29962.0	2.21	---	---	500.0	525.0	25.0	200000.0
3	C20/25	2200	B500	20.0	0.000	-2.0	-3.5	2.00	29962.0	2.21	---	---	500.0	525.0	25.0	200000.0
4	C20/25	2200	B500	20.0	0.000	-2.0	-3.5	2.00	29962.0	2.21	---	---	500.0	525.0	25.0	200000.0

3.4. concrete columns

structure of concrete columns

explanations: max ρ = maximum (arithmetic) reinforcement ratio

Nr.	cross section	width/ diameter	thickn	heig	edge distanc	main reinforce	max ρ
		cm	cm	m	cm	cm²	%
5	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
6	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
7	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
8	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
9	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
10	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
11	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
12	rectangl	40.0	40.0	3.500	5.0	0.00	8.0

structure of concrete columns

explanations: max ρ = maximum (arithmetic) reinforcement ratio

Nr.	cross section	width/ diameter cm	thickn cm	heig m	edge distanc cm	main reinforce cm^2	max ρ %
13	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
14	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
15	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
16	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
17	rectangl	40.0	40.0	3.500	5.0	0.00	8.0
18	rectangl	40.0	40.0	3.500	5.0	0.00	8.0

verification options for concrete columns acc. to EC 2 (design)

explanations: column **(M)**: minimum reinforcement for columns; column **(K)**: simplified buckling verification (model support method)
material description see 'material characteristics of concrete columns'

Nr.	concr	BSt$_l$	(M)	(K)	Nr.	concr	BSt$_l$	(M)	(K)
5	C20/25	B500	no	yes	12	C20/25	B500	no	yes
6	C20/25	B500	no	yes	13	C20/25	B500	no	yes
7	C20/25	B500	no	yes	14	C20/25	B500	no	yes
8	C20/25	B500	no	yes	15	C20/25	B500	no	yes
9	C20/25	B500	no	yes	16	C20/25	B500	no	yes
10	C20/25	B500	no	yes	17	C20/25	B500	no	yes
11	C20/25	B500	no	yes	18	C20/25	B500	no	yes

verification options for concrete columns acc. to EC 2 (crack verification)

explanations: initial crack formation from bending or centric constraint (tensile restraint) by direct (self-induced) or indirect (outside induced) loading.
creep-,shrinkage influences are taken into account via a modification of the concrete stress-strain diagram with the coefficients $\varphi_{\infty,t0}$ and $\varepsilon_{cs,\infty}$.

Nr.	Ø of long.rein in mm	bond property	crackwidth w_k in mm	cracks from load	init.crack formati from
5	16	good	0.30	ys	centr.const(direct)
6	16	good	0.30	ys	centr.const(direct)
7	16	good	0.30	ys	centr.const(direct)
8	16	good	0.30	ys	centr.const(direct)
9	16	good	0.30	ys	centr.const(direct)
10	16	good	0.30	ys	centr.const(direct)
11	16	good	0.30	ys	centr.const(direct)
12	16	good	0.30	ys	centr.const(direct)
13	16	good	0.30	ys	centr.const(direct)
14	16	good	0.30	ys	centr.const(direct)
15	16	good	0.30	ys	centr.const(direct)
16	16	good	0.30	ys	centr.const(direct)
17	16	good	0.30	ys	centr.const(direct)
18	16	good	0.30	ys	centr.const(direct)

material characteristics for bars for verifications acc. to EC 2

explanations: ρ_c: concrete maximum density; BSt$_l$: reinforcing steel grade of the longitudinal reinforcement (B500 = B500A)
concrete material data: f_{ck}: cylinder compressive strength; α_c: reduction coefficient (Gl. 3.15); ε_{c2}, ε_{c2u}: strains;
n_c: exponent for the description of the stress-strain line (Gl. 3.17); E_{cm}: mean modulus of elasticity (secant modulus)
f_{ctm}: mean value of the centric tensile strength; for deformation calculations: final creep coefficient $\varphi_{\infty,t0}$; final shrinkage strain $\varepsilon_{cs,\infty}$
reinforcement material data: f_{yk}: elastic limit; f_{tk}: tensile strength; ε_{su}: strain at failure; E_s: elastic modulus

bar	concr.	ρ_c kg/m^3	f_{ck} MN/m^2	α_c	ε_{c2} ‰	ε_{c2u} ‰	n_c	E_{cm} MN/m^2	f_{ctm} MN/m^2	$\varphi_{\infty,t0}$	ε_{cs} ‰
5	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
6	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
7	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
8	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
9	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
10	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
11	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
12	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
13	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
14	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
15	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
16	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---

material characteristics for bars for verifications acc. to EC 2

explanations: ρ_C: concrete maximum density; BSt_l: reinforcing steel grade of the longitudinal reinforcement (B500 = B500A)
concrete material data: f_{ck}: cylinder compressive strength; α_C: reduction coefficient (Gl. 3.15); ε_{c2}, ε_{c2u}: strains;
n_C: exponent for the description of the stress-strain line (Gl. 3.17); E_{cm}: mean modulus of elasticity (secant modulus)
f_{ctm}: mean value of the centric tensile strength; for deformation calculations: final creep coefficient $\varphi_{\infty,t0}$; final shrinkage strain $\varepsilon_{cs,\infty}$
reinforcement material data: f_{yk}: elastic limit; f_{tk}: tensile strength; ε_{su}: strain at failure; E_s: elastic modulus

bar	concr.	ρ_c kg/m³	f_{ck} MN/m²	α_c	ε_{c2} ‰	ε_{c2u} ‰	n_c	E_{cm} MN/m²	f_{ctm} MN/m²	$\varphi_{\infty,t0}$	ε_{cs} ‰
17	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---
18	C20/25	2200	20.0	s.NAD	-2.0	-3.5	2.00	29962.0	2.21	---	---

bar	BSt_l	f_{yk} MN/m²	f_{tk} MN/m²	ε_{su} ‰	E_s MN/m²	bar	BSt_l	f_{yk} MN/m²	f_{tk} MN/m²	ε_{su} ‰	E_s MN/m²
5	B500	500.0	525.0	25.0	200000.0	12	B500	500.0	525.0	25.0	200000.0
6	B500	500.0	525.0	25.0	200000.0	13	B500	500.0	525.0	25.0	200000.0
7	B500	500.0	525.0	25.0	200000.0	14	B500	500.0	525.0	25.0	200000.0
8	B500	500.0	525.0	25.0	200000.0	15	B500	500.0	525.0	25.0	200000.0
9	B500	500.0	525.0	25.0	200000.0	16	B500	500.0	525.0	25.0	200000.0
10	B500	500.0	525.0	25.0	200000.0	17	B500	500.0	525.0	25.0	200000.0
11	B500	500.0	525.0	25.0	200000.0	18	B500	500.0	525.0	25.0	200000.0

material safety coefficiente for reinforced concrete structures

explanations: γ_C: concrete safety factor; γ_S: reinforcement safety factor

permanent+variable		fatigue		earthquake		exceptional	
γ_c	γ_s	γ_c	γ_s	γ_c	γ_s	γ_c	γ_s
1.50	1.15	1.50	1.15	1.50	1.15	1.30	1.00

4. result of the load distribution

4.1. characteristic values

assumptions: the panel stiffness for absorbing the bending moments is estimated at 30 %. warping forces are taken into account at 0 %.
Hx (u_{Mx}), Hy (u_{My}) and Mz (Θ_{Mz}) refer to the shear centre; Vz (u_{Sz}), Mx (Θ_{Sx}) and My (Θ_{Sy}) refer to the centre of gravity.

characteristic values	x	y
grav.centre (S)	15.000 m	6.522 m
shear centre (M)	15.000 m	7.500 m

4.2. unit deformations of the rigid plate

the table values are to be multiplied by 10^{-4}

due to	u_{Mx} mm	u_{My} mm	u_{Sz} mm	Θ_{Sx} ‰	Θ_{Sy} ‰	Θ_{Mz} ‰
Hx = 1 kN	1.3675	0	0	0	0	0
Hy = 1 kN	0	0.6676	0	0	0	0
Vz = 1 kN	0	0	0.1134	0	0	0
Mx = 1 kNm	0	0	0	0.0193	0	0
My = 1 kNm	0	0	0	0	0.0782	0
Mz = 1 kNm	0	0	0	0	0	0.0026

4.3. loads on walls and columns due to global unit loads

plate loads due to Hx = 1 kN

wall	H	qa	qe
-	N	N/m	N/m
1	500.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	500.00	0.00	0.00

plate loads due to Hy = 1 kN

wall	H	qa	qe
-	N	N/m	N/m
1	0.00	0.00	0.00
2	500.00	0.00	0.00
3	500.00	0.00	0.00
4	0.00	0.00	0.00

plate loads due to Mz = 1 kNm

wall	H	qa	qe
-	N	N/m	N/m
1	7.24	0.00	0.00
2	-29.52	0.00	0.00
3	29.52	0.00	0.00
4	-7.24	0.00	0.00

5. ceiling panel, load schemes

The following specifications are used to automatically distribute vertical surface loads from dead weight or traffic to the wallplates.
Load schemes are defined for this purpose. Edge distances and recesses are assigned to each load scheme. They are used to determine the exact structure of the load-bearing plate. Reference is made to the load scheme used in the description of the load cases.

Whereas in the "rigid slab" model, the stiffnesses of the wall plates are decisive for the distribution of the loads, in the "flexible slab" model, the size of the load application area assigned to the individual wall disc (column) is decisive.
Both models represent a state of equilibrium and are weighted.

Current determination: 0 % "rigid slab" model, 100 % "flexible slab" model (see also page 1: building model).

load scheme: standard

in this load scheme, the load ordinates were specified directly as a result of a ceiling load of 1 kN/m².

wall	qa	qe
-	kN/m	kN/m
1	3.88	3.88
2	1.18	4.96
3	1.18	4.96
4	3.86	3.86

column	V	column	V	column	V	column	V
-	kN	-	kN	-	kN	-	kN
5	13.70	9	32.10	13	32.00	17	13.60
6	13.70	10	36.90	14	37.60	18	5.20
7	36.90	11	37.60	15	5.20		
8	32.10	12	32.00	16	13.60		

6. actions and load cases

6.1. description of the load structure

On the left-hand side, the relationships between the actions and load cases are shown in a tree structure.
On the right-hand side, the overlay-specific properties are assigned to the objects on the left.

used symbols: action load case

1: permanent loads	**permanent loads**
1: dead weight	additive
2: live loads	**live loads of the category B - offices**
2: traffic	additive
3: snown loads	**snown: places up to SL + 1000 m**
3: snown (fully)	additive
4: wind loads	**wind loads**
4: wind from the left (centric)	alternative
5: wind from the left (- eccentricity)	alternative
6: wind from the left (+ eccentricity)	alternative
7: wind from the right (centric)	alternative
8: wind from the right (- eccentricity)	alternative
9: wind from the right (+ eccentricity)	alternative
10: wind from the front (centric)	alternative
11: wind from the front (- eccentricity)	alternative
12: wind from the front (+ eccentricity)	alternative
13: wind from the rear (centric)	alternative
14: wind from the rear (- eccentricity)	alternative
15: wind from the rear (+ eccentricity)	alternative
0: imperfections	
16: imperfection (1)	alternative
17: imperfection (2)	alternative
18: imperfection (3)	alternative
19: imperfection (4)	alternative

6.2. superposition factors of the actions

safety factors and combination coefficients acc. to Eurocode; clld = class of load duration (only relevant for wooden panels)
Ψ_E is the Ψ_2-value for the earthquake design situation

action	γ_{sup}	γ_{inf}	Ψ_0	Ψ_1	Ψ_2	Ψ_E	clld
1	1.35	1.00	1.00	1.00	1.00	1.00	permanent
2	1.50	0.00	0.70	0.50	0.30	0.23	medium-term
3	1.50	0.00	0.50	0.20	0.00	0.50	short-term
4	1.50	0.00	0.60	0.20	0.00	0.00	(wind)
0	1.00	0.00	1.00	1.00	1.00	1.00	permanent

6.3. description of the load cases

6.3.1. load case 1: dead weight

resultant and deformations of the rigid slab in the load case 1: dead weight

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	30296.87 kN	u_{Sz} =	0.343471 mm
ΣMx =	28775.77 kNm	Θ_{Sx} =	0.055603 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.2. load case 2: traffic

resultant and deformations of the rigid slab in the load case 2: traffic

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	9567.43 kN	u_{Sz} =	0.108464 mm
ΣMx =	9087.09 kNm	Θ_{Sx} =	0.017559 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.3. load case 3: snown (fully)

resultant and deformations of the rigid slab in the load case 3: snown (fully)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	309.80 kN	u_{Sz} =	0.003512 mm
ΣMx =	294.25 kNm	Θ_{Sx} =	0.000569 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.4. load case 4: wind from the left (centric)

resultant and deformations of the rigid slab in the load case 4: wind from the left (centric)

ΣHx =	305.95 kN	u_{Mx} =	0.041840 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣMy =	-2532.53 kNm	Θ_{Sy} =	-0.019816 ‰
ΣMz =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.5. load case 5: wind from the left (- eccentricity)

resultant and deformations of the rigid slab in the load case 5: wind from the left (- eccentricity)

ΣHx =	207.43 kN	u_{Mx} =	0.028367 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣMy =	-1717.02 kNm	Θ_{Sy} =	-0.013435 ‰
ΣMz =	257.80 kNm	Θ_{Mz} =	0.000067 ‰

6.3.6. load case 6: wind from the left (+ eccentricity)

resultant and deformations of the rigid slab in the load case 6: wind from the left (+ eccentricity)

ΣH_x =	207.43 kN	u_{Mx} =	0.028367 mm
ΣH_y =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣM_x =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣM_y =	-1717.02 kNm	Θ_{Sy} =	-0.013435 ‰
ΣM_z =	-257.80 kNm	Θ_{Mz} =	-0.000067 ‰

6.3.7. load case 7: wind from the right (centric)

resultant and deformations of the rigid slab in the load case 7: wind from the right (centric)

ΣH_x =	-305.95 kN	u_{Mx} =	-0.041840 mm
ΣH_y =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣM_x =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣM_y =	2532.53 kNm	Θ_{Sy} =	0.019816 ‰
ΣM_z =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.8. load case 8: wind from the right (- eccentricity)

resultant and deformations of the rigid slab in the load case 8: wind from the right (- eccentricity)

ΣH_x =	-207.43 kN	u_{Mx} =	-0.028367 mm
ΣH_y =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣM_x =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣM_y =	1717.02 kNm	Θ_{Sy} =	0.013435 ‰
ΣM_z =	-257.80 kNm	Θ_{Mz} =	-0.000067 ‰

6.3.9. load case 9: wind from the right (+ eccentricity)

resultant and deformations of the rigid slab in the load case 9: wind from the right (+ eccentricity)

ΣH_x =	-207.43 kN	u_{Mx} =	-0.028367 mm
ΣH_y =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣM_x =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣM_y =	1717.02 kNm	Θ_{Sy} =	0.013435 ‰
ΣM_z =	257.80 kNm	Θ_{Mz} =	0.000067 ‰

6.3.10. load case 10: wind from the front (centric)

resultant and deformations of the rigid slab in the load case 10: wind from the front (centric)

ΣH_x =	0.00 kN	u_{Mx} =	0.000000 mm
ΣH_y =	-693.69 kN	u_{My} =	-0.046312 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣM_x =	-5636.22 kNm	Θ_{Sx} =	-0.010891 ‰
ΣM_y =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣM_z =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.11. load case 11: wind from the front (- eccentricity)

resultant and deformations of the rigid slab in the load case 11: wind from the front (- eccentricity)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	-480.25 kN	u_{My} =	-0.032062 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	-3902.00 kNm	Θ_{Sx} =	-0.007540 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	1092.11 kNm	Θ_{Mz} =	0.000285 ‰

6.3.12. load case 12: wind from the front (+ eccentricity)

resultant and deformations of the rigid slab in the load case 12: wind from the front (+ eccentricity)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	-480.25 kN	u_{My} =	-0.032062 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	-3902.00 kNm	Θ_{Sx} =	-0.007540 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	-1092.12 kNm	Θ_{Mz} =	-0.000285 ‰

6.3.13. load case 13: wind from the rear (centric)

resultant and deformations of the rigid slab in the load case 13: wind from the rear (centric)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	693.69 kN	u_{My} =	0.046312 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	5636.22 kNm	Θ_{Sx} =	0.010891 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	0.00 kNm	Θ_{Mz} =	0.000000 ‰

6.3.14. load case 14: wind from the rear (- eccentricity)

resultant and deformations of the rigid slab in the load case 14: wind from the rear (- eccentricity)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	480.25 kN	u_{My} =	0.032062 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	3902.00 kNm	Θ_{Sx} =	0.007540 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	-1092.11 kNm	Θ_{Mz} =	-0.000285 ‰

6.3.15. load case 15: wind from the rear (+ eccentricity)

resultant and deformations of the rigid slab in the load case 15: wind from the rear (+ eccentricity)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	480.25 kN	u_{My} =	0.032062 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	3902.00 kNm	Θ_{Sx} =	0.007540 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	1092.12 kNm	Θ_{Mz} =	0.000285 ‰

6.3.16. load case 16: imperfection (1)

resultant and deformations of the rigid slab in the load case 16: imperfection (1)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	36.30 kN	u_{My} =	0.002423 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	381.15 kNm	Θ_{Sx} =	0.000736 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	12.71 kNm	Θ_{Mz} =	0.000003 ‰

6.3.17. load case 17: imperfection (2)

resultant and deformations of the rigid slab in the load case 17: imperfection (2)

ΣHx =	0.00 kN	u_{Mx} =	0.000000 mm
ΣHy =	-36.30 kN	u_{My} =	-0.002423 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	-381.15 kNm	Θ_{Sx} =	-0.000736 ‰
ΣMy =	0.00 kNm	Θ_{Sy} =	0.000000 ‰
ΣMz =	-12.71 kNm	Θ_{Mz} =	-0.000003 ‰

6.3.18. load case 18: imperfection (3)

resultant and deformations of the rigid slab in the load case 18: imperfection (3)

ΣHx =	36.30 kN	u_{Mx} =	0.004964 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣMy =	-381.15 kNm	Θ_{Sy} =	-0.002982 ‰
ΣMz =	-12.70 kNm	Θ_{Mz} =	-0.000003 ‰

6.3.19. load case 19: imperfection (4)

resultant and deformations of the rigid slab in the load case 19: imperfection (4)

ΣHx =	-36.30 kN	u_{Mx} =	-0.004964 mm
ΣHy =	0.00 kN	u_{My} =	0.000000 mm
ΣV =	0.00 kN	u_{Sz} =	0.000000 mm
ΣMx =	0.00 kNm	Θ_{Sx} =	0.000000 ‰
ΣMy =	381.15 kNm	Θ_{Sy} =	0.002982 ‰
ΣMz =	12.70 kNm	Θ_{Mz} =	0.000003 ‰

7. sum of the vertical loads

at the height of the top plate of the storey to be verified

explanations: line "permanent": only from action of the type "permanent loads". line "maximum": Actions of the variable load type are fully recognised ($\Psi_i = 1$). All other lines according to DIN 1055-100 or Eurocode. xg and yg describe the position of the centre of mass. The calculation is based on all actions except restraint, prestressing, special loads and earthquakes. In addition, the categories wind loads, temperature loads and subsoil settlement are ignored for the variable loads.

combination	characteristic values				design values			
	- ΣV -		xg	yg	- ΣV -		xg	yg
-	kN	t	m	m	kN	t	m	m
perman.	30297	3029.7	15.00	7.47	40901	4090.1	15.00	7.47
quasi-perm.	33167	3316.7	15.00	7.47	45206	4520.6	15.00	7.47
frequ.	35081	3508.1	15.00	7.47	48076	4807.6	15.00	7.47
rarely	40019	4001.9	15.00	7.47	55484	5548.4	15.00	7.47
maximum	40174	4017.4	15.00	7.47	55717	5571.7	15.00	7.47

8. bearing forces of the walls

8.1. bearing forces of the walls (mode of action)

bearing forces of the walls in action 1: permanent loads

minimum and maximum forces in the wall-floor joint (characteristic) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	258.02	258.02	258.02	258.02	258.02	258.02	0.00	0.00
2	78.47	204.15	329.84	78.47	204.15	329.84	0.00	0.00
3	78.47	204.15	329.84	78.47	204.15	329.84	0.00	0.00
4	256.69	256.69	256.69	256.69	256.69	256.69	0.00	0.00

bearing forces of the walls in action 2: live loads

minimum and maximum forces in the wall-floor joint (characteristic) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	81.48	81.48	81.48	81.48	81.48	81.48	0.00	0.00
2	24.78	64.47	104.16	24.78	64.47	104.16	0.00	0.00
3	24.78	64.47	104.16	24.78	64.47	104.16	0.00	0.00
4	81.06	81.06	81.06	81.06	81.06	81.06	0.00	0.00

bearing forces of the walls in action 3: snown loads

minimum and maximum forces in the wall-floor joint (characteristic) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	2.64	2.64	2.64	2.64	2.64	2.64	0.00	0.00
2	0.80	2.09	3.37	0.80	2.09	3.37	0.00	0.00
3	0.80	2.09	3.37	0.80	2.09	3.37	0.00	0.00
4	2.62	2.62	2.62	2.62	2.62	2.62	0.00	0.00

bearing forces of the walls in action 4: wind loads

minimum and maximum forces in the wall-floor joint (characteristic) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	208.71	8.79	208.71	-208.71	-8.79	-208.71	152.98	-152.98
2	185.72	2.07	181.67	-185.72	-2.07	-181.67	346.84	-346.84
3	185.72	2.07	181.67	-185.72	-2.07	-181.67	346.84	-346.84
4	208.71	11.39	208.71	-208.71	-11.39	-208.71	152.98	-152.98

bearing forces of the walls in action imperfections

minimum and maximum forces in the wall-floor joint (characteristic) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	28.87	0.59	28.87	-28.87	-0.59	-28.87	18.06	-18.06
2	11.46	0.31	11.18	-11.46	-0.31	-11.18	17.78	-17.78
3	11.60	0.31	11.33	-11.60	-0.31	-11.33	18.52	-18.52
4	28.96	0.77	28.96	-28.96	-0.77	-28.96	18.24	-18.24

8.2. bearing forces of the walls in the permanent and temporary design situation

minimum and maximum forces in the wall-floor joint (factorised) at the start, in the centre and at the end of the plate

wall	max qa	max qm	max qe	min qa	min qm	min qe	max H	min H
-	kN/m	kN/m	kN/m	kN/m	kN/m	kN/m	kN	kN
1	777.79	481.03	777.79	-83.91	244.24	-83.91	247.52	-247.52
2	422.59	376.06	840.87	-211.57	200.74	46.15	538.04	-538.04
3	422.74	376.06	841.01	-211.71	200.74	46.01	538.79	-538.79
4	775.64	481.11	775.64	-85.34	238.83	-85.34	247.71	-247.71

9. extreme verification loads

9.1. permanent and temporary design situation

extreme wall loads (SUV)

for the permanent and temporary design situation

wall		qa	qe	H	from load case
-		kN/m	kN/m	kN	-
1	max qa	**650.89**	220.83	-247.52	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[7]+[19]
	max qe	220.83	**650.89**	247.52	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[4]+[18]
	max H	42.99	473.05	**247.52**	[1]+1.50*[4]+[18]
	max V	481.03	481.03	-0.09	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[17]
	min qe	473.05	**42.99**	-247.52	[1]+1.50*[7]+[19]
	min V	244.24	244.24	0.09	[1]+1.50*[13]+[16]
2	max qa	**318.13**	377.96	-538.04	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[10]+[17]
	max qe	-53.02	**736.40**	538.04	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[13]+[16]
	max H	-107.10	509.06	**538.04**	[1]+1.50*[13]+[16]
	max V	145.88	606.23	-0.37	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[7]+[19]
	min qe	264.04	**150.62**	-538.04	[1]+1.50*[10]+[17]
	min V	75.05	326.42	0.37	[1]+1.50*[4]+[18]
3	max qa	**318.13**	377.96	-538.79	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[10]+[17]
	max qe	-53.02	**736.40**	538.79	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[13]+[16]
	max H	-107.10	509.06	**538.79**	[1]+1.50*[13]+[16]
	max V	145.88	606.23	-0.37	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[4]+[18]
	min qe	264.04	**150.62**	-538.79	[1]+1.50*[10]+[17]
	min V	75.05	326.42	0.37	[1]+1.50*[7]+[19]
4	max qa	**648.64**	218.58	-247.71	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[7]+[19]
	max qe	218.58	**648.64**	247.71	1.35*[1]+0.70*1.50*[2]+0.50*1.50*[3]+1.50*[4]+[18]
	max H	41.66	471.72	**247.71**	[1]+1.50*[4]+[18]
	max V	481.11	481.11	-0.09	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min qe	471.72	**41.66**	-247.71	[1]+1.50*[7]+[19]
	min V	238.83	238.83	0.09	[1]+1.50*[10]+[17]

extreme column loads (SUV)

for the permanent and temporary design situation

column		V	from load case
-		kN	-
5	max V	**1674.06**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[17]
	min V	**901.98**	[1]+1.50*[13]+[16]
6	max V	**1674.06**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[17]
	min V	**901.98**	[1]+1.50*[13]+[16]
7	max V	**4495.21**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[19]
	min V	**2451.70**	[1]+1.50*[13]+[18]
8	max V	**3910.61**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[17]
	min V	**2132.53**	[1]+1.50*[13]+[16]
9	max V	**3910.61**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[17]
	min V	**2132.53**	[1]+1.50*[13]+[16]
10	max V	**4495.21**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[10]+[18]
	min V	**2451.70**	[1]+1.50*[13]+[19]
11	max V	**4582.10**	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	**2495.56**	[1]+1.50*[10]+[17]

extreme column loads (SUV)

for the permanent and temporary design situation

column		V	from load case
-		kN	-
12	max V	3900.11	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	2123.16	[1]+1.50*[10]+[17]
13	max V	3900.11	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	2123.16	[1]+1.50*[10]+[17]
14	max V	4582.10	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	2495.56	[1]+1.50*[10]+[17]
15	max V	640.56	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	334.00	[1]+1.50*[10]+[17]
16	max V	1663.56	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	892.60	[1]+1.50*[10]+[17]
17	max V	1663.56	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	892.60	[1]+1.50*[10]+[17]
18	max V	640.56	1.35*[1]+1.50*[2]+0.50*1.50*[3]+0.60*1.50*[13]+[16]
	min V	334.00	[1]+1.50*[10]+[17]

9.2. quasi-permanent combination

9.3. frequent combination

9.4. rare combination

10. extreme panel deformations

extreme corner point displacements (QS)

for the quasi-permanent combination

point	at		ux	uy	uz	from load case
-	m		mm	mm	mm	-
1	x = -0.35	max ux	**0.0049**	0.0001	-0.0844	[1]+[18]
	y = -0.35	max uy	0.0000	**0.0024**	-0.0437	[1]+[16]
		max uz	-0.0049	-0.0001	**0.0072**	[1]+[19]
		min ux	**-0.0049**	-0.0001	0.0072	[1]+[19]
		min uy	0.0000	**-0.0024**	-0.0336	[1]+[17]
		min uz	0.0049	0.0001	**-0.0881**	[1]+0.30*[2]+[18]
2	x = 30.35	max ux	**0.0049**	-0.0001	0.0072	[1]+[18]
	y = -0.35	max uy	0.0000	**0.0025**	-0.0437	[1]+[16]
		max uz	0.0049	-0.0001	**0.0072**	[1]+[18]
		min ux	**-0.0049**	0.0001	-0.0844	[1]+[19]
		min uy	0.0000	**-0.0025**	-0.0336	[1]+[17]
		min uz	-0.0049	0.0001	**-0.0881**	[1]+0.30*[2]+[19]
3	x = -0.35	max ux	**0.0050**	0.0001	0.7886	[1]+[18]
	y = 15.35	max uy	0.0000	**0.0024**	0.8409	[1]+[16]
		max uz	-0.0050	-0.0001	**0.9592**	[1]+0.30*[2]+[19]
		min ux	**-0.0050**	-0.0001	0.8801	[1]+[19]
		min uy	0.0000	**-0.0024**	0.8279	[1]+[17]
		min uz	0.0050	0.0001	**0.7886**	[1]+[18]
4	x = 30.35	max ux	**0.0050**	-0.0001	0.8801	[1]+[18]
	y = 15.35	max uy	0.0000	**0.0025**	0.8409	[1]+[16]
		max uz	0.0050	-0.0001	**0.9592**	[1]+0.30*[2]+[18]
		min ux	**-0.0050**	0.0001	0.7886	[1]+[19]
		min uy	0.0000	**-0.0025**	0.8279	[1]+[17]
		min uz	-0.0050	0.0001	**0.7886**	[1]+[19]

extreme corner point displacements (S)

for the rare combination

point	at		ux	uy	uz	from load case
-	m		mm	mm	mm	-
1	x = -0.35	max ux	**0.0468**	0.0001	-0.3886	[1]+[4]+[18]
	y = -0.35	max uy	0.0000	**0.0487**	-0.1185	[1]+[13]+[16]
		max uz	-0.0468	-0.0001	**0.3113**	[1]+[7]+[19]
		min ux	**-0.0468**	-0.0001	0.3113	[1]+[7]+[19]
		min uy	0.0000	**-0.0487**	0.0413	[1]+[10]+[17]
		min uz	0.0468	0.0001	**-0.3948**	[1]+0.50*[2]+0.20*[3]+[4]+[18]
2	x = 30.35	max ux	**0.0468**	-0.0001	0.3113	[1]+[4]+[18]
	y = -0.35	max uy	0.0000	**0.0488**	-0.1185	[1]+[13]+[16]
		max uz	0.0468	-0.0001	**0.3113**	[1]+[4]+[18]
		min ux	**-0.0468**	0.0001	-0.3886	[1]+[7]+[19]
		min uy	0.0000	**-0.0488**	0.0413	[1]+[10]+[17]
		min uz	-0.0468	0.0001	**-0.3948**	[1]+0.50*[2]+0.20*[3]+[7]+[19]
3	x = -0.35	max ux	**0.0468**	0.0001	0.4844	[1]+[4]+[18]
	y = 15.35	max uy	0.0000	**0.0487**	0.9370	[1]+[13]+[16]
		max uz	-0.0468	-0.0001	**1.3178**	[1]+0.50*[2]+0.20*[3]+[7]+[19]
		min ux	**-0.0468**	-0.0001	1.1843	[1]+[7]+[19]
		min uy	0.0000	**-0.0487**	0.7317	[1]+[10]+[17]
		min uz	0.0468	0.0001	**0.4844**	[1]+[4]+[18]
4	x = 30.35	max ux	**0.0468**	-0.0001	1.1843	[1]+[4]+[18]
	y = 15.35	max uy	0.0000	**0.0488**	0.9370	[1]+[13]+[16]
		max uz	0.0468	-0.0001	**1.3178**	[1]+0.50*[2]+0.20*[3]+[4]+[18]
		min ux	**-0.0468**	0.0001	0.4844	[1]+[7]+[19]
		min uy	0.0000	**-0.0488**	0.7317	[1]+[10]+[17]
		min uz	-0.0468	0.0001	**0.4844**	[1]+[7]+[19]

11. verification of immovability

displacements

h_{ges} = 24.50 m; $\kappa = h_{ges}/(h_o+h_G)$ = 1.14; number of storeys: n_s = 5
ΣV = 40.019 MN (see sum of the V loads); $F_{ED} = \kappa\Sigma V$ = 45.603 MN; γ_{CE} = 1.2

X-direction: θ_{Sy} = 7.82464e-06 /MNm *)

$$EI_y = \frac{1}{\gamma_{CE}} \cdot \frac{h_G}{\theta_{Sy}} = 372754 \text{ MNm}^2$$

$$0.31 \frac{n_s}{n_s + 1.6} \cdot \frac{EI_y}{h_{ges}^2} = 145.84 \quad >= \quad F_{ED}$$

verification fulfilled

Y-direction: θ_{Sx} = 1.9323e-06 /MNm *)

$$EI_x = \frac{1}{\gamma_{CE}} \cdot \frac{h_G}{\theta_{Sx}} = 1509428 \text{ MNm}^2$$

$$0.31 \frac{n_s}{n_s + 1.6} \cdot \frac{EI_x}{h_{ges}^2} = 590.57 \quad >= \quad F_{ED}$$

verification fulfilled

*) see unit deformations of the rigid plate

rotation about the z-axis

wall	E	I	a	EIa²	G	I_T	GI_T
-	MN/m²	m⁴	m	MNm⁴	MN/m²	m⁴	MNm²
1	29962.0	5.243	7.58	9025649	12484.1	0.0295	368.2
4	29962.0	5.243	7.58	9025649	12484.1	0.0295	368.2
2	29962.0	22.497	15.08	153286104	12484.1	0.0479	598.3
3	29962.0	22.497	15.08	153286104	12484.1	0.0479	598.3
Σ			EI_ω =	324623506		GI_T =	1932.9

loads from rare combination (max V, serviceability):

wall	q_a	q_e	q_m	l	r	$\kappa q_m l r^2$
-	kN/m	kN/m	kN/m	m	m	MNm²
1	346.69	346.69	346.69	6.40	7.58	145.27
2	105.21	437.24	271.22	10.40	15.29	751.05
3	105.21	437.24	271.22	10.40	15.29	751.05
4	346.67	346.67	346.67	6.40	7.58	145.26
				$\Sigma F_{ED,j} r^2$ =		1792.63

column	V	r	κVr²
-	kN	m	MNm²
5	1207.27	11.72	188.82
6	1207.27	11.72	188.82
7	3242.23	9.34	322.36
8	2820.57	3.91	49.02
9	2820.57	3.91	49.02
10	3242.23	9.34	322.36
11	3304.84	9.34	328.58
12	2812.94	3.91	48.88

column	V	r	κVr²
-	kN	m	MNm²
13	2812.94	3.91	48.88
14	3304.84	9.34	328.58
15	461.79	16.77	148.00
16	1199.65	11.72	187.63
17	1199.65	11.72	187.63
18	461.79	16.77	148.00
		Σ $F_{ED,j}$ r² =	2546.57

$\Sigma F_{ED,j} r^2$ (from walls and columns) = 4339.20 MNm²

$$\frac{1}{h_{ges}}\sqrt{\frac{EI_\omega}{\sum F_{ED,j}\, r_j^2}} + \frac{1}{2.28}\sqrt{\frac{GI_T}{\sum F_{ED,j}\, r_j^2}} = 11.46 > 2.06 = \sqrt{\frac{n_s + 1.6}{0.31\, n_s}}$$

verification fulfilled

12. material-dependent verification results

12.1. concrete walls

reinforced concrete wall results (wall 1)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}, n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh}, a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

		design				princ.comp. stress		crack verif.				final result		
ξ	η	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	σ_{1d}	U_σ	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	a_{sh}	a_{sv}	
m	m	kN/m	kN/m	cm²/m	cm²/m	N/mm²	%	kN/m	kN/m	cm²/m	cm²/m	cm²/m	cm²/m	
0.00	0.00	-650.9	---	0.36	1.80			-302.1	---	4.75	5.42	4.75	5.42	a_{sh} = max
		-650.9	---	0.36	1.80			-302.1	---	4.75	5.42	4.75	5.42	a_{sv} = max
		-650.9	---			2.71	24							σ_{1d}
0.00	1.75	-714.3	---	0.36	1.80			-306.7	---	4.75	5.42	4.75	5.42	a_{sh}
		-714.3	---	0.36	1.80			-306.7	---	4.75	5.42	4.75	5.42	a_{sv}
		-714.3	---			2.98	26							σ_{1d}
0.00	3.50	-777.8	---	0.36	1.80			-311.3	---	4.75	5.42	4.75	5.42	a_{sh}
		-777.8	---	0.36	1.80			-311.3	---	4.75	5.42	4.75	5.42	a_{sv}
		-777.8	---			3.24	29							σ_{1d} = max
1.60	0.00	-543.4	43.5	0.36	1.80			-292.3	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-543.4	43.5	0.36	1.80			-292.3	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-543.4	43.5			2.28	20							σ_{1d}
1.60	1.75	-575.1	43.5	0.36	1.80			-294.6	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-575.1	43.5	0.36	1.80			-294.6	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-575.1	43.5			2.41	21							σ_{1d}
1.60	3.50	-606.8	43.5	0.36	1.80			-296.9	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-606.8	43.5	0.36	1.80			-296.9	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-606.8	43.5			2.54	22							σ_{1d}
3.20	0.00	-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sh}
		-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sv}
		-481.0	0.0			2.00	18							σ_{1d}
3.20	1.75	-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sh}
		-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sv}
		-481.0	0.0			2.00	18							σ_{1d}
3.20	3.50	-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sh}
		-435.9	58.0	0.36	1.80			-282.5	4.2	4.75	5.42	4.75	5.42	a_{sv}
		-481.0	0.0			2.00	18							σ_{1d}
4.80	0.00	-328.3	43.5	0.36	1.80			-272.7	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-328.3	43.5	0.36	1.80			-272.7	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-543.4	-43.5			2.28	20							σ_{1d}
4.80	1.75	-296.6	43.5	0.36	1.80			-270.3	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-296.6	43.5	0.36	1.80			-270.3	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-575.1	-43.5			2.41	21							σ_{1d}
4.80	3.50	-264.9	43.5	0.36	1.80			-268.0	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-264.9	43.5	0.36	1.80			-268.0	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-606.8	-43.5			2.54	22							σ_{1d}
6.40	0.00	-220.8	---	0.36	1.80			-262.9	---	4.75	5.42	4.75	5.42	a_{sh}

reinforced concrete wall results (wall 1)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}$,$n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh},a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

		design				princ.comp. stress		crack verif.				final result		
ξ	η	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	σ_{1d}	U_σ	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	a_{sh}	a_{sv}	
m	m	kN/m	kN/m	cm²/m	cm²/m	N/mm²	%	kN/m	kN/m	cm²/m	cm²/m	cm²/m	cm²/m	
		-220.8	---	0.36	1.80			-262.9	---	4.75	5.42	4.75	5.42	a_{sv}
		-650.9	---			2.71	24							σ_{1d}
6.40	1.75	-157.4	---	0.36	1.80			-258.2	---	4.75	5.42	4.75	5.42	a_{sh}
		-157.4	---	0.36	1.80			-258.2	---	4.75	5.42	4.75	5.42	a_{sv}
		-714.3	---			2.98	26							σ_{1d}
6.40	3.50	-93.9	---	0.36	1.80			-253.6	---	4.75	5.42	4.75	5.42	a_{sh}
		-93.9	---	0.36	1.80			-253.6	---	4.75	5.42	4.75	5.42	a_{sv}
		-777.8	---			3.24	29							σ_{1d}

maximum reinforcement: **max a_{sh} = 4.75 cm²/m max a_{sv} = 5.42 cm²/m**
maximum principal compr. stress: **max σ_{1d} = 3.24 N/mm²** (U_σ = 29% ≤ 100%) ⇒ verification fulfilled

reinforced concrete wall results (wall 2)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}$,$n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh},a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

		design				princ.comp. stress		crack verif.				final result		
ξ	η	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	σ_{1d}	U_σ	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	a_{sh}	a_{sv}	
m	m	kN/m	kN/m	cm²/m	cm²/m	N/mm²	%	kN/m	kN/m	cm²/m	cm²/m	cm²/m	cm²/m	
0.00	0.00	-318.1	---	0.36	1.80			-93.9	---	4.75	5.42	4.75	5.42	a_{sh} = max
		-318.1	---	0.36	1.80			-93.9	---	4.75	5.42	4.75	5.42	a_{sv} = max
		-318.1	---			1.33	12							σ_{1d}
0.00	1.75	-370.4	---	0.36	1.80			-95.6	---	4.75	5.42	4.75	5.42	a_{sh}
		-370.4	---	0.36	1.80			-95.6	---	4.75	5.42	4.75	5.42	a_{sv}
		-370.4	---			1.54	14							σ_{1d}
0.00	3.50	211.6	---	0.46	2.32			-97.4	---	4.75	5.42	4.75	5.42	a_{sh}
		211.6	---	0.46	2.32			-97.4	---	4.75	5.42	4.75	5.42	a_{sv}
		-422.6	---			1.76	16							σ_{1d}
2.60	0.00	-46.9	-58.2	0.64	1.80			-158.8	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-333.1	58.2	0.36	1.80			-158.8	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-333.1	58.2			1.43	13							σ_{1d}
2.60	1.75	-20.8	-58.2	0.64	1.80			-159.6	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-359.2	58.2	0.36	1.80			-159.6	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-359.2	58.2			1.54	14							σ_{1d}
2.60	3.50	5.3	-58.2	0.64	1.80			-160.5	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-385.3	58.2	0.36	1.80			-160.5	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-385.3	58.2			1.64	15							σ_{1d}
5.20	0.00	-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
5.20	1.75	-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
5.20	3.50	-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.6	0.36	1.80			-223.6	2.6	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
7.80	0.00	-363.0	58.2	0.36	1.80			-288.5	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-363.0	58.2	0.36	1.80			-288.5	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-539.0	-58.2			2.27	20							σ_{1d}
7.80	1.75	-336.9	58.2	0.36	1.80			-287.6	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-336.9	58.2	0.36	1.80			-287.6	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-565.2	-58.2			2.38	21							σ_{1d}
7.80	3.50	-310.8	58.2	0.36	1.80			-286.8	1.9	4.75	5.42	4.75	5.42	a_{sh}
		-310.8	58.2	0.36	1.80			-286.8	1.9	4.75	5.42	4.75	5.42	a_{sv}
		-591.3	-58.2			2.49	22							σ_{1d}
10.40	0.00	-378.0	---	0.36	1.80			-353.4	---	4.75	5.42	4.75	5.42	a_{sh}
		-378.0	---	0.36	1.80			-353.4	---	4.75	5.42	4.75	5.42	a_{sv}
		-736.4	---			3.07	27							σ_{1d}
10.40	1.75	-325.7	---	0.36	1.80			-351.6	---	4.75	5.42	4.75	5.42	a_{sh}

reinforced concrete wall results (wall 2)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}$,$n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh},a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

		design				princ.comp. stress		crack verif.				final result		
ξ	η	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	σ_{1d}	U_σ	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	a_{sh}	a_{sv}	
m	m	kN/m	kN/m	cm²/m	cm²/m	N/mm²	%	kN/m	kN/m	cm²/m	cm²/m	cm²/m	cm²/m	
		-325.7	---	0.36	1.80			-351.6	---	4.75	5.42	4.75	5.42	a_{sv}
		-788.6	---			3.29	29							σ_{1d}
10.40	3.50	-273.5	---	0.36	1.80			-349.9	---	4.75	5.42	4.75	5.42	a_{sh}
		-273.5	---	0.36	1.80			-349.9	---	4.75	5.42	4.75	5.42	a_{sv}
		-840.9	---			3.50	31							σ_{1d} = max

maximum reinforcement: **max a_{sh} = 4.75 cm²/m max a_{sv} = 5.42 cm²/m**
maximum principal compr. stress: **max σ_{1d} = 3.50 N/mm²** (U_σ = 31% ≤ 100%) ⇒ verification fulfilled

reinforced concrete wall results (wall 3)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}$,$n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh},a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

		design				princ.comp. stress		crack verif.				final result		
ξ	η	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	σ_{1d}	U_σ	$n_{\eta\eta}$	$n_{\xi\eta}$	a_{sh}	a_{sv}	a_{sh}	a_{sv}	
m	m	kN/m	kN/m	cm²/m	cm²/m	N/mm²	%	kN/m	kN/m	cm²/m	cm²/m	cm²/m	cm²/m	
0.00	0.00	-318.1	---	0.36	1.80			-93.9	---	4.75	5.42	4.75	5.42	a_{sh} = max
		-318.1	---	0.36	1.80			-93.9	---	4.75	5.42	4.75	5.42	a_{sv} = max
		-318.1	---			1.33	12							σ_{1d}
0.00	1.75	-370.4	---	0.36	1.80			-95.7	---	4.75	5.42	4.75	5.42	a_{sh}
		-370.4	---	0.36	1.80			-95.7	---	4.75	5.42	4.75	5.42	a_{sv}
		-370.4	---			1.54	14							σ_{1d}
0.00	3.50	211.7	---	0.46	2.32			-97.5	---	4.75	5.42	4.75	5.42	a_{sh}
		211.7	---	0.46	2.32			-97.5	---	4.75	5.42	4.75	5.42	a_{sv}
		-422.7	---			1.76	16							σ_{1d}
2.60	0.00	-46.9	-58.3	0.64	1.80			-158.8	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-333.1	58.3	0.36	1.80			-158.8	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-333.1	58.3			1.43	13							σ_{1d}
2.60	1.75	-20.8	-58.3	0.64	1.80			-159.7	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-359.2	58.3	0.36	1.80			-159.7	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-359.2	58.3			1.54	14							σ_{1d}
2.60	3.50	5.4	-58.3	0.64	1.80			-160.6	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-385.4	58.3	0.36	1.80			-160.6	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-385.4	58.3			1.64	15							σ_{1d}
5.20	0.00	-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
5.20	1.75	-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
5.20	3.50	-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sh}
		-348.0	77.7	0.36	1.80			-223.6	2.7	4.75	5.42	4.75	5.42	a_{sv}
		-376.1	0.1			1.57	14							σ_{1d}
7.80	0.00	-363.0	58.3	0.36	1.80			-288.5	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-363.0	58.3	0.36	1.80			-288.5	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-539.0	-58.3			2.27	20							σ_{1d}
7.80	1.75	-336.8	58.3	0.36	1.80			-287.6	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-336.8	58.3	0.36	1.80			-287.6	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-565.2	-58.3			2.38	21							σ_{1d}
7.80	3.50	-310.7	58.3	0.36	1.80			-286.7	2.0	4.75	5.42	4.75	5.42	a_{sh}
		-310.7	58.3	0.36	1.80			-286.7	2.0	4.75	5.42	4.75	5.42	a_{sv}
		-591.4	-58.3			2.49	22							σ_{1d}
10.40	0.00	-378.0	---	0.36	1.80			-353.4	---	4.75	5.42	4.75	5.42	a_{sh}
		-378.0	---	0.36	1.80			-353.4	---	4.75	5.42	4.75	5.42	a_{sv}
		-736.4	---			3.07	27							σ_{1d}
10.40	1.75	-325.7	---	0.36	1.80			-351.6	---	4.75	5.42	4.75	5.42	a_{sh}
		-325.7	---	0.36	1.80			-351.6	---	4.75	5.42	4.75	5.42	a_{sv}
		-788.7	---			3.29	29							σ_{1d}
10.40	3.50	-273.3	---	0.36	1.80			-349.8	---	4.75	5.42	4.75	5.42	a_{sh}

reinforced concrete wall results (wall 3)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}, n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh}, a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

ξ m	η m	design $n_{\eta\eta}$ kN/m	design $n_{\xi\eta}$ kN/m	design a_{sh} cm²/m	design a_{sv} cm²/m	princ.comp. stress σ_{1d} N/mm²	princ.comp. stress U_σ %	crack verif. $n_{\eta\eta}$ kN/m	crack verif. $n_{\xi\eta}$ kN/m	crack verif. a_{sh} cm²/m	crack verif. a_{sv} cm²/m	final result a_{sh} cm²/m	final result a_{sv} cm²/m	
		-273.3	---	0.36	1.80			-349.8	---	4.75	5.42	4.75	5.42	a_{sv}
		-841.0	---			3.50	31							σ_{1d} = max

maximum reinforcement: **max a_{sh} = 4.75 cm²/m max a_{sv} = 5.42 cm²/m**
maximum principal compr. stress: **max σ_{1d} = 3.50 N/mm²** (U_σ = 31% ≤ 100%) ⇒ verification fulfilled

reinforced concrete wall results (wall 4)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta}, n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), a_{sh}, a_{sv}: reinforcement horizontal,vertical (per side)
σ_{1d}: principal compr. stress in state 1, $U_\sigma = \sigma_{1d}/\sigma_{Rd}$: cross-section utilisation due to principal compr. stress
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

ξ m	η m	design $n_{\eta\eta}$ kN/m	design $n_{\xi\eta}$ kN/m	design a_{sh} cm²/m	design a_{sv} cm²/m	princ.comp. stress σ_{1d} N/mm²	princ.comp. stress U_σ %	crack verif. $n_{\eta\eta}$ kN/m	crack verif. $n_{\xi\eta}$ kN/m	crack verif. a_{sh} cm²/m	crack verif. a_{sv} cm²/m	final result a_{sh} cm²/m	final result a_{sv} cm²/m	
0.00	0.00	-648.6	---	0.36	1.80			-300.6	---	4.75	5.42	4.75	5.42	a_{sh} = max
		-648.6	---	0.36	1.80			-300.6	---	4.75	5.42	4.75	5.42	a_{sv} = max
		-648.6	---			2.70	24							σ_{1d}
0.00	1.75	-712.1	---	0.36	1.80			-305.3	---	4.75	5.42	4.75	5.42	a_{sh}
		-712.1	---	0.36	1.80			-305.3	---	4.75	5.42	4.75	5.42	a_{sv}
		-712.1	---			2.97	26							σ_{1d}
0.00	3.50	-775.6	---	0.36	1.80			-310.0	---	4.75	5.42	4.75	5.42	a_{sh}
		-775.6	---	0.36	1.80			-310.0	---	4.75	5.42	4.75	5.42	a_{sv}
		-775.6	---			3.23	29							σ_{1d} = max
1.60	0.00	-541.1	43.5	0.36	1.80			-290.8	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-541.1	43.5	0.36	1.80			-290.8	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-541.1	43.5			2.27	20							σ_{1d}
1.60	1.75	-572.9	43.5	0.36	1.80			-293.1	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-572.9	43.5	0.36	1.80			-293.1	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-572.9	43.5			2.40	21							σ_{1d}
1.60	3.50	-604.6	43.5	0.36	1.80			-295.5	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-604.6	43.5	0.36	1.80			-295.5	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-604.6	43.5			2.53	22							σ_{1d}
3.20	0.00	-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sh}
		-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sv}
		-481.1	0.0			2.00	18							σ_{1d}
3.20	1.75	-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sh}
		-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sv}
		-481.1	0.0			2.00	18							σ_{1d}
3.20	3.50	-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sh}
		-433.6	58.1	0.36	1.80			-281.0	4.3	4.75	5.42	4.75	5.42	a_{sv}
		-481.1	0.0			2.00	18							σ_{1d}
4.80	0.00	-326.1	43.5	0.36	1.80			-271.2	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-326.1	43.5	0.36	1.80			-271.2	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-541.1	-43.5			2.27	20							σ_{1d}
4.80	1.75	-294.3	43.5	0.36	1.80			-268.9	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-294.3	43.5	0.36	1.80			-268.9	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-572.9	-43.5			2.40	21							σ_{1d}
4.80	3.50	-262.6	43.5	0.36	1.80			-266.5	3.2	4.75	5.42	4.75	5.42	a_{sh}
		-262.6	43.5	0.36	1.80			-266.5	3.2	4.75	5.42	4.75	5.42	a_{sv}
		-604.6	-43.5			2.53	22							σ_{1d}
6.40	0.00	-218.6	---	0.36	1.80			-261.4	---	4.75	5.42	4.75	5.42	a_{sh}
		-218.6	---	0.36	1.80			-261.4	---	4.75	5.42	4.75	5.42	a_{sv}
		-648.6	---			2.70	24							σ_{1d}
6.40	1.75	-155.1	---	0.36	1.80			-256.7	---	4.75	5.42	4.75	5.42	a_{sh}
		-155.1	---	0.36	1.80			-256.7	---	4.75	5.42	4.75	5.42	a_{sv}
		-712.1	---			2.97	26							σ_{1d}
6.40	3.50	-91.6	---	0.36	1.80			-252.0	---	4.75	5.42	4.75	5.42	a_{sh}
		-91.6	---	0.36	1.80			-252.0	---	4.75	5.42	4.75	5.42	a_{sv}
		-775.6	---			3.23	29							σ_{1d}

maximum reinforcement: **max a_{sh} = 4.75 cm²/m max a_{sv} = 5.42 cm²/m**
maximum principal compr. stress: **max σ_{1d} = 3.23 N/mm²** (U_σ = 29% ≤ 100%) ⇒ verification fulfilled

reinforced concrete wall results (anchor tensile force, wall 1)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta},n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), Z: anchor tensile force in the floor joint (uls)

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
0.00	3.50	-777.8	---		
				---	---
1.60	3.50	-606.8	43.5		
				---	---
3.20	3.50	-435.9	58.0		

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
				---	---
4.80	3.50	-264.9	43.5		
				---	---
6.40	3.50	-93.9	---		

reinforced concrete wall results (anchor tensile force, wall 2)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta},n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), Z: anchor tensile force in the floor joint (uls)

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
0.00	3.50	211.6	---		
				---	---
2.60	3.50	5.3	-58.2		
				---	---
5.20	3.50	-348.0	77.6		

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
				---	---
7.80	3.50	-310.8	58.2		
				---	---
10.40	3.50	-273.5	---		

reinforced concrete wall results (anchor tensile force, wall 3)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta},n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), Z: anchor tensile force in the floor joint (uls)

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
0.00	3.50	211.7	---		
				---	---
2.60	3.50	5.4	-58.3		
				---	---
5.20	3.50	-348.0	77.7		

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
				---	---
7.80	3.50	-310.7	58.3		
				---	---
10.40	3.50	-273.3	---		

reinforced concrete wall results (anchor tensile force, wall 4)

explanations: ξ,η: coordinates of the design point on the wall plate (ξ=0,η=0: top left)
$n_{\eta\eta},n_{\xi\eta}$: design normal forces ($n_{\xi\xi}$ = 0), Z: anchor tensile force in the floor joint (uls)

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
0.00	3.50	-775.6	---		
				---	---
1.60	3.50	-604.6	43.5		
				---	---
3.20	3.50	-433.6	58.1		

ξ m	η m	$n_{\eta\eta}$ kN/m	$n_{\xi\eta}$ kN/m	Z_l kN	Z_r kN
				---	---
4.80	3.50	-262.6	43.5		
				---	---
6.40	3.50	-91.6	---		

12.2. concrete columns

concrete columns results

explanations: N_d: design normal force, A_s: reinforcement evenly distributed
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

	design		crack verif.		
Nr. -	N_d kN	A_s cm²	N_d kN	A_s cm²	A_s cm²
5	-1674.1	5.78	-997.8	8.95	8.95
6	-1674.1	5.78	-997.8	8.95	8.95
7	-4495.2	61.68	-997.8	61.68	61.68
8	-3910.6	48.23	-997.8	48.23	48.23
9	-3910.6	48.23	-997.8	48.23	48.23
10	-4495.2	61.68	-997.8	61.68	61.68

	design		crack verif.		
Nr. -	N_d kN	A_s cm²	N_d kN	A_s cm²	A_s cm²
11	-4582.1	63.68	-997.8	63.68	63.68
12	-3900.1	47.99	-997.8	47.99	47.99
13	-3900.1	47.99	-997.8	47.99	47.99
14	-4582.1	63.68	-997.8	63.68	63.68
15	-640.6	2.21	-379.1	8.95	8.95
16	-1663.6	5.74	-990.6	8.95	8.95

concrete columns results

explanations: N_d: design normal force, A_s: reinforcement evenly distributed
The final reinforcement contains reinforcement components from design, crack verif. and main reinforcement.

Nr.	design N_d	design A_s	crack verif. N_d	crack verif. A_s	A_s
-	kN	cm²	kN	cm²	cm²
17	-1663.6	5.74	-990.6	8.95	8.95
18	-640.6	2.21	-379.1	8.95	8.95

maximum reinforcement: **max A_s = 63.68 cm²**

12.3. summary

explanations: max. req. a_{sv}, max. req. a_{sh}: maximum required reinforcement vertical,horizontal (per side)
max. req. $A_{s,z}$: maximum required reinforcement for tension anchorage

Nr	type, material	max. utilization		max. req. asv	max. req. ash	max. req. Asz
1	reinf.concwall	29%	✓	5.42 cm²/m	4.75 cm²/m	
2	reinf.concwall	31%	✓	5.42 cm²/m	4.75 cm²/m	
3	reinf.concwall	31%	✓	5.42 cm²/m	4.75 cm²/m	
4	reinf.concwall	29%	✓	5.42 cm²/m	4.75 cm²/m	
5	reinf.conccolumn	0%	✓	8.95 cm²/m		
6	reinf.conccolumn	0%	✓	8.95 cm²/m		
7	reinf.conccolumn	0%	✓	61.68 cm²/m		
8	reinf.conccolumn	0%	✓	48.23 cm²/m		
9	reinf.conccolumn	0%	✓	48.23 cm²/m		
10	reinf.conccolumn	0%	✓	61.68 cm²/m		
11	reinf.conccolumn	0%	✓	63.68 cm²/m		
12	reinf.conccolumn	0%	✓	47.99 cm²/m		
13	reinf.conccolumn	0%	✓	47.99 cm²/m		
14	reinf.conccolumn	0%	✓	63.68 cm²/m		
15	reinf.conccolumn	0%	✓	8.95 cm²/m		
16	reinf.conccolumn	0%	✓	8.95 cm²/m		
17	reinf.conccolumn	0%	✓	8.95 cm²/m		
18	reinf.conccolumn	0%	✓	8.95 cm²/m		
	maximum	31%	✓			

all required verifications successfully fulfilled.

13. parameters of the national annexes

Selected design parameters of the national annex
Deutschland

EN 1992-1-1 (EC 2, Hochbau), NA Deutschland

chapter	value	meaning
2.4.2.4(1)		partial factors for concrete and reinforcing steel
	γ_c = 1.50 γ_s = 1.15	permanent and temporary design situation
	γ_c = 1.50 γ_s = 1.15	design situation for fatigue
	γ_c = 1.50 γ_s = 1.15	design situation for earthquake
	γ_c = 1.30 γ_s = 1.00	exceptional design situation
2.4.2.4(2)	γ_c = 1.00 γ_s = 1.00	serviceability limit state
3.1.6(1)P	α_{cc} = 0.85	reduction coefficient for the concrete compressive strength
3.1.6(2)P	α_{ct} = 1.00	reduction coefficient for the concrete tensile strength
5.8.3.1(1)	λ_{lim} s. NA-DE	slenderness limit value for single compression members
7.3.4(3)	k_3 = 0.00	cracks: coefficient for determining the maximum crack spacing for completed crack pattern
	k_4 = 0.278	cracks: coefficient for determining the maximum crack spacing for

chapter	value	meaning
		completed crack pattern
9.5.2(2)	$A_{s,min} = 0.150\ N_{Ed}/f_{yd}$	minimum reinforcement for columns [cm²]
9.6.2(1)	$A_{s,vmin}$ s. NA-DE	vertical minimum reinforcement for walls [cm²]
11.3.5(1)	$\alpha_{lcc} = 0.75$	lightweight concrete: reduction coefficient for the concrete compress
11.3.5(2)	$\alpha_{lct} = 1.00$	lightweight concrete: reduction coefficient for the concrete tensile