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Projekt:

NADGRADNJA ŽELEZNIŠKE POSTAJE GROSUPLJE

Št. projekta: **3674**

Št. načrta: **3674_3/2**

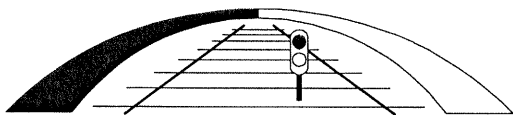
Objekt: PODHOD na postaji Grosuplje

STATIČNI RAČUN

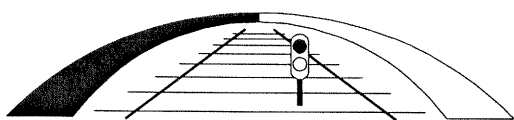
Podhod

Ljubljana, marec 2018

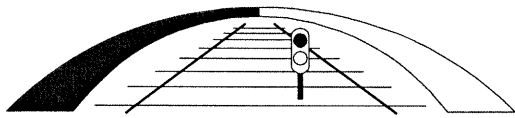
Računala: Sandra Hribar Pureber, u.d.i.g.



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1 POROČILO K STATIČNEMU RAČUNU

Statični račun obsega analizo podhoda, stopnišča in klančine.

Objekt je analiziran s 3D ploskovnim modelom. Statični izračun je izveden s programom SoFiSTiK.

Dokaz mehanske odpornosti in stabilnosti konstrukcije podhoda je izdelan skladno s:

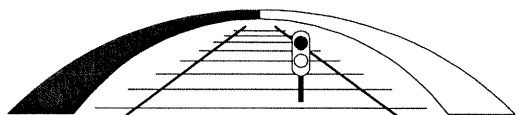
- SIST EN 1990 – določitev varnostnih faktorjev in kombinacij
- SIST EN 1991-2 – prometna obtežba (upoštevani faktor $\alpha=1,10$)
- SIST EN 1992 – betonska konstrukcija
- SIST EN 1997 – zemeljski pritiski
- SIST EN 1998 – seizmična obtežba

Dimenzioniranje je izvedeno po metodi mejnih stanj (MSN in MSU) skladno s standardom EN 1992.

Hidroizolacijo vertikalnih površin v stiku z zemljo ter spodnje plošče predstavlja sistem 'bele kadi', pri čemer so razpoke omejene na 0,20 mm.

Prekladna konstrukcija je hidroizolirana z bitumenskimi hidroizolacijskimi trakovi, pri čemer so razpoke omejene glede na kriterij trajnosti na 0,30 mm.

Upoštevana je kvaliteta betona C 30/37 in kvaliteta armature B500B.

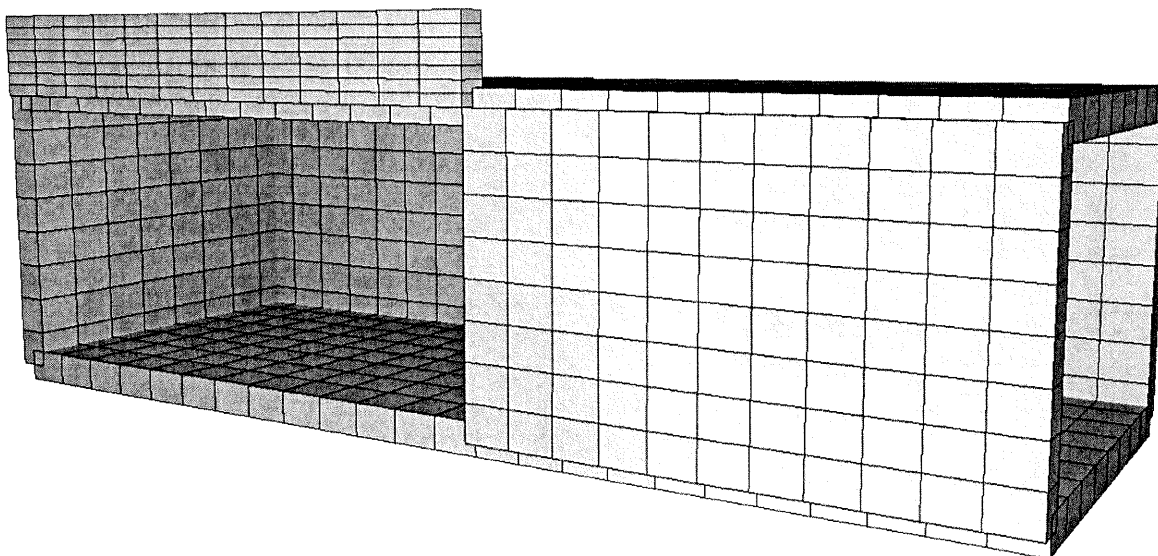


2 PODHOD

2.1 ZASNOVA

Podhod je zasnovan kot zaprt armiranobetonski okvir na elastični podlagi. Svetli razpon znaša 4,0 m. Debelina prekladne plošče, sten in talne plošče je 35 cm. Svetla višina konstrukcije podhoda je 2,80 m. Razdeljen je na štiri kampade. Vse kampade so enako armirane.

Kampada 1



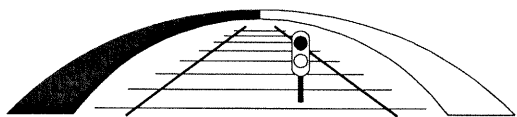
Kampada 4

Beton C30/37

Armatura B500B

Zaščitna plast betona: 4,5 cm (5 cm)

Modul reakcije tal $C_v = 20.000 \text{ kN/m}^3$



2.2 OBTEŽBA

2.2.1 Lastna teža in stalna koristna obtežba

Lastna teža	$\gamma = 25 \text{ kN/m}^3$
Hidroizolacija + zaščitni sloj betona d=6cm 1,5 kN/m ²
Tirna greda $0,75 \cdot 20 =$ 15 kN/m ²

2.2.2 Mirni zemeljski pritisk

$$k_m = 1 - \sin \varphi_m = 1 - \sin 30^\circ = 0,5$$

$$e_{m1} = \gamma \cdot h_1 \cdot k_m = 20 \cdot 1,0 \cdot 0,5 = 10 \text{ kN/m}^2$$

$$e_{m2} = \gamma \cdot h_2 \cdot k_m = 20 \cdot 4,2 \cdot 0,5 = 42 \text{ kN/m}^2$$

Upoštevam še komprimacijski pritisk $e_{comp} = 25 \text{ kN/m}^2$, ki se ne superponira z zemeljskim pritiskom (poenostavljen diagram).

2.2.3 Prometna obtežba

$$\alpha = 1,10$$

Upoštevana je prometna shema LM 71 in shema težkih vozil SW/2.

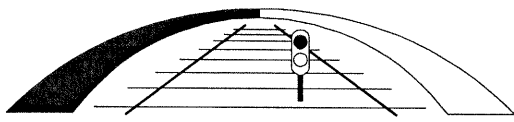
2.2.3.1 Dinamični koeficient

$$\phi = \frac{1,44}{\sqrt{L_\phi} - 0,2} + 0,82 = \frac{1,44}{\sqrt{4,35} - 0,2} + 0,82 = 1,58 < \phi_{d,max} = 1,67$$

2.2.3.2 LM71

→vertikalna obtežba:

$$p_{v1} = 1,1 \cdot 52 = 57 \text{ kN/m}^2 \text{ DS 804}$$



→ horizontalna obtežba:

$$p_{h1} = 0,5 \cdot 57 = 29 \text{ kN/m}^2$$

→ horizontalna obtežba na globini 3,9 m:

$$p_{h2} = 1,1 \cdot 17 \cdot 0,5 = 9,5 \text{ kN/m}^2$$

$$p_h = \frac{29 + 9,5}{2} = 19 \text{ kN/m}^2 \dots \text{upoštevano konstantno po višini stene}$$

Deluje na širini $b = 3,0 \text{ m}$. Lahko deluje v kombinaciji z ali brez vertikalne prometne obtežbe.

2.2.3.3 Sila zaviranja oz. speljevanja

$$Q_z = 1,10 \cdot 35 \cdot 4,35 \cdot 0,6 = 100 \text{ kN/tir} < 1000 \text{ kN}$$

2.2.4 Krčenje in lezenje betona

Konstrukcija se praktično v celoti neovirano krči. Krčenje na izbranem statičnem modelu ne da dodatnih obremenitev.

2.2.5 Temperaturne spremembe

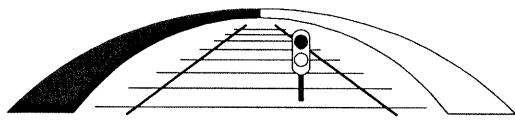
→ enakomerna sprememba temperature:

$$\text{zgornja ploskev: } \Delta T_{M,heat} = 10^\circ\text{C} \quad ,$$

..upoštevana je različna enakomerna temperaturna sprememba med prekladno ploščo, ki je bolj izpostavljena segrevanju in se zato segreje oz. hladi prej kot ostali elementi, in stenami ter talno ploščo.

→ neenakomerno segrevanje:

$$\text{zgornja ploskev: } dif \Delta T_M = 9^\circ\text{C} \quad ,$$



2.2.6 Potresna obtežba

Kategorija tal: A → S=1,0

$$T_B=0,15s$$

$$T_C=0,5s$$

$$T_D=2,0s$$

Potresna cona: $a_g=0,2m/s^2$

$$q=1,5$$

Upoštevam lastno težo in stalno koristno obtežbo.

Nihajni čas konstrukcije(program Sofistik): $t_x = 0,24s$

$$t_y = 0,14s$$

Merodajna masa:

$$m = 250t$$

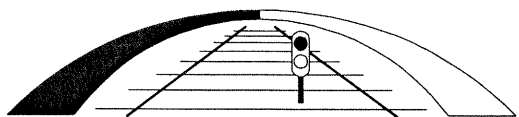
$$S_d = a_g \cdot S \cdot 2,5/q = 0,2 \cdot 9,81 \cdot 1,0 \cdot 2,5/1,5 = 3,3$$

$$F_b = m \cdot S_d = 250 \cdot 3,3 = 830kN$$

→ + kombinacije:

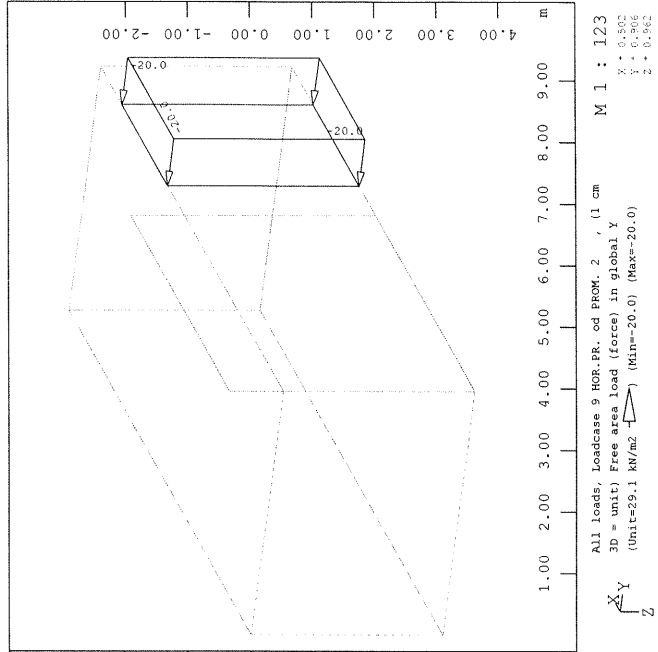
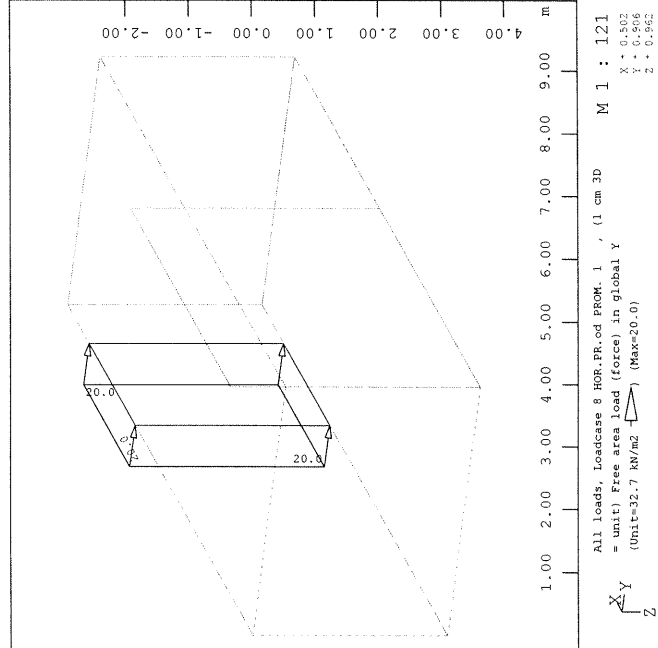
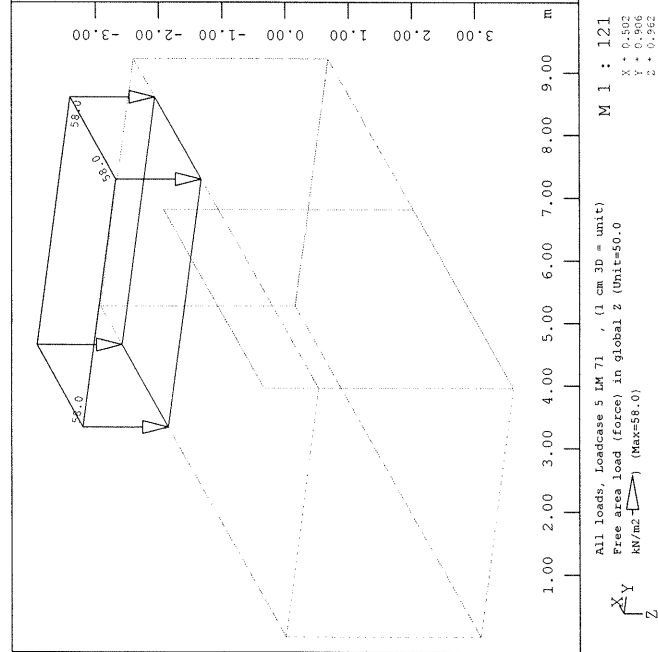
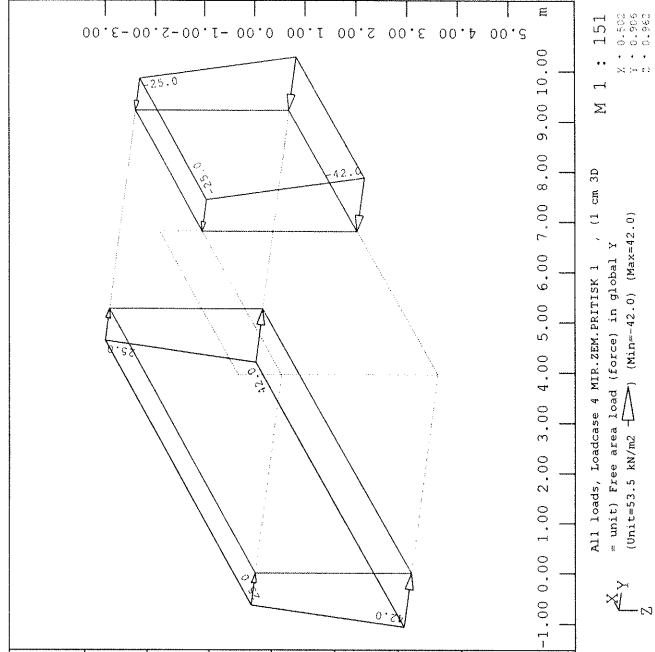
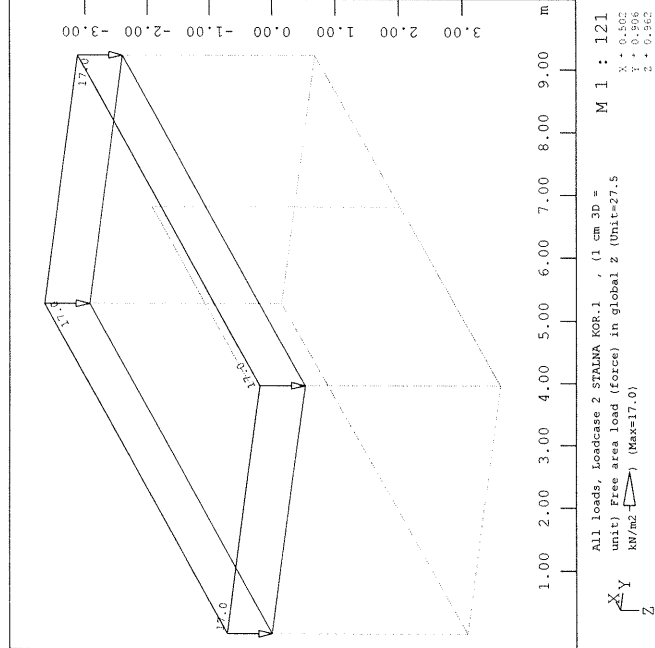
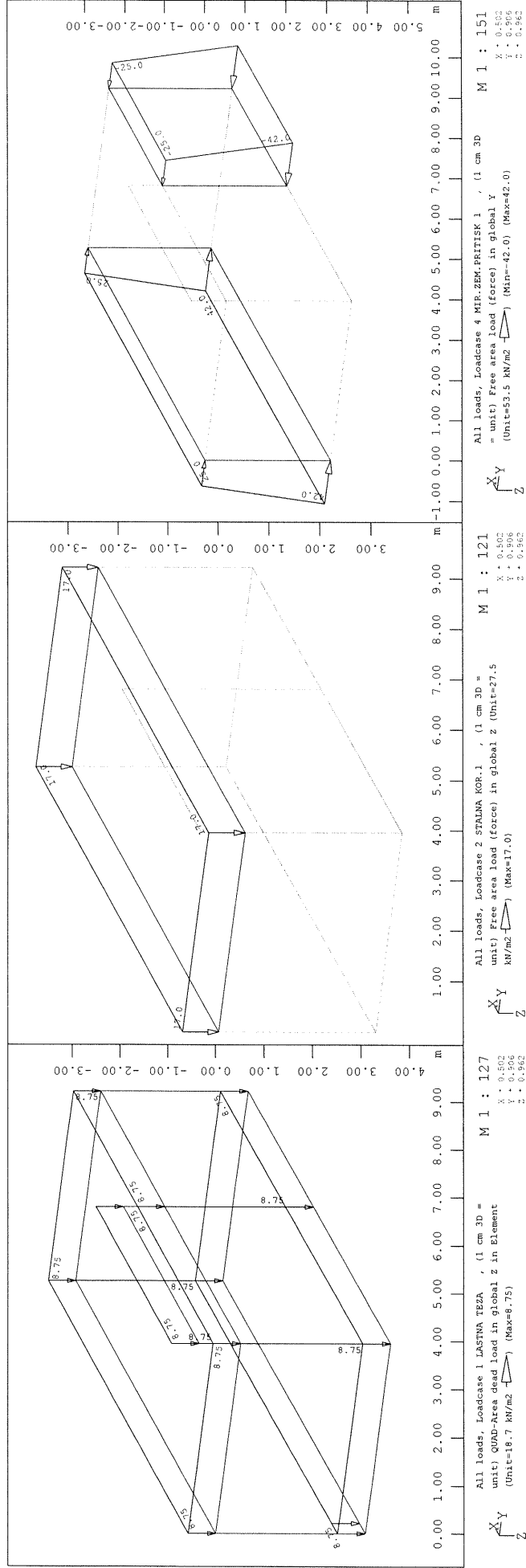
$$E_{Edx} + 0,3E_{Edy}$$

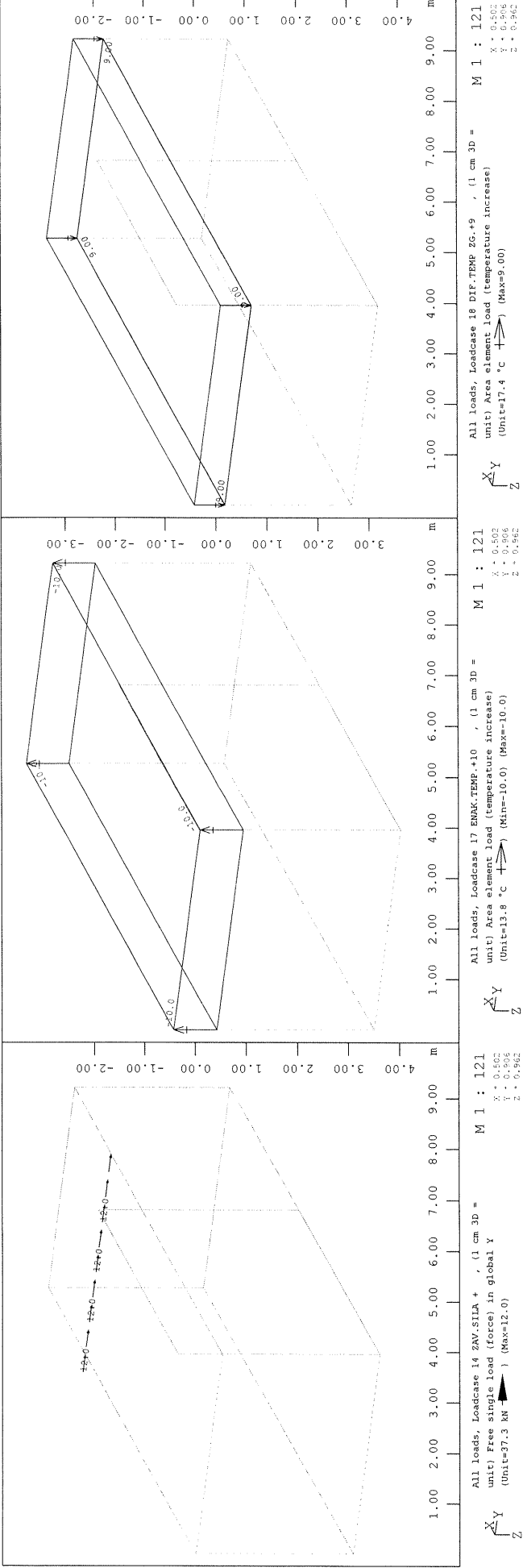
$$0,3E_{Edx} + E_{Edy}$$



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2.2.7 Grafični prikaz obtežb





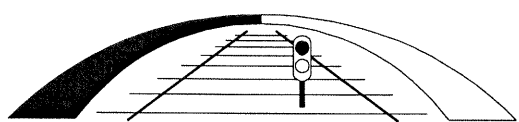
Podhod
 INVERSE VECTOR ITERATION

Sum of masses and mass moments of inertia

Node	TM			RM			RMB [tm2]
	X[t]	Y[t]	Z[t]	X[tm2]	Y[tm2]	Z[tm2]	
total ¹	248.599	248.599	248.599	0.000	0.000	0.000	-
	S[m] ²			RM(S) ³			
	5.847	2.084	0.980	1028.798	74.749	5.333	
				74.749	3741.538	-40.926	
activ ¹	248.599	248.599	248.599	0.000	0.000	0.000	-
	S[m] ²			RM(S) ³			
	5.847	2.084	0.980	1028.798	74.749	5.333	
				74.749	3741.538	-40.926	
				5.333	-40.926	3877.079	
¹ sum of the total and the active nodal masses							
² coordinates of the center of gravity							
³ 3x3 rotational mass matrix at the center of gravity							
TM translational masses in X-, Y- and Z-direction							
RM rotational masses about X-, Y- and Z-axis							
RMB warping mass							

Processing
 Eigenvalues

Eigenvalues										
No.	LC	λ	error	ω	f	T	ξ	Meff		
		[rad2/sec2]	[-]	[rad/sec]	[Hz]	[sec]	[o/o]	X[o/o]	Y[o/o]	Z[o/o]
1	250	6.7874E+02	0.00E+00	26.053	4.146	0.241	0.000	0.0	60.7	0.0
2	251	2.0775E+03	0.00E+00	45.579	7.254	0.138	0.000	34.9	0.0	1.9
3	252	3.5766E+03	1.97E-08	59.805	9.518	0.105	0.000	1.0	0.0	92.1
4	253	4.6599E+03	5.92E-07	68.264	10.865	0.092	0.000	1.4	0.0	1.7
$\Sigma(Meff)^1$							37.2	60.8	95.6	
¹ Total effective mass in X-, Y- and Z-direction.										
No.	eigenmode number		f		eigenfrequency					
LC	load case		T		eigenperiod					
λ	eigenvalue		ξ		modal damping ratio					
error	relative eigenvalue error		Meff		effective modal mass in X-, Y- and Z-direction					
ω	circular eigenfrequency									



2.3 ULS – MEJNO STANJE NOSILNOSTI

2.3.1 Obtežne kombinacije

→ dominantna je prometna obtežba

$$1,35(1,0) \times G + 1,5(0,5) \times E_m + 1,45(\phi \times p_v + 1,0(0) \times Q_z) + 1,5(0) \times p_h + 1,5 \times 0,6 \times T$$

→ dominantna je temperaturna obtežba

$$1,35(1,0) \times G + 1,5(0,5) \times E_m + 1,45 \times 0,8(1,0(0) \times \phi \times p_v + 1,0(0) \times Q_z) + 1,5(0) \times 0,8 \times p_h + 1,5 \times T$$

→ potresna kombinacija: ni merodajna

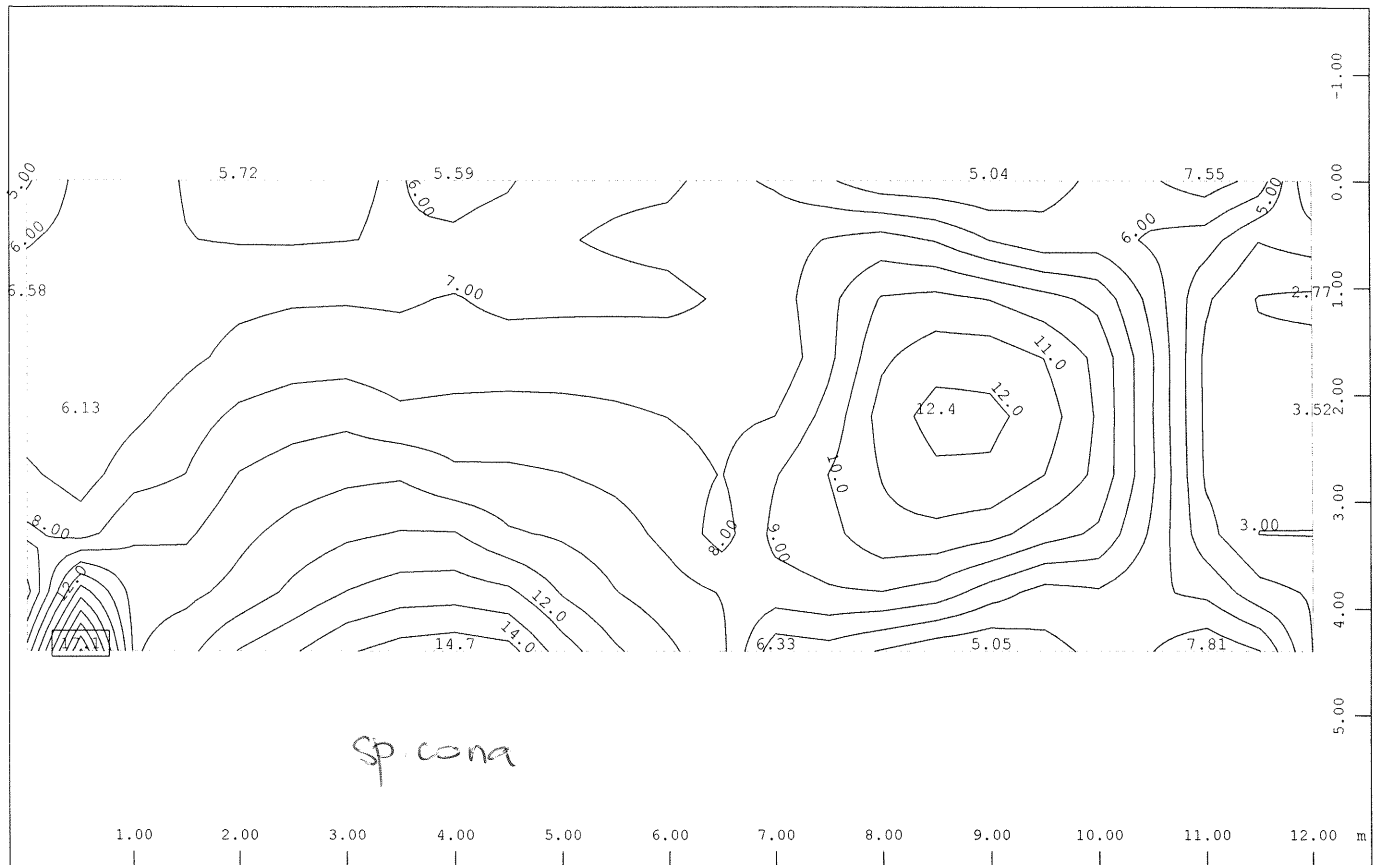
2.3.2 Dimenzioniranje okvirja

C 30/37, B500B, $a = 4,5 (5,0) \text{ cm}$

$$\gamma_c = 1,5, \quad \gamma_s = 1,15, \quad f_{cd} = \frac{0,85 \cdot 30}{1,5} = 17 \text{ MPa}, \quad f_{yd} = \frac{500}{1,15} = 435 \text{ MPa}$$

Iskanje maksimalnih notranjih sil in dimenzioniranje je izvedeno s programom Sofistik.

PREKLADNA PLOŠĆA



Sector of system Group 3

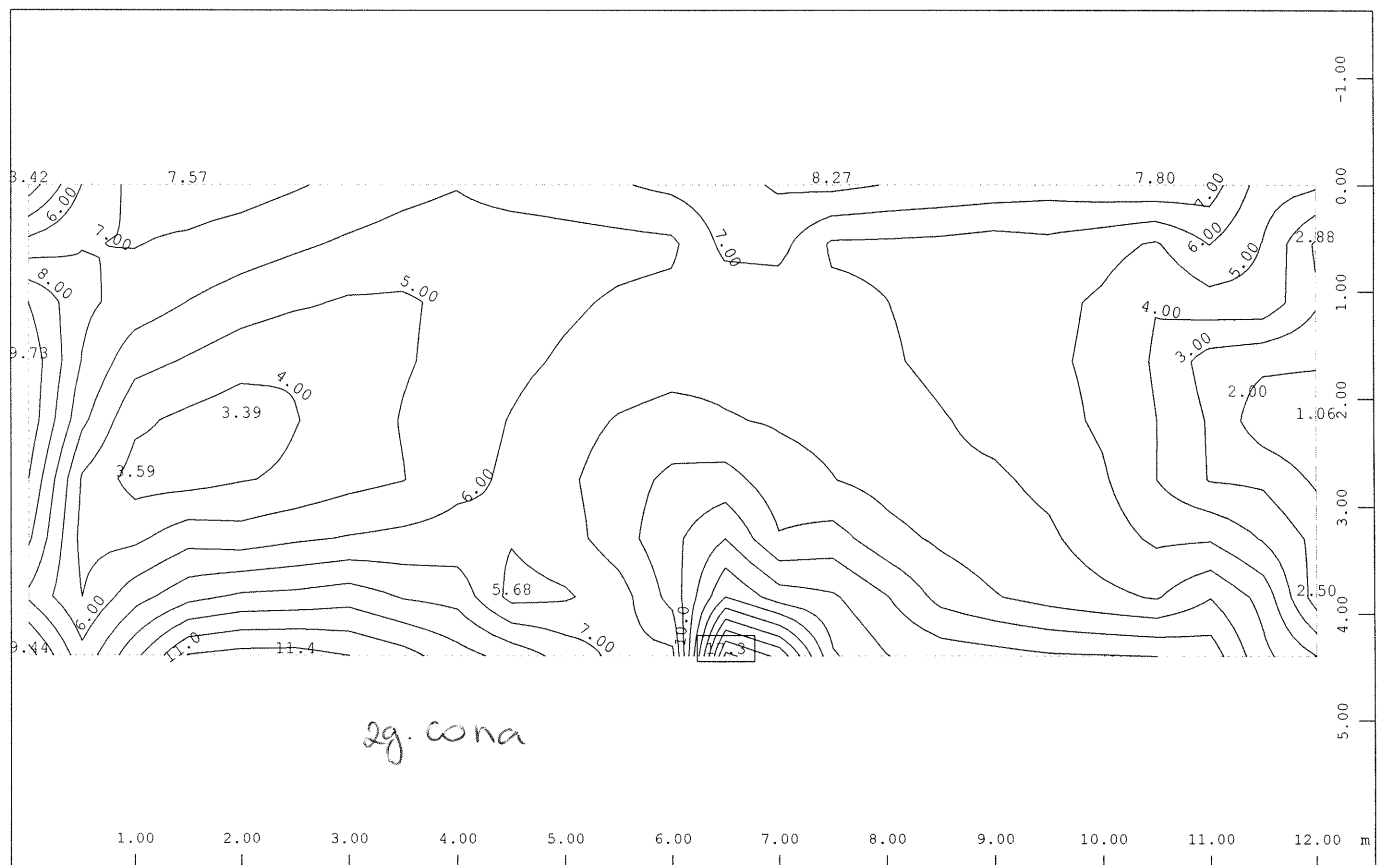
X
Y

Quadrilateral Elements , lower Principal reinforcements (1st layer) in Node
1 , from 2.77 to 17.1 step 1.00 cm²/m



Design Case

M 1 : 71



Sector of system Group 3

X
Y

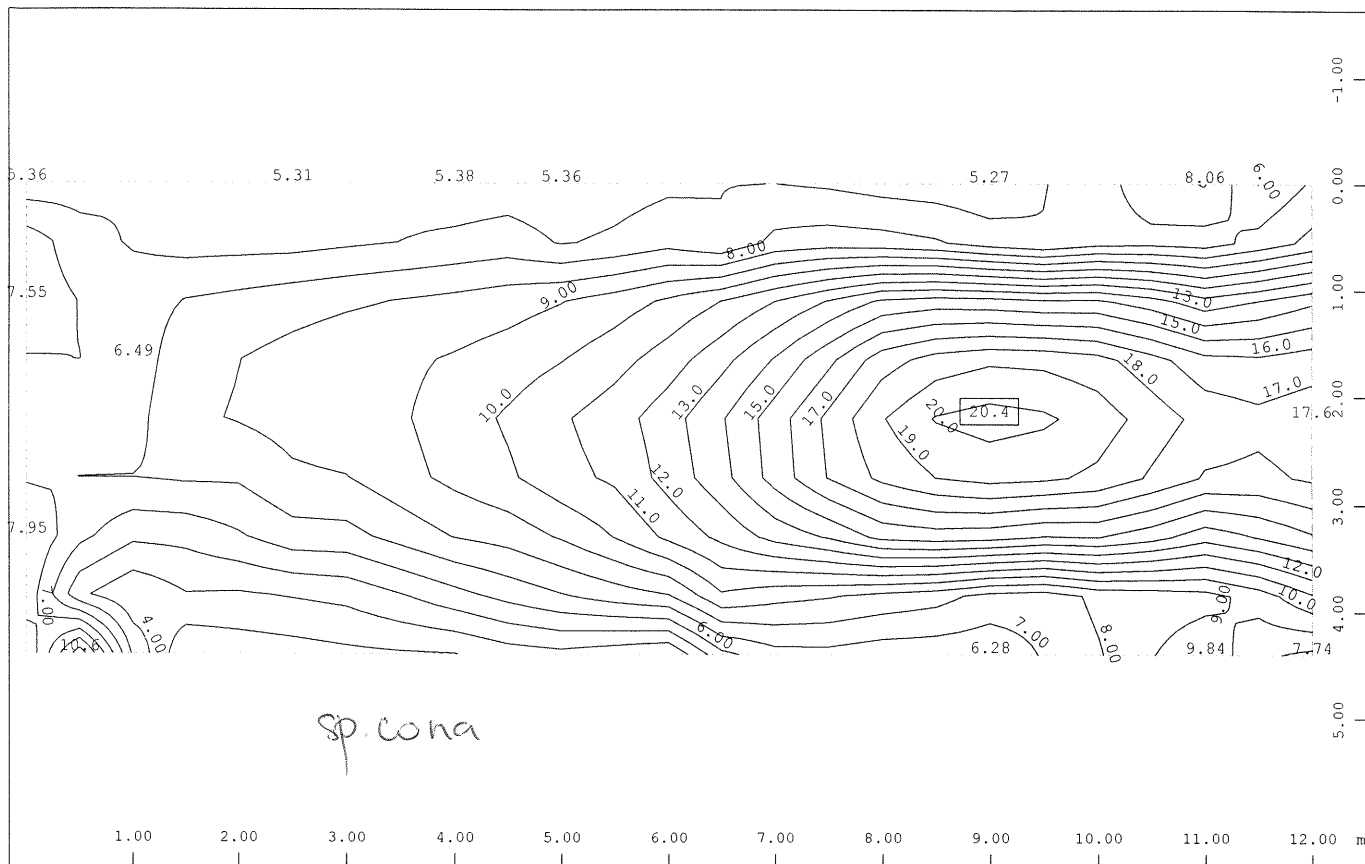
Quadrilateral Elements , upper Principal reinforcements (1st layer) in Node
1 , from 1.06 to 17.3 step 1.00 cm²/m



Design Case

M 1 : 71

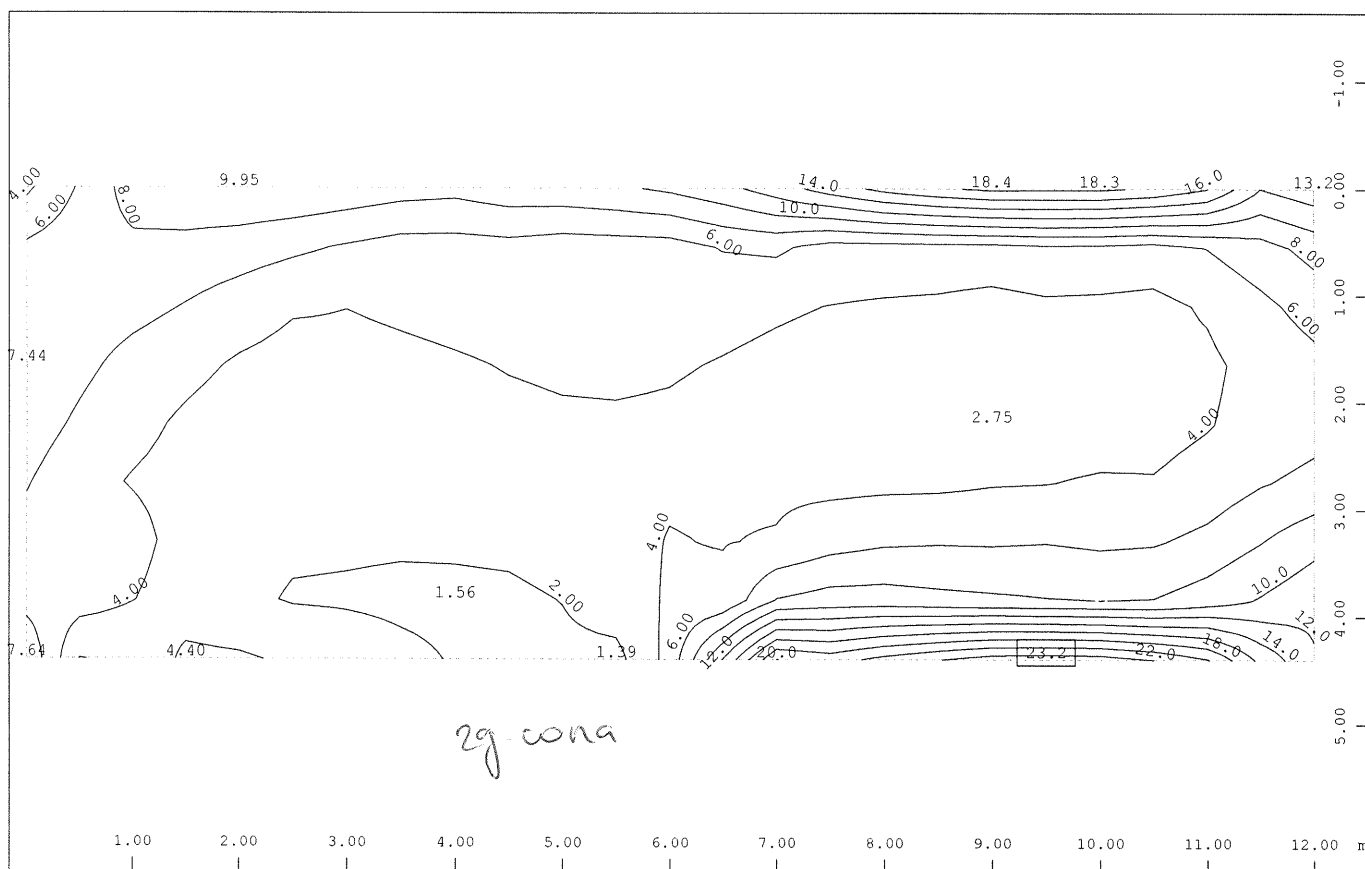
PREKLADNA PLOŠTA



Sector of system Group 3
 Quadrilateral Elements , lower Cross reinforcements (2nd layer) in Node
 , from 2.13 to 20.4 step 1.00 cm²/m

① Design Case 1

M 1 : 71



Sector of system Group 3
 Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node
 , from 1.39 to 23.2 step 2.00 cm²/m

① Design Case 1

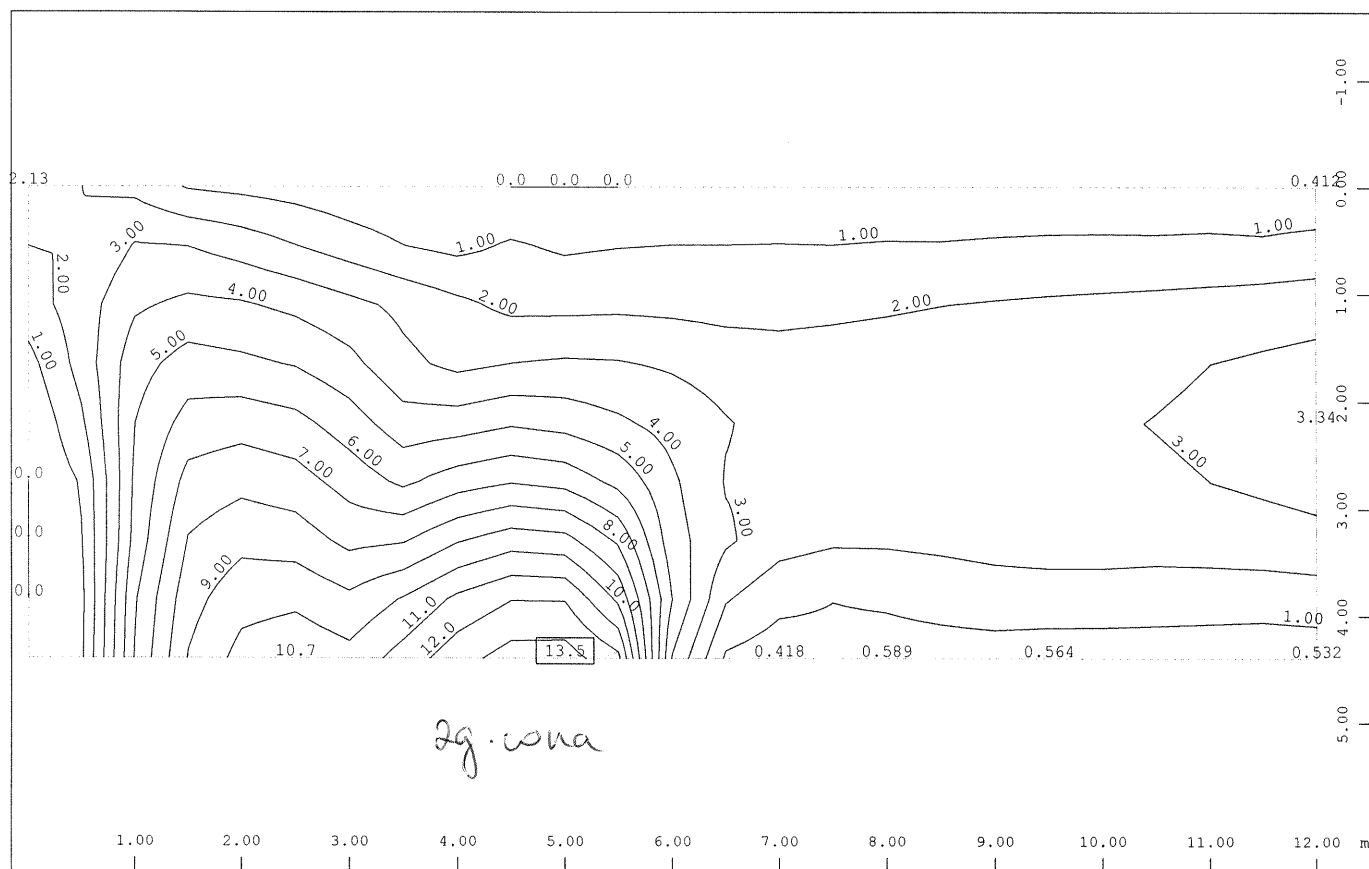
M 1 : 71

[illegible]

M 1 : 71

$$\begin{array}{c} Z-X \\ | \\ Y \end{array}$$


Design Case



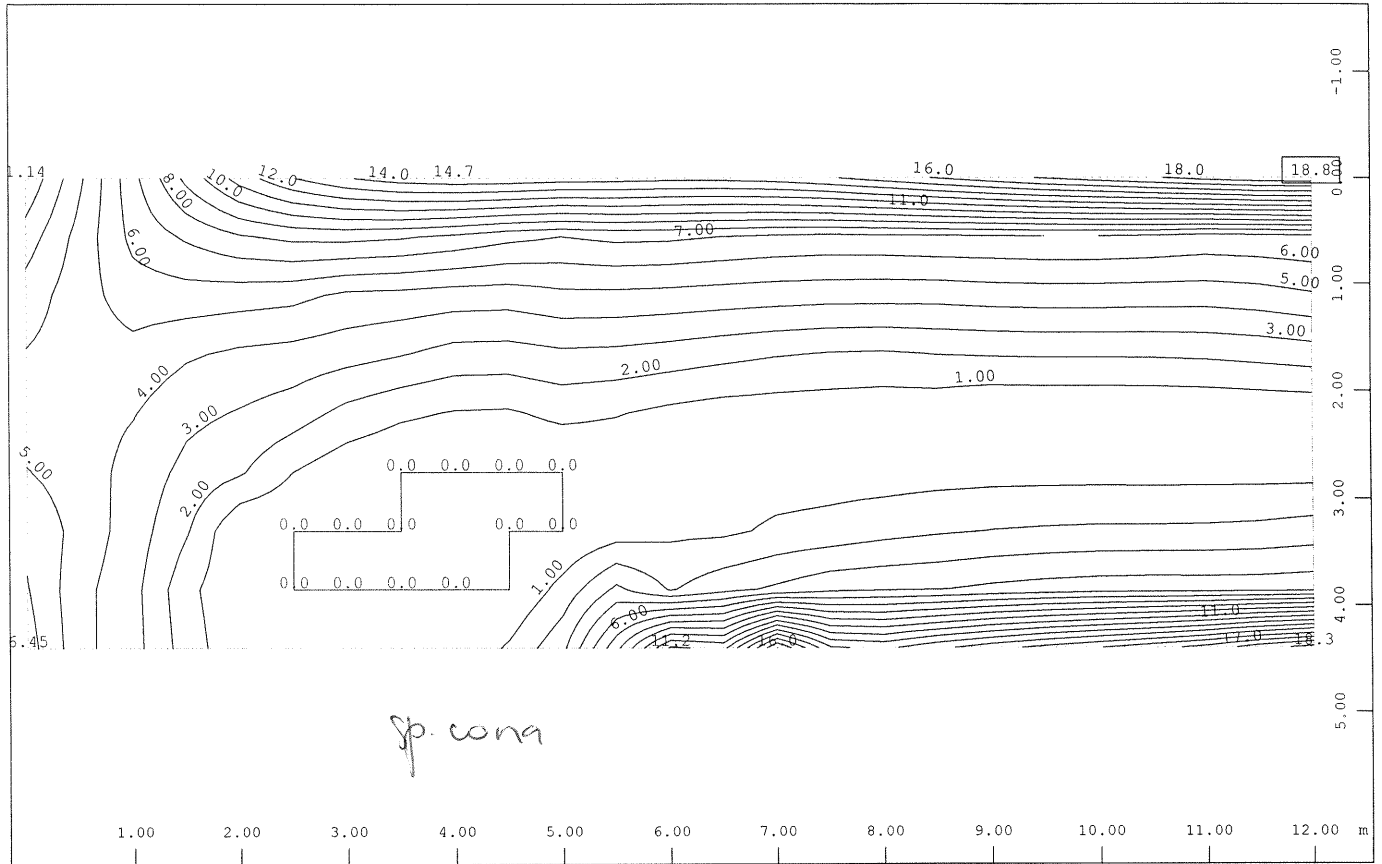
M 1 : 71

$$\begin{array}{c} Z-X \\ | \\ Y \end{array}$$

②

Design Case

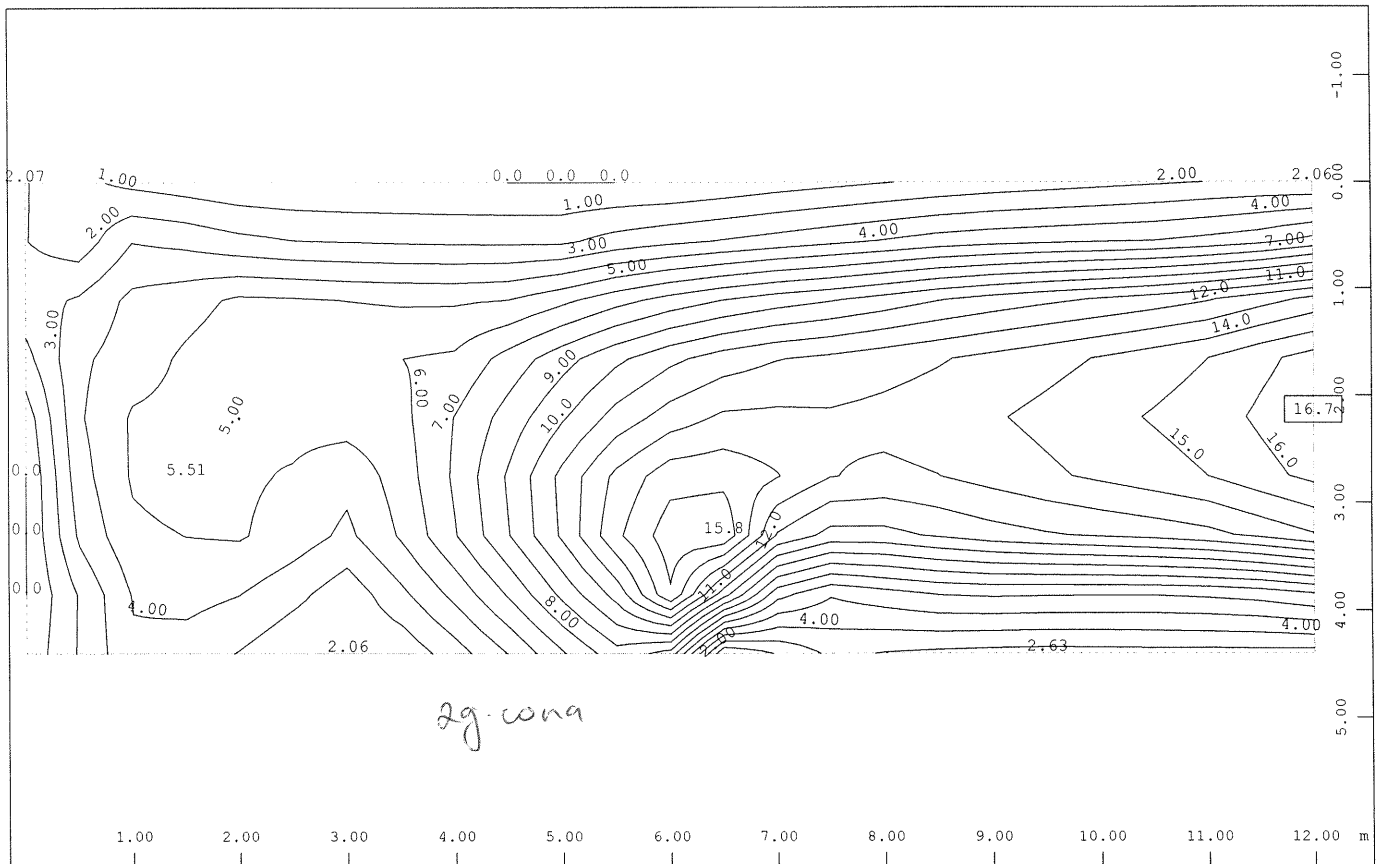
TALNA PLOŠČA



Sector of system Group 1
 Quadrilateral Elements , lower Cross reinforcements (2nd layer) in Node
 , from 0 to 18.8 step 1.00 cm²/m

① Design Case 1

M 1 : 71

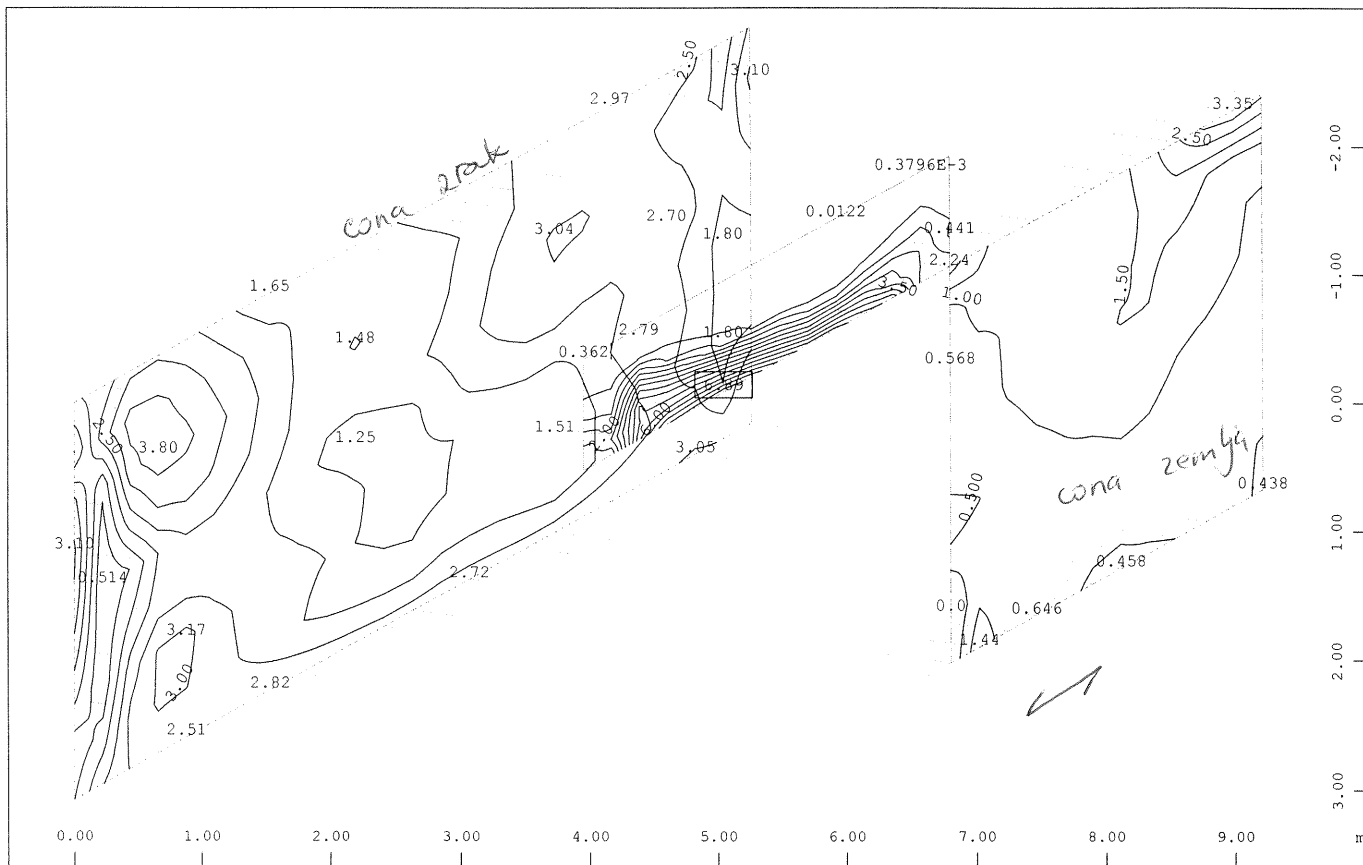


Sector of system Group 1
 Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node
 , from 0 to 16.7 step 1.00 cm²/m

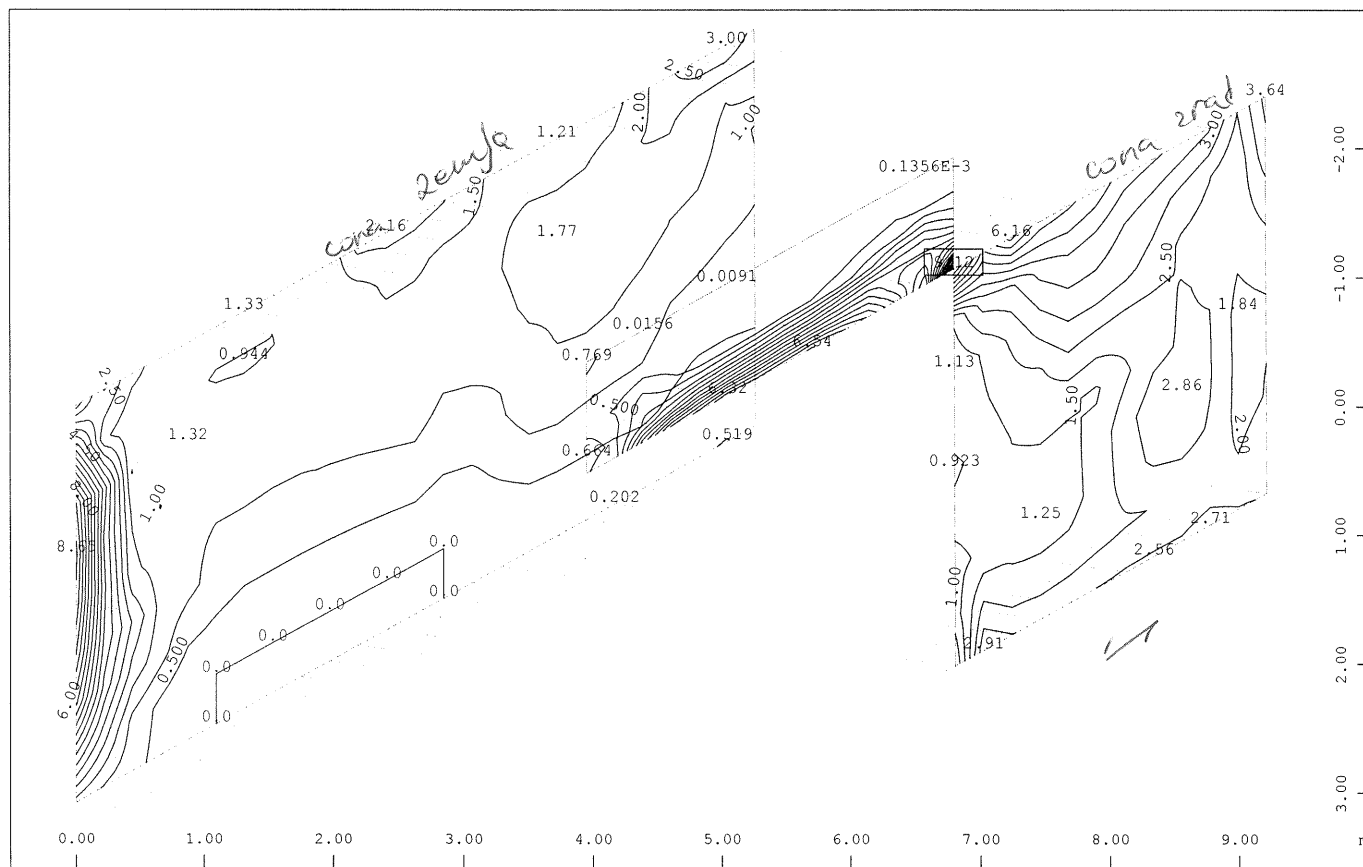
① Design Case 1

M 1 : 71

STEP 1

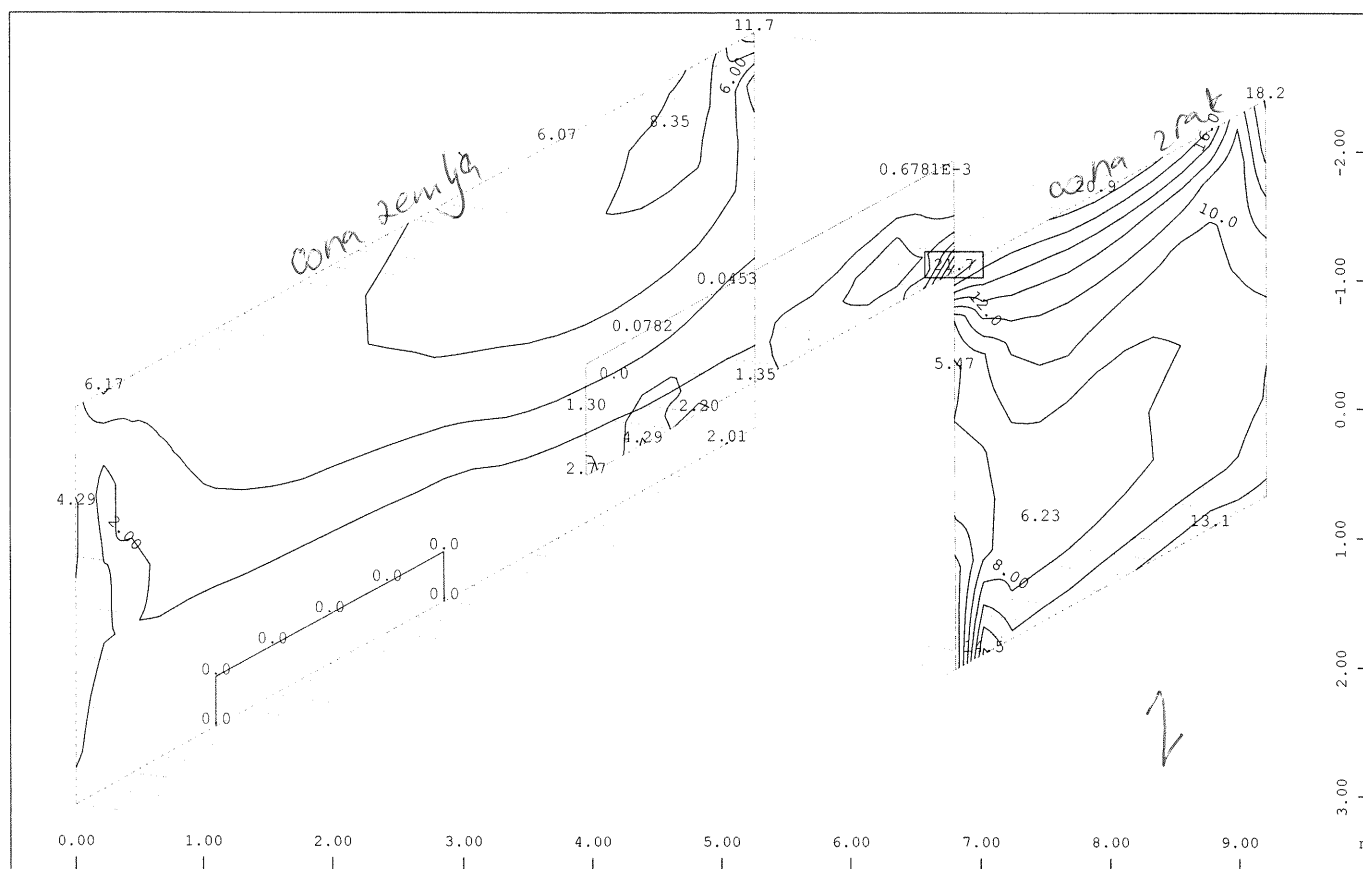


Sector of system Quadrilateral Elements Group 2 4 7
 Quadrilateral Elements , lower Principal reinforcements (1st layer) in Node 1 , from 0 to 6.89 step 0.500 cm²/m
 Z , Design Case
 M 1 : 59
 X * 0.502
 Y * 0.906
 Z * 0.962



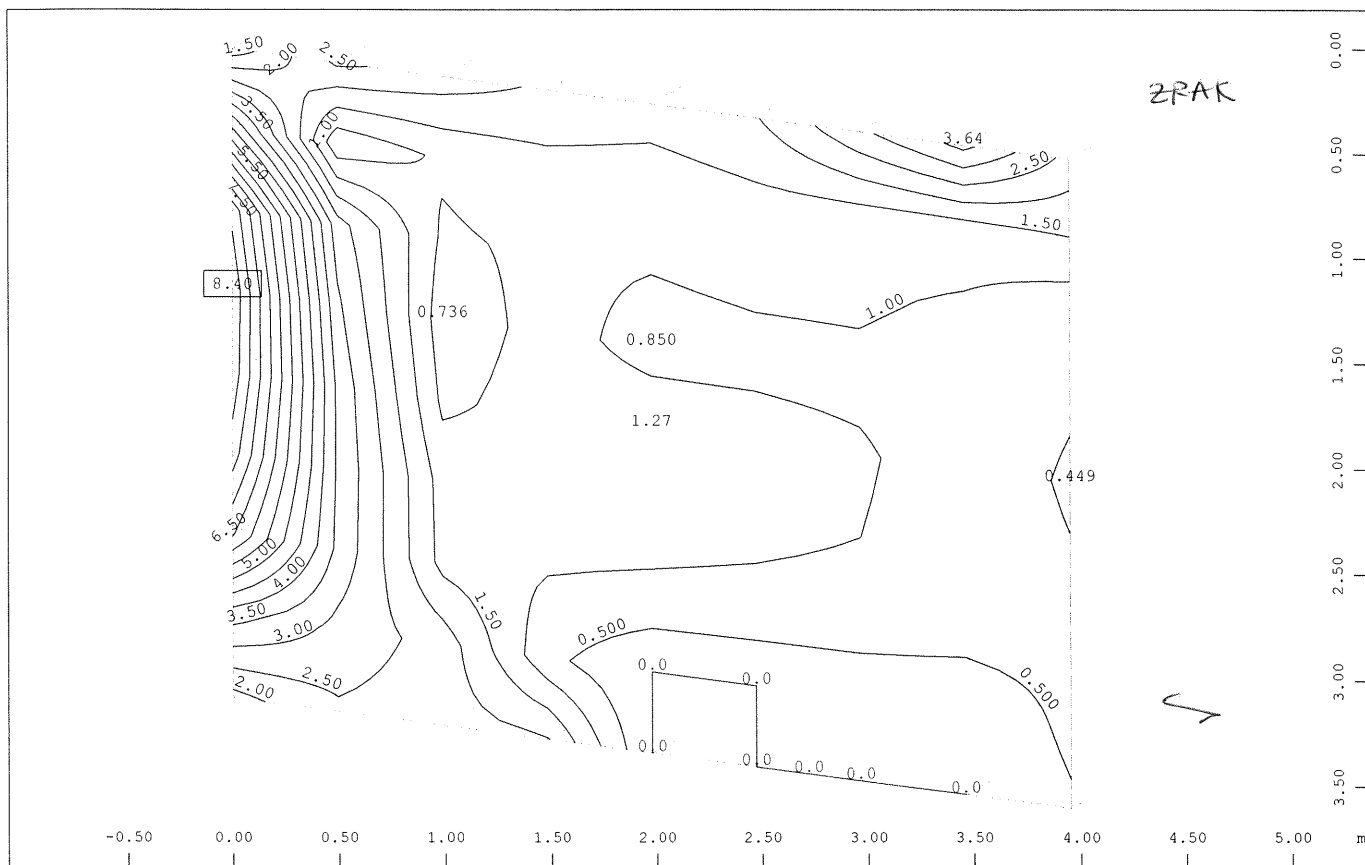
Sector of system Quadrilateral Elements Group 2 4 7
 Quadrilateral Elements , upper Principal reinforcements (1st layer) in Node 1 , from 0 to 9.12 step 0.500 cm²/m
 Z , Design Case
 M 1 : 59
 X * 0.502
 Y * 0.906
 Z * 0.962

```
M 1 : 59
X * 0.502
Y * 0.906
Z * 0.962
```



```
M 1 : 59
X * 0.502
Y * 0.906
Z * 0.962
```

ČELNA STENA

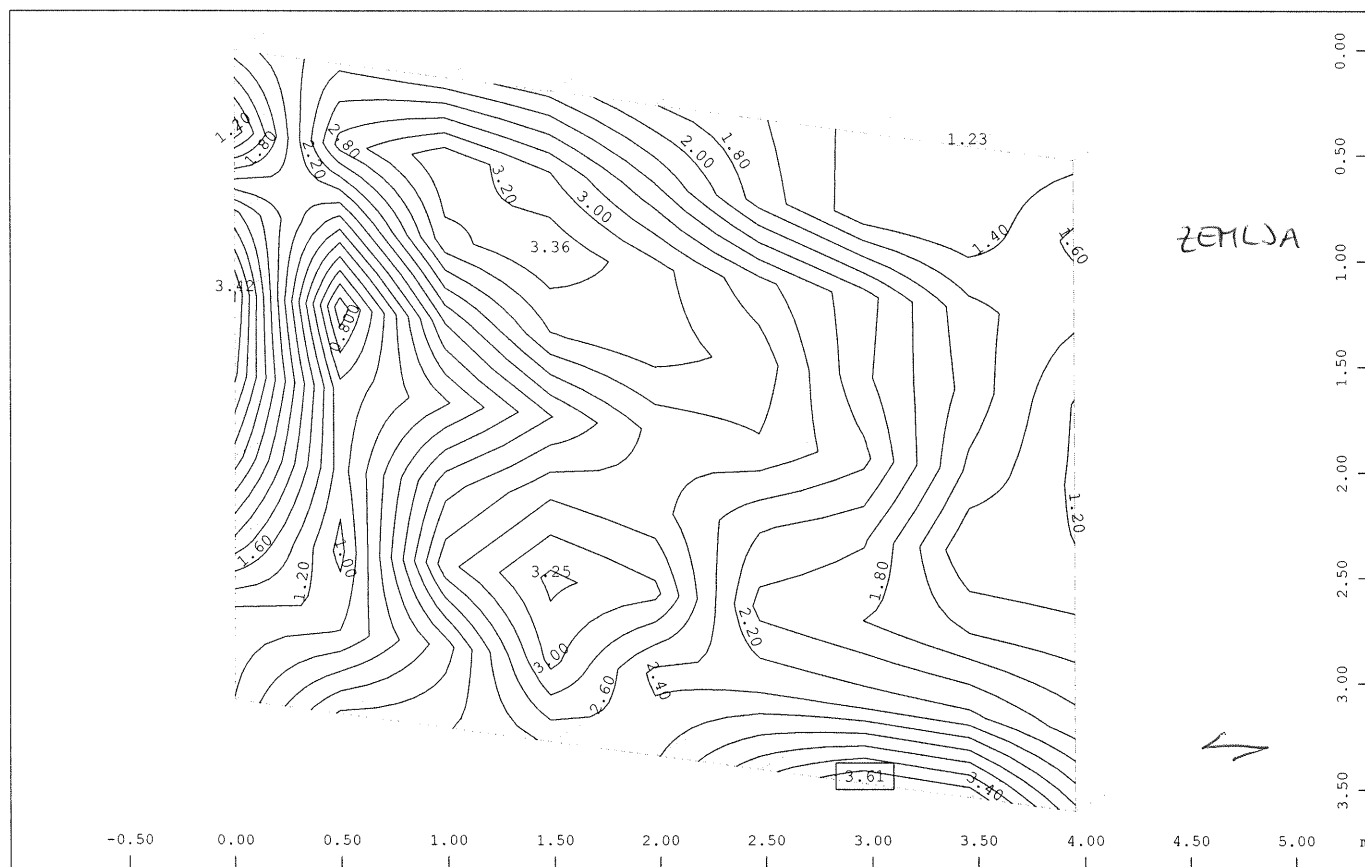


XY
Z

Sector of system Group 5
Quadrilateral Elements , lower Principal reinforcements (1st layer) in Node
1 , from 0 to 8.40 step 0.500 cm²/m

↖, Design Case

M 1 : 36
X * 0.502
Y * 0.906
Z * 0.962



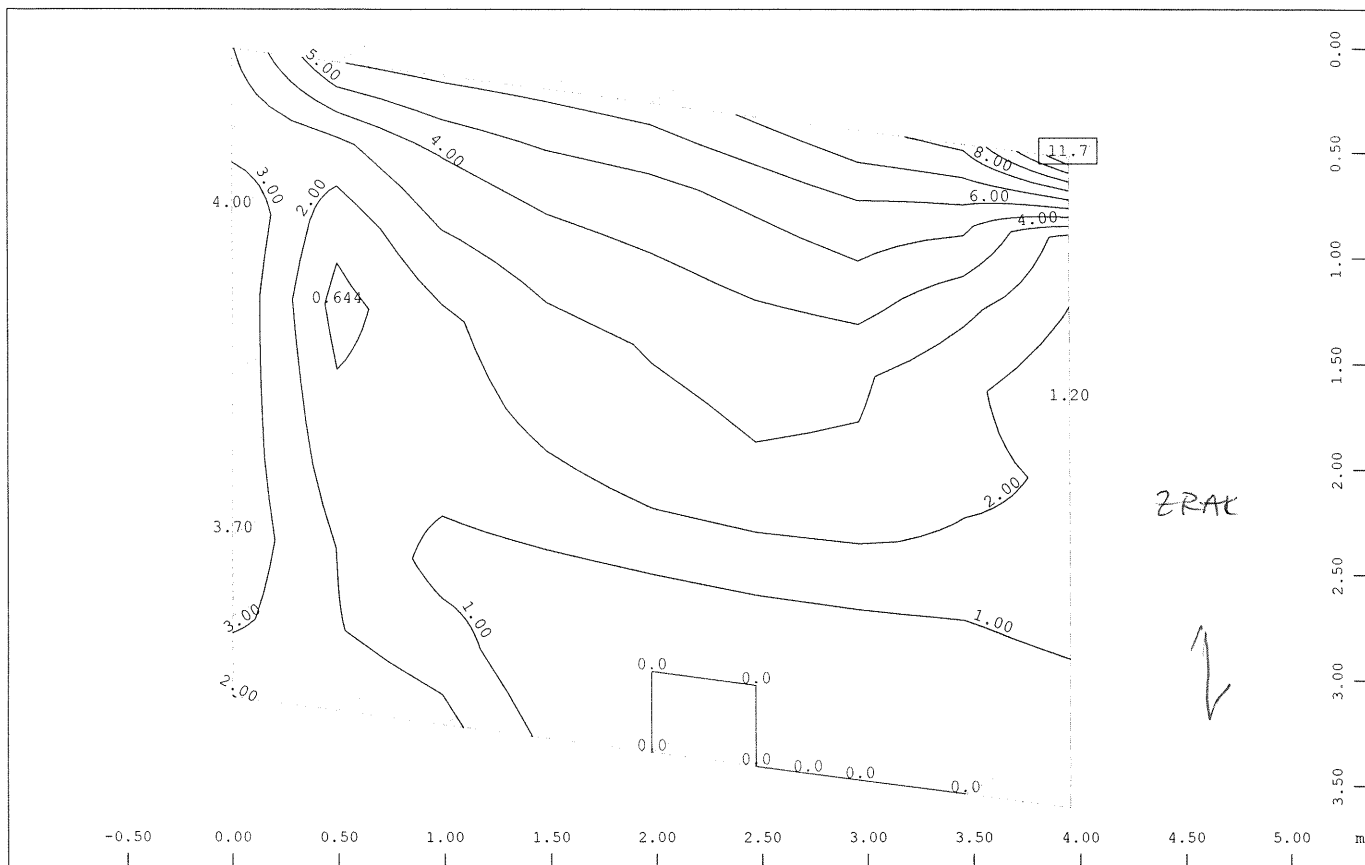
XY
Z

Sector of system Group 5
Quadrilateral Elements , upper Principal reinforcements (1st layer) in Node
1 , from 0.456 to 3.61 step 0.200 cm²/m

↖, Design Case

M 1 : 36
X * 0.502
Y * 0.906
Z * 0.962

CELNA STENA

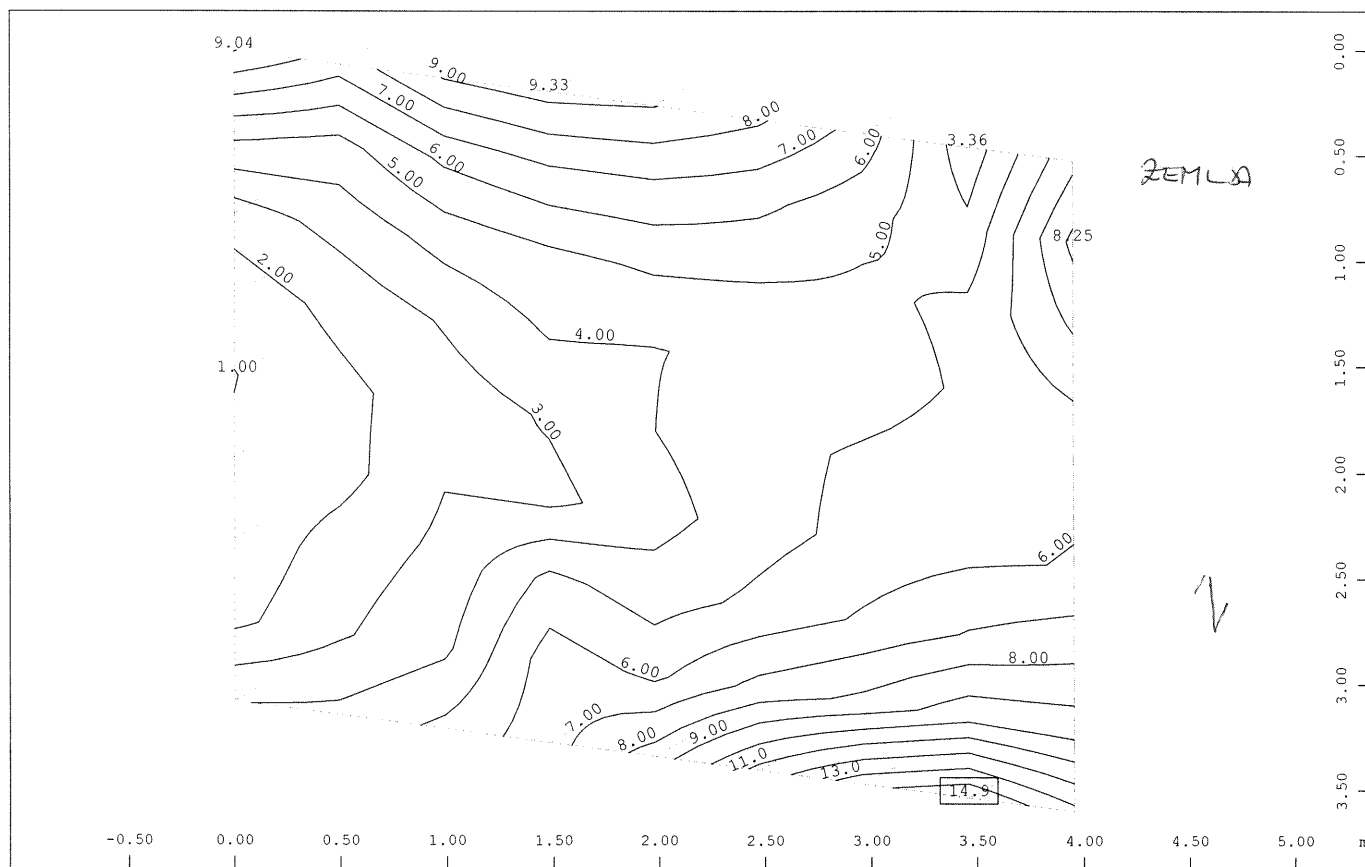


X
Y
Z

Sector of system Group 5
 Quadrilateral Elements , lower Cross reinforcements (2nd layer) in Node
 , from 0 to 11.7 step 1.00 cm²/m

1, Design Case 1

M 1 : 36
 X * 0.502
 Y * 0.906
 Z * 0.962

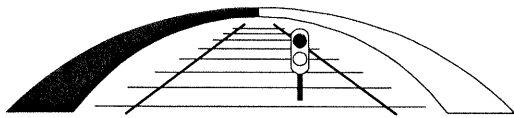


X
Y
Z

Sector of system Group 5
 Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node
 , from 0.970 to 14.9 step 1.00 cm²/m

1, Design Case 1

M 1 : 36
 X * 0.502
 Y * 0.906
 Z * 0.962



2.3.3 Strig

2.3.3.1 Kampada 1 - Prekladna plošča

STRIG

$f_{ck} =$	30	MPa
$f_{yk} =$	500	MPa
$d =$	0.35	m
$b_w =$	1	m
$A_{sl} =$	20.4	cm ²
$A_c =$	3500	cm ²

$$C = 0.12$$

$$k = 1.829$$

$$\rho_1 = 0.00701$$

$$V_{Rd,c} = 176 \text{ kN}$$

$$V_{Ed,zg.plošča} = 180 \text{ kN}$$

Strižna armatura ni potrebna.

2.3.3.2 Kampada 1 - Talna plošča

STRIG

$f_{ck} =$	30	MPa
$f_{yk} =$	500	MPa
$d =$	0.35	m
$b_w =$	1	m
$A_{sl} =$	15.9	cm ²
$A_c =$	3500	cm ²

$$C = 0.12$$

$$k = 1.829$$

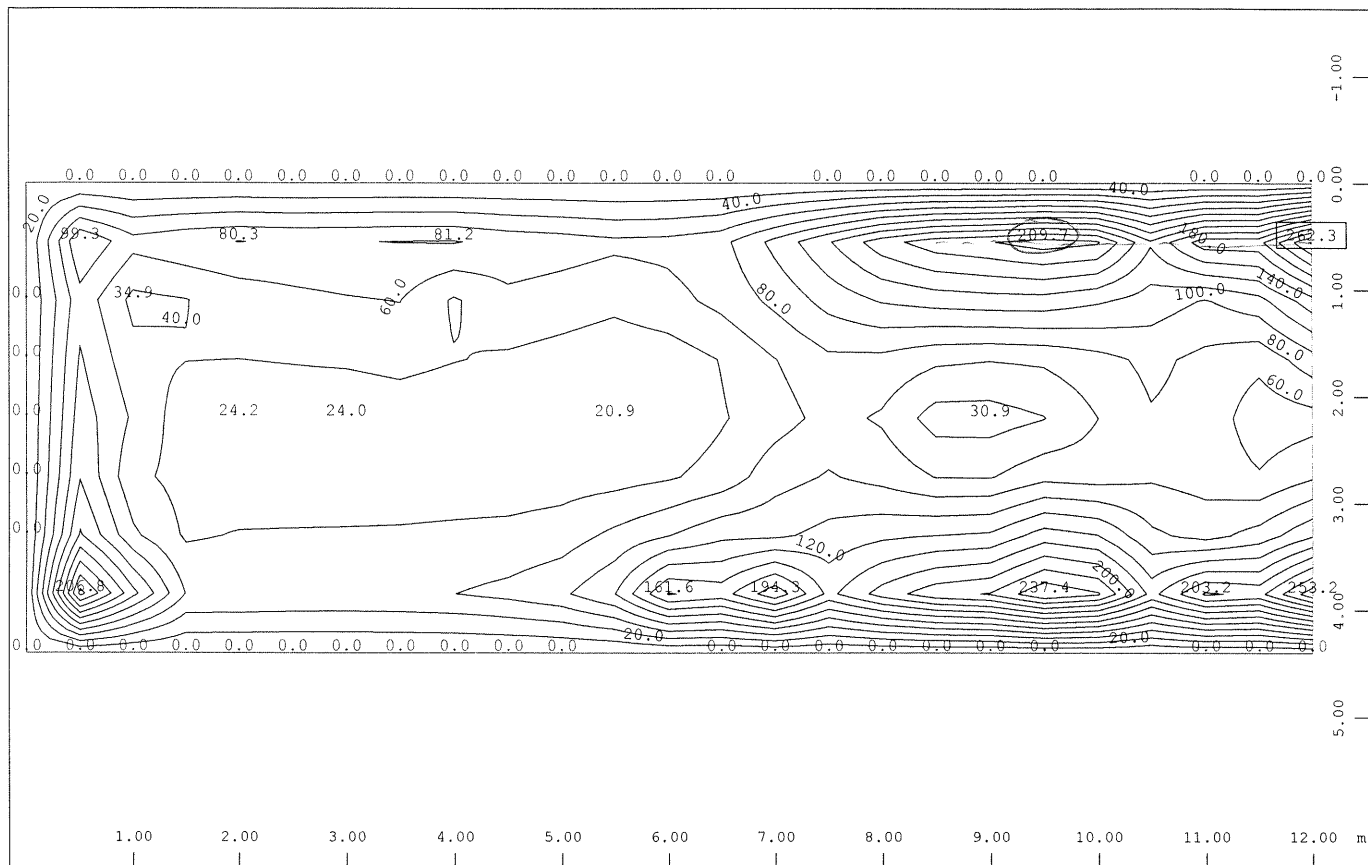
$$\rho_1 = 0.00546$$

$$V_{Rd,c} = 162 \text{ kN}$$

$$V_{Ed,sp.plošča} = 180 \text{ kN}$$

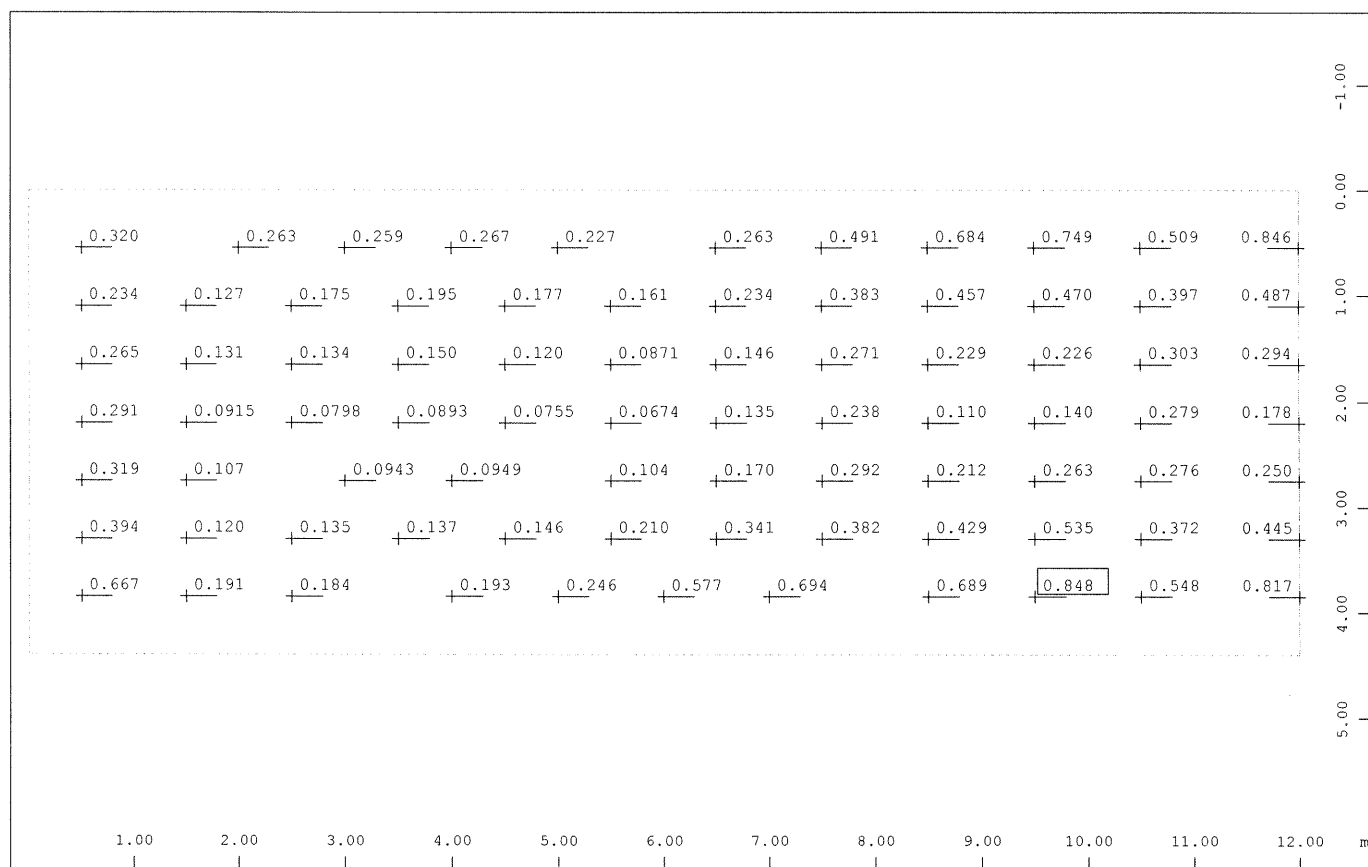
Strižna armatura ni potrebna.

PREKLADNA PLOŠKA



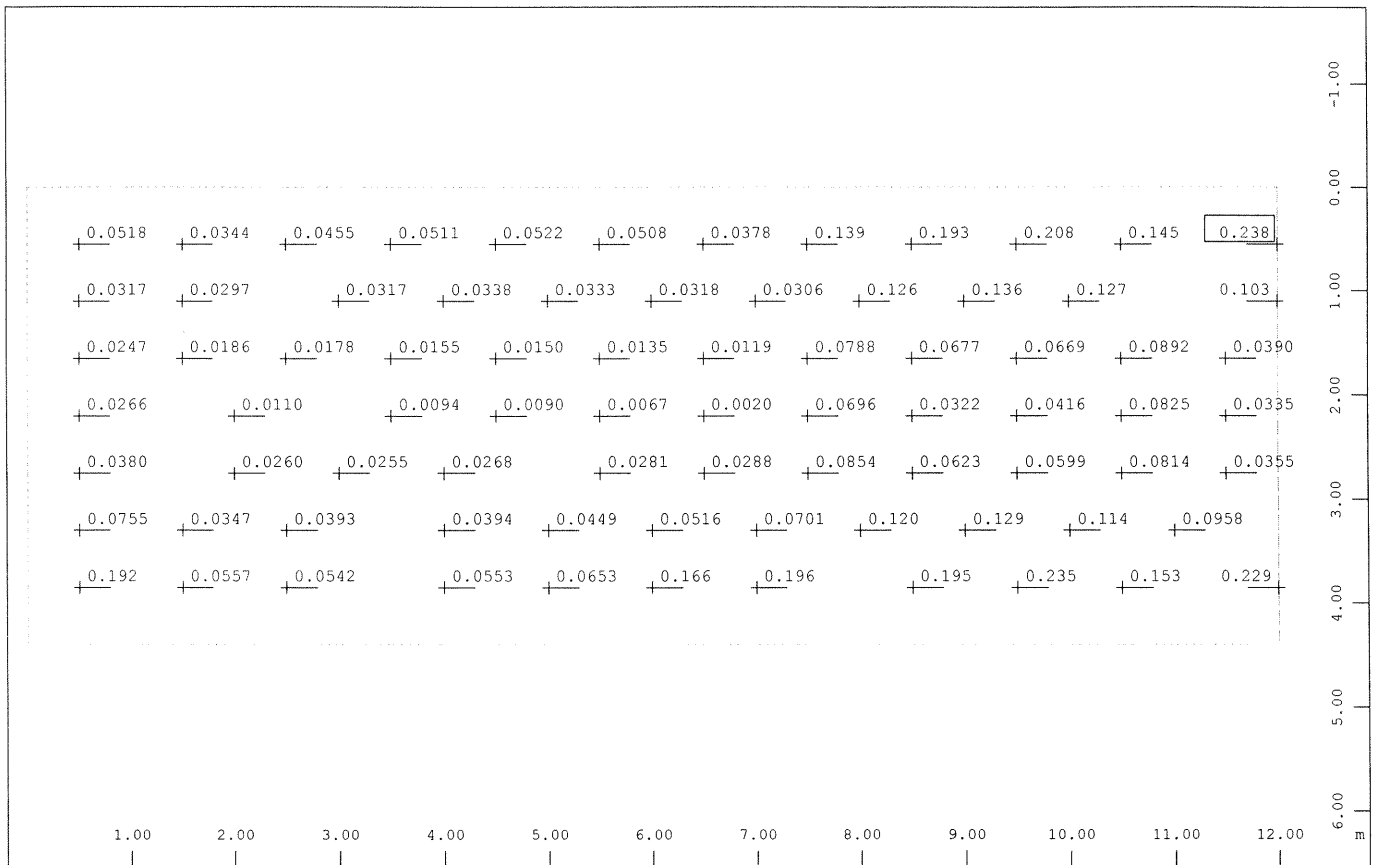
Sector of system Group 3
Maximum design shear force VSD in Node, Design Case 2, from 0 to 262.3 step 20.0 kN/m

M 1 : 71



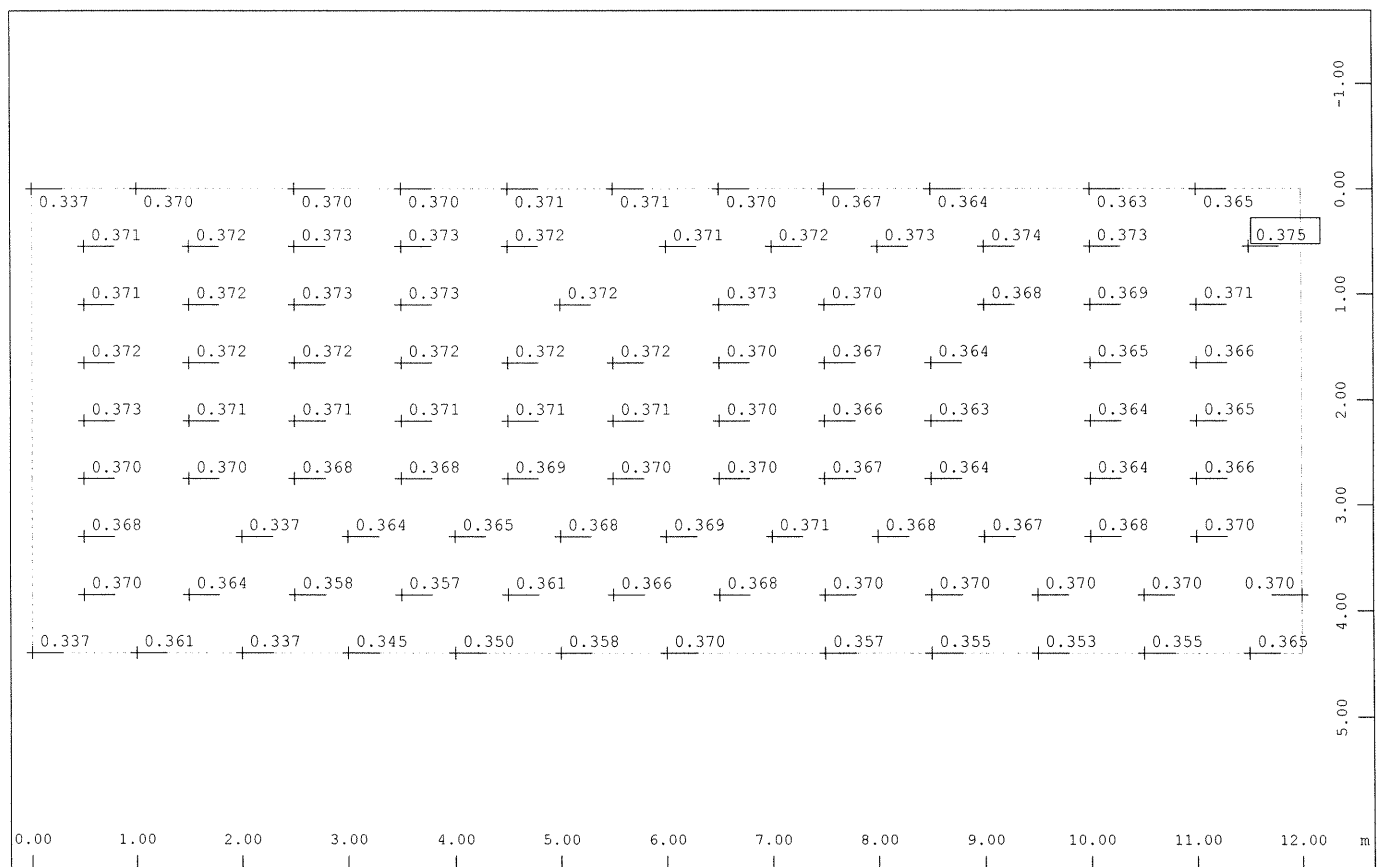
Sector of system Group 3
Quadrilateral Elements, Design shear stress $v=V/(b \cdot d)$ in Node in MPa, Design Case 2
(Max=0.848)

M 1 : 72



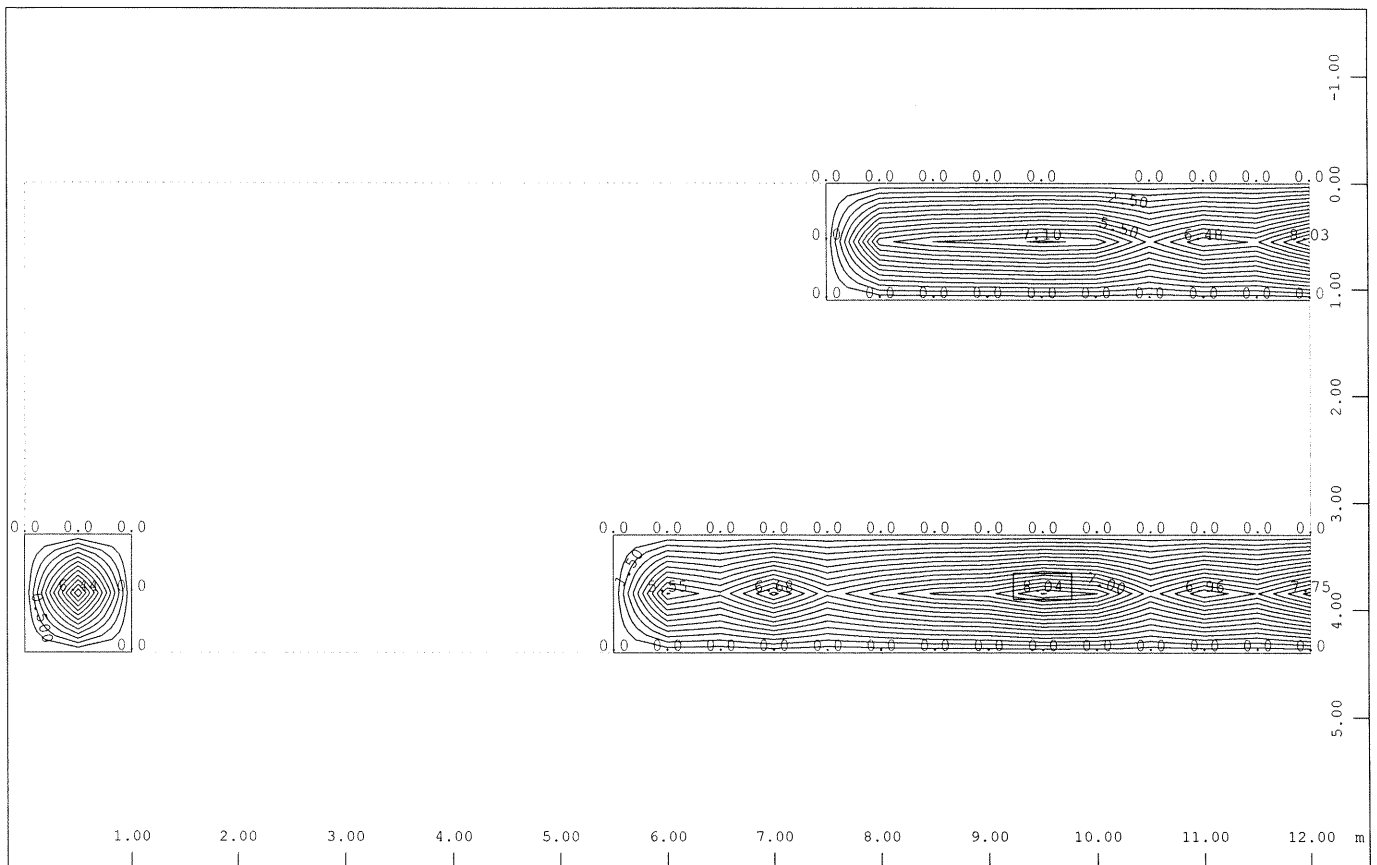
Sector of system Group 3
max.VED / VRDmax in Node, Design Case 2 (Max=0.238)

M 1 : 73



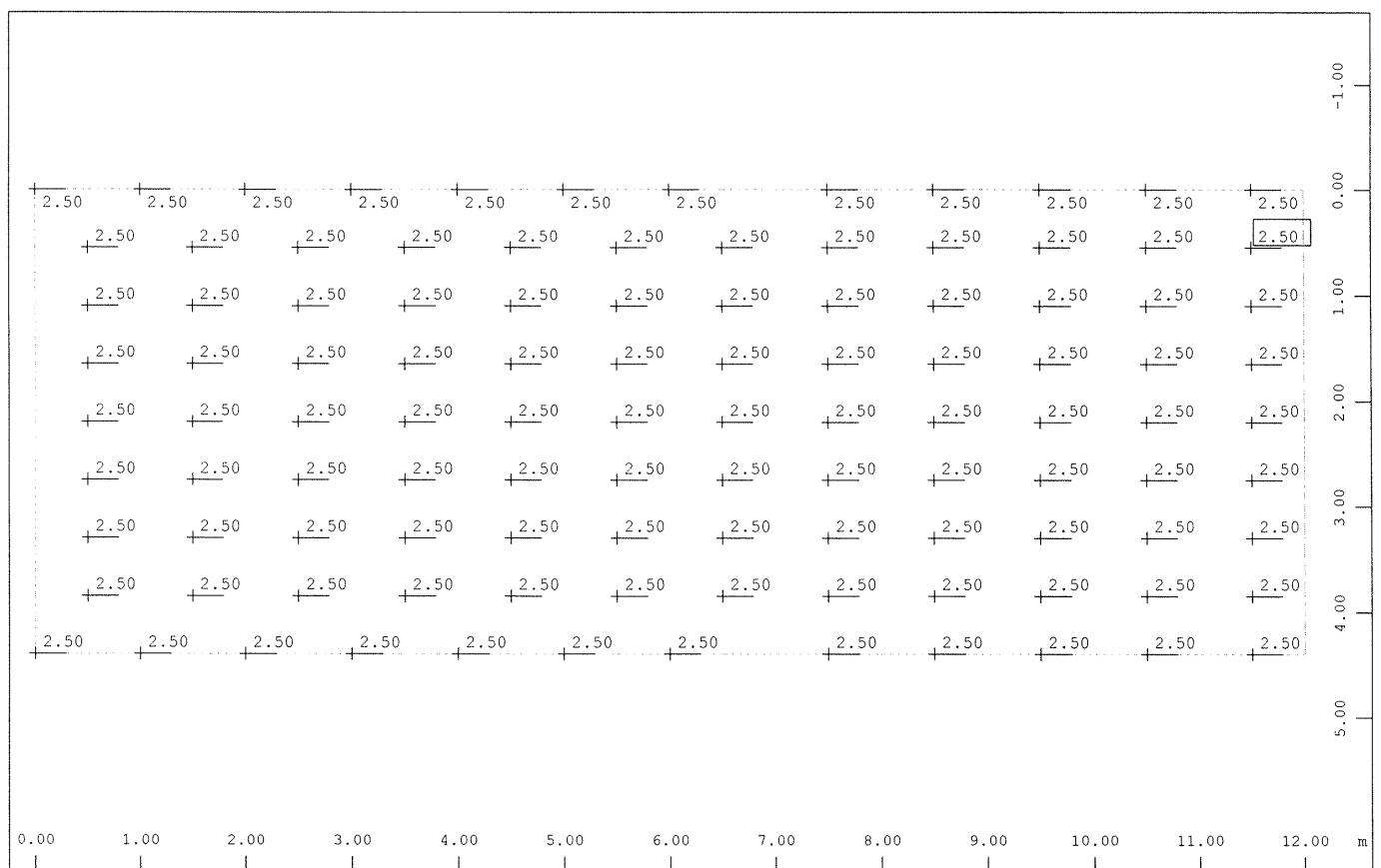
Sector of system Group 3
Shift rule value (not considered in reinforcement) in Node in m, Design Case 2
(Max=0.375)

M 1 : 72



Sector of system Group 3
 Quadrilateral Elements , Shear reinforcement in Node \bigcirc , Design Case 2 , from 0 to 8.04
 step 0.500 cm²/m²

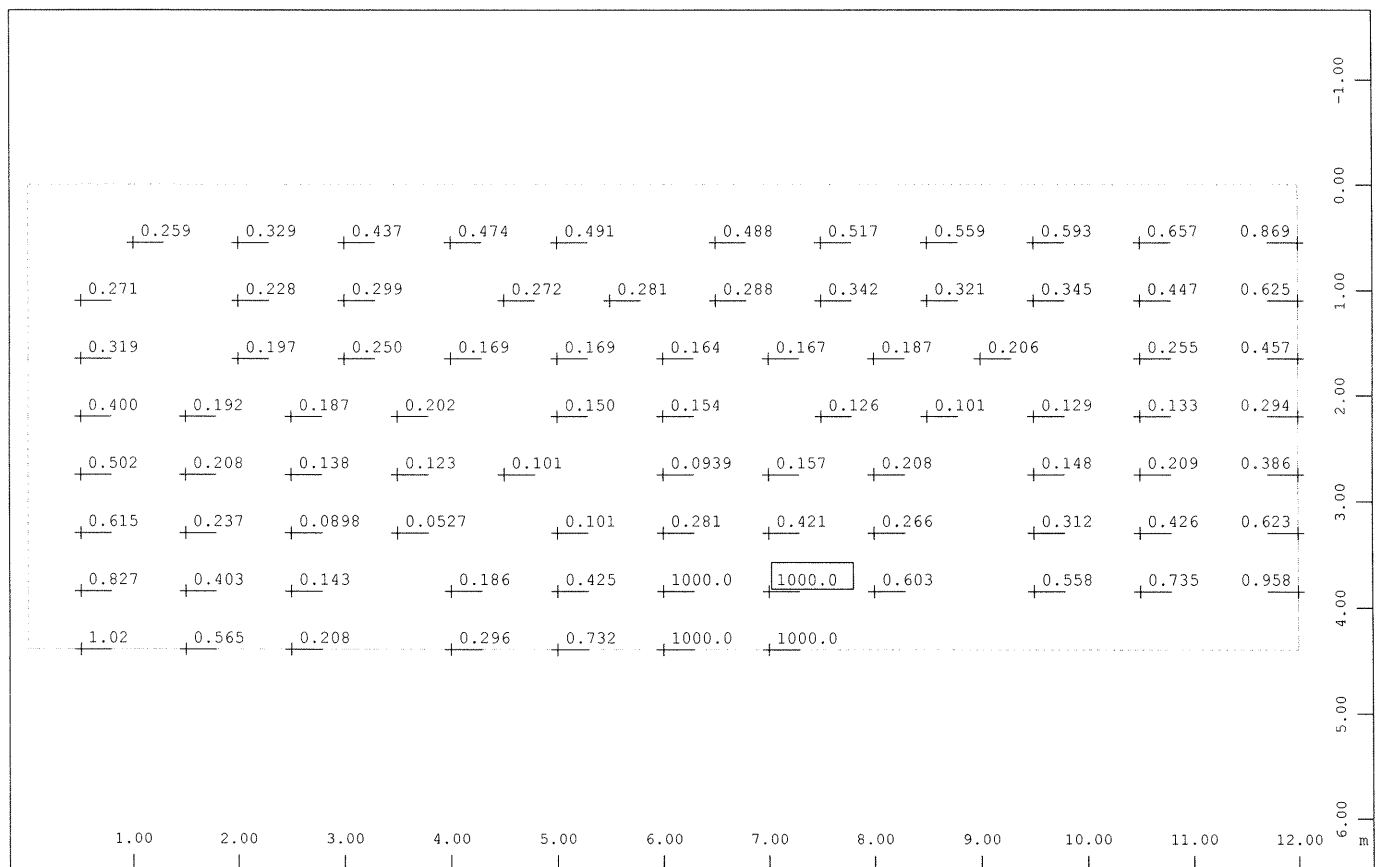
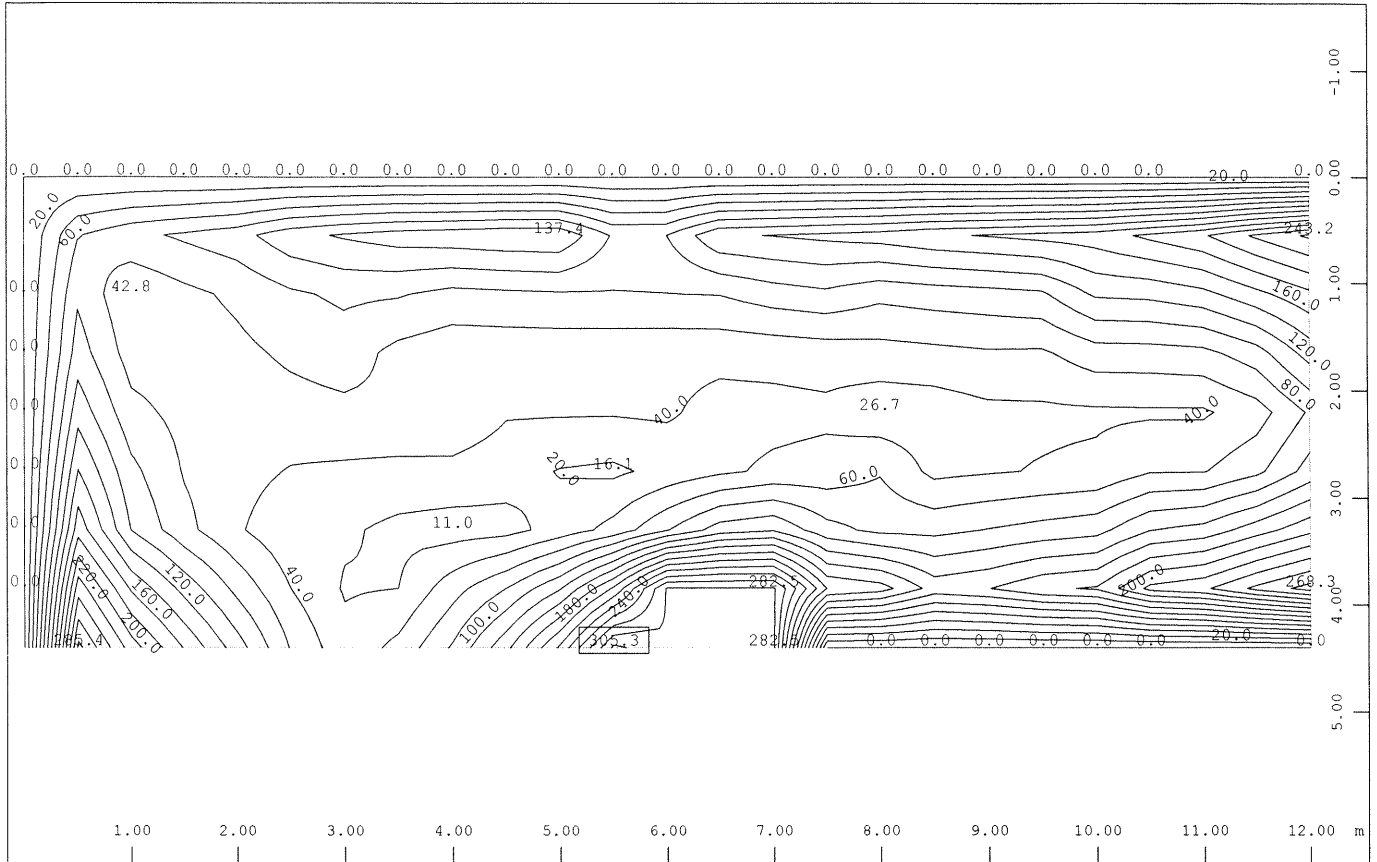
M 1 : 71

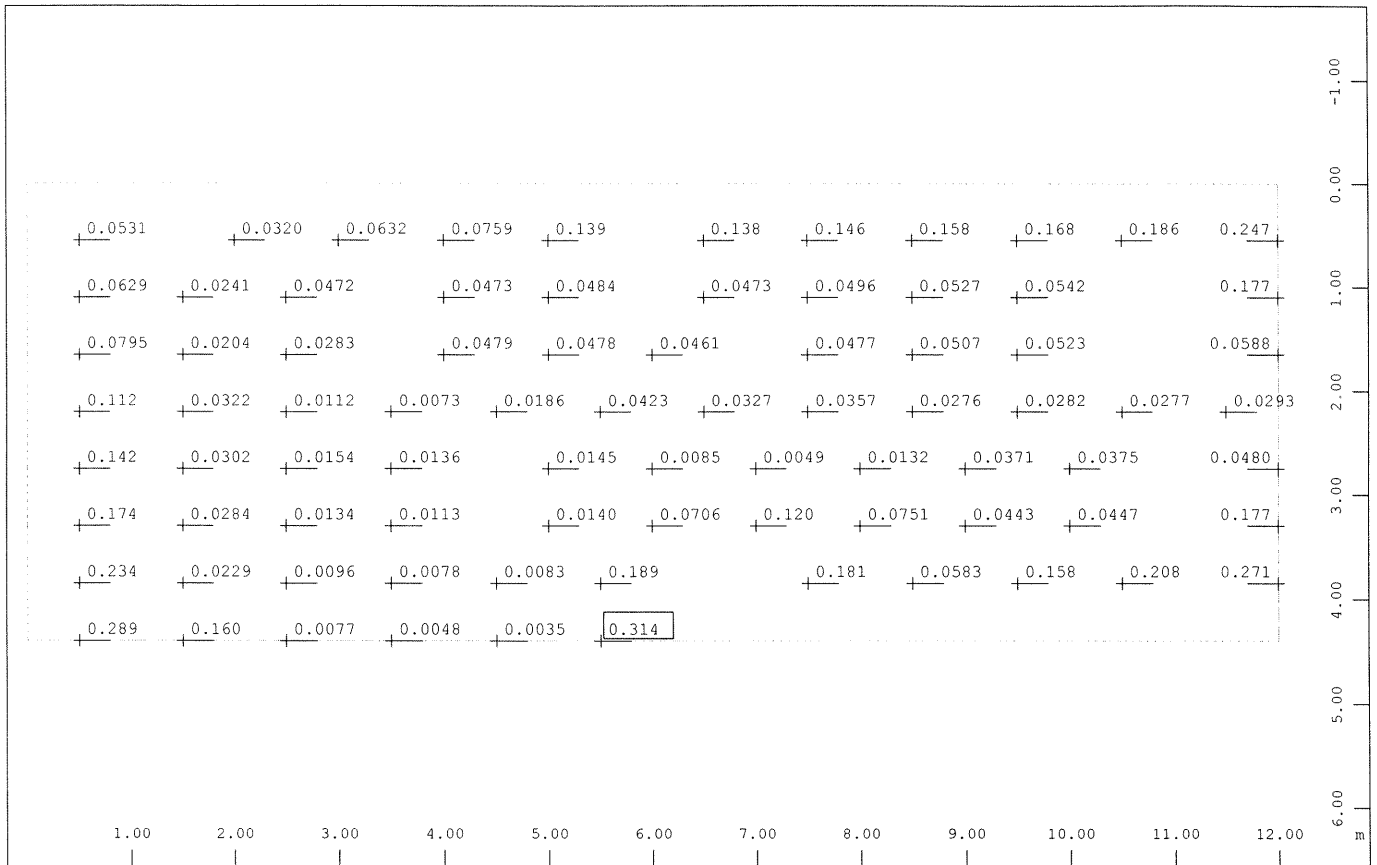


Sector of system Group 3
 maximum cot-theta in Node, Design Case 2 (Max=2.50)

M 1 : 72

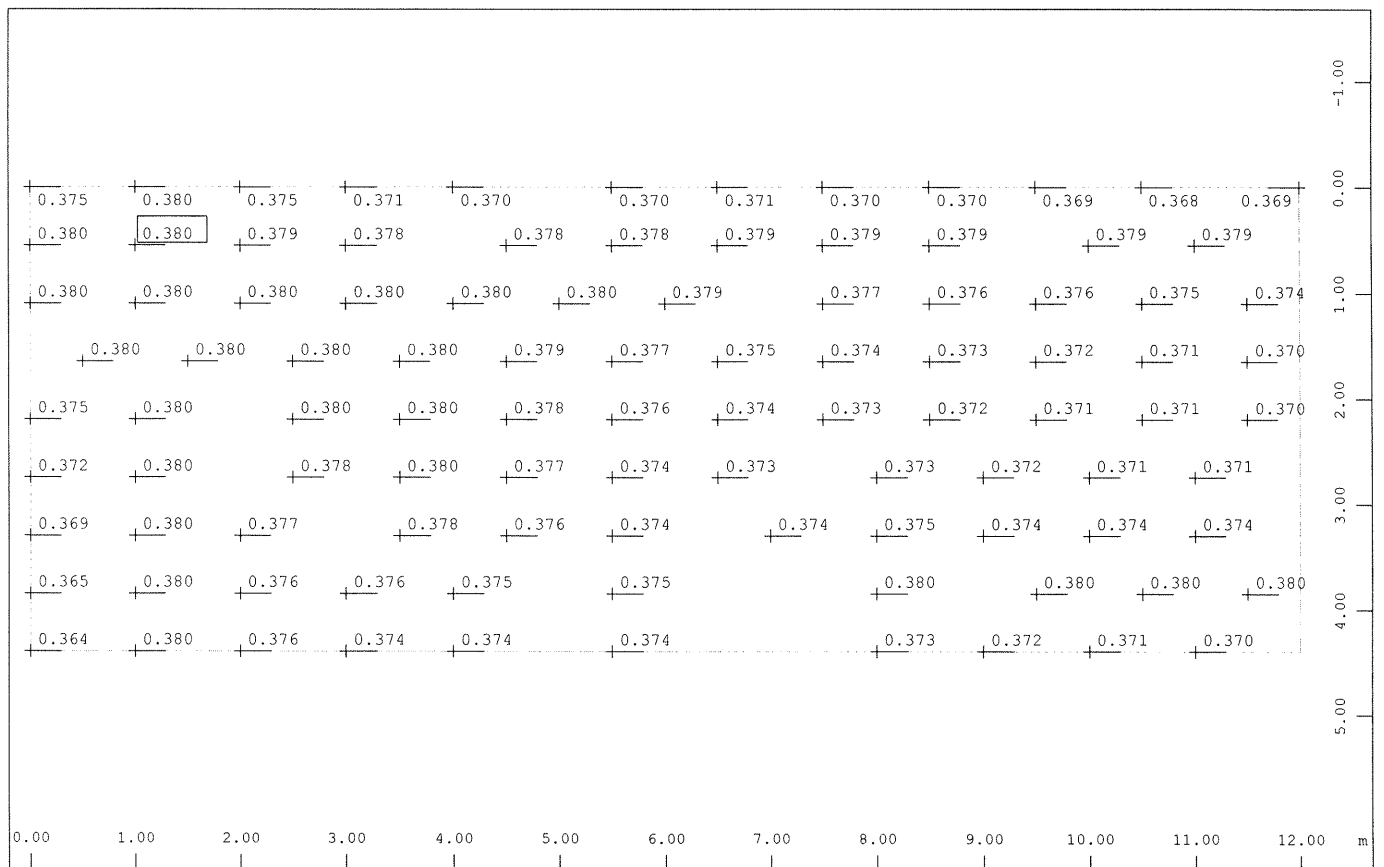
TALNA PLOSCA





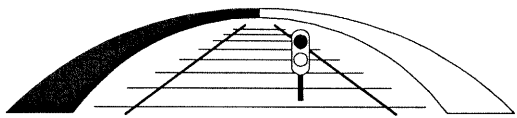
Sector of system Group 1
max.VED / VRDmax in Node, Design Case 2 (Max=0.314)

M 1 : 73



Sector of system Group 1
Shift rule value (not considered in reinforcement) in Node in m, Design Case 2
(Max=0.380)

M 1 : 72



2.4 SLS – MEJNO STANJE UPORABNOSTI

2.4.1 Obtežne kombinacije

CR (*characteristic-rare*)

→ dominantna je prometna obtežba

$$1,0 \times G + 1,0 \times E_m + 1,0(\phi \times p_v + 1,0(0) \times Q_z) + 1,0(0) \times p_h + 0,6 \times T$$

→ dominantna je temperaturna obtežba

$$1,0 \times G + 1,0 \times E_m + 0,8(\phi \times p_v + 1,0(0) \times Q_z) + 0,8(0) \times p_h + 1,0 \times T$$

F (*frequent*)

→ dominantna je prometna obtežba

$$1,0 \times G + 1,0 \times E_m + 0,8(\phi \times p_v + 1,0(0) \times Q_z) + 1,0(0) \times p_h + 0,5 \times T$$

→ dominantna je temperaturna obtežba

$$1,0 \times G + 1,0 \times E_m + 0,0(\phi \times p_v + 1,0(0) \times Q_z) + 0,8(0) \times p_h + 1,0 \times T$$

QP (*quasi permanent*)

$$1,0 \times G + 1,0 \times E_m + 0,5 \times T$$

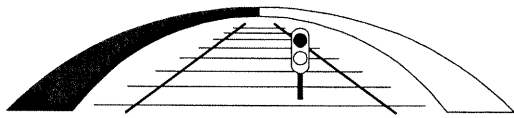
Za kontrolo razpok je merodajna kombinacija QP, kjer razpoke v tem primeru ne sme preseči 0,3 mm.

Ker je vodotesnost konstrukcije predvidena po tehnologiji bele kadi, so razpoke v stenah in talni plošči omejene na 0,20 mm. Dimenzionirane so pri kombinaciji SLS-F.

2.4.2 Kontrole

Tlačne napetosti v betonu

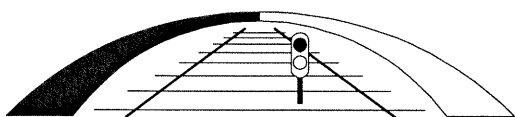
$$\sigma_{c,max} = 7,0 \text{ MPa} < 0,6 f_{ck} = 0,6 \cdot 30 = 18 \text{ MPa} \dots \text{O.K}$$



Razpoke

Razpoke so v stenah s stikom z zemljo in spodnji plošči zaradi tehnologije 'bele kadi' omejene na 0,2mm (kombinacija SLS-F). Minimalna armatura zaradi tehnologije 'bele kadi' je v stenah debeline 35 cm $\Phi 14/15$ cm.

V zgornji plošči so razpoke omejene na 0,3mm (kombinacija QP).



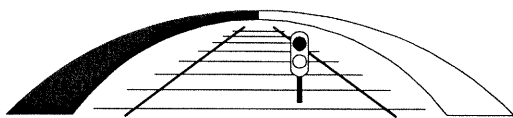
2.4.2.1 Prekladna plošča

RAZPOKE prekladna plošča-sredina-SLS QP

potrebna arm. A_s (cm ²)	20.9		
premer arm. Φ (mm)	20		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	67		
osna sila N_{prip} (kN) ... - tlak / + nateg	0		
visina prereza h ... (cm)	38	32.5	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFOICIENTI			
koef.sprijem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef. trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca $b=100$ cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	67.00		
nap.v arm. σ_s (kN/cm ²)	10.85		
nap.v arm.brez upost.osne sile σ'_s	10.85		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	11.04		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1104		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.019		
$5*(c+\Phi/2)$	27.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	333		
$\varepsilon_{sm} - \varepsilon_{cm}$	0.00033		
w_k ... karakteristčna sirina razpok (mm)	0.108	$< w_{dop} = 0,30$ mm	OK

PREKLADNA PLOŠČA: spodnja armatura-sredina plošče

Φ 20/15

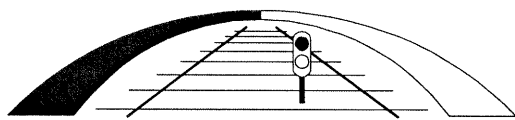


RAZPOKE prekladna plošča - rob -SLS QP

potrebna arm. A_s (cm ²)	20.9		
premer arm. ϕ (mm)	20		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	80		
osna sila N_{prip} (kN) ... - tlak / + nateg	0		
visina prereza h ... (cm)	35	29.5	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFOICIENTI			
koef.sprijem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef. trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca b=100cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	80.00		
nap.v arm. σ_s (kN/cm ²)	14.27		
nap.v arm.brez upost.osne sile σ'_s	14.27		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	10.19		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1019		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.021		
$5*(c+\phi/2)$	27.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	319		
$\varepsilon_{sm} - \varepsilon_{cm}$	0.00043		
w_k ... karakteristicna sirina razpok (mm)	0.137	$< w_{dop} = 0,30mm$	OK

TALNA PLOŠČA: rob

ϕ 20/15



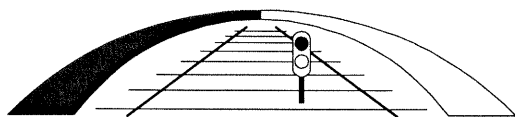
2.4.2.2 Talna plošča

RAZPOKE talna plošča - sredina -SLS F

potrebna arm. A_s (cm ²)	20.9		
premer arm. ϕ (mm)	20		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	95		
osna sila N_{prip} (kN) ... - tlak / + nateg	0		
visina prereza h ... (cm)	35	29.5	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFIGIENTI			
koef.sprijem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef. trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca b=100cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	95.00		
nap.v arm. σ_s (kN/cm ²)	16.95		
nap.v arm.brez upost.osne sile σ'_s	16.95		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	10.19		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1019		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.021		
$5*(c+\phi/2)$	27.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	319		
$\varepsilon_{sm} - \varepsilon_{cm}$	0.00053		
w_k ... karakteristčna sirina razpok (mm)	0.169	< $w_{dop} = 0,20mm$	OK

TALNA PLOŠČA: sredina

ϕ 20/15

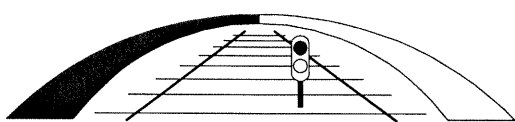


RAZPOKE talna plošča - rob -SLS F

potrebna arm. A_s (cm ²)	20.9		
premer arm. ϕ (mm)	20		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	85		
osna sila N_{prip} (kN) ... - tlak / + nateg	0		
visina prereza h ... (cm)	35	29.5	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFIICIENTI			
koef.sprjem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef. trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca b=100cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	85.00		
nap.v arm. σ_s (kN/cm ²)	15.16		
nap.v arm.brez upost.osne sile σ'_s	15.16		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	10.19		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1019		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.021		
$5*(c+\phi/2)$	27.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	319		
$\varepsilon_{sm} - \varepsilon_{cm}$	0.00045		
w_k ... karakteristčna sirina razpok (mm)	0.145	$< w_{dop} = 0,20mm$	OK

TALNA PLOŠČA: rob

ϕ 20/15



2.4.2.3 Stene

RAZPOKE stena-SLS F

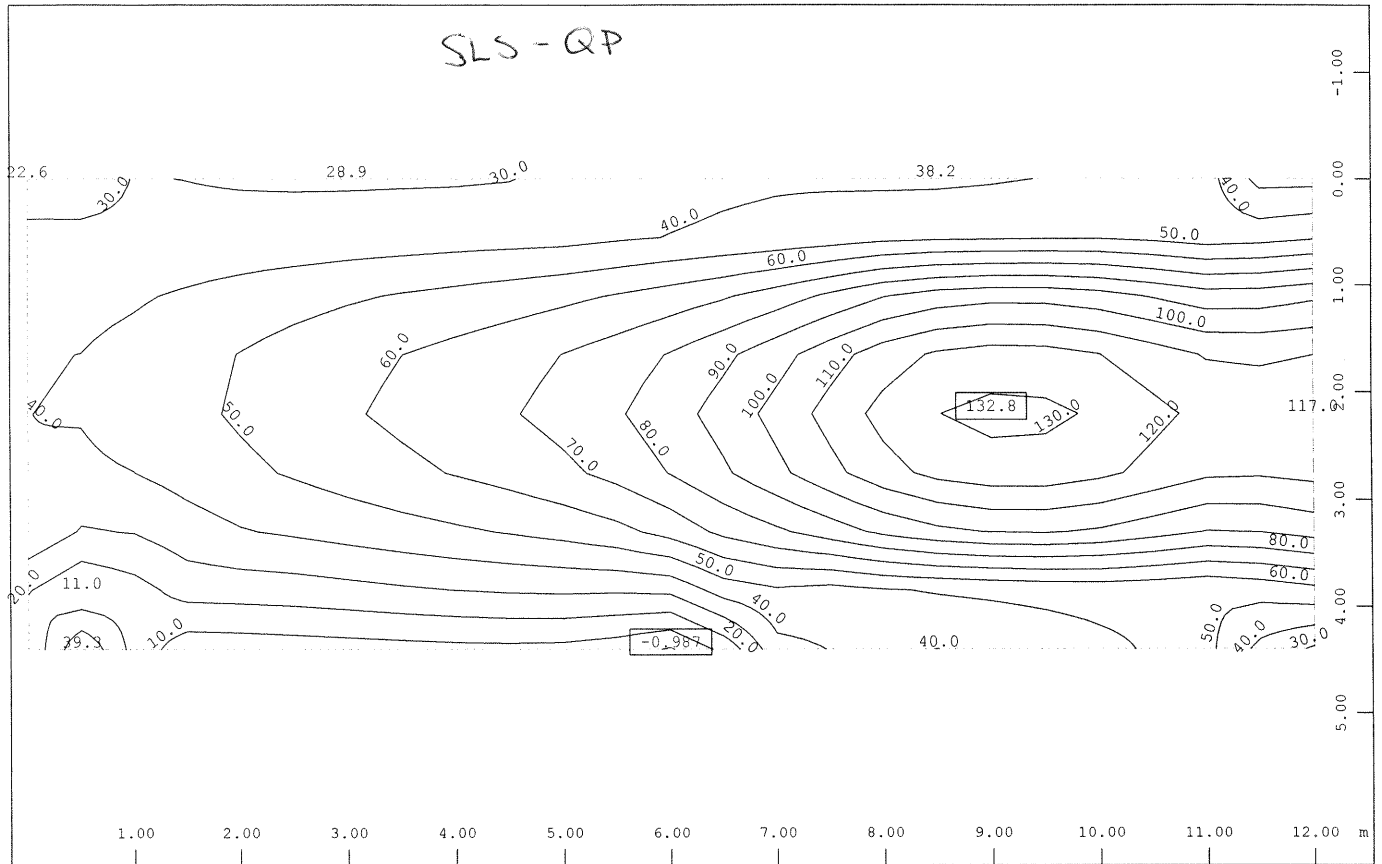
potrebna arm. A_s (cm ²)	20.9		
premer arm. Φ (mm)	20		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	110		
osna sila N_{prip} (kN) ... - tlak / + nateg	-100		
visina prereza h ... (cm)	35	29.5	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFOICIENTI			
koef.sprijem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef.trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca b=100cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	122.00		
nap.v arm. σ_s (kN/cm ²)	16.98		
nap.v arm.brez upost.osne sile σ'_s	19.63		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	10.19		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1019		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.021		
$5*(c+\Phi/2)$	27.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	319		
$\varepsilon_{sm} - \varepsilon_{cm}$	0.00053		
w_k ... karakteristčna sirina razpok (mm)	0.169	$< w_{dop} = 0,20mm$	OK

STENA ZG. in SP.

Φ 20/15

PREKLADNA PLOŠKA

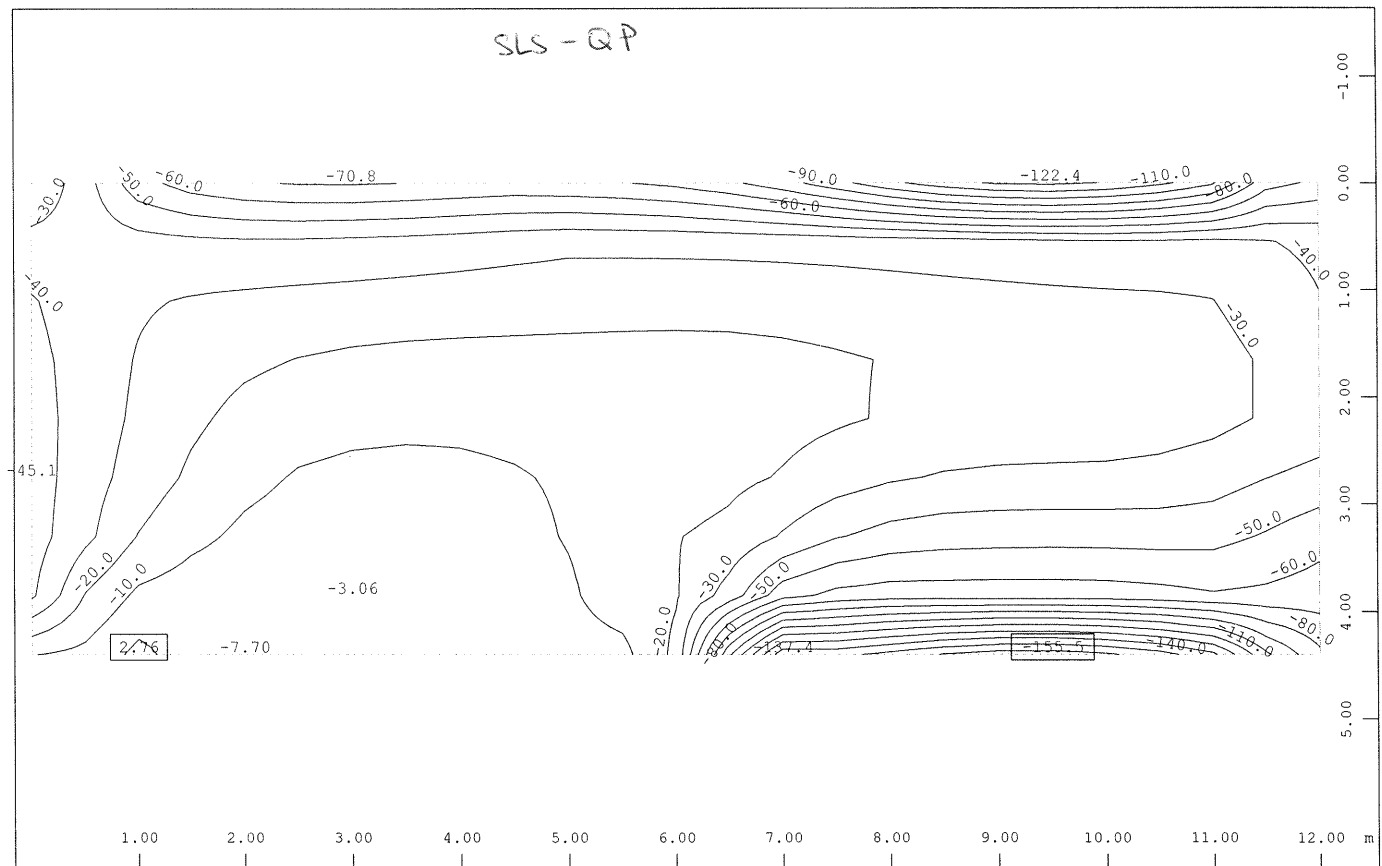
SLS - QP



Sector of system Group 3
Bending moment m-yy in local y in Node \updownarrow , Loadcase 7003 MAX-MY QUAD, from -0.987 to 132.8 step 10.0 kNm/m

M 1 : 71

SLS - QP

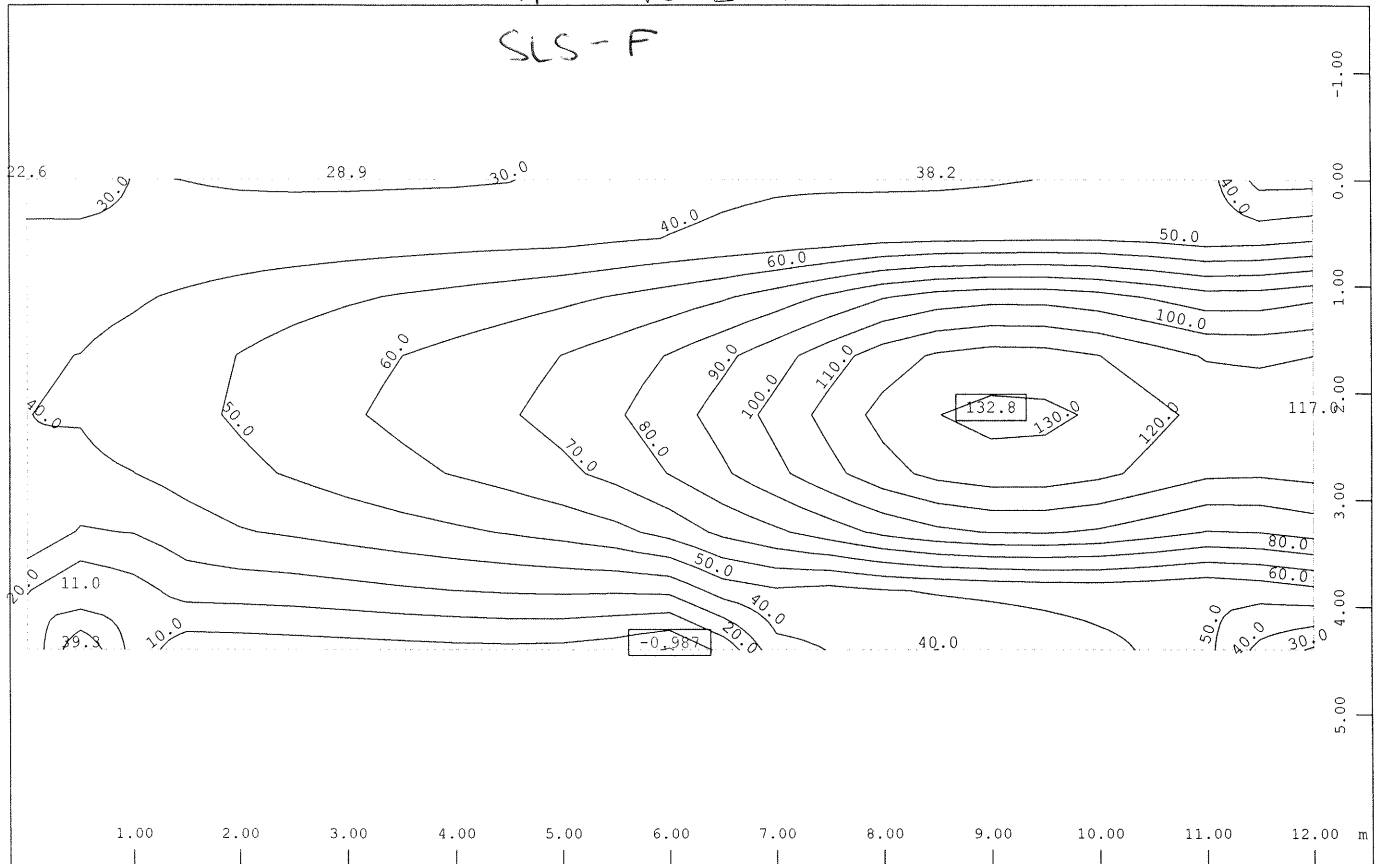


Sector of system Group 3
Bending moment m-yy in local y in Node \updownarrow , Loadcase 7004 MIN-MY QUAD, from -155.5 to 2.76 step 10.0 kNm/m

M 1 : 71

PREKLADNA PLOŠŤA

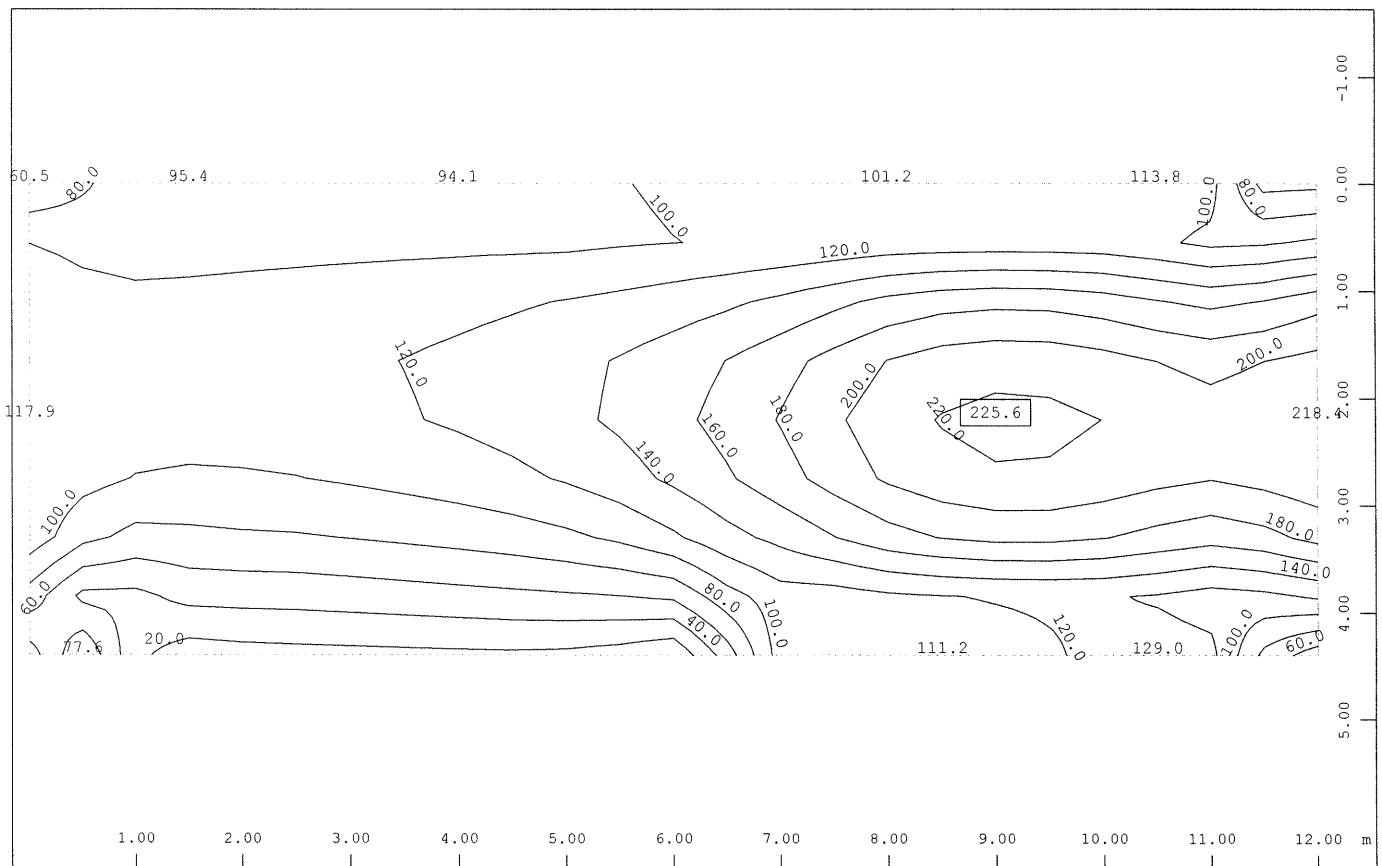
SLS - F



X
Y

Sector of system Group 3
Bending moment m_{yy} in local y in Node 132.8 step 10.0 kNm/m

M 1 : 71

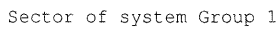


X
Y

Sector of system Group 3
Bending moment m_{yy} in local y in Node 225.6 step 20.0 kNm/m

M 1 : 71

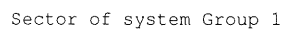
SLS - F



M 1 : 71

$$\begin{array}{c} \text{Z} - \text{X} \\ | \\ \text{Y} \end{array}$$

Bending moment m-yy in local y in Node \updownarrow , Loadcase 7003 MAX-MY QUAD , from -11.6 to 125.9
step 10.0 kNm/m



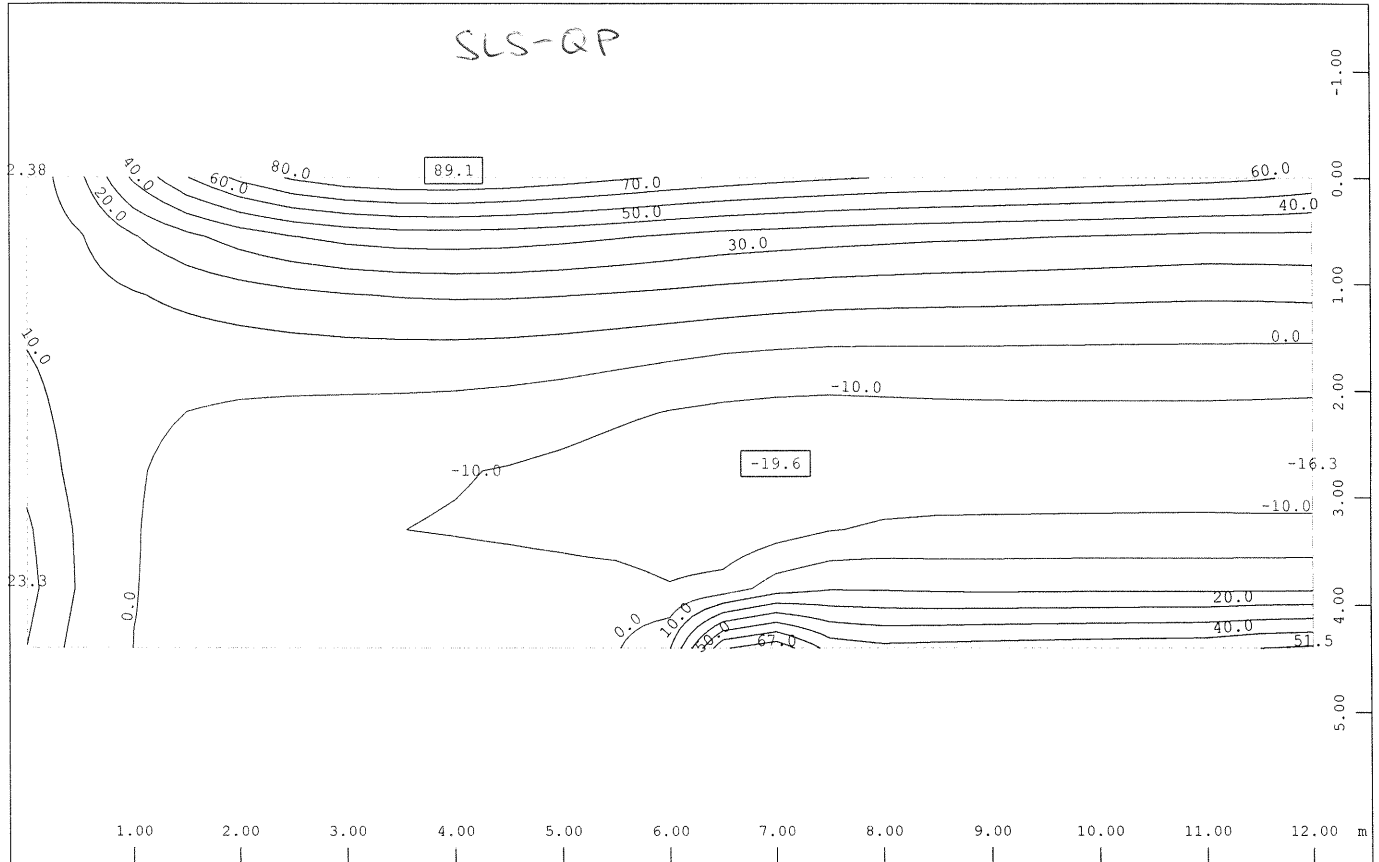
M 1 : 71

$$\begin{array}{c} Z-X \\ | \\ Y \end{array}$$

Bending moment m-yy in local y in Node \updownarrow , Loadcase 7004 MIN-MY QUAD, from -115.5 to 18.6
step 10.0 kNm/m

TALNA PLOŠTA

SLS-QP

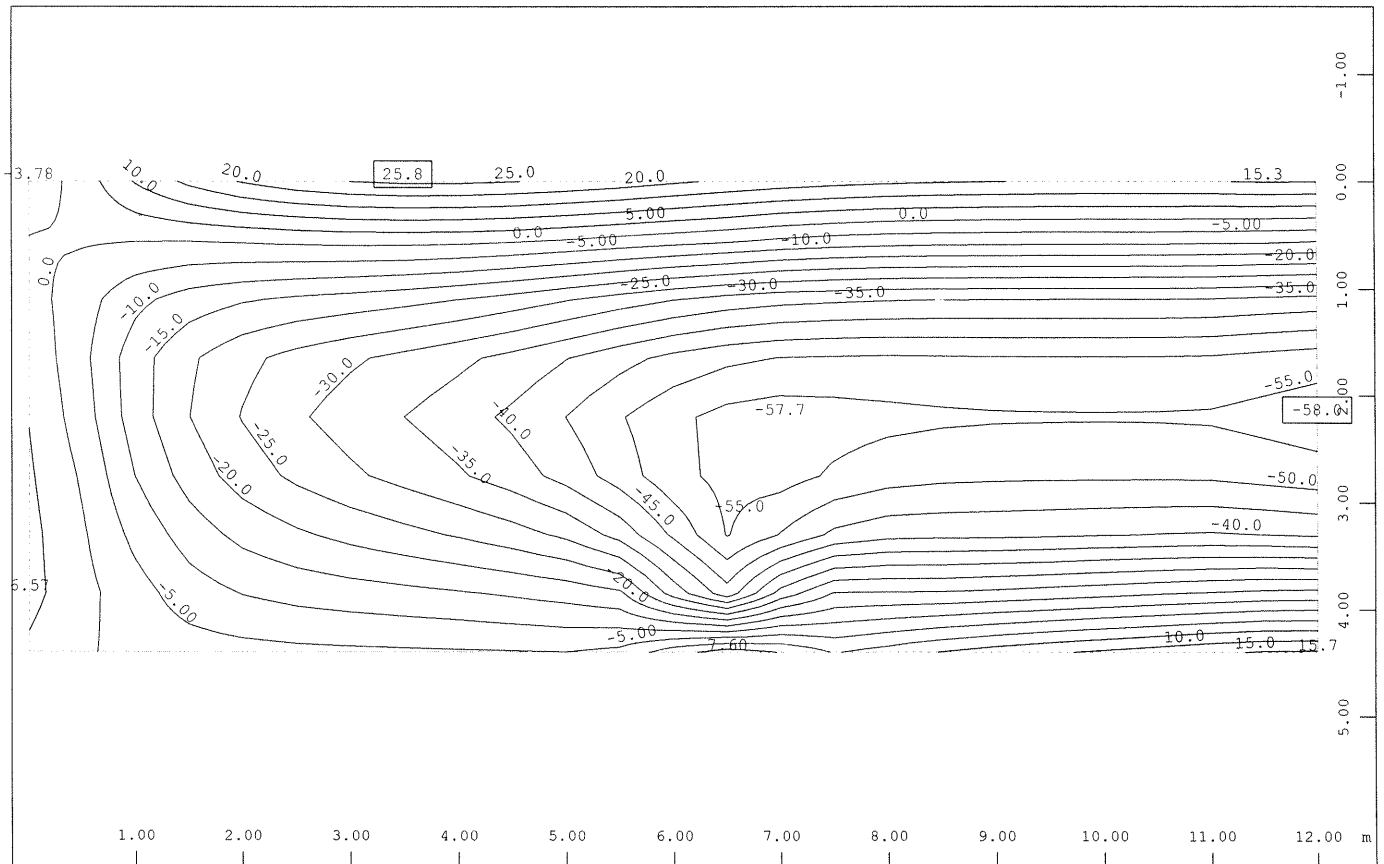


X
Y

Sector of system Group 1

M 1 : 71

Bending moment m-yy in local y in Node \updownarrow , Loadcase 6003 MAX-MY QUAD, from -19.6 to 89.1
step 10.0 kNm/m



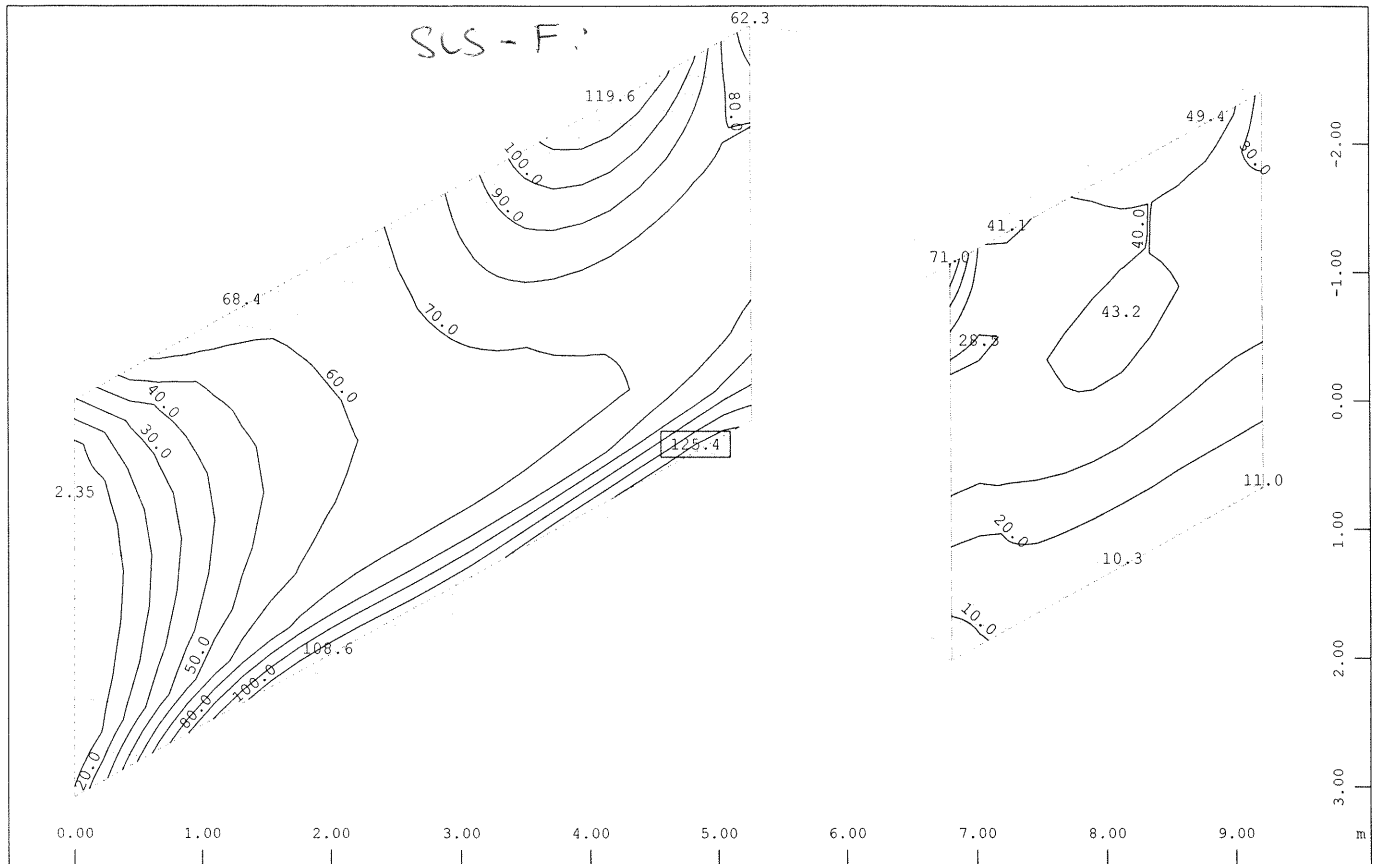
X
Y

Sector of system Group 1

M 1 : 71

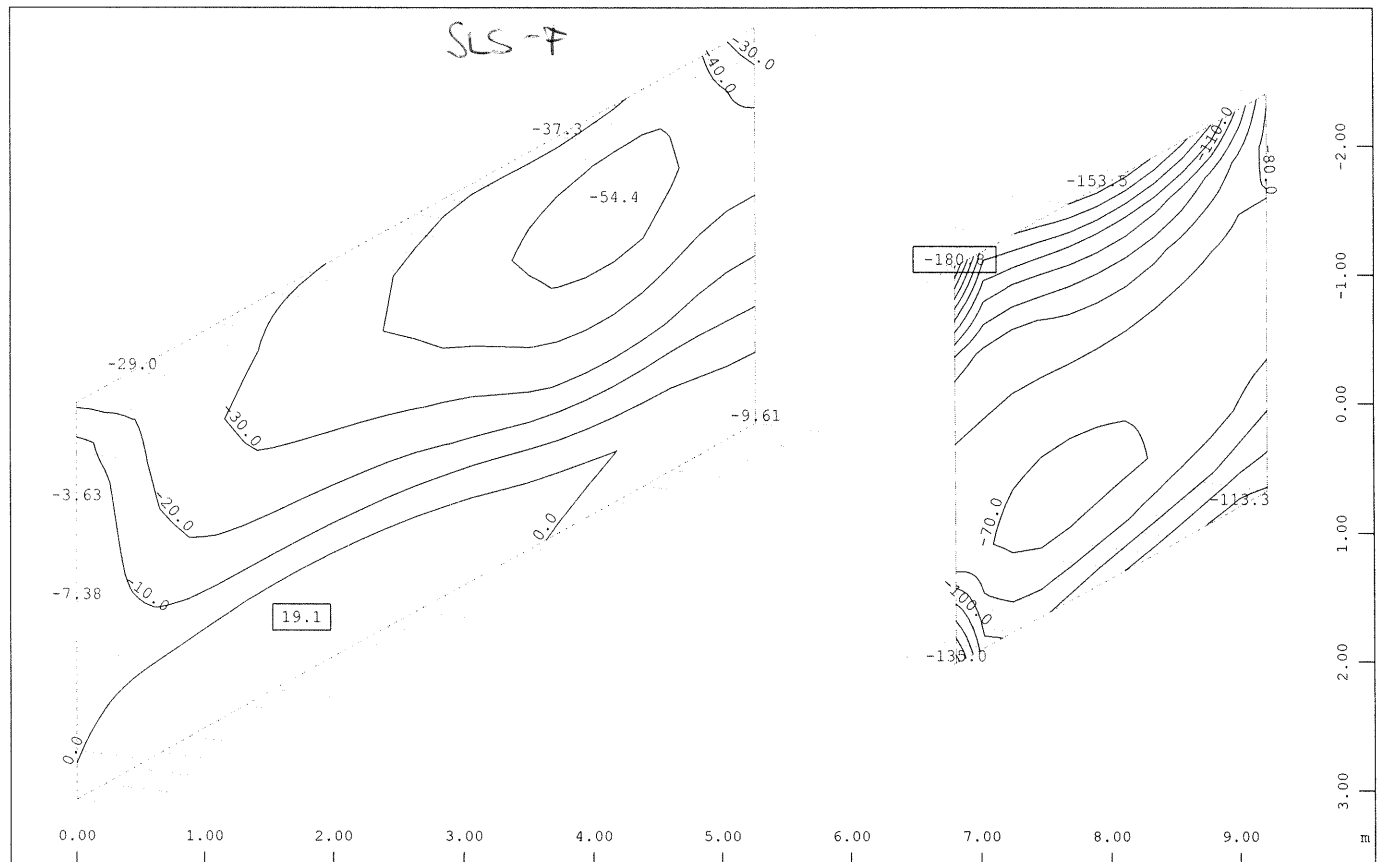
Bending moment m-yy in local y in Node \updownarrow , Loadcase 6004 MIN-MY QUAD, from -58.0 to 25.8
step 5.00 kNm/m

STONE



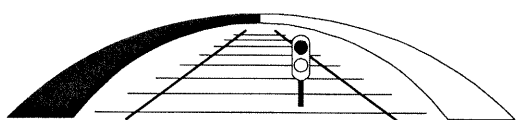
Sector of system Quadrilateral Elements Group 2 4
Bending moment m-yy in local y in Node \updownarrow , Loadcase 7003 MAX-MY QUAD, from 0.0666 to 125.4 step 10.0 kNm/m

M 1 : 59
X * 0.502
Y * 0.906
Z * 0.962



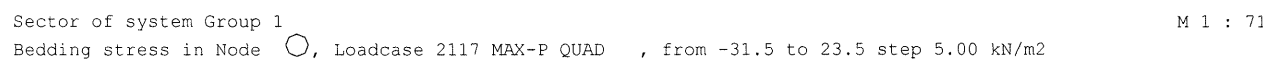
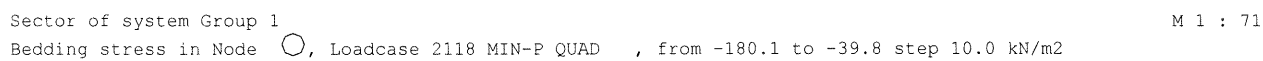
Sector of system Quadrilateral Elements Group 2 4
Bending moment m-yy in local y in Node \updownarrow , Loadcase 7004 MIN-MY QUAD, from -180.8 to 19.1 step 10.0 kNm/m

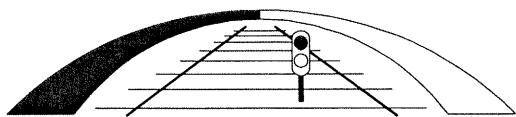
M 1 : 59
X * 0.502
Y * 0.906
Z * 0.962



sž - projektivno podjetje ljubljana d.d.
projektiranje, inženiring, svetovanje
Ukmarjeva ulica 6, SI - 1000 Ljubljana
tel.: 01/ 300 76 00, fax.: 01/ 300 76 36

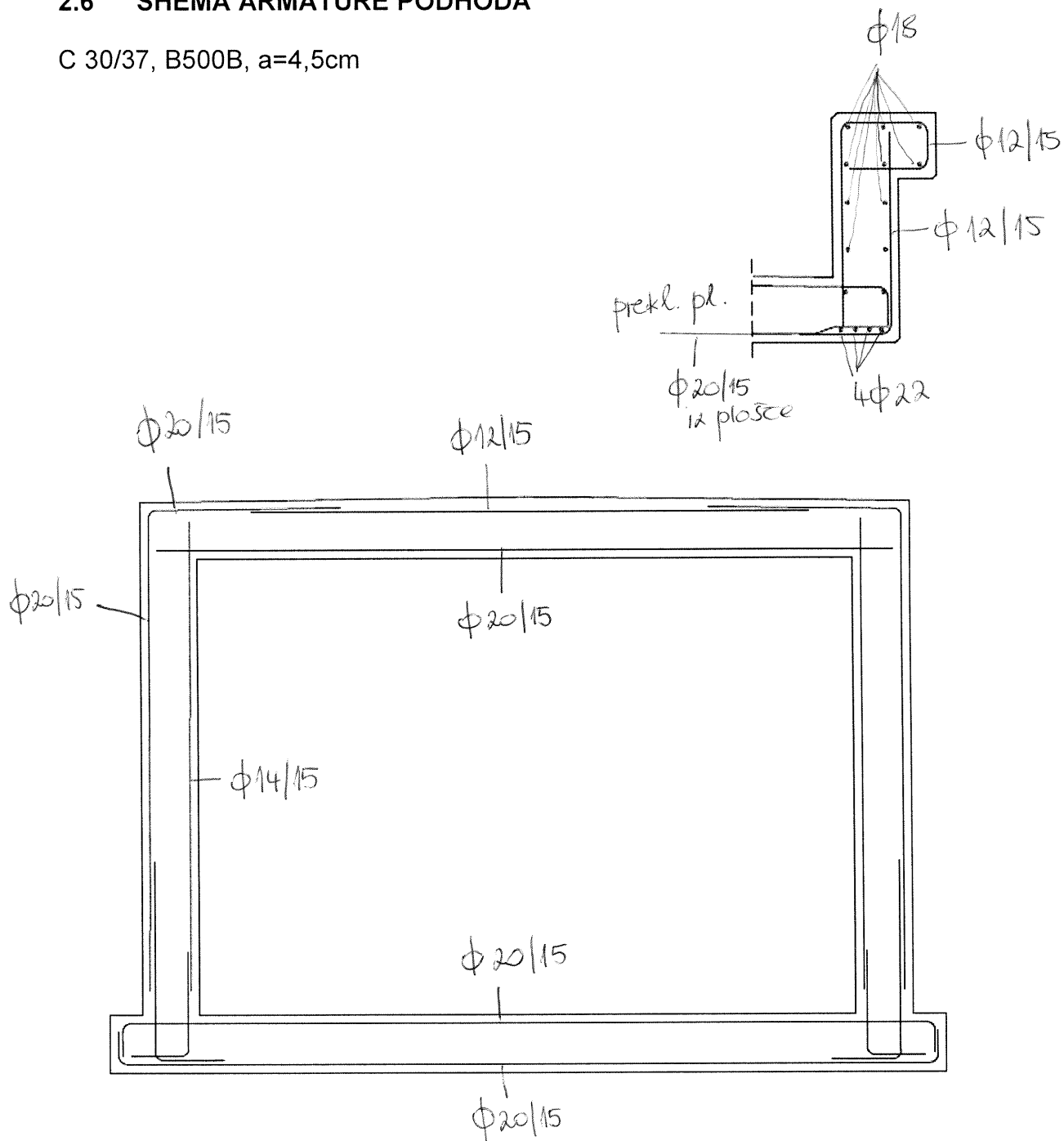
2.5 KONTAKTNE NAPETOSTI V TEMELJNIH TLEH





2.6 SHEMA ARMATURE PODHODA

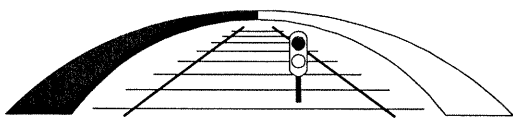
C 30/37, B500B, $a=4,5\text{cm}$



VZDOLŽNA ARMATURA: $\phi 14/15\text{ cm}$

ČELNE STENE: $\phi 16/15\text{ cm}$

- v stenah ob odprtinah formirati arm. steber s $4\phi 22$ in lasnicami $\phi 12/15\text{ cm}$



2.6.1 NOSILEC NAD STOPNIŠČEM

2.6.1.1 Kampada 4 (nosilec nad stopniščem in dvigalom)

$$q_{LT} = 0,5 \cdot 25 + 1,0 \cdot 22 = 35 \text{ kN/m}^2$$

$$p = 10 \text{ kN/m}^2$$

$$q_{d,pl} = 1,35 \cdot 35 + 1,5 \cdot 10 = 62 \text{ kN/m}^2$$

$$q_{d,nos} = 62 \cdot 2,5 = 155 \text{ kN/m'}$$

$$M_d = \frac{155 \cdot 6,0^2}{8} = 697 \text{ kNm}$$

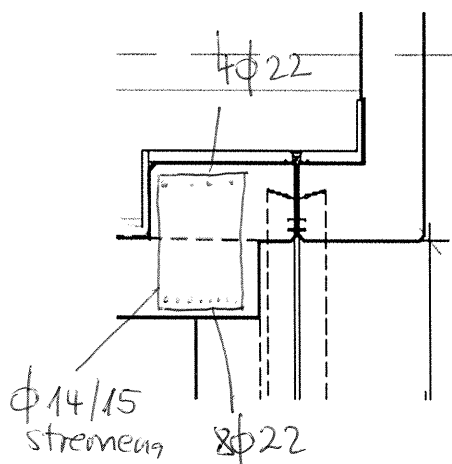
$$k_h = \frac{697}{1700 \cdot 0,50 \cdot 0,6^2} = 0,228$$

$$A_s = 1,112 \cdot \frac{697}{43,5 \cdot 60} = 30 \text{ cm}^2 \rightarrow 8\phi 22$$

$$A'_s = 1,011 \cdot 0,2 \cdot \frac{697}{43,5 \cdot 60} = 5,4 \text{ cm}^2 \rightarrow 3\phi 22$$

$$V_d = \frac{155 \cdot 6,0}{2} = 465 \text{ kN} \rightarrow \frac{A_{sw}}{s} = 18 \text{ cm}^2$$

$\rightarrow \text{stremena } \phi \frac{14}{15} \text{ cm}$



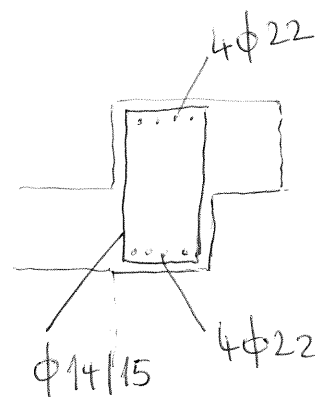
2.6.1.2 Kampade 1, 2, 3

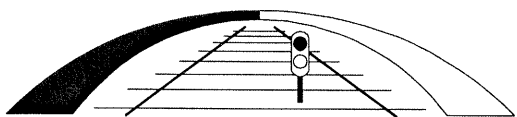
$$M_d = \frac{155 \cdot 4,3^2}{8} = 358 \text{ kNm}$$

$$k_h = \frac{358}{1700 \cdot 0,35 \cdot 0,6^2} = 0,167$$

$$A_s = 1,062 \cdot \frac{358}{43,5 \cdot 60} = 14,6 \text{ cm}^2 \rightarrow 4\phi 22$$

$$V_d = \frac{155 \cdot 4,3}{2} = 333 \text{ kN} \rightarrow \frac{A_{sw}}{s} = 9 \text{ cm}^2 \rightarrow \text{stremena } \phi \frac{14}{15} \text{ cm}$$





3 JAŠEK DVIGALA

Jašek je zasnovan kot zaprt AB okvir. Svetle mere okvirja znašajo 1,60x 180m. Debelina sten znaša 35 cm. Talna plošča je debeline 40 cm

Beton C30/37

Armatura B500B

Zaščitna plast betona: 4,5 cm (5 cm)

Modul reakcije tal $C_v = 20.000 \text{ kN/m}^3$

3.1 OBTEŽBA

3.1.1 Lastna teža in stalna koristna obtežba

Lastna teža	$\gamma = 25 \text{ kN/m}^3$
-------------	------------------------------

3.1.2 Mirni zemeljski pritisk

$$k_m = 1 - \sin \varphi_m = 1 - 30^\circ = 0,5$$

$$e_{mj} = \gamma \cdot h_{2j} \cdot k_m = 20 \cdot 5,4 \cdot 0,5 = 54 \text{ kN/m}^2$$

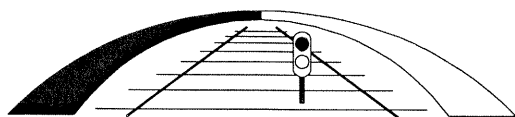
$$e_{ms} = \gamma \cdot h_{2s} \cdot k_m = 20 \cdot 3,8 \cdot 0,5 = 38 \text{ kN/m}^2$$

Upoštevam še komprimacijski pritisk $e_{comp} = 25 \text{ kN/m}^2$.

Poenostavljen diagram: enakomerno po višini:

$$e_{mj} = \frac{54 + 25}{2} = 40 \text{ kN/m}^2$$

$$e_{ms} = \frac{38 + 25}{2} = 32 \text{ kN/m}^2$$



3.2 DIMENZIONIRANJE

$$M_d = 1,5 \cdot \frac{40 \cdot 2,0^2}{8} = 30 \text{ kNm}$$

Dimenzioniranje enojne armature (upoqib)

$$f_{ck} = 30 \text{ MPa}$$

$$f_{yk} = 500 \text{ MPa}$$

$$h = 35 \text{ cm}$$

$$b = 100 \text{ cm}$$

$$M = 30 \text{ kNm}$$

$$N = 0 \text{ kN}$$

$$A_{s1} = 2.2 \text{ cm}^2$$

Pogoj 'bele kadi' za stene in plošče debeline 35 cm: $\phi 14/15 \text{ cm}$

Ob vratni odprtini je oslabitev prereza. Na tem mestu se izdelata armaturna ojačitev – robni nosilec.

$$q = 1,35 \cdot 25 + 1,5 \cdot 20 = 64 \text{ kN/m}^2$$

$$\frac{l_y}{l_x} = \frac{2,0}{2,2} = 0,9$$

$$m_{y,frm} = \frac{q \cdot l_y \cdot l_y}{8,46} = \frac{64 \cdot 2,2 \cdot 2,0}{8,46} = 32 \text{ kNm}$$

$$f_{ck} = 30 \text{ MPa}$$

$$f_{yk} = 500 \text{ MPa}$$

$$h = 20 \text{ cm}$$

$$b = 50 \text{ cm}$$

$$M = 32 \text{ kNm}$$

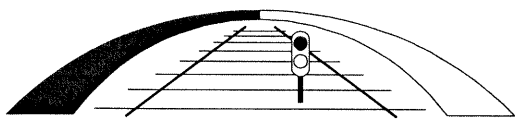
$$N = \text{ kN}$$

$$A_{s1} = 5,3 \text{ cm}^2$$

$$d = 15 \text{ cm}$$

$$f_{cd} = 1,70 \text{ kN/cm}^2$$

→ 3Φ16



4 STOPNIŠČE

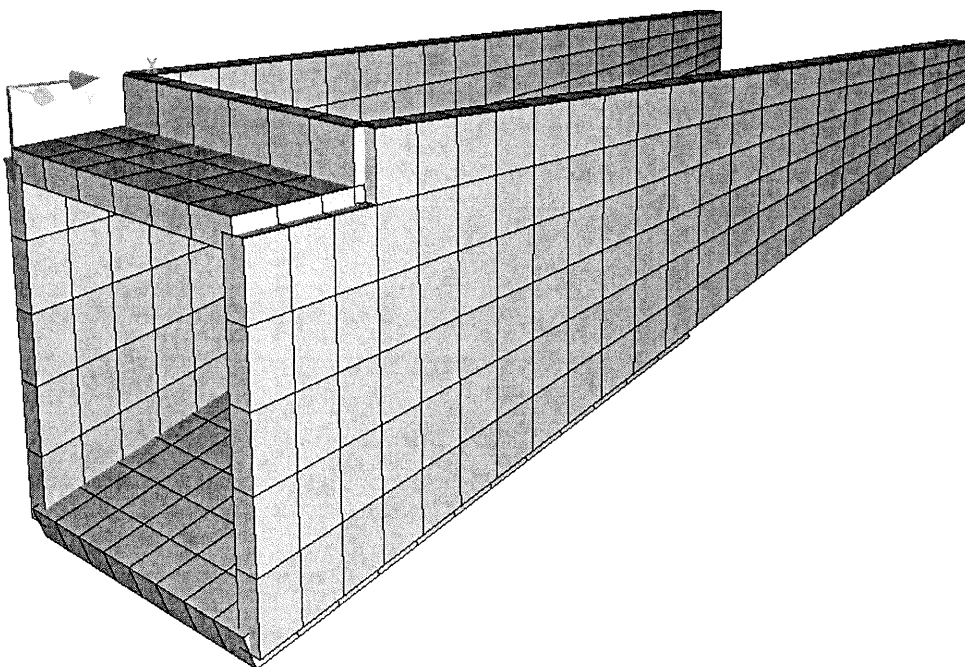
4.1 ZASNOVA

Stopnišče je zasnovano kot okvirna konstrukcija na elastični podlagi. Steni stopnišča sta vpeti v talno ploščo in medsebojno povezani na višjem delu z zaključno steno.

Debelina talne plošče prve rame ter podesta je 40 cm, druga rama ima debelino 25 cm. Stranske stene so debeline 35 cm, del stene, ki je dvignjen nad stopnicami, pa je debeline 25 cm. Navpična razporna stena je debeline 25 cm, vodoravna 35 cm.

Pod talno ploščo se izdelata ustrezno zbit tamponski sloj debeline 30 cm iz peščeno prodnega materiala. Togost tal je predstavljena z modulom reakcije tal.

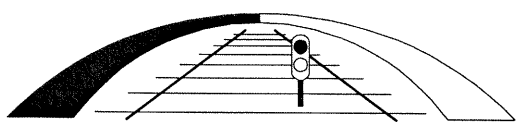
Modul reakcije tal $C_v = 20.000 \text{ kN/m}^3$



Ploskovni elementi : talna plošča $d = 0,40 / 0,25 \text{ m}$

Ploskovni elementi: stena $d = 0,35 \text{ m}$

Ploskovni elementi: razporna stena $d=0,25 / 0,35\text{m}$



4.2 OBTEŽBA

4.2.1 Lastna teža in stalna koristna obtežba

Lastna teža		$\gamma = 25 \text{ kN/m}^3$
Stopnice:	$d = 12 \text{ cm}$3,0 kN/m ²

4.2.1 Nadstrešnica

Nadstrešnica deluje na krono sten stopnišča na mestih, kjer so pritrjeni jekleni stebri nadstrešnice.

MaxM:

$$V = 21 \text{ kN}$$

$$F_{\text{hor}} = 16 \text{ kN}$$

$$M = 19 \text{ kNm}$$

MaxV:

$$V = 37 \text{ kN}$$

$$F_{\text{hor}} = 1 \text{ kN}$$

$$M = 7 \text{ kNm}$$

4.2.2 Mirni zemeljski pritisk

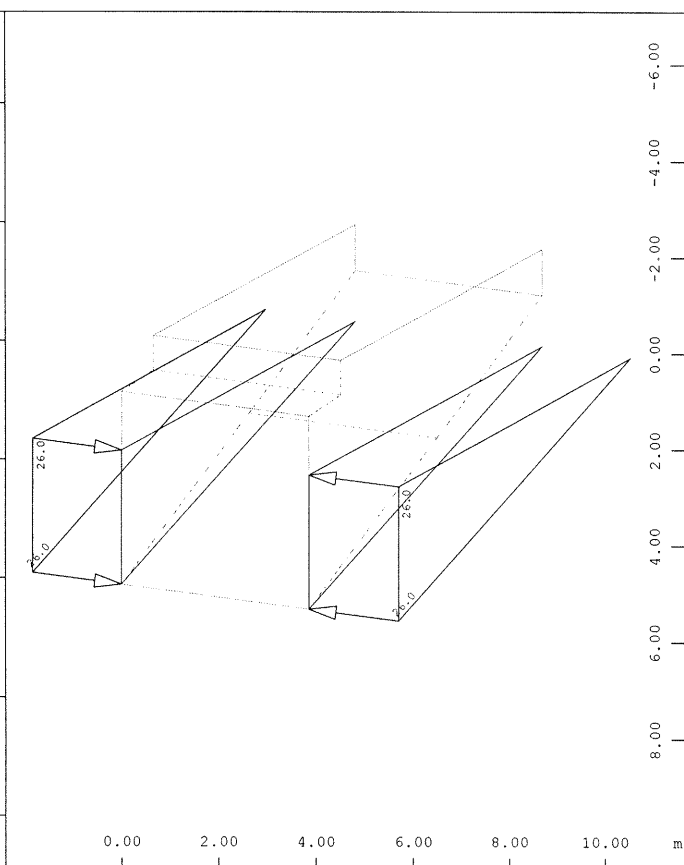
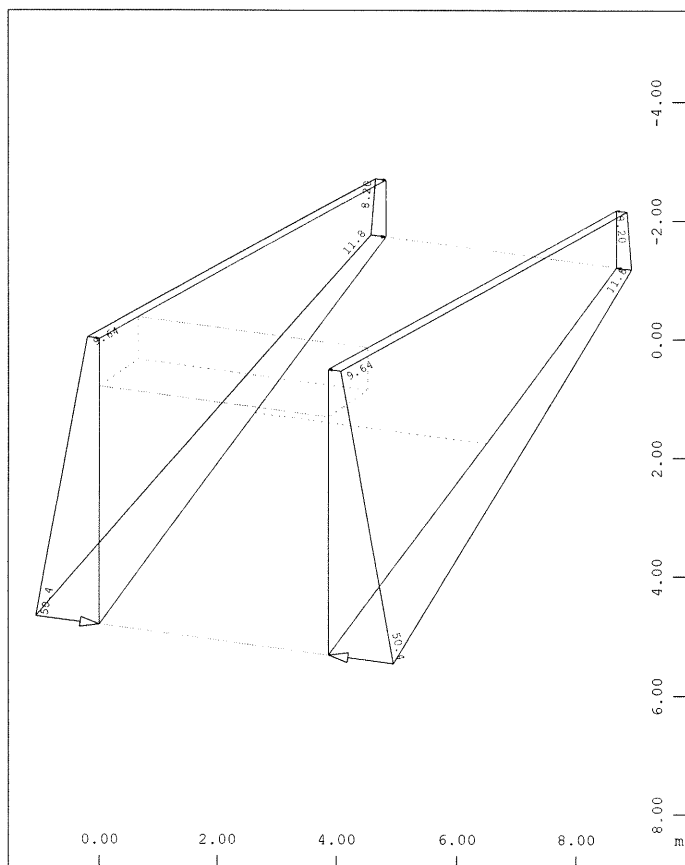
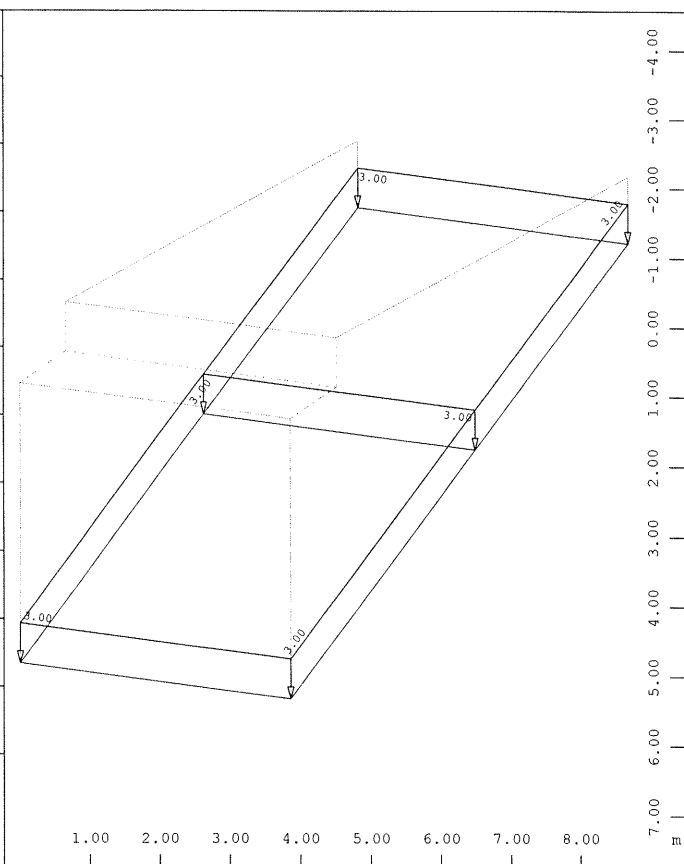
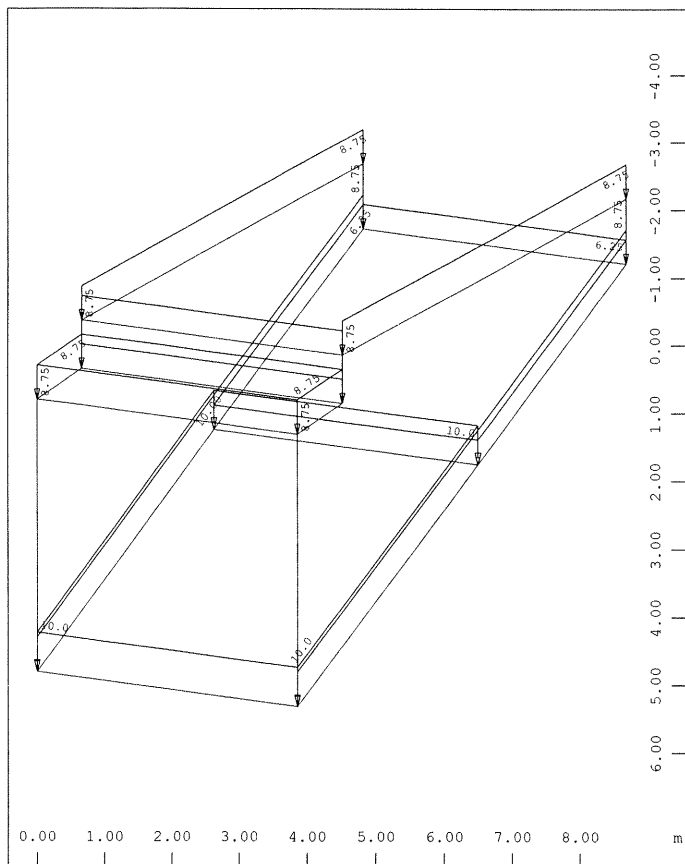
$$k_m = 1 - \sin \varphi_m = 1 - 30^\circ = 0,5$$

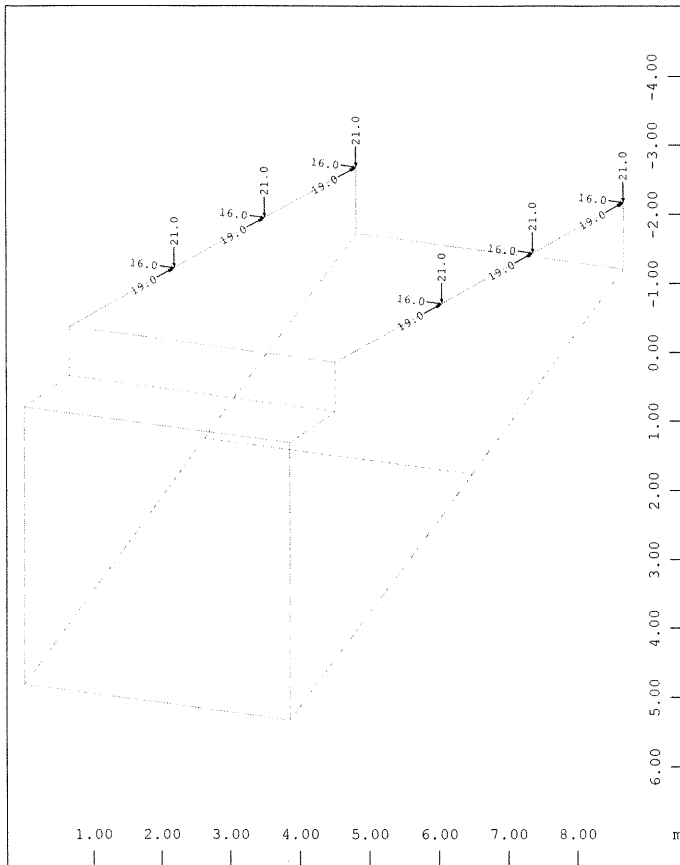
$$e_{m1} = \gamma \cdot h_1 \cdot k_m = 20 \cdot 5,0 \cdot 0,5 = 50 \text{ kN/m}^2$$

Upoštevam še komprimacijski pritisk $e_{\text{comp}} = 10 \text{ kN/m}^2$, ki se ne superponira z zemeljskim pritiskom.

4.2.1 Horizonatlni pritisk od prometa

$$e_{mh,prom} = p' \cdot k_m = 52 \cdot 0,5 = 26 \text{ kN/m}^2$$

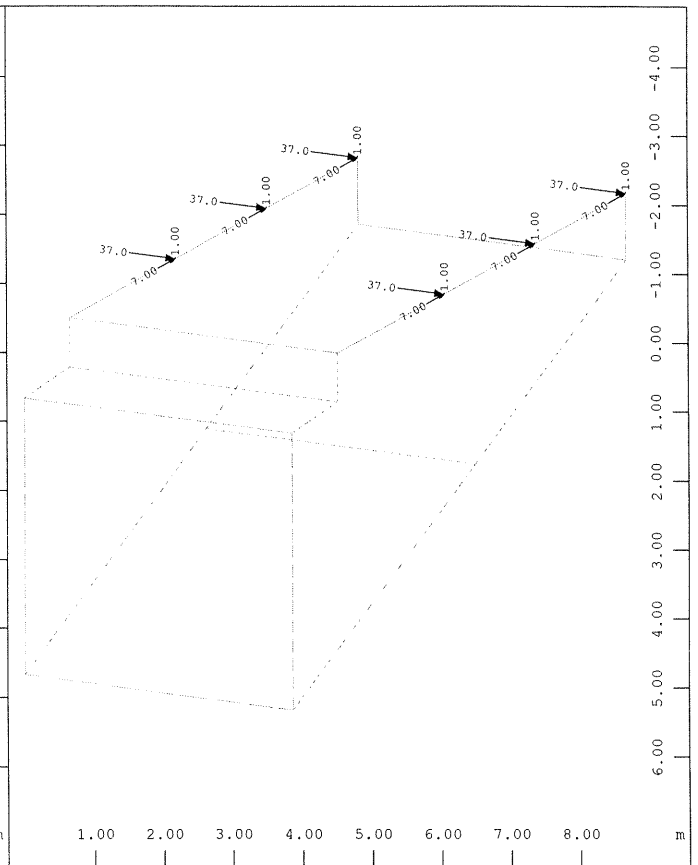




All loads, Loadcase 5 NADSTRESNICA 1, (1 cm 3D = unit) Free single load (force) in global Y (Unit=74.7 kN, Max=16.0), Free single load (force) in global Z (Unit=74.7 kN, Max=21.0), Free single load (moment) about global X (Unit=37.3 kNm, Max=19.0)

M 1 : 110

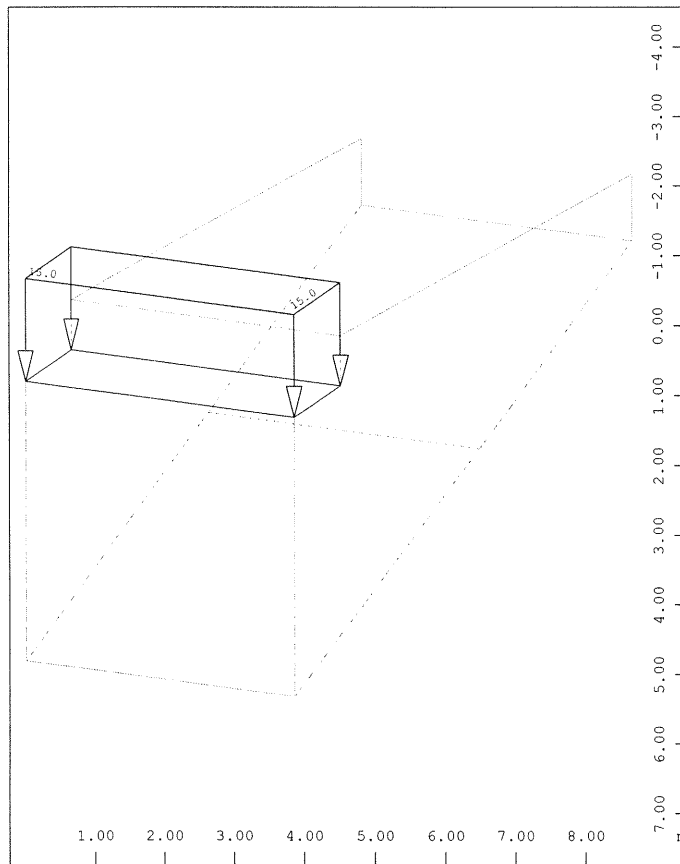
X * 0.592
Y * 0.906
Z * 0.962



All loads, Loadcase 6 NADSTRESNICA 2, (1 cm 3D = unit) Free single load (force) in global Y (Unit=55.0 kN, Max=37.0), Free single load (force) in global Z (Unit=55.0 kN, Max=1.00), Free single load (moment) about global X (Unit=13.8 kNm, Max=7.00)

M 1 : 110

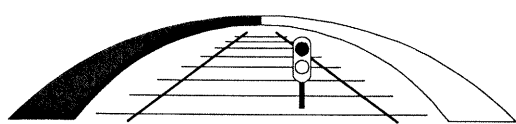
X * 0.592
Y * 0.906
Z * 0.962



All loads, Loadcase 7 PL.PERON, (1 cm 3D = unit) Area element load (force) vector (Unit=10.7 kN/m², Max=15.0)

M 1 : 109

X * 0.592
Y * 0.906
Z * 0.962



4.3 ULS – MEJNO STANJE NOSILNOSTI

4.3.1 Obtežna kombinacija

$$1,35(1,0) \times G + 1,5(0,5) \times E_m + 1,45 \times e_{ph}$$

4.3.2 Dimenzioniranje

C 30/37, BSt 500 S, $a = 4,5$ (5,0) cm

$$\gamma_c = 1,5, \quad \gamma_s = 1,15, \quad f_{cd} = \frac{0,85 \cdot 30}{1,5} = 17 \text{ MPa}, \quad f_{yd} = \frac{500}{1,15} = 435 \text{ MPa}$$

Iskanje maksimalnih notranjih sil in dimenzioniranje je izvedeno s programom Sofistik.

4.3.3 Kontrola striga

STRIG

$$f_{ck} = 30 \text{ MPa}$$

$$f_{yk} = 500 \text{ MPa}$$

$$d = 0.35 \text{ m}$$

$$b_w = 1 \text{ m}$$

$$A_{sl} = 10.26 \text{ cm}^2$$

$$A_c = 3500 \text{ cm}^2$$

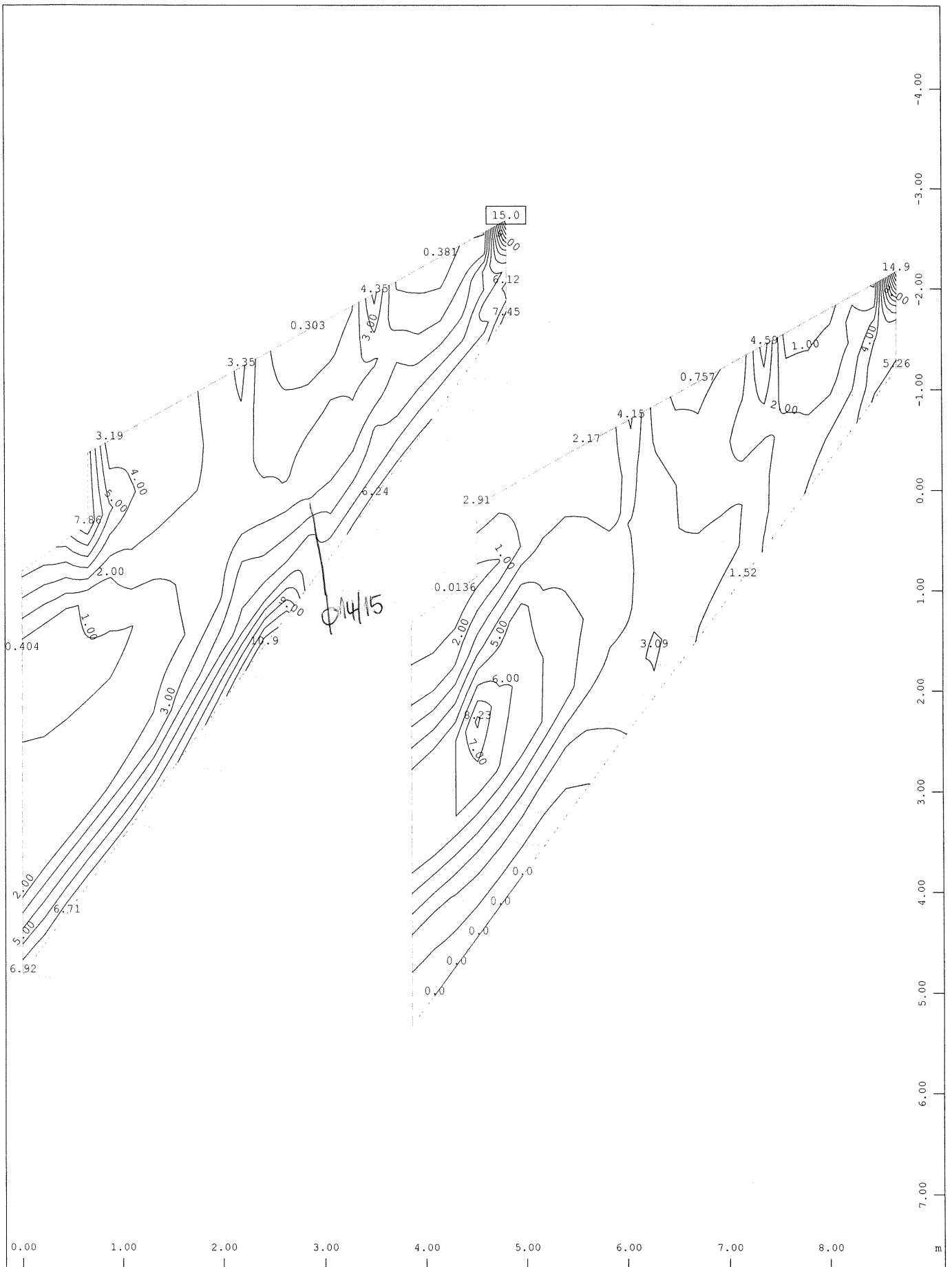
$$C = 0.12$$

$$k = 1.829$$

$$\rho_1 = 0.00353$$

$$V_{Rd,c} = \underline{140} \text{ kN} > V = 100 \text{ kN}$$

Strižna armatura ni potrebna

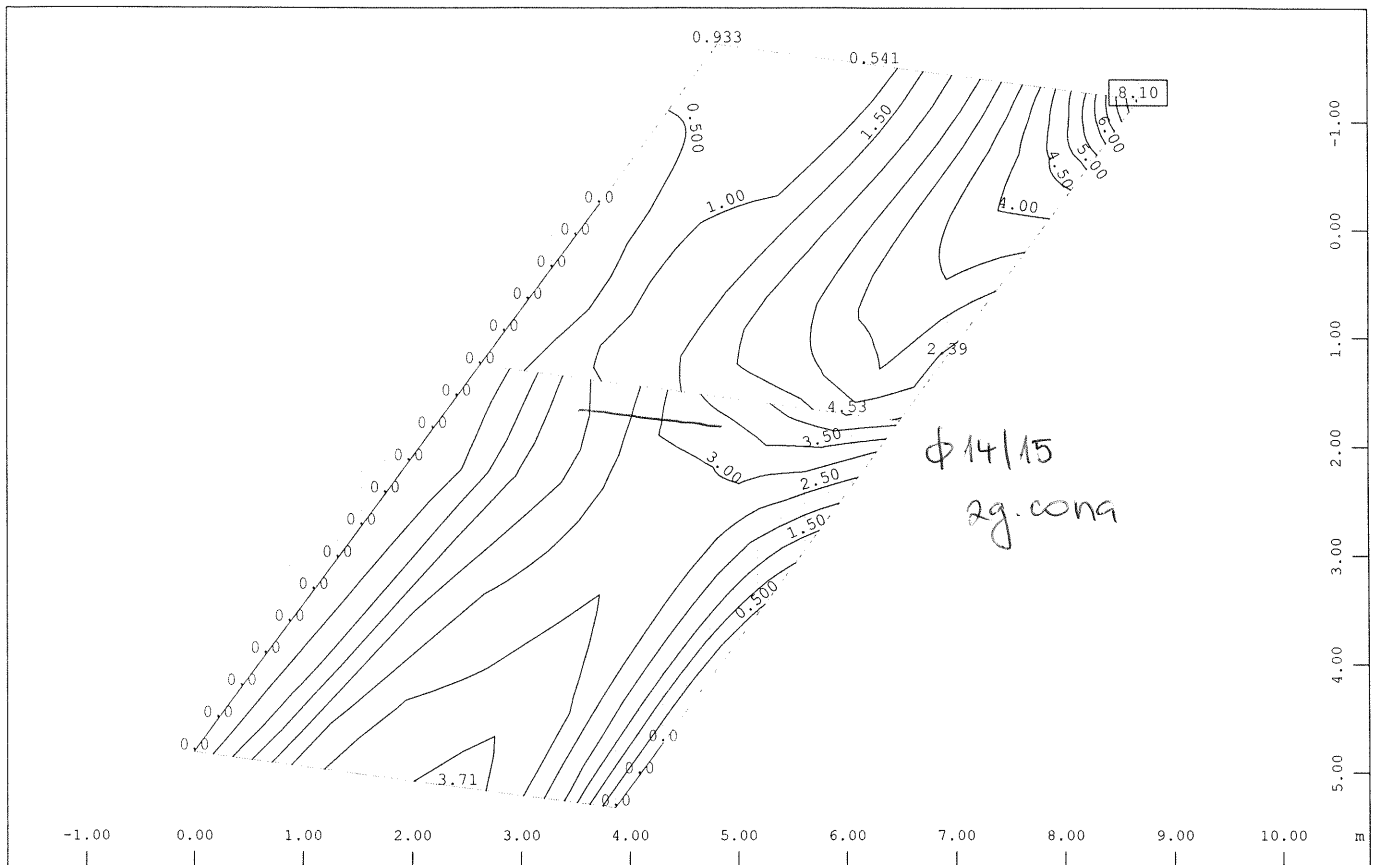


Sector of system Quadrilateral Elements Group 1 2

Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node
 , from 0 to 15.0 step 1.00 cm²/m

1, Design Case 1

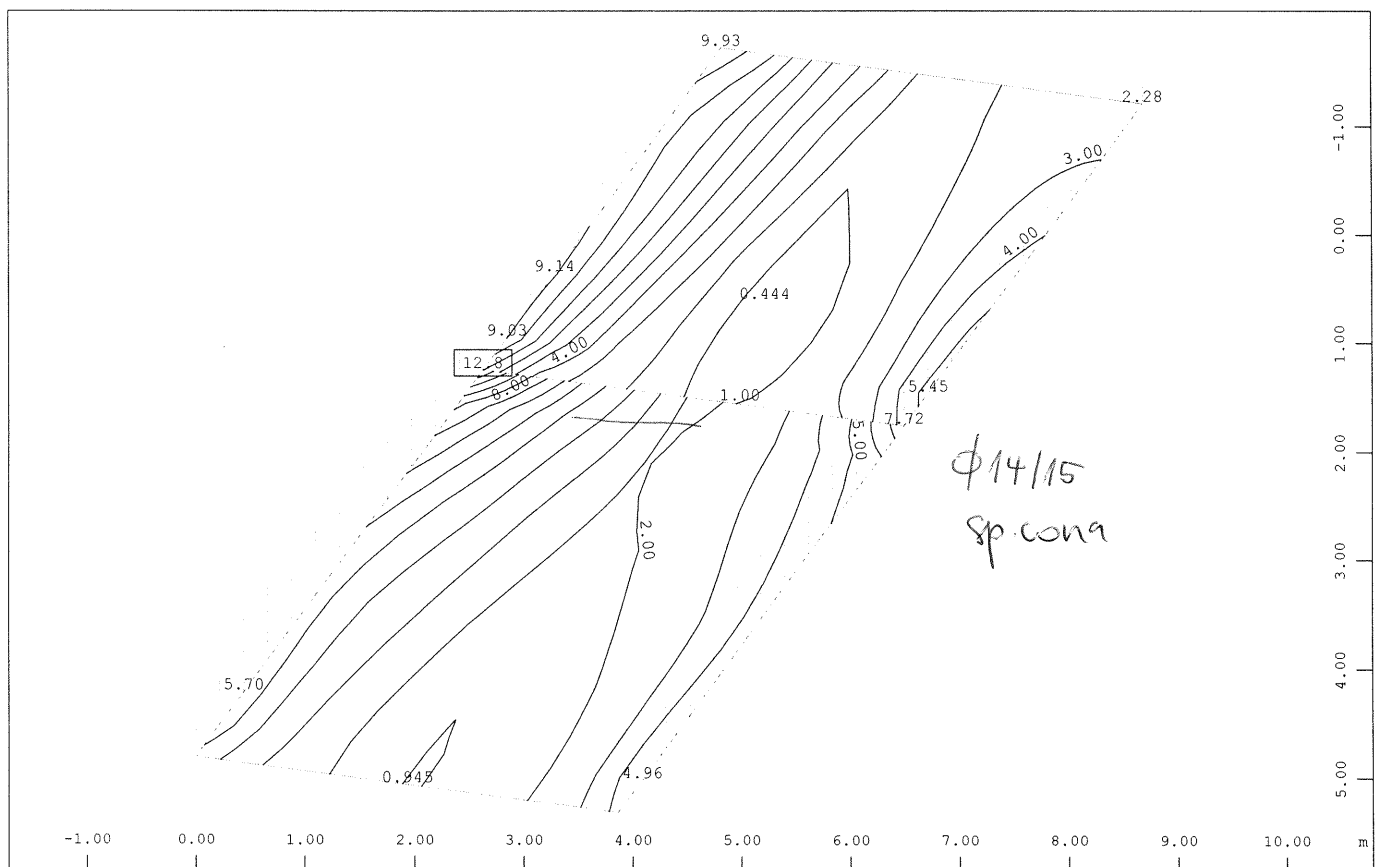
M 1 : 52
 X * 0.502
 Y * 0.906
 Z * 0.962



Sector of system Group 3
 Quadrilateral Elements , lower Principal reinforcements (1st layer) in Node
 1 , from 0 to 8.10 step 0.500 cm²/m

↗, Design Case

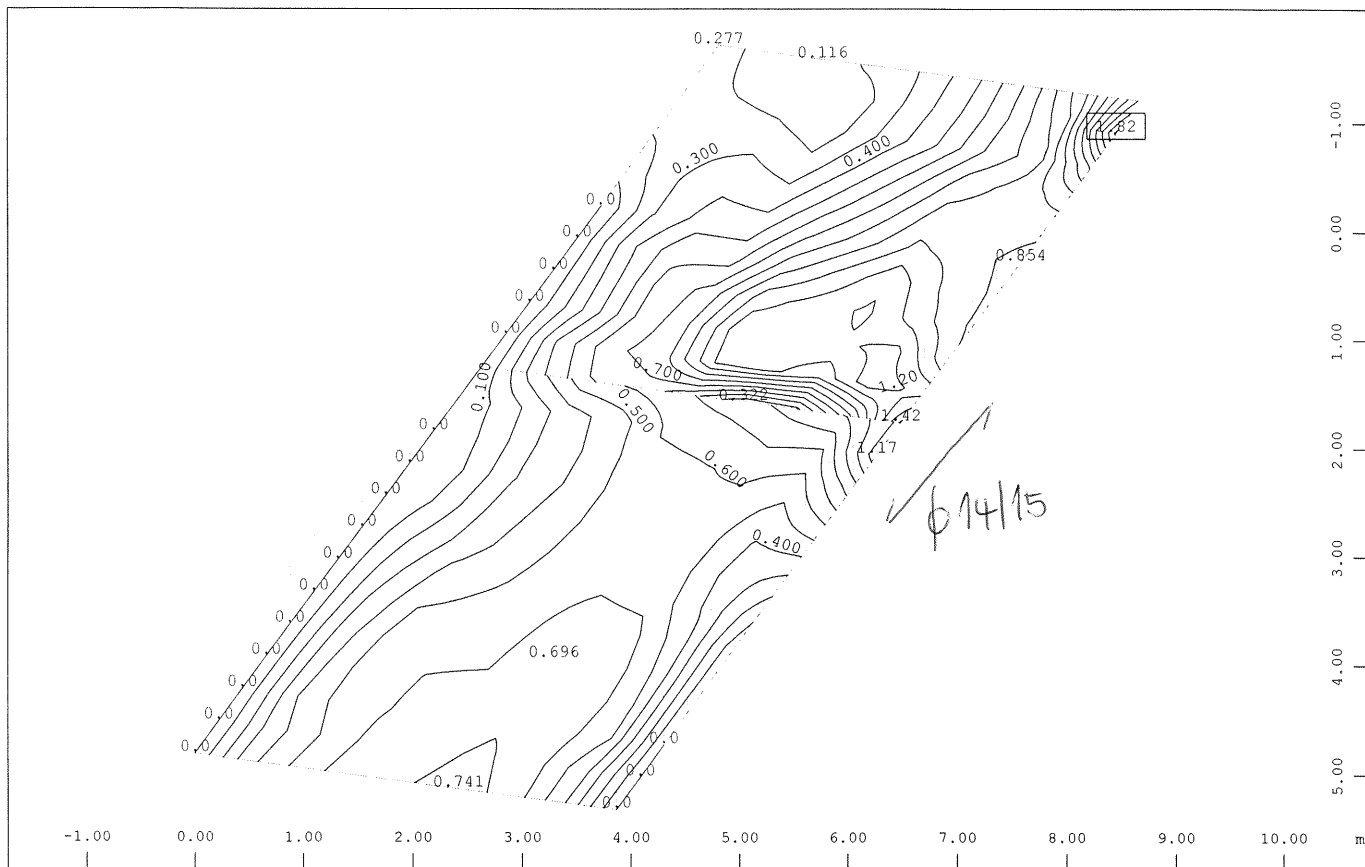
M 1 : 70
 X * 0.502
 Y * 0.906
 Z * 0.962



Sector of system Group 3
 Quadrilateral Elements , upper Principal reinforcements (1st layer) in Node
 1 , from 0.444 to 12.8 step 1.00 cm²/m

↗, Design Case

M 1 : 70
 X * 0.502
 Y * 0.906
 Z * 0.962

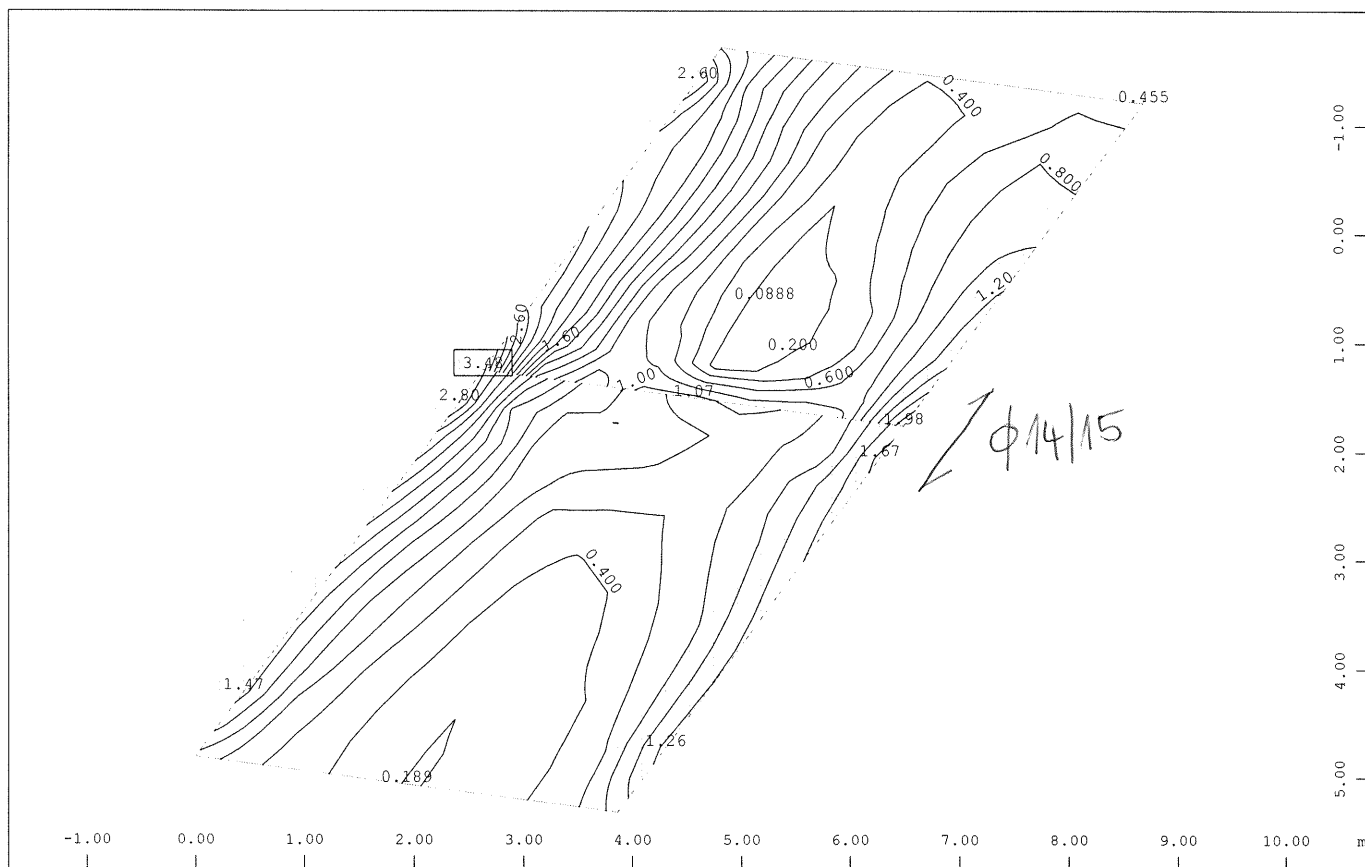


X
Y
Z

Sector of system Group 3
Quadrilateral Elements , lower Cross reinforcements (2nd layer) in Node
, from 0 to 1.82 step 0.100 cm²/m

Z , Design Case 1

M 1 : 70
X * 0.502
Y * 0.906
Z * 0.962

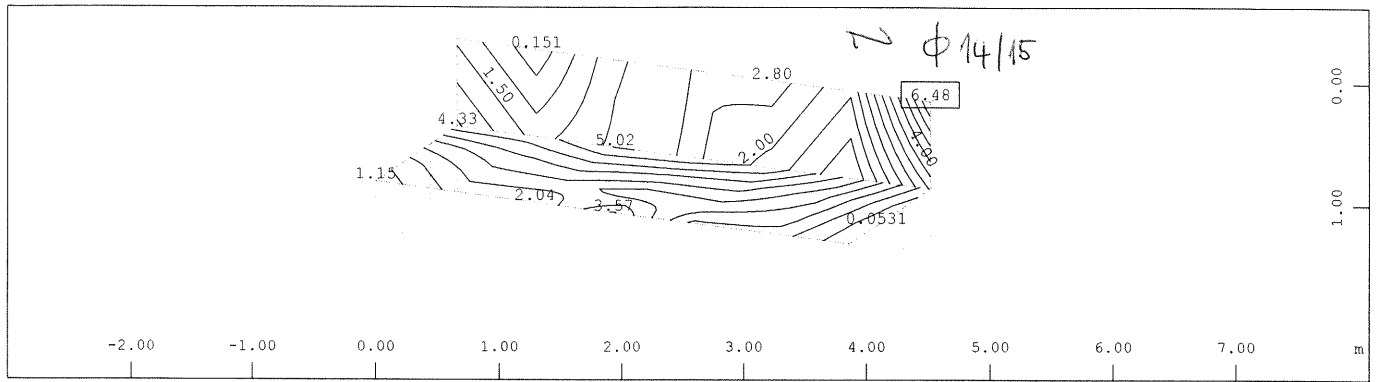


X
Y
Z

Sector of system Group 3
Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node
, from 0.0888 to 3.48 step 0.200 cm²/m

Z , Design Case 1

M 1 : 70
X * 0.502
Y * 0.906
Z * 0.962

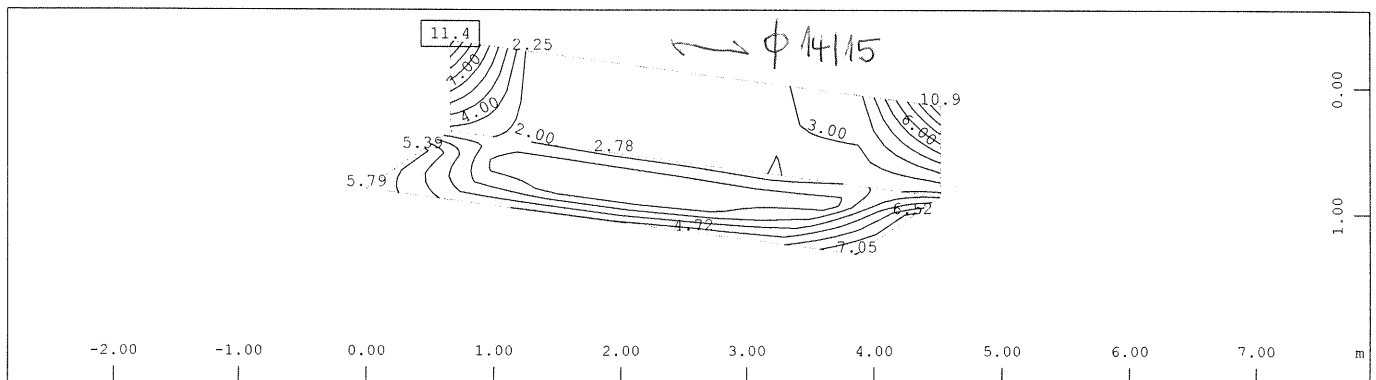


X
Y
Z

Sector of system Group 4
Quadrilateral Elements , upper Principal reinforcements (1st layer) in Node
1 , from 0.0531 to 6.48 step 0.500 cm²/m

↔, Design Case

M 1 : 62
X * 0.502
Y * 0.906
Z * 0.962

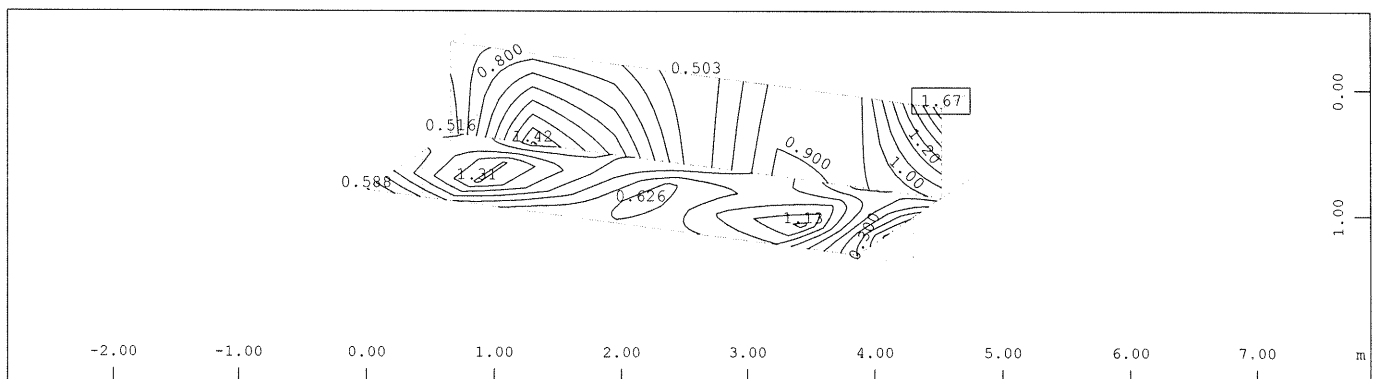


X
Y
Z

Sector of system Group 4
Quadrilateral Elements , lower Principal reinforcements (1st layer) in Node
1 , from 0.0603 to 11.4 step 1.00 cm²/m

↔, Design Case

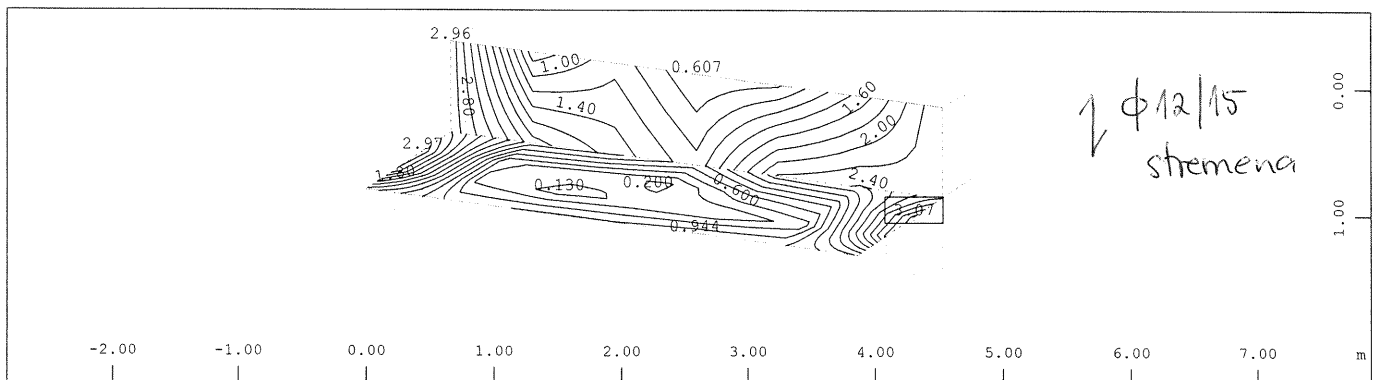
M 1 : 60
X * 0.502
Y * 0.906
Z * 0.962



X
Y
Z

Sector of system Group 4
Quadrilateral Elements , upper Cross reinforcements (2nd layer) in Node, Design Case 1 ,
from 0.181 to 1.67 step 0.100 cm²/m

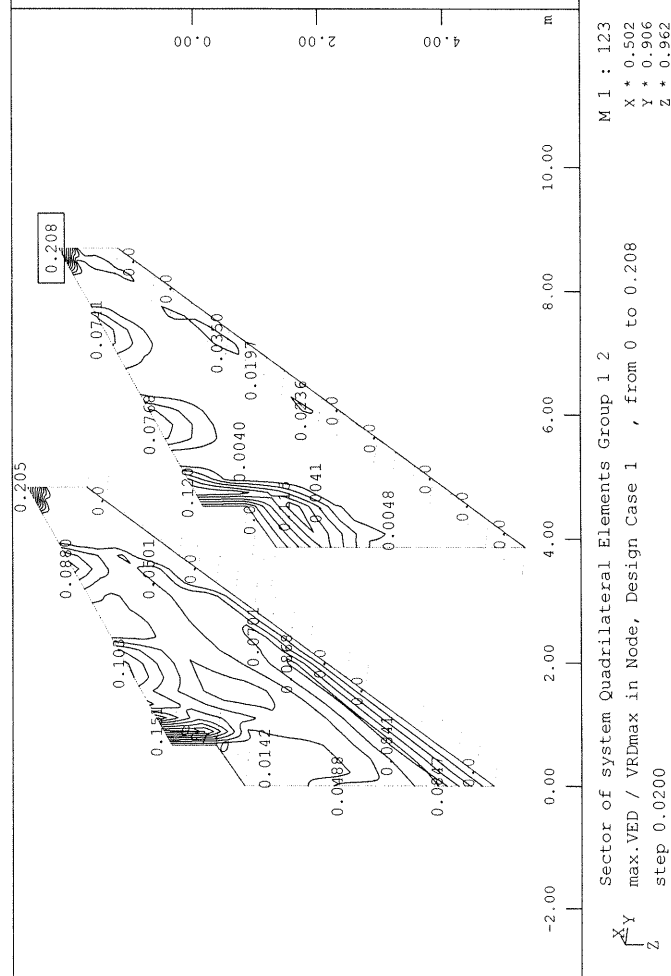
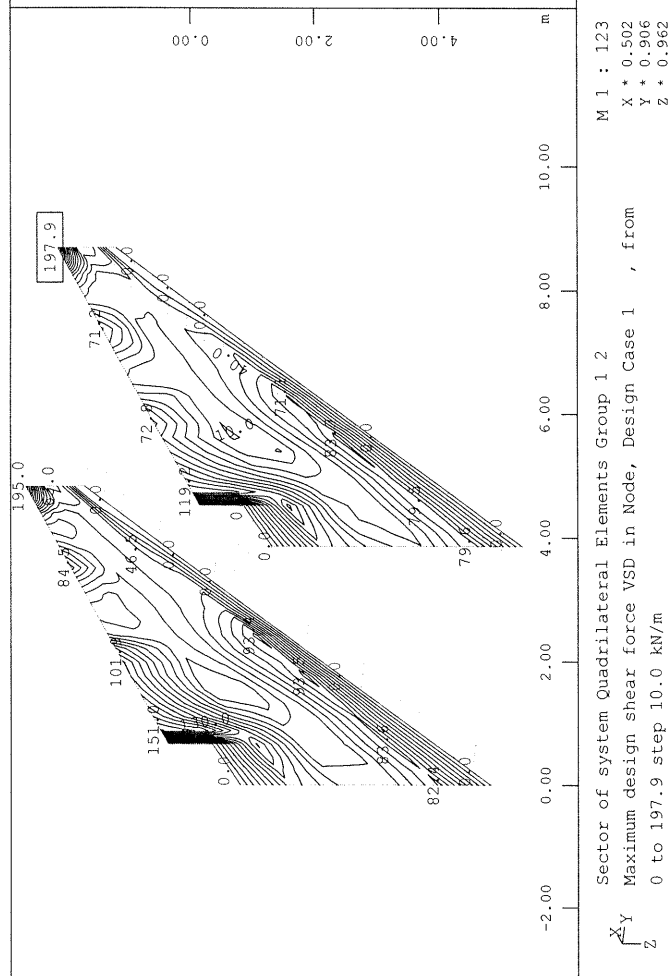
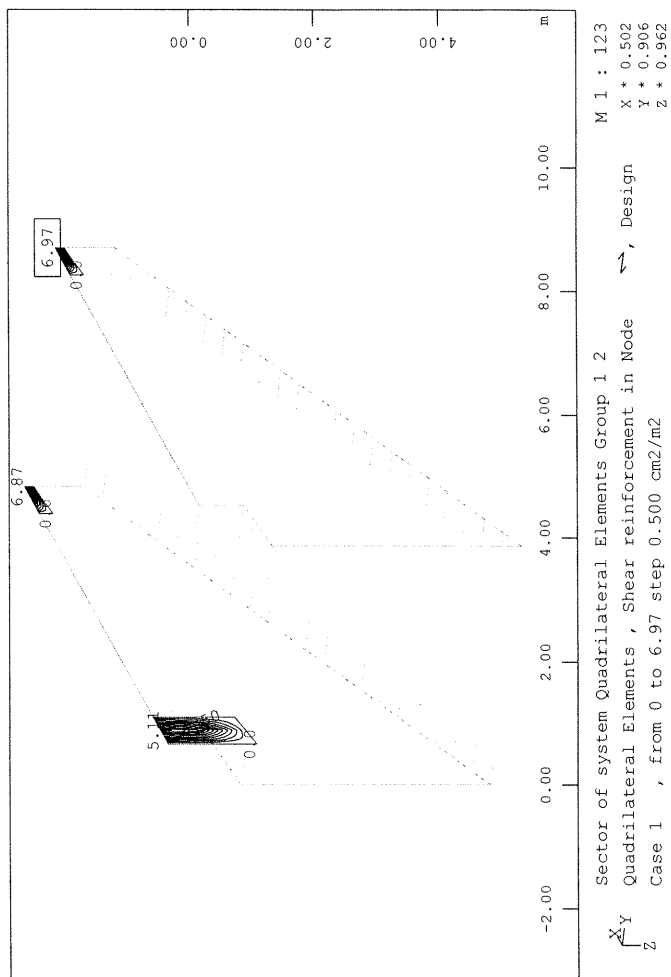
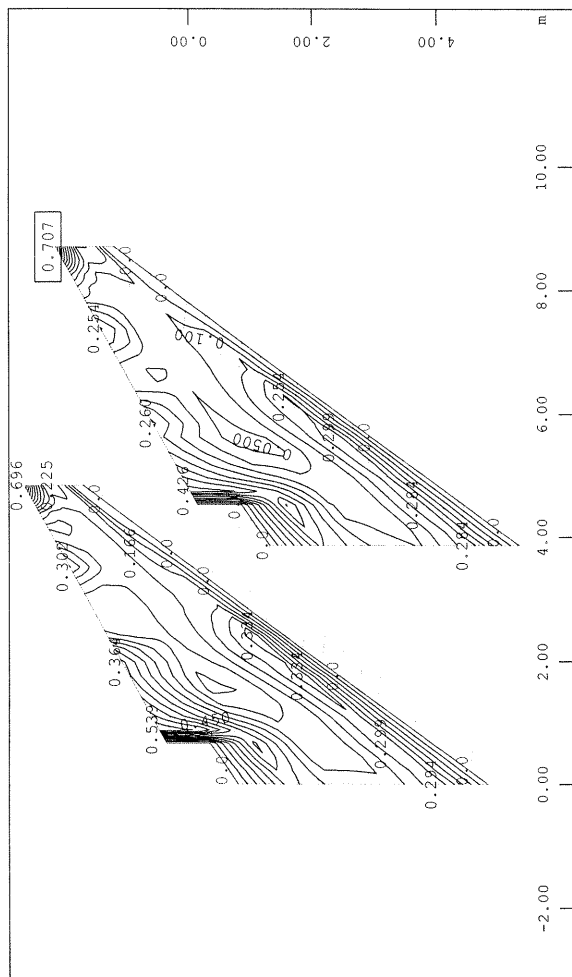
M 1 : 60
X * 0.502
Y * 0.906
Z * 0.962

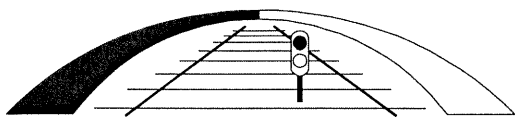


X
Y
Z

Sector of system Group 4
Quadrilateral Elements , lower Cross reinforcements (2nd layer) in Node, Design Case 1 ,
from 0.130 to 3.07 step 0.200 cm²/m

M 1 : 60
X * 0.502
Y * 0.906
Z * 0.962





4.4 SLS – MEJNO STANJE UPORABNOSTI

4.4.1 Obtežne kombinacije

CR (*characteristic-rare*)

→ dominantna je prometna obtežba

$$1,0 \times G + 1,0 \times E_m + 1,0(0) \times p_h$$

QP (*quasi permanent*)

$$1,0 \times G + 1,0 \times E_m + 0,5 \times T$$

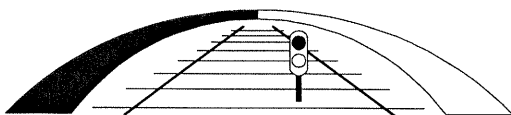
4.4.2 Kontrole

4.4.2.1 Tlačne napetosti v betonu

$$\sigma_{c,max} = 6,3 \text{ MPa} < 0,6 f_{ck} = 0,6 \cdot 30 = 18 \text{ MPa} \dots \text{O.K}$$

4.4.2.2 Razpoke

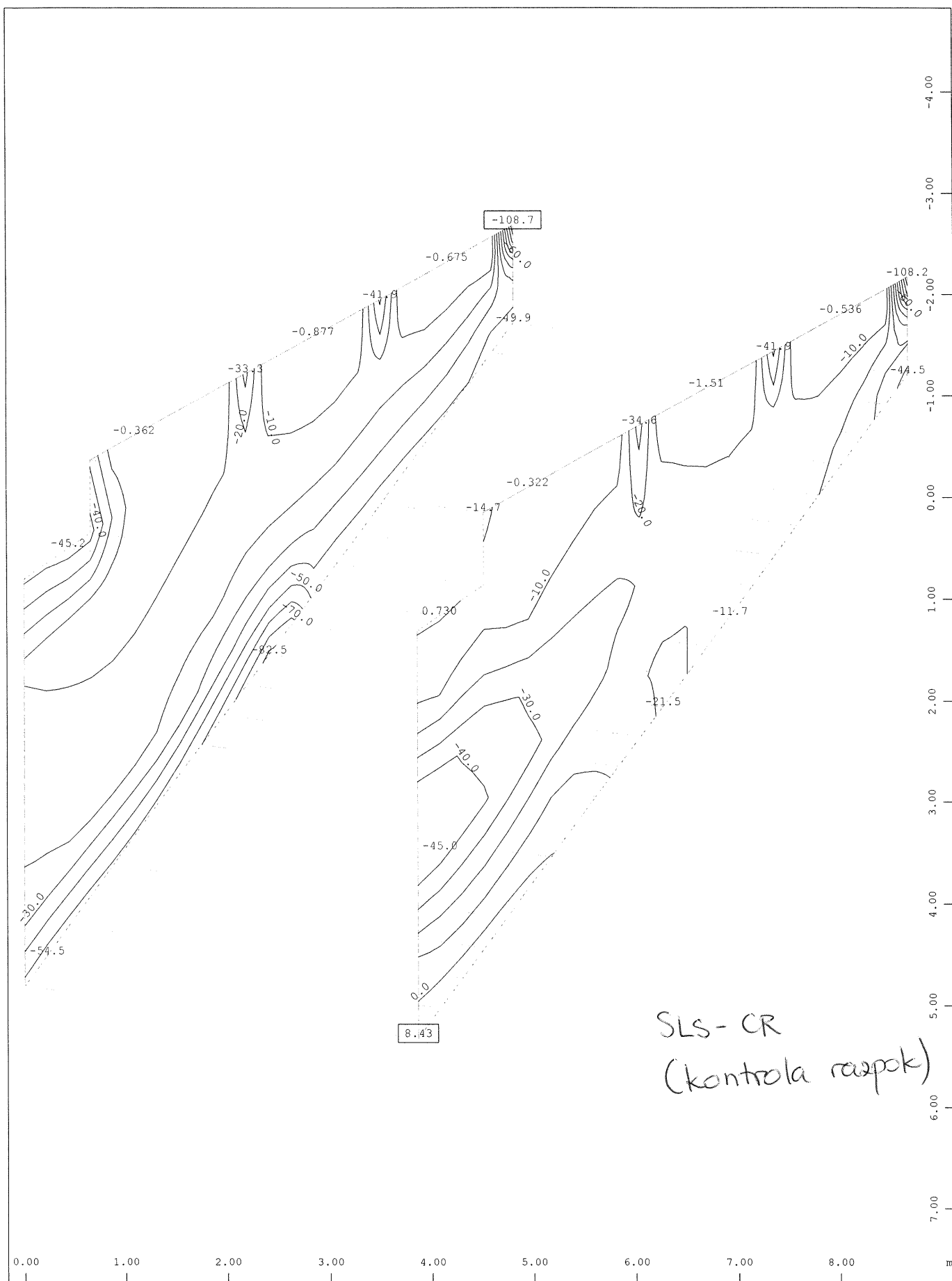
Razpoke so v stenah in spodnji plošči zaradi tehnologije 'bele kadi' omejene na 0,2mm.



RAZPOKE

potrebna arm. A_s (cm ²)	13.4		
premer arm. ϕ (mm)	16		
razdalja med arm. palicami e (cm)	15		
moment M_{upor} (kNm)	60		
osna sila N_{prip} (kN) ... - tlak / + nateg	-30		
visina prereza h ... (cm)	35	29.7	stat.visina
koef.raz.dvoj.sil $k_z=1/k_s$	0.9091		
KOEFIGIENTI			
koef.sprijem.arm.in bet. k_1	0.8	RA	
koef.oblike nap.v prerezu k_2	0.5	upogib	
zascitni sloj bet. c (cm)	4.5		
koef.visine tlacne cone k_x	0.15		
koef. trajanja obt. k_t	0.4	dolgotr.obt.	
sirina plosce, nosilca b (cm)	100	plosca $b=100$ cm	
E_{cm}	3300		
f_{ctm} ... nat.trdnost bet. (odvisna marka betona)	2.9	C 30/37	
mom.na arm. $M_{upor,s}$ (kNm)	63.66		
nap.v arm. σ_s (kN/cm ²)	15.36		
nap.v arm.brez upost.osne sile σ'_s	16.58		
$h_{c,eff}$... sodel.natezna visina bet.prereza (cm)	10.18		
$A_{c,eff}$... efekt.sodel.natezni bet. (cm ²)	1018		
$\rho_{p,eff}$... koef.arm.sodel.nateznega bet.	0.013		
$5*(c+\phi/2)$	26.5		
$s_{r,max}$... največja razdalja med razpokami (mm)	360		
$\varepsilon_{sm} = \varepsilon_{cm}$	0.00046		
w_k ... karakteristicna sirina razpok (mm)	0.166	< $w_{dop} = 0,20$ mm OK	

ϕ 16/15



Sector of system Quadrilateral Elements Group 1 2

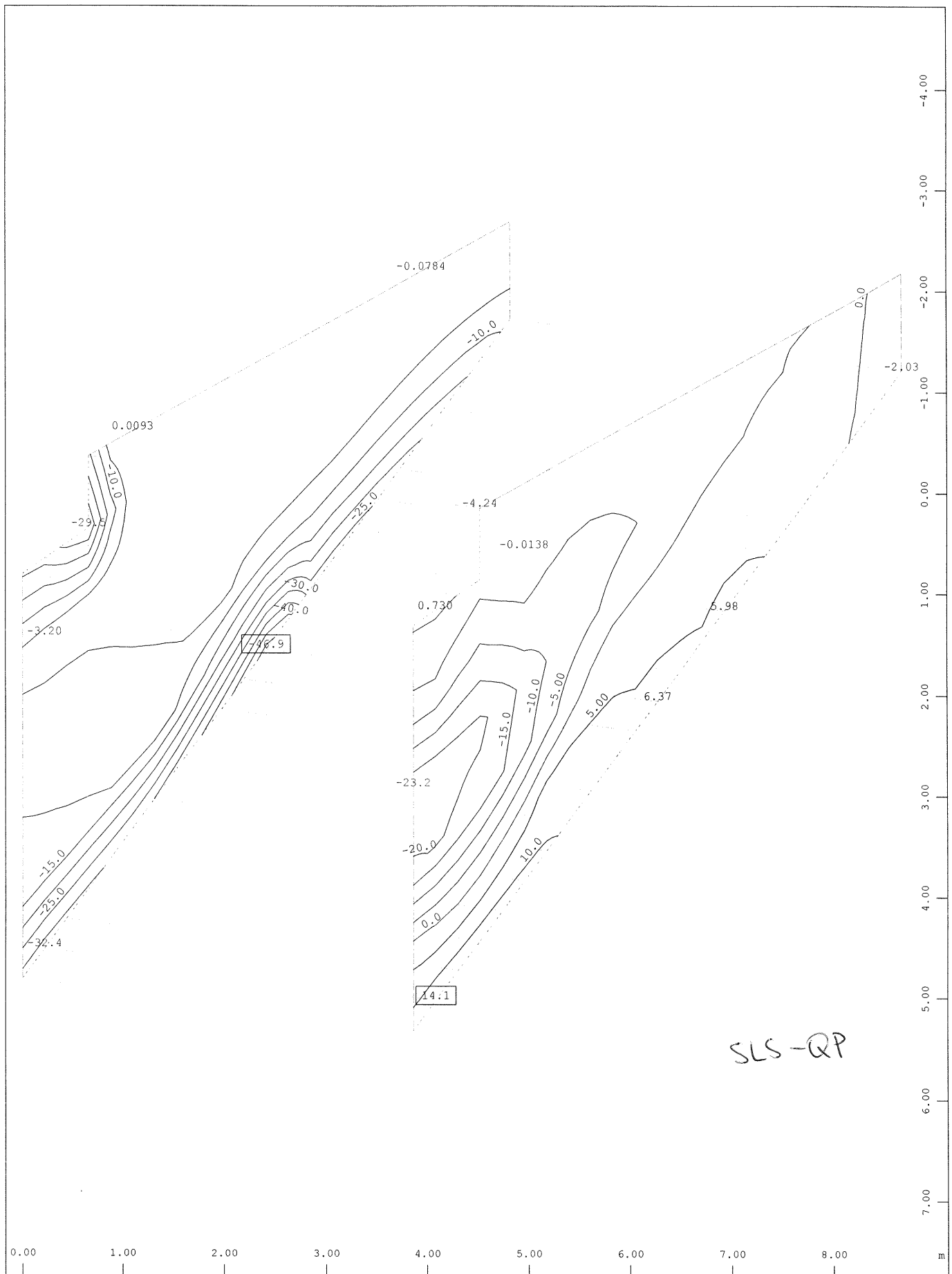
Bending moment m-yy in local y in Node \updownarrow , Loadcase 2004 MIN-MY QUAD, from -108.7 to 8.43
step 10.0 kNm/m

M 1 : 52

X * 0.502

Y * 0.906

Z * 0.962



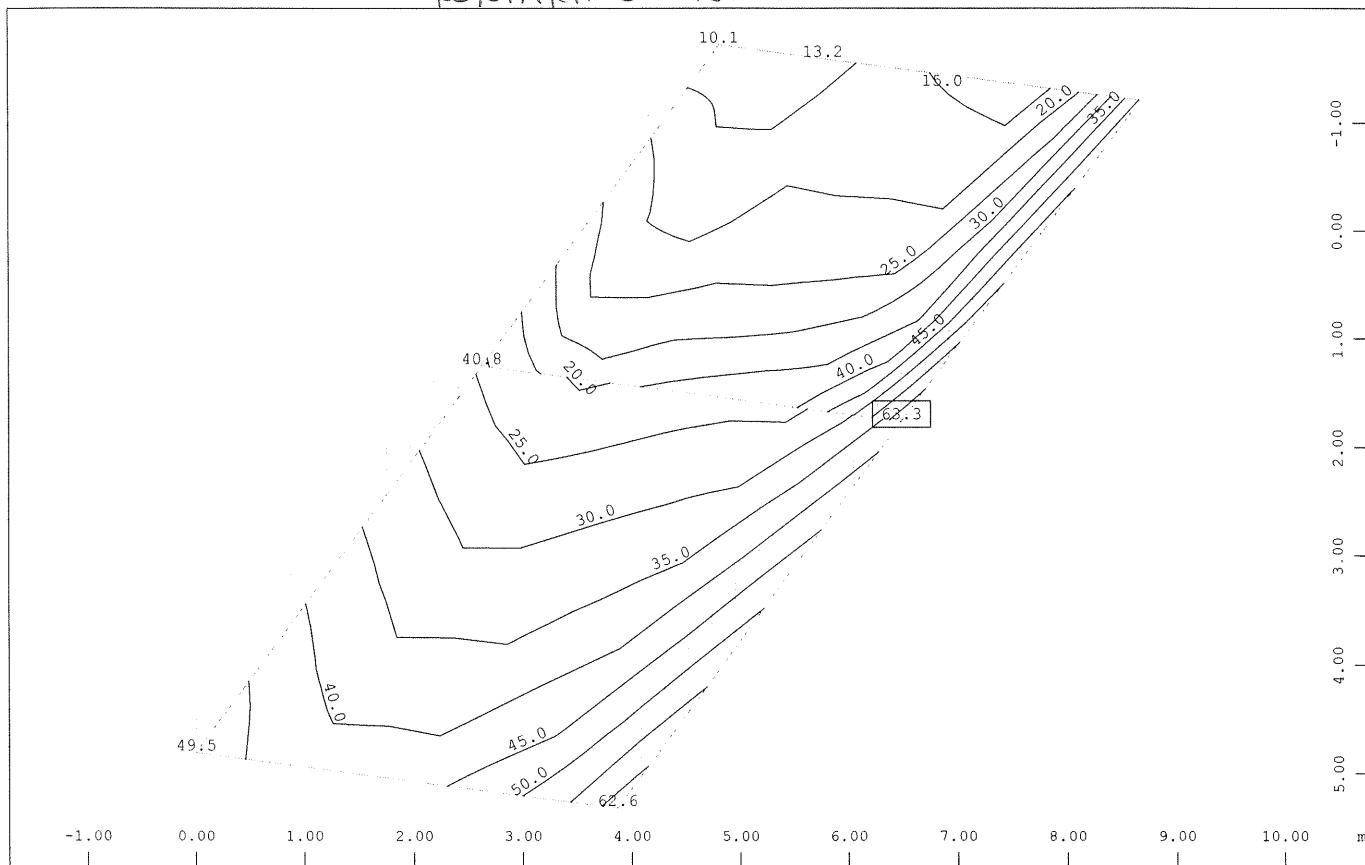
X
Y
Z

Sector of system Quadrilateral Elements Group 1 2

Bending moment m_{yy} in local y in Node 14:1, Loadcase 3004 MIN-MY QUAD, from -46.9 to 14.1
step 5.00 kNm/m

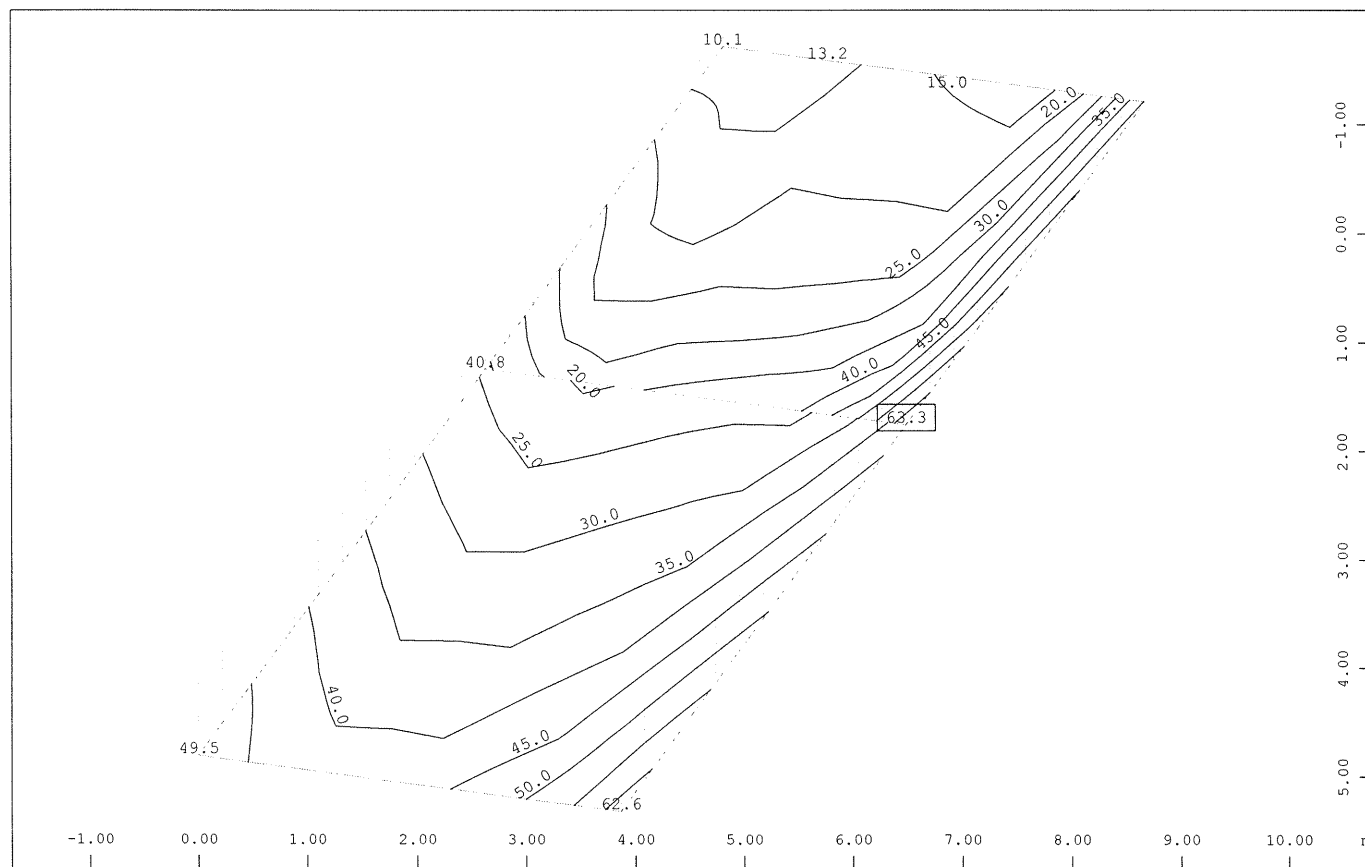
M 1 : 52
X * 0.502
Y * 0.906
Z * 0.962

KONTAKTNE NAPETOSTI



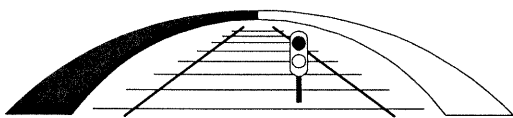
Sector of system Group 3
Bedding stress in Node ↕, Loadcase 2117 MAX-P QUAD , from 10.1 to 63.3 step 5.00 kN/m²

M 1 : 70
X * 0.502
Y * 0.906
Z * 0.962

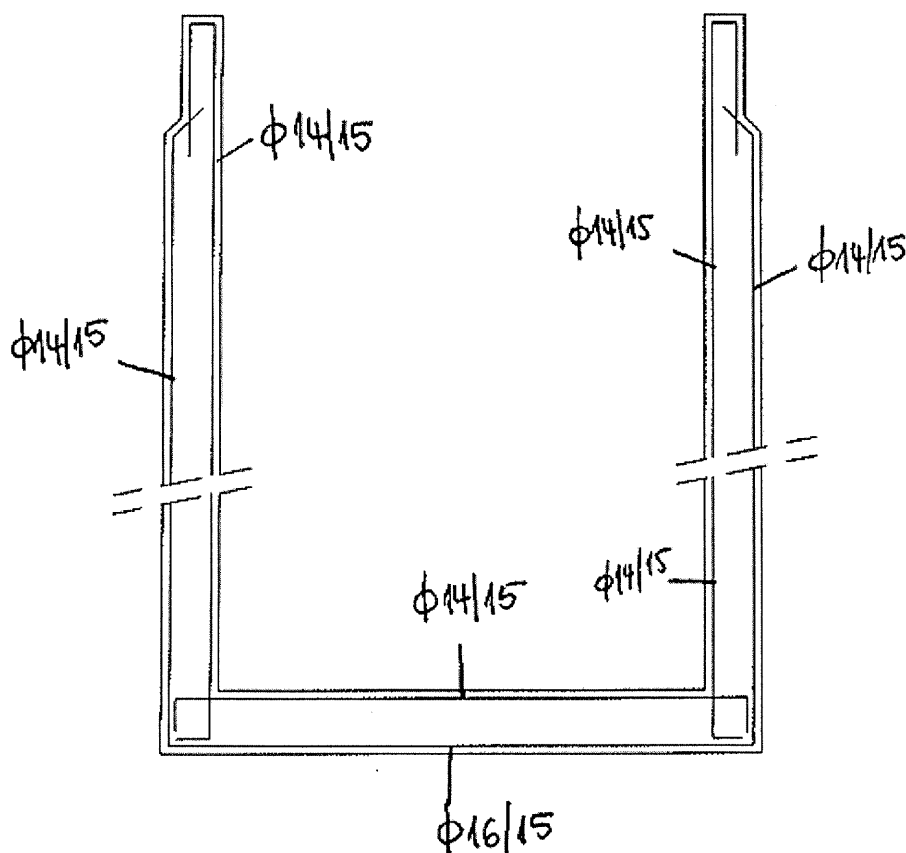


Sector of system Group 3
Bedding stress in Node ↕, Loadcase 2117 MAX-P QUAD , from 10.1 to 63.3 step 5.00 kN/m²

M 1 : 70
X * 0.502
Y * 0.906
Z * 0.962

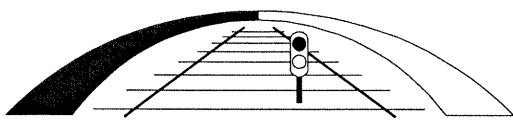


4.5 Skica armature



VZDOLŽNA ARMATURA $\phi 14/15$ ("BK")

RAZPORNİ ŽID $\phi 14/15$ V vse smeri



5 KONTROLA VZGONA

5.1 VZGON OKVIRNE KONSTRUKCIJE

$$V = 4,7 \cdot 3,5 \cdot 10 = 164 \text{ kN}$$

$$G = 25 \cdot [0,35 \cdot (2 \cdot 4,7 + 2 \cdot 2,8) + 0,30 \cdot 4] + 4,7 \cdot 0,6 \cdot (20 - 10) = 218 \text{ kN}$$

$$f = \frac{\gamma_{G, stb} \cdot G}{V} = \frac{0,9 \cdot 218}{164} = 1,2 > 1,0 \rightarrow OK$$

Upoštevana je voda do terena.

5.2 VZGON STOPNIŠČA

$$V = 23,1 \cdot 4,6 \cdot 10 = 1060 \text{ kN}$$

$$G = 25 \cdot [5,9 \cdot 4,6 + 2 \cdot 0,35 \cdot 18,0 + 2 \cdot 0,25 \cdot 9 + 0,35 \cdot 1,66 \cdot 3,9 + 0,25 \cdot 0,6 \cdot 3,9]$$

$$G = 1180$$

$$f = \frac{\gamma_{G, stb} \cdot G}{V} = \frac{0,9 \cdot 1175}{1060} = 1,0 > 1,0 \rightarrow OK$$

Ni upoštevana še teža jeklene nadstrešnice.

5.3 VZGON DVIGALA

$$V = 2,3 \cdot 2,5 \cdot 6 \cdot 10 = 345 \text{ kN}$$

$$G = 25 \cdot [2,3 \cdot 2,5 \cdot 0,4 + 0,35 \cdot 6(2 \cdot 2,3 + 2 \cdot 1,8)] = 490 \text{ kN}$$

$$f = \frac{\gamma_{G, stb} \cdot G}{V} = \frac{0,9 \cdot 490}{345} = 1,0 > 1,28 \rightarrow OK$$