NASLOVNA STRAN NAČRTA GRADBENIH KONSTRUKCIJ – MAPA I

OSNOVNI PODATKI O GRADNJI

naziv gradnje: Vrtec in telovadnica s podzemno garažo OŠ Bistrica ob Sotli

kratek opis gradnje: Investitor Občina Bistrica ob Sotli želi zgraditi vrtec in telovadnico s podzemno garažo s pripadajočo zunanjo ureditvijo. Objekt bo podolgovate tlorisne oblike z orientacijo daljše stranice slemena v smeri S-J. Objekt bo v delu vrtca in telovadnice etažnosti K+P+1, v delu garaže pa pretežno etažnosti K.

vrste gradnje:

- ☐ novogradnja - novozgrajen objekt
- ☒ novogradnja - prizidava
- ☐ rekonstrukcija
- ☐ sprememba namembnosti
- ☐ odstranitev

DOKUMENTACIJA

vrsta dokumentacije: PZI

številka projekta: 14/2020

☐ sprememba dokumentacije

PODATKI O NAČRTU

strokovno področje načrta: NAČRT S PODROČJA GRADBENIŠTVA

številka načrta: 01/21-K

datum izdelave: julij 2021

PODATKI O IZDELOVALCU NAČRTA

ime in priimek pooblaščenega inženirja: Uroš Žvan, univ. dipl. inž. grad.

identifikacijska številka: IZS G-0028

podpis pooblaščenega inženirja:

UROŠ ŽVAN
univ. dipl. inž. grad.
IZS G-0028

PODATKI O PROJEKTANTU

projektant (naziv družbe): Engenerija, Vid ŽOGAN s.p.

naslov: Zdraviliški trg 15, 3250 Rogaška Slatina

vodja projekta: Vid Žogan , univ. dipl. inž. Grad

identifikacijska številka: IZS G-3879

podpis vodja projekta:

VID ŽOGAN
univ.dipl.inž.grad.
IZS G-3879

odg. oseba projektanta: Vid Žogan , univ. dipl. inž. grad.

podpis odg. osebe projektanta

engenerija
arhitekturno in grad. projektiranje
Vid Žogan s.p.
Zdraviliški trg 15, 3250 Rogaška Slatina

2. VSEBINA MAPE I

3. VSEBINA MAPE II

4. VSEBINA MAPE III

5. TEHNIČNO POROČILO

1 PODATKI O INVESTITORJU IN OBJEKTU

Investitor Občina Bistrica ob Sotli, Bistrica ob Sotli 17, 3256 Bistrica ob Sotli, ima namen zgraditi vrtec in telovadnico s podzemno garažo s pripadajočo zunanjo ureditvijo. Objekt bo podolgovate tlorisne oblike z orientacijo daljše stranice slemena v smeri S-J. Objekt bo v delu vrtca in telovadnice etažnosti K+P+1, v delu garaže pa pretežno etažnosti K. Predmet izvedbe je klasična AB kosntrukcija. Oblika strehe je asimetrična dvokapnica v naklonu 12°- 23°.

Celoto konstrukcije sestavljajo trije tehnično različni deli objekta.

- Podzemna garaža z uvozom
- Vrtec
- Športna dvorana

Tlorisni gabariti objekta na koti -3.90m znašajo 75,25x36,85m. Dimenzije se nanašajo na osne razdalje nosilne AB konstrukcije.

2 OPIS KONSTRUKCIJE

Objekti novogranje:

TEMELJNA TLA

Talna plošča je debeline 28 in 58 cm. Izdelana je kot plošča na utrjeni elastični podlagi. Elastično podlago predstavlja dobro uvaljano gramozno nasutje, oziroma po potrebi trda toplotna izolacija XPS. Z računalniškim modelom je predpostavljena podajnost podlage c=15.000 kN/m3,
Računsko ugotovljena kontaktna napetost na zemljino izpeljana iz navedenih podatkov znaša v mejnem stanju uporabnosti:

Področje talne plošče podzemne garaže
MSU=1,0g+1,0q = …..σ = 0,0108 kN/cm2…..posedek 7,25mm
Področje talne plošče dvorane
MSU=1,0g+1,0q = …..σ = 0,0087 kN/cm2…..posedek 7,27mm
Podlago je potrebno utrditi na nosilnost σ = 0,02 kN/cm2

Pri izvedbi temeljenja je obvezna prisotnost geologa, ki mora zagotoviti navedeno nosilnost temeljnih tal ob relativnih posedkih, ki ne bodo poškodovali konstrukcije. V kolikor temeljna tla v realnosti ne dosegajo pričakovanih nosilnosti, geolog predpiše sanacijo temeljnih tal. Svoje mnenje in rešitve vpiše v gradbeni dnevnik.

PODZEMNA GARAŽA Z UVOZOM

Garaža je izvedena kot A.B. stenska konstrukcija. Talna plošča je izvedena v debelini 28 in 58 cm v betonu C30/37 XC2 z dodatki proti krčenju. Stene so debeline 25 cm C25/30 XC3. Zemljina predstavlja agresiven medij, zato je potrebno v stiku beton -zemlja upoštevati zaščitni sloj betona 4 cm sicer zadostuje 2,5 cm.

VRTEC

Področje vrtca je izvedeno kot A.B. stenska konstrukcija. Plošča poz 100;200;in 300 so debeline 28cm, Za celoto konstrukcije področja vrtca uporabimo beton C25/30 XC3. Stene so debeline 25 cm C25/30 XC3. Zaščitni sloj znaša 2,5 cm. Plošča poz 300 obremenjujemo s tehnološkimi napravami za ogrevanje in hlajenje. Obremenitve so opisane v nadaljevanju tega elaborata.
Strešna konstrukcija vrtca je asimetrična lesena dvokapnica, ki jo sestavljajo špirovci 14/20 cm, glavne lege lepljen les 20/60 cm, stebri 20/20 cm z ročicami.

ŠPORTNA DVORANA
Področje dvorane obravnavam kot okvirno monolitno konstrukcijo na talni plošči. Talna plošča je izvedena v debelini 28 cm v betonu C30/37 XC2 z dodatki proti krčenju. Rob talne plošče je ojačan z temeljno gredo, kamor sidramo stene in stebre konstrukcije. Stene med stebri so debeline 25 cm, C25/30 XC3. Nosilni stebri so dimenzij 60/60 cm in segajo do višine 11,39 m
Zemljina predstavlja agresiven medij, zato je potrebno v stiku beton -zemlja upoštevati zaščitni sloj betona 4 cm sicer zadostuje 2,5 cm. Statična zasnova temeljenja so pasovni temelji-grede s talno ploščo. Statično delujeta povezano. V računu jih tako tudi obdelujemo. Stebri in stene dvorane so monolitno nadaljevanje iz talne plošče. Dilatacije zaradi značilne zasnove niso predvidene.
Streha je asimetrična dvokapnica in se nadaljuje kot podaljšek strehe vrtca. V dvoranskem delu je strešna konstrukcija izvedena kot jeklena palična konstrukcija s sekundarnimi nosilci. Ležišča jeklenih nosilcev so izdelana na vrhu A.B. stebrov 60/60 cm.

OSEBNO DVIGALO
Ob stopnišču se izvede dvigalo z vstopi na treh višinskih lokacijah. Izvajalec gradbenih del – (betonskih sten dvigala) debeline 25 cm, mora dela izvesti natančno po grafičnih in ustnih navodilih - zahtevah izbranega proizvajalca dvigala in v dogovoru z njim. To pomeni, na njegovo zahtevo puščati potrebne izreze in ojačitve v stenah in ploščah jaška dvigala. V primeru nejasnosti se je potrebno pravočasno posvetovati z odgovornim projektantom.

TRIBUNA ZA GLEDALCE
Plošče tribun se izvedejo kot dvoetažne. Na koti 0,00 in +3,90, Debeline so 20 cm. Estrihi nad ploščami tribune se izvedejo v min debelini 12 cm, nad toplotnimi izolacijami, zaradi možnosti preboja ob močnejših lokalnih obremenitvah. Konstrukcija sedišč se izvede kot armiranobetonska. Sestavljajo jo žagasti nosilci, ki s svojim načinom izvedbe dodatno ne obremenjujejo same plošče tribune in tribunski montažni elementi za pritrjevanje sedišč. Montažni elementi so debeline 16 cm in razpona do 6,00m. Celotna armatura konstrukcije je klasična. RA, S 500B.

Armatura in beton
Kvaliteta armature in betona je podana ob izračunu in dimenzioniranju vsakega gradbenega elementa.Na objektu uporabljamo izključno armaturo opremljeno z ustrezno atestno dokumentacijo. Predvidena kvaliteta armature je S 500B (MA in RA) . Za izdelavo konstruktivnih elementov je potrebno uporabiti beton proizveden v kontrolirani gradbeni proizvodnji z ustreznimi dokazili.

STREŠNA KONSTRUKCIJA ŠPORTNE DVORANE
Strešna kosntrukcija je sestavljena iz jeklenih primarnih paličnih nosilcev, strešnih sekundarnih nosilcev, zavetrovanja ter lesenih nosilcev na noviju stropa. Palični nosilci, ki potekajo med osema 9 in 13 so sestavljeni iz jeklenih profilov HEB 180 in HEB 140. Profili paličnih nosilcev so medsebojno varjeni, razen na sredini kjer je palični nosilec razdeljen zaradi transporta, na tem mestu so predvideni vijačni spoji. Strešna sekundarna konstrukcija je sestavljena iz HEB 140 medsebojno zavetrovana s zategami Φ16, enako zavetrovanje se pojavi pri paličnih nosilcih v oseh B in E.

Zaradi zavese ki se nahaja v stropu so dodani pomožni nosilci HEB 140, prav tako so dodani pomožni nosilci HOP 120x80x5 za montiranje košev na obeh koncih telovadnice.

Lesena konstrukcija stropa je sestavljena iz lepljenih nosilcev dimenzij b/h = 8/25 cm. Nosilci so med osema 10-11 in 12-13 zavetrovani lesenimi plohi dimenzij b/h = 12/5 cm ki so vijačeni na lesene nosilce.

Konstrukcija je medsebojno vijačena in varjena. Palični nosilci so preko predhodno vgrajenih sider sidrani na stebre konstrukcije. Strešni nosilci so sidrani preko hilti sider na stene v oseh 8 in 14. Vijačeni spoji so iz vijakov M12, M16, M20, Hilti HIT HY200 + HIT-Z M12.
Uporabljeno jeklo kvalitete S235 JR, vijaki in sidra kvalitete 8.8. Razred izvedbe EXC2

3 OSNOVNE ANALIZE KONSTRUKCIJE

Konstrukcija je bila analizirana v skladu s standardi družine Evrokod SIST EN 1990 do SIST EN 1999.

Modalna analiza je izvedena z upoštevanjem 30% spremenljive obtežbe kategorije A.

Seizmična odpornost konstrukcije bo zagotovljena v skladu s standardom SIST EN 1998 in slovenskim nacionalnim dodatkom za sledeče pogoje:
- projektni pospešek temeljnih tal 0,2×g
- kategorija tal C do D
- koeficient dušenja 0,05
- naključna ekscentričnost 0,05×L
- kategorija objekta II
- konstrukcija regularna po višini in tlorisu
- razred duktilnosti M
- dvojni sistem z dominantnimi stenami
- faktor obnašanja konstrukcije 2,0

Požarna odpornost

Iz arhitekturne zasnove privzemam zahtevo po požarni odpornosti konstrukcije R60. Velja za vse elemente konstrukcije.

4 ZAKLJUČEK

Gradbena dela na objektu, lahko izvajajo le za ta opravila strokovno usposobljene osebe. Za eventualne projektne nejasnosti, ali uvajanje sprememb med gradnjo, se je potrebno posvetovati z odgovornim projektantom.

sestavil:
Filip Peharda, m.i.g.

6. STATIČNI IZRAČUN

VPLIVI NA AB KONSTRUKCIJO

Zraven običajnih obremenitev lastne teže, snega, vetra in potresa, so za potrebe uporabe objekta definirane še naslednje koristne obtežbe. Prikaz koristnih obremenitev konstrukcije.

- Talna plošča garaže, lahka vozila 3,00 kN/m2
- Plošča poz 100;200; 4,00 kN/m2
- Plošča poz 300 podstrešje 3,00 kN/m2 + enote za ogrevanje / prezračevanje
- Talna plošča dvorane 5,00 kN/m2

Podrobne obremenitve od posameznih enot za ogrevanje in prezračevanje so podane v statičnem izračunu.

SPREMENLJIVIV VPLIVI:

VETER..hitrost vetra, Slovenija 1.cona, 20m/s

SNEG...........................sneg 2.cona Bistrica ob Sotli, nadmorska višina 230m
Na strehi je privzeta povečana obremenitev od snega 1,40 kN/m2, zaradi snegobranov, ki posledično omogočajo kopičenje snega.

VPLIVI NA JEKLENO KONSTRUKCIJO STREHE

Opisani pri statičnem izračunu strehe

STATIČNI IZRAČUN OBJEKTA

Objekt:	VRTEC IN TELOVADNICA S PODZEMNO GARAŽO OŠ BISTRICA OB SOTLI
Kraj:	BISTRICA OB SOTLI
Investitor:	OBČINA BISTRICA OB SOTLI; BISTRICA OB SOTLI 17; 2356 BISTRICA OB SOTLI
Št.projekta	14/2020
Št.načrta	01/21-K
datum:	Julij 2021

Kazalo

A: SPLOŠNE OBTEŽBE
2.1 Veter - definicija obremenitve

Zunanji pritisk **We1** = **q**ref***c**e(ze)***c**pe
We1 = 250*1,91*1,3 = 620,75 N/m2 = 0,62 kN/m2

Notranji pritisk **W**e**2** =**q**ref***c**e(ze)***c**pi
We1 = 250*1,91*0,8 = 382 N/m2 = 0,38 kN/m2

qref — referentni pritisk srednje hitrosti vetra
qref = (&/2)*vref**2
qref = **0,5*1,25*20**2 = 250 N**

& — gostota zraka =1,25 kg/m3
v(ref) — referentna hitrost vetra
vref = **c**dir***c**tem***c**alt***v**ref,o
vref **= 1*1*1*20 = 20 m/s**

cdir — koeficient smeri =1, 00
ctem — koeficient začasnosti = 1,00
calt — koeficient nadmorske višine = 1,00
cref,o — osnovna vrednost referentne hitrosti
Slovenija 1.cona BISTRICA OB SOTLI = 20 m/s

ce — koeficient izpostavljenosti
ce(z)=**c**r(z)**2 * **c**t(z)**2 * (1+(7***k**r/(**c**r(z)***c**t(z)))
ce(z)= **0,811**2 * 1,00**2 * (1+7*0,22/(0,811*1)) = 0,658*2,89 = 1,91**

cr(z) — koeficient hrapavosti
cr(z)=**k**r***ln**(**z/z**o) — tab. 8,1
cr(z)= 0,22*ln(12,00/0,30) =0,811
zo — dolžina hrapavosti = 0,30 m
z — višina objekta = 12,00 m

ct(z) — koeficient topografije = 1,00
kr — koeficient terena = 0,22

cpe — koeficient zunanjega pritiska = **c**pe10 = **1,30**
cpi = — koeficient notranjega pritiska = **0,80**

cd = — koeficient dinamičnega odgovora =**1,00** — Konstrukcija ni občutljiva na dinamični odgovor
cf = — koeficient sile
cf =cfo*ksilamda = 0,67*2,0 =**1,34**
fi = A/Ac =1/1 = 1,00
Ksi lambda = 0,67 (tab 10.14.1.)
cfo = 2,00
Aref **=** — referenčna površina za enoto 1m2

Sila vetra **Fw=q**ref***c**e(ze)*****c**d*cf*A**ref
Fw=250*1,91*1,00*1,34*1,0 = **640** N/m2

Koeficienti oblike objekta

			e=5,85m
Sila vetra	**0,64** kN/m2		Veter na stebre hale
Stene pritisk	**0,80**	0,51 kN/m2	3,00 kN/m1
Stene sesanje	**0,50**	0,32 kN/m2	1,87 kN/m1
Streha pritisk	**0,40**	0,26 kN/m2	1,50 kN/m1
Streha sesanje	**0,40**	0,26 kN/m2	1,50 kN/m1

2.2 Sneg - definicija obremenitve

s=**μ**i***C**e***C**t***s**k
s=0,8*1*1*1,422 **= 1,138** kN/m2 Naklon strehe 12 in 23° asimetrična dvokapnica

μi	koefiient oblike obremenitve od snega	
	kot naklona strešine	0- 30° --> μi**=0,8**
		30-60 --> μi=**0,8*(60-α)/30 =**
		>60° --> μi**=0**
Ce	koeficient izpostavljenosti = 1,0	
Ct	termični koeficient = 1,0	
sk	Vrednost obremenitve od snega kN/m2	
	BISTRICA OB SOTLI, NADMORSKA VIŠINA =230 m	

sk= (0,642*Z+0,009)(1+(A/728)^2) a=nadmorska višina BISTRICA OB SOTLI
sk= 1,293*1,10 = Z=št.cone…BISTRICA OB SOTLI=2
sk= 1,422

Predvidena je zaščita s snegobrani, kar pomeni zadrževanje snega kot obtežba strehe
Za izračun privzamem obtežbo 1,40 kN/m2

2.3 Obtežba od potresa - obremenitve pri simulacija potresa

2,31 Karakteristike objekta in terena

Faktor pomembnosti za 475 let povratne dobe **=1,0**
Faktor pomembnosti običajne stavbe…γi **= 1,2**
Projektni pospešek tal za BISTRICA OB SOTLI = **0,20g *1,2=0,24**
(pomnoženo s fakt.pomembnosti stavbe γi)
Sistem, pravilen po višini in tlorisu, duktilnosti **DCM**
Tip tal "C do D", povzeto po geološkem poročilu

2,32 Nihajni čas objekta

T1= Ct*H^(3/4) =	**0,419**	sekunde
Ct = **0,065**		jekleni okvirji - 0,085, A.B.okvirji - 0,075; ostale konstrukcije - 0,050
H = **12,00**		višina objekta v (m)

2,33 Definicija gravitacijskih sil ki sodelujejo v potresu

	m2	Fg=(1.0g+0,3q) kN/m2	Fg=(1.0g+0.3q) kN	Lokacija H(m)	Stene kN
Streha	534	1,22	651,48	11,00	0,00
Etaža poz 300	451	11,62	5.240,62	7,80	4.617,00
Etaža poz 200	451	12,65	5.705,15	3,90	4.617,00
		Seštevki	**11.597,25**		**9.234,00**

Odbitek odprtin v stenah 10% 0,90

2,34 Uporaba metode z horizontalnimi potresnimi silami

Faktor obnašanja konstrukcije

q = **q**o***k**w >1,5 = 3,6*1,0 = **3,60**

kw - faktor ki upošteva prevladujoč način rušenja pri konstrukcijskih sistemih s stenami…. =1,0
qo - osnovna vrednost faktorja obnašanja za DCM = 3,0
αu/α1 - faktor dodatne nosilnosti v statično nedoločenih konstrukcijah = 1,2
qo = 3,0*αu/α1 = 3,0*1,2 = **3,6**

Projektni spekter pospeškov in potresne sile na objekt

Tb<T>Tc
Sd(T) = **a**g * **S** * **β**o / q = 0,24 *1,25 * 2,5 / 3,60 = **0,2083 g**

ag…(pospešek tal po karti pospeškov)…+ faktor pomembnosti - šola	0,240
S… (parameter tal za tip tal "Cdo D"))….vrednosti interpoliramo	1,25
βo… (faktor za viskozno dušenje za vse vrste tal)	2,50

m (objekta) = mE1+mE2+mE3.... = **2083,1 T**
Fb (objekta) = Sd(T)*m*λ = (0,0779*9,81)*m*λ)= **3.618,78** kN
λ = (za več etaž 0,85 sicer 1,0) 0,85

Razdelitev sil po etažah

Fi = Fb*zi*Wi / Σ zj*Wj

	Smer Fb(x)	
Fb1...Nivo strehe =	368,93 kN	0,69 kN/m2
Fb3...Nivo poz 300 =	2104,39 kN	4,67 kN/m2
Fb4...Nivo poz 200 =	1145,46 kN	2,54 kN/m2
Fb5...Nivo poz 100 =	0,00 kN	

Torzijski vpliv zaradi slučajne ekscentričnosti, ter razlike med masnim in vstrajnostnim središčem

Lx =	**23,75**	m
Ly =	**75,25**	m
Mx = Fb(x)*0,05*Ly		kNm
My = Fb(x)*0,05*Lx		kNm
Ma =(Mx^2+My^2)^(1/2)		kNm

	Slučajna excentr.		Razlika med mas.in vstr.središči			Skupaj
	Ma		**r(m)**	**Mr**		**Ma+Mr**
Ma1...Nivo strehe =	1455,59	kNm	**0,00**	0,00	kNm	**1455,59**
Ma3...Nivo poz 300 =	8302,76	kNm	**0,00**	0,00	kNm	**8302,76**
Ma4...Nivo poz 200 =	4519,36	kNm	**0,00**	0,00	kNm	**4519,36**
Ma5...Nivo poz 100 =	0,00	kNm	**0,00**	0,00	kNm	**0,00**

Deleže potresnih statičnih sil podamo na modelu objekta

Za enoetažne dele objekta, športna dvorana, podajamo horizontalne potresne sile:
Fb= 0,2083 x teža incidentne mase objekta

Sx,y iz reakcij PN = (1.0g+0.3q)*0,1917 = (55,40+0,30*100,29)*0,2083 = 17,80 kN
Sx,y iz mase zidov d=30 cm = 0,30*25*0,2083 = 1,56 kN dvorana

2,40 Zasutje objekta z zemljino

2.41 Podatki

Debelina sten	0,25	m
Debelina talne plošče	0,28	m
Podtalnice ni		m
Teža betona	25,00	kN/m3
Teža vode	10,00	kN/m3
Teža zemljine	20,00	kN/m3
Strižni kot zemljine (vezana zemljina, peski z glino)	25,00	stopinj
Karakteristične vrednosti Ka…(tehničar 2 str. 711)	0,41	

2.42 Obremenitve od zemljine

q = &*H*Ka =	H=(m1)	0,00	0,00	kN/m2
q = &*H*Ka =	H=(m1)	0,50	4,10	kN/m2
q = &*H*Ka =	H=(m1)	1,00	8,20	kN/m2
q = &*H*Ka =	H=(m1)	1,50	12,30	kN/m2
q = &*H*Ka =	H=(m1)	2,00	16,40	kN/m2
q = &*H*Ka =	H=(m1)	2,50	20,50	kN/m2
q = &*H*Ka =	H=(m1)	3,00	24,60	kN/m2
q = &*H*Ka =	H=(m1)	3,50	28,70	kN/m2

2.43 Obremenitve od vode (pogojna prisotnost podtalnice)

q = &*H =	H=(m1)	0,00	0,00	kN/m2
q = &*H =	H=(m1)	0,50	5,00	kN/m2
q = &*H =	H=(m1)	1,00	10,00	kN/m2
q = &*H =	H=(m1)	1,50	15,00	kN/m2
q = &*H =	H=(m1)	2,00	20,00	kN/m2
q = &*H =	H=(m1)	2,50	25,00	kN/m2
q = &*H =	H=(m1)	3,00	30,00	kN/m2
q = &*H =	H=(m1)	3,50	35,00	kN/m2

REZULTATI STATIČNEGA IZRAČUNA

Obvezen je ogled temeljnih tal s strani geologa. Ta računske predpostavke primerja z dejanskim stanjem izkopa na objektu. Z vpisom v gradbeni dnevnik poda svoje mnenje, o morebiti potrebni dodatni obdelavi temeljnih tal.
Računska napetost na temeljna tla velja za obremenitev v mejnem stanju uporabnosti:

2.44 Privzeti pdatki iz literature

Kot notranjega trenja Fi	Naklon zidu proti zemljini	-30 stopinj	-12 stopinj	0 stopinj	12 stopinj
20°	20	**	0,57	0,65	0,81
	10	**	0,50	0,55	0,68
	0	**	0,44	0,49	0,60
	-10	**	0,38	0,42	0,50
	-20	**	0,32	0,35	0,40
30°	20	0,34	0,43	0,50	0,59
	10	0,30	0,36	0,41	0,48
	0	0,26	0,30	0,33	0,38
	-10	0,22	0,25	0,27	0,31
	-20	0,18	0,20	0,21	0,24
40°	20	0,27	0,33	0,38	0,43
	10	0,22	0,26	0,29	0,32
	0	0,18	0,20	0,22	0,24
	-10	0,13	0,15	0,16	0,17
	-20	0,10	0,10	0,11	0,12

Koti notranjega trenja za posamezne vrste zemljine

Nevezana zemljina Gramoz	35°
Slabo vezana zemljina peski, gramozi	30°
Vezana zemljina peski z glino	25°
Vezana zemljina glina	20°

3.20 Tribuna dvorane

Plošča tribune je izvedena kot polno armirana plošča d=20cm,

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,5**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Ploskovne obremenitve plošče tribune

	g	p	g+p	EM
Koristna obremenitev		6,00	6,00	kN/m2
A.B. tribune (sprememba)	3,00		3,00	kN/m2
Obdelava tal	0,40		0,40	kN/m2
Estrih 7cm	1,75		1,75	kN/m2
Izolativni sloji	0,20		0,20	kN/m2
Lastna teža plošče, zajame PRG	7,00		7,00	kN/m2
Omet	0,60		0,60	kN/m2
Skupaj	**12,95**	**6,00**	**18,95**	kN/m2

Obtežni primeri / armatura plošče glej prilogo

Osnovni obtežni primeri

1	g	Lastna teža
2	p	Koristna vertikalna obremenitev

Kombinacije

A=	1,0*g+1,0*p	/ kontrola reakcij in deformacij
B=	1,35*g+1,5*q	/ dimenzioniranje

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka:	SPTribuna.twp
Datum preračuna:	3.4.2021

Način preračuna:	2D model (Zp, Xr, Yr)

[X] Teorija I-ga reda [ ] Modalna analiza [ ] Stabilnost

[ ] Teorija II-ga reda [ ] Seizmični preračun [ ] Ofset gred

[ ] Faze gradnje

Velikost modela

Število vozlišč:	7437
Število ploskovnih elementov:	6966
Število grednih elementov	0
Število robnih elementov	6312
Število osnovnih obtežnih primerov:	2
Število kombinacij obtežb:	2

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

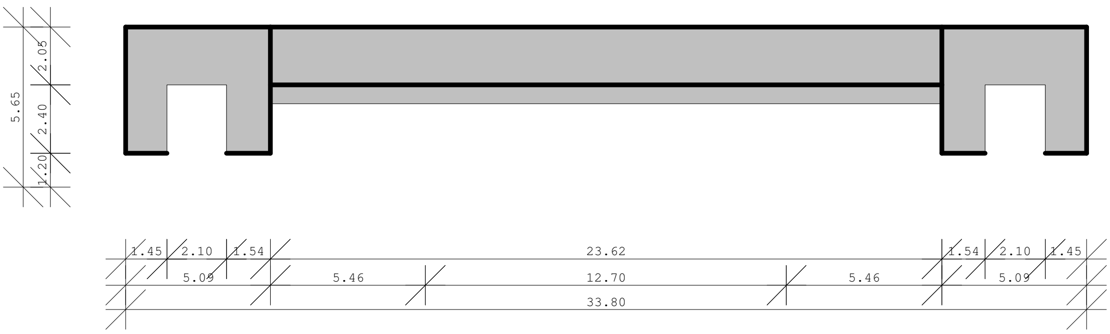
Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

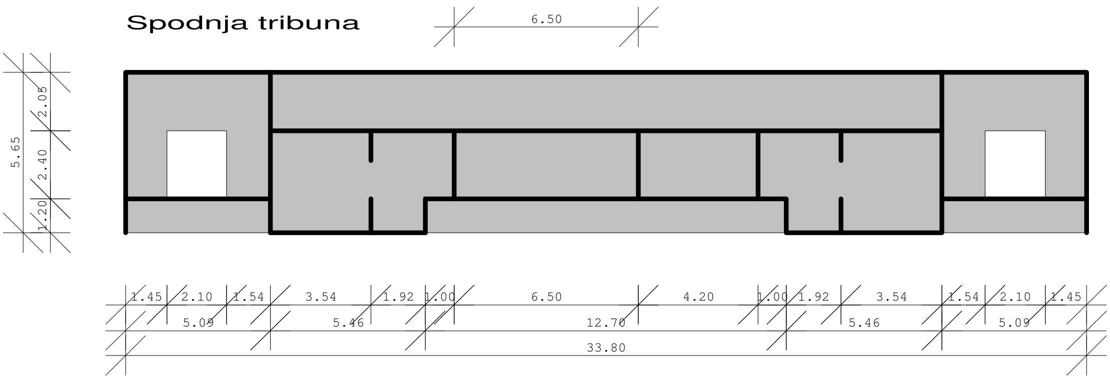
Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.200	0.100	1	Tanka plošča	Izotropna			

Gornja tribuna



Spodnja tribuna



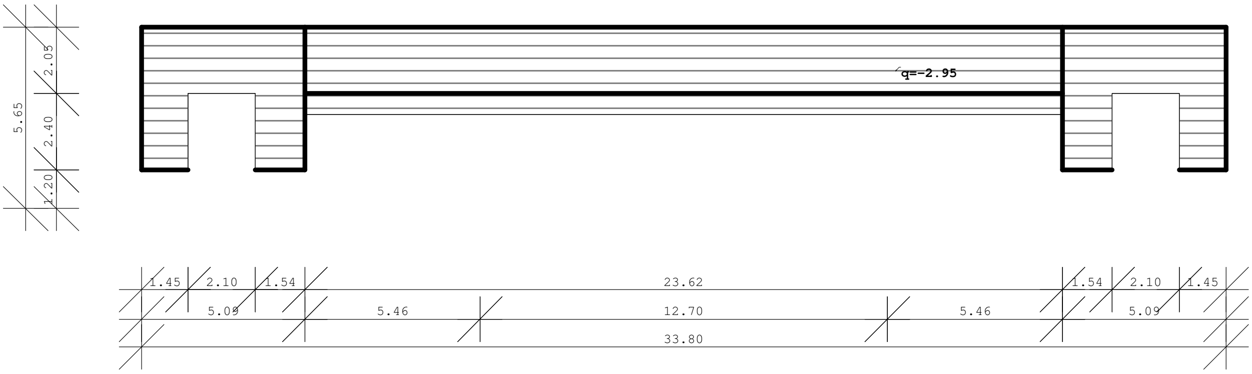
Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba

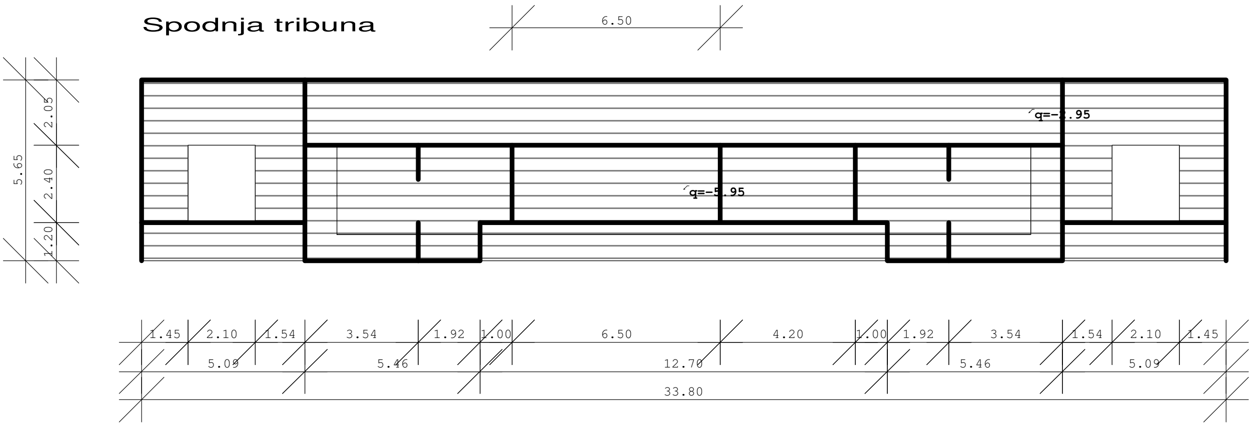
No	Naziv
3	Kombinacija: 1.0g+1.0q (I+II)
4	Kombinacija: 1.35g+1.5q (1.35xI+1.5xII)

Obt. 1: Stalna obtežba (g)

Gornja tribuna

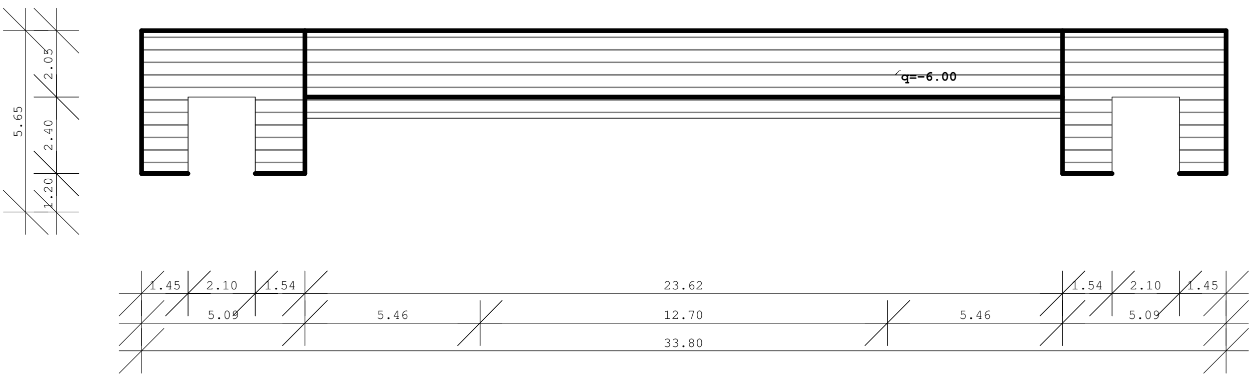


Spodnja tribuna

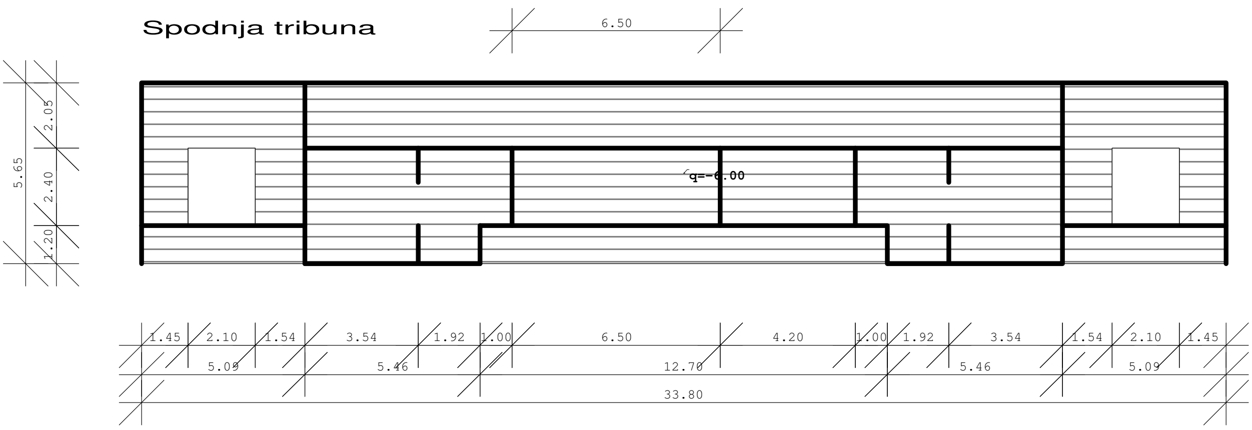


Obt. 2: Koristna obtežba

Gornja tribuna

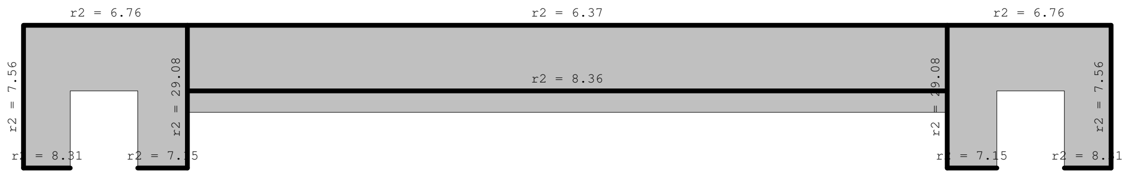


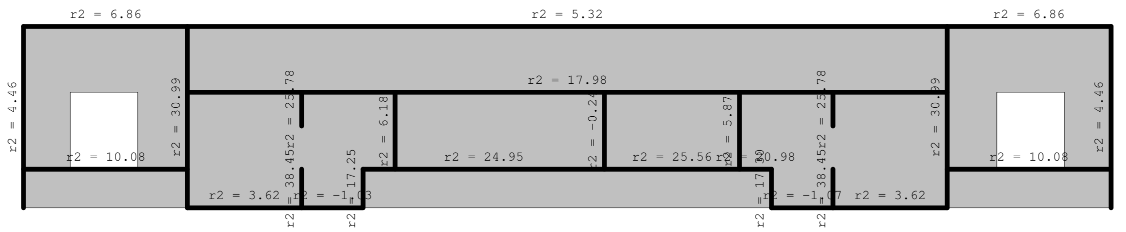
Spodnja tribuna



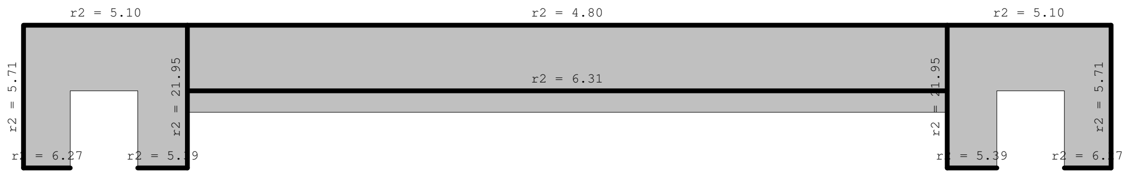
Statični preračun

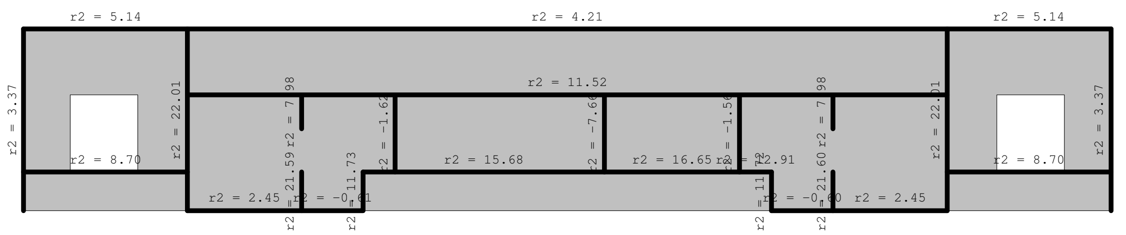
Obt. 1: Stalna obtežba (g)





Reakcije podpor
Obt. 2: Koristna obtežba

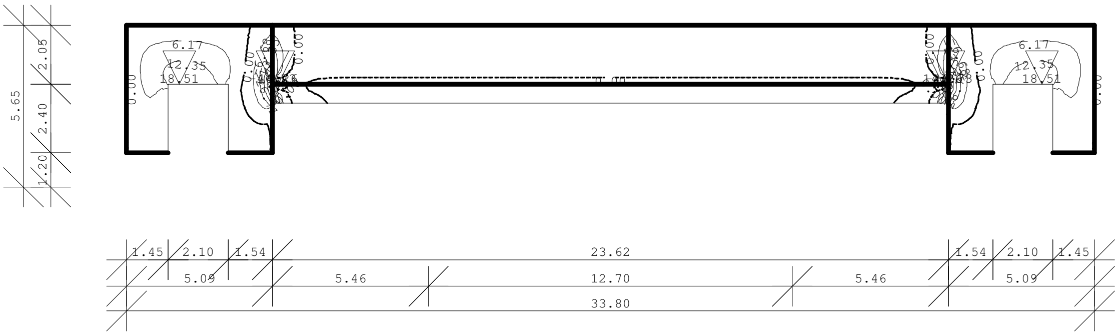




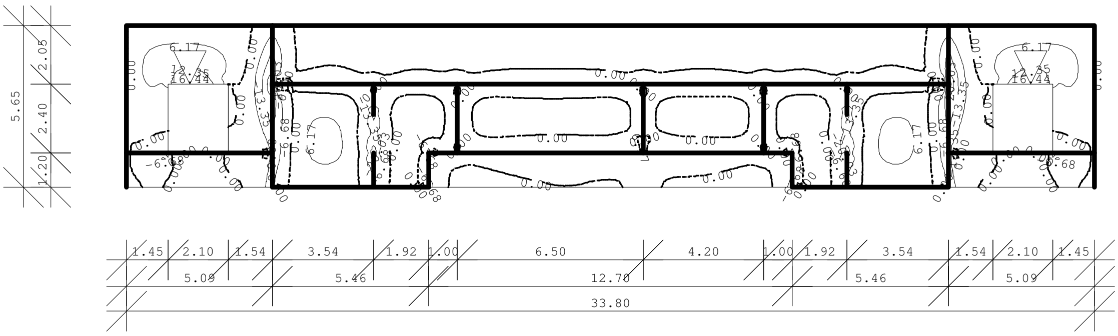
Reakcije podpor

Obt. 4: 1.35g+1.5q

Gornja tribuna

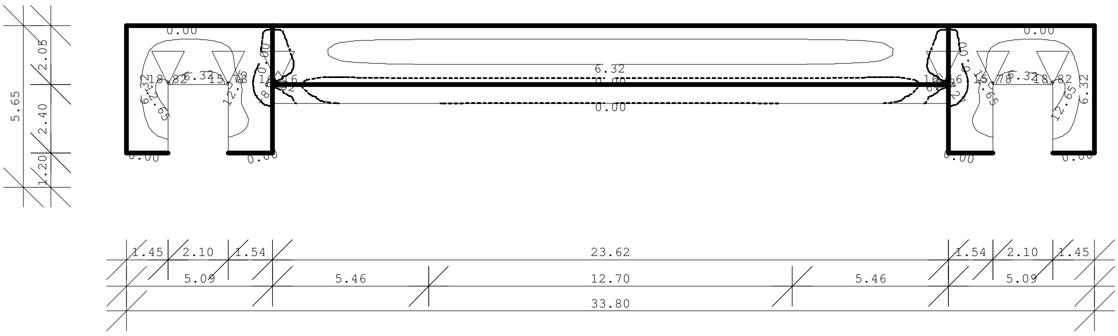


Spodnja tribuna

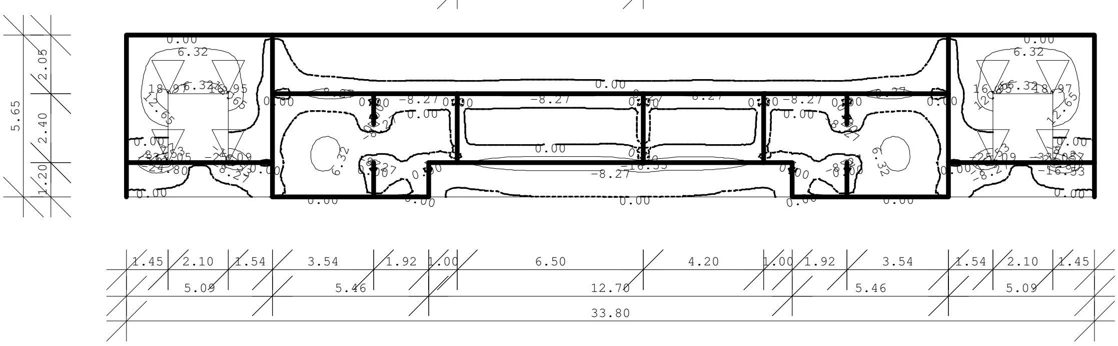


Vplivi v plošči: max Mx= 18.51 / min Mx= -46.73 kNm/m
Obt. 4: 1.35g+1.5q

Gornja tribuna



Spodnja tribuna



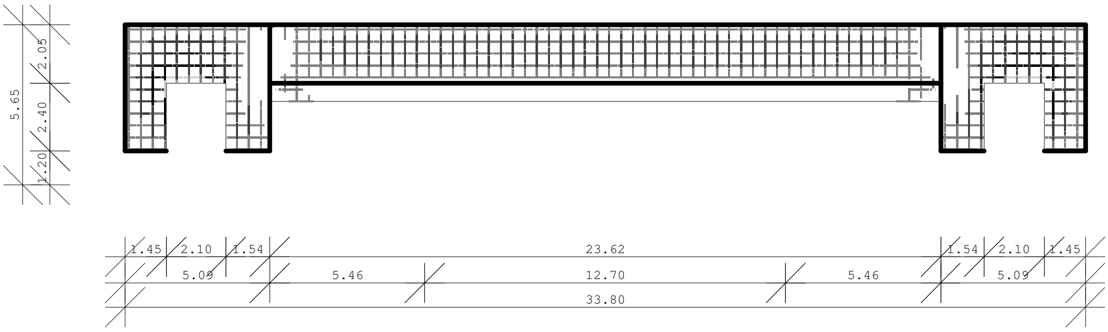
Vplivi v plošči: max My= 18.97 / min My= -33.05 kNm/m

Dimenzioniranje (beton)

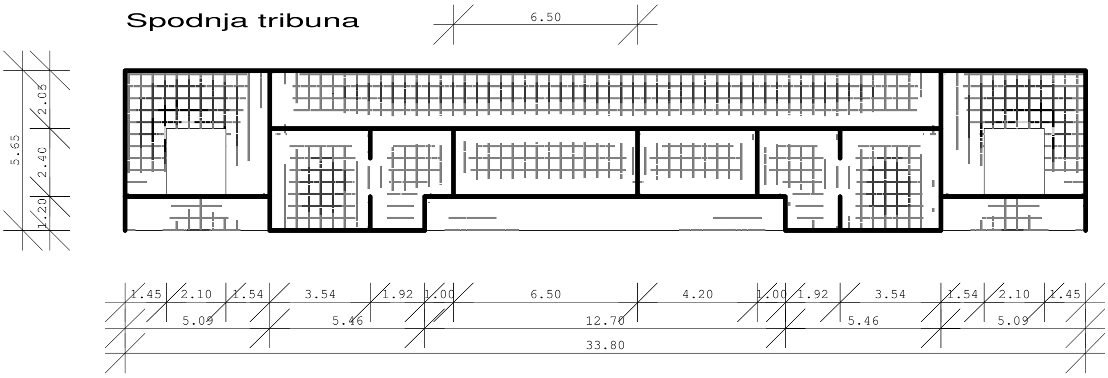
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - sp.cona [cm2/m]
0.00
0.64
1.28
1.92
2.56

Gornja tribuna



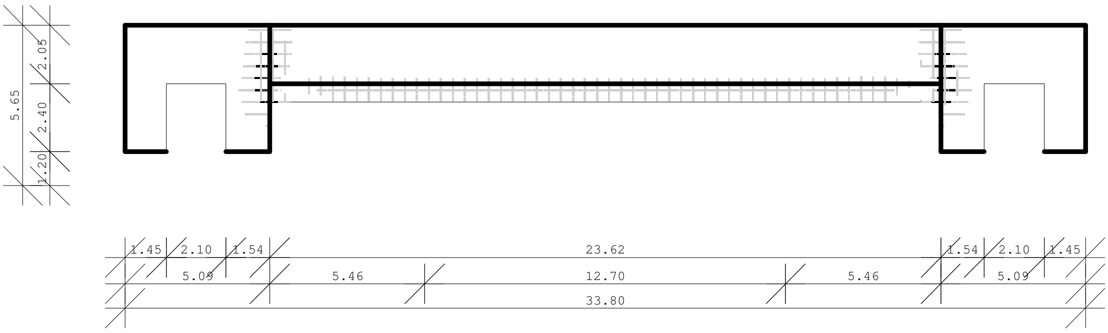
Spodnja tribuna



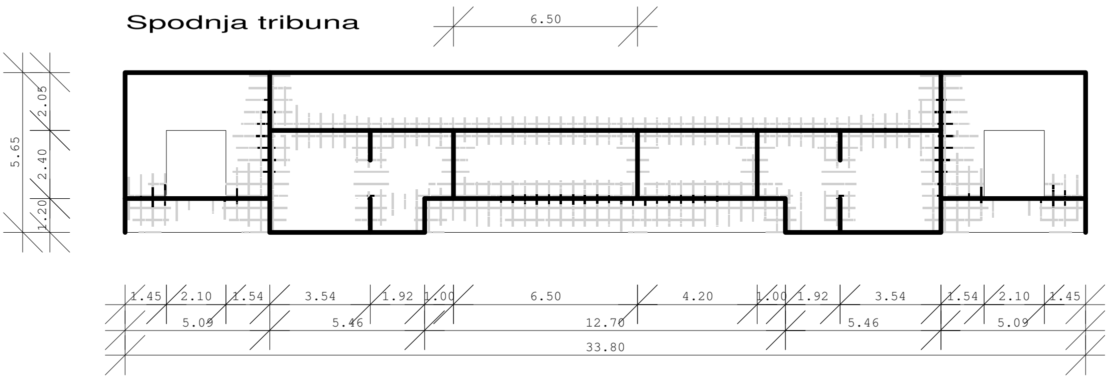
Aa - sp.cona - max As= 2.55 cm2/m
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-5.09
-3.82
-2.55
-1.27
0.00

Gornja tribuna



Spodnja tribuna



Aa - zg.cona - max Az= -5.08 cm2/m

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	ME Tribuna.twp
Datum preračuna:	14.7.2021
Način preračuna:	2D model (Zp, Xr, Yr)

[X] Teorija I-ga reda [ ] Modalna analiza [ ] Stabilnost

[ ] Teorija II-ga reda [ ] Seizmični preračun [ ] Ofset gred

[ ] Faze gradnje

Velikost modela

Število vozlišč:	1353
Število ploskovnih elementov:	1210
Število grednih elementov	121
Število robnih elementov	240
Število osnovnih obtežnih primerov:	2
Število kombinacij obtežb:	2

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Tabele materialov

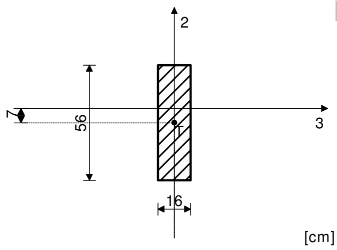
No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

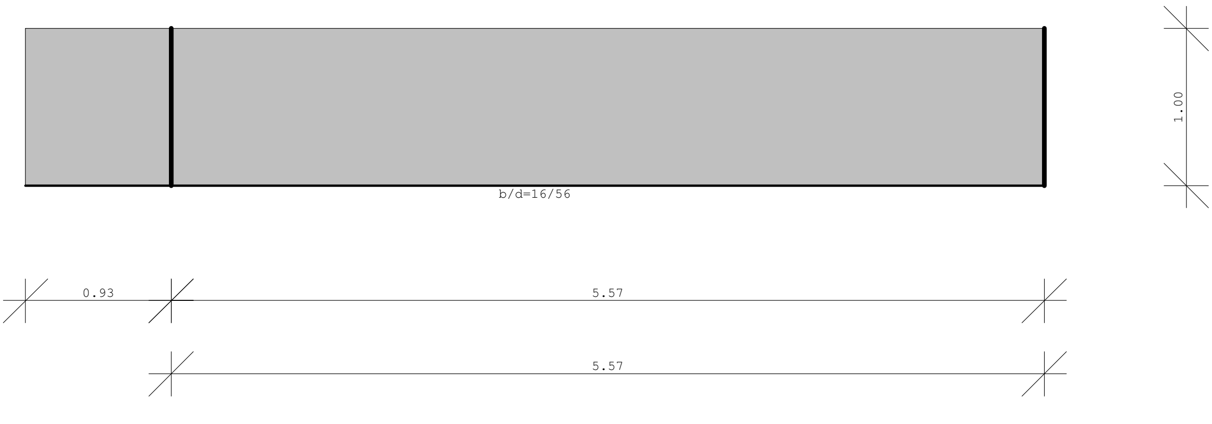
No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.160	0.080	1	Tanka plošča	Izotropna			

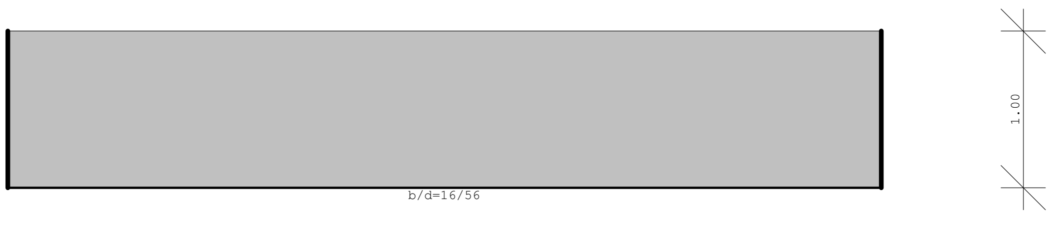
Seti gred

Set: 1 Presek: Pravokotni



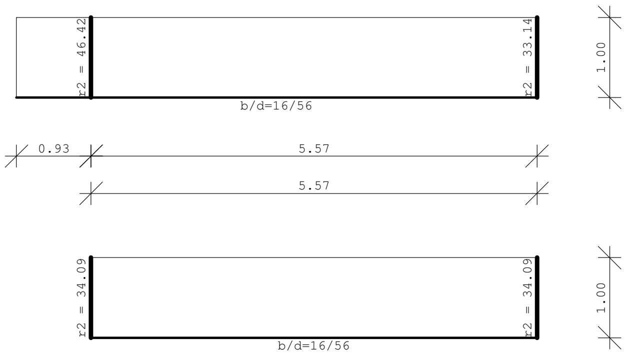
Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		8.960e-2	7.467e-2	7.467e-2	6.270e-4	1.911e-4	2.342e-3





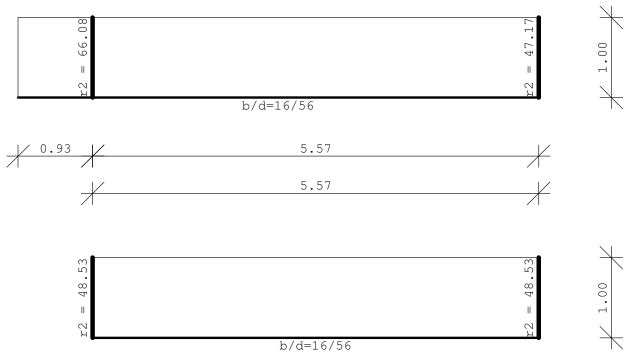
Statični preračun

Obt. 3: MSU - 1.0g+1.0q



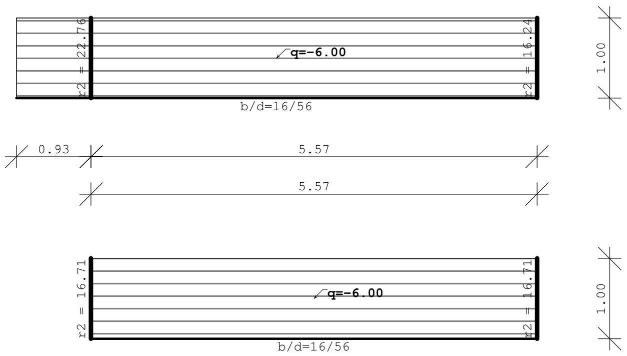
Reakcije podpor

Obt. 4: MSN - 1.35g+1.5q



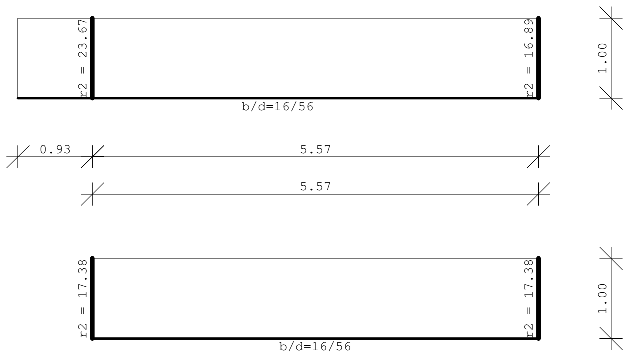
Reakcije podpor

Obt. 2: Koristna obtežba



Reakcije podpor

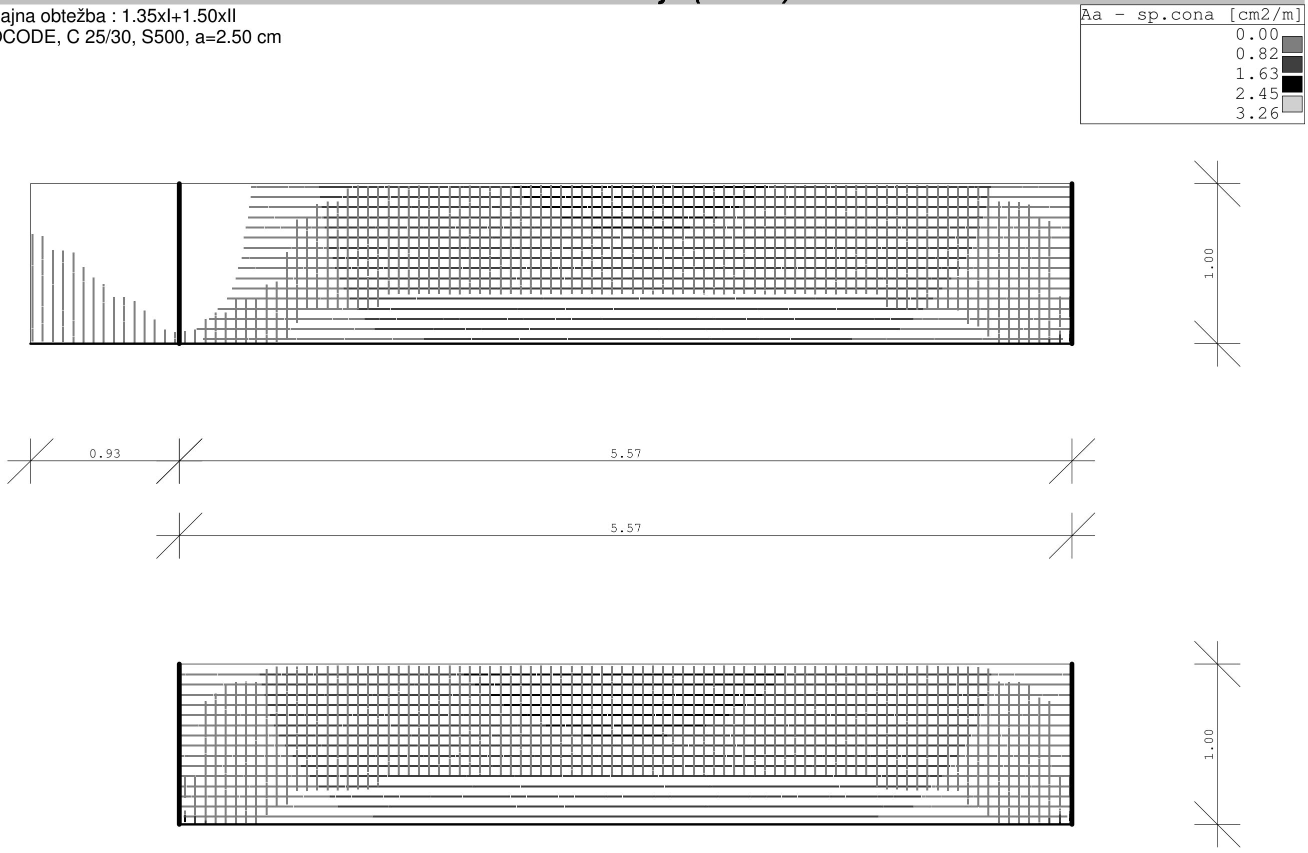
Obt. 1: Stalna obtežba (g)



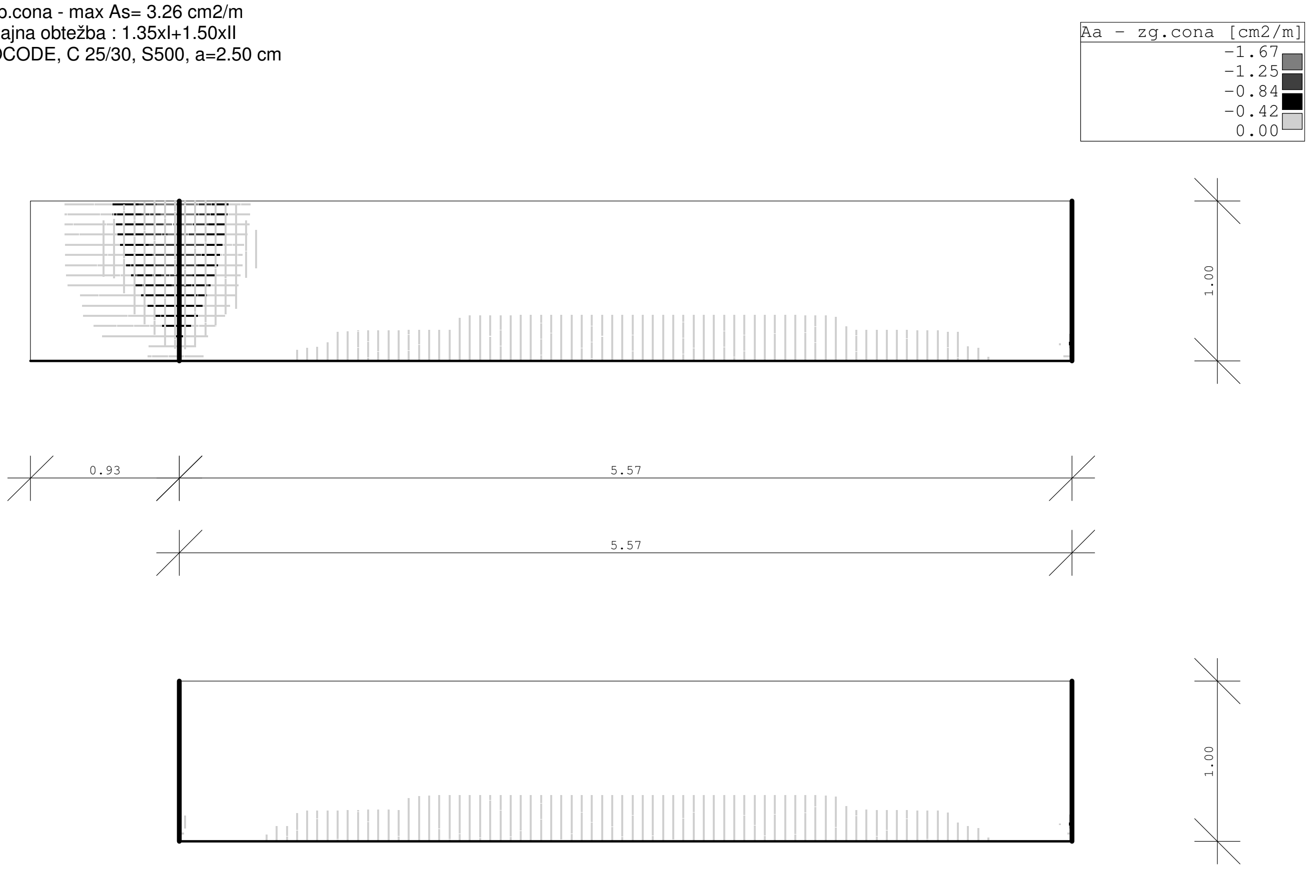
Reakcije podpor

Dimenzioniranje (beton)

Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm

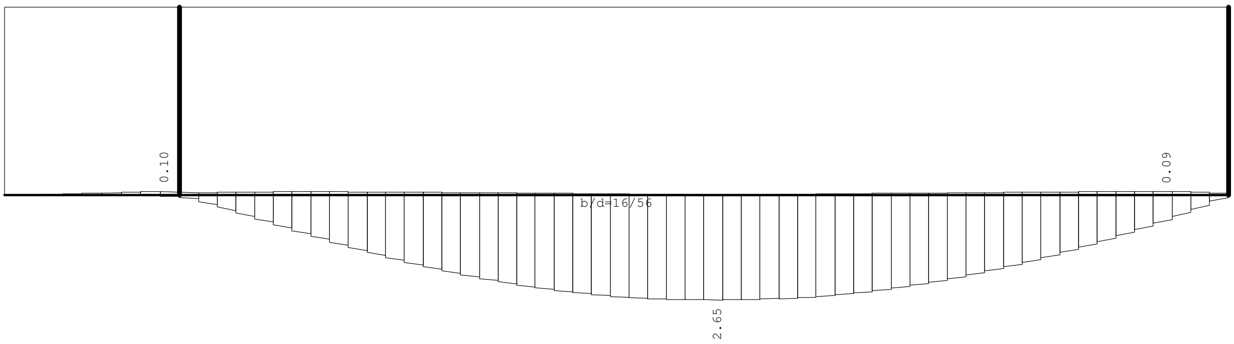


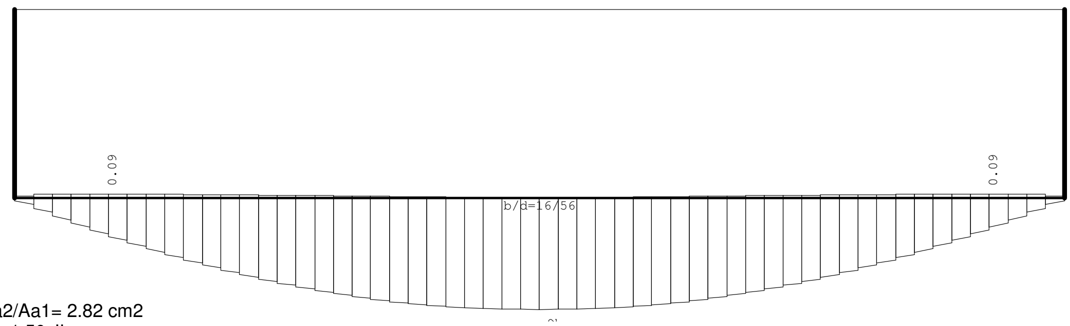
Aa - sp.cona - max As= 3.26 cm2/m
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm



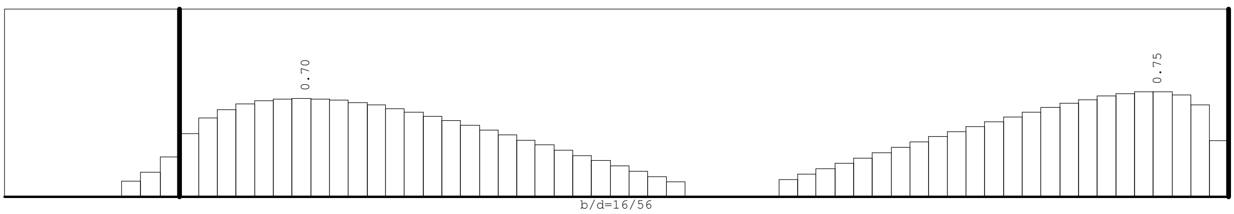
Aa - zg.cona - max Az= -1.66 cm2/m

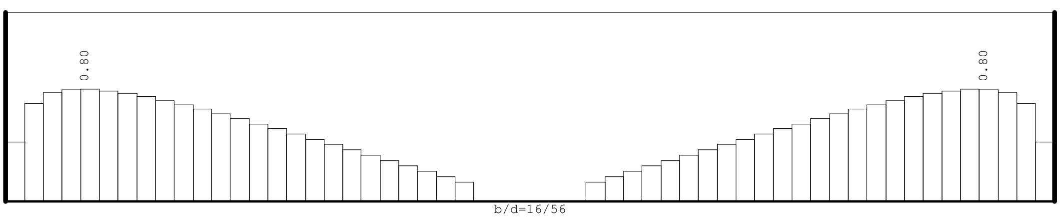
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500





Armatura v gredah: max Aa2/Aa1= 2.82 cm2
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500





Armatura v gredah: max Aa,st= 0.80 cm2

3.30 Dostopi stopnice dvorane B:

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,50**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Definicija obtežbe stopnišča

Debelina nosilne plošče 16 cm

Vertikalne obremenitve naklon rame 30°	**g**	**p**	**g+p**	**EM**
Koristna obremenitev		5,77	5,77	kN/m2
Obdelava tal	0,36		0,36	kN/m2
Estrih	1,50		1,50	kN/m2
Nastopne ploskve	0,50		0,50	kN/m2
Lastna teža plošče	4,61		4,61	kN/m2
Omet	0,50		0,50	kN/m2
Skupaj	**7,47**	**5,77**	**13,24**	kN/m2
Rmax stopniščne rame na ploščo	7,41	5,72	13,13	kN/m1

Obtežni primeri / armatura glej prilogo

Osnovni obtežni primeri

1 g — Lastna teža
2 p — Koristna vertikalna obremenitev

Kombinacije

A= 1,0*g+1,0*p — / kontrola reakcij in deformacij
B= 1,35*g+1,50*p — / dimenzioniranje

Račun in izbira armature notranjega stopnišča

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Stopnice-B.twp
Datum preračuna:	11.3.2021

Način preračuna: 2D model (Zp, Xr, Yr)

- [x] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [ ] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč:	951
Število ploskovnih elementov:	868
Število grednih elementov	0
Število robnih elementov	468
Število osnovnih obtežnih primerov:	2
Število kombinacij obtežb:	2

Enote mer

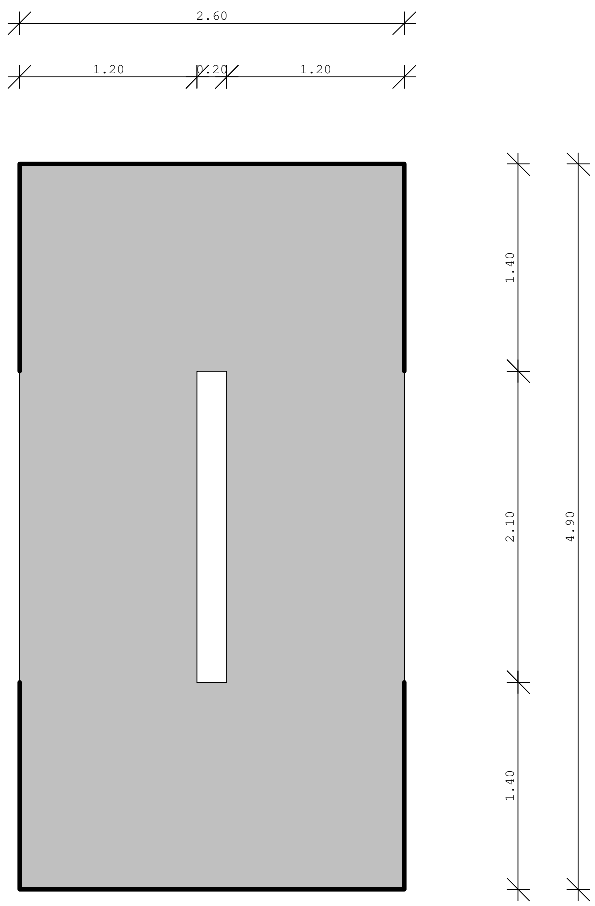
Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

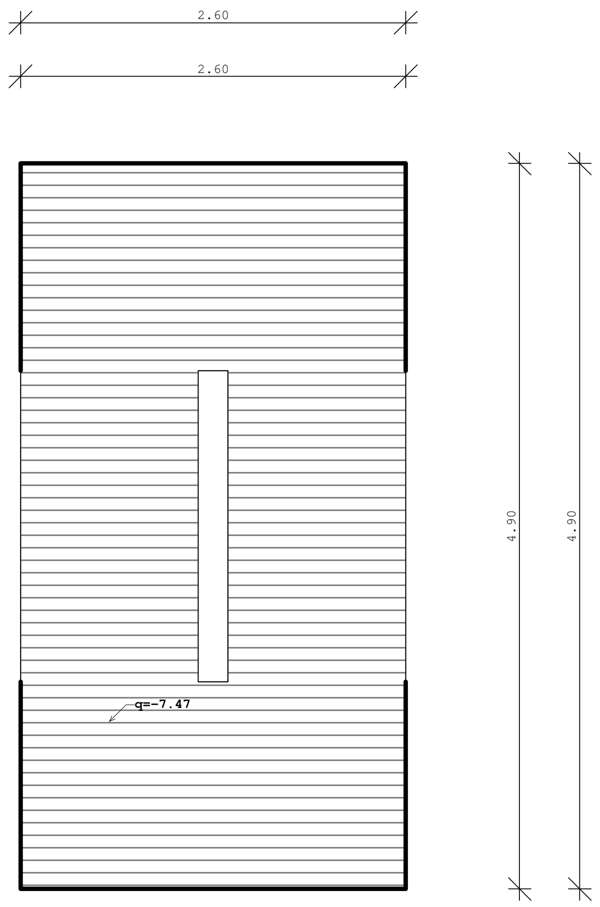
Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.160	0.080	1	Tanka plošča	Izotropna			

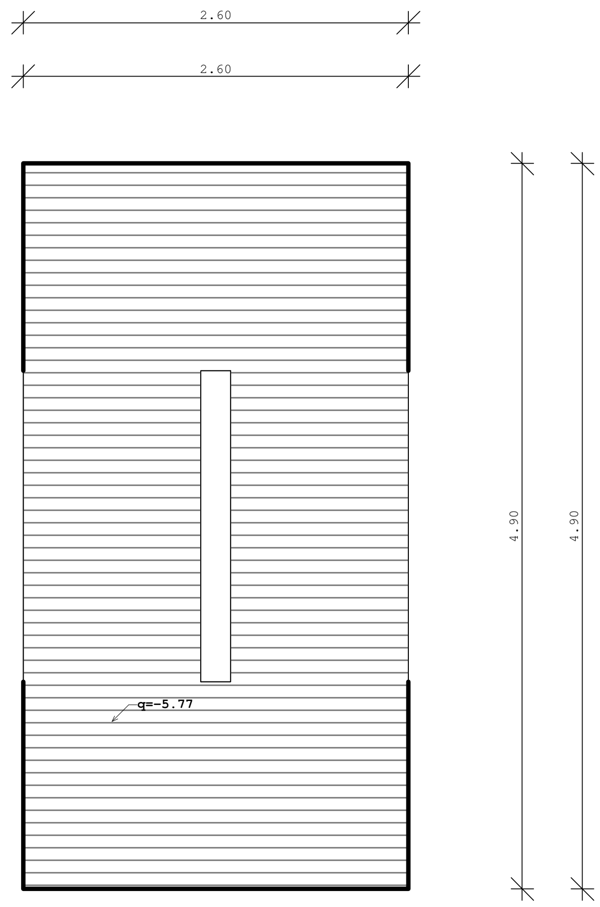


Vhodni podatki - Obtežba, Statični preračun

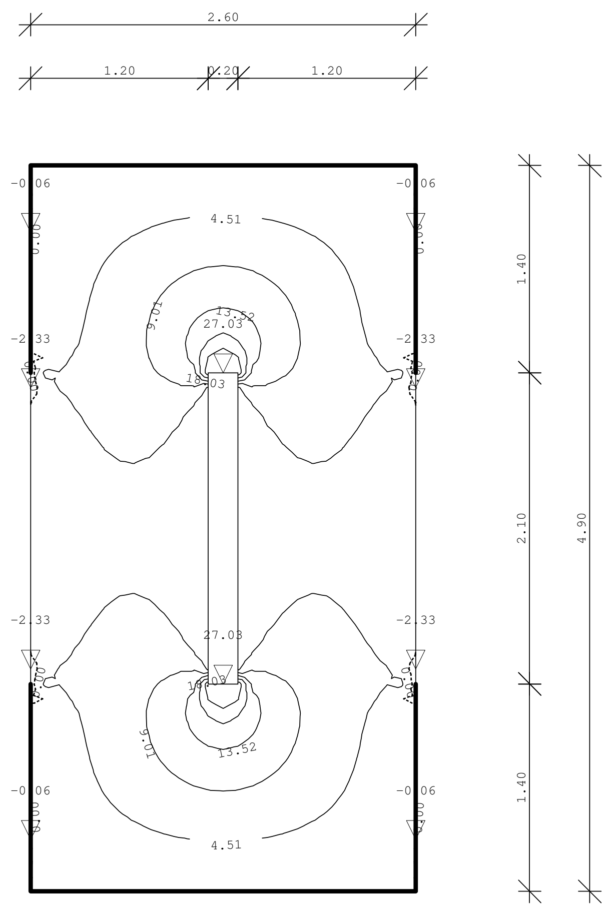
Obt. 1: Stalna obtežba



Obt. 2: Koristna obtežba

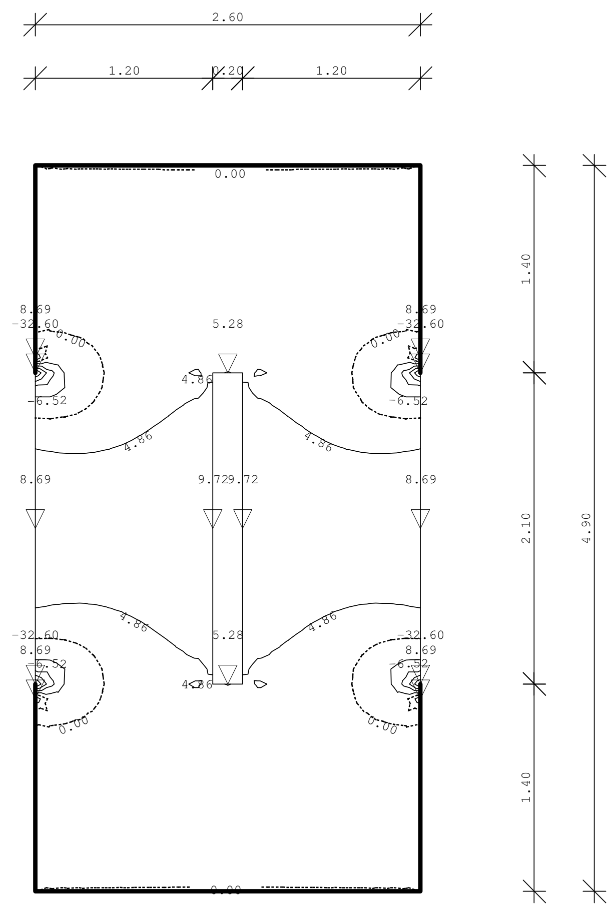


Obt. 4: MSN - 1.35g+1.5q



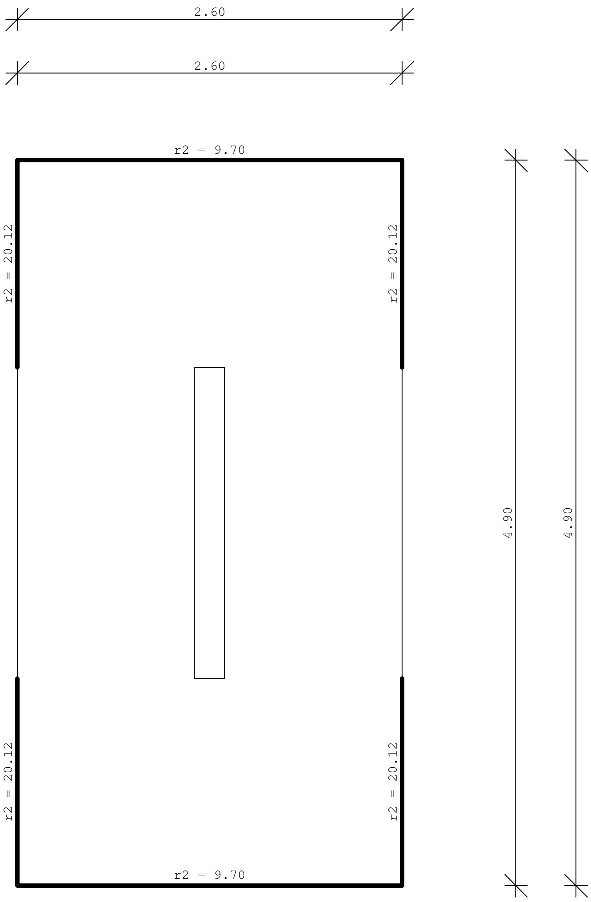
Vplivi v plošči: max Mx= 27.03 / min Mx= -2.33 kNm/m

Obt. 4: MSN - 1.35g+1.5q



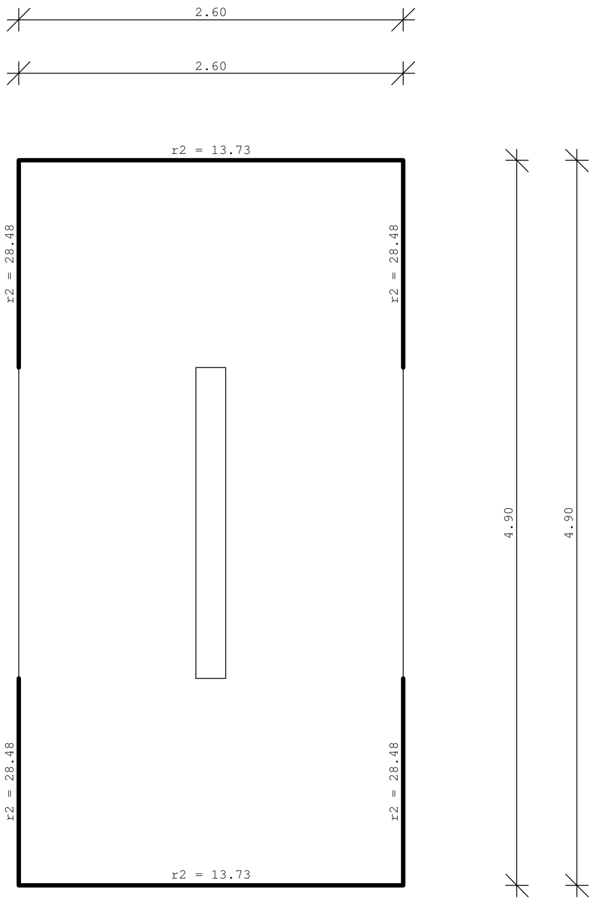
Vplivi v plošči: max My= 9.72 / min My= -32.60 kNm/m

Obt. 3: MSU - 1.0g+1.0q



Reakcije podpor

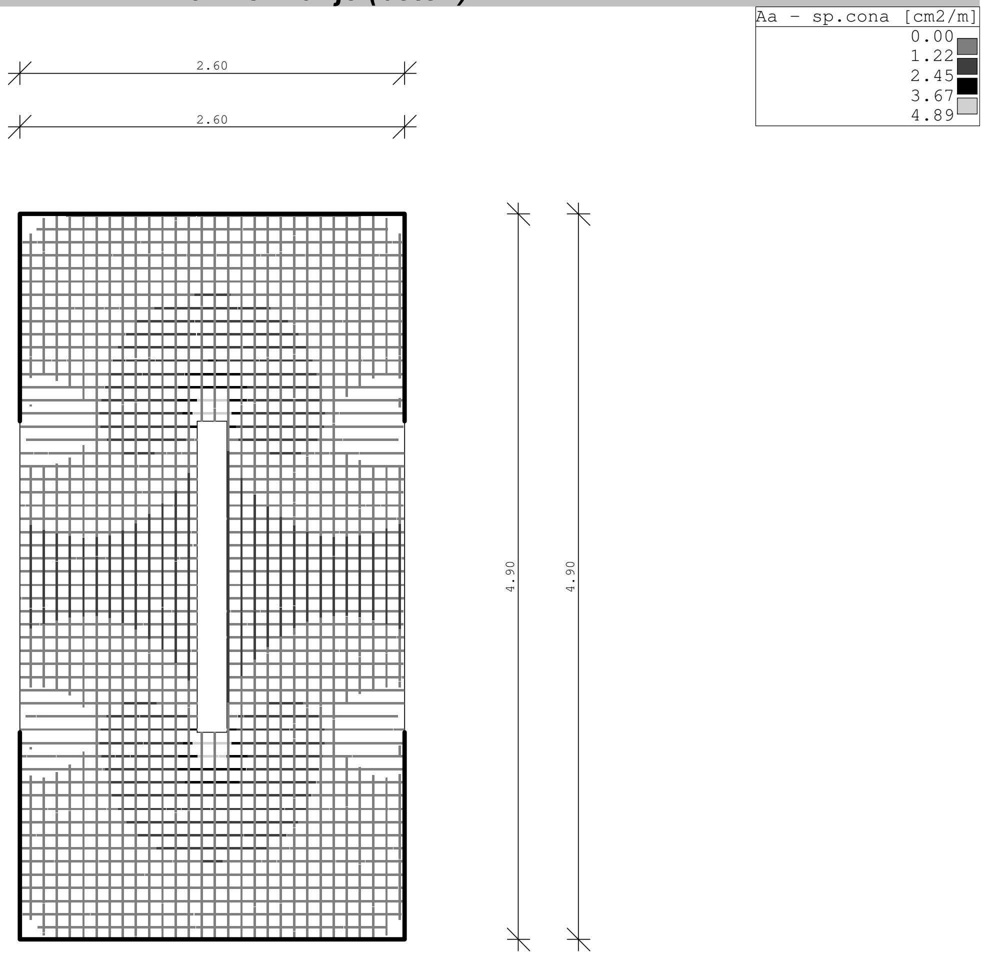
Obt. 4: MSN - 1.35g+1.5q



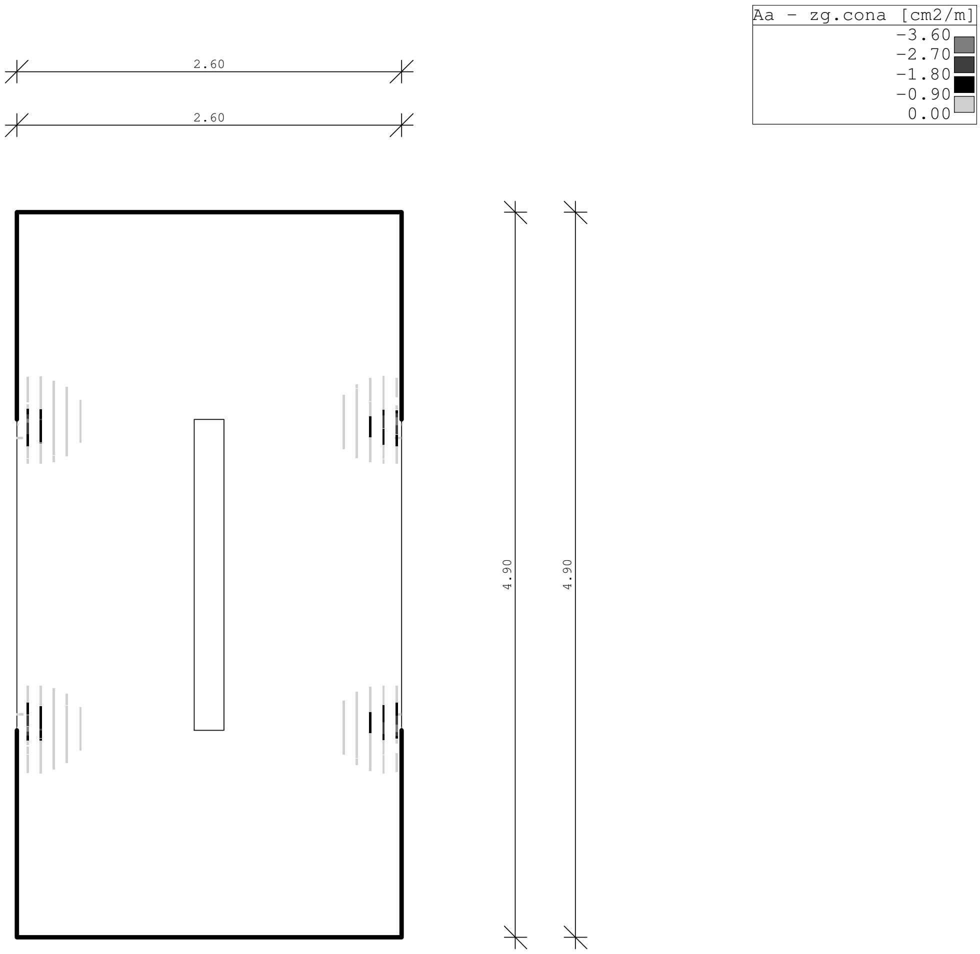
Reakcije podpor

Dimenzioniranje (beton)

Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm



Aa - sp.cona - max As= 4.88 cm2/m
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm



Aa - zg.cona - max Az= -3.59 cm2/m

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka:	Model B.twp
Datum preračuna:	28.4.2021
Način preračuna:	3D model

[ ] Teorija I-ga reda
[ ] Modalna analiza
[ ] Stabilnost
[X] Teorija II-ga reda
[ ] Seizmični preračun
[ ] Ofset gred
[ ] Faze gradnje

Velikost modela

Število vozlišč:	28729
Število ploskovnih elementov:	23533
Število grednih elementov	6369
Število robnih elementov	124716
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

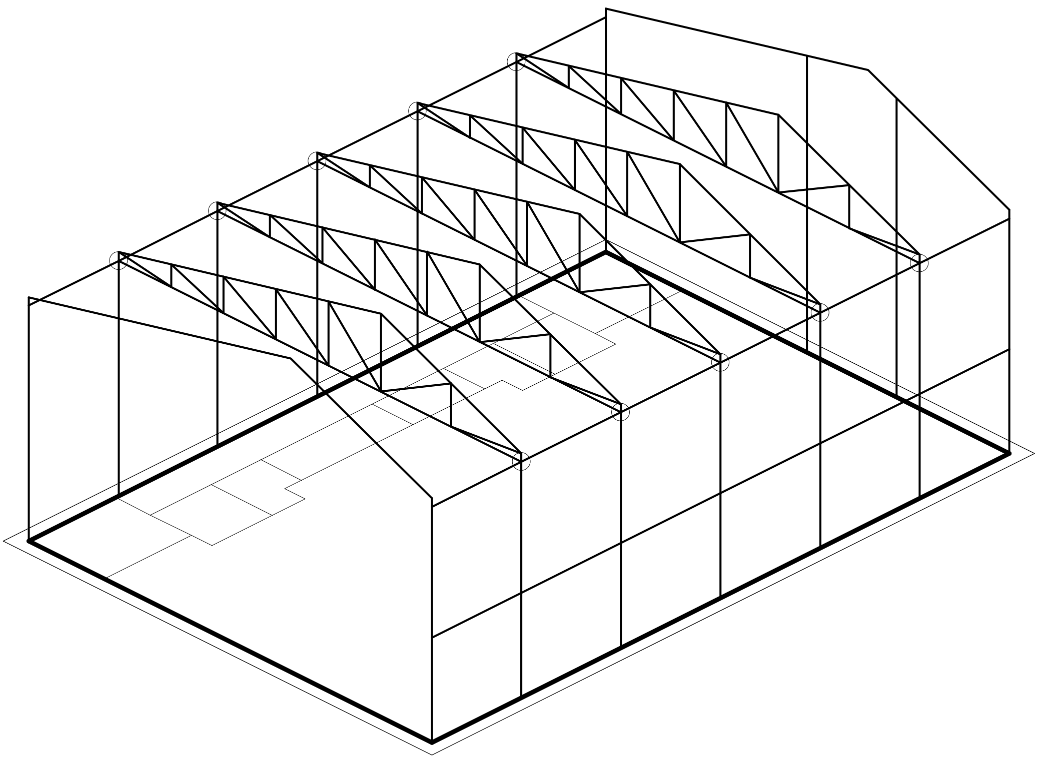
Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20
2	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
3	Jeklo	2.100e+8	0.30	78.50	1.000e-5	2.100e+8	0.30

Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.250	0.125	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	2	Tanka plošča	Izotropna			



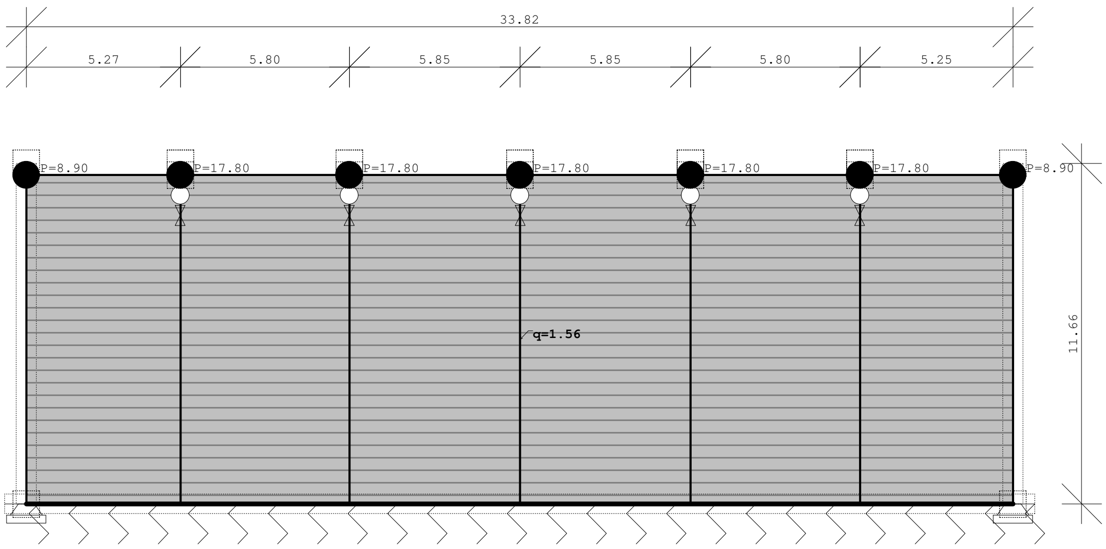
Izometrija

Lista obtežnih primerov

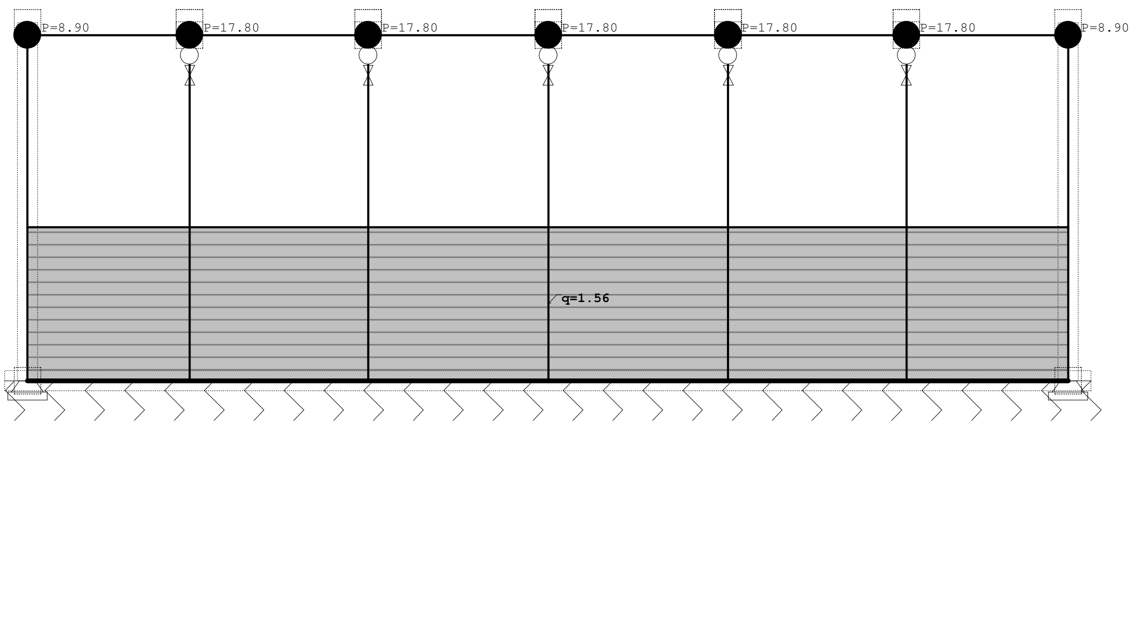
No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)

No	Naziv
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 5: Potres Sx



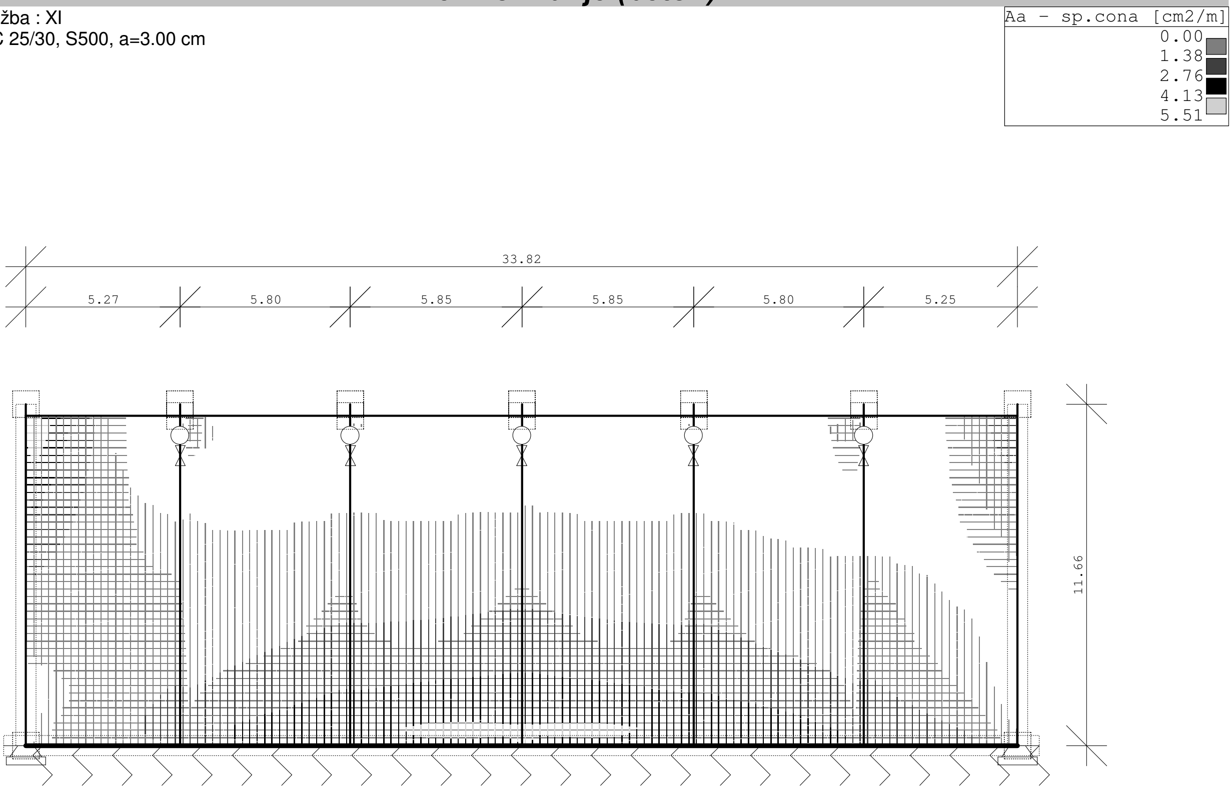
Okvir: V_1
Obt. 5: Potres Sx



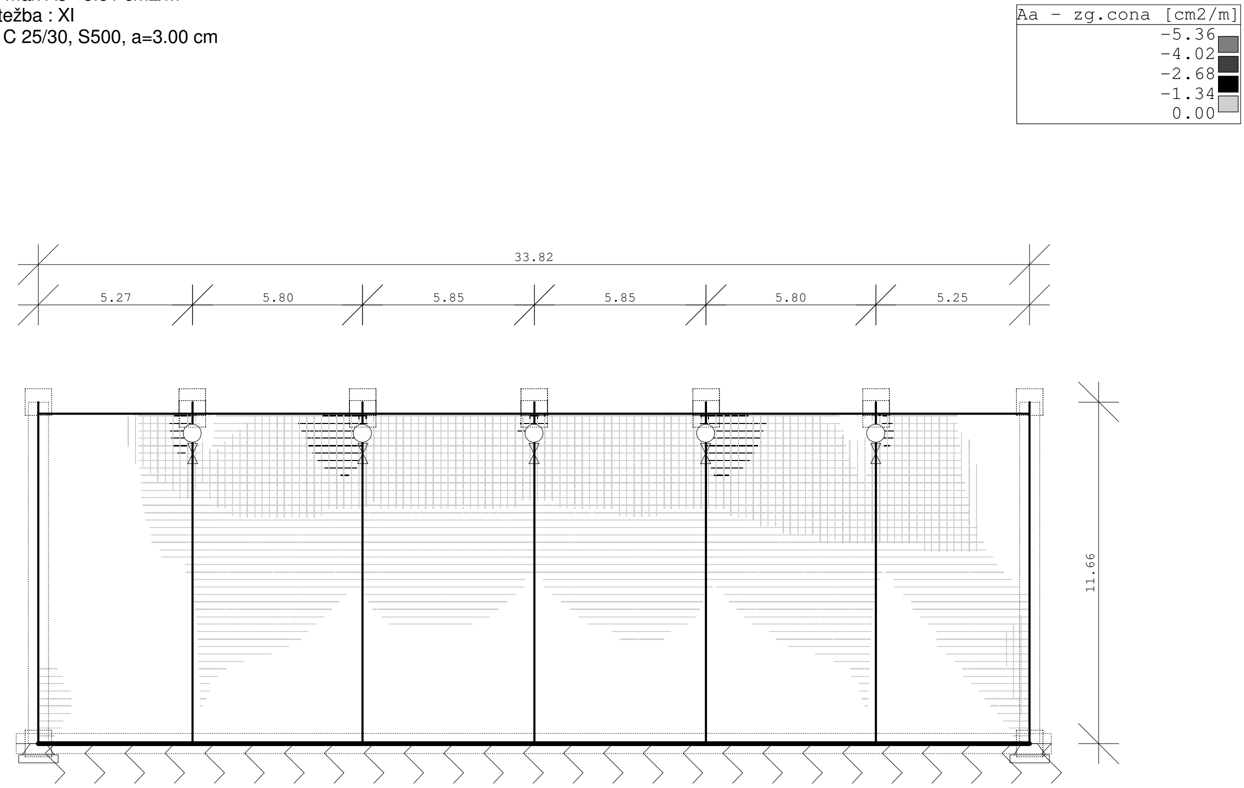
Okvir: V_2

Dimenzioniranje (beton)

Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm

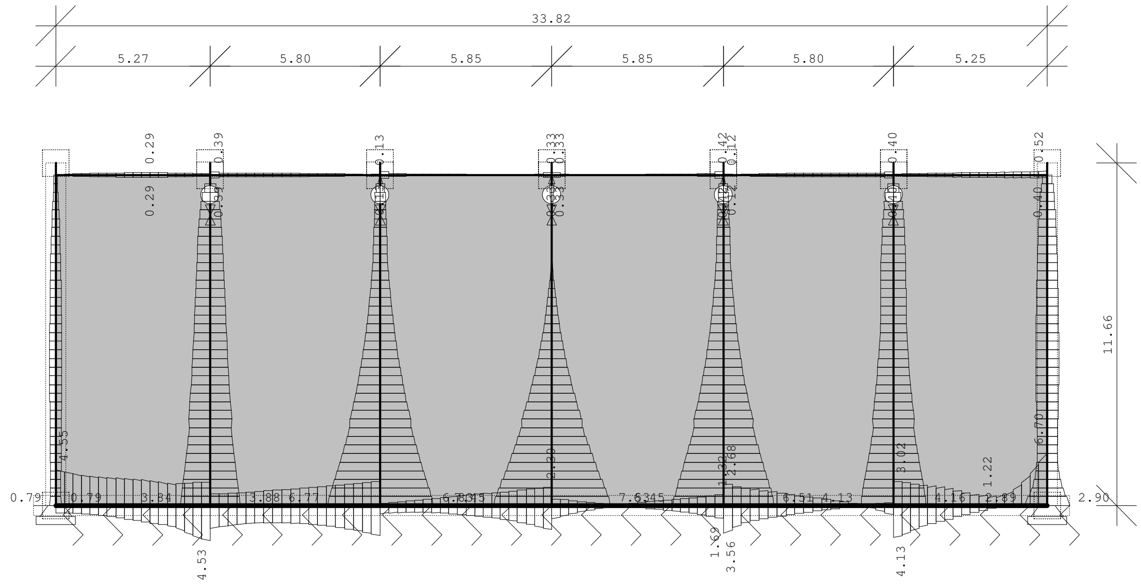


Okvir: V_1
Aa - sp.cona - max As= 5.51 cm2/m
Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm

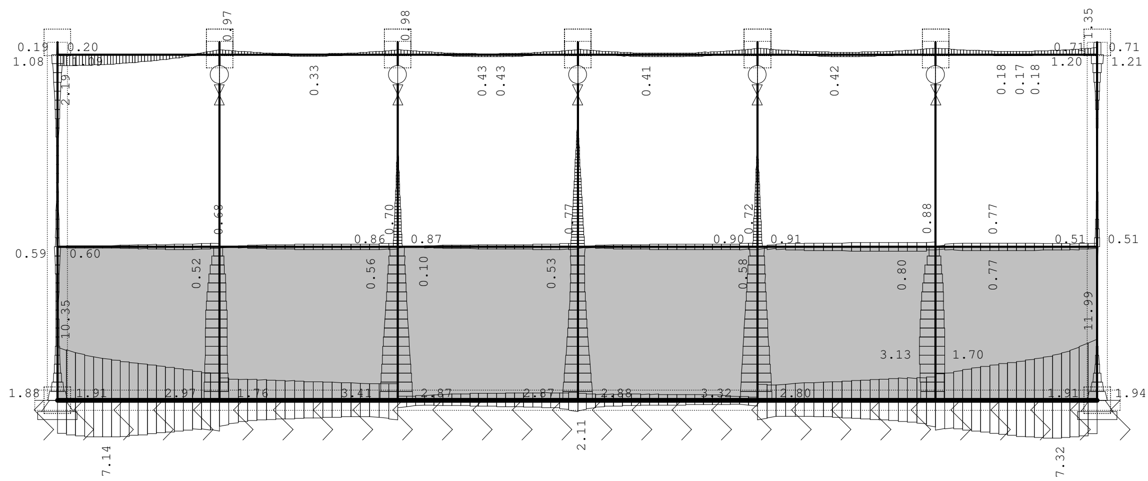


Okvir: V_1
Aa - zg.cona - max Az= -5.35 cm2/m

Merodajna obtežba : XI
EUROCODE, C 25/30, S500

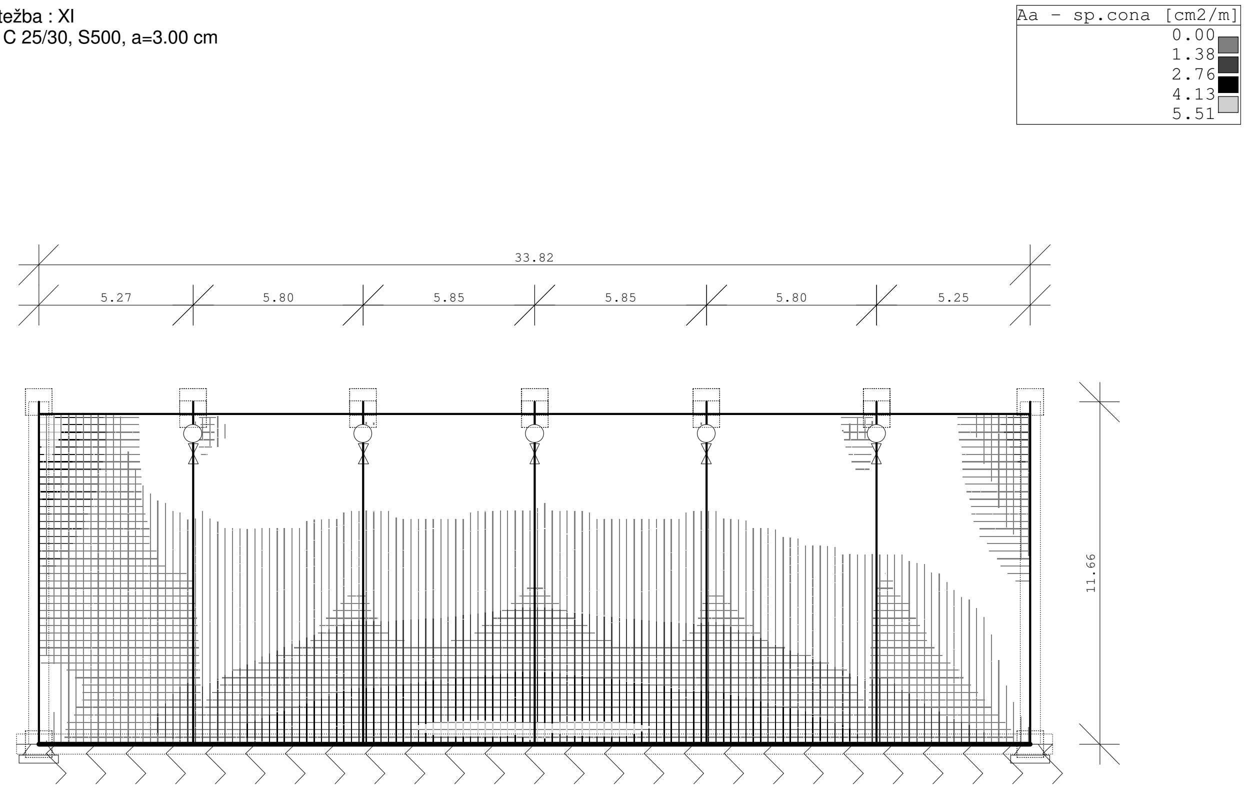


Okvir: V_1
Armatura v gredah: max Aa2/Aa1= 7.53 cm2
Merodajna obtežba : XI
EUROCODE, C 25/30, S500

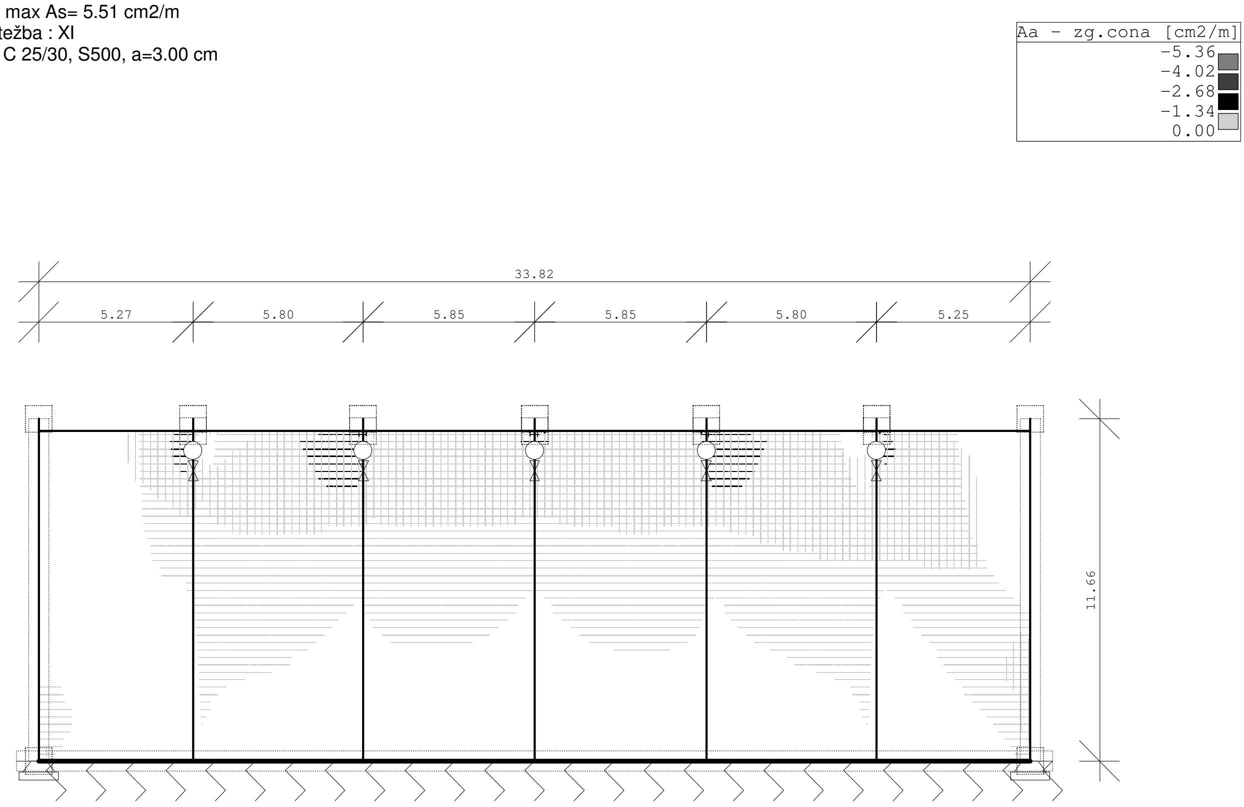


Okvir: V_2
Armatura v gredah: max Aa2/Aa1= 11.99 cm2

Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm



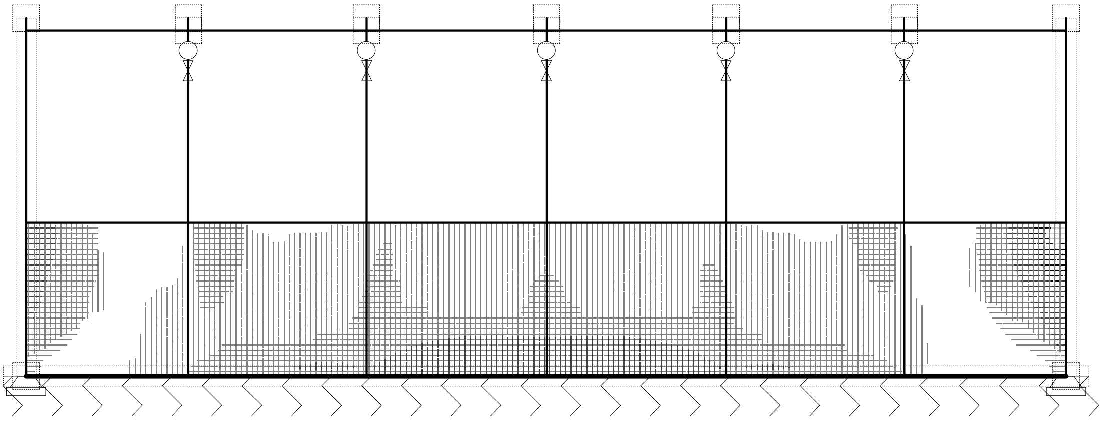
Okvir: V_1
Aa - sp.cona - max As= 5.51 cm2/m
Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm



Okvir: V_1
Aa - zg.cona - max Az= -5.35 cm2/m

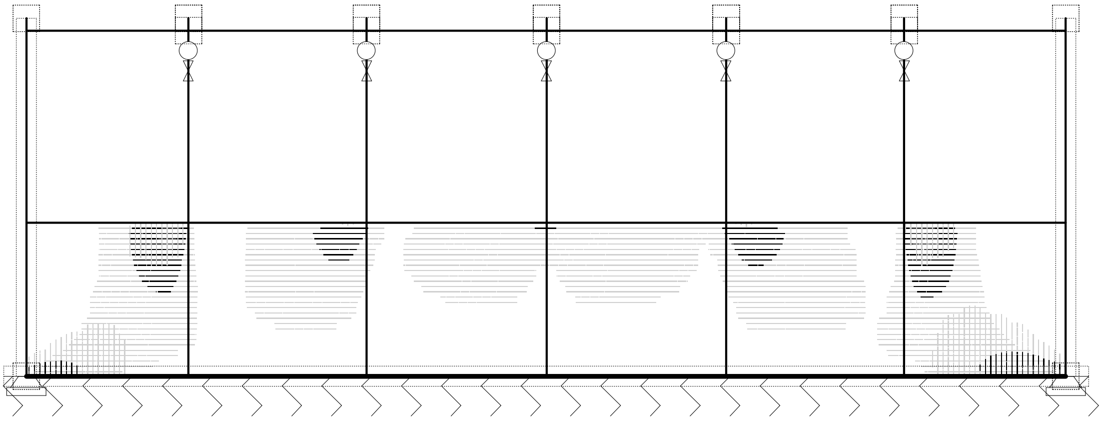
Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm

Aa - sp.cona [cm2/m]
0.00
1.13
2.27
3.40
4.53



Okvir: V_2
Aa - sp.cona - max As= 4.53 cm2/m
Merodajna obtežba : XI
EUROCODE, C 25/30, S500, a=3.00 cm

Aa - zg.cona [cm2/m]
-2.41
-1.81
-1.21
-0.60
0.00



Okvir: V_2
Aa - zg.cona - max Az= -2.40 cm2/m

3.50 Temeljenje dvorane, talna plošča

Splošno

Temeljenje dvorane prikažemo s statičnim modelom celote objekta "B"
Deluje kot temeljna plošča obdana robno ojačitvijo po obsegu plošče. Robna ojačitev smiselno deluje kot pasovni temelj, s talno ploščo povezan v celoto. Statično sodelujeta in tako jih tudi obravnavamo.

Izbira materialov

Beton	**C30/37**	XC2 Priporočam uporabo nizkohidratacijskega cementa, nizek VC in dodatke proti krčenju betona.
Armatura	**S500**	
Zašč.sloj	**4,00**	cm
fck=	**20**	Mpa
fcd=fck/1,5=	13,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Obremenitve talne plošče

Ploskovne obremenitve talne plošče	**g**	**p**	**g+p**	**EM**
Koristna obremenitev		5,00	5,00	kN/m2
Obdelava tal z izolacijami	0,50		0,50	kN/m2
Lastna teža plošče d=28 cm	7,00		7,00	kN/m2
Skupaj	**7,50**	**5,00**	**12,50**	kN/m2

Osnovni obtežni primeri

1	g	Lastna teža
2	p	Koristna vertikalna obremenitev

Kombinacije

A=	1,0*g+1,0*p	/ kontrola reakcij in deformacij
B=	1,35*g+1,5*q	/ dimenzioniranje

Rezultati

Napetost pod temeljenjem v fazi "Mejno stanje uporabnosti**" MSU-(1,0g+1,0q) = 0,008728 kN/cm2**
Posedek talne plošče v navedenih razmerah = **7,27 mm**
Izračunani posedek velja za predpostavljeno računsko podajnost 15000 KN/m3

Izkop gradbene jame je potrebno izvesti ob prisotnosti geologa. Ta, predpostavke tega modela primerja z dejanskim stanjem na objektu in z vpisom v gradbeni dnevnik poda svoje ugotovitve. V primeru, da so dejanska tla neustrezna, poda sanacijo temeljnih tal.

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Talna plošča dvorane.twp
Datum preračuna:	28.4.2021
Način preračuna:	3D model

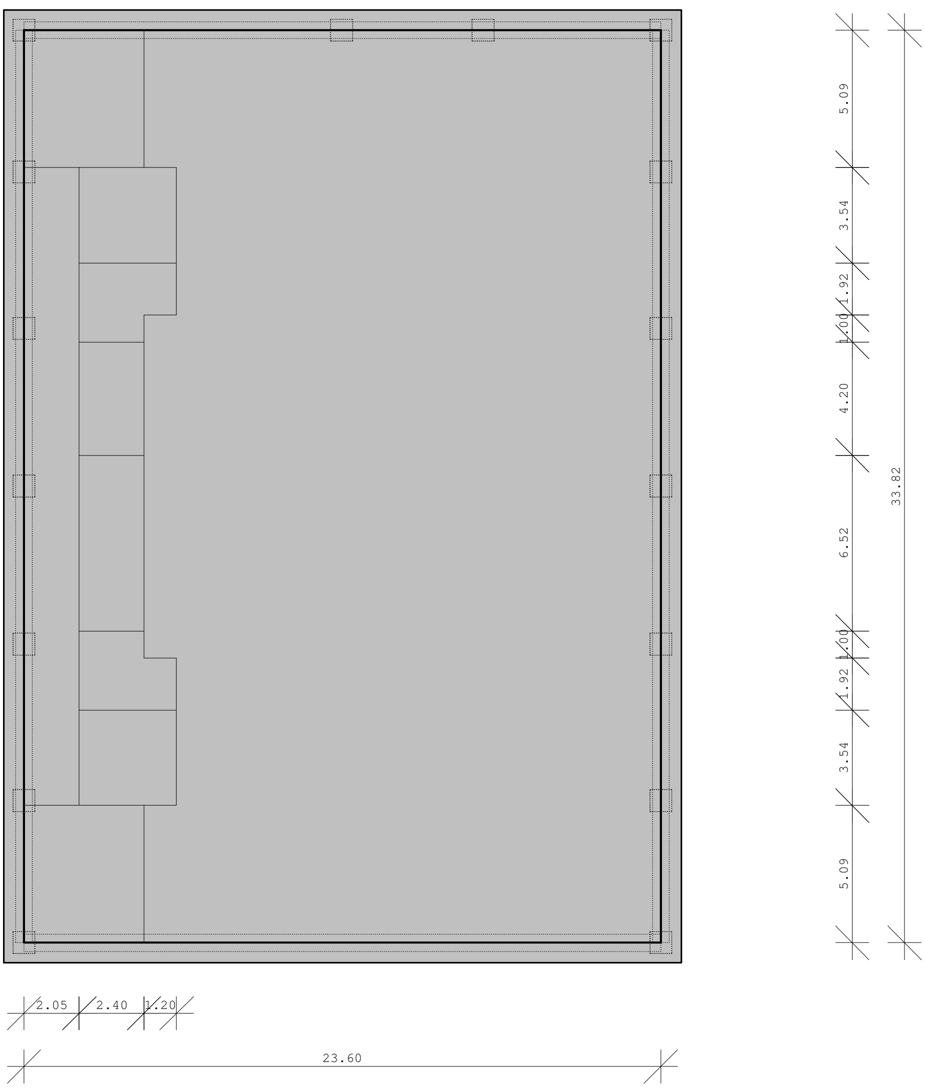
- [ ] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [x] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč:	28729
Število ploskovnih elementov:	23533
Število grednih elementov	6369
Število robnih elementov	124716
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius



Nivo: Temeljenje dvorane [0.00]

Vhodni podatki - Obtežba

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20
2	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
3	Jeklo	2.100e+8	0.30	78.50	1.000e-5	2.100e+8	0.30

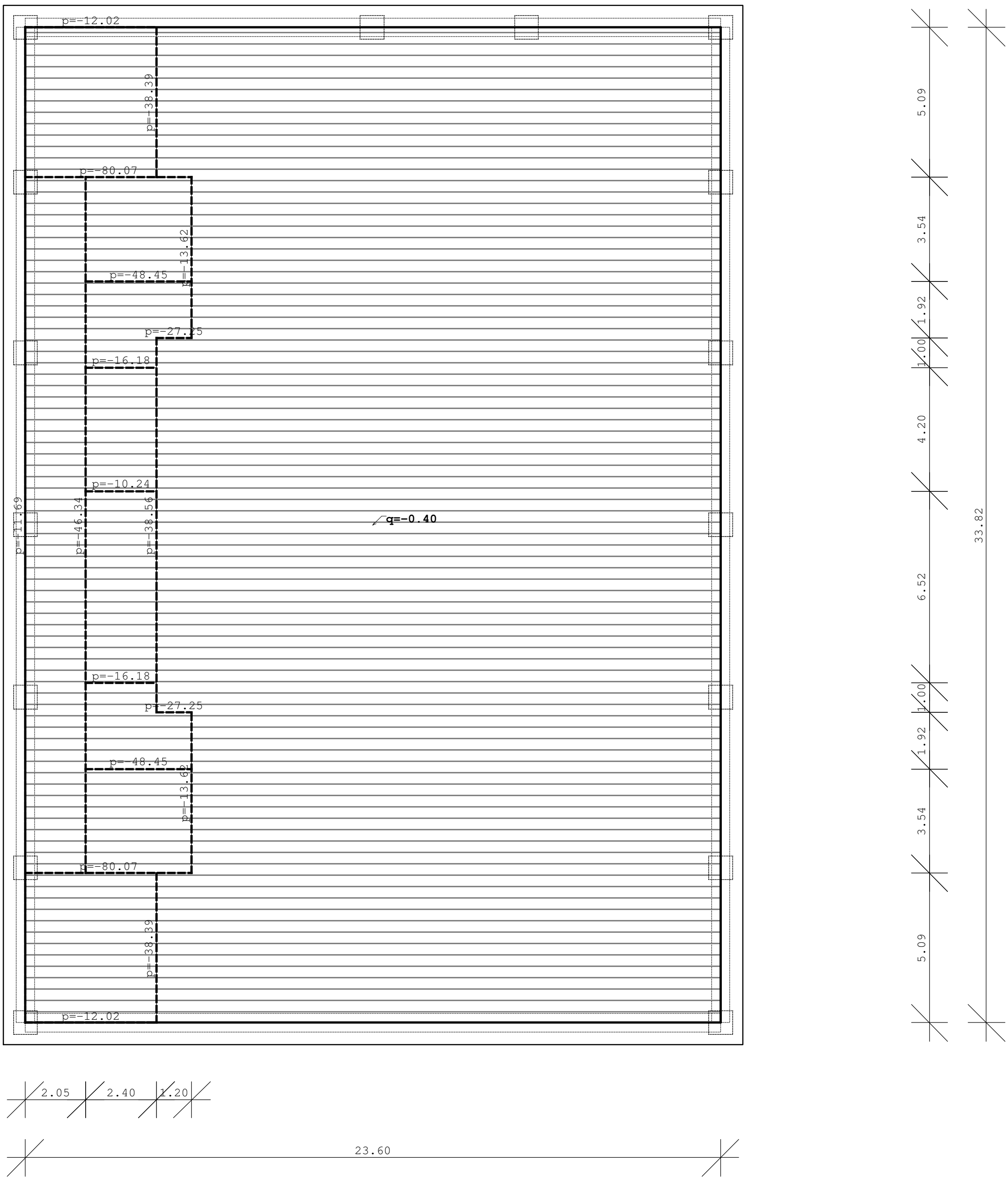
Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.250	0.125	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	2	Tanka plošča	Izotropna			

Lista obtežnih primerov

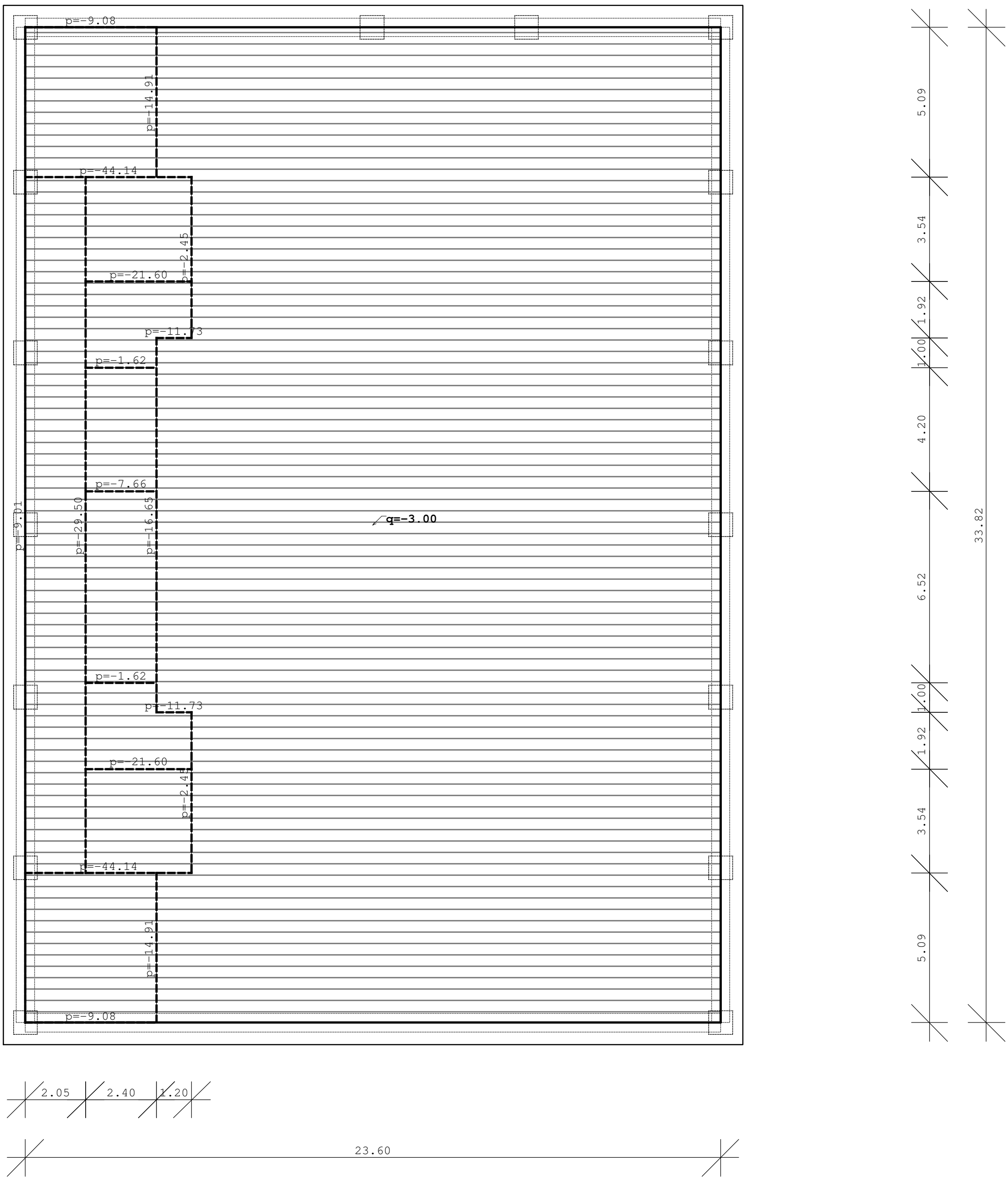
No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 1: Stalna obtežba (g)



Nivo: Temeljenje dvorane [0.00]

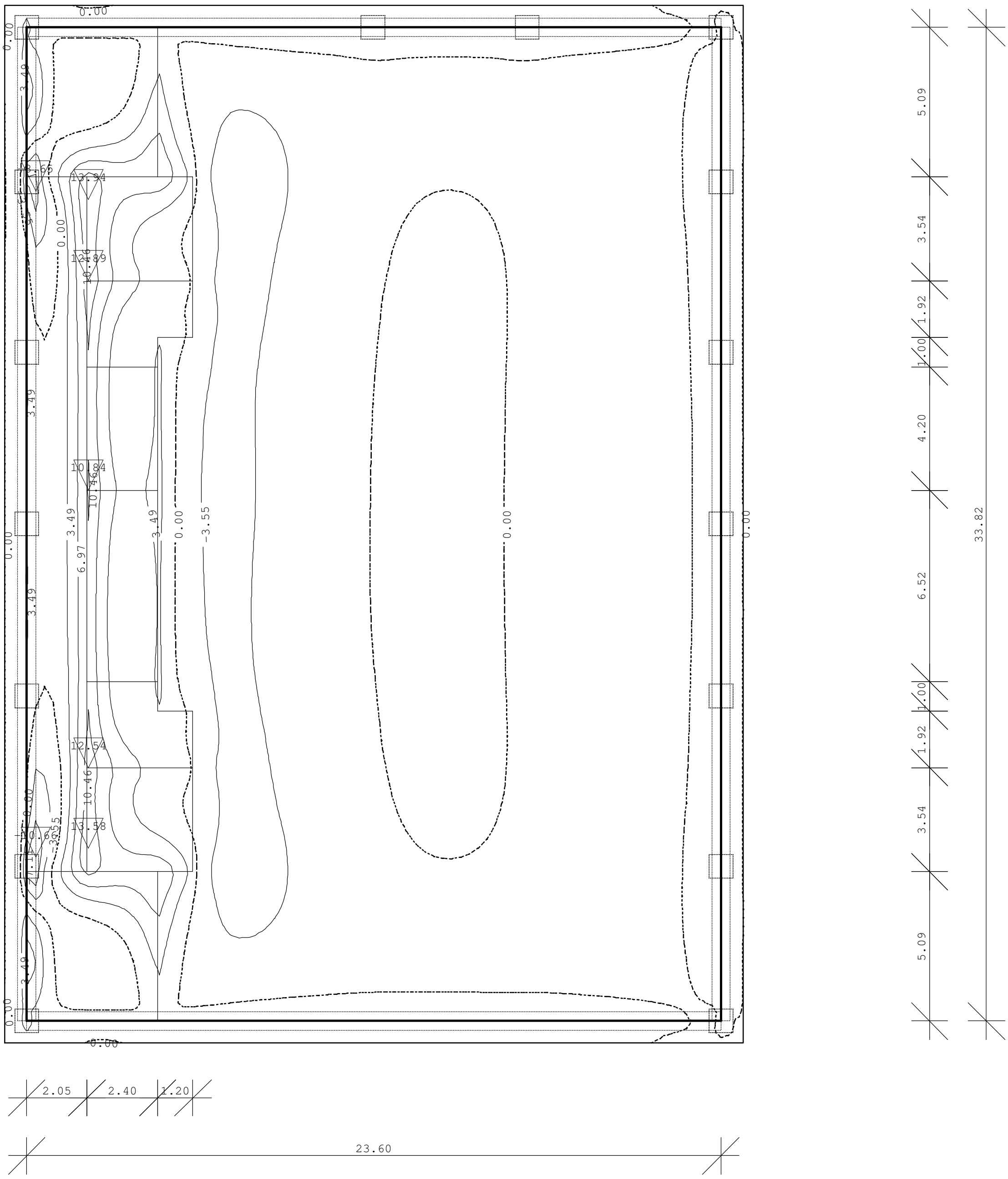
Obt. 2: Koristna obtežba



Nivo: Temeljenje dvorane [0.00]

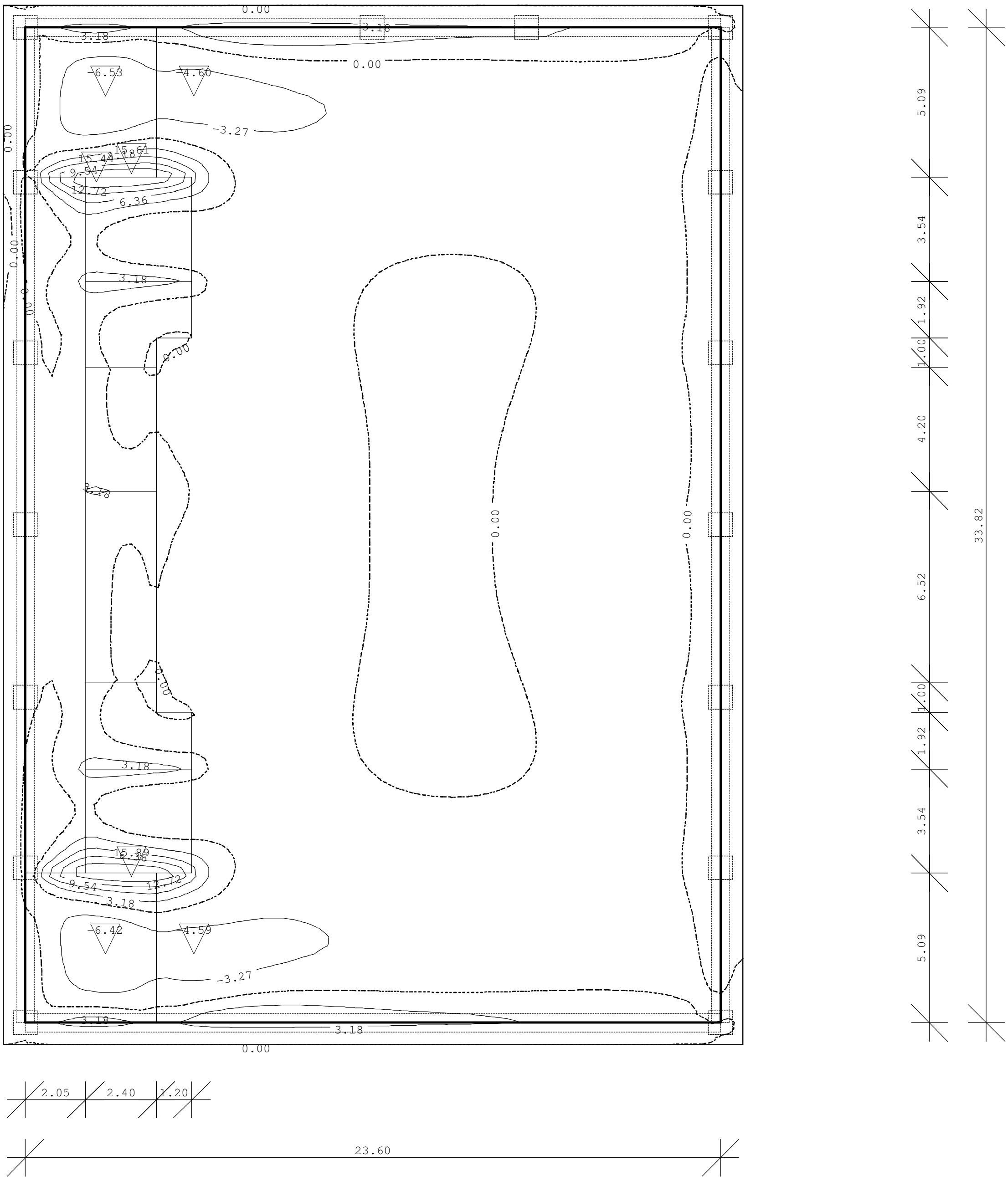
Statični preračun

Obt. 2: Koristna obtežba



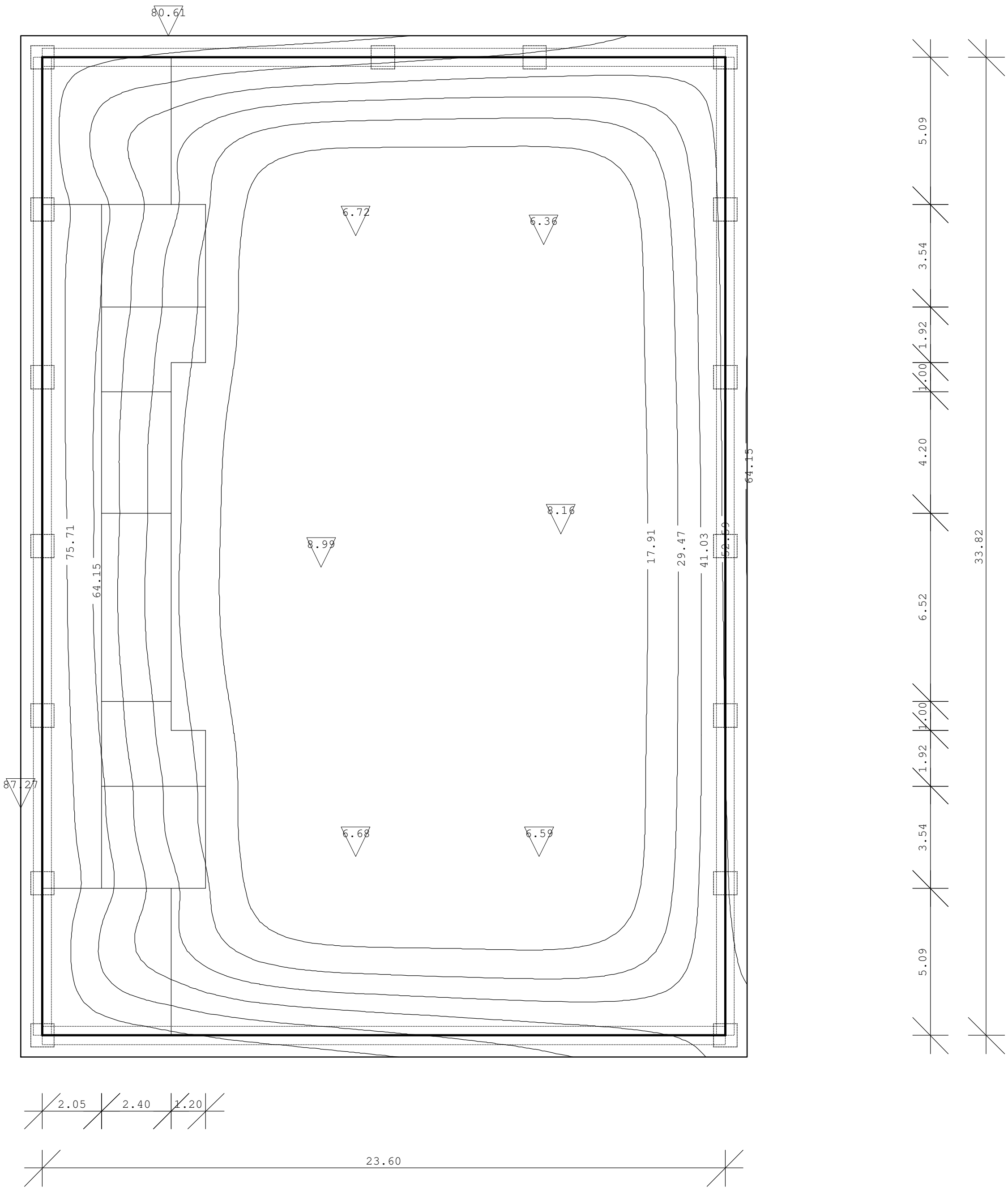
Nivo: Temeljenje dvorane [0.00]
Vplivi v plošči: max Mx= 13.94 / min Mx= -10.66 kNm/m

Obt. 2: Koristna obtežba



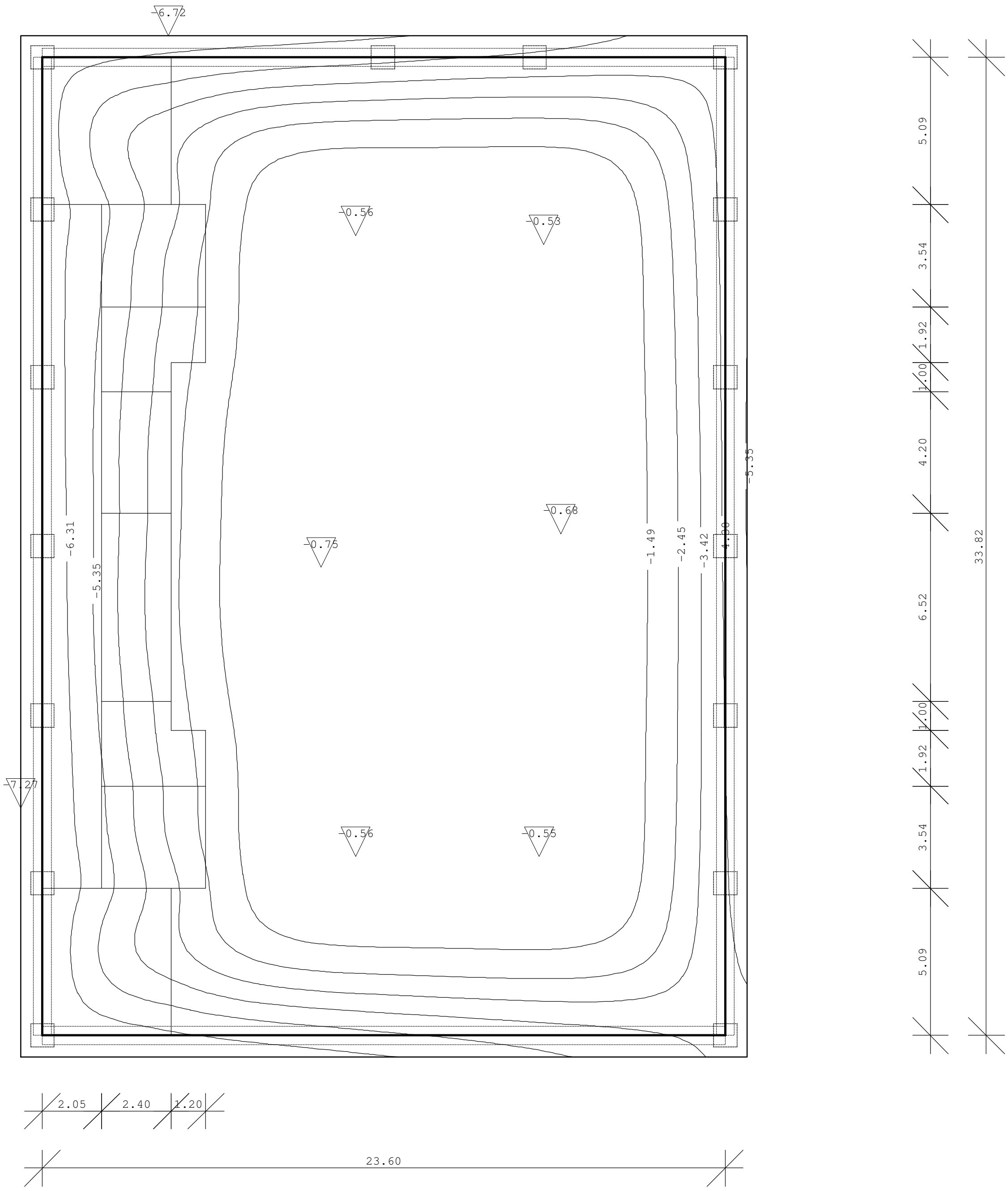
Nivo: Temeljenje dvorane [0.00]
Vplivi v plošči: max My= 15.89 / min My= -6.53 kNm/m

Obt. 7: MSU - 1.0g+1.0q+1.0Wx



Nivo: Temeljenje dvorane [0.00]
Vplivi v pov.podpori: max σ,tal= 87.27 / min σ,tal= 6.36 kN/m2

Obt. 7: MSU - 1.0g+1.0q+1.0Wx

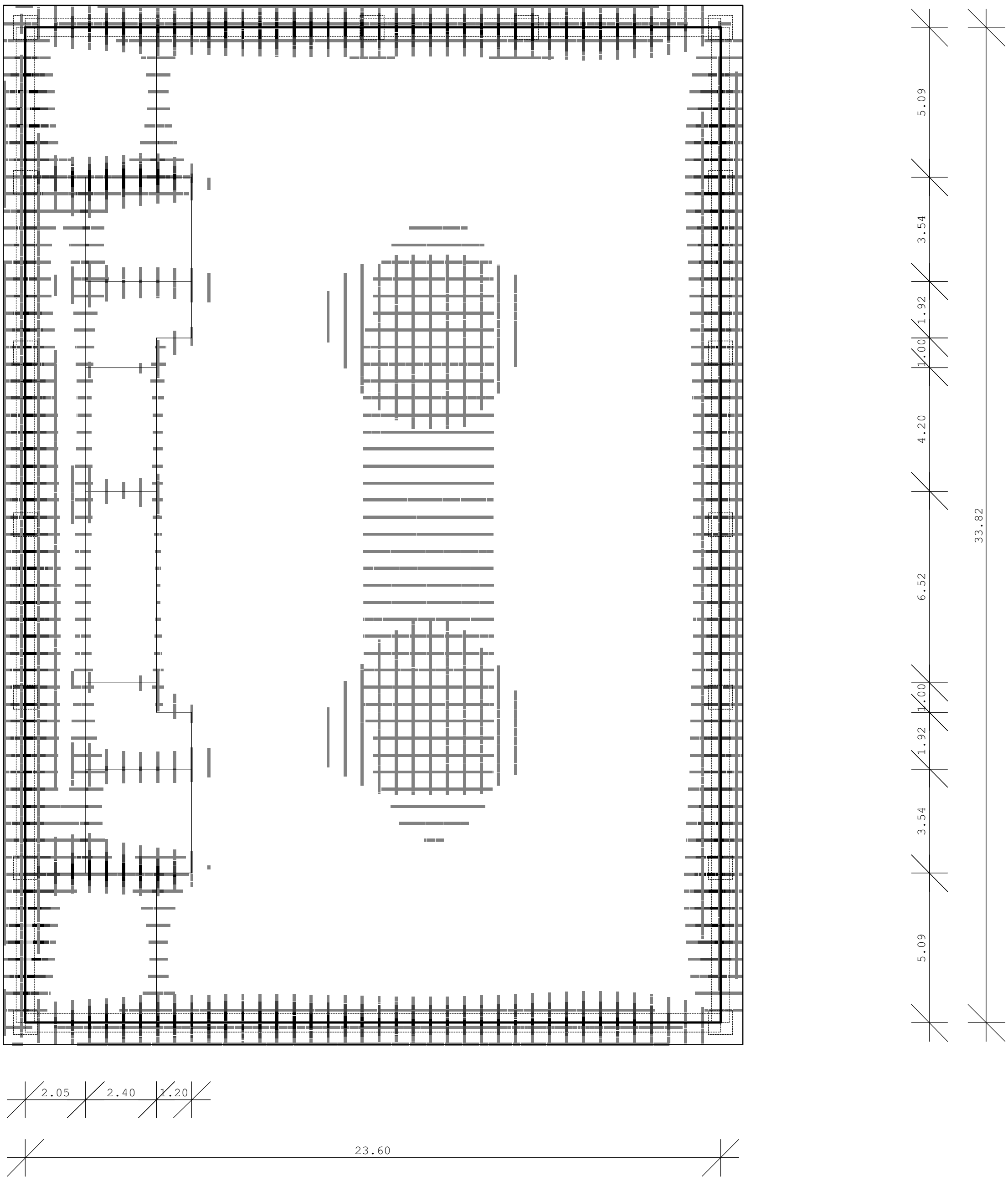


Nivo: Temeljenje dvorane [0.00]
Vplivi v pov.podpori: max s,tal= -0.53 / min s,tal= -7.27 m / 1000

Dimenzioniranje (beton)

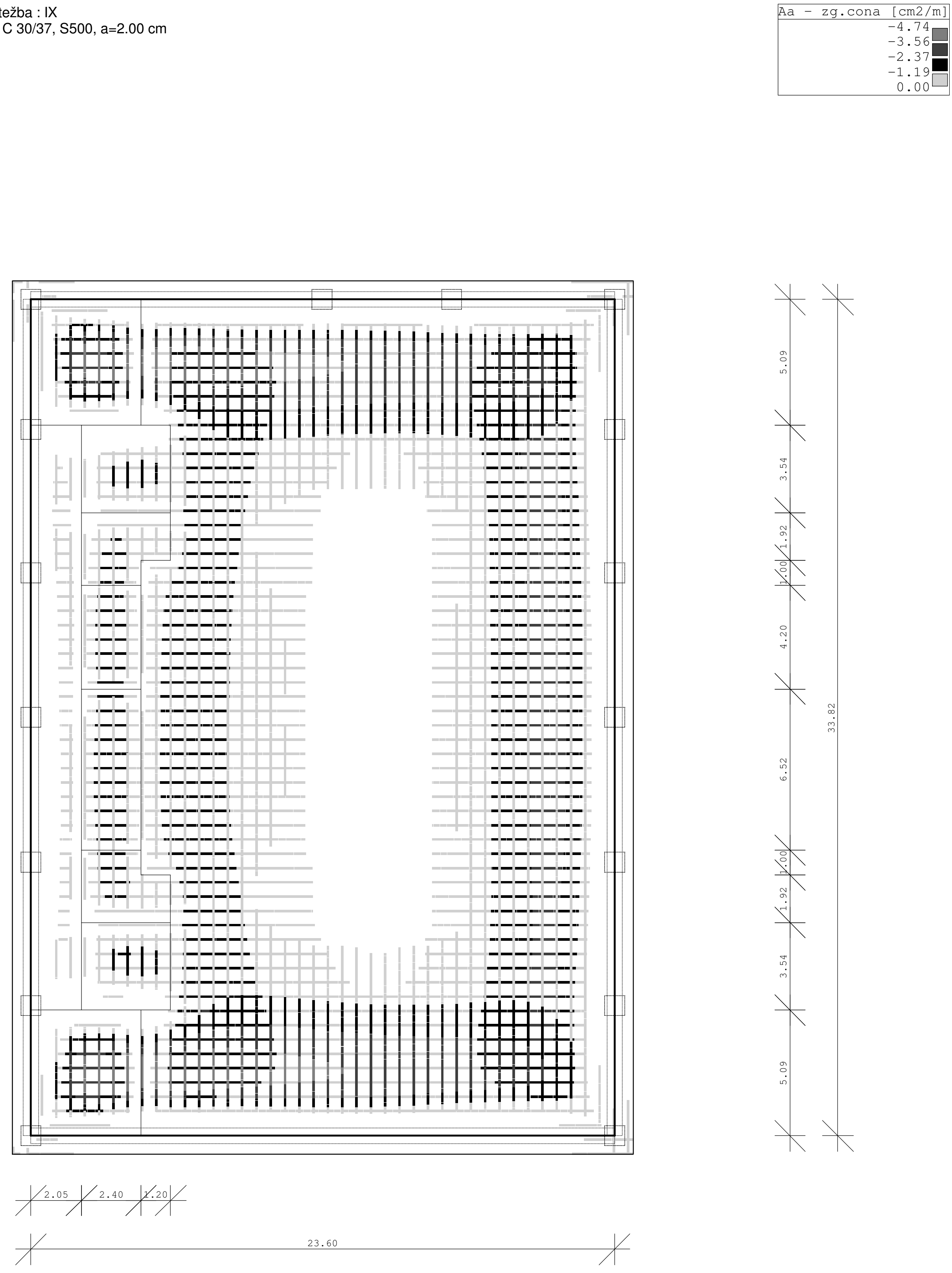
Merodajna obtežba : IX
EUROCODE, C 30/37, S500, a=3.00 cm

Aa - sp.cona [cm2/m]
0.00
1.53
3.06
4.58
6.11



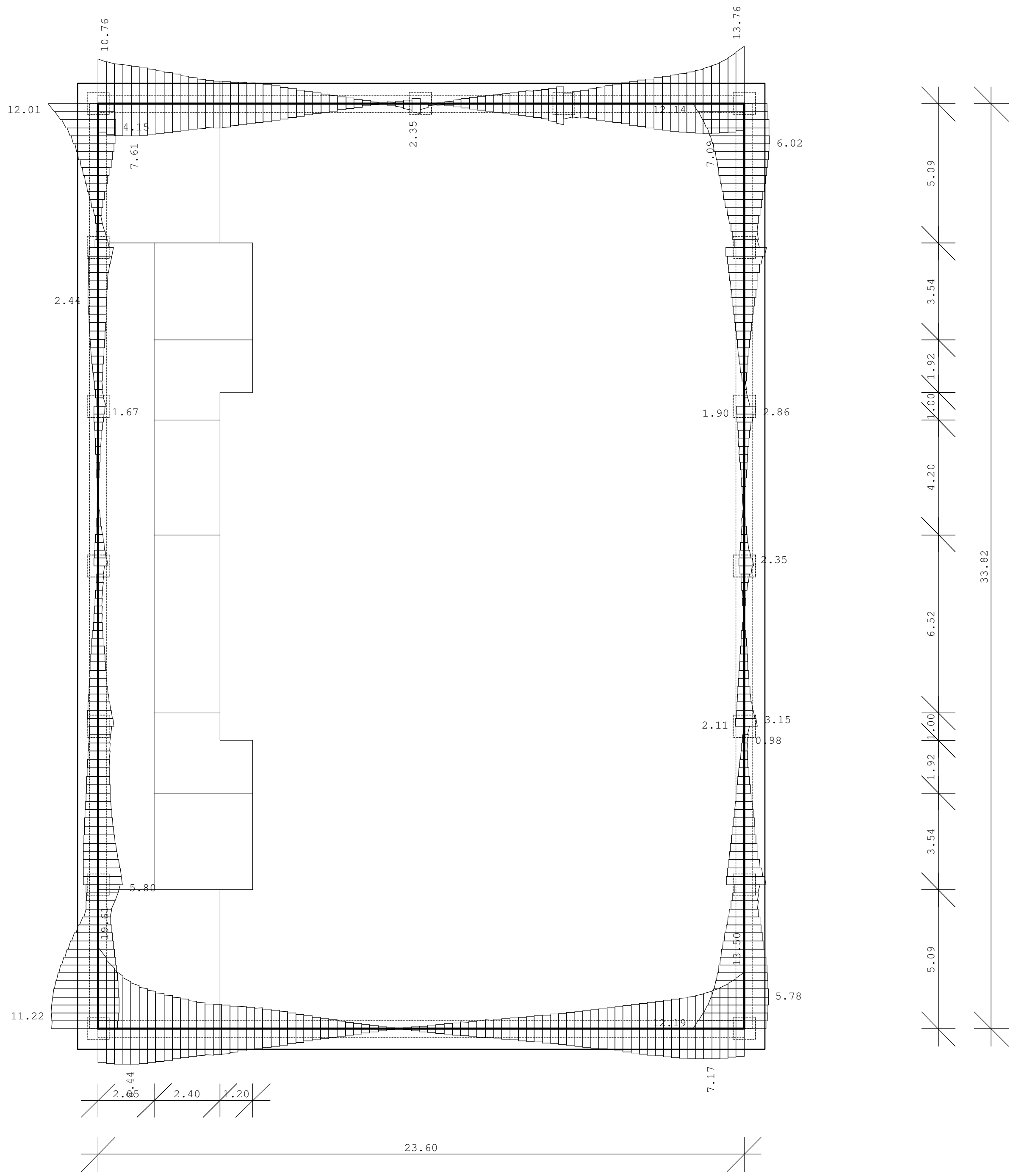
Nivo: Temeljenje dvorane [0.00]
Aa - sp.cona - max As= 6.11 cm2/m

Merodajna obtežba : IX
EUROCODE, C 30/37, S500, a=2.00 cm



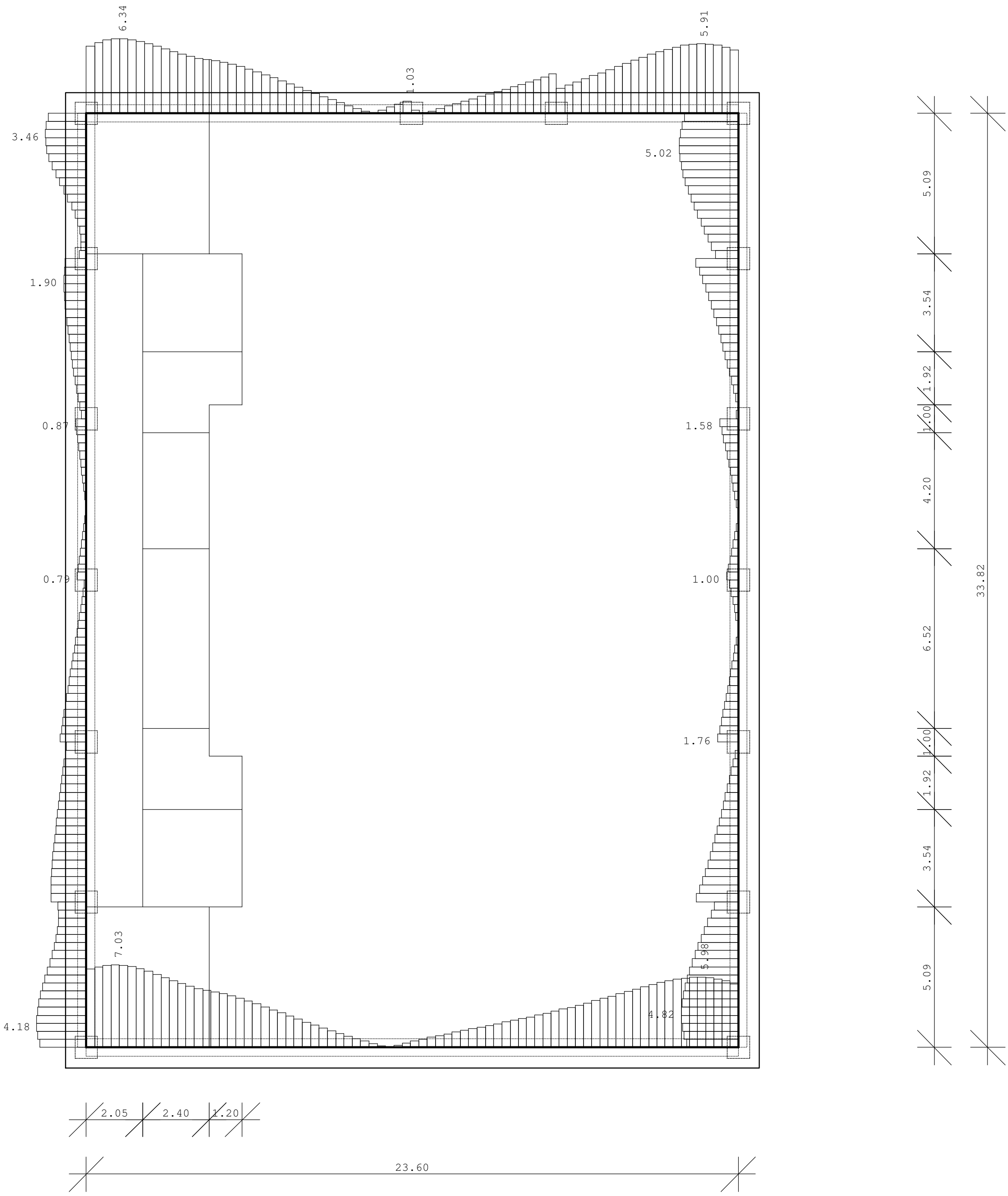
Nivo: Temeljenje dvorane [0.00]
Aa - zg.cona - max Az= -4.73 cm2/m

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Temeljenje dvorane [0.00]
Armatura v gredah: max Aa2/Aa1= 19.61 cm2

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Temeljenje dvorane [0.00]
Armatura v gredah: max Aa,st= 7.03 cm2

4.00 C: PODROČJE OBJEKTA PODZEMNE GARAŽE IN NADGRADNJE
4.10 Leseno ostrešje
4.11 Obtežbe strehe

Vertikalne obremenitve strehe, naklon 12 in 23°, (asimetrična dvokapnica)

	g	q	g+q	EM
Sendvič kritina na letvah - pločevina	0,35		0,35	kN/m2
Obdelava strehe in izolacije	0,30		0,30	kN/m2
Sneg, privzamem 1,40 **vpliv snegobranov**		1,40	1,40	kN/m2
Skupaj	**0,65**	**1,40**	**2,05**	kN/m2
Špirovci lastna teža	0,15		0,15	kN/m2
Skupaj	**0,80**	**1,40**	**2,20**	kN/m2
Incidentna obremenitev v potresu 1,0g+0,30q	**0,80**	**0,42**	**1,22**	kN/m2

Pritisk vetra na strešino +/- 0,26 kN/m2

Špirovci

Vplivna računska širina obremenitve **1,00** m1
Lastna teža 14/20 **0,15** kN/m1

Obremenitev "LT" = 0,15 kN/m1
Obremenitev "g" = 0,65 kN/m1
Obremenitev "q" = 1,40 kN/m1+veter
Kombinacija "LT+g" = 0,80 kN/m1
Kombinacija "LT+g+q" = 2,20 kN/m1+veter

Opazovani obtežni primeri /

Osnovni obtežni primeri
1 g Lastna teža
2 p Koristna vertikalna obremenitev

Kombinacije
A= 1,0*g+1,0*p / kontrola reakcij in deformacij
B= 1,35*g+1,5*q / dimenzioniranje
C= 1,0*g+0,30*q / incidentna obremenitev, potres

Izbira dimenzij ostrešja obkjekta

Špirovci	**14/20 cm**	Lepljen lameliran les, čez dve polji v enem kosu
Glavna lesena lega	**20/60 cm,**	Lepljen lameliran les
Kapne lege	**18/18 cm**	Lepljen lameliran les
Ročice	**16x16 cm**	Lepljen lameliran les
Čelni zaključek strehe	**20/60 cm**	Lepljen lameliran les

4.12 Dimenzioniranje lesenih delov ostrešja

Uporabljeni materiali in karakteristike

Les iglavci, kvaliteta **C24** 2.upor.razred

$f_{m,k}$ =	2,40	kN/cm2	Upogib
$f_{t,0,k}$ =	1,40	kN/cm2	Nateg paralelno
$f_{t,90,k}$ =	0,40	kN/cm2	Nateg pravokotno
$f_{c,0,k}$ =	2,10	kN/cm2	Tlak paralelno
$f_{c,90,k}$ =	0,53	kN/cm2	Tlak pravokotno
$f_{v,k}$ =	0,25	kN/cm2	Strig
$E_{0,mean}$	1100,00	kN/cm2	Modul elast.paralelno
$E_{90,mean}$	37,00	kN/cm2	Modul elast.pravokotno
$E_{0,05}$	740,00	kN/cm2	Modul elastično paralelno uklon
G_{mean}	69,00	kN/cm2	Strižni modul
ρ_k =	350,00	kg/m3	Gostota karakteristična
ρ_{mean} =	420,00	kg/m3	Gostota povprečna

Modifikacijski faktorji za masiven, lepljeni lamelirani les in iz furnirjev lepljeni les (do 20% vlage)

Kmod,P	**0,60**	Stalna obtežba
Kmod,L	**0,70**	Dolgotrajna (do 10 let)
Kmod,M	**0,80**	Srednje trajna (do 6 mes)
Kmod,S	**0,90**	Kratkotrajna (do 1 teden)

Koeficienti lezenja - trajna obtežba

Razred 1	**K**def =	**0,60**	C30
Razred 2	**K**def =	**0,80**	C24
Razred 3	**K**def =	**2,00**	C16

Pri spremenljivih obtežbah…splošno...ψ2*Kdef

Varnostni faktorji za material

γ_m =	**1,30**	Masivni les, iverke, priključki
γ_m =	**1,25**	Lepljen lameliran les
γ_m =	**1,20**	Iz furnirjev lepljen les

Obtežni primeri

Osnovni obtežni primeri

1 g — Lastna teža
2 p — Koristna vertikalna obremenitev

Kombinacije

A= 1,0*g+1,0*p — / kontrola reakcij in deformacij
B= 1,35*g+1,5*q — / dimenzioniranje

OSTREŠJE Špirovec 14/20

Podatki

B	14,00	cm			Širina prereza
H	20,00	cm			Višina prereza
L	okvir	cm			Dolžina elementa
.γm =	1,25				Lepljen lameliran les
Kmod,merodajni	0,90				Stalna obtežba
W = B*H^2 /6 =	933,33	cm3			
Ix = B*H^3 /12 =	9333,33	cm4			

MSN - upogib, strig

fm,d = fm,k*kmod /.γm =	1,73	kN/cm2			
fv,d = fv,k*kmod /.γm =	0,18	kN/cm2			
Md = (prg) =	7,14	kNm			
6md = Md/W =	**0,77**	<= fm,d =	**1,73**	kN/cm2	
Vd = (prg) =	8,98	kN			
Td = Vd/((2/3)*B*H) =	**0,05**	<= fv,d =	**0,18**	kN/cm2	

MSU - Napetosti, deformacije

Md = (prg) =	4,91	kNm
6m = Md/W =	**0,53**	kN/cm2

OSTREŠJE Glavna srednja lega 20/60, lepljen lameliran les

Podatki

B	20,00	cm			Širina prereza
H	60,00	cm			Višina prereza
L max	okvir	cm			Dolžina elementa
.γm =	1,25				Lepljen lameliran les
Kmod,merodajni	0,90				Stalna obtežba
W = B*H^2 /6 =	12000,00	cm3			
Ix = B*H^3 /12 =	360000,00	cm4			

MSN - upogib, strig

fm,d = fm,k*kmod /.γm =	1,73	kN/cm2			
fv,d = fv,k*kmod /.γm =	0,18	kN/cm2			
Md = (prg) =	175,86	kNm			
6md = Md/W =	**1,47**	<= fm,d =	**1,73**	kN/cm2	
Vd = (prg) =	87,99	kN			
Td = Vd/((2/3)*B*H) =	**0,11**	<= fv,d =	**0,18**	kN/cm2	dovolim

MSU - Napetosti, deformacije

Md = (prg) =	122,16	kNm
6m = Md/W =	**1,02**	kN/cm2

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Špirovci.twp
Datum preračuna:	15.3.2021
Način preračuna:	2D model (Xp, Zp, Yr)

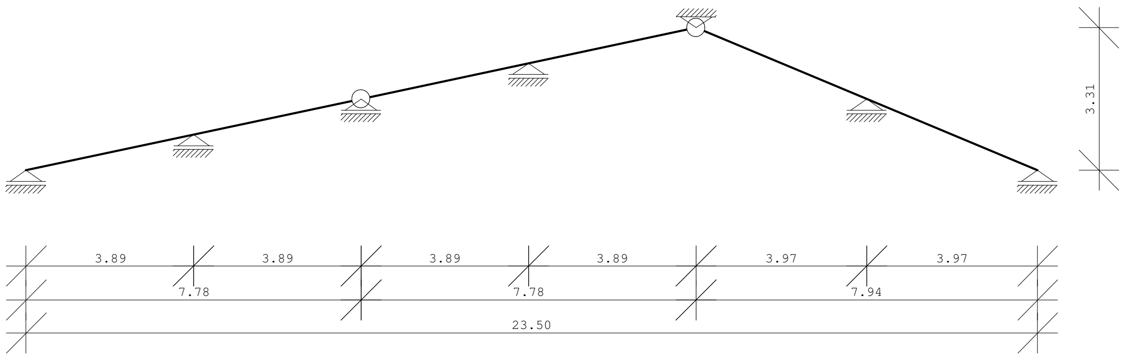
- [x] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [ ] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč:	243
Število ploskovnih elementov:	0
Število grednih elementov	242
Število robnih elementov	9
Število osnovnih obtežnih primerov:	3
Število kombinacij obtežb:	2

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

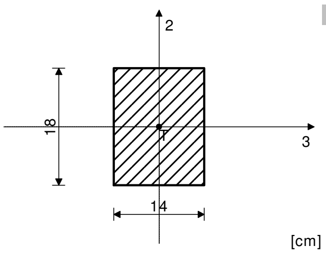


Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Les-Iglavci-Lamelirani	1.100e+7	0.20	5.00	1.000e-5	1.100e+7	0.20

Seti gred

Set: 1 Presek: Pravokotni



Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		2.520e-2	2.100e-2	2.100e-2	8.643e-5	4.116e-5	6.804e-5

Vhodni podatki - Obtežba

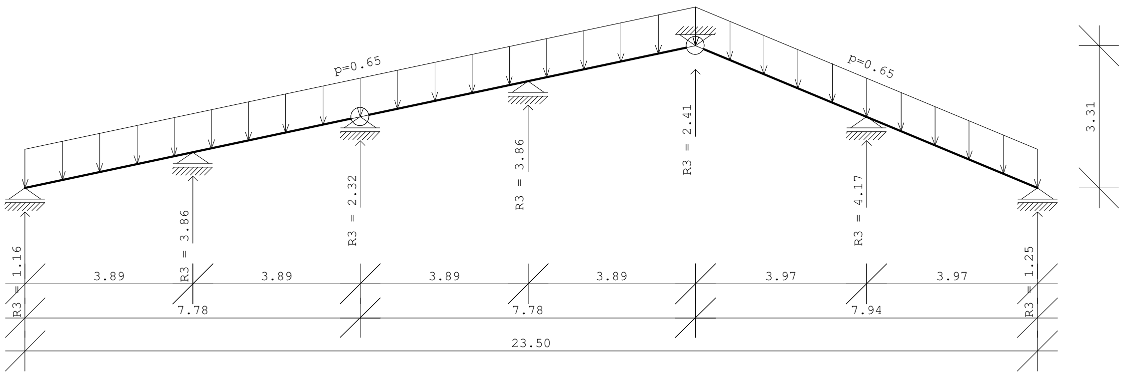
Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter

No	Naziv
4	Kombinacija: 1,0g+1,0q+1.0w (I+II+III)
5	Kombinacija: 1,35g+1,5q+1.5w (1.35xI+1.5xII+1.5xIII)

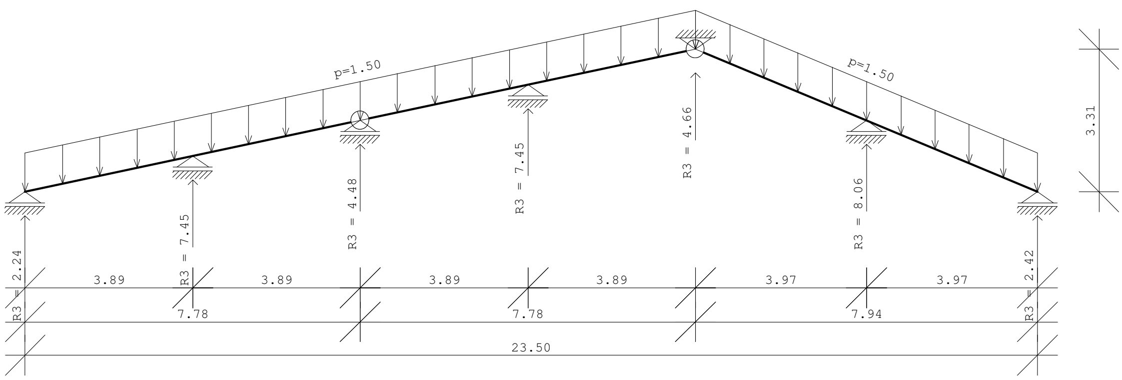
Statični preračun

Obt. 1: Stalna obtežba (g)



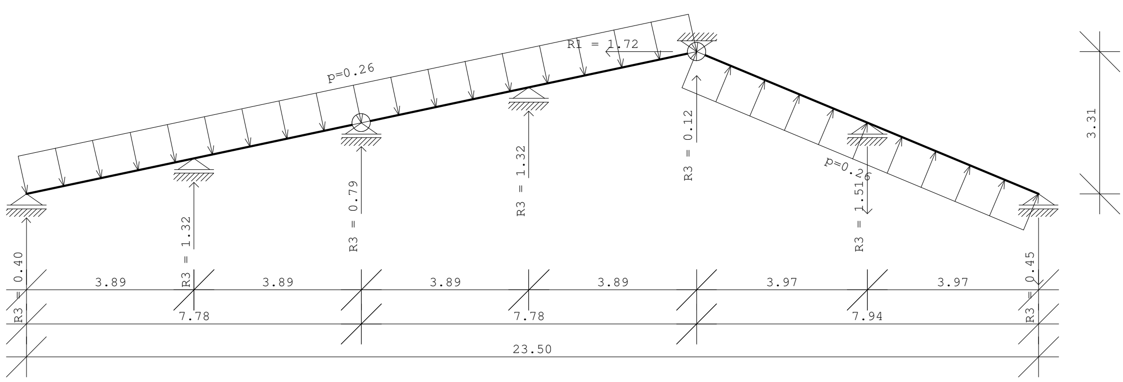
Reakcije podpor

Obt. 2: Koristna obtežba



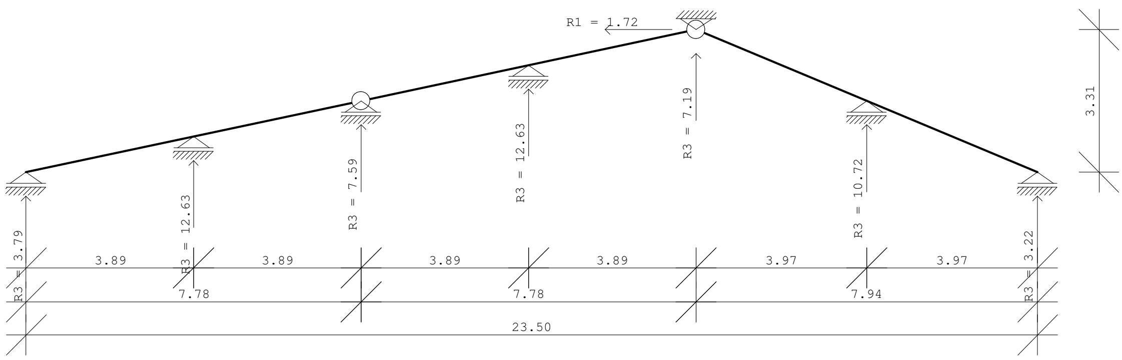
Reakcije podpor

Obt. 3: Veter

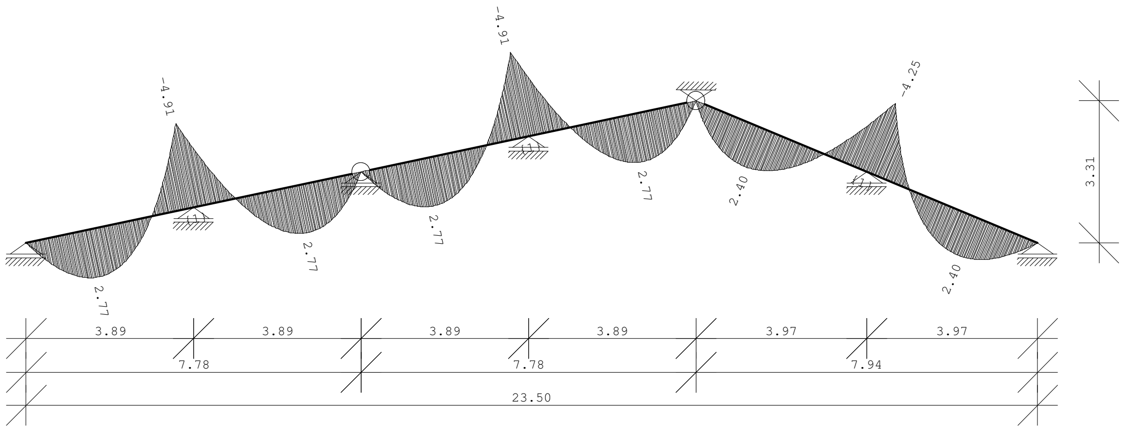


Reakcije podpor

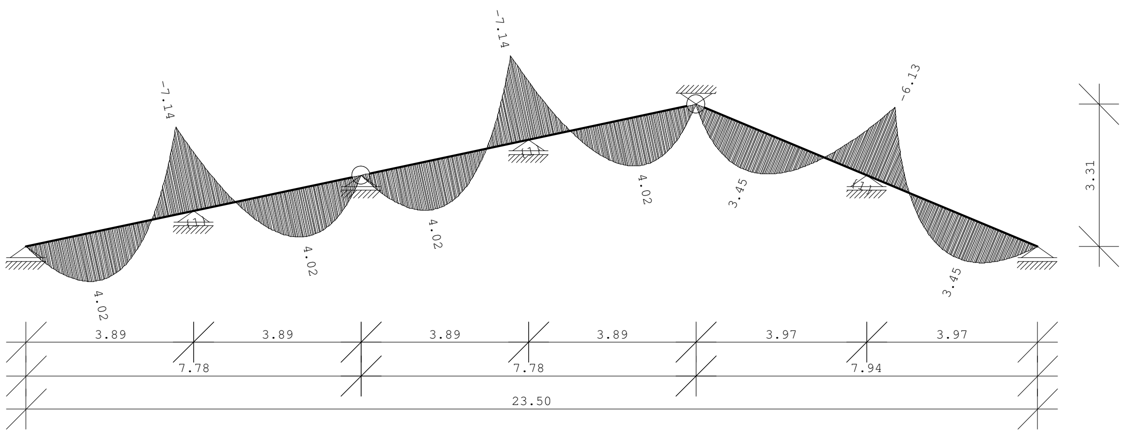
Obt. 4: 1,0g+1,0q+1.0w



Reakcije podpor
Obt. 4: 1,0g+1,0q+1.0w

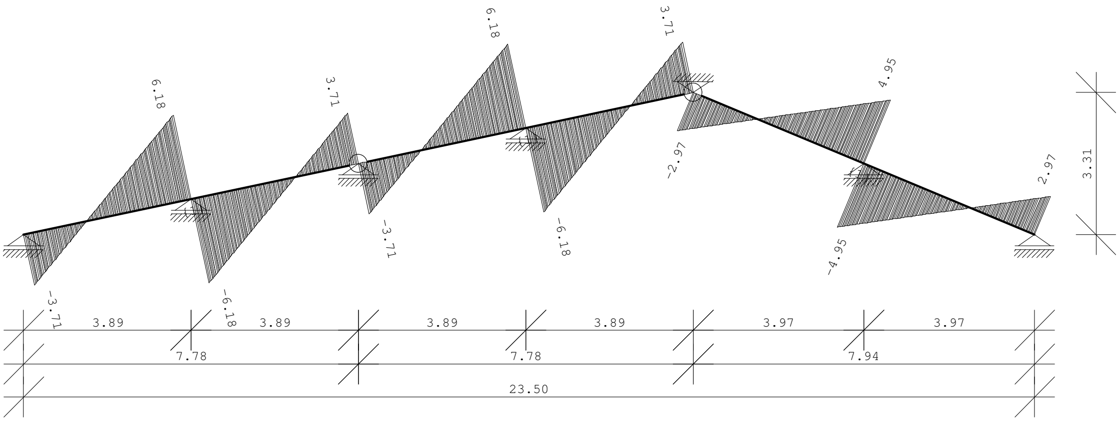


Vplivi v gredi: max M3= 2.77 / min M3= -4.91 kNm
Obt. 5: 1,35g+1,5q+1.5w

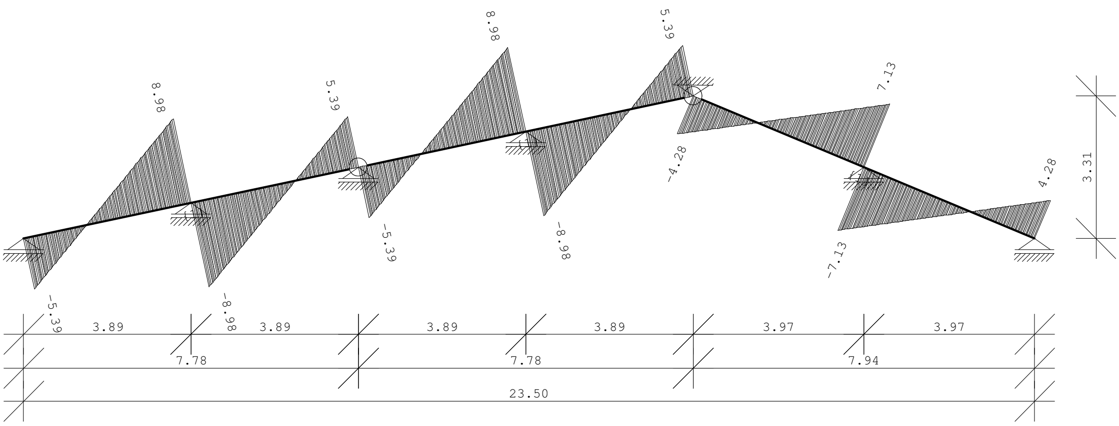


Vplivi v gredi: max M3= 4.02 / min M3= -7.14 kNm

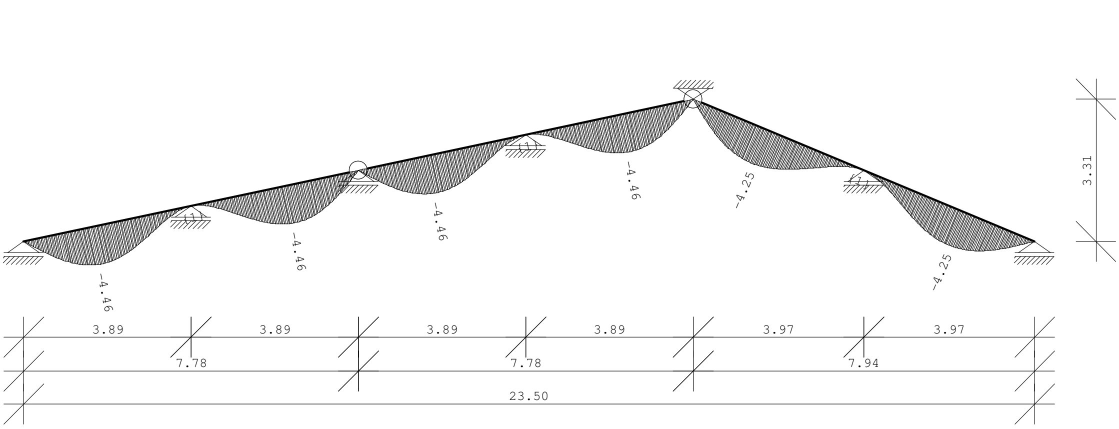
Obt. 4: 1,0g+1,0q+1.0w



Vplivi v gredi: max T2= 6.18 / min T2= -6.18 kN
Obt. 5: 1,35g+1,5q+1.5w



Vplivi v gredi: max T2= 8.98 / min T2= -8.98 kN
Obt. 4: 1,0g+1,0q+1.0w



Vplivi v gredi: max Zp= -0.00 / min Zp= -4.46 m / 1000

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka: Glavna lesena lega.twp
Datum preračuna: 13.7.2021

Način preračuna: 2D model (Zp, Xr, Yr)

- [X] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [ ] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč: 1958
Število ploskovnih elementov: 0
Število grednih elementov: 1957
Število robnih elementov: 51
Število osnovnih obtežnih primerov: 2
Število kombinacij obtežb: 3

Enote mer

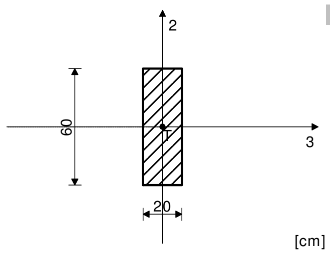
Dolžina: m [cm,mm]
Sila: kN
Temperatura: Celsius

Tabele materialov

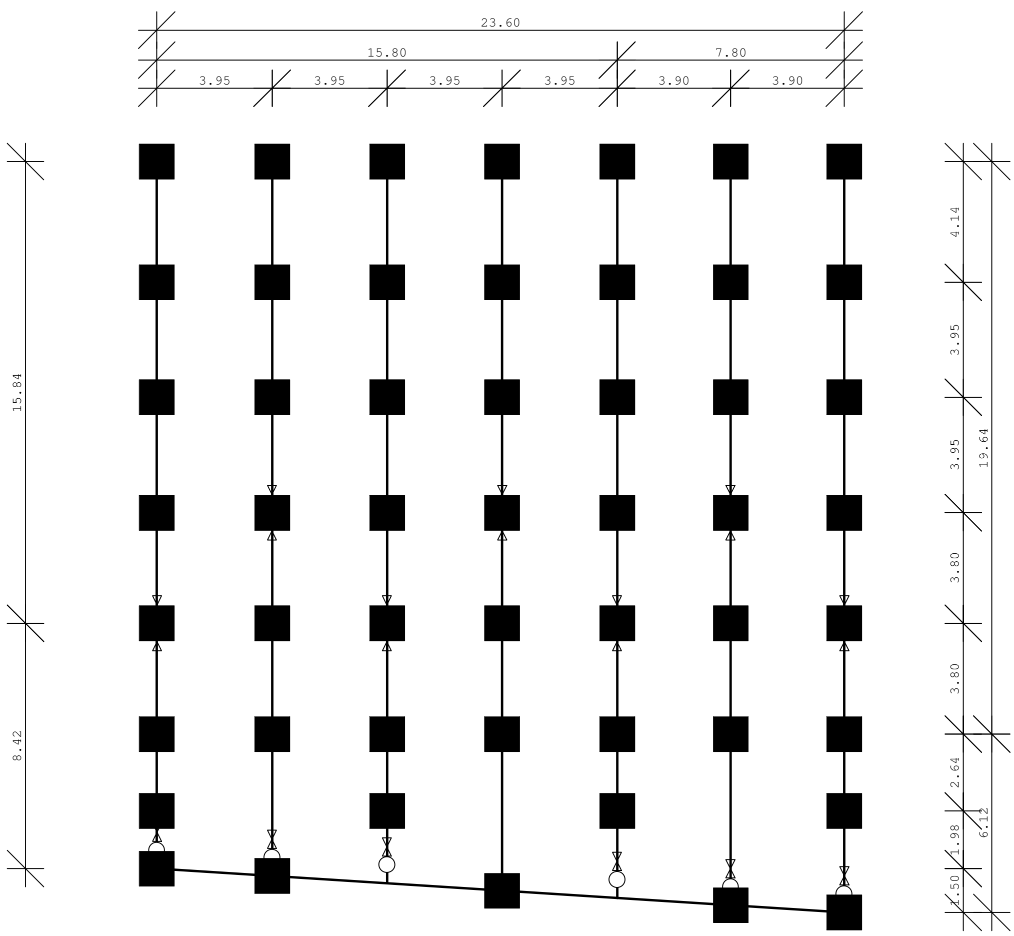
No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Les-Iglavci-Lamelirani	1.100e+7	0.20	5.00	1.000e-5	1.100e+7	0.20

Seti gred

Set: 1 Presek: Pravokotni



Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		1.200e-1	1.000e-1	1.000e-1	1.264e-3	4.000e-4	3.600e-3

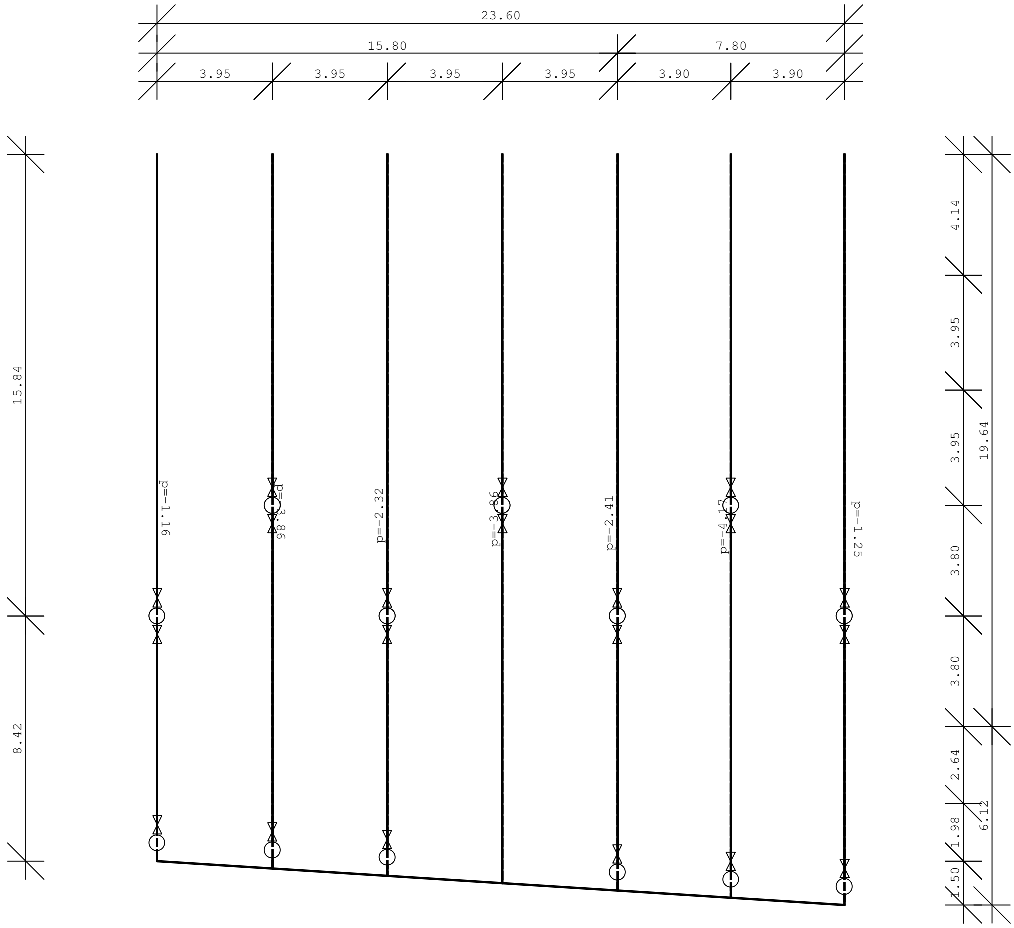


Vhodni podatki - Obtežba

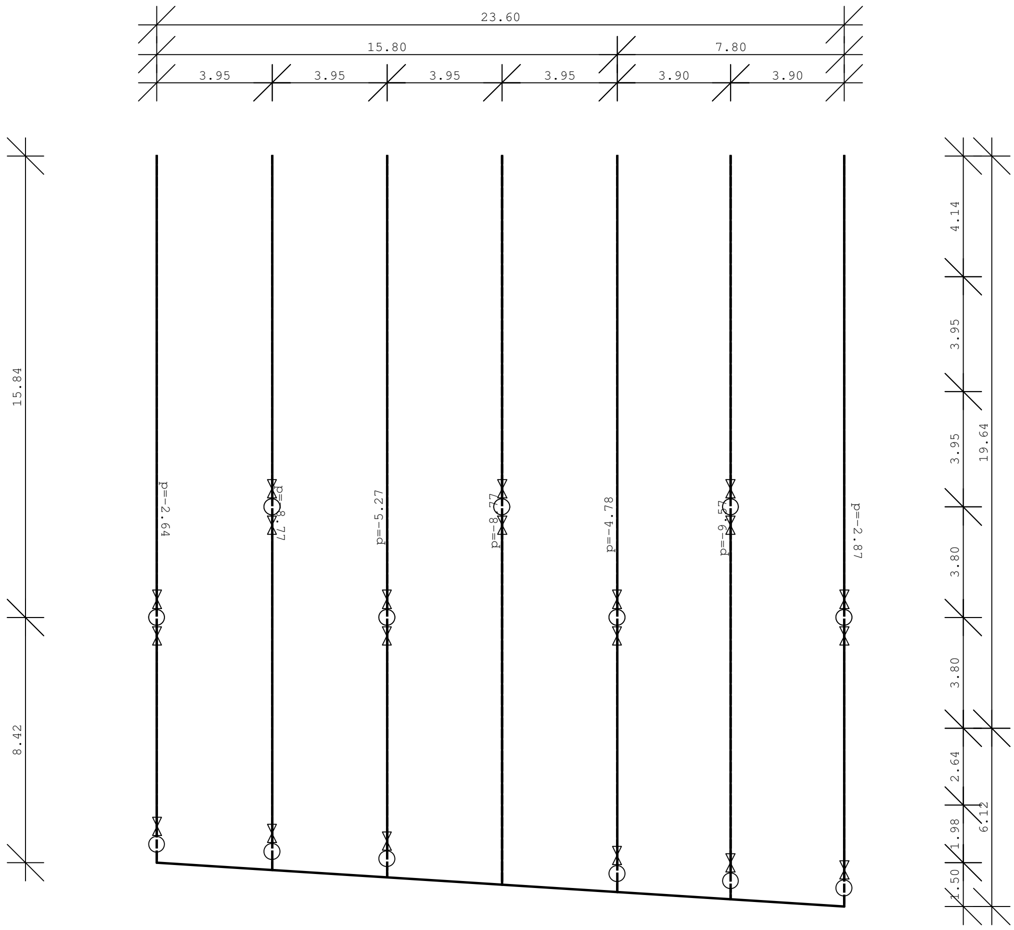
Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Kombinacija: 1.0g+1.0q (I+II)
4	Kombinacija: 1.35g+1.5q (1.35xI+1.5xII)
5	Kombinacija: 1.0g+0.3*q (I+0.3xII)

Obt. 1: Stalna obtežba (g)

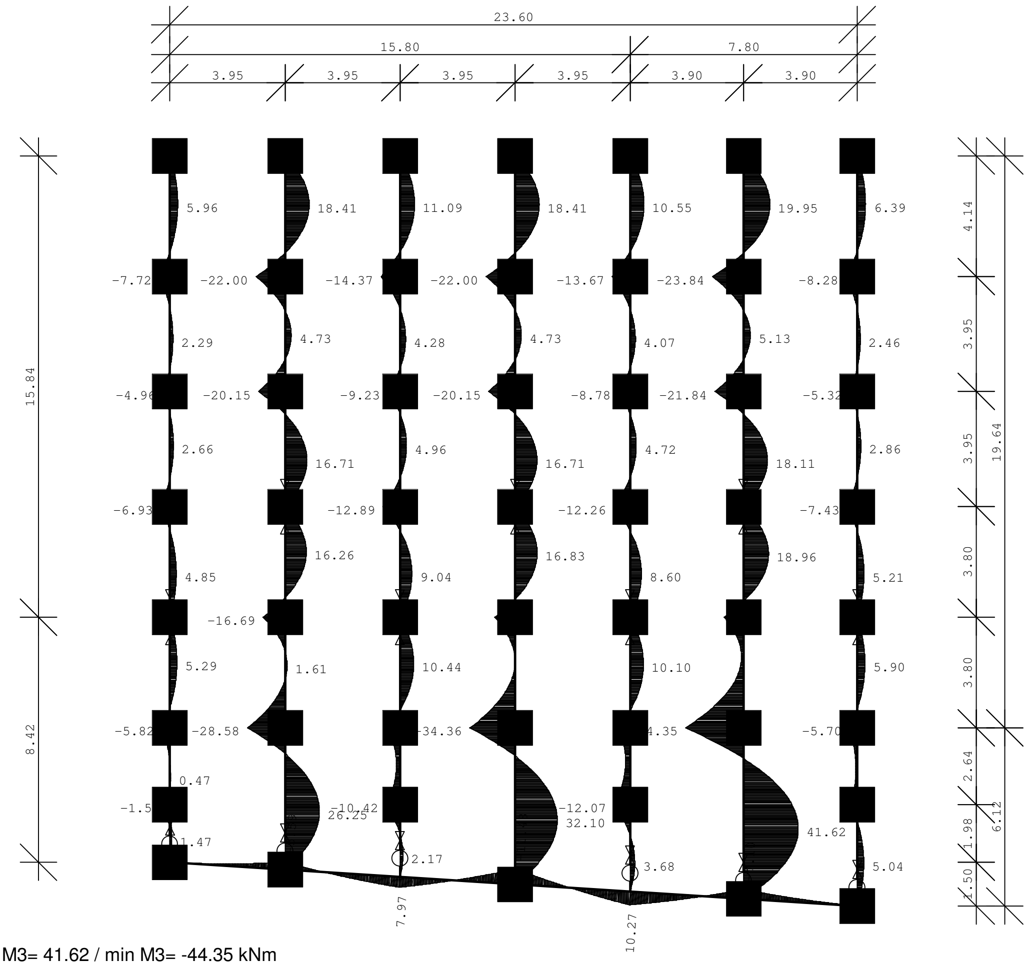


Obt. 2: Koristna obtežba



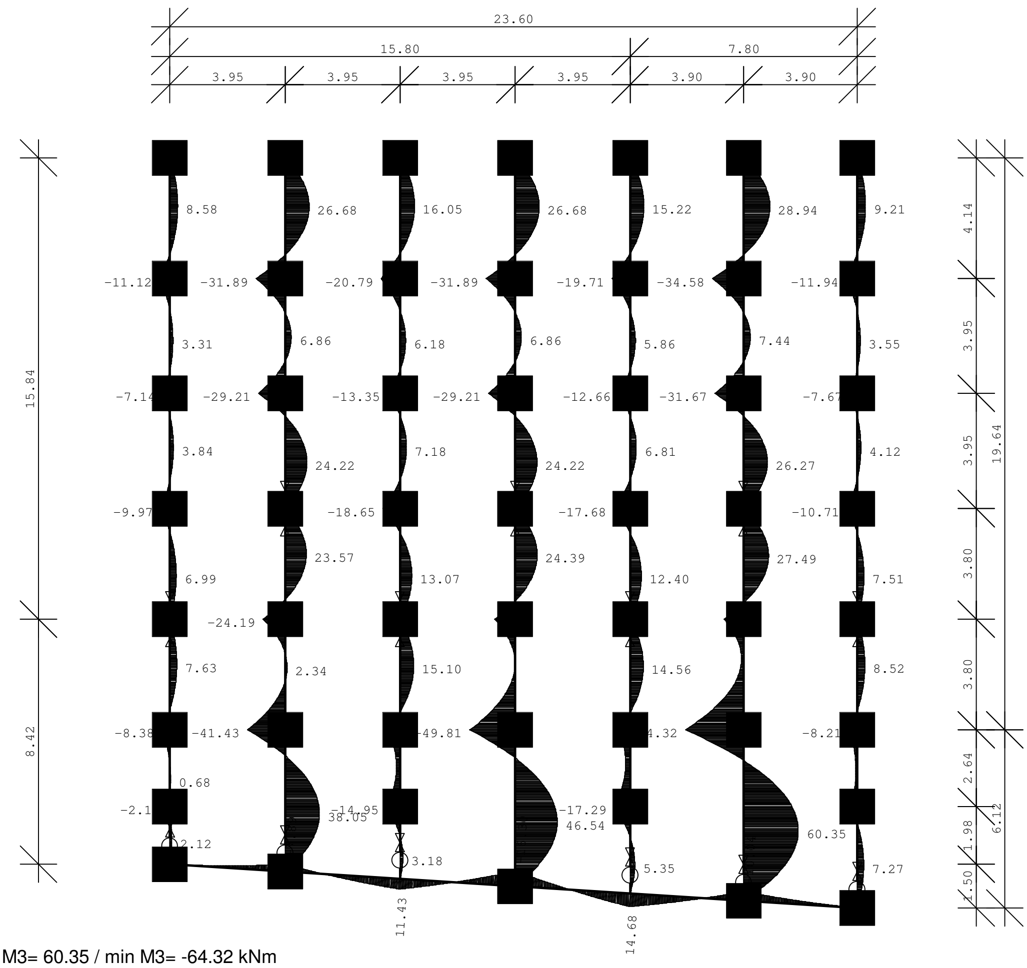
Statični preračun

Obt. 3: 1.0g+1.0q



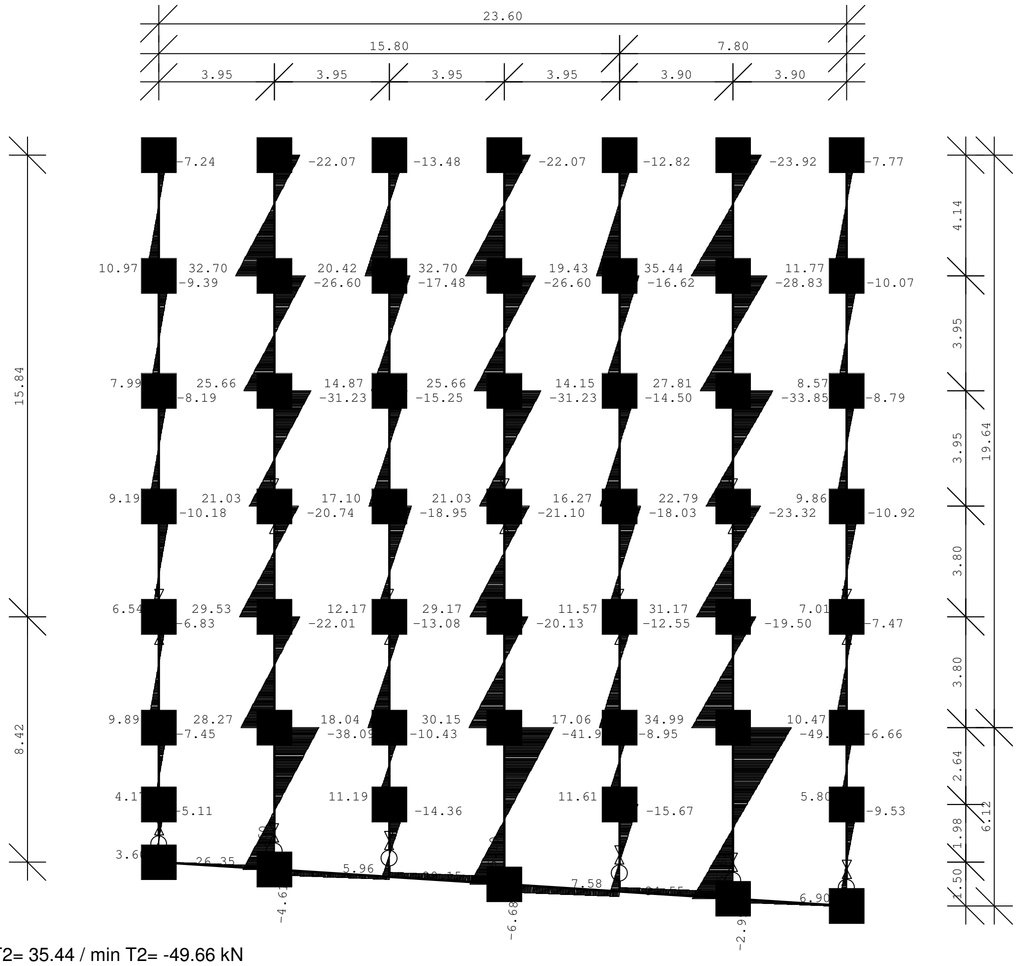
Vplivi v gredi: max M3= 41.62 / min M3= -44.35 kNm

Obt. 4: 1.35g+1.5q



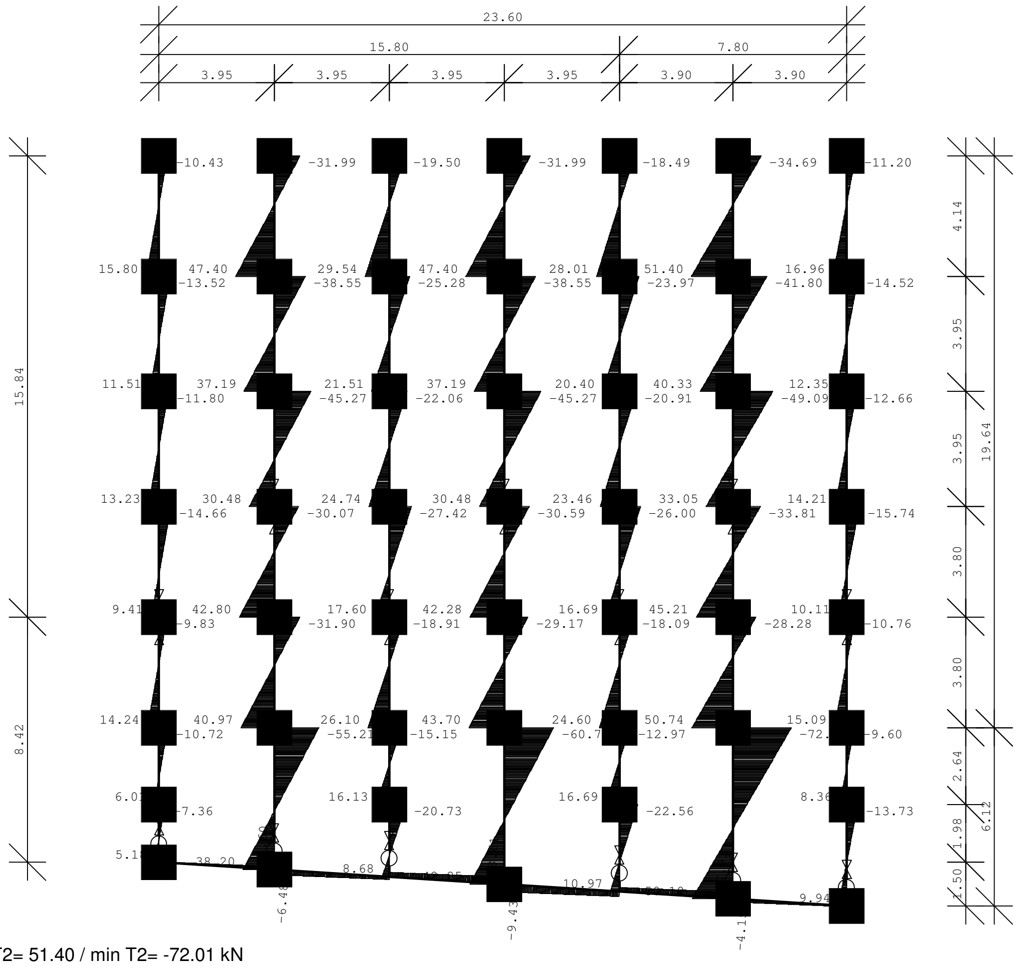
Vplivi v gredi: max M3= 60.35 / min M3= -64.32 kNm

Obt. 3: 1.0g+1.0q



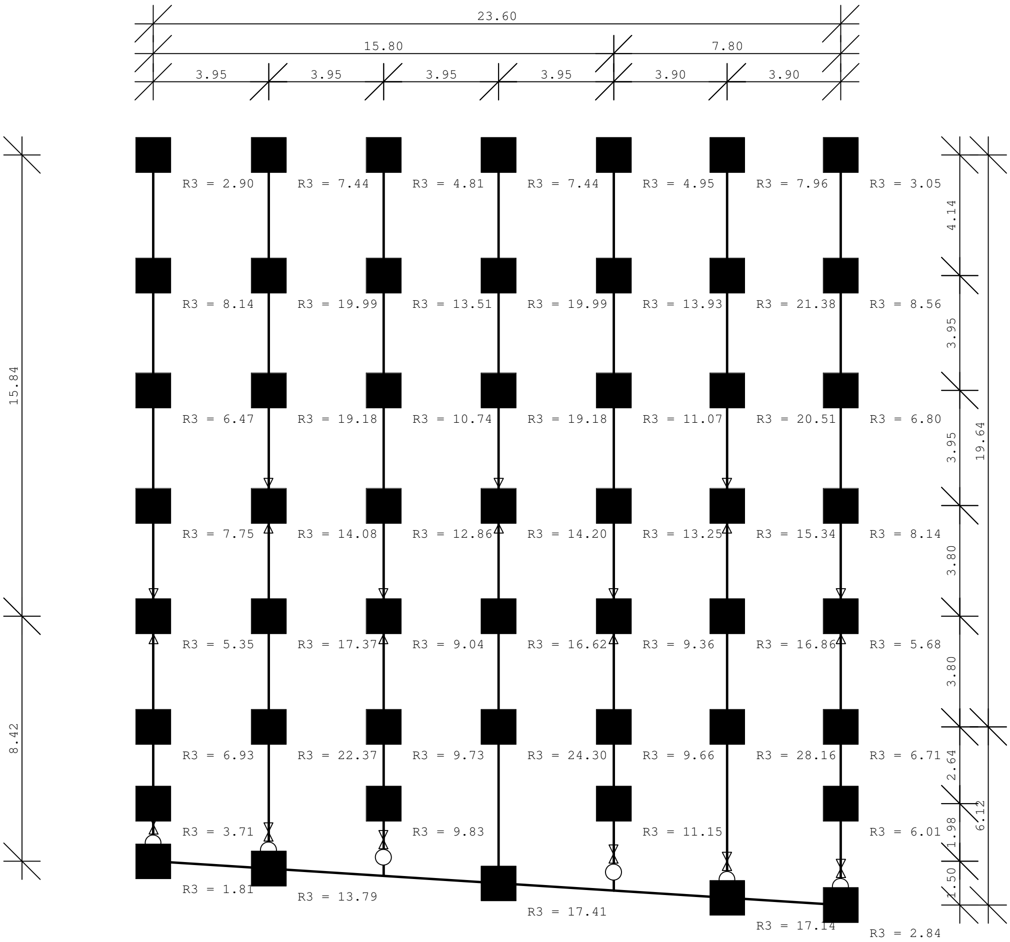
Vplivi v gredi: max T2= 35.44 / min T2= -49.66 kN

Obt. 4: 1.35g+1.5q



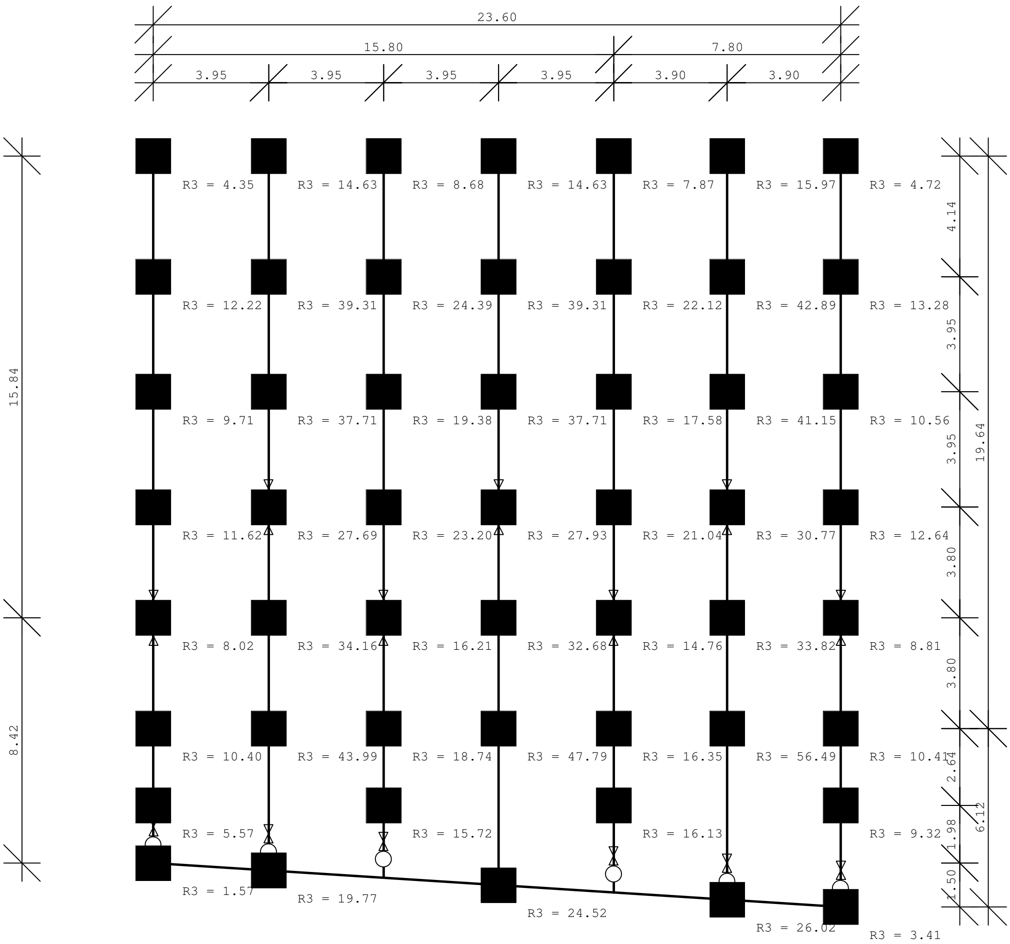
Vplivi v gredi: max T2= 51.40 / min T2= -72.01 kN

Obt. 1: Stalna obtežba (g)



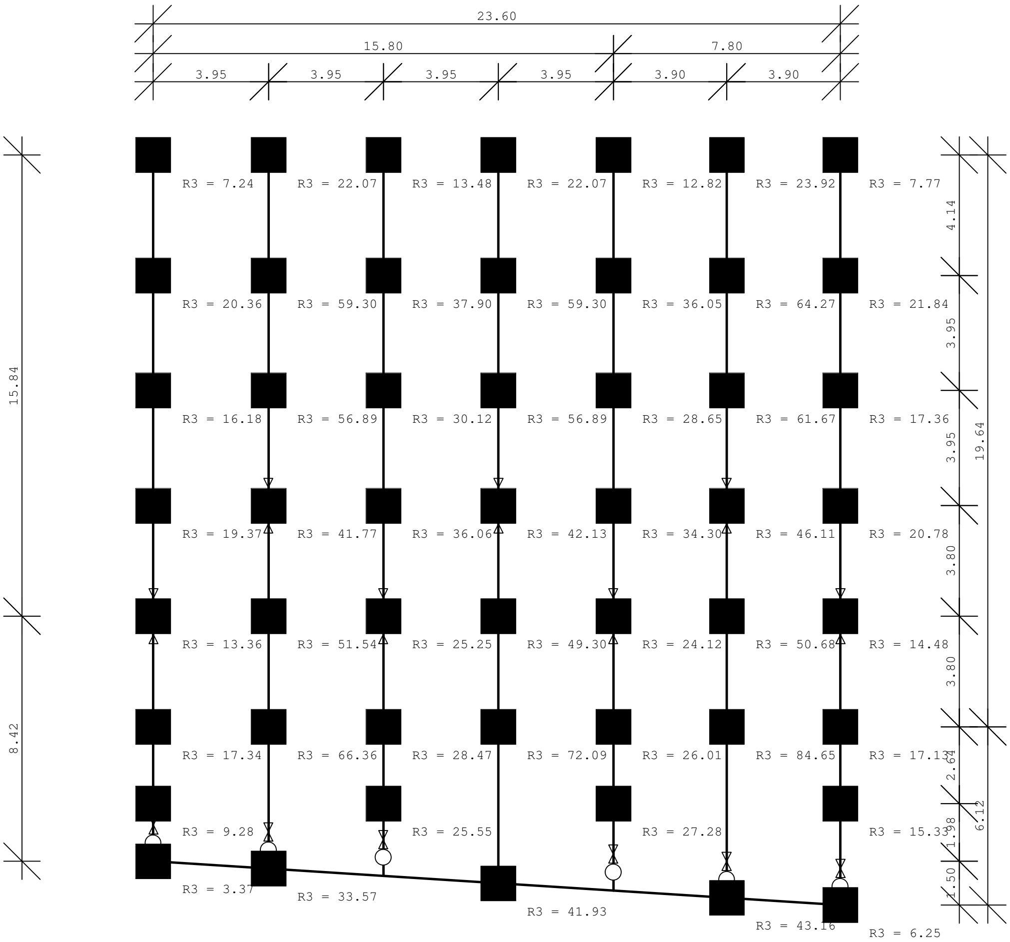
Reakcije podpor

Obt. 2: Koristna obtežba



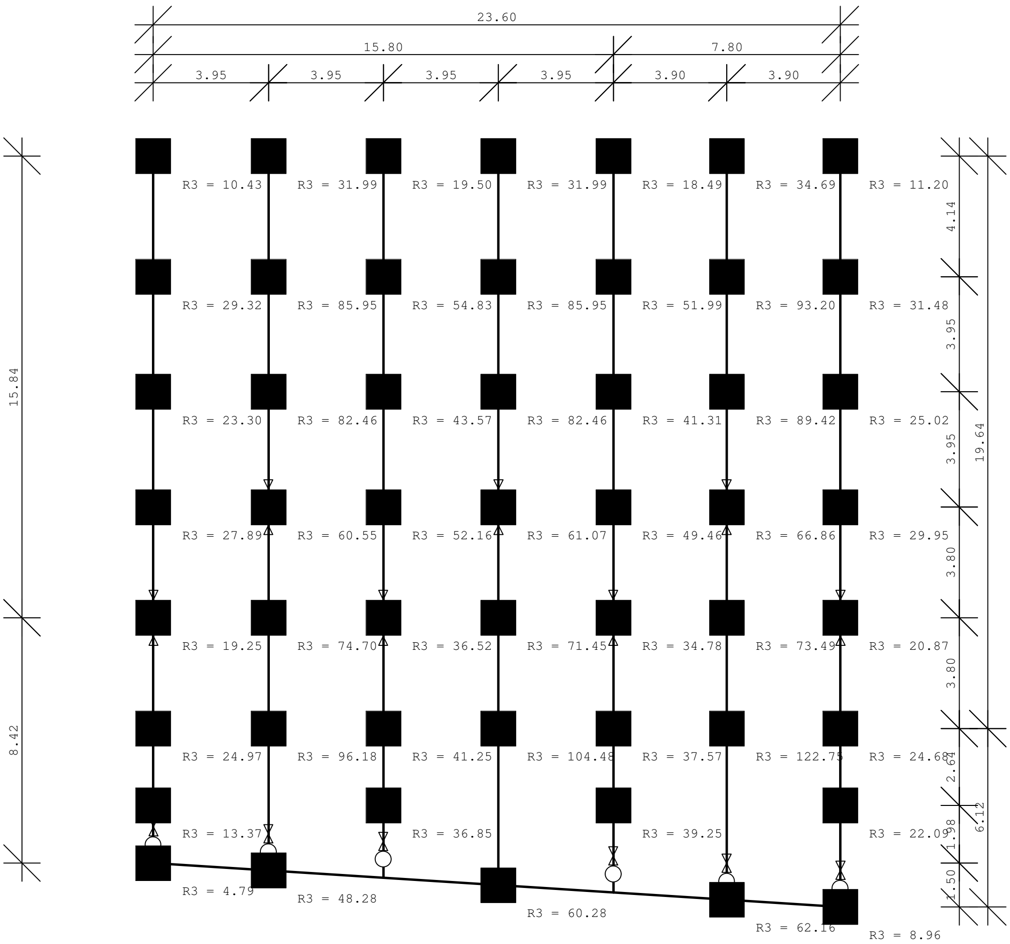
Reakcije podpor

Obt. 3: 1.0g+1.0q



Reakcije podpor

Obt. 4: 1.35g+1.5q



Reakcije podpor

4.20 A.B. PLOŠČE
4.21 A.B.Plošča poz 300 nad nadstropjem, pod ostrešjem

Plošča poz 300, nad etažo je izvedena kot polno armirana plošča d=28cm,

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,5**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Obremenitve plošče POZ 300 nad nadstropjem	g	p	g+p	EM
Koristna obremenitev		3,00	3,00	kN/m2
Tehnološke obremenitve, povprečno	2,52		2,52	kN/m2
Zaključek izolacijskih slojev	0,40		0,40	kN/m2
Izolacijski sloji	0,20		0,20	kN/m2
Lastna teža plošče d=28 cm	7,00		7,00	kN/m2
Omet ali lahki viseči strop	0,60		0,60	kN/m2
Skupaj	**10,72**	**3,00**	**13,72**	kN/m2
Incidentna obremenitev v potresu 1,0g+0,30q	**10,72**	**0,90**	**11,62**	kN/m2

Tehnološke obremenitve

Enote za ogrevanje in prezračevanje

Prezračevanje za servisni del kleti	**230 kg=**	1,63m2	**1,41**	kN/m2
Prezračevalna naprava za vrtec	**550 kg=**	3,06m2	**1,79**	kN/m2
Prezračevalna naprava za telovadnico	**2274kg=**	9,00m2	**2,52**	kN/m2

Obtežni primeri / armatura plošče glej prilogo

Osnovni obtežni primeri

1 g — Lastna teža
2 p — Koristna vertikalna obremenitev

Kombinacije

A= 1,0*g+1,0*p — / kontrola reakcij in deformacij
B= 1,35*g+1,5*q — / dimenzioniranje
C= 1,0*g+0,30*q — / incidentna obremenitev, potres

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Talna plošča garaže.twp
Datum preračuna:	12.7.2021

Način preračuna:	3D model

[ ] Teorija I-ga reda   [ ] Modalna analiza   [ ] Stabilnost

[X] Teorija II-ga reda   [ ] Seizmični preračun   [ ] Ofset gred

[ ] Faze gradnje

Velikost modela

Število vozlišč:	31627
Število ploskovnih elementov:	31968
Število grednih elementov	1158
Število robnih elementov	62178
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

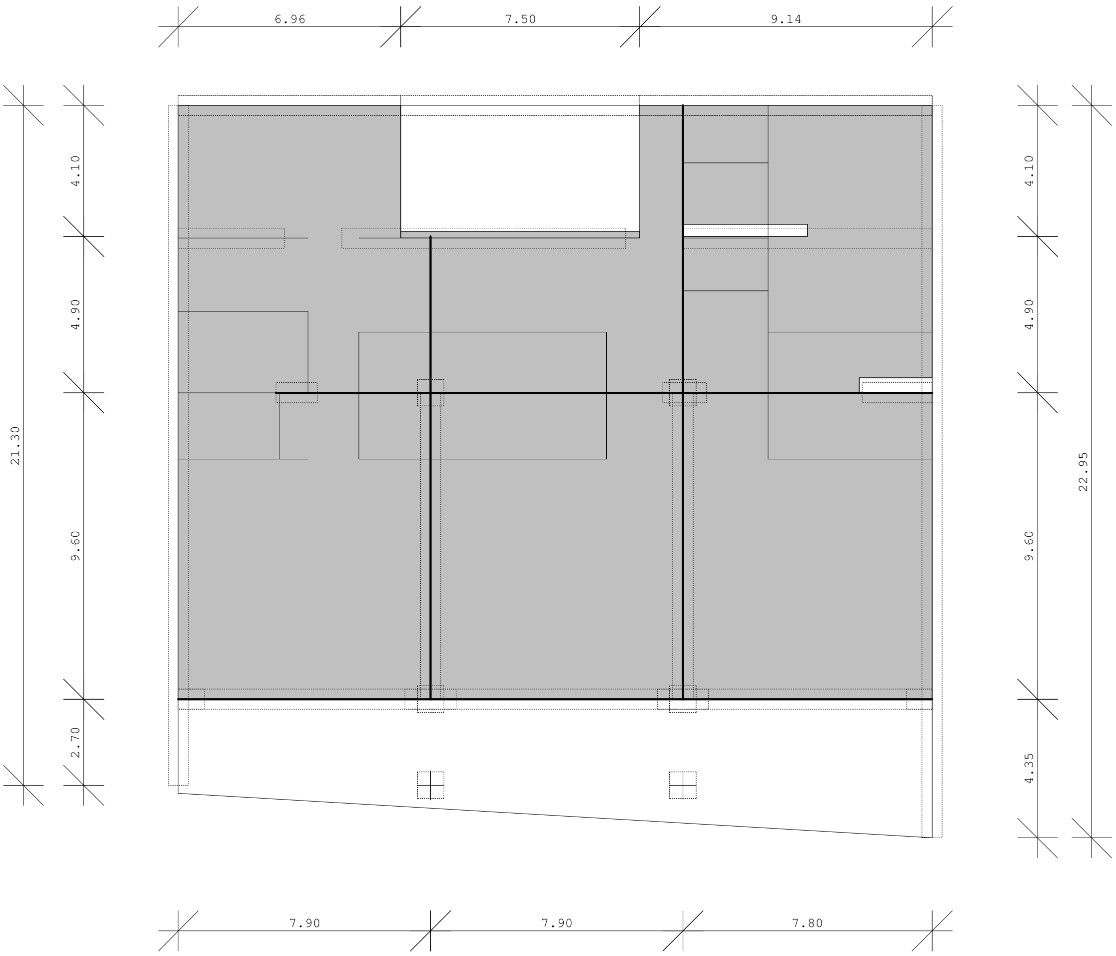
Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
2	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.580	0.290	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	1	Tanka plošča	Izotropna			
<3>	0.280	0.140	2	Tanka plošča	Izotropna			
<4>	0.280	0.140	2	Tanka plošča	Izotropna			
<5>	0.280	0.140	2	Tanka plošča	Izotropna			
<6>	0.250	0.125	2	Tanka plošča	Izotropna			

Vhodni podatki - Obtežba



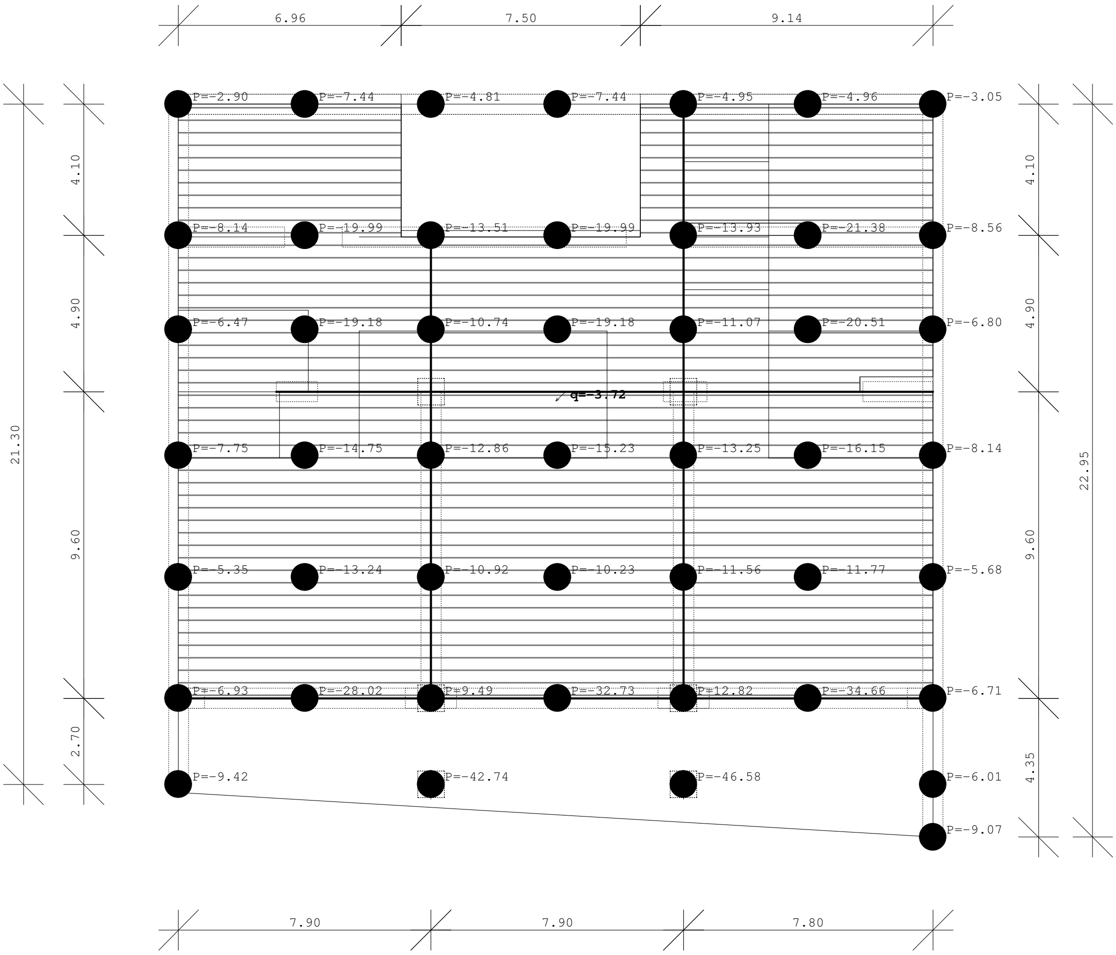
Nivo: Plošča 300 [11.30]

Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)

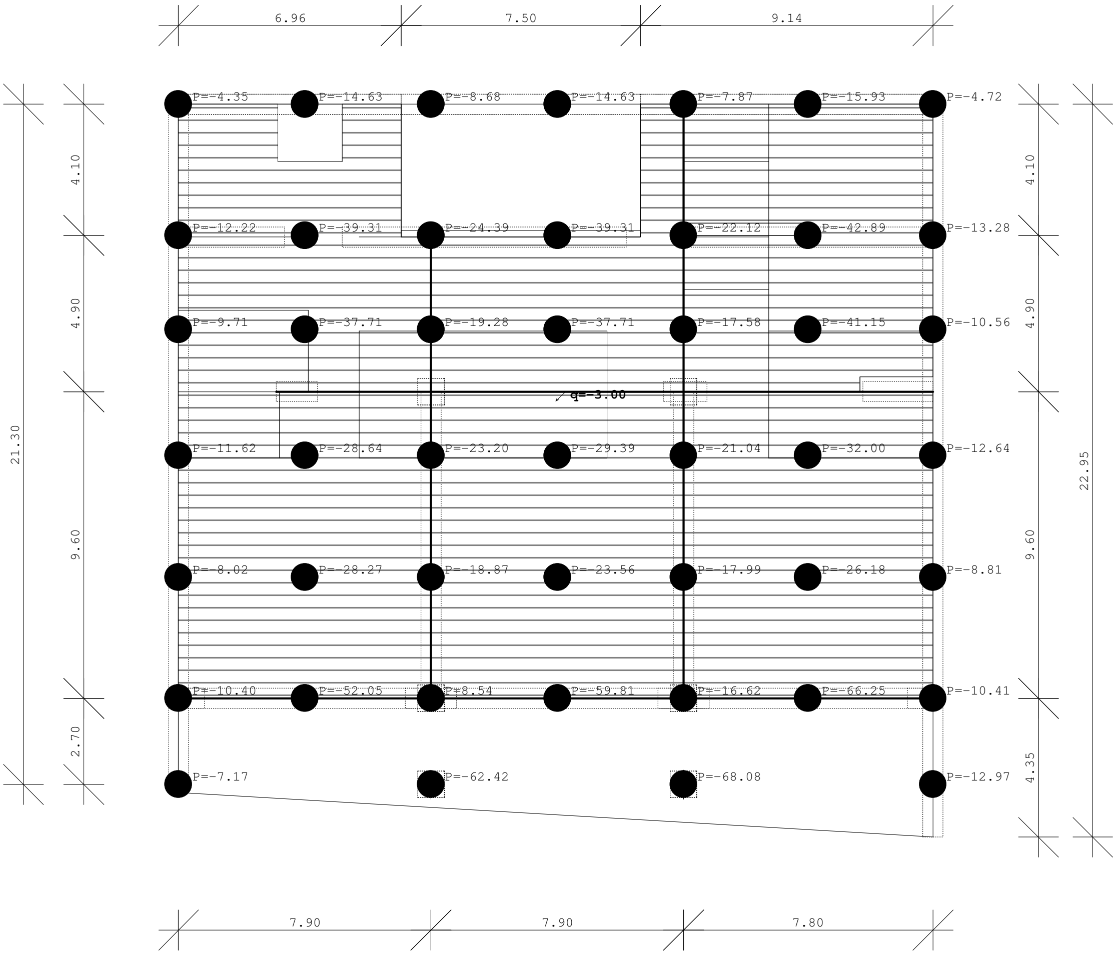
No	Naziv
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 1: Stalna obtežba (g)



Nivo: Plošča 300 [11.30]

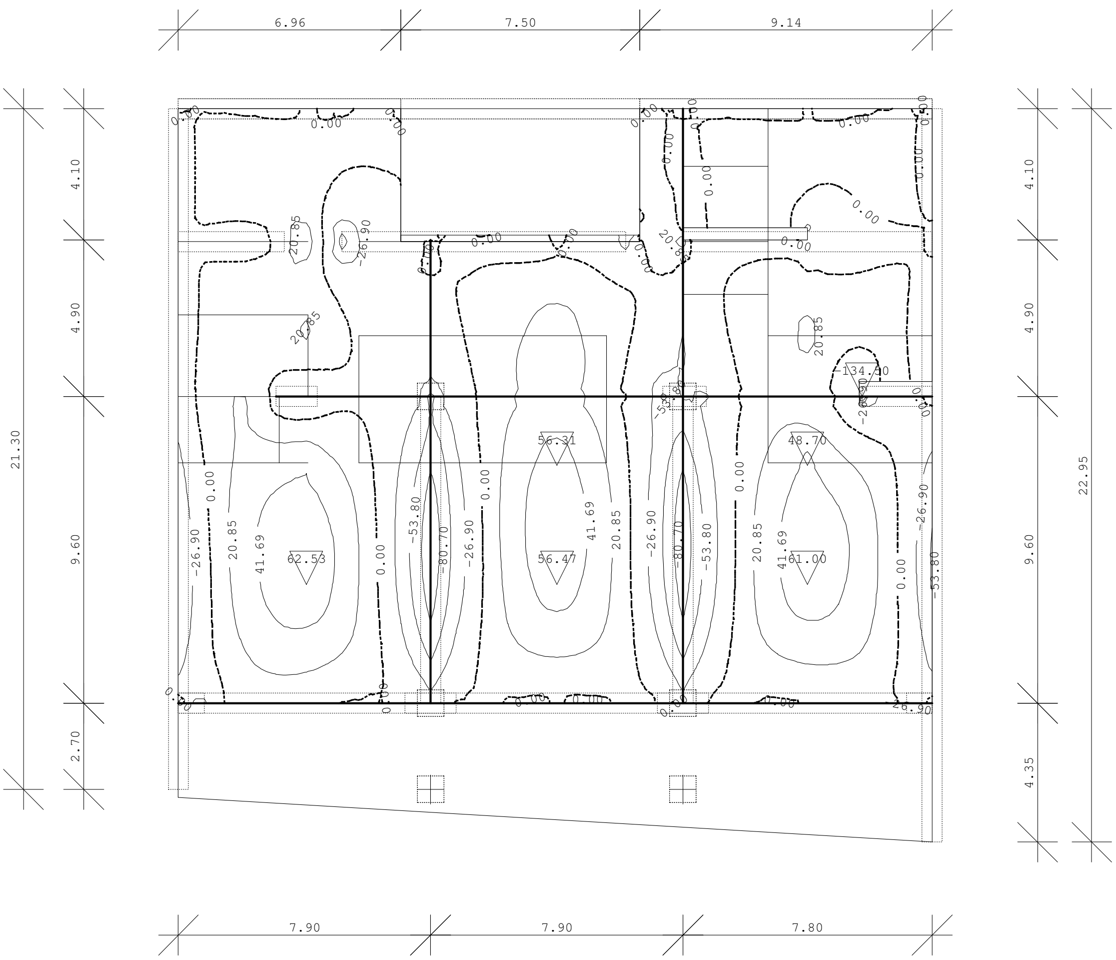
Obt. 2: Koristna obtežba



Nivo: Plošča 300 [11.30]

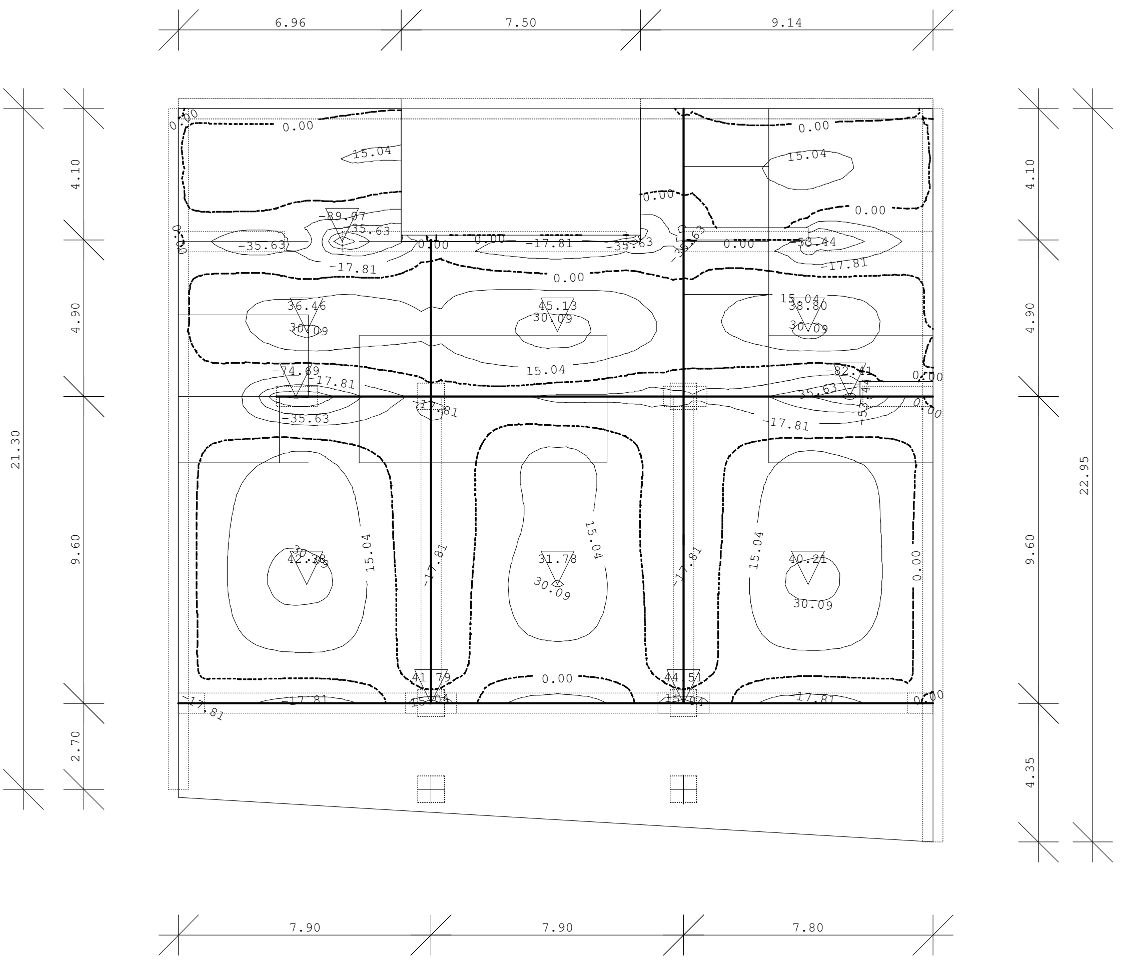
Statični preračun

Obt. 9: MSN - 1.35g+1.5q+1.5Wx



Nivo: Plošča 300 [11.30]
Vplivi v plošči: max Mx= 62.53 / min Mx= -134.50 kNm/m

Obt. 9: MSN - 1.35g+1.5q+1.5Wx

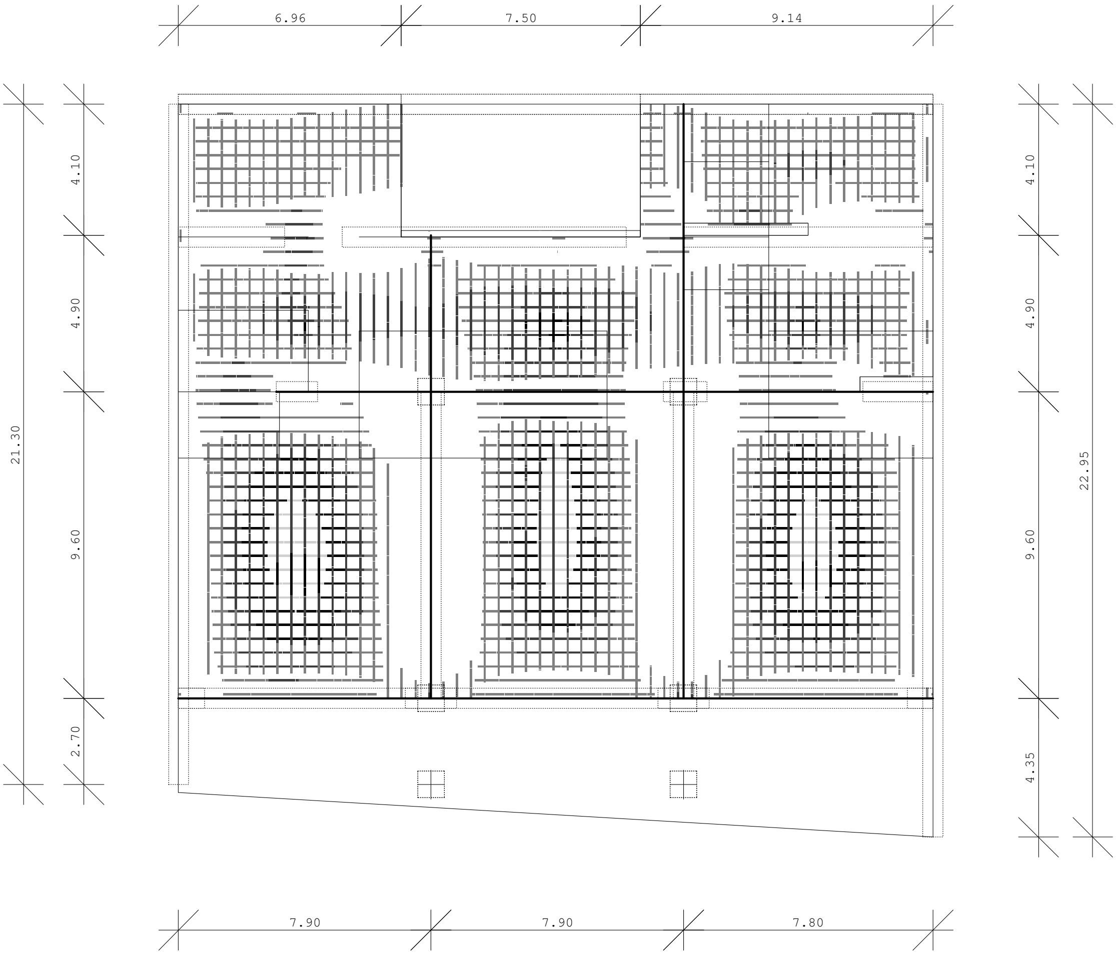


Nivo: Plošča 300 [11.30]
Vplivi v plošči: max My= 45.13 / min My= -89.07 kNm/m

Dimenzioniranje (beton)

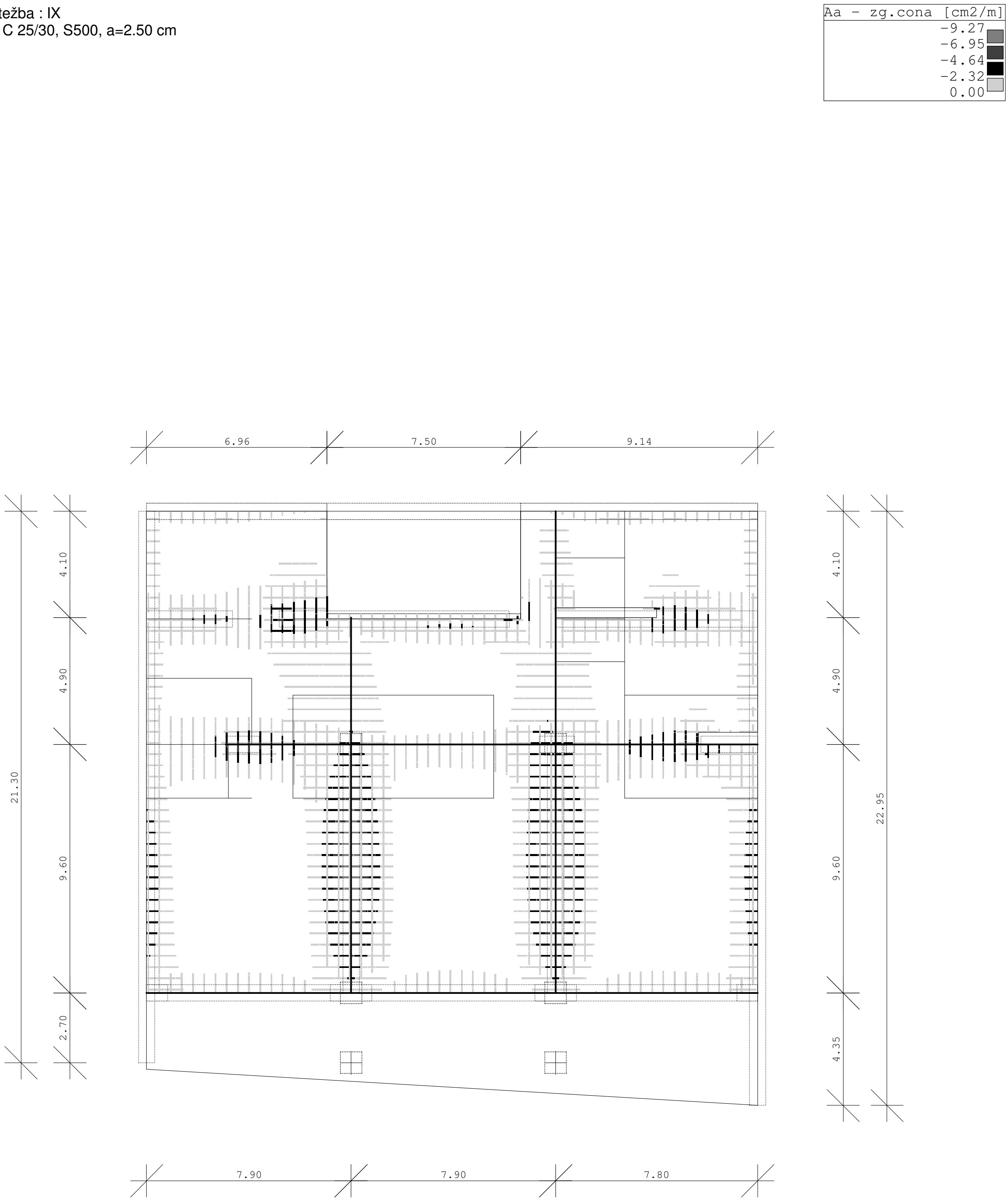
Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=3.00 cm

Aa - sp.cona [cm2/m]
0.00
1.50
3.00
4.49
5.99



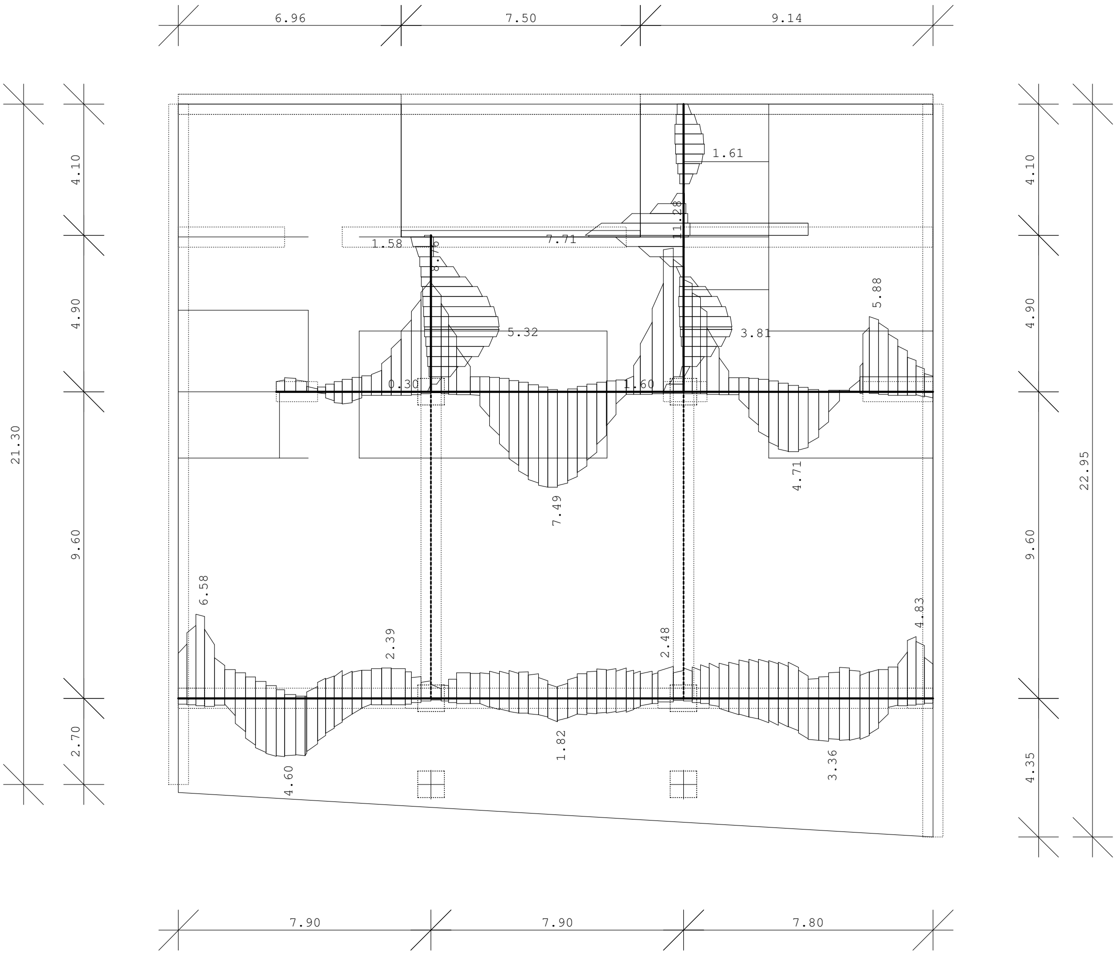
Nivo: Plošča 300 [11.30]
Aa - sp.cona - max As= 5.99 cm2/m

Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=2.50 cm



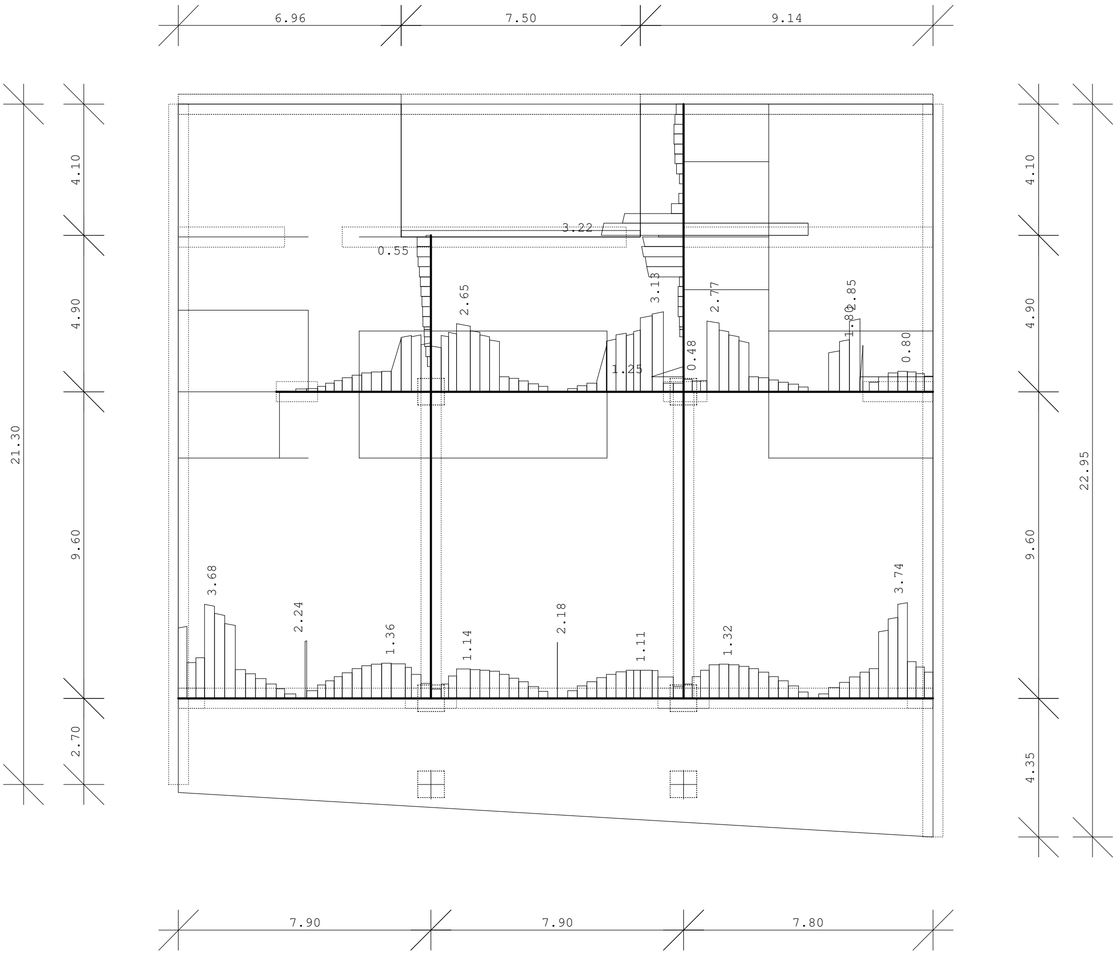
Nivo: Plošča 300 [11.30]
Aa - zg.cona - max Az= -9.26 cm2/m

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 300 [11.30]
Armatura v gredah: max Aa2/Aa1= 11.28 cm2

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 300 [11.30]
Armatura v gredah: max Aa,st= 3.74 cm2

4.22 A.B.Plošča poz 200 nad pritličjem

Plošča nad pritličjem je izvedena kot polno armirana plošča d=28cm,

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,5**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Ploskovne obremenitve plošče POZ 200	**g**	**p**	**g+p**	**EM**
Koristna obremenitev		4,00	4,00	kN/m2
Predelne stene	1,50		1,50	kN/m2
Zaključne obdelave	0,40		0,40	kN/m2
Estrih 7 cm	1,75		1,75	kN/m2
Izolacijski sloji	0,20		0,20	kN/m2
Lastna teža plošče d=28 cm	7,00		7,00	kN/m2
Omet ali lahki viseči strop	0,60		0,60	kN/m2
Skupaj	**11,45**	**4,00**	**15,45**	kN/m2
Incidentna obremenitev v potresu 1,0g+0,30q	**11,45**	**1,20**	**12,65**	kN/m2

Obtežni primeri / armatura plošče glej prilogo

Osnovni obtežni primeri

1	g	Lastna teža
2	p	Koristna vertikalna obremenitev

Kombinacije

A=	1,0*g+1,0*p	/ kontrola reakcij in deformacij
B=	1,35*g+1,5*q	/ dimenzioniranje
C=	1,0*g+0,30*q	/ incidentna obremenitev, potres

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka: Talna plošča garaže.twp
Datum preračuna: 12.7.2021

Način preračuna: 3D model

[ ] Teorija I-ga reda [ ] Modalna analiza [ ] Stabilnost

[X] Teorija II-ga reda [ ] Seizmični preračun [ ] Ofset gred

[ ] Faze gradnje

Velikost modela

Število vozlišč: 31627
Število ploskovnih elementov: 31968
Število grednih elementov 1158
Število robnih elementov 62178
Število osnovnih obtežnih primerov: 6
Število kombinacij obtežb: 6

Enote mer

Dolžina: m [cm,mm]
Sila: kN
Temperatura: Celsius

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
2	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

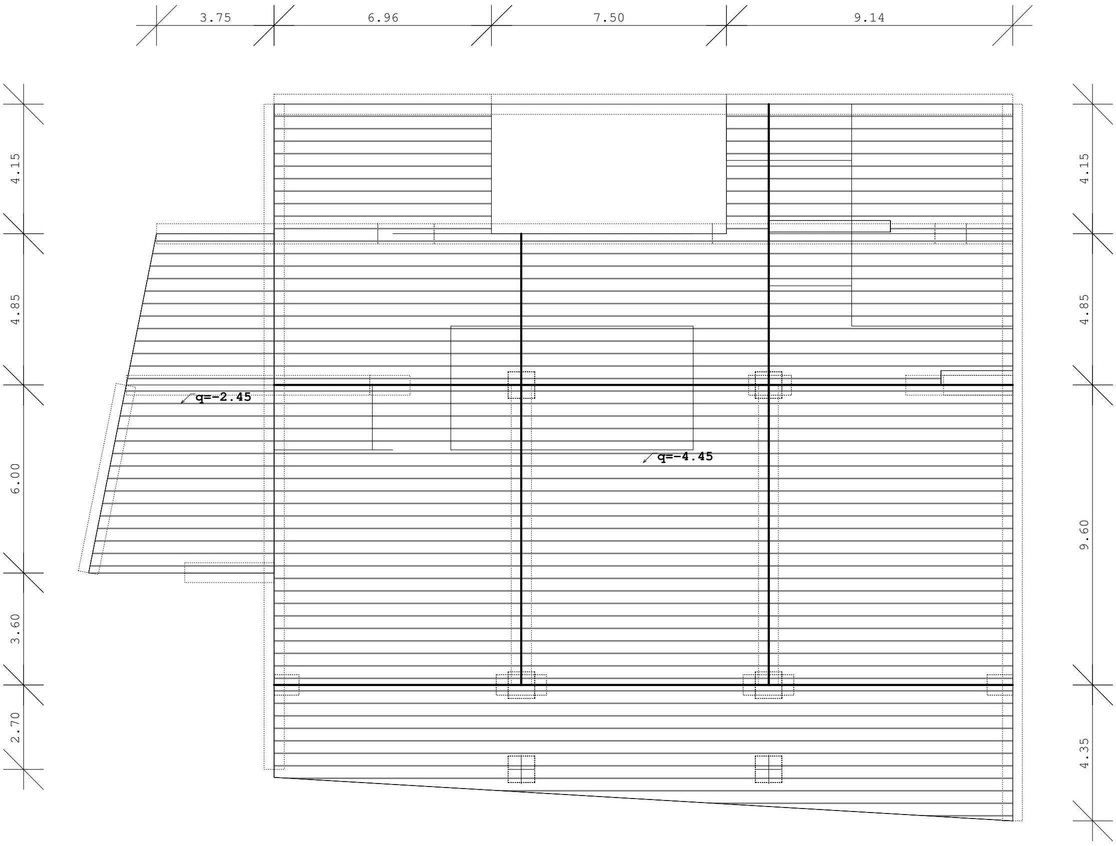
No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.580	0.290	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	1	Tanka plošča	Izotropna			
<3>	0.280	0.140	2	Tanka plošča	Izotropna			
<4>	0.280	0.140	2	Tanka plošča	Izotropna			
<5>	0.280	0.140	2	Tanka plošča	Izotropna			
<6>	0.250	0.125	2	Tanka plošča	Izotropna			

Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)

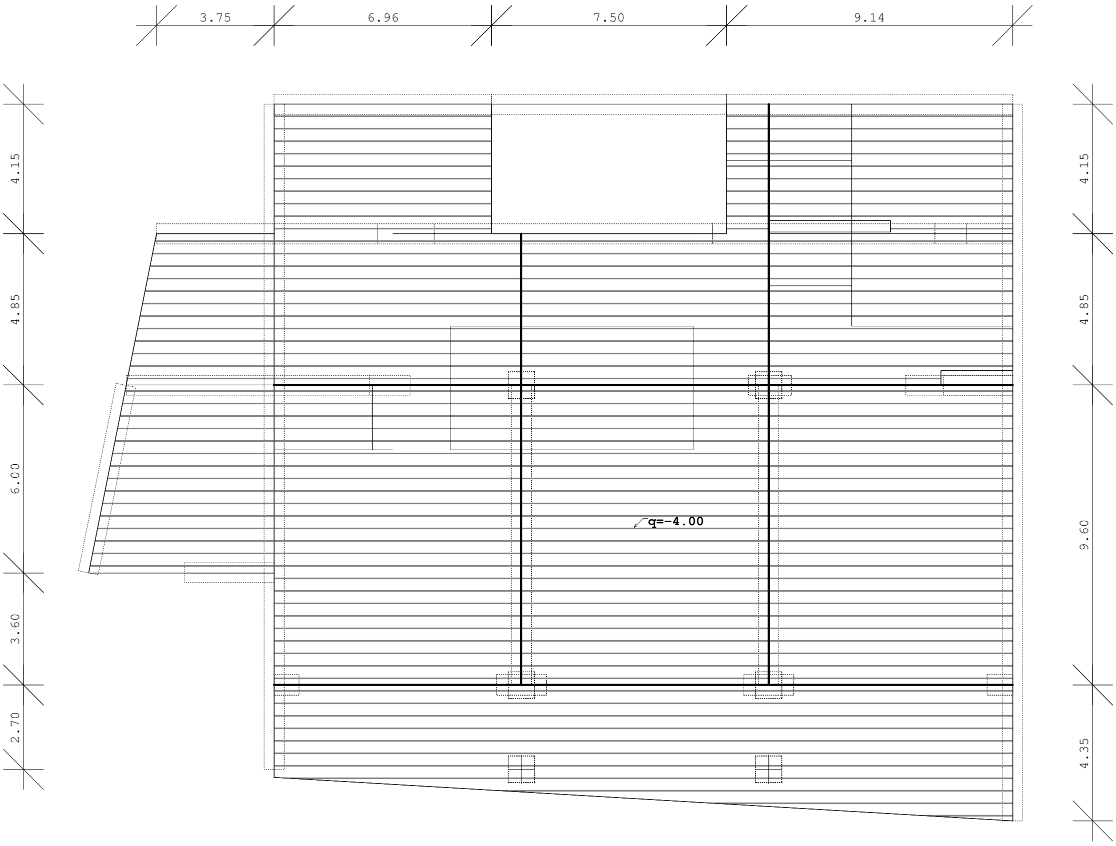
No	Naziv
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 1: Stalna obtežba (g)



Nivo: Plošča 200 [7.40]

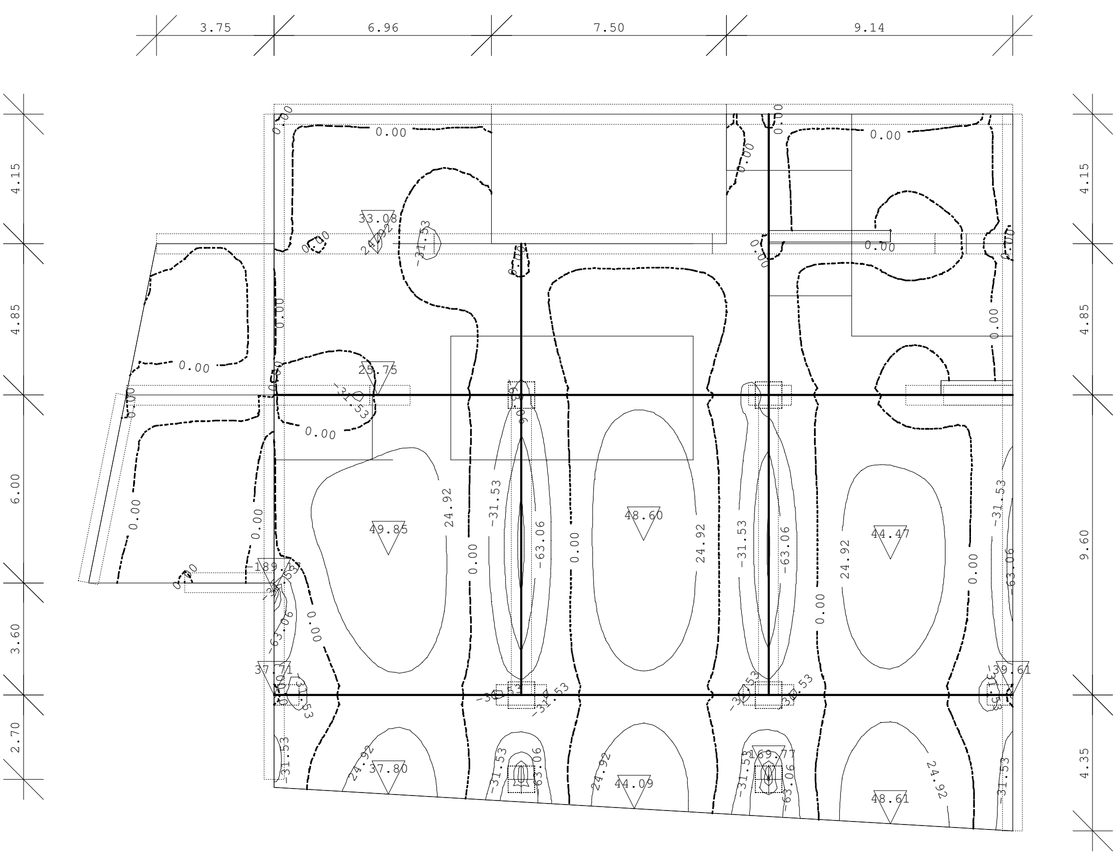
Obt. 2: Koristna obtežba



Nivo: Plošča 200 [7.40]

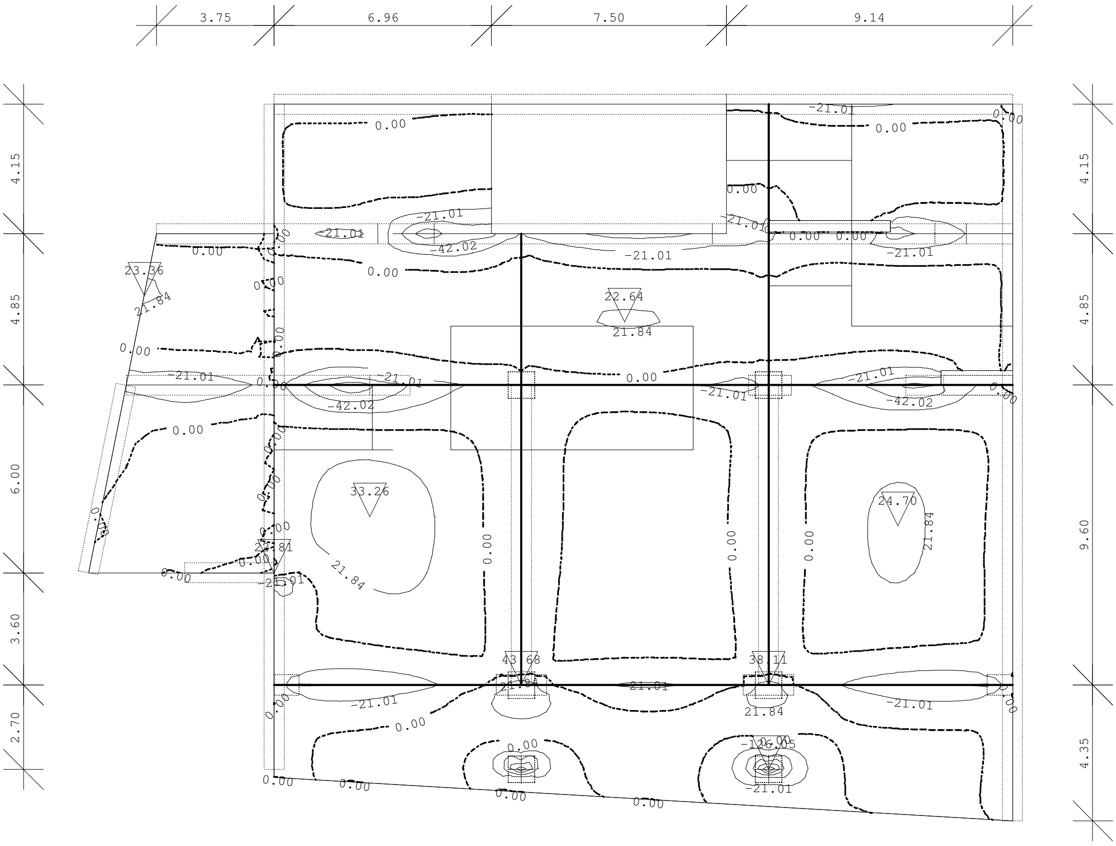
Statični preračun

Obt. 9: MSN - 1.35g+1.5q+1.5Wx



Nivo: Plošča 200 [7.40]
Vplivi v plošči: max Mx= 49.85 / min Mx= -189.17 kNm/m

Obt. 9: MSN - 1.35g+1.5q+1.5Wx

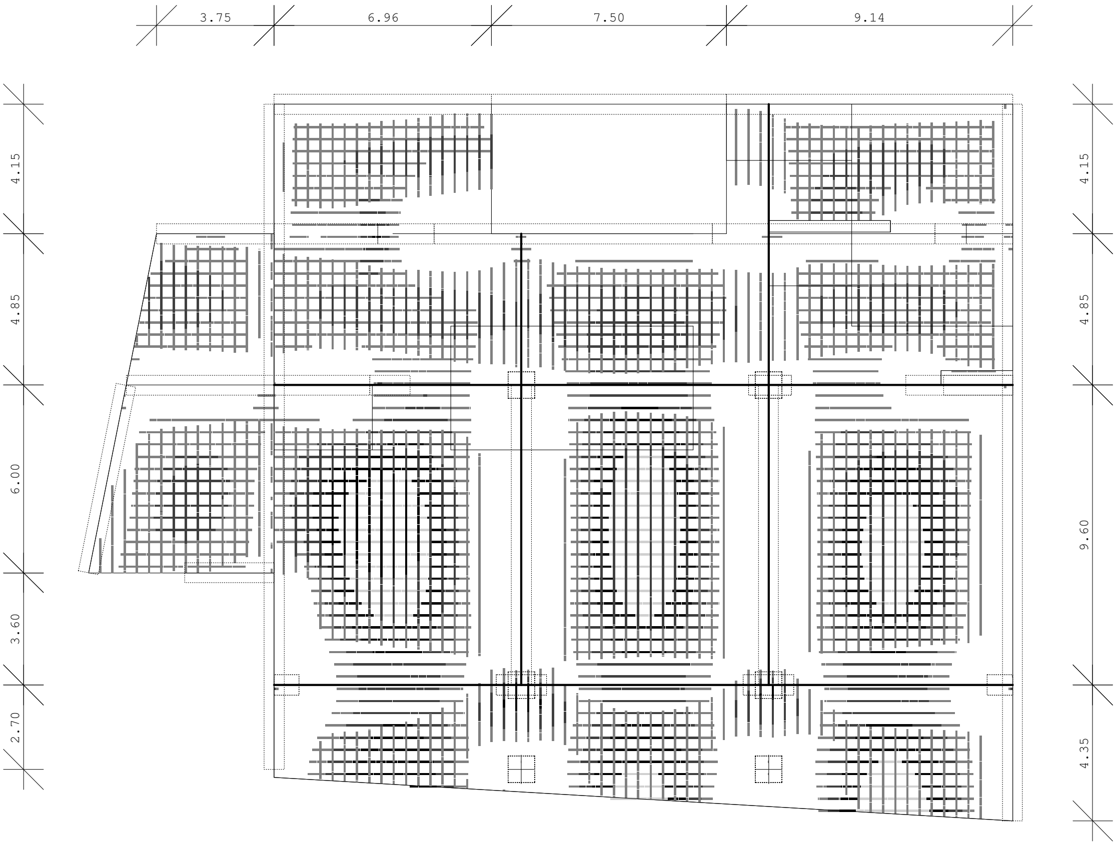


Nivo: Plošča 200 [7.40]
Vplivi v plošči: max My= 43.68 / min My= -126.05 kNm/m

Dimenzioniranje (beton)

Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=3.00 cm

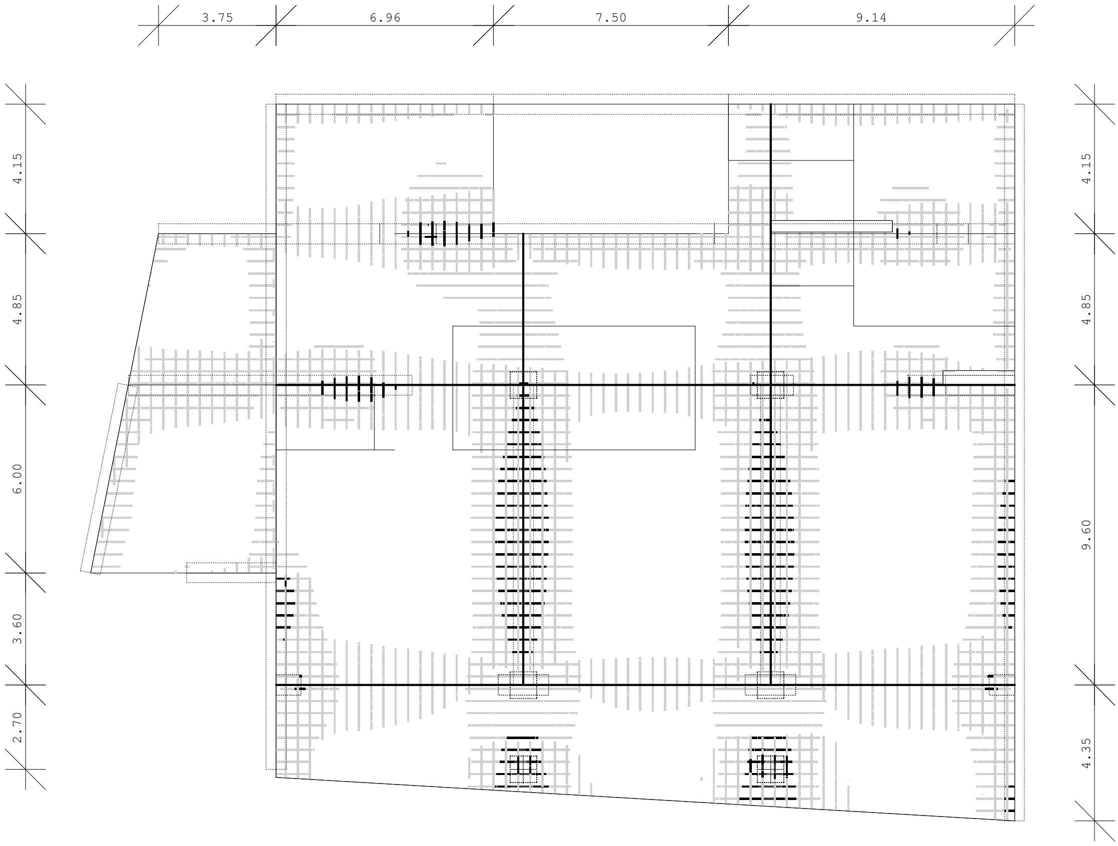
Aa - sp.cona [cm2/m]
0.00
1.19
2.37
3.56
4.74



Nivo: Plošča 200 [7.40]
Aa - sp.cona - max As= 4.74 cm2/m

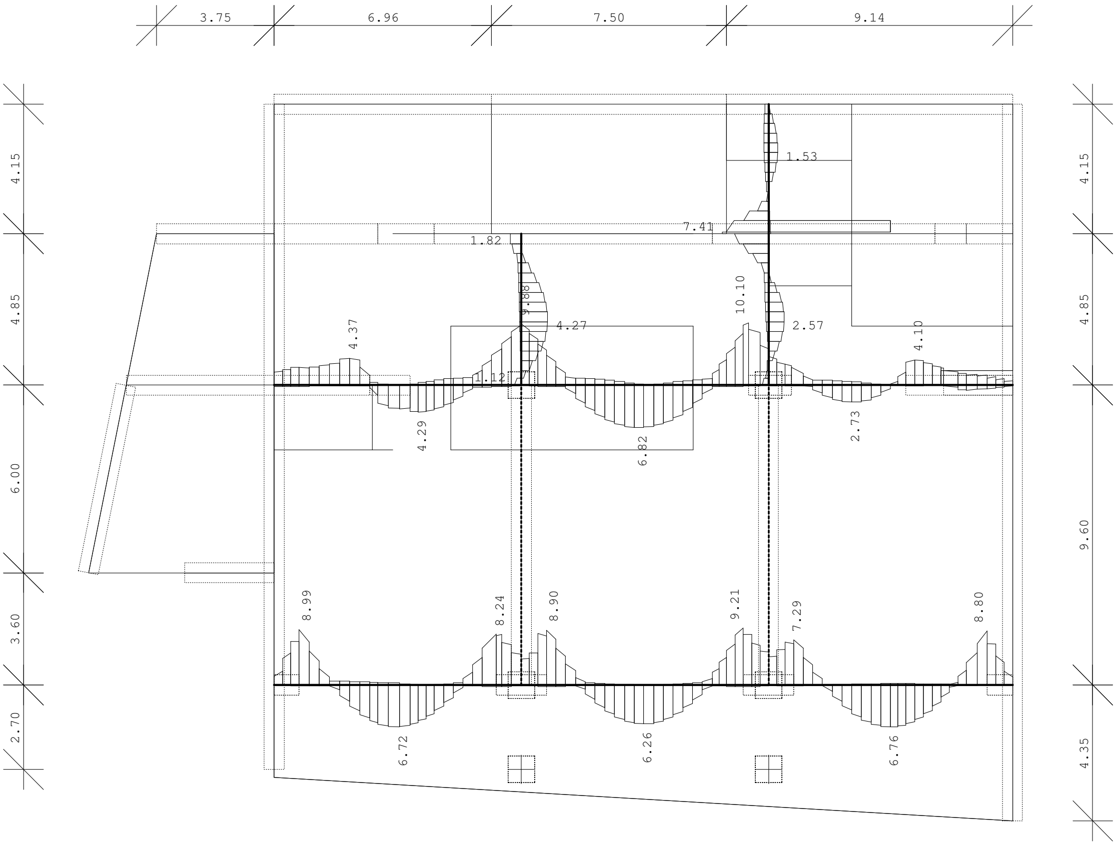
Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-14.75
-11.06
-7.38
-3.69
0.00



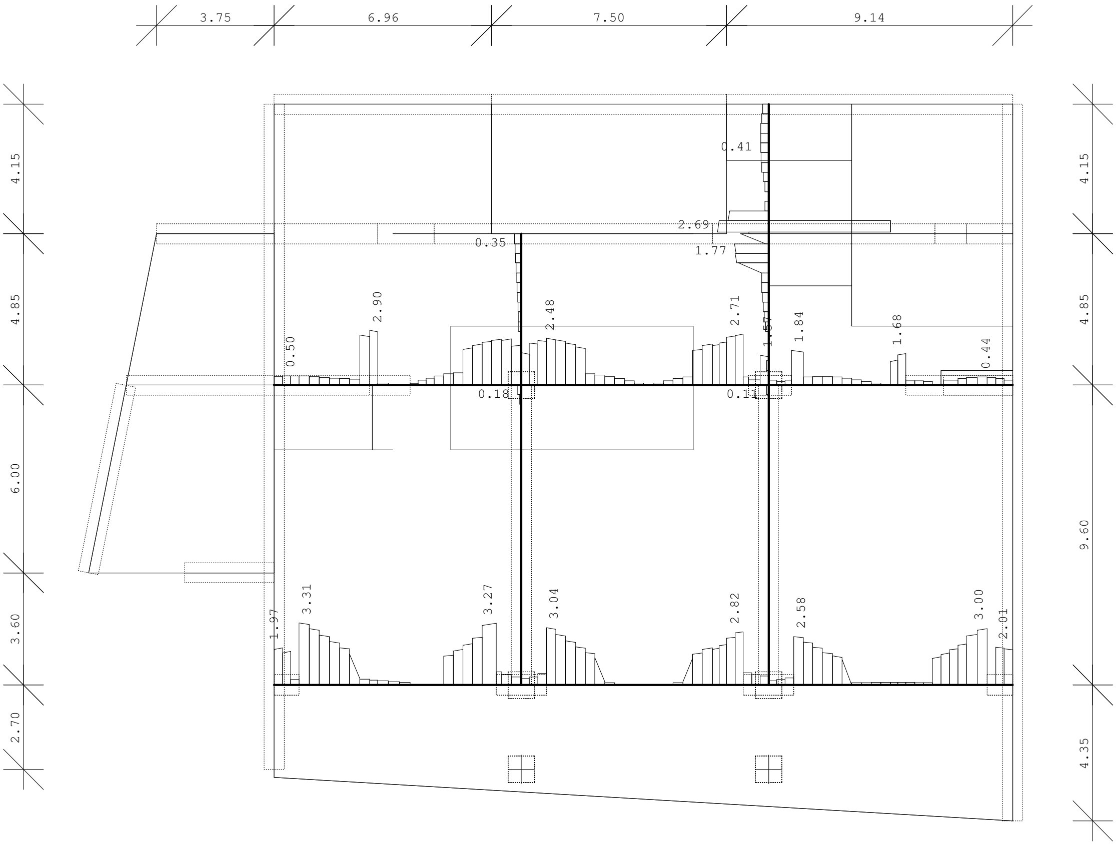
Nivo: Plošča 200 [7.40]
Aa - zg.cona - max Az= -14.74 cm2/m

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 200 [7.40]
Armatura v gredah: max Aa2/Aa1= 10.10 cm2

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 200 [7.40]
Armatura v gredah: max Aa,st= 3.31 cm2

4.23 A.B.Plošča poz 100 nad podzemno garažo

Plošča nad kletjo je izvedena kot polno armirana plošča d=28cm,

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,5**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Ploskovne obremenitve plošče POZ 100 notranjost objekta

	g	p	g+p	EM
Koristna obremenitev		4,00	4,00	kN/m2
Predelne stene	1,50		1,50	kN/m2
Zaključne obdelave	0,40		0,40	kN/m2
Estrih 7cm	1,75		1,75	kN/m2
Izolativni sloji	0,20		0,20	kN/m2
Lastna teža plošče d=28 cm	7,00		7,00	kN/m2
Omet	0,60		0,60	kN/m2
Skupaj	**11,45**	**4,00**	**15,45**	kN/m2

Ploskovne obremenitve plošče POZ 100 dvoriščni del

	g	p	g+p	EM
Koristna obremenitev		4,00	4,00	kN/m2
Nasutje 25-50 cm	7,60		7,60	kN/m2
Izolativni sloji	0,20		0,20	kN/m2
Lastna teža plošče d=28 cm	7,00		7,00	kN/m2
Skupaj	**14,80**	**4,00**	**18,80**	kN/m2

Incidentna obremenitev v potresu 1,0g+0,30q	**11,45**	**1,20**	**12,65**	kN/m2

Obtežni primeri / armatura plošče glej prilogo

Osnovni obtežni primeri

1	g	Lastna teža
2	p	Koristna vertikalna obremenitev

Kombinacije

A=	1,0*g+1,0*p	/ kontrola reakcij in deformacij
B=	1,35*g+1,5*q	/ dimenzioniranje
C=	1,0*g+0,30*q	/ incidentna obremenitev, potres

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Talna plošča garaže.twp
Datum preračuna:	12.7.2021
Način preračuna:	3D model

- [ ] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [x] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč:	31627
Število ploskovnih elementov:	31968
Število grednih elementov	1158
Število robnih elementov	62178
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

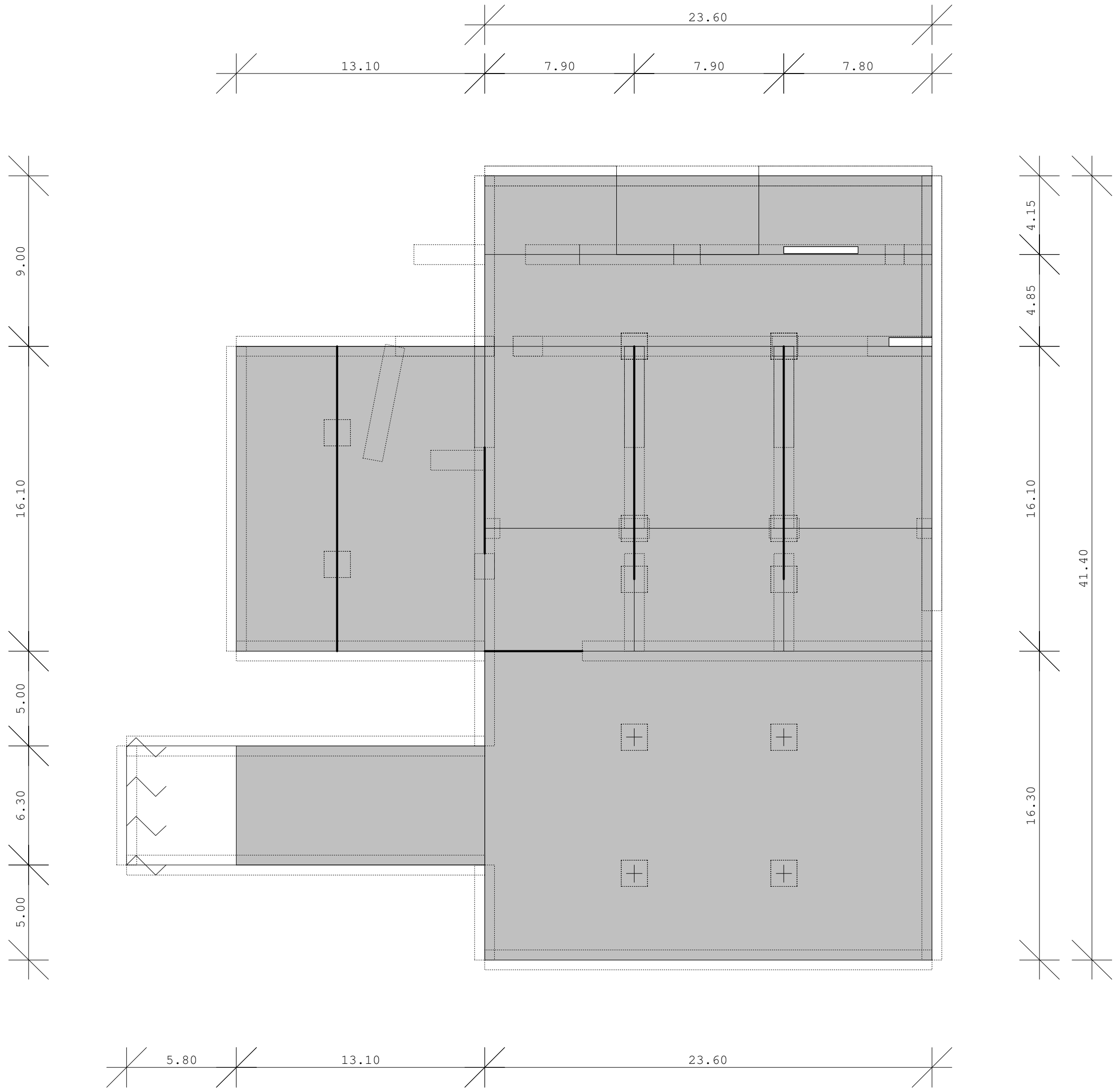
Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
2	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.580	0.290	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	1	Tanka plošča	Izotropna			
<3>	0.280	0.140	2	Tanka plošča	Izotropna			
<4>	0.280	0.140	2	Tanka plošča	Izotropna			
<5>	0.280	0.140	2	Tanka plošča	Izotropna			
<6>	0.250	0.125	2	Tanka plošča	Izotropna			

Vhodni podatki - Obtežba



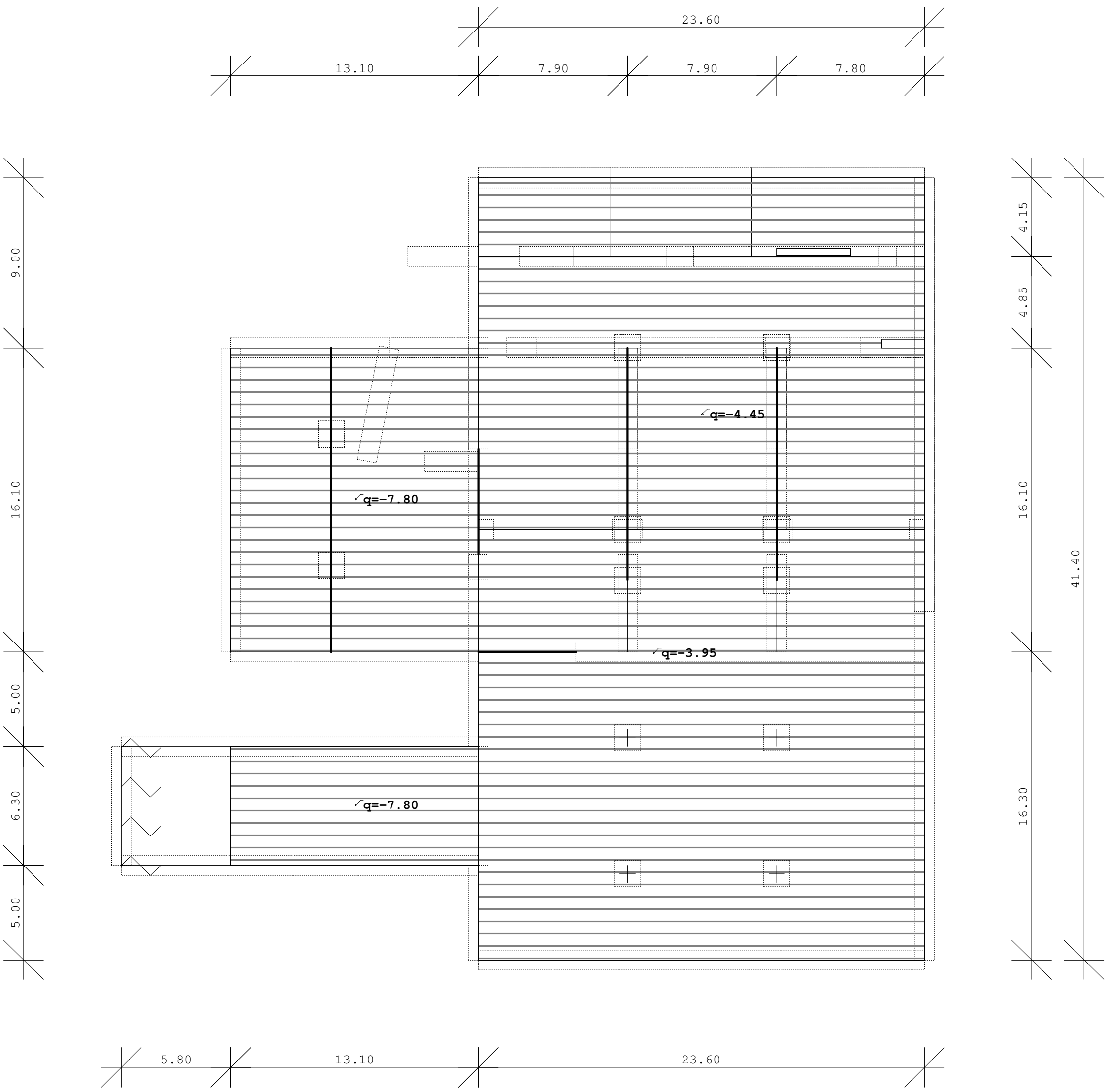
Nivo: Plošča 100 [3.50]

Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)

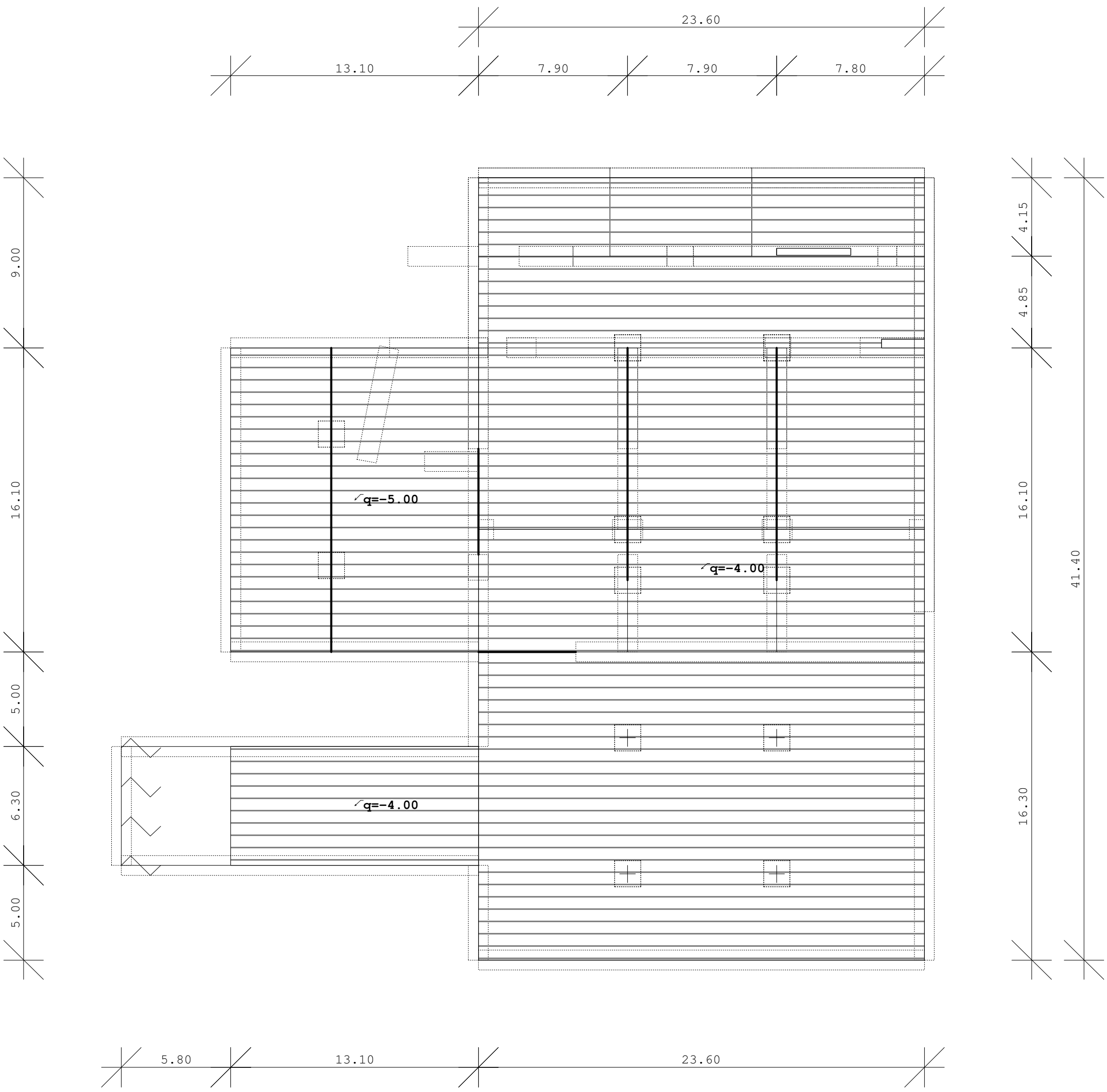
No	Naziv
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 1: Stalna obtežba (g)



Nivo: Plošča 100 [3.50]

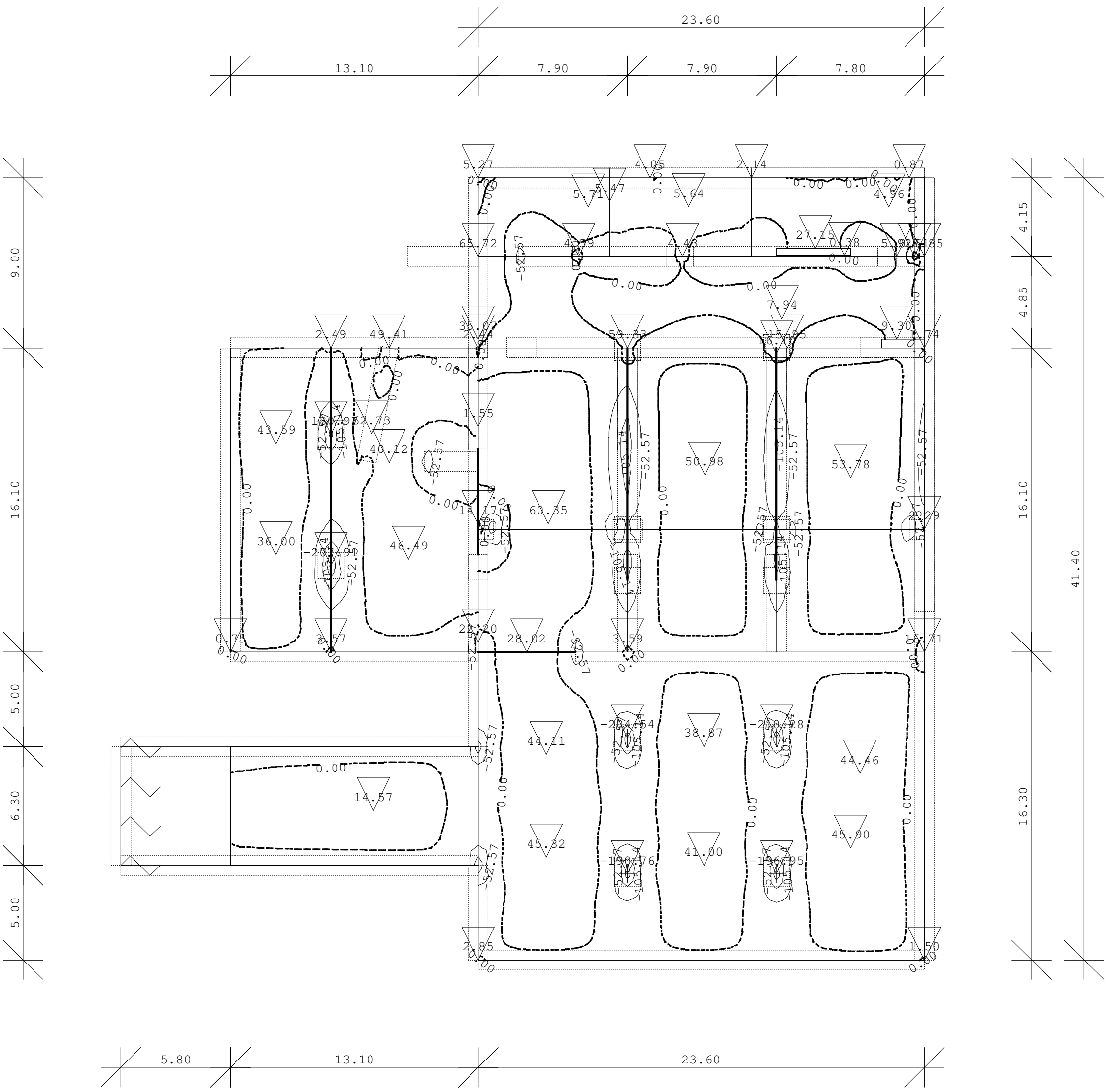
Obt. 2: Koristna obtežba



Nivo: Plošča 100 [3.50]

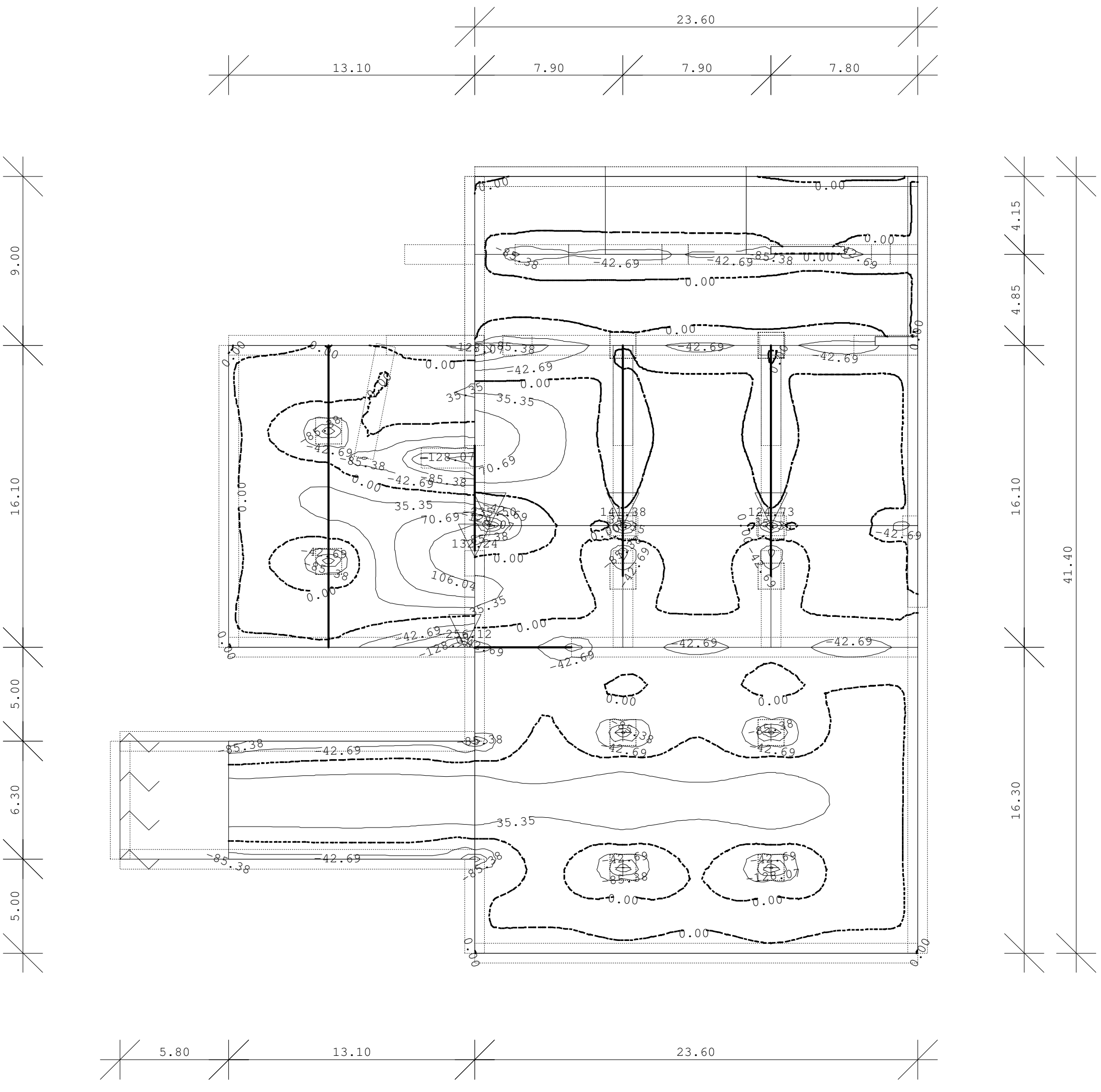
Statični preračun

Obt. 9: MSN - 1.35g+1.5q+1.5Wx



Nivo: Plošča 100 [3.50]
Vplivi v plošči: max Mx= 65.72 / min Mx= -210.28 kNm/m

Obt. 9: MSN - 1.35g+1.5q+1.5Wx

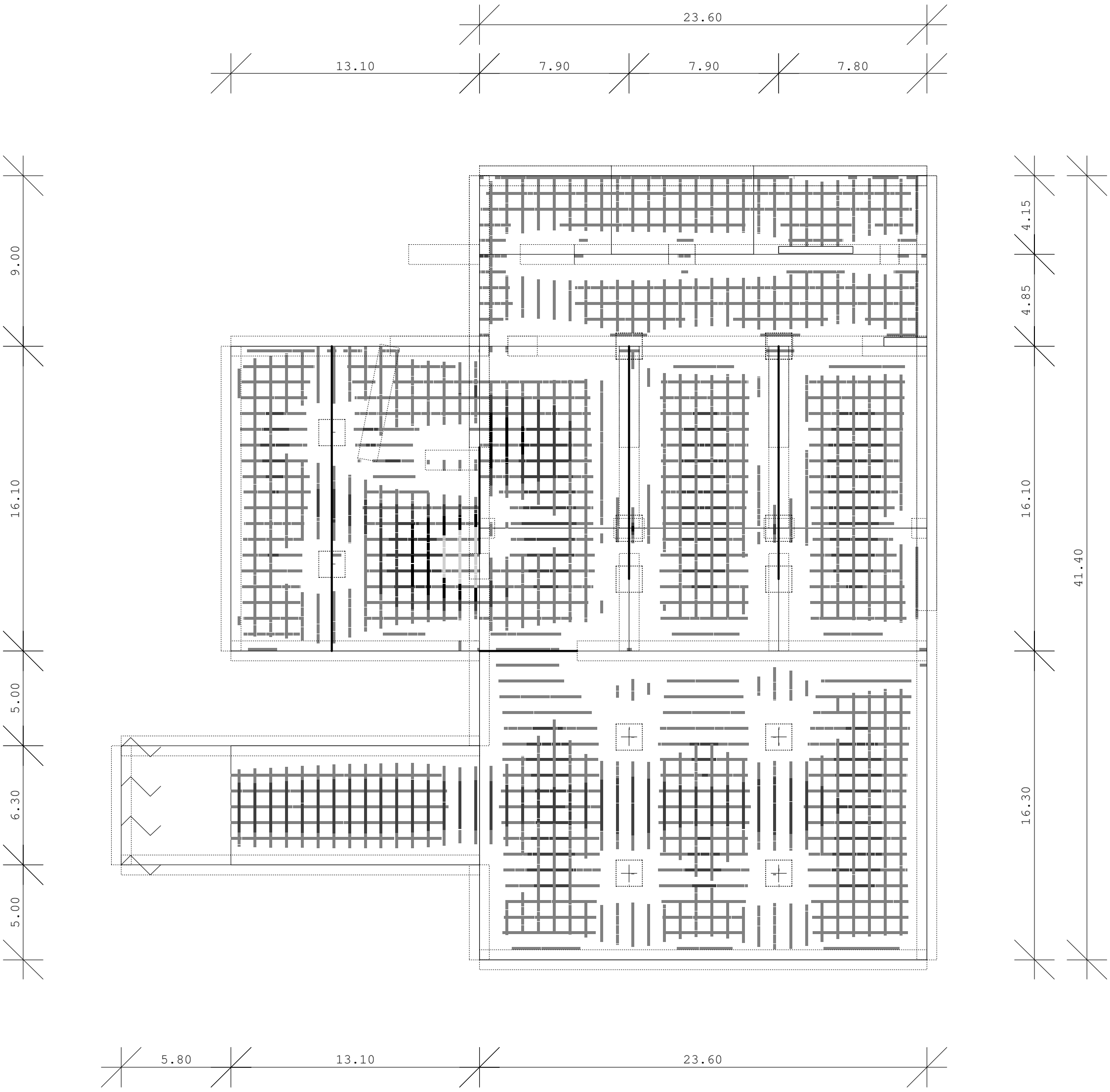


Nivo: Plošča 100 [3.50]
Vplivi v plošči: max My= 141.38 / min My= -256.12 kNm/m

Dimenzioniranje (beton)

Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=3.00 cm

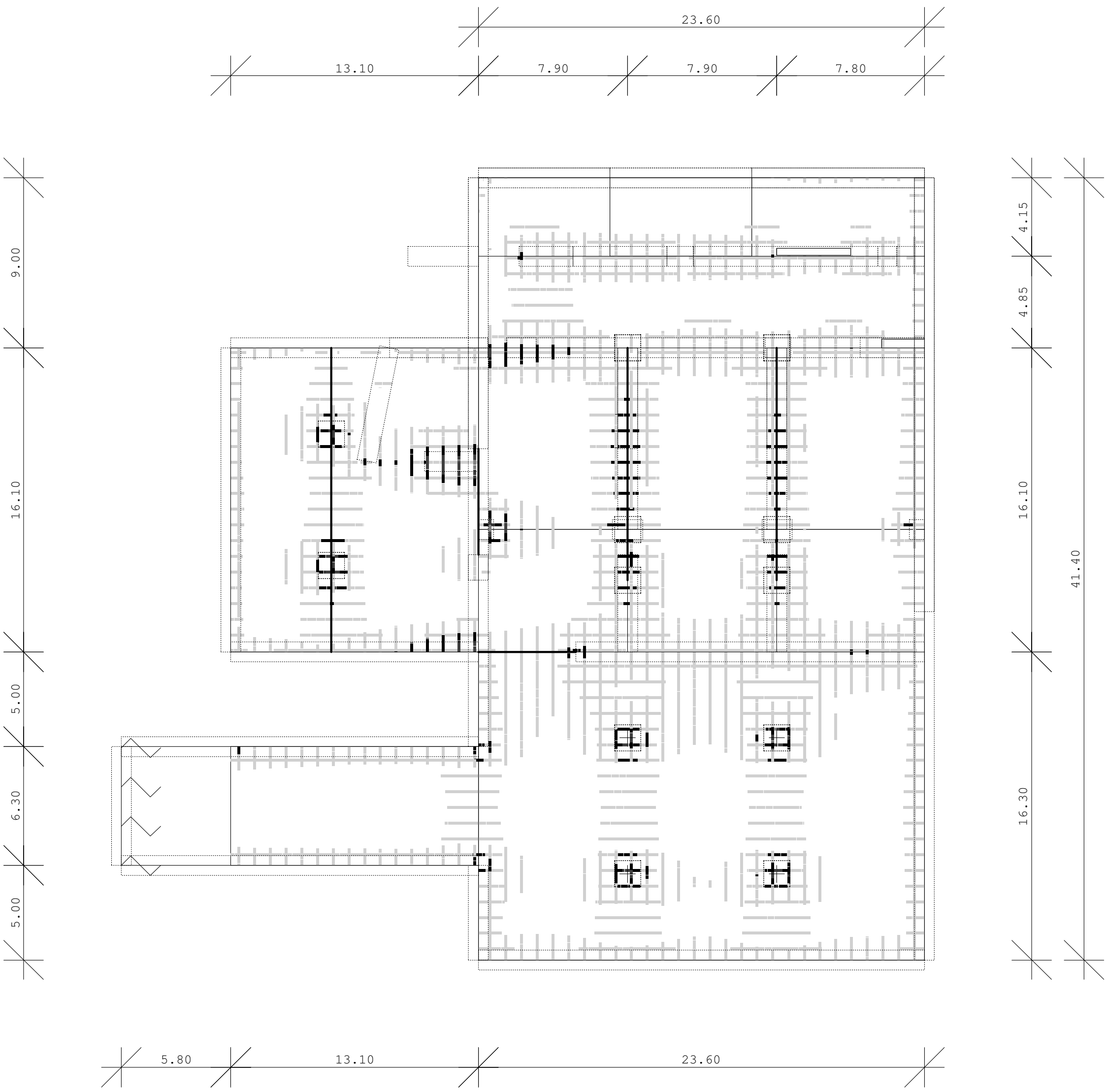
Aa - sp.cona [cm2/m]
0.00
3.30
6.61
9.91
13.21



Nivo: Plošča 100 [3.50]
Aa - sp.cona - max As= 13.20 cm2/m

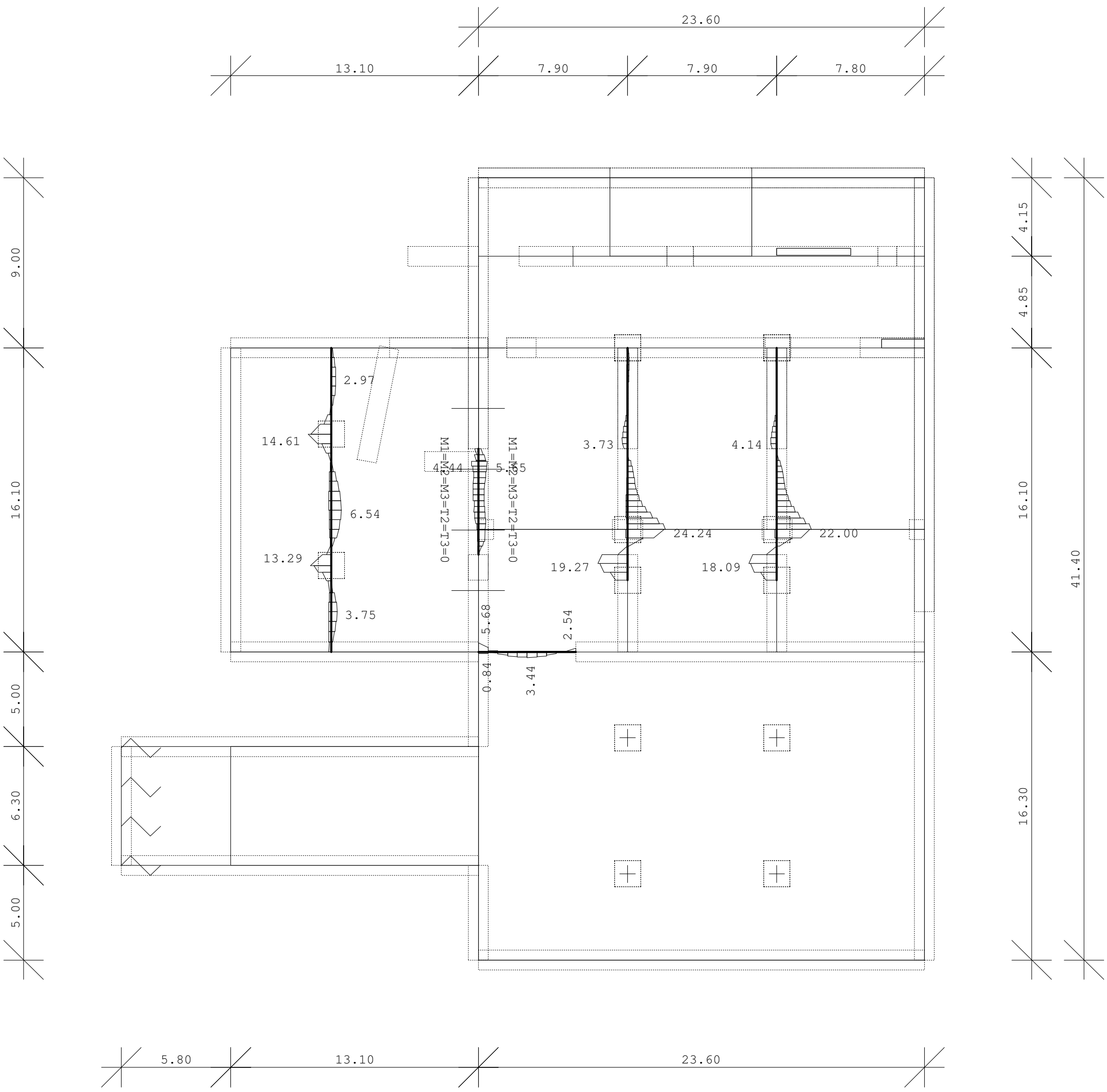
Merodajna obtežba : IX
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-22.30
-16.73
-11.15
-5.58
0.00



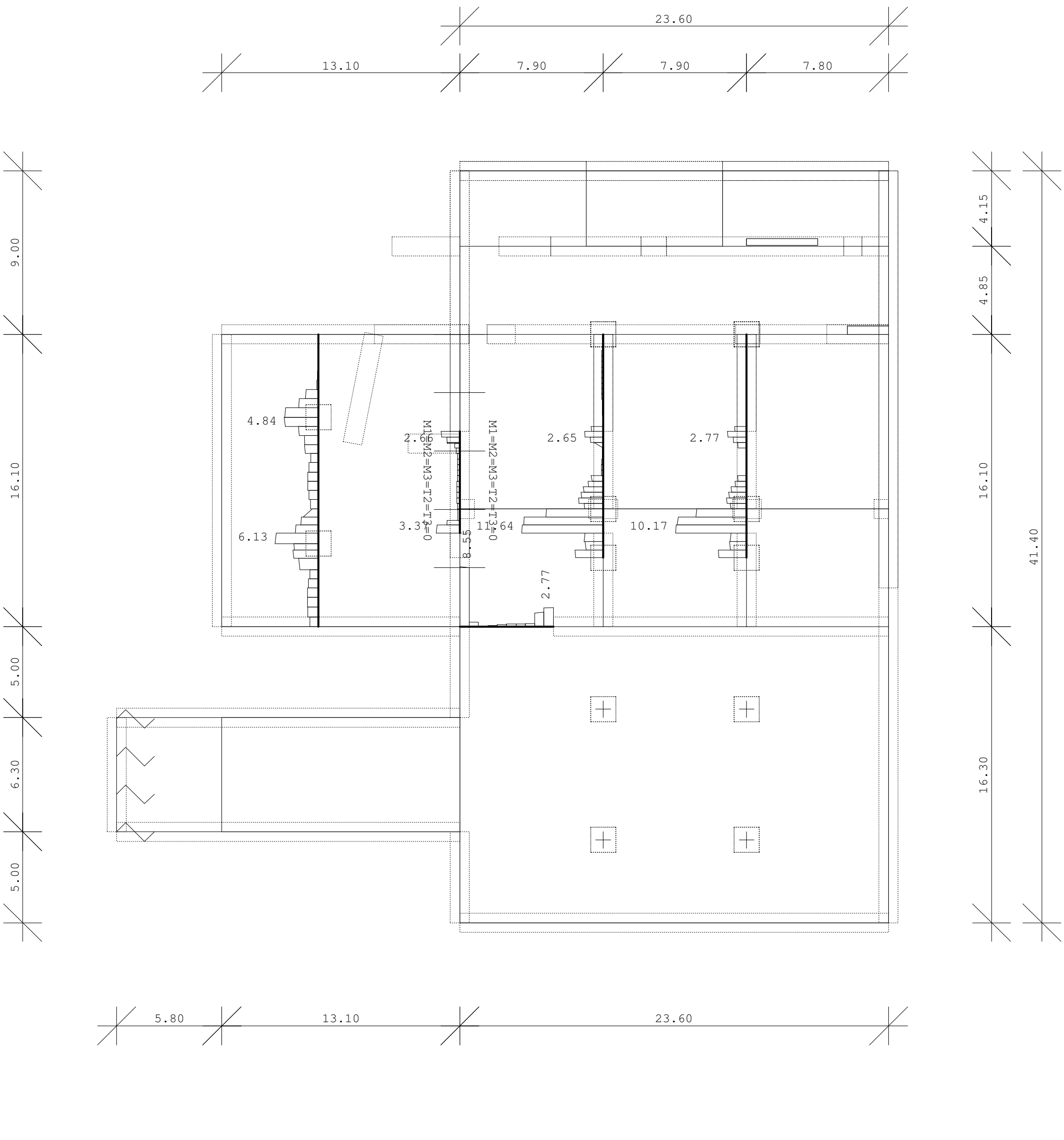
Nivo: Plošča 100 [3.50]
Aa - zg.cona - max Az= -22.29 cm2/m

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 100 [3.50]
Armatura v gredah: max Aa2/Aa1= 24.24 cm2

Merodajna obtežba : IX
EUROCODE, C 25/30, S500



Nivo: Plošča 100 [3.50]
Armatura v gredah: max Aa,st= 11.64 cm2

4.24 A.B.Talna plošča podzemne garaže

A.B. plošča je plavajoča talna plošča. Izdelana je na utrjenem gramoznem nasutju - elastični podlagi.
ali trdi toplotni izolaciji XPS. Podatki o kvaliteti temeljnih tal v času izračuna niso na voljo.
Računsko podajnost izrazim z c=15000 kN/m3. Debelina plošče je 28 cm, delno 58 cm.

Kletna etaža je armiranobetonske izvedbe, vpeta v talno ploščo. Stene in talna plošča statično sodelujeta.
Robovi plošče so zato enakomerneje obremennjeni.

Uporabljeni materiali

Beton	**C25/30**	XC2 Priporočam uporabo nizkohidratacijskega cementa, nizek VC in dodatke proti krčenju betona.
Armatura	**S500**	
Zašč.sloj	2,5 cm	Če ni stika betona plošče z zemljino
	4,0 cm	Če je beton v stiku z zemljino ' ustrezno povečati "d" plošče
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Obremenitve talne plošče

Ploskovne obremenitve talne plošče

	g	p	g+p	EM
Koristna obremenitev		3,00	3,00	kN/m2
Obdelava tal z izolacijami	0,40		0,40	kN/m2
Lastna teža plošče d=28; 58 cm (PRG)	0,00		0,00	kN/m2
Skupaj	**0,40**	**3,00**	**3,40**	kN/m2

Osnovni obtežni primeri

1 g — Lastna teža
2 p — Koristna vertikalna obremenitev

Kombinacije

A= 1,0*g+1,0*p — / kontrola reakcij in deformacij
B= 1,35*g+1,5*q — / dimenzioniranje

Rezultati

Napetost pod temeljno ploščo v fazi "Mejno stanje uporabnosti**" MSU-(1,0g+1,0q) = 0,0108 kN/cm2**
Posedek talne plošče v navedenih razmerah = **7,25 mm**
Izračunani posedek velja za predpostavljeno računsko podajnost 15000 KN/m3

Izkop gradbene jame je potrebno izvesti ob prisotnosti geologa. Ta, predpostavke tega modela primerja z dejanskim stanjem na objektu in z vpisom v gradbeni dnevnik poda svoje ugotovitve. V primeru, da so dejanska tla neustrezna, niso v skladu s predpostavkami računa, poda sanacijo temeljnih tal.

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Talna plošča garaže.twp
Datum preračuna:	12.7.2021

Način preračuna:	3D model

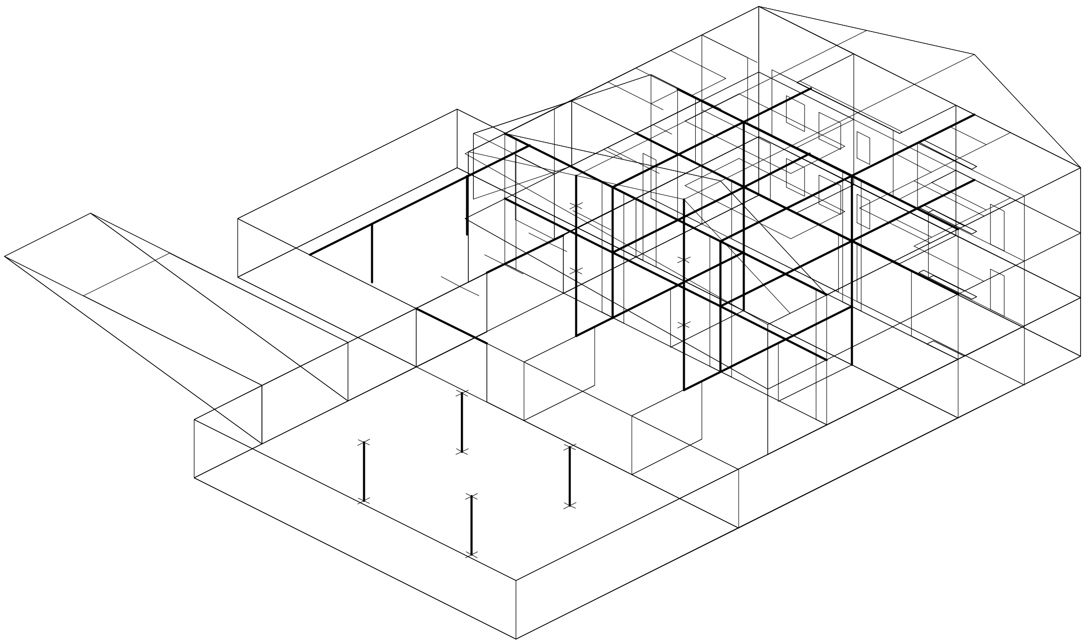
- [ ] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [x] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

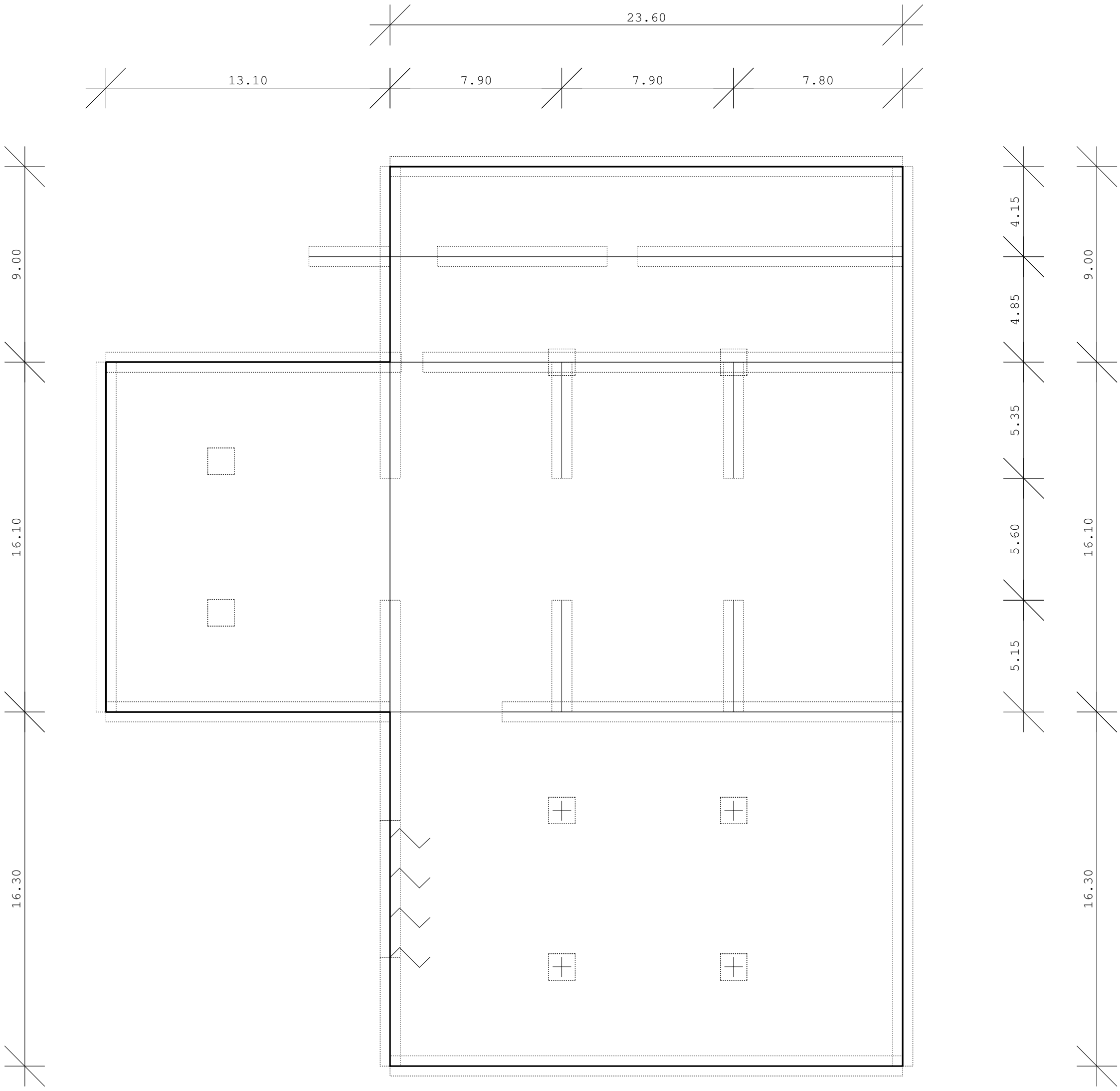
Število vozlišč:	31627
Število ploskovnih elementov:	31968
Število grednih elementov	1158
Število robnih elementov	62178
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius



Izometrija



Nivo: Talna plošča garaže [0.00]

Vhodni podatki - Obtežba

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
2	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

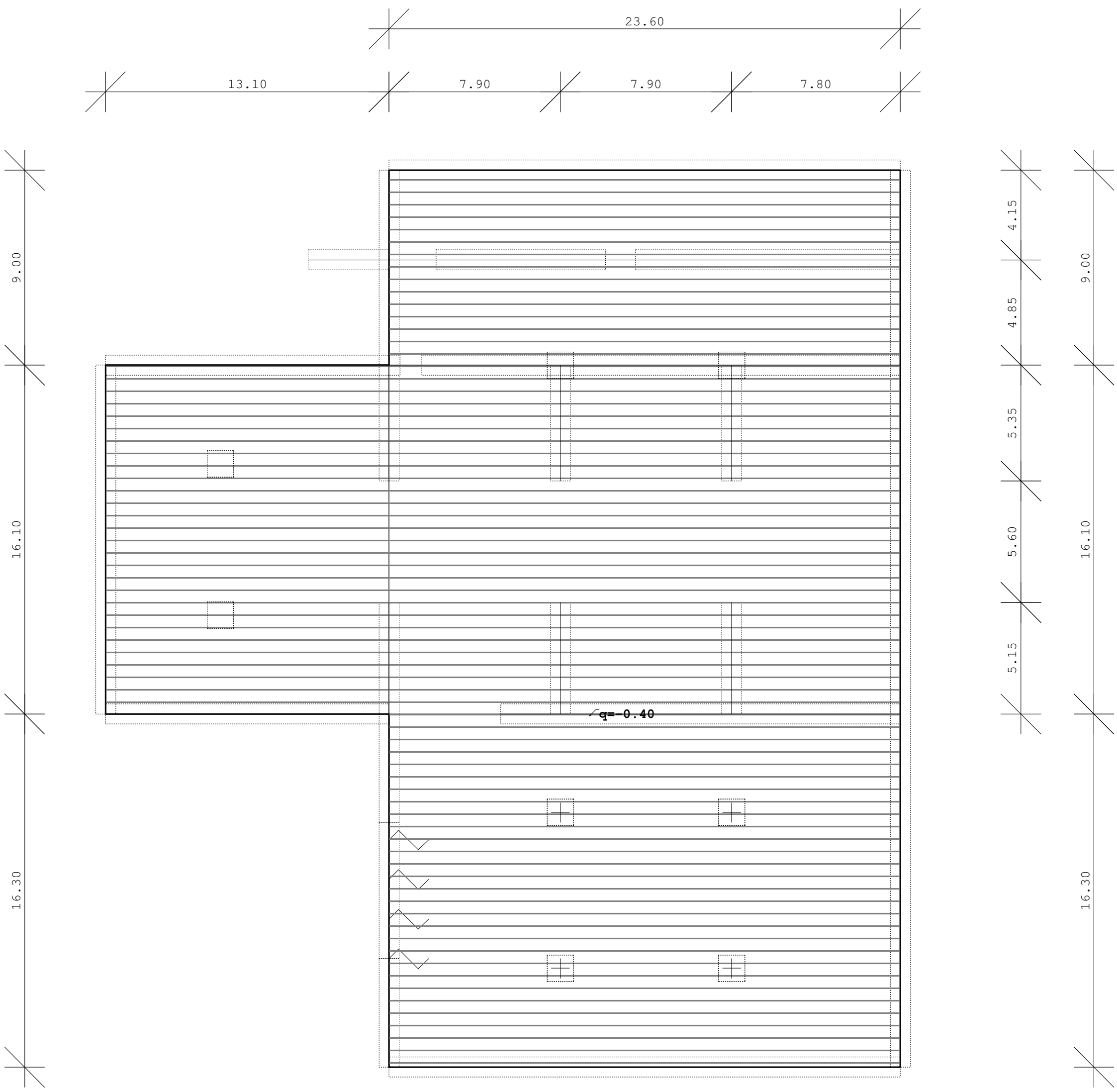
No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.580	0.290	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	1	Tanka plošča	Izotropna			
<3>	0.280	0.140	2	Tanka plošča	Izotropna			
<4>	0.280	0.140	2	Tanka plošča	Izotropna			
<5>	0.280	0.140	2	Tanka plošča	Izotropna			
<6>	0.250	0.125	2	Tanka plošča	Izotropna			

Lista obtežnih primerov

No	Naziv
1	Stalna obtežba (g)
2	Koristna obtežba
3	Veter Wx
4	Veter Wy
5	Potres Sx
6	Potres Sy
7	Kombinacija: MSU - 1.0g+1.0q+1.0Wx (I+II+III)

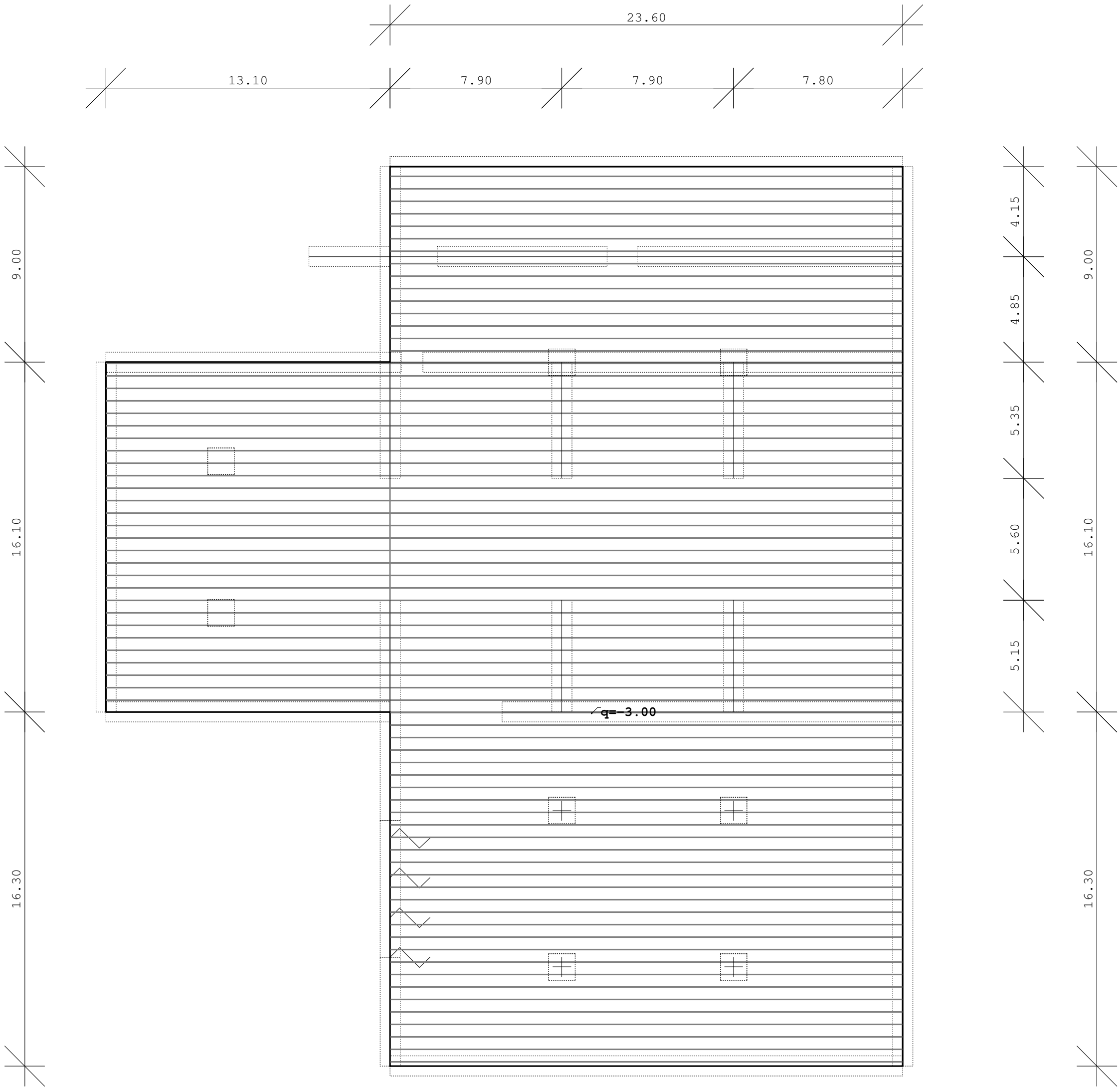
No	Naziv
8	Kombinacija: MSU - 1.0g+1.0q+1.0Wy (I+II+IV)
9	Kombinacija: MSN - 1.35g+1.5q+1.5Wx (1.35xI+1.5xII)
10	Kombinacija: MSN - 1.35+1.5q+1.5Wy (1.35xI+1.5xII+ +1.5xIV)
11	Kombinacija: Potres x+komb (I+V+0.3xVI)
12	Kombinacija: Potres y+komb (I+0.3xV+VI)

Obt. 1: Stalna obtežba (g)



Nivo: Talna plošča garaže [0.00]

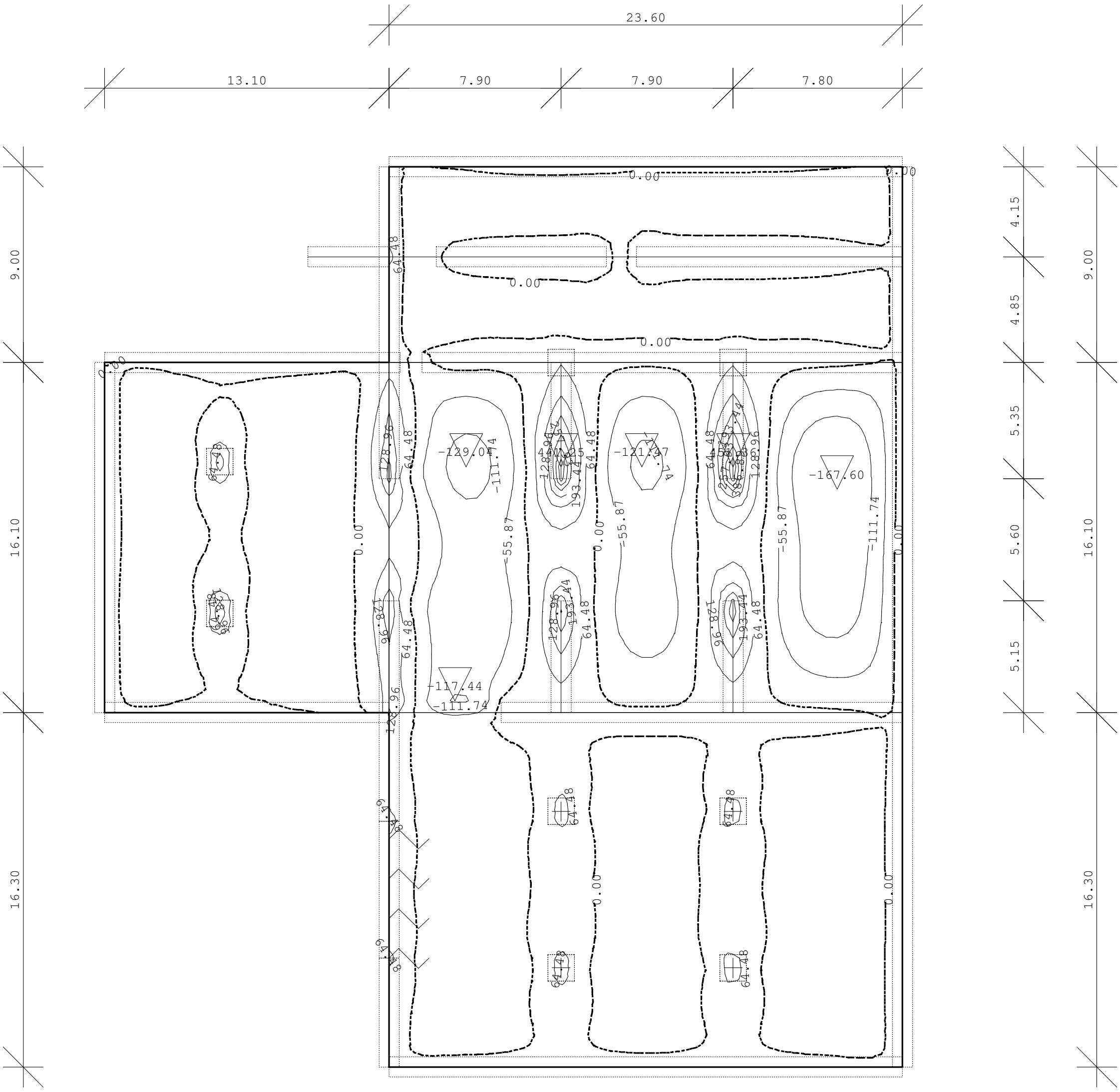
Obt. 2: Koristna obtežba



Nivo: Talna plošča garaže [0.00]

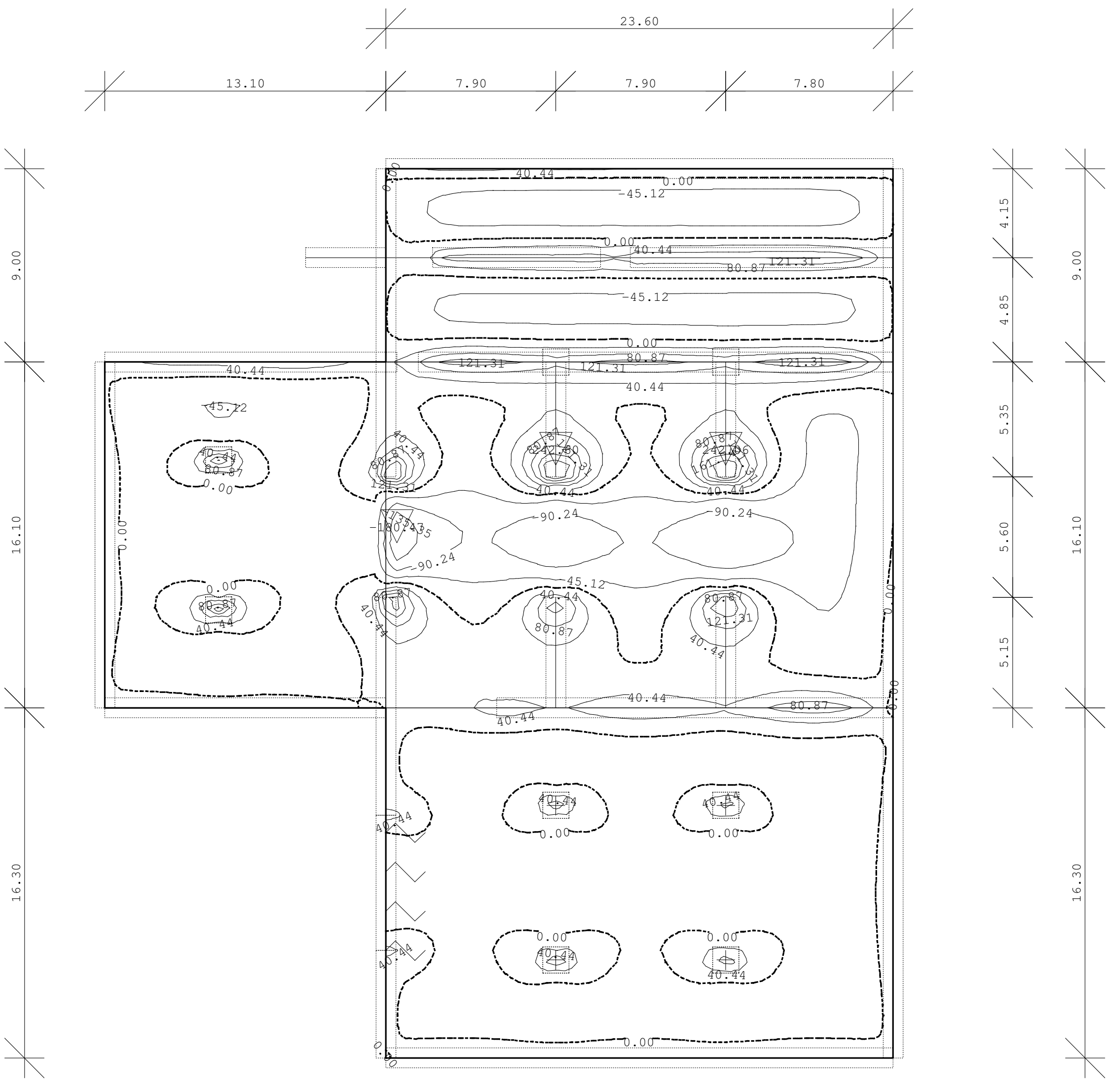
Statični preračun

Obt. 7: MSU - 1.0g+1.0q+1.0Wx



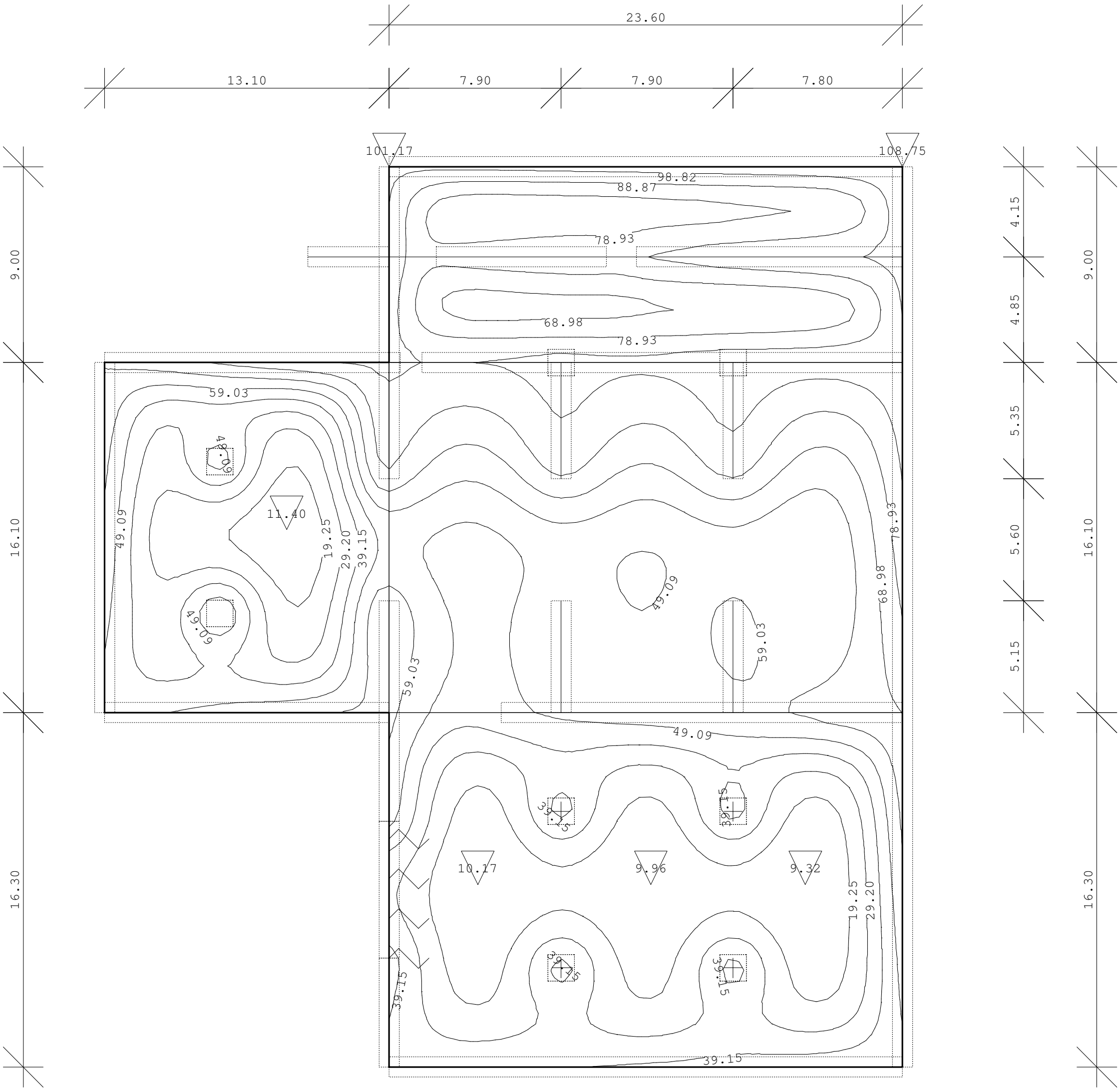
Nivo: Talna plošča garaže [0.00]
Vplivi v plošči: max Mx= 451.36 / min Mx= -167.60 kNm/m

Obt. 7: MSU - 1.0g+1.0q+1.0Wx



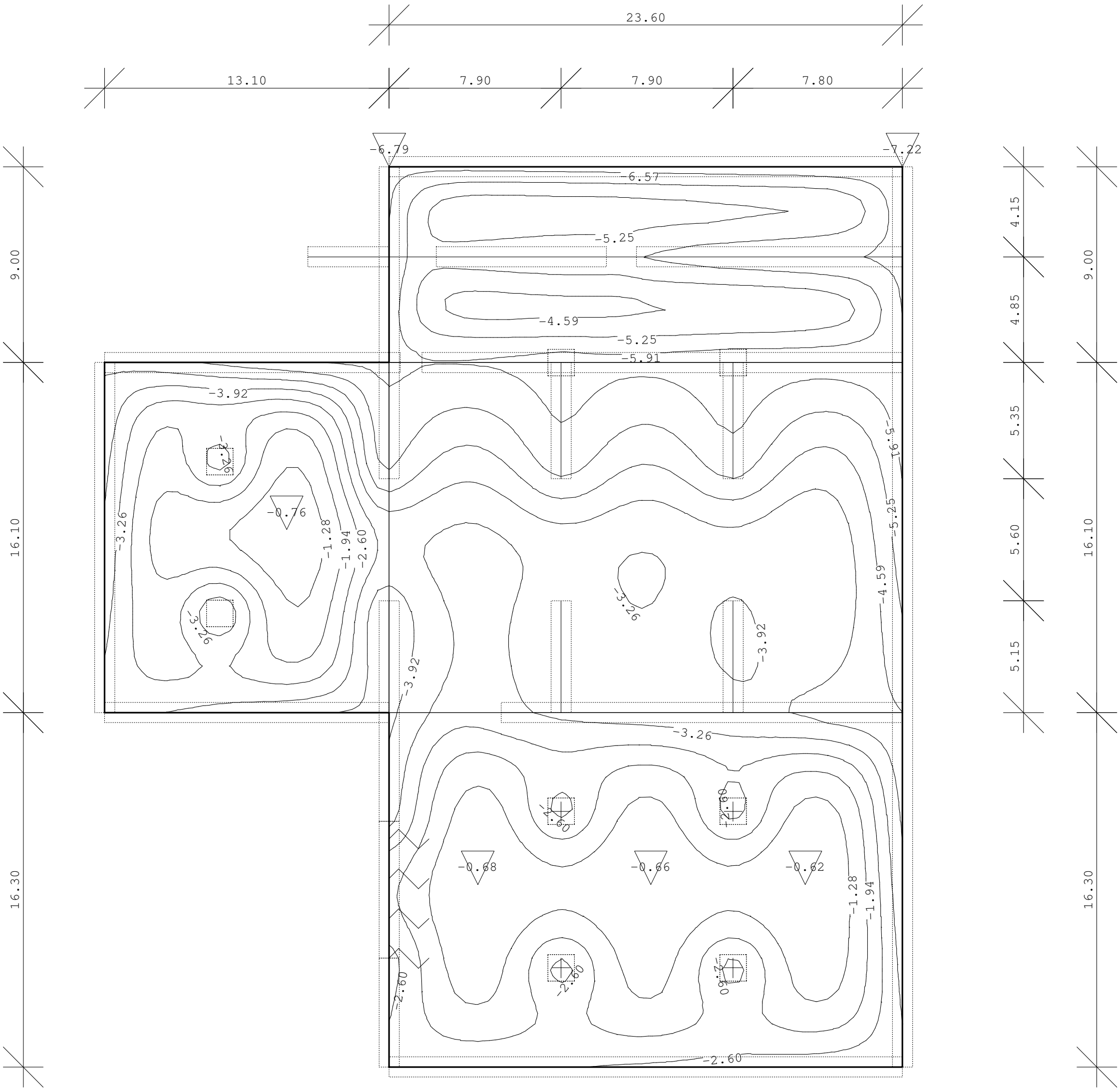
Nivo: Talna plošča garaže [0.00]
Vplivi v plošči: max My= 242.60 / min My= -180.47 kNm/m

Obt. 7: MSU - 1.0g+1.0q+1.0Wx



Nivo: Talna plošča garaže [0.00]
Vplivi v pov.podpori: max σ,tal= 108.75 / min σ,tal= 9.32 kN/m2

Obt. 8: MSU - 1.0g+1.0q+1.0Wy

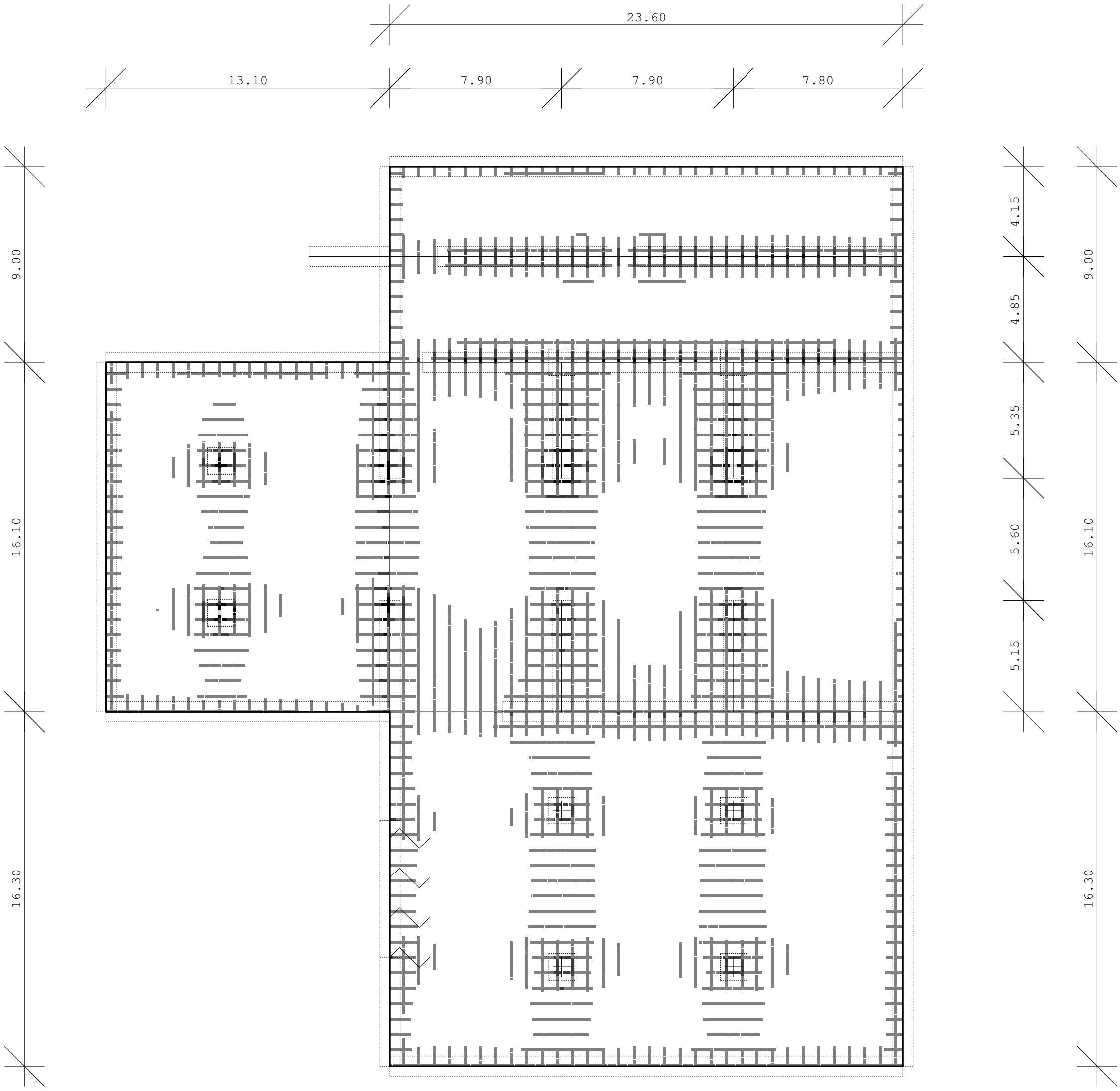


Nivo: Talna plošča garaže [0.00]
Vplivi v pov.podpori: max s,tal= -0.62 / min s,tal= -7.22 m / 1000

Dimenzioniranje (beton)

Merodajna obtežba : IX
EUROCODE, C 30/37, S500, a=3.00 cm

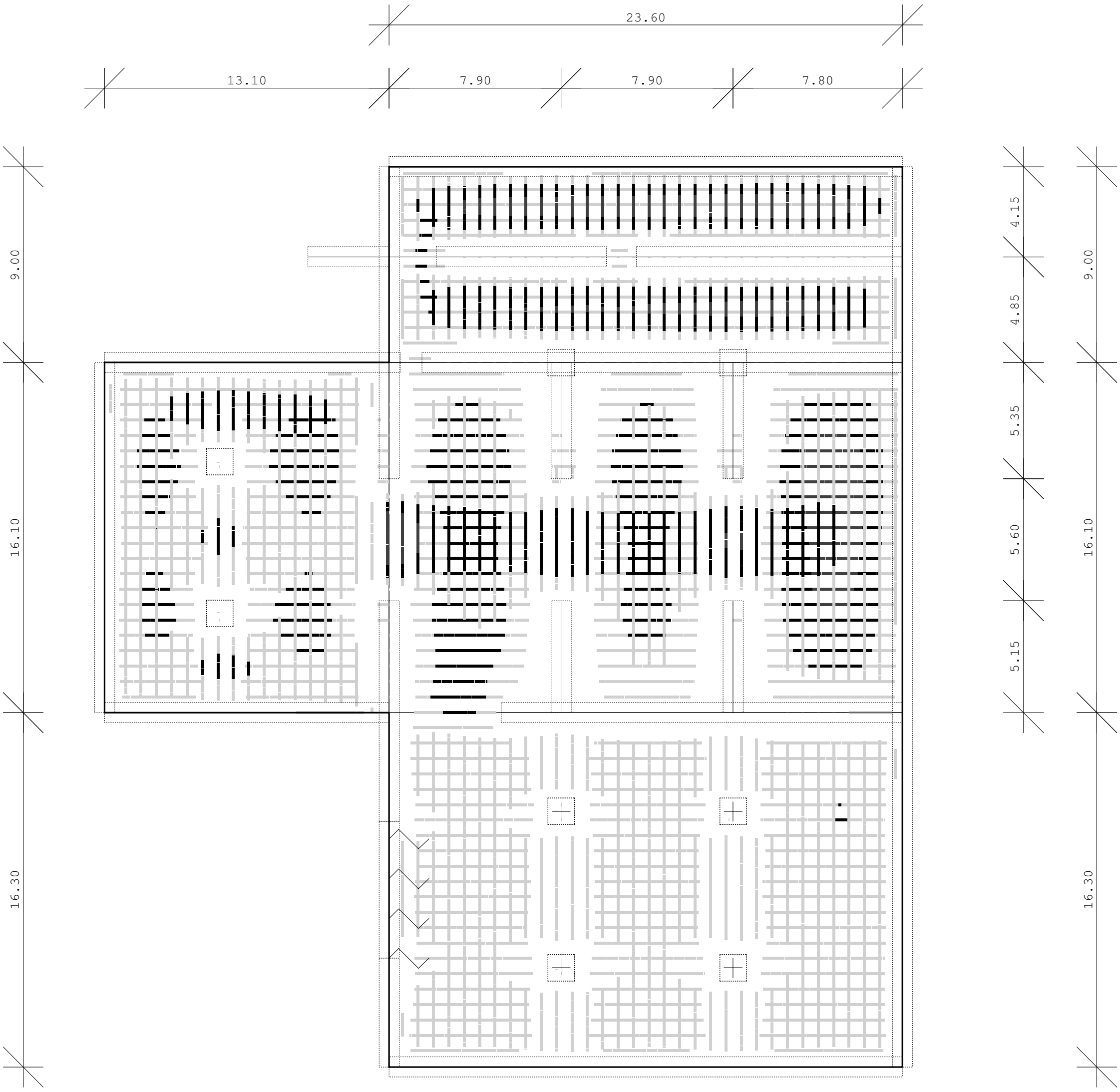
Aa - sp.cona [cm2/m]
0.00
6.95
13.90
20.85
27.80



Nivo: Talna plošča garaže [0.00]
Aa - sp.cona - max As= 27.79 cm2/m

Merodajna obtežba : IX
EUROCODE, C 30/37, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-15.20
-11.40
-7.60
-3.80
0.00



Nivo: Talna plošča garaže [0.00]
Aa - zg.cona - max Az= -15.19 cm2/m

4.30 Dostopi Stopnice C: vrtec

Uporabljeni materiali

Beton	**C25/30**	XC3
Armatura	**S500**	
Zašč.sloj	**2,50**	cm
fck=	**25**	Mpa
fcd=fck/1,5=	16,66667	Mpa
fctk=	**2**	Mpa
Crd,c=fctk/1,5	1,33	Mpa
fyk=	**500**	Mpa
fyd=fyk/1,15	434,78	Mpa

Definicija obtežbe stopnišča

Debelina nosilne plošče 20 cm

Vertikalne obremenitve naklon rame 30°	g	p	g+p	EM
Koristna obremenitev		5,77	5,77	kN/m2
Zaključna obdelava tal - linolej	0,36		0,36	kN/m2
Izravnava nastopnih ploskev	1,00		1,00	kN/m2
Lastna teža plošče	5,77		5,77	kN/m2
Omet	0,50		0,50	kN/m2
Skupaj	**7,63**	**5,77**	**13,40**	kN/m2
Rmax spodnje stopniščne rame na ploščo	3,57	2,76	6,33	kN/m1
Rmax gornje stopniščne rame na ploščo	6,18	4,77	10,95	kN/m1

Obtežni primeri / armatura glej prilogo

Osnovni obtežni primeri

1 g — Lastna teža
2 p — Koristna vertikalna obremenitev

Kombinacije

A= 1,0*g+1,0*p — / kontrola reakcij in deformacij
B= 1,35*g+1,50*p — / dimenzioniranje

Račun in izbira armature notranjega stopnišča

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka:	Stopnice-C.twp
Datum preračuna:	11.3.2021

Način preračuna: 2D model (Zp, Xr, Yr)

- [x] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [ ] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

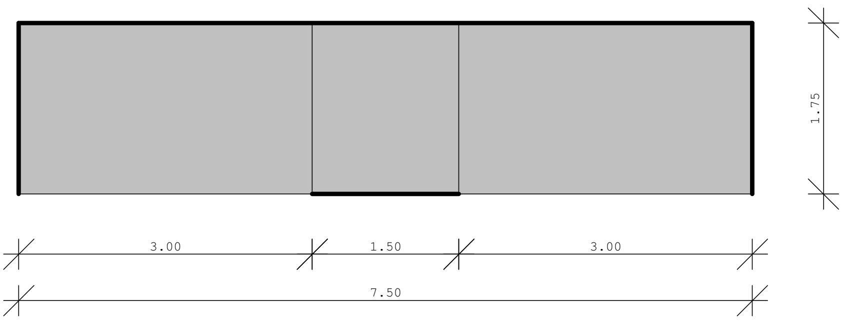
Velikost modela

Število vozlišč:	2888
Število ploskovnih elementov:	2700
Število grednih elementov	0
Število robnih elementov	1902
Število osnovnih obtežnih primerov:	2
Število kombinacij obtežb:	2

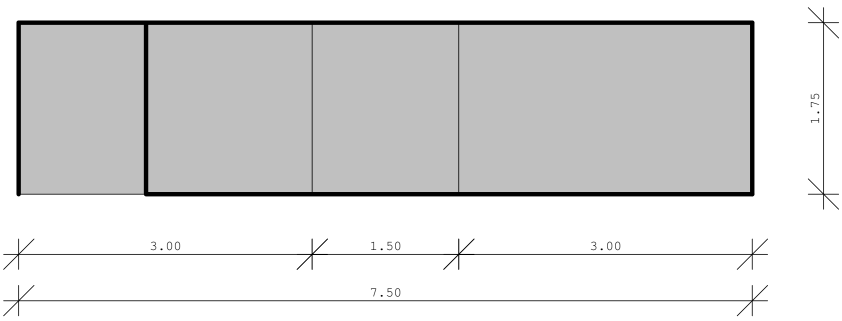
Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Gornje stopniščno rame



Spodnje stopniščno rame



Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.160	0.080	1	Tanka plošča	Izotropna			

Lista obtežnih primerov

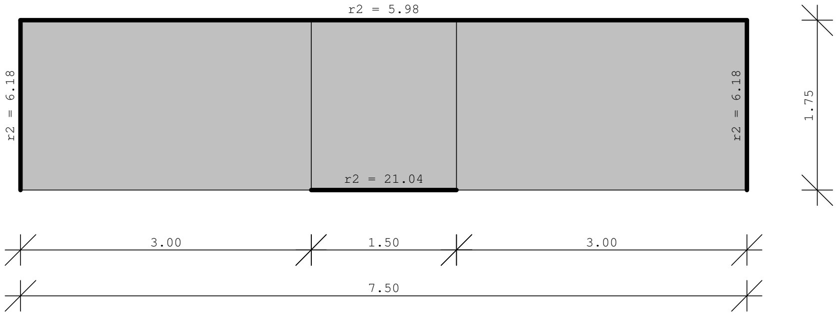
No	Naziv
1	Stalna obtežba
2	Koristna obtežba

No	Naziv
3	Kombinacija: MSU - 1.0g+1.0q (I+II)
4	Kombinacija: MSN - 1.35g+1.5q (1.35xI+1.5xII)

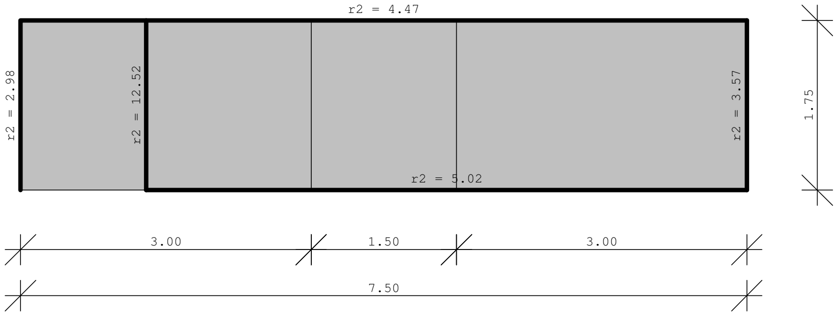
Statični preračun

Obt. 1: Stalna obtežba

Gornje stopniščno rame

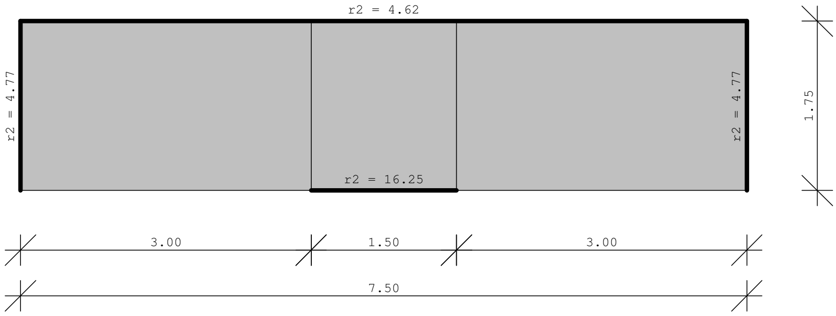


Spodnje stopniščno rame

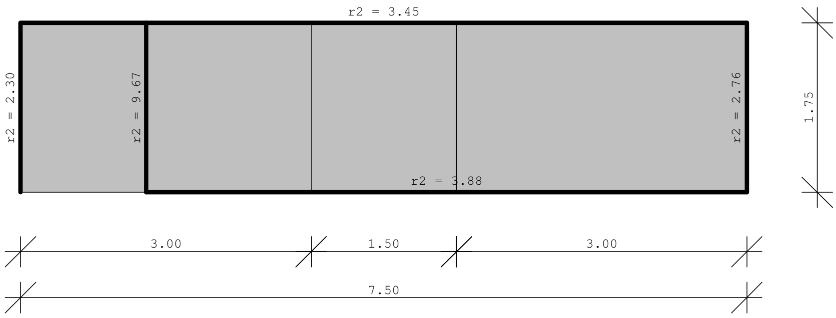


Reakcije podpor
Obt. 2: Koristna obtežba

Gornje stopniščno rame

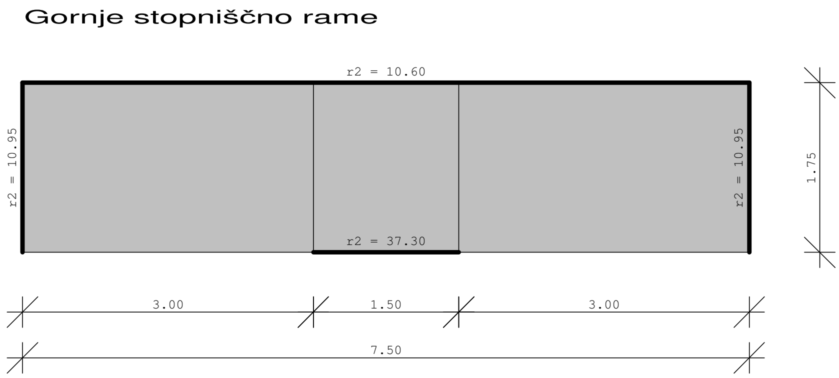


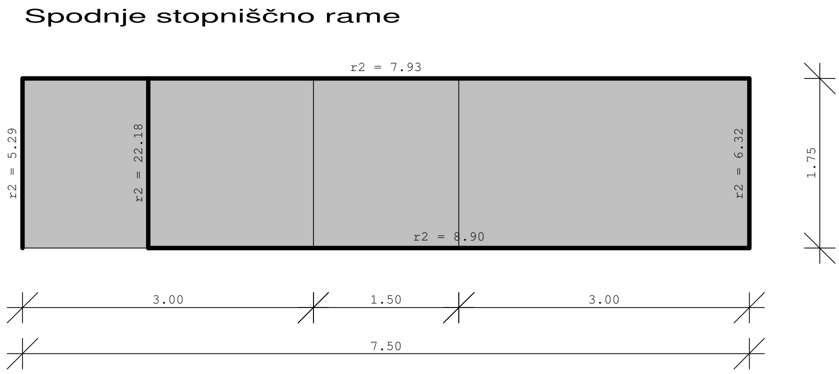
Spodnje stopniščno rame



Reakcije podpor

Obt. 3: MSU - 1.0g+1.0q

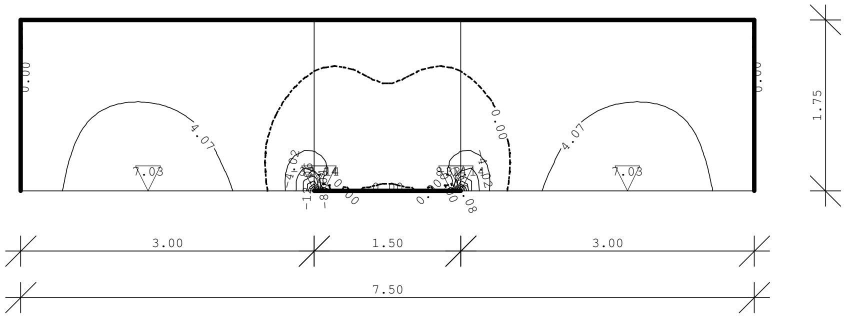




Reakcije podpor

Obt. 3: MSU - 1.0g+1.0q

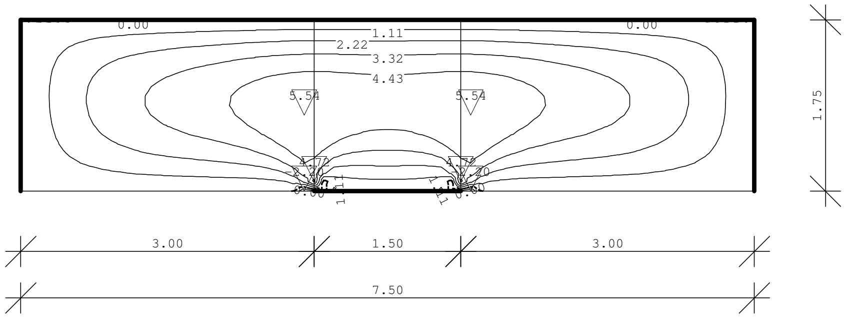
Gornje stopniščno rame



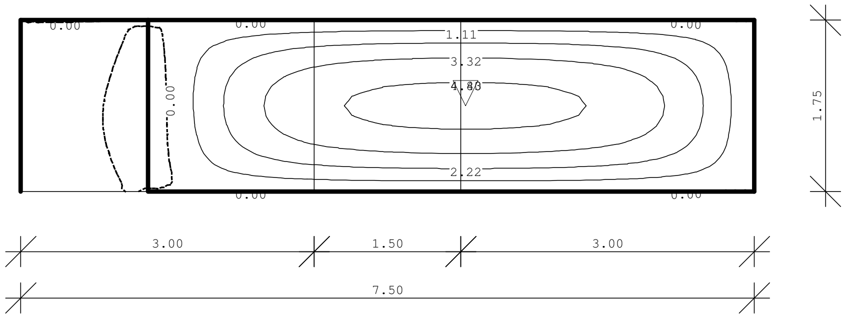
Spodnje stopniščno rame

Vplivi v plošči: max Mx= 8.14 / min Mx= -32.14 kNm/m
Obt. 3: MSU - 1.0g+1.0q

Gornje stopniščno rame



Spodnje stopniščno rame



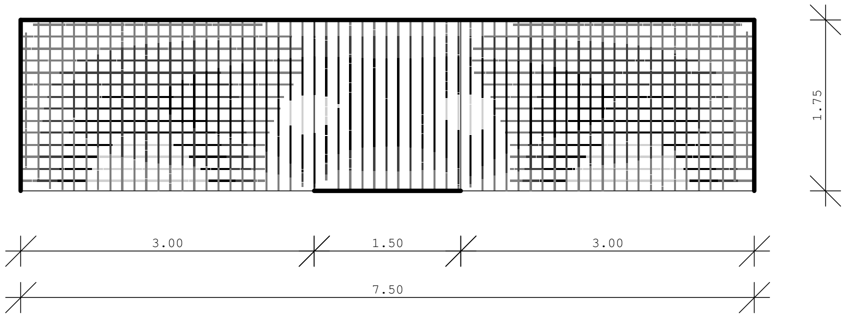
Vplivi v plošči: max My= 5.54 / min My= -2.20 kNm/m

Dimenzioniranje (beton)

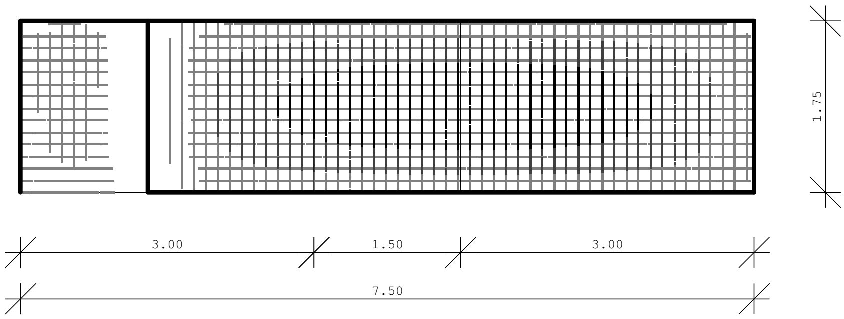
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - sp.cona [cm2/m]
0.00
0.44
0.87
1.31
1.74

Gornje stopniščno rame



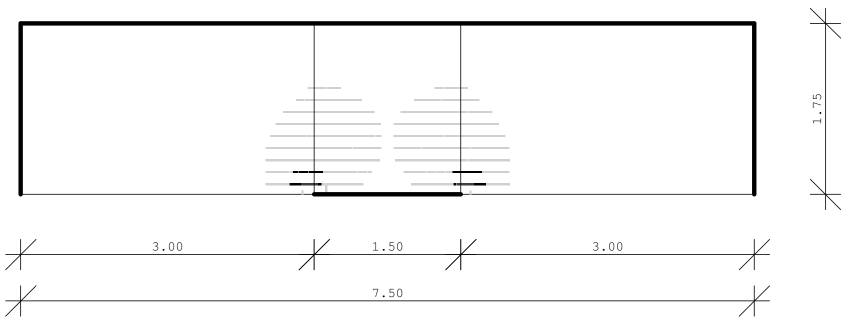
Spodnje stopniščno rame



Aa - sp.cona - max As= 1.73 cm2/m
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-5.18
-3.89
-2.59
-1.30
0.00

Gornje stopniščno rame



Spodnje stopniščno rame

Aa - zg.cona - max Az= -5.18 cm2/m

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka:	JekSteber Stopnic.twp
Datum preračuna:	13.7.2021
Način preračuna:	2D model (Xp, Zp, Yr)

☐ Teorija I-ga reda ☐ Modalna analiza ☐ Stabilnost

☒ Teorija II-ga reda ☐ Seizmični preračun ☐ Ofset gred

☐ Faze gradnje

Velikost modela

Število vozlišč:	82
Število ploskovnih elementov:	0
Število grednih elementov	82
Število robnih elementov	6
Število osnovnih obtežnih primerov:	1
Število kombinacij obtežb:	1

Enote mer

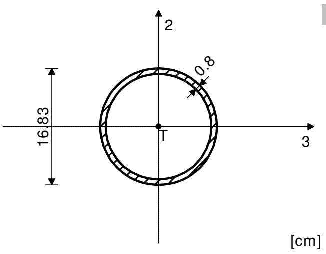
Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Jeklo	2.100e+8	0.30	78.50	1.000e-5	2.100e+8	0.30

Seti gred

Set: 1 Presek: Cevasti



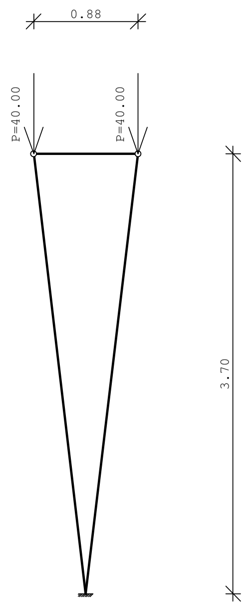
Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		4.029e-3	2.115e-3	2.115e-3	2.595e-5	1.297e-5	1.297e-5

Lista obtežnih primerov

No	Naziv
1	1.35g+1.5q (g)

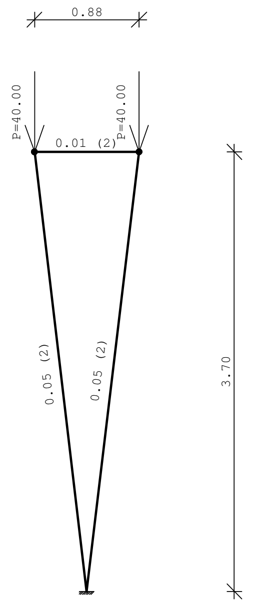
No	Naziv
2	Kombinacija: MSN 1,35g+1,5q (I)

Obt. 1: 1.35g+1.5q (g)

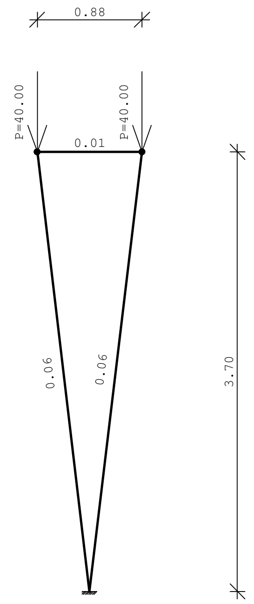


Dimenzioniranje (jeklo)

Obt. 1: 1.35g+1.5q (g)



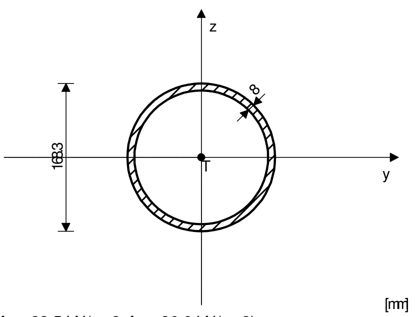
Obt. 1: 1.35g+1.5q (g)



Kontrola napetosti

PALICA 1 - 67
PREČNI PREREZ: Cevasti [Fe 360]
EUROCODE

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	40.288	cm2
Ay =	21.149	cm2
Az =	21.149	cm2
Ix =	2594.5	cm4
Iy =	1297.3	cm4
Iz =	1297.3	cm4
Wy =	154.16	cm3
Wz =	154.16	cm3
Wy,pl =	205.74	cm3
Wz,pl =	205.74	cm3
γM0 =	1.100	
γM1 =	1.100	
γM2 =	1.250	
Anet/A =	0.900	

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 2, konec palice)

Računska osna sila	Nsd =	-41.598	kN
Prečna sila v z smeri	Vsd_z =	0.090	kN
Upogibni moment okoli y osi	Msd_y =	0.079	kNm
Sistemska dolžina palice	L =	372.61	cm

5.3 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

5.4 NOSILNOST PREČNIH PREREZOV
5.4.4 Tlak

Plastična računska nosilnost	Npl.Rd =	860.69	kN
Računska nosilnost na tlak	Nc.Rd =	860.69	kN

Pogoj 5.16: Nsd <= Nc.Rd (41.60 <= 860.69)

5.4.5 Upogib y-y

Računski plastični moment	Mpl.Rd =	43.953	kNm
Računska nos.na lokalno izbočitev	Mo.Rd =	32.935	kNm
Računski elastični moment	Mel.Rd =	32.935	kNm
Računska nosilnost na upogib	Mc.Rd =	43.953	kNm

Pogoj 5.17: Msd_y <= Mc.Rd_y (0.08 <= 43.95)

5.4.6 Strig
Računska plast.nos.na strig z-z Vpl.Rd = 260.86 kN
Pogoj 5.20: Vsd_z <= Vpl.Rd_z (0.09 <= 260.86)

5.4.9 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: Vsd_z <= 50%Vpl.Rd_z

5.4.8 Upogib in osna sila
Razmerje Nsd / Npl.Rd 0.048
Pogoj 5.36: (0.05 <= 1)

Kontrola stabilnosti

5.5 NOSILNOST ELEMENTOV
5.5.1 Uklonska nosilnost

Uklonska dolžina y-y	l,y =	372.61	cm
Vztrajnostni radij y-y	i,y =	5.675	cm
Vitkost y-y	λ,y =	65.663	
Relativna vitkost y-y	λ_y =	0.699	
Uklonska krivulja za os y-y: A	α =	0.210	
Koeficient nepopolnosti	χ,y =	0.848	
Koeficient efektivnega prereza	βA =	1.000	
Računska uklonska nosilnost	Nb.Rd_y =	729.93	kN

Pogoj 5.45: Nsd <= Nb.Rd_y (41.60 <= 729.93)

Uklonska dolžina z-z	l,z =	372.61	cm
Vztrajnostni radij z-z	i,z =	5.675	cm
Vitkost z-z	λ,z =	65.663	
Relativna vitkost z-z	λ_z =	0.699	
Uklonska krivulja za os z-z: A	α =	0.210	
Koeficient nepopolnosti	χ,z =	0.848	
Koeficient efektivnega prereza	βA =	1.000	
Računska uklonska nosilnost	Nb.Rd_z =	729.93	kN

Pogoj 5.45: Nsd <= Nb.Rd_z (41.60 <= 729.93)

5.5.2 Bočna zvrnitev upogibnih nosilcev

Koeficient	C1 =	1.132	
Koeficient	C2 =	0.459	
Koeficient	C3 =	0.525	
Koef.ukl.dolžine za uklon	k =	1.000	
Koef.ukl.dolžine za vbočenje	kw =	1.000	
Koordinata	zg =	0.000	cm
Koordinata	zj =	0.000	cm
Razmak med bočnimi podporami	L =	372.61	cm
Sektorski vztrajnostni moment	Iw =	0.000	cm6
Krit.moment bočne zvrnitve	Mcr =	2280.5	kNm
Koeficient	βw =	1.000	
Koeficient imperf.	αLT =	0.210	
Brezdimenz.vitkost	λLT_ =	0.146	
Koeficient zmanjšanja	χLT =	1.000	
Računska uklonska nosilnost	Mb.Rd =	43.953	kNm

Kontrola bočne zvrnitve ni potrebna: λ_LT <= 0.4

5.5.4 Upogib in tlak

Koeficient nepopolnosti	χmin =	0.848
Nsd / ...		0.057
Koeficient oblike momenta	βy =	1.706
Koeficient	μy =	-0.077
Koeficient	ky =	1.004
ky * My / ...		0.002

Pogoj 5.51: (0.06 <= 1)

Koeficient nepopolnosti	χ_z =	0.848
Nsd/ ...		0.057
Koeficient nepopolnosti	χLT =	1.000
Koef.obl.mom.za bočno zvrnitev	βM.LT =	1.706
Koeficient	μLT =	0.029
Koeficient	kLT =	0.999
kLT * My / ...		0.002

Pogoj 5.52: (0.06 <= 1)

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija

Datoteka:	Model C.twp
Datum preračuna:	16.6.2021

Način preračuna:	3D model

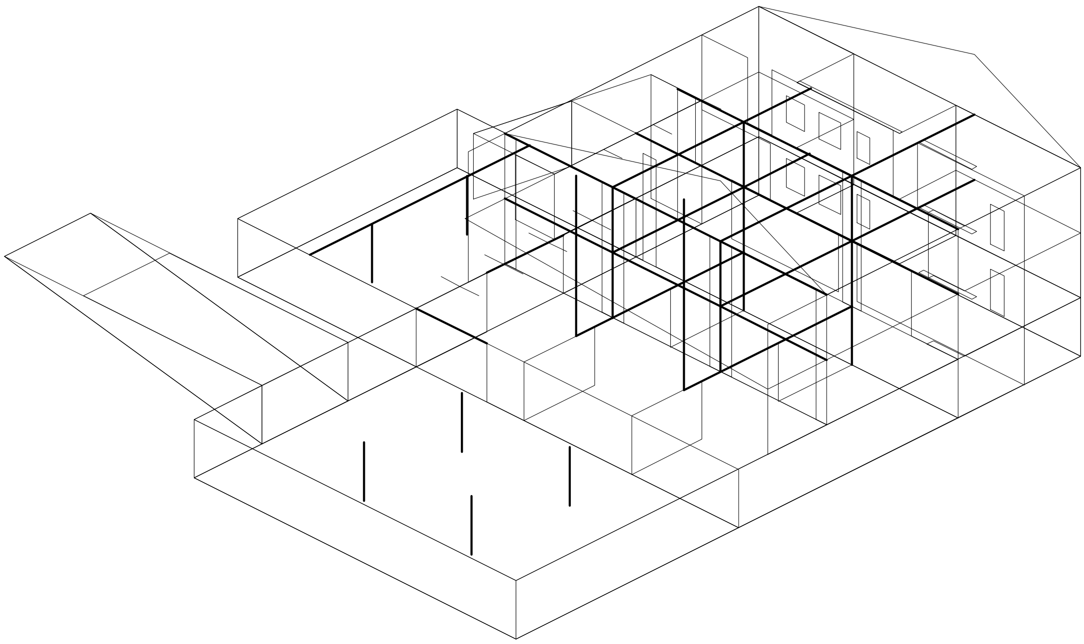
- [X] Teorija I-ga reda
- [ ] Modalna analiza
- [ ] Stabilnost
- [ ] Teorija II-ga reda
- [ ] Seizmični preračun
- [ ] Ofset gred
- [ ] Faze gradnje

Velikost modela

Število vozlišč:	31627
Število ploskovnih elementov:	31968
Število grednih elementov	1158
Število robnih elementov	62178
Število osnovnih obtežnih primerov:	6
Število kombinacij obtežb:	6

Enote mer

Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius



Izometrija

Tabele materialov

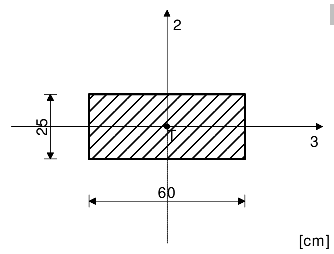
No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Beton C30/37	3.300e+7	0.20	25.00	1.000e-5	3.300e+7	0.20
2	Beton C25/30	3.150e+7	0.20	25.00	1.000e-5	3.150e+7	0.20

Seti plošč

No	d[m]	e[m]	Material	Tip preračuna	Ortotropija	E2[kN/m2]	G[kN/m2]	α
<1>	0.580	0.290	1	Tanka plošča	Izotropna			
<2>	0.280	0.140	1	Tanka plošča	Izotropna			
<3>	0.280	0.140	2	Tanka plošča	Izotropna			
<4>	0.280	0.140	2	Tanka plošča	Izotropna			
<5>	0.280	0.140	2	Tanka plošča	Izotropna			
<6>	0.250	0.125	2	Tanka plošča	Izotropna			

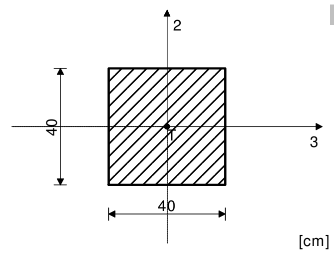
Seti gred

Set: 1 Presek: Pravokotni



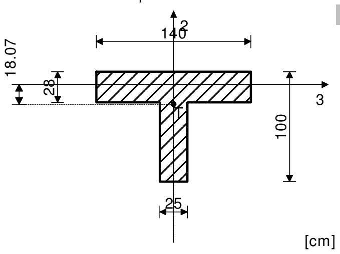
Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		1.500e-1	1.250e-1	1.250e-1	2.307e-3	4.500e-3	7.812e-4

Set: 2 Presek: Pravokotni



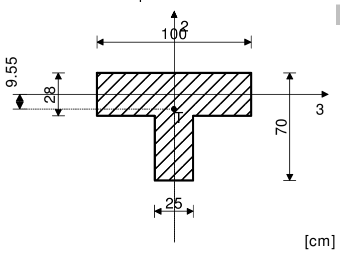
Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		1.600e-1	1.333e-1	1.333e-1	3.605e-3	2.133e-3	2.133e-3

Set: 3 Presek: T-prerez



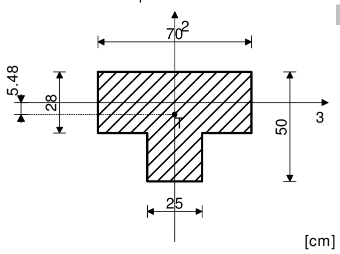
Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		5.720e-1	2.666e-1	4.342e-1	1.399e-2	6.496e-2	4.118e-2

Set: 4 Presek: T-prerez



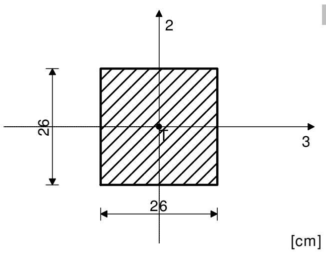
Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		3.850e-1	2.243e-1	3.240e-1	9.505e-3	2.388e-2	1.273e-2

Set: 5 Presek: T-prerez



Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		2.510e-1	1.959e-1	2.246e-1	6.268e-3	8.290e-3	4.187e-3

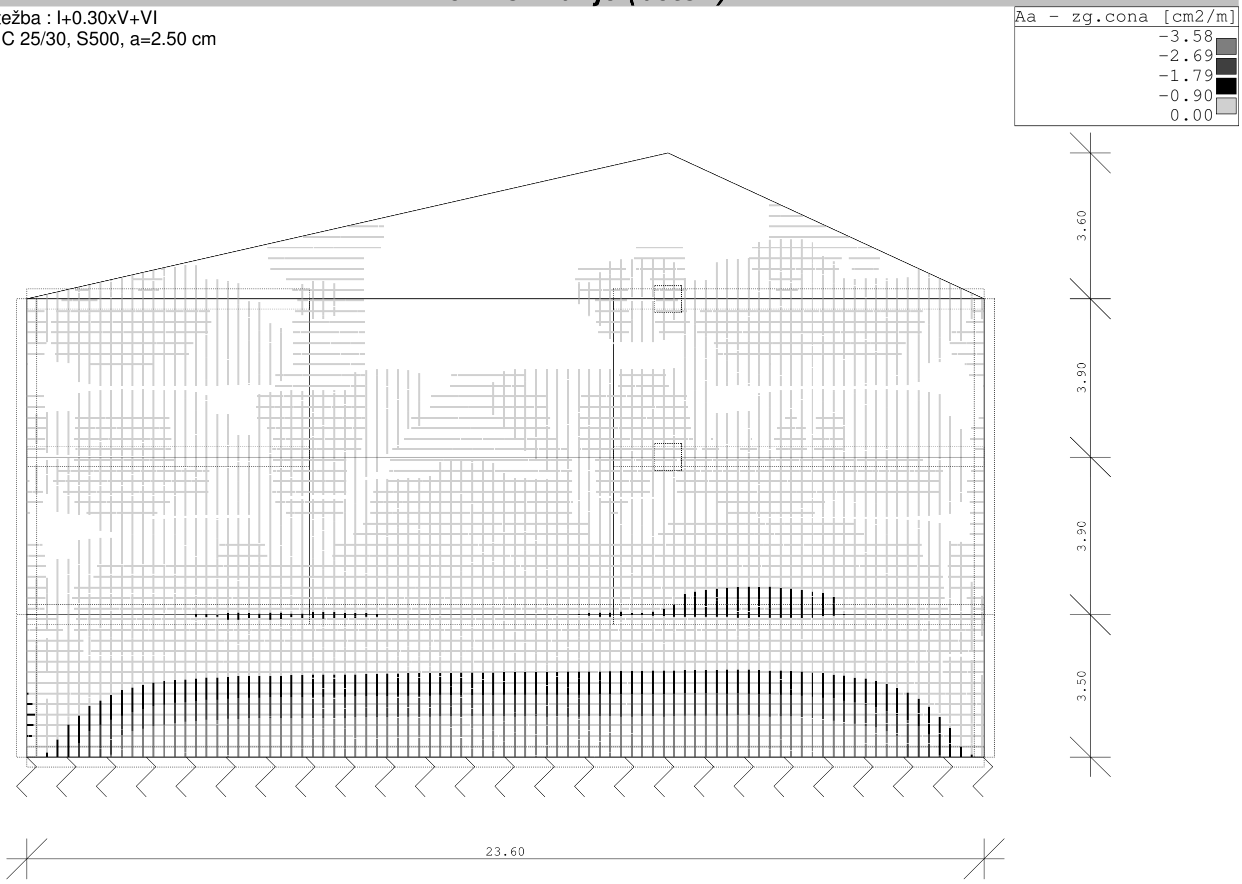
Set: 7 Presek: Pravokotni



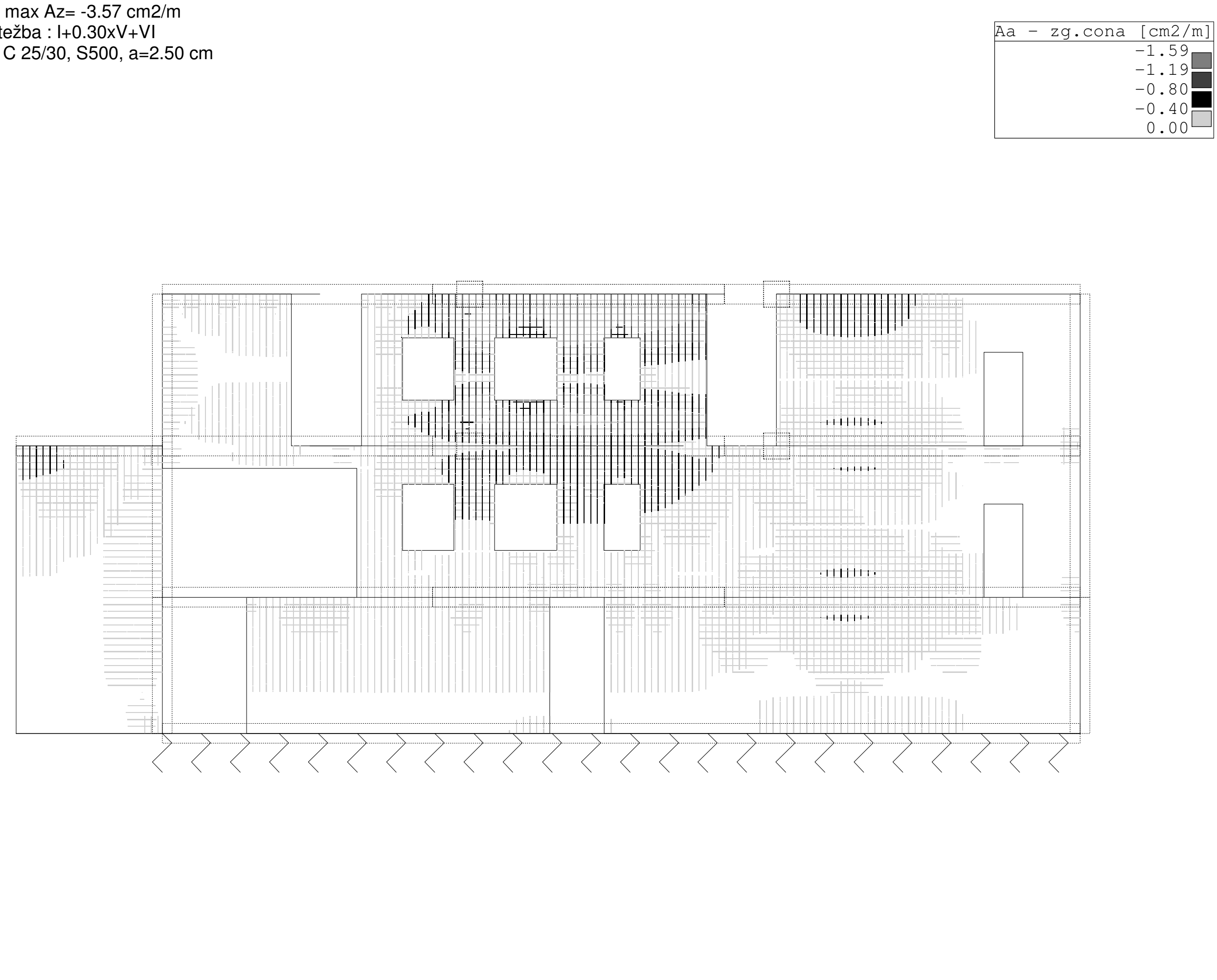
Mat.	P/Z	A1	A2	A3	I1	I2	I3
2		6.760e-2	5.633e-2	5.633e-2	6.436e-4	3.808e-4	3.808e-4

Dimenzioniranje (beton)

Merodajna obtežba : I+0.30xV+VI
EUROCODE, C 25/30, S500, a=2.50 cm

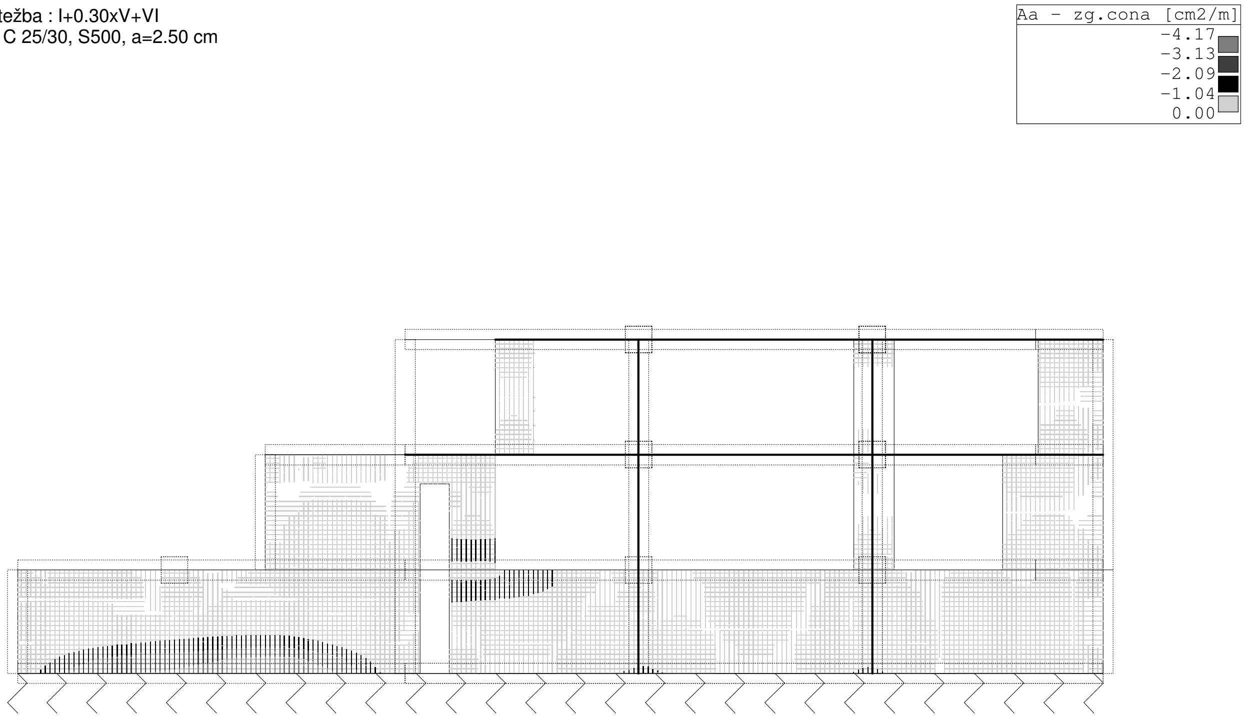


Okvir: H_10
Aa - zg.cona - max Az= -3.57 cm2/m
Merodajna obtežba : I+0.30xV+VI
EUROCODE, C 25/30, S500, a=2.50 cm

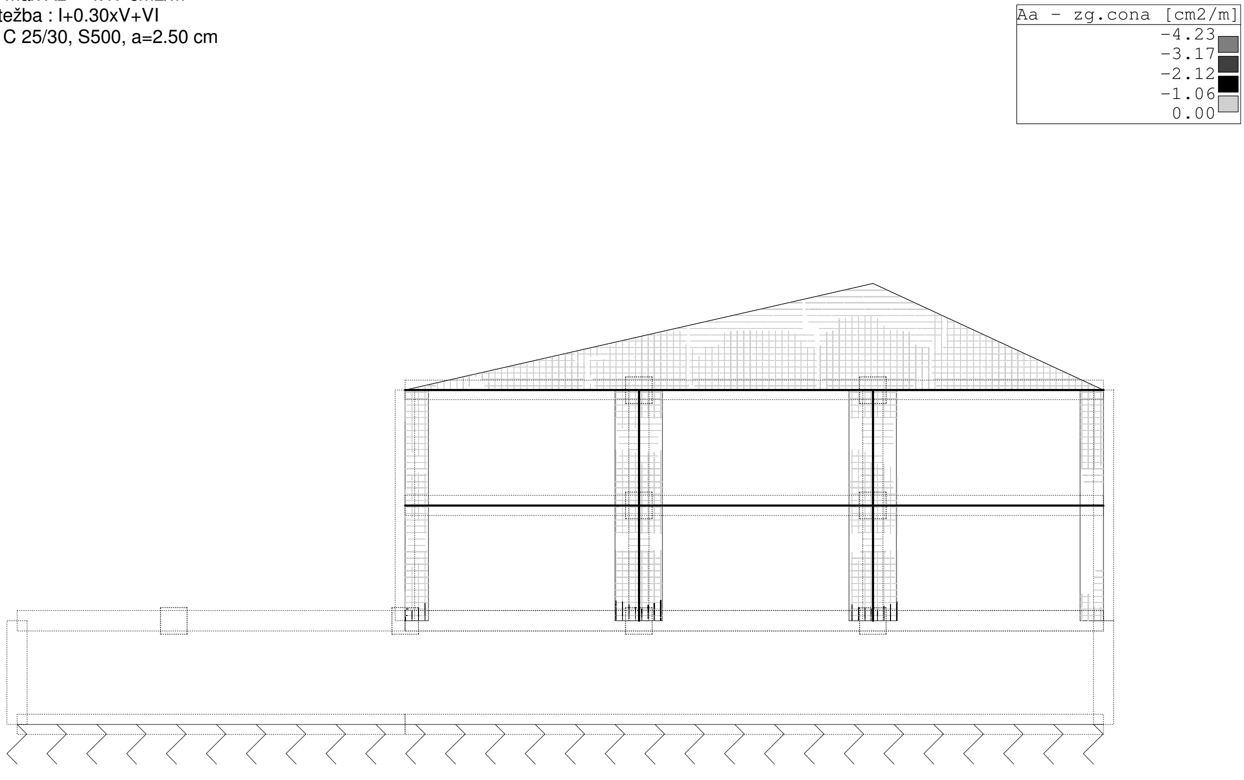


Okvir: H_9
Aa - zg.cona - max Az= -1.59 cm2/m

Merodajna obtežba : I+0.30xV+VI
EUROCODE, C 25/30, S500, a=2.50 cm



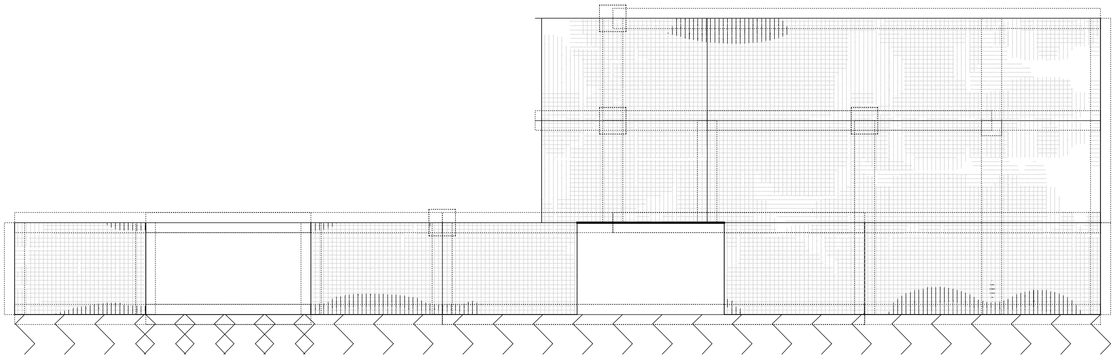
Okvir: H_8
Aa - zg.cona - max Az= -4.17 cm2/m
Merodajna obtežba : I+0.30xV+VI
EUROCODE, C 25/30, S500, a=2.50 cm



Okvir: H_6
Aa - zg.cona - max Az= -4.23 cm2/m

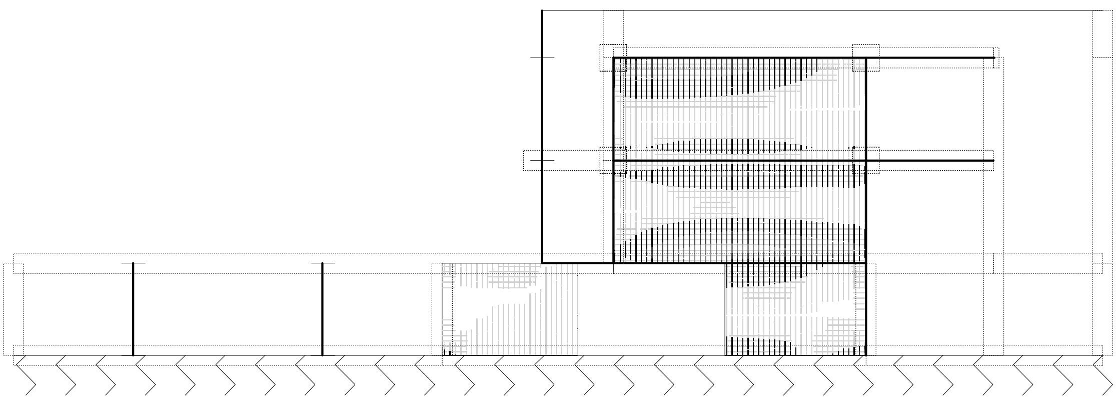
Merodajna obtežba : I+V+0.30xVI
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-5.06
-3.80
-2.53
-1.26
0.00



Okvir: V_3
Aa - zg.cona - max Az= -5.05 cm2/m
Merodajna obtežba : I+V+0.30xVI
EUROCODE, C 25/30, S500, a=2.50 cm

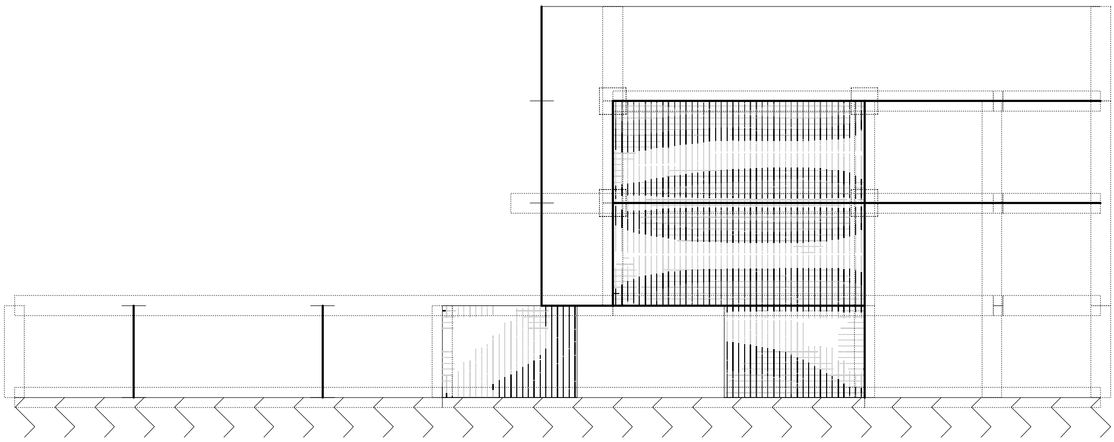
Aa - zg.cona [cm2/m]
-1.02
-0.77
-0.51
-0.25
0.00



Okvir: V_4
Aa - zg.cona - max Az= -1.02 cm2/m

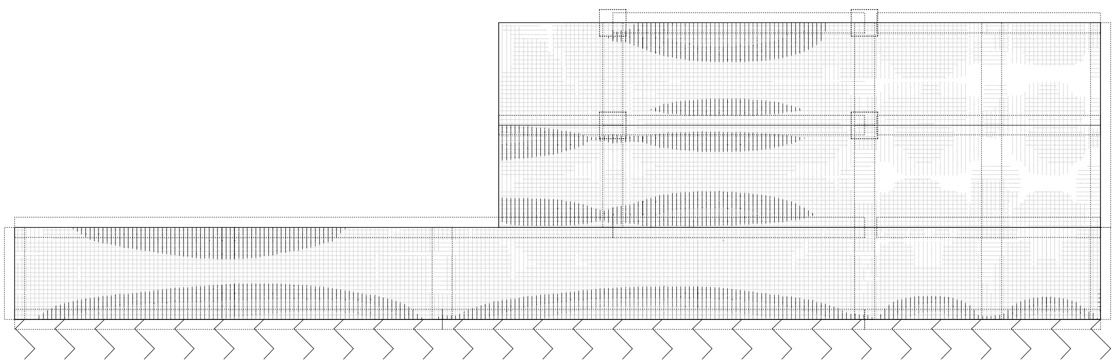
Merodajna obtežba : I+V+0.30xVI
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-0.58
-0.44
-0.29
-0.14
0.00



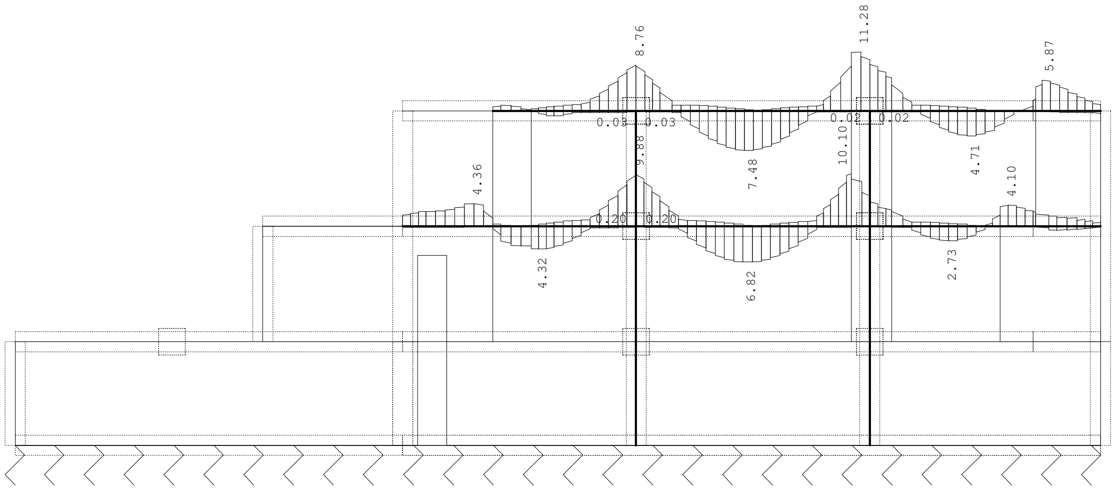
Okvir: V_5
Aa - zg.cona - max Az= -0.58 cm2/m
Merodajna obtežba : I+V+0.30xVI
EUROCODE, C 25/30, S500, a=2.50 cm

Aa - zg.cona [cm2/m]
-3.47
-2.60
-1.74
-0.87
0.00

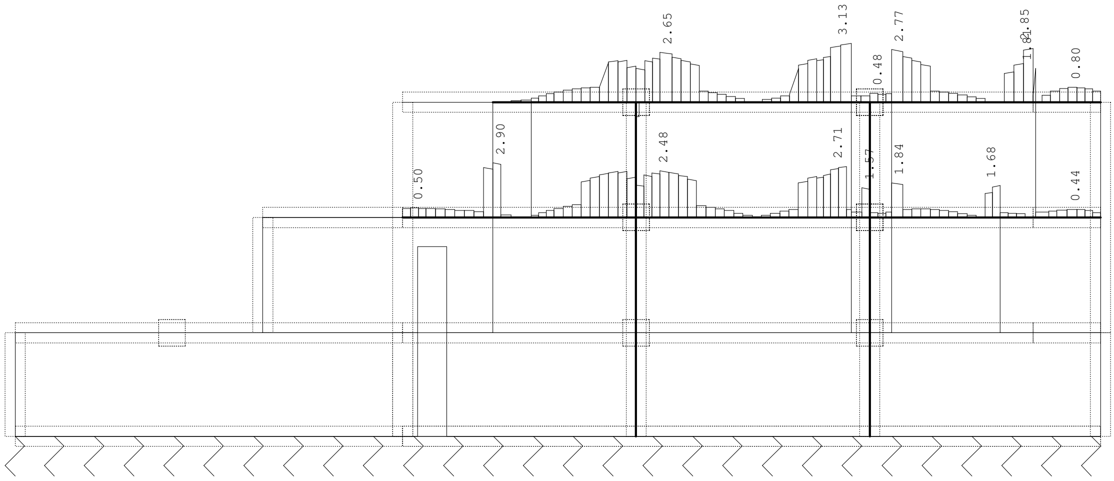


Okvir: V_6
Aa - zg.cona - max Az= -3.46 cm2/m

Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500

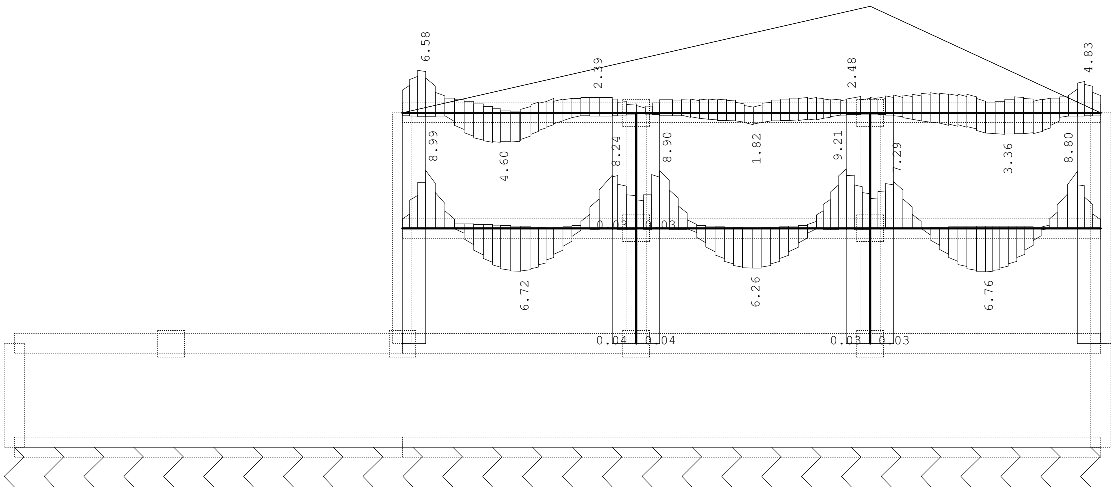


Okvir: H_8
Armatura v gredah: max Aa2/Aa1= 11.28 cm2
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500

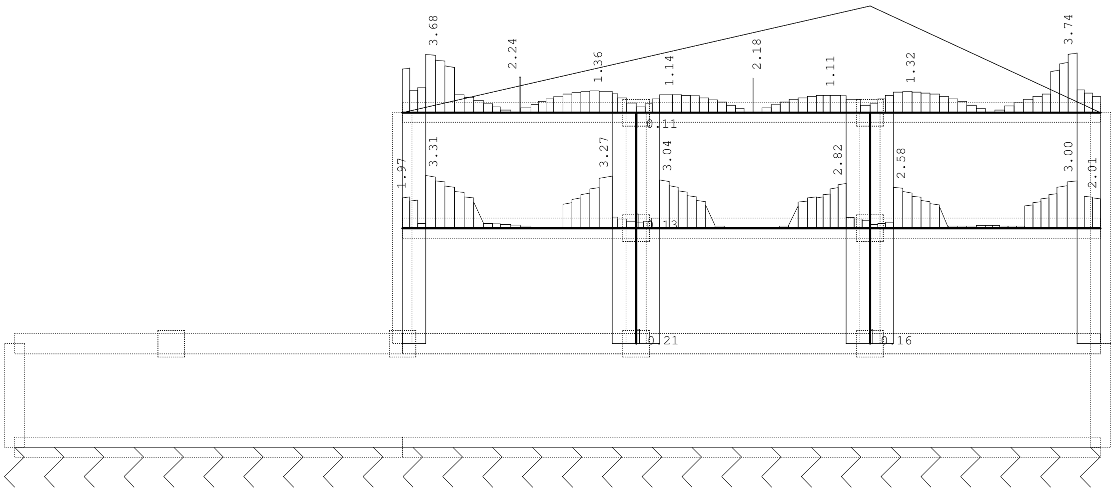


Okvir: H_8
Armatura v gredah: max Aa,st= 3.13 cm2

Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500

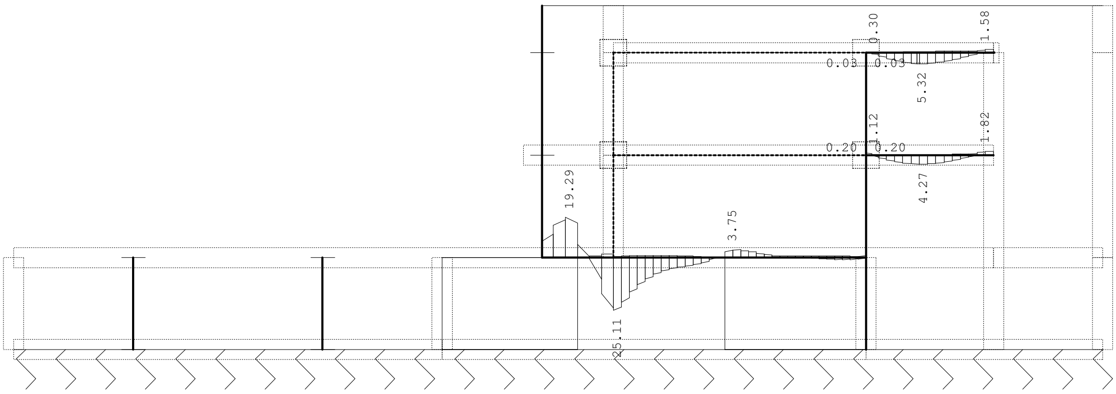


Okvir: H_6
Armatura v gredah: max Aa2/Aa1= 9.21 cm2
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500

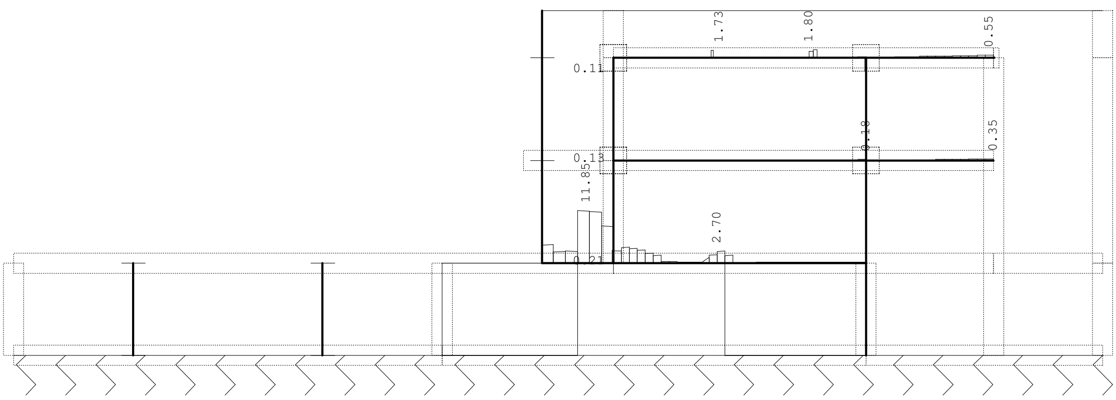


Okvir: H_6
Armatura v gredah: max Aa,st= 3.74 cm2

Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500



Okvir: V_4
Armatura v gredah: max Aa2/Aa1= 25.11 cm2
Merodajna obtežba : 1.35xI+1.50xII
EUROCODE, C 25/30, S500



Okvir: V_4
Armatura v gredah: max Aa,st= 11.85 cm2

Osnovni podatki o modelu, Vhodni podatki - Konstrukcija, Vhodni podatki - Obtežba

Datoteka:	Harfa fasade.twp
Datum preračuna:	16.6.2021

Način preračuna: 2D model (Xp, Zp, Yr)

☐ Teorija I-ga reda ☐ Modalna analiza ☐ Stabilnost

☒ Teorija II-ga reda ☐ Seizmični preračun ☐ Ofset gred

☐ Faze gradnje

Velikost modela

Število vozlišč:	397
Število ploskovnih elementov:	0
Število grednih elementov	398
Število robnih elementov	8
Število osnovnih obtežnih primerov:	1
Število kombinacij obtežb:	2

Enote mer

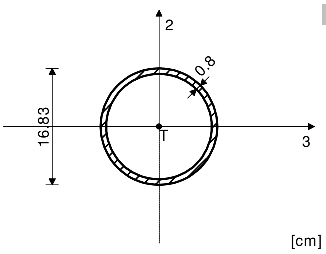
Dolžina:	m [cm,mm]
Sila:	kN
Temperatura:	Celsius

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Jeklo	2.100e+8	0.30	78.50	1.000e-5	2.100e+8	0.30

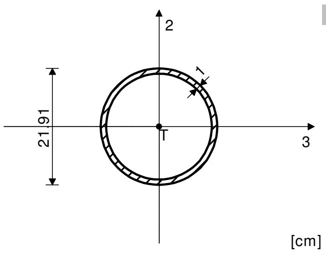
Seti gred

Set: 1 Presek: Cevasti



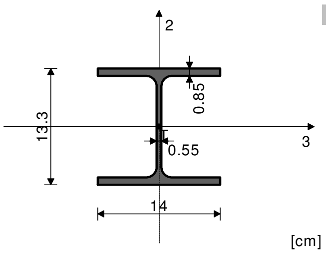
Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		4.029e-3	2.115e-3	2.115e-3	2.595e-5	1.297e-5	1.297e-5

Set: 2 Presek: Cevasti



Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		6.569e-3	3.442e-3	3.442e-3	7.197e-5	3.598e-5	3.598e-5

Set: 3 Presek: IPBl 140



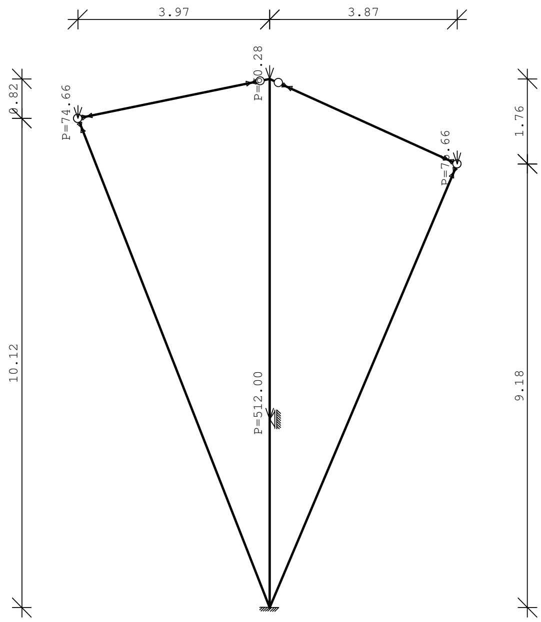
Mat.	P/Z	A1	A2	A3	I1	I2	I3
1		3.140e-3	1.011e-3	2.129e-3	8.160e-8	3.890e-6	1.030e-5

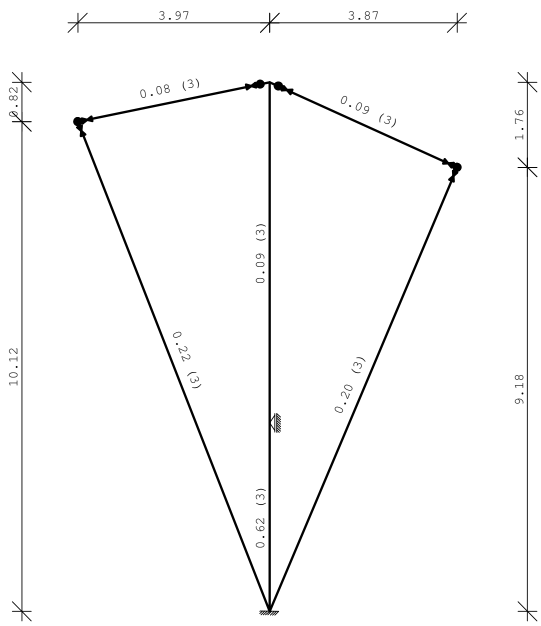
Lista obtežnih primerov

No	Naziv
1	1.0g+1.0q vnos (g)
2	Kombinacija: MSU (I)
3	Kombinacija: MSN (1.45xI)

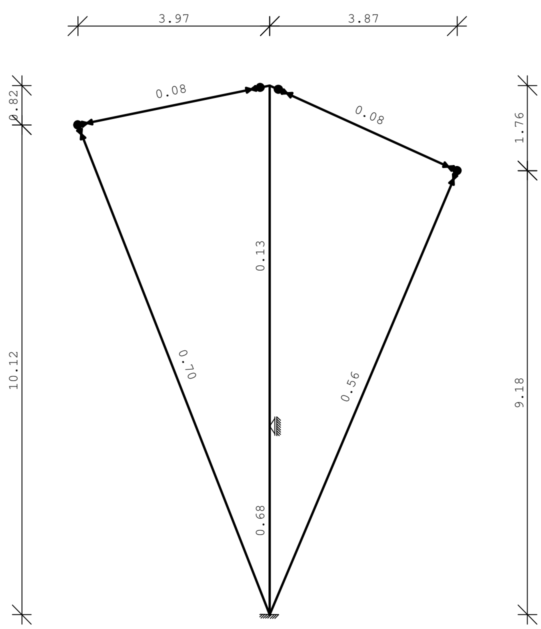
Dimenzioniranje (jeklo)

Obt. 1: 1.0g+1.0q vnos (g)





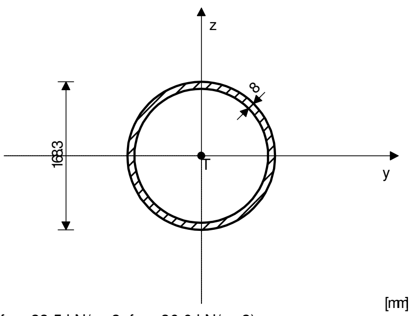
Kontrola napetosti



Kontrola stabilnosti

PALICA 216 - 1
PREČNI PREREZ: Cevasti [Fe 360]
EUROCODE

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	40.288 cm2
Ay =	21.149 cm2
Az =	21.149 cm2
Ix =	2594.5 cm4
Iy =	1297.3 cm4
Iz =	1297.3 cm4
Wy =	154.16 cm3
Wz =	154.16 cm3
Wy,pl =	205.74 cm3
Wz,pl =	205.74 cm3
γM0 =	1.100
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 3, začetek palice)

Računska osna sila	Nsd =	-113.06 kN
Prečna sila v z smeri	Vsd_z =	1.172 kN
Upogibni moment okoli y osi	Msd_y =	3.066 kNm
Sistemska dolžina palice	L =	1087.1 cm

5.3 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

5.4 NOSILNOST PREČNIH PREREZOV
5.4.4 Tlak

Plastična računska nosilnost	Npl.Rd =	860.69 kN
Računska nosilnost na tlak	Nc.Rd =	860.69 kN

Pogoj 5.16: Nsd <= Nc.Rd (113.06 <= 860.69)

5.4.5 Upogib y-y

Računski plastični moment	Mpl.Rd =	43.953 kNm
Računska nos.na lokalno izbočitev	Mo.Rd =	32.935 kNm
Računski elastični moment	Mel.Rd =	32.935 kNm
Računska nosilnost na upogib	Mc.Rd =	43.953 kNm

Pogoj 5.17: Msd_y <= Mc.Rd_y (3.07 <= 43.95)

5.4.6 Strig

Računska plast.nos.na strig z-z	Vpl.Rd =	260.86 kN

Pogoj 5.20: Vsd_z <= Vpl.Rd_z (1.17 <= 260.86)

5.4.9 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: Vsd_z <= 50%Vpl.Rd_z

5.4.8 Upogib in osna sila

Razmerje Nsd / Npl.Rd	0.131
Razmerje Msd_y / Mpl.Rd_y	0.070

Pogoj 5.36: (0.20 <= 1)

5.5 NOSILNOST ELEMENTOV
5.5.1 Uklonska nosilnost

Uklonska dolžina y-y	l,y =	1087.1 cm
Vztrajnostni radij y-y	i,y =	5.675 cm
Vitkost y-y	λ,y =	191.57
Relativna vitkost y-y	λ_y =	2.040
Uklonska krivulja za os y-y: A	α =	0.210
Koeficient nepopolnosti	χ,y =	0.215
Koeficient efektivnega prereza	βA =	1.000
Računska uklonska nosilnost	Nb.Rd_y =	184.92 kN

Pogoj 5.45: Nsd <= Nb.Rd_y (113.06 <= 184.92)

Uklonska dolžina z-z	l,z =	1087.1 cm
Vztrajnostni radij z-z	i,z =	5.675 cm
Vitkost z-z	λ,z =	191.57
Relativna vitkost z-z	λ_z =	2.040
Uklonska krivulja za os z-z: A	α =	0.210
Koeficient nepopolnosti	χ,z =	0.215
Koeficient efektivnega prereza	βA =	1.000
Računska uklonska nosilnost	Nb.Rd_z =	184.92 kN

Pogoj 5.45: Nsd <= Nb.Rd_z (113.06 <= 184.92)

5.5.2 Bočna zvrnitev upogibnih nosilcev

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	1087.1 cm
Sektorski vztrajnostni moment	Iw =	0.000 cm6
Krit.moment bočne zvrnitve	Mcr =	781.65 kNm
Koeficient	βw =	1.000
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.249
Koeficient zmanjšanja	χLT =	0.989
Računska uklonska nosilnost	Mb.Rd =	43.480 kNm

Kontrola bočne zvrnitve ni potrebna: λ_LT <= 0.4

5.5.4 Upogib in tlak

Koeficient nepopolnosti	χmin =	0.215
Nsd / ...		0.611
Koeficient oblike momenta	βy =	1.799
Koeficient	μy =	-0.486
Koeficient	ky =	1.270
ky * My / ...		0.089

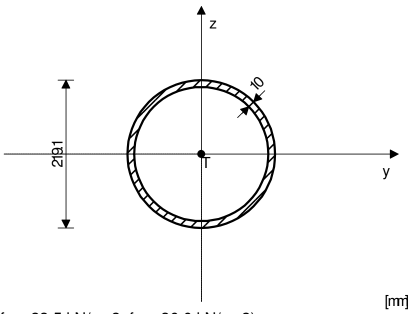
Pogoj 5.51: (0.70 <= 1)

Koeficient nepopolnosti	χ_z =	0.215
Nsd/ ...		0.611
Koeficient nepopolnosti	χLT =	0.989
Koef.obl.mom.za bočno zvrnitev	βM.LT =	1.799
Koeficient	μLT =	0.401
Koeficient	kLT =	0.777
kLT * My / ...		0.055

Pogoj 5.52: (0.67 <= 1)

PALICA 1 - 137
PREČNI PREREZ: Cevasti [Fe 360]
EUROCODE

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	65.691 cm2
Ay =	34.416 cm2
Az =	34.416 cm2
Ix =	7196.9 cm4
Iy =	3598.4 cm4
Iz =	3598.4 cm4
Wy =	328.47 cm3
Wz =	328.47 cm3
Wy,pl =	437.56 cm3
Wz,pl =	437.56 cm3
$\gamma M0$ =	1.100
$\gamma M1$ =	1.100
$\gamma M2$ =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 3, konec palice)

Računska osna sila	Nsd =	-866.01 kN
Prečna sila v z smeri	Vsd_z =	0.088 kN
Upogibni moment okoli y osi	Msd_y =	0.121 kNm
Sistemska dolžina palice	L =	390.00 cm

5.3 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

5.4 NOSILNOST PREČNIH PREREZOV
5.4.4 Tlak

Plastična računska nosilnost	Npl.Rd =	1403.4 kN
Računska nosilnost na tlak	Nc.Rd =	1403.4 kN

Pogoj 5.16: Nsd <= Nc.Rd (866.01 <= 1403.39)

5.4.5 Upogib y-y

Računski plastični moment	Mpl.Rd =	93.479 kNm
Računska nos.na lokalno izbočitev	Mo.Rd =	70.174 kNm
Računski elastični moment	Mel.Rd =	70.174 kNm
Računska nosilnost na upogib	Mc.Rd =	93.479 kNm

Pogoj 5.17: Msd_y <= Mc.Rd_y (0.12 <= 93.48)

5.4.6 Strig

Računska plast.nos.na strig z-z	Vpl.Rd =	424.50 kN

Pogoj 5.20: Vsd_z <= Vpl.Rd_z (0.09 <= 424.50)

5.4.9 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: Vsd_z <= 50%Vpl.Rd_z

5.4.8 Upogib in osna sila

Razmerje Nsd / Npl.Rd	0.617

Pogoj 5.36: (0.62 <= 1)

5.5 NOSILNOST ELEMENTOV
5.5.1 Uklonska nosilnost

Uklonska dolžina y-y	l,y =	390.00 cm
Vztrajnostni radij y-y	i,y =	7.401 cm
Vitkost y-y	λ,y =	52.694
Relativna vitkost y-y	λ_y =	0.561
Uklonska krivulja za os y-y: A	α =	0.210
Koeficient nepopolnosti	χ,y =	0.904
Koeficient efektivnega prereza	βA =	1.000
Računska uklonska nosilnost	Nb.Rd_y =	1268.8 kN

Pogoj 5.45: Nsd <= Nb.Rd_y (866.01 <= 1268.85)

Uklonska dolžina z-z	l,z =	390.00 cm
Vztrajnostni radij z-z	i,z =	7.401 cm
Vitkost z-z	λ,z =	52.694
Relativna vitkost z-z	λ_z =	0.561
Uklonska krivulja za os z-z: A	α =	0.210
Koeficient nepopolnosti	χ,z =	0.904
Koeficient efektivnega prereza	βA =	1.000
Računska uklonska nosilnost	Nb.Rd_z =	1268.8 kN

Pogoj 5.45: Nsd <= Nb.Rd_z (866.01 <= 1268.85)

5.5.2 Bočna zvrnitev upogibnih nosilcev

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	390.00 cm
Sektorski vztrajnostni moment	Iw =	0.000 cm6
Krit.moment bočne zvrnitve	Mcr =	6043.6 kNm
Koeficient	βw =	1.000
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.130
Koeficient zmanjšanja	χLT =	1.000
Računska uklonska nosilnost	Mb.Rd =	93.479 kNm

Kontrola bočne zvrnitve ni potrebna: λ_LT <= 0.4

5.5.4 Upogib in tlak

Koeficient nepopolnosti	χmin =	0.904
Nsd / ...		0.683
Koeficient oblike momenta	βy =	1.361
Koeficient	μy =	-0.385
Koeficient	ky =	1.239
ky * My / ...		0.002

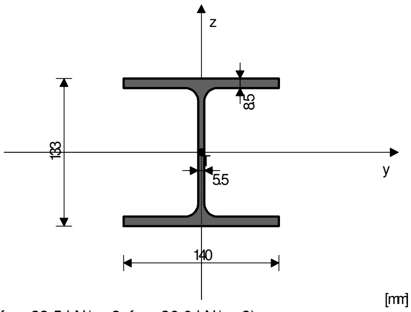
Pogoj 5.51: (0.68 <= 1)

Koeficient nepopolnosti	χ_z =	0.904
Nsd/ ...		0.683
Koeficient nepopolnosti	χLT =	1.000
Koef.obl.mom.za bočno zvrnitev	βM.LT =	1.361
Koeficient	μLT =	-0.035
Koeficient	kLT =	1.022
kLT * My / ...		0.001

Pogoj 5.52: (0.68 <= 1)

PALICA 339 - 216
PREČNI PREREZ: IPBl 140 [Fe 360]
EUROCODE

GEOMETRIJSKE KARAKTERISTIKE prereza



	Ax =	31.400 cm2
	Ay =	21.293 cm2
	Az =	10.107 cm2
	Ix =	8.160 cm4
	Iy =	1030.0 cm4
	Iz =	389.00 cm4
	Wy =	154.89 cm3
	Wz =	55.571 cm3
	Wy,pl =	173.32 cm3
	Wz,pl =	83.300 cm3
	γM0 =	1.100
	γM1 =	1.100
	γM2 =	1.250
	Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

PALICA IZPOSTAVLJENA NATEGU IN UPOGIBU
(obtežni primer 3, na 202.7 cm od začetka palice)

Računska osna sila	Nsd =	41.043 kN
Prečna sila v z smeri	Vsd_z =	-0.011 kN
Upogibni moment okoli y osi	Msd_y =	0.696 kNm
Sistemska dolžina palice	L =	405.38 cm

5.3 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

5.4 NOSILNOST PREČNIH PREREZOV
5.4.3 Nateg

Plast.rač.nosilnost bruto prereza	Npl.Rd =	670.82 kN
Mejna rač.nosilnost neto prereza	Nu.Rd =	732.50 kN
Računska nos. na nateg	Nt.Rd =	670.82 kN

Pogoj 5.13: Nsd <= Nt.Rd (41.04 <= 670.82)

5.4.5 Upogib y-y

Računski plastični moment	Mpl.Rd =	37.028 kNm
Računska nos.na lokalno izbočitev	Mo.Rd =	33.090 kNm
Računski elastični moment	Mel.Rd =	33.090 kNm
Računska nosilnost na upogib	Mc.Rd =	37.028 kNm

Pogoj 5.17: Msd_y <= Mc.Rd_y (0.70 <= 37.03)

5.4.6 Strig
Računska plast.nos.na strig z-z Vpl.Rd = 124.67 kN
Pogoj 5.20: Vsd_z <= Vpl.Rd_z (0.01 <= 124.67)

5.4.9 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: Vsd_z <= 50%Vpl.Rd_z

5.4.8 Upogib in osna sila

Razmerje Nsd / Npl.Rd	0.061
Razmerje Msd_y / Mpl.Rd_y	0.019

Pogoj 5.36: (0.08 <= 1)

5.5 NOSILNOST ELEMENTOV
5.5.2 Bočna zvrnitev upogibnih nosilcev

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	405.38 cm
Sektorski vztrajnostni moment	Iw =	15064 cm6
Krit.moment bočne zvrnitve	Mcr =	73.062 kNm
Koeficient	βw =	1.000
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.747
Koeficient zmanjšanja	χLT =	0.825
Računska uklonska nosilnost	Mb.Rd =	30.539 kNm

5.5.3 Upogib in nateg

Redukcijski koef.za vektorske vplive	ψvec =	0.800
Elast.odp.mom.za krajne tlač.vlakno	Wcom =	154.89 cm3
Efektivni rač.notranji moment	Meff.sd =	0.000 kNm

Pogoj 5.50: Meff.sd <= Mb.Rd (0.00 <= 30.54)

5.6 LOKALNO IZBOČENJE ZARADI STRIGA
za strig v ravnini z-z

Višina stojine	d =	11.600 cm
Debelina stojine	tw =	0.550 cm
Ni prečnih ojačitev v sredini		
Koeficient izbočenja pri strigu	kτ =	5.340

Ni potrebna kontrola izbočenja zaradi striga
Pogoj: d / tw <= 69 ε (21.09 <= 69.00)

5.6.7 Interakcija prečne sile, upogiba in osne sile
za strig v ravnini z-z
Računski plastični moment pasnic Mf.Rd = 33.686 kNm
Pogoji 5.66a in 5.66b so izpolnjeni

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 3, začetek palice)

Računska osna sila	Nsd =	40.896 kN
Prečna sila v z smeri	Vsd_z =	-0.721 kN
Sistemska dolžina palice	L =	405.38 cm

5.4 NOSILNOST PREČNIH PREREZOV
5.4.6 Strig
Računska plast.nos.na strig z-z Vpl.Rd = 124.67 kN
Pogoj 5.20: Vsd_z <= Vpl.Rd_z (0.72 <= 124.67)

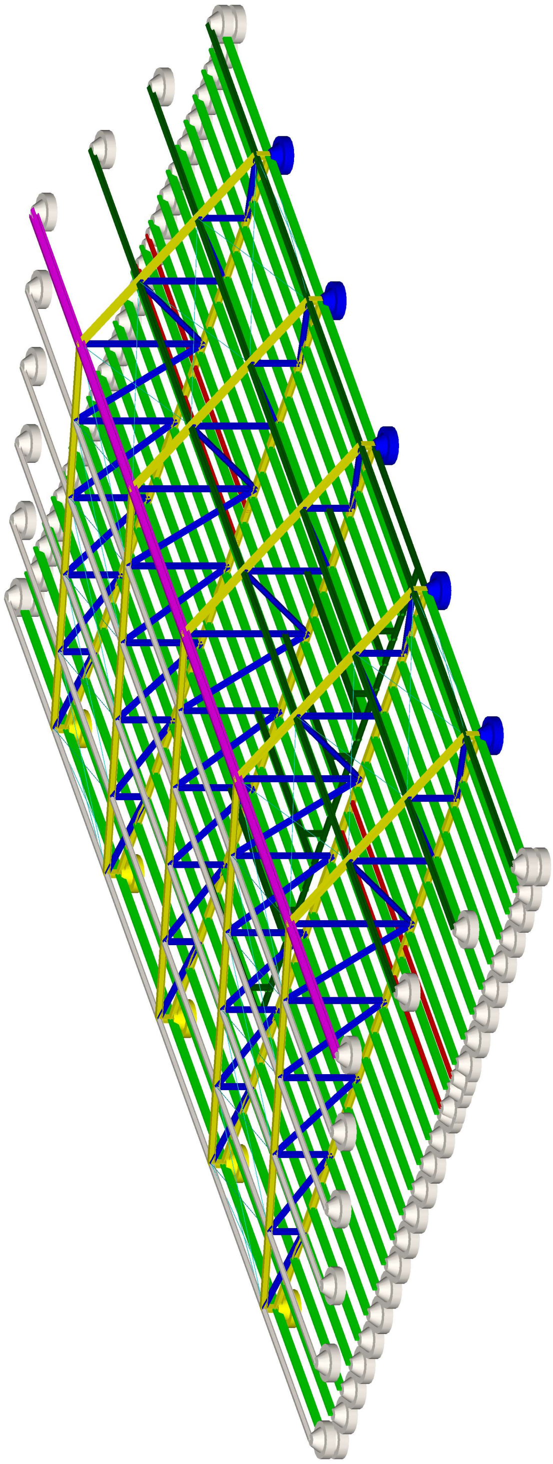
5.6 LOKALNO IZBOČENJE ZARADI STRIGA
za strig v ravnini z-z

Višina stojine	d =	11.600 cm
Debelina stojine	tw =	0.550 cm
Ni prečnih ojačitev v sredini		
Koeficient izbočenja pri strigu	kτ =	5.340

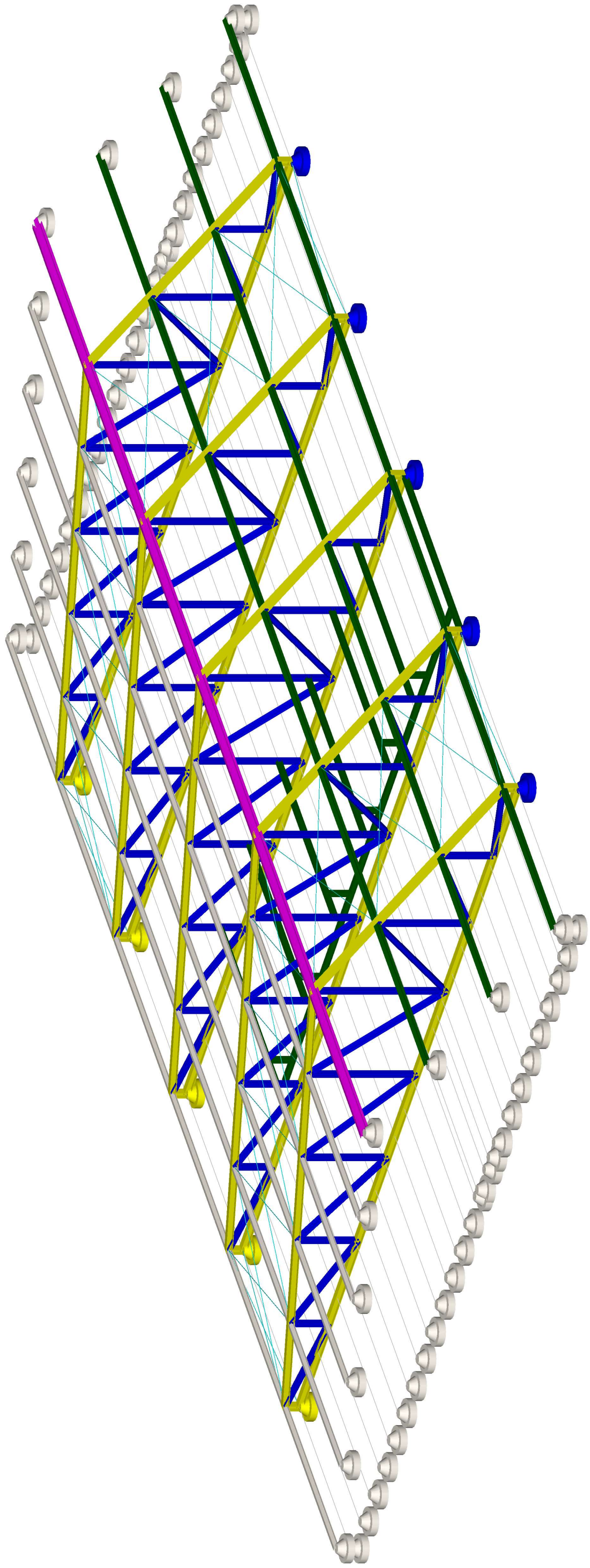
Ni potrebna kontrola izbočenja zaradi striga
Pogoj: d / tw <= 69 ε (21.09 <= 69.00)

Vhodni podatki - Konstrukcija

STREŠNA KOSNTRUKCIJA ŠPORTNE DVORANE



Izometrija (celotna kosntrukcija)



Izometrija (palični in strešni nsoilci)

Shema nivojev

Naziv	z [m]	h [m]
	0.70	0.70

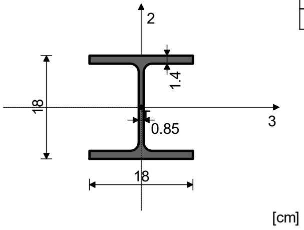
Naziv	z [m]	h [m]
	0.00	

Tabele materialov

No	Naziv materiala	E[kN/m2]	μ	γ[kN/m3]	αt[1/C]	Em[kN/m2]	μm
1	Jeklo S235 JR	2.100e+8	0.30	78.50	1.000e-5	2.100e+8	0.30
2	Les-Iglavci-Lamelirani GL28h	1.260e+7	0.20	5.00	1.000e-5	1.260e+7	0.20
3	Jeklo S235 JR	2.100e+8	0.30	0.00	1.000e-5	2.100e+8	0.30

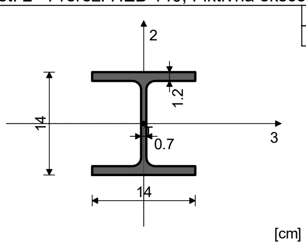
Seti gred

Set: 1 Prerez: HEB 180, Fiktivna ekscentričnost



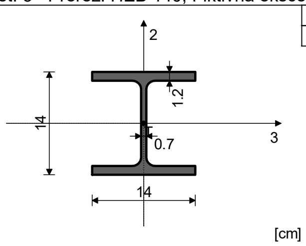
Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	6.530e-3	2.029e-3	4.501e-3	4.230e-7	1.360e-5	3.830e-5

Set: 2 Prerez: HEB 140, Fiktivna ekscentričnost



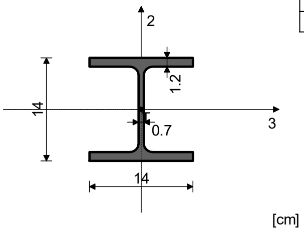
Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	4.300e-3	1.312e-3	2.988e-3	2.010e-7	5.500e-6	1.510e-5

Set: 3 Prerez: HEB 140, Fiktivna ekscentričnost



Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	4.300e-3	1.312e-3	2.988e-3	2.010e-7	5.500e-6	1.510e-5

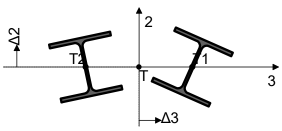
Set: 4 Prerez: HEB 140, Fiktivna ekscentričnost



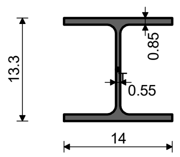
Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	4.300e-3	1.312e-3	2.988e-3	2.010e-7	5.500e-6	1.510e-5

Set: 5 Prerez: 2xHEA 140, Fiktivna ekscentričnost

Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	6.280e-3	2.255e-3	4.025e-3	1.632e-7	9.955e-5	1.926e-5



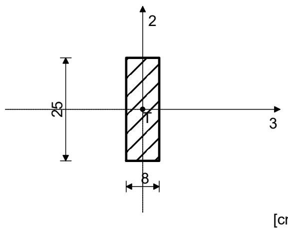
No	Prerez	Δ3 [cm]	Δ2 [cm]	α	Mat.
1	HEA 140	12.00	0.00	-0.42	1
2	HEA 140	-12.00	0.00	0.21	1



[cm]

HEA 140

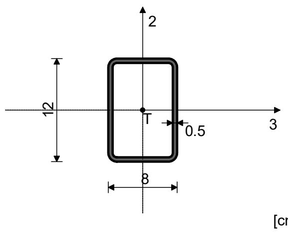
Set: 6 Prerez: b/d=8/25, Fiktivna ekscentričnost



Mat.	A1	A2	A3	I1	I2	I3
2 - Les-Iglavci-L...	2.000e-2	1.667e-2	1.667e-2	3.407e-5	1.067e-5	1.042e-4

[cm]

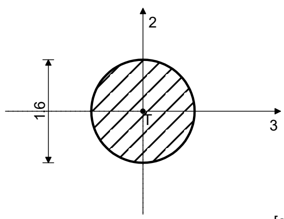
Set: 7 Prerez: HOP [] 120x80x5, Fiktivna ekscentričnost



Mat.	A1	A2	A3	I1	I2	I3
1 - Jeklo S235 JR	1.836e-3	1.200e-3	8.000e-4	3.915e-6	1.808e-6	3.415e-6

[cm]

Set: 8 Prerez: D=1.6, Prosta nelinearna (natezna) palica, Fiktivna ekscentričnost



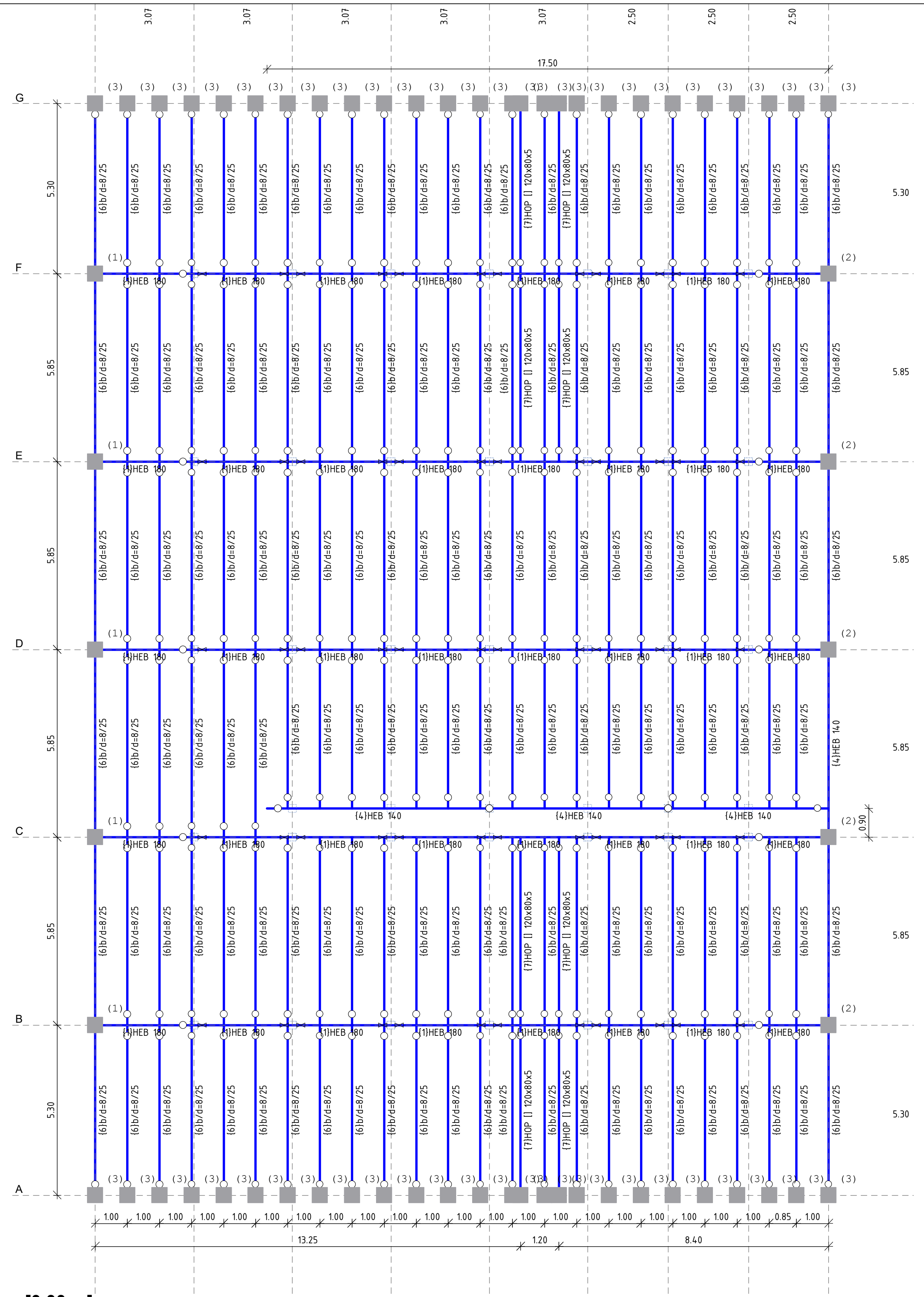
Mat.	A1	A2	A3	I1	I2	I3
3 - Jeklo S235 JR	2.011e-4	1.810e-4	1.810e-4	6.434e-9	3.217e-9	3.217e-9

[cm]

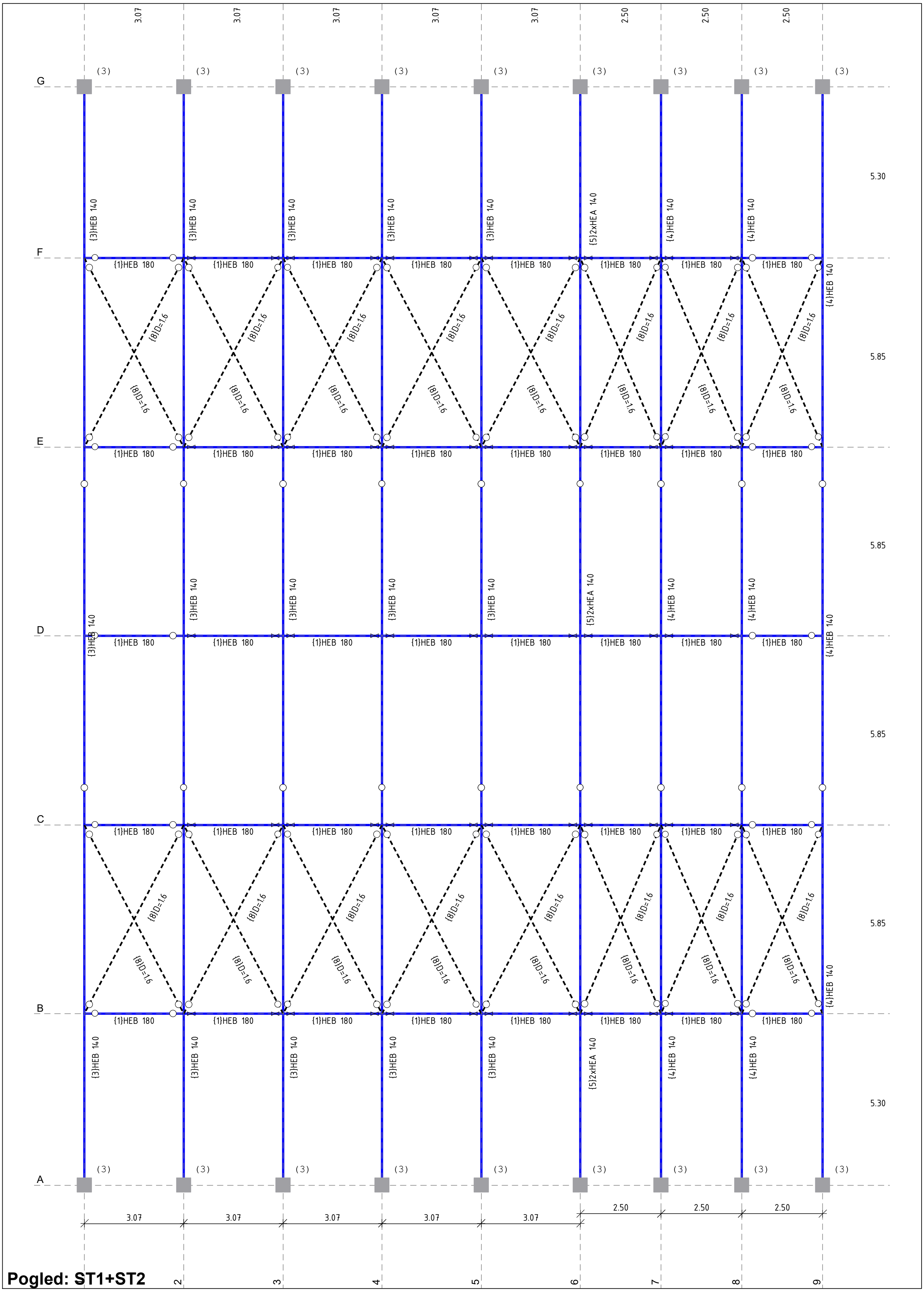
Seti točkovnih podpor

Set	K,R1	K,R2	K,R3	K,M1	K,M2	K,M3
1	1.000e+10	1.000e+10	1.000e+10			
2		1.000e+10	1.000e+10			
3	1.000e+10		1.000e+10			

TLORISNA GEOMETRIJA KOSNTRUKCIJE

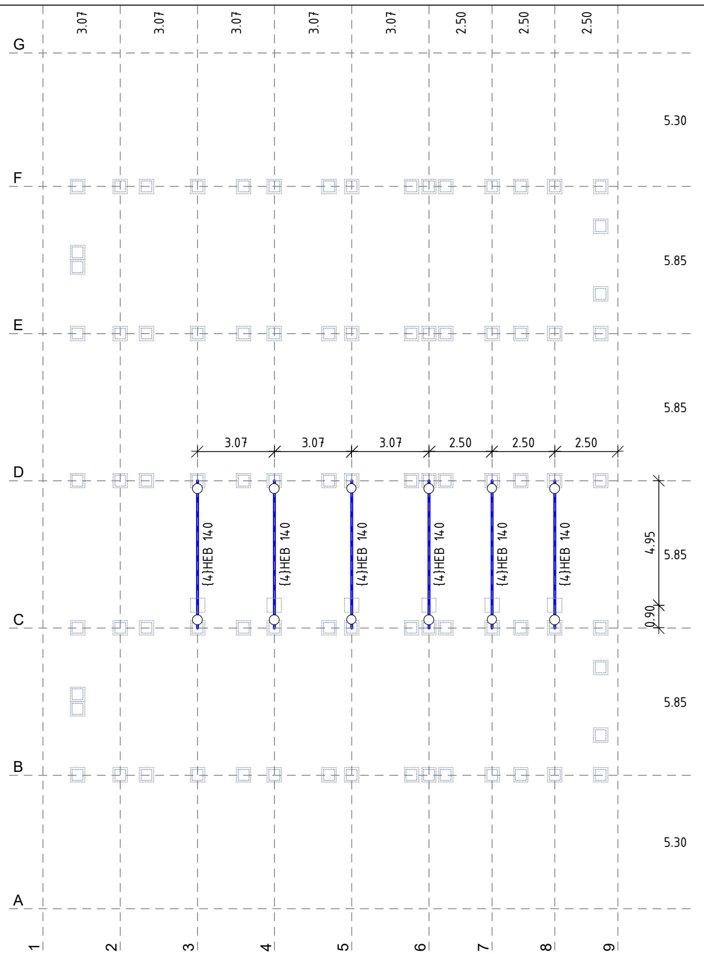


Nivo: [0.00 m]



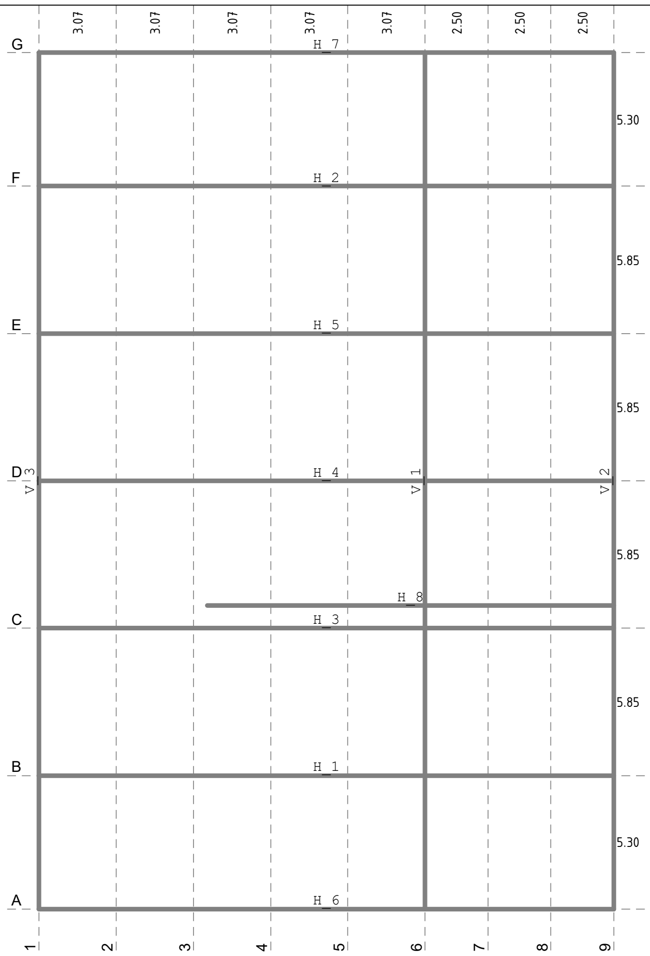
Pogled: ST1+ST2

UROŠ ŽVAN s.p., ZRKOVSKA 75, 2000 MARIBOR

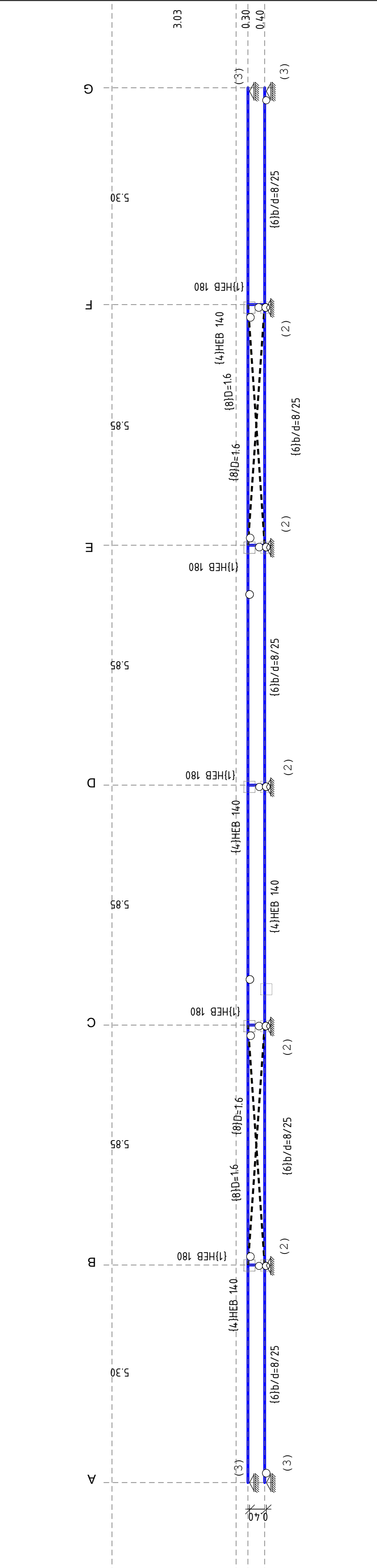


Nivo: [0.70 m]

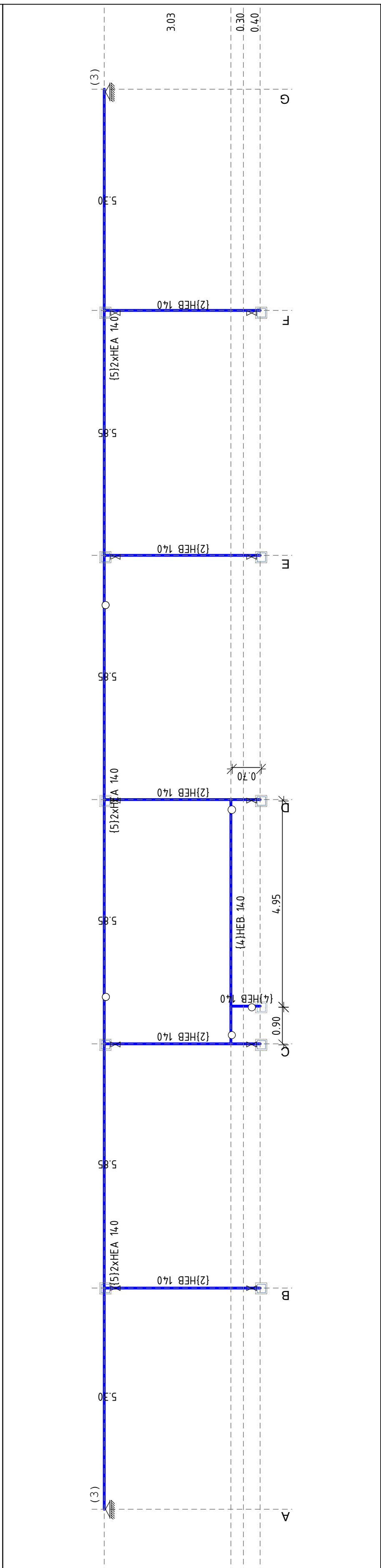
VERTIKALNA GEOMETRIJA KONSTRUKCIJE - OKVIRJI



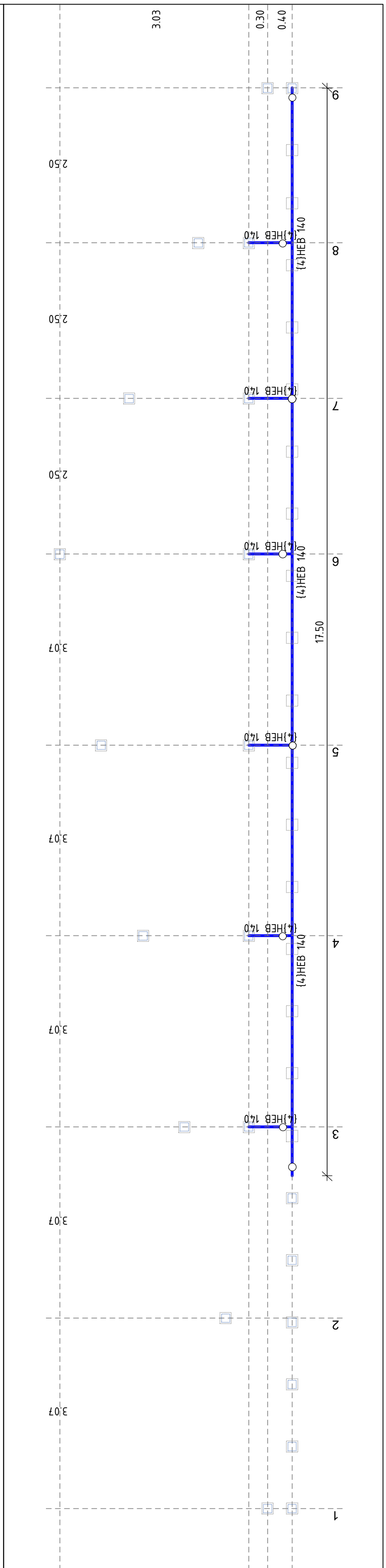
Dispozicija okvirjev



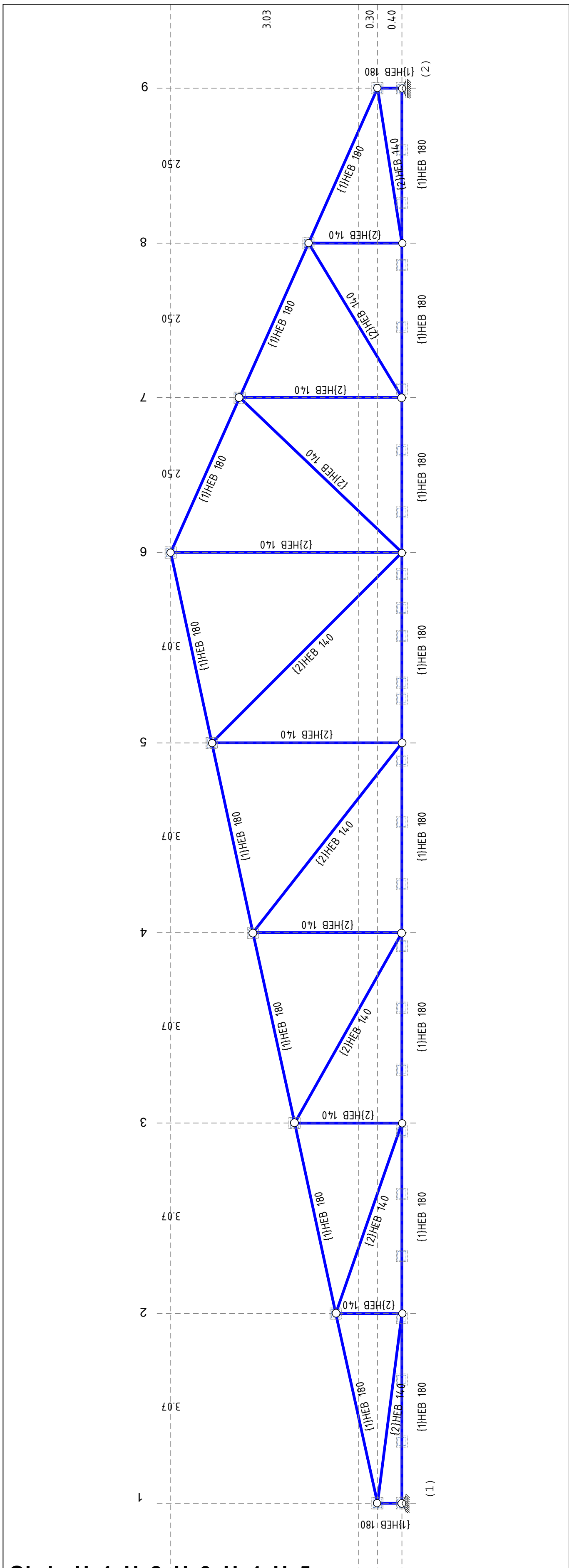
Okvir: V_2



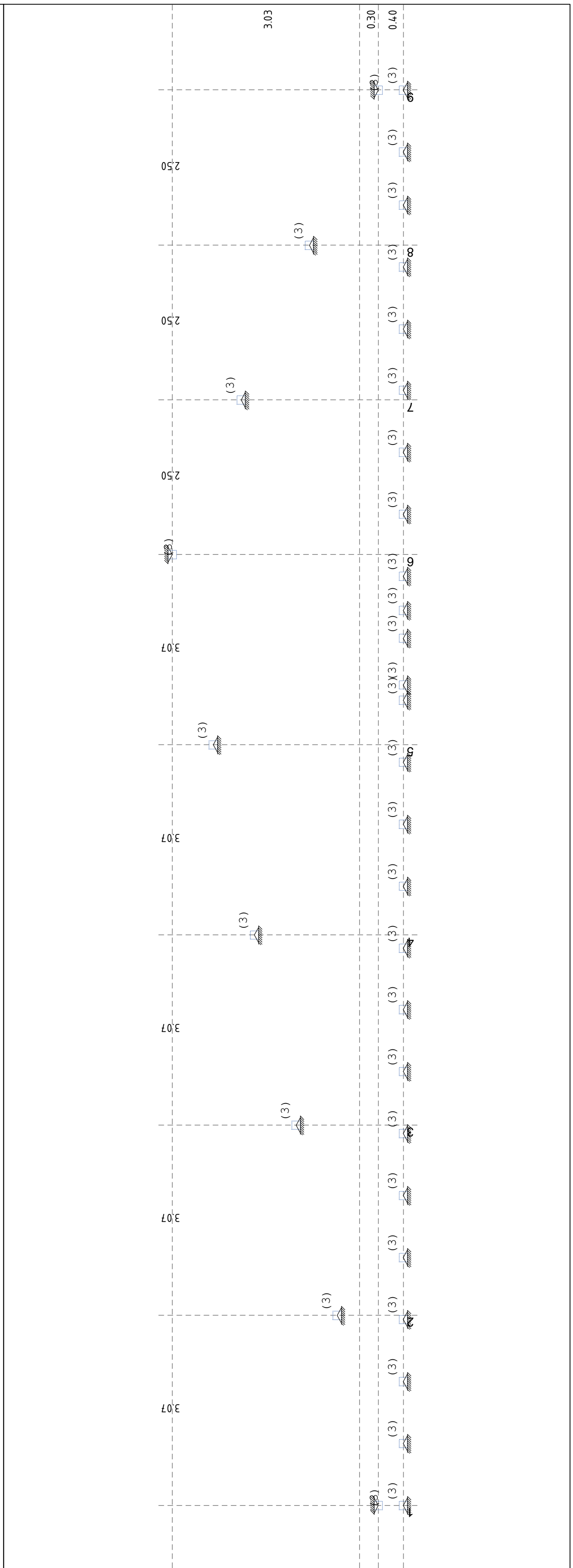
Okvir: V_1



Okvir: H_8



Okvir: H_1, H_2, H_3, H_4, H_5



Okvir: H_6, H_7

Vhodni podatki - Obtežba

Lista obtežnih primerov

LC	Naziv
1	Stalna (g)
2	Sneg1
3	Sneg2
4	Sneg3
5	Veter1 srk
6	Veter1 tlak
7	Veter2 srk
8	Veter3 srk
9	Veter3 tlak
10	Veter4 srk
11	Komb.: 1.35xI+1.5xIV+0.9xX
12	Komb.: 1.35xI+1.5xIV+0.9xIX
13	Komb.: 1.35xI+1.5xIV+0.9xVIII
14	Komb.: 1.35xI+1.5xIV+0.9xVII
15	Komb.: 1.35xI+1.5xIV+0.9xVI
16	Komb.: 1.35xI+1.5xIV+0.9xV
17	Komb.: 1.35xI+1.5xIII+0.9xX
18	Komb.: 1.35xI+1.5xIII+0.9xIX
19	Komb.: 1.35xI+1.5xIII+0.9xVIII
20	Komb.: 1.35xI+1.5xIII+0.9xVII
21	Komb.: 1.35xI+1.5xIII+0.9xVI
22	Komb.: 1.35xI+1.5xIII+0.9xV
23	Komb.: 1.35xI+1.5xII+0.9xX
24	Komb.: 1.35xI+1.5xII+0.9xIX
25	Komb.: 1.35xI+1.5xII+0.9xVIII
26	Komb.: 1.35xI+1.5xII+0.9xVII
27	Komb.: 1.35xI+1.5xII+0.9xVI
28	Komb.: 1.35xI+1.5xII+0.9xV
29	Komb.: 1.35xI+0.75xIV+1.5xX
30	Komb.: 1.35xI+0.75xIV+1.5xIX
31	Komb.: 1.35xI+0.75xIV+1.5xVIII
32	Komb.: 1.35xI+0.75xIV+1.5xVII
33	Komb.: 1.35xI+0.75xIV+1.5xVI
34	Komb.: 1.35xI+0.75xIV+1.5xV
35	Komb.: 1.35xI+0.75xIII+1.5xX
36	Komb.: 1.35xI+0.75xIII+1.5xIX
37	Komb.: 1.35xI+0.75xIII+1.5xVIII
38	Komb.: 1.35xI+0.75xIII+1.5xVII
39	Komb.: 1.35xI+0.75xIII+1.5xVI
40	Komb.: 1.35xI+0.75xIII+1.5xV
41	Komb.: 1.35xI+0.75xII+1.5xX
42	Komb.: 1.35xI+0.75xII+1.5xIX
43	Komb.: 1.35xI+0.75xII+1.5xVIII
44	Komb.: 1.35xI+0.75xII+1.5xVII
45	Komb.: 1.35xI+0.75xII+1.5xVI
46	Komb.: 1.35xI+0.75xII+1.5xV
47	Komb.: I+1.5xIV+0.9xX
48	Komb.: I+1.5xIV+0.9xIX
49	Komb.: I+1.5xIV+0.9xVIII
50	Komb.: I+1.5xIV+0.9xVII
51	Komb.: I+1.5xIV+0.9xVI
52	Komb.: I+1.5xIV+0.9xV
53	Komb.: I+1.5xIII+0.9xX
54	Komb.: I+1.5xIII+0.9xIX
55	Komb.: I+1.5xIII+0.9xVIII
56	Komb.: I+1.5xIII+0.9xVII
57	Komb.: I+1.5xIII+0.9xVI
58	Komb.: I+1.5xIII+0.9xV
59	Komb.: I+1.5xII+0.9xX
60	Komb.: I+1.5xII+0.9xIX
61	Komb.: I+1.5xII+0.9xVIII
62	Komb.: I+1.5xII+0.9xVII
63	Komb.: I+1.5xII+0.9xVI
64	Komb.: I+1.5xII+0.9xV
65	Komb.: I+0.75xIV+1.5xX
66	Komb.: I+0.75xIV+1.5xIX
67	Komb.: I+0.75xIV+1.5xVIII
68	Komb.: I+0.75xIV+1.5xVII
69	Komb.: I+0.75xIV+1.5xVI
70	Komb.: I+0.75xIV+1.5xV
71	Komb.: I+0.75xIII+1.5xX
72	Komb.: I+0.75xIII+1.5xIX
73	Komb.: I+0.75xIII+1.5xVIII
74	Komb.: I+0.75xIII+1.5xVII

LC	Naziv
75	Komb.: I+0.75xIII+1.5xVI
76	Komb.: I+0.75xIII+1.5xV
77	Komb.: I+0.75xII+1.5xX
78	Komb.: I+0.75xII+1.5xIX
79	Komb.: I+0.75xII+1.5xVIII
80	Komb.: I+0.75xII+1.5xVII
81	Komb.: I+0.75xII+1.5xVI
82	Komb.: I+0.75xII+1.5xV
83	Komb.: 1.35xI+1.5xX
84	Komb.: 1.35xI+1.5xIX
85	Komb.: 1.35xI+1.5xVIII
86	Komb.: 1.35xI+1.5xVII
87	Komb.: 1.35xI+1.5xVI
88	Komb.: 1.35xI+1.5xV
89	Komb.: 1.35xI+1.5xIV
90	Komb.: 1.35xI+1.5xIII
91	Komb.: 1.35xI+1.5xII
92	Komb.: I+1.5xX
93	Komb.: I+1.5xIX
94	Komb.: I+1.5xVIII
95	Komb.: I+1.5xVII
96	Komb.: I+1.5xVI
97	Komb.: I+1.5xV
98	Komb.: I+1.5xIV
99	Komb.: I+1.5xIII
100	Komb.: I+1.5xII
101	Komb.: 1.35xI
102	Komb.: I
103	Komb.: I+II
104	Komb.: I+III
105	Komb.: IV
106	Komb.: I+IV
107	Komb.: I+V
108	Komb.: II+V
109	Komb.: I+II+V
110	Komb.: III+V
111	Komb.: I+III+V
112	Komb.: IV+V
113	Komb.: I+IV+V
114	Komb.: I+VI
115	Komb.: II+VI
116	Komb.: I+II+VI
117	Komb.: III+VI
118	Komb.: I+III+VI
119	Komb.: IV+VI
120	Komb.: I+IV+VI
121	Komb.: I+VII
122	Komb.: II+VII
123	Komb.: I+II+VII
124	Komb.: III+VII
125	Komb.: I+III+VII
126	Komb.: IV+VII
127	Komb.: I+IV+VII
128	Komb.: I+VIII
129	Komb.: II+VIII
130	Komb.: I+II+VIII
131	Komb.: III+VIII
132	Komb.: I+III+VIII
133	Komb.: IV+VIII
134	Komb.: I+IV+VIII
135	Komb.: I+IX
136	Komb.: II+IX
137	Komb.: I+II+IX
138	Komb.: III+IX
139	Komb.: I+III+IX
140	Komb.: IV+IX
141	Komb.: I+IV+IX
142	Komb.: I+X
143	Komb.: II+X
144	Komb.: I+II+X
145	Komb.: III+X
146	Komb.: I+III+X
147	Komb.: IV+X
148	Komb.: I+IV+X

VPLIVI NA KONSTRUKCIJO

STALNI VPLIVI:

STREHA

- Sendvič panel debeline 120	0,25 kN/m^2
- SKUPAJ brez lastne teže	0,25 kN/m^2

STROP

- lesena podkonstrukcija	0,30 kN/m^2
- TI 250mm	0,10 kN/m^2
- Gips požarno odporna plošča + CD profili	0,20 kN/m^2
- Vezana ploščpa + lesena podkosntrukcija	0,15 kN/m^2
- SKUPAJ brez lastne teže	0,75 kN/m^2

ZAVESA

- zavesa 1,00 kN/m'/ 2	0,50 kN/m'

VRVI (postavljene na razmiku 1 m, 6 vrvi)

- vrvi za plezanje (vertikalno)	2,00 kN
- vrvi za plezanje (horizontalno)	0,90 kN

KOŠ

- koš za košarko 12 kN/4 ležišča(vertikalno)	3,00 kN
- koš za košarko 1 kN/4 ležišča(horizontalno)	0,25 kN

SPREMENLJIVIV VPLIVI:

STREHE

- sneg (210 m n.m.v., cona A2, □=0,8)	1,15 kN/m^2
sneg □=0,8*0,5	0,58 kN/m^2

- VETER - posebej opisan na naslednji strni

UROŠ ŽVAN s.p., ZRKOVSKA 75, 2000 MARIBOR

OSNOVNE VREDNOSTI OBTEŽBE VETRA

V SKLADU S SIST EN 1991-1-4:2005

Osnovna hitrost vetra:

Področje

večina Slovenije

Hitrosti vetra:

Cona 1 (večina Slovenije):
20 m/s pod 800m
25 m/s od 800 m do 1600 m
30 m/s od 1600 m do 2000 m
40 m/s nad 2000 m

Cona 2 (Trnovski gozd, Notranjska, Karavanke):
25m/s pod 1600 m
30 m/s od 1600 do 2000 m
40 m/s nad 2000 m

Cona 3 (Primorje, Kras in del Vipavske doline):
30 m/s

Nadmorska višina	**210**	m

Temeljna osnovna hitrost vetra

Vb,0=	**20,00**	**m/s**
Cdir=	1,00	faktor smeri
Csesaon=	1,00	faktor letnega časa

Osnovna hitrost vetra je:

Vb=	**20,00**	**m/s**

Srednji veter

Kategorija terena

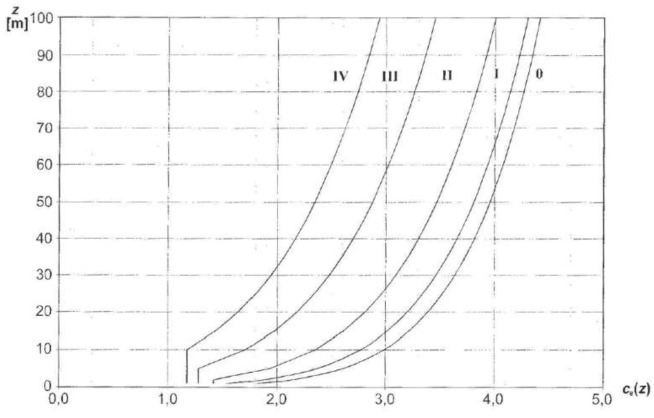
Področja z običajnim rastlinjem in stavbami ali s posameznimi ovirami na razdaliji največ 20 višin ovir (vasi, podeželje, gozd)

Višina nad tlemi [h]	Z_e =	**13,50**	m
Kat II, refer. vrednost	$z_{0,II}$ =	0,05	m
Hrapavostna dolžina	z_0 =	0,300	m
Najmanjša višina	z_{min} =	5,00	m
Največja višina	z_{max} =	18,00	m
Faktor terena	k_r =	0,22	
Faktor hrapavosti	$C_r(z)$=	**0,82**	
Srednja hitrost vetra	$v_m(z)$=	**16,40**	m/s

Vetrna turbolenca	$I_v(z)$=	**0,26**	
Osnovni tlak	q_b =	**0,25**	kN/m^2
Tlak pri največjih sunkih	$q_p(z)$=	**0,48**	kN/m^2
Faktor izpostavljenosti	$C_e(z)$=	**1,91**	

Preglednica 4.1: Kategorije terena in terenski parametri

Kategorija terena	z_0 m	z_{min} m
0 Morsko ali obalno področje, izpostavljeno proti odprtemu morju	0,003	1
I Jezersko ali ravninsko področje z zanemarljivim rastlinjem in brez ovir	0,01	1
II Področje z nizkim rastlinjem (trava) in posameznimi ovirami (drevesi, stavbami) na razdalji najmanj 20 višin ovir	0,05	2
III Področja z običajnim rastlinjem ali stavbami ali s posameznimi ovirami na razdalji največ 20 višin ovir (vasi, podeželsko okolje, stalni gozd)	0,3	5
IV Področje, kjer je najmanj 15 % površine pokrite s stavbami s povprečno višino več kot 15 m	1,0	10
OPOMBA: Kategorije terena so ilustrirane v A.1.		



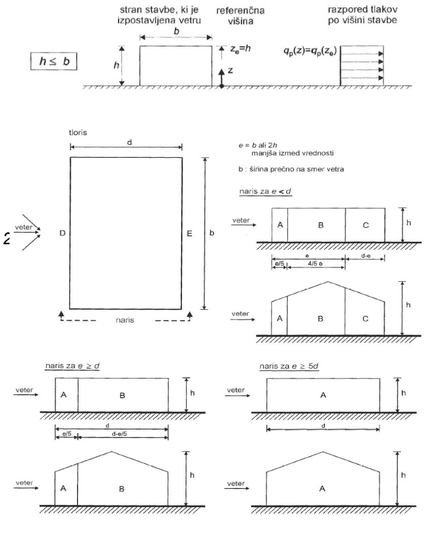
Slika 4.2: Diagrami faktorja izpostavljenosti $c_e(z)$ za c_O = 1,0, k_I = 1,0

Preračun vetra za obremenitev vetra na strešne nosilce

PRITISK VETRA NA STENE

V SKLADU S SIST EN 1991-1-4:2005

Referenčna višina nad tlemi	$Z_e = h =$	**13,50**	*m*
Višina objekta	$h =$	13,50	*m*
Širina prečno na veter	$b =$	34,00	*m*
Dolžina v smeri vetra	$d =$	23,60	*m*
	$h/d=$	0,57	
Tlak pri največjih sunkih vetra	$q_p(Z)$	**0,64**	kN/m^2
Razmerja:	$h \leq b$	**DA**	
	$b < h \leq 2b$	**NE**	
	$h > 2b$	**NE**	
Cone:	$e =$	27,00	*m*
	$e/5 =$	5,40	*m*
	$4/5\ e =$	21,60	*m*
	$d - e =$	-3,40	*m*



Slika 7.5: Razdelitev sten na področja

Referenčna višina stavbe h ≤ b

Zunanji pritiski vetra po conah		A srk	B srk	C	D pritisk	E srk
$h \leq b$	$C_{pe,10}$	-1,20	-0,80	/	0,74	-0,39
$w_e = C_{pe} \cdot q_p(Z)$ [kN/m2]	$w_e =$	**-0,76**	**-0,51**	**/**	**0,47**	**-0,25**

Kombinacija zunanjih in notranjih pristiskov

Ekstremne vrednosti notranjih pritiskov

Notranji pritisk	C_{pi}	0
Notranji srk	C_{pi}	0

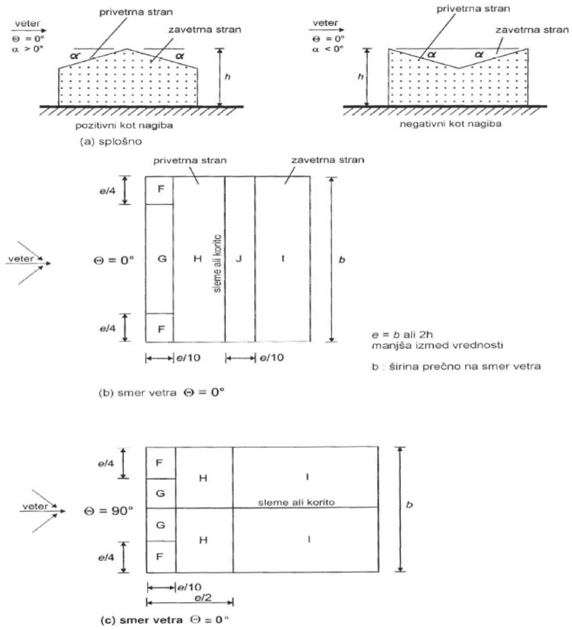
Zunanji pritiski/srki+ notranji pritiski vetra po conah		A srk	B srk	C	D pritisk	E srk
$h \leq b$	$C_{pe,10}$	-1,20	-0,80	/	0,74	-0,39
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	$w_e =$	**-0,76**	**-0,51**	**/**	**0,47**	**-0,25**

Zunanji pritiski/srki+ notranji srki vetra po conah		A srk	B srk	C	D pritisk	E srk
$h \leq b$	$C_{pe,10}$	-1,20	-0,80	/	0,74	-0,39
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	$w_e =$	**-0,76**	**-0,51**	**/**	**0,47**	**-0,25**

PRITISK VETRA NA STREHO DVOKAPNICO

V SKLADU S SIST EN 1991-1-4:2005

Referenčna višina nad tlemi	$Z_e = h =$	**13,50**	*m*
Višina objekta	***h* =**	13,50	*m*
Širina prečno na veter	***b* =**	34,00	*m*
Dolžina v smeri vetra	***d* =**	23,60	*m*
Tlak pri največjih sunkih vetra	$q_p(Z)$	**0,64**	kN/m^2
Nagib strehe	***α* =**	**15,00**	°
Dimenzije con	***e* =**	27,00	*m*
	***e/4* =**	6,75	*m*
	***b* - 2 • *e/4* =**	20,50	*m*
	***e/10* =**	2,70	*m*
	***e/2* =**	13,50	*m*



Slika 7.8: Razdelitev dvokapnice na področja

Veter pravokotno na kap

Θ = 0°

Zunanji pritiski vetra po conah		**F**		**G**		**H**		**I**		**J**	
		srk	pritisk	srk	pritisk	srk	pritisk	srk	srk	srk	srk
Nagib strehe α = 15	$C_{pe,10}$	-0,90	0,20	-0,80	0,20	-0,30	0,20	-0,40	0,00	-1,00	0,00
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	w_e =	**-0,57**	**0,13**	**-0,51**	**0,13**	**-0,19**	**0,13**	**-0,25**	**/**	**-0,64**	**/**

Veter vzporedno s kapom

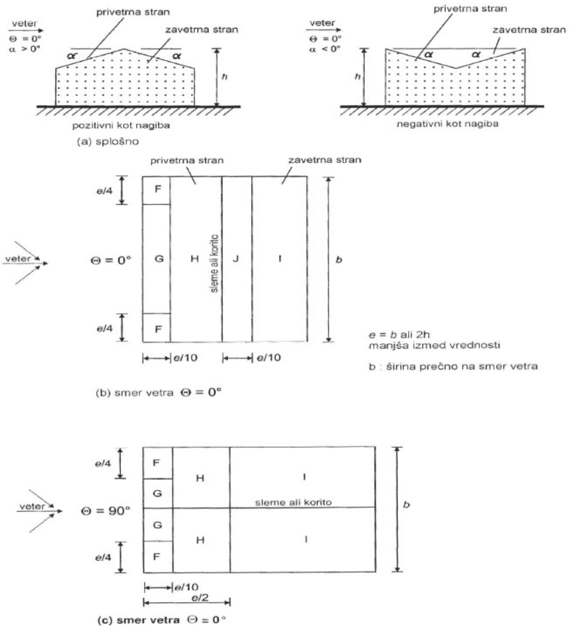
Θ = 90°

Zunanji pritiski vetra po conah		**F**	**G**	**H**	**I**
		srk	srk	srk	srk
Nagib strehe α = 15	$C_{pe,10}$	-1,30	-1,30	-0,60	-0,50
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	w_e =	**-0,83**	**-0,83**	**-0,38**	**-0,32**

PRITISK VETRA NA STREHO DVOKAPNICO

V SKLADU S SIST EN 1991-1-4:2005

Referenčna višina nad tlemi	$Z_e = h =$	**13,50**	*m*
Višina objekta	$h =$	13,50	*m*
Širina prečno na veter	$b =$	34,00	*m*
Dolžina v smeri vetra	$d =$	23,60	*m*
Tlak pri največjih sunkih vetra	$q_p(Z)$	**0,64**	kN/m^2
Nagib strehe	$\alpha =$	**26,00**	°
Dimenzije con	$e =$	27,00	*m*
	$e/4 =$	6,75	*m*
	$b - 2 \cdot e/4 =$	20,50	*m*
	$e/10 =$	2,70	*m*
	$e/2 =$	13,50	*m*



Slika 7.8: Razdelitev dvokapnice na področja

Veter pravokotno na kap

Θ = 0°

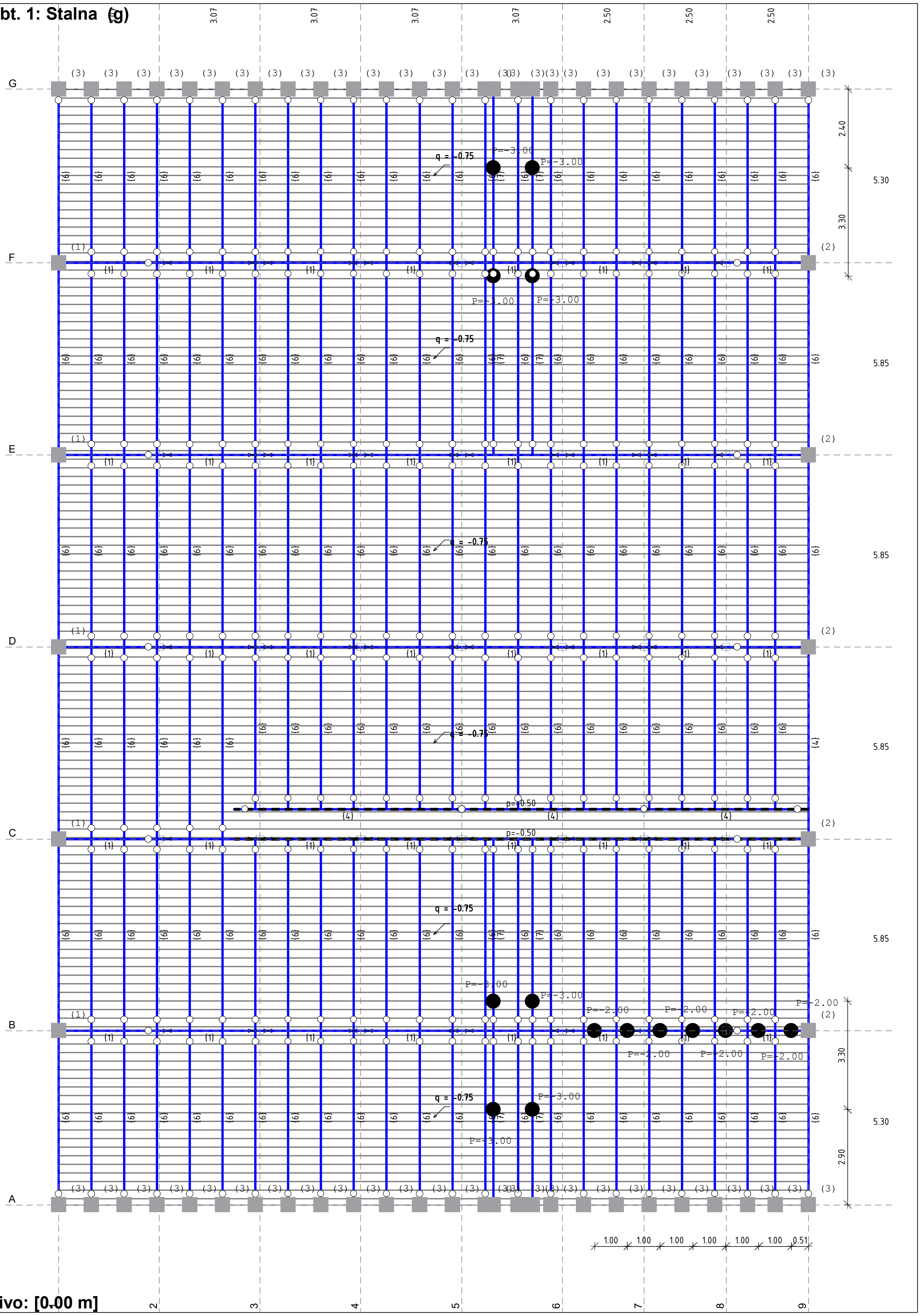
Zunanji pritiski vetra po conah		F		G		H		I		J	
		srk	pritisk	srk	pritisk	srk	pritisk	srk	srk	srk	srk
Nagib strehe α = 26	$C_{pe,10}$	-0,61	0,57	-0,58	0,35	-0,23	0,35	-0,40	0,00	-0,63	0,00
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	$w_e =$	**-0,39**	**0,36**	**-0,37**	**0,22**	**-0,14**	**0,22**	**-0,25**	**/**	**-0,40**	**/**

Veter vzporedno s kapom

Θ = 90°

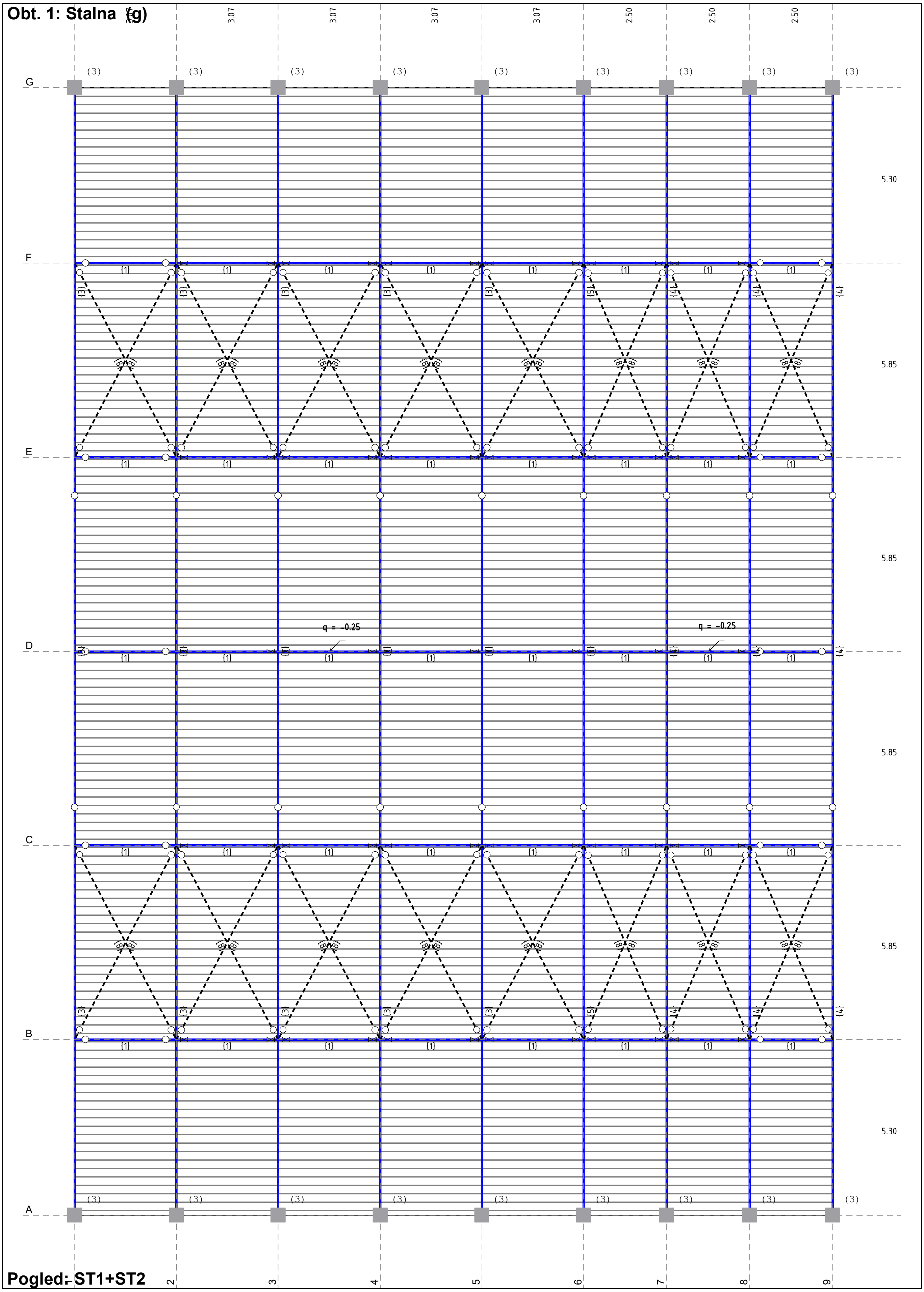
Zunanji pritiski vetra po conah		F	G	H	I
		srk	srk	srk	srk
Nagib strehe α = 26	$C_{pe,10}$	-1,15	-1,37	-0,75	-0,50
$w_e = Cp_e \cdot q_p(Z)$ [kN/m2]	$w_e =$	**-0,73**	**-0,87**	**-0,48**	**-0,32**

Obt. 1: Stalna (g)



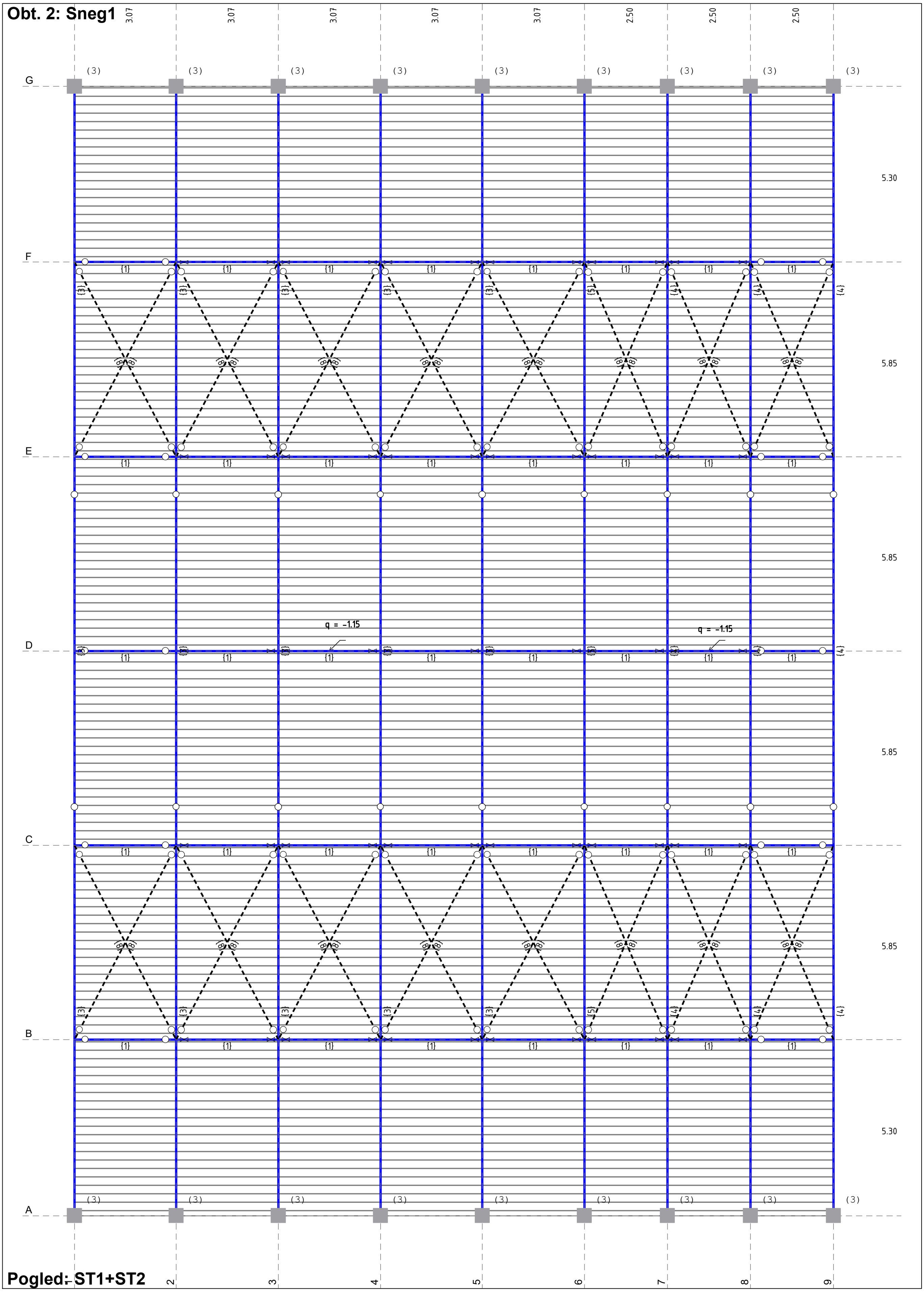
Nivo: [0.00 m]

Obt. 1: Stalna (g)



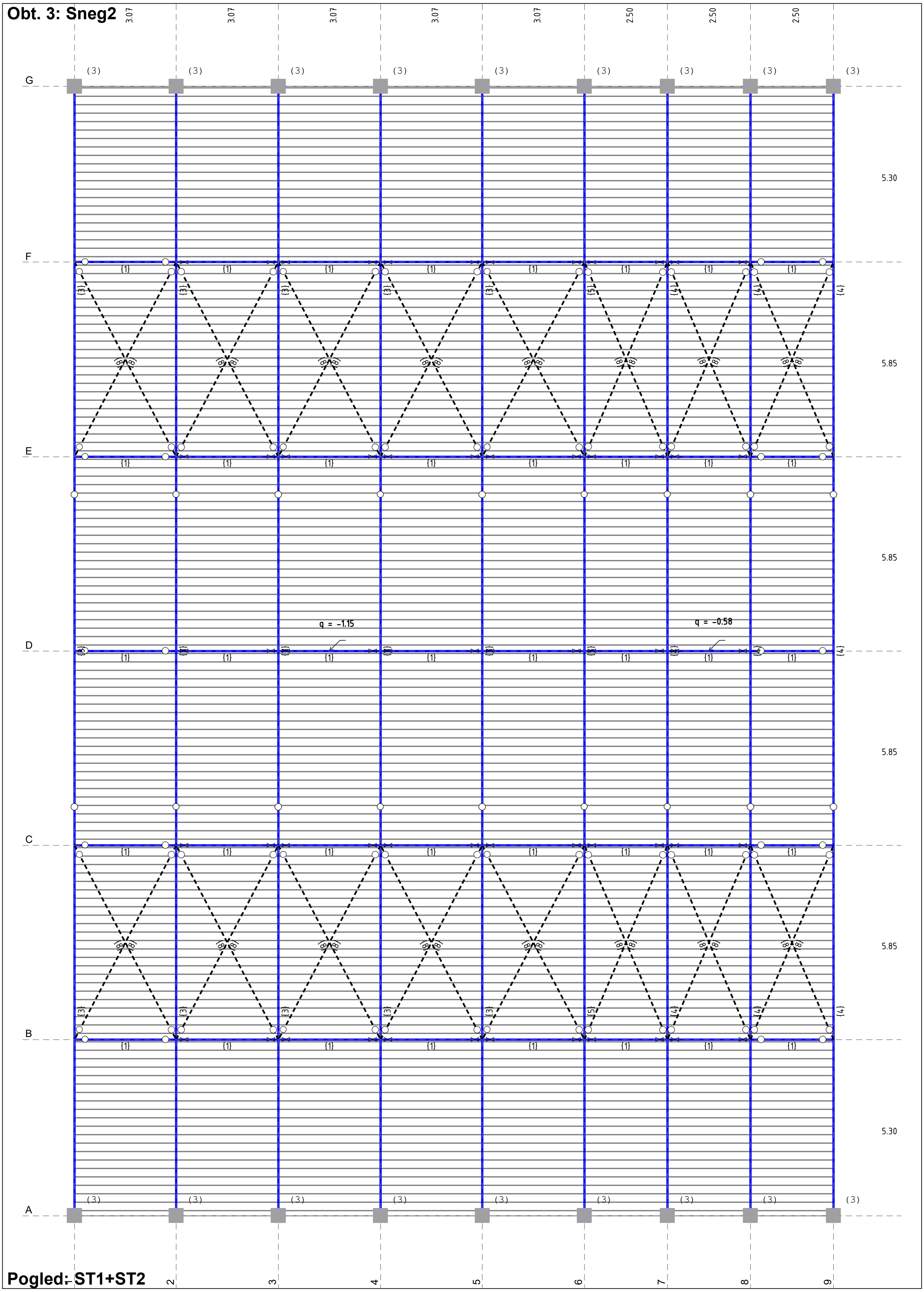
Pogled: ST1+ST2

Obt. 2: Sneg1



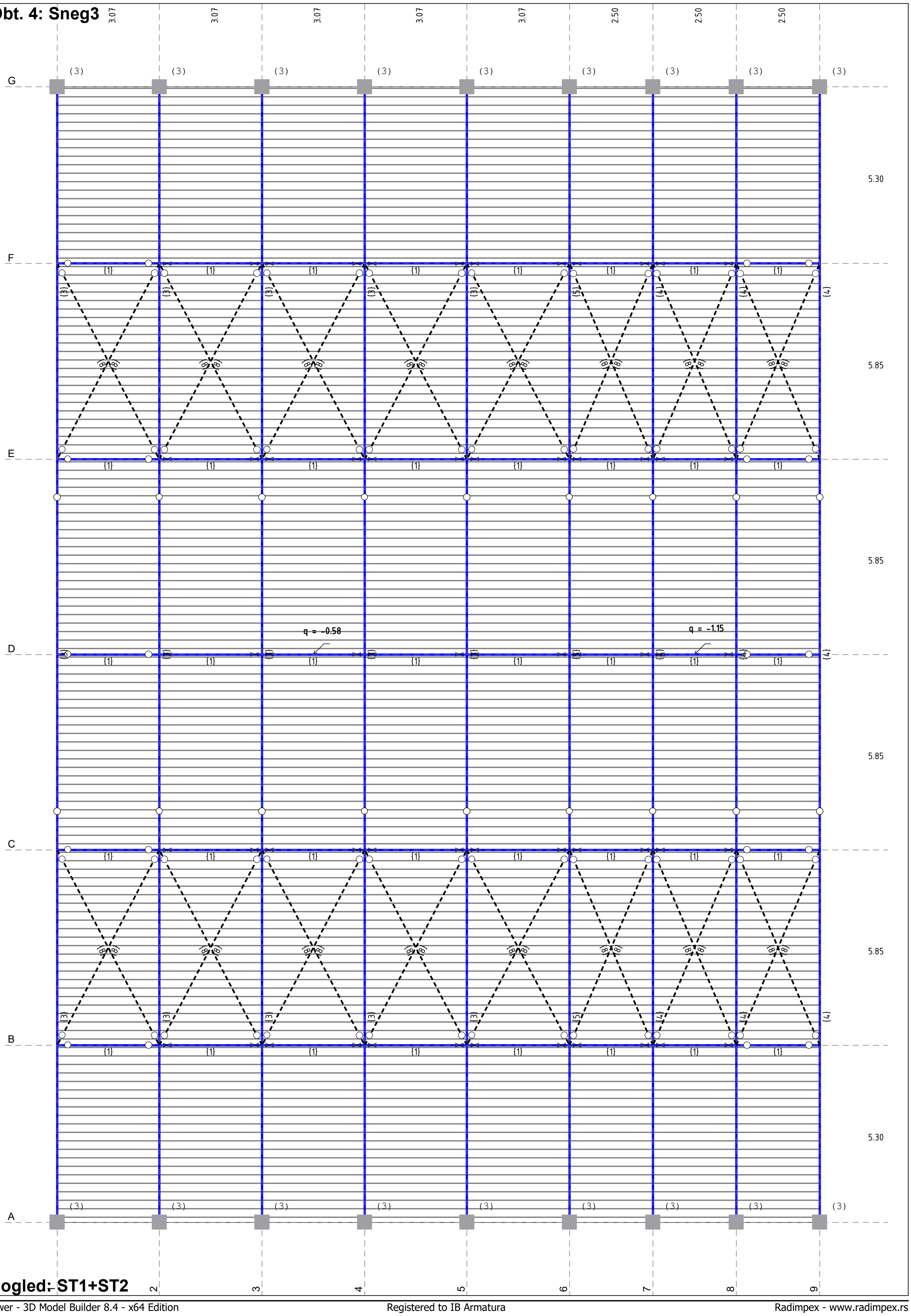
Pogled: ST1+ST2

Obt. 3: Sneg2



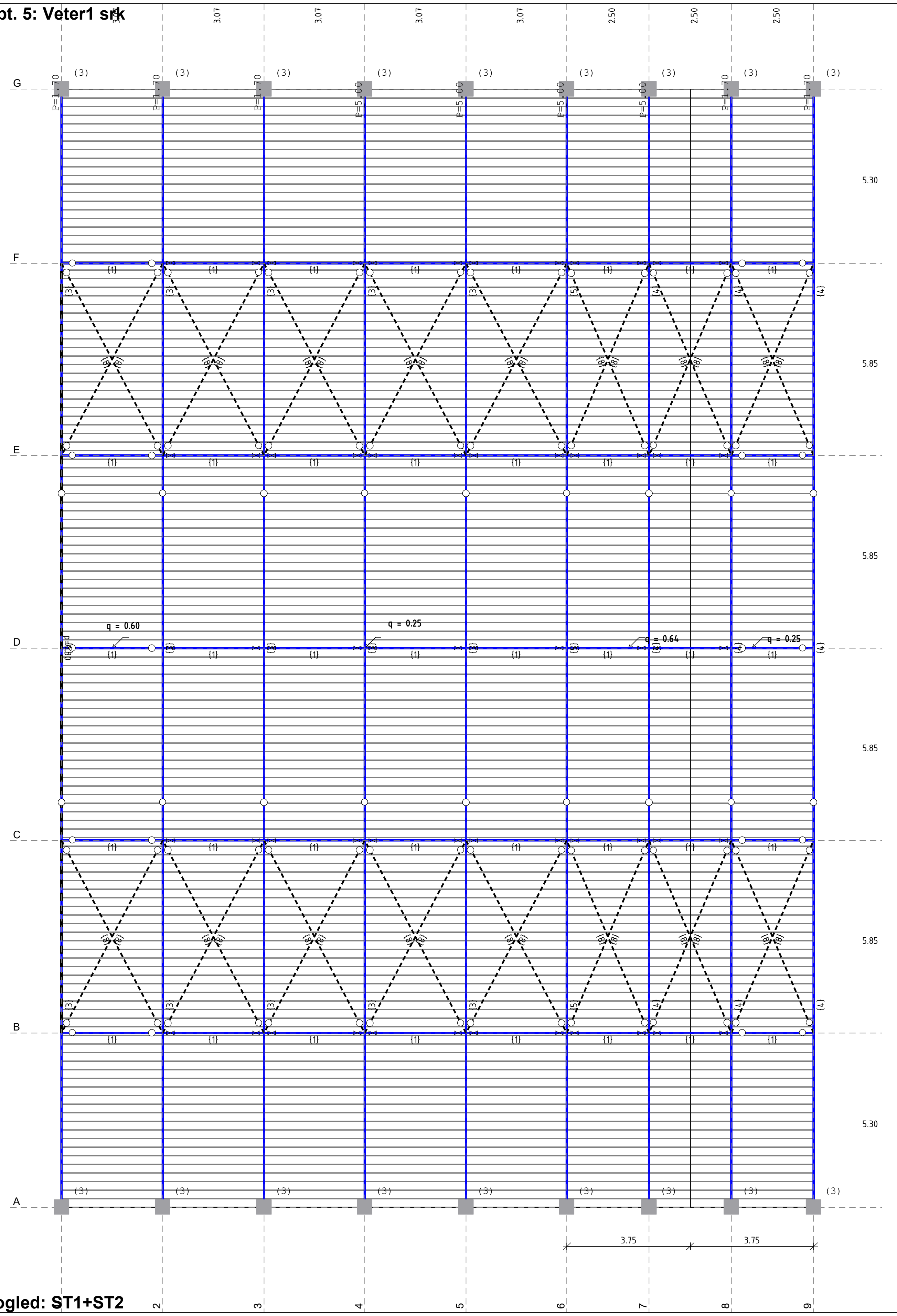
Pogled: ST1+ST2

Obt. 4: Sneg3



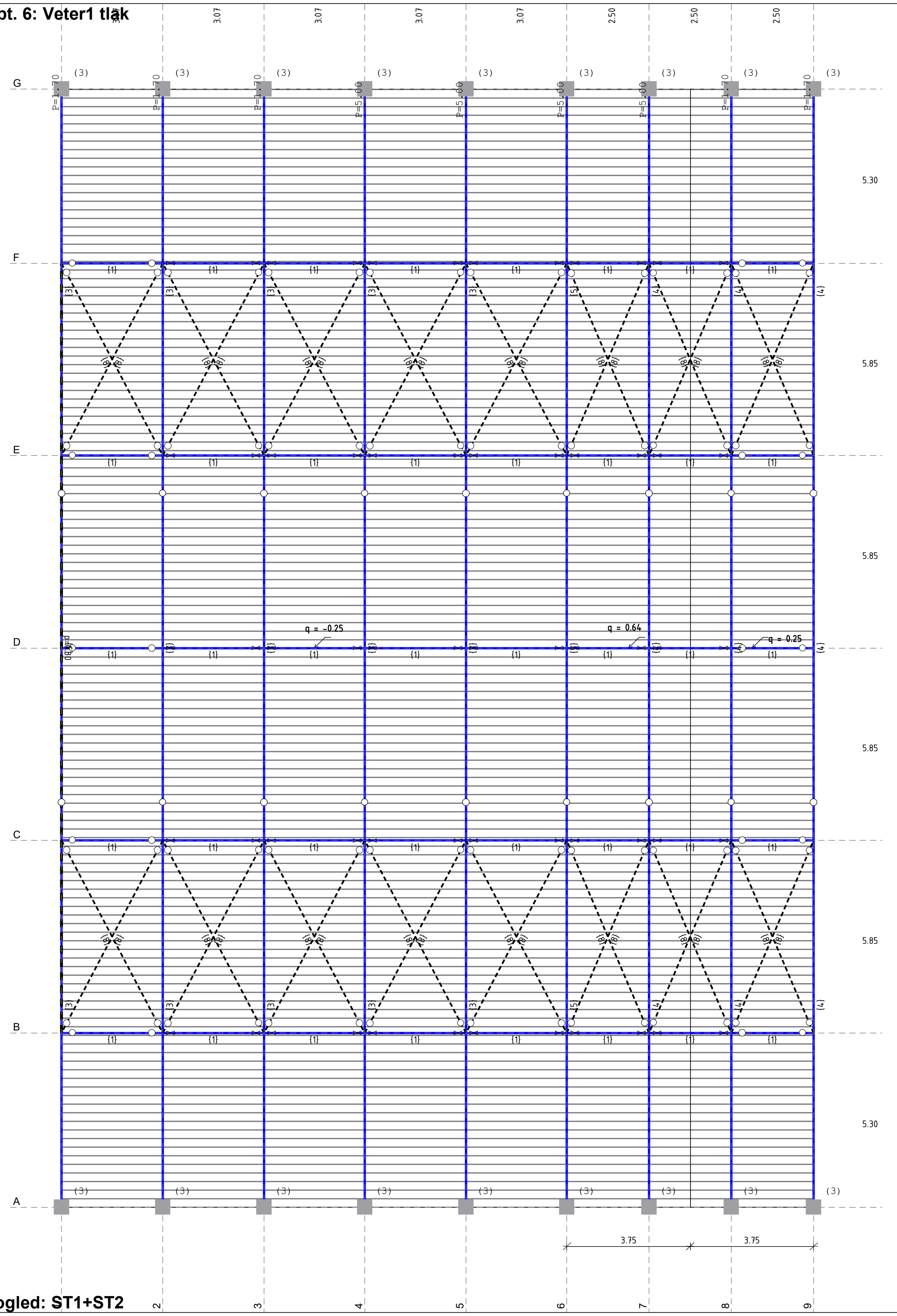
Pogled: ST1+ST2

Obt. 5: Veter1 srk



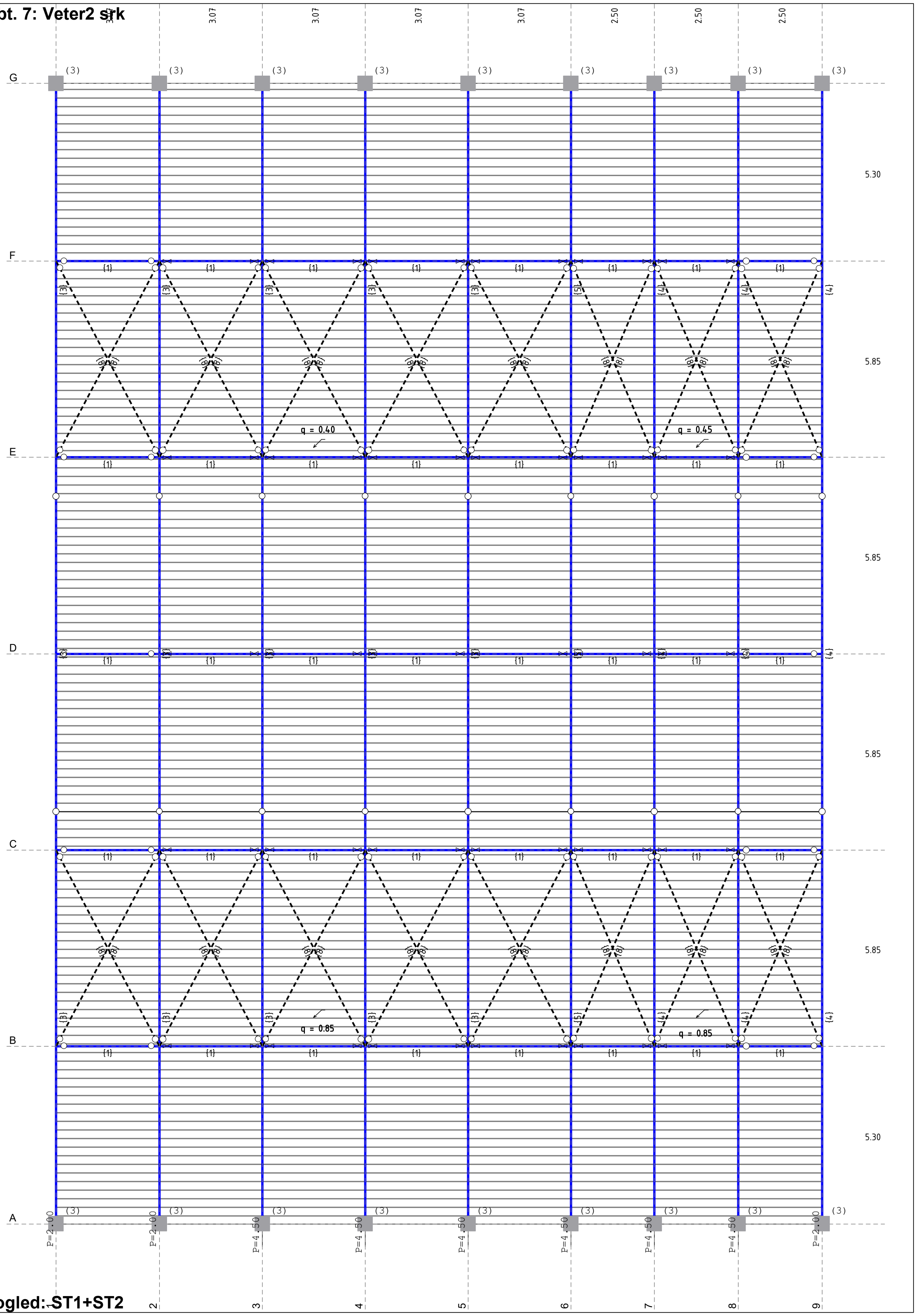
Pogled: ST1+ST2

Obt. 6: Veter1 tlak



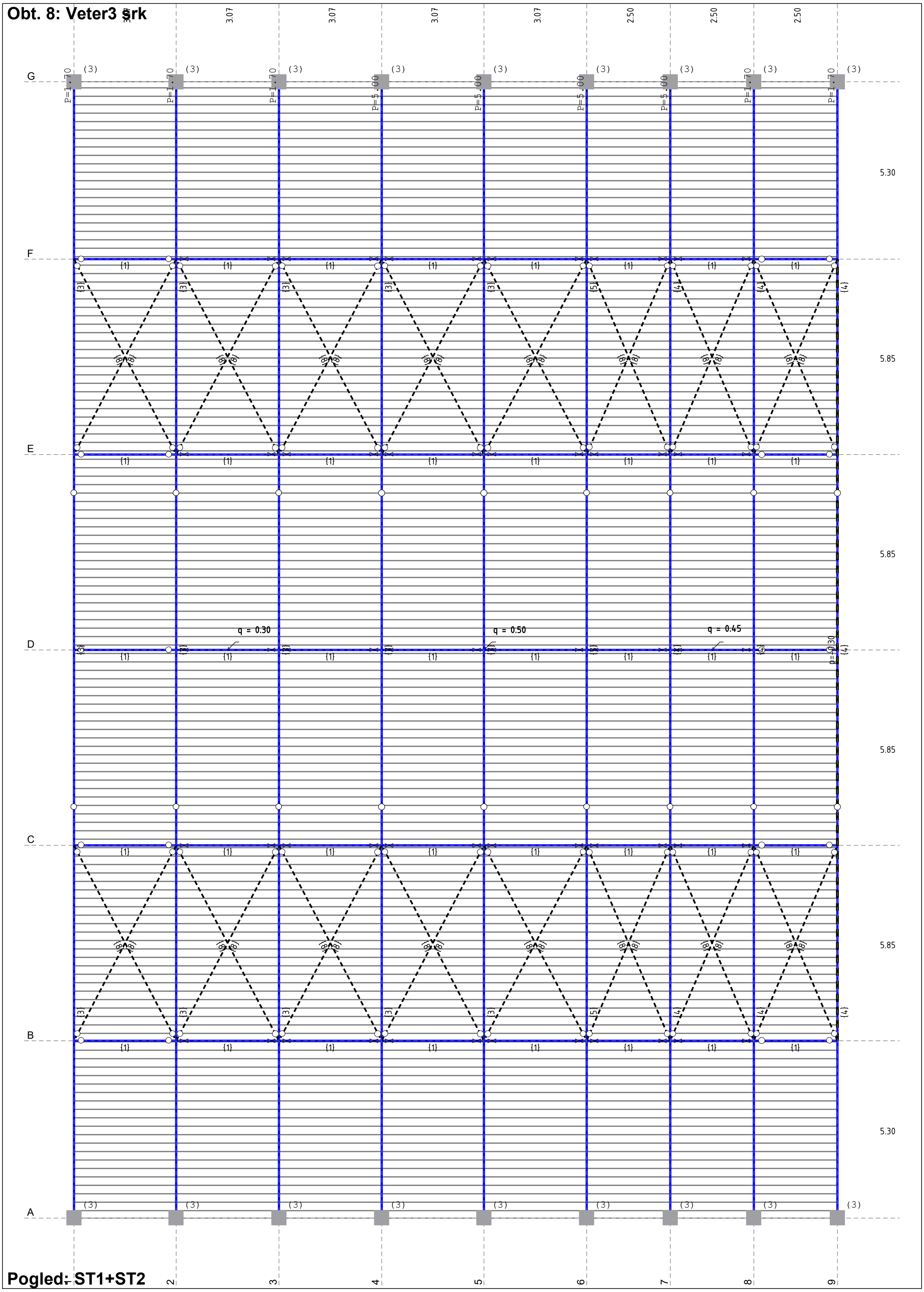
Pogled: ST1+ST2

Obt. 7: Veter2 srk



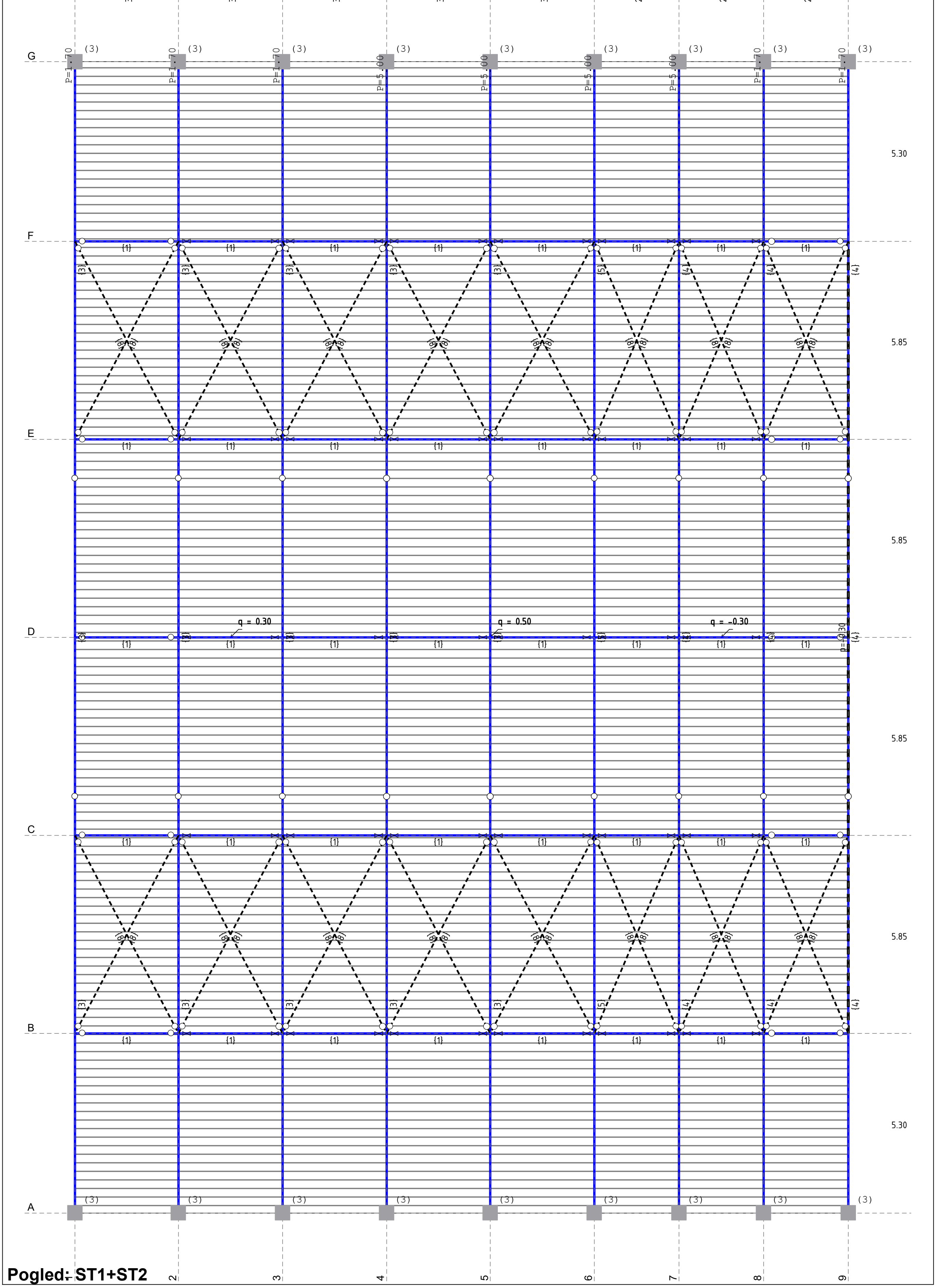
Pogled: ST1+ST2

Obt. 8: Veter3 šrk



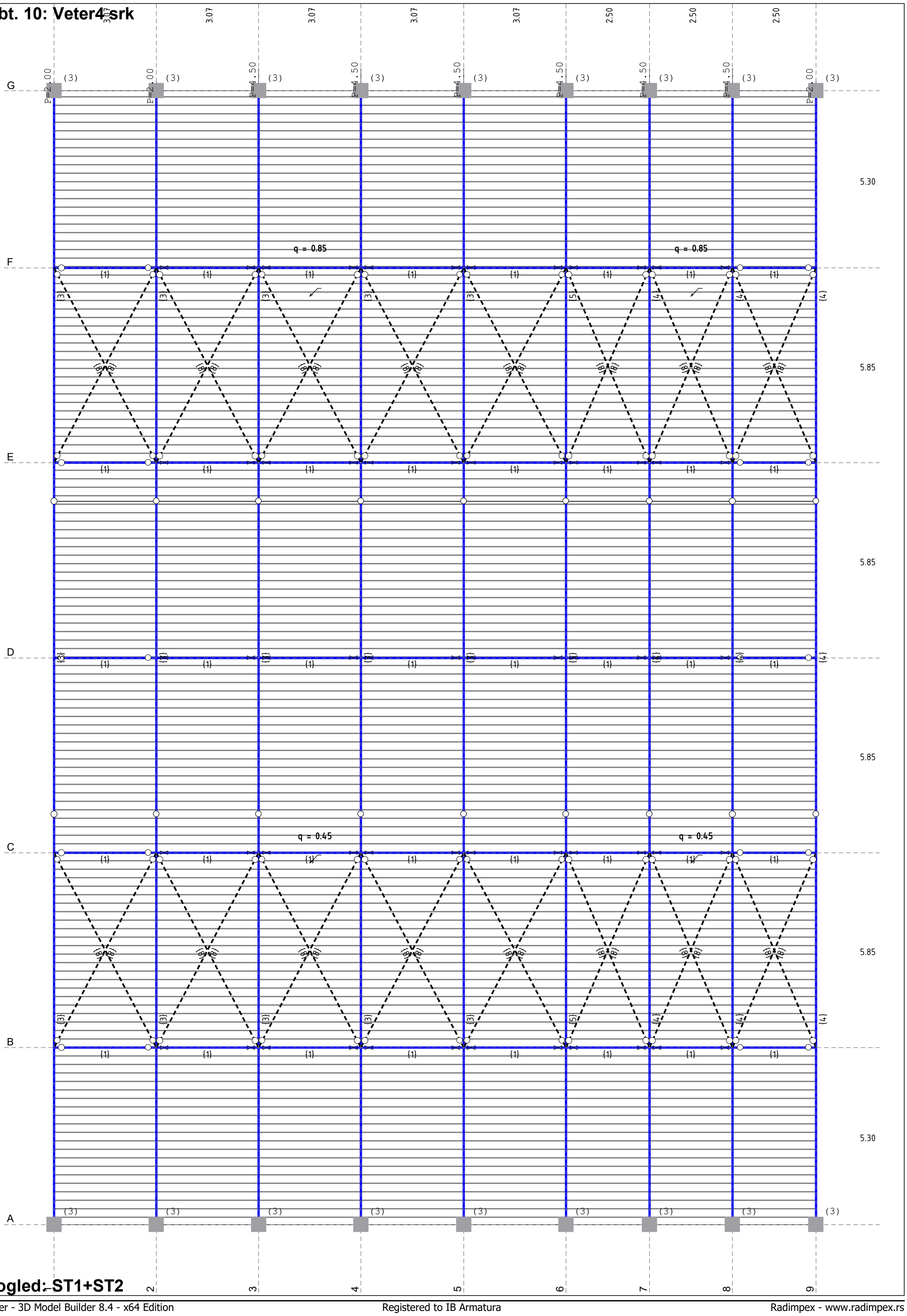
Pogled: ST1+ST2

Obt. 9: Veter3 tlak



Pogled: ST1+ST2

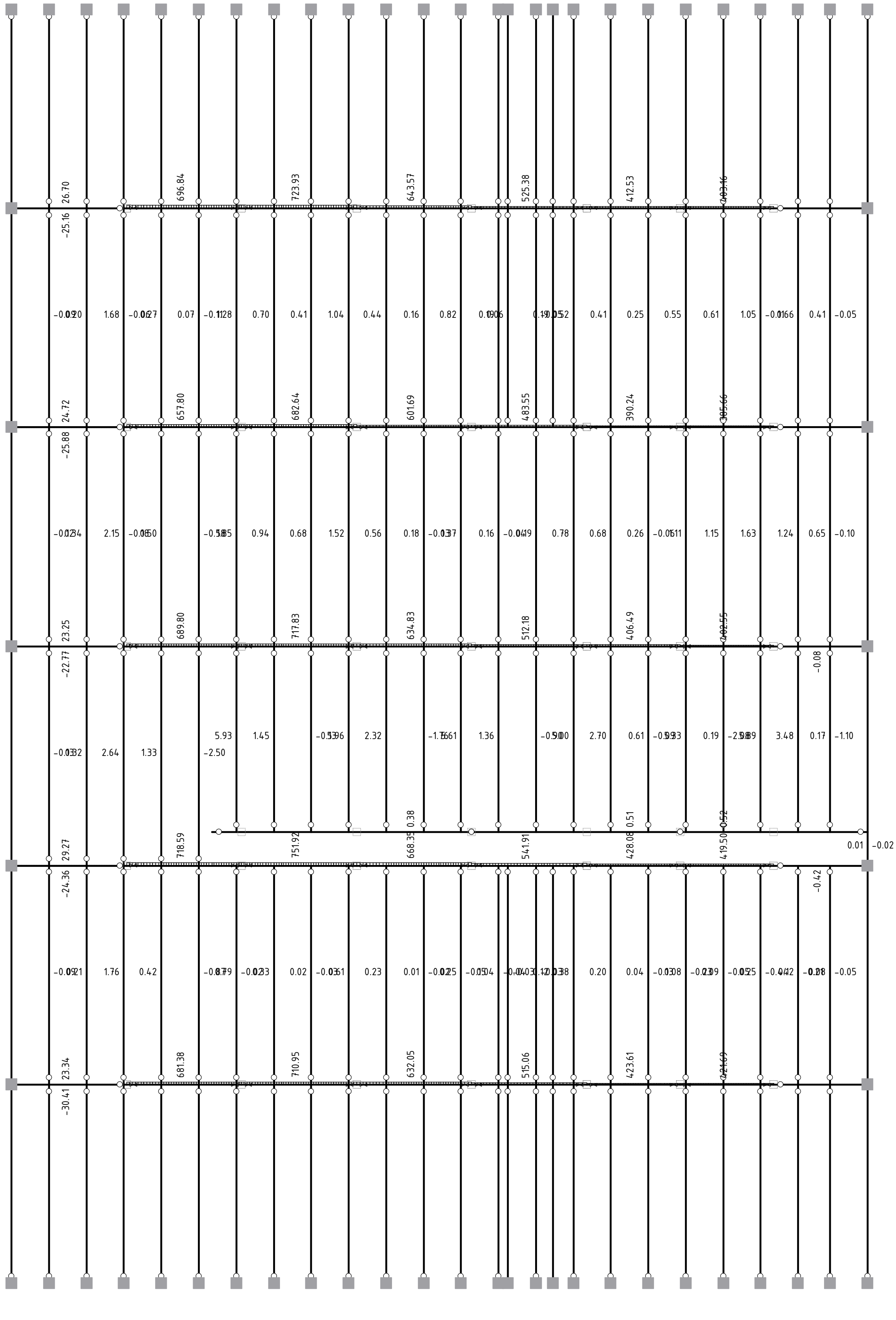
Obt. 10: Veter4 srk



Pogled: ST1+ST2

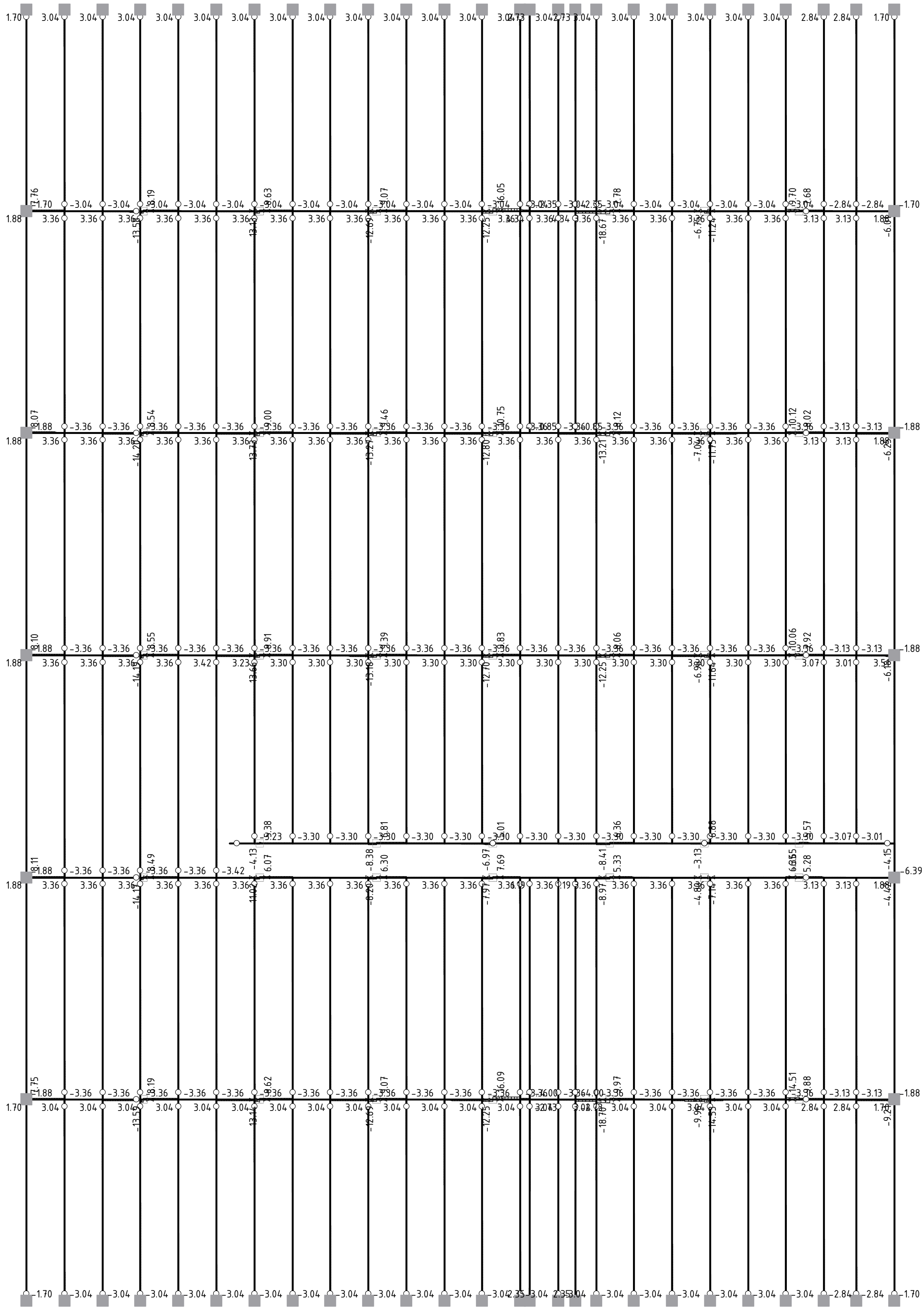
Statični preračun

Obt. 149: [MSN] 11-101



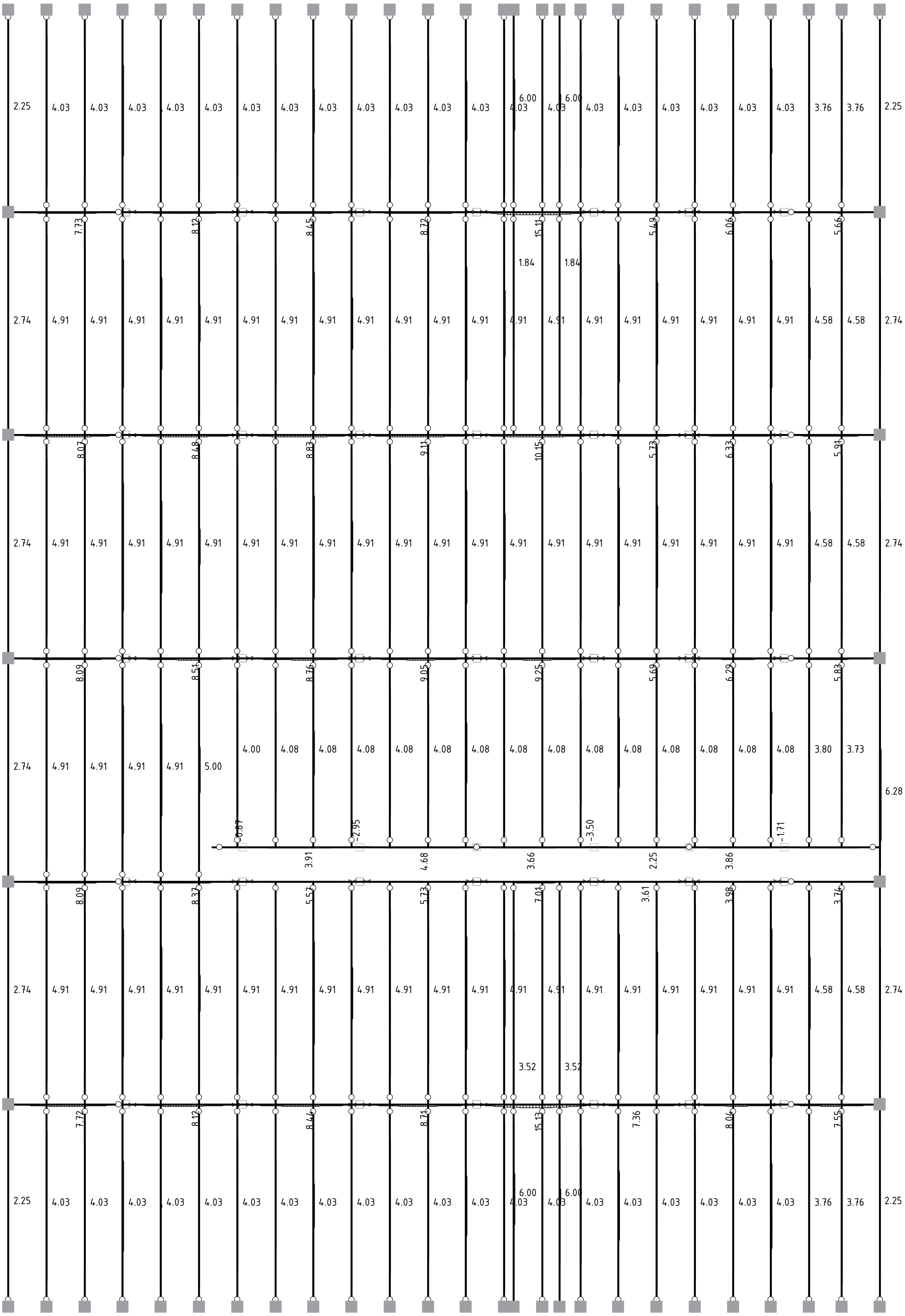
Nivo: [0.00 m]
Vplivi v gredi: max N1= 751.92 / min N1= -30.41 kN

Obt. 149: [MSN] 11-101



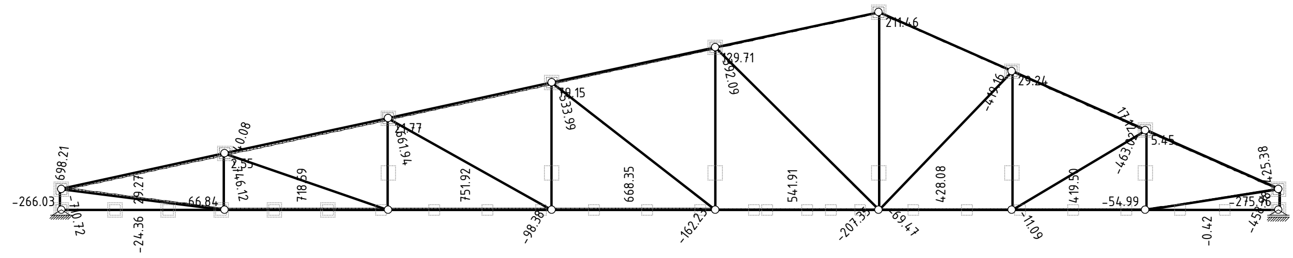
Nivo: [0.00 m]
Vplivi v gredi: max T2= 16.09 / min T2= -18.70 kN

Obt. 149: [MSN] 11-101



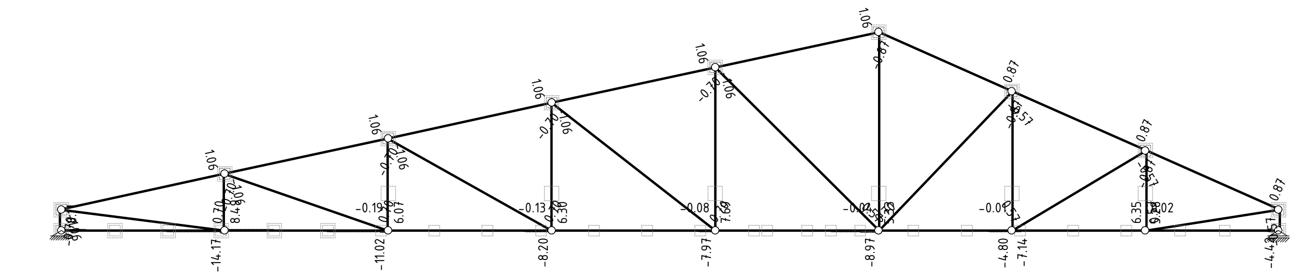
Nivo: [0.00 m]
Vplivi v gredi: max M3= 15.13 / min M3= -3.50 kNm

Obt. 149: [MSN] 11-101



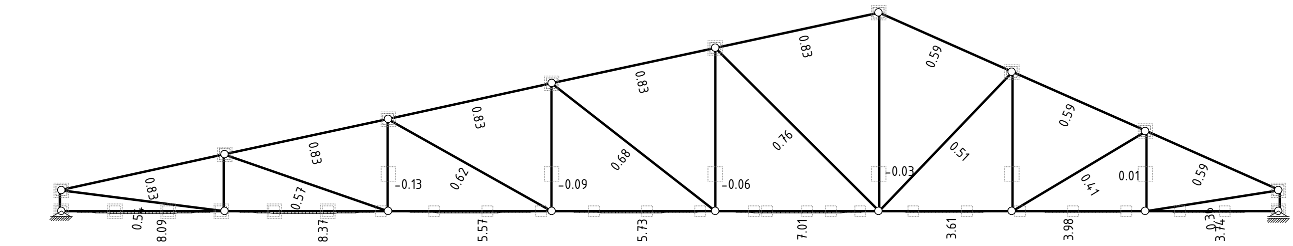
Okvir: H_3
Vplivi v gredi: max N1= 751.92 / min N1= -746.12 kN

Obt. 149: [MSN] 11-101



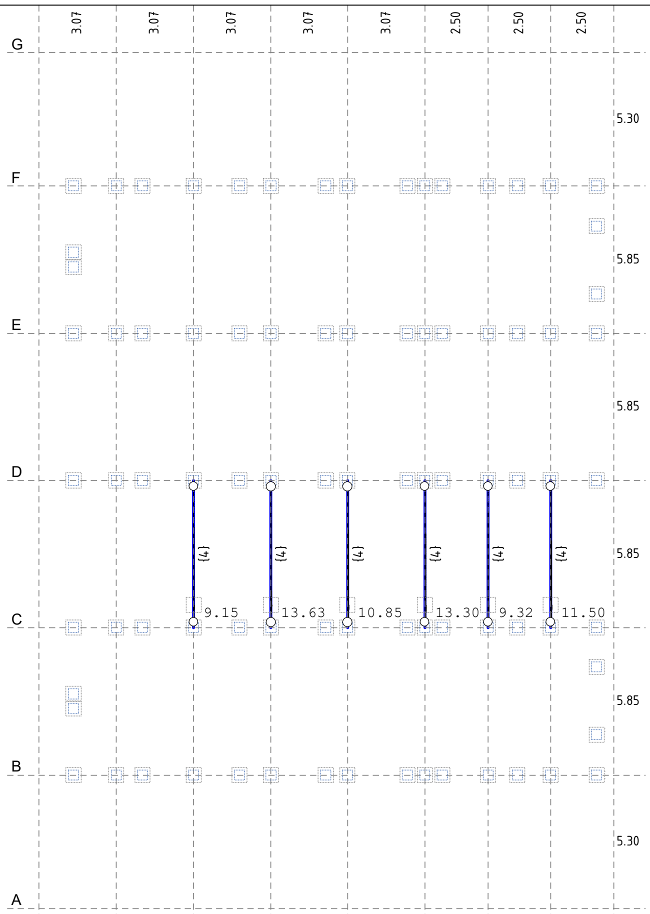
Okvir: H_3
Vplivi v gredi: max T2= 8.49 / min T2= -14.17 kN

Obt. 149: [MSN] 11-101



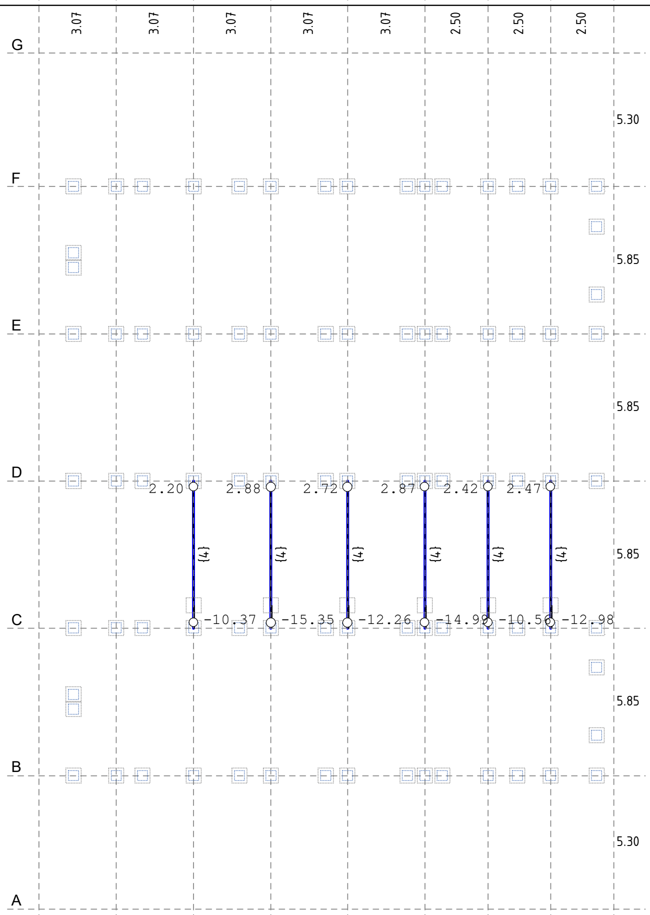
Okvir: H_3
Vplivi v gredi: max M3= 8.37 / min M3= -0.13 kNm

Obt. 149: [MSN] 11-101



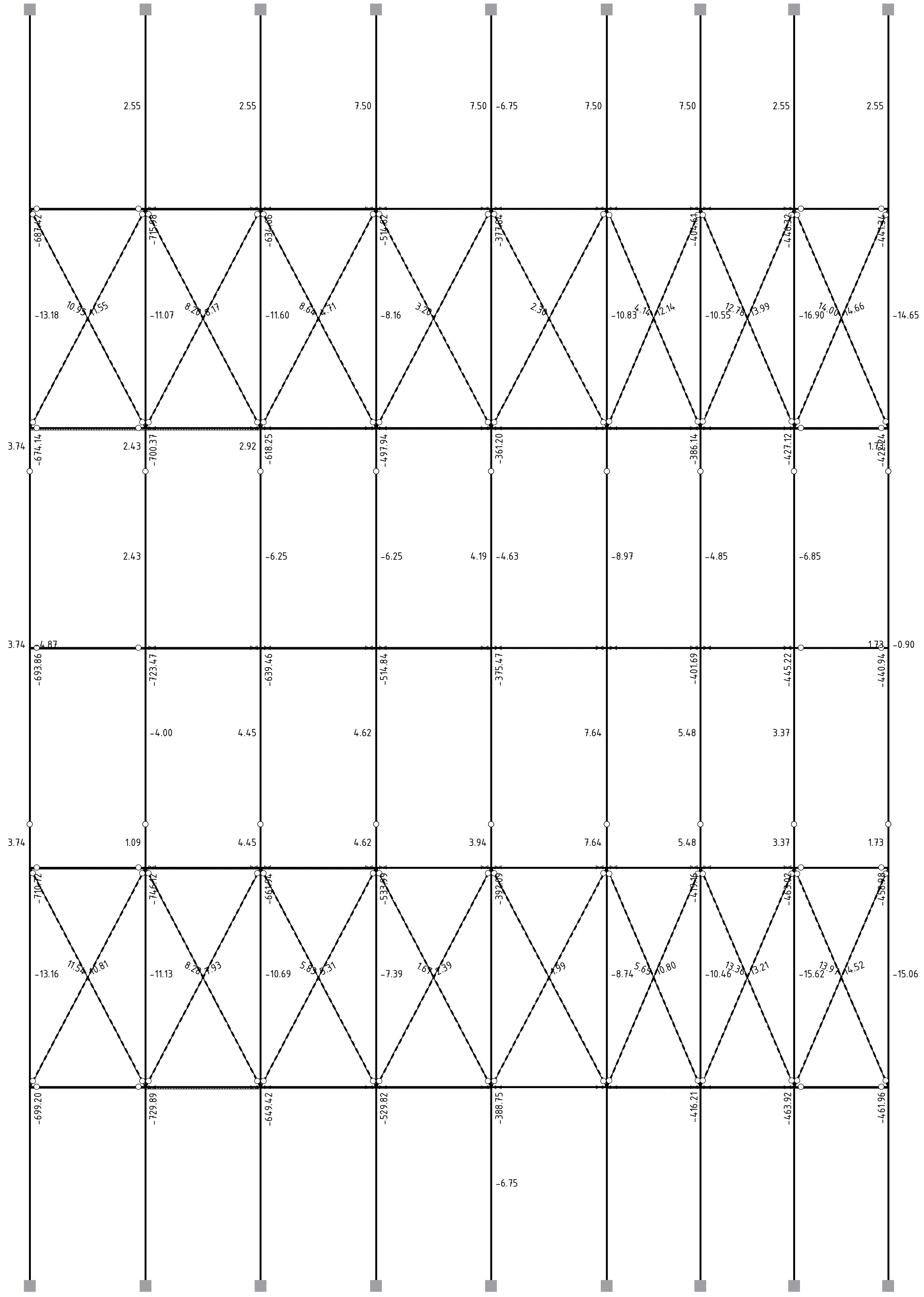
Nivo: [0.70 m]
Vplivi v gredi: max M3= 13.63 / min M3= 0.00 kNm

Obt. 149: [MSN] 11-101



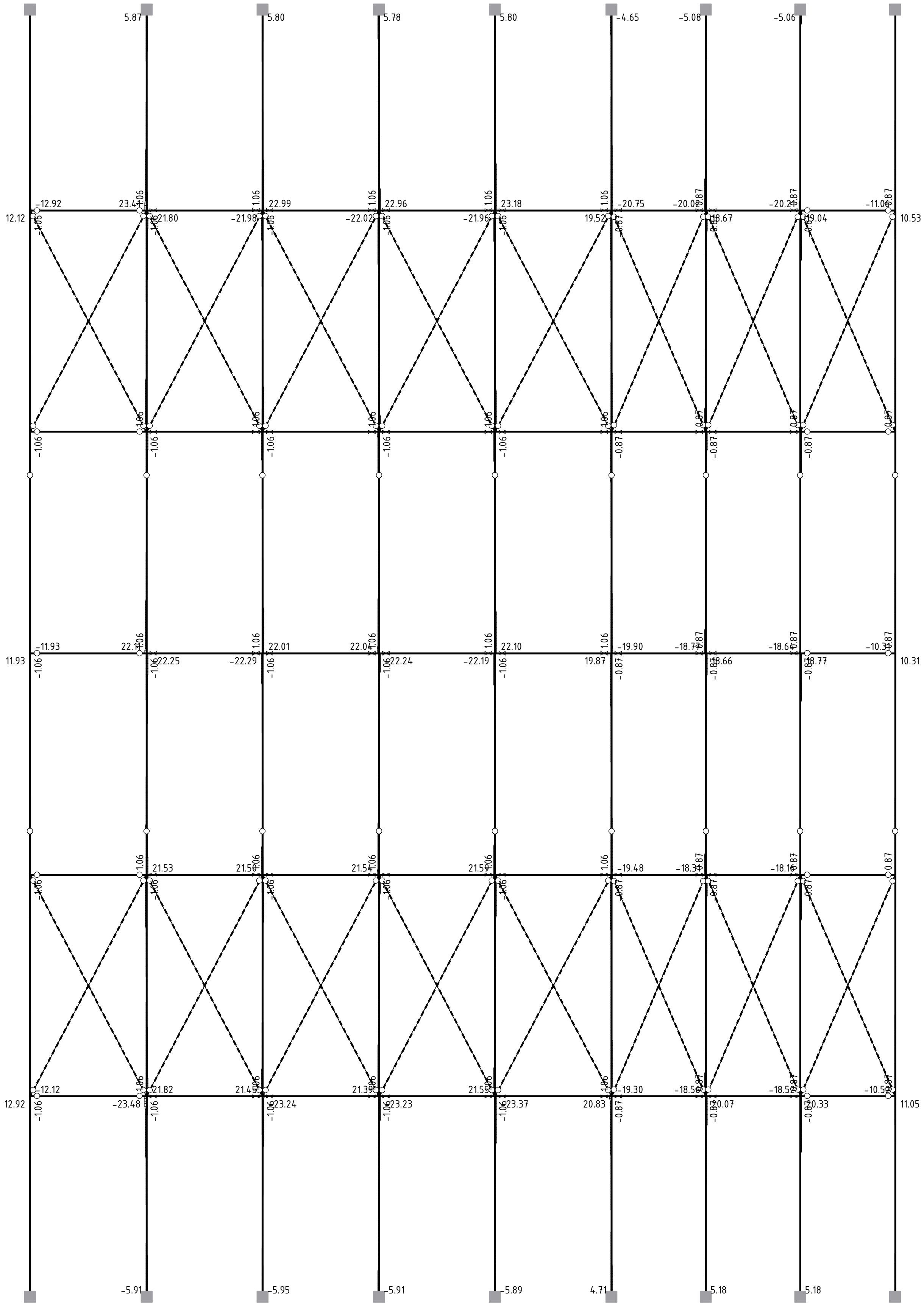
Nivo: [0.70 m]
Vplivi v gredi: max T2= 2.88 / min T2= -15.35 kN

Obt. 149: [MSN] 11-101



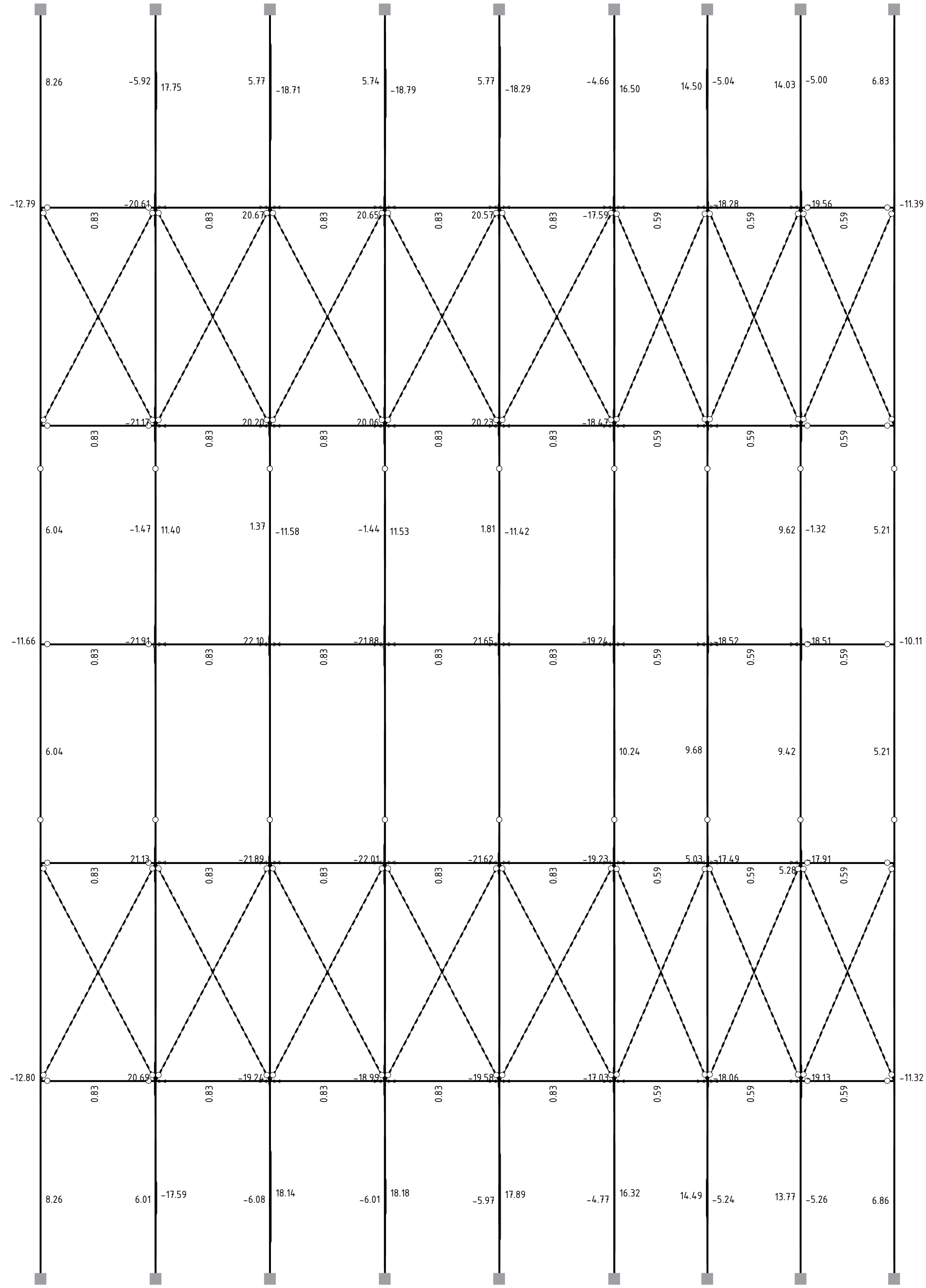
Pogled: ST1+ST2
Vplivi v gredi: max N1= 14.66 / min N1= -746.12 kN

Obt. 149: [MSN] 11-101

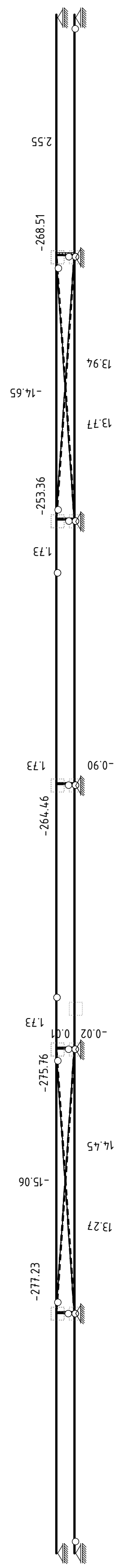
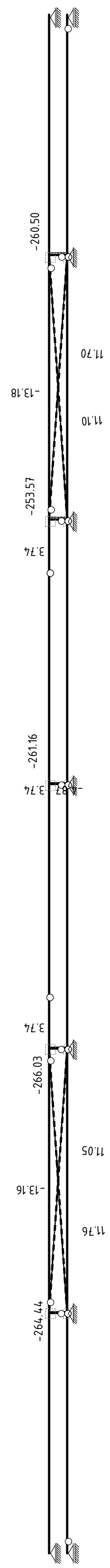


Pogled: ST1+ST2
Vplivi v gredi: max T2= 23.41 / min T2= -23.48 kN

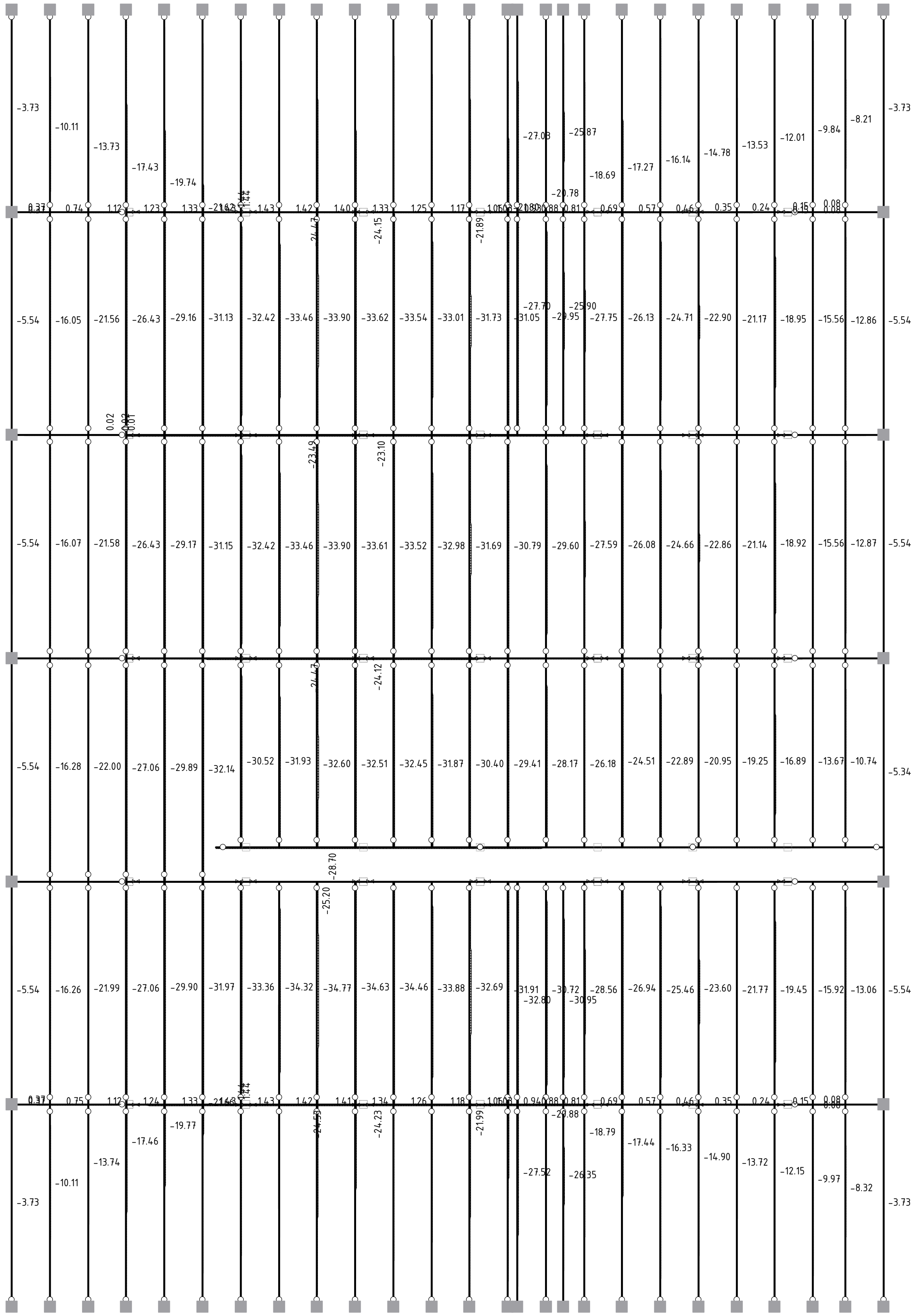
Obt. 149: [MSN] 11-101



Pogled: ST1+ST2
Vplivi v gredi: max M3= 22.10 / min M3= -22.01 kNm

Obt. 149: [MSN] 11-101	Obt. 149: [MSN] 11-101
	
Okvir: V_2	**Okvir: V_3**
Vplivi v gredi: max N1= 14.45 / min N1= -277.23 kN	**Vplivi v gredi: max N1= 11.76 / min N1= -266.03 kN**

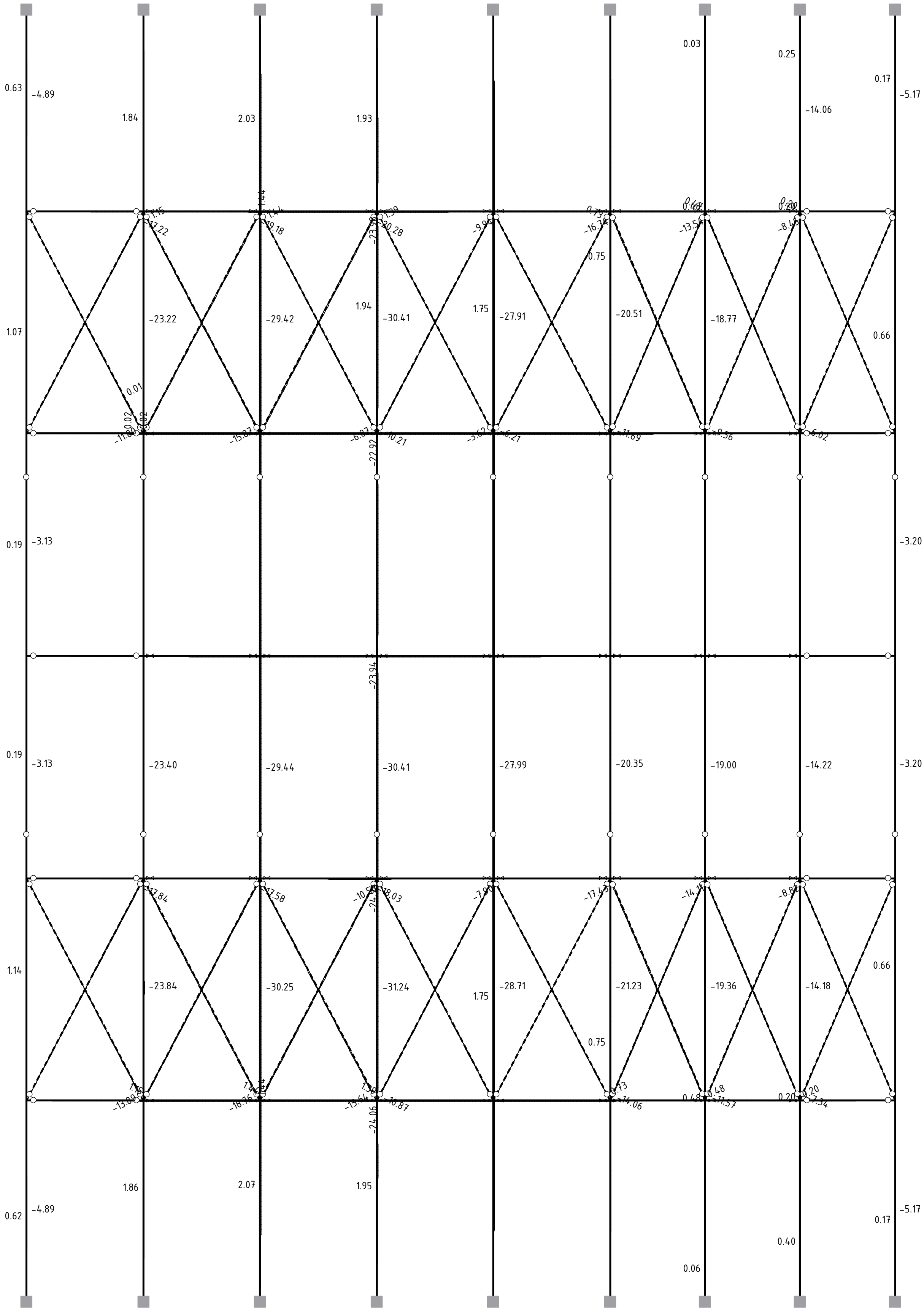
Obt. 150: [MSU] 102-148



Nivo: [0.00 m]

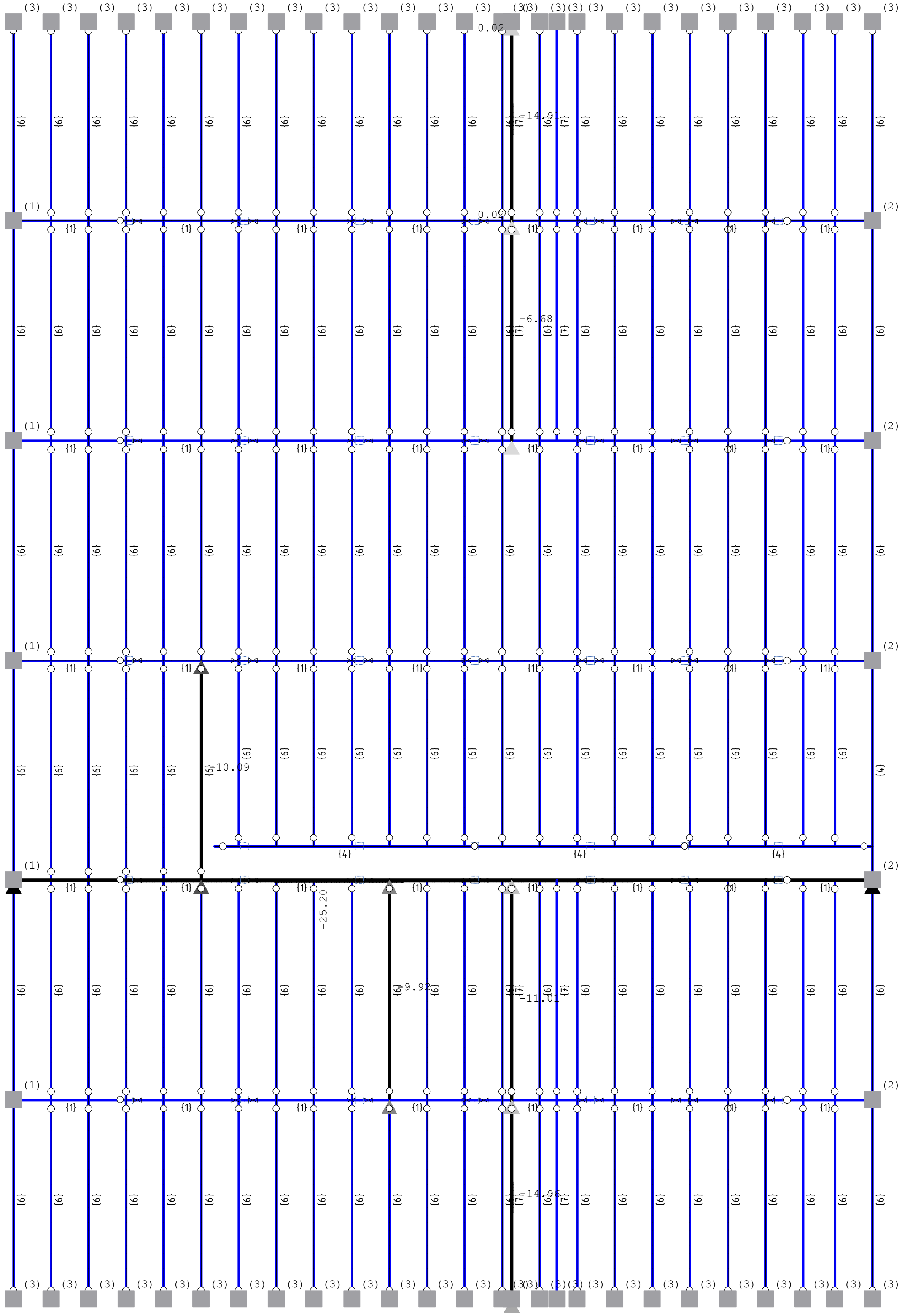
Vplivi v gredi: max Zp= 1.44 / min Zp= -34.77 m / 1000

Obt. 150: [MSU] 102-148



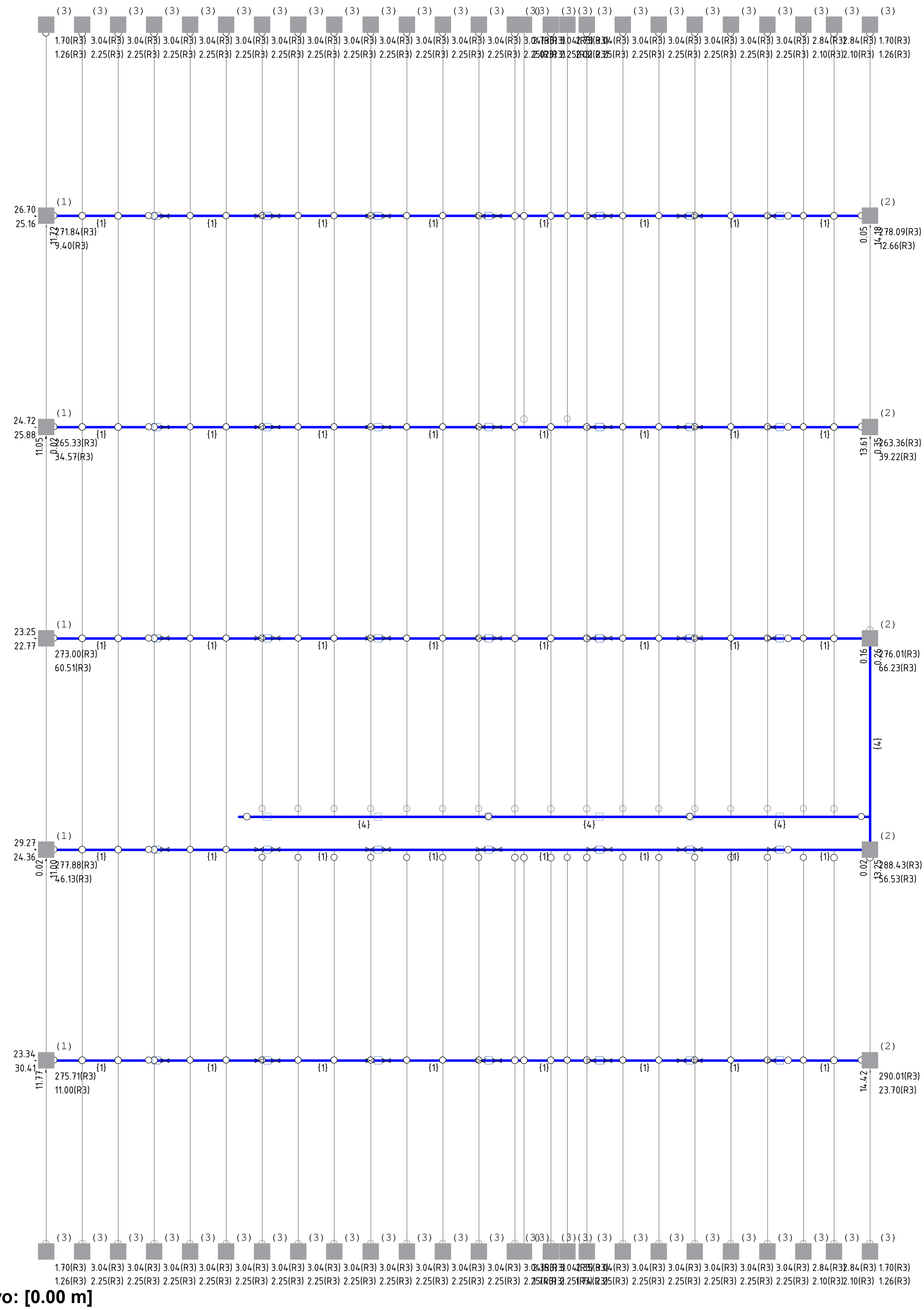
Pogled: ST1+ST2
Vplivi v gredi: max Zp= 2.07 / min Zp= -31.25 m / 1000

Obt. 116: I+II+VI



Nivo: [0.00 m]
Vplivi v gredi: max u,rel.(Z)= 0.02 / min u,rel.(Z)= -25.20 m / 1000

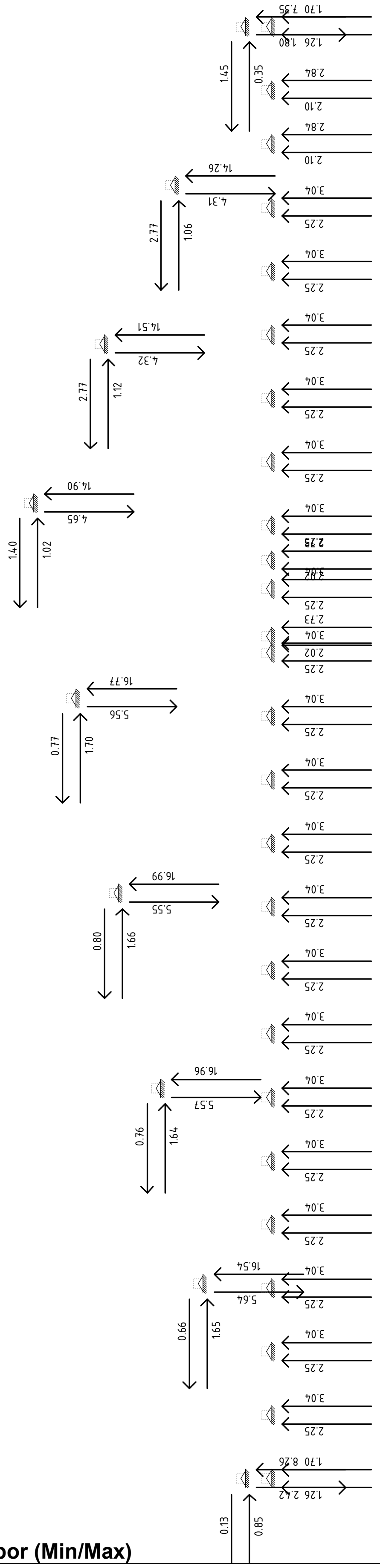
Obt. 149: [MSN] 11-101



Nivo: [0.00 m]

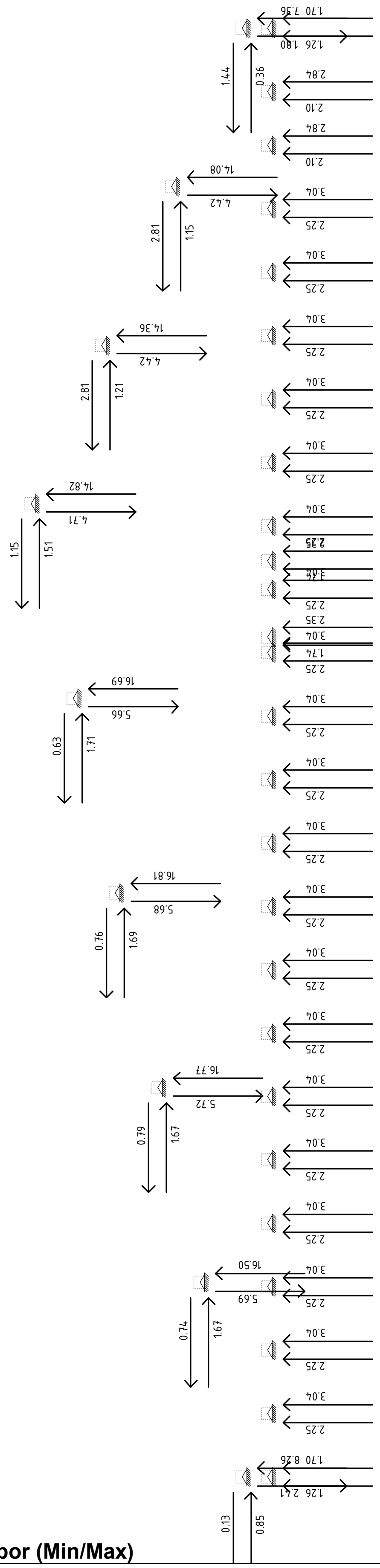
Reakcije podpor (Min/Max)

Obt. 149: [MSN] 11-101



Okvir: H_7
Reakcije podpor (Min/Max)

Obt. 149: [MSN] 11-101



Okvir: H_6
Reakcije podpor (Min/Max)

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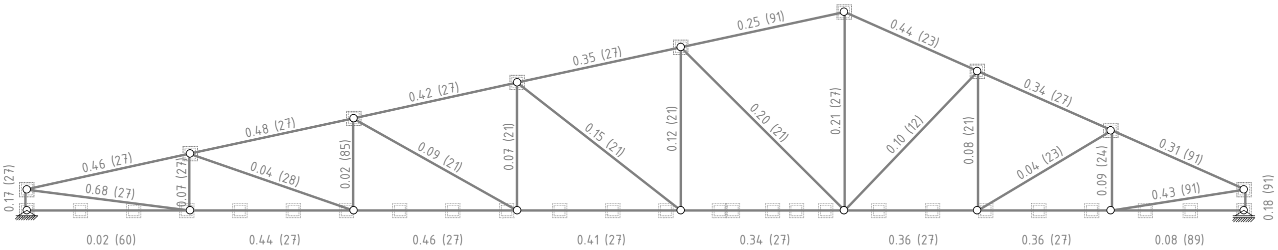
Dimenzioniranje (jeklo)

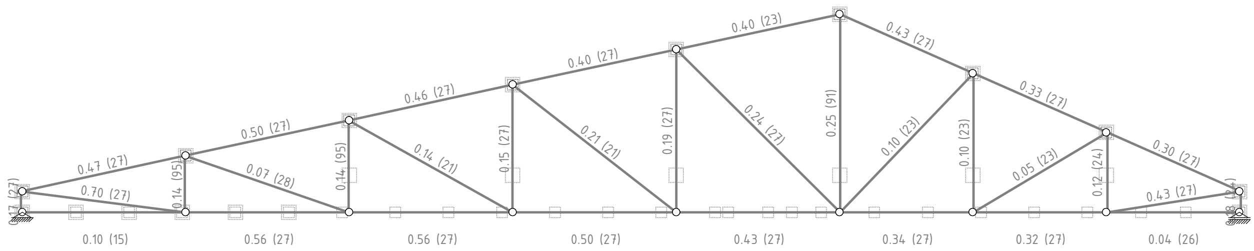
Merodajna obtežba - EUROCODE 3 (EN 1993-1-1:2005)

No	Obtežni primeri
1	Stalna (g)
2	Sneg1
3	Sneg2
4	Sneg3
5	Veter1 srk
6	Veter1 tlak
7	Veter2 srk
8	Veter3 srk
9	Veter3 tlak
10	Veter4 srk

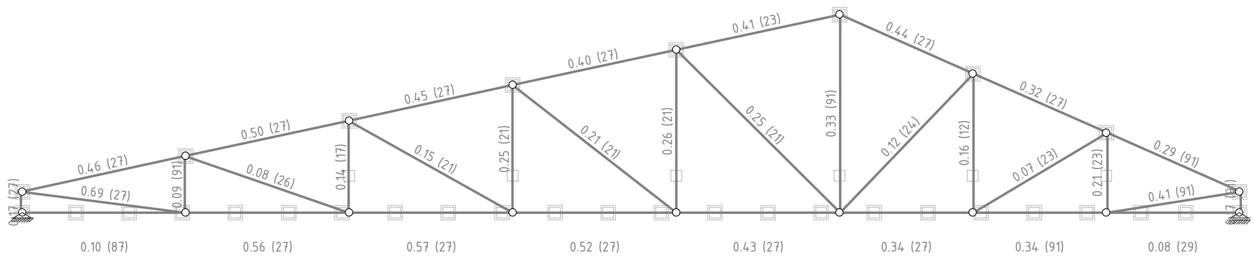
No	Kombinacije obtežb	
11	1.35xI+1.5xIV+0.9xX	+
12	1.35xI+1.5xIV+0.9xIX	+
13	1.35xI+1.5xIV+0.9xVIII	+
14	1.35xI+1.5xIV+0.9xVII	+
15	1.35xI+1.5xIV+0.9xVI	+
16	1.35xI+1.5xIV+0.9xV	+
17	1.35xI+1.5xIII+0.9xX	+
18	1.35xI+1.5xIII+0.9xIX	+
19	1.35xI+1.5xIII+0.9xVIII	+
20	1.35xI+1.5xIII+0.9xVII	+
21	1.35xI+1.5xIII+0.9xVI	+
22	1.35xI+1.5xIII+0.9xV	+
23	1.35xI+1.5xII+0.9xX	+
24	1.35xI+1.5xII+0.9xIX	+
25	1.35xI+1.5xII+0.9xVIII	+
26	1.35xI+1.5xII+0.9xVII	+
27	1.35xI+1.5xII+0.9xVI	+
28	1.35xI+1.5xII+0.9xV	+
29	1.35xI+0.75xIV+1.5xX	+
30	1.35xI+0.75xIV+1.5xIX	+
31	1.35xI+0.75xIV+1.5xVIII	+
32	1.35xI+0.75xIV+1.5xVII	+
33	1.35xI+0.75xIV+1.5xVI	+
34	1.35xI+0.75xIV+1.5xV	+
35	1.35xI+0.75xIII+1.5xX	+
36	1.35xI+0.75xIII+1.5xIX	+
37	1.35xI+0.75xIII+1.5xVIII	+
38	1.35xI+0.75xIII+1.5xVII	+
39	1.35xI+0.75xIII+1.5xVI	+
40	1.35xI+0.75xIII+1.5xV	+
41	1.35xI+0.75xII+1.5xX	+
42	1.35xI+0.75xII+1.5xIX	+
43	1.35xI+0.75xII+1.5xVIII	+
44	1.35xI+0.75xII+1.5xVII	+
45	1.35xI+0.75xII+1.5xVI	+
46	1.35xI+0.75xII+1.5xV	+
47	I+1.5xIV+0.9xX	+
48	I+1.5xIV+0.9xIX	+
49	I+1.5xIV+0.9xVIII	+
50	I+1.5xIV+0.9xVII	+
51	I+1.5xIV+0.9xVI	+
52	I+1.5xIV+0.9xV	+
53	I+1.5xIII+0.9xX	+
54	I+1.5xIII+0.9xIX	+
55	I+1.5xIII+0.9xVIII	+
56	I+1.5xIII+0.9xVII	+
57	I+1.5xIII+0.9xVI	+
58	I+1.5xIII+0.9xV	+
59	I+1.5xII+0.9xX	+
60	I+1.5xII+0.9xIX	+
61	I+1.5xII+0.9xVIII	+
62	I+1.5xII+0.9xVII	+
63	I+1.5xII+0.9xVI	+
64	I+1.5xII+0.9xV	+
65	I+0.75xIV+1.5xX	+
66	I+0.75xIV+1.5xIX	+
67	I+0.75xIV+1.5xVIII	+
68	I+0.75xIV+1.5xVII	+
69	I+0.75xIV+1.5xVI	+
70	I+0.75xIV+1.5xV	+
71	I+0.75xIII+1.5xX	+
72	I+0.75xIII+1.5xIX	+
73	I+0.75xIII+1.5xVIII	+
74	I+0.75xIII+1.5xVII	+
75	I+0.75xIII+1.5xVI	+
76	I+0.75xIII+1.5xV	+
77	I+0.75xII+1.5xX	+
78	I+0.75xII+1.5xIX	+
79	I+0.75xII+1.5xVIII	+
80	I+0.75xII+1.5xVII	+
81	I+0.75xII+1.5xVI	+
82	I+0.75xII+1.5xV	+
83	1.35xI+1.5xX	+
84	1.35xI+1.5xIX	+
85	1.35xI+1.5xVIII	+
86	1.35xI+1.5xVII	+
87	1.35xI+1.5xVI	+
88	1.35xI+1.5xV	+
89	1.35xI+1.5xIV	+
90	1.35xI+1.5xIII	+
91	1.35xI+1.5xII	+
92	I+1.5xX	+
93	I+1.5xIX	+
94	I+1.5xVIII	+
95	I+1.5xVII	+
96	I+1.5xVI	+
97	I+1.5xV	+
98	I+1.5xIV	+
99	I+1.5xIII	+
100	I+1.5xII	+
101	1.35xI	+



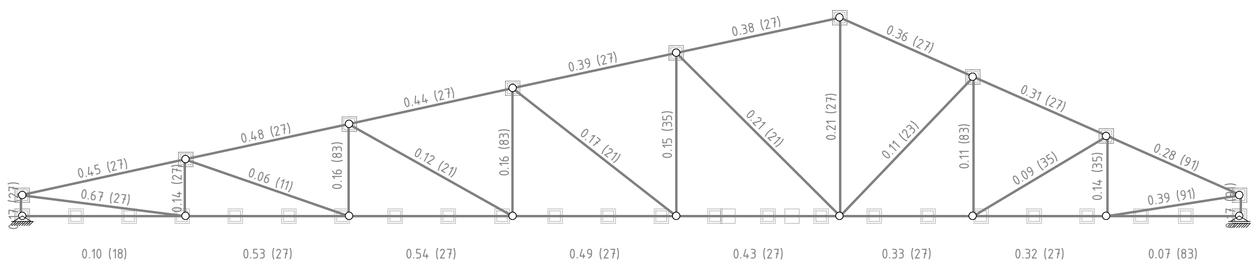
Okvir: H_1
Kontrola napetosti



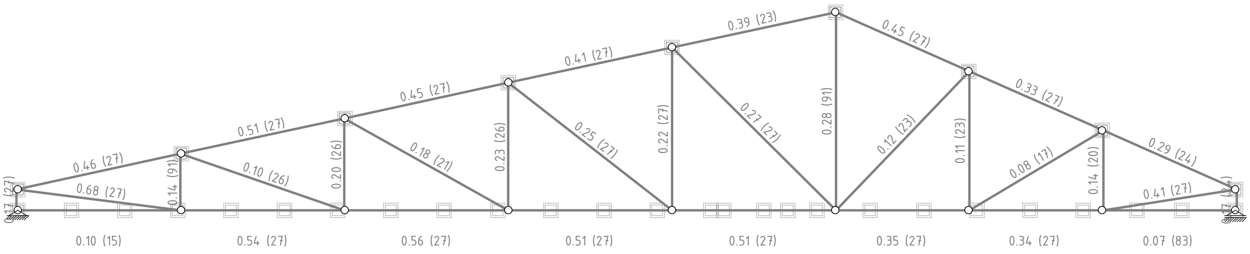
Okvir: H_3
Kontrola napetosti



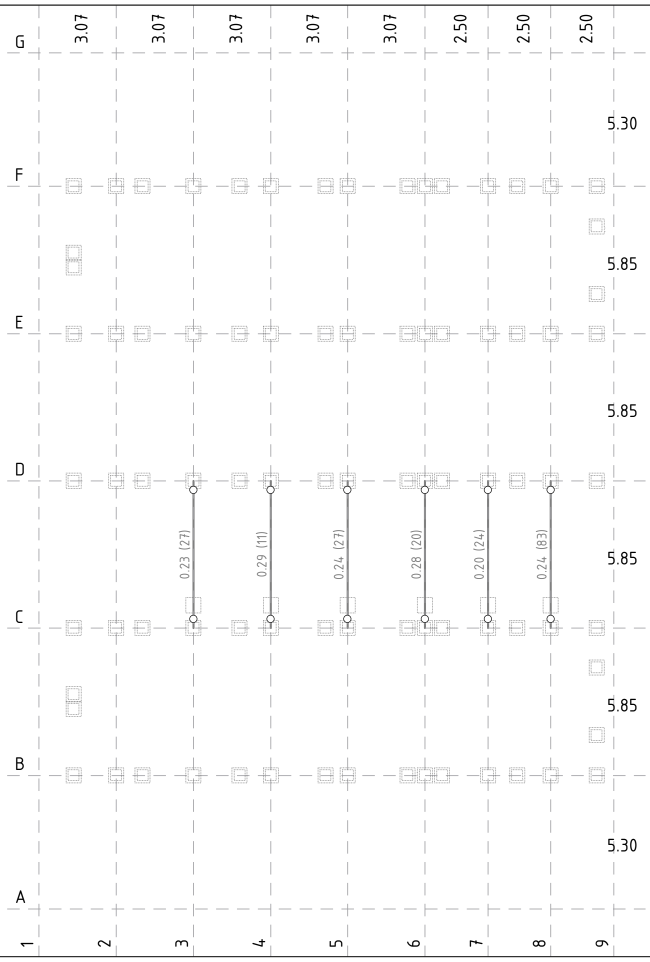
Okvir: H_4
Kontrola napetosti



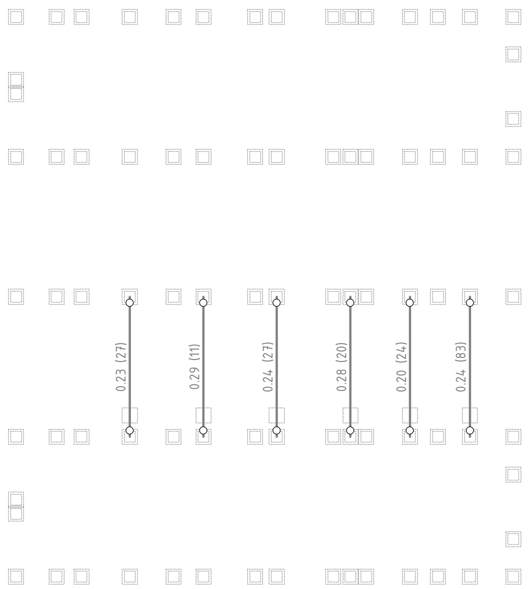
Okvir: H_5
Kontrola napetosti



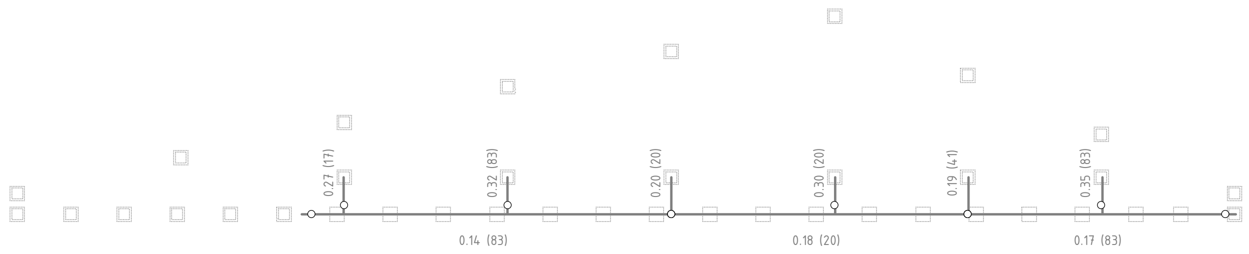
Okvir: H_2
Kontrola napetosti



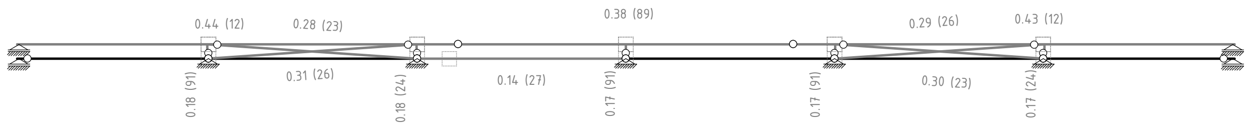
Nivo: [0.70 m]
Kontrola napetosti



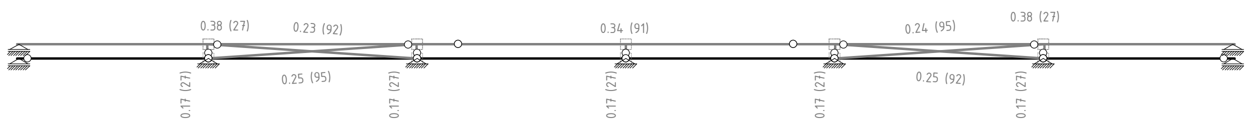
Nivo: [0.70 m]
Kontrola napetosti



Okvir: H_8
Kontrola napetosti



Okvir: V_2
Kontrola napetosti



Okvir: V_3
Kontrola napetosti

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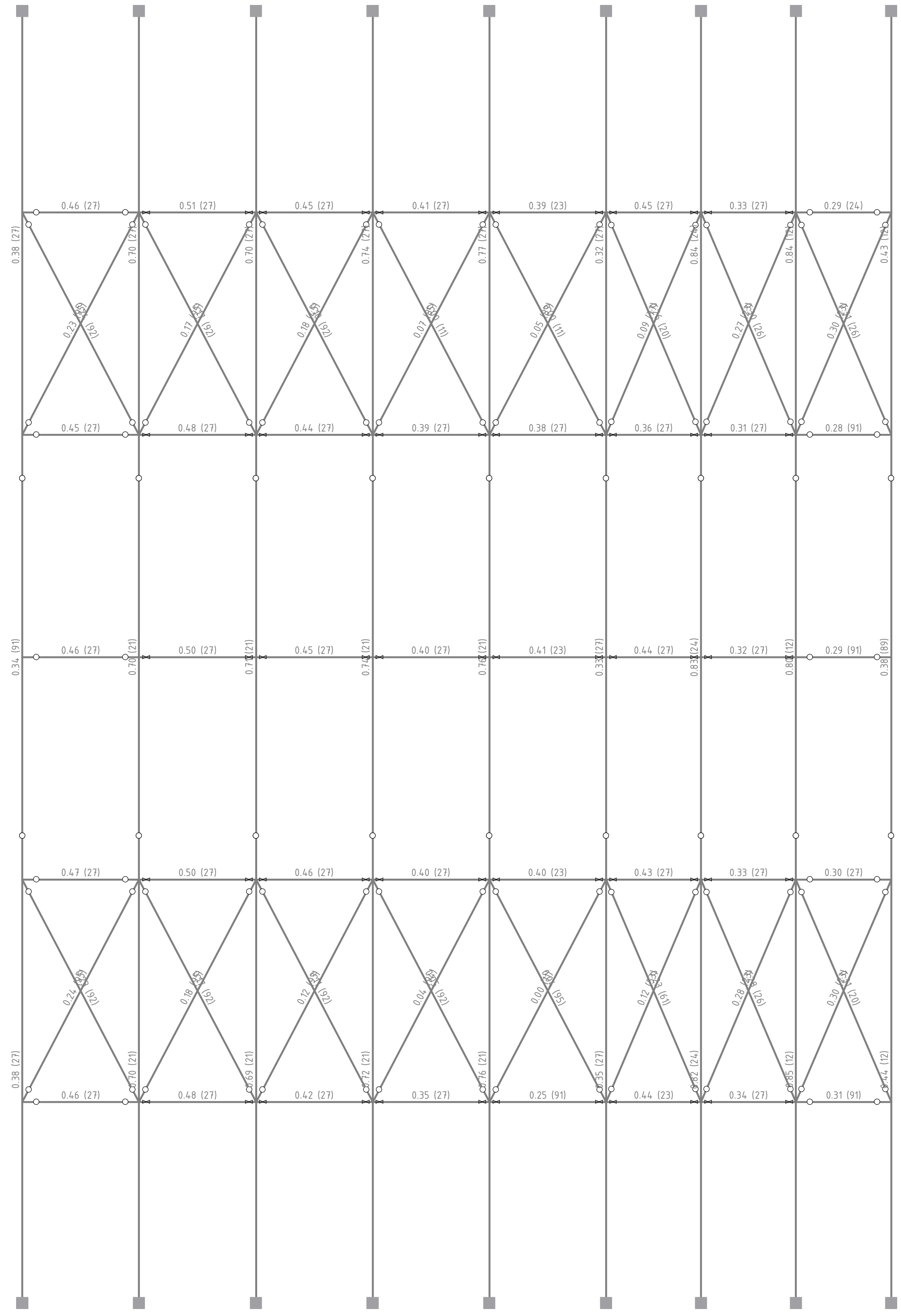
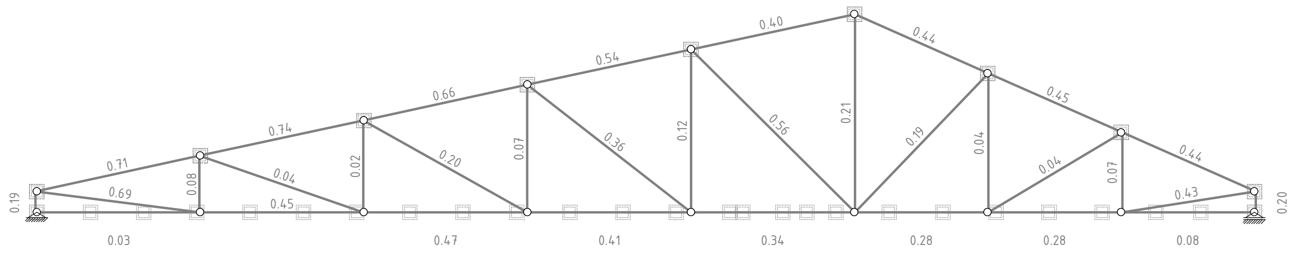
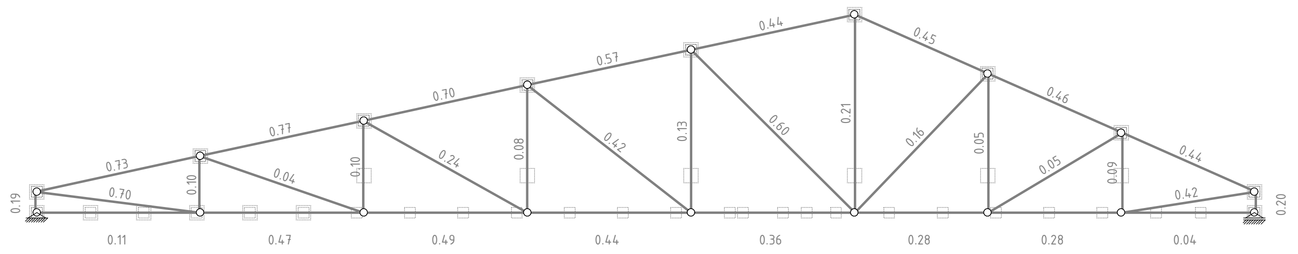


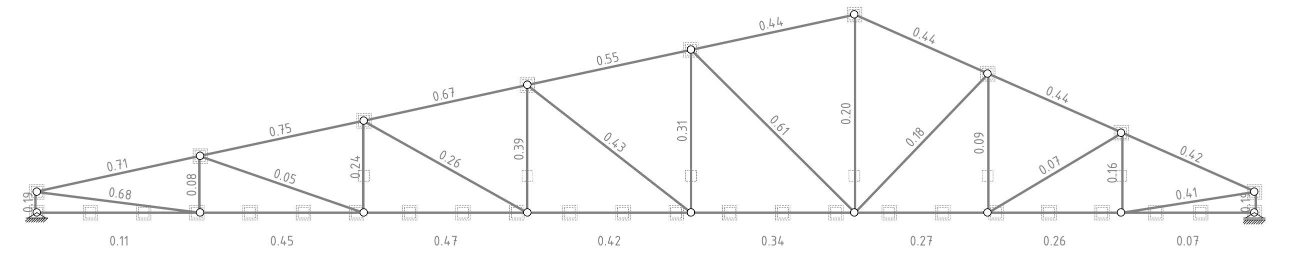
Pogled: ST1+ST2
Kontrola napetosti



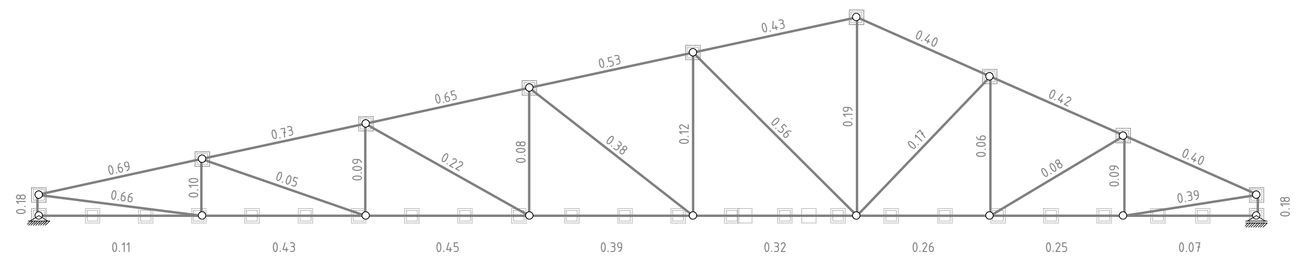
Okvir: H_1
Kontrola stabilnosti



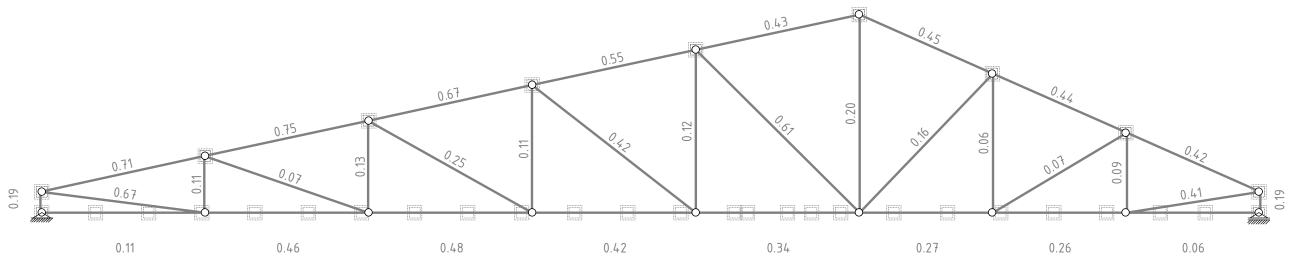
Okvir: H_3
Kontrola stabilnosti



Okvir: H_4
Kontrola stabilnosti



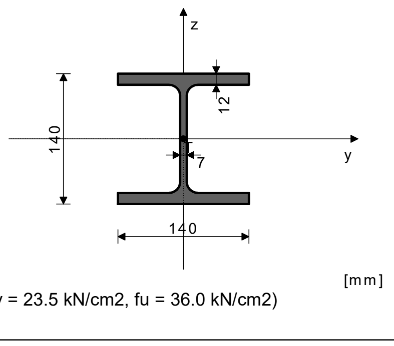
Okvir: H_5
Kontrola stabilnosti



Okvir: H_2
Kontrola stabilnosti

PALICA 1020-675
PREČNI PREREZ: HEB 140 [S 235] [Set: 2]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	43.000 cm2
Ay =	29.880 cm2
Az =	13.120 cm2
Ix =	20.100 cm4
Iy =	1510.0 cm4
Iz =	550.00 cm4
Wy =	215.71 cm3
Wz =	78.571 cm3
Wy,pl =	245.57 cm3
Wz,pl =	117.60 cm3
γM0 =	1.000
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

27. γ=0.70	91. γ=0.68	21. γ=0.68
90. γ=0.66	24. γ=0.64	28. γ=0.63
25. γ=0.62	18. γ=0.62	23. γ=0.62
22. γ=0.61	19. γ=0.60	63. γ=0.60
17. γ=0.59	100. γ=0.58	57. γ=0.58
26. γ=0.57	15. γ=0.57	45. γ=0.56
99. γ=0.56	39. γ=0.56	20. γ=0.55
89. γ=0.55	60. γ=0.54	64. γ=0.53
61. γ=0.52	54. γ=0.52	59. γ=0.51
12. γ=0.51	58. γ=0.51	55. γ=0.50
33. γ=0.50	16. γ=0.50	13. γ=0.49
53. γ=0.49	11. γ=0.48	62. γ=0.48
42. γ=0.47	51. γ=0.47	81. γ=0.47
36. γ=0.46	56. γ=0.46	75. γ=0.46
98. γ=0.45	46. γ=0.45	14. γ=0.45
43. γ=0.44	40. γ=0.44	37. γ=0.43
87. γ=0.42	41. γ=0.41	48. γ=0.41
30. γ=0.41	35. γ=0.41	69. γ=0.40
52. γ=0.40	49. γ=0.40	34. γ=0.39
47. γ=0.38	101. γ=0.38	31. γ=0.38
78. γ=0.37	72. γ=0.36	44. γ=0.36
38. γ=0.35	82. γ=0.35	29. γ=0.35
50. γ=0.35	79. γ=0.34	76. γ=0.34
73. γ=0.34	84. γ=0.33	96. γ=0.32
77. γ=0.32	66. γ=0.31	71. γ=0.30
88. γ=0.30	32. γ=0.30	85. γ=0.29
70. γ=0.29	67. γ=0.28	83. γ=0.27
80. γ=0.26	74. γ=0.26	65. γ=0.25
93. γ=0.23	86. γ=0.22	97. γ=0.20
68. γ=0.20	94. γ=0.20	92. γ=0.17
95. γ=0.12		

PALICA IZPOSTAVLJENA NATEGU IN UPOGIBU
(obtežni primer 27, na 20.6 cm od začetka palice)

Računska osna sila	N_{Ed} =	698.20 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-0.606 kN

Upogibni moment okoli y osi	$M_{Ed,y}$ =	0.135 kNm
Sistemska dolžina palice	L =	309.59 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

6.2 NOSILNOST PREČNIH PREREZOV
6.2.3 Nateg

Plast.rač.nosilnost bruto prereza	$N_{pl,Rd}$ =	1010.5 kN
Mejna rač.nosilnost neto prereza	$N_{u,Rd}$ =	1003.1 kN
Računska nos. na nateg	$N_{t,Rd}$ =	1003.1 kN

Pogoj 6.5: N_{Ed} <= $N_{t,Rd}$ (698.20 <= 1003.10)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wy,eff =	196.51 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	46.179 kNm

Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (0.13 <= 46.18)

6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	110.17 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	110.17 kN

Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (0.61 <= 110.17)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$	0.691

Pogoj 6.41: (0.01 <= 1)

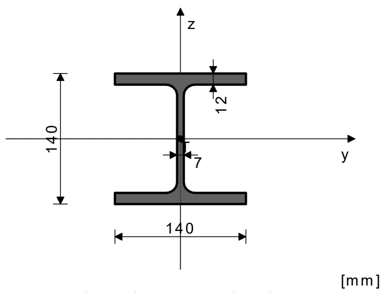
6.3 NOSILNOST ELEMENTA NA UKLON
6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	309.59 cm
Sektorski vztrajnostni moment	Iw =	22479 cm6
Krit.moment bočne zvrnitve	Mcr =	179.30 kNm
Ustrezni odpornostni moment	Wy =	245.57 cm3
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.567
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.902
Računska uklonska nosilnost	$M_{b,Rd}$ =	47.320 kNm

Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (0.13 <= 47.32)

PALICA 3710-3688
PREČNI PREREZ: HEB 140 [S 235] [Set: 2]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	43.000 cm2
Ay =	29.880 cm2
Az =	13.120 cm2
Ix =	20.100 cm4
Iy =	1510.0 cm4
Iz =	550.00 cm4
Wy =	215.71 cm3
Wz =	78.571 cm3
Wy,pl =	245.57 cm3
Wz,pl =	117.60 cm3
γM0 =	1.000
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

21. γ=0.60	27. γ=0.60	90. γ=0.56
91. γ=0.56	22. γ=0.53	28. γ=0.53
19. γ=0.52	18. γ=0.51	25. γ=0.51
57. γ=0.51	24. γ=0.51	63. γ=0.51
39. γ=0.50	17. γ=0.50	45. γ=0.50
23. γ=0.50	99. γ=0.48	15. γ=0.48
100. γ=0.48	20. γ=0.47	26. γ=0.47
58. γ=0.44	89. γ=0.44	64. γ=0.44
33. γ=0.44	55. γ=0.42	61. γ=0.42
54. γ=0.42	53. γ=0.42	60. γ=0.42
75. γ=0.42	81. γ=0.42	59. γ=0.42
16. γ=0.41	51. γ=0.39	40. γ=0.39
46. γ=0.39	13. γ=0.39	12. γ=0.39
56. γ=0.39	87. γ=0.38	11. γ=0.38
62. γ=0.38	37. γ=0.36	43. γ=0.36
98. γ=0.36	69. γ=0.36	36. γ=0.35
42. γ=0.35	14. γ=0.35	35. γ=0.35
41. γ=0.35	34. γ=0.33	101. γ=0.33
52. γ=0.32	49. γ=0.31	76. γ=0.30
82. γ=0.30	48. γ=0.30	47. γ=0.30
96. γ=0.30	31. γ=0.30	38. γ=0.30
44. γ=0.30	30. γ=0.29	29. γ=0.29
73. γ=0.27	79. γ=0.27	88. γ=0.27
72. γ=0.27	78. γ=0.27	50. γ=0.27
71. γ=0.26	77. γ=0.26	70. γ=0.24
85. γ=0.24	32. γ=0.24	84. γ=0.24
83. γ=0.23	74. γ=0.22	80. γ=0.22
67. γ=0.21	66. γ=0.21	65. γ=0.20
97. γ=0.19	86. γ=0.18	68. γ=0.16
94. γ=0.16	93. γ=0.15	92. γ=0.15
95. γ=0.10		

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 21, na 123.9 cm od začetka palice)

Računska osna sila	N_{Ed} =	-206.35 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	0.166 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-0.300 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	0.619 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	0.442 kNm
Sistemska dolžina palice	L =	433.74 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

6.2 NOSILNOST PREČNIH PREREZOV
6.2.4 Tlak

Računska nosilnost na tlak	$N_{c,Rd}$ =	1010.5 kN

Pogoj 6.9: N_{Ed} <= $N_{c,Rd}$ (206.35 <= 1010.50)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wy,eff =	196.51 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	46.179 kNm

Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (0.62 <= 46.18)

6.2.5 Upogib z-z
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wz,eff =	69.834 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	16.411 kNm

Pogoj 6.12: $M_{Ed,z}$ <= $M_{c,Rd,z}$ (0.44 <= 16.41)

6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	110.17 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	110.17 kN

Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (0.30 <= 110.17)

Računska strižna nosilnost	$V_{pl,Rd,y}$ =	454.21 kN
Računska strižna nosilnost	$V_{c,Rd,y}$ =	454.21 kN

Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (0.17 <= 454.21)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$; $V_{Ed,y}$ <= 50%$V_{pl,Rd,y}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$		0.204
Zmanjšana plast.upogibna nosilnost	$M_{N,z,Rd}$ =	27.636 kNm
Koeficient	β =	1.021
Razmerje ($M_{z,Ed}$ / $M_{N,z,Rd}$)^β		0.015

Pogoj 6.41: (0.01 <= 1)

6.3 NOSILNOST ELEMENTA NA UKLON
6.3.1.1 Nosilnost na uklon

Uklonska dolžina y-y	l,y =	433.74 cm
Relativna vitkost y-y	λ_y =	0.779
Uklonska krivulja za os y-y: B	α =	0.340
Elastična kritična sila	$N_{cr,y}$ =	1663.6 kN
Koeficient nepopolnosti	χ,y =	0.737
Računska uklonska nosilnost	$N_{b,Rd,y}$ =	677.12 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,y}$ (206.35 <= 677.12)

Uklonska dolžina z-z	l,z =	433.74 cm
Relativna vitkost z-z	λ_z =	1.291
Uklonska krivulja za os z-z: C	α =	0.490
Koeficient nepopolnosti	χ,z =	0.392
Računska uklonska nosilnost	$N_{b,Rd,z}$ =	360.54 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,z}$ (206.35 <= 360.54)

6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000

Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	433.74 cm
Sektorski vztrajnostni moment	Iw =	22479 cm6
Krit.moment bočne zvrnitve	Mcr =	120.53 kNm
Ustrezni odpornostni moment	W_y =	245.57 cm3
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	$\lambda LT\_$ =	0.692
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.851
Računska uklonska nosilnost	$M_{b,Rd}$ =	44.672 kNm

Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (0.62 <= 44.67)

6.3.3. Elementi konstantnega prečnega prereza obremenjeni z upogibom in osnim tlakom
Preračun koeficienta interakcije je izvršen z alternativno metodo št.2 (Aneks B)

Koeficient oblike momenta	C_{my} =	0.950
Koeficient oblike momenta	C_{mz} =	0.555
Koeficient oblike momenta	C_{mLT} =	0.950
Koeficient interakcije	k_{yy} =	1.118
Koeficient interakcije	k_{yz} =	0.600
Koeficient interakcije	k_{zy} =	0.918
Koeficient interakcije	k_{zz} =	0.999

Koeficient nepopolnosti	χy =	0.737
N_{Ed} / (χy N_{Rk} / γM1)		0.305
kyy * (M_{yEd} + ΔM_{yEd}) / ...		0.015
kyz * (M_{zEd} + ΔM_{zEd}) / ...		0.011

Pogoj 6.61: (0.33 <= 1)

Koeficient nepopolnosti	χz =	0.392
N_{Ed} / (χz N_{Rk} / γM1)		0.572
kzy * (M_{yEd} + ΔM_{yEd}) / ...		0.013
kzz * (M_{zEd} + ΔM_{zEd}) / ...		0.018

Pogoj 6.62: (0.60 <= 1)

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 21, na 20.7 cm od začetka palice)

Računska osna sila	N_{Ed} =	-206.02 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	0.166 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-0.633 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	0.138 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	0.614 kNm
Sistemska dolžina palice	L =	433.74 cm

6.2 NOSILNOST PREČNIH PREREZOV
6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	110.17 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	110.17 kN

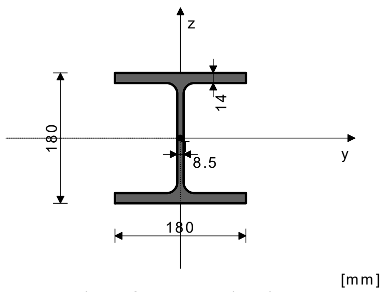
Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (0.63 <= 110.17)

Računska strižna nosilnost	$V_{pl,Rd,y}$ =	454.21 kN
Računska strižna nosilnost	$V_{c,Rd,y}$ =	454.21 kN

Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (0.17 <= 454.21)

PALICA 1184-675
PREČNI PREREZ: HEB 180 [S 235] [Set: 1]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	65.300 cm2
Ay =	45.010 cm2
Az =	20.290 cm2
Ix =	42.300 cm4
Iy =	3830.0 cm4
Iz =	1360.0 cm4
Wy =	425.56 cm3
Wz =	151.11 cm3
Wy,pl =	479.91 cm3
Wz,pl =	226.80 cm3
γM0 =	1.000
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

27. γ=0.73	91. γ=0.71	21. γ=0.71
90. γ=0.69	24. γ=0.67	28. γ=0.66
25. γ=0.65	18. γ=0.65	23. γ=0.65
22. γ=0.64	19. γ=0.63	63. γ=0.63
17. γ=0.62	100. γ=0.61	57. γ=0.60
26. γ=0.60	15. γ=0.60	45. γ=0.60
39. γ=0.59	99. γ=0.59	20. γ=0.58
89. γ=0.58	60. γ=0.56	64. γ=0.55
61. γ=0.55	54. γ=0.54	59. γ=0.54
12. γ=0.54	33. γ=0.53	58. γ=0.53
55. γ=0.53	16. γ=0.53	13. γ=0.52
53. γ=0.52	11. γ=0.51	62. γ=0.50
42. γ=0.50	51. γ=0.50	81. γ=0.49
36. γ=0.49	75. γ=0.48	56. γ=0.48
46. γ=0.48	98. γ=0.47	14. γ=0.47
43. γ=0.47	40. γ=0.47	37. γ=0.46
87. γ=0.45	41. γ=0.44	48. γ=0.44
30. γ=0.43	35. γ=0.43	69. γ=0.43
52. γ=0.42	49. γ=0.42	34. γ=0.41
47. γ=0.41	101. γ=0.41	31. γ=0.40
78. γ=0.39	44. γ=0.38	72. γ=0.38
29. γ=0.38	38. γ=0.37	82. γ=0.37
50. γ=0.37	79. γ=0.36	76. γ=0.36
73. γ=0.35	84. γ=0.34	96. γ=0.34
77. γ=0.34	66. γ=0.33	71. γ=0.33
88. γ=0.32	32. γ=0.32	85. γ=0.31
70. γ=0.31	67. γ=0.30	83. γ=0.29
80. γ=0.28	65. γ=0.27	74. γ=0.27
93. γ=0.24	86. γ=0.23	97. γ=0.22
68. γ=0.21	94. γ=0.21	92. γ=0.18
95. γ=0.13		

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 27, na 146.6 cm od začetka palice)

Računska osna sila	N_{Ed} =	-710.51 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-0.071 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	0.831 kNm
Sistemska dolžina palice	L =	314.14 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

6.2 NOSILNOST PREČNIH PREREZOV
6.2.4 Tlak

Računska nosilnost na tlak	$N_{c,Rd}$ =	1534.6 kN

Pogoj 6.9: N_{Ed} <= $N_{c,Rd}$ (710.51 <= 1534.55)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wy,eff =	385.37 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	90.561 kNm

Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (0.83 <= 90.56)

6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	175.30 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	175.30 kN

Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (0.07 <= 175.30)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$		0.463
Zmanjšana plast.upogibna nosilnost	$M_{N,y,Rd}$ =	68.360 kNm
Koeficient	α =	1.000
Razmerje ($M_{y,Ed}$ / $M_{N,y,Rd}$)^α		0.012

Pogoj 6.41: (0.01 <= 1)

6.3 NOSILNOST ELEMENTA NA UKLON
6.3.1.1 Nosilnost na uklon

Uklonska dolžina y-y	l,y =	314.14 cm
Relativna vitkost y-y	λ_y =	0.437
Uklonska krivulja za os y-y: B	α =	0.340
Elastična kritična sila	$N_{cr,y}$ =	8043.9 kN
Koeficient nepopolnosti	χ,y =	0.911
Računska uklonska nosilnost	$N_{b,Rd,y}$ =	1271.2 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,y}$ (710.51 <= 1271.18)

Uklonska dolžina z-z	l,z =	314.14 cm
Relativna vitkost z-z	λ_z =	0.733
Uklonska krivulja za os z-z: C	α =	0.490
Koeficient nepopolnosti	χ,z =	0.704
Računska uklonska nosilnost	$N_{b,Rd,z}$ =	982.37 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,z}$ (710.51 <= 982.37)

6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	314.14 cm
Sektorski vztrajnostni moment	Iw =	93746 cm6
Krit.moment bočne zvrnitve	Mcr =	443.98 kNm
Ustrezni odpornostni moment	W_y =	479.91 cm3

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Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	$\lambda LT\_$ =	0.504
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.923
Računska uklonska nosilnost	$M_{b,Rd}$ =	94.634 kNm

Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (0.83 <= 94.63)

6.3.3. Elementi konstantnega prečnega prereza obremenjeni z upogibom in osnim tlakom
Preračun koeficienta interakcije je izvršen z alternativno metodo št.2 (Aneks B)

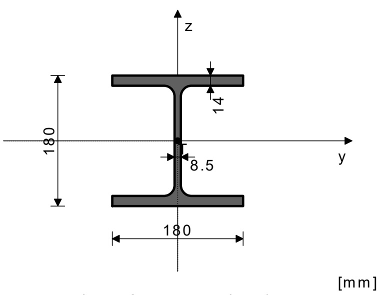
Koeficient oblike momenta	C_{my} =	0.950
Koeficient oblike momenta	C_{mz} =	1.000
Koeficient oblike momenta	C_{mLT} =	0.950
Koeficient interakcije	k_{yy} =	1.076
Koeficient interakcije	k_{yz} =	0.976
Koeficient interakcije	k_{zy} =	0.924
Koeficient interakcije	k_{zz} =	1.626

Koeficient nepopolnosti	χ_y =	0.911
N_{Ed} / (χ_y N_{Rk} / $\gamma M1$)		0.559
kyy * (M_{yEd} + ΔM_{yEd}) / ...		0.009

Pogoj 6.61: (0.57 <= 1)

PALICA 1504-2105
PREČNI PREREZ: HEB 180 [S 235] [Set: 1]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	65.300 cm2
Ay =	45.010 cm2
Az =	20.290 cm2
Ix =	42.300 cm4
Iy =	3830.0 cm4
Iz =	1360.0 cm4
Wy =	425.56 cm3
Wz =	151.11 cm3
Wy,pl =	479.91 cm3
Wz,pl =	226.80 cm3
$\gamma M0$ =	1.000
$\gamma M1$ =	1.100
$\gamma M2$ =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

27. γ=0.49	21. γ=0.48	91. γ=0.47
90. γ=0.45	28. γ=0.44	24. γ=0.44
25. γ=0.44	22. γ=0.43	63. γ=0.43
18. γ=0.42	19. γ=0.42	23. γ=0.42
57. γ=0.41	15. γ=0.41	26. γ=0.41
17. γ=0.40	45. γ=0.40	100. γ=0.40
39. γ=0.39	20. γ=0.39	89. γ=0.38
99. γ=0.38	64. γ=0.38	60. γ=0.37
61. γ=0.37	33. γ=0.36	16. γ=0.36
58. γ=0.36	54. γ=0.36	12. γ=0.36
13. γ=0.35	59. γ=0.35	55. γ=0.35
51. γ=0.34	11. γ=0.33	53. γ=0.33
81. γ=0.33	62. γ=0.33	75. γ=0.33
46. γ=0.32	56. γ=0.32	14. γ=0.32
42. γ=0.32	98. γ=0.32	40. γ=0.31
36. γ=0.31	43. γ=0.31	87. γ=0.30
37. γ=0.30	69. γ=0.29	52. γ=0.29
41. γ=0.29	48. γ=0.28	35. γ=0.28
49. γ=0.28	34. γ=0.28	30. γ=0.27
47. γ=0.27	101. γ=0.27	31. γ=0.26
44. γ=0.26	82. γ=0.25	50. γ=0.25
38. γ=0.25	78. γ=0.25	29. γ=0.25
76. γ=0.24	72. γ=0.24	79. γ=0.24
96. γ=0.23	73. γ=0.23	88. γ=0.22
77. γ=0.22	84. γ=0.21	32. γ=0.21
71. γ=0.21	70. γ=0.21	85. γ=0.20
66. γ=0.20	67. γ=0.19	83. γ=0.19
80. γ=0.19	74. γ=0.18	65. γ=0.18
86. γ=0.15	97. γ=0.15	93. γ=0.14
68. γ=0.14	94. γ=0.14	92. γ=0.12
95. γ=0.09		

PALICA IZPOSTAVLJENA NATEGU IN UPOGIBU
(obtežni primer 27, na 21.0 cm od začetka palice)

Računska osna sila	N_{Ed} =	751.92 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	-0.604 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-7.909 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	1.691 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	-0.574 kNm
Sistemska dolžina palice	L =	307.00 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

Koeficient nepopolnosti	χ_z =	0.704
N_{Ed} / (χ_z N_{Rk} / $\gamma M1$)		0.723
kzy * (M_{yEd} + ΔM_{yEd}) / ...		0.008

Pogoj 6.62: (0.73 <= 1)

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 27, na 20.9 cm od začetka palice)

Računska osna sila	N_{Ed} =	-710.69 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-0.921 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	0.208 kNm
Sistemska dolžina palice	L =	314.14 cm

6.2 NOSILNOST PREČNIH PREREZOV
6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	175.30 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	175.30 kN

Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (0.92 <= 175.30)

6.2 NOSILNOST PREČNIH PREREZOV
6.2.3 Nateg

Plast.rač.nosilnost bruto prereza	$N_{pl,Rd}$ =	1534.6 kN
Mejna rač.nosilnost neto prereza	$N_{u,Rd}$ =	1523.3 kN
Računska nos. na nateg	$N_{t,Rd}$ =	1523.3 kN

Pogoj 6.5: N_{Ed} <= $N_{t,Rd}$ (751.92 <= 1523.32)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wy,eff =	385.37 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	90.561 kNm

Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (1.69 <= 90.56)

6.2.5 Upogib z-z
Upoštevajo se tudi luknje za vezna sredstva.

Efektivni odpornostni moment	Wz,eff =	134.67 cm3
Računska nosilnost na upogib	$M_{c,Rd}$ =	31.649 kNm

Pogoj 6.12: $M_{Ed,z}$ <= $M_{c,Rd,z}$ (0.57 <= 31.65)

6.2.6 Strig

Računska strižna nosilnost	$V_{pl,Rd,z}$ =	175.30 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	175.30 kN

Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (7.91 <= 175.30)

Računska strižna nosilnost	$V_{pl,Rd,y}$ =	681.31 kN
Računska strižna nosilnost	$V_{c,Rd,y}$ =	681.31 kN

Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (0.60 <= 681.31)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$; $V_{Ed,y}$ <= 50%$V_{pl,Rd,y}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$		0.490

Pogoj 6.41: (0.00 <= 1)

6.3 NOSILNOST ELEMENTA NA UKLON
6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	0.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	307.00 cm
Sektorski vztrajnostni moment	Iw =	93746 cm6
Krit.moment bočne zvrnitve	Mcr =	458.20 kNm
Ustrezni odpornostni moment	Wy =	479.91 cm3
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	$\lambda LT\_$ =	0.496
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.925
Računska uklonska nosilnost	$M_{b,Rd}$ =	94.885 kNm

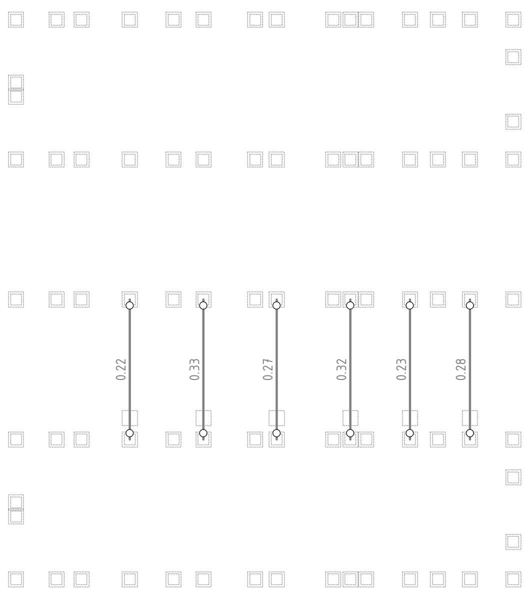
Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (1.69 <= 94.88)

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 23, na 21.0 cm od začetka palice)

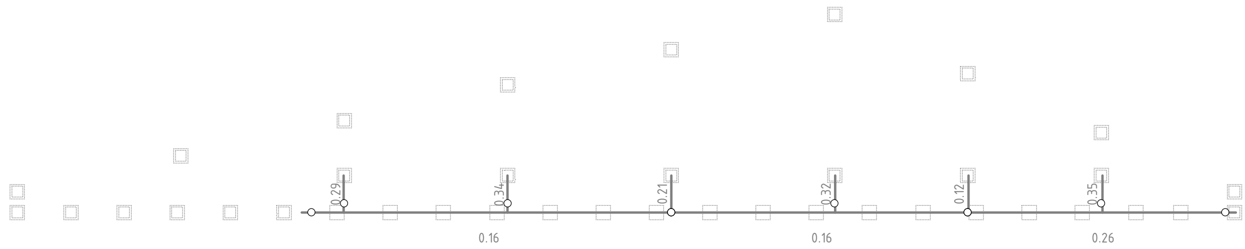
Računska osna sila	N_{Ed} =	634.34 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	-0.740 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-7.910 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	1.691 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	0.601 kNm
Sistemska dolžina palice	L =	307.00 cm

6.2 NOSILNOST PREČNIH PREREZOV
6.2.6 Strig

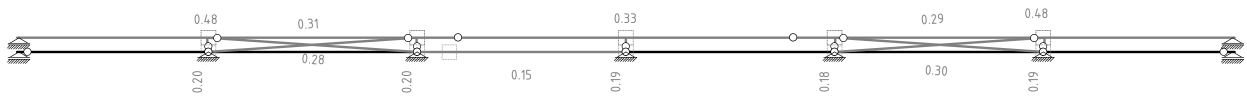
Računska strižna nosilnost	$V_{pl,Rd,z}$ =	175.30 kN	Računska strižna nosilnost	$V_{c,Rd,y}$ =	681.31 kN
Računska strižna nosilnost	$V_{c,Rd,z}$ =	175.30 kN	**Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (0.74 <= 681.31)**		
Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (7.91 <= 175.30)					
Računska strižna nosilnost	$V_{pl,Rd,y}$ =	681.31 kN			



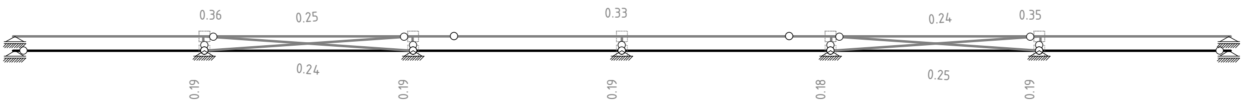
Nivo: [0.70 m]
Kontrola stabilnosti



Okvir: H_8
Kontrola stabilnosti



Okvir: V_2
Kontrola stabilnosti

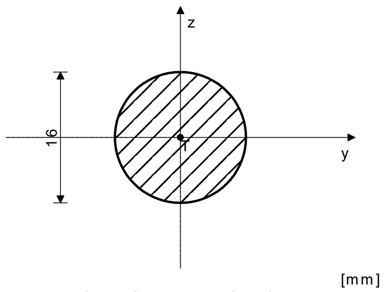


Okvir: V_3
Kontrola stabilnosti

PALICA 8278-8956

PREČNI PREREZ: Krožni [S 235] [Set: 8]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	2.011 cm2
Ay =	1.810 cm2
Az =	1.810 cm2
Ix =	0.643 cm4
Iy =	0.322 cm4
Iz =	0.322 cm4
Wy =	0.402 cm3
Wz =	0.402 cm3
Wy,pl =	0.683 cm3
Wz,pl =	0.683 cm3
γM0 =	1.000
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

23. γ=0.30	35. γ=0.29	41. γ=0.29
77. γ=0.29	29. γ=0.29	71. γ=0.29
65. γ=0.29	83. γ=0.28	92. γ=0.28
53. γ=0.20	59. γ=0.20	17. γ=0.20
11. γ=0.20	47. γ=0.19	25. γ=0.00
26. γ=0.00	27. γ=0.00	28. γ=0.00
14. γ=0.00	30. γ=0.00	31. γ=0.00
32. γ=0.00	33. γ=0.00	34. γ=0.00
15. γ=0.00	36. γ=0.00	37. γ=0.00
38. γ=0.00	39. γ=0.00	40. γ=0.00
16. γ=0.00	42. γ=0.00	43. γ=0.00
44. γ=0.00	45. γ=0.00	46. γ=0.00
12. γ=0.00	48. γ=0.00	49. γ=0.00
50. γ=0.00	51. γ=0.00	52. γ=0.00
18. γ=0.00	54. γ=0.00	55. γ=0.00
56. γ=0.00	57. γ=0.00	58. γ=0.00
19. γ=0.00	60. γ=0.00	61. γ=0.00
62. γ=0.00	63. γ=0.00	64. γ=0.00
20. γ=0.00	66. γ=0.00	67. γ=0.00
68. γ=0.00	69. γ=0.00	70. γ=0.00
21. γ=0.00	72. γ=0.00	73. γ=0.00
74. γ=0.00	75. γ=0.00	76. γ=0.00
22. γ=0.00	78. γ=0.00	79. γ=0.00
80. γ=0.00	81. γ=0.00	82. γ=0.00
13. γ=0.00	84. γ=0.00	85. γ=0.00
86. γ=0.00	87. γ=0.00	88. γ=0.00
89. γ=0.00	90. γ=0.00	91. γ=0.00
24. γ=0.00	93. γ=0.00	94. γ=0.00
95. γ=0.00	96. γ=0.00	97. γ=0.00
98. γ=0.00	99. γ=0.00	100. γ=0.00
101. γ=0.00		

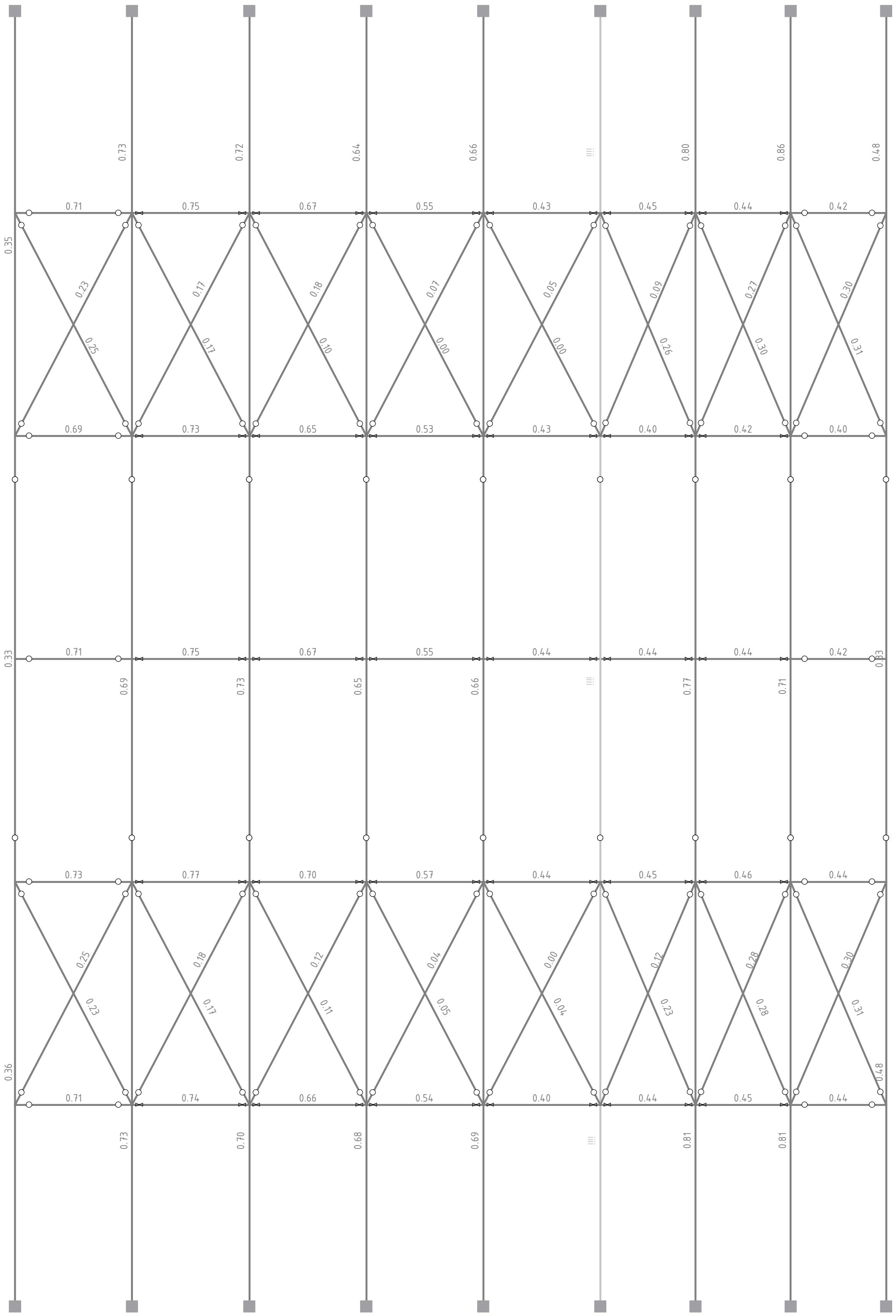
PALICA IZPOSTAVLJENA CENTRIČNEMU NATEGU
(obtežni primer 23, začetek palice)

Računska osna sila	N_{Ed} =	13.941 kN
Sistemska dolžina palice	L =	586.37 cm

6.2 NOSILNOST PREČNIH PREREZOV
6.2.3 Nateg

Plast.rač.nosilnost bruto prereza	$N_{pl,Rd}$ =	47.250 kN
Mejna rač.nosilnost neto prereza	$N_{u,Rd}$ =	46.904 kN
Računska nos. na nateg	$N_{t,Rd}$ =	46.904 kN

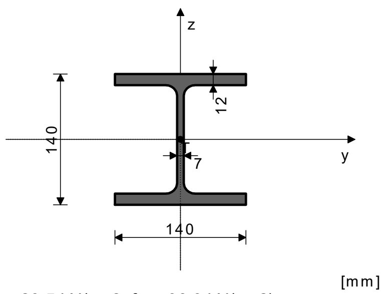
Pogoj 6.5: N_{Ed} <= $N_{t,Rd}$ (13.94 <= 46.90)



Pogled: ST1+ST2
Kontrola stabilnosti

PALICA 9115-7843
PREČNI PREREZ: HEB 140 [S 235] [Set: 4]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	43.000 cm2
Ay =	29.880 cm2
Az =	13.120 cm2
Ix =	20.100 cm4
Iy =	1510.0 cm4
Iz =	550.00 cm4
Wy =	215.71 cm3
Wz =	78.571 cm3
Wy,pl =	245.57 cm3
Wz,pl =	117.60 cm3
γM0 =	1.000
γM1 =	1.100
γM2 =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

12. γ=0.86	24. γ=0.86	60. γ=0.81
48. γ=0.78	16. γ=0.76	15. γ=0.76
28. γ=0.75	27. γ=0.75	26. γ=0.75
89. γ=0.73	91. γ=0.72	13. γ=0.72
25. γ=0.72	14. γ=0.71	64. γ=0.70
63. γ=0.70	52. γ=0.68	51. γ=0.68
98. γ=0.68	100. γ=0.67	61. γ=0.67
62. γ=0.66	50. γ=0.66	49. γ=0.64
23. γ=0.62	30. γ=0.61	42. γ=0.61
11. γ=0.60	18. γ=0.58	66. γ=0.56
78. γ=0.56	59. γ=0.55	47. γ=0.55
54. γ=0.53	22. γ=0.48	21. γ=0.48
36. γ=0.47	20. γ=0.47	90. γ=0.45
19. γ=0.44	34. γ=0.44	46. γ=0.44
45. γ=0.44	33. γ=0.44	58. γ=0.43
41. γ=0.43	57. γ=0.43	72. γ=0.42
32. γ=0.41	44. γ=0.41	99. γ=0.40
55. γ=0.39	70. γ=0.39	69. γ=0.38
56. γ=0.38	82. γ=0.38	81. γ=0.38
43. γ=0.37	31. γ=0.37	29. γ=0.37
17. γ=0.36	68. γ=0.36	80. γ=0.35
53. γ=0.34	84. γ=0.33	83. γ=0.33
92. γ=0.33	67. γ=0.32	79. γ=0.32
65. γ=0.31	77. γ=0.31	35. γ=0.31
37. γ=0.31	71. γ=0.30	40. γ=0.30
39. γ=0.29	38. γ=0.29	93. γ=0.28
73. γ=0.27	74. γ=0.25	76. γ=0.25
75. γ=0.25	101. γ=0.19	95. γ=0.18
87. γ=0.18	86. γ=0.17	88. γ=0.17
94. γ=0.17	85. γ=0.16	97. γ=0.12
96. γ=0.11		

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 12, na 700.0 cm od začetka palice)

Računska osna sila	N_{Ed} =	-11.048 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	-7.538 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	19.036 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	-19.557 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	7.935 kNm
Sistemska dolžina palice	L =	1230.0 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

6.2 NOSILNOST PREČNIH PREREZOV
6.2.4 Tlak
Računska nosilnost na tlak $N_{c,Rd}$ = 1010.5 kN
Pogoj 6.9: N_{Ed} <= $N_{c,Rd}$ (11.05 <= 1010.50)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.
Efektivni odpornostni moment Wy,eff = 189.52 cm3
Računska nosilnost na upogib $M_{c,Rd}$ = 44.537 kNm
Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (19.56 <= 44.54)

6.2.5 Upogib z-z
Upoštevajo se tudi luknje za vezna sredstva.
Efektivni odpornostni moment Wz,eff = 62.994 cm3
Računska nosilnost na upogib $M_{c,Rd}$ = 14.804 kNm
Pogoj 6.12: $M_{Ed,z}$ <= $M_{c,Rd,z}$ (7.93 <= 14.80)

6.2.6 Strig
Računska strižna nosilnost $V_{pl,Rd,z}$ = 110.17 kN
Računska strižna nosilnost $V_{c,Rd,z}$ = 110.17 kN
Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (19.04 <= 110.17)

Računska strižna nosilnost $V_{pl,Rd,y}$ = 438.41 kN
Računska strižna nosilnost $V_{c,Rd,y}$ = 438.41 kN
Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (7.54 <= 438.41)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$; $V_{Ed,y}$ <= 50%$V_{pl,Rd,y}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$		0.011
Zmanjšana plast.upogibna nosilnost	$M_{N,y,Rd}$ =	57.709 kNm
Koeficient	α =	2.000
Razmerje ($M_{y,Ed}$ / $M_{N,y,Rd}$)^α		0.115
Zmanjšana plast.upogibna nosilnost	$M_{N,z,Rd}$ =	27.636 kNm
Koeficient	β =	1.000
Razmerje ($M_{z,Ed}$ / $M_{N,z,Rd}$)^β		0.287

Pogoj 6.41: (0.40 <= 1)

6.3 NOSILNOST ELEMENTA NA UKLON
6.3.1.1 Nosilnost na uklon

Uklonska dolžina y-y	l,y =	585.00 cm
Relativna vitkost y-y	λ_y =	1.051
Uklonska krivulja za os y-y: B	α =	0.340
Elastična kritična sila	$N_{cr,y}$ =	914.50 kN
Koeficient nepopolnosti	χ,y =	0.565
Računska uklonska nosilnost	$N_{b,Rd,y}$ =	518.96 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,y}$ (11.05 <= 518.96)

Uklonska dolžina z-z	l,z =	585.00 cm
Relativna vitkost z-z	λ_z =	1.742
Uklonska krivulja za os z-z: C	α =	0.490
Koeficient nepopolnosti	χ,z =	0.248
Računska uklonska nosilnost	$N_{b,Rd,z}$ =	227.51 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,z}$ (11.05 <= 227.51)

6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	7.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	585.00 cm
Sektorski vztrajnostni moment	Iw =	22479 cm6
Krit.moment bočne zvrnitve	Mcr =	75.392 kNm
Ustrezni odpornostni moment	W_y =	245.57 cm3
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.875
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.750
Računska uklonska nosilnost	$M_{b,Rd}$ =	39.360 kNm

Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (19.56 <= 39.36)

6.3.3. Elementi konstantnega prečnega prereza obremenjeni z upogibom in osnim tlakom
Preračun koeficienta interakcije je izvršen z alternativno metodo št.2 (Aneks B)

Koeficient oblike momenta	C_{my} =	0.950
Koeficient oblike momenta	C_{mz} =	0.950
Koeficient oblike momenta	C_{mLT} =	0.950
Koeficient interakcije	k_{yy} =	0.966
Koeficient interakcije	k_{yz} =	0.609
Koeficient interakcije	k_{zy} =	0.993
Koeficient interakcije	k_{zz} =	1.015

Koeficient nepopolnosti	χ_y =	0.565
N_{Ed} / (χ_y N_{Rk} / γM1)		0.021
kyy * (M_{yEd} + ΔM_{yEd}) / ...		0.480
kyz * (M_{zEd} + ΔM_{zEd}) / ...		0.192

Pogoj 6.61: (0.69 <= 1)

Koeficient nepopolnosti	χ_z =	0.248
N_{Ed} / (χ_z N_{Rk} / γM1)		0.049
kzy * (M_{yEd} + ΔM_{yEd}) / ...		0.493
kzz * (M_{zEd} + ΔM_{zEd}) / ...		0.320

Pogoj 6.62: (0.86 <= 1)

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 12, na 700.0 cm od začetka palice)

Računska osna sila	N_{Ed} =	1.530 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	7.972 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	-20.205 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	-18.446 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	7.500 kNm
Sistemska dolžina palice	L =	1230.0 cm

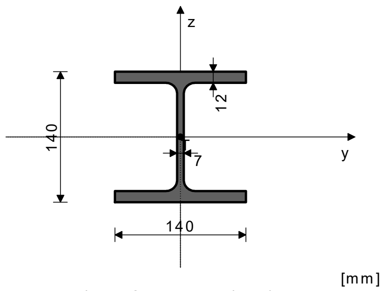
6.2 NOSILNOST PREČNIH PREREZOV
6.2.6 Strig
Računska strižna nosilnost $V_{pl,Rd,z}$ = 110.17 kN

Računska strižna nosilnost $V_{c,Rd,z}$ = 110.17 kN
Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (20.21 <= 110.17)

Računska strižna nosilnost $V_{pl,Rd,y}$ = 438.41 kN

PALICA 3498-6811
PREČNI PREREZ: HEB 140 [S 235] [Set: 3]
EUROCODE 3 (EN 1993-1-1:2005)

GEOMETRIJSKE KARAKTERISTIKE prereza



Ax =	43.000 cm2
Ay =	29.880 cm2
Az =	13.120 cm2
Ix =	20.100 cm4
Iy =	1510.0 cm4
Iz =	550.00 cm4
Wy =	215.71 cm3
Wz =	78.571 cm3
Wy,pl =	245.57 cm3
Wz,pl =	117.60 cm3
$\gamma M0$ =	1.000
$\gamma M1$ =	1.100
$\gamma M2$ =	1.250
Anet/A =	0.900

(fy = 23.5 kN/cm2, fu = 36.0 kN/cm2)

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

27. γ=0.73	21. γ=0.73	63. γ=0.69
57. γ=0.69	91. γ=0.65	90. γ=0.65
24. γ=0.62	25. γ=0.62	18. γ=0.62
19. γ=0.62	26. γ=0.61	20. γ=0.61
100. γ=0.61	99. γ=0.61	28. γ=0.59
22. γ=0.59	56. γ=0.59	62. γ=0.59
60. γ=0.58	61. γ=0.58	54. γ=0.58
55. γ=0.58	17. γ=0.56	64. γ=0.56
58. γ=0.55	59. γ=0.53	23. γ=0.53
53. γ=0.52	39. γ=0.51	45. γ=0.51
15. γ=0.48	75. γ=0.48	81. γ=0.48
51. γ=0.45	89. γ=0.40	33. γ=0.38
12. γ=0.37	13. γ=0.37	14. γ=0.37
98. γ=0.36	69. γ=0.35	16. γ=0.35
49. γ=0.33	48. γ=0.33	37. γ=0.32
44. γ=0.32	43. γ=0.32	36. γ=0.32
38. γ=0.32	42. γ=0.32	11. γ=0.32
50. γ=0.31	92. γ=0.30	83. γ=0.30
52. γ=0.30	79. γ=0.29	73. γ=0.29
72. γ=0.29	74. γ=0.29	80. γ=0.29
78. γ=0.29	40. γ=0.28	46. γ=0.28
47. γ=0.26	87. γ=0.26	65. γ=0.25
29. γ=0.25	82. γ=0.25	76. γ=0.25
70. γ=0.23	34. γ=0.23	41. γ=0.22
35. γ=0.22	96. γ=0.22	32. γ=0.21
31. γ=0.20	30. γ=0.19	68. γ=0.19
77. γ=0.19	71. γ=0.19	66. γ=0.17
67. γ=0.17	97. γ=0.16	95. γ=0.16
88. γ=0.15	86. γ=0.15	101. γ=0.15
93. γ=0.12	94. γ=0.11	84. γ=0.10
85. γ=0.10		

PALICA IZPOSTAVLJENA PRITISKU IN UPOGIBU
(obtežni primer 27, na 1115.0 cm od začetka palice)

Računska osna sila	N_{Ed} =	-0.525 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	-4.564 kN
Prečna sila v z smeri	$V_{Ed,z}$ =	22.003 kN
Upogibni moment okoli y osi	$M_{Ed,y}$ =	-21.169 kNm
Upogibni moment okoli z osi	$M_{Ed,z}$ =	5.000 kNm
Sistemska dolžina palice	L =	1230.0 cm

5.5 KLASIFIKACIJA PREČNIH PREREZOV
Razred prereza 1

6.2 NOSILNOST PREČNIH PREREZOV
6.2.4 Tlak
Računska nosilnost na tlak $N_{c,Rd}$ = 1010.5 kN
Pogoj 6.9: N_{Ed} <= $N_{c,Rd}$ (0.53 <= 1010.50)

6.2.5 Upogib y-y
Upoštevajo se tudi luknje za vezna sredstva.
Efektivni odpornostni moment Wy,eff = 188.93 cm3
Računska nosilnost na upogib $M_{c,Rd}$ = 44.399 kNm
Pogoj 6.12: $M_{Ed,y}$ <= $M_{c,Rd,y}$ (21.17 <= 44.40)

6.2.5 Upogib z-z
Upoštevajo se tudi luknje za vezna sredstva.
Efektivni odpornostni moment Wz,eff = 62.478 cm3
Računska nosilnost na upogib $M_{c,Rd}$ = 14.682 kNm
Pogoj 6.12: $M_{Ed,z}$ <= $M_{c,Rd,z}$ (5.00 <= 14.68)

6.2.6 Strig

Računska strižna nosilnost $V_{c,Rd,y}$ = 438.41 kN
Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (7.97 <= 438.41)

Računska strižna nosilnost $V_{pl,Rd,z}$ = 110.17 kN
Računska strižna nosilnost $V_{c,Rd,z}$ = 110.17 kN
Pogoj 6.17: $V_{Ed,z}$ <= $V_{c,Rd,z}$ (22.00 <= 110.17)

Računska strižna nosilnost $V_{pl,Rd,y}$ = 437.12 kN
Računska strižna nosilnost $V_{c,Rd,y}$ = 437.12 kN
Pogoj 6.17: $V_{Ed,y}$ <= $V_{c,Rd,y}$ (4.56 <= 437.12)

6.2.10 Upogib z osno in prečno silo
Ni potrebno zmanjšanje upogibne nosilnosti
Pogoj: $V_{Ed,z}$ <= 50%$V_{pl,Rd,z}$; $V_{Ed,y}$ <= 50%$V_{pl,Rd,y}$

6.2.9 Upogib in osna sila

Razmerje N_{Ed} / $N_{pl,Rd}$		0.001
Zmanjšana plast.upogibna nosilnost	$M_{N,y,Rd}$ =	57.709 kNm
Koeficient	α =	2.000
Razmerje ($M_{y,Ed}$ / $M_{N,y,Rd}$)^α		0.135
Zmanjšana plast.upogibna nosilnost	$M_{N,z,Rd}$ =	27.636 kNm
Koeficient	β =	1.000
Razmerje ($M_{z,Ed}$ / $M_{N,z,Rd}$)^β		0.181

Pogoj 6.41: (0.32 <= 1)

6.3 NOSILNOST ELEMENTA NA UKLON
6.3.1.1 Nosilnost na uklon

Uklonska dolžina y-y	l,y =	585.00 cm
Relativna vitkost y-y	λ_y =	1.051
Uklonska krivulja za os y-y: B	α =	0.340
Elastična kritična sila	$N_{cr,y}$ =	914.50 kN
Koeficient nepopolnosti	χ,y =	0.565
Računska uklonska nosilnost	$N_{b,Rd,y}$ =	518.96 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,y}$ (0.53 <= 518.96)

Uklonska dolžina z-z	l,z =	585.00 cm
Relativna vitkost z-z	λ_z =	1.742
Uklonska krivulja za os z-z: C	α =	0.490
Koeficient nepopolnosti	χ,z =	0.248
Računska uklonska nosilnost	$N_{b,Rd,z}$ =	227.51 kN

Pogoj 6.46: N_{Ed} <= $N_{b,Rd,z}$ (0.53 <= 227.51)

6.3.2.1 Nosilnost na bočno-torzijski uklon

Koeficient	C1 =	1.132
Koeficient	C2 =	0.459
Koeficient	C3 =	0.525
Koef.ukl.dolžine za uklon	k =	1.000
Koef.ukl.dolžine za vbočenje	kw =	1.000
Koordinata	zg =	7.000 cm
Koordinata	zj =	0.000 cm
Razmak med bočnimi podporami	L =	585.00 cm
Sektorski vztrajnostni moment	Iw =	22479 cm6
Krit.moment bočne zvrnitve	Mcr =	75.392 kNm
Ustrezni odpornostni moment	Wy =	245.57 cm3
Koeficient imperf.	αLT =	0.210
Brezdimenz.vitkost	λLT_ =	0.875
Koeficient zmanjšanja (6.3.2.2.)	χLT =	0.750
Računska uklonska nosilnost	$M_{b,Rd}$ =	39.360 kNm

Pogoj 6.54: $M_{Ed,y}$ <= $M_{b,Rd}$ (21.17 <= 39.36)

6.3.3. Elementi konstantnega prečnega prereza obremenjeni z upogibom in osnim tlakom
Preračun koeficienta interakcije je izvršen z alternativno metodo št.2 (Aneks B)

Koeficient oblike momenta	C_{my} =	0.950
Koeficient oblike momenta	C_{mz} =	0.950
Koeficient oblike momenta	C_{mLT} =	0.950
Koeficient interakcije	k_{yy} =	0.951
Koeficient interakcije	k_{yz} =	0.572
Koeficient interakcije	k_{zy} =	1.000
Koeficient interakcije	k_{zz} =	0.953

Koeficient nepopolnosti	χ_y =	0.565
N_{Ed} / (χ_y N_{Rk} / $\gamma M1$)		0.001
kyy * (M_{yEd} + ΔM_{yEd}) / ...		0.511
kyz * (M_{zEd} + ΔM_{zEd}) / ...		0.114

Pogoj 6.61: (0.63 <= 1)

Koeficient nepopolnosti	χ_z =	0.248
N_{Ed} / (χ_z N_{Rk} / $\gamma M1$)		0.002
kzy * (M_{yEd} + ΔM_{yEd}) / ...		0.538
kzz * (M_{zEd} + ΔM_{zEd}) / ...		0.190

Pogoj 6.62: (0.73 <= 1)

KONTROLA STRIŽNE NOSILNOSTI
(obtežni primer 21, na 530.0 cm od začetka palice)

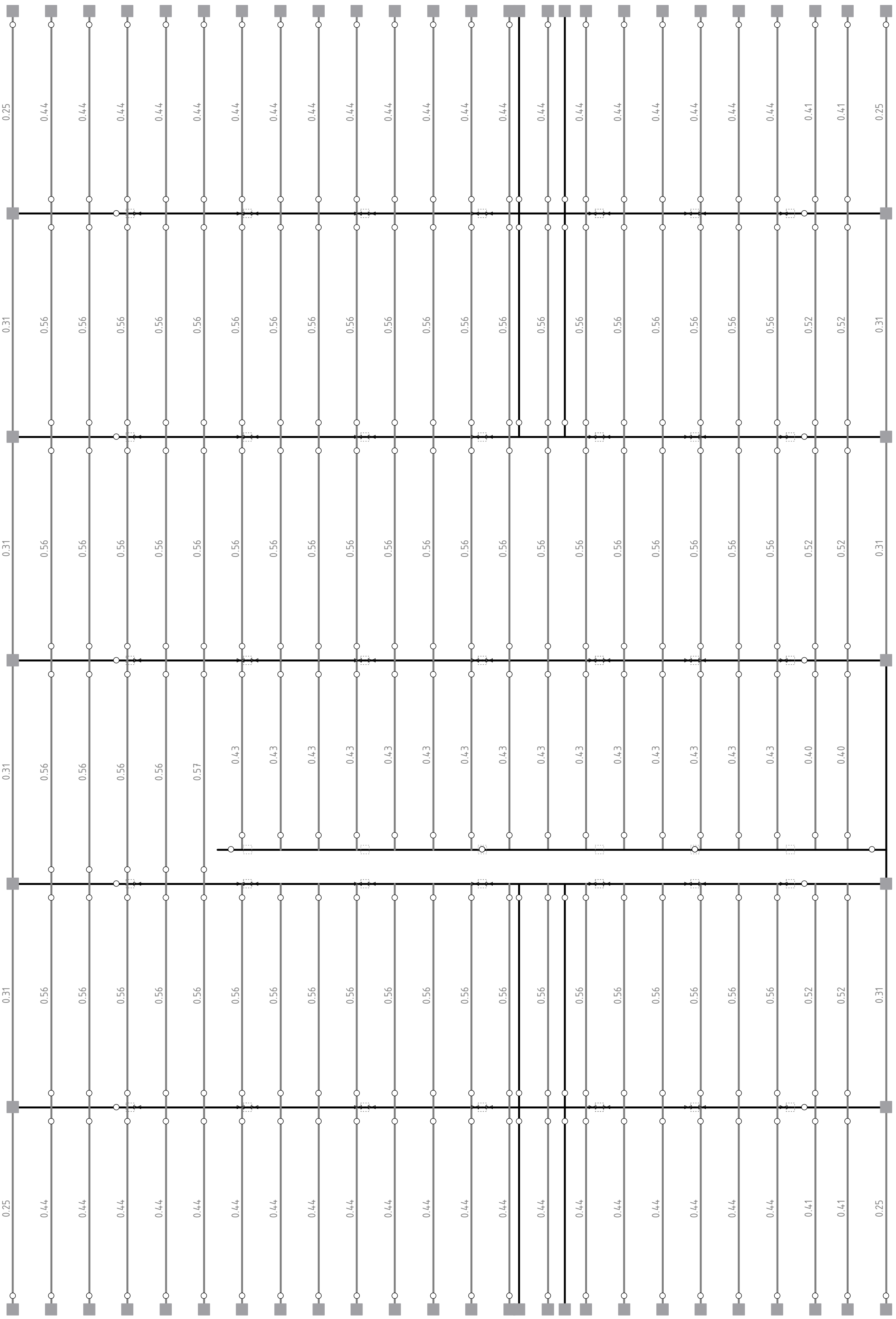
Računska osna sila	N_{Ed} =	1.530 kN
Prečna sila v y smeri	$V_{Ed,y}$ =	-4.923 kN

Prečna sila v z smeri $V_{Ed,z}$ = 23.408 kN
Upogibni moment okoli y osi $M_{Ed,y}$ = -18.948 kNm
Upogibni moment okoli z osi $M_{Ed,z}$ = 5.442 kNm
Sistemska dolžina palice L = 1230.0 cm

6.2 NOSILNOST PREČNIH PREREZOV
6.2.6 Strig
Računska strižna nosilnost $V_{pl,Rd,z}$ = 110.17 kN
Računska strižna nosilnost $V_{c,Rd,z}$ = 110.17 kN
Pogoj 6.17: $V_{Ed,z} <= V_{c,Rd,z}$ (23.41 <= 110.17)

Računska strižna nosilnost $V_{pl,Rd,y}$ = 431.83 kN
Računska strižna nosilnost $V_{c,Rd,y}$ = 431.83 kN
Pogoj 6.17: $V_{Ed,y} <= V_{c,Rd,y}$ (4.92 <= 431.83)

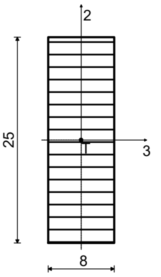
Dimenzioniranje (les)



Nivo: [0.00 m]
Kontrola stabilnosti

UROŠ ŽVAN s.p., ZRKOVSKA 75, 2000 MARIBOR

PALICA 3266-4976
Lepljen lameliran les - GL24h
v smeri zgornjega roba palice
Debelina lamele 5.00 cm
Eksploatacijski razred 1
EUROCODE (EN 1995-1-1)



[cm]

FAKTORJI IZKORIŠČENOSTI PO KOMBINACIJAH OBTEŽB

101. γ=0.56	12. γ=0.42	13. γ=0.42
14. γ=0.42	15. γ=0.42	16. γ=0.42
17. γ=0.42	18. γ=0.42	19. γ=0.42
20. γ=0.42	21. γ=0.42	22. γ=0.42
23. γ=0.42	24. γ=0.42	25. γ=0.42
26. γ=0.42	27. γ=0.42	28. γ=0.42
29. γ=0.42	30. γ=0.42	31. γ=0.42
32. γ=0.42	33. γ=0.42	34. γ=0.42
35. γ=0.42	36. γ=0.42	37. γ=0.42
38. γ=0.42	39. γ=0.42	40. γ=0.42
41. γ=0.42	42. γ=0.42	43. γ=0.42
44. γ=0.42	45. γ=0.42	46. γ=0.42
83. γ=0.42	84. γ=0.42	85. γ=0.42
86. γ=0.42	87. γ=0.42	88. γ=0.42
89. γ=0.42	90. γ=0.42	91. γ=0.42
11. γ=0.42	57. γ=0.31	58. γ=0.31
59. γ=0.31	60. γ=0.31	61. γ=0.31
62. γ=0.31	63. γ=0.31	64. γ=0.31
65. γ=0.31	66. γ=0.31	67. γ=0.31
68. γ=0.31	69. γ=0.31	70. γ=0.31
71. γ=0.31	72. γ=0.31	73. γ=0.31
74. γ=0.31	75. γ=0.31	76. γ=0.31
77. γ=0.31	78. γ=0.31	79. γ=0.31
80. γ=0.31	81. γ=0.31	82. γ=0.31
47. γ=0.31	48. γ=0.31	49. γ=0.31
50. γ=0.31	51. γ=0.31	52. γ=0.31
53. γ=0.31	54. γ=0.31	55. γ=0.31
92. γ=0.31	93. γ=0.31	94. γ=0.31
95. γ=0.31	96. γ=0.31	97. γ=0.31
98. γ=0.31	99. γ=0.31	100. γ=0.31
56. γ=0.31		

KONTROLA NORMALNIH NAPETOSTI
(obtežni primer 101, na 282.4 cm od začetka palice)

Računska osna sila	Ned =	0.583 kN
Prečna sila v smeri osi 2	V2ed =	-0.116 kN
Upogibni moment okoli osi 3	M3ed =	-4.903 kNm

KONTROLA NAPETOSTI - NATEG IN UPOGIB
Vrsta obtežbe: osnovno - stalno

Korekcijski koeficient	Kmod =	0.600
Parcialni koef. za karakteristike materiala	γm =	1.250
Dodatek za elemente z malimi dimenzijami - os 2	Kh_2 =	1.100
Dodatek za elemente z malimi dimenzijami - os 3	Kh_3 =	1.091
Dodatek za elemente z malimi dimenzijami - nateg	Kh_t =	1.100
Karakteristična natezna trdnost	ft,0,k =	16.500 MPa
Računska natezna trdnost	ft,0,d =	8.712 MPa
Faktor oblik (za pravokotni prerez)	km =	0.700
Karakteristična upogibna trdnost	fm,k =	24.000 MPa
Računska upogibna trdnost - os 2	fm,2,d =	12.672 MPa
Računska upogibna trdnost - os 3	fm,3,d =	12.574 MPa
Normalna natezna napetost	σt,0,d =	0.029 MPa
Odpornostni moment	W3 =	833.33 cm3
Normalna upogibna napetost okoli osi 3	σm3,d =	5.884 MPa

σm3,d <= fm,3,d (5.884 <= 12.574)

Izkoriščenost prereza je 46.8%

σt,0,d / ft,0,d + km x (σm3,d / fm,3,d) + σm2,d / fm,2,d <= 1
(0.331 <= 1)

Izkoriščenost prereza je 33.1%

σt,0,d / ft,0,d + σm3,d / fm,3,d + km x (σm2,d / fm,2,d) <= 1
(0.471 <= 1)

Izkoriščenost prereza je 47.1%

DOKAZ BOČNE STABILNOSTI
Vrsta obtežbe: osnovno - stalno

Korekcijski koeficient	Kmod =	0.600
Parcialni koef. za karakteristike materiala	γm =	1.250
Razmak pridržanih točk pravokotno na smer osi 2		
	lef =	585.00 cm
5% fraktil modula E paralelno z vlakni	E0.05 =	9400.0 MPa
5% fraktil strižnega modula G	G0.05 =	480.00 MPa
Torzijski vztrajnostni moment	Itor =	3416.8 cm4
Vztrajnostni moment	I2 =	1066.7 cm4
Odpornostni moment	W3 =	833.33 cm3
Kritična napetost uklona	σm,crit =	26.133 MPa
Relativna vitkost za uklon	λrel =	0.958
Koeficient	k_krit =	0.841
Normalna upogibna napetost okoli osi 3	σm3,d =	5.884 MPa

σm,3,d <= k_krit x fm,3,d (5.884 <= 10.578)

Izkoriščenost prereza je 55.6%

KONTROLA STRIŽNIH NAPETOSTI
(obtežni primer 101, začetek palice)

Prečna sila v smeri osi 2	V2ed =	-3.356 kN

KONTROLA NAPETOSTI - STRIG
Vrsta obtežbe: osnovno - stalno

Korekcijski koeficient	Kmod =	0.600
Parcialni koef. za karakteristike materiala	γm =	1.250
Karakteristična strižna napetost	fv,k =	2.700 MPa
Računska strižna trdnost	fv,d =	1.296 MPa
Površina prečnega prereza	A =	200.00 cm2
Dejanska strižna napetost(os 2)	τ2,d =	0.252 MPa

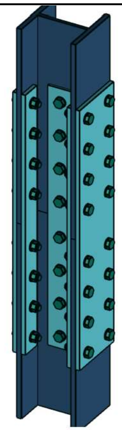
τ2,d <= fv,d (0.252 <= 1.296)

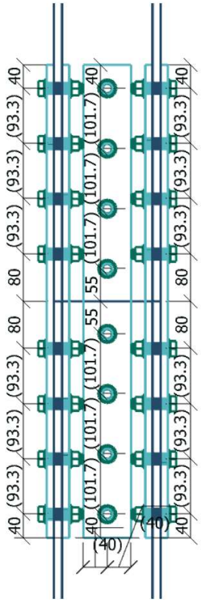
Izkoriščenost prereza je 19.4%

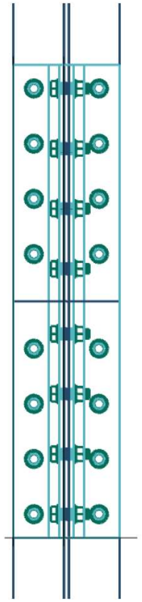
GRAITEC GRAITEC INNOVATION www.graitec.com 17 Burospace 91572 Bièvres	*Project*	SPOJ HEB 180 PALIČNI NOSILEC		
	Address			
	Report		*Execution class EN 1090-2*	**EXC2**
	Designed by		*Date*	
	Verified by		*Date*	
	Revision	**0**	*Drawing*	

Splice Report

Maximum Work Ratio	**82.66 %**	**Passed**







1 Joint description

Joint contains the following assemblies:

- Assembly on left upper flange

- Assembly on right upper flange

- Assembly on left lower flange

- Assembly on right lower flange

- Assembly on left web

- Assembly on right web

Assembly on left upper flange

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Left Upper Inner Flange	12 mm	400 mm
2	Splice plate	Left Upper Inner Flange	12 mm	400 mm
3	Left upper flange	HEB180	14 mm	600 mm
4	Splice plate	Left Upper Flange	12 mm	400 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157$ mm²

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

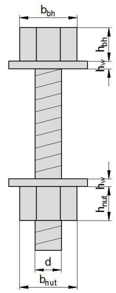
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A



Assembly on right upper flange

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Right Upper Inner Flange	12 mm	400 mm
2	Splice plate	Right Upper Inner Flange	12 mm	400 mm
3	Splice plate	Right Upper Flange	12 mm	400 mm
4	Right upper flange	HEB180	14 mm	600 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157\ mm^2$

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

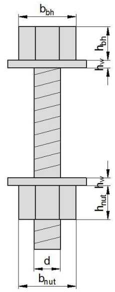
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A



Assembly on left lower flange

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Left Lower Flange	12 mm	400 mm
2	Left lower flange	HEB180	14 mm	600 mm
3	Splice plate	Left Lower Inner Flange	12 mm	400 mm
4	Splice plate	Left Lower Inner Flange	12 mm	400 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157\ mm^2$

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

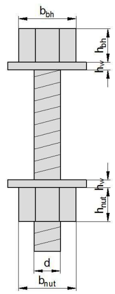
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A



Assembly on right lower flange

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Right Lower Inner Flange	12 mm	400 mm
2	Splice plate	Right Lower Inner Flange	12 mm	400 mm
3	Splice plate	Right Lower Flange	12 mm	400 mm
4	Right lower flange	HEB180	14 mm	600 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157\ mm^2$

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

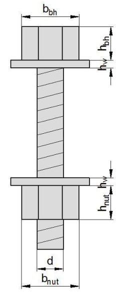
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A



Assembly on left web

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Left Web	8 mm	400 mm
2	Left web	HEB180	8.5 mm	600 mm
3	Splice plate	Left Web	8 mm	400 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157\ mm^2$

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

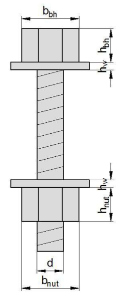
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A



<u>**Assembly on right web**</u>

Id	Plate Type	Profile origin	Plate Thickness	Length
1	Splice plate	Right Web	8 mm	400 mm
2	Right web	HEB180	8.5 mm	600 mm
3	Splice plate	Right Web	8 mm	400 mm

Bolts dimensions and properties

Bolt shear area $A_s = 157$ mm²

Diameter $d = 16$ mm

Bolt Nut Height $h_{nut} = 13$ mm

Bolt Nut Width $b_{nut} = 27$ mm

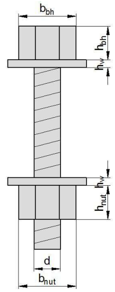
Washer Thickness $h_w = 8$ mm

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Bolted connection category: A

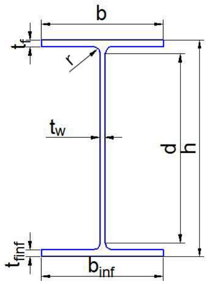


Profiles characteristics are detailed below:

HEB180

Material: S235 (EN 10025-2)

Dimensions	**Characteristics**
$h = 180$ mm	$A = 6525$ mm²
$t_w = 8.5$ mm	$I_y = 3831$ cm^4
$d = 122$ mm	$I_z = 1363$ cm^4
$b = 180$ mm	$W_{pl,y} = 481.4$ cm³
$t_f = 14$ mm	
$b_{inf} = 180$ mm	$W_{el,y,sup} = 425.7$ cm³
$t_{f,inf} = 14$ mm	$W_{el,y,inf} = 425.7$ cm³
$r = 15$ mm	



1 Load combinations description

Joint ID	Comb. Index	Load Combination Description	Comb. Type	Position	V (kN)	M (kN·m)	N (kN)
	1	ULS 1	ULS	Right	20	15	700
				Left	20	15	700
Maximum Efforts					**20**	**15**	**700**
Minimum Efforts					**20**	**15**	**700**

The torsor is defined in the member's local system!

1 Design Assumptions

Design standards

EN 1993-1-1 Design of Steel Structures. General Rules and Rules for Buildings

EN 1993-1-8 Design of Steel Structures. Design of Joints

EN 1993-1 National Annex: General Eurocode.

Units

Dimensions:	**mm**	Area:	**mm²**
Forces:	**kN**	Inertia modulus:	**cm³**
Bending moments:	**kN·m**	Inertia Moment:	**cm⁴**
Stresses:	**MPa**	Rotational Stiffness:	**kN·m/rad**
Angles:	°		

Bolts

The shear plane passes through the THREADED part of the bolt.

Approximate value for the transformation parameter, according to Table 5.4:

$\beta = 1$

Bolt tension reduction factor, according to EN 1090:

$\alpha = 1$

Safety Coefficients

Structural steel

$\gamma_{M0} = 1$

$\gamma_{M1} = 1.1$

$\gamma_{M2} = 1.25$ - for bolts/anchors, welds, plates in bearing

$\gamma_{M2} = 1.25$ - for cross-sections in tension to fracture

Corrosion conditions

EN 10025, the steel is used unprotected (without improved atmospheric corrosion resistance).

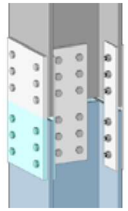
Conventions

Tension is considered positive (compression is considered negative).

Bending moment is considered positive if clockwise (in above elevation).

Strong axis of the profile is considered "y-y" and weak axis "z-z".

The joint comprises 6 assemblies. Next, verifications are performed for each assembly (duplicated assemblies are excluded).



1 Verification of left upper flange assembly

In the following, the assembly components are denoted plates originating from joint profiles. Their role in the assembly (plate type), profiles of origin, thickness and corresponding forces are detailed in the table below.

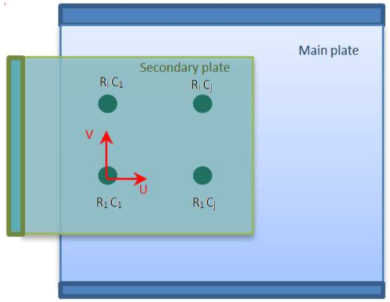
Forces are obtained by projecting the initial efforts in the local system of the bolts group. The forces are transferred to assembly components with the following pattern:
plate -> bolts -> pressure on holes.

Id	Plate Type	Profile origin	Plate Thickness	Force U	Force V
1	Splice plate	Left Upper Inner Flange	12 mm	88.11 kN	0 kN
2	Splice plate	Left Upper Inner Flange	12 mm	88.11 kN	0 kN
3	Left upper flange	HEB180	14 mm	352.43 kN	0 kN
4	Splice plate	Left Upper Flange	12 mm	176.21 kN	0 kN

Note: U, V are horizontal and vertical directions (based on plate local coordinate system).

1.1 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \leq e_1$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 40\ mm$ — **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \leq e_2$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 25\ mm$ — **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \leq p_1$ — EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \leq 93.3\ mm$ — **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \leq \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$40\ mm \leq \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \leq \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$25\ mm \leq \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \leq \min(14 \cdot t_{min}; 175\ mm)$ — EN 1993-1-8, Table 3.3

$93.3\ mm \leq \min(14 \times 12\ mm; 175\ mm) = 168\ mm$ — **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.1.2 Compression verifications

Verification is not required.

1.1.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 720\ mm^2 \times \frac{235\ MPa}{1} = 169.2\ kN$$ — EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 60\ mm \times 12\ mm = 720\ mm^2$

Check relation becomes: $88.11\ kN \leq 169.2\ kN$

Work Ratio: 52.07 % — **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (60\ mm - 1 \times 18\ mm) \times 12\ mm = 504\ mm^2$$

$$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 504\ mm^2 \times \frac{360\ MPa}{1.25} = 130.64\ kN$$ — EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $88.11\ kN \leq 130.64\ kN$

Work Ratio: 67.44 % — **Passed**

1.1.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

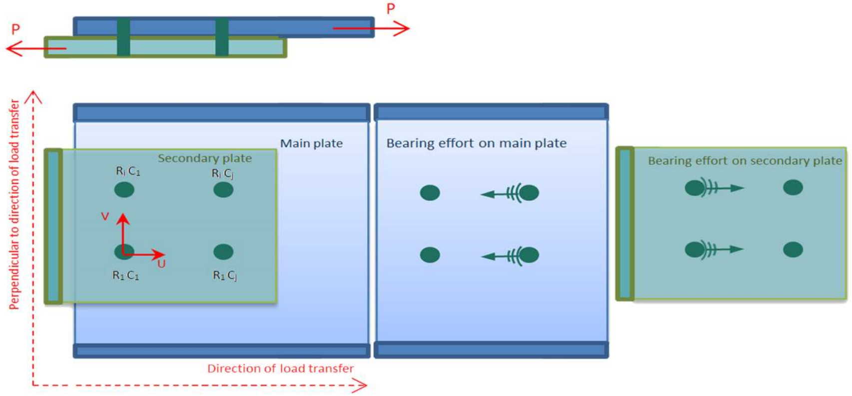
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C2	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C3	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C4	edge bolt	35	3.74	edge bolt	25	2.19	2.19

Bolt Location	FvEd_N,u	FvEdM,u	FvEd
	(kN)	(kN)	(kN)
R1 C1	22.03	0	22.03
R1 C2	22.03	0	22.03
R1 C3	22.03	0	22.03
R1 C4	22.03	0	22.03

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	121.04	22.03	18.2 %	Passed
R1 C2	16	12	121.04	22.03	18.2 %	Passed
R1 C3	16	12	121.04	22.03	18.2 %	Passed
R1 C4	16	12	89.66	22.03	24.57 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.1.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

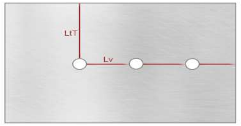
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 257 \times 12 = 3084\ mm^2$

$L_v = 257\ mm$ (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^T \cdot t = 16 \times 12 = 192\ mm^2$

$L_t^T = 16\ mm$ (1 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 192}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 3084}{1} = 473.72\ kN$$

$V_{Ed} \le V_{eff,Rd}$ $88.11 \le 473.72\ kN$

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.1.6 Welds verification

Verification is not required.

1.2 Left upper flange

1.2.1 Compression verifications

Verification is not required.

1.2.2 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2520\ mm^2 \times \frac{235\ MPa}{1} = 592.2\ kN$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 14\ mm = 2520\ mm^2$

Check relation becomes: $352.43\ kN \le 592.2\ kN$

Work Ratio: 59.51 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 14\ mm = 2016\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 2016\ mm^2 \times \frac{360\ MPa}{1.25} = 522.55\ kN$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $352.43\ kN \le 522.55\ kN$

Work Ratio: 67.44 % **Passed**

1.2.3 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

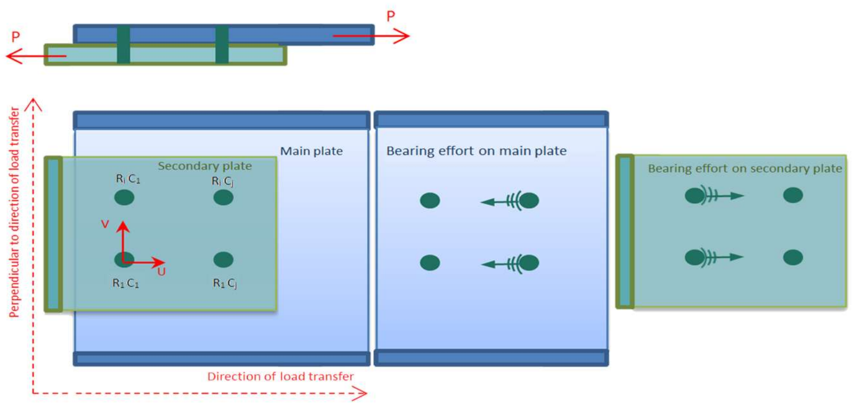
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	80	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	inner bolt	93.3	18	800	360	1
R2 C1	end bolt	80	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	inner bolt	93.3	18	800	360	1

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	-44.05	0	-44.05
R1 C2	-44.05	0	-44.05
R1 C3	-44.05	0	-44.05
R1 C4	-44.05	0	-44.05
R2 C1	-44.05	0	-44.05
R2 C2	-44.05	0	-44.05
R2 C3	-44.05	0	-44.05
R2 C4	-44.05	0	-44.05

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	14	161.28	-44.05	27.31 %	Passed
R1 C2	16	14	161.28	-44.05	27.31 %	Passed
R1 C3	16	14	161.28	-44.05	27.31 %	Passed
R1 C4	16	14	161.28	-44.05	27.31 %	Passed
R2 C1	16	14	161.28	-44.05	27.31 %	Passed
R2 C2	16	14	161.28	-44.05	27.31 %	Passed
R2 C3	16	14	161.28	-44.05	27.31 %	Passed
R2 C4	16	14	161.28	-44.05	27.31 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.2.4 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

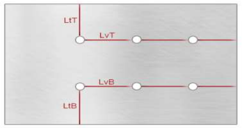
$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = (L_v^T + L_v^B) \cdot t = (297 + 297) \times 14 = 8316$ mm²

$L_v^T = 297$ mm (4 holes, diameter 18 mm)

$L_v^B = 297$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 14 = 728$ mm²

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 728}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 8316}{1} = 1337.96 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $352.43 \leq 1337.96$ kN

Passed

Block Tearing Verification on V - Direction

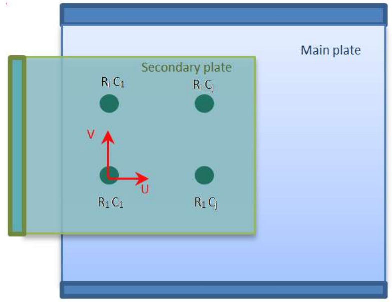
Verification is not required.

1.2.5 Welds verification

Verification is not required.

1.3 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \leq e_1$ EN 1993-1-8, Table 3.3

1.2×18 mm $= 21.6$ mm ≤ 40 mm **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \leq e_2$ EN 1993-1-8, Table 3.3

1.2×18 mm $= 21.6$ mm ≤ 35 mm **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \leq p_1$ EN 1993-1-8, Table 3.3

2.2×18 mm $= 39.6$ mm ≤ 93.3 mm **Passed**

Minimum spacing between the centers of 2 holes, measured on "V" direction

$2.4 \cdot d_0 \leq p_2$ EN 1993-1-8, Table 3.3

2.4×18 mm $= 43.2$ mm ≤ 110 mm **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \leq \max(8 \cdot t_{min}; 125 \text{ mm})$ EN 1993-1-8, Table 3.3

$40 \text{ mm} \leq \max(8 \times 12 \text{ mm}; 125 \text{ mm}) = 125$ mm **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \leq \max(8 \cdot t_{min}; 125 \text{ mm})$ EN 1993-1-8, Table 3.3

$35 \text{ mm} \leq \max(8 \times 12 \text{ mm}; 125 \text{ mm}) = 125$ mm **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \leq \min(14 \cdot t_{min}; 175 \text{ mm})$ EN 1993-1-8, Table 3.3

$93.3 \text{ mm} \leq \min(14 \times 12 \text{ mm}; 175 \text{ mm}) = 168$ mm **Passed**

Maximum spacing between the centers of 2 holes on "V" direction

$p_2 \leq \min(14 \cdot t_{min}; 175 \text{ mm})$ EN 1993-1-8, Table 3.3

$110 \text{ mm} \leq \min(14 \times 12 \text{ mm}; 175 \text{ mm}) = 168$ mm **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.3.2 Compression verifications

Verification is not required.

1.3.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2160\ mm^2 \times \frac{235\ MPa}{1} = 507.6\ kN$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 12\ mm = 2160\ mm^2$

Check relation becomes: $176.21\ kN \le 507.6\ kN$

Work Ratio: 34.71 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 12\ mm = 1728\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 1728\ mm^2 \times \frac{360\ MPa}{1.25} = 447.9\ kN$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $176.21\ kN \le 447.9\ kN$

Work Ratio: 39.34 % **Passed**

1.3.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

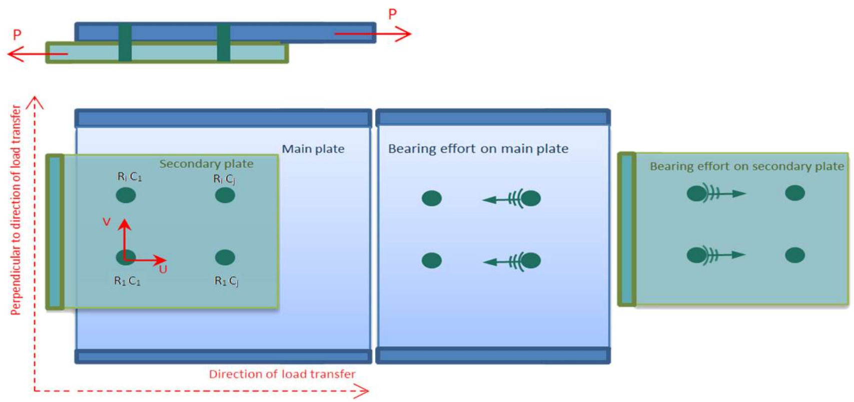
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74
R2 C1	inner bolt	93.3	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u	FvEdM,u	FvEd
	(kN)	(kN)	(kN)
R1 C1	22.03	0	22.03
R1 C2	22.03	0	22.03
R1 C3	22.03	0	22.03
R1 C4	22.03	0	22.03
R2 C1	22.03	0	22.03
R2 C2	22.03	0	22.03
R2 C3	22.03	0	22.03
R2 C4	22.03	0	22.03

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	138.24	22.03	15.93 %	Passed
R1 C2	16	12	138.24	22.03	15.93 %	Passed
R1 C3	16	12	138.24	22.03	15.93 %	Passed
R1 C4	16	12	102.4	22.03	21.51 %	Passed
R2 C1	16	12	138.24	22.03	15.93 %	Passed
R2 C2	16	12	138.24	22.03	15.93 %	Passed
R2 C3	16	12	138.24	22.03	15.93 %	Passed
R2 C4	16	12	102.4	22.03	21.51 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.3.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

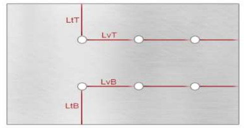
$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = (L_v^T + L_v^B) \cdot t = (257 + 257) \times 12 = 6168\ mm^2$

$L_v^T = 257$ mm (4 holes, diameter 18 mm)

$L_v^B = 257$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 12 = 624\ mm^2$

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 624}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 6168}{1} = 1016.57\ kN$$

$V_{Ed} \le V_{eff,Rd}$ 176.21 ≤ 1016.57 kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.3.6 Welds verification

Verification is not required.

1 Bolts verification

1 Bolts Shear Verification

Check relation: $F_{v,Ed} \leq F_{v,Rd}$

Combination: [1]: ULS 1

$F_{v,Ed}$ - *effective shear force per bolt*

$F_{v,Rd} = n_s \times \alpha_v \times A \times \frac{f_{ub}}{\gamma_{M2}}$ *(design shear resistance per bolt)* **EN 1993-1-8, 3.6.1, table 3.4**

Shear plane passes through the threaded portion of the bolt. Terms "A" and "αv" are detailed below.

$A = A_s = 157\ mm^2$

$\alpha_v = 0.6$ **EN 1993-1-8, 3.6.1, table 3.4**

The table below shows the design shear resistance of each bolt.

Bolt Location	ns	αv	A	Fub	FvRd	FvRd reduced
	(adim.)	(adim.)	(mm²)	(MPa)	(kN)	(kN)
R1 C1	2	0.6	157	800	119.07	119.07
R1 C2	2	0.6	157	800	119.07	119.07
R1 C3	2	0.6	157	800	119.07	119.07
R1 C4	2	0.6	157	800	119.07	119.07
R2 C1	2	0.6	157	800	119.07	119.07
R2 C2	2	0.6	157	800	119.07	119.07
R2 C3	2	0.6	157	800	119.07	119.07
R2 C4	2	0.6	157	800	119.07	119.07

Note: Shear resistance is reduced due to 3.6.1 (3), EN 1993-1-8.

Effective shear force of each bolt is shown in the following table:

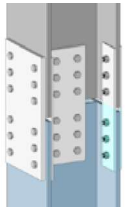
Bolt Location	FvEd_N,u	FvEd_M,u	FvEd_T,v	FvEd_M,v	FvEd*
	(kN)	(kN)	(kN)	(kN)	(kN)
R1 C1	44.05	0	0	0	44.05
R1 C2	44.05	0	0	0	44.05
R1 C3	44.05	0	0	0	44.05
R1 C4	44.05	0	0	0	44.05
R2 C1	44.05	0	0	0	44.05
R2 C2	44.05	0	0	0	44.05
R2 C3	44.05	0	0	0	44.05
R2 C4	44.05	0	0	0	44.05

$$*F_{v,Ed} = \sqrt{(F_{v,Ed\_N,u} + F_{v,Ed\_M,u})^2 + (F_{v,Ed\_T,v} + F_{v,Ed\_M,v})^2}$$

In the following, the check relation is verified by replacing the corresponding values for each bolt.

Bolt Location	FvRd	FvEd	Work Ratio	Verification Status
	(kN)	(kN)	(%)	
R1 C1	119.07	44.05	37 %	Passed
R1 C2	119.07	44.05	37 %	Passed
R1 C3	119.07	44.05	37 %	Passed
R1 C4	119.07	44.05	37 %	Passed
R2 C1	119.07	44.05	37 %	Passed
R2 C2	119.07	44.05	37 %	Passed
R2 C3	119.07	44.05	37 %	Passed
R2 C4	119.07	44.05	37 %	Passed

1 Verification of left lower flange assembly



In the following, the assembly components are denoted plates originating from joint profiles. Their role in the assembly (plate type), profiles of origin, thickness and corresponding forces are detailed in the table below.

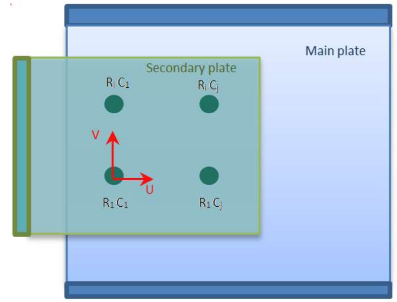
Forces are obtained by projecting the initial efforts in the local system of the bolts group. The forces are transferred to assembly components with the following pattern:
plate -> bolts -> pressure on holes.

Id	Plate Type	Profile origin	Plate Thickness	Force U	Force V
1	Splice plate	Left Lower Flange	12 mm	94.13 kN	0 kN
2	Left lower flange	HEB180	14 mm	188.25 kN	0 kN
3	Splice plate	Left Lower Inner Flange	12 mm	47.06 kN	0 kN
4	Splice plate	Left Lower Inner Flange	12 mm	47.06 kN	0 kN

Note: U, V are horizontal and vertical directions (based on plate local coordinate system).

1.1 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \le e_1$ — EN 1993-1-8, Table 3.3

1.2×18 mm $= 21.6$ mm ≤ 40 mm — **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \le e_2$ — EN 1993-1-8, Table 3.3

1.2×18 mm $= 21.6$ mm ≤ 35 mm — **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \le p_1$ — EN 1993-1-8, Table 3.3

2.2×18 mm $= 39.6$ mm ≤ 93.3 mm — **Passed**

Minimum spacing between the centers of 2 holes, measured on "V" direction

$2.4 \cdot d_0 \le p_2$ — EN 1993-1-8, Table 3.3

2.4×18 mm $= 43.2$ mm ≤ 110 mm — **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \le \max(8 \cdot t_{min}; 125$ mm$)$ — EN 1993-1-8, Table 3.3

40 mm $\le \max(8 \times 12$ mm$;125$ mm$) = 125$ mm — **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \le \max(8 \cdot t_{min}; 125$ mm$)$ — EN 1993-1-8, Table 3.3

35 mm $\le \max(8 \times 12$ mm$;125$ mm$) = 125$ mm — **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \le \min(14 \cdot t_{min}; 175$ mm$)$ — EN 1993-1-8, Table 3.3

93.3 mm $\le \min(14 \times 12$ mm$;175$ mm$) = 168$ mm — **Passed**

Maximum spacing between the centers of 2 holes on "V" direction

$p_2 \le \min(14 \cdot t_{min}; 175$ mm$)$ — EN 1993-1-8, Table 3.3

110 mm $\le \min(14 \times 12$ mm$;175$ mm$) = 168$ mm — **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.1.2 Compression verifications

Verification is not required.

1.1.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2160\ mm^2 \times \frac{235\ MPa}{1} = 507.6\ kN$ — EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 12\ mm = 2160\ mm^2$

Check relation becomes: $94.13\ kN \leq 507.6\ kN$

Work Ratio: 18.54 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 12\ mm = 1728\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 1728\ mm^2 \times \frac{360\ MPa}{1.25} = 447.9\ kN$ — EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $94.13\ kN \leq 447.9\ kN$

Work Ratio: 21.02 % **Passed**

1.1.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

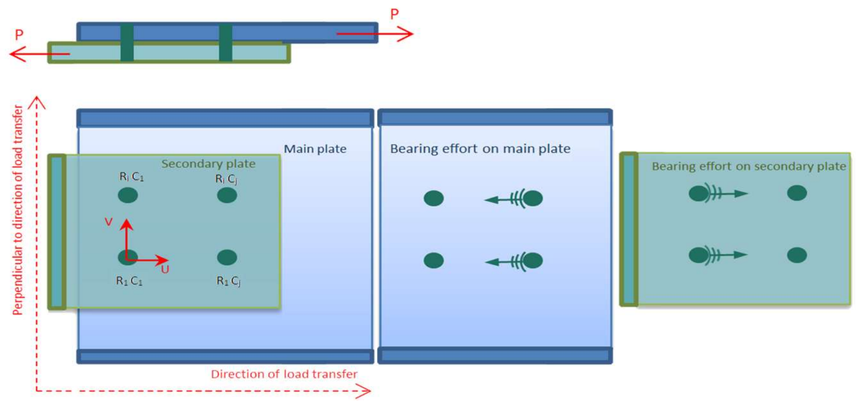
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74
R2 C1	inner bolt	93.3	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	11.77	0	11.77
R1 C2	11.77	0	11.77
R1 C3	11.77	0	11.77
R1 C4	11.77	0	11.77
R2 C1	11.77	0	11.77
R2 C2	11.77	0	11.77
R2 C3	11.77	0	11.77
R2 C4	11.77	0	11.77

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	138.24	11.77	8.51 %	Passed
R1 C2	16	12	138.24	11.77	8.51 %	Passed
R1 C3	16	12	138.24	11.77	8.51 %	Passed
R1 C4	16	12	102.4	11.77	11.49 %	Passed
R2 C1	16	12	138.24	11.77	8.51 %	Passed
R2 C2	16	12	138.24	11.77	8.51 %	Passed
R2 C3	16	12	138.24	11.77	8.51 %	Passed
R2 C4	16	12	102.4	11.77	11.49 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.1.5 Block tearing verification

Block Tearing Verification on U - Direction

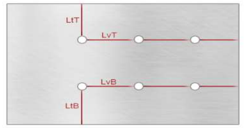
Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear



$A_{n,v} = (L_v^T + L_v^B) \cdot t = (257 + 257) \times 12 = 6168$ mm²

$L_v^T = 257$ mm (4 holes, diameter 18 mm)

$L_v^B = 257$ mm (4 holes, diameter 18 mm)

Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 12 = 624$ mm²

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 624}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 6168}{1} = 1016.57 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $94.13 \leq 1016.57$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.1.6 Welds verification

Verification is not required.

1.2 Left lower flange

1.2.1 Compression verifications

Verification is not required.

1.2.2 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2520\ mm^2 \times \frac{235\ MPa}{1} = 592.2\ kN$ — EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 14\ mm = 2520\ mm^2$

Check relation becomes: $188.25\ kN \leq 592.2\ kN$

Work Ratio: 31.79 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 14\ mm = 2016\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 2016\ mm^2 \times \frac{360\ MPa}{1.25} = 522.55\ kN$ — EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $188.25\ kN \leq 522.55\ kN$

Work Ratio: 36.03 % **Passed**

1.2.3 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

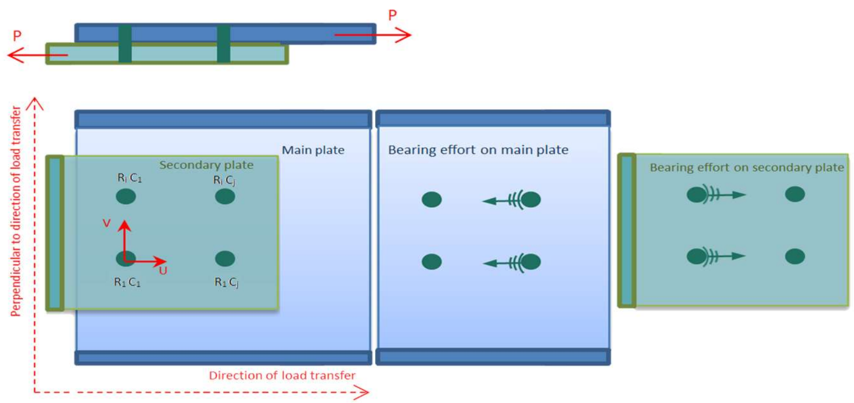
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	80	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	inner bolt	93.3	18	800	360	1
R2 C1	end bolt	80	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	inner bolt	93.3	18	800	360	1

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u	FvEdM,u	FvEd
	(kN)	(kN)	(kN)
R1 C1	-23.53	0	-23.53
R1 C2	-23.53	0	-23.53
R1 C3	-23.53	0	-23.53
R1 C4	-23.53	0	-23.53
R2 C1	-23.53	0	-23.53
R2 C2	-23.53	0	-23.53
R2 C3	-23.53	0	-23.53
R2 C4	-23.53	0	-23.53

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	14	161.28	-23.53	14.59 %	Passed
R1 C2	16	14	161.28	-23.53	14.59 %	Passed
R1 C3	16	14	161.28	-23.53	14.59 %	Passed
R1 C4	16	14	161.28	-23.53	14.59 %	Passed
R2 C1	16	14	161.28	-23.53	14.59 %	Passed
R2 C2	16	14	161.28	-23.53	14.59 %	Passed
R2 C3	16	14	161.28	-23.53	14.59 %	Passed
R2 C4	16	14	161.28	-23.53	14.59 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.2.4 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \leq V_{eff,Rd}$

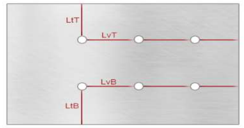
Combination: [1]: ULS 1

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = (L_v^T + L_v^B) \cdot t = (297 + 297) \times 14 = 8316\ mm^2$



$L_v^T = 297$ mm (4 holes, diameter 18 mm)

$L_v^B = 297$ mm (4 holes, diameter 18 mm)

Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 14 = 728\ mm^2$

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 728}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 8316}{1} = 1337.96\ kN$$

$V_{Ed} \leq V_{eff,Rd}$ $188.25 \leq 1337.96$ kN

Passed

Block Tearing Verification on V - Direction

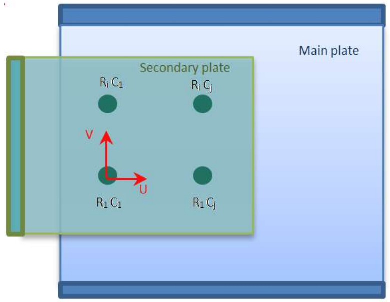
Verification is not required.

1.2.5 Welds verification

Verification is not required.

1.3 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \le e_1$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 40\ mm$ — **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \le e_2$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 25\ mm$ — **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \le p_1$ — EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \le 93.3\ mm$ — **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \le \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$40\ mm \le \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \le \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$25\ mm \le \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \le \min(14 \cdot t_{min}; 175\ mm)$ — EN 1993-1-8, Table 3.3

$93.3\ mm \le \min(14 \times 12\ mm; 175\ mm) = 168\ mm$ — **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.3.2 Compression verifications

Verification is not required.

1.3.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 720\ mm^2 \times \frac{235\ MPa}{1} = 169.2\ kN$ — EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 60\ mm \times 12\ mm = 720\ mm^2$

Check relation becomes: $47.06\ kN \le 169.2\ kN$

Work Ratio: 27.82 % — **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (60\ mm - 1 \times 18\ mm) \times 12\ mm = 504\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 504\ mm^2 \times \frac{360\ MPa}{1.25} = 130.64\ kN$ — EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $47.06\ kN \le 130.64\ kN$

Work Ratio: 36.03 % — **Passed**

1.3.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

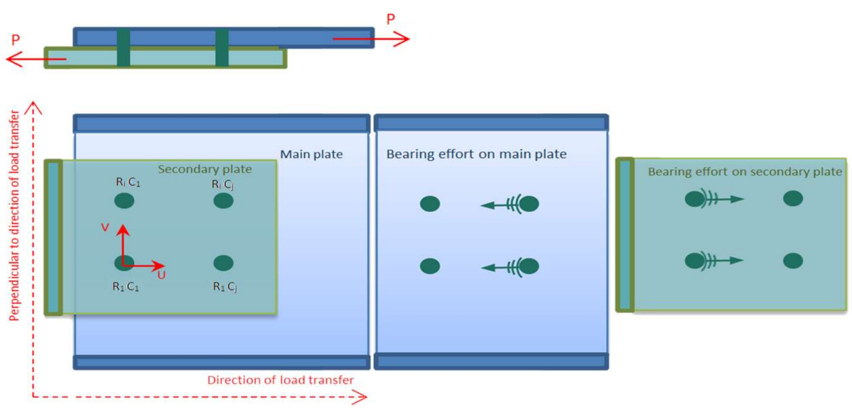
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C2	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C3	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C4	edge bolt	35	3.74	edge bolt	25	2.19	2.19

Bolt Location	FvEd_N,u	FvEdM,u	FvEd
	(kN)	(kN)	(kN)
R1 C1	11.77	0	11.77
R1 C2	11.77	0	11.77
R1 C3	11.77	0	11.77
R1 C4	11.77	0	11.77

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	121.04	11.77	9.72 %	Passed
R1 C2	16	12	121.04	11.77	9.72 %	Passed
R1 C3	16	12	121.04	11.77	9.72 %	Passed
R1 C4	16	12	89.66	11.77	13.12 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.3.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

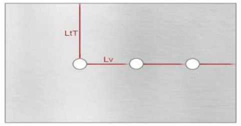
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 257 \times 12 = 3084$ mm²

$L_v = 257$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^T \cdot t = 16 \times 12 = 192$ mm²

$L_t^T = 16$ mm (1 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 192}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 3084}{1} = 473.72 \text{ kN}$$

$V_{Ed} \le V_{eff,Rd}$ $47.06 \le 473.72$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.3.6 Welds verification

Verification is not required.

1 Bolts verification

1 Bolts Shear Verification

Check relation: $F_{v,Ed} \le F_{v,Rd}$

Combination: [1]: ULS 1

$F_{v,Ed}$ - *effective shear force per bolt*

$F_{v,Rd} = n_s \times \alpha_v \times A \times \frac{f_{ub}}{\gamma_{M2}}$ *(design shear resistance per bolt)* **EN 1993-1-8, 3.6.1, table 3.4**

Shear plane passes through the threaded portion of the bolt. Terms "A" and "αv" are detailed below.

$A = A_s = 157$ mm²

$\alpha_v = 0.6$ **EN 1993-1-8, 3.6.1, table 3.4**

The table below shows the design shear resistance of each bolt.

Bolt Location	ns	αv	A	Fub	FvRd	FvRd reduced
	(adim.)	(adim.)	(mm²)	(MPa)	(kN)	(kN)
R1 C1	2	0.6	157	800	119.07	119.07
R1 C2	2	0.6	157	800	119.07	119.07
R1 C3	2	0.6	157	800	119.07	119.07
R1 C4	2	0.6	157	800	119.07	119.07
R2 C1	2	0.6	157	800	119.07	119.07
R2 C2	2	0.6	157	800	119.07	119.07
R2 C3	2	0.6	157	800	119.07	119.07
R2 C4	2	0.6	157	800	119.07	119.07

Note: Shear resistance is reduced due to 3.6.1 (3), EN 1993-1-8.

Effective shear force of each bolt is shown in the following table:

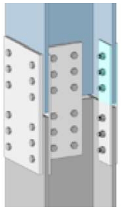
Bolt Location	FvEd_N,u	FvEd_M,u	FvEd_T,v	FvEd_M,v	FvEd*
	(kN)	(kN)	(kN)	(kN)	(kN)
R1 C1	23.53	0	0	0	23.53
R1 C2	23.53	0	0	0	23.53
R1 C3	23.53	0	0	0	23.53
R1 C4	23.53	0	0	0	23.53
R2 C1	23.53	0	0	0	23.53
R2 C2	23.53	0	0	0	23.53
R2 C3	23.53	0	0	0	23.53
R2 C4	23.53	0	0	0	23.53

$$*F_{v,Ed} = \sqrt{(F_{v,Ed\_N,u} + F_{v,Ed\_M,u})^2 + (F_{v,Ed\_T,v} + F_{v,Ed\_M,v})^2}$$

In the following, the check relation is verified by replacing the corresponding values for each bolt.

Bolt Location	FvRd	FvEd	Work Ratio	Verification Status
	(kN)	(kN)	(%)	
R1 C1	119.07	23.53	19.76 %	Passed
R1 C2	119.07	23.53	19.76 %	Passed
R1 C3	119.07	23.53	19.76 %	Passed
R1 C4	119.07	23.53	19.76 %	Passed
R2 C1	119.07	23.53	19.76 %	Passed
R2 C2	119.07	23.53	19.76 %	Passed
R2 C3	119.07	23.53	19.76 %	Passed
R2 C4	119.07	23.53	19.76 %	Passed

1 Verification of right lower flange assembly



In the following, the assembly components are denoted plates originating from joint profiles. Their role in the assembly (plate type), profiles of origin, thickness and corresponding forces are detailed in the table below.

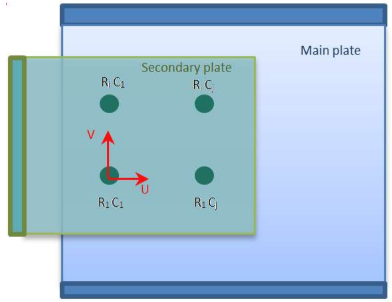
Forces are obtained by projecting the initial efforts in the local system of the bolts group. The forces are transferred to assembly components with the following pattern:
plate -> bolts -> pressure on holes.

Id	Plate Type	Profile origin	Plate Thickness	Force U	Force V
1	Splice plate	Right Lower Flange	12 mm	94.13 kN	0 kN
2	Right lower flange	HEB180	14 mm	188.25 kN	0 kN
3	Splice plate	Right Lower Inner Flange	12 mm	47.06 kN	0 kN
4	Splice plate	Right Lower Inner Flange	12 mm	47.06 kN	0 kN

Note: U, V are horizontal and vertical directions (based on plate local coordinate system).

1.1 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \leq e_1$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 40\ mm$ **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \leq e_2$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 35\ mm$ **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \leq p_1$ EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \leq 93.3\ mm$ **Passed**

Minimum spacing between the centers of 2 holes, measured on "V" direction

$2.4 \cdot d_0 \leq p_2$ EN 1993-1-8, Table 3.3

$2.4 \times 18\ mm = 43.2\ mm \leq 110\ mm$ **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \leq \max(8 \cdot t_{min}; 125\ mm)$ EN 1993-1-8, Table 3.3

$40\ mm \leq \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \leq \max(8 \cdot t_{min}; 125\ mm)$ EN 1993-1-8, Table 3.3

$35\ mm \leq \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \leq \min(14 \cdot t_{min}; 175\ mm)$ EN 1993-1-8, Table 3.3

$93.3\ mm \leq \min(14 \times 12\ mm; 175\ mm) = 168\ mm$ **Passed**

Maximum spacing between the centers of 2 holes on "V" direction

$p_2 \leq \min(14 \cdot t_{min}; 175\ mm)$ EN 1993-1-8, Table 3.3

$110\ mm \leq \min(14 \times 12\ mm; 175\ mm) = 168\ mm$ **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.1.2 Compression verifications

Verification is not required.

1.1.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2160\ mm^2 \times \frac{235\ MPa}{1} = 507.6\ kN$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 12\ mm = 2160\ mm^2$

Check relation becomes: $94.13\ kN \leq 507.6\ kN$

Work Ratio: 18.54 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 12\ mm = 1728\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 1728\ mm^2 \times \frac{360\ MPa}{1.25} = 447.9\ kN$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $94.13\ kN \leq 447.9\ kN$

Work Ratio: 21.02 % **Passed**

1.1.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

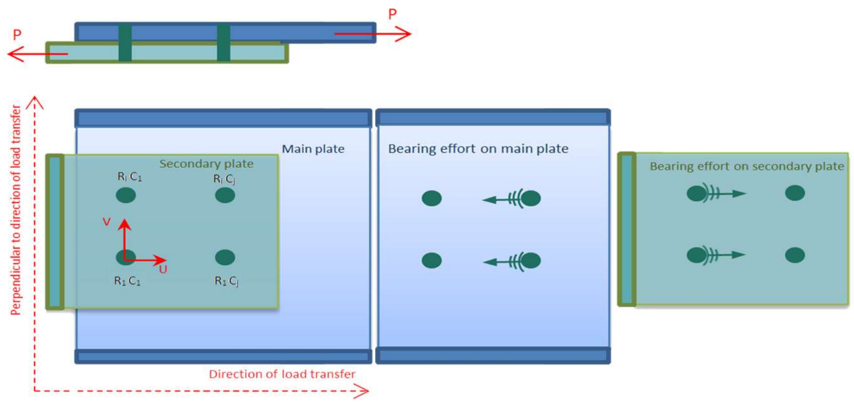
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74
R2 C1	inner bolt	93.3	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	11.77	0	11.77
R1 C2	11.77	0	11.77
R1 C3	11.77	0	11.77
R1 C4	11.77	0	11.77
R2 C1	11.77	0	11.77
R2 C2	11.77	0	11.77
R2 C3	11.77	0	11.77
R2 C4	11.77	0	11.77

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	138.24	11.77	8.51 %	Passed
R1 C2	16	12	138.24	11.77	8.51 %	Passed
R1 C3	16	12	138.24	11.77	8.51 %	Passed
R1 C4	16	12	102.4	11.77	11.49 %	Passed
R2 C1	16	12	138.24	11.77	8.51 %	Passed
R2 C2	16	12	138.24	11.77	8.51 %	Passed
R2 C3	16	12	138.24	11.77	8.51 %	Passed
R2 C4	16	12	102.4	11.77	11.49 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.1.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

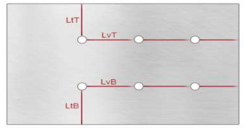
$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = (L_v^T + L_v^B) \cdot t = (257 + 257) \times 12 = 6168$ mm²

$L_v^T = 257$ mm (4 holes, diameter 18 mm)

$L_v^B = 257$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 12 = 624$ mm²

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 624}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 6168}{1} = 1016.57 \text{ kN}$$

$V_{Ed} \le V_{eff,Rd}$ $94.13 \le 1016.57$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.1.6 Welds verification

Verification is not required.

1.2 Right lower flange

1.2.1 Compression verifications

Verification is not required.

1.2.2 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 2520\ mm^2 \times \frac{235\ MPa}{1} = 592.2\ kN$$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 180\ mm \times 14\ mm = 2520\ mm^2$

Check relation becomes: $188.25\ kN \le 592.2\ kN$

Work Ratio: 31.79 % — **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (180\ mm - 2 \times 18\ mm) \times 14\ mm = 2016\ mm^2$$

$$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 2016\ mm^2 \times \frac{360\ MPa}{1.25} = 522.55\ kN$$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $188.25\ kN \le 522.55\ kN$

Work Ratio: 36.03 % — **Passed**

1.2.3 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

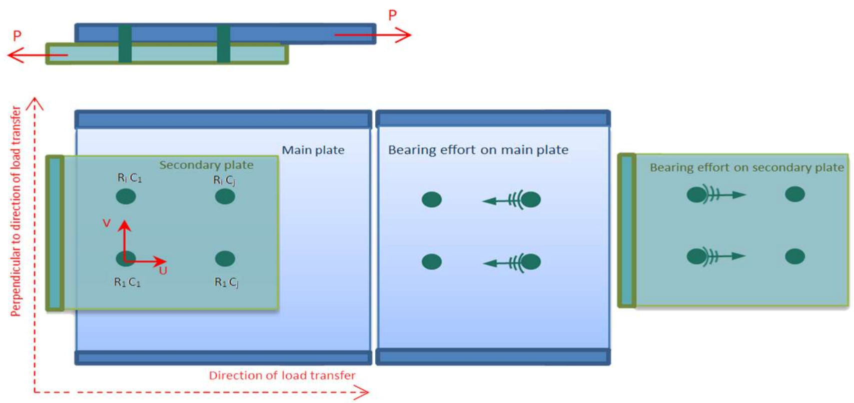
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	80	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	inner bolt	93.3	18	800	360	1
R2 C1	end bolt	80	18	800	360	1
R2 C2	inner bolt	93.3	18	800	360	1
R2 C3	inner bolt	93.3	18	800	360	1
R2 C4	inner bolt	93.3	18	800	360	1

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C2	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C3	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R1 C4	edge bolt	35	3.74	inner bolt	110	6.86	2.5
R2 C1	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C2	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C3	inner bolt	110	6.86	edge bolt	35	3.74	2.5
R2 C4	inner bolt	110	6.86	edge bolt	35	3.74	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	-23.53	0	-23.53
R1 C2	-23.53	0	-23.53
R1 C3	-23.53	0	-23.53
R1 C4	-23.53	0	-23.53
R2 C1	-23.53	0	-23.53
R2 C2	-23.53	0	-23.53
R2 C3	-23.53	0	-23.53
R2 C4	-23.53	0	-23.53

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	14	161.28	-23.53	14.59 %	Passed
R1 C2	16	14	161.28	-23.53	14.59 %	Passed
R1 C3	16	14	161.28	-23.53	14.59 %	Passed
R1 C4	16	14	161.28	-23.53	14.59 %	Passed
R2 C1	16	14	161.28	-23.53	14.59 %	Passed
R2 C2	16	14	161.28	-23.53	14.59 %	Passed
R2 C3	16	14	161.28	-23.53	14.59 %	Passed
R2 C4	16	14	161.28	-23.53	14.59 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.2.4 Block tearing verification

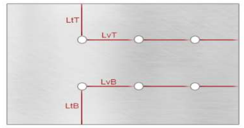
Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$



Net area subjected to shear

$A_{n,v} = (L_v^T + L_v^B) \cdot t = (297 + 297) \times 14 = 8316$ mm²

$L_v^T = 297$ mm (4 holes, diameter 18 mm)

$L_v^B = 297$ mm (4 holes, diameter 18 mm)

Net area subjected to tension

$A_{n,t} = (L_t^T + L_t^B) \times t = (26 + 26) \times 14 = 728$ mm²

$L_t^T = 26$ mm (2 holes, diameter 18 mm)

$L_t^B = 26$ mm (2 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 728}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 8316}{1} = 1337.96 \text{ kN}$$

$V_{Ed} \le V_{eff,Rd}$ $188.25 \le 1337.96$ kN

Passed

Block Tearing Verification on V - Direction

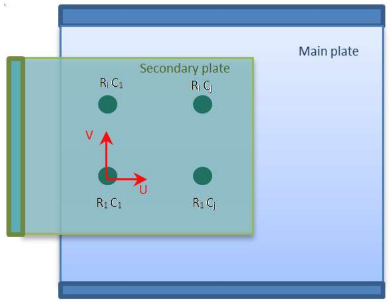
Verification is not required.

1.2.5 Welds verification

Verification is not required.

1.3 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \le e_1$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 40\ mm$ — **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \le e_2$ — EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 25\ mm$ — **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \le p_1$ — EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \le 93.3\ mm$ — **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \le \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$40\ mm \le \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \le \max(8 \cdot t_{min}; 125\ mm)$ — EN 1993-1-8, Table 3.3

$25\ mm \le \max(8 \times 12\ mm; 125\ mm) = 125\ mm$ — **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \le \min(14 \cdot t_{min}; 175\ mm)$ — EN 1993-1-8, Table 3.3

$93.3\ mm \le \min(14 \times 12\ mm; 175\ mm) = 168\ mm$ — **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.3.2 Compression verifications

Verification is not required.

1.3.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 720\ mm^2 \times \frac{235\ MPa}{1} = 169.2\ kN$$ — EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 60\ mm \times 12\ mm = 720\ mm^2$

Check relation becomes: $47.06\ kN \le 169.2\ kN$

Work Ratio: 27.82 % — **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ — EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (60\ mm - 1 \times 18\ mm) \times 12\ mm = 504\ mm^2$$

$$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 504\ mm^2 \times \frac{360\ MPa}{1.25} = 130.64\ kN$$ — EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $47.06\ kN \le 130.64\ kN$

Work Ratio: 36.03 % — **Passed**

1.3.4 Shear verifications

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

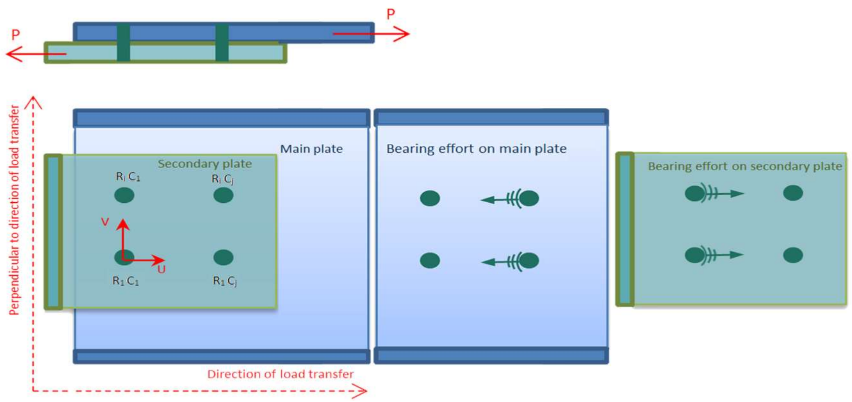
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	93.3	18	800	360	1
R1 C2	inner bolt	93.3	18	800	360	1
R1 C3	inner bolt	93.3	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C2	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C3	edge bolt	35	3.74	edge bolt	25	2.19	2.19
R1 C4	edge bolt	35	3.74	edge bolt	25	2.19	2.19

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	11.77	0	11.77
R1 C2	11.77	0	11.77
R1 C3	11.77	0	11.77
R1 C4	11.77	0	11.77

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	12	121.04	11.77	9.72 %	Passed
R1 C2	16	12	121.04	11.77	9.72 %	Passed
R1 C3	16	12	121.04	11.77	9.72 %	Passed
R1 C4	16	12	89.66	11.77	13.12 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.3.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

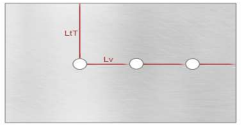
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 257 \times 12 = 3084$ mm²

$L_v = 257$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^T \cdot t = 16 \times 12 = 192$ mm²

$L_t^T = 16$ mm (1 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 192}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 3084}{1} = 473.72 \text{ kN}$$

$V_{Ed} \le V_{eff,Rd}$ $47.06 \le 473.72$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.3.6 Welds verification

Verification is not required.

1 Bolts verification

1 Bolts Shear Verification

Check relation: $F_{v,Ed} \le F_{v,Rd}$

Combination: [1]: ULS 1

$F_{v,Ed}$ - *effective shear force per bolt*

$F_{v,Rd} = n_s \times \alpha_v \times A \times \frac{f_{ub}}{\gamma_{M2}}$ *(design shear resistance per bolt)* **EN 1993-1-8, 3.6.1, table 3.4**

Shear plane passes through the threaded portion of the bolt. Terms "A" and "αv" are detailed below.

$A = A_s = 157$ mm²

$\alpha_v = 0.6$ **EN 1993-1-8, 3.6.1, table 3.4**

The table below shows the design shear resistance of each bolt.

Bolt Location	ns	αv	A	Fub	FvRd	FvRd reduced
	(adim.)	(adim.)	(mm²)	(MPa)	(kN)	(kN)
R1 C1	2	0.6	157	800	119.07	119.07
R1 C2	2	0.6	157	800	119.07	119.07
R1 C3	2	0.6	157	800	119.07	119.07
R1 C4	2	0.6	157	800	119.07	119.07
R2 C1	2	0.6	157	800	119.07	119.07
R2 C2	2	0.6	157	800	119.07	119.07
R2 C3	2	0.6	157	800	119.07	119.07
R2 C4	2	0.6	157	800	119.07	119.07

Note: Shear resistance is reduced due to 3.6.1 (3), EN 1993-1-8.

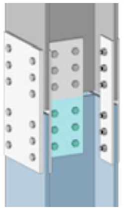
Effective shear force of each bolt is shown in the following table:

Bolt Location	FvEd_N,u	FvEd_M,u	FvEd_T,v	FvEd_M,v	FvEd*
	(kN)	(kN)	(kN)	(kN)	(kN)
R1 C1	23.53	0	0	0	23.53
R1 C2	23.53	0	0	0	23.53
R1 C3	23.53	0	0	0	23.53
R1 C4	23.53	0	0	0	23.53
R2 C1	23.53	0	0	0	23.53
R2 C2	23.53	0	0	0	23.53
R2 C3	23.53	0	0	0	23.53
R2 C4	23.53	0	0	0	23.53

$$*F_{v,Ed} = \sqrt{(F_{v,Ed\_N,u} + F_{v,Ed\_M,u})^2 + (F_{v,Ed\_T,v} + F_{v,Ed\_M,v})^2}$$

In the following, the check relation is verified by replacing the corresponding values for each bolt.

Bolt Location	FvRd	FvEd	Work Ratio	Verification
	(kN)	(kN)	(%)	Status
R1 C1	119.07	23.53	19.76 %	Passed
R1 C2	119.07	23.53	19.76 %	Passed
R1 C3	119.07	23.53	19.76 %	Passed
R1 C4	119.07	23.53	19.76 %	Passed
R2 C1	119.07	23.53	19.76 %	Passed
R2 C2	119.07	23.53	19.76 %	Passed
R2 C3	119.07	23.53	19.76 %	Passed
R2 C4	119.07	23.53	19.76 %	Passed



1 Verification of left web assembly

In the following, the assembly components are denoted plates originating from joint profiles. Their role in the assembly (plate type), profiles of origin, thickness and corresponding forces are detailed in the table below.

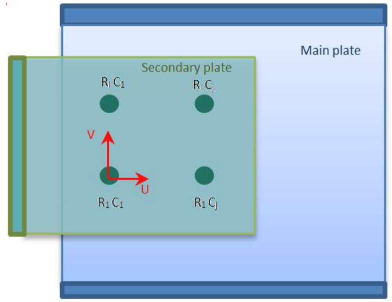
Forces are obtained by projecting the initial efforts in the local system of the bolts group. The forces are transferred to assembly components with the following pattern:
plate -> bolts -> pressure on holes.

Id	Plate Type	Profile origin	Plate Thickness	Force U	Force V
1	Splice plate	Left Web	8 mm	79.66 kN	10 kN
2	Left web	HEB180	8.5 mm	159.32 kN	20 kN
3	Splice plate	Left Web	8 mm	79.66 kN	10 kN

Note: U, V are horizontal and vertical directions (based on plate local coordinate system).

1.1 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \leq e_1$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 40\ mm$ **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \leq e_2$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \leq 40\ mm$ **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \leq p_1$ EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \leq 101.7\ mm$ **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \leq max(8 \cdot t_{min};125\ mm)$ EN 1993-1-8, Table 3.3

$40\ mm \leq max(8 \times 8\ mm;125\ mm) = 125\ mm$ **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \leq max(8 \cdot t_{min};125\ mm)$ EN 1993-1-8, Table 3.3

$40\ mm \leq max(8 \times 8\ mm;125\ mm) = 125\ mm$ **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \leq min(14 \cdot t_{min};175\ mm)$ EN 1993-1-8, Table 3.3

$101.7\ mm \leq min(14 \times 8\ mm;175\ mm) = 112\ mm$ **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.1.2 Compression verifications

Verification is not required.

1.1.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 640\ mm^2 \times \frac{235\ MPa}{1} = 150.4\ kN$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30} \times t_p = 80\ mm \times 8\ mm = 640\ mm^2$

Check relation becomes: $79.66\ kN \leq 150.4\ kN$

Work Ratio: 52.97 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = (h_{30} - n_{b,v} \times d_{o,v}) \times t_p = (80\ mm - 1 \times 18\ mm) \times 8\ mm = 496\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 496\ mm^2 \times \frac{360\ MPa}{1.25} = 128.56\ kN$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $79.66\ kN \leq 128.56\ kN$

Work Ratio: 61.96 % **Passed**

1.1.4 Shear verifications

1 Shear Yielding Verification

Check relation: $V_{Ed} \leq V_{pl,Rd}$

Combination: [1]: ULS 1

$V_{pl,Rd} = n \cdot A_v \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 1 \times 640\ mm^2 \times \frac{235\ MPa}{\sqrt{3} \times 1} = 86.83\ kN$

$A_v = h_p \cdot t_p = 80\ mm \times 8\ mm = 640\ mm^2$

Check relation becomes: $10\ kN \leq 86.83\ kN$

Work Ratio: 11.52 % **Passed**

1 Shear Ultimate Verification

Check relation: $V_{Ed} \leq V_{u,Rd}$

Combination: [1]: ULS 1

$V_{u,Rd} = 0.9 \times n \times A_{v,net} \times \frac{f_u}{\sqrt{3} \times \gamma_{M2}} = 0.9 \times 1 \times 496\ mm^2 \times \frac{360\ MPa}{\sqrt{3} \times 1.25} = 74.23\ kN$

n - number of connected objects;

$A_{v,net} = (h - n_v \times d_{0,v}) \times t = (80\ mm - 1 \times 18\ mm) \times 8\ mm = 496\ mm^2$

nv - number of vertical bolt rows;

Check relation becomes: $10\ kN \leq 74.23\ kN$

Work Ratio: 13.47 % **Passed**

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

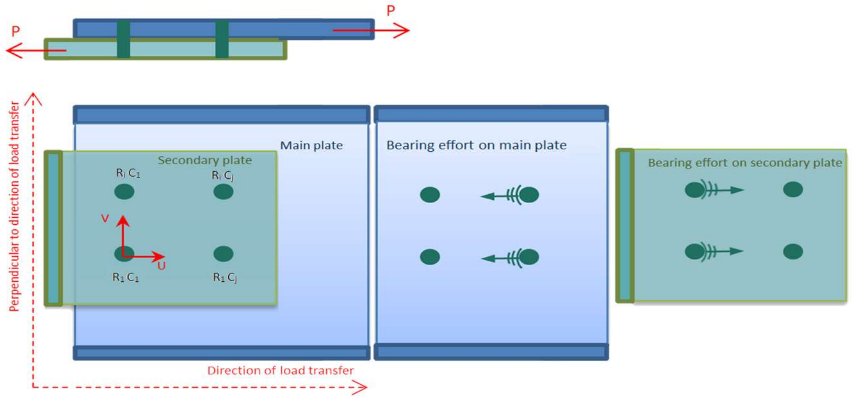
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	101.7	18	800	360	1
R1 C2	inner bolt	101.7	18	800	360	1
R1 C3	inner bolt	101.7	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C2	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C3	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C4	edge bolt	40	4.52	edge bolt	40	4.52	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	19.92	0	19.92
R1 C2	19.92	0	19.92
R1 C3	19.92	0	19.92
R1 C4	19.92	0	19.92

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	8	92.16	19.92	21.61 %	Passed
R1 C2	16	8	92.16	19.92	21.61 %	Passed
R1 C3	16	8	92.16	19.92	21.61 %	Passed
R1 C4	16	8	68.27	19.92	29.17 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	40	18	800	360	0.74
R1 C2	end bolt	40	18	800	360	0.74
R1 C3	end bolt	40	18	800	360	0.74
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	inner bolt	110	6.86	inner bolt	101.7	6.21	2.5
R1 C2	inner bolt	101.7	6.21	inner bolt	101.7	6.21	2.5
R1 C3	inner bolt	101.7	6.21	inner bolt	101.7	6.21	2.5
R1 C4	inner bolt	101.7	6.21	edge bolt	40	4.52	2.5

Bolt Location	FvEd_T,v (kN)	FvEd_M,v (kN)	FvEd (kN)
R1 C1	2.5	4.09	6.59
R1 C2	2.5	1.36	3.86
R1 C3	2.5	-1.36	1.14
R1 C4	2.5	-4.09	-1.59

FvEd_T,v - vertical component (v direction) from in-plane force
FvEd_M,u - vertical component (v direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (v direction component)
Replacing the values from above, table from below is showing the bearing resistance for vertical component of efforts (V).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	8	68.27	6.59	9.65 %	Passed
R1 C2	16	8	68.27	3.86	5.66 %	Passed
R1 C3	16	8	68.27	1.14	1.67 %	Passed
R1 C4	16	8	68.27	-1.59	2.32 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

1.1.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

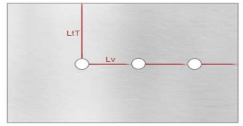
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 282 \times 8 = 2256$ mm²

$L_v = 282$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^T \cdot t = 31 \times 8 = 248$ mm²

$L_t^T = 31$ mm (1 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 248}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 2256}{1} = 377.51 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $79.66 \leq 377.51$ kN

Passed

Block Tearing Verification on V - Direction

Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

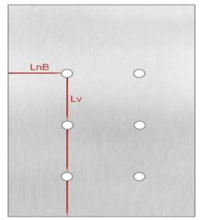
The bolts are not centered on members:

$$V_{eff,2,Rd} = 0.5 \cdot \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v^B \cdot t = 31 \times 8 = 248$ mm²

$L_v^B = 31$ mm (1 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^B \cdot t = 31 \times 8 = 248$ mm²

$L_t^B = 31$ mm (4 holes, diameter 18 mm)

The bolts are not centered on members:

$$V_{eff,2,Rd} = 0.5 \cdot \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = 0.5 \times \frac{360 \times 248}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 248}{1} = 69.36 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $10 \leq 69.36$ kN

Passed

1.1.6 Welds verification

Verification is not required.

1.2 Left web

1.2.1 Compression verifications

Verification is not required.

1.2.2 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 6525\ mm^2 \times \frac{235\ MPa}{1} = 1533.38\ kN$ EN 1993-1-1 6.2.3 (6.6)

A = 6525 mm² (profile area)

Check relation becomes: $159.32\ kN \leq 1533.38\ kN$

Work Ratio: 10.39 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$A_{net} = A - (n_{b,v} \times d_{o,v} \times t_p) = 6525\ mm^2 - (1 \times 18\ mm \times 8.5\ mm) = 6372\ mm^2$

$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 6372\ mm^2 \times \frac{360\ MPa}{1.25} = 1651.62\ kN$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $159.32\ kN \leq 1651.62\ kN$

Work Ratio: 9.65 % **Passed**

1.2.3 Shear verifications

1 Shear Yielding Verification

Check relation: $V_{Ed} \leq V_{pl,Rd}$

Combination: [1]: ULS 1

$V_{pl,Rd} = n \cdot A_v \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 1 \times 1530\ mm^2 \times \frac{235\ MPa}{\sqrt{3} \times 1} = 207.59\ kN$

$A_v = h_p \cdot t_p = 180\ mm \times 8.5\ mm = 1530\ mm^2$

Check relation becomes: $20\ kN \leq 207.59\ kN$

Work Ratio: 9.63 % **Passed**

1 Shear Ultimate Verification

Check relation: $V_{Ed} \leq V_{u,Rd}$

Combination: [1]: ULS 1

$V_{u,Rd} = 0.9 \times n \times A_{v,net} \times \frac{f_u}{\sqrt{3} \times \gamma_{M2}} = 0.9 \times 1 \times 1377\ mm^2 \times \frac{360\ MPa}{\sqrt{3} \times 1.25} = 206.07\ kN$

n - number of connected objects;

$A_{v,net} = (h - n_v \times d_{0,v}) \times t = (180\ mm - 1 \times 18\ mm) \times 8.5\ mm = 1377\ mm^2$

nv - number of vertical bolt rows;

Check relation becomes: $20\ kN \leq 206.07\ kN$

Work Ratio: 9.71 % **Passed**

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

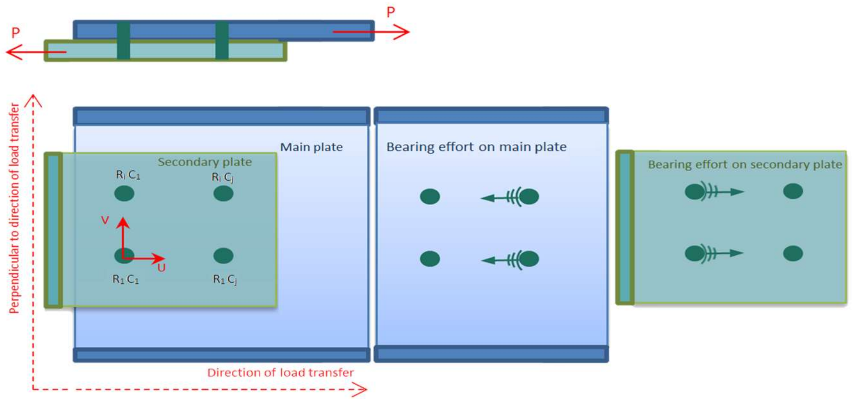
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	55	18	800	360	1
R1 C2	inner bolt	101.7	18	800	360	1
R1 C3	inner bolt	101.7	18	800	360	1
R1 C4	inner bolt	101.7	18	800	360	1

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	-	0	-	-	0	-	2.5
R1 C2	-	0	-	-	0	-	2.5
R1 C3	-	0	-	-	0	-	2.5
R1 C4	-	0	-	-	0	-	2.5

Bolt Location	FvEd_N,u	FvEdM,u	FvEd
	(kN)	(kN)	(kN)
R1 C1	-39.83	0	-39.83
R1 C2	-39.83	0	-39.83
R1 C3	-39.83	0	-39.83
R1 C4	-39.83	0	-39.83

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d	t	FbRd	FvEd	Work Ratio	Status
	(mm)	(mm)	(kN)	(kN)	(%)	
R1 C1	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C2	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C3	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C4	16	8.5	97.92	-39.83	40.68 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.2.4 Block tearing verification

Block Tearing Verification on U - Direction

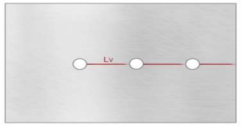
Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear



$A_{n,v} = L_v \cdot t = 297 \times 8.5 = 2524.5$

$L_v = 297$ mm (4 holes, diameter 18 mm)

Net area subjected to tension

Does not exist.

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 0}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 2524.5}{1} = 342.52 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $159.32 \leq 342.52$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.2.5 Welds verification

Verification is not required.

1 Bolts verification

1 Bolts Shear Verification

Check relation: $F_{v,Ed} \leq F_{v,Rd}$

Combination: [1]: ULS 1

$F_{v,Ed}$ - *effective shear force per bolt*

$F_{v,Rd} = n_s \times \alpha_v \times A \times \frac{f_{ub}}{\gamma_{M2}}$ *(design shear resistance per bolt)* **EN 1993-1-8, 3.6.1, table 3.4**

Shear plane passes through the threaded portion of the bolt. Terms "A" and "αv" are detailed below.

$A = A_s = 157$ mm²

$\alpha_v = 0.6$ **EN 1993-1-8, 3.6.1, table 3.4**

The table below shows the design shear resistance of each bolt.

Bolt Location	ns	αv	A	Fub	FvRd	FvRd reduced
	(adim.)	(adim.)	(mm²)	(MPa)	(kN)	(kN)
R1 C1	2	0.6	157	800	118.13	118.13
R1 C2	2	0.6	157	800	118.13	118.13
R1 C3	2	0.6	157	800	118.13	118.13
R1 C4	2	0.6	157	800	118.13	118.13

Note: Shear resistance is reduced due to 3.6.1 (3), EN 1993-1-8.

Effective shear force of each bolt is shown in the following table:

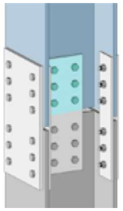
Bolt Location	FvEd_N,u (kN)	FvEd_M,u (kN)	FvEd_T,v (kN)	FvEd_M,v (kN)	FvEd* (kN)
R1 C1	39.83	0	5	8.17	41.95
R1 C2	39.83	0	5	2.72	40.57
R1 C3	39.83	0	5	-2.72	39.9
R1 C4	39.83	0	5	-8.17	39.96

$$*F_{v,Ed} = \sqrt{(F_{v,Ed\_N,u} + F_{v,Ed\_M,u})^2 + (F_{v,Ed\_T,v} + F_{v,Ed\_M,v})^2}$$

In the following, the check relation is verified by replacing the corresponding values for each bolt.

Bolt Location	FvRd (kN)	FvEd (kN)	Work Ratio (%)	Verification Status
R1 C1	118.13	41.95	35.51 %	Passed
R1 C2	118.13	40.57	34.35 %	Passed
R1 C3	118.13	39.9	33.77 %	Passed
R1 C4	118.13	39.96	33.83 %	Passed

1 Verification of right web assembly



In the following, the assembly components are denoted plates originating from joint profiles. Their role in the assembly (plate type), profiles of origin, thickness and corresponding forces are detailed in the table below.

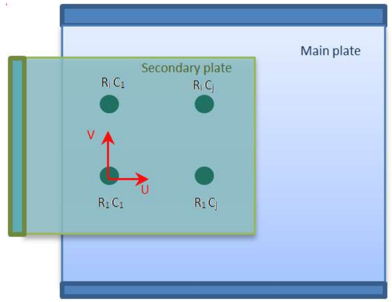
Forces are obtained by projecting the initial efforts in the local system of the bolts group. The forces are transferred to assembly components with the following pattern:
plate -> bolts -> pressure on holes.

Id	Plate Type	Profile origin	Plate Thickness	Force U	Force V
1	Splice plate	Right Web	8 mm	79.66 kN	10 kN
2	Right web	HEB180	8.5 mm	159.32 kN	20 kN
3	Splice plate	Right Web	8 mm	79.66 kN	10 kN

Note: U, V are horizontal and vertical directions (based on plate local coordinate system).

1.1 Splice plate

1 Holes distances conditions



Distance Conditions for Round Holes

Minimum edge distance on "U" direction

$1.2 \cdot d_0 \le e_1$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 40\ mm$ **Passed**

Minimum edge distance perpendicular on "U" direction ("V" direction)

$1.2 \cdot d_0 \le e_2$ EN 1993-1-8, Table 3.3

$1.2 \times 18\ mm = 21.6\ mm \le 40\ mm$ **Passed**

Minimum spacing between the centers of 2 holes, measured on "U" direction

$2.2 \cdot d_0 \le p_1$ EN 1993-1-8, Table 3.3

$2.2 \times 18\ mm = 39.6\ mm \le 101.7\ mm$ **Passed**

Maximum distance for steel used unprotected, according to EN 10025-5*

Maximum edge distance on "U" direction

$e_1 \le \max(8 \cdot t_{min};125\ mm)$ EN 1993-1-8, Table 3.3

$40\ mm \le \max(8 \times 8\ mm;125\ mm) = 125\ mm$ **Passed**

Maximum edge distance perpendicular on "U" direction ("V" direction)

$e_2 \le \max(8 \cdot t_{min};125\ mm)$ EN 1993-1-8, Table 3.3

$40\ mm \le \max(8 \times 8\ mm;125\ mm) = 125\ mm$ **Passed**

Maximum spacing between the centers of 2 holes on "U" direction

$p_1 \le \min(14 \cdot t_{min};175\ mm)$ EN 1993-1-8, Table 3.3

$101.7\ mm \le \min(14 \times 8\ mm;175\ mm) = 112\ mm$ **Passed**

** Verification to avoid local buckling and to prevent corrosion*

1.1.2 Compression verifications

Verification is not required.

1.1.3 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \le N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$N_{pl,Rd} = n\times A\times\frac{f_y}{\gamma_{M0}} = 1\times 640\ mm^2\times\frac{235\ MPa}{1} = 150.4\ kN$$ EN 1993-1-1 6.2.3 (6.6)

$A = h_{30}\times t_p = 80\ mm\times 8\ mm = 640\ mm^2$

Check relation becomes: $79.66\ kN \le 150.4\ kN$

Work Ratio: 52.97 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \le N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$A_{net} = (h_{30} - n_{b,v}\times d_{o,v})\times t_p = (80\ mm - 1\times 18\ mm)\times 8\ mm = 496\ mm^2$$

$$N_{u,Rd} = 0.9\times n_{obj}\times A_{net}\times\frac{f_u}{\gamma_{M2}} = 0.9\times 1\times 496\ mm^2\times\frac{360\ MPa}{1.25} = 128.56\ kN$$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $79.66\ kN \le 128.56\ kN$

Work Ratio: 61.96 % **Passed**

1.1.4 Shear verifications

1 Shear Yielding Verification

Check relation: $V_{Ed} \le V_{pl,Rd}$

Combination: [1]: ULS 1

$$V_{pl,Rd} = n\cdot A_v\cdot\frac{f_y}{\sqrt{3}\cdot\gamma_{M0}} = 1\times 640\ mm^2\times\frac{235\ MPa}{\sqrt{3}\times 1} = 86.83\ kN$$

$A_v = h_p\cdot t_p = 80\ mm\times 8\ mm = 640\ mm^2$

Check relation becomes: $10\ kN \le 86.83\ kN$

Work Ratio: 11.52 % **Passed**

1 Shear Ultimate Verification

Check relation: $V_{Ed} \le V_{u,Rd}$

Combination: [1]: ULS 1

$$V_{u,Rd} = 0.9\times n\times A_{v,net}\times\frac{f_u}{\sqrt{3}\times\gamma_{M2}} = 0.9\times 1\times 496\ mm^2\times\frac{360\ MPa}{\sqrt{3}\times 1.25} = 74.23\ kN$$

n - number of connected objects;

$A_{v,net} = (h - n_v\times d_{0,v})\times t = (80\ mm - 1\times 18\ mm)\times 8\ mm = 496\ mm^2$

nv - number of vertical bolt rows;

Check relation becomes: $10\ kN \le 74.23\ kN$

Work Ratio: 13.47 % **Passed**

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \le F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1\cdot\alpha_b\cdot d\cdot t\cdot\frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

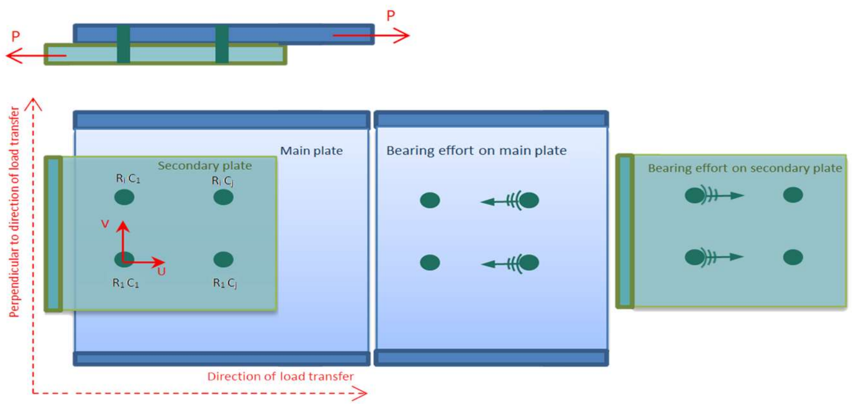
End bolt: $\alpha_b = \min(\frac{e_1}{3\cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3\cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8\cdot\frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4\cdot\frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	inner bolt	101.7	18	800	360	1
R1 C2	inner bolt	101.7	18	800	360	1
R1 C3	inner bolt	101.7	18	800	360	1
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C2	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C3	edge bolt	40	4.52	edge bolt	40	4.52	2.5
R1 C4	edge bolt	40	4.52	edge bolt	40	4.52	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	19.92	0	19.92
R1 C2	19.92	0	19.92
R1 C3	19.92	0	19.92
R1 C4	19.92	0	19.92

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	8	92.16	19.92	21.61 %	Passed
R1 C2	16	8	92.16	19.92	21.61 %	Passed
R1 C3	16	8	92.16	19.92	21.61 %	Passed
R1 C4	16	8	68.27	19.92	29.17 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	40	18	800	360	0.74
R1 C2	end bolt	40	18	800	360	0.74
R1 C3	end bolt	40	18	800	360	0.74
R1 C4	end bolt	40	18	800	360	0.74

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	inner bolt	110	6.86	inner bolt	101.7	6.21	2.5
R1 C2	inner bolt	101.7	6.21	inner bolt	101.7	6.21	2.5
R1 C3	inner bolt	101.7	6.21	inner bolt	101.7	6.21	2.5
R1 C4	inner bolt	101.7	6.21	edge bolt	40	4.52	2.5

Bolt Location	FvEd_T,v (kN)	FvEd_M,v (kN)	FvEd (kN)
R1 C1	2.5	4.09	6.59
R1 C2	2.5	1.36	3.86
R1 C3	2.5	-1.36	1.14
R1 C4	2.5	-4.09	-1.59

FvEd_T,v - vertical component (v direction) from in-plane force
FvEd_M,u - vertical component (v direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (v direction component)
Replacing the values from above, table from below is showing the bearing resistance for vertical component of efforts (V).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	8	68.27	6.59	9.65 %	Passed
R1 C2	16	8	68.27	3.86	5.66 %	Passed
R1 C3	16	8	68.27	1.14	1.67 %	Passed
R1 C4	16	8	68.27	-1.59	2.32 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

1.1.5 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

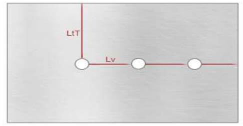
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 282 \times 8 = 2256\ mm^2$

$L_v = 282\ mm$ (4 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^T \cdot t = 31 \times 8 = 248\ mm^2$

$L_t^T = 31\ mm$ (1 holes, diameter 18 mm)

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 248}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 2256}{1} = 377.51\ kN$$

$V_{Ed} \le V_{eff,Rd}$ $79.66 \le 377.51\ kN$

Passed

Block Tearing Verification on V - Direction

Check relation: $V_{Ed} \le V_{eff,Rd}$

Combination: [1]: ULS 1

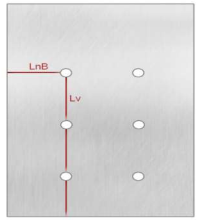
The bolts are not centered on members:

$$V_{eff,2,Rd} = 0.5 \cdot \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v^B \cdot t = 31 \times 8 = 248\ mm^2$

$L_v^B = 31\ mm$ (1 holes, diameter 18 mm)



Net area subjected to tension

$A_{n,t} = L_t^B \cdot t = 31 \times 8 = 248\ mm^2$

$L_t^B = 31\ mm$ (4 holes, diameter 18 mm)

The bolts are not centered on members:

$$V_{eff,2,Rd} = 0.5 \cdot \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = 0.5 \times \frac{360 \times 248}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 248}{1} = 69.36\ kN$$

$V_{Ed} \le V_{eff,Rd}$ $10 \le 69.36\ kN$

Passed

1.1.6 Welds verification

Verification is not required.

1.2 Right web

1.2.1 Compression verifications

Verification is not required.

1.2.2 Tension verifications

1 Tension Yielding Verification

Check relation: $N_{Ed} \leq N_{pl,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$N_{pl,Rd} = n \times A \times \frac{f_y}{\gamma_{M0}} = 1 \times 6525\ mm^2 \times \frac{235\ MPa}{1} = 1533.38\ kN$$ EN 1993-1-1 6.2.3 (6.6)

A = 6525 mm² (profile area)

Check relation becomes: $159.32\ kN \leq 1533.38\ kN$

Work Ratio: 10.39 % **Passed**

1 Tension Ultimate Verification

Check relation: $N_{Ed} \leq N_{u,Rd}$ EN 1993-1-1 6.2.3 (6.5)

Combination: [1]: ULS 1

$$A_{net} = A - (n_{b,v} \times d_{o,v} \times t_p) = 6525\ mm^2 - (1 \times 18\ mm \times 8.5\ mm) = 6372\ mm^2$$

$$N_{u,Rd} = 0.9 \times n_{obj} \times A_{net} \times \frac{f_u}{\gamma_{M2}} = 0.9 \times 1 \times 6372\ mm^2 \times \frac{360\ MPa}{1.25} = 1651.62\ kN$$ EN 1993-1-1 6.2.3 (6.7)

Check relation becomes: $159.32\ kN \leq 1651.62\ kN$

Work Ratio: 9.65 % **Passed**

1.2.3 Shear verifications

1 Shear Yielding Verification

Check relation: $V_{Ed} \leq V_{pl,Rd}$

Combination: [1]: ULS 1

$$V_{pl,Rd} = n \cdot A_v \cdot \frac{f_y}{\sqrt{3} \cdot \gamma_{M0}} = 1 \times 1530\ mm^2 \times \frac{235\ MPa}{\sqrt{3} \times 1} = 207.59\ kN$$

$A_v = h_p \cdot t_p = 180\ mm \times 8.5\ mm = 1530\ mm^2$

Check relation becomes: $20\ kN \leq 207.59\ kN$

Work Ratio: 9.63 % **Passed**

1 Shear Ultimate Verification

Check relation: $V_{Ed} \leq V_{u,Rd}$

Combination: [1]: ULS 1

$$V_{u,Rd} = 0.9 \times n \times A_{v,net} \times \frac{f_u}{\sqrt{3} \times \gamma_{M2}} = 0.9 \times 1 \times 1377\ mm^2 \times \frac{360\ MPa}{\sqrt{3} \times 1.25} = 206.07\ kN$$

n - number of connected objects;

$A_{v,net} = (h - n_v \times d_{0,v}) \times t = (180\ mm - 1 \times 18\ mm) \times 8.5\ mm = 1377\ mm^2$

nv - number of vertical bolt rows;

Check relation becomes: $20\ kN \leq 206.07\ kN$

Work Ratio: 9.71 % **Passed**

1 Bending and Shear Verification

Verification is not required.

The bearing resistance of bolts is determined for two different directions of efforts: horizontal (U) and vertical (V). Directions are given in the bolts group plane.

For each direction, the check relation is: $F_{v,Ed} \leq F_{b,Rd}$

$F_{v,Ed}$ - design shear force for individual fastener

$F_{b,Rd}$ - design bearing resistance (determined separately for each component of efforts)

Combination: [1]: ULS 1

According to table 3.4 from EN 1993-1-8, design bearing resistance is determined with the following formula:

$$F_{b,Rd} = k_1 \cdot \alpha_b \cdot d \cdot t \cdot \frac{f_u}{\gamma_{M2}}$$

α_b factor is determined according to the bolt position in the direction of load transfer (end bolt / inner bolt).

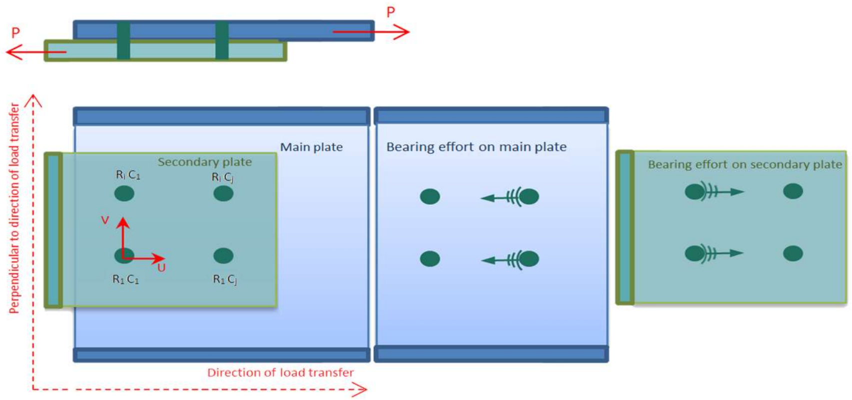
End bolt: $\alpha_b = \min(\frac{e_1}{3 \cdot d_0}, \frac{f_{ub}}{f_u}, 1)$

Inner bolt: $\alpha_b = \min(\frac{p_1}{3 \cdot d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1)$

k_1 factor is determined according to the bolt position perpendicular to the direction of load transfer (edge bolt / inner bolt). Supplementary, we'll consider also the bolt distances (left and right) till the next bolt or till the plate edge. The minimum value is taken.

Edge bolt: $k_1 = \min(2.8 \cdot \frac{e_2}{d_0} - 1.7,\ 2.5)$

Inner bolt: $k_1 = \min(1.4 \cdot \frac{p_2}{d_0} - 1.7,\ 2.5)$



a) Bearing resistance for the horizontal component of efforts (U)

Bolts position in the direction of load transfer

Bolt Location	Position	e1 / p1	d0	Fub	Fu	αb
		(mm)	(mm)	(MPa)	(MPa)	
R1 C1	end bolt	55	18	800	360	1
R1 C2	inner bolt	101.7	18	800	360	1
R1 C3	inner bolt	101.7	18	800	360	1
R1 C4	inner bolt	101.7	18	800	360	1

Bolts position perpendicular to the direction of load transfer

	Left (L)			Right (R)			
Bolt Location	k1 Position	e2 / p2 (mm)	k1_L	k1 Position	e2 / p2 (mm)	k1_R	k1 = min (k1_L,k1_R)
R1 C1	-	0	-	-	0	-	2.5
R1 C2	-	0	-	-	0	-	2.5
R1 C3	-	0	-	-	0	-	2.5
R1 C4	-	0	-	-	0	-	2.5

Bolt Location	FvEd_N,u (kN)	FvEdM,u (kN)	FvEd (kN)
R1 C1	-39.83	0	-39.83
R1 C2	-39.83	0	-39.83
R1 C3	-39.83	0	-39.83
R1 C4	-39.83	0	-39.83

FvEd_N,u - horizontal component (u direction) from in-plane force
FvEd_M,u - horizontal component (u direction) from out of plane moment
FvEd - sum of the above two components = shear force in bolt (u direction component)
Replacing the values from above, table from below is showing the bearing resistance for horizontal component of efforts (U).

Bolt Location	d (mm)	t (mm)	FbRd (kN)	FvEd (kN)	Work Ratio (%)	Status
R1 C1	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C2	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C3	16	8.5	97.92	-39.83	40.68 %	Passed
R1 C4	16	8.5	97.92	-39.83	40.68 %	Passed

Note: Negative value for FvEd shows the orientation of the bearing effort.

b) Bearing resistance for the vertical component of efforts (V)

Verification is not required.

1.2.4 Block tearing verification

Block Tearing Verification on U - Direction

Check relation: $V_{Ed} \leq V_{eff,Rd}$

Combination: [1]: ULS 1

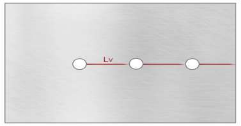
The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}}$$

Net area subjected to shear

$A_{n,v} = L_v \cdot t = 297 \times 8.5 = 2524.5$

$L_v = 297$ mm (4 holes, diameter 18 mm)



Net area subjected to tension

Does not exist.

The bolts are centered on members:

$$V_{eff,1,Rd} = \frac{f_u \cdot A_{n,t}}{\gamma_{M2}} + \frac{1}{\sqrt{3}} \cdot \frac{f_y \cdot A_{n,v}}{\gamma_{M0}} = \frac{360 \times 0}{1.25} + \frac{1}{\sqrt{3}} \times \frac{235 \times 2524.5}{1} = 342.52 \text{ kN}$$

$V_{Ed} \leq V_{eff,Rd}$ $159.32 \leq 342.52$ kN

Passed

Block Tearing Verification on V - Direction

Verification is not required.

1.2.5 Welds verification

Verification is not required.

1 Bolts verification

1 Bolts Shear Verification

Check relation: $F_{v,Ed} \leq F_{v,Rd}$

Combination: [1]: ULS 1

$F_{v,Ed}$ - *effective shear force per bolt*

$F_{v,Rd} = n_s \times \alpha_v \times A \times \frac{f_{ub}}{\gamma_{M2}}$ *(design shear resistance per bolt)* EN 1993-1-8, 3.6.1, table 3.4

Shear plane passes through the threaded portion of the bolt. Terms "A" and "αv" are detailed below.

$A = A_s = 157$ mm²

$\alpha_v = 0.6$ EN 1993-1-8, 3.6.1, table 3.4

The table below shows the design shear resistance of each bolt.

Bolt Location	ns	αv	A	Fub	FvRd	FvRd reduced
	(adim.)	(adim.)	(mm²)	(MPa)	(kN)	(kN)
R1 C1	2	0.6	157	800	118.13	118.13
R1 C2	2	0.6	157	800	118.13	118.13
R1 C3	2	0.6	157	800	118.13	118.13
R1 C4	2	0.6	157	800	118.13	118.13

Note: Shear resistance is reduced due to 3.6.1 (3), EN 1993-1-8.

Effective shear force of each bolt is shown in the following table:

Bolt Location	FvEd_N,u (kN)	FvEd_M,u (kN)	FvEd_T,v (kN)	FvEd_M,v (kN)	FvEd* (kN)
R1 C1	39.83	0	5	8.17	41.95
R1 C2	39.83	0	5	2.72	40.57
R1 C3	39.83	0	5	-2.72	39.9
R1 C4	39.83	0	5	-8.17	39.96

$$*F_{v,Ed} = \sqrt{(F_{v,Ed\_N,u} + F_{v,Ed\_M,u})^2 + (F_{v,Ed\_T,v} + F_{v,Ed\_M,v})^2}$$

In the following, the check relation is verified by replacing the corresponding values for each bolt.

Bolt Location	FvRd (kN)	FvEd (kN)	Work Ratio (%)	Verification Status
R1 C1	118.13	41.95	35.51 %	Passed
R1 C2	118.13	40.57	34.35 %	Passed
R1 C3	118.13	39.9	33.77 %	Passed
R1 C4	118.13	39.96	33.83 %	Passed

1 Local buckling resistance of the splice plates

1 Verification on upper flange

Local buckling resistance of the splice should not be checked if the following conditions are fulfilled:

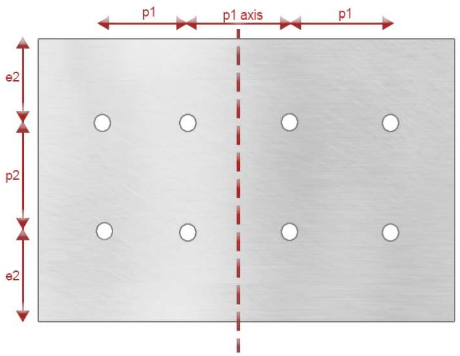
$\frac{p_{1axis}}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

$\frac{p_1}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

Supplementary, the following should not exceed the local buckling requirements:

$\frac{e_2}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

with $\varepsilon = \sqrt{\frac{235}{f_y}}$



Position	Length (L)	Plate Thickness	f_y	ε	Ratio (L/t)	Ratio Limit	Ratio Status
	(mm)	(mm)	(MPa)	(adim.)	(adim.)	(adim.)	
p1	93.3	12	235	1	7.78	9	Passed
p1 Axis	160	12	235	1	13.33	9	Failed
e2	35	12	235	1	2.92	9	Passed

Note: Length (L) refers to either spacings between the fasteners (p1, p2), or edge distances (e2).

Local buckling requirements are exceeded. Resistance verification is required!

Check relation: $N_{f,Ed} \leq N_{b,Rd}$

Combination [1]: ULS 1

$N_{f,Ed}$ - design force of the flange splice plate

$N_{b,Rd}$ - design resistance of the flange splice plate

$N_{b,Rd} = \frac{\chi \cdot A \cdot f_y}{\gamma_{M1}}$ EN 1993-1-1 6.3.1.1 (6.47)

$\chi = \frac{1}{(\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2})} \leq 1.0$ EN 1993-1-1 6.3.1.2 (6.49)

$\Phi = 0.5 \cdot (1 + \alpha \cdot (\bar{\lambda} - 0.2) + \bar{\lambda}^2)$ EN 1993-1-1 6.3.1.2

$\alpha = 0.49$ (curve C) EN 1993-1-1 Table 6.1

Class 1 cross-section is considered:

$\bar{\lambda} = \frac{L_{cr}}{i \cdot \lambda_1}$ EN 1993-1-1 6.3.1.3 (6.50)

where $L_{cr} = 0.6 \cdot L$ EN 1993-1-8 Table 3.3

$\lambda_1 = 93.9 \cdot \varepsilon$ EN 1993-1-1 6.3.1.3

$A = b \cdot t$

Position	b	t	Area (A)	$\bar{\lambda}$	Φ	χ	γ_{M1}	$N_{f,Ed}$	$N_{b,Rd}$	Work Ratio	Status
	(mm)	(mm)	(mm²)	(adim.)	(adim.)	(adim.)	(adim.)	(kN)	(kN)	(adim.)	
p1 Axis	60	12	720	0.3	0.57	0.95	1.1	88.11	146.32	0.6	Passed

1 Verification on web

Local buckling resistance of the splice should not be checked if the following conditions are fulfilled:

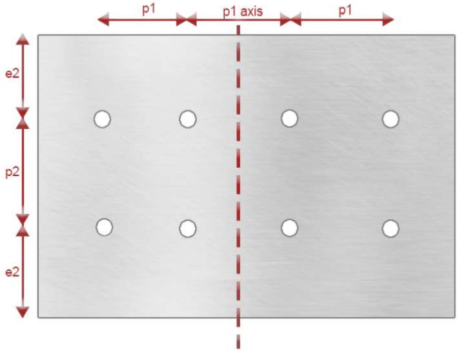
$\frac{p_{1axis}}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

$\frac{p_1}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

Supplementary, the following should not exceed the local buckling requirements:

$\frac{e_2}{t} \leq 9 \cdot \varepsilon$ EN 1993-1-8 Table 3.3(2)

with $\varepsilon = \sqrt{\frac{235}{f_y}}$



Position	Length (L)	Plate Thickness	f_y	ε	Ratio (L/t)	Ratio Limit	Ratio Status
	(mm)	(mm)	(MPa)	(adim.)	(adim.)	(adim.)	
p1	101.7	8	235	1	12.71	9	Failed
p1 Axis	110	8	235	1	13.75	9	Failed
e2	40	8	235	1	5	9	Passed

Note: Length (L) refers to either spacings between the fasteners (p1, p2), or edge distances (e2).

Local buckling requirements are exceeded. Resistance verification is required!

Check relation: $N_{w,Ed} \leq N_{b,Rd}$

Combination [1]: ULS 1

$N_{w,Ed}$ - design force of the web splice plate

$N_{b,Rd}$ - design resistance of the web splice plate

$$N_{b,Rd} = \frac{\chi \cdot A \cdot f_y}{\gamma_{M1}}$$ EN 1993-1-1 6.3.1.1 (6.47)

$$\chi = \frac{1}{(\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2})} \leq 1.0$$ EN 1993-1-1 6.3.1.2 (6.49)

$$\Phi = 0.5 \cdot (1 + \alpha \cdot (\bar{\lambda}^2 - 0.2) + \bar{\lambda}^2)$$ EN 1993-1-1 6.3.1.2

$\alpha = 0.49$ (curve C) EN 1993-1-1 Table 6.1

Class 1 cross-section is considered:

$$\bar{\lambda} = \frac{L_{cr}}{i \cdot \lambda_1}$$ EN 1993-1-1 6.3.1.3 (6.50)

where $L_{cr} = 0.6 \cdot L$ EN 1993-1-8 Table 3.3

$\lambda_1 = 93.9 \cdot \varepsilon$ EN 1993-1-1 6.3.1.3

$A = (e_2 + p_2/2) \cdot t$

Position	b	t	Area (A)	$\bar{\lambda}$	Φ	χ	γ_{M1}	$N_{w,Ed}$	$N_{b,Rd}$	Work Ratio	Status
	(mm)	(mm)	(mm²)	(adim.)	(adim.)	(adim.)	(adim.)	(kN)	(kN)	(adim.)	
p1	80	8	480	0.28	0.56	0.96	1.1	0	98.27	0.61	Passed
p1 Axis	80	8	480	0.31	0.57	0.95	1.1	0	97.07	0.62	Passed

9.3 Verification on lower flange

Local buckling resistance of the splice should not be checked if the following conditions are fulfilled:

$$\frac{p_{1axis}}{t} \leq 9 \cdot \varepsilon$$ EN 1993-1-8 Table 3.3(2)

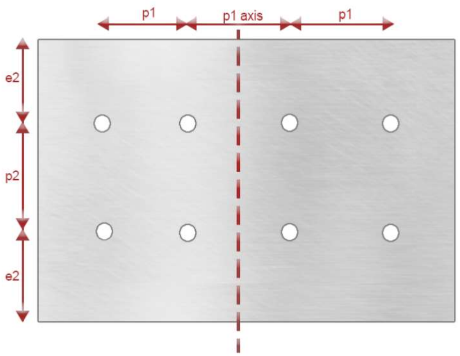
$$\frac{p_1}{t} \leq 9 \cdot \varepsilon$$ EN 1993-1-8 Table 3.3(2)

Supplementary, the following should not exceed the local buckling requirements:

$$\frac{p_2}{t} \leq 33 \cdot \varepsilon$$ EN 1993-1-8 Table 3.3(2)

$$\frac{e_2}{t} \leq 9 \cdot \varepsilon$$ EN 1993-1-8 Table 3.3(2)

with $\varepsilon = \sqrt{\frac{235}{f_y}}$



Position	Length (L)	Plate Thickness (t)	f_y	ε	L/t	Ratio Limit	Ratio Status
	(mm)	(mm)	(MPa)	(adim.)	(adim.)	(adim.)	
p1	93.3	12	235	1	7.78	9	Passed
p1 Axis	160	12	235	1	13.33	9	Failed
e2	35	12	235	1	2.92	9	Passed
p2	110	12	235	1	9.17	33	Passed

Note: Length (L) refers to either spacings between the fasteners (p1, p2), or edge distances (e2).

Local buckling requirements are exceeded. Resistance verification is required!

Check relation: $N_{f,Ed} \leq N_{b,Rd}$

Combination [1]: ULS 1

$N_{f,Ed}$ - design force of the flange splice plate

$N_{b,Rd}$ - design resistance of the flange splice plate

$$N_{b,Rd} = \frac{\chi \cdot A \cdot f_y}{\gamma_{M1}}$$ EN 1993-1-1 6.3.1.1 (6.47)

$$\chi = \frac{1}{(\Phi + \sqrt{\Phi^2 - \bar{\lambda}^2})} \leq 1.0$$ EN 1993-1-1 6.3.1.2 (6.49)

$$\Phi = 0.5 \cdot (1 + \alpha \cdot (\bar{\lambda} - 0.2) + \bar{\lambda}^2)$$ EN 1993-1-1 6.3.1.2

$\alpha = 0.49$ (curve C) EN 1993-1-1 Table 6.1

Class 1 cross-section is considered:

$$\bar{\lambda} = \frac{L_{cr}}{i \cdot \lambda_1}$$ EN 1993-1-1 6.3.1.3 (6.50)

where $L_{cr} = 0.6 \cdot L$ EN 1993-1-8 Table 3.3

$\lambda_1 = 93.9 \cdot \varepsilon$ EN 1993-1-1 6.3.1.3

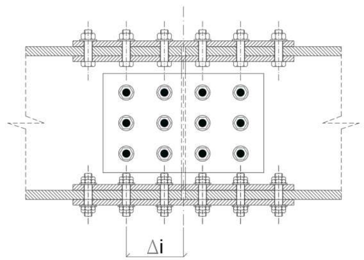
$A = b \cdot t$

Position	b	t	Area (A)	$\bar{\lambda}$	Φ	χ	γ_{M1}	$N_{f,Ed}$	$N_{b,Rd}$	Work Ratio	Status
	(mm)	(mm)	(mm²)	(adim.)	(adim.)	(adim.)	(adim.)	(kN)	(kN)	(adim.)	
p1 Axis	180	12	2160	0.3	0.57	0.95	1.1	94.13	438.97	0.21	Passed

10 Net Section Verification

10.1 Splice Sections Description

Not applicable for this type of joint.



Id	Position	Description
1	-360 mm	Left Last Bolts On Web
2	-55 mm	Left First Bolts On Web
3	55 mm	Right First Bolts On Web
4	360 mm	Right Last Bolts On Web

Next, for each combination, in each splice section, verifications will be performed for combined bending, shear and axial.
Two pairs of results(combined bending and shear, combined bending and axial) are provided.
- first corresponds to max ratio of bending and shear,
- second corresponds to max ratio of bending and axial.
If one or more verifications are not performed, they are not displayed.

10.2 Max ratio for Bending and Shear Verification

Combo: [1]: ULS 1

Max ratio for Bending and Shear verification was obtained in splice section at: -360 mm

Fastener holes in tensioned zone may be ignored if following condition is satisfied (6.2.5(4)).

Check relation: $\frac{A_{f,net} \cdot 0.9 \cdot f_u}{\gamma_{M2}} \geq \frac{A_f \cdot f_y}{\gamma_{M0}}$ **EN 1993-1-1 6.2.5 (6.16)**

$A_{f,net} = 5364$ mm² (net area of the tensioned section)

$A_f = 6525$ mm² (gross area of the tensioned section)

Check relation becomes: $1390.35\ kN \geq 1533.38\ kN$

Condition is not fulfilled. In this case fastener holes in section need to be taken into account. Calculation will follow using net area.

10.2.1 Bending and Shear Verification

Check relation: $M_{Ed} \leq M_{c,Rd}$ **EN 1993-1-1 6.2.5 (1)**

Verify if: $V_{Ed} \leq V_{pl,Rd}/2$

$V_{Ed} = 20$ kN (shear force)

$V_{pl,Rd} = 253.85$ kN (shear resistance)

In this case, the relationship is satisfied. According to EN 1993-1-1 6.2.8 (2), the shear effect on the moment resistance may be neglected. In this case, the moment resistance is:

$M_{c,Rd} = W_{el,min} \cdot f_y/\gamma_{M0} = 348.28\ cm^3 \times 235\ MPa/1 = 81.85\ kN \cdot m$

Check relation becomes: $22.2\ kN \cdot m \leq 81.85\ kN \cdot m$

Work Ratio: 27.12 % **Passed**

10.2.2 Bending and Axial Verification

As shown earlier effective shear force on cross-section does not exceed 50% of the plastic design shear resistance of the cross-section, so no reduction of fy must be applied.(see. 6.2.10 (6.45))

Check relation: $M_{Ed} \leq M_{N,Rd}$

Section: Class 3

$\sigma_{x,Ed} \leq f_y/\gamma_{M0}$ **EN 1993-1-1 6.2.9.1 (6.42)**

$$\sigma_{x,Ed} = \frac{|N_{Ed}|}{A_{net}} + \frac{|M_{y,Ed}|}{W_{el,y,min}} = \frac{|700\ kN|}{5364\ mm^2} + \frac{|22.2\ kN \cdot m|}{348.28\ cm^3} = 194.24\ MPa$$

Check relation becomes: $194.24\ MPa \leq 235\ MPa/1$

Work Ratio: 82.66 % **Passed**

10.3 Max ratio for Bending and Axial Verification

Combo: [1]: ULS 1

Max ratio for Bending and Axial verification was obtained in splice section at:-360 mm

Fastener holes in tensioned zone may be ignored if following condition is satisfied (6.2.5(4)).

Check relation: $\frac{A_{f,net} \cdot 0.9 \cdot f_u}{\gamma_{M2}} \geq \frac{A_f \cdot f_y}{\gamma_{M0}}$ **EN 1993-1-1 6.2.5 (6.16)**

$A_{f,net} = 5364$ mm² (net area of the tensioned section)

$A_f = 6525$ mm² (gross area of the tensioned section)

Check relation becomes: $1390.35\ kN \geq 1533.38\ kN$

Condition is not fulfilled. In this case fastener holes in section need to be taken into account. Calculation will follow using net area.

10.3.1 Bending and Shear Verification

Check relation: $M_{Ed} \leq M_{c,Rd}$ **EN 1993-1-1 6.2.5 (1)**

Verify if: $V_{Ed} \leq V_{pl,Rd}/2$

$V_{Ed} = 20$ kN (shear force)

$V_{pl,Rd} = 253.85$ kN (shear resistance)

In this case, the relationship is satisfied. According to EN 1993-1-1 6.2.8 (2), the shear effect on the moment resistance may be neglected. In this case, the moment resistance is:

$M_{c,Rd} = W_{el,min} \cdot f_y/\gamma_{M0} = 348.28\ cm^3 \times 235\ MPa/1 = 81.85\ kN \cdot m$

Check relation becomes: $22.2\ kN \cdot m \leq 81.85\ kN \cdot m$

Work Ratio: 27.12 % **Passed**

10.3.2 Bending and Axial Verification

As shown earlier effective shear force on cross-section does not exceed 50% of the plastic design shear resistance of the cross-section, so no reduction of fy must be applied.(see. 6.2.10 (6.45))

Check relation: $M_{Ed} \leq M_{N,Rd}$

Section: Class 3

$\sigma_{x,Ed} \leq f_y/\gamma_{M0}$ **EN 1993-1-1 6.2.9.1 (6.42)**

$$\sigma_{x,Ed} = \frac{|N_{Ed}|}{A_{net}} + \frac{|M_{y,Ed}|}{W_{el,y,min}} = \frac{|700\ kN|}{5364\ mm^2} + \frac{|22.2\ kN \cdot m|}{348.28\ cm^3} = 194.24\ MPa$$

Check relation becomes: $194.24\ MPa \leq 235\ MPa/1$

Work Ratio: 82.66 % **Passed**

11 Warning and error messages

There are no calculation errors or warnings.

12 Summary

Verification	Objects	Combination	Force	Resistance	Work Ratio	Status
Bending and axial force (net section)	[Main Beam] HEB180 S235	[1]: ULS 1	194.24 MPa	235 MPa	82.66 %	Passed
Tension ultimate	[Sec. Beam] HEB180 S235	[1]: ULS 1	352.43 kN	522.55 kN	67.44 %	Passed
Local buckling	[Plate] Web8 mm S235	[1]: ULS 1	59.75 kN	97.07 kN	61.55 %	Passed
Tension yielding	[Sec. Beam] HEB180 S235	[1]: ULS 1	352.43 kN	592.2 kN	59.51 %	Passed
Block tearing	[Sec. Beam] HEB180 S235	[1]: ULS 1	159.32 kN	342.52 kN	46.52 %	Passed
Bearing verification of bolts	[Sec. Beam] HEB180 S235	[1]: ULS 1	-39.83 kN	97.92 kN	40.68 %	Passed
Bolt shear	[Bolts] M16 8.8On sec. beam	[1]: ULS 1	44.05 kN	119.07 kN	37 %	Passed
Bending and shear force (net section)	[Main Beam] HEB180 S235	[1]: ULS 1	22.2 kN	81.85 kN	27.12 %	Passed
Shear ultimate	[Plate] Right Web 8 mm S235	[1]: ULS 1	10 kN	74.23 kN	13.47 %	Passed
Shear yielding	[Plate] Right Web 8 mm S235	[1]: ULS 1	10 kN	86.83 kN	11.52 %	Passed
Maximum Work Ratio:					**82.66 %**	**Passed**

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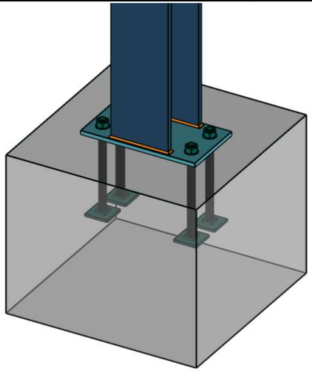
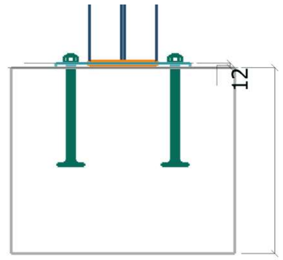
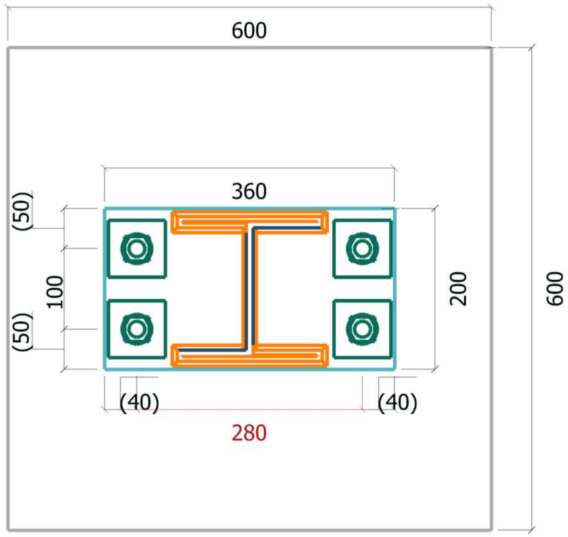
	Verified by		Date	
	Revision		Drawing	

Base Plate Report

Maximum Work Ratio	50 %	Passed





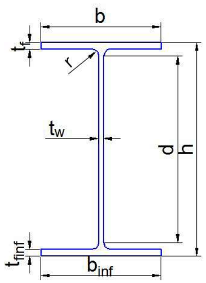


1 Joint description

Column HEB180 (Section Class 1)

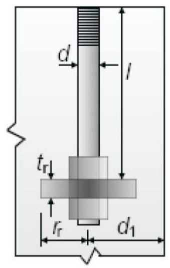
Material: S235 (EN 10025-2)

Dimensions	Characteristics
$h = 180$ mm	$A = 6525$ mm²
$t_w = 8.5$ mm	$A_v = 2024$ mm²
$d = 122$ mm	$I_y = 3831$ cm⁴
$b = 180$ mm	$I_z = 1363$ cm⁴
$t_f = 14$ mm	$W_{pl,y} = 481.4$ cm³
$b_{inf} = 180$ mm	$W_{pl,z} = 231$ cm³
$t_{f,inf} = 14$ mm	$W_{el,y,sup} = 425.7$ cm³
$r = 15$ mm	$W_{el,y,inf} = 425.7$ cm³



Anchors dimensions and properties

Anchor shear area	$A_s = 245$ mm²	Class 8.8
Anchor length	$L = 264$ mm	$f_{yb} = 640$ MPa
Diameter	$d = 20$ mm (Flat bar)	$f_{ub} = 800$ MPa
Nut Height	$h_{nut} = 16$ mm	
Nut Width	$b_{nut} = 36$ mm	
Washer Thickness	$h_w = 3$ mm	
Anchor Plate Thickness	$t_r = 12$ mm	
Distance	$r_r = 40$ mm	
Distance	$d_l = 160$ mm	



Base Plate

200 mm×360 mm×12 mm — Material: S235 (EN 10025-2)

Section Dimensions

Height	$h = 200$ mm
Width	$b = 360$ mm
Thickness	$t = 12$ mm
Holes diameter	$d_0 = 20$ mm

Concrete

Length	$L = 600$ mm	$f_{ck} = 25$ MPa
Width	$B = 600$ mm	$E = 31475.81$ MPa
Height	$h = 500$ mm	

2 Load combinations description

Comb. Index	Load Combination Description	Comb. Type	V (kN)	M (kN·m)	N (kN)
1	min(N)	ULS	50	4	0
Maximum Efforts			**50**	**4**	**0**
Minimum Efforts			**50**	**4**	**0**

The torsor is defined in the member's local system!

3 Design Assumptions

Design standards

EN 1993-1-1 Design of Steel Structures. General Rules and Rules for Buildings

EN 1993-1-8 Design of Steel Structures. Design of Joints

EN 1992-1-1 Design of Concrete Structures. General Rules and Rules for Buildings

EN 1993-1 National Annex: General Eurocode.

Units

Dimensions:	**mm**	Area:	**mm²**
Forces:	**kN**	Inertia modulus:	**cm³**
Bending moments:	**kN·m**	Inertia Moment:	**cm⁴**
Stresses:	**MPa**	Rotational Stiffness:	**kN·m/rad**
Angles:	°		

Anchors

The shear plane passes through the threaded part of the anchor.

T-Stub Failure Method: Method 1

Prying Effect: Auto

Approximate value for the transformation parameter, according to Table 5.4 (EN 1993-1-8):

$\beta = 1$

Anchor tension reduction factor, according to EN 1090:

$\alpha = 1$

Poor bond conditions are considered.

Safety Coefficients

Structural steel — Structural concrete:

$\gamma_{M0} = 1$ — $\gamma_c = 1.5$

$\gamma_{M1} = 1.1$

$\gamma_{M2} = 1.25$ - for bolts/anchors, welds, plates in bearing

$\gamma_{M2} = 1.25$ - for cross-sections in tension to fracture

Corrosion conditions

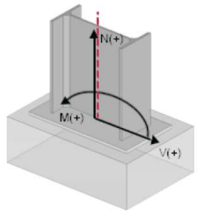
EN 10025, the steel is used unprotected (without improved atmospheric corrosion resistance).

Conventions

Tension is considered positive (compression is considered negative).

Bending moment is considered positive if clockwise (in above elevation).

Strong axis of the profile is considered "y-y" and weak axis "z-z".



Application domain:

The joint members are I or H construction steel profiles.

$N_{j,Ed} \le 5\% \times N_{pl,Rd}$

4 Holes distances conditions

Next, "Right" holes and "Left" holes refer to the joint part to which the holes belong (e.g. right plate).

4.1 Minimum distance conditions for round holes

Minimum edge distance on the load direction

$1.2 \times d_0 \le e_1$ — **EN 1993-1-8, Table 3.3**

Right holes $1.2 \times 20\ mm = 24\ mm \le 50\ mm$ — **Passed**

Minimum edge distance perpendicular on the load direction

$1.2 \times d_0 \le e_2$ — **EN 1993-1-8, Table 3.3**

Right holes $1.2 \times 20\ mm = 24\ mm \le 40\ mm$ — **Passed**

Minimum spacing between the centers of 2 holes, measured on the direction of the load

$2.2 \times d_0 \le p_1$ — **EN 1993-1-8, Table 3.3**

Right holes $2.2 \times 20\ mm = 44\ mm \le 100\ mm$ — **Passed**

Minimum spacing between the centers of 2 holes, measured perpendicular on the direction of the load

$2.4 \times d_0 \le p_2$ — **EN 1993-1-8, Table 3.3**

Right holes $2.4 \times 20\ mm = 48\ mm \le 280\ mm$ — **Passed**

4.2 Maximum distance for steel without improved atmospheric corrosion resistance

Note: Steel conforming to EN 10025-5*.

*Maximum spacing between the centers of 2 holes perpendicular on the load direction, according to EN 10025-5**

$p_2 \le \min(14 \times t_{min};175\ mm)$ — **EN 1993-1-8, Table 3.3**

Right holes $280\ mm \le \min(14 \times 12\ mm;175\ mm) = 168\ mm$ — **Constructive condition failed**

* Verification to avoid local buckling and to prevent corrosion

5 Compression verifications

5.1 Compression resistance of the column

Column cross section design bending moment resistance reduced if necessary, to allow for shear force. Its formula is shown below.

The profile is class 1, so the moment resistance of the section is calculated using the plastic modulus:

$$M_{c,Rd} = \frac{W_{c,pl} \times f_y}{\gamma_{M0}} = \frac{481.4\ cm^3 \times 235\ MPa}{1} = 113.13\ kN \cdot m$$

EN1993-1-1. 6.2.5

The Design Combined Compression Resistance of the Column Flange and the Adjacent Compression Zone of the Column Web:

$$F_{c,fb,Rd} = \frac{M_{c,Rd}}{(h - t_{fb})} = \frac{113.13\ kN \cdot m}{(180\ mm - 14\ mm)} = 681.5\ kN$$

EN 1993-1-8, 6.2.6.7

5.2 Compression verification of the column base

Check relation: $N_{c,Ed} \leq N_{c,Rd}$

Combination: [1]: min(N)

$N_{c,Ed} = N_{Ed} = 0$ kN <u>(verification of check relation is not necessary because of the tensile axial force - EN 1993-1-8 6.2.8.2)</u>

Concrete compression resistance force under column base (2 flanges+web)

$$N_{c,Rd} = 2 \cdot F_{c,pl,Rd} + F_{c,w,Rd}$$

$$f_{jd} = f_{cd} = \eta \cdot \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c} = 1 \times 1 \times \frac{25\ \text{MPa}}{1.5} = 16.67\ \text{MPa}$$ **EN 1992-1-1, 3.1.6(1) + 3.1.7(3)**

For determining the compression resistance under the column base, an additional bearing width needs to be determined:

$$c_0 = t_{bp} \cdot \sqrt{\frac{f_y}{3 \cdot f_{jd} \cdot \gamma_{M0}}} = 12\ \text{mm} \times \sqrt{\frac{235\ \text{MPa}}{3 \times 16.67\ \text{MPa} \times 1}} = 26\ \text{mm}$$ **EN 1993-1-8, 6.2.5(4)**

Compression resistance of concrete under column flange

The design bearing resistance under the base plate will be calculated considering the loaded area equal with the maximum design distribution area having a similar shape.

$$F_{c,pl,Rd} = A_{eff} \cdot f_{jd}$$ **EN 1993-1-8, 6.2.6.9**

Effective bearing area

$$A_{eff} = b_{eff} \cdot l_{eff}$$

Calculation of the bearing pressure zone width

The bearing pressure zone exceeds the plate length:

$c = 10$ mm

$$b_{eff} = t_f + c + c_0 = 14\ \text{mm} + 10\ \text{mm} + 26\ \text{mm} = 50\ \text{mm}$$ **EN 1993-1-8, 6.2.5(3)**

c - available space outside the flange measured in the direction of the corresponding distance

Calculation of the bearing pressure zone length

$$c_0 = 26\ \text{mm} < \frac{b_{pl} - b_f}{2} = \frac{360\ \text{mm} - 180\ \text{mm}}{2} \rightarrow c = c_0 = 26\ \text{mm}$$

$$l_{eff} = b_f + 2 \cdot c = 180\ \text{mm} + 2 \times 26\ \text{mm} = 232\ \text{mm}$$ **EN 1993-1-8, 6.2.5(3)**

Replacing the values of effective dimensions, the design bearing resistance becomes:

$$F_{c,pl,Rd} = 50\ \text{mm} \times 232\ \text{mm} \times 16.67\ \text{MPa} = 193.42\ \text{kN}$$ **EN 1992-1-1, 6.7 (3)**

Compression resistance of concrete under column web

$$b_{eff,w} = t_w + 2 \cdot c_0 = 8.5\ \text{mm} + 2 \times 26\ \text{mm} = 60.5\ \text{mm}$$

$$F_{c,w,Rd} = b_{eff,w} \cdot l_{eff,w} \cdot f_{jd}$$

$$l_{eff,w} = h - 2 \cdot t_f - 2 \cdot c_0 = 180\ \text{mm} - 2 \times 14\ \text{mm} - 2 \times 26\ \text{mm} = 100\ \text{mm}$$ **EN 1992-1-1, 6.7 (3)**

Replacing the values of effective dimensions, the design bearing resistance of the web becomes:

$$F_{c,w,Rd} = b_{eff,w} \cdot l_{eff,w} \cdot f_{jd} = 60.5\ \text{mm} \times 100\ \text{mm} \times 16.67\ \text{MPa} = 100.85\ \text{kN}$$

Resistance of the spread footing in axial compression

$$N_{c,Rd} = 2 \cdot F_{c,pl,Rd} + F_{c,w,Rd} = 2 \times 193.42\ \text{kN} + 100.85\ \text{kN} = 487.69\ \text{kN}$$ **EN 1993-1-8, 6.2.8.2 (1)**

The column is tensioned, so the verification in axial compression of the spread footing, EN 1993-1-8, 6.2.8.2 (1) is not necessary.

6 Anchor Verifications

Anchor-bolt dimensions and mechanical properties

Diameter: $d = 20$ mm (Flat bar)

Class 8.8

$f_{yb} = 640$ MPa

$f_{ub} = 800$ MPa

Shear area: $A_s = 245\ \text{mm}^2$

Length: $L = 264$ mm

6.1 Anchor bolt tension verification

Check relation: $F_{t,Ed} \leq F_{t,Rd}$

Combination: [1]: min(N)

Design Tension Force for one Anchor (from bending moment and axial force)

The verification will be made for the most solicited anchor/bolt.

$$F_{t,M,Ed} = \left| M_{Ed} \times \frac{h_l}{n_v \times \sum(h_r^2)} \right| = \left| 4\ \text{kN} \cdot \text{m} \times \frac{133\ \text{mm}}{2 \times 18778\ \text{mm}^2} \right| = 14.17\ \text{kN}$$

h_l - the distance from the most tensioned anchor/bolt (on row 1) to the center of rotation;

$\sum(h_r^2)$ - the sum of square distances from the current tensioned anchor/bolt row to center of rotation;

The center of rotation will be considered in the middle thickness of the compressed flange/haunch flange.

$$F_{t,N,Ed} = \frac{N_{Ed}}{n_b} = \frac{0\ \text{kN}}{4} = 0\ \text{kN}$$

Axial force is positive (tension):

$$F_{t,Ed} = F_{t,M,Ed} + F_{t,N,Ed} = 14.17\ \text{kN} + (0\ \text{kN}) = 14.17\ \text{kN}$$

Design Tension Force Resistance for one Anchor

$$F_{t,Rd} = k_2 \times A_s \times \frac{f_{ub}}{\gamma_{M2}} = 0.9 \times 245\ \text{mm}^2 \times \frac{800\ \text{MPa}}{1.25} = 141.12\ \text{kN}$$ **EN 1993-1-8, 3.6.1, table 3.4**

Anchor Bond Resistance for one Anchor

For Headed Anchors:

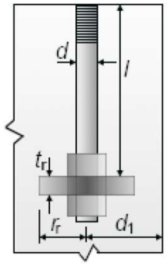
The following calculation is based on "Recommandations pour le dimensionnement des assemblages selon la NF EN 1993-1-8" (CNC2M, April 2015).

$$F_{t,bd,Rd} = 2.55 \cdot f_{cd} \cdot \pi \cdot \left(r_{rr}^2 - d^2/4\right) \cdot \left(1 - \frac{r_{rr}}{v}\right)$$ **EN 1993-1-8, 6.2.6.12 (3)**

where: $f_{cd} = \eta \cdot \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c} = 1 \times 1 \times \frac{25\ MPa}{1.5} = 16.67\ MPa$

$v = min(l, d_l, p) = min(258\ mm, 160\ mm, 100\ mm) = 100\ mm$

$r_{rr} = min(r_r, d_l) = min(40\ mm, 160\ mm) = 40\ mm$



$$F_{t,bd,Rd} = 2.55 \times 16.67\ MPa \times \pi \times ((40\ mm)^2 - (20\ mm)^2/4) \times \left(1 - \frac{40\ mm}{100\ mm}\right) = 126.17\ kN$$

$F_{t,Rd} = min(F_{t,Rd}; F_{t,Rd,bd}) = min(141.12\ kN; 126.17\ kN) = 126.17\ kN$ EN 1993-1-8, 6.2.6.12 (3)

Therefore, check relation becomes:

$14.17\ kN \le 126.17\ kN$

Work Ratio: 11.23 % **Passed**

6.2 Anchor bolt shear verification

Check relation: $F_{v,Ed} \le F_{b,Rd}$

Combination: [1]: min(N)

$$F_{v,Ed} = \frac{V_{Ed}}{n_v \times n_b} = \frac{50\ kN}{1 \times 4} = 12.5\ kN$$

Bearing resistance of an anchor bolt

$F_{b,Rd} = min(F_{1,b,Rd}; F_{2,b,Rd})$

$$F_{1,b,Rd} = 1 \cdot k_1 \cdot \alpha_{b1} \cdot d \cdot \sum(t_i) \cdot \frac{f_u}{\gamma_{M2}} = 1 \times 2.5 \times 0.83 \times 20\ mm \times 12\ mm \times \frac{360\ MPa}{1.25} = 144\ kN$$

EN 1993-1-8, 3.6.1, table 3.4

$\alpha_b = min(\alpha_d; \frac{f_{ub}}{f_u}; 1) = min(0.83; \frac{800\ MPa}{360\ MPa}; 1) = 0.83$ EN 1993-1-8, 3.6.1, table 3.4

$\alpha_d = min(\frac{e_1}{3d_0}; \frac{p_1}{3d_0} - 0.25) = min(\frac{50\ mm}{3 \times 20\ mm}; \frac{100\ mm}{3 \times 20\ mm} - 0.25) = 0.83$ EN 1993-1-8, 3.6.1, table 3.4

$F_{2,b,Rd} = \alpha_{b2} \times A_s \times \frac{f_{ub}}{\gamma_{M2}} = 0.25 \times 245\ mm^2 \times \frac{800\ MPa}{1.25} = 38.89\ kN$ EN 1993-1-8, 3.6.1, table 3.4

$\alpha_{b2} = 0.44 - 0.0003 \cdot f_{yb} = 0.44 - 0.0003 \times 640\ MPa = 0.25$

$f_{yb} = min(640; max(235; f_y)) = 640\ MPa$

$F_{b,Rd} = min(F_{1,b,Rd}; F_{2,b,Rd}) = min(144\ kN; 38.89\ kN) = 38.89\ kN$

$|12.5\ kN| \le 38.89\ kN$

Work Ratio: 32.14 % **Passed**

6.3 Anchor bolt combined shear-tension verification

Check relation: $\left|\frac{F_{v,Ed}}{F_{v,Rd}}\right| + \left|\frac{F_{t,Ed}}{1.4 \times F_{t,Rd}}\right| \le 1$ EN 1993-1-8, 3.6.1, table 3.4

Combination: [1]: min(N)

$\left|\frac{12.5\ kN}{38.89\ kN}\right| + \left|\frac{14.17\ kN}{1.4 \times 126.17\ kN}\right| \le 1$ EN 1993-1-8, 3.6.1, table 3.4

$0.4 \le 1$

Work Ratio: 40.16 % **Passed**

6.4 Summary - Individual anchor bolt verifications

Table is presented for the most solicited anchor.

	Tension Verification	Shear Verification	Shear and Tension Verification
Combination	[1]: min(N)	[1]: min(N)	[1]: min(N)
Force	14.17 kN	12.5 kN	0.40
Resistance	141.12 kN	38.89 kN	1
Work Ratio	11.23%	32.14%	40.16%
Verification	Passed	Passed	Passed

7 Stiffeners verifications

Verification not necessary!

8 Tension verifications

Verification is not necessary.

9 Shear verifications

9.1 Column web panel in shear

Check relation: $V_{wp,Ed} \le V_{wp,Rd}$

$V_{wp,Ed} = V_{Ed} = 50\ kN$

For an unstiffened column web panel, EN 1993-1-8 6.2.6.1(2):

$$V_{wp,Rd} = 0.9 \times A_v \times \frac{f_{y,wc}}{\sqrt{3} \times \gamma_{M0}} = 0.9 \times 2024\ mm^2 \times \frac{235\ MPa}{\sqrt{3} \times 1} = 247.15\ kN$$

$50\ kN \le 247.15\ kN$

Work Ratio: 20.23 % Passed

9.2 Shear verification of the bolt rows

Check relation: $V_{Ed} \le V_{u,Rd}$

Combination: [1]: min(N)

n1 - number of bolts that are not required to resist tension; EN 1993-1-8 6.2.2 (2a)

n2 - number of bolts that are also required to resist tension; EN 1993-1-8 6.2.2 (2b)

$$V_{Rd} = (n_1 + \frac{0.4}{1.4} \times n_2) \times F_{sh,Rd} = (2 + \frac{0.4}{1.4} \times 2) \times 38.89\ kN = 99.99\ kN$$ EN 1993-1-8 6.2.2 (2)

$50\ kN \le 99.99\ kN$

Work Ratio: 50 % Passed

10 Equivalent T-Stub method - introduction

This method is used for the Column Flange Bending Resistance.

1. Design resistance of a T-Stub, if the prying effect is not developed, (Lb>Lb):*

$F_{t,Rd} = \min(F_{t,1-2,Rd}; F_{t,3,Rd})$ EN 1993-1-8, 6.2.4.1 (7)

Tension resistance for the 1-2 failure mode (yield in bending of connection):

$$F_{t,1-2,Rd} = \frac{2 \times M_{pl,1,Rd}}{m}$$ EN 1993-1-8, Table 6.2

Tension resistance of the plate for the third mode of failure:

$F_{t,3,Rd} = \sum F_{t,Rd} = n \times F_{t,Rd} = n \times 126.17\ kN$ EN 1993-1-8, Table 6.2

2. Design resistance of a T-Stub, if the prying effect is developed, (Lb<Lb):*

$F_{t,Rd} = \min(F_{t,1,Rd}; F_{t,2,Rd}; F_{t,3,Rd})$ EN 1993-1-8, 6.2.4.1 (6)

Tension resistance of the plate/flange for the first mode of failure (complete yielding of the connection at bending of the plate/flange):

$$F_{t,1,Rd} = \frac{4 \times M_{pl,1,Rd} + 2 \times M_{bp,Rd}}{m}$$ EN 1993-1-8, Table 6.2

Tension resistance of the plate for the second mode of failure (yielding of the connection at bending with bolt failure in tension):

$$F_{t,2,Rd} = \frac{2 \times M_{pl,2,Rd} + \sum F_{t,Rd}}{m + n}$$ EN 1993-1-8, Table 6.2

Tension resistance of the plate for the third mode of failure (bolt failure):

$F_{t,3,Rd} = \sum F_{t,Rd} = n \times F_{t,Rd} = n \times 126.17\ kN$ EN 1993-1-8, Table 6.2

Plastic resistances of the plates for the failure modes

$$M_{pl,1,Rd} = 0.25 \times \sum l_{eff,1} \times t_f^2 \times \frac{f_y}{\gamma_{M0}}$$ EN 1993-1-8, Table 6.2

$$M_{pl,2,Rd} = 0.25 \times \sum l_{eff,2} \times t_f^2 \times \frac{f_y}{\gamma_{M0}}$$ EN 1993-1-8, Table 6.2

(If there are backing plates):

$$M_{bp,1,Rd} = 0.25 \times \sum l_{eff,1} \times t_{bp}^2 \times \frac{f_{y,bp}}{\gamma_{M0}}$$ EN 1993-1-8, Table 6.2

Lb - is the anchor bolt elongation length, taken as equal to the sum of 8 times the nominal bolt diameter, the grout layer (if it exists), the plate thickness, the washer and half of the height of the nut.

$$L_b^* = 8.8 \times \frac{m^3 \times n_r \times A_s}{\sum l_{eff,1} \times t^3}$$ EN 1993-1-8, Table 6.11

nr - number of rows (nr>1, for groups).

Failure Patterns Effective Lengths

lcp - row effective length for a circular failure pattern;
lcpg - group effective length for a circular failure pattern;
lnc - row effective length for a non-circular failure pattern;
lncg - group effective length for a non-circular failure pattern;
leff1 - the effective length for the first mode of failure (minimum between effective length of the circular or non-circular failure pattern);
leff2 - the effective length for the second mode of failure (non-circular failure pattern);

Column Web Tension Resistance (6.2.6.8)

$$F_{t,wb,Rd} = b_{eff,tr,wb} \times t_{wb} \times \frac{f_{y,b}}{\gamma_{M0}}$$

$F_{t,1,Rd} \le F_{t,2,Rd} \rightarrow b_{eff,tr,wb} = l_{eff,1}$

$F_{t,1,Rd} > F_{t,2,Rd} \rightarrow b_{eff,tr,wb} = l_{eff,2}$

Not applicable!

$$F_{t,wc,Rd} = \omega \times b_{eff,t,wc} \times t_{wc} \times \frac{f_{y,wc}}{\gamma_{M0}}$$

$F_{t,1,Rd} \le F_{t,2,Rd} \rightarrow b_{eff,t,wc} = l_{eff,1}$

$F_{t,1,Rd} > F_{t,2,Rd} \rightarrow b_{eff,t,wc} = l_{eff,2}$

$$\omega_1 = \frac{1}{\sqrt{1 + 1.3 \times (\frac{b_{eff,t,wc} \times t_{wc}}{A_{vc}})^2}}$$ EN 1993-1-8, table 5.4

$$\omega_2 = \frac{1}{\sqrt{1 + 5.2 \times (\frac{b_{eff,t,wc} \times t_{wc}}{A_{vc}})^2}}$$

$A_{vc} = 2024\ mm^2$

$t_{wc} = 8.5\ mm$

$\beta = 1 \rightarrow \omega = \omega_1$

Bolt row tension resistance

The minimum resistance for rows and groups is calculated as the minimum resistance between:

- Column Web Tension Resistance; EN 1993-1-8, 6.2.6.3
- Base Plate in Bending under Tension Resistance; EN 1993-1-8, 6.2.6.11

$F_{t,Rd}^{min} = \min(F_{t,wc,Rd}; F_{t,ep,Rd})$

Effective resistance of a row in a group is calculated as the difference between the group minimum resistance and the rest of the rows minimum resistance:

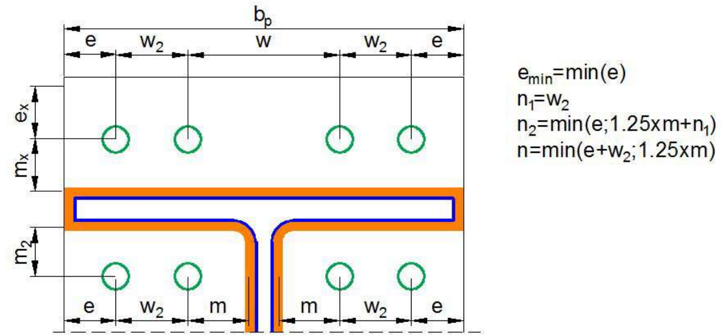
$F_{t,Rd,eff,gr} = F_{t,Rd}^{min} - \sum(F_{t,Rd,eff})$

The effective resistance of the row is equal to the effective resistance of a row in a group or the row minimum resistance, whichever is the smallest.

11 T-Stub method

11.1 Geometrical parameters

Geometrical Parameters (EN 1993-1-8, 6.2.6.4)													
Row/ Group	**Position**	**bp**	**emin**	**m**	**e**	**e1**	**mx**	**n**	**w**	**ex**	**n1**	**n2**	**w2**
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	Right	360	40	131.2	40	0	0	40	280	0	0	0	0



Equivalent T-Stub effective lengths of failure patterns

Effective End Plate Lengths (EN 1993-1-8, table 6.6)												
Row/ Group	λ_1	λ_2	λ_1*	λ_2*	α	α*	l_{cp}	$l_{cp,g}$	l_{nc}	$l_{nc,g}$	$l_{eff,1}$	$l_{eff,2}$
	-	-	-	-	-	-	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
1	0.766	0.112	0.000	0.000	6.167	0.000	824.5	412.3	809.3	521.8	809.3	809.3

11.2 End plate in bending resistance

End Plate Bending Resistance (EN 1993-1-8, table 6.2)												
Row/ Group	L_b*	Prying	$M_{pl,1Rd}$	$M_{pl,2,Rd}$	$M_{bp,Rd}$	$F_{t,1,Rd}$	$F_{t,2,Rd}$	$F_{t,3,Rd}$	$F_{t,1-2,Rd}$	$F_{t,ep,Rd}$	Failure	
	(mm)	Effect	(kN·m)	(kN·m)	(kN·m)	(kN)	(kN)	(kN)	(kN)	(kN)	Mode	Pattern
1	3483.9	Yes	6.85	6.85	-	208.69	138.92	252.35	-	138.92	2	NC

11.3 Column web in tension resistance

Column Web Tension Resistance (EN 1993-1-8, 6.2.6.3)					
Row/ Group	ω	ω_1	ω_2	$b_{eff,t,wc}$	$F_{t,wc,Rd}$
	-	-	-	(mm)	(kN)
1	0.25	0.25	0.13	809.3	403.93

11.4 Rows tension resistance

Row	$F_{t,ep,Rd}$	$F_{t,wc,Rd}$	$F_{t,Rd,min}$	$F_{t,Rd,eff}$*	Failure
1	138.92 kN	403.93 kN	138.92 kN	**138.92 kN**	EP-NC

11.5 Bending moment classification

Load eccentricity

$e = \frac{M_{j,Ed}}{N_{j,Ed}} = \frac{4\ kN\cdot m}{0\ kN} = \infty$

Lever arm of left tension zone

$z_{t,L} = \frac{\sum(F_{t,Rd} \times h_{rel})}{\sum F_{t,rd}} = \frac{6.95\ kN\cdot m}{138.92\ kN} = 50\ mm$ EN 1993-1-8, 6.2.8.1

$F_{T,l,Rd} = 138.92\ kN$ EN 1993-1-8, 6.2.8.3 (2)

$F_{C,r,Rd} = 193.42\ kN$ EN 1993-1-8, 6.2.8.3 (5)

Loading: Left Tension - Right Compression EN 1993-1-8, 6.2.8.1 Figure 6.18

$M_{j,Rd} = 17.36\ kN\cdot m$ EN 1993-1-8, 6.2.8.3 (6), Table 6.7

11.6 Bending moment verification

Check relation: $M_{j,Ed} \le M_{j,Rd}$

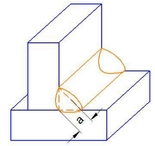
Combination: [1]: min(N)

$|4\ kN\cdot m| \le |17.36\ kN\cdot m|$

Work Ratio: 23.04 % Passed

12 Weld verifications

12.1 Weld dimension conditions



Minimum Throat Thickness EN 1993-1-8, 4.5.2 (2)

$a \ge 3mm$

Upper Flange Weld Verification $6\ mm \ge 3\ mm$ Passed

Web Weld Verification $4\ mm \ge 3\ mm$ Passed

Minimum Length EN 1993-1-8, 4.5.1 (2)

$l_{eff} \ge max(6 \times a;30mm)$

Upper Flange Weld Verification $64.8\ mm \ge max(6\times6;30) = 36\ mm$ Passed

Web Weld Verification $122\ mm \ge max(6\times4;30) = 30\ mm$ Passed

12.2 Member weld verification by moment resistance (weld design method: simplified)

Upper Flange Weld Verification

Check relation: $F_{w,Ed,Res} \le F_{w,Rd}$

Combination: [1]: min(N)

$F_{w,Ed,Res} = \frac{M_{y,Ed}}{H_f} + \frac{N_{Ed}}{2} = \frac{17.36\ kN\cdot m}{166\ mm} + \frac{0\ kN}{2} = 104.6\ kN$

$F_{w,Rd} = n_{Obj} \cdot n_w \cdot a \cdot l_{eff} \cdot \frac{f_u}{\sqrt{3} \cdot \beta_w \cdot \gamma_{M2}}$

$= 1\times1\times6\ mm\times297.5\ mm\times\frac{360\ MPa}{\sqrt{3}\times0.8\times1.25} = 371.01\ kN$

EN 1993-1-8, 4.8 (1)

$104.6\ kN \le 371.01\ kN$

Work Ratio: 28.19 % Passed

Web Weld Verification

Check relation: $F_{w,Ed,Res} \le F_{w,Rd}$

Combination: [1]: min(N)

$F_{w,Ed,Res} = V_{Ed} = 50\ kN$

$F_{w,Rd} = n_{Obj} \cdot n_w \cdot a \cdot l_{eff} \cdot \frac{f_u}{\sqrt{3} \cdot \beta_w \cdot \gamma_{M2}}$ EN 1993-1-8, 4.8 (1)

$= 1\times2\times4\times122\times\frac{360}{\sqrt{3}\times0.8\times1.25} = 202.86$

$50\ kN \le 202.86\ kN$

Work Ratio: 24.65 % Passed

13 Rotational Stiffness

13.1 Stiffness coefficients for basic joint components (EN 1993-1-8, Table 6.11)

- calculated taking into account effective lengths for individual tensioned rows and effective lengths for tensioned rows as part of a group;

Effective stiffness coefficient of one bolt row in tension

$k_{eff} = \frac{1}{\frac{1}{k_{15}} + \frac{1}{k_{16}}}$ EN 1993-1-8, 6.3.3.1 (6.30)

Row 1

$L_b \le L_b^*$: 183 mm ≤ 3483.9 mm →

Prying effect is developed: EN 1993-1-8, 6.2.3.1, Table 6.2

Stiffness coefficient for base plate in bending under tension

$k_{15} = 0.85 \times l_{eff} \times \frac{t_p^3}{m^3} = 0.85 \times 809.3\ mm \times \frac{(12\ mm)^3}{(131.2\ mm)^3} = 0.5\ mm$ EN 1993-1-8, Table 6.11

Stiffness coefficient for bolts in tension

$k_{16} = 1.6 \times \frac{A_s}{L_b} = 1.6 \times \frac{245\ mm^2}{183\ mm} = 2.1\ mm$ EN 1993-1-8, Table 6.11

$k_{eff} = \frac{1}{\frac{1}{k_{15}} + \frac{1}{k_{16}}} = \frac{1}{\frac{1}{0.5\ mm} + \frac{1}{2.1\ mm}} = 0.4\ mm$ EN 1993-1-8, 6.3.3.1 (6.30)

Row	k_{eff} (mm)	h_r (mm)	$k_{eff} \times h_r$ (mm²)	$k_{eff} \times h_r^2$ (cm³)
1	0.4	133	56.2	7.47
			$\sum(k_{eff} \times h_r) = 56.2\ mm^2$	$\sum(k_{eff} \times h_r^2) = 7.47\ cm^3$

Equivalent stiffness coefficient of the tensioned area

$k_{eq} = \frac{\sum k_{eff} \times h_r}{z_{eq}} = \frac{56.2\ mm^2}{133\ mm} = 0.4\ mm$ EN 1993-1-8, 6.3.3.1 (6.29)

Equivalent lever arm

$z_{eq} = \frac{\sum k_{eff} \times h_r^2}{\sum k_{eff} \times h_r} = \frac{7.47\ cm^3}{56.2\ mm^2} = 133\ mm$ EN 1993-1-8, 6.3.3.1 (6.31)

Stiffness coefficient for concrete in compression

$k_{13} = \frac{E_c}{1.275 \times E_s} \times \sqrt{b_{eff} \times l_{eff}} = \frac{31475.81\ MPa}{1.275 \times 210000\ MPa} \times \sqrt{50\ mm \times 232\ mm} = 12.7\ mm$ EN 1993-1-8, Table 6.11

13.2 Initial stiffness determination

For dominant bending moment joints (right-compression, left-tension):

$S_{j,ini} = E \times \frac{z^2}{(\frac{1}{k_{t,L}} + \frac{1}{k_{c,R}})} =$

$= 210000\ MPa \times \frac{(125\ mm)^2}{(\frac{1}{0.4\ mm} + \frac{1}{12.7\ mm})} = 1341\ kN{\cdot}m/rad$

EN 1993-1-8, 6.3.4, Table 6.12

$z = z_{t,L} + z_{c,R} = 50\ mm + 75\ mm = 125\ mm$ EN 1993-1-8, 6.3.4, Table 6.12

Tension stiffness coefficient of the left side of the joint:

$k_{t,L} = k_{eq} = 0.4\ mm$ EN 1993-1-8, 6.3.4 (1)

Compression stiffness coefficient of the right side of the joint:

$k_{c,R} = k_{13} = 12.7\ mm$ EN 1993-1-8, 6.3.4 (1)

The bearing pressure zone exceeds the plate length, EN 1993-1-8 6.2.8.2:

$z_{c,L} = z_{c,R} = \frac{h}{2} + c - \frac{b_{eff}}{2} = \frac{180\ mm}{2} + 10\ mm - \frac{50\ mm}{2} = 75\ mm$ EN 1993-1-8 6.2.8.2

13.3 Rotational stiffness calculation

Secant stiffness:

$S_j = \frac{S_{j,ini}}{\mu}$ EN 1993-1-8, 5.1.2 (4)

Stiffness ratio:

$M_{j,Ed} = 4\ kN{\cdot}m \le \frac{2}{3} \times M_{j,Rd} = \frac{2}{3} \times 17.36\ kN{\cdot}m \rightarrow \mu = 1$

$S_j = \frac{S_{j,ini}}{\mu} = \frac{1341\ kN{\cdot}m/rad}{1} = 1341\ kN{\cdot}m/rad$ EN 1993-1-8, 5.1.2 (4)

13.4 Rotational Stiffness Classification

Slenderness of the column assumed pinned at both ends:

$\lambda_0 = \frac{L_c}{\sqrt{\frac{I}{A}}} \times \frac{1}{\lambda_1} = \frac{700\ mm}{\sqrt{\frac{3831\ cm^4}{6525\ mm^2}}} \times \frac{1}{93.91} = 0.1$

$\lambda_1 = \pi \times \sqrt{\frac{E}{f_y}} = \pi \times \sqrt{\frac{210000\ MPa}{235\ MPa}} = 93.91$

EN 1993-1-8, 5.2.2.5 (2)

The joint is contained in a braced structure (the bracings reduce at least 80% of displacement)

$\lambda_0 = 0.1 \le 0.5$; $S_{j,ini} = 1341\ kN{\cdot}m/rad > 0$

The joint is considered Rigid. EN 1993-1-8, 5.2.2.5 (2)

14 Warning and error messages

Type	Description
Warning	Constructive conditions for positioning of holes have failed (EN 1993-1-8 table 3.3). Load case: 1

15 Summary

Verification	Combination	Force	Resistance	Work Ratio	Status
Shear of the anchor bolt rows	[1]: min(N)	50 kN	99.99 kN	50 %	Passed
Anchor bolt shear and tension	[1]: min(N)	0.4	1	40.16 %	Passed
Anchor bolt shear	[1]: min(N)	12.5 kN	38.89 kN	32.14 %	Passed
Flange weld	[1]: min(N)	104.6 kN	371.01 kN	28.19 %	Passed
Web weld	[1]: min(N)	50 kN	202.86 kN	24.65 %	Passed
Bending moment	[1]: min(N)	4 kN·m	17.36 kN·m	23.04 %	Passed
Column web panel in shear	[1]: min(N)	50 kN	247.15 kN	20.23 %	Passed
Anchor bolt tension	[1]: min(N)	14.17 kN	126.17 kN	11.23 %	Passed
Maximum Work Ratio:				**50 %**	**Passed**

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Podjetje:	IB ARMATURA	Stran:	1
Naslov:		Projektant:	
Telefon I Faks:	|	E-mail:	
Projektiranje :	Concrete - Jul 13, 2021	Datum:	15. 07. 2021
Točka pritrjevanja:			

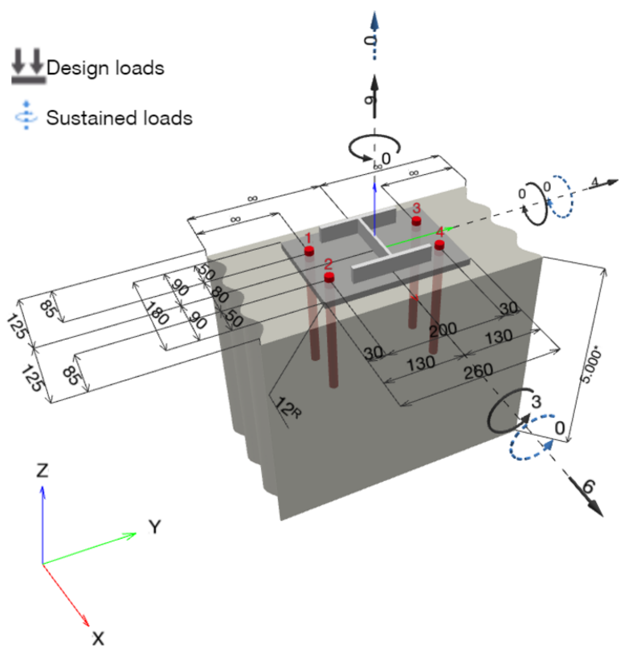
Komentar projektanta: SPOJ NOSILCA HEB140 NA BETONSKO STENO

1 Vhodni podatki

Tip in velikost sidra :	**HIT-HY 200-A + HAS-U 8.8 M16**
Povratna doba (življenjska doba v letih):	50
Številka artikla:	2223884 HAS-U 8.8 M16x300 (element) / 434674 HIT-HY 200-A (kemično sidro)
Efektivna sidrna globina :	$h_{ef,act}$ = 220,0 mm ($h_{ef,limit}$ = - mm)
Material:	8.8
Tehnična ocena artikla:	ETA 11/0493
Izdano I Veljavno:	14. 12. 2020 | -
Kontrola:	Projektna metoda EN 1992-4, Kemično sidro
Vgradnja z nadvišanjem:	e_b = 0,0 mm (brez nadvišanja); t = 12,0 mm
Ležiščna pločevina^R :	l_x x l_y x t = 180,0 mm x 260,0 mm x 12,0 mm; (Priporočena debelina ležiščne pločevine: ni izračunano)
Profil:	IPBi/HEA, IPBI 140 / HE 140 A; (L x W x T x FT) = 133,0 mm x 140,0 mm x 5,5 mm x 8,5 mm
Osnovni material:	razpokan beton, C25/30, $f_{c,cyl}$ = 25,00 N/mm^2; h = 5.000,0 mm, Temp. kratko./dolgo.: 0/0 °C, Delni varnostni faktor materiala, ki ga določi uporabnik γ_c = 1,500
Vgradnja:	**izvrtina izvrtana z udarnim svedrom, Pogoji vgradnje: Suho**
Ojačitev:	brez armature ali razmak med armaturo >= 150 mm (any Ø) or >= 100 mm (Ø <= 10 mm)
	brez vzdolžne armature po robu betona

^{R} - Izdelan izračun je zasnovan ob predpostavki toge ležiščne pločevine

Geometrija [mm] & Obtežba [kN, kNm]



1.1 Obtežna kombinacija

Primer	Opis	Sile [kN] / Momenti [kNm]	Potresno	požar	Izkoriščenost [%]
1	Combination 1	$N = 9{,}000$; $V_x = 6{,}000$; $V_y = 4{,}000$; $M_x = 3{,}000$; $M_y = 0{,}000$; $M_z = 0{,}000$; $N_{sus} = 0{,}000$; $M_{x,sus} = 0{,}000$; $M_{y,sus} = 0{,}000$;	ne	ne	88

2 Kontrola I Izkoriščenost (Merodajen obtežni primer)

		Projektne vrednosti [kN]		Izkoriščenost	
Obtežba	**Kontrola**	**Obtežba**	**Kapaciteta**	**β_N / β_V [%]**	**Status**
Nateg	Porušitev po konusu betona	18,815	24,659	77 / -	OK
Strig	Porušitev po robu betona v smeri x+	6,325	18,211	- / 35	OK

Obtežba	**β_N**	**β_V**	**α**	**Izkoriščenost $\beta_{N,V}$ [%]**	**Status**
Kombinacija nateznih in strižnih obremenitev	0,763	0,347	1,500	88	OK

3 Opozorila

- Upoštevajte vse podrobnosti in namige/opozorila v poročilu!

Izbrano pritrjevanje ustreza projektnim pogojem!

Podjetje:	IB ARMATURA	Stran:	4
Naslov:		Projektant:	
Telefon I Faks:	|	E-mail:	
Projektiranje :	Concrete - Jul 13, 2021	Datum:	15. 07. 2021
Točka pritrjevanja:			

4 Opombe; Vaše dolžnosti sodelovanja

- Vse informacije in podatki, ki jih vsebuje programska oprema, se nanašajo izključno na uporabo izdelkov Hilti in temeljijo na načelih, formulah in varnostnih predpisih v skladu s tehničnimi navodili podjetja Hilti ter navodili za uporabo, montažo in montažo itd. ki jih mora uporabnik dosledno upoštevati. Vse vsebovane vrednosti so povprečne številke, zato je treba pred uporabo ustreznega izdelka Hilti opraviti preskuse, specifične za uporabo. Rezultati izračunov s programsko opremo v osnovi temeljijo na podatkih, ki jih vnesete. Zato prevzemate vso odgovornost za odsotnost napak, popolnost in ustreznost podatkov, ki jih morate vnesti. Poleg tega prevzemate vso odgovornost za to, da rezultate izračunov pregleda in popravi strokovnjak, zlasti glede skladnosti z veljavnimi normativi in dovoljenji, preden jih uporabite za svoj specifični objekt. Programska oprema služi le kot pomoč pri razlagi norm in dovoljenj brez kakršnega koli jamstva o odsotnosti napak, pravilnosti in ustreznosti rezultatov ali primernosti za določeno aplikacijo.
- Za preprečevanje ali omejitev škode, ki jo povzroča programska oprema, morate sprejeti vse potrebne in razumne ukrepe. Zlasti morate poskrbeti za redno varnostno kopiranje izračunov in podatkov ter po potrebi redno posodabljati programsko opremo, ki jo ponuja Hilti. Če ne uporabljate funkcije AutoUpdate programske opreme, morate z uporabo ročnih posodobitev prek spletnega mesta Hilti zagotoviti, da uporabljate trenutno in posodobljeno različico programske opreme. Hilti ne bo odgovoren za posledice, kot so obnovitev izgubljenih ali poškodovanih podatkov ali programov, ki so posledica krivdne kršitve dolžnosti.