

File :C:\Users\arjen.STEP\Desktop\torsion.xfem

### **Table of contents**

1.Input Data .....	2
1.1 NODES.....	2
1.2 BEAMS.....	2
1.3 PROFILES.....	2
1.4 LOAD CASES.....	5
1.5 LOAD CASE 1 Dead load Including self-weight.....	5
1.6 LOAD CASE 2 Live load.....	5
2.1 LOAD CASES.....	6
2.1.1 Reaction forces.....	6
2.2 ULTIMATE LIMIT STATES (ULS).....	6
2.2.1 Load combinations.....	6
2.2.2 Envelope reaction forces.....	7
2.2.3 Envelope beam forces.....	7
2.3 SERVICE LIMIT STATES (SLS).....	8
2.3.1 Load combinations.....	8
2.3.2 Envelope node displacements.....	9
2.3.3 Beam deformations.....	9
2.4 REINFORCEMENT - Beam 1 - Beam Numbers: 1,5.....	12
2.4.1 Longitudinal reinforcement.....	12
2.4.2 Longitudinal reinforcement - Ultimate limit state (ULS).....	12
2.4.3 Longitudinal reinforcement - Service limit state (SLS).....	13
2.4.4 Stirrups / Extra longitudinal reinforcement.....	13
2.4.5 Shear / Torsion reinforcement - Ultimate limit state (ULS).....	14
2.5 REINFORCEMENT - Beam 2 - Beam Numbers: 2,6.....	14
2.5.1 Longitudinal reinforcement.....	14
2.5.2 Longitudinal reinforcement - Ultimate limit state (ULS).....	14
2.5.3 Longitudinal reinforcement - Service limit state (SLS).....	15
2.5.4 Stirrups / Extra longitudinal reinforcement.....	15
2.5.5 Shear / Torsion reinforcement - Ultimate limit state (ULS).....	16
2.6 REINFORCEMENT - Beam 3 - Beam Numbers: 3,7.....	17
2.6.1 Longitudinal reinforcement.....	17
2.6.2 Longitudinal reinforcement - Ultimate limit state (ULS).....	17
2.6.3 Longitudinal reinforcement - Service limit state (SLS).....	18
2.6.4 Stirrups / Extra longitudinal reinforcement.....	18
2.6.5 Shear / Torsion reinforcement - Ultimate limit state (ULS).....	19
2.7 REINFORCEMENT - Beam 4 - Beam Numbers: 4,8.....	19
2.7.1 Longitudinal reinforcement.....	19
2.7.2 Longitudinal reinforcement - Ultimate limit state (ULS).....	19
2.7.3 Longitudinal reinforcement - Service limit state (SLS).....	20
2.7.4 Stirrups / Extra longitudinal reinforcement.....	20
2.7.5 Shear / Torsion reinforcement - Ultimate limit state (ULS).....	21

**1. Input Data**

Applied standards: : NEN-EN 1992-1-1+C1:2011/NB:2016+A1:2020 nl

Consequence class : CC1

Gravity acceleration g : 9,81 m/s<sup>2</sup>**1.1 NODES**

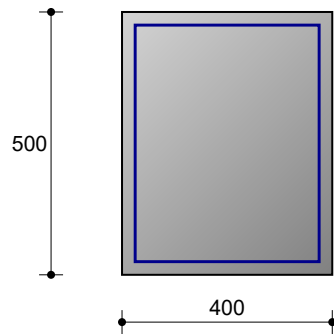
Node Number	Coordinates			Restrains					
	X [mm]	Y [mm]	Z [mm]	Tx	Ty	Tz	Rx	Ry	Rz
1	6000	0	0	A	A	A			
2	6000	3000	0	A	A	A			
3	6000	6000	0	A	A	A			
4	6000	9000	0	A	A	A			
5	10500	0	0	A	A	A	A		
6	10500	3000	0	A	A	A	A		
7	10500	6000	0	A	A	A	A		
8	10500	9000	0	A	A	A	A		
9	13000	0	0						
10	13000	3000	0						
11	13000	6000	0						
12	13000	9000	0						

**1.2 BEAMS**

Beam Number	Node		Beam connections		Profile	Length [mm]
	from	to	begin	begin		
1	5	1	aaaaaa	aaaaaa	Profile 1	4500
2	6	2	aaaaaa	aaaaaa	Profile 2	4500
3	7	3	aaaaaa	aaaaaa	Profile 3	4500
4	8	4	aaaaaa	aaaaaa	Profile 4	4500
5	9	5	aaaaaa	aaaaaa	Profile 1	2500
6	10	6	aaaaaa	aaaaaa	Profile 2	2500
7	11	7	aaaaaa	aaaaaa	Profile 3	2500
8	12	8	aaaaaa	aaaaaa	Profile 4	2500

**1.3 PROFILES**

Profile Number	Name	Weight [kg/m]	E [N/mm <sup>2</sup> ]	A [mm <sup>2</sup> ]	Ix [mm <sup>4</sup> ]	Iy [mm <sup>4</sup> ]	Iz [mm <sup>4</sup> ]
1	Profile 1	500,0	6748	2E5	5,4742E9	4,1667E9	2,6667E9
2	Profile 2	500,0	6748	2E5	5,4742E9	4,1667E9	2,6667E9
3	Profile 3	500,0	6748	2E5	5,4742E9	4,1667E9	2,6667E9
4	Profile 4	500,0	6748	2E5	5,4742E9	4,1667E9	2,6667E9

**Profile 1**

Element type

Prefab

Concrete grade

Steel grade

Number of stirrup sections

Env. class

Concrete surface

 $\Delta C_{dev}$ 

Cover

Nominal cover  $c_{nom}$ 

Beam

no

C20/25

B500B

2

Top side

XC1

Can be checked

5 mm

25 mm

20 mm

Structural Class S4

Creep coefficient 2,70

Granule diameter 31,50 mm

Angle compression strut 40

Bottom side

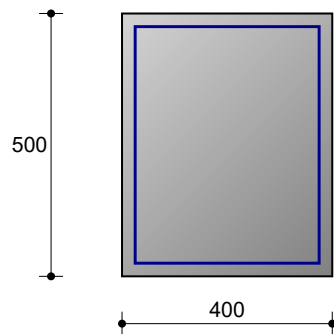
XC1

Can be checked

25 mm

20 mm

EN 1992-1-1 (4.1)

**Profile 2**

Element type

Prefab

Concrete grade

Steel grade

Number of stirrup sections

Env. class

Concrete surface

 $\Delta C_{dev}$ 

Cover

Nominal cover  $c_{nom}$ 

Beam

no

C20/25

B500B

2

Top side

XC1

Can be checked

5 mm

25 mm

20 mm

Structural Class S4

Creep coefficient 2,70

Granule diameter 31,50 mm

Angle compression strut 40

Bottom side

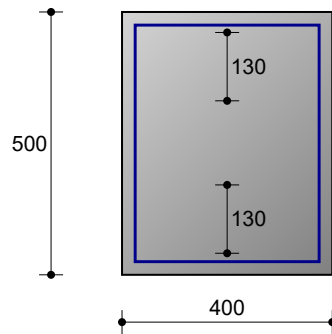
XC1

Can be checked

25 mm

20 mm

EN 1992-1-1 (4.1)

**Profile 3**

Element type

Prefab

Concrete grade

Steel grade

Number of stirrup sections

Env. class

Concrete surface

 $\Delta C_{dev}$ 

Cover

Nominal cover  $c_{nom}$ 

Beam

no

C20/25

B500B

2

Top side

XC1

Can be checked

5 mm

25 mm

20 mm

Structural Class S4

Creep coefficient 2,70

Granule diameter 31,50 mm

Angle compression strut 40

Bottom side

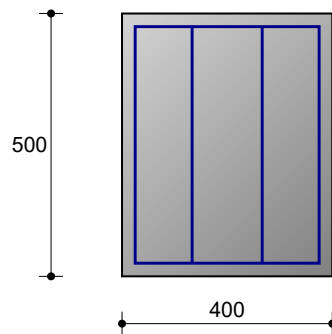
XC1

Can be checked

25 mm

20 mm

EN 1992-1-1 (4.1)

**Profile 4**

Element type

Prefab

Concrete grade

Steel grade

Number of stirrup sections

Env. class

Concrete surface

 $\Delta C_{dev}$ 

Cover

Nominal cover  $c_{nom}$ 

Beam

no

C20/25

B500B

4

Top side

XC1

Can be checked

5 mm

25 mm

20 mm

Structural Class S4

Creep coefficient 2,70

Granule diameter 31,50 mm

Angle compression strut 40

Bottom side

XC1

Can be checked

25 mm

20 mm









EN 1992-1-1 (4.1)

**1.4 LOAD CASES**

no.	Description	Type	$\psi_0$	$\psi_1$	$\psi_2$
1	Dead load	Dead load incl. self-weight	1,00	1,00	1,00
2	Live load	E:storage	1,00	0,90	0,80

Total self-weight: : 13734 kg.

**1.5 LOAD CASE 1 Dead load Including self-weight****1.5.1 Beam loads**

Beam Number	Directio	Type	Loads				Distance from		
			q1	q2	Angl	Exc.	Node	a [mm]	L [mm]
1	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	5	0	4500
2	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	6	0	4500
3	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	7	0	4500
4	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	8	0	4500
5	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	9	0	2500
6	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	10	0	2500
7	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	11	0	2500
8	G-Z	 q	-4,905 kN/m	-4,905 kN/m	0,0	0,0	12	0	2500

**1.6 LOAD CASE 2 Live load****1.6.1 Beam loads**

Beam Number	Directio	Type	Loads				Distance from		
			q1	q2	Angl	Exc.	Node	a [mm]	L [mm]
1	L-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	5	0	4500
1	L-X	 M	-10,000 kNm			0,0	5	2560	
2	L-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	6	0	4500
2	L-X	 M	-10,000 kNm			0,0	6	2560	
3	L-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	7	0	4500
3	L-X	 M	-10,000 kNm			0,0	7	2560	
4	L-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	8	0	4500
4	L-X	 M	-10,000 kNm			0,0	8	2560	
5	G-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	9	0	2500
6	G-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	10	0	2500
7	G-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	11	0	2500
8	G-Z	 q	-20,000 kN/m	-20,000 kN/m	0,0	0,0	12	0	2500

## **2.Calculation Results**

### **2.1 LOAD CASES**

#### **Geometric linear analysis**

##### **2.1.1 Reaction forces**

Node Number	Load case	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
1	1			7,630			
	2			31,111			
2	1			7,630			
	2			31,111			
3	1			7,630			
	2			31,111			
4	1			7,630			
	2			31,111			
5	1			26,705			
	2			108,889	-10,000		
6	1			26,705			
	2			108,889	-10,000		
7	1			26,705			
	2			108,889	-10,000		
8	1			26,705			
	2			108,889	-10,000		
Minimum / maximum values							
1	1			7,630			
5	2			108,889			
5	2				-10,000		
5	2				-10,000		

### **2.2 ULTIMATE LIMIT STATES (ULS)**

#### **2.2.1 Load combinations**

##### **Geometric nonlinear analysis**

Combination Number	Description	Type
1	Dead load	ULS
2	Live load	ULS

Combination Number	Load case ( $\psi \times \gamma$ )			
	1	2		
1	1,00 x 1,22	1,00 x 1,35		
2	1,00 x 1,08	1,00 x 1,35		

### 2.2.2 Envelope reaction forces

Node Number	Comb. Number	Fx [kN]	Fy [kN]	Fz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
1	1			<b>51,309</b>			
	2			<b>50,240</b>			
2	1			<b>51,309</b>			
	2			<b>50,240</b>			
3	1			<b>51,309</b>			
	2			<b>50,240</b>			
4	1			<b>51,309</b>			
	2			<b>50,240</b>			
5	1			<b>179,580</b>	<b>-13,500</b>		
	2			<b>175,841</b>	-13,500		
6	1			<b>179,580</b>	<b>-13,500</b>		
	2			<b>175,841</b>	-13,500		
7	1			<b>179,580</b>	<b>-13,500</b>		
	2			<b>175,841</b>	-13,500		
8	1			<b>179,580</b>	<b>-13,500</b>		
	2			<b>175,841</b>	-13,500		
Minimum / maximum values							
1	2			<b>50,240</b>			
5	1			<b>179,580</b>			
5	1				<b>-13,500</b>		
5	1				<b>-13,500</b>		

### 2.2.3 Envelope beam forces

Beam Number	Comb. Number	Node Number	x-local [mm]	Nx-local [kN]	Vy-local [kN]	Vz-local [kN]	Mx-local [kNm]	My-local [kNm]	Mz-local [kNm]	
1	1	5		0,000	0,000	<b>97,120</b>	<b>13,500</b>	<b>-103,075</b>	0,000	
		5		0,000	0,000	<b>95,098</b>	13,500	<b>-100,929</b>	0,000	
	2		2944	0,000	0,000	0,000	0,000	<b>39,907</b>	0,000	
			2944	0,000	0,000	0,000	0,000	<b>39,076</b>	0,000	
	1	1	1		0,000	0,000	<b>51,309</b>	0,000	0,000	0,000
		2	1		0,000	0,000	<b>50,240</b>	0,000	0,000	0,000
2	1	6		0,000	0,000	<b>97,120</b>	<b>13,500</b>	<b>-103,075</b>	0,000	
		6		0,000	0,000	<b>95,098</b>	13,500	<b>-100,929</b>	0,000	
	1		2944	0,000	0,000	0,000	0,000	<b>39,907</b>	0,000	
			2944	0,000	0,000	0,000	0,000	<b>39,076</b>	0,000	
	1	2	2		0,000	0,000	<b>51,309</b>	0,000	0,000	0,000
		2	2		0,000	0,000	<b>50,240</b>	0,000	0,000	0,000
3	1	7		0,000	0,000	<b>97,120</b>	<b>13,500</b>	<b>-103,075</b>	0,000	
		7		0,000	0,000	<b>95,098</b>	13,500	<b>-100,929</b>	0,000	
	1		2944	0,000	0,000	0,000	0,000	<b>39,907</b>	0,000	
			2944	0,000	0,000	0,000	0,000	<b>39,076</b>	0,000	
	1	3	3		0,000	0,000	<b>51,309</b>	0,000	0,000	0,000
		2	3		0,000	0,000	<b>50,240</b>	0,000	0,000	0,000
4	1	8		0,000	0,000	<b>97,120</b>	<b>13,500</b>	<b>-103,075</b>	0,000	
		8		0,000	0,000	<b>95,098</b>	13,500	<b>-100,929</b>	0,000	
	1		2944	0,000	0,000	0,000	0,000	<b>39,907</b>	0,000	

Beam Number	Comb. Number	Node Number	x-local [mm]	Nx-local [kN]	Vy-local [kN]	Vz-local [kN]	Mx-local [kNm]	My-local [kNm]	Mz-local [kNm]
4	2		2944	0,000	0,000	0,000	0,000	<b>39,076</b>	0,000
	1	4		0,000	0,000	<b>51,309</b>	0,000	0,000	0,000
	2	4		0,000	0,000	<b>50,240</b>	0,000	0,000	0,000
5	1	5		0,000	0,000	<b>82,460</b>	0,000	<b>103,075</b>	0,000
	2	5		0,000	0,000	<b>80,744</b>	0,000	<b>100,929</b>	0,000
6	1	6		0,000	0,000	<b>82,460</b>	0,000	<b>103,075</b>	0,000
	2	6		0,000	0,000	<b>80,744</b>	0,000	<b>100,929</b>	0,000
7	1	7		0,000	0,000	<b>82,460</b>	0,000	<b>103,075</b>	0,000
	2	7		0,000	0,000	<b>80,744</b>	0,000	<b>100,929</b>	0,000
8	1	8		0,000	0,000	<b>82,460</b>	0,000	<b>103,075</b>	0,000
	2	8		0,000	0,000	<b>80,744</b>	0,000	<b>100,929</b>	0,000

## 2.3 SERVICE LIMIT STATES (SLS)

### 2.3 1 Load combinations

#### Geometric nonlinear analysis

Combination Number	Description	Type
3	Dead load	SLS
4	Live load	SLS
5	SLS Permanent	SLS Permanent
6	SLS Quasi-permanent	SLS Quasi-permanent



Combination Number	Load case ( $\psi \times \gamma$ )			
	1	2		
3	1,00 x 1,00	1,00 x 1,00		
4	1,00 x 1,00	1,00 x 1,00		
5	1,00 x 1,00			
6	1,00 x 1,00	0,80 x 1,00		

### 2.3.2 Envelope node displacements

Node Number	Comb. Number	dx [mm]	dy [mm]	dz [mm]	drx [mrad]	dry [mrad]	drz [mrad]
1	3	0,0	0,0	0,0	1,8	1,3	0,0
	5	0,0	0,0	0,0	0,0	0,3	0,0
2	3	0,0	0,0	0,0	1,8	1,3	0,0
	5	0,0	0,0	0,0	0,0	0,3	0,0
3	3	0,0	0,0	0,0	1,8	1,3	0,0
	5	0,0	0,0	0,0	0,0	0,3	0,0
4	3	0,0	0,0	0,0	1,8	1,3	0,0
	5	0,0	0,0	0,0	0,0	0,3	0,0
5	3	0,0	0,0	0,0	0,0	0,8	0,0
	5	0,0	0,0	0,0	0,0	0,2	0,0
6	3	0,0	0,0	0,0	0,0	0,8	0,0
	5	0,0	0,0	0,0	0,0	0,2	0,0
7	3	0,0	0,0	0,0	0,0	0,8	0,0
	5	0,0	0,0	0,0	0,0	0,2	0,0
8	3	0,0	0,0	0,0	0,0	0,8	0,0
	5	0,0	0,0	0,0	0,0	0,2	0,0
9	3	0,0	0,0	-6,3	0,0	3,1	0,0
	5	0,0	0,0	-1,2	0,0	0,6	0,0
10	3	0,0	0,0	-6,3	0,0	3,1	0,0
	5	0,0	0,0	-1,2	0,0	0,6	0,0
11	3	0,0	0,0	-6,3	0,0	3,1	0,0
	5	0,0	0,0	-1,2	0,0	0,6	0,0
12	3	0,0	0,0	-6,3	0,0	3,1	0,0
	5	0,0	0,0	-1,2	0,0	0,6	0,0
Minimum / maximum values							
1	3	0,0					
1	3	0,0					
1	3		0,0				
1	3		0,0				
9	3			-6,3			
1	5			0,0			
1	5				0,0		
1	3				1,8		
5	5					0,2	
9	3					3,1	
1	3						0,0
1	3						0,0

### 2.3.3 Beam deformations

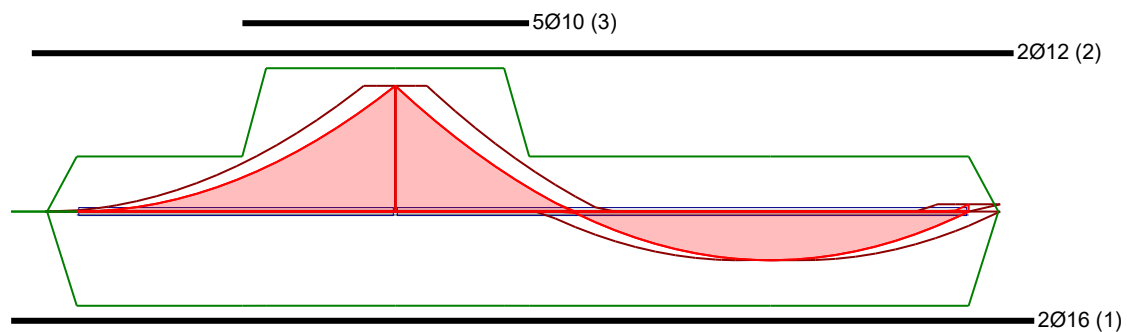
Beam Number	Comb. Number	x-local [mm]	dfy-local [mm]	dfz-local [mm]
1	3	0	0,0	0,0
		336	0,0	-0,1
		2560	0,0	1,3

Beam Number	Comb. Number	x-local [mm]	dfy-local [mm]	dfz-local [mm]
1	3	4500	0,0	0,0
1	4	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
1	5	0	<b>0,0</b>	0,0
		4500	0,0	0,0
1	6	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,1
		4500	0,0	0,0
2	3	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
2	4	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
2	5	0	<b>0,0</b>	0,0
		4500	0,0	0,0
2	6	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,1
		4500	0,0	0,0
3	3	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
3	4	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
3	5	0	<b>0,0</b>	0,0
		4500	0,0	0,0
3	6	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,1
		4500	0,0	0,0
4	3	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
4	4	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,3
		4500	0,0	0,0
4	5	0	<b>0,0</b>	0,0
		4500	0,0	0,0
4	6	0	<b>0,0</b>	0,0
		336	0,0	<b>-0,1</b>
		<b>2560</b>	<b>0,0</b>	1,1
		4500	0,0	0,0
5	3	0	<b>0,0</b>	0,0
		1575	0,0	<b>-0,7</b>

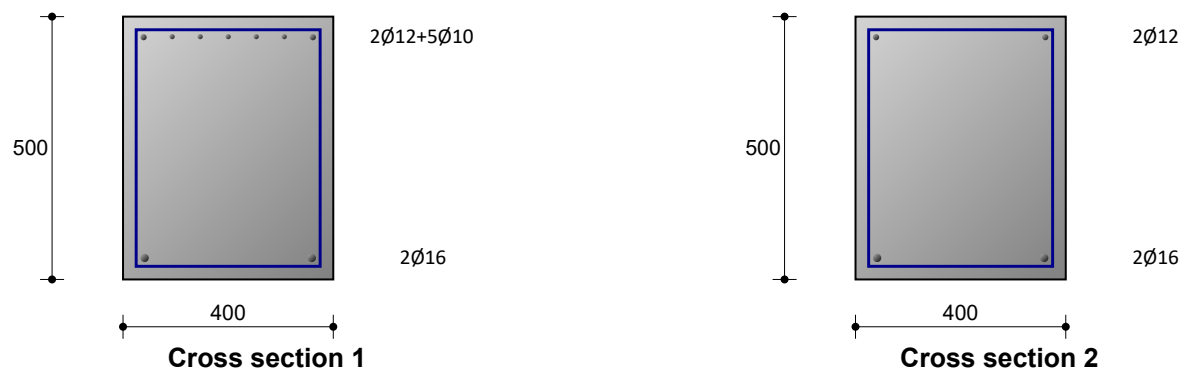
Beam Number	Comb. Number	x-local [mm]	dfy-local [mm]	dfz-local [mm]
5	3	2500	0,0	0,0
5	4	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
5	5	0	0,0	0,0
		1575	0,0	-0,1
		2500	0,0	0,0
5	6	0	0,0	0,0
		1575	0,0	-0,6
		2500	0,0	0,0
6	3	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
6	4	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
6	5	0	0,0	0,0
		1575	0,0	-0,1
		2500	0,0	0,0
6	6	0	0,0	0,0
		1575	0,0	-0,6
		2500	0,0	0,0
7	3	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
7	4	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
7	5	0	0,0	0,0
		1575	0,0	-0,1
		2500	0,0	0,0
7	6	0	0,0	0,0
		1575	0,0	-0,6
		2500	0,0	0,0
8	3	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
8	4	0	0,0	0,0
		1575	0,0	-0,7
		2500	0,0	0,0
8	5	0	0,0	0,0
		1575	0,0	-0,1
		2500	0,0	0,0
8	6	0	0,0	0,0
		1575	0,0	-0,6
		2500	0,0	0,0

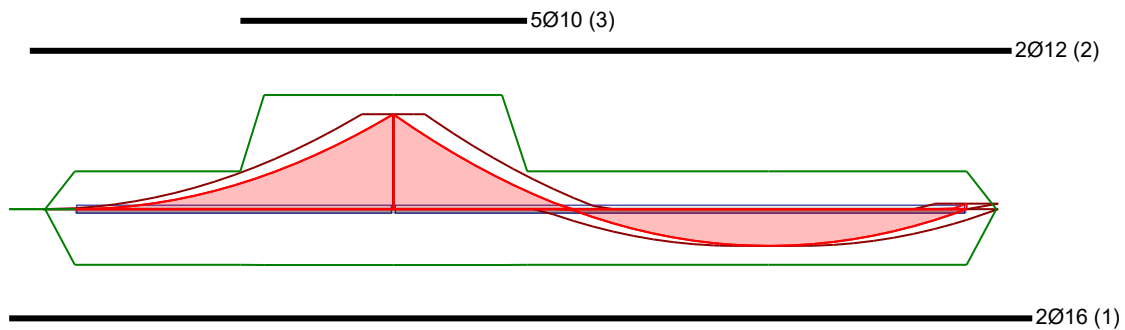
**2.4 REINFORCEMENT - Beam 1 - Beam Numbers: 1,5****2.4.1 Longitudinal reinforcement**

no.	from x [mm]	to x [mm]	Length [mm]	Side	Reinforcement	z [mm]	Ld begin [mm]	Ld end [mm]	Weight [kg]
1	-515	7515	8030	Bottom	2Ø16	-467	160	165	25,3
2	-353	7353	7706	Top	2Ø12	-33	120	120	13,7
3	1300	3550	2250	Top	5Ø10	-33	186	196	6,9
Total									46,0

**Envelope shifted M-line (ULS)****2.4.2 Longitudinal reinforcement - Ultimate limit state (ULS)**

x [mm]	Sect.	MEd [kNm]	MRd [kNm]	As,req [mm <sup>2</sup> ]	xu [mm]	xu,max [mm]	Side	Reinforcement	Remarks
2500	1	-103,1	-117,5	540	52,2	246,9	Top	2Ø12+5Ø10	
5444	2	39,9	77,2	200	41,4	245,5	Bottom	2Ø16	





Envelope shifted M-line (SLS)

### 2.4.3 Longitudinal reinforcement - Service limit state (SLS)

Control of cracking without direct calculation

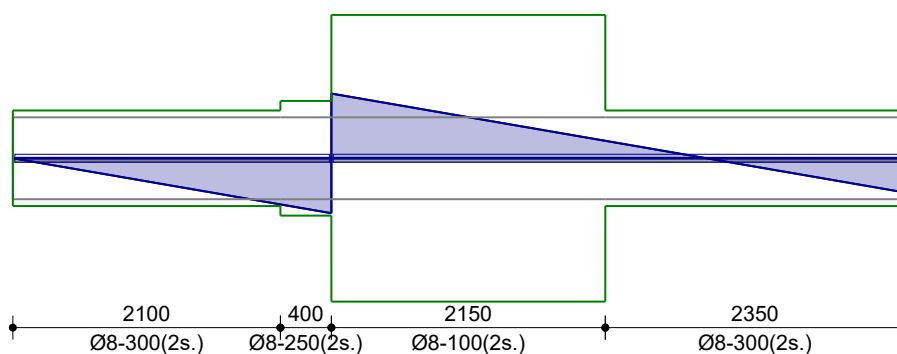
...EN 1992-1-1 art.7.3.3

x [mm]	Sect.	Mk [kNm]	MRk [kNm]	s [mm]	s,max [mm]	Ø [mm]	Ø,max [mm]	Remarks
2500	1	-77,8	-93,6	54,3	100,0	10,6	10,0	
5444	2	30,1	45,6	318,0	215,2	16,0	16,0	

### 2.4.4 Stirrups / Extra longitudinal reinforcement

from x [mm]	to x [mm]	Length [mm]	Stirrups	Asl,req [mm <sup>2</sup> ]	Rem.
0	2100	2100	Ø8-300 (2s.)	0	
2100	2500	400	Ø8-250 (2s.)	0	
2500	4650	2150	Ø8-100 (2s.)	2236	
4650	7000	2350	Ø8-300 (2s.)	0	

6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.



Envelope D-line (ULS)

**2.4.5 Shear / Torsion reinforcement - Ultimate limit state (ULS)**

...EN 1992-1-1 art.6.3.2

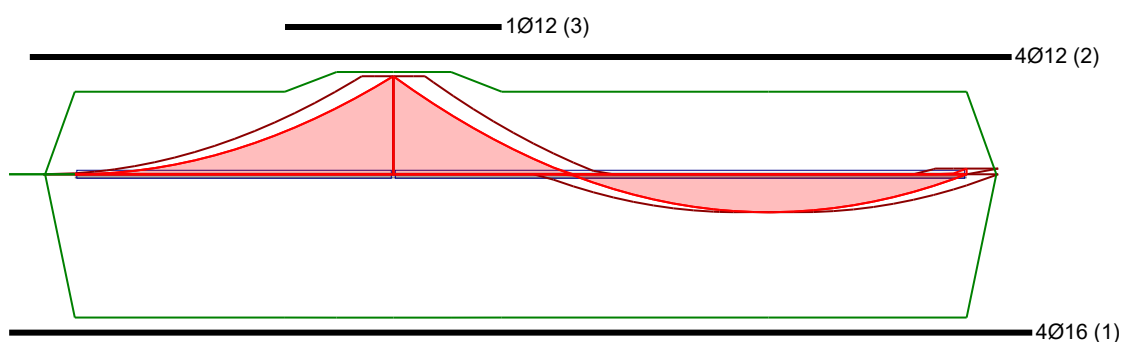
x [mm]	VEd [kN]	TEd [kNm]	VRd,c [kN]	TRd,c [kNm]	VRd,max [kN]	TRd,max [kNm]	Side	Stirrups	Rem.
2100	69,3	0,0	61,5	25,8	650,9	90,5	Top	Ø8-300 (2s.)	
2500	82,5	0,0	61,5	25,8	650,9	90,5	Top	Ø8-250 (2s.)	
2500	97,1	13,5	61,5	25,8	650,9	90,5	Top	Ø8-100 (2s.)	
4700	24,6	13,5	61,5	25,8	650,9	90,5	Top	Ø8-300 (2s.)	
2100	69,3	0,0	61,5	25,8	650,9	90,5	Bottom	Ø8-300 (2s.)	
2500	82,5	0,0	61,5	25,8	650,9	90,5	Bottom	Ø8-250 (2s.)	
2500	97,1	13,5	61,5	25,8	650,9	90,5	Bottom	Ø8-100 (2s.)	
4700	24,6	13,5	61,5	25,8	650,9	90,5	Bottom	Ø8-300 (2s.)	

x [mm]	VEd [kN]	TEd [kNm]	AswT	AswV [mm <sup>2</sup> /mm]	Asw,req	Asw,act	Asl,req [mm <sup>2</sup> ]	Stirrups	Rem.
2100	69,3	0,0	0,000	0,162	0,162	0,168	0	Ø8-300 (2s.)	
2500	82,5	0,0	0,000	0,193	0,193	0,201	0	Ø8-250 (2s.)	
2500	97,1	13,5	0,116	0,227	0,343	0,503	223	Ø8-100 (2s.)	6)
4700	24,6	13,5	0,000	0,000	0,000	0,168	0	Ø8-300 (2s.)	

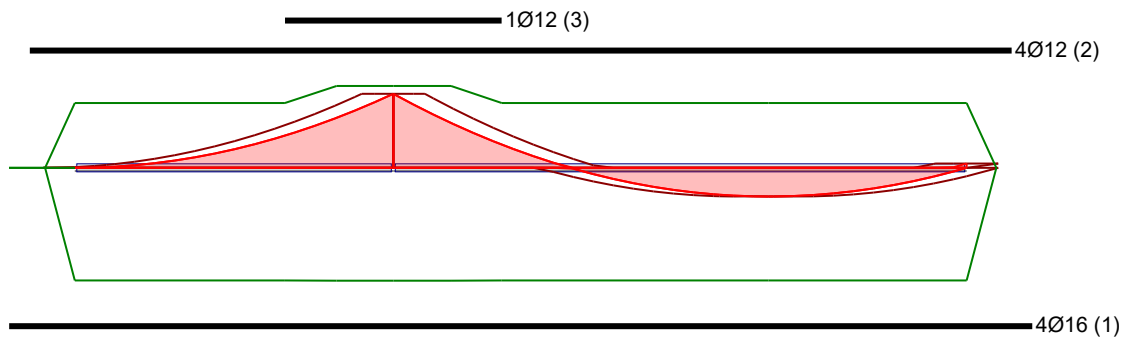
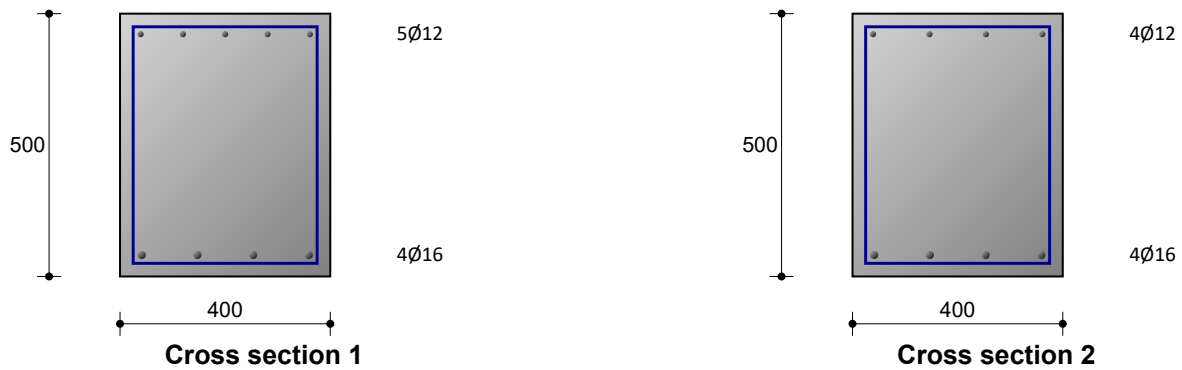
6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.

**2.5 REINFORCEMENT - Beam 2 - Beam Numbers: 2,6****2.5.1 Longitudinal reinforcement**

no.	from x [mm]	to x [mm]	Length [mm]	Side	Reinforcement	z [mm]	Ld begin [mm]	Ld end [mm]	Weight [kg]
1	-515	7515	8030	Bottom	4Ø16	-467	160	160	50,7
2	-353	7353	7706	Top	4Ø12	-33	120	120	27,4
3	1650	3350	1700	Top	1Ø12	-33	405	397	1,5
Total									79,6

**Envelope shifted M-line (ULS)****2.5.2 Longitudinal reinforcement - Ultimate limit state (ULS)**

x [mm]	Sect.	MEd [kNm]	MRd [kNm]	As,req [mm <sup>2</sup> ]	xu [mm]	xu,max [mm]	Side	Reinforcement	Remarks
2500	1	-103,1	-107,5	541	46,0	246,6	Top	5Ø12	
5444	2	39,9	150,6	199	59,8	245,5	Bottom	4Ø16	



Envelope shifted M-line (SLS)

**2.5.3 Longitudinal reinforcement - Service limit state (SLS)**

Control of cracking without direct calculation

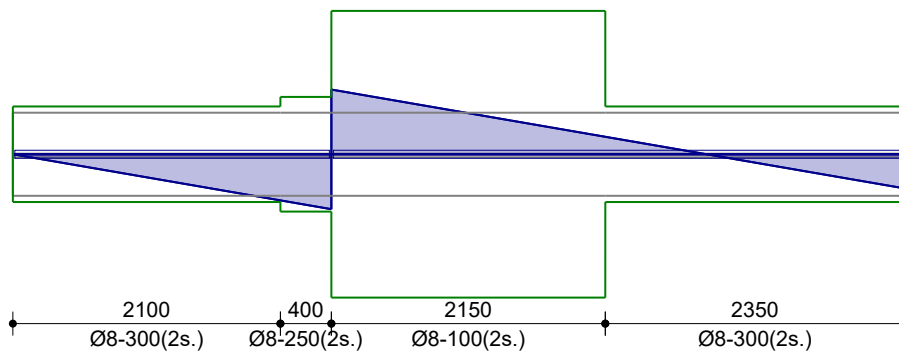
...EN 1992-1-1 art.7.3.3

x [mm]	Sect.	Mk [kNm]	MRk [kNm]	s [mm]	s,max [mm]	Ø [mm]	Ø,max [mm]	Remarks
2500	1	-77,8	-86,1	80,5	100,0	12,0	9,8	
5444	2	30,1	118,4	106,0	106,0	16,0	9,5	

**2.5.4 Stirrups / Extra longitudinal reinforcement**

from x [mm]	to x [mm]	Length [mm]	Stirrups	Asl,req [mm <sup>2</sup> ]	Rem.
0	2100	2100	Ø8-300 (2s.)	0	
2100	2500	400	Ø8-250 (2s.)	0	
2500	4650	2150	Ø8-100 (2s.)	2236)	
4650	7000	2350	Ø8-300 (2s.)	0	

6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.



Envelope D-line (ULS)

## 2.5.5 Shear / Torsion reinforcement - Ultimate limit state (ULS)

...EN 1992-1-1 art.6.3.2

x [mm]	VEd [kN]	TEd [kNm]	VRd,c [kN]	TRd,c [kNm]	VRd,max [kN]	TRd,max [kNm]	Side	Stirrups	Rem.
2100	69,3	0,0	62,4	25,8	653,8	90,5	Top	Ø8-300 (2s.)	
2500	82,5	0,0	62,4	25,8	653,8	90,5	Top	Ø8-250 (2s.)	
2500	97,1	13,5	62,4	25,8	653,8	90,5	Top	Ø8-100 (2s.)	
4700	24,6	13,5	62,4	25,8	653,8	90,5	Top	Ø8-300 (2s.)	
2100	69,3	0,0	62,4	25,8	653,8	90,5	Bottom	Ø8-300 (2s.)	
2500	82,5	0,0	62,4	25,8	653,8	90,5	Bottom	Ø8-250 (2s.)	
2500	97,1	13,5	62,4	25,8	653,8	90,5	Bottom	Ø8-100 (2s.)	
4700	24,6	13,5	62,4	25,8	653,8	90,5	Bottom	Ø8-300 (2s.)	

x [mm]	VEd [kN]	TEd [kNm]	AswT	AswV	Asw,req	Asw,act	Asl,req [mm <sup>2</sup> ]	Stirrups	Rem.
2100	69,3	0,0	0,000	0,162	0,162	0,168	0	Ø8-300 (2s.)	
2500	82,5	0,0	0,000	0,193	0,193	0,201	0	Ø8-250 (2s.)	
2500	97,1	13,5	0,116	0,227	0,343	0,503	223	Ø8-100 (2s.)	6)
4700	24,6	13,5	0,000	0,000	0,000	0,168	0	Ø8-300 (2s.)	

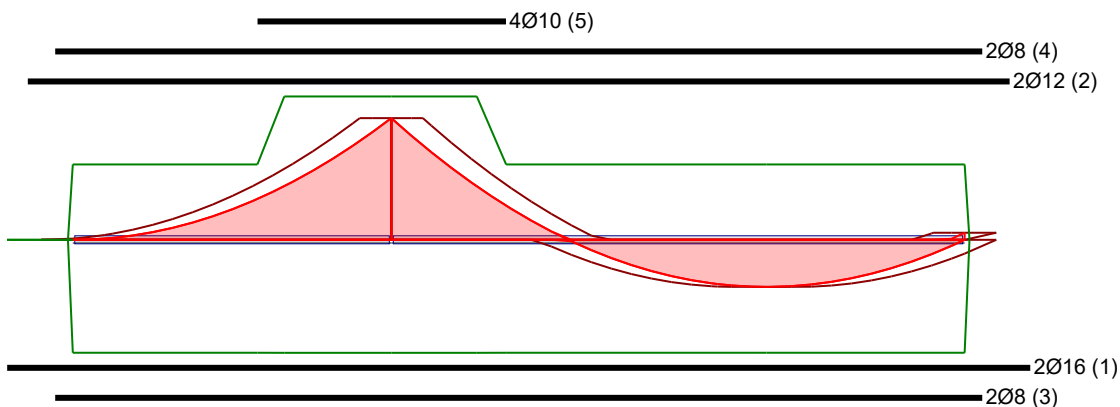
6) Extra longitudinal reinforcement ( $A_{sl,req}$ ) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.



**2.6 REINFORCEMENT - Beam 3 - Beam Numbers: 3,7**

**2.6.1 Longitudinal reinforcement**

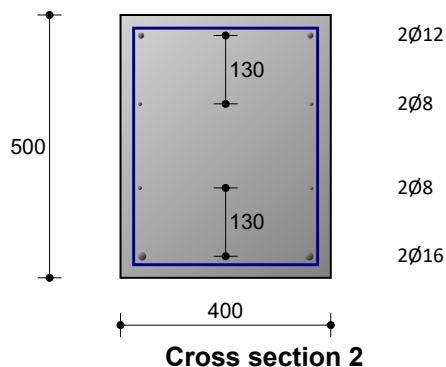
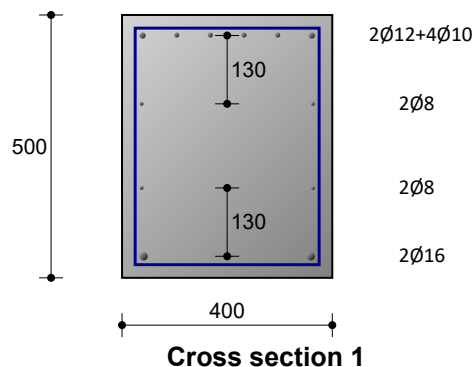
no.	from x [mm]	to x [mm]	Length [mm]	Side	Reinforcement	z [mm]	Ld begin [mm]	Ld end [mm]	Weight [kg]
1	-515	7515	8030	Bottom	2Ø16	-467	160	160	25,3
2	-353	7353	7706	Top	2Ø12	-33	120	120	13,7
3	-138	7138	7276	Bottom	2Ø8	-409	100	100	5,7
4	-138	7138	7276	Top	2Ø8	-89	100	100	5,7
5	1450	3400	1950	Top	4Ø10	-33	210	229	4,8
Total									55,3

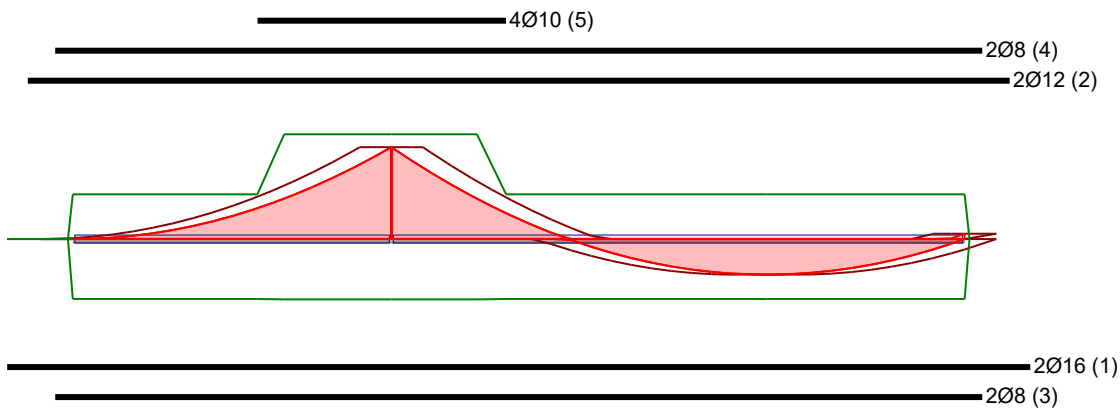


**Envelope shifted M-line (ULS)**

**2.6.2 Longitudinal reinforcement - Ultimate limit state (ULS)**

x [mm]	Sect.	MEd [kNm]	MRd [kNm]	As,req [mm <sup>2</sup> ]	xu [mm]	xu,max [mm]	Side	Reinforcement	Remarks
2500	1	-103,1	-121,4	440	59,1	216,3	Top	2Ø12+4Ø10+2Ø	
5444	2	39,9	95,7	98	54,4	208,1	Bottom	2Ø16+2Ø8	





Envelope shifted M-line (SLS)

2.6.3 Longitudinal reinforcement - Service limit state (SLS)

Control of cracking without direct calculation

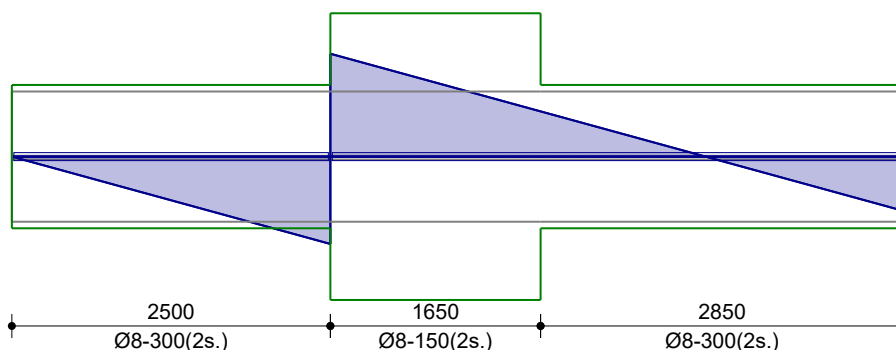
...EN 1992-1-1 art.7.3.3

x [mm]	Sect.	Mk [kNm]	MRk [kNm]	s [mm]	s,max [mm]	Ø [mm]	Ø,max [mm]	Remarks
2500	1	-77,8	-88,8	65,0	100,0	10,8	10,0	
5444	2	30,1	50,8	318,0	215,2	16,0	16,0	

2.6.4 Stirrups / Extra longitudinal reinforcement

from x [mm]	to x [mm]	Length [mm]	Stirrups	Asl,req [mm <sup>2</sup> ]	Rem.
0	2500	2500	Ø8-300 (2s.)	0	
2500	4150	1650	Ø8-150 (2s.)	1656	
4150	7000	2850	Ø8-300 (2s.)	0	

6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.



Envelope D-line (ULS)

**2.6.5 Shear / Torsion reinforcement - Ultimate limit state (ULS)**

...EN 1992-1-1 art.6.3.2

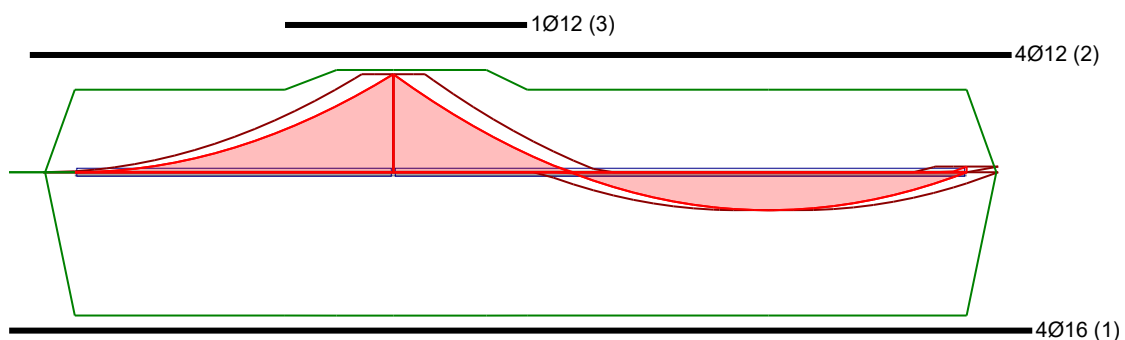
x [mm]	VEd [kN]	TEd [kNm]	VRd,c [kN]	TRd,c [kNm]	VRd,max [kN]	TRd,max [kNm]	Side	Stirrups	Rem.
2500	62,3	0,0	57,9	25,8	597,0	90,5	Top	Ø8-300 (2s.)	
2500	73,3	10,0	57,9	25,8	597,0	90,5	Top	Ø8-150 (2s.)	
4200	31,0	10,0	57,9	25,8	597,0	90,5	Top	Ø8-300 (2s.)	
2500	62,3	0,0	57,9	25,8	597,0	90,5	Bottom	Ø8-300 (2s.)	
2500	73,3	10,0	57,9	25,8	597,0	90,5	Bottom	Ø8-150 (2s.)	
4200	31,0	10,0	57,9	25,8	597,0	90,5	Bottom	Ø8-300 (2s.)	

x [mm]	VEd [kN]	TEd [kNm]	AswT	AswV	Asw,req	Asw,act	Asl,req [mm <sup>2</sup> ]	Stirrups	Rem.
2500	62,3	0,0	0,000	0,159	0,159	0,168	0	Ø8-300 (2s.)	
2500	73,3	10,0	0,086	0,187	0,273	0,335	165	Ø8-150 (2s.)	6)
4200	31,0	10,0	0,000	0,000	0,000	0,168	0	Ø8-300 (2s.)	

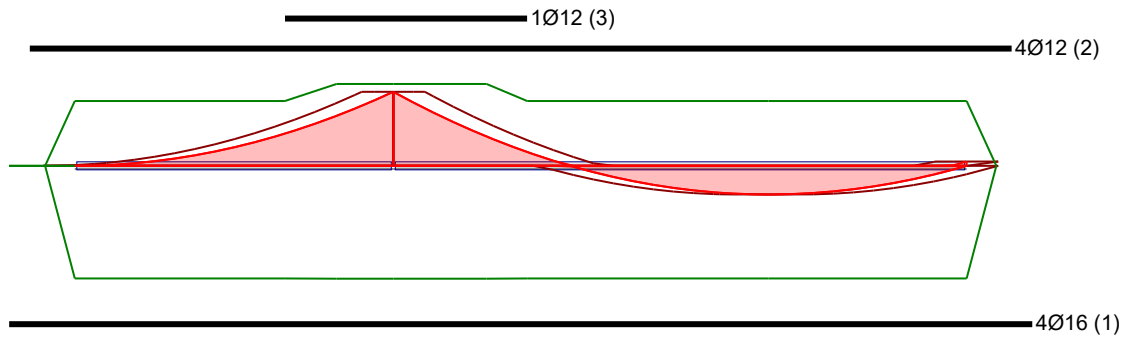
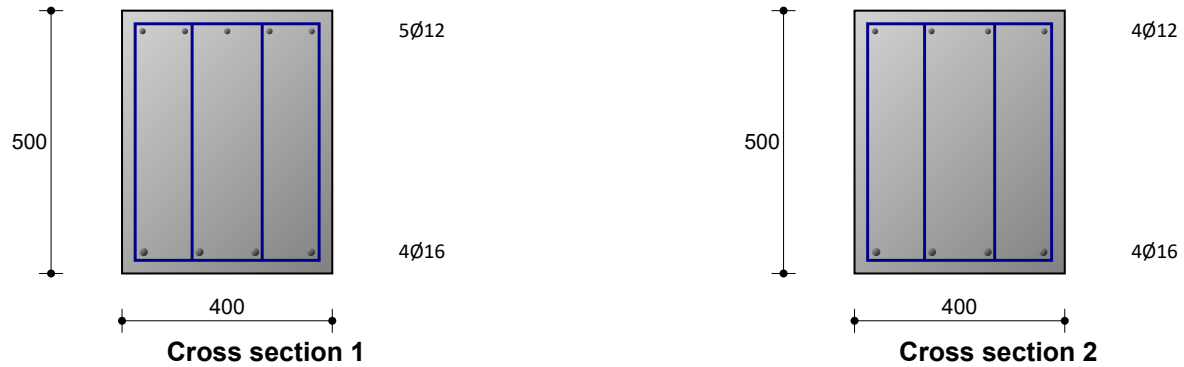
6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.

**2.7 REINFORCEMENT - Beam 4 - Beam Numbers: 4,8****2.7.1 Longitudinal reinforcement**

no.	from x [mm]	to x [mm]	Length [mm]	Side	Reinforcement	z [mm]	Ld begin [mm]	Ld end [mm]	Weight [kg]
1	-515	7515	8030	Bottom	4Ø16	-467	160	160	50,7
2	-353	7353	7706	Top	4Ø12	-33	120	120	27,4
3	1650	3550	1900	Top	1Ø12	-33	405	319	1,7
Total									79,7

**Envelope shifted M-line (ULS)****2.7.2 Longitudinal reinforcement - Ultimate limit state (ULS)**

x [mm]	Sect.	MEd [kNm]	MRd [kNm]	As,req [mm <sup>2</sup> ]	xu [mm]	xu,max [mm]	Side	Reinforcement	Remarks
2500	1	-103,1	-107,5	541	46,0	246,6	Top	5Ø12	
5444	2	39,9	150,6	199	59,8	245,5	Bottom	4Ø16	



Envelope shifted M-line (SLS)

**2.7.3 Longitudinal reinforcement - Service limit state (SLS)**

Control of cracking without direct calculation

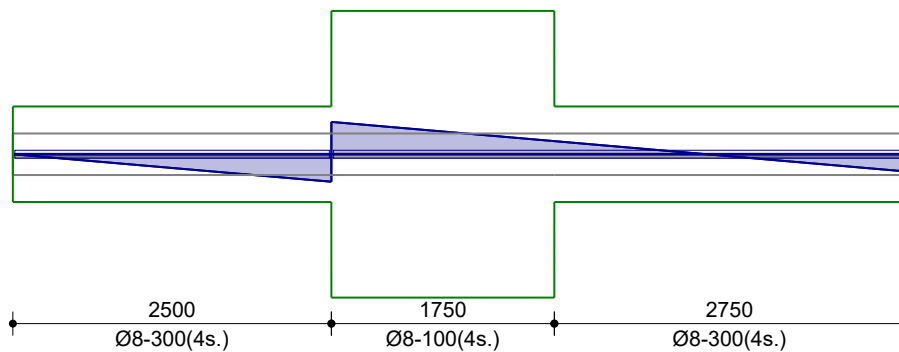
...EN 1992-1-1 art.7.3.3

x [mm]	Sect.	Mk [kNm]	MRk [kNm]	s [mm]	s,max [mm]	Ø [mm]	Ø,max [mm]	Remarks
2500	1	-77,8	-86,1	80,5	100,0	12,0	9,8	
5444	2	30,1	118,4	106,0	106,0	16,0	9,5	

**2.7.4 Stirrups / Extra longitudinal reinforcement**

from x [mm]	to x [mm]	Length [mm]	Stirrups	Asl,req [mm <sup>2</sup> ]	Rem.
0	2500	2500	Ø8-300 (4s.)	0	
2500	4250	1750	Ø8-100 (4s.)	2236)	
4250	7000	2750	Ø8-300 (4s.)	2236)	

6) Extra longitudinal reinforcement (Asl,req) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.



Envelope D-line (ULS)

## 2.7.5 Shear / Torsion reinforcement - Ultimate limit state (ULS)

...EN 1992-1-1 art.6.3.2

x [mm]	VEd [kN]	TEd [kNm]	VRd,c [kN]	TRd,c [kNm]	VRd,max [kN]	TRd,max [kNm]	Side	Stirrups	Rem.
2500	82,5	0,0	62,4	25,8	653,8	90,5	Top	Ø8-300 (4s.)	
2500	97,1	13,5	62,4	25,8	653,8	90,5	Top	Ø8-100 (4s.)	
4300	37,7	13,5	62,4	25,8	653,8	90,5	Top	Ø8-300 (4s.)	
2500	82,5	0,0	62,4	25,8	653,8	90,5	Bottom	Ø8-300 (4s.)	
2500	97,1	13,5	62,4	25,8	653,8	90,5	Bottom	Ø8-100 (4s.)	
4300	37,7	13,5	62,4	25,8	653,8	90,5	Bottom	Ø8-300 (4s.)	

x [mm]	VEd [kN]	TEd [kNm]	AswT	AswV	Asw,req	Asw,act	Asl,req [mm <sup>2</sup> ]	Stirrups	Rem.
2500	82,5	0,0	0,000	0,096	0,096	0,168	0	Ø8-300 (4s.)	
2500	97,1	13,5	0,116	0,113	0,229	0,503	223	Ø8-100 (4s.)	6)
4300	37,7	13,5	0,116	0,044	0,160	0,168	223	Ø8-300 (4s.)	6)

6) Extra longitudinal reinforcement ( $A_{sl,req}$ ) is required! This additional longitudinal reinforcement must be evenly distributed around the perimeter.