DECEN d.o.o.

ODGOVORNI PROJEKTANT

LUKA KOČEVAR S.P.

PROJEKTANT

NAČRT GRADBENIH KONSTRUKCIJ - 2

DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.

INVESTITOR:	INŠTITUT JOŽEF STEFAN Jamova 39 1000 LJUBLJANA
NAZIV GRADNJE:	DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.
LOKACIJA:	REAKTORSKI CENTER PODGORICA Brinje 40 1262 Dol pri Ljubljani
VRSTA PROJEKTA:	PZI
ŠT. PROJEKTA:	09-2024
ŠT. NAČRTA:	09/2024-G
DATUM:	DECEMBER 2024

PRILOGA 1C

NASLOVNA STRAN NAČRTA

PODATKI O GRADNJI		
naziv gradnje		**INSTITUT "JOŽEF STEFAN" DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.**
kratek opis gradnje		
Nameravana je izgradnja AB dvigalnega jaška ob obstoječem jeklenem stopnišču z razširitvijo jeklene konstrukcije za izvedbo podestov za dostop v dvigalo.		
VRSTE GRADNJE	☐	**NOVOGRADNJA - NOVOZGRAJEN OBJEKT**
označiti vse ustrezne vrste gradnje	☑	**NOVOGRADNJA - PRIZIDAVA**
	☐	**REKONSTRUKCIJA**
	☐	**SPREMEMBA NAMEMBNOSTI**
	☐	**ODSTRANITEV CELOTNEGA OBJEKTA**
	☐	**LEGALIZACIJA**
	☐	**MANJŠA REKONSTRUKCIJA**
PODATKI O PROJEKTNI DOKUMENTACIJI		
vrsta dokumentacije		**PZI-G**
številka projekta		**09-2024**
PODATKI O NAČRTU		
strokovno področje načrta		**NAČRT GRADBENIŠTVA - 2**
naziv načrta		**INSTITUT "JOŽEF STEFAN" DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.**
številka načrta		**09-2024-G**
datum izdelave		**DECEMBER 2024**
datum spremembe		
PODATKI O PROJEKTANTU NAČRTA		
projektant načrta (naziv družbe)		**Decen d.o.o.**
naslov		**Šešče pri Preboldu 32A, 3312 Prebold**
odgovorna oseba projektanta načrta		**Vinko Debelak u.d.i.g. G-0837**
podpis odgovorne osebe projektanta načrta		DeCen, d.o.o. PREBOLD
PODATKI O IZDELOVALCU NAČRTA		
ime in priimek pooblaščenega arhitekta, pooblaščenega inženirja		**Vinko Debelak u.d.i.g.**
identifikacijska številka		**G-0837**
podpis pooblaščenega arhitekta, pooblaščenega inženirja		VINKO DEBELAK univ. dipl. inž. grad. IZS G-0837

PRILOGA 2C

IZJAVA PROJEKTANTA NAČRTA IN POOBLAŠČENEGA STOKOVNJAKA, KI JE IZDELAL NAČRT V PZI IN PID

PROJEKTANT NAČRTA	
projektant načrta (naziv družbe)	**Decen d.o.o.**
naslov	**Šešče pri Preboldu 32A, 3312 Prebold**
odgovorna oseba projektanta načrta	**Vinko Debelak u.d.i.g. G-0837**

IN POOBLAŠČENI STROKOVNJAK, KI JE IZDELAL NAČRT	
pooblaščeni strokovnjak	**Vinko Debelak u.d.i.g. G-0837**

IZJAVLJAVA:

da načrt

vrsta dokumentacije	**PZI-G**
strokovno področje načrta	**NAČRT GRADBENIŠTVA - 2**
naziv načrta	**INSTITUT "JOŽEF STEFAN" DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.**
številka načrta	**09-2024-G**
datum izdelave	**DECEMBER 2024**

upošteva relevantne predpise in druge normativne dokumente ter da so upoštevane ustrezne bistvene in druge zahteve.

pooblaščeni strokovnjak	**Vinko Debelak u.d.i.g.**
identifikacijska številka	**G-0837**
podpis pooblaščenega strokovnjaka	VINKO DEBELAK univ. dipl. inž. grad. IZS G-0837
odgovorna oseba projektanta načrta	**Vinko Debelak u.d.i.g. G-0837**
podpis odgovorne osebe projektanta načrta	DeCen d.o.o. PREBOLD

TEHNIČNO POROČILO 3

1. OPIS OBJEKTA 3

2. OPIS KONSTRUKCIJE 3

2.1. Statični sistem 3
2.2. Računski pristop 3
2.3. Nosilni elementi 4
2.3.1. Temelji 4
2.3.2. Armiranobetonske stene 4
2.3.3. Plošče 4
2.3.4. Krovni sloj 4
2.3.5. Nega betona 4
2.3.6. Jeklena konstrukcija 4
2.4. Požarna Varnost 5

3. LASTNOSTI TEMELJNIH TAL 5

4. MATERIALI 5

4.1. Beton 5
4.2. Armatura 6
4.3. Konstrukcijsko Jeklo 6

5. OBETŽBA 7

5.1. Stalna obtežba 7
5.1.1. Lastna teža ''G'' 7
5.1.2. Zemeljski pritisk ''SP'' 7
5.2. Spremenljiva obtežba 7
5.2.1. Koristna obtežba ''K'' 7
5.2.2. Obtežba snega ''Snow'' 7
5.2.3. Veter ''Wind'' 7
5.3. Potresna obtežba ''SM'' 8
5.3.1. Horizontalni spekter 8
5.3.2. Metode kombiniranja 8
5.4. Kombinacijski faktorji 9
5.5. Mejno Stanje Uporabnosti 9

6. ANALIZA KONSTRUKCIJE 10

6.1. Računski model 10
6.1.1. Geometrija 10
6.2. Modalna analiza s spektri odziva 10
6.2.1. Spekter odziva 10
6.2.2. Nihajne oblike 11
6.2.3. Participacija modalnih mas 12
6.2.4. Občutljivost etaž 12
6.3. Temeljenje 13
6.3.1. Piloti 13
6.4. Plošče in stene 22
6.4.1. Temeljna plošča 22
6.4.2. Stena jug 24
6.4.3. Stena zahod 26
6.4.1. Stena sever 28
6.4.1. Stena vzhod 30
6.4.2. Strešna plošča jaška 32

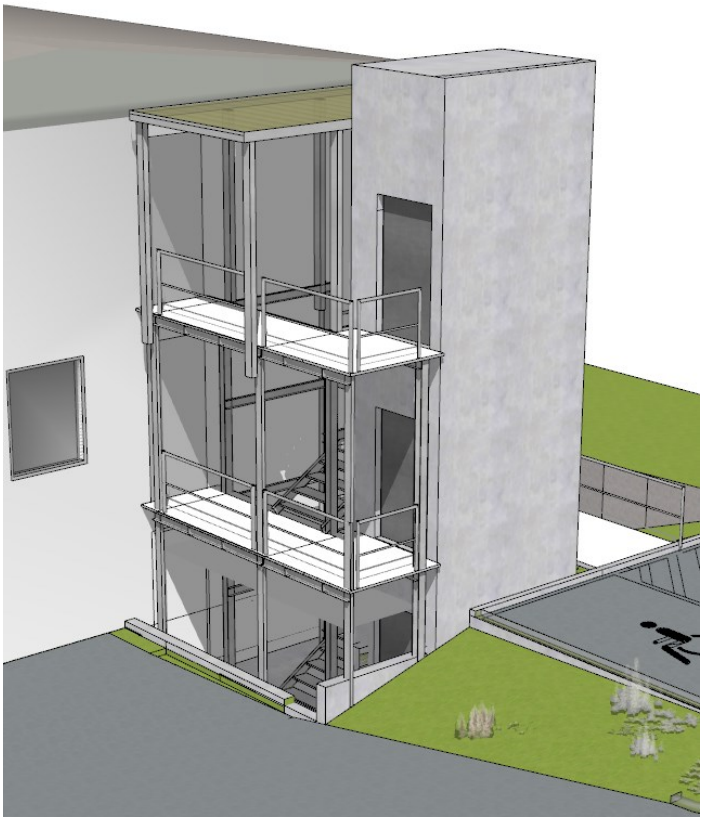
6.4.1. Oporni zid 33
6.5. Jeklena konstrukcija 35

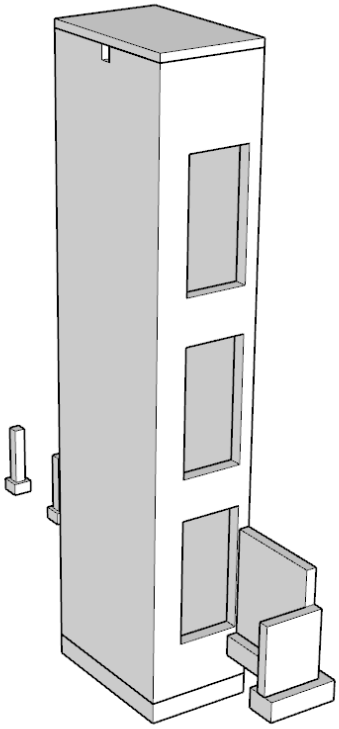
GRAFIČNI DEL 37

TEHNIČNO POROČILO

1. OPIS OBJEKTA

Naziv stavbe	Dvigalo ob stavbi prizidka k reaktorju II
Predvidena uporaba	Vertikalna komunikacija
Splošen opis	Objekt sestavlja AB dvigalni jašek in podaljšani podesti iz obstoječega jeklenega stopnišča.
Gabariti objekta	2,1 m x 4,9 m x 11,9 m





2. OPIS KONSTRUKCIJE

2.1. STATIČNI SISTEM

Statični sistem objekta sestavljajo AB stene (ploskovni elementi) temeljeno na pilotih (linijski elementi) in jeklena konstrukcija (linijski elementi).

2.2. RAČUNSKI PRISTOP

Za izračun je uporabljena metoda končnih elementov (MKE). Za določitev armature je uporabljena linearna metoda (TPR) v kombinaciji z modalno analizo s spektri odziva. Jeklena konstrukcija je kontrolirana ločeno (TPR).

2.3. NOSILNI ELEMENTI

2.3.1. TEMELJI

Dvigalni jašek je temeljen na temeljni plošči debeline 40cm, ki leži na 6 pilotih Ø40cm globine 6m. Oporni AB zid je temeljen na pasovnih temeljih dim. 60/40cm. Zaliti morajo biti z betonom kvalitete C25/30, XC1 in armirani z armaturo B500B.

2.3.2. ARMIRANOBETONSKE STENE

AB stene bodo debeline 20cm in 25cm, zalite z betonom C30/37, XF1, XC4 in armirane z armaturo B500B.

2.3.3. PLOŠČE

Plošča na vrhu dvigalnega jaška je debeline 15 cm, zalite z betonom C30/37, XF1, XC4 in armirane z armaturo B500B. Ploščo je potrebno pustiti zaopaženo minimalno 7dni.

2.3.4. KROVNI SLOJ

Krovni sloj betona velja za vso temeljene 4cm (piloti, temeljne plošče, pasovni temelji) in za vse višje ležeče AB elemente 3 cm od zunanjosti betona do armature.

2.3.5. NEGA BETONA

Svetuje se, da se beton vgrajuje pri temperaturi okolja 5-40°C. Izven tega območja se smatra za betoniranje v ekstremnih pogojih in so potrebni posebni ukrepi in dodatki. Pod nego betona se smatra, da je betonu v začetku hidratacije zagotovljena ustrezna vlaga. Spodnja tabela predstavlja potrebno število dni nege betona (zalivanje) v odvisnosti od temperature in relativne vlage okolja.

	RH [%]			
temp. [°C]	0-25	25-50	50-75	75-100
35-40	7	6	5	4
30-35	6	5	4	3
25-30	5	4	3	
20-25	4	3		
15-20	3		brez posebne nege	
10-15	3			
5-10	3	3		



Močenje betona v prvih 12h je potrebno opravljati z nastavkom za meglo ali prho. Po tem lahko s curkom. V poletnih dneh je priporočena uporaba vodo-vpojnega pokrivala npr. karton, koprena, filc, itd.

2.3.6. JEKLENA KONSTRUKCIJA

Preverjeni so glavni nosilni elementi. Delavniške načrte izdela izbrani izvajalec.

2.4. POŽARNA VARNOST

SIST EN 1992-1-2:2005

Iz Študije požarne varnosti izhaja, da mora konstrukcija objekta zagotavljati požarno odpornost za čas 30 minut. Nosilni elementi konstrukcije (stene, stebri, plošče, nosilci) morajo izpolnjevati pogoje za razred REI 30. Zahteve iz Študije požarne varnosti so za armiranobetonske nosilne elemente upoštevane tako, da so zagotovljene minimalne dimenzije nosilnih elementov konstrukcije ter minimalni osni odmiki armature od roba betona posameznih konstrukcijskih elementov.

V skladu s SIST EN 1992-1-2:2005 so upoštevane naslednje minimalne dimenzije:
- polne nosilne stene (REI 30): d_{min} = 17 cm, a_{min} = 2.5 cm

Debeline nosilnih armiranobetonskih sten v objektu bodo 20cm in 25cm. Zaščitni sloj za znaša 3.0cm, kar izpolnjuje pogoje o minimalni osni oddaljenosti armature od roba betona (a_{min}).

3. LASTNOSTI TEMELJNIH TAL

Vrednosti temeljnih tal so privzete iz Geomehanskega poročila »GG 31/12 GS« iz dne 26.06.2012 podjetja GEOSTERN d.o.o. Ekstrapolirane so naslednje vrednosti:

- Modul reakcije tal za pilote:
  - na konici pilotov 4,7 MN/m, z=10m
  - bočno na plašč 30 MN/m^2, z∈(9m,10m)
  - bočno na plašč 6,45 MN/m^2, z∈(4m,9m)

- Modul reakcije tal bočno na AB stene 0,84 MN/m^3
- Prenos sil temeljne plošče na temeljna tla je onemogočen
- Za modalno analizo s spektri odziva je uporabljen podan tip tal B.

Pred izvedbo globokega temeljenja mora geomehanik ugotoviti dejanske vrednosti temeljnih tal in pisno potrditi ekstrapolirane vrednosti. V kolikor ugotovljene vrednosti niso enake ali ne presegajo ekstrapoliranih, se o tem obvesti projektanta gradbenih konstrukcij. Gradnja se ustaviti do nadaljnjih navodil.

4. MATERIALI

4.1. BETON

EN 206, EN 197

KVALITETA C25/30:

Specifična gostota	γ_k = 23,3 kN/m^3
Tlačna trdnost	f_{ck} = 2,5 kN/cm^2
Natezna trdnost	f_{ctm} = 0,26 kN/cm^2
Elastični modul	E_{cm} = 3100 kN/cm^2
Koef. temp. raztezka	α_a = 1×10-5/°C



KVALITETA C30/37:

Specifična gostota	$\gamma_k = 23{,}3\ kN/m^3$
Tlačna trdnost	$f_{ck} = 3{,}0\ kN/cm^2$
Natezna trdnost	$f_{ctm} = 0{,}29\ kN/cm^2$
Elastični modul	$E_{cm} = 3300\ kN/cm^2$
Koef. temp. raztezka	$\alpha_a = 1\times10\text{-}5/°C$



4.2. ARMATURA

EN 10025-2, EN 10080

KVALITETA B500B:

Specifična gostota	$\gamma_k = 78{,}5\ kN/m^3$
Meja elastičnosti	$f_{yk} = 50\ kN/cm^2$
Elastični modul	$E_s = 20\ MN/cm^2$
Koef. temp. raztezka	$\alpha_a = 1.2\times10\text{-}5/°C$



4.3. KONSTRUKCIJSKO JEKLO

EN 1993-1-1, EN 10025, EN 10113, EN 10210, EN 10219

KVALITETA S235:

Specifična gostota	$\gamma_k = 78{,}5\ kN/m^3$
Napetost tečenja	$f_y = 23{,}5\ kN/cm^2$
Natezna trdnost	$f_u = 36\ kN/cm^2$
Elastični modul	$E_s = 21\ MN/cm^2$
Korelacijski faktor zvarov	$\beta_w = 0{,}8$
Koef. temp. raztezka	$\alpha_a = 1.2\times10\text{-}5/°C$



5. OBETŽBA

5.1. STALNA OBTEŽBA

5.1.1. LASTNA TEŽA "G"

SIST EN 1991-1-1:2004

Lastna teža je samodejno upoštevana v programu za statični preračun. Za specifično gostoto uporabljenega materiala glej poglavje »Materiali«.

5.1.2. ZEMELJSKI PRITISK "SP"

Podatki zasipnega materiala:

GW-dh	γ [kg/m³]	φ [°]	φ_{cv} [°]	μ	E_s [kN/cm²]
	2141	41,5	33,2	0,2	47,78
Well graded gravel					

Bočna obremenitev sten:

$$p_m = p_0 + \gamma \cdot (\Delta h + z) \cdot (1 - \sin(\varphi))$$

$$p_m(1{,}4m) = 21{,}4\ kN \cdot 1{,}4m \cdot (1 - \sin(33{,}2°)) = 13{,}8 \frac{kN}{m^2}$$

$$p_m(2{,}0m) = 21{,}4\ kN \cdot 2{,}0m \cdot (1 - \sin(33{,}2°)) = 19{,}7 \frac{kN}{m^2}$$

$$p_m(3{,}5m) = 21{,}4\ kN \cdot 3{,}5m \cdot (1 - \sin(33{,}2°)) = 33{,}9 \frac{kN}{m^2}$$

5.2. SPREMENLJIVA OBTEŽBA

5.2.1. KORISTNA OBTEŽBA "K"

SIST EN 1991-1-4:2005

Koristno obtežbo predstavljajo vse stvari, ki niso trajno spojene z objektom (pohištvo, oprema, ljudje itd.) Vrednost koristne obtežbe za stopnišče smo izbrali 2,5 kN/m^2. Polno dvigalo upoštevamo kot utež 25kN.

5.2.2. OBTEŽBA SNEGA "SNOW"

SIST EN 1991-1-3:2004/A1:2015

Za izračun je bila uporabljena snežna obtežba (Dlubal – EC SLO) na lokaciji izvedbe objekta:
s_k = 1,47 kN/m^2

5.2.3. VETER "WIND"

SIST EN 1991-1-4:2005

Upoštevan je bil pritisk vetrne obtežbe na izbrani lokaciji pri osnovni hitrosti vetra $v_{b,0}$ = 20 m/s in vetrni coni III.

5.3. POTRESNA OBTEŽBA "SM"

SIST EN 1998-1:2005

Za izračun vpliva potresa je bila uporabljena modalna analiza s spektri odziva. Upošteva se odziv konstrukcije v smereh X in Y.

5.3.1. HORIZONTALNI SPEKTER

Parametrična oblika
Faktor pomembnosti: γ_I = 1
Tip tal: B, tip 1
Projektni pospešek tal: a_g = 2,698 m/s^2
Faktor obnašanja: q = 3,0
Faktor tal: S = 1,2
Začetek konstantnega dela spektra: T_B = 0,15 s
Konec konstantnega dela spektra: T_C = 0,50 s
Začetek konstantnega dela premika spektra: T_D = 2,0 s
Koeficient spodnje meje: β = 0,2

5.3.2. METODE KOMBINIRANJA

Kombinacija modalnih odzivov: Samodejno (CQC)
Viskozno dušenje: ξ' = 0,05
Kombinacija komponent seizmičnega delovanj: SRSS

5.4. KOMBINACIJSKI FAKTORJI

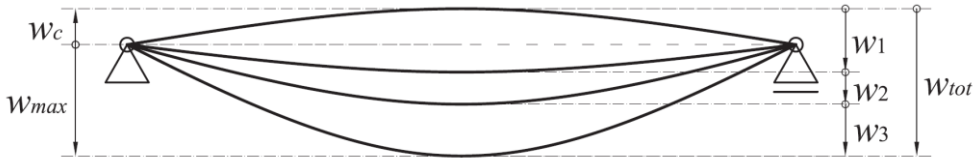
SIST EN 1990:2004

Vrsta vpliva	Stalna in začasna stanja		Nezgodna stanja		ψ_0	ψ_1	ψ_2
	neugodno	ugodno	neugodno	Ugodno			
G- stalni vplivi							
G1: lastna teža	1,35	1	1	1	1	1	1
G2: stalna teža	1,35	1	1	1	1	1	1
C: reologija	1,35	0	1	0	1	1	1
Q - spremenljivi vplivi	1,5	0	1	0	0,7	0,5	0,3
QB: pisarne	1,5	0	1	0	0,7	0,7	0,6
QD: trgovine	1,5	0	1	0	1	0,9	0,8
QE: skladišča	1,5	0	1	0	0	0	0
QH: strehe	1,5	0	1	0			
S: Sneg (<1000m)	1,5	0	1	0	0,5	0,2	0
W: Veter (po izgradnji)	1,5	0	1	0	0,6	0,2	0

5.5. MEJNO STANJE UPORABNOSTI

SIST EN 1990

DEL KONSTRUKCIJE	**Mejne vrednosti pri karakteristični kombinaciji vplivov**	
	w_{max}	$w_2 + w_3$
Strehe nasploh	L/200*	L/250
Pohodne strehe	L/250	L/300
Stropovi nasploh	L/250	L/300
Strehe in stropovi, ki nosijo krhke obloge (npr. mavec), in zelo toge predelne stene	L/300	L/350
Stropovi, ki podpirajo stebre, razen v primerih, če so ti upogibki izračunani pri celoviti analizi konstrukcije	L/400	L/350
*v primeru, da je w_{max} pomemben za videz konstrukcije	L/400	L/500
L razpon med podporami ali dvojna dolžina konzole	L/250	-

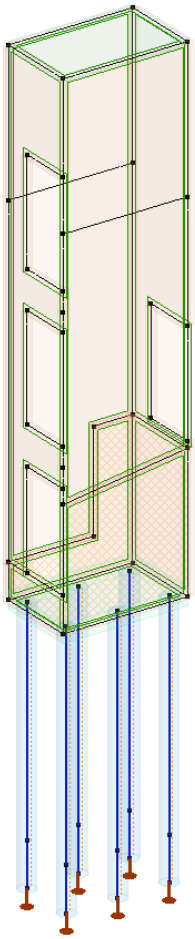


w_c nadvišanje neobremenjenega konstrukcijskega elementa
w_1 začetni del upogibka zaradi stalnih vplivov v ustrezni kombinaciji skladno z enačbami (6.14a)
w_2 *del upogibka zaradi dolgotrajnega delovanja stalne obtežbe*
w_3 *dodatni del upogibka zaradi spremenljivih vplivov v ustrezni kombinaciji skladno z enačbami (6.14a) do (6.16b)*
w_{tot} *celoten upogibek kot vsota* w_1, w_2 *in* w_3
w_{max} *končni upogibek z upoštevanjem nadvišanja*

6. ANALIZA KONSTRUKCIJE

6.1. RAČUNSKI MODEL

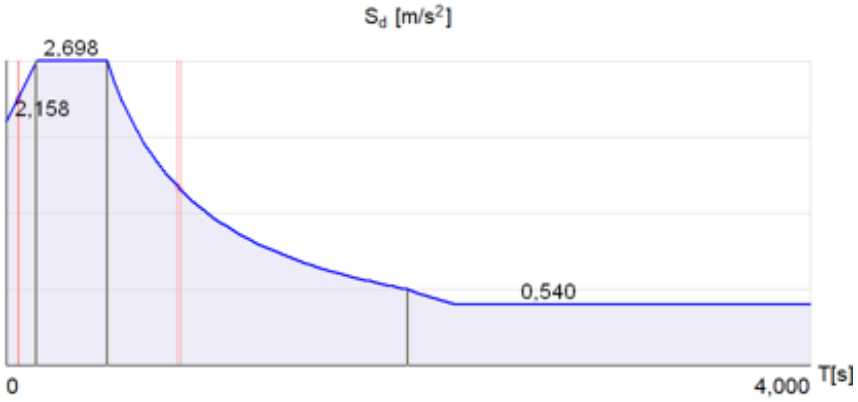
6.1.1. GEOMETRIJA



Računski model sestavljajo piloti podprti s točkovnimi in linijskimi vzmetmi. Na pilotih je AB dvigalni jašek sestavljen iz ploskovnih elementov. Vse je med sabo togo povezano.

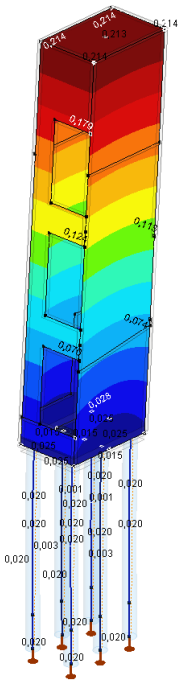
6.2. MODALNA ANALIZA S SPEKTRI ODZIVA

6.2.1. SPEKTER ODZIVA

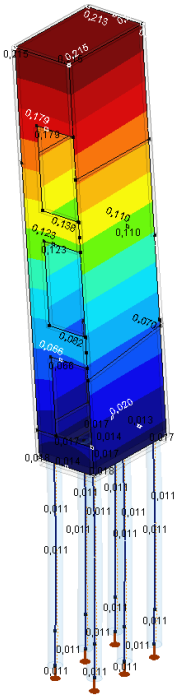


6.2.2. NIHAJNE OBLIKE

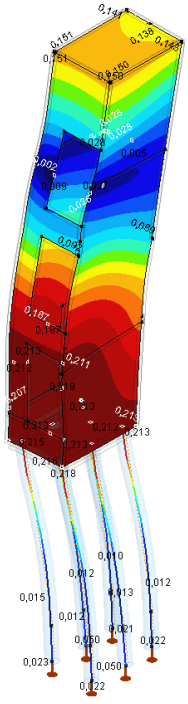
Upoštevane so bile vse nihajne oblike katerih participacija presega 0,5% ($\varepsilon_{xx} \vee \varepsilon_{yy} \vee \varepsilon_{zz} \geq 0{,}005$)
Prikazane so prve 4 relevantne nihajne oblike.



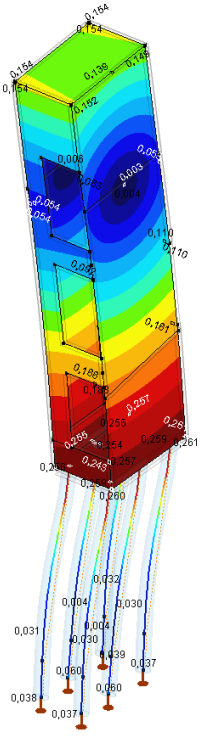
1. nihajna oblika



2. nihajna oblika



4. nihajna oblika



5. nihajna oblika

6.2.3. PARTICIPACIJA MODALNIH MAS

No.	f [Hz]	T [s]	εX	εY	εZ	εXX	εYY	εZZ	ΣiεX	ΣiεY	ΣiεZ	ΣiεXX	ΣiεYY	ΣiεZZ
1	1,16	0,864	0,814	0	0	0	0,186	0	0,814	0	0	0	0,186	0
2	1,18	0,85	0	0,809	0	0,191	0	0	0,814	0,809	0	0,191	0,186	0
4	16,3	0,061	0	0,184	0	0,78	0,002	0,001	0,814	0,993	0	0,971	0,188	0,001
5	17,69	0,057	0,185	0	0	0,002	0,808	0	0,999	0,993	0	0,973	0,996	0,001
			0,999	**0,993**	0	0,973	0,996	0,001						

6.2.4. OBČUTLJIVOST ETAŽ

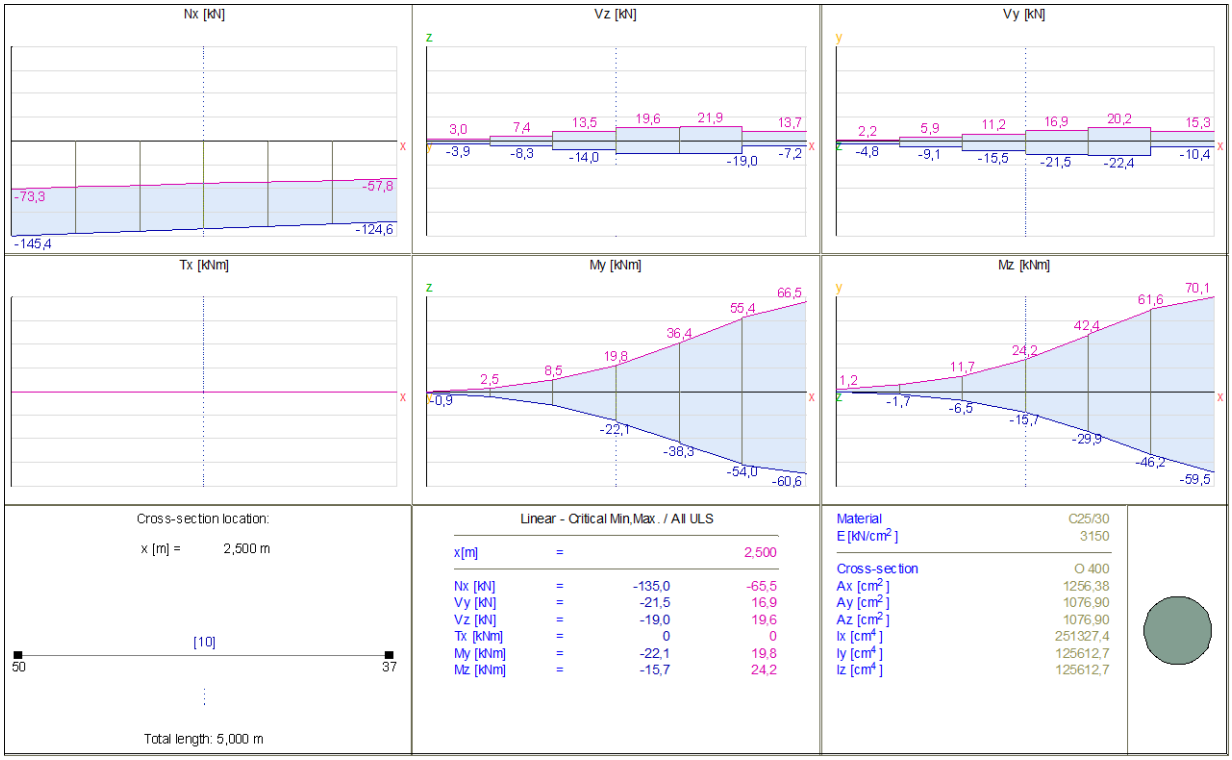
Storeys	X/Y	Z [cm]	h [cm]	Θmax	Ptot [kN]	Vtot [kN]	Vtot/Ptot	M [kg]
Storey 3	X	1160	0	0,052	248,2	47,5	19%	25302,62
	Y			0,05		48,3	19%	25302,62
Storey 2	X	673	487	0,064	383	61,5	16%	13737,94
	Y			0,063		62,4	16%	13737,94
Storey 1	X	347	326	0,078	533,2	73	14%	15308,27
	Y			0,076		73,7	14%	15308,27

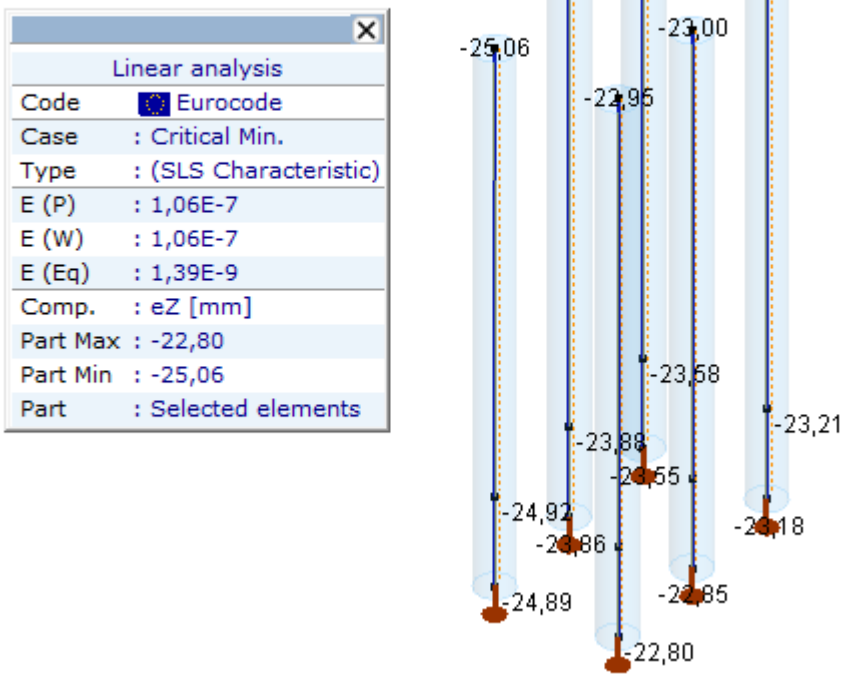
EN 1998-1:2004, 4.4.2.2, (3)

Θ_{max} < 0,3 ...vpliv drugega reda se lahko zanemari

6.3. TEMELJENJE

6.3.1. PILOTI





Maksimalni posedek pilotov 25mm.

Column reinforcement

Structural member: Beam 12

Verification for eccentric axial force

Materials

Concrete **C25/30** f_{ck} = 25 MPa Rebar steel **B500B** f_{yk} = 500 MPa

Buckling parameters

Element length: l = 5,000 m

Factor depending on the support conditions		The effective length
Cantilever	β_{yy} = 2	$l_{0,y} = \beta_{yy} \cdot l = 2 \cdot 5{,}000 = 10{,}000$ m
Cantilever	β_{zz} = 2	$l_{0,z} = \beta_{zz} \cdot l = 2 \cdot 5{,}000 = 10{,}000$ m

Column cross-section parameters

Diameter: D_{col} = 400,0 mm

The area of concrete cross section:

$$A_c = \frac{D_{col}^2}{4} \cdot \pi = \frac{400{,}0^2}{4} \cdot 3{,}1416 = 1{,}2566 \cdot 10^5 \text{ mm}^2$$

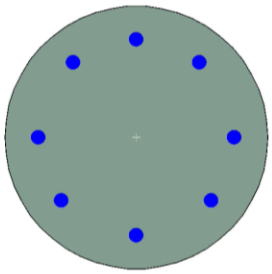
Concrete cover of the longitudinal reinforcement: c = 40 mm

Reinforcement parameters

Name: **6o22**

Reinforcement symmetrical to the z axis

8ϕ22 (A_s = 3041 mm²)



Longitudinal rebars

	Rebar diameter	Rebar position		Cross-section area	Second moment of area of reinforcement, about the centre of area of the concrete	
	ϕ [mm]	y [mm]	z [mm]	A_s [mm²]	$I_{s,y}$ [mm⁴]	$I_{s,z}$ [mm⁴]
1.	22	200	348,8	380	8417272	0
2.	22	295,7	314	380	4939459	3477814
3.	22	348,8	200	380	0	8417272
4.	22	314	104,3	380	3477815	4939459
5.	22	200	51,19	380	8417273	0
6.	22	86,01	104,3	380	3477815	4939458
7.	22	51,19	200	380	0	8417273
8.	22	104,3	314	380	4939459	3477815
Total				**3041**	$3{,}3669 \cdot 10^7$	$3{,}3669 \cdot 10^7$

Center of gravity of the concrete cross-section:

$$y_{CG,c} = z_{CG,c} = \frac{D_{col}}{2} = \frac{400{,}0}{2} = 200 \text{ mm}$$

The second moment of area of the concrete cross-section:

$$I_{cy} = I_{cz} = \frac{3{,}14159265358979 \cdot \left(\frac{D_{col}}{2}\right)^4}{4} = \frac{3{,}14159265358979 \cdot \left(\frac{400{,}0}{2}\right)^4}{4} = 1{,}2566 \cdot 10^9 \text{ mm}^4$$

The radius of gyration of the uncracked concrete section:

$$i_y = \sqrt{\frac{I_{cy}}{A_c}} = \sqrt{\frac{1{,}2566 \cdot 10^9}{1{,}2566 \cdot 10^5}} = 100 \text{ mm} = 0{,}1 \text{ m}$$

$$i_z = \sqrt{\frac{I_{cz}}{A_c}} = \sqrt{\frac{1{,}2566 \cdot 10^9}{1{,}2566 \cdot 10^5}} = 100 \text{ mm} = 0{,}1 \text{ m}$$

The second moment of area of the reinforcing steel:

$$I_{sy} = \Sigma\left(A_{s,i} \cdot (z_{s,i} - z_{CG,c})^2\right) = 3{,}3669 \cdot 10^7 \text{ mm}^4$$

$$I_{sz} = \Sigma\left(A_{s,i} \cdot (y_{s,i} - y_{CG,c})^2\right) = 3{,}3669 \cdot 10^7 \text{ mm}^4$$

The radius of gyration of the total reinforcement area:

$$i_{sy} = \sqrt{\frac{I_{sy}}{A_s}} = \sqrt{\frac{3{,}3669 \cdot 10^7}{3041}} = 105{,}2 \text{ mm} \qquad i_{sz} = \sqrt{\frac{I_{sz}}{A_s}} = \sqrt{\frac{3{,}3669 \cdot 10^7}{3041}} = 105{,}2 \text{ mm}$$

Design values of material properties

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1{,}5} = 16{,}7 \text{ MPa} = 16667 \text{ kPa}$$ EN 1992-1-1 3.1.6. (1)P (3.15)

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1{,}15} = 435 \text{ MPa} = 4{,}35 \cdot 10^5 \text{ kPa}$$ EN 1992-1-1 3.2.7. (2) Fig. 3.8

Column forces in the critical section

Load case: **[ST+G] {±SM1 2} (0,3*K+0,3*SP)**

Internal forces at the top of the column segment:

$N_{Ed,0,T}$ = 78,7 kN $M_{Ed,0,Ty}$ = 3,94 kNm $M_{Ed,0,Tz}$ = 6,18 kNm

Internal forces at the bottom of the column segment:

$N_{Ed,0,B}$ = 81,2 kN $M_{Ed,0,By}$ = 0,829 kNm $M_{Ed,0,Bz}$ = 7,61 kNm

Initial eccentricity:

$$e_{e,x,y} = \frac{M_{Ed,0z}}{N_{Ed,0}} = \frac{6{,}18}{78{,}7} = 0{,}0786 \text{ m} \qquad e_{e,x,z} = \frac{-M_{Ed,0y}}{N_{Ed,0}} = \frac{-3{,}94}{78{,}7} = -0{,}0501 \text{ m}$$

Eccentricity due to geometrical imperfections

The equivalent inclination representing imperfection: EN 1992-1-1 5.2. (5) (5.1)

$$\Theta_i = \Theta_0 \cdot \alpha_h \cdot \alpha_m = 0{,}005 \cdot 0{,}89443 \cdot 1 = 0{,}0044721$$

Equivalent eccentricity representing imperfections:

$$e_{iy} = \frac{\Theta_i \cdot l_{0,z}}{2} = \frac{0{,}0044721 \cdot 10{,}000}{2} = 0{,}0224 \text{ m} \qquad e_{iz} = \frac{\Theta_i \cdot l_{0,y}}{2} = \frac{0{,}0044721 \cdot 10{,}000}{2} = 0{,}0224 \text{ m}$$ EN 1992-1-1 (5.1)

Eccentricity due to geometrical imperfections

	Cantilever	Cantilever
at the bottom end	$e_{i,1y} = e_{iy} = 0{,}0224$ m	$e_{i,1z} = e_{iz} = 0{,}0224$ m
at the top end	$e_{i,2y}$ = 0 m	$e_{i,2z}$ = 0 m
at the position of verification	$e_{i,x,y} = e_{i,2y} = 0$ m	$e_{i,x,z} = e_{i,2z} = 0$ m

Slenderness criterion for isolated members

Slenderness limit: EN 1992-1-1 (5.13N)

$$\lambda_{limy} = \frac{20 \cdot A_y \cdot B \cdot C_y}{\sqrt{n}} = \frac{20 \cdot 0{,}71429 \cdot 1{,}4702 \cdot 0{,}7}{\sqrt{0{,}034894}} = 78{,}707 \qquad \lambda_{limz} = \frac{20 \cdot A_z \cdot B \cdot C_z}{\sqrt{n}} = \frac{20 \cdot 0{,}71429 \cdot 1{,}4702 \cdot 0{,}7}{\sqrt{0{,}034894}} = 78{,}707$$

where: $A_y = \frac{1}{1+0,2\cdot\phi_{efy}} = \frac{1}{1+0,2\cdot 2} = 0,71429$ $A_z = \frac{1}{1+0,2\cdot\phi_{efz}} = \frac{1}{1+0,2\cdot 2} = 0,71429$

$B = \sqrt{1+2\cdot\omega} = \sqrt{1+2\cdot 0,5808} = 1,4702$

$C_y = 0,7$ $C_z = 0,7$

The slenderness ratio: EN 1992-1-1 (5.14)

$\lambda_y = \frac{l_{0,y}}{i_y} = \frac{10,000}{0,100} = 100 > \lambda_{limy} = 78,707$!! $\lambda_z = \frac{l_{0,z}}{i_z} = \frac{10,000}{0,100} = 100 > \lambda_{limz} = 78,707$!!

The second order effects should be taken into account in both directions.

Eccentricity due to second order effects

First order bending moment including the effect of imperfections:

$M_{0Edy} = M_{Ed01y} - N_{Ed}\cdot e_{iz} = (-0,221) - 78,7\cdot 0,0224 = -2,0$ kNm

$M_{0Edz} = M_{Ed01z} + N_{Ed}\cdot e_{iy} = 0,203 + 78,7\cdot 0,0224 = 2,0$ kNm EN 1992-1-1 5.8.8.2. (1)

Method based on nominal curvature EN 1992-1-1 5.8.8.

The correction factor depending on axial load:

$K_r = \frac{n_u - n}{n_u - n_{bal}} = \frac{1,5808 - 0,034894}{1,5808 - 0,4} = 1,3092 > 1 \rightarrow K_r = 1$ EN 1992-1-1 (5.36)

The factor for taking account of creep: EN 1992-1-1 (5.37)

$K_{\phi y} = \max(1+\beta_y\cdot\phi_{efy}\ ;\ 1) = \max(1+(-0,19167)\cdot 2\ ;\ 1) = 1$ $K_{\phi z} = \max(1+\beta_z\cdot\phi_{efz}\ ;\ 1) = \max(1+(-0,19167)\cdot 2\ ;\ 1) = 1$

Strain of reinforcement at design yield strength:

$\varepsilon_{yd} = \frac{f_{yd}}{E_s} = \frac{4,35\cdot 10^5}{2\cdot 10^8} = 0,002175$

Curvature:

$\kappa_y = K_r\cdot K_{\phi y}\cdot\kappa_{0y} = 1\cdot 1\cdot 0,015836 = 0,015836$ $\kappa_z = K_r\cdot K_{\phi z}\cdot\kappa_{0z} = 1\cdot 1\cdot 0,015836 = 0,015836$ EN 1992-1-1 (5.34)

where:

$\kappa_{0y} = \frac{\varepsilon_{yd}}{0,45\cdot d_z} = \frac{0,002175}{0,45\cdot 0,305} = 0,015836$ $\kappa_{0z} = \frac{\varepsilon_{yd}}{0,45\cdot d_y} = \frac{0,002175}{0,45\cdot 0,305} = 0,015836$

Determination of the coefficient depending on the curvature distribution

The nominal stiffness:

$EI_y = K_{cy}\cdot E_{cd}\cdot I_{cy} + K_s\cdot E_s\cdot I_{sy} = 0,0076496\cdot 2,623\cdot 10^7\cdot 0,00126 + 1\cdot 2\cdot 10^8\cdot 3,3669\cdot 10^{-5} = 6986$ kNm²

$EI_z = K_{cz}\cdot E_{cd}\cdot I_{cz} + K_s\cdot E_s\cdot I_{sz} = 0,0076496\cdot 2,623\cdot 10^7\cdot 0,00126 + 1\cdot 2\cdot 10^8\cdot 3,3669\cdot 10^{-5} = 6986$ kNm² EN 1992-1-1 (5.21)

The buckling load based on nominal stiffness:

$N_{by} = \frac{\pi^2\cdot EI_y}{l_{0,y}^2} = \frac{3,1416^2\cdot 6986}{10,000^2} = 689$ kN $N_{bz} = \frac{\pi^2\cdot EI_z}{l_{0,z}^2} = \frac{3,1416^2\cdot 6986}{10,000^2} = 689$ kN EN 1992-1-1 (5.17)

The coefficient which depends on the distribution of first order moment: EN 1992-1-1 5.8.7.3 (1)

$r_M = \frac{M_{01y}}{M_{02y}} = \frac{(-1,85)}{3,94} = -0,47023$

$c_{0y} = c_{0,min} + \frac{c_{0,max} - c_{0,min}}{r_{M,max} - r_{M,min}}\cdot(r_M - r_{M,min}) = 12 + \frac{8-12}{1-(-1)}\cdot((-0,47023) - (-1)) = 10,94$

$r_M = \frac{M_{01z}}{M_{02z}} = \frac{1,84}{6,18} = 0,29715$

$c_{0z} = c_{0,min} + \frac{c_{0,max} - c_{0,min}}{r_{M,max} - r_{M,min}}\cdot(r_M - r_{M,min}) = 12 + \frac{8-12}{1-(-1)}\cdot(0,29715 - (-1)) = 9,4057$

Coefficient depending on the distribution of curvature due to second order effects:

$c_2 = \pi^2 = 3{,}1416^2 = 9{,}8696$

Coefficient depending on the curvature distribution:

$$c_y = c_2 \cdot \frac{N_{Ed}}{N_{by}} + c_{0y} \cdot \left(1 - \frac{N_{Ed}}{N_{by}}\right) = 9{,}8696 \cdot \frac{78{,}7}{689} + 10{,}94 \cdot \left(1 - \frac{78{,}7}{689}\right) = 10{,}818 \; > c_2 = \pi^2 = 3{,}1416^2 = 9{,}8696 \; \rightarrow \; c_y = c_2 \; = \; 9{,}8696$$

$$c_z = c_2 \cdot \frac{N_{Ed}}{N_{bz}} + c_{0z} \cdot \left(1 - \frac{N_{Ed}}{N_{bz}}\right) = 9{,}8696 \cdot \frac{78{,}7}{689} + 9{,}4057 \cdot \left(1 - \frac{78{,}7}{689}\right) = 9{,}4586 \; < c_2 \; = \; 9{,}8696$$

The second order eccentricity:

$$e_{2,y} = \frac{\kappa_z \cdot l_{0,z}^{\,2}}{c_z} = \frac{0{,}015836 \cdot 10{,}000^2}{9{,}4586} = 0{,}167 \text{ m} \qquad e_{2,z} = \frac{\kappa_y \cdot l_{0,y}^{\,2}}{c_y} = \frac{0{,}015836 \cdot 10{,}000^2}{9{,}8696} = 0{,}16 \text{ m}$$ EN 1992-1-1 5.8.8.2 (3)

Position of the section with the highest utilization: $x = 5$ m

First order eccentricity including the imperfections:

$e_{0,x,y} = e_{e,x,y} + e_{i,x,y} = 0{,}0786 + 0 = 0{,}0786$ m $\qquad e_{0,x,z} = e_{e,x,z} - e_{i,x,z} = (-0{,}0501) - 0 = -0{,}0501$ m

$e_{0,x} = \sqrt{e_{0,x,y}^{\,2} + e_{0,x,z}^{\,2}} = \sqrt{0{,}0786^2 + (-0{,}0501)^2} = 0{,}0932$ m

Direction of the first order eccentricity:

$$\omega_{e0} = \arctan \frac{e_{0,x,z}}{e_{0,x,y}} = \arctan \frac{(-0{,}0501)}{0{,}0786} = -32{,}54\,°$$

$$e_{2,x,1} = \cos \frac{\pi \cdot x_{e2}}{2 \cdot l} \cdot e_{2,y} = \cos \frac{3{,}1416 \cdot 5}{2 \cdot 5} \cdot 0{,}167 = 1{,}0251 \cdot 10^{-17} \text{ m}$$ Cantilever

$$e_{2,x,2} = \cos \frac{\pi \cdot x_{e2}}{2 \cdot l} \cdot e_{2,z} = \cos \frac{3{,}1416 \cdot 5}{2 \cdot 5} \cdot 0{,}16 = 9{,}8246 \cdot 10^{-18} \text{ m}$$ Cantilever

$e_{2,x} = 9{,}8246 \cdot 10^{-18}$ m

$e_{2,x,y} = e_{2,x} \cdot \cos(\omega_{e0} + (-90{,}00\,°)) = 9{,}8246 \cdot 10^{-18} \cdot \cos((-32{,}54°) + (-90{,}00\,°)) = -5{,}2847 \cdot 10^{-18}$ m $\qquad e_{2,x,z} =$

$= e_{2,x} \cdot \sin(\omega_{e0} + (-90{,}00\,°)) = 9{,}8246 \cdot 10^{-18} \cdot \sin((-32{,}54°) + (-90{,}00\,°)) = -8{,}2821 \cdot 10^{-18}$ m

Minimum eccentricity : EN 1992-1-1 6.1. (4)

$$e_{min,y} = \max\left(\frac{h_y}{30} \; ; \; 20\right) = \max\left(\frac{400{,}0}{30} \; ; \; 20\right) = 20 \text{ mm} = 0{,}02 \text{ m}$$

$$e_{min,z} = \max\left(\frac{h_z}{30} \; ; \; 20\right) = \max\left(\frac{400{,}0}{30} \; ; \; 20\right) = 20 \text{ mm} = 0{,}02 \text{ m}$$

The critical eccentricity :

$e_{d,x,y} = e_{0,x,y} - e_{2,x,y} = 0{,}0786 - (-5{,}2847 \cdot 10^{-18}) = 0{,}0786$ m $\qquad e_{d,x,z} = e_{0,x,z} + e_{2,x,z} = (-0{,}0501) + (-8{,}2821 \cdot 10^{-18}) = -0{,}0501$ m

$|e_{d,x,y}| = 0{,}0786 > e_{min,y} = 0{,}02$ m ✔

$|e_{d,x,z}| = 0{,}0501 > e_{min,z} = 0{,}02$ m ✔

Column forces in the critical section

Load case: **[ST+G] {±SM1 2} (0,3*K+0,3*SP)**

$N_{Ed} = 60{,}2$ kN

$M_{Edy} = (-N_{Ed}) \cdot e_{d,x,z} = (-60{,}2) \cdot (-0{,}0501) = 3{,}02$ kNm $\qquad M_{Edz} = N_{Ed} \cdot e_{d,x,y} = 60{,}2 \cdot 0{,}0786 = 4{,}73$ kNm

$M_{Ed} = \sqrt{M_{Edy}^{\,2} + M_{Edz}^{\,2}} = \sqrt{3{,}02^2 + 4{,}73^2} = 5{,}62$ kNm

Checking detailing rules EN 1992-1-1 9.5

Load case: **[1,35*ST+1,35*G] {1,5*K} (1,5*0,6*Wind [01] X+.S.O)**

$N_{Ed} = 147$ kN

The minimum area of longitudinal reinforcement: EN 1992-1-1 9.5.2 (2) (9.12N)

$$A_{s,min} = \text{Max}\left(\frac{0{,}1 \cdot N_{Ed}}{f_{yd}} = \frac{0{,}1 \cdot 147}{4{,}35 \cdot 10^5} = 0{,}34 \; ; \; 0{,}002 \cdot A_c = 0{,}002 \cdot 0{,}126 = 2{,}51\right) = 2{,}51 \text{ cm}^2 < A_s = 0{,}00304 \text{ m}^2$$ ✔

The maximum area of longitudinal reinforcement: EN 1992-1-1 9.5.2 (3)

$A_{s,max} = 0{,}04 \cdot A_c = 0{,}04 \cdot 0{,}126 = 50{,}27 \text{ cm}^2 > A_s = 0{,}00304 \text{ m}^2$ ✔

The maximum spacing of the transverse reinforcement along the column: EN 1992-1-1 9.5.3 (3)

$s_{cl,tmax} = \min(20 \cdot \phi_{sl,min} ; b ; 400) = \min(20 \cdot 22 ; 400 ; 400) = 400 \text{ mm} > s_{w,max} = 12 \text{ cm}$ ✔

In sections within a distance of $h = 400$ mm above or below a beam or slab stirrup spacing should not exceed the following value

$0{,}6 \cdot s_{cl,tmax} = 0{,}6 \cdot 400 = 240 \text{ mm} > s_w = 12 \text{ cm}$ ✔

Detailing rules to ensure local ductility EN 1998-1 5.4.3.2.2.

The minimum area of longitudinal reinforcement: EN 1998-1 5.4.3.2.2. (1)P

$A_{sl,min} = A_c \cdot \rho_{l,min} = 0{,}126 \cdot 0{,}01 = 1257 \text{ mm}^2 < A_s = 0{,}00304 \text{ m}^2$ ✔

The minimum area of longitudinal reinforcement: EN 1998-1 5.4.3.2.2. (1)P

$A_{sl,max} = A_c \cdot \rho_{l,max} = 0{,}126 \cdot 0{,}04 = 5027 \text{ mm}^2 > A_s = 0{,}00304 \text{ m}^2$ ✔

The minimum stirrup diameter: EN 1998-1 5.4.3.2.2. (10)P

$d_{bw,min} = 6 \text{ mm} < \phi_w = 8 \text{ mm}$ ✔

The concrete cover for stirrups: $c_w = 3$ cm

Width of the confined core (between the centerline of stirrups):

$$b_o = b - 2 \cdot \left(c_w + \frac{d_{bw}}{2} \right) = 40 - 2 \cdot \left(3 + \frac{1}{2} \right) = 33 \text{ cm}$$

The maximum stirrup spacing: EN 1998-1 5.4.3.2.2. (11) (5.18)

$$s_{t,max} = \min\left(\frac{b_o}{2} ; 18 ; 8 \cdot d_{bL} \right) = \min\left(\frac{33}{2} ; 18 ; 8 \cdot 2 \right) = 16 \text{ cm} > s_w = 12 \text{ cm}$$ ✔

Design value of the resistance at the critical eccentricity:

$N_{Rd(e)} = 101 \text{ kN}$

$M_{Rd(e)} = \sqrt{M_{Rd(e)y}^{\ 2} + M_{Rd(e)z}^{\ 2}} = \sqrt{5{,}07^2 + 7{,}94^2} = 9{,}42 \text{ kNm}$

Utilization for constant eccentricity:

$$\eta_{(e)m} = \frac{N_{Ed}}{N_{Rd(e)}} = \frac{60{,}2}{101} = 0{,}59599 \leq 1 \quad \textbf{passed}$$

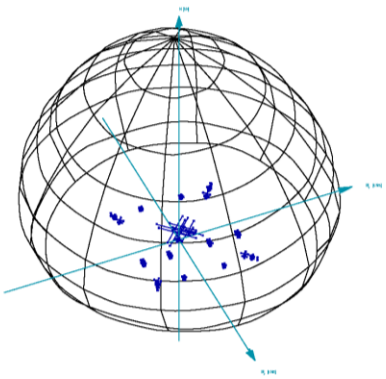
Design value of the resistance at the critical axial force:

$N_{Rd(N)} = N_{Ed} = 60{,}2 \text{ kN}$

$M_{Rd(N)} = \sqrt{M_{Rd(N)y}^{\ 2} + M_{Rd(N)z}^{\ 2}} = \sqrt{4{,}99^2 + 7{,}82^2} = 9{,}27 \text{ kNm}$

Moment utilization:

$$\eta_{(N)m} = \frac{M_{Ed}}{M_{Rd(N)}} = \frac{5{,}62}{9{,}27} = 0{,}60562 \leq 1 \quad \textbf{passed}$$



Column reinforcement

Structural member: Beam 12

Shear and torsion check

Materials

Concrete **C25/30** f_{ck} = 25 MPa Rebar steel **B500B** f_{yk} = 500 MPa

Column cross-section parameters

Diameter: D_{col} = 400,0 mm

The area of concrete cross section:

$$A_c = \frac{D_{col}^2}{4} \cdot \pi = \frac{400{,}0^2}{4} \cdot 3{,}1416 = 1{,}2566 \cdot 10^5 \text{ mm}^2$$

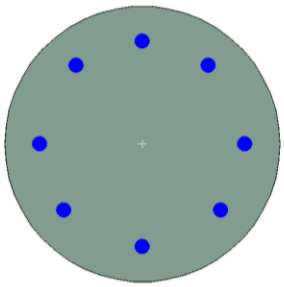
Concrete cover of the longitudinal reinforcement: c = 40 mm

Reinforcement parameters

Name: **6o22**

Reinforcement symmetrical to the z axis

8ϕ22 (A_s = 3041 mm²)



Longitudinal rebars

	Rebar diameter	Rebar position		Cross-section area	Second moment of area of reinforcement, about the centre of area of the concrete	
	ϕ [mm]	y [mm]	z [mm]	A_s [mm²]	$I_{s,y}$ [mm⁴]	$I_{s,z}$ [mm⁴]
1.	22	200	348,8	380	8417272	0
2.	22	295,7	314	380	4939459	3477814
3.	22	348,8	200	380	0	8417272
4.	22	314	104,3	380	3477815	4939459
5.	22	200	51,19	380	8417273	0
6.	22	86,01	104,3	380	3477815	4939458
7.	22	51,19	200	380	0	8417273
8.	22	104,3	314	380	4939459	3477815
Total				**3041**	$3{,}3669 \cdot 10^7$	$3{,}3669 \cdot 10^7$

Stirrup

Stirrup diameter: ϕ_w = 8 mm ($A_{\phi w}$ = $5{,}0265 \cdot 10^{-5}$ m²)

Stirrup spacing: s_w = 12 cm = 0,12 m

Center of gravity of the concrete cross-section:

$$y_{CG,c} = z_{CG,c} = \frac{D_{col}}{2} = \frac{400{,}0}{2} = 200 \text{ mm}$$

The second moment of area of the concrete cross-section:

$$I_{cy} = I_{cz} = \frac{3{,}14159265358979 \cdot \left(\frac{D_{col}}{2}\right)^4}{4} = \frac{3{,}14159265358979 \cdot \left(\frac{400{,}0}{2}\right)^4}{4} = 1{,}2566 \cdot 10^9 \text{ mm}^4$$

The radius of gyration of the uncracked concrete section:

$$i_y = \sqrt{\frac{I_{cy}}{A_c}} = \sqrt{\frac{1{,}2566 \cdot 10^9}{1{,}2566 \cdot 10^5}} = 100 \text{ mm} = 0{,}1 \text{ m}$$

$$i_z = \sqrt{\frac{I_{cz}}{A_c}} = \sqrt{\frac{1{,}2566 \cdot 10^9}{1{,}2566 \cdot 10^5}} = 100 \text{ mm} = 0{,}1 \text{ m}$$

The second moment of area of the reinforcing steel:

$$I_{sy} = \Sigma\left(A_{s,i} \cdot (z_{s,i} - z_{CG,c})^2\right) = 3{,}3669 \cdot 10^7 \text{ mm}^4$$

$$I_{sz} = \Sigma\left(A_{s,i} \cdot (y_{s,i} - y_{CG,c})^2\right) = 3{,}3669 \cdot 10^7 \text{ mm}^4$$

The radius of gyration of the total reinforcement area:

$$i_{sy} = \sqrt{\frac{I_{sy}}{A_s}} = \sqrt{\frac{3{,}3669 \cdot 10^7}{3041}} = 105{,}2 \text{ mm} \qquad i_{sz} = \sqrt{\frac{I_{sz}}{A_s}} = \sqrt{\frac{3{,}3669 \cdot 10^7}{3041}} = 105{,}2 \text{ mm}$$

Design values of material properties

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1{,}5} = 16{,}7 \text{ MPa} = 16667 \text{ kPa}$$ EN 1992-1-1 3.1.6. (1)P (3.15)

$$f_{ctd} = \frac{\alpha_{ct} \cdot f_{ctk,0.05}}{\gamma_c} = \frac{1 \cdot 1{,}8}{1{,}5} = 1{,}2 \text{ MPa} = 1197 \text{ kPa}$$ EN 1992-1-1 3.1.6. (2)P (3.16)

Design yield strength of rebar steel: EN 1992-1-1 3.2.7. (2) Fig. 3.8

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1{,}15} = 435 \approx 435 \text{ MPa} = 4{,}35 \cdot 10^5 \text{ kPa} \qquad f_{ywd} = f_{yd} = 4{,}35 \cdot 10^5 \text{ kPa}$$

Creep factor: $\varphi(\infty, t_0) = 2$ EN 1992-1-1 3.1.7. (2)

Column forces in the critical section

Load case: **[ST+G] {±SM1 2} (0,3*K+0,3*SP)**

$N_{Ed} = 62{,}8 \text{ kN}$

$V_{Edy} = V_{Ed,0y} - \max(V_{Ed,EQ,y} ; V_{Ed,EQ,cap,y}) = (-2{,}44) - \max(19{,}8 ; 0) = -22{,}2 \text{ kN}$

$V_{Edz} = V_{Ed,0z} + V_{Ed,EQ,z} = 0{,}556 + 19{,}4 = 20 \text{ kN}$

Checking detailing rules EN 1992-1-1 9.5

Load case: **[1,35*ST+1,35*G] {1,5*K} (1,5*0,6*Wind [01] X+.S.O)**

$N_{Ed} = 147 \text{ kN}$

The minimum area of longitudinal reinforcement: EN 1992-1-1 9.5.2 (2) (9.12N)

$$A_{s,min} = \text{Max}\left(\frac{0{,}1 \cdot N_{Ed}}{f_{yd}} = \frac{0{,}1 \cdot 147}{435} = 0{,}34 ; 0{,}002 \cdot A_c = 0{,}002 \cdot 1{,}2566 \cdot 10^5 = 2{,}51\right) = 2{,}51 \text{ cm}^2 < A_s = 3041 \text{ mm}^2$$ ✔

The maximum area of longitudinal reinforcement: EN 1992-1-1 9.5.2 (3)

$A_{s,max} = 0{,}04 \cdot A_c = 0{,}04 \cdot 1{,}2566 \cdot 10^5 = 50{,}27 \text{ cm}^2 > A_s = 3041 \text{ mm}^2$ ✔

The maximum spacing of the transverse reinforcement along the column: EN 1992-1-1 9.5.3 (3)

$s_{cl,tmax} = \min(20 \cdot \phi_{sl,min} ; b ; 400) = \min(20 \cdot 22 ; 400 ; 400) = 400 \text{ mm} > s_{w,max} = 12 \text{ cm}$ ✔

In sections within a distance of $h = 400$ mm above or below a beam or slab stirrup spacing should not exceed the following value

$0{,}6 \cdot s_{cl,tmax} = 0{,}6 \cdot 400 = 240 \text{ mm} > s_w = 12 \text{ cm}$ ✔

Detailing rules to ensure local ductility EN 1998-1 5.4.3.2.2.

The minimum area of longitudinal reinforcement: EN 1998-1 5.4.3.2.2. (1)P

$A_{sl,min} = A_c \cdot \rho_{l,min} = 1{,}2566 \cdot 10^5 \cdot 0{,}01 = 1257 \text{ mm}^2 < A_s = 3041 \text{ mm}^2$ ✔

The minimum area of longitudinal reinforcement: EN 1998-1 5.4.3.2.2. (1)P

$A_{sl,max} = A_c \cdot \rho_{l,max} = 1{,}2566 \cdot 10^5 \cdot 0{,}04 = 5027 \text{ mm}^2 > A_s = 3041 \text{ mm}^2$ ✔

The minimum stirrup diameter: EN 1998-1 5.4.3.2.2. (10)P

$d_{bw,min} = 6 \text{ mm} < \phi_w = 8 \text{ mm}$ ✔

The concrete cover for stirrups: $c_w = 3 \text{ cm}$

Width of the confined core (between the centerline of stirrups):

$$b_o = b - 2\cdot\left(c_w + \frac{d_{bw}}{2}\right) = 40 - 2\cdot\left(3 + \frac{1}{2}\right) = 33 \text{ cm}$$

The maximum stirrup spacing: EN 1998-1 5.4.3.2.2. (11) (5.18)

$$s_{t,max} = \min\left(\frac{b_o}{2}\ ;\ 18\ ;\ 8\cdot d_{bL}\right) = \min\left(\frac{33}{2}\ ;\ 18\ ;\ 8\cdot 2\right) = 16 \text{ cm} > s_w = 12 \text{ cm}$$ ✔

Pure shear

Angle of the concrete compression strut: $\Theta = 45{,}00\ ^\circ$ ($\cot\Theta = 1$)

The reduction factor for circular stirrups: $\lambda_{1,y} = 0{,}83568$ $\lambda_{1,z} = 0{,}83419$

Equivalent (approximate) width of the circular cross section: $b_w = 0{,}8\cdot D_{col} = 0{,}8\cdot 0{,}4 = 320{,}0$ mm

Shear resistance (y)

The design shear resistance of the member without shear reinforcement: EN 1992-1-1 6.2.2. (1)

$$V_{Rd,c,min} = (v_{min} + k_1\cdot\sigma_{cp})\cdot b_w\cdot d_y = (0{,}442 + 0{,}15\cdot 0{,}5)\cdot 320\cdot 273 = 45229 \text{ N} = 45{,}2 \text{ kN}$$

$$V_{Rd,c,y} = \left(C_{Rd,c}\cdot k\cdot(100\cdot\rho_l\cdot f_{ck})^{1/3} + k_1\cdot\sigma_{cp}\right)\cdot b_w\cdot d_y = (0{,}12\cdot 1{,}8556\cdot(100\cdot 0{,}013043\cdot 25)^{1/3} + 0{,}15\cdot 0{,}5)\cdot 320\cdot 273 = 68752 \text{ N} = 68{,}8 \text{ kN}$$ EN 1992-1-1 (6.2.b)

$V_{Rd,c,y} = 68{,}8 \text{ kN} > V_{Rd,c,min} = 45{,}2 \text{ kN}$

The design value of shear resistance of the shear reinforcement:

$$V_{Rd,s,y} = \lambda_{1,y}\cdot\frac{A_{sw}}{s_w}\cdot z_y\cdot f_{ywd}\cdot\cot\Theta = 0{,}83568\cdot\frac{0{,}000101}{12}\cdot 0{,}239\cdot 435\cdot\cot 45{,}00^\circ = 72{,}7 \text{ kN}$$

The design value of shear resistance: EN 1992-1-1 (6.9.)

$$V_{Rd,max,y} = \frac{\alpha_{cw}\cdot b_w\cdot z_y\cdot v_1\cdot f_{cd}}{\cot\Theta + \tan\Theta} = \frac{1{,}0209\cdot 320{,}0\cdot 0{,}239\cdot 0{,}54\cdot 16667}{\cot 45{,}00^\circ + \tan 45{,}00^\circ} = 351 \text{ kN}$$

The shear resistance of the cross-section:

$$V_{Rd,y} = \min(\max(V_{Rd,c,y}\ ;\ V_{Rd,s,y})\ ;\ V_{Rd,max,y}) = \min(\max(68{,}8\ ;\ 72{,}7)\ ;\ 351) = 72{,}7 \text{ kN}$$

Shear resistance (z)

$$V_{Rd,c,min} = (v_{min} + k_1\cdot\sigma_{cp})\cdot b_w\cdot d_z = (0{,}445 + 0{,}15\cdot 0{,}5)\cdot 320\cdot 268 = 44622 \text{ N} = 44{,}6 \text{ kN}$$

$$V_{Rd,c,z} = \left(C_{Rd,c}\cdot k\cdot(100\cdot\rho_l\cdot f_{ck})^{1/3} + k_1\cdot\sigma_{cp}\right)\cdot b_w\cdot d_z = (0{,}12\cdot 1{,}8638\cdot(100\cdot 0{,}013297\cdot 25)^{1/3} + 0{,}15\cdot 0{,}5)\cdot 320\cdot 268 = 68109 \text{ N} = 68{,}1 \text{ kN}$$

$V_{Rd,c,z} = 68{,}1 \text{ kN} > V_{Rd,c,min} = 44{,}6 \text{ kN}$

$$V_{Rd,s,z} = \lambda_{1,z}\cdot\frac{A_{sw}}{s_w}\cdot z_z\cdot f_{ywd}\cdot\cot\Theta = 0{,}83419\cdot\frac{0{,}000101}{12}\cdot 0{,}234\cdot 435\cdot\cot 45{,}00^\circ = 71 \text{ kN}$$

$$V_{Rd,max,z} = \frac{\alpha_{cw}\cdot b_w\cdot z_z\cdot v_1\cdot f_{cd}}{\cot\Theta + \tan\Theta} = \frac{1{,}0209\cdot 320{,}0\cdot 0{,}234\cdot 0{,}54\cdot 16667}{\cot 45{,}00^\circ + \tan 45{,}00^\circ} = 343 \text{ kN}$$

$$V_{Rd,z} = \min(\max(V_{Rd,c,z}\ ;\ V_{Rd,s,z})\ ;\ V_{Rd,max,z}) = \min(\max(68{,}1\ ;\ 71)\ ;\ 343) = 71 \text{ kN}$$

Check

Shear utilization in y and z direction:

$$\eta_{V,y} = \frac{|V_{Edy}|}{V_{Rd,y}} = \frac{|(-22{,}2)|}{72{,}7} = 0{,}30592 \le 1 \quad \textbf{passed} \qquad \eta_{V,z} = \frac{|V_{Edz}|}{V_{Rd,z}} = \frac{|20|}{71} = 0{,}2815 \le 1 \quad \textbf{passed}$$

The shear resistance of the cross-section: Resultant shear force

$$V_{Rd} = V_{Rd,y}\cdot\frac{V_{Edy}^2}{V_{Edy}^2 + V_{Edz}^2} + V_{Rd,z}\cdot\frac{V_{Edz}^2}{V_{Edy}^2 + V_{Edz}^2} = 72{,}7\cdot\frac{(-22{,}2)^2}{(-22{,}2)^2 + 20^2} + 71\cdot\frac{20^2}{(-22{,}2)^2 + 20^2} = 72 \text{ kN}$$

Overall shear utilization without torsion:

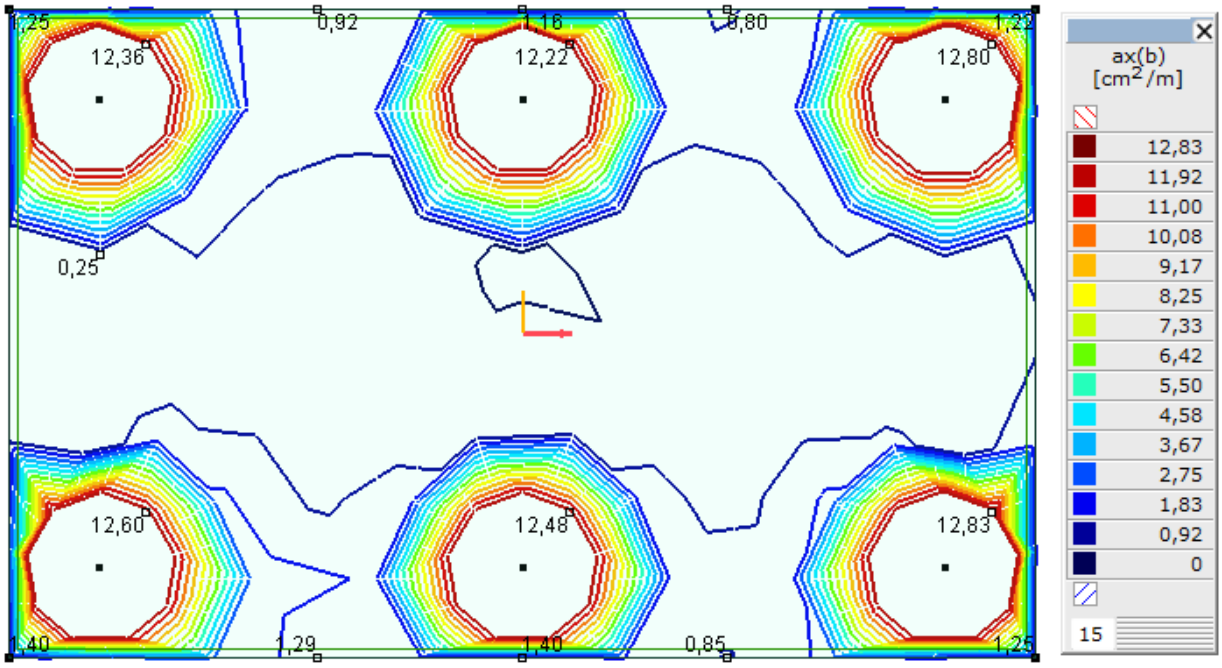
$$\eta_V = \frac{\sqrt{V_{Edy}^2 + V_{Edz}^2}}{V_{Rd}} = \frac{\sqrt{(-22{,}2)^2 + 20^2}}{72} = 0{,}41564 \le 1 \quad \textbf{passed}$$

Shear with torsion

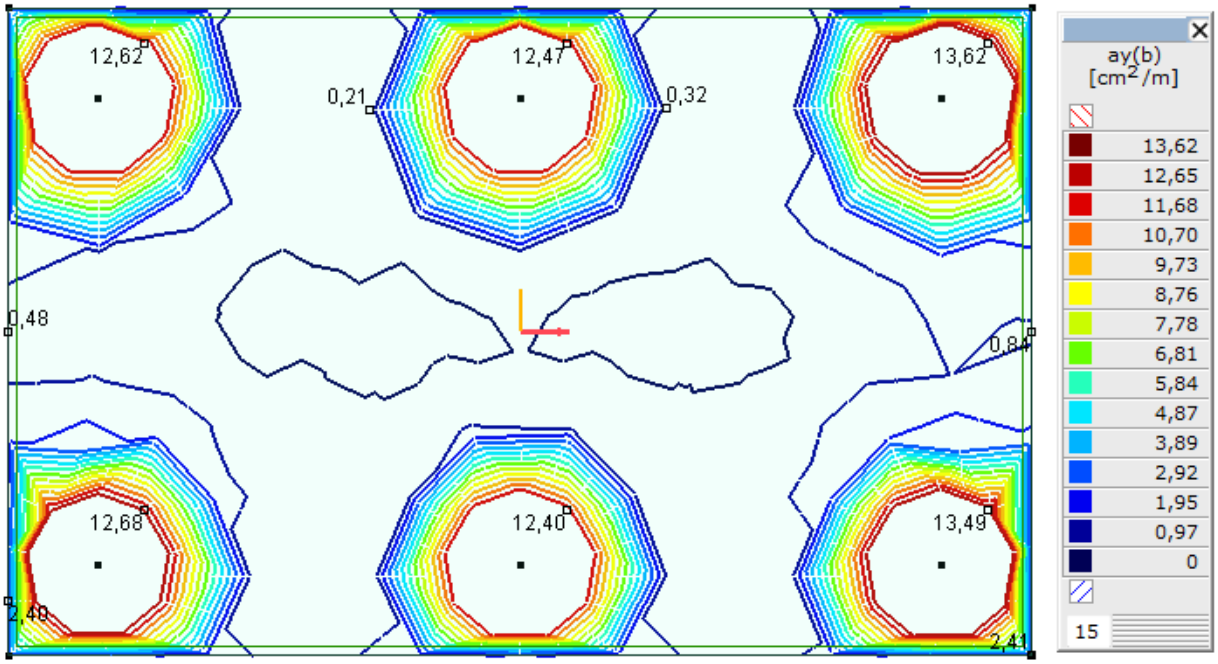
$|T_{Ed}| = |0| = 0 \text{ kNm} < 0{,}001 \text{ kNm}$ Torsion is negligible

6.4. PLOŠČE IN STENE

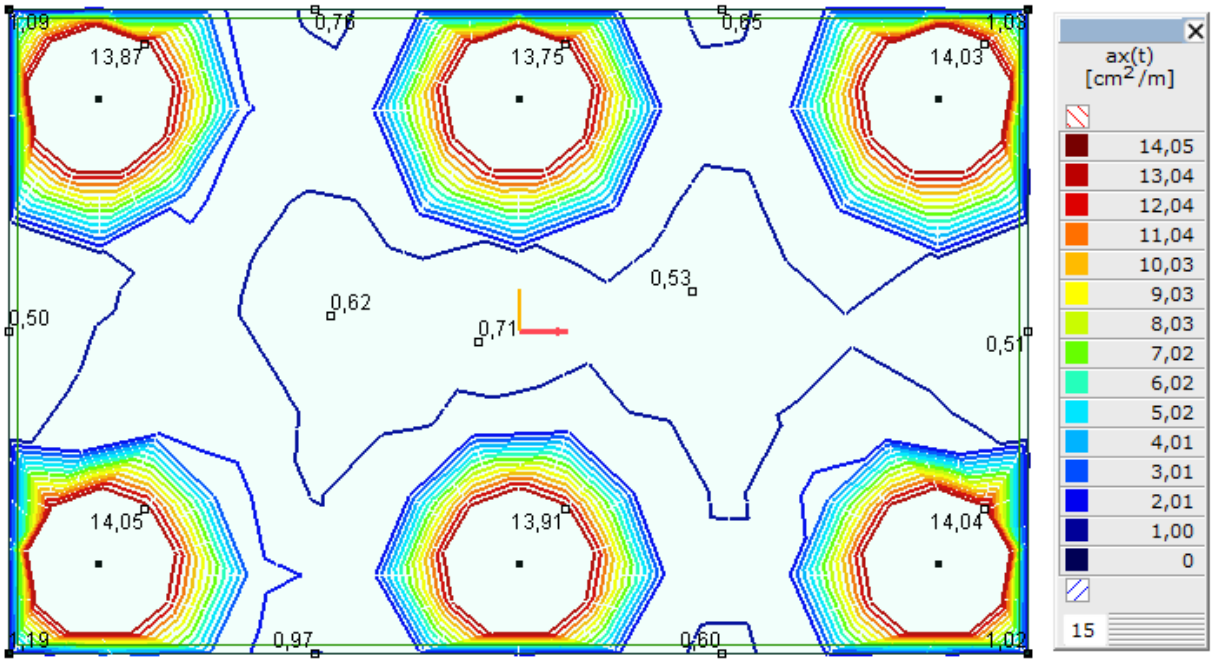
6.4.1. TEMELJNA PLOŠČA



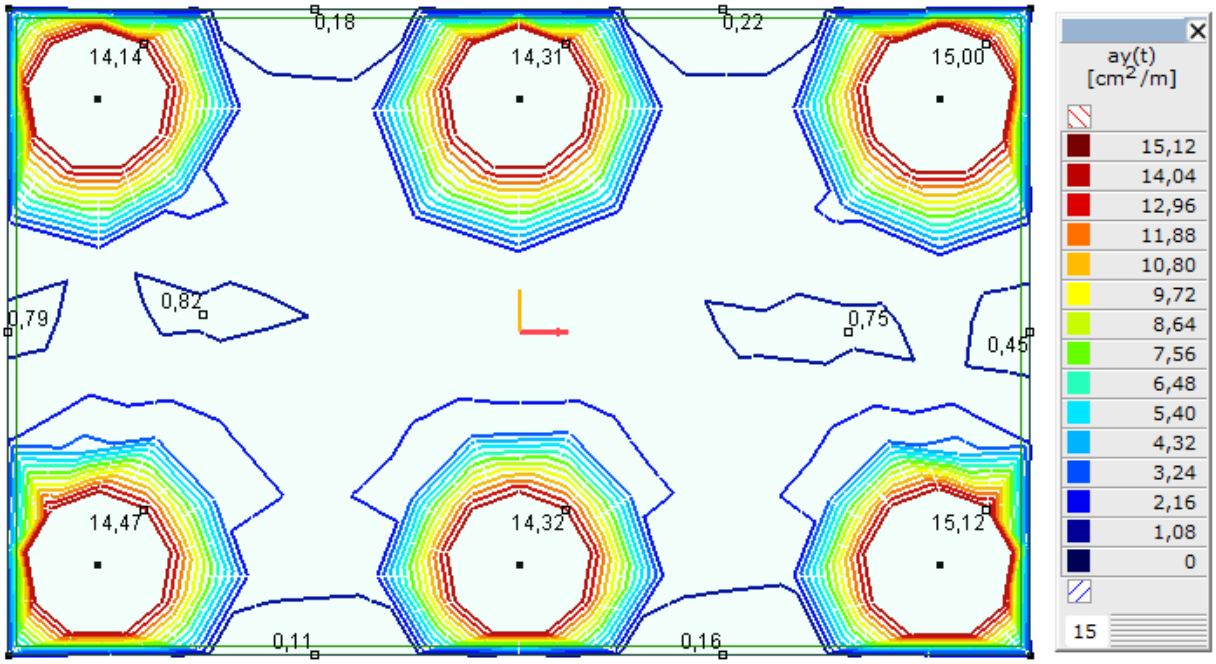
Potrebna armatura v smeri X, spodaj (rdeča os) [cm²/m]



Potrebna armatura v smeri Y, spodaj (rumena os) [cm²/m]

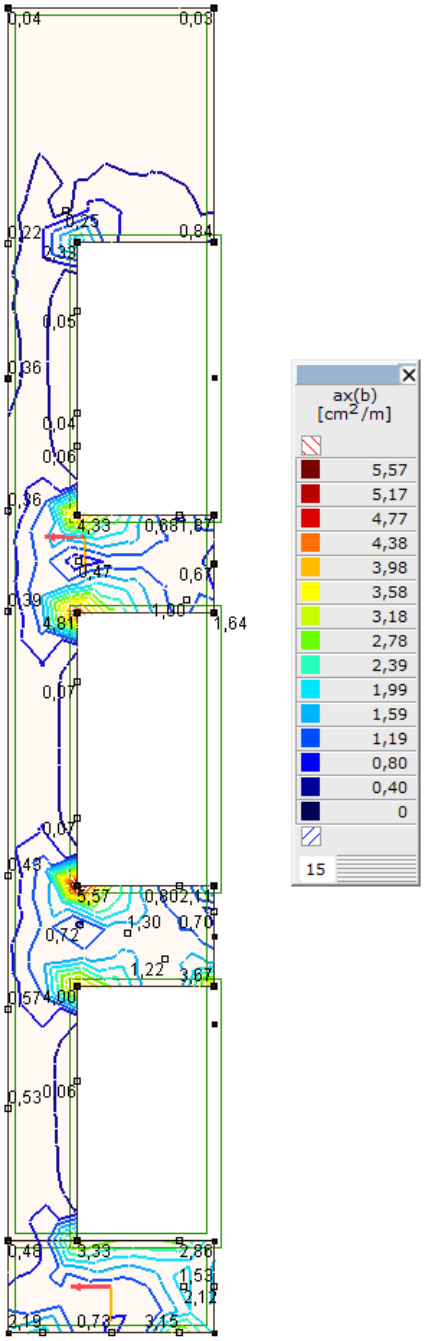


Potrebna armatura v smeri X, zgoraj (rdeča os) [cm²/m]

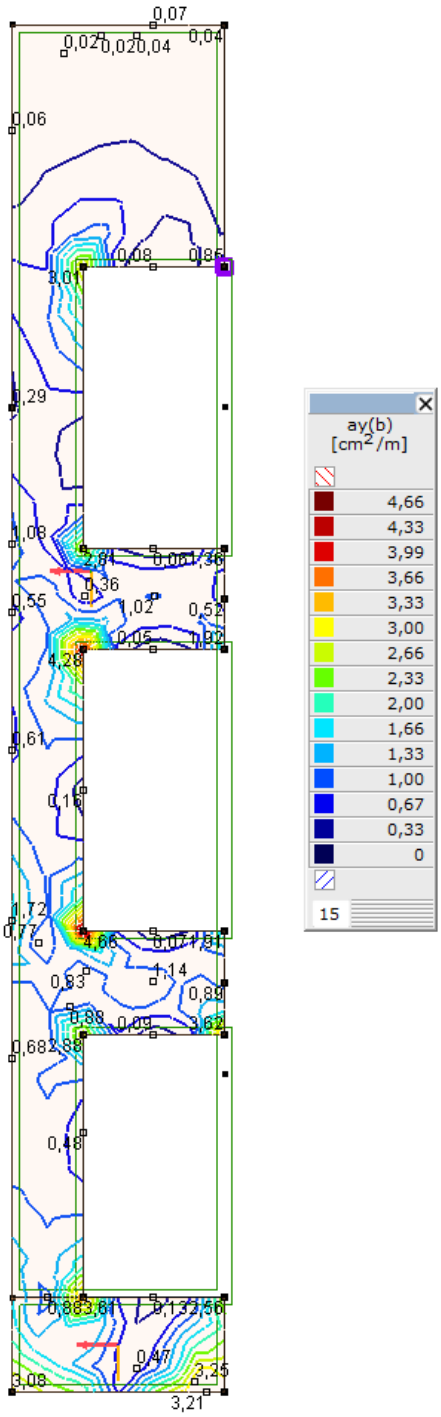


Potrebna armatura v smeri Y, zgoraj (rumena os) [cm²/m]

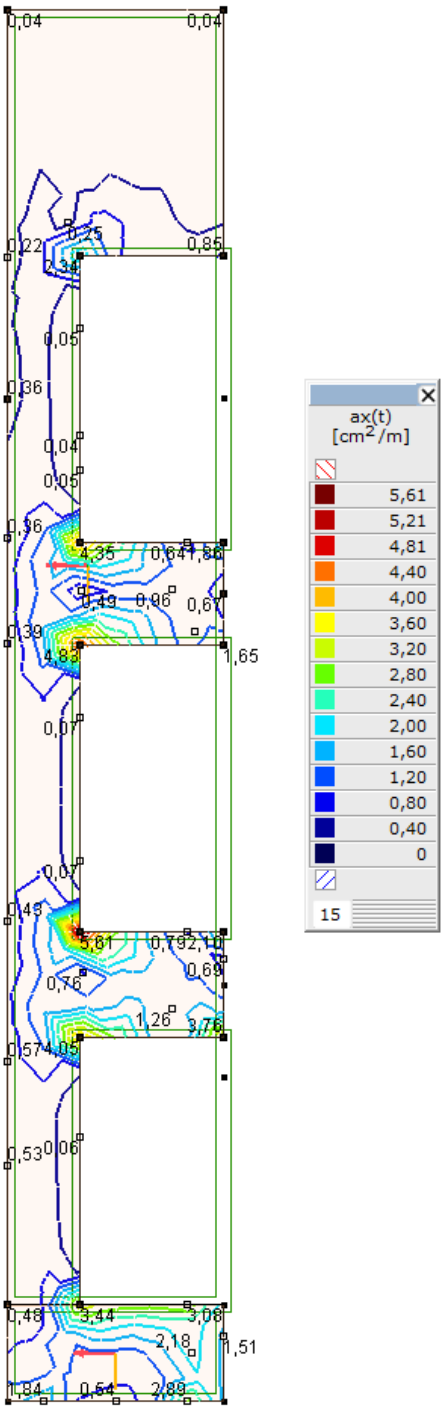
6.4.2. STENA JUG



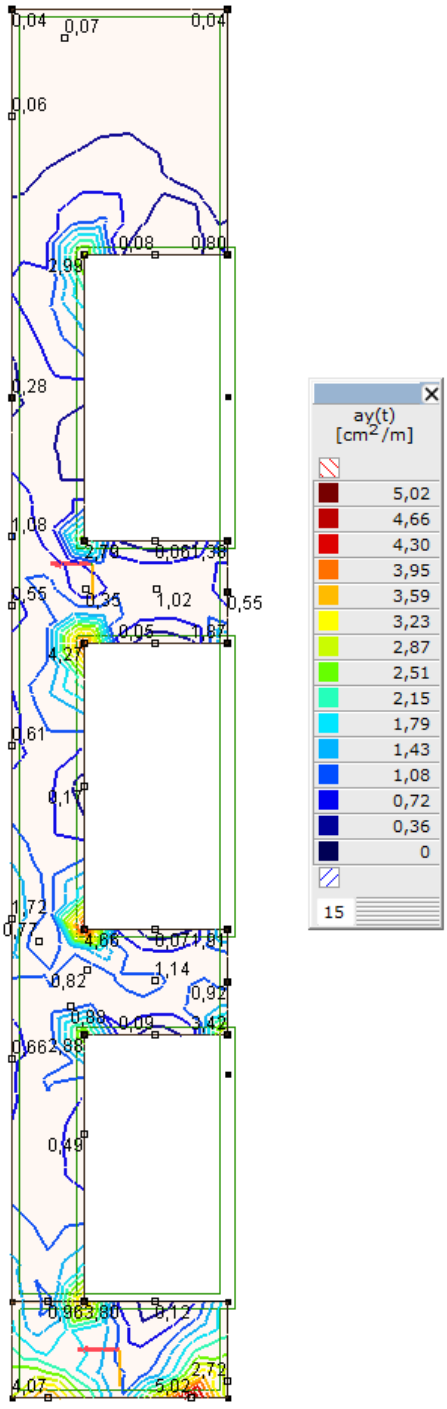
Potrebna armatura v smeri X (rdeča os), spodaj (nasprotna smer zelene osi) [cm²/m]



Potrebna armatura v smeri Y (rumena os), spodaj (nasprotna smer zelene osi) [cm²/m]

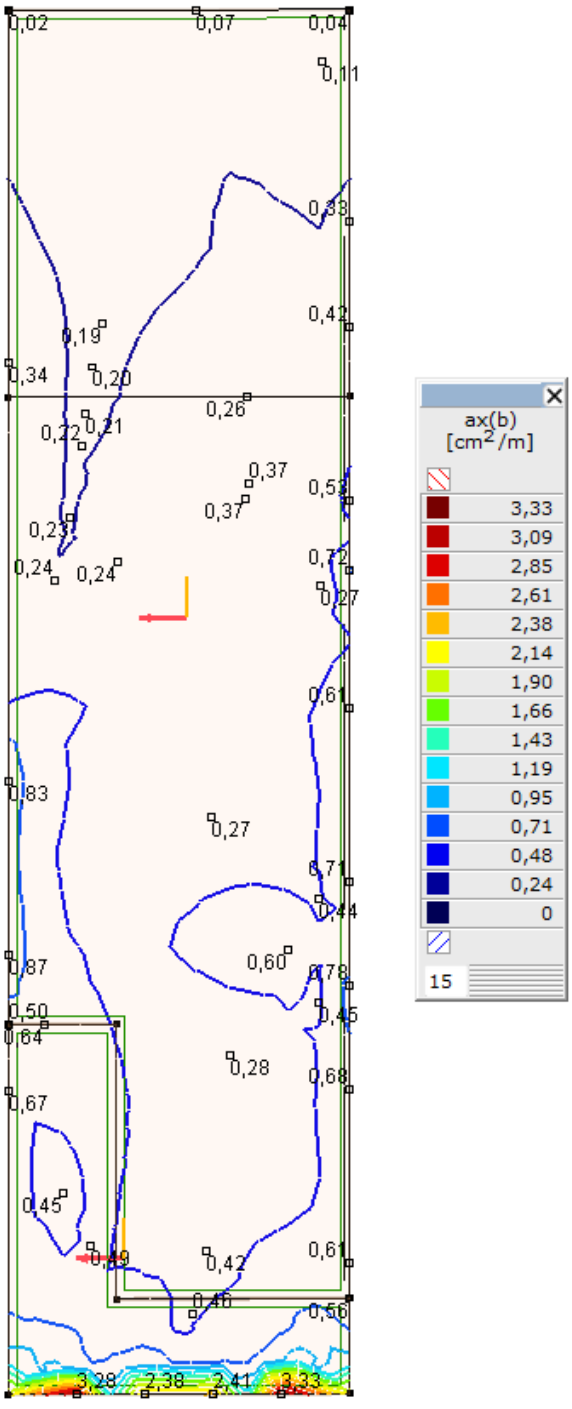


Potrebna armatura v smeri X (rdeča os), zgoraj (v smeri zelene osi) [cm²/m]

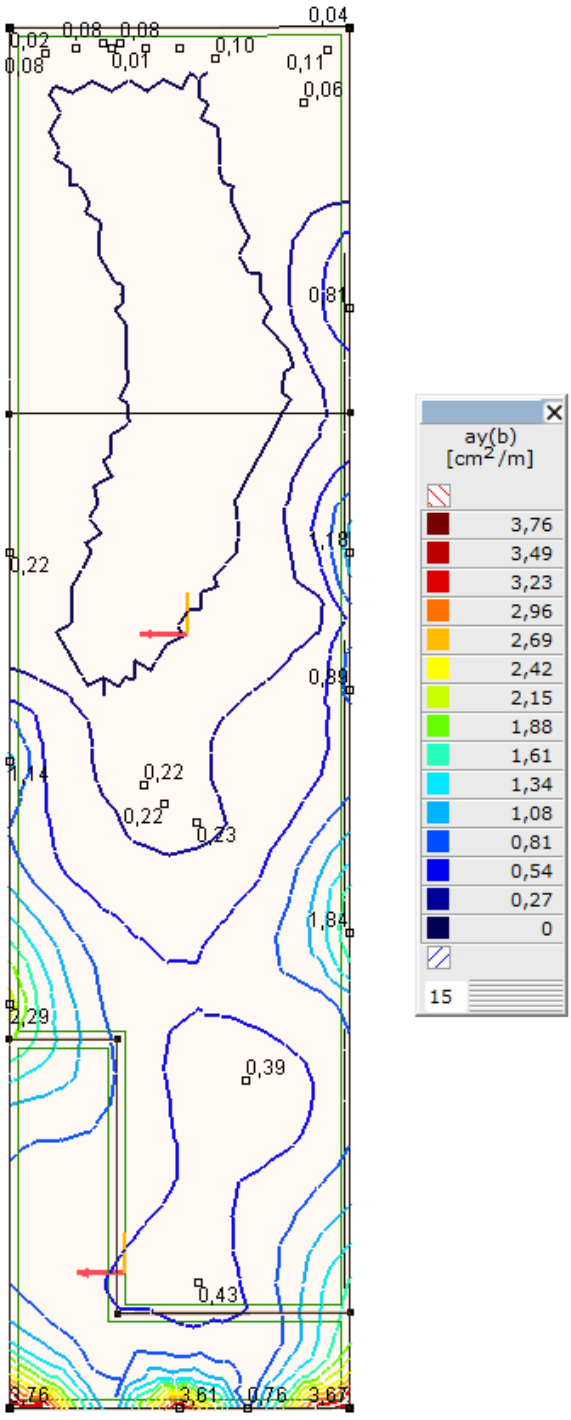


Potrebna armatura v smeri Y (rumena os), zgoraj (v smeri zelene osi) [cm²/m]

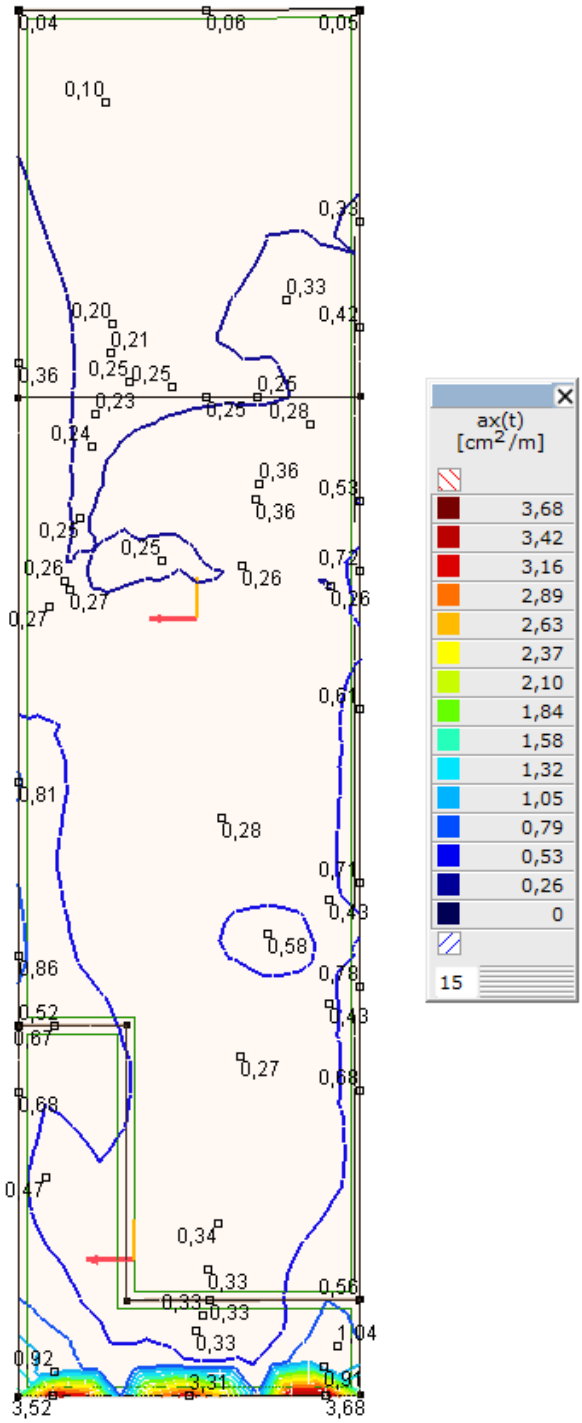
6.4.3. STENA ZAHOD



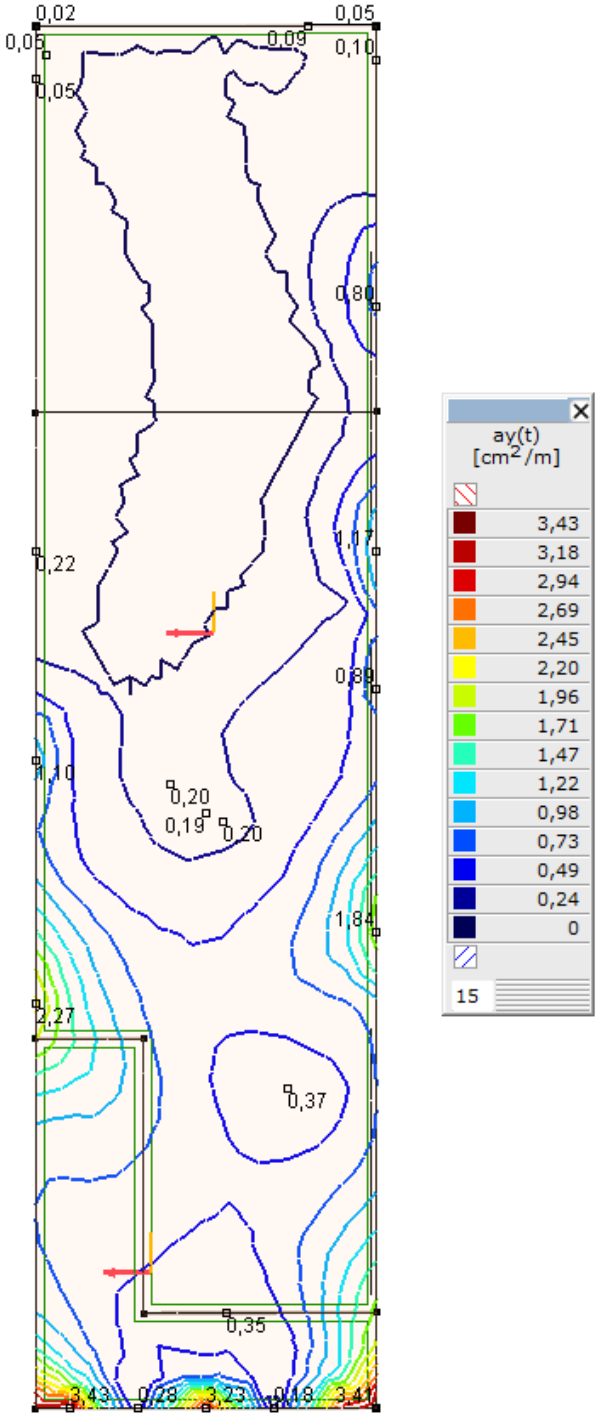
Potrebna armatura v smeri X (rdeča os), spodaj (nasprotna smer zelene osi) [cm²/m]



Potrebna armatura v smeri Y (rumena os), spodaj (nasprotna smer zelene osi) [cm²/m]

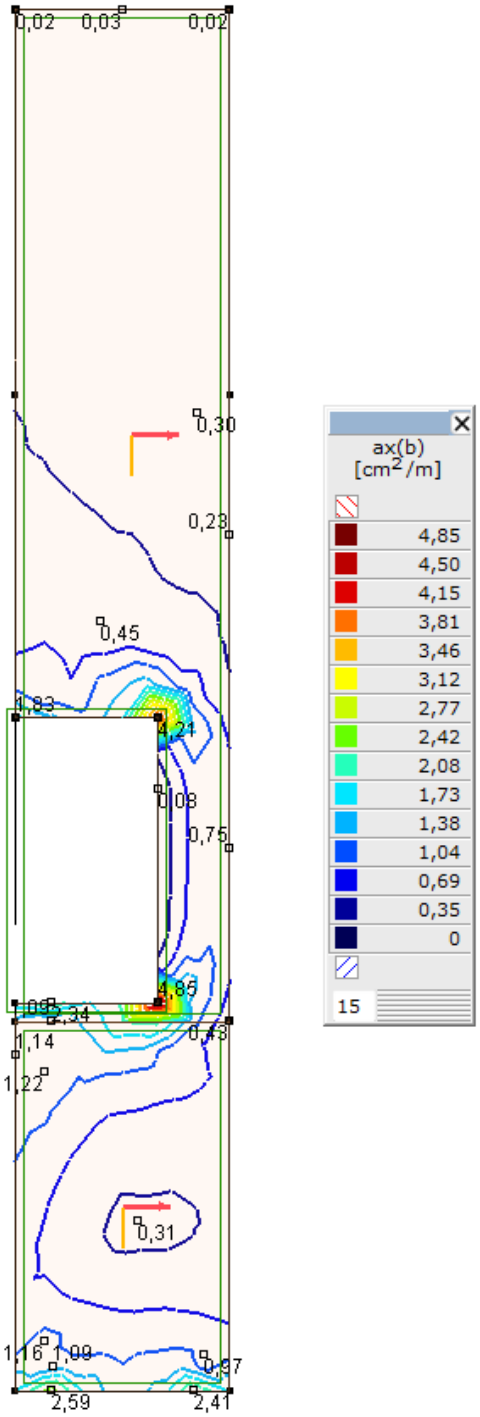


Potrebna armatura v smeri X (rdeča os), zgoraj (v smeri zelene osi) [cm²/m]

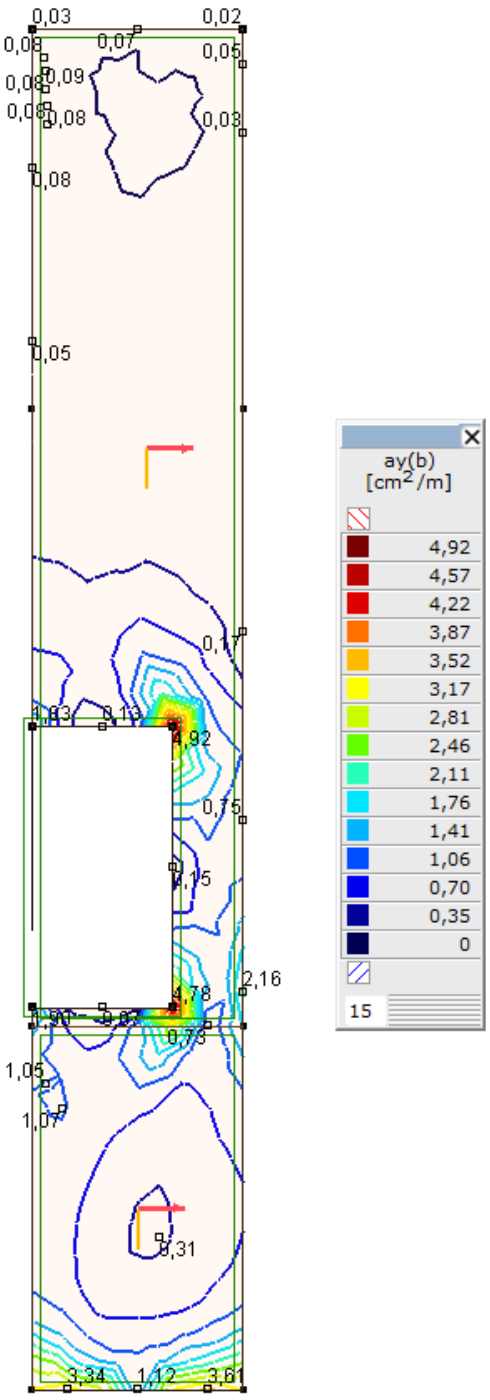


Potrebna armatura v smeri Y (rumena os), zgoraj (v smeri zelene osi) [cm²/m]

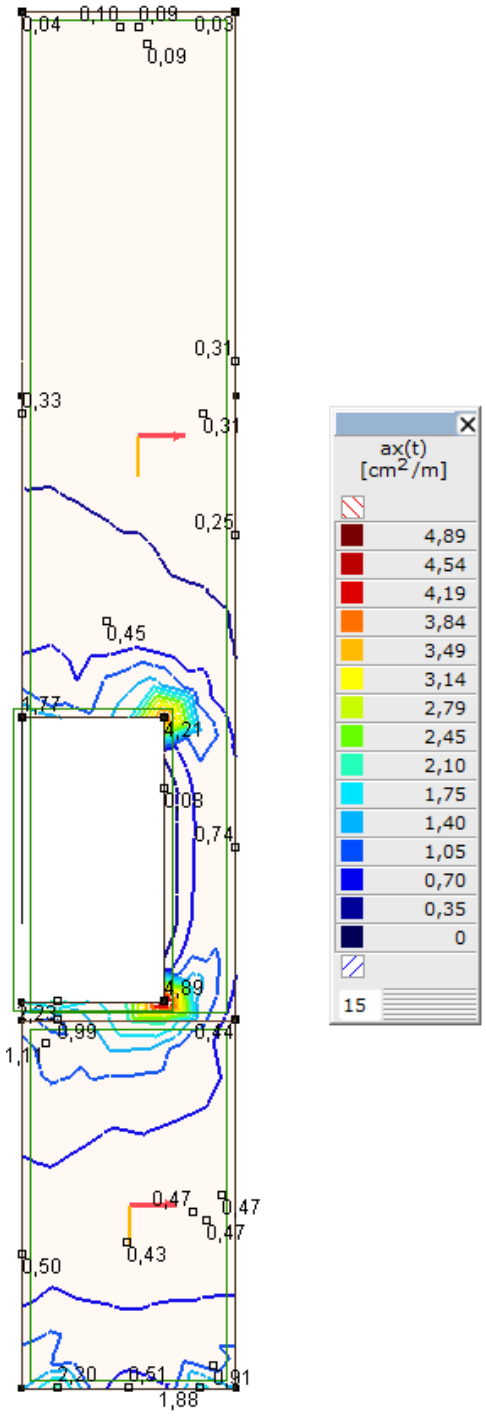
6.4.1. STENA SEVER



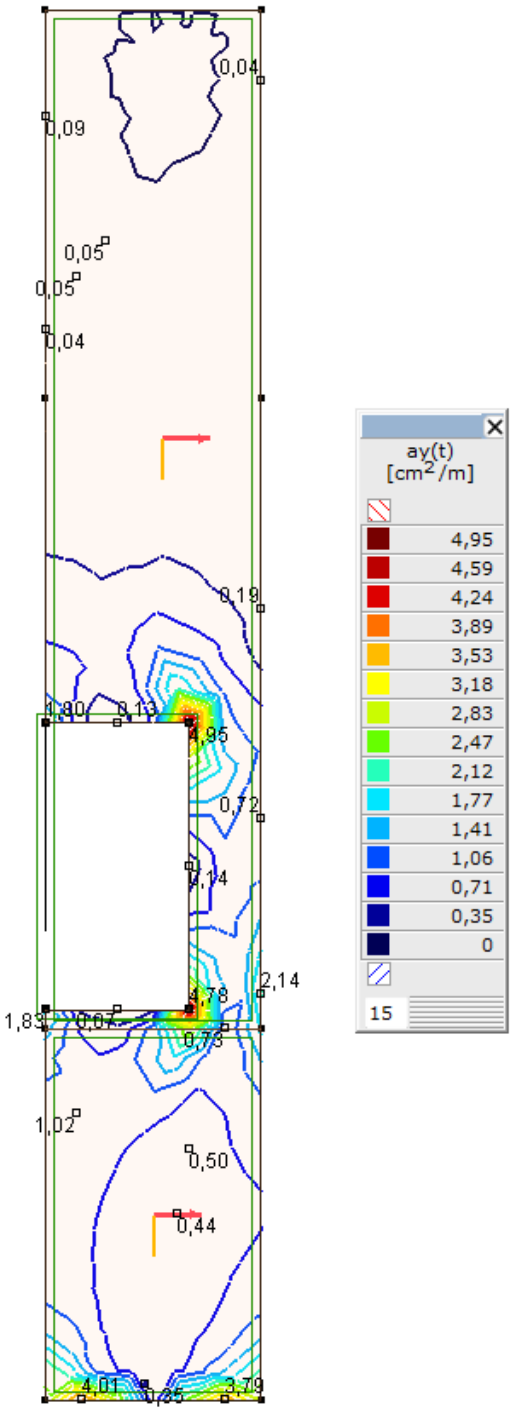
Potrebna armatura v smeri X (rdeča os), spodaj (nasprotna smer zelene osi) [cm²/m]



Potrebna armatura v smeri Y (rumena os), spodaj (nasprotna smer zelene osi) [cm²/m]

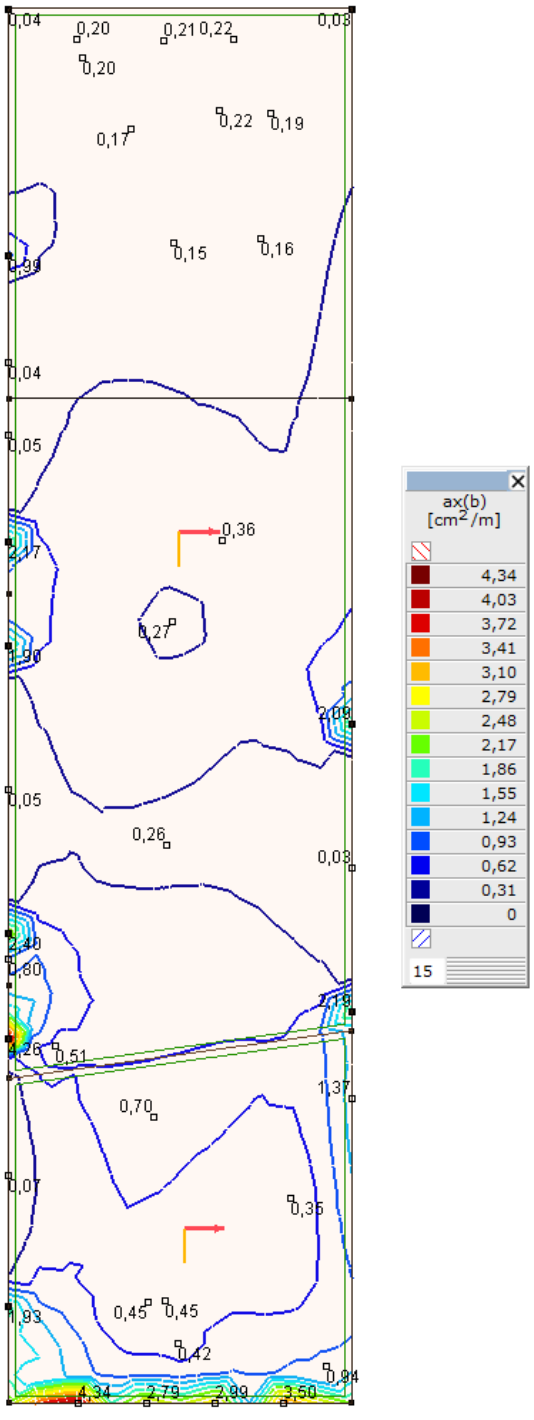


Potrebna armatura v smeri X (rdeča os), zgoraj (v smeri zelene osi) [cm²/m]

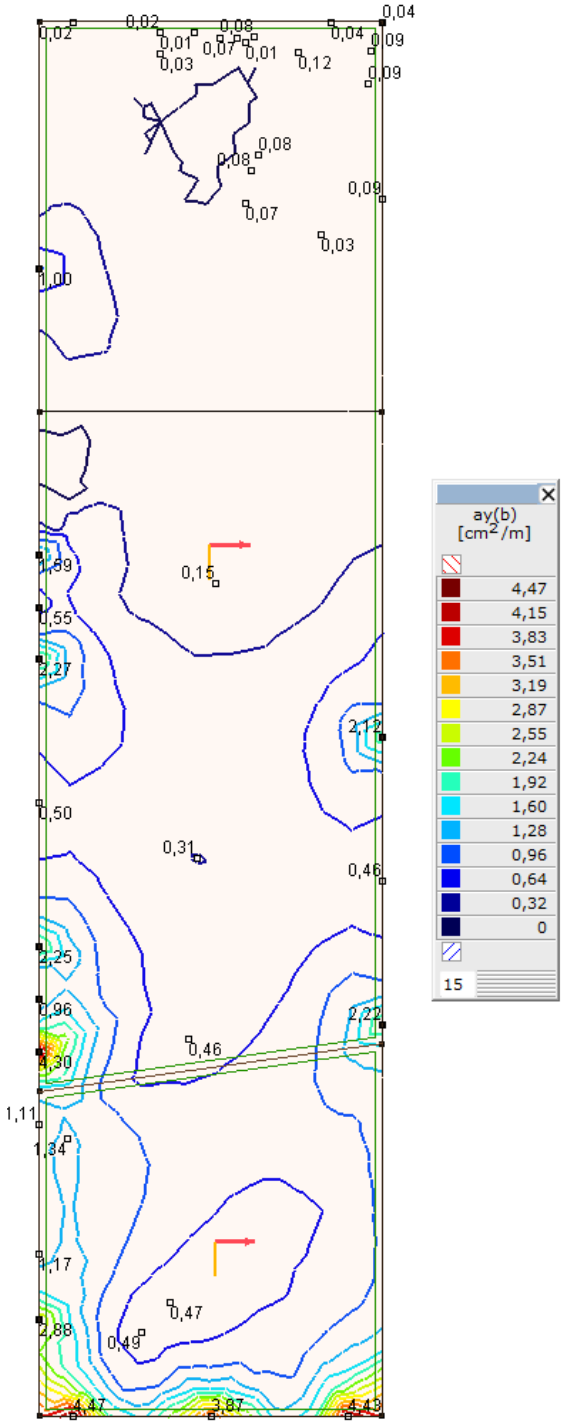


Potrebna armatura v smeri Y (rumena os), zgoraj (v smeri zelene osi) [cm²/m]

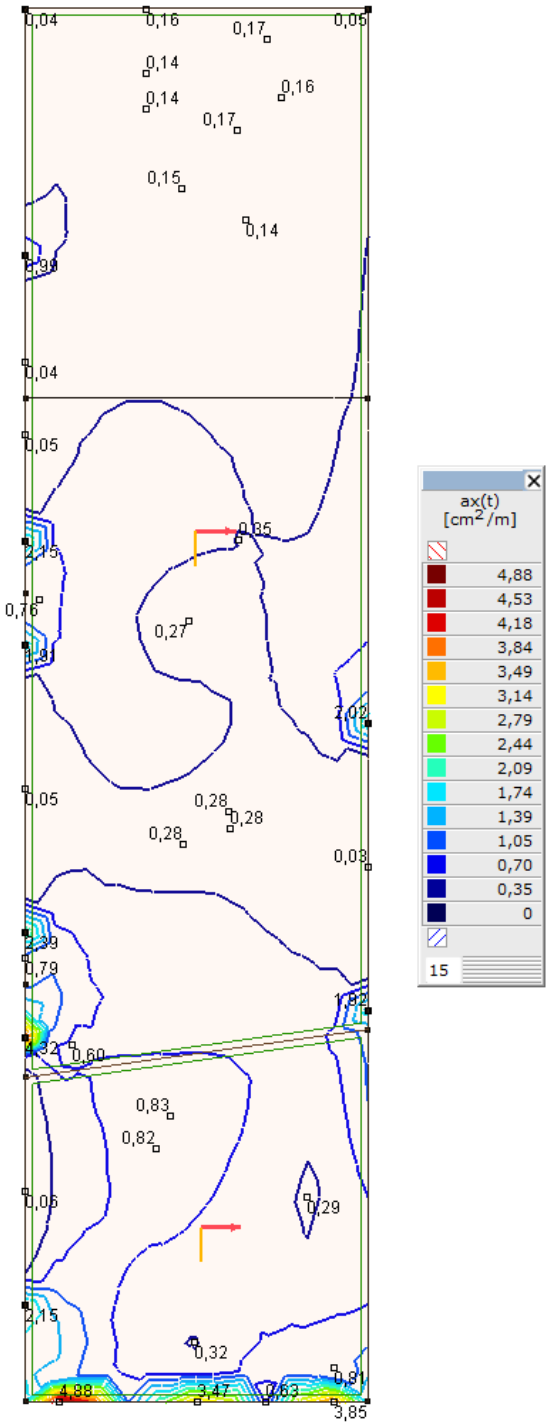
6.4.1. STENA VZHOD



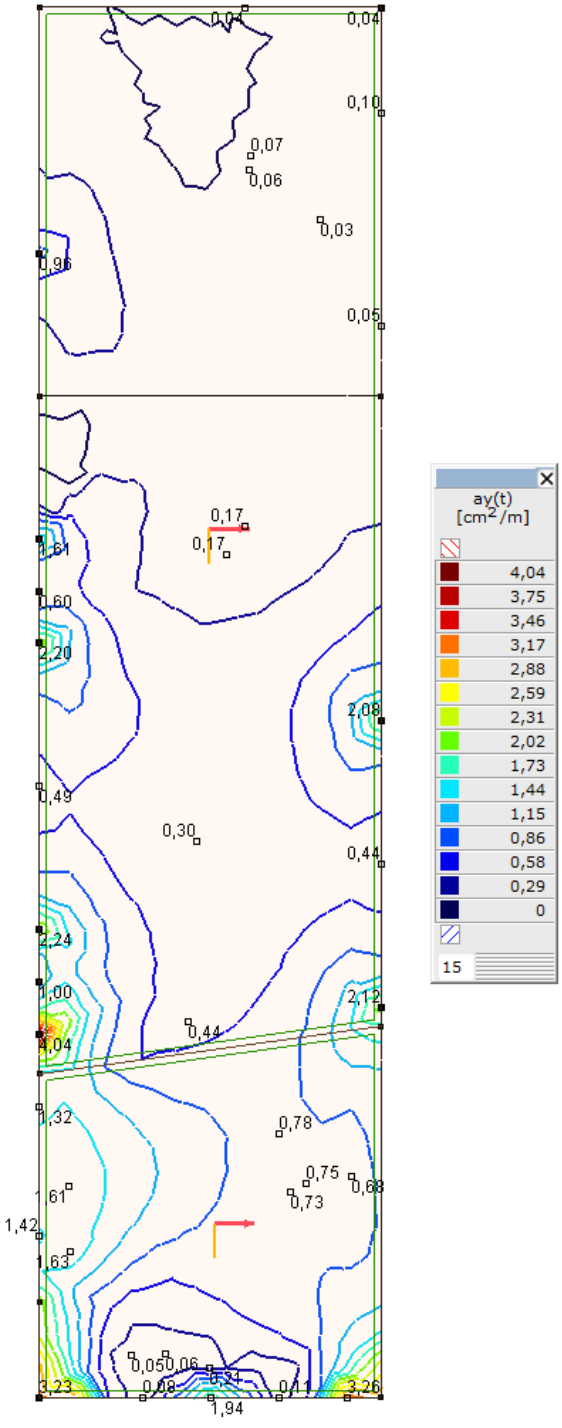
Potrebna armatura v smeri X (rdeča os), spodaj (nasprotna smer zelene osi) [cm²/m]



Potrebna armatura v smeri Y (rumena os), spodaj (nasprotna smer zelene osi) [cm²/m]

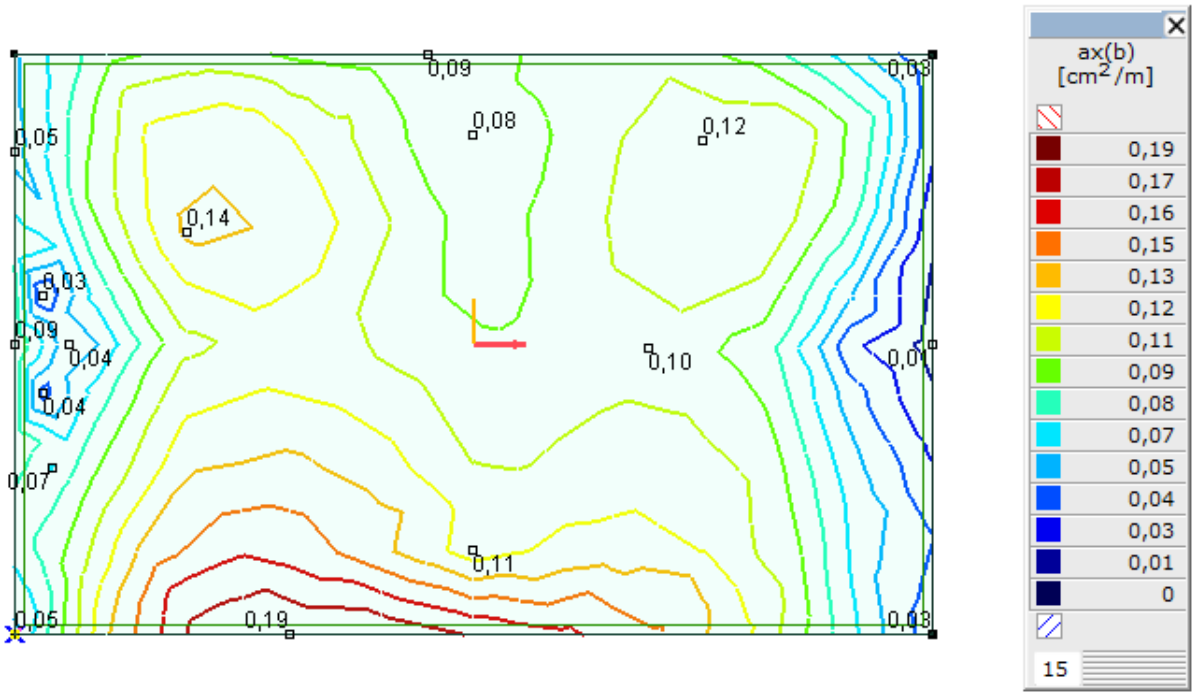


Potrebna armatura v smeri X (rdeča os), zgoraj (v smeri zelene osi) [cm²/m]

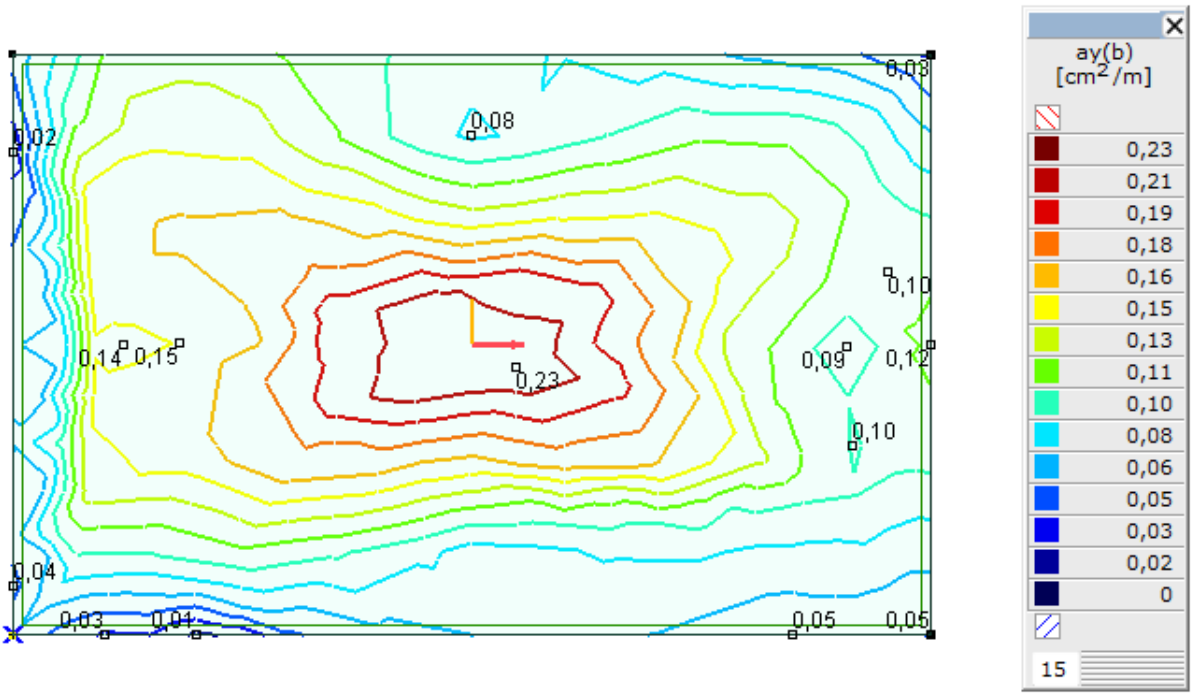


Potrebna armatura v smeri Y (rumena os), zgoraj (v smeri zelene osi) [cm²/m]

6.4.2. STREŠNA PLOŠČA JAŠKA

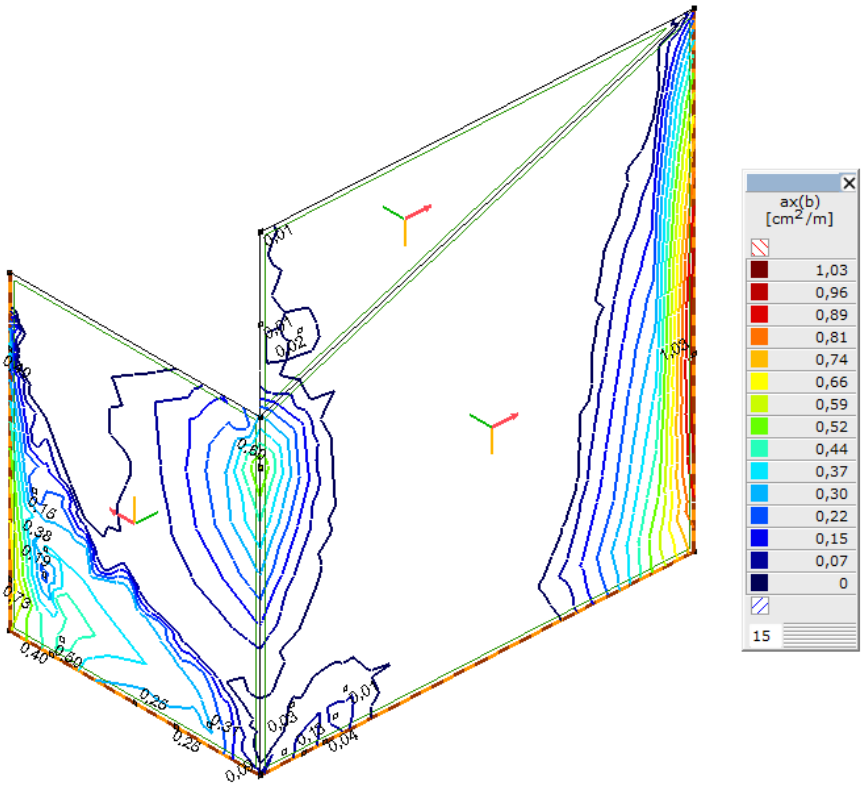


Potrebna armatura v smeri X, spodaj (rdeča os) [cm²/m]

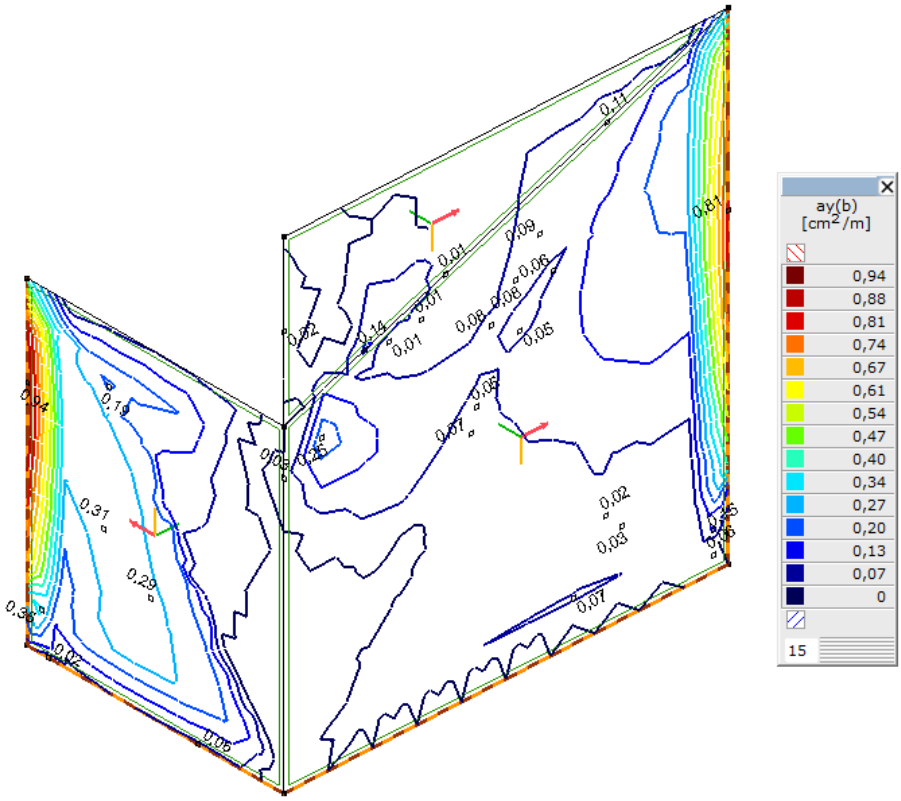


Potrebna armatura v smeri Y, spodaj (rumena os) [cm²/m]

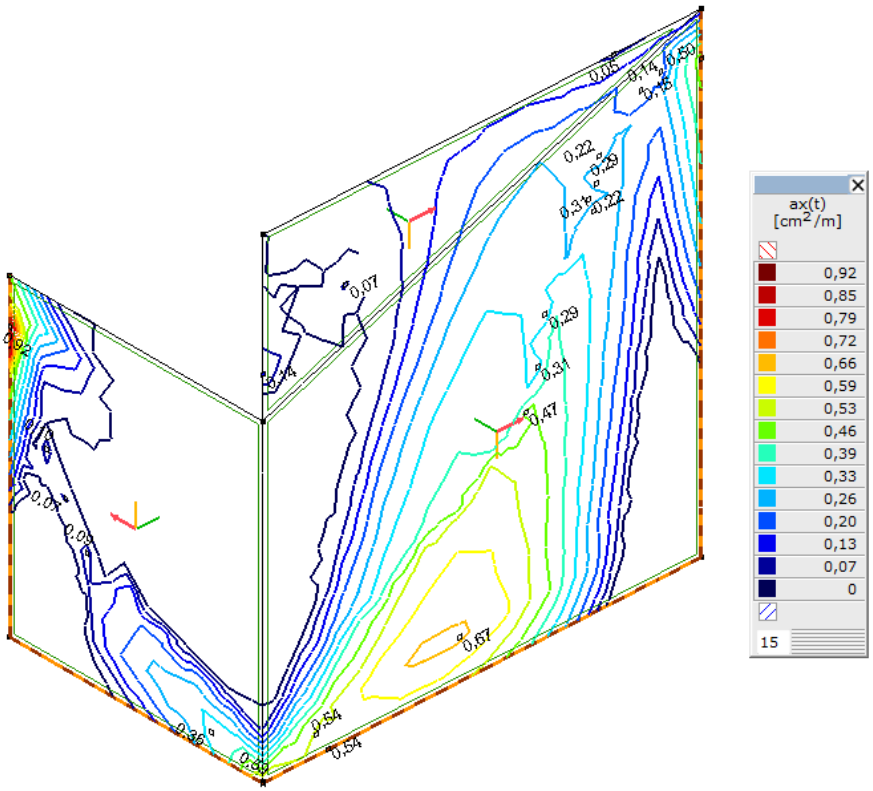
6.4.1. OPORNI ZID



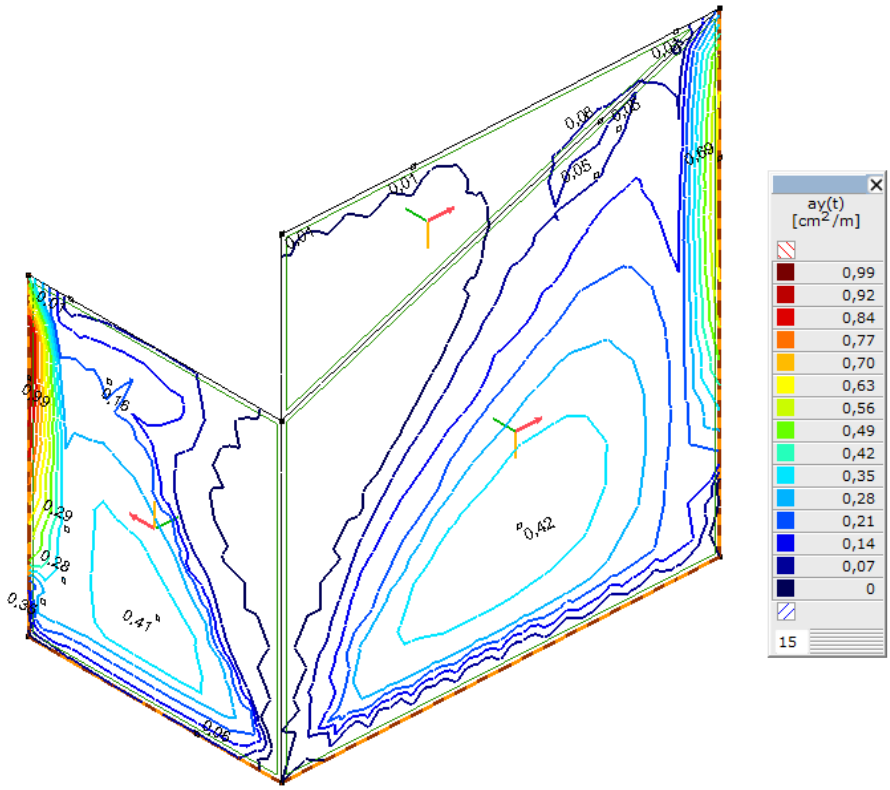
Potrebna armatura v smeri X (rdeča os), spodaj (nasprotna smer zelene osi) [cm²/m]



Potrebna armatura v smeri Y (rumena os), spodaj (nasprotna smer zelene osi) [cm²/m]

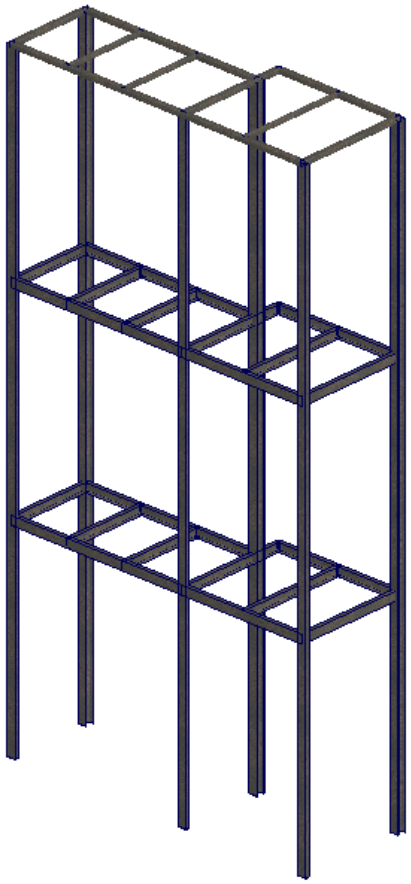


Potrebna armatura v smeri X (rdeča os), zgoraj (v smeri zelene osi) [cm²/m]

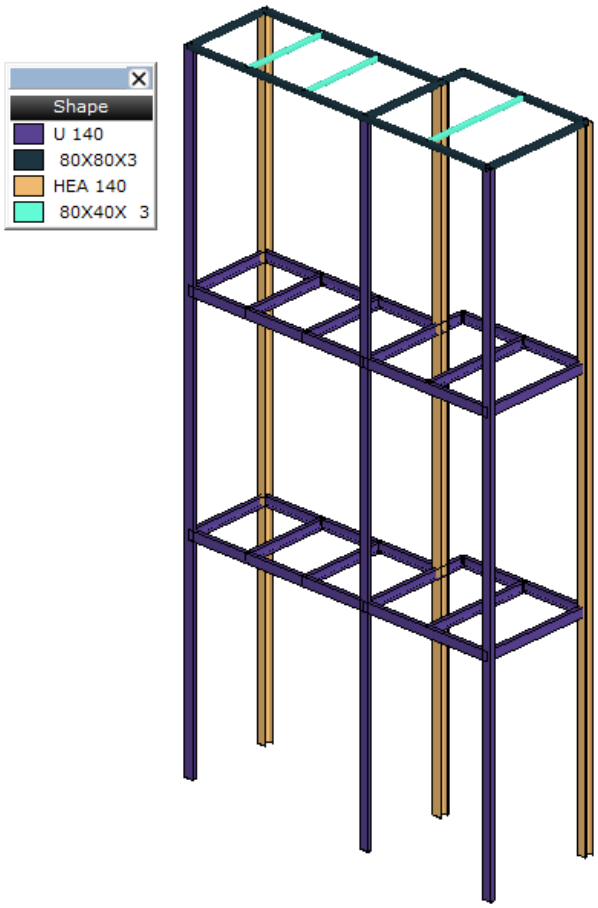


Potrebna armatura v smeri Y (rumena os), zgoraj (v smeri zelene osi) [cm²/m]

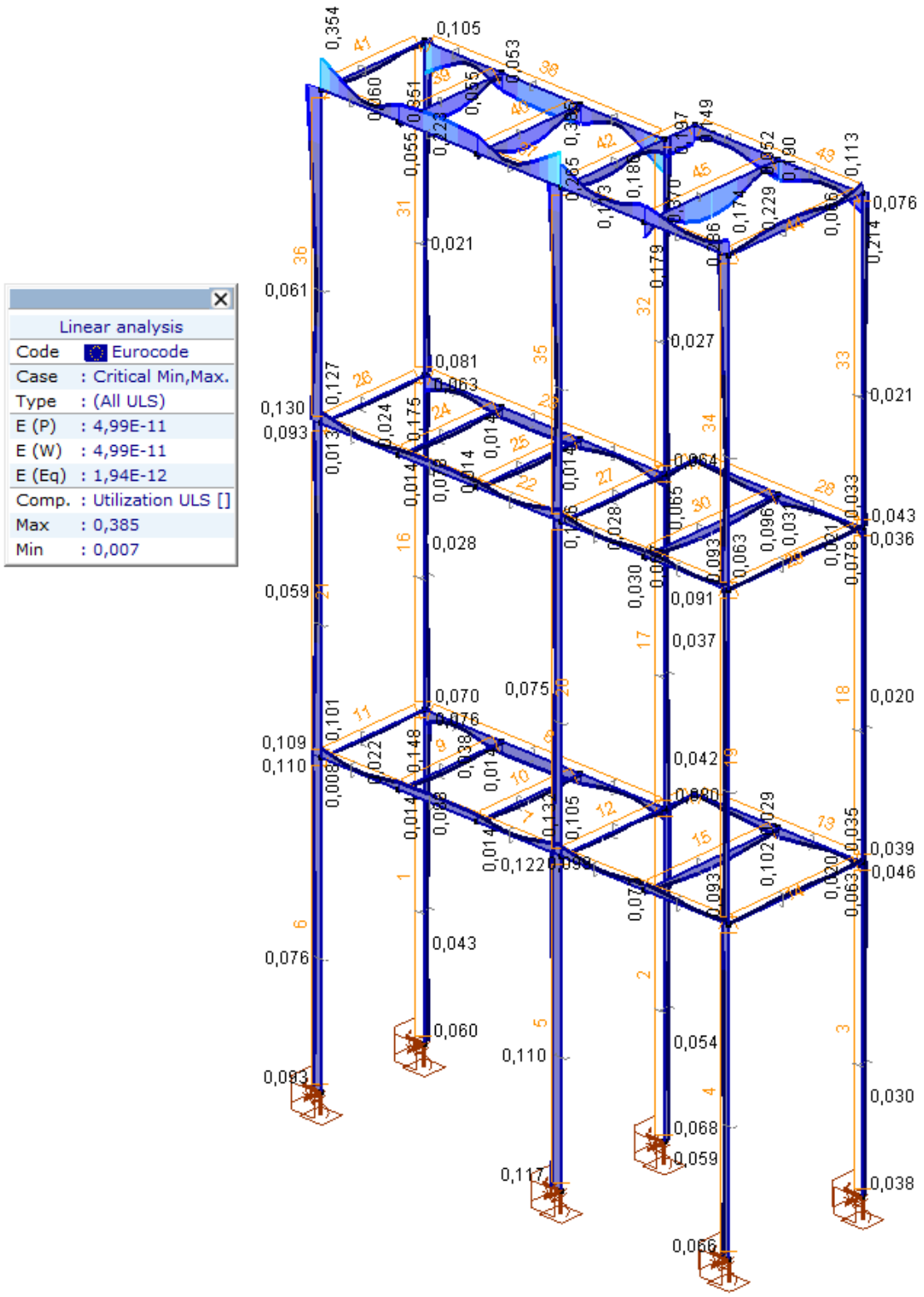
6.5. JEKLENA KONSTRUKCIJA



Prikaz jeklene konstrukcije. Poudarjen del je nova izvedba.



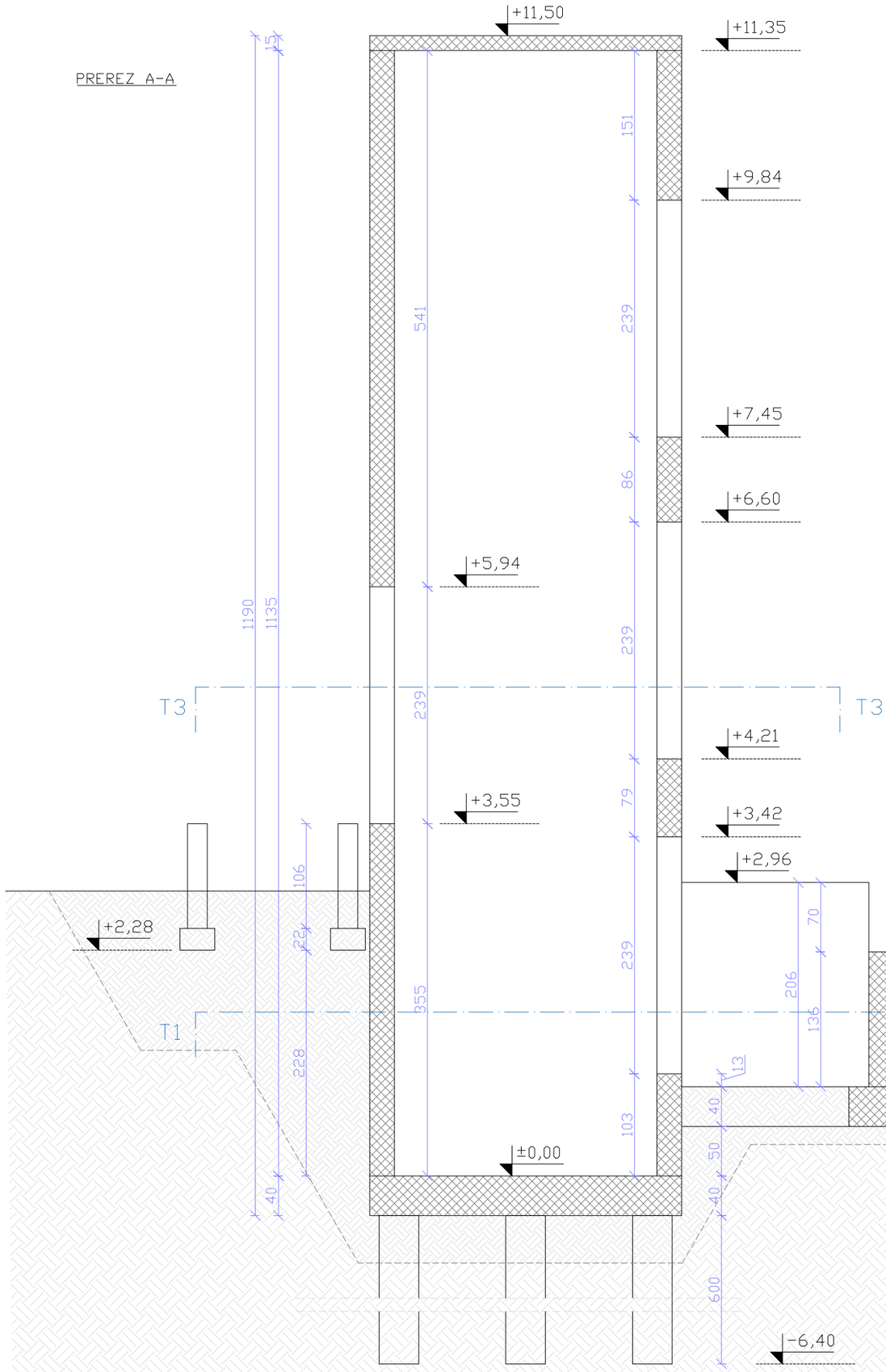
Prikaz uporabljenih profilov.

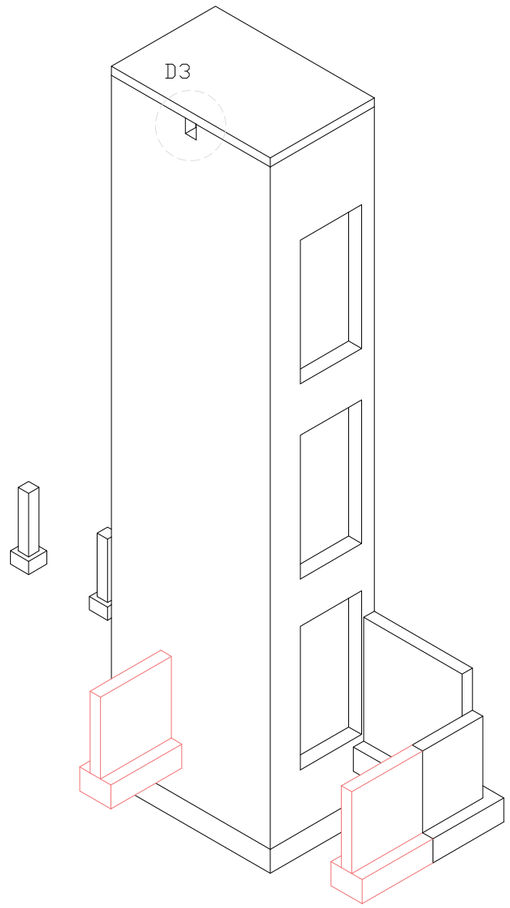


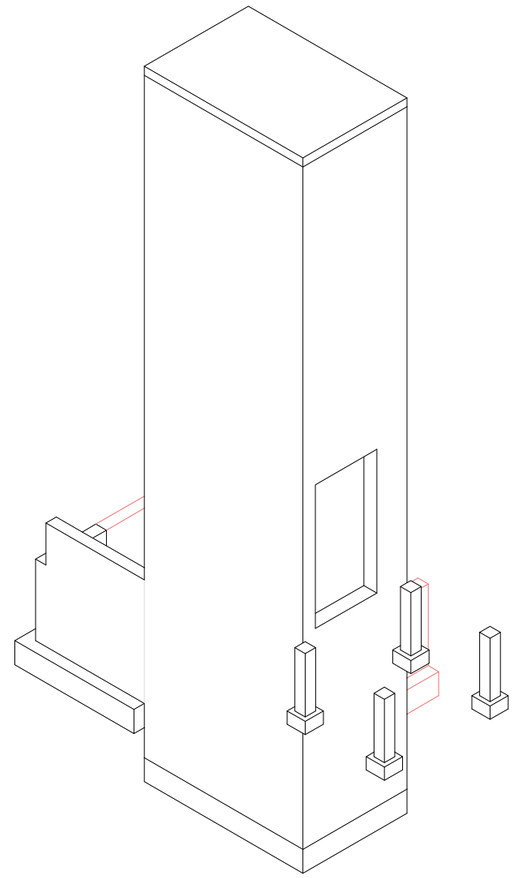
Mejno stanje nosilnosti. Max. izkoriščenost profilov po nosilnosti je 38,5%. Nadaljnje kontrole niso potrebne.

GRAFIČNI DEL

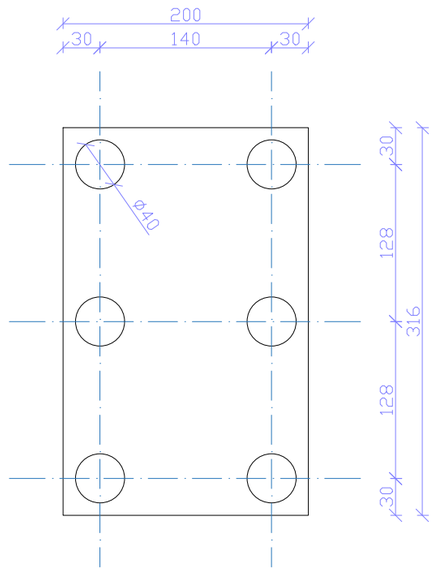
PREREZ A-A



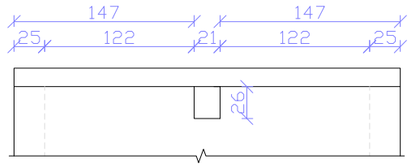




POZICIJE PILOTOV



DETAJL 3

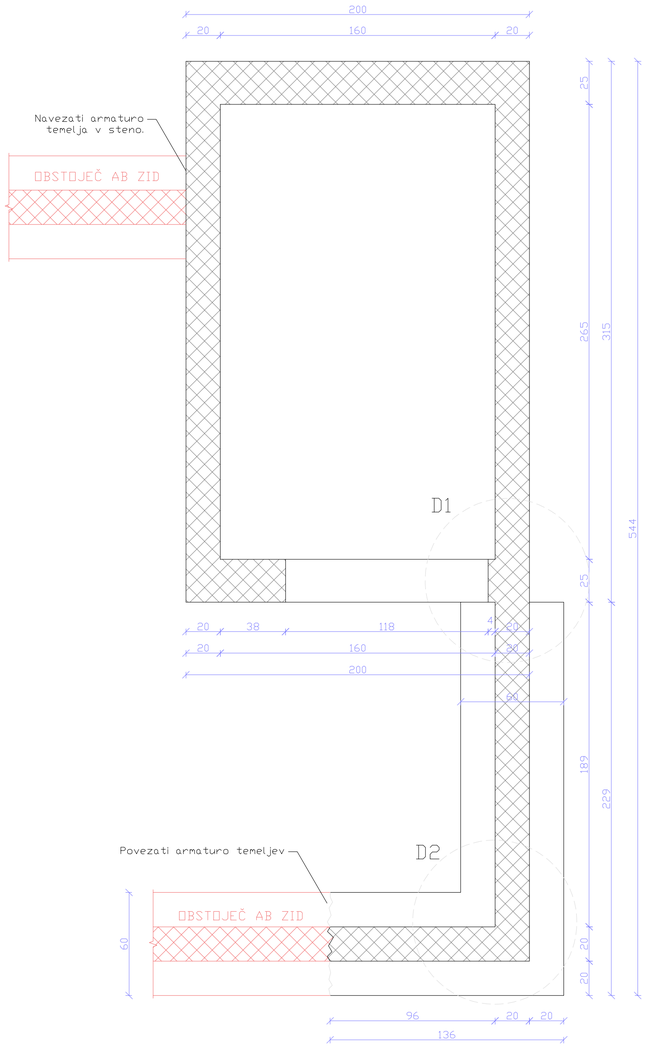


PREČNI PREREZ A-A, M1:50

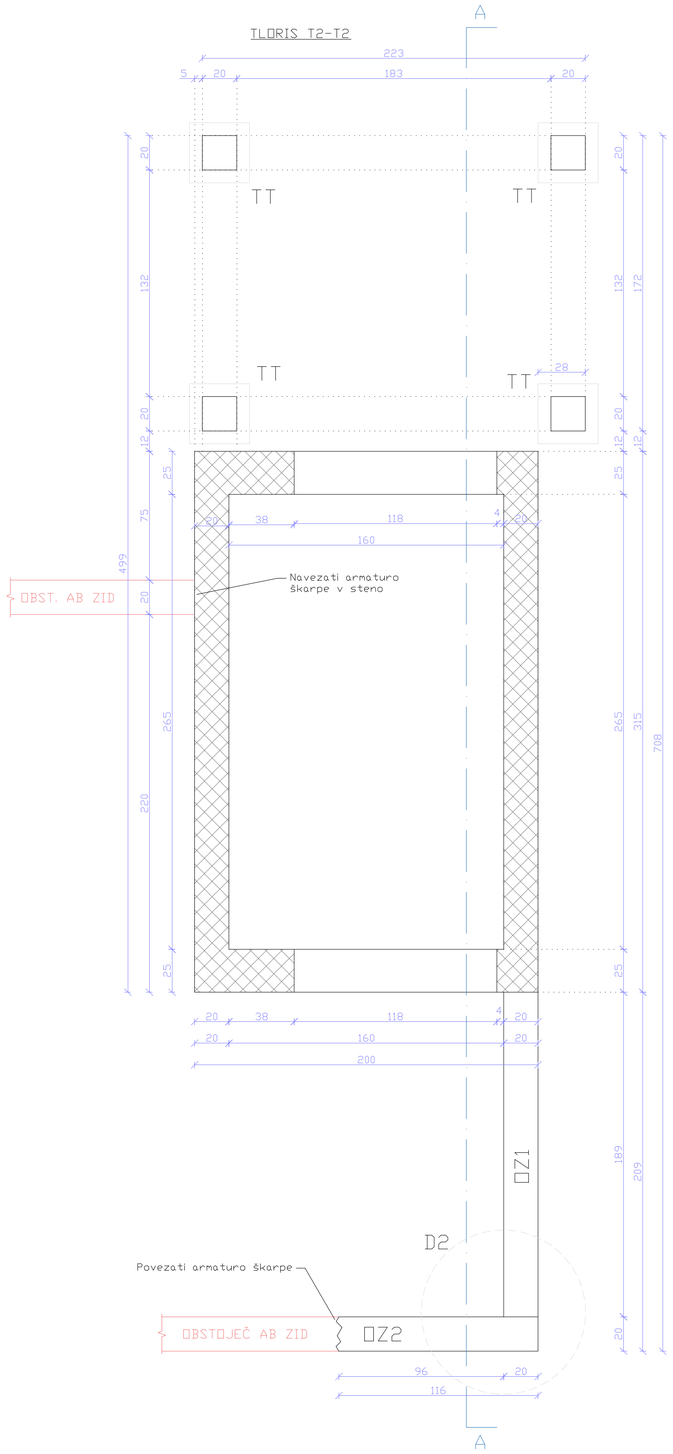
NAZIV GRADNJE:	DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.
INVESTITOR:	Inštitut Jožef Stefan Jamova 39 1000 LJUBLJANA
PROJEKTANT:	DECEN d.o.o., Šešče pri preboldu 32A, 3312 Prebold
VODJA PROJEKTA:	IGOR BERLOT, univ.dipl.ing.arh. ŠPELA NARDONI KOVAČ, univ.dipl.ing.arh.,
POOBLAŠČENI INŽENIR:	Vinko DEBELAK, univ.dip.inž.grad., G-0837
SODELAVCI:	Luka KOČEVAR, dip.inž.grad.

faza projekta:	PZI-G	šifra projekta:	09/2024-G
datum izdelave:	DECEMBER 2024	št. strani:	1/3

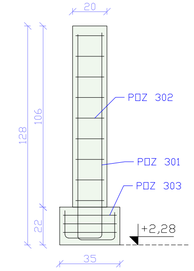
TLORIS T1-T1



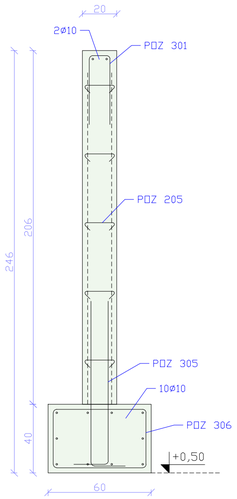
TLORIS T2-T2



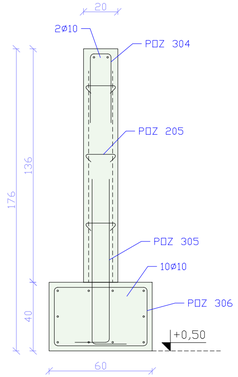
Točkovni temelj "TT"



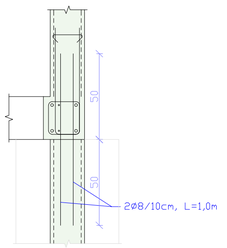
Oporni zid "OZ1"



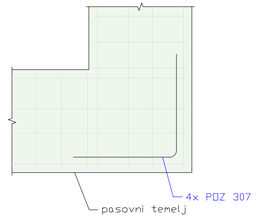
Oporni zid "OZ2"

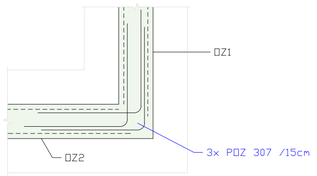


DETAJL 1

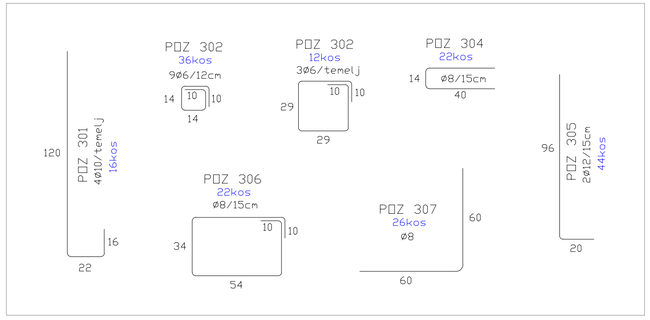


DETAJL 2





LEGENDA ARMATURE



PREKRIVANJE ARMATURE

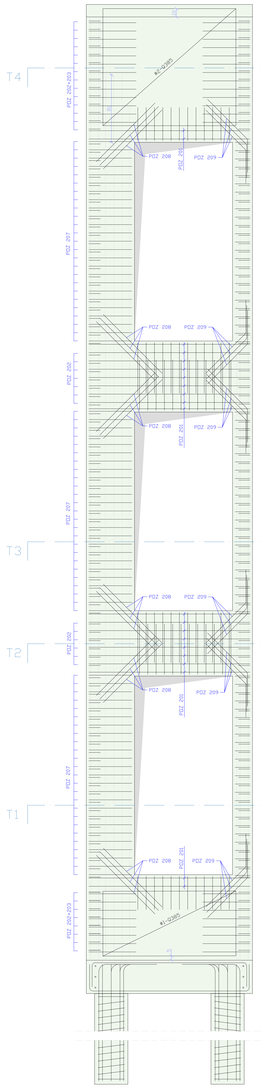
ø8.....25cm
ø10.....40cm
ø12.....50cm
ø14.....60cm
ø16.....70cm

TLORIS, M1:20

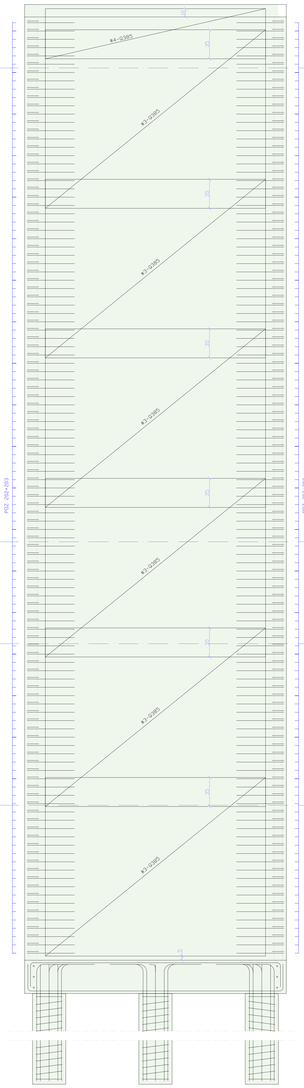
NAZIV GRADNJE:	DVIGALO OB STAVBI PRIZIDKA K REAKTORJU II.
INVESTITOR:	Inštitut Jožef Stefan Jamova 39 1000 LJUBLJANA
PROJEKTANT:	DECEN d.o.o., Šešče pri preboldu 32A, 3312 Prebold
VODJA PROJEKTA:	IGOR BERLOT, univ.dipl.ing.arh. ŠPELA NARDONI KOVAČ, univ.dipl.ing.arh.,
POOBLAŠČENI INŽENIR:	Vinko DEBELAK, univ.dip.inž.grad., G-0837
SODELAVCI:	Luka KOČEVAR, dip.inž.grad.

faza projekta:	PZI-G	šifra projekta:	09/2024-G
datum izdelave:	DECEMBER 2024	št. strani:	2/3

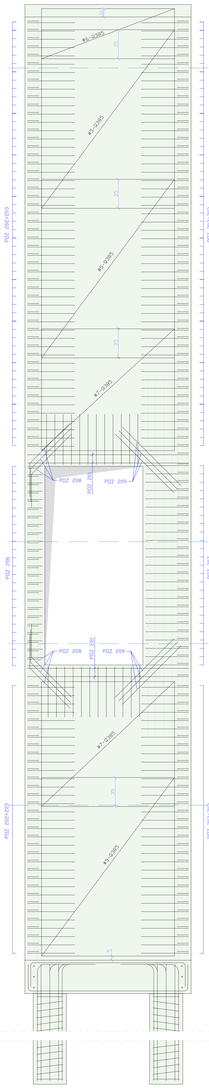
POGLED JUG



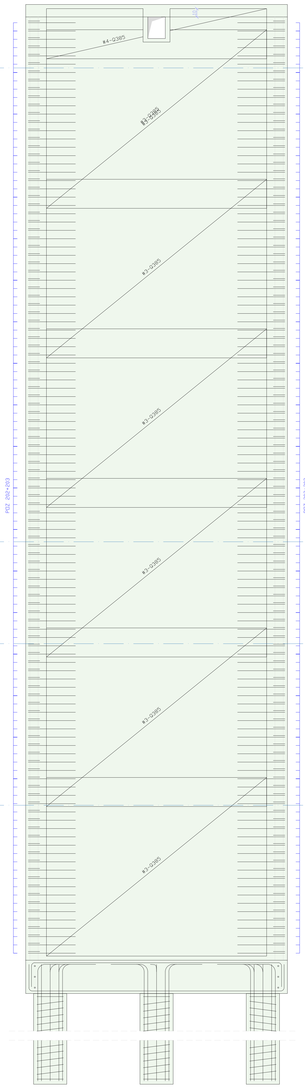
POGLED VZHOD



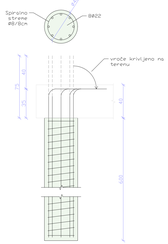
POGLED SEVER



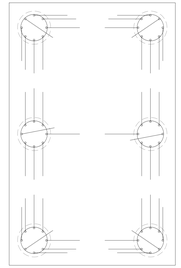
POGLED ZAHOD



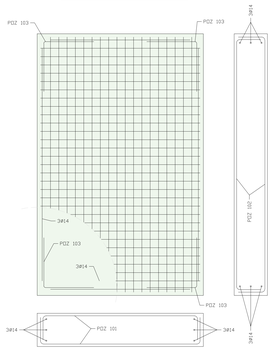
ARMATURNI NAČRT PILOTOV



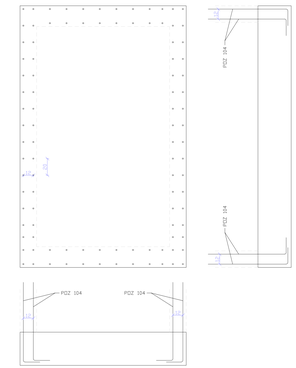
KRIVLJENJE VZDOLŽNE ARMATURE PILOTOV



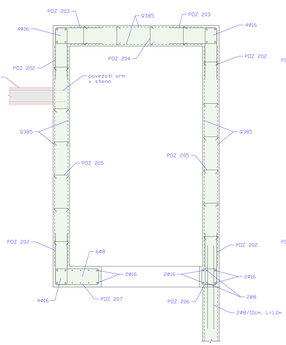
ARMATURNI NAČRT TEMELJNE PLOŠČE



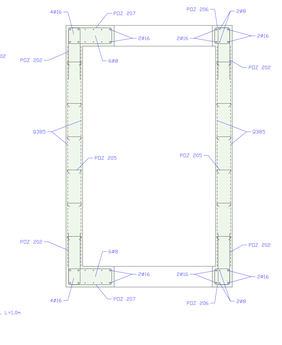
SIDRNI NASTAVKI ZA AB STENE



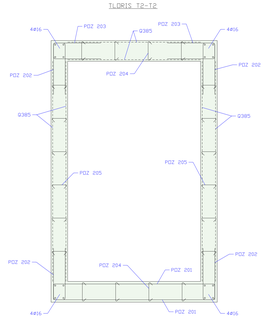
TLORIS T1-T1



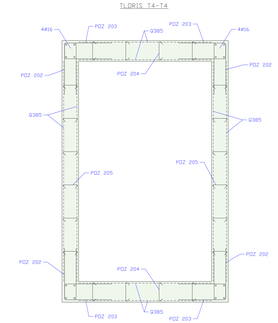
TLORIS T2-T3



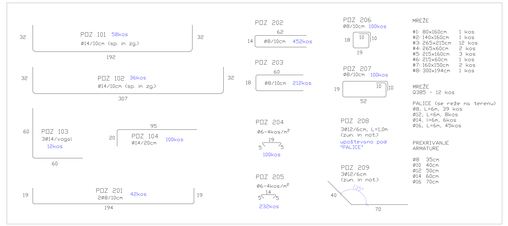
TLORIS T2-T2



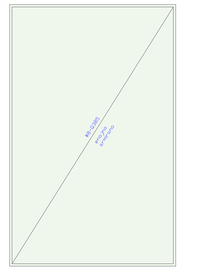
TLORIS T4-T4



LEGENDA ARMATURE



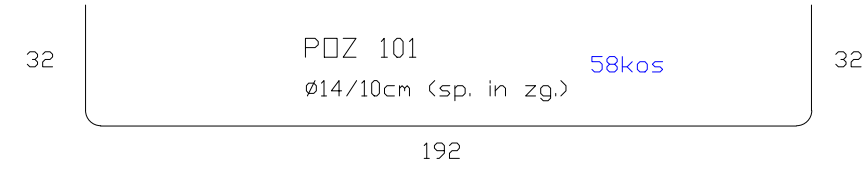
ARMATURNI NAČRT STREŠNE PLOŠČE

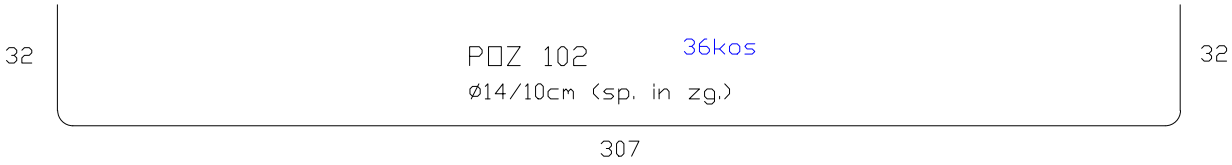


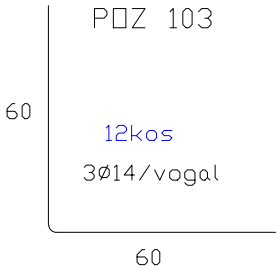
ARMATURNI NAČRT DVIGALNEGA JAŠKA M1:20

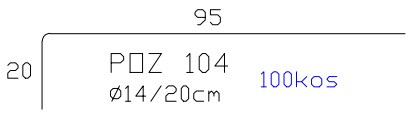
NAZIV GRADILIŠČA:	DVIGALO OB STAVBI PRIZIDKA K REAKTORJU B
INVESTITOR:	Institut Jožef Stefan Jamova 39 1000 LJUBLJANA
PROJEKTANT:	DEGEN d.o.o., Česta cel pridelka 12A, 3312 Prebold
VODJA PROJEKTA:	ALEŠ BERLEC, univ.dipl.inž.grad., SIPES-A NARODNI KOVAČ, univ.dipl.inž.arh.,
PODKLASIRAL INŽENIR:	Silvo ERŽELJ, univ.dipl.inž.grad., G-0837
SODELAVCI:	Luka KOČEVAR, dip.inž.grad.
faza projekta: PZI-G	številka projekta: 09/2024-G
datum izdelave: DECEMBER 2024	št. strani: 3/5

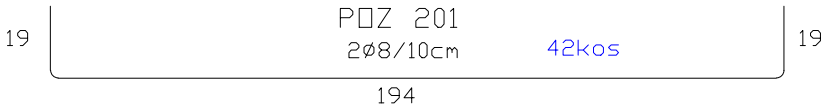
IZVLEČEK ARMATURE

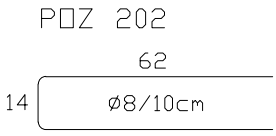


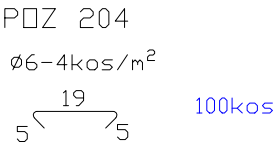


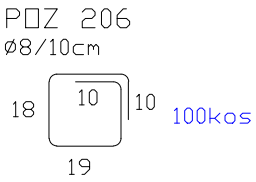


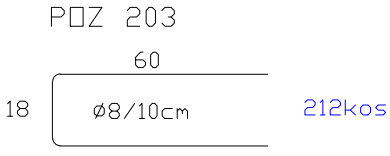


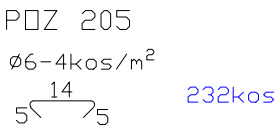


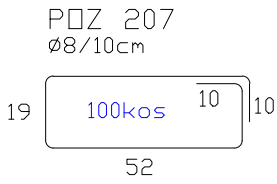








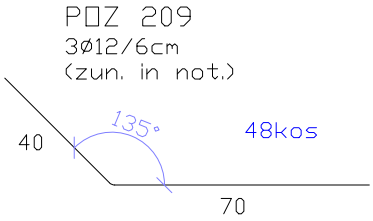




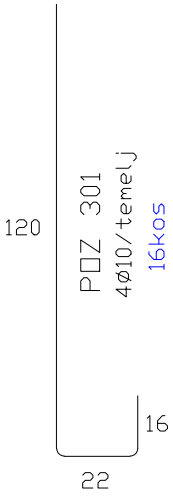
POZ 208

3ø12/6cm, L=1,0m
(zun. in not.)

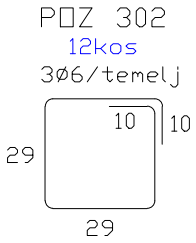
upoštevano pod "PALICE"

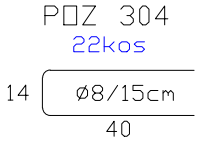


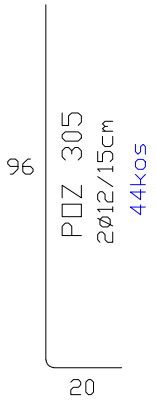
IZVLEČEK ARMATURE

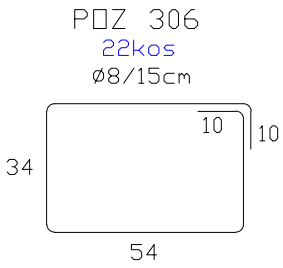


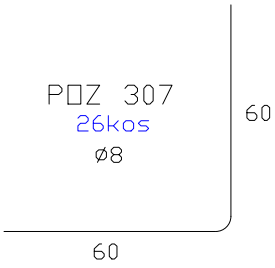












MREŽE
Q385 - 12 kos

PALICE (se reže na terenu)
ø8, L=6m, 32 kos
ø12, L=6m, 8kos
ø14, l=6m, 6kos
ø16, L=6m, 45kos

OPOMBA:
Armatura za pilote se zveže v železokrivnici.