Static calculation of a slab structure using the method of finite elements

Elements:

Quadrangular and triangular DKT-elements based on the slab theory of Kirchhoff in conjunction with bar elements of girder grids

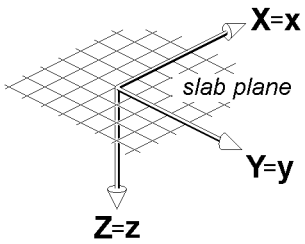
Degrees of freedom of deformations:

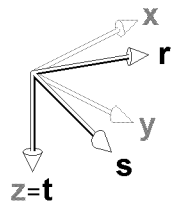
Displacement in z-direction, rotation about the x- and y-axis

Coordinate systems:

X-Y-Z global 3D coordinate system
x-y-z coordinate system of the plane
r-s-t individual coordinate system of nodes
l-m-n coordinate system of bars
e-f-g coordinate system of supported lines

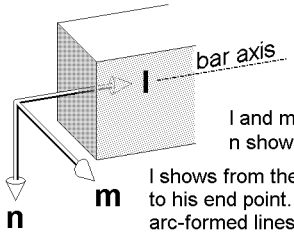
All coordinate systems are right handed orthogonal





The r-s-t-system results from a user-defined rotation of the X-Y-Z-system around the z-axis.

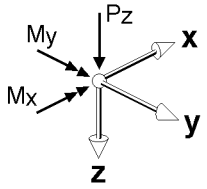
For all nodes, whose r-s-t-system aren't explicit given, r-s-t = x-y-z is valid.



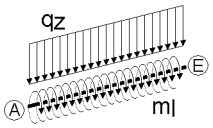
l and m lay in the slab-plane. n shows in z-direction.

l shows from the start point of the bar to his end point. In case of circular arc-formed lines l tangentially touchs the cirular arc.

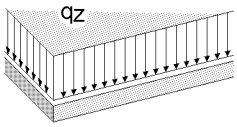
Loads:



Point loads
optionally also defined in the r-s-t-system

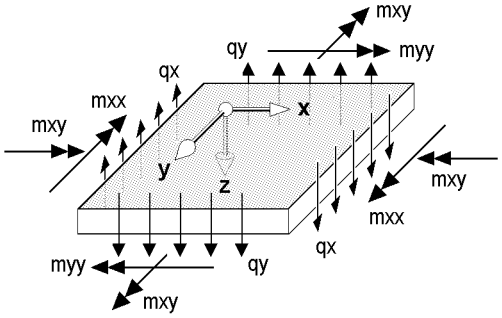


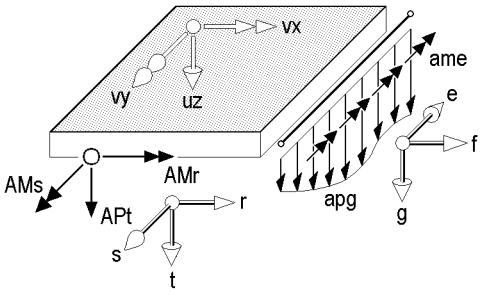
Line loads
optionally also linear-variable; pay attention to the line orientation of the torsional moment ml



Area loads
Dead loads and area loads act always in z-direction. In case of temperature loads Δt is the difference between the temperature of the upper and the lower extreme fibre.

Results:





mxx, myy	bending moments [kNm/m]
mxy	torsional moments [kNm/m]
qx, qy	shear forces [kN/m]
uz	displacements [mm]
vx, vy	rotations [mm/m]
AMr, AMs, APt	reactions of supported points [kNm, kN]
ame, apg	reactions of supported lines [kNm/m, kN/m]

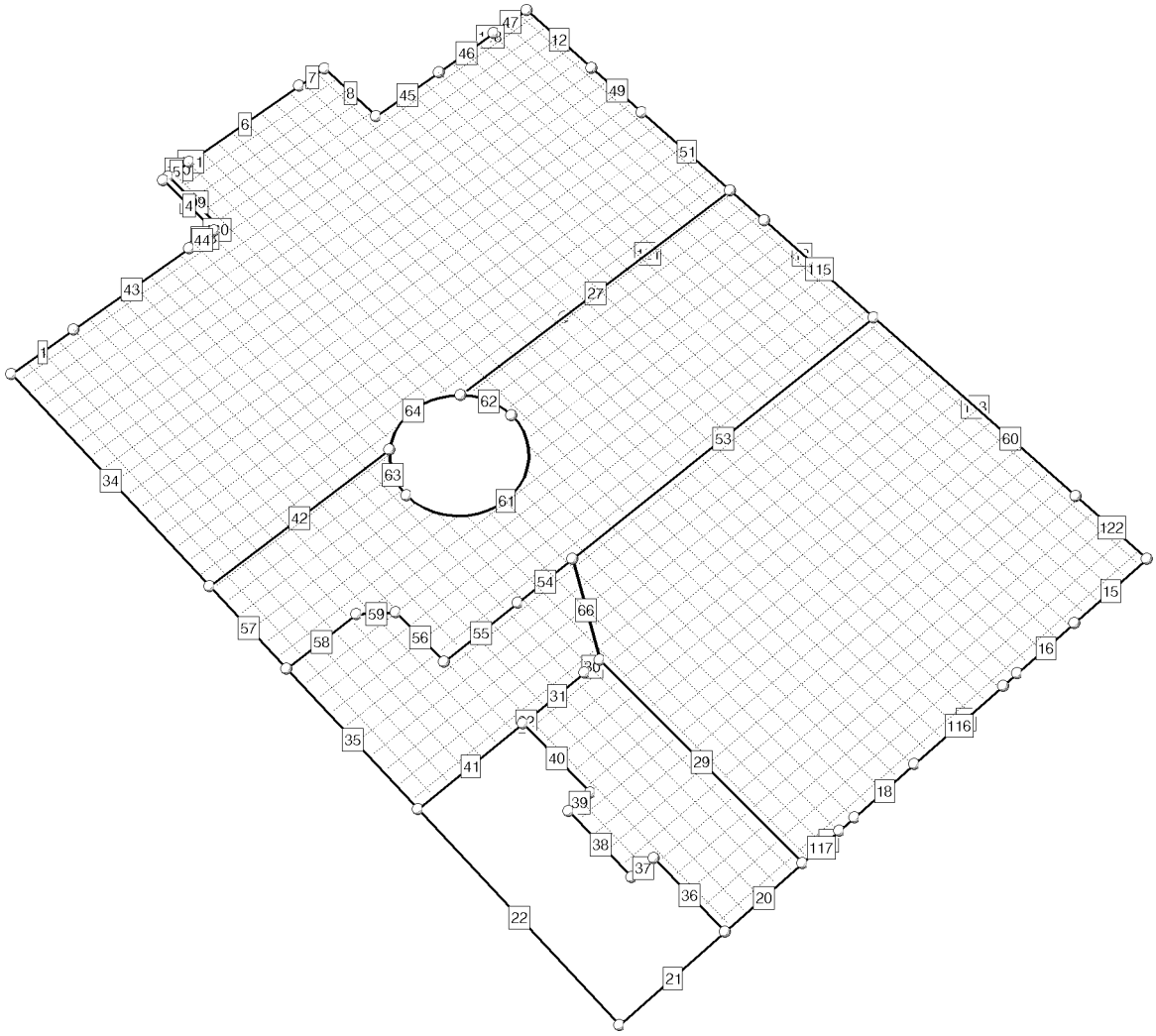
GLOBAL INFORMATION

Remarks with respect to calculation

Calculation of the system is linear. Elastic bedding of areas are respected by the method of foundation modulus. The load combinations, which are associated to the demanded verifications, will be described by the defined rules for building extremes as well as the defined load spectra. Remarks with respect to the non-linear behaviour are recorded at this place, but calculation ignores them.

Overview: Complete system

with line numbers



Points and coordinates of points in the slab plane

Type=**Rnd**: The point is on the edge of a plane position. **Type**=**Fix**: The point is part of a plane position and is respected by the mesh generator. **Type**= **-** : The point is not of relevance to the mesh generator.

point	x	y	sheet	type	point	x	y	sheet	type
-	m	m	-	-	-	m	m	-	-
1	2.000	2.000	System	Rnd	8	8.133	0.900	System	Rnd
2	3.000	2.000	System	Rnd	9	8.133	2.000	System	Rnd
3	4.910	2.000	System	Rnd	10	9.263	2.000	System	Rnd
4	5.323	2.000	System	Rnd	11	10.273	2.000	System	Rnd
5	5.323	0.900	System	Rnd	12	10.880	2.000	System	Rnd
6	5.773	0.900	System	Rnd	13	10.880	6.100	System	Rnd
7	7.683	0.900	System	Rnd	14	10.880	8.800	System	Rnd

Points and coordinates of points in the slab plane

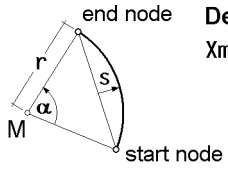
Type=Rnd: The point is on the edge of a plane position. **Type=Fix**: The point is part of a plane position and is respected by the mesh generator. **Type= -** : The point is not of relevance to the mesh generator.

point	x	y	sheet	type
-	m	m	-	-
15	10.880	13.540	System	Rnd
16	9.560	13.540	System	Rnd
17	8.550	13.540	System	Rnd
18	6.770	13.540	System	Rnd
19	5.760	13.540	System	Rnd
20	4.905	13.540	System	Rnd
21	3.655	13.540	System	Rnd
22	2.005	13.540	System	-
27	2.000	6.100	System	Rnd
28	4.905	10.040	System	fix
29	4.655	10.040	System	fix
30	3.755	10.040	System	fix
31	2.005	10.040	System	Rnd
32	3.655	12.340	System	Rnd
33	3.305	12.340	System	Rnd
34	3.305	11.240	System	Rnd
35	3.655	11.240	System	Rnd
36	3.655	10.040	System	Rnd
37	4.900	6.100	System	Rnd
40	6.100	6.100	System	Rnd
41	10.880	3.350	System	Rnd
42	10.880	4.360	System	Rnd
44	5.580	8.800	System	fix
45	4.680	8.800	System	fix
46	3.480	8.800	System	fix
47	3.480	7.900	System	fix
48	2.000	7.600	System	Rnd
49	3.100	7.600	System	fix
50	4.634	6.751	System	Rnd
51	6.384	6.751	System	Rnd
97	5.010	2.000	LF: 5	-
98	5.410	2.000	LF: 5	-
100	5.410	0.900	LF: 5	-
102	5.810	0.900	LF: 5	-
103	7.820	0.900	LF: 5	-
105	8.220	0.900	LF: 5	-
109	10.880	6.750	LF: 5	-
110	10.880	12.350	LF: 5	-
111	8.300	13.540	LF: 5	-
112	5.510	13.540	LF: 5	-
113	10.130	2.000	LF: 5	-
118	7.880	6.100	LF: 5	-
126	7.820	0.900	LF: 6	-
127	8.220	0.900	LF: 6	-

Straight lines

Type=Rnd: The straight line describes the edge of a plane position. **Type=Fix**: The straight line is part of a plane position and is respected by the mesh generator. **Type= -** : The straight line is not of relevance to the mesh generator.

line	start	end	length	sheet	type
-	-	-	m	-	-
1	1	2	1.000	System	Rnd
4	4	5	1.100	System	Rnd
5	5	6	0.450	System	Rnd
6	6	7	1.910	System	Rnd
7	7	8	0.450	System	Rnd
8	8	9	1.100	System	Rnd
12	12	41	1.350	System	Rnd
13	13	14	2.700	System	Rnd
15	15	16	1.320	System	Rnd
16	16	17	1.010	System	Rnd
17	17	18	1.780	System	Rnd
18	18	19	1.010	System	Rnd
19	19	20	0.855	System	Rnd
20	20	21	1.250	System	Rnd
21	21	22	1.650	System	-
22	22	31	3.500	System	-
27	13	40	4.780	System	fix
29	20	28	3.500	System	fix
30	28	29	0.250	System	fix
31	29	30	0.900	System	fix
32	30	36	0.100	System	fix
34	27	1	4.100	System	Rnd
35	31	48	2.440	System	Rnd
36	21	32	1.200	System	Rnd
37	32	33	0.350	System	Rnd
38	33	34	1.100	System	Rnd
39	34	35	0.350	System	Rnd
40	35	36	1.200	System	Rnd
41	36	31	1.650	System	Rnd
42	27	37	2.900	System	fix
43	2	3	1.910	System	Rnd
44	3	4	0.413	System	Rnd
45	9	10	1.130	System	Rnd
46	10	11	1.010	System	Rnd
47	11	12	0.607	System	Rnd
49	41	42	1.010	System	Rnd
51	42	13	1.740	System	Rnd
53	14	44	5.300	System	fix
54	44	45	0.900	System	fix
55	45	46	1.200	System	fix
56	46	47	0.900	System	fix
57	27	48	1.500	System	Rnd
58	48	49	1.100	System	fix
59	49	47	0.484	System	fix
60	14	15	4.740	System	Rnd
65	28	44	1.412	LF: 3	-
66	28	44	1.412	LF: 4	-
108	97	4	0.313	LF: 5	-
109	98	100	1.100	LF: 5	-
110	100	6	0.363	LF: 5	-
115	109	14	2.050	LF: 5	-
116	111	18	1.530	LF: 5	-
117	112	20	0.605	LF: 5	-
118	113	11	0.143	LF: 5	-
121	13	118	3.000	LF: 5	-
122	110	15	1.190	LF: 5	-
140	4	98	0.087	LF: 6	-
141	6	102	0.037	LF: 6	-
143	14	110	3.550	LF: 6	-



Definition of a circular arc

Xm Ym Zm	coordinates of the centre point M of the arc
l	arch length
s	arch rise
r	arch radius
α	interior angle

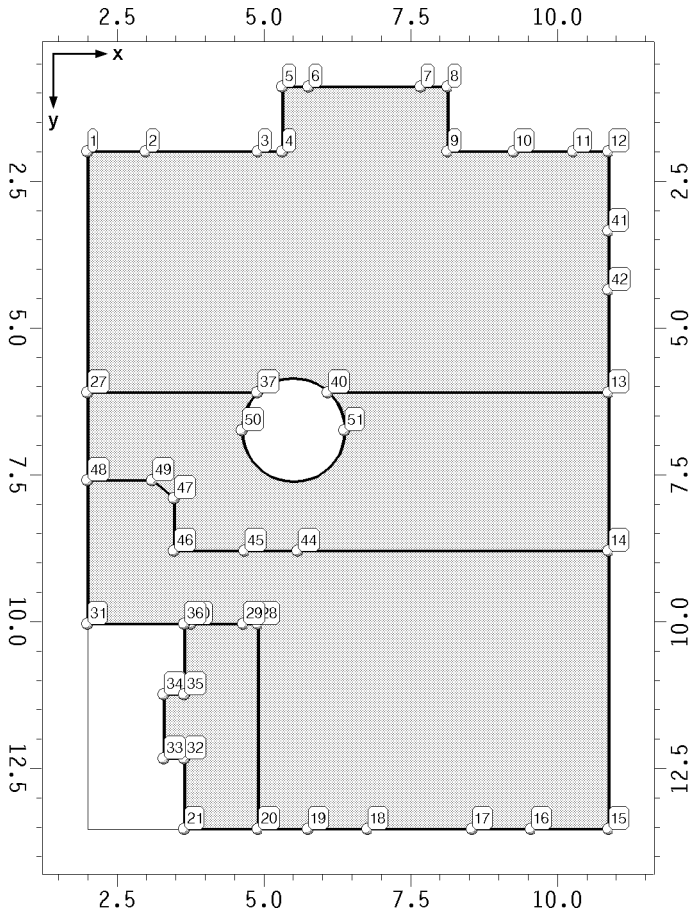
Circular arcs

Type=Rnd: The circular arc describes the edge of plane position . **Type=Fix**: The circular arc is part of a plane position and is respected by the mesh generator. **Type= -** : The circular arc is not of relevance to the mesh generator.

line	start	end	Xm	Ym	Zm	r	s	l	α	sheet	type
-	-	-	m	m	m	m	m	m	°	-	-
61	50	51	5.509	6.751	0.000	0.875	0.875	2.749	180.000	System	Rnd
62	51	40	5.509	6.745	0.000	0.875	0.075	0.731	47.868	System	Rnd
63	37	50	5.509	6.729	0.000	0.875	0.074	0.724	47.366	System	Rnd
64	40	37	5.500	6.729	0.000	0.869	0.240	1.324	87.306	System	Rnd

PLANE POSITION 20: POSITION 20 A

Position 20: Position 20 A in plane: slab plane



Points in position 20: Position 20 A

x and y are applied to the coordinate system of plane `slab plane`

Type=Rnd: The point is on the edge of the plane position. **Type=Fix**: The point is inside of the plane position and is respected by the mesh generator. **Type= -** : The point is not of relevance to the mesh generator.

point	x	y	type	point	x	y	type	point	x	y	type
-	m	m	-	-	m	m	-	-	m	m	-
1	2.000	2.000	Rnd	16	9.560	13.540	Rnd	36	3.655	10.040	Rnd
2	3.000	2.000	Rnd	17	8.550	13.540	Rnd	37	4.900	6.100	Rnd
3	4.910	2.000	Rnd	18	6.770	13.540	Rnd	40	6.100	6.100	Rnd
4	5.323	2.000	Rnd	19	5.760	13.540	Rnd	41	10.880	3.350	Rnd
5	5.323	0.900	Rnd	20	4.905	13.540	Rnd	42	10.880	4.360	Rnd
6	5.773	0.900	Rnd	21	3.655	13.540	Rnd	44	5.580	8.800	fix
7	7.683	0.900	Rnd	27	2.000	6.100	Rnd	45	4.680	8.800	fix
8	8.133	0.900	Rnd	28	4.905	10.040	fix	46	3.480	8.800	fix
9	8.133	2.000	Rnd	29	4.655	10.040	fix	47	3.480	7.900	fix
10	9.263	2.000	Rnd	30	3.755	10.040	fix	48	2.000	7.600	Rnd
11	10.273	2.000	Rnd	31	2.005	10.040	Rnd	49	3.100	7.600	fix
12	10.880	2.000	Rnd	32	3.655	12.340	Rnd	50	4.634	6.751	Rnd
13	10.880	6.100	Rnd	33	3.305	12.340	Rnd	51	6.384	6.751	Rnd
14	10.880	8.800	Rnd	34	3.305	11.240	Rnd				
15	10.880	13.540	Rnd	35	3.655	11.240	Rnd				

Definitions of areas

Lines in polygonal order (line-by-line) with indication of orientation (from node - to node)

line	from - to		line	from - to		line	from - to		line	from - to		line	from - to	
Edge of plane position 20: Position 20 A														
1	1	2	43	2	3	44	3	4	4	4	5	5	5	6
6	6	7	7	7	8	8	8	9	45	9	10	46	10	11
47	11	12	12	12	41	49	41	42	51	42	13	13	13	14
60	14	15	15	15	16	16	16	17	17	17	18	18	18	19
19	19	20	20	20	21	36	21	32	37	32	33	38	33	34
39	34	35	40	35	36	41	36	31	35	31	48	57	48	27
34	27	1												
Notch														
63	37	50	61	50	51	62	51	40	64	40	37			

Other lines, which are defined in the position

Type=Fix: The line is respected by the mesh generator. **Type= -** : The line is not of relevance to the mesh generator.

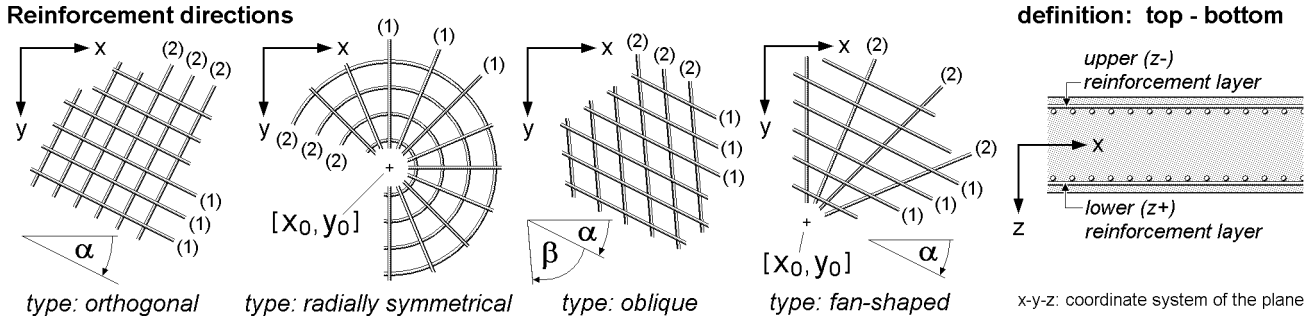
line	start	end	type	line	start	end	type	line	start	end	type
-	-	-	-	-	-	-	-	-	-	-	-
27	13	40	fix	32	30	36	fix	55	45	46	fix
29	20	28	fix	42	27	37	fix	56	46	47	fix
30	28	29	fix	53	14	44	fix	58	48	49	fix
31	29	30	fix	54	44	45	fix	59	49	47	fix

Calculation values of the position 20: Position 20 A

Material designation: Reinforced concrete C20/25

Geom. characteristic value		Phys. characteristic value		Other characteristic value	
Gross area:	100.15 m2	E-modulus:	24913.83 MN/m2	Length of element edges:	0.35 m
Net area:	97.73 m2	Poisson's ratio:	0.20 -	Generation direction:	0.00 °
Circumference:	43.74 m	Temp. coeff.:	1.00 10-5/K	Eccentricity:	no
Thickness:	20.00 cm	Bedding:	no		

Explanation of design properties



Design properties of plane position 20:

Edge distances	Initial reinforcement	Reinforcement direction	Reinforcement arrangement
(1)top = 3.5 cm (2)top = 4.5 cm (1)bottom= 3.5 cm (2)bottom= 4.5 cm	(1)top = 0.00 cm²/m (2)top = 0.00 cm²/m (1)bottom= 0.00 cm²/m (2)bottom= 0.00 cm²/m	Type: orthogonal with α = 0.00 °	Tensile reinforcement Transformation due to Baumann

Material properties of position 20:

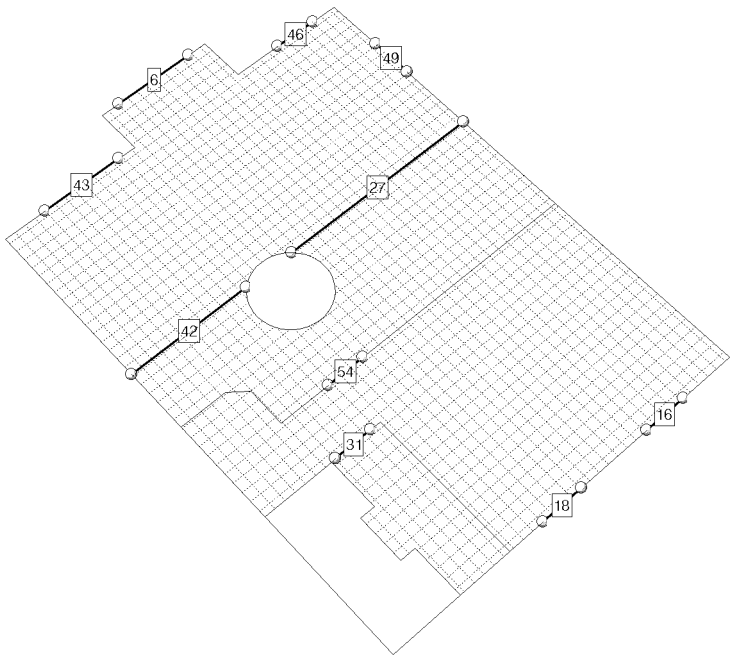
Material properties for verifications according to DIN 1045-1: concrete C20/25 reinforcement BSt 500
Concr.: ρ_c = 2200 kg/m³ f_{ck} = 20.0 MN/m² α = 0.850 ε_{c2} = -2.0‰ ε_{c2u} = -3.5‰ n_c = 2.00
E_{cm} = 24913.8 MN/m² f_{ctm} = 2.21 MN/m²
Reinf.: f_{yk} = 500.0 MN/m² f_{tk} = 525.0 MN/m² ε_{su} = 25.0‰ E_s = 200000.0 MN/m²

Maximum (rated) reinforcement ratio: max μ = 8.0%

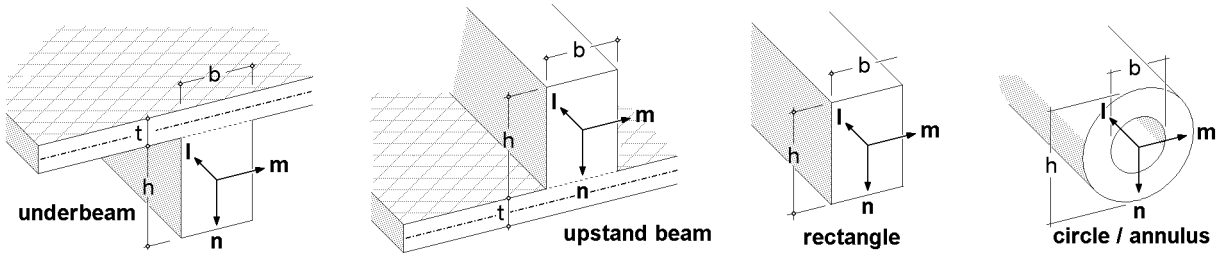
BARS

Lines with bar attributes

with line numbers



Explanations of the bar types



Description of bars

At haunched beams, subscript A refers to the cross-section of the start node and subscript E to cross-section of the end node.

line	start	end	bar type	h	b	t
-	-	-	-	cm	cm	cm
6	6	7	rectangle	20.0	24.0	---
16	16	17	rectangle	20.0	24.0	---
18	18	19	rectangle	20.0	24.0	---
27	13	40	rectangle	20.0	30.0	---
31	29	30	rectangle	20.0	24.0	---
42	27	37	rectangle	20.0	30.0	---
43	2	3	rectangle	20.0	24.0	---
46	10	11	rectangle	20.0	24.0	---
49	41	42	rectangle	20.0	24.0	---
54	44	45	rectangle	20.0	24.0	---

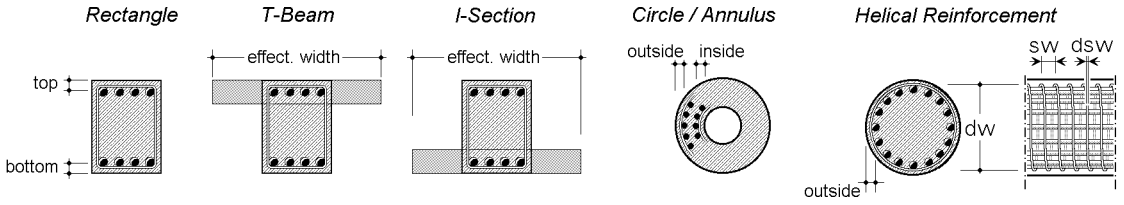
Calculation values of bars

At haunched beams, subscript A refers to the cross-section of the start node and subscript E to cross-section of the end node.

line	E-modulus	μ	αt	I_l	I_m
-	MN/m²	-	10^{-5} /K	cm⁴	cm⁴
6	24914	0.200	1.000	0	16000
16	24914	0.200	1.000	0	16000
18	24914	0.200	1.000	0	16000
27	24914	0.200	1.000	0	20000
31	24914	0.200	1.000	0	16000

line	E-modulus	μ	αt	I_l	I_m
-	MN/m²	-	10^{-5} /K	cm⁴	cm⁴
42	24914	0.200	1.000	0	20000
43	24914	0.200	1.000	0	16000
46	24914	0.200	1.000	0	16000
49	24914	0.200	1.000	0	16000
54	24914	0.200	1.000	0	16000

Explanation of design properties



Design properties of bars

Explanations: column **(S)** = symmetric condition of reinforcement arrangement: Z = tensile reinforcement, S = symmetric (top = bottom)
The effective width is only relevant at under-/upstand beams. max ρ = maximum (rated) reinforcement ratio

bar	edge distances		initial reinf.		S	eff. width		max ρ
	top	bottom	top	bottom		start	end	
	cm	cm	cm²	cm²	-	cm	cm	%
6	3.5	3.5	0.00	0.00	Z	--	--	8.0
16	3.5	3.5	0.00	0.00	Z	--	--	8.0
18	3.5	3.5	0.00	0.00	Z	--	--	8.0
27	5.0	5.0	0.00	0.00	Z	--	--	8.0
31	3.5	3.5	0.00	0.00	Z	--	--	8.0
42	5.0	5.0	0.00	0.00	Z	--	--	8.0
43	5.0	5.0	0.00	0.00	Z	--	--	8.0

Design properties of bars

Explanations: column **(S)** = symmetric condition of reinforcement arrangement: Z = tensile reinforcement, S = symmetric (top = bottom)
The effective width is only relevant at under-/upstand beams. max ρ = maximum (rated) reinforcement ratio

bar	edge distances		initial reinf.		S	eff. width		max ρ
	top	bottom	top	bottom		start	end	
	cm	cm	cm²	cm²	-	cm	cm	%
46	5.0	5.0	0.00	0.00	Z	--	--	8.0
49	5.0	5.0	0.00	0.00	Z	--	--	8.0
54	5.0	5.0	0.00	0.00	Z	--	--	8.0

Material properties of bars for verifications according to DIN 1045-1

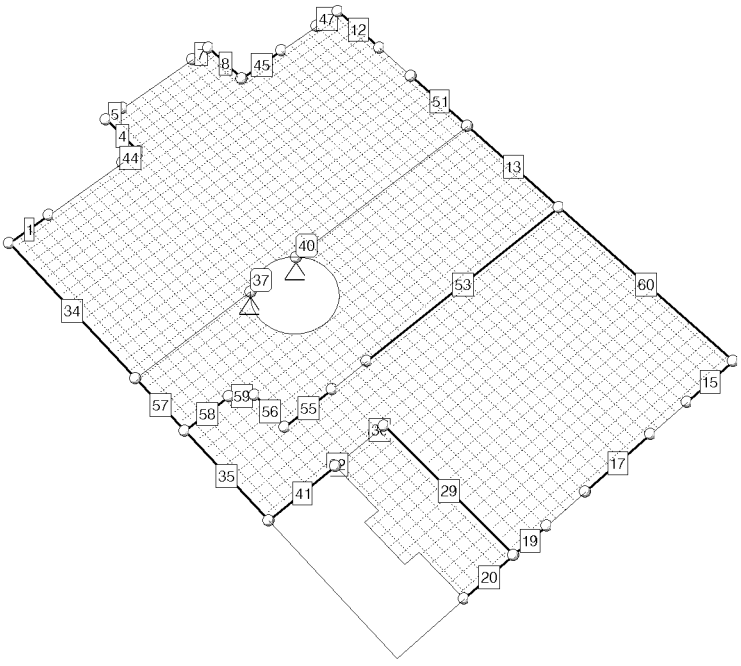
Explanations: ρ_C: maximum density of concrete; BSt: steel quality of longitudinal reinforcement
Material properties of concrete: f_{ck}: compressive strength of cylinder; α_c: reduction factor (eqn. 67); ε_{c2}, ε_{c2u}: strains;
n_c: exponent to describe the stress-strain-diagram (eqn. 65); E_{cm}: mean elastic modulus (secant modulus)
f_{ctm}: mean value of centric tensile strength; calculation of deformations: final creep coefficient $\varphi_{\infty,t0}$; final shrinkage strain ε_{cs},
Exposure classes for reinforcement corrosion XC, concrete attack XF, concrete corrosion (moisture class AKR) W
Material properties of reinforcement: f_{yk}: yield strength; f_{tk}: tensile strength; ε_{su}: elongation at failure; E_s: elastic modulus

bar	concrete	ρ_C	BSt	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	XC	XF	W
		kg/m³		MN/m²		‰	‰		MN/m²	MN/m²		‰	MN/m²	MN/m²	‰	MN/m²			
6	C25/30	2200	500	25.0	0.850	-2.0	-3.5	2.00	26662.6	2.56	---	---	500.0	525.0	25.0	200000.0	---	---	---
16	C25/30	2200	500	25.0	0.850	-2.0	-3.5	2.00	26662.6	2.56	---	---	500.0	525.0	25.0	200000.0	---	---	---
18	C25/30	2200	500	25.0	0.850	-2.0	-3.5	2.00	26662.6	2.56	---	---	500.0	525.0	25.0	200000.0	---	---	---
27	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---
31	C25/30	2200	500	25.0	0.850	-2.0	-3.5	2.00	26662.6	2.56	---	---	500.0	525.0	25.0	200000.0	---	---	---
42	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---
43	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---
46	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---
49	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---
54	C20/25	2200	500	20.0	0.850	-2.0	-3.5	2.00	24913.8	2.21	---	---	500.0	525.0	25.0	200000.0	---	---	---

BEARING INFORMATION

Supported lines and points

with numbers of lines and points



Supported lines

Cug: spring constants against a displacement in z-direction. Cve: spring constants against a rotation about the longitudinal axis. Cvf: spring constants against a rotation about the transveral axis. In case of non-linear calculation the denoted disability of displacement takes effect only by: (1) positive displacements, (2) negative displacements, (3) always.

line -	Cug MN/m2	Cve MNm/m	Cvf MNm/m	line -	Cug MN/m2	Cve MNm/m	Cvf MNm/m
1	<rigid>(1)	--	--	34	<rigid>(1)	--	--
4	<rigid>(1)	--	--	35	<rigid>(1)	--	--
5	<rigid>(1)	--	--	41	<rigid>(1)	--	--
7	<rigid>(1)	--	--	44	<rigid>(1)	--	--
8	<rigid>(1)	--	--	45	<rigid>(1)	--	--
12	<rigid>(1)	--	--	47	<rigid>(1)	--	--
13	<rigid>(1)	--	--	51	<rigid>(1)	--	--
15	<rigid>(1)	--	--	53	2000.000(1)	--	--
17	<rigid>(1)	--	--	55	2000.000(1)	--	--
19	<rigid>(1)	--	--	56	2000.000(1)	--	--
20	<rigid>(1)	--	--	57	<rigid>(1)	--	--
29	<rigid>(1)	--	--	58	2000.000(1)	--	--
30	<rigid>(1)	--	--	59	2000.000(1)	--	--
32	<rigid>(1)	--	--	60	<rigid>(1)	--	--

Supported points

Cut: spring constants against a displacement in z-direction. Cvr: spring constants against a rotation about the r-axis. Cvs: spring constants against a rotation about the s-axis. In case of non-linear calculation the denoted disability of displacement takes effect only by: (1) positive displacements, (2) negative displacements, (3) always.

point -	Cut MN/m	Cvr MNm	Cvs MNm
37	<rigid>(1)	--	--
40	<rigid>(1)	--	--

LOADING STRUCTURE

Description of loading structure

On the left-hand side, the relationship between the actions effects, load case file and load cases are shown in a tree structure. The right-hand side shows the characteristics of the superposition to the associated objects on the left-hand. In terms of the superposition, a load case file is equivalent to an extreme rule of the defined objects therein and can be additive or alternatively superpositioned.

Used symbols:  Action effect  Load case file  Load case

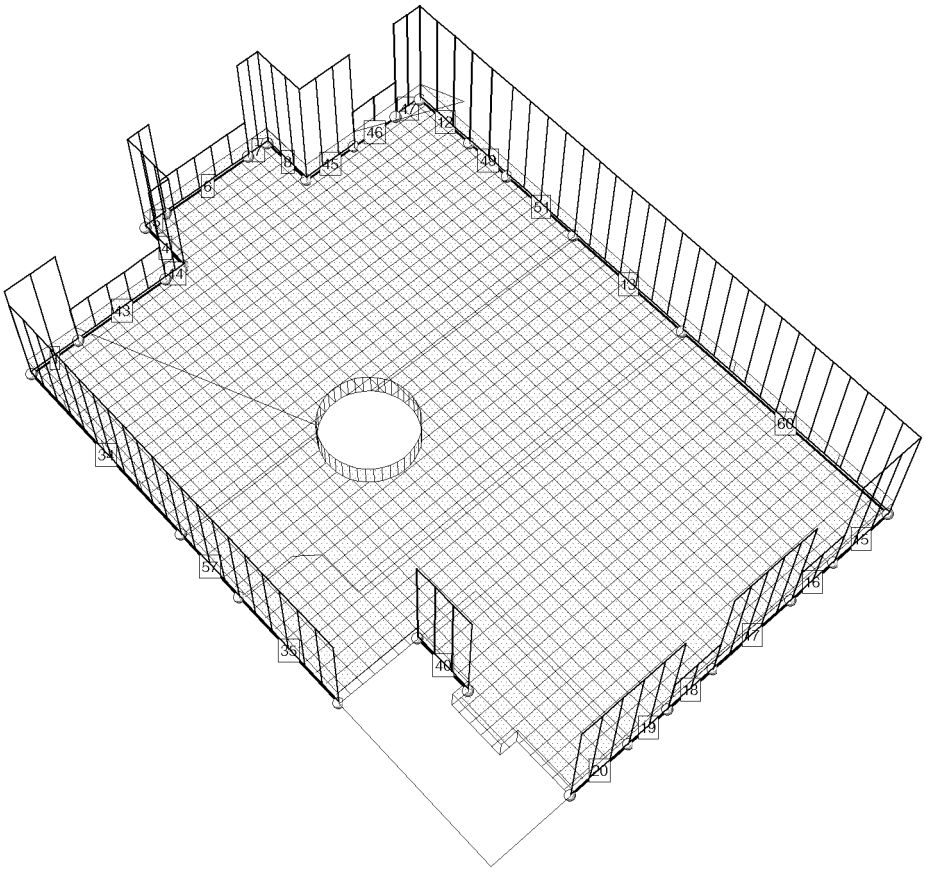
Description of loading structure

On the left-hand side, the relationship between the actions effects, load case file and load cases are shown in a tree structure. The right-hand side shows the characteristics of the superposition to the associated objects on the left-hand. In terms of the superposition, a load case file is equivalent to an extreme rule of the defined objects therein and can be additive or alternatively superpositioned.

1: permanent loads	**permanent loads**
1: dead load (1)	additive
5: Load spectrum 1	additive
2: live loads (1)	**transient live loads of housing, office rooms**
2: live loads (1/1)	additive
3: live loads (1/2)	additive
4: live loads (1/3)	additive
6: Load spectrum 2	additive

LOAD PICTURES IN LOAD CASE 1: DEAD LOAD (1)

Loaded objects in load case 1



Denoted loaded objects

type	number	designation
position	20	Position 20 A

Density of expelled areas in load case 1

area type -	no. designation -	γ kN/m³
position	20 Position 20 A	25.000

Area loads in load case 1

Linear transient area loads are defined by inputting load ordinates at 3 different points.

area type -	no. designation -	at point -	qz kN/m2
position	20 Position 20 A	const.	1.500

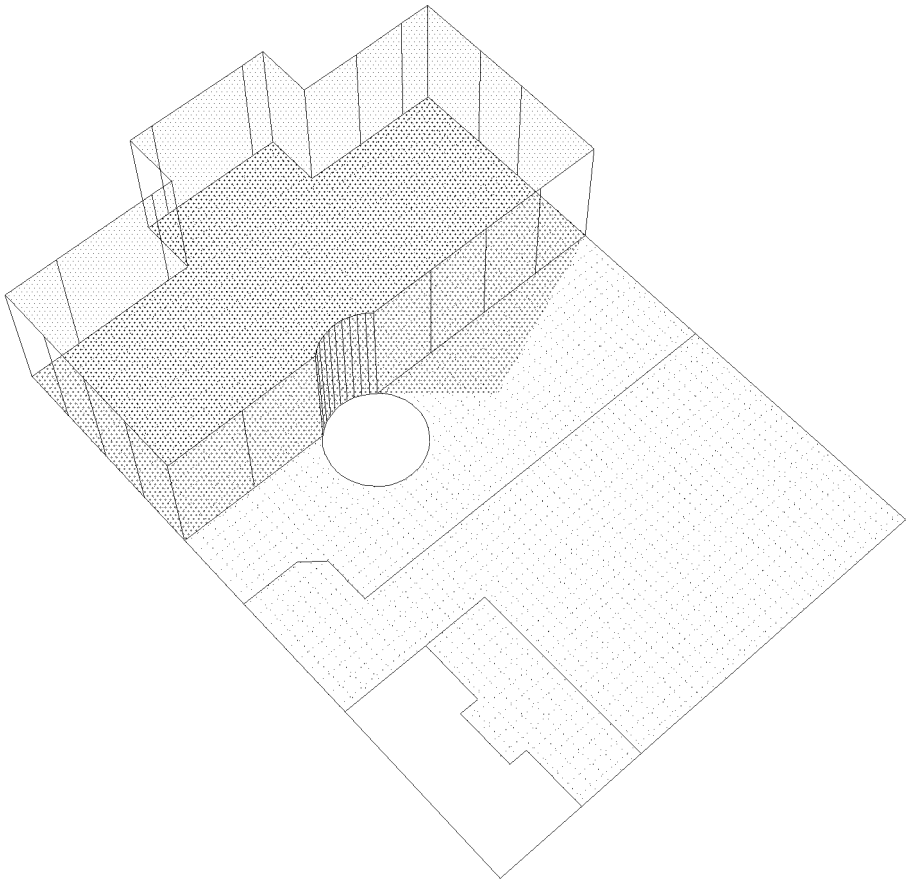
Line loads in load case 1

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line -	start -	end -	qz kN/m	mT kNm/m	line -	start -	end -	qz kN/m	mT kNm/m
40	35	36	8.100	0.000	**5**	5	6	8.200	0.000
35	31	48	6.860	0.000	**6**	6	7	3.000	0.000
57	27	48	6.860	0.000	**7**	7	8	8.200	0.000
34	27	1	6.860	0.000	**8**	8	9	8.200	0.000
60	14	15	8.200	0.000	**45**	9	10	8.200	0.000
13	13	14	8.200	0.000	**46**	10	11	3.000	0.000
51	42	13	8.200	0.000	**47**	11	12	8.200	0.000
49	41	42	8.200	0.000	**20**	20	21	8.200	0.000
12	12	41	8.200	0.000	**19**	19	20	8.200	0.000
1	1	2	8.200	0.000	**18**	18	19	3.000	0.000
43	2	3	3.000	0.000	**17**	17	18	8.200	0.000
44	3	4	8.200	0.000	**16**	16	17	3.000	0.000
4	4	5	8.200	0.000	**15**	15	16	8.200	0.000

LOAD PICTURES IN LOAD CASE 2: LIVE LOADS (1/1)

Loaded objects in load case 2



Denoted loaded objects

type	number	designation
Load area	1	neue Load area

Edge descriptions of load areas

Lines in polygonal order (line-by-line) with indication of orientation (from node - to node)

line	from - to		line	from - to		line	from - to		line	from - to		line	from - to	
Load area 1: neue Load area in plane slab plane														
42	27	37	64	37	40	27	40	13	51	13	42	49	42	41
12	41	12	47	12	11	46	11	10	45	10	9	8	9	8
7	8	7	6	7	6	5	6	5	4	5	4	44	4	3
43	3	2	1	2	1	34	1	27						

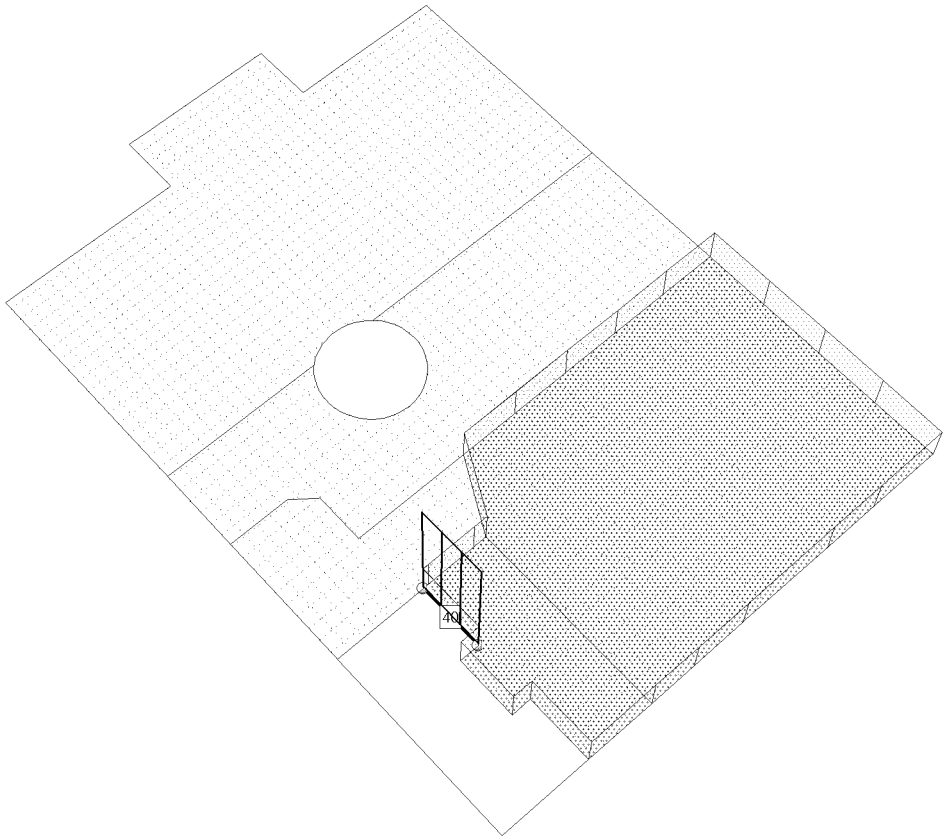
Area loads in load case 2

Linear transient area loads are defined by inputting load ordinates at 3 different points.

area type	no.	designation	at point	q_z
-	-	-	-	kN/m2
Load area	1	neue Load area	const.	2.700

LOAD PICTURES IN LOAD CASE 3: LIVE LOADS (1/2)

Loaded objects in load case 3



Denoted loaded objects

type	number	designation
Load area	2	neue Load area

Edge descriptions of load areas

Lines in polygonal order (line-by-line) with indication of orientation (from node - to node)

line	from - to		line	from - to		line	from - to		line	from - to		line	from - to	
Load area 2: neue Load area in plane slab plane														
65	28	44	53	44	14	60	14	15	15	15	16	16	16	17
17	17	18	18	18	19	19	19	20	20	20	21	36	21	32
37	32	33	38	33	34	39	34	35	40	35	36	32	36	30
31	30	29	30	29	28									

Area loads in load case 3

Linear transient area loads are defined by inputting load ordinates at 3 different points.

area type -	no. designation -	at point -	q_z kN/m2
Load area	2 neue Load area	const.	2.700

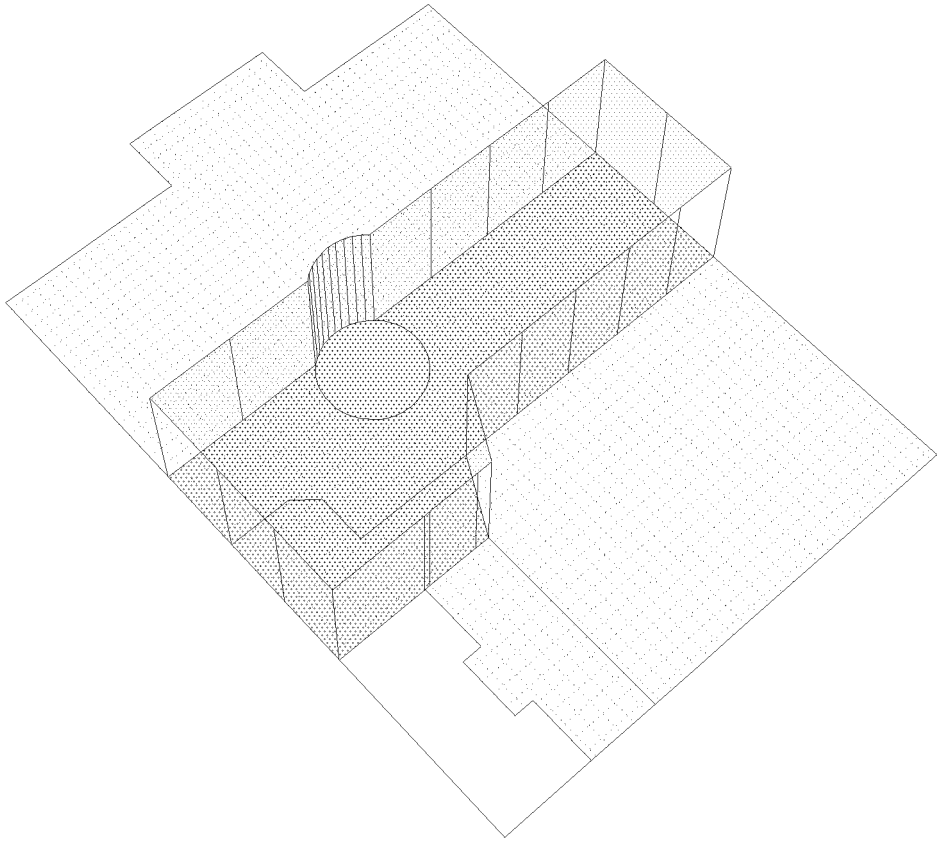
Line loads in load case 3

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line	start	end	qz	mT
-	-	-	kN/m	kNm/m
40	35	36	9.400	0.000

LOAD PICTURES IN LOAD CASE 4: LIVE LOADS (1/3)

Loaded objects in load case 4



Denoted loaded objects

type	number	designation
Load area	3	neue Load area

Edge descriptions of load areas

Lines in polygonal order (line-by-line) with indication of orientation (from node - to node)

line	from - to		line	from - to		line	from - to		line	from - to		line	from - to	
Load area 3: neue Load area in plane slab plane														
66	28	44	53	44	14	13	14	13	27	13	40	64	40	37
42	37	27	57	27	48	35	48	31	41	31	36	32	36	30
31	30	29	30	29	28									

Area loads in load case 4

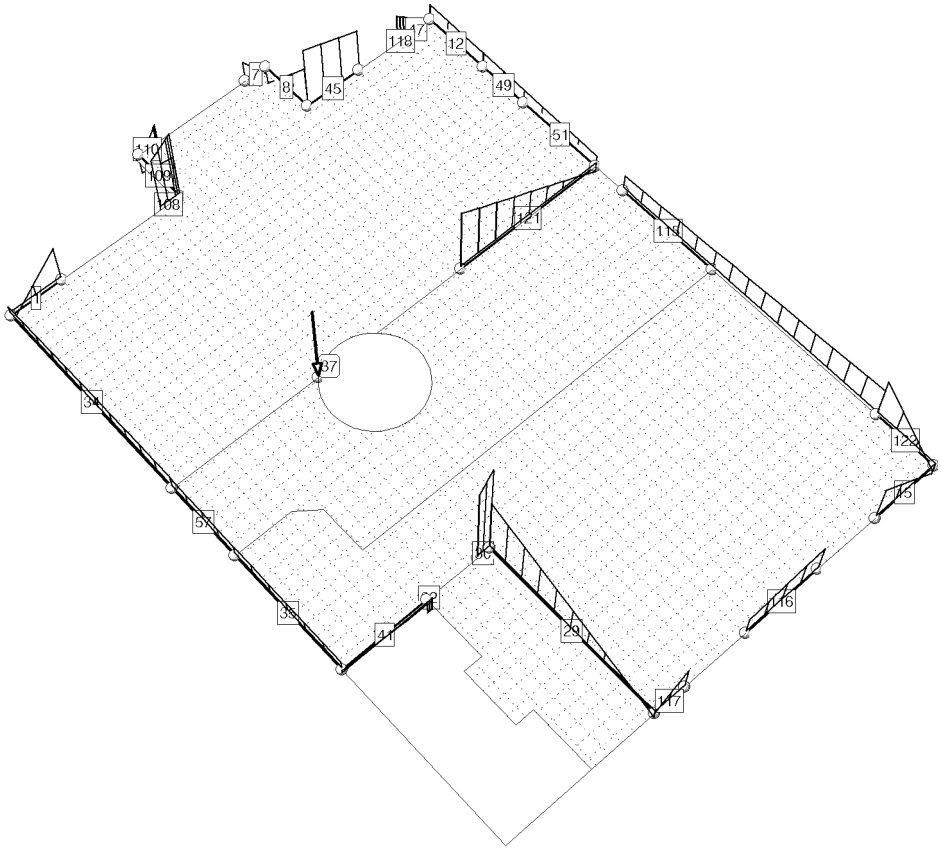
Linear transient area loads are defined by inputting load ordinates at 3 different points.

area type	no. designation	at point	qz
-	-	-	kN/m2
Load area	3 neue Load area	const.	2.700

LOAD PICTURES IN LOAD CASE 5: LOAD SPECTRUM 1

Loaded objects in load case 5

The pictures of these load casees were imported from the support reactions of the building component "Position 30 A".



Line loads in load case 5

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line	start	end	qz	m1	line	start	end	qz	m1
-	-	-	kN/m	kNm/m	-	-	-	kN/m	kNm/m
1A	1		-22.425	0.000	115E		14	35.240	0.000
1E		2	65.385	0.000	15A	15		-27.538	0.000
108A	97		102.298	0.000	15E		16	66.617	0.000
108E		4	124.875	0.000	116A	111		50.042	0.000
109A	98		79.980	0.000	116E		18	31.585	0.000
109E		100	-49.574	0.000	117A	112		40.240	0.000
110A	100		-24.717	0.000	117E		20	-7.717	0.000
110E		6	25.856	0.000	118A	113		49.483	0.000
12A	12		24.342	0.000	118E		11	37.718	0.000
12E		41	21.501	0.000	121A	13		-19.569	0.000
115A	109		25.123	0.000	121E		118	119.815	0.000

Line loads in load case 5

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line	start	end	qz	mτ
-	-	-	kN/m	kNm/m
29A	20		-18.540	0.000
29E		28	111.910	0.000
30A	28		197.574	0.000
30E		29	159.844	0.000
32A	30		-31.458	0.000
32E		36	-30.196	0.000
122A	110		75.272	0.000
122E		15	-21.385	0.000
34A	27		22.482	0.000
34E		1	13.516	0.000
35A	31		14.286	0.000
35E		48	17.011	0.000
41A	36		-6.615	0.000
41E		31	5.674	0.000
7A	7		32.492	0.000
7E		8	-23.382	0.000
8A	8		-43.881	0.000
8E		9	73.331	0.000
45A	9		112.132	0.000
45E		10	75.350	0.000
140A	4		124.875	0.000
140E		98	131.105	0.000
141A	6		25.856	0.000
141E		102	30.936	0.000
47A	11		37.718	0.000
47E		12	-12.011	0.000
143A	14		35.240	0.000
143E		110	52.759	0.000
49A	41		21.501	0.000
49E		42	19.375	0.000
51A	42		19.375	0.000
51E		13	15.713	0.000
57A	27		18.686	0.000
57E		48	17.011	0.000

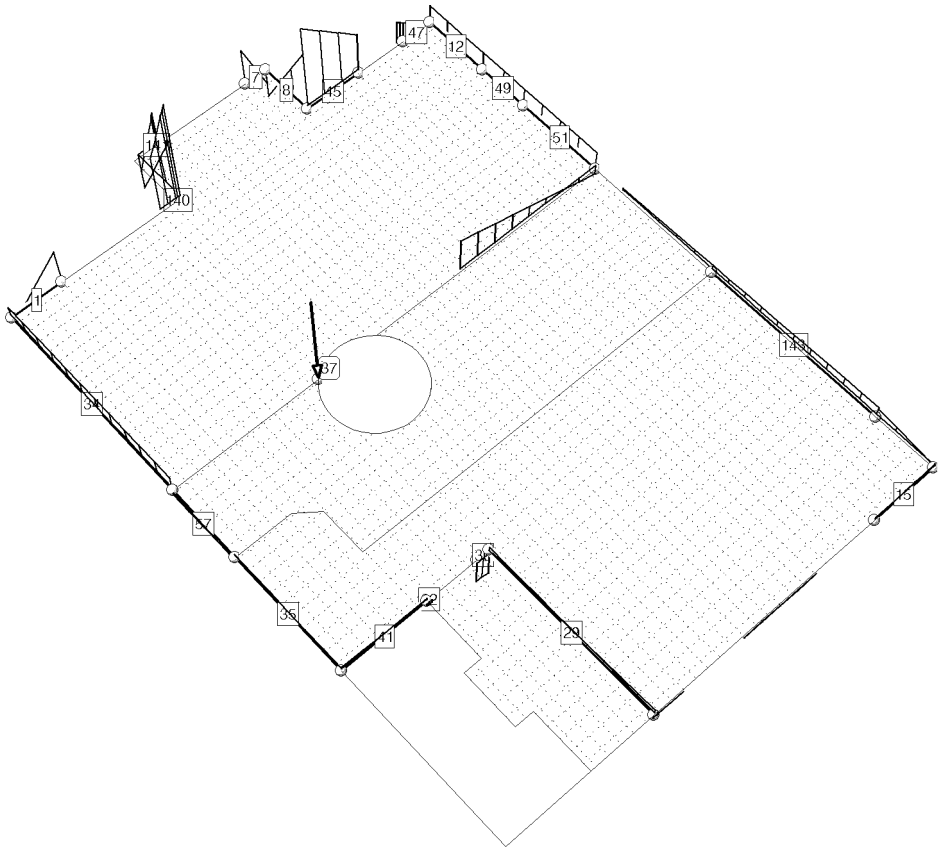
Point loads in load case 5

point	syst.	Pz(Pt)	Mx(Mr)	My(Ms)
-	-	kN	kNm	kNm
37	r-s-t	153.425	0.000	0.000

LOAD PICTURES IN LOAD CASE 6: LOAD SPECTRUM 2

Loaded objects in load case 6

The pictures of these load casees were imported from the support reactions of the building component "Position 30 A".



Line loads in load case 6

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line	start	end	qz	my	line	start	end	qz	my
-	-	-	kN/m	kNm/m	-	-	-	kN/m	kNm/m
1A	1		-13.334	0.000	29A	20		4.006	0.000
1E		2	34.317	0.000	29E		28	-4.665	0.000
108A	97		60.954	0.000	30A	28		-30.953	0.000
108E		4	96.472	0.000	30E		29	-28.173	0.000
109A	98		66.737	0.000	32A	30		-2.729	0.000
109E		100	-41.795	0.000	32E		36	-2.422	0.000
110A	100		-21.730	0.000	122A	110		6.981	0.000
110E		6	28.448	0.000	122E		15	-1.526	0.000
12A	12		15.473	0.000	34A	27		13.534	0.000
12E		41	15.441	0.000	34E		1	9.172	0.000
115A	109		1.419	0.000	35A	31		0.172	0.000
115E		14	4.190	0.000	35E		48	-1.499	0.000
15A	15		1.104	0.000	41A	36		-1.071	0.000
15E		16	-2.437	0.000	41E		31	1.927	0.000
116A	111		-0.763	0.000	7A	7		34.937	0.000
116E		18	-0.153	0.000	7E		8	-20.347	0.000
117A	112		-1.463	0.000	8A	8		-36.108	0.000
117E		20	0.390	0.000	8E		9	60.038	0.000
118A	113		22.811	0.000	45A	9		87.347	0.000
118E		11	17.304	0.000	45E		10	40.430	0.000
121A	13		-10.175	0.000	140A	4		96.472	0.000
121E		118	34.363	0.000	140E		98	106.274	0.000

Line loads in load case 6

At variable line loads, subscript A refers to the coordinates of the start node and subscript E to coordinates of the end node.

line	start	end	qz	mT
-	-	-	kN/m	kNm/m
141A	6		28.448	0.000
141E		102	33.488	0.000
47A	11		17.304	0.000
47E		12	-5.972	0.000
143A	14		4.190	0.000
143E		110	8.989	0.000
49A	41		15.441	0.000
49E		42	15.417	0.000
51A	42		15.417	0.000
51E		13	15.375	0.000
57A	27		-2.527	0.000
57E		48	-1.499	0.000

Point loads in load case 6

point	syst.	Pz(Pt)	Mx(Mr)	My(Ms)
-	-	kN	kNm	kNm
37	r-s-t	97.216	0.000	0.000

DESCRIPTION OF DEMANDED VERIFICATIONS

The following means:

Ψ_{dom} in rule of superposition DIN 1055-100: Combination coefficient of a leading traffic load action
in rule of superposition DIN 18800: Combination coefficient of a minor combination
Ψ_{sub} in rule of superposition DIN 1055-100: Combination coefficient of a non-leading traffic load action
in rule of superposition DIN 18800: Combination coefficient of a main combination
γ_{sup} Partial safety factor for unfavourable load positions
γ_{inf} Partial safety factor for favourable load positions

Rules of superposition FB101 and Eurocode are comparable with DIN 1055-100
In non-linear analysis, rules of extremization will not be considered

Verification 1: DIN 1045-1 Design calculation

DIN 1045-1 Design calculation: Design resistance according to DIN 1045-1 (10.2, 10.3, 10.4)

Design options to verification 1:

Bending design calculation
- [x] Shear design calculation
  - [x] z from Bending design calculation
  - [ ] z = 0.9 d ≤ d - 2 cnom
  - [ ] z of bending design calc. ≤ d - 2 cnom
  - [x] Design calculation in reinforcement directions
  - [ ] Design calculation in main shear direction
  - [ ] NO limitation of VRdct
- [x] with minimum/transverse reinforcement (bending, shear)
- [ ] DIN 1045-1 (7.01) incl. corr.2 (6.05)
- [x] DIN 1045-1 (8.08)

1: Standard combination

Rules of extremization to verification 1,type: standard, Rule of superposition: DIN1055-100
Safety factor of material: γ_C = 1.50, γ_S = 1.15

action	Ψ_{dom}	Ψ_{sub}	γ_{sup}	γ_{inf}
1	1.00	1.00	1.35	1.00
2	1.00	0.70	1.50	0.00

Table of design plane positions (Verification 1)

Explanations: column **(M)**: minimum reinforcement of slabs; column **(Q)**: transverse reinf. - minimum portions of main reinf.
column **(S)**: shear design calc. (with 'no' resp. 'with' minimum reinf. of shear); column **(P)**: if possible, avoid shear reinf. (by increasing longitud. reinf.)
BSt_l, BSt_q: steel quality of longitudinal, shear reinforcement ('Gitter': synonym of lattice girder
with f_{yk} = 420 MN/m². Verifications basing on approval documents are NOT kept !); $c_{v,D}$: concrete cover of compression reinf.;
Θ: angle of compression strut (0 = minimum); α_q: angle of shear reinforcement; column **(F)**: joint; column **(O)**: finish of joint
Description of material see: 'Material properties of plane position'

pos.	concrete	BSt_l	(M)	(Q)	(S)	BSt_q	$c_{v,D}$ cm	Θ °	(P)	α_q °	(F)	(O)
20	C20/25	500	no	0.20	no	----	---	---	--	---	----	

Table of design bars (Verification 1)

Explanations: column **(M)**: minimum reinforcement of beams
b_j: breadth of joints (0 = web breadth); column **(W)**: efficiency factor of stirrups in circular cross-sections; t_{eff}: torsion, effect. wall thickness (0 = according to design
more explanations s. plane positions; description of material see: 'Material properties of bars'

bar	concrete	BSt_l	(M)	(S)	BSt_q	$c_{v,D}$ cm	Θ °	(F)	(O)	b_j cm	(W) -	t_{eff} cm
6	C25/30	500	yes	with	500	3.0	0	no	---	--	--	0.0
16	C25/30	500	yes	with	500	3.0	0	no	---	--	--	0.0
18	C25/30	500	yes	with	500	3.0	0	no	---	--	--	0.0
27	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0
31	C25/30	500	yes	with	500	3.0	0	no	---	--	--	0.0
42	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0
43	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0
46	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0
49	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0
54	C20/25	500	yes	with	500	3.0	0	no	---	--	--	0.0

Verification 2: Analysis

Analysis: Analysis without verifications

1: Standard combination

Rules of extremization to verification 2,type: standard, Rule of superposition: old design code

action	γ_{sup}	γ_{inf}
1	1.00	1.00
2	1.00	0.00

Verification 3: Export of support reactions

Export of support reactions: Export of reactions of supported lines and points

Load spectra to verification 3
Factorization of load cases. Negative numbers of load cases refer to imperfections

LK	1	2	3	4	5	6
1	1.00	-	-	-	1.00	-
2	-	1.00	1.00	1.00	-	1.00