

Beam Design - B1**Design Code - EC2****Beam dimension**

Span L	6490 mm
Breadth b	200 mm
Height h	450 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of floor	1.00	kN/m ²
Finishes	0.25	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.25	kN/m
Weight of wall	6.00	kN/m
Impose load	3.00	kN/m ²

Yield strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions**Design forces**

Design moment (Mid) M_{Ed}	99.00 kNm
Design moment (End) M_{Ed}	74.00 kNm
Shear force V_{Ed}	91 kN

Flexural design		Mid section			End section		
Effective depth	d	398	mm		398	mm	
Constant	K	0.125		(<0.167)	0.093		(<0.167)
Lever arm	z	348	mm		362	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		0	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	788	mm ²		566	mm ²	
Area of tension steel provided	$A_{s,prov}$	804	mm ²	4 T16	603	mm ²	3 T16

Shear

Shear resistance $V_{Rd,max}$	222 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	242 mm		
Max. link spacing s_{max}	177 mm	Provide 2R6 @ 150 c/c	

Deflection

Req. tension reinforcement ρ	0.010		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	19.22		
Actual l/d	16.31	< allowable) OK	

Beam Design - B2**Design Code - EC2****Beam dimension**

Span L	5724 mm
Breadth b	200 mm
Height h	450 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of floor	1.00	kN/m ²
Finishes	0.25	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.25	kN/m
Weight of wall	6.00	kN/m
Impose load	3.00	kN/m ²

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions**Design forces**

Design moment (Mid) M_{Ed}	112.00 kNm
Design moment (End) M_{Ed}	140.00 kNm
Shear force V_{Ed}	125 kN

Flexural design		Mid section			End section		
Effective depth	d	406	mm		406	mm	
Constant	K	0.136		(<0.167)	0.170		(> 0.167)
Lever arm	z	349	mm		332	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		18	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	888	mm ²		1168	mm ²	
Area of tension steel provided	$A_{s,prov}$	1005	mm ²	5 T16	1206	mm ²	6 T16

Shear

Shear resistance $V_{Rd,max}$	227 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	181 mm		
Max. link spacing s_{max}	177 mm	<u>Provide 2R6 @ 150 c/c</u>	

Deflection

Req. tension reinforcement ρ	0.011		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	18.76		
Actual l/d	14.10	(< allowable)	OK

Beam Design - B3

Design Code - EC2

Beam dimension

Span L	5720 mm
Breadth b	200 mm
Height h	400 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of slab	3.25	kN/m ²
Finishes	1.5	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.00	kN/m
Weight of wall	6.00	kN/m
Impose load	2.00	kN/m ²

Yield strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions

Design forces

Design moment (Mid) M_{Ed}	58.00 kNm
Design moment (End) M_{Ed}	96.00 kNm
Shear force V_{Ed}	80 kN

Flexural design		Mid section			End section		
Effective depth	d	356	mm		356	mm	
Constant	K	0.092		(<0.167)	0.151		(<0.167)
Lever arm	z	324	mm		299	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		0	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	495	mm ²		888	mm ²	
Area of tension steel provided	$A_{s,prov}$	603	mm ²	3 T16	1206	mm ²	6 T16

Shear

Shear resistance $V_{Rd,max}$	199 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	124 mm		
Max. link spacing s_{max}	177 mm	Provide R6 @ 100 c/c	

Deflection

Req. tension reinforcement ρ	0.007		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	16.39		
Actual l/d	16.07	(< allowable)	OK

Beam Design - B4

Design Code - EC2

Beam dimension

Span L	4875 mm
Breadth b	200 mm
Height h	400 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of slab	3.25	kN/m ²
Finishes	1.5	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.00	kN/m
Weight of wall	6.00	kN/m
Impose load	2.00	kN/m ²

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions

Design forces

Design moment (Mid) M_{Ed}	62.00 kNm
Design moment (End) M_{Ed}	74.00 kNm
Shear force V_{Ed}	85 kN

Flexural design		Mid section			End section		
Effective depth	d	356	mm		356	mm	
Constant	K	0.098		(<0.167)	0.117		(<0.167)
Lever arm	z	322	mm		315	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		0	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	533	mm ²		652	mm ²	
Area of tension steel provided	$A_{s,prov}$	603	mm ²	3 T16	804	mm ²	4 T16

Shear

Shear resistance $V_{Rd,max}$	199 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	116 mm		
Max. link spacing s_{max}	177 mm	<u>Provide R6 @ 100 c/c</u>	

Deflection

Req. tension reinforcement ρ	0.007		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	16.01		
Actual l/d	13.69	(< allowable)	OK

Beam Design - B5**Design Code - EC2****Beam dimension**

Span L	4428 mm
Breadth b	200 mm
Height h	400 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of slab	3.25	kN/m ²
Finishes	1.5	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.00	kN/m
Weight of wall	6.00	kN/m
Impose load	2.00	kN/m ²

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions**Design forces**

Design moment (Mid) M_{Ed}	55.00 kNm
Design moment (End) M_{Ed}	69.00 kNm
Shear force V_{Ed}	80 kN

Flexural design		Mid section			End section		
Effective depth	d	356	mm		356	mm	
Constant	K	0.087		(<0.167)	0.109		(<0.167)
Lever arm	z	326	mm		318	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		0	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	467	mm ²		602	mm ²	
Area of tension steel provided	$A_{s,prov}$	603	mm ²	3 T16	603	mm ²	3 T16

Shear

Shear resistance $V_{Rd,max}$	199 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	123 mm		
Max. link spacing s_{max}	177 mm	<u>Provide R6 @ 100 c/c</u>	

Deflection

Req. tension reinforcement ρ	0.007		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	16.72		
Actual l/d	12.44	(< allowable)	OK

Beam Design - B6**Design Code - EC2****Beam dimension**

Span L	5436 mm
Breadth b	200 mm
Height h	400 mm
Bar diameter Φ	16 mm
Cover c_{nom}	30 mm

Actions		
Self weight of slab	3.25	kN/m ²
Finishes	1.5	kN/m ²
Ceiling and services	0.25	kN/m ²
Self weight of beam	2.00	kN/m
Weight of wall	6.00	kN/m
Impose load	2.00	kN/m ²

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Stirrups f_{ywd}	250 N/mm ²

Actions**Design forces**

Design moment (Mid) M_{Ed}	40.00 kNm
Design moment (End) M_{Ed}	46.00 kNm
Shear force V_{Ed}	35 kN

Flexural design		Mid section			End section		
Effective depth	d	356	mm		356	mm	
Constant	K	0.063		(<0.167)	0.073		(<0.167)
Lever arm	z	335	mm		332	mm	
Area of compression steel required	$A'_{s,req}$	0	mm ²		0	mm ²	
Area of compression steel provided	$A'_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16
Area of tension steel required	$A_{s,req}$	331	mm ²		384	mm ²	
Area of tension steel provided	$A_{s,prov}$	402	mm ²	2 T16	402	mm ²	2 T16

Shear

Shear resistance $V_{Rd,max}$	199 kN	(> V_{Ed})	OK
Diameter of links Φ	6 mm		
Link spacing s	282 mm		
Max. link spacing s_{max}	177 mm	<u>Provide R6 @ 100 c/c</u>	

Deflection

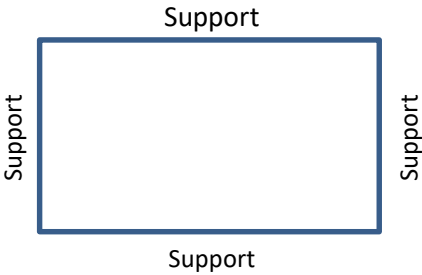
Req. tension reinforcement ρ	0.005		
Req. compression reinforcement ρ'	0.000		
Reference reinforcement ratio ρ_o	0.005		
Allowable l/d	19.41		
Actual l/d	15.27	(< allowable)	OK

2 Way Slab Design

Design Code - EC2

Slab dimensions

Short span	Lx	5.24	m
Long span	Ly	5.52	m
Ratio	Ly/Lx	1.05	
Cover	c _{nom}	25	mm
Concrete strength	f _{ck}	25	N/mm ²
Steel strength	f _{yk}	415	N/mm ²
Bar diameter	Φ	10	mm
Slab thickness	h	140	mm
Dead load	g _k	5.5	kN/m ²
Imposed load	q _k	2	kN/m ²
Ultimate load	n	10.43	kN/m ²



		Mid-span		End support			
		Short	Long	Short & continous	Short & discontinous	Long & continous	Long & discontinous
Moment coefficient	β	0.026	0.024	0.041		0.037	
Bending Moment	M	7.44	6.87	11.74		10.59	
Effective depth	d	110	100	110		100	
Constant	K	0.025	0.027	0.039		0.042	
lever arm	z	105	95	105		95	
Steel area required	A _{s,req}	197	200	311		309	
Minimum steel area	A _{s,min}	336	336	336		336	
Max. bar spacing	s _{max}	250	250	250		250	
Steel area provided	A _{s,prov}	523	523	523		523	
Reinforcement ratio	ρ	0.179	0.200	0.283		0.309	
Basic span/eff.depth		48					
Actual span/eff.depth		26					

Top Main Reinforcement	T 10 @	150	c/c
Top Distribution Steel	T 10 @	150	c/c
Bottom Steel	T 10 @	150	c/c B/W

Cantilever Slab Design

Design Code - EC2

slab dimensions

Span	L	1.2	m	
Cover	C _{nom}	25	m	
Concrete strength	f _{ck}	25	N/mm ²	
Steel strength	f _{yk}	415	N/mm ²	
Bar diameter	Φ	10	mm	
Slab thickness	h	140	mm	
Dead load	g _k	7	kN/m2	
Imposed load	q _k	2	kN/m2	
Ultimate load	n	12.45	kN/m2	
Bending moment	M	8.96	kNm	
Effective Depth	d	110		
Constant	K	0.0296		
	K'	0.21	> K so no compression reinforcement required	
lever arm	z	105		
steel area required	A _{s,req}	238	mm ² /m	
Steel area provided	A _{s,prov}	523	mm ² /m	
	l/d	32.90		<u>T 10 @ 150 c/c</u>
Allowable span/d eff		72.42		
Actual span/d eff		10.91	So deflection ok	

Footing Design - F1

Design Code - EC2

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Height of column h	300 mm
Width of column b	200 mm
Ultimate load $N_{ed,ult}$	510 kN
Service load $N_{ed,serv}$	360 kN
Bearing capacity	150 kN/m ²
Net safe bearing pressure p_{net}	141.25 kN/m ²
Area required A_{req}	2.55 m ²
Area provided A_{prov}	2.56 m ²

Dimension of footing

Length (x direction) L	1600 mm
Breadth (y direction) B	1600 mm
Depth D	350 mm

Earth pressure p_E	199.22 kN/m ²
Nominal cover c_{nom}	40 mm
Bar diameter Φ	12 mm

Bending moment (y-y direction)

Effective depth d	298 mm
BM @ the face of column M	78.09 kNm
Constant K	0.022
Lever arm z	283 mm
Area of steel required $A_{s,req}$	764 mm ²
Min.steel required $A_{s,min}$	387 mm ²
Area of steel provided $A_{s,prov}$	1017 mm ²

T 12 @ 200 mm c/c

Face shear (@face of column)

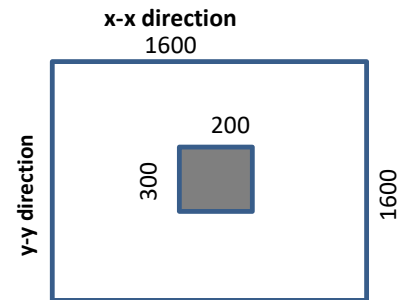
Max. shear resistance $V_{Rd,max}$	1609.20 kN	(> $N_{ed,ult}$)	OK
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Transverse shear (@distance d)

Design transverse shear(y-y) V_{Ed}	128.14 kN		
Design shear resistance $V_{Rd,c}$	209.79 kN	(> V_{Ed})	OK

Punching shear (@ distance 2d)

Critical perimeter	4745 mm		
Area with in perimeter	1771944 mm ²		
% steel ρ	0.21	(< 2%)	OK
Punching shear force V _{Ed}	157.00 kN		
Shear resistance V _{Rd,c}	622.14 kN	(> V _{Ed})	OK



Footing Design - F2

Design Code - EC2

Yeild strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Height of column h	300 mm
Width of column b	200 mm
Ultimate load $N_{ed,ult}$	345 kN
Service load $N_{ed,serv}$	250 kN
Bearing capacity	150 kN/m ²
Net safe bearing pressure p_{net}	141.25 kN/m ²
Area required A_{req}	1.77 m ²
Area provided A_{prov}	1.96 m ²

Dimension of footing

Length (x direction) L	1400 mm
Breadth (y direction) B	1400 mm
Depth D	350 mm

Earth pressure p_E	176.02 kN/m ²
Nominal cover c_{nom}	40 mm
Bar diameter Φ	12 mm

Bending moment (y-y direction)

Effective depth d	298 mm
BM @ the face of column M	44.36 kNm
Constant K	0.014
Lever arm z	283 mm
Area of steel required $A_{s,req}$	434 mm ²
Min.steel required $A_{s,min}$	387 mm ²
Area of steel provided $A_{s,prov}$	1130 mm ²

T 12 @ 150 mm c/c

Face shear (@face of column)

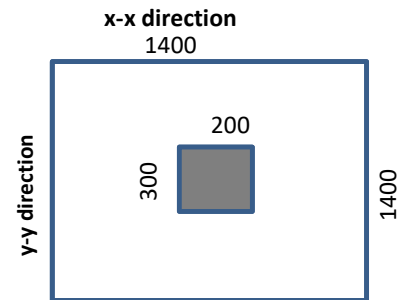
Max. shear resistance $V_{Rd,max}$	1609.20 kN	(> $N_{ed,ult}$)	OK
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Transverse shear (@distance d)

Design transverse shear(y-y) V_{Ed}	74.42 kN		
Design shear resistance $V_{Rd,c}$	183.57 kN	($> V_{Ed}$)	OK

Punching shear (@ distance 2d)

Critical perimeter	4745 mm		
Area with in perimeter	1771944 mm ²		
% steel ρ	0.27	(< 2%)	OK
Punching shear force V _{Ed}	33.10 kN		
Shear resistance V _{Rd,c}	622.14 kN	(> V _{Ed})	OK



Footing Design - F3

Design Code - EC2

Yield strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	415 N/mm ²
Height of column h	200 mm
Width of column b	300 mm
Ultimate load $N_{ed,ult}$	402 kN
Service load $N_{ed,serv}$	294 kN
Bearing capacity	150 kN/m ²
Net safe bearing pressure p_{net}	141.25 kN/m ²
Area required A_{req}	2.08 m ²
Area provided A_{prov}	2.40 m ²

Dimension of footing

Length (x direction) L	1200 mm
Breadth (y direction) B	2000 mm
Depth D	350 mm

Earth pressure p_E	167.50 kN/m ²
Nominal cover c_{nom}	40 mm
Bar diameter Φ	12 mm

Bending moment (x-x direction)

Effective depth d	304 mm
BM @ the face of column M	135.68 kNm
Constant K	0.029
Lever arm z	289 mm
Area of steel required $A_{s,req}$	1301 mm ²
Min. steel required $A_{s,min}$	474 mm ²
Area of steel provided $A_{s,prov}$	1582 mm ²

T 12 @ 150 mm c/c

Bending moment (y-y direction)

Effective depth d	292 mm
BM @ the face of column M	83.75 kNm/m
Constant K	0.039
Lever arm z	277 mm
Area of steel required $A_{s,req}$	836 mm ² /m
Min. steel required $A_{s,min}$	380 mm ² /m
Area of steel provided $A_{s,prov}$	904 mm ² /m

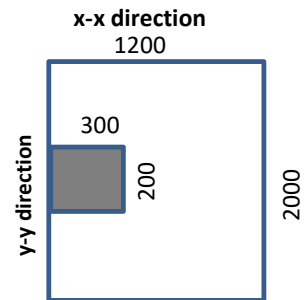
T 12 @ 150 mm c/c

Face shear (@face of column)

Design shear stress v_{Ed}	1.97 N/mm ²	
Max. shear resistance $v_{Rd,max}$	4.50 N/mm ²	(> v_{Ed}) OK

Transverse shear (@distance d)

Design transverse shear (x-x) V_{Ed}	160.00 kN	
Design shear resistance $V_{Rd,c}$	279.68 kN	(> V_{Ed}) OK



Footing Design - F4

Design Code - EC2

Yeild strength of materials

Concrete	f_{ck}	25	N/mm ²
Rebar	f_{yk}	415	N/mm ²
Height of column	h	200	mm
Width of column	b	300	mm
Ultimate load	$N_{ed,ult}$	276	kN
Service load	$N_{ed,serv}$	201	kN
Bearing capacity		150	kN/m ²
Net safe bearing pressure	p_{net}	141.25	kN/m ²
Area required	A_{req}	1.42	m ²
Area provided	A_{prov}	1.50	m ²

Dimension of footing

Length (x direction)	L	1000	mm
Breadth (y direction)	B	1500	mm
Depth	D	350	mm

Earth pressure	p_E	184.00	kN/m ²
Nominal cover	c_{nom}	40	mm
Bar diameter	Φ	12	mm

Bending moment (x-x direction)

Effective depth	d	304	mm
BM @ the face of column	M	67.62	kNm
Constant	K	0.020	
Lever arm	z	289	mm
Area of steel required	$A_{s,req}$	649	mm ²
Min.steel required	$A_{s,min}$	395	mm ²
Area of steel provided	$A_{s,prov}$	904	mm ²

T 12 @ 200 mm c/c

Bending moment (y-y direction)

Effective depth	d	292	mm
BM @ the face of column	M	51.75	kNm/m
Constant	K	0.024	
Lever arm	z	277	mm
Area of steel required	$A_{s,req}$	517	mm ² /m
Min.steel required	$A_{s,min}$	380	mm ² /m
Area of steel provided	$A_{s,prov}$	678	mm ² /m

T 12 @ 200 mm c/c

Face shear (@face of column)

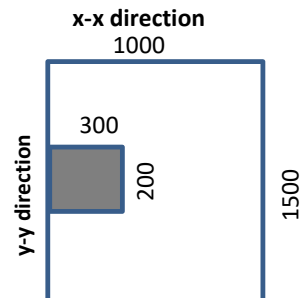
Design shear stress	v_{Ed}	1.35	N/mm ²
Max. shear resistance	$v_{Rd,max}$	4.50	N/mm ²

(> v_{Ed}) **OK**

Transverse shear (@distance d)

Design transverse shear(x-x)	V_{Ed}	100.46	kN
Design shear resistance	$V_{Rd,c}$	209.76	kN

(> V_{Ed}) **OK**



Footing Design - F5

Design Code - EC2

Yield strength of materials

Concrete f_{ck}	25 N/mm ²
Rebar f_{yk}	416 N/mm ²
Height of column h	200 mm
Width of column b	200 mm
Ultimate load $N_{ed,ult}$	136 kN
Service load $N_{ed,serv}$	98 kN
Bearing capacity	150 kN/m ²
Net safe bearing pressure p_{net}	141.25 kN/m ²
Area required A_{req}	0.69 m ²
Area provided A_{prov}	0.81 m ²

Dimension of footing

Length (x direction) L	900 mm
Breadth (y direction) B	900 mm
Depth D	350 mm

Earth pressure p_E	167.90 kN/m ²
Nominal cover c_{nom}	40 mm
Bar diameter Φ	12 mm

Bending moment (y-y direction)

Effective depth d	298 mm
BM @ the face of column M	9.26 kNm
Constant K	0.005
Lever arm z	283 mm
Area of steel required $A_{s,req}$	90 mm ²
Min. steel required $A_{s,min}$	387 mm ²
Area of steel provided $A_{s,prov}$	565 mm ²

T 12 @ 200 mm c/c

Face shear (@face of column)

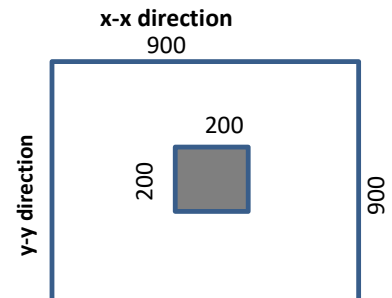
Max. shear resistance $V_{Rd,max}$	1072.80 kN	(> $N_{ed,ult}$)	OK
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Transverse shear (@distance d)

Design transverse shear(y-y) V_{Ed}	7.86 kN		
Design shear resistance $V_{Rd,c}$	118.01 kN	($> V_{Ed}$)	OK

Punching shear (@ distance 2d)

Critical perimeter	4545 mm		
Area with in perimeter	1632744 mm ²		
% steel ρ	0.21	(< 2%)	OK
Punching shear force V _{Ed}	-138.14 kN		
Shear resistance V _{Rd,c}	595.91 kN	(> V _{Ed})	OK



1 Level:

- Name :
- Reference level : 0.00 (m)
- Concrete creep coefficient : $\phi_p = 3.02$
- Cement class : N
- Environment class : X0
- Structure class : S1

2 Column: C1

Number: 15

2.1 Material properties:

- Concrete : C25/30 $f_{ck} = 25.00$ (MPa)
Unit weight : 2501.36 (kG/m³)
Aggregate size : 20.0 (mm)
- Longitudinal reinforcement: : $f_{yk} = 415.00$ (MPa)
Ductility class : -
- Transversal reinforcement: : $f_{yk} = 250.00$ (MPa)

2.2 Geometry:

- 2.2.1 Rectangular 200.0 x 300.0 (mm)
- 2.2.2 Height: L = 3.44 (m)
- 2.2.3 Slab thickness = 0.00 (m)
- 2.2.4 Beam height = 0.48 (m)
- 2.2.5 Cover = 40.0 (mm)

2.3 Calculation options:

- Calculations according to : EN 1992-1-1:2004 AC:2008
- Seismic dispositions : No requirements
- Precast column : no
- Pre-design : no
- Slenderness taken into account : yes
- Compression : with bending
- Ties : to slab
- Fire resistance class : No requirements

2.4 Loads:

Case	Nature	Group	γ_f	N (kN)	My(s) (kN*m)	My(i) (kN*m)	Mz(s) (kN*m)	Mz(i) (kN*m)
DL1	dead load(Structural)	3	1.35	84.46	10.26	0.00	-1.65	0.00
DL1	dead load(Structural)	4	1.35	82.05	-9.77	0.00	-0.16	0.00
DL1	dead load(Structural)	5	1.35	57.28	4.82	0.00	0.35	0.00
DL1	dead load(Structural)	6	1.35	41.30	-0.07	0.00	-0.09	0.00
DL1	dead load(Structural)	15	1.35	74.65	0.12	0.00	0.37	0.00
DL1	dead load(Structural)	17	1.35	76.57	-1.28	0.00	0.88	0.00
DL1	dead load(Structural)	18	1.35	62.05	-2.07	0.00	0.25	0.00
DL1	dead load(Structural)	19	1.35	71.41	-0.11	0.00	-0.21	0.00
DL1	dead load(Structural)	20	1.35	82.64	-0.54	0.00	-0.07	0.00
DL1	dead load(Structural)	21	1.35	60.46	-1.67	0.00	-0.02	0.00
DL1	dead load(Structural)	26	1.35	61.01	-2.18	0.00	-0.31	0.00

DL1	dead load(Structural)	27	1.35	70.50	-0.19	0.00	0.00	0.00
DL1	dead load(Structural)	28	1.35	77.57	-1.55	0.00	-1.17	0.00
DL1	dead load(Structural)	29	1.35	76.70	-0.16	0.00	-0.80	0.00
DL1	dead load(Structural)	424	1.35	105.60	-2.02	0.00	-1.39	0.00
DL2	dead load(Structural)	3	1.35	62.92	6.20	0.00	-1.76	0.00
DL2	dead load(Structural)	4	1.35	47.90	-5.25	0.00	0.07	0.00
DL2	dead load(Structural)	5	1.35	36.90	2.72	0.00	0.17	0.00
DL2	dead load(Structural)	6	1.35	22.31	0.51	0.00	-0.34	0.00
DL2	dead load(Structural)	15	1.35	47.31	-0.38	0.00	-0.58	0.00
DL2	dead load(Structural)	17	1.35	61.17	-0.51	0.00	1.26	0.00
DL2	dead load(Structural)	18	1.35	44.67	-0.98	0.00	-0.05	0.00
DL2	dead load(Structural)	19	1.35	45.61	-0.57	0.00	0.34	0.00
DL2	dead load(Structural)	20	1.35	33.51	-0.91	0.00	-0.11	0.00
DL2	dead load(Structural)	21	1.35	31.97	-0.18	0.00	0.10	0.00
DL2	dead load(Structural)	26	1.35	71.56	-2.21	0.00	-1.29	0.00
DL2	dead load(Structural)	27	1.35	41.45	-0.69	0.00	-0.60	0.00
DL2	dead load(Structural)	28	1.35	91.56	-1.63	0.00	-0.85	0.00
DL2	dead load(Structural)	29	1.35	52.04	-0.37	0.00	-0.65	0.00
DL2	dead load(Structural)	424	1.35	48.70	-0.77	0.00	-1.24	0.00
DL21	dead load(Structural)	3	1.35	28.43	3.17	0.00	-0.45	0.00
DL21	dead load(Structural)	4	1.35	27.63	-2.98	0.00	-0.04	0.00
DL21	dead load(Structural)	5	1.35	19.78	1.71	0.00	0.11	0.00
DL21	dead load(Structural)	6	1.35	11.78	-0.06	0.00	-0.03	0.00
DL21	dead load(Structural)	15	1.35	25.27	0.10	0.00	0.21	0.00
DL21	dead load(Structural)	17	1.35	24.37	-0.48	0.00	0.19	0.00
DL21	dead load(Structural)	18	1.35	20.29	-0.74	0.00	0.09	0.00
DL21	dead load(Structural)	19	1.35	24.67	0.00	0.00	-0.16	0.00
DL21	dead load(Structural)	20	1.35	36.13	-0.30	0.00	-0.02	0.00
DL21	dead load(Structural)	21	1.35	20.51	-0.45	0.00	-0.01	0.00
DL21	dead load(Structural)	26	1.35	19.83	-0.80	0.00	-0.11	0.00
DL21	dead load(Structural)	27	1.35	24.28	-0.04	0.00	0.08	0.00
DL21	dead load(Structural)	28	1.35	24.86	-0.58	0.00	-0.28	0.00
DL21	dead load(Structural)	29	1.35	26.11	-0.01	0.00	-0.37	0.00
DL21	dead load(Structural)	424	1.35	39.82	-0.79	0.00	-0.38	0.00
DL211	live load(Category A)	3	1.50	29.47	4.35	0.00	-0.60	0.00
DL211	live load(Category A)	4	1.50	30.64	-4.17	0.00	-0.08	0.00
DL211	live load(Category A)	5	1.50	20.34	2.24	0.00	0.15	0.00
DL211	live load(Category A)	6	1.50	13.00	-0.03	0.00	-0.01	0.00
DL211	live load(Category A)	15	1.50	26.03	0.10	0.00	0.29	0.00
DL211	live load(Category A)	17	1.50	25.29	-0.64	0.00	0.26	0.00
DL211	live load(Category A)	18	1.50	20.81	-0.94	0.00	0.12	0.00
DL211	live load(Category A)	19	1.50	24.84	0.01	0.00	-0.20	0.00
DL211	live load(Category A)	20	1.50	34.17	-0.22	0.00	-0.03	0.00
DL211	live load(Category A)	21	1.50	19.66	-0.74	0.00	-0.01	0.00
DL211	live load(Category A)	26	1.50	20.33	-1.00	0.00	-0.15	0.00
DL211	live load(Category A)	27	1.50	24.40	-0.03	0.00	0.10	0.00
DL211	live load(Category A)	28	1.50	25.77	-0.74	0.00	-0.38	0.00
DL211	live load(Category A)	29	1.50	26.94	-0.01	0.00	-0.50	0.00
DL211	live load(Category A)	424	1.50	42.30	-1.04	0.00	-0.55	0.00

γ_f - load factor

2.5 Calculation results:

Safety factors $R_d/E_d = 1.06 > 1.0$

2.5.1 ULS/ALS Analysis

Design combination: $1.35DL1+1.35DL2+1.35DL21+1.50DL211$ (A)

Combination type: ULS

Internal forces:

$N_{sd} = 281.55$ (kN) $M_{sdy} = 33.04$ (kN*m) $M_{sdz} = -6.11$ (kN*m)

Design forces:

Upper node

$N = 281.55$ (kN) $N^*_{etotz} = 45.99$ (kN*m) $N^*_{etoty} = -13.40$ (kN*m)

Eccentricity:	ez (My/N)	ey (Mz/N)
Static	eEd: 117.3 (mm)	-21.7 (mm)
Imperfection	ei: 8.6 (mm)	0.0 (mm)
Initial	e0: 125.9 (mm)	-21.7 (mm)
Minimal	emin: 20.0 (mm)	20.0 (mm)
Total	etot: 163.4 (mm)	-47.6 (mm)

2.5.1.1. Detailed analysis-Direction Y:

2.5.1.1.1 Slenderness analysis

Sway structure

L (m)	Lo (m)	λ	λ_{lim}	
3.44	3.44	39.69	25.78	Slender column

2.5.1.1.2 Buckling analysis

MA = 33.04 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = 33.04 (kN*m)
ea = $\theta_1 \cdot l_0 / 2 = 8.6$ (mm)
 $\theta_1 = \theta_0 \cdot \alpha_h \cdot \alpha_m = 0.01$
 $\theta_0 = 0.01$
 $\alpha_h = 1.00$
 $\alpha_m = (0,5(1+1/m))^{0.5} = 1.00$
m = 1.00

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 1.30$$

$$\beta = 1.23$$

$$N_b = (\pi^2 \cdot EJ) / l_0^2 = 1450.52 \text{ (kN)}$$

$$EJ = K_c \cdot E_{cd} \cdot J_c + K_s \cdot E_s \cdot J_s = 1736.64 \text{ (kN*m}^2\text{)}$$

$$\varphi_{ef} = 2.00$$

$$J_c = 450000000.0 \text{ (mm}^4\text{)}$$

$$J_s = 7258335.7 \text{ (mm}^4\text{)}$$

$$K_c = 0.02 \text{ ()}$$

$$K_s = 1.00 \text{ ()}$$

$$M_{Edmin} = 5.63 \text{ (kN*m)}$$

$$M_{Ed} = \max \left\{ M_{Edmin}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 45.99 \text{ (kN*m)}$$

2.5.1.2. Detailed analysis-Direction Z:

2.5.1.2.1 Slenderness analysis

Sway structure

L (m)	Lo (m)	λ	λ_{lim}	
3.44	3.44	59.54	25.78	Slender column

2.5.1.2.2 Buckling analysis

MA = -6.11 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = -6.11 (kN*m)
ea = 0.0 (mm)
Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 2.19$$

$\beta = 1.23$
 $N_b = (\pi^2 * EJ) / l_0^2 = 572.88 \text{ (kN)}$
 $EJ = K_c * E_{cd} * J_c + K_s * E_s * J_s = 685.88 \text{ (kN*m}^2\text{)}$
 $\varphi_{ef} = 2.00$
 $J_c = 200000000.0 \text{ (mm}^4\text{)}$
 $J_s = 2479495.7 \text{ (mm}^4\text{)}$
 $K_c = 0.04 \text{ ()}$
 $K_s = 1.00 \text{ ()}$
 $M_{Edmin} = 5.63 \text{ (kN*m)}$

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = -13.40 \text{ (kN*m)}$$

2.5.2 Reinforcement:

Real (provided) area

$A_{sr} = 1206.37 \text{ (mm}^2\text{)}$

Ratio:

$\rho = 2.01 \%$

2.6 Reinforcement:

Main bars (I):

- 6 $\phi 16$ $l = 3.40 \text{ (m)}$

Transversal reinforcement (I):

stirrups: 21 $\phi 6$ $l = 0.78 \text{ (m)}$

pins 21 $\phi 6$ $l = 0.27 \text{ (m)}$

1 Level:

- Name :
- Reference level : 0.00 (m)
- Concrete creep coefficient : $\phi_p = 3.02$
- Cement class : N
- Environment class : X0
- Structure class : S1

2 Column: C2

Number: 11

2.1 Material properties:

- Concrete : C25/30 $f_{ck} = 25.00$ (MPa)
Unit weight : 2501.36 (kG/m³)
Aggregate size : 20.0 (mm)
- Longitudinal reinforcement: : $f_{yk} = 415.00$ (MPa)
Ductility class : -
- Transversal reinforcement: : $f_{yk} = 250.00$ (MPa)

2.2 Geometry:

- 2.2.1 Rectangular 200.0 x 300.0 (mm)
- 2.2.2 Height: L = 3.40 (m)
- 2.2.3 Slab thickness = 0.00 (m)
- 2.2.4 Beam height = 0.40 (m)
- 2.2.5 Cover = 40.0 (mm)

2.3 Calculation options:

- Calculations according to : EN 1992-1-1:2004 AC:2008
- Seismic dispositions : No requirements
- Precast column : no
- Pre-design : no
- Slenderness taken into account : yes
- Compression : with bending
- Ties : to slab
- Fire resistance class : No requirements

2.4 Loads:

Case	Nature	Group	γ_f	N (kN)	My(s) (kN*m)	My(i) (kN*m)	Mz(s) (kN*m)	Mz(i) (kN*m)
DL1	dead load(Structural)	1	1.35	76.57	-3.22	0.00	3.54	0.00
DL1	dead load(Structural)	2	1.35	17.36	0.37	0.00	1.50	0.00
DL1	dead load(Structural)	12	1.35	54.35	4.66	0.00	-0.23	0.00
DL1	dead load(Structural)	13	1.35	88.73	-1.21	0.00	0.20	0.00
DL1	dead load(Structural)	14	1.35	39.65	4.34	0.00	-0.41	0.00
DL1	dead load(Structural)	22	1.35	81.15	-1.28	0.00	-0.10	0.00
DL1	dead load(Structural)	25	1.35	83.36	-0.79	0.00	-0.13	0.00
DL1	dead load(Structural)	31	1.35	39.55	-4.64	0.00	-0.24	0.00
DL1	dead load(Structural)	32	1.35	58.39	-4.90	0.00	-0.28	0.00
DL1	dead load(Structural)	33	1.35	86.98	-1.49	0.00	-0.80	0.00
DL1	dead load(Structural)	34	1.35	80.16	-1.37	0.00	-0.17	0.00

DL2	dead load(Structural)	1	1.35	51.83	-3.11	0.00	1.18	0.00
DL2	dead load(Structural)	2	1.35	5.92	0.66	0.00	0.81	0.00
DL2	dead load(Structural)	12	1.35	37.28	2.74	0.00	-0.07	0.00
DL2	dead load(Structural)	13	1.35	36.66	1.16	0.00	-0.29	0.00
DL2	dead load(Structural)	14	1.35	15.80	1.15	0.00	-0.46	0.00
DL2	dead load(Structural)	22	1.35	33.43	0.88	0.00	0.28	0.00
DL2	dead load(Structural)	25	1.35	28.71	0.90	0.00	-0.18	0.00
DL2	dead load(Structural)	31	1.35	26.82	-3.74	0.00	-0.36	0.00
DL2	dead load(Structural)	32	1.35	44.72	-3.72	0.00	-0.24	0.00
DL2	dead load(Structural)	33	1.35	57.21	-0.85	0.00	-0.82	0.00
DL2	dead load(Structural)	34	1.35	32.00	0.85	0.00	-0.54	0.00
DL21	dead load(Structural)	1	1.35	22.82	-0.97	0.00	1.09	0.00
DL21	dead load(Structural)	2	1.35	2.27	0.07	0.00	0.50	0.00
DL21	dead load(Structural)	12	1.35	17.55	1.83	0.00	-0.09	0.00
DL21	dead load(Structural)	13	1.35	32.56	-0.52	0.00	0.18	0.00
DL21	dead load(Structural)	14	1.35	11.81	1.56	0.00	-0.10	0.00
DL21	dead load(Structural)	22	1.35	30.68	-0.52	0.00	-0.12	0.00
DL21	dead load(Structural)	25	1.35	33.43	-0.27	0.00	-0.05	0.00
DL21	dead load(Structural)	31	1.35	11.85	-1.66	0.00	-0.04	0.00
DL21	dead load(Structural)	32	1.35	19.84	-1.91	0.00	-0.08	0.00
DL21	dead load(Structural)	33	1.35	32.83	-0.53	0.00	-0.41	0.00
DL21	dead load(Structural)	34	1.35	29.99	-0.54	0.00	0.01	0.00
DL211	live load(Category A)	1	1.50	24.08	-1.27	0.00	1.53	0.00
DL211	live load(Category A)	2	1.50	2.92	0.16	0.00	0.67	0.00
DL211	live load(Category A)	12	1.50	18.29	2.37	0.00	-0.10	0.00
DL211	live load(Category A)	13	1.50	34.22	-0.66	0.00	0.23	0.00
DL211	live load(Category A)	14	1.50	12.39	2.10	0.00	-0.14	0.00
DL211	live load(Category A)	22	1.50	31.63	-0.71	0.00	-0.14	0.00
DL211	live load(Category A)	25	1.50	35.63	-0.43	0.00	-0.06	0.00
DL211	live load(Category A)	31	1.50	12.45	-2.26	0.00	-0.07	0.00
DL211	live load(Category A)	32	1.50	20.56	-2.51	0.00	-0.12	0.00
DL211	live load(Category A)	33	1.50	34.30	-0.77	0.00	-0.51	0.00
DL211	live load(Category A)	34	1.50	30.91	-0.74	0.00	0.02	0.00

γ_f - load factor

2.5 Calculation results:

Safety factors $R_d/E_d = 1.24 > 1.0$

2.5.1 ULS/ALS Analysis

Design combination: 1.35DL1+1.35DL2+1.35DL21+1.50DL211 (A)

Combination type: ULS

Internal forces:

$N_{sd} = 240.28$ (kN) $M_{sdy} = -11.76$ (kN*m) $M_{sdz} = 10.13$ (kN*m)

Design forces:

Upper node

$N = 240.28$ (kN) $N^*etotz = -14.65$ (kN*m) $N^*etoty = 23.42$ (kN*m)

Eccentricity:

	e_z (My/N)	e_y (Mz/N)
Static	$e_{Ed} = -49.0$ (mm)	42.2 (mm)
Imperfection	$e_i = 0.0$ (mm)	8.5 (mm)
Initial	$e_0 = -49.0$ (mm)	50.7 (mm)
Minimal	$e_{min} = 20.0$ (mm)	20.0 (mm)
Total	$e_{tot} = -61.0$ (mm)	97.5 (mm)

2.5.1.1. Detailed analysis-Direction Y:

2.5.1.1.1 Slenderness analysis

Sway structure

L (m) L_0 (m) λ λ_{lim}

3.40	3.40	39.26	28.01	Slender column
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2.5.1.1.2 Buckling analysis

MA = -11.76 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = -11.76 (kN*m)
ea = 0.0 (mm)

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 1.25$$

$$\beta = 1.23$$

$$N_b = (\pi^2 * EJ) / l_0^2 = 1446.45 \text{ (kN)}$$

$$EJ = K_c * E_{cd} * J_c + K_s * E_s * J_s = 1694.19 \text{ (kN*m}^2\text{)}$$

$$\varphi_{ef} = 1.97$$

$$J_c = 450000000.0 \text{ (mm}^4\text{)}$$

$$J_s = 7258335.7 \text{ (mm}^4\text{)}$$

$$K_c = 0.02 \text{ ()}$$

$$K_s = 1.00 \text{ ()}$$

$$M_{Edmin} = 4.81 \text{ (kN*m)}$$

$$M_{Ed} = \max \left\{ M_{Edmin}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = -14.65 \text{ (kN*m)}$$

2.5.1.2. Detailed analysis-Direction Z:

2.5.1.2.1 Slenderness analysis

Sway structure

L (m)	Lo (m)	λ	λ_{lim}	Slender column
3.40	3.40	58.89	28.01	

2.5.1.2.2 Buckling analysis

MA = 10.13 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = 10.13 (kN*m)
ea = $\theta_1 * l_0 / 2 = 8.5 \text{ (mm)}$

$$\theta_1 = \theta_0 * \alpha_h * \alpha_m = 0.01$$

$$\theta_0 = 0.01$$

$$\alpha_h = 1.00$$

$$\alpha_m = (0.5(1 + 1/m))^{0.5} = 1.00$$

$$m = 1.00$$

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 1.92$$

$$\beta = 1.23$$

$$N_b = (\pi^2 * EJ) / l_0^2 = 561.42 \text{ (kN)}$$

$$EJ = K_c * E_{cd} * J_c + K_s * E_s * J_s = 657.58 \text{ (kN*m}^2\text{)}$$

$$\varphi_{ef} = 1.97$$

$$J_c = 200000000.0 \text{ (mm}^4\text{)}$$

$$J_s = 2479495.7 \text{ (mm}^4\text{)}$$

$$K_c = 0.03 \text{ ()}$$

$$K_s = 1.00 \text{ ()}$$

$$M_{Edmin} = 4.81 \text{ (kN*m)}$$

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 23.42 \text{ (kN*m)}$$

2.5.2 Reinforcement:

Real (provided) area

Asr = 1206.37 (mm²)

Ratio:

ρ = 2.01 %

2.6 Reinforcement:

Main bars ():

- 6 ϕ16 l = 3.36 (m)

Transversal reinforcement: ():

stirrups: 21 ϕ6 l = 0.78 (m)

pins 21 ϕ6 l = 0.27 (m)

1 Level:

- Name : Story 1
- Reference level : 0.00 (m)
- Concrete creep coefficient : $\phi_p = 3.12$
- Cement class : N
- Environment class : X0
- Structure class : S1

2 Column: C3

Number: 4

2.1 Material properties:

- Concrete : C25/30 $f_{ck} = 25.00$ (MPa)
Unit weight : 2501.36 (kG/m³)
Aggregate size : 20.0 (mm)
- Longitudinal reinforcement: : $f_{yk} = 415.00$ (MPa)
Transversal reinforcement: : $f_{yk} = 250.00$ (MPa)

2.2 Geometry:

- 2.2.1 Rectangular 200.0 x 200.0 (mm)
- 2.2.2 Height: L = 3.40 (m)
- 2.2.3 Slab thickness = 0.00 (m)
- 2.2.4 Beam height = 0.40 (m)
- 2.2.5 Cover = 40.0 (mm)

2.3 Calculation options:

- Calculations according to : EN 1992-1-1:2004 AC:2008
- Seismic dispositions : No requirements
- Precast column : no
- Pre-design : no
- Slenderness taken into account : yes
- Compression : with bending
- Ties : to slab

2.4 Loads:

Case	Nature	Group	γ_f	N (kN)	My(s) (kN*m)	My(i) (kN*m)	Mz(s) (kN*m)	Mz(i) (kN*m)
DL1	dead load(Structural)	46	1.35	22.81	0.10	0.00	0.10	0.00
DL1	dead load(Structural)	47	1.35	33.30	0.79	0.00	1.04	0.00
DL1	dead load(Structural)	50	1.35	56.68	1.65	0.00	0.17	0.00
DL1	dead load(Structural)	49	1.35	52.29	-1.68	0.00	-0.05	0.00
DL2	dead load(Structural)	46	1.35	-4.32	0.00	0.00	0.03	0.00
DL2	dead load(Structural)	47	1.35	-5.26	0.19	0.00	0.12	0.00
DL2	dead load(Structural)	50	1.35	-1.90	0.10	0.00	-0.29	0.00
DL2	dead load(Structural)	49	1.35	-1.96	0.21	0.00	-0.25	0.00
DL21	dead load(Structural)	46	1.35	6.27	0.03	0.00	0.02	0.00
DL21	dead load(Structural)	47	1.35	9.14	0.27	0.00	0.34	0.00
DL21	dead load(Structural)	50	1.35	18.44	0.54	0.00	0.06	0.00
DL21	dead load(Structural)	49	1.35	16.90	-0.54	0.00	-0.02	0.00
DL211	live load(Category A)	46	1.50	8.92	0.06	0.00	0.02	0.00

DL211	live load(Category A)	47	1.50	12.73	0.33	0.00	0.43	0.00
DL211	live load(Category A)	50	1.50	24.81	0.73	0.00	0.11	0.00
DL211	live load(Category A)	49	1.50	22.83	-0.73	0.00	0.01	0.00

γ_f - load factor

2.5 Calculation results:

The reinforcing steel strength exceeds the range of values allowed by the code - 3.2.2 (3)

Safety factors $R_d/E_d = 1.20 > 1.0$

2.5.1 ULS/ALS Analysis

Design combination: 1.35DL1+1.35DL2+1.35DL21+1.50DL211 (A)

Combination type: ULS

Internal forces:

$N_{sd} = 136.05$ (kN) $M_{sdy} = 4.18$ (kN*m) $M_{sdz} = 0.08$ (kN*m)

Design forces:

Upper node

$N = 136.05$ (kN) $N^*_{etotz} = 13.61$ (kN*m) $N^*_{etoty} = 2.72$ (kN*m)

Eccentricity:	e_z (My/N)	e_y (Mz/N)
Static	$e_{Ed} = 30.7$ (mm)	0.6 (mm)
Imperfection	$e_i = 8.5$ (mm)	0.0 (mm)
Initial	$e_0 = 39.2$ (mm)	0.6 (mm)
Minimal	$e_{min} = 20.0$ (mm)	20.0 (mm)
Total	$e_{tot} = 100.0$ (mm)	20.0 (mm)

2.5.1.1. Detailed analysis-Direction Y:

2.5.1.1.1 Slenderness analysis

Sway structure

L (m)	L_0 (m)	λ	λ_{lim}	
3.40	3.40	58.89	27.52	Slender column

2.5.1.1.2 Buckling analysis

$M_A = 4.18$ (kN*m) $M_B = 0.00$ (kN*m)

Case: Cross-section at the column end (Upper node), Slenderness taken into account

$M_0 = 4.18$ (kN*m)

$e_a = \theta_1 \cdot l_0 / 2 = 8.5$ (mm)

$\theta_1 = \theta_0 \cdot \alpha_h \cdot \alpha_m = 0.01$

$\theta_0 = 0.01$

$\alpha_h = 1.00$

$\alpha_m = (0.5(1+1/m))^{0.5} = 1.00$

$m = 1.00$

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 2.55$$

$\beta = 1.23$

$N_b = (\pi^2 \cdot E J) / l_0^2 = 244.36$ (kN)

$E J = K_c \cdot E_{cd} \cdot J_c + K_s \cdot E_s \cdot J_s = 286.21$ (kN*m²)

$\varphi_{ef} = 1.87$

$J_c = 133333333.3$ (mm⁴)

$J_s = 957255.8$ (mm⁴)

$K_c = 0.03$ ()

$K_s = 1.00$ ()

$M_{Edmin} = 2.72$ (kN*m)

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 13.61 \text{ (kN*m)}$$

2.5.1.2. Detailed analysis-Direction Z:

2.5.1.2.1 Slenderness analysis

Sway structure

L (m)	Lo (m)	λ	λ_{lim}	
3.40	3.40	58.89	27.52	Slender column

2.5.1.2.2 Buckling analysis

MA = 0.08 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = 0.08 (kN*m)
ea = 0.0 (mm)

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 2.55$$

$$\beta = 1.23$$

$$N_b = (\pi^2 * EJ) / l_0^2 = 244.36 \text{ (kN)}$$

$$EJ = K_c * E_{cd} * J_c + K_s * E_s * J_s = 286.21 \text{ (kN*m}^2\text{)}$$

$$\varphi_{ef} = 1.87$$

$$J_c = 133333333.3 \text{ (mm}^4\text{)}$$

$$J_s = 957255.8 \text{ (mm}^4\text{)}$$

$$K_c = 0.03 \text{ ()}$$

$$K_s = 1.00 \text{ ()}$$

$$M_{Ed \min} = 2.72 \text{ (kN*m)}$$

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 2.72 \text{ (kN*m)}$$

2.5.2 Reinforcement:

Real (provided) area

$$A_{sr} = 452.39 \text{ (mm}^2\text{)}$$

Ratio:

$$\rho = 1.13 \%$$

2.6 Reinforcement:

Main bars ():

- 4 $\phi 12$ l = 3.36 (m)

Transversal reinforcement: ():

stirrups: 21 $\phi 6$ l = 0.58 (m)

1 Level:

- Name : Story 1
- Reference level : 0.00 (m)
- Concrete creep coefficient : $\phi_p = 3.02$
- Cement class : N
- Environment class : X0
- Structure class : S1

2 Column: C5

Number: 5

2.1 Material properties:

- Concrete : C25/30 $f_{ck} = 25.00$ (MPa)
Unit weight : 2501.36 (kG/m³)
Aggregate size : 20.0 (mm)
- Longitudinal reinforcement: : $f_{yk} = 415.00$ (MPa)
Ductility class : -
- Transversal reinforcement: : $f_{yk} = 250.00$ (MPa)

2.2 Geometry:

- 2.2.1 Rectangular 200.0 x 200.0 (mm)
- 2.2.2 Height: L = 3.44 (m)
- 2.2.3 Slab thickness = 0.00 (m)
- 2.2.4 Beam height = 0.48 (m)
- 2.2.5 Cover = 40.0 (mm)

2.3 Calculation options:

- Calculations according to : EN 1992-1-1:2004 AC:2008
- Seismic dispositions : No requirements
- Precast column : no
- Pre-design : no
- Slenderness taken into account : yes
- Compression : with bending
- Ties : to slab
- Fire resistance class : No requirements

2.4 Loads:

Case	Nature	Group	γ_f	N (kN)	My(s) (kN*m)	My(i) (kN*m)	Mz(s) (kN*m)	Mz(i) (kN*m)
DL1	dead load(Structural)	240	1.35	97.55	1.25	0.00	0.24	0.00
DL1	dead load(Structural)	241	1.35	97.21	-1.85	0.00	0.26	0.00
DL1	dead load(Structural)	242	1.35	96.61	2.18	0.00	0.25	0.00
DL1	dead load(Structural)	243	1.35	98.45	-0.69	0.00	0.15	0.00
DL1	dead load(Structural)	480	1.35	66.60	0.07	0.00	0.35	0.00
DL2	dead load(Structural)	240	1.35	41.76	-3.02	0.00	0.11	0.00
DL2	dead load(Structural)	241	1.35	20.92	0.69	0.00	0.11	0.00
DL2	dead load(Structural)	242	1.35	62.14	4.20	0.00	0.61	0.00
DL2	dead load(Structural)	243	1.35	77.37	-0.30	0.00	0.41	0.00
DL2	dead load(Structural)	480	1.35	-1.12	-0.39	0.00	0.05	0.00
DL21	dead load(Structural)	240	1.35	39.17	0.51	0.00	0.09	0.00

DL21	dead load(Structural)	241	1.35	39.89	-0.70	0.00	0.10	0.00
DL21	dead load(Structural)	242	1.35	39.60	0.82	0.00	0.09	0.00
DL21	dead load(Structural)	243	1.35	39.49	-0.32	0.00	0.06	0.00
DL21	dead load(Structural)	480	1.35	20.06	0.02	0.00	0.10	0.00
DL211	live load(Category A)	240	1.50	41.30	0.63	0.00	0.12	0.00
DL211	live load(Category A)	241	1.50	41.05	-0.89	0.00	0.13	0.00
DL211	live load(Category A)	242	1.50	40.74	1.05	0.00	0.13	0.00
DL211	live load(Category A)	243	1.50	41.65	-0.39	0.00	0.09	0.00
DL211	live load(Category A)	480	1.50	26.61	0.03	0.00	0.16	0.00

γ_f - load factor

2.5 Calculation results:

Safety factors $R_d/E_d = 1.19 > 1.0$

2.5.1 ULS/ALS Analysis

Design combination: 1.35DL1+1.35DL2+1.35DL21+1.50DL211 (A)

Combination type: ULS

Internal forces:

$N_{sd} = 328.89$ (kN) $M_{sdy} = 11.29$ (kN*m) $M_{sdz} = 1.48$ (kN*m)

Design forces:

Upper node

$N = 328.89$ (kN) $N^*_{etotz} = 15.24$ (kN*m) $N^*_{etoty} = 18.10$ (kN*m)

Eccentricity:	e_z (My/N)	e_y (Mz/N)
Static	$e_{Ed} = 34.3$ (mm)	4.5 (mm)
Imperfection	$e_i = 0.0$ (mm)	8.6 (mm)
Initial	$e_0 = 34.3$ (mm)	13.1 (mm)
Minimal	$e_{min} = 20.0$ (mm)	20.0 (mm)
Total	$e_{tot} = 46.3$ (mm)	55.0 (mm)

2.5.1.1 Detailed analysis-Direction Y:

2.5.1.1.1 Slenderness analysis

Sway structure

L (m)	L_0 (m)	λ	λ_{lim}	
3.44	3.44	39.69	21.84	Slender column

2.5.1.1.2 Buckling analysis

$M_A = 11.29$ (kN*m) $M_B = 0.00$ (kN*m)

Case: Cross-section at the column end (Upper node), Slenderness taken into account

$M_0 = 11.29$ (kN*m)

$e_a = 0.0$ (mm)

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 1.35$$

$\beta = 1.23$

$N_b = (\pi^2 * EJ) / l_0^2 = 1487.88$ (kN)

$EJ = K_c * E_{cd} * J_c + K_s * E_s * J_s = 1781.37$ (kN*m²)

$\varphi_{ef} = 2.03$

$J_c = 450000000.0$ (mm⁴)

$J_s = 7258335.7$ (mm⁴)

$K_c = 0.03$ ()

$K_s = 1.00$ ()

$M_{Edmin} = 6.58$ (kN*m)

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 15.24 \text{ (kN*m)}$$

2.5.1.2. Detailed analysis-Direction Z:

2.5.1.2.1 Slenderness analysis

Sway structure

L (m)	Lo (m)	λ	λ_{lim}	
3.44	3.44	59.54	21.84	Slender column

2.5.1.2.2 Buckling analysis

MA = 1.48 (kN*m) MB = 0.00 (kN*m)
Case: Cross-section at the column end (Upper node), Slenderness taken into account
M0 = 1.48 (kN*m)
ea = $\theta_1 * l_0 / 2 = 8.6$ (mm)
 $\theta_1 = \theta_0 * \alpha_h * \alpha_m = 0.01$
 $\theta_0 = 0.01$
 $\alpha_h = 1.00$
 $\alpha_m = (0.5(1 + 1/m))^{0.5} = 1.00$
m = 1.00

Method based on nominal stiffness

$$\left[1 + \frac{\beta}{(N_B / N) - 1} \right] = 4.20$$

$\beta = 1.23$
Nb = $(\pi^2 * EJ) / l_0^2 = 455.65$ (kN)
EJ = Kc * Ecd * Jc + Ks * Es * Js = 545.52 (kN*m2)
 $\varphi_{ef} = 2.03$
Jc = 200000000.0 (mm4)
Js = 1628601.6 (mm4)
Kc = 0.04 ()
Ks = 1.00 ()

MEdmin = 6.58 (kN*m)

$$M_{Ed} = \max \left\{ M_{Ed \min}; \left[1 + \frac{\beta}{(N_B / N) - 1} \right] M_{0Ed} \right\} = 18.10 \text{ (kN*m)}$$

2.5.2 Reinforcement:

Real (provided) area Asr = 804.25 (mm2)
Ratio: $\rho = 1.34 \%$

2.6 Reinforcement:

Main bars ():

- 4 $\phi 16$ l = 3.40 (m)

Transversal reinforcement: ():

stirrups: 21 $\phi 6$ l = 0.78 (m)