# Projekt čelične konstrukcije stadiona Višnjik

**Ćosić, Monika**

**Master's thesis / Diplomski rad**

**2019**

*Degree Grantor / Ustanova koja je dodijelila akademski / stručni stupanj:*
**University of Split, Faculty of Civil Engineering, Architecture and Geodesy / Sveučilište u Splitu, Fakultet građevinarstva, arhitekture i geodezije**

*Permanent link / Trajna poveznica:* https://urn.nsk.hr/urn:nbn:hr:123:557270

*Rights / Prava:* In copyright / Zaštićeno autorskim pravom.

*Download date / Datum preuzimanja:* **2024-12-19**

*Repository / Repozitorij:*

FCEAG Repository - Repository of the Faculty of Civil Engineering, Architecture and Geodesy, University of Split

zir.nsk.hr

UNIVERSITY OF SPLIT

dabar
DIGITALNI AKADEMSKI ARHIVI I REPOZITORIJI

**SVEUČILIŠTE U SPLITU**
**FAKULTET GRAĐEVINARSTVA ARHITEKTURE I GEODEZIJE**

# DIPLOMSKI RAD

**Monika Ćosić**

**Split, 2019.**

**SVEUČILIŠTE U SPLITU**
**FAKULTET GRAĐEVINARSTVA ARHITEKTURE I GEODEZIJE**

**Monika Ćosić**

# Projekt čelične konstrukcije stadiona Višnjik

**Diplomski rad**

**Split, 2019.**

# Projekt čelične konstrukcije stadiona Višnjik

***Sažetak:***

Prema podlogama arhitektonskog rješenja, izrađen je projekt čelične konstrukcije stadiona Višnjik u Zadru. Arhitektonskim podlogama zadana je tlocrtna, uzdužna i poprečna dispozicija kao i oblik konstruktivnih elemenata. Na temelju zadanih gabarita napravljen je proračunski model na kojem je izvršeno dimenzioniranje svih konstruktivnih elemenata. Za odabrane elemente konstrukcije izvršen je proračun spojeva te su napravljeni građevinski nacrti i iskaz materijala. Svi proračuni konstrukcije izvedeni su prema normama Eurocode-a.

***Ključne riječi:***

čelična konstrukcija, stadion, priključci, nacrti

# Steel construction project for Višnjik stadium

***Abstract:***

Steel construction project for Višnjik stadium in Zadar was made according to the drawings of architectural solution. The arcitectural drawings defined ground, longitudinal and transverse plans, as well as the type of construction elements. Structure model was made based on given dimensions, which was used for dimensioning all construction elements. Calculation of joints, construction design and bill of material were made for selected elements of the construction. All calculations related to the construction were carried out under the Eurocode norms.

***Keywords:***

steel construction, stadium, joints, drawings

**SVEUČILIŠTE U SPLITU**
**FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE**

| | |
|---|---|
| STUDIJ: | **DIPLOMSKI SVEUČILIŠNI STUDIJ GRAĐEVINARSTVA** |
| KANDIDAT: | Monika Ćosić |
| BROJ INDEKSA: | 685 |
| KATEDRA: | **Katedra za metalne i drvene konstrukcije** |
| PREDMET: | Metalne konstrukcije |

# ZADATAK ZA DIPLOMSKI RAD

Tema: Projekt čelične konstrukcije stadiona Višnjik

Opis zadatka: Na temelju zadanih arhitektonskih podloga potrebno je napraviti proračun čelične konstrukcije stadiona Višnjik smještenog na području Zadra. Projekt treba sadržavati proračunski model konstrukcije pomoću kojeg će se izvršiti dimenzioniranje konstruktivnih elemenata u skladu s HRN EN 1993, HRN EN 1994 i HRN EN 1992.
Također je potrebno proračunati spojeve te izraditit pripadajuće nacrte.

U Splitu, ožujak 2019.

Voditelj Diplomskog rada:

Prof. dr. sc. Ivica Boko

Predsjednik Povjerenstva
za završne i diplomske ispite:
Doc. dr. sc. Ivo Andrić

# SADRŽAJ:


1. TEHNIČKI OPIS 1
   1.1. Opis konstrukcije 1
   1.2. O proračunu konstrukcije 2
   1.3. Materijal za izradu konstrukcije 3
   1.5. Primjenjeni propisi 4
   1.6. Antikorozivna zaštita 4
   1.7. Protupožarna zaštita 6
2. NUMERIČKI MODEL KONSTRUKCIJE 7
3. ANALIZA OPTEREĆENJA 10
   3.1. Stalno opterećenje 10
   3.2. Dodatno stalno opterećenje 10
   3.3. Promjenjivo (pokretno) opterećenje 11
   3.4. Opterećenje snijegom 12
   3.5. Opterećenje vjetrom 14
   3.6. Djelovanje temeprature 21
   3.7. Potres 22
4. KOMBINACIJE DJELOVANJA 23
   4.1. Granično stanje nosivosti 23
   4.2. Granično stanje uporabivosti 23
5. DIMENZIONIRANJE ELEMENATA KONSTRUKCIJE 24
   5.1. Pomaci konstrukcije 24
   5.2. Dimenzioniranje stupa pozicije S1 28
   5.3. Dimenzioniranje gornjeg pojasa rešetke pozicije R1 32
   5.4. Dimenzioniranje donjeg pojasa rešetke pozicije R1 34
   5.5. Dimenzioniranje vertikale rešetke pozicije R1 38
   5.6. Dimenzioniranje ispune rešetke pozicije R1 42
   5.7. Dimenzioniranje gornjeg pojasa rešetke pozicije R2 47
   5.8. Dimenzioniranje donjeg pojasa rešetke pozicije R2 50
   5.9. Dimenzioniranje vertikale rešetke pozicije R2 54
   5.10. Dimenzioniranje ispune rešetke pozicije R2 58
   5.11. Dimenzioniranje gornjeg pojasa rešetke pozicije R3 62
   5.12. Dimenzioniranje donjeg pojasa rešetke pozicije R3 67
   5.13. Dimenzioniranje vertikale rešetke pozicije R3 71
   5.14. Dimenzioniranje ispune rešetke pozicije R3 76

5.15. Dimenzioniranje gornjeg pojasa rešetke pozicije R4 81
5.16. Dimenzioniranje donjeg pojasa rešetke pozicije R4 86
5.17. Dimenzioniranje vertikale rešetke pozicije R4 90
5.18. Dimenzioniranje ispune rešetke pozicije R4 94
5.19. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 1) 99
5.20. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 2) 103
5.21. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 3) 107
5.22. Dimenzioniranje ispune rešetke pozicije R5 (segment 1) 111
5.23. Dimenzioniranje ispune rešetke pozicije R5 (segment 2) 115
5.24. Dimenzioniranje donjeg pojasa rešetke pozicije R6 (segment 2) 124
5.25. Dimenzioniranje ispune rešetke pozicije R6 (segment 1) 128
5.26. Dimenzioniranje ispune rešetke pozicije R6 (segment 2) 132
5.27. Dimenzioniranje krovne podrožnice pozicije KP1 136
5.28. Dimenzioniranje krovne podrožnice pozicije KP2 140
5.29. Dimenzioniranje bočne podrožnice pozicije BP 143
5.30. Dimenzioniranje bočnog sprega pozicije BS 147
6. SPOJEVI 148
6.1. Spoj stupa s pločom 148
6.2. Montažni nastavak donjeg pojasa 152
6.3. Montažni nastavak gornjeg pojasa 162
6.4. Montažni nastavak ispune 172
6.5. Spoj donjeg pojasa i ispune rešetke sa stupom 182
6.6. Spoj gonjeg pojasa rešetke sa stupom 193
6.7. Spoj ispune s donjim pojasom 205
6.8. Spoj ispune sa gornjim pojasom 213
7. TEŽINA KONSTRUKCIJE 221
8. DIMENZIONIRANJE TEMELJA SAMCA 222
8.1. Proračun dimenzija temlja samca 222
9. GRAFIČKI PRILOZI 223
10. LITERATURA 224

# 1. TEHNIČKI OPIS

## 1.1. Opis konstrukcije

Predmet ovog projekta je čelična konstrukcija stadiona Višnjik smještenog na području Zadra. Obuhvat se nalazi unutar Športskog centra „Višnjik“ koji je pozicioniran između Poluotoka (stare gradske jezgre) na jugu i stambenog naselja Bili Brig na sjeveroistoku. Odabrani obuhvat je kat. čestica 3838/1 koja je u vlasništvu Republike Hrvatske. Zona obuhvata 9,61 ha. Kompleks ŠC „Višnjik“ omeđen je sa sjeverozapadne strane Ulicom Edvina Androvića, s juga Ulicom Domovinskog rata, s jugoistoka Splitskom ulicom i sa sjeverne strane Ulicom Slavka Perovića. Pristup glavnom parkingu je s ulice Slavka Perovića, dok su omogućeni kolni ulazi sa sve četiri strane kompleksa.

Objekt se funkcionalno sastoji od dva dijela, nogometnog i atletskog stadiona međusobno povezanih natkrivenim trijemom i garažom u prizemlju. Objekt je planiran kao višeetažna konstrukcija sa višenamjenskim sadržajem. U podzemnoj etaži su smješene garaže, prostori namjenjeni igračima, službenim osobama, prostorija za održavanje stadiona te skladište. U nadzemnim etažama se nalaze uredi, smještajne jedinice, kuglana, teretana, fitness prostor i caffe bar.

Vertikalnu nosivu konstrukciju čine armirano betonski i čelični stupovi oblika poprečnog presjeka „I“. Krovna konstrukcija se sastoji od čeličnih rešetkastih nosača oslonjenih na čelične i armirano betonske stupove. Rešetkasti nosači su izrađeni od šupljih čeličnih profila kvadratnog poprečnog presjeka. Međukatne konstrukcije su armirano betonske ploče. Tribine su izrađene od armiranog betona.
Temelji su armirano betonski, izvedeni kao temelji samci, kvadratnog tlocrtnog oblika. Iznad temelja je postavljena temeljna armirano betonska ploča.
Odvodnja je rješena padovima krova.

Ukupna širina objekta je 160 m, dok duljina iznosi 198 m. Ukupna površina krovne plohe je 18563,7 $m^2$, a visina objekta je 18,5 m.

## 1.2. O proračunu konstrukcije

Proračun konstrukcije napravljen je uz pomoć programskog paketa SCIA Engineer 19.0. Proračun reznih sila, te dimenzioniranje konstruktivnih elemenata provedeno je korištenjem programa SCIA Engineer 19.0. Spojevi su izračunati uz pomoć programa IDEA StatiCa, dok je za grafički dio projekta korišten AutoCAD 2018.

Proračun reznih sila izvršen je po linearnoj teoriji elastičnosti prvog reda. Proračunom su obuhvaćena sva djelovanja na konstrukciju, a to su: vlastita težina, dodatno stalno opterećenje, pokretno opterećenje, opterećenje snijegom, vjetarom, djelovanje temperature i potres.

S obzirom na lokaciju objekta napravljena je analiza opterećenja koja obuhvaća djelovanje snijega i vjetra. Objekt se nalazi na području Zadra, te prema karti snijega za Republiku Hrvatsku ova građevina spada u 1. područje – priobalje i otoci, što određuje karakterističnu vrijednost opterećenja snijegom na tlu. U obzir je uzeta i nadmorska visina na kojoj se nalazi objekt. Za opterećenje vjetrom odabrana je zona III, kategorija zemljišta 0, te je u obzir uzeta visina objekta i njegova zaštičenost.

Budući da je vjetar dominantno opterećenje za ovakav tip objekta, posvećena mu je velika pažnja. Konstrukcija je otvorenog tipa pa je promatrano tlačno i podtlačno djelovanje vjetra. U proračunskom modelu opterećenje vjetrom je prikazano kao površinsko opterećenje na krovnim panelima.

Za svaki element konstrukcije određena je mjerodavna kombinacija opterećenja za provjeru krajnjeg graničnog stanja i graničnog stanja uporabivosti. Za svako granično stanje napravljene su posebne kombinacije uz poštivanje parcijalnih faktora sigurnosti prema EN 1991.

Rezultati uključuju rezne sile i pomake određenih djelova konstrukcije. Rezne sile su dane u jedinicama kN za poprečne i uzdužne sile, kNm za momente, te u mm za pomake konstrukcije. U obzir su uzete sve mjerodavne kombinacije opterećenja , te je svaki element dimenzioniran sukladno njegovim reznim silama.

## 1.3. Materijal za izradu konstrukcije

Materijal za izradu glavne nosive konstrukcije, kao i stupova je čelik S355.
Konstruktivni elementi će međusobno bit vezani vijčanim i zavarenim spojevima. Vijci korišteni za izvedbu ove konstrukcije su: M12, M16, M22, M24, M27 i M36, svi kvalitete 5.6. Spojevi i nastavci elemenata konstrukcije uključuju dodatne ploče i ukrute, također iste kvalitete čelika.

Za betonski dio konstrukcije predviđen je beton klase C40/50. Temelji su armirano betosnki, klasa betona C25/30, armatura B500B.

## 1.4. Opis montaže konstrukcije

Izvedba konstrukcije je montažna. Svi elementi konstrukcije predgotovljeni stižu na gradilište te se međusobno vežu vijcima.

Nulta faza montaže, nakon izvedenih svih predhodno potrebnih radova, je montaža stupova. Stup se pridržaje dizalicom dok se ne postigne vertikalnost pomoću dvostrukih vijaka. Nakon provjere vertikalnosti, vrši se ispunjenje prostora između spojne i betonske ploče ekspandirajućim mortom.

Nakon toga se na stupove veže bočna sekundarna konstrukcija, glavni i sekundarni rešetkasti nosači.

Svi elementi konstrukcije se dovoze na gradilište duljine do 15 m zbog transporta. Na gradilištu se spajaju u veće segmente i takvi podižu dizalicom na predviđenu poziciju te vijčano i zavarima spajaju na ostatak konstrukcije.

## 1.5. Primjenjeni propisi

Proračun i dimenzioniranje svih elemenata čelične konstrukcije provedeni su u skladu sa EUROCODE-om 3, a analiza djelovanja na konstrukciju napravljena je u skladu sa EUROCODE-om 1. Posebno je proveden proračun zavarenih spojeva prema EN 1993, dio 1-8.

## 1.6. Antikorozivna zaštita

Kod čelika pod korozijom se podrazumijeva oksidacija željeza pri djelovanju vlage i raznih nečistoća. Agensi koji ubrzavaju hrđanje su zagađena atmosfera, industrijsko područje zagađeno sumporom, sol itd.

Zaštita čeličnih konstrukcija od hrđanja vrši se:

- premazima

- cinkom

- metalizacijom

- uporabom specijalnih čelika

- katodnom zaštitom

Zaštita premazima obavlja se u svrhu sprječavanja kontakta kisika i vlage sa čelikom. Premazivanje se obično vrši bojanjem u dva sloja: osnovni premaz i zaštitni premaz. Osnovni premaz neposredno štiti čelik, a potrebno je da bude izrađen od tvari koje nisu štetne po ljudsko zdravlje. Zaštitni sloj služi za zaštitu osnovnog premaza.

Prerano propadanje konstrukcije najčešće nastaje uslijed loših detalja u konstrukciji (nepristupačna mjesta za bojenje, mjesta gdje se zadržava voda, oštri bridovi gdje se ne može nanijeti zahtjevana debljina premaza i i sl.) koje treba nastojati izbjegavati.

Sistem zaštite bojom sastoji se iz:

- pripreme površine – trajnost premaza ovisi o prionjivosti boje za metalnu površinu, što ovisi o čistoći površine prije bojanja. Čiščenje se vrši četkama, pjeskarenjem, plamenikom ili kemijskim sredstvima.

- nanošenje boje – bojenje se vrši četkom, valjkom ili prskanjem. Treba paziti na ograničenja za pojedine boje. Broj slojeva premaza obično se sastoji od dva, a specifično od četiri ili više slojeva. Novi premaz može se vršiti tek kada je predhodni potpuno suh. Debljini premaza potrebno je posvetiti posebnu pažnju. Općenito, deblji premaz povećava trajnost zaštite. Ukupna debljina suhih premaza treba se kretati između 0,1 – 0,4 mm.

Dobro izvedeni premazi traju:

- do 30 godina u zatvorenoj prostoriji

- do 20 godina kod konstrukcija zaštićenih od kiše

- do 10 godina u prirodi

- 2 do 3 godine u zagađenom okolišu

Zaštita pocinčavanjem podrazumijeva vrste zaštite koje se ostvaruju nanošenjem prevlake cinka. Mase i debljine prevlaka cinka za pojedine elemente određene su prema Pravilniku o tehničkim mjerama i uvjetima za zaštitu čeličnih konstrukcija od korozije i ne mogu biti manje od 500g/m2 elementa debljine 5 mm. Sve čelične konstrukcije prethodno treba odmastiti, očistiti razblaženom otopinom klorovodične kiseline te isprati hladnom vodom. Neposredno prije pocinčavanja čelična konstrukcija se stavlja u taljevinu ili otopinu za flusiranje.

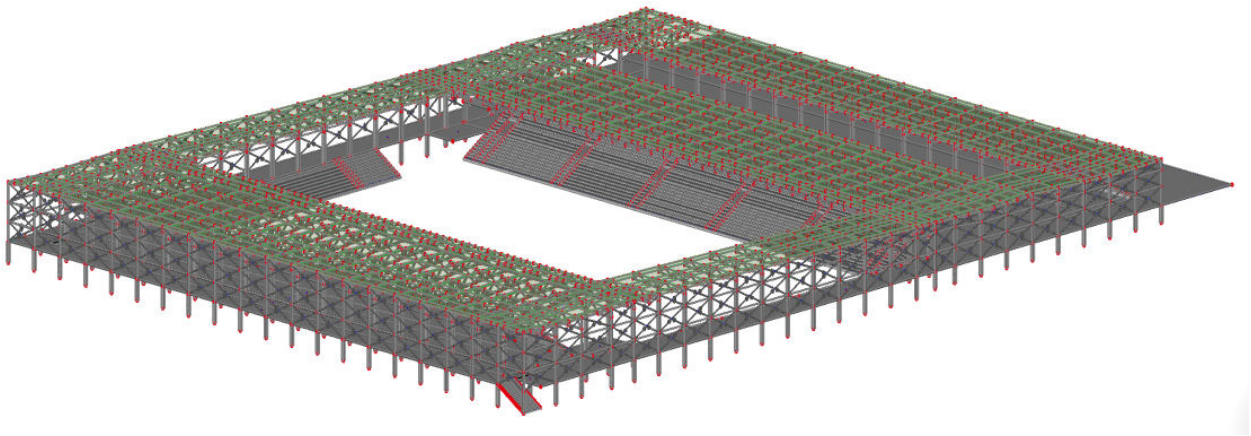
Toplo pocinčavanje se izvodi stavljanjem tekućine u rastopljeni cink. Cink mora biti kvaliteta Zn 97,5 do Zn 99,5 prema HRN EN ISO 14713:2001. Prevlaka cinka dobivena toplim postupkom mora biti homogena i mora prekrivati osnovicu. Prevlaka cinka mora čvrsto prianjati za čeličnu površinu i ne smije se ljuštiti niti pucati pri uporabi. Prije montaže potrebno je izvršiti kontrolu prevlake cinka prema HRN C.A1. 558, odnosno mase prevlake cinka prema HRN A6.021.

## 1.7. Protupožarna zaštita

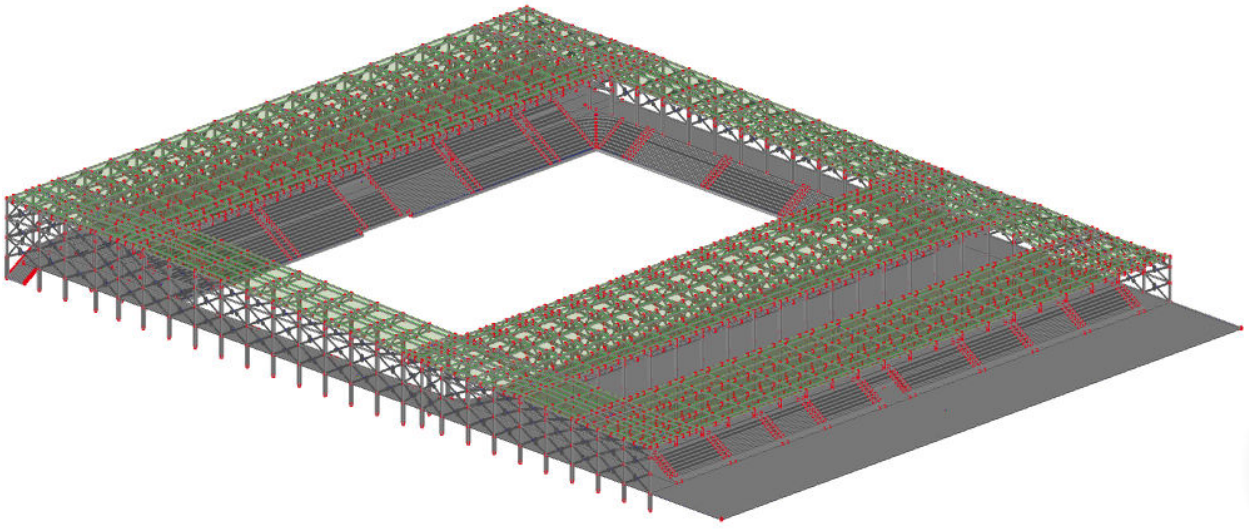
Pri izvedbi osigurat će se provedba svih propisa o zaštiti od požara. Pristup i intervencija vatrogasnog vozila omogućit će se sa zapadne strane parcele. Zahtijevana vatrootpornost elemenata čelične konstrukcije je F30. Osiguranje vatrootpornosti osiguravamo specijalnim ekspandirajućim premazima.

# 2. NUMERIČKI MODEL KONSTRUKCIJE

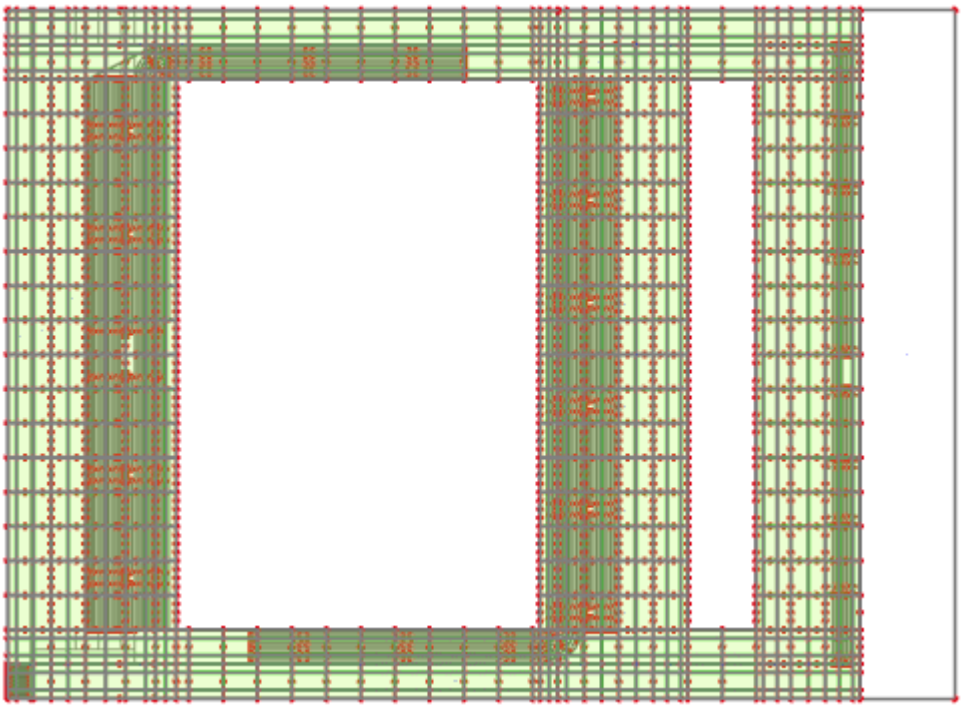
Numerički 3D render modela konstrukcije je izrađen u programu Scia Engineer 2019.



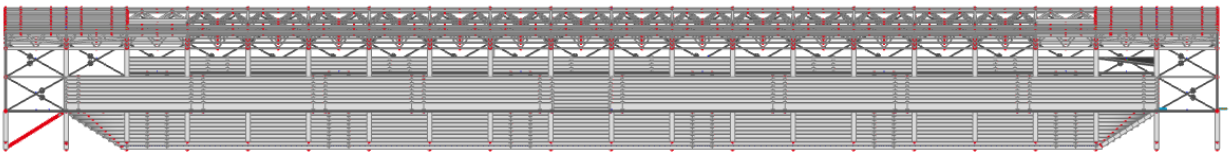
***Slika 2.1.*** *Izmometrijski prikaz 3D modela*



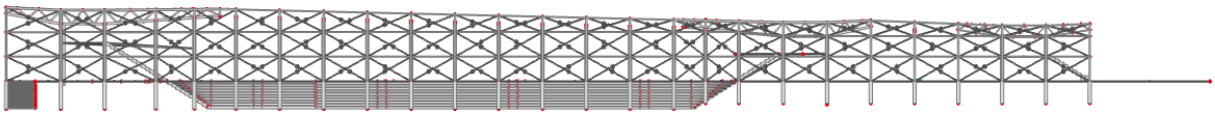
***Slika 2.2.*** *Izmometrijski prikaz 3D modela*



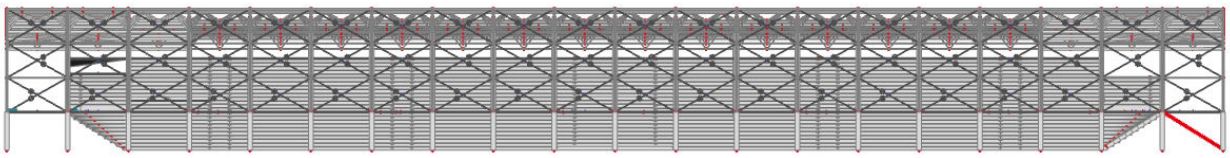
***Slika 2.3.*** *Tlocrtni prikaz modela*



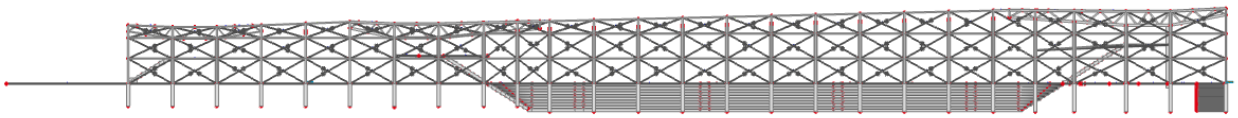
***Slika 2.4.*** *Prikaz istočnog pročelja*



***Slika 2.5.*** *Prikaz južnog pročelja*



***Slika 2.6.*** *Prikaz zapadnog pročelja*



***Slika 2.7.*** *Prikaz sjevernog pročelja*

# 3. ANALIZA OPTEREĆENJA

## 3.1. Stalno opterećenje

Stalno opterećenje uključeno je kroz numerički model.

## 3.2. Dodatno stalno opterećenje

pozicija 300 - krov

- sendvič paneli (aluminij) 0,25 kN/m$^2$
- instalacije 0,20 kN/m$^2$

Ukupno dodatno stalno opterećenje: $g_{300}$=0,45 kN/m$^2$

a) pozicija 200

- završna obrada poda 0,24 kN/m$^2$
- AB estrih 1,25 kN/m$^2$
- hidroizolacija 0,10 kN/m$^2$

Ukupno dodatno stalno opterećenje: $g_{200}$=1,59 kN/m$^2$

b) pozicija 100

- završna obrada poda 0,24 kN/m$^2$
- AB estrih 1,25 kN/m$^2$
- hidroizolacija 0,10 kN/m$^2$

Ukupno dodatno stalno opterećenje: $g_{100}$=1,59 kN/m$^2$

c) stubište

- završna obrada gazišta – kamena ploča 0,56 kN/m$^2$
- cementni namaz 0,20 kN/m$^2$

Ukupno dodatno stalno opterećenje: $g_{stubište}$=0,76 kN/m$^2$

d) tribine

- završna obrada poda 0,24 kN/m$^2$
- cementni namaz 0,20 kN/m$^2$
- oprema 0,20 kN/m$^2$

Ukupno dodatno stalno opterećenje: $g_{tribine}$=0,64 kN/m$^2$

## 3.3. Promjenjivo (pokretno) opterećenje

a) pozicija 300 – krov

Za pokretno opterećenje na krovu uzima se opterećenje snijegom i vjetrom koje je obrađeno u zasebnim stavkama.

b) Pozicija 200,100 i tribine

| Kategorija | Prostor | EC1 $q_k$ (kN/m$^2$) | $Q_k$ (kN) |
|---|---|---|---|
| A | - sobe | 2.0 | 2.0 |
| | - stubišta | 3.0 | 2.0 |
| | - balkoni | 4.0 | 2.0 |
| B | - uredski prostori | 3.0 | 2.0 |
| C | $C_1$ – prostorije sa stolovima u školama, kavanama, restoranima, blagovaonicama, knjižnicama, recepcijama | 3.0 | 4.0 |
| | $C_2$ – prostorije s nepomičnim stolcima u crkvama, kazalištima ili kinima, sobe za sastanke, dvorane za predavanja, čekaonice | 4.0 | 4.0 |
| | $C_3$ – prostorije bez prepreka za kretanje ljudi u muzejima, izložbenim prostorima, pristupi u javnim i administrativnim zgradama, hotelima i sl. | 5.0 | 4.0 |
| | $C_4$ – športske prostorije i prostori za igru npr. plesne dvorane, gimnastičke dvorane, pozornice i sl. | 5.0 | 7.0 |
| | $C_5$ – prostorije za velika okupljanja ljudi, zgrade za javne priredbe, koncertne dvorane, športske dvorane s gledalištem, terase. | 5.0 | 4.0 |
| D | $D_1$ – prostorije u trgovinama | 5.0 | 4.0 |
| | $D_2$ – prostorije u robnim kućama i trgovinama na veliko, papirnicama | 5.0 | 7.0 |
| E | E - skladišta uključujući knjižnice | 6.0 | 7.0 |

***Slika 3.1.*** *Vrijednosti korisnog djelovanja u zgradama*

- stubišta – 3.0 kN/m$^2$
- uredski prostori – 3.0 kN/m$^2$

- prostori sa stolovima u školama, kavanama, restoranima, blagovaonicama, knjižnicama, recepcijama – 3.0 kN/m$^2$

- prostorije za velika okupljanja ljudi, zgrade za javne priredbe, koncertne dvorane, športske dvorane s gledalištem, terase – 5.0 kN/m$^2$

## 3.4. Opterećenje snijegom

Opterećenje snijegom na krovu

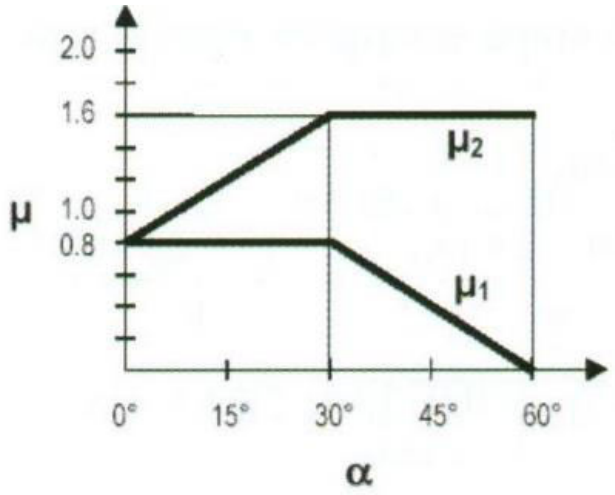
$s = \mu_1 \cdot C_e \cdot C_t \cdot s_k$

$\mu_1$ - koeficijent oblika opterećenja snijegom

$C_e$ - koeficijent izloženosti (obično se usvaja vrijednost 1,0)

$C_t$ - toplinski koeficijent (obično se usvaja vrijednost 1,0)

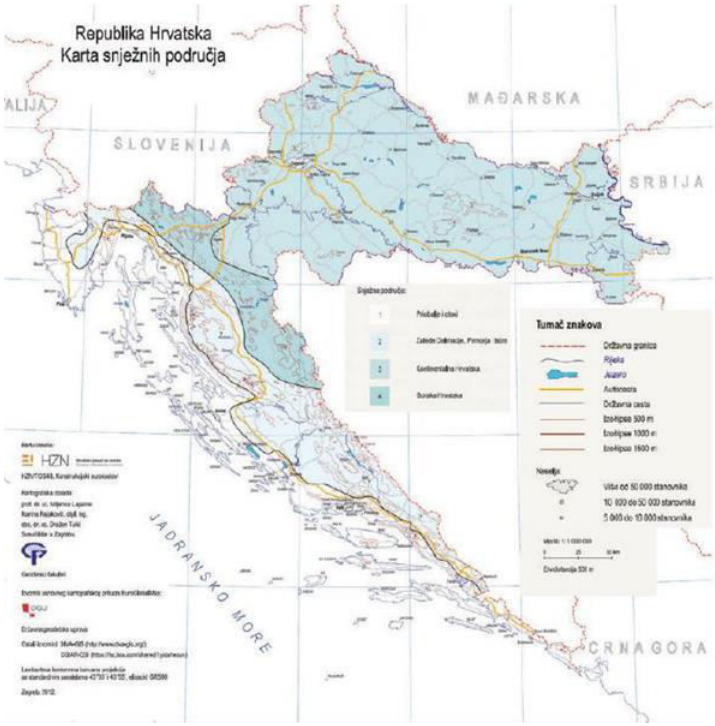
$s_k$ - karakteristična vrijednost opterećenja snijegom na tlu




***Slika 3.2.*** *Koeficijenti oblika opterećenja snijegom*

- za krov nagiba $\alpha \leq 2{,}8°$ očitana je vrijednost $\mu_1 = 0{,}8$

Prema karti snijega za Republiku Hrvatsku ova građevina spada u 1. područje – priobalje i otoci, te je prema nadmorskoj visini očitana vrijednost $s_k$ (karakteristična vrijednost opterećenja snijegom na tlu) $\Rightarrow s_k = 0{,}5$ kN/m$^2$




***Slika 3.3.*** *Karta snijega za Republiku Hrvatsku*

| Nadmorska visina do [m] | 1. područje – priobalje i otoci [kN/m$^2$] | 2. područje – zaleđe Dalmacije, Primorja i Istre [kN/m$^2$] | 3. područje – kontinentalna Hrvatska [kN/m$^2$] | 4. područje – gorska Hrvatska [kN/m$^2$] |
|---|---|---|---|---|
| 100 | 0,50 | 0,75 | 1,00 | 1,25 |
| 200 | 0,50 | 0,75 | 1,25 | 1,50 |
| 300 | 0,50 | 0,75 | 1,50 | 1,75 |
| 400 | 0,50 | 1,00 | 1,75 | 2,00 |
| 500 | 0,50 | 1,25 | 2,00 | 2,50 |
| 600 | 0,50 | 1,50 | 2,25 | 3,00 |
| 700 | 0,50 | 2,00 | 2,50 | 3,50 |
| 800 | 0,50 | 2,50 | 2,75 | 4,00 |
| 900 | 1,00 | 3,00 | 3,00 | 4,50 |
| 1 000 | 2,00 | 4,00 | 3,50 | 5,00 |
| 1 100 | 3,00 | 5,00 | 4,00 | 5,50 |
| 1 200 | 4,00 | 6,00 | 4,50 | 6,00 |
| 1 300 | 5,00 | 7,00 | | 7,00 |
| 1 400 | 6,00 | 8,00 | | 8,00 |
| 1 500 | | 9,00 | | 9,00 |
| 1 600 | | 10,00 | | 10,00 |
| 1 700 | | 11,00 | | 11,00 |
| 1 800 | | 12,00 | | |

***Tablica 3.1.*** *Karakteristične vrijednosti opterećenja snijegom za pojedina područja i nadmorske visine*

$$s = \mu_1 \cdot C_e \cdot C_t \cdot s_k$$

$\mu_1$ - koeficijent oblika$\Rightarrow \mu_1 = 0{,}8$

$C_e$ - koeficijent izloženosti $\Rightarrow C_e = 1{,}0$

$C_t$ - toplinski koeficijent $\Rightarrow C_t = 1{,}0$

$s_k$ - karakteristična vrijednost opterećenja snijegom na tlu

$$s = 0{,}8 \cdot 1{,}0 \cdot 1{,}0 \cdot 0{,}5 = 0{,}4 \; kN / m^2$$

## 3.5. Opterećenje vjetrom

Osnovni pritisak vjetra računa se prema izrazu:

$$q_b = \frac{1}{2} \cdot \rho \cdot v_b^2 \left[ kN / m^2 \right]$$

gdje je:

$q_b$ - osnovni pritisak vjetra

$v_b$ – osnovna brzina vjetra

$\rho$ – gustoća zraka ($\rho$=1,25 kg/m$^3$)

Osnovna brzina vjetra $v_b$ dana je izrazom:

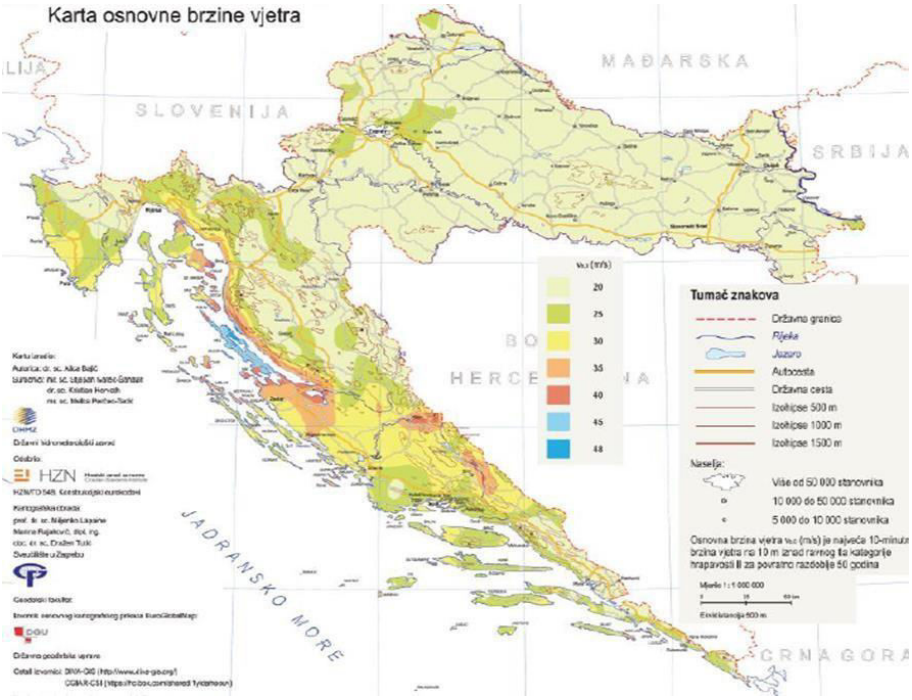
$$v_b = c_{dir} \cdot c_{season} \cdot v_{b0}$$

gdje je:

$v_{b0}$ – fundamentalna vrijednost osnovne brzine vjetra; očitava se iz karte

$c_{dir}$ – koeficijent smjera vjetra (obično se uzima vrijednost 1,0)

$c_{season}$ – koeficijent ovisan o godišnjem dobu (obično se uzima vrijednost 1,0)




***Slika 3.4.*** *Karta osnovnih brzina vjetra za Republiku Hrvatsku*

Osnovni pritisak vjetra:

$v_b$ = 30,0 (m/s) – očitano za područje Zadra

$c_{dir} = c_{season} = 1,0$

$$v_b = c_{dir} \cdot c_{season} \cdot v_{b0}$$

$$v_b = 1,0 \cdot 1,0 \cdot 30$$

$$v_b = 30 \left[ m/s \right]$$

$$q_b = \frac{1}{2} \cdot \rho \cdot v_b^2 \left[ kN/m^2 \right]$$

$$q_b = \frac{1}{2} \cdot 1,25 \cdot 30^2$$

$$q_b = 562,5 \left[ N/m^2 \right] = 0,5625 \left[ kN/m^2 \right]$$

Nakon dobivenih vrijednosti $v_b$ i $v_{b0}$, definira se srednja brzina vjetra $v_m(z)$ iznad terena:

$$v_m(z) = v_b \cdot c_r(z) \cdot c_0(z) \left[ m/s \right]$$

gdje je:

$c_r(z)$ – faktor hrapavosti terena

$c_0(z)$ – faktor orografije ili opisivanje brežuljaka ili gora (obično se uzima 1,0)

Faktor hrapavosti $c_r(z)$ određuje se prema:

$$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right) \text{ za } z_{min} \leq z \leq z_{max}$$

$$c_r(z) = c_r(z_{min}) \text{ za } z \leq z_{min}$$

gdje je:

$z_0$ – duljina hrapavosti

$k_r$ – faktor terena ovisan o duljini hrapavosti

$z_{min}$ – minimalna visina hrapavosti

$z_{max}$ – maksimalna visina hrapavosti (usvaja se vrijednost 200m)

Faktor terena $k_r$ se određuje prema izrazu:

$$k_r = 0{,}19 \cdot \left(\frac{z_0}{z_{0,II}}\right)^{0{,}07}$$

gdje je:

$z_0$ – duljina hrapavosti

$k_r$ – faktor terena ovisan o duljini hrapavosti

$z_{0,II}$ – duljina hrapavosti za kategoriju terena II – (prema tablici iznosi 0,05)

Vrijednosti $z_0$ i $z_{min}$ za pojedinu kategoriju terena očitavaju se iz sljedeće tablice:

| Kategorija terena | | $z_0$ [m] | $z_{min}$ [m] |
|---|---|---|---|
| 0 | More ili priobalna područja izložena otvorenom moru | 0,003 | 1 |
| I | Jezera ili ravna i horizontalno položena područja sa zanemarivom vegetacijom i bez prepreka | 0,01 | 1 |
| II | Područja s niskom vegetacijom, npr. travom, i izoliranim preprekama (drveće, zgrade) s razmakom najmanje 20 visina prepreke | 0,05 | 2 |
| III | Područja sa stalnim pokrovom od vegetacije ili zgrade ili područja s izoliranim preprekama s razmakom najviše 20 visina prepreke (npr. sela, predgrađa, stalna šuma) | 0,3 | 5 |
| IV | Područja s najmanje 15 % površine pokrivene zgradama čija prosječna visina premašuje 15 m | 1,0 | 10 |

***Tablica 3.2**. Vrijednosti $z_0$ i $z_{min}$ za različite kategorije terena*

$$k_r = 0,19 \cdot \left( \frac{z_0}{z_{0,II}} \right)^{0,07}$$

$$k_r = 0,19 \cdot \left( \frac{0,003}{0,05} \right)^{0,07} = 0,156$$

$$c_r(z) = k_r \cdot \ln\left( \frac{z}{z_0} \right) \text{ za } z_{min} \leq z \leq z_{max}$$

$$c_r(z) = 0,156 \cdot \ln\left( \frac{18,50}{0,003} \right)$$

$$c_r(z) = 1,361$$

$$c_0(z) = 1,0$$

$$v_m(z) = v_b \cdot c_r(z) \cdot c_0(z) \left[ m/s \right]$$

$$v_m(18,5) = 30 \cdot 1,361 \cdot 1,0 = 40,83 \left[ m/s \right]$$

Intenzitet turbulencije $I_v(z)$ računa se prema izrazu:

$$I_{v(z)} = \frac{k_I}{c_{o(z)} \cdot \ln\left( \frac{z}{z_0} \right)}$$

gdje je:

$k_I$ – faktor turbulencije (obično se uzima vrijednost 1,0, ukoliko nije drugačije definirano Nacionalnim dodatkom)

$$I_{v(z)} = \frac{1,0}{1,0 \cdot \ln\left( \frac{18,50}{0,003} \right)}$$

$$I_{v(z)} = 0,115$$

Pritisak brzine vjetra pri udaru $q_p(z)$ se računa prema sljedećem izrazu:

$$q_{p(z)} = c_e(z) \cdot q_b = \left[ 1 + 7I_v(z) \right] \cdot \frac{1}{2} \cdot \rho \cdot {v_m}^2(z)$$

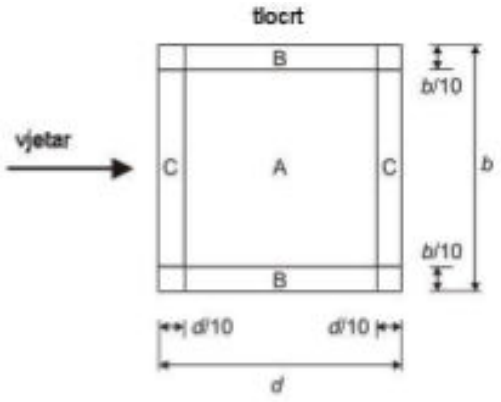
gdje je:

$c_e(z)$ – faktor izloženosti i odnosi se na pritisak te ovisi o visini iznad terena z i kategoriji terena

$$q_{p(z)} = \left[1 + 7 \cdot 0{,}115\right] \cdot \frac{1}{2} \cdot 1{,}25 \cdot 40{,}83^2 \cdot 10^{-3}$$

$$q_{p(18{,}5)} = 1{,}88\left[kN/m^2\right]$$

Proračun koeficijenta pritiska za jednostrešnu nadstrešnicu:




***Slika 3.5.*** *Zone djelovanja vjetra*

| Nagib krova $\alpha$ | Zapriječenost $\varphi$ | Koeficijenti sveukupne sile $c_f$ | Područje A | Područje B | Područje C |
|---|---|---|---|---|---|
| 0° | Najveća vrijednost, svi $\varphi$ | + 0,2 | + 0,5 | + 1,8 | + 1,1 |
| | Najmanja vrijednost, $\varphi$=0 | – 0,5 | – 0,6 | – 1,3 | – 1,4 |
| | Najmanja vrijednost, $\varphi$ = 1 | – 1,3 | – 1,5 | – 1,8 | – 2,2 |

***Tablica 3.3****. Vrijednosti koeficijenata pritiska vjetra*

*Napomena: uzete su maksimalne vrijednosti koeficijenata pritiska vjetra*

**Rezultirajuće djelovanje tlaka po zonama:**

$$w_e = q_p \cdot c_{p,net} \left[ kN / m^2 \right]$$

| PODRUČJE | $q_p$(kN/m$^2$) | $c_{p,net}$ | $w_e$(kN/m$^2$) |
|---|---|---|---|
| A | 1,88 | -1.5 | -2.82 |
| B | 1,88 | -1.8 | -3.38 |
| C | 1,88 | -2.2 | -4.14 |

***Tablica 3.4.*** *Rezultirajuće djelovanje tlaka po zonama*

**Rezultirajuće djelovanje podtlaka po zonama:**

$$w_i = q_p \cdot c_{p,net} \left[ kN / m^2 \right]$$

| PODRUČJE | $q_p$(kN/m$^2$) | $c_{p,net}$ | $w_i$(kN/m$^2$) |
|---|---|---|---|
| A | 1,88 | +0,5 | +0.94 |
| B | 1,88 | +1.8 | +3.38 |
| C | 1,88 | +1,1 | +2.07 |

***Tablica 3.5.*** *Rezultirajuće djelovanje podtlaka po zonama*

**Trenje po krovu od djelovanja vjetra**

Sila trenja od djelovanja vjetra računa se prema formuli:

$$F_{fr} = c_{fr} \cdot q_p(z) \cdot A_{fr}$$

gdje je:

$c_{fr}$ - koeficijent trenja (određuje se prema tablici 2.6.)

$q_p(z)$ – pritisak brzine vjetra pri udaru

$A_{fr}$ - površina usporedno sa smjerom vjetra

$A_{fr}$ = 18676,86 $m^2$

| Površina | Koeficijent trenja $c_{fr}$ |
|---|---|
| Glatka<br>(npr. čelik, glatki beton) | 0,01 |
| Gruba<br>(npr. grubi beton, katranske ploče) | 0,02 |
| Vrlo gruba<br>(npr. valovite, rebraste i naborane površine) | 0,04 |

***Tablica 3.6.*** *Koeficijent trenja $c_{fr}$ za zidove, parapete i krovne površine*

$$F_{fr} = 0,04 \cdot 1,88 \cdot 18676,86$$

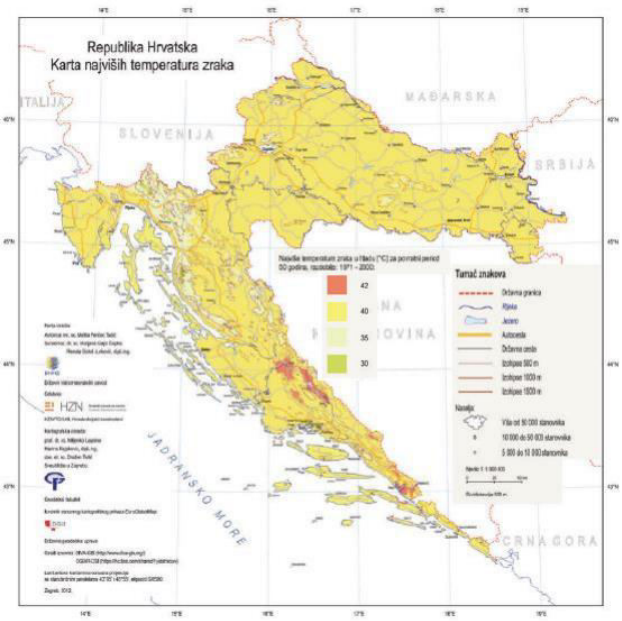
$$F_{fr} = 1404,5kN$$

$$f_{tr} = \frac{F_{fr}}{A_{krova}}\left(kN/m^2\right)$$

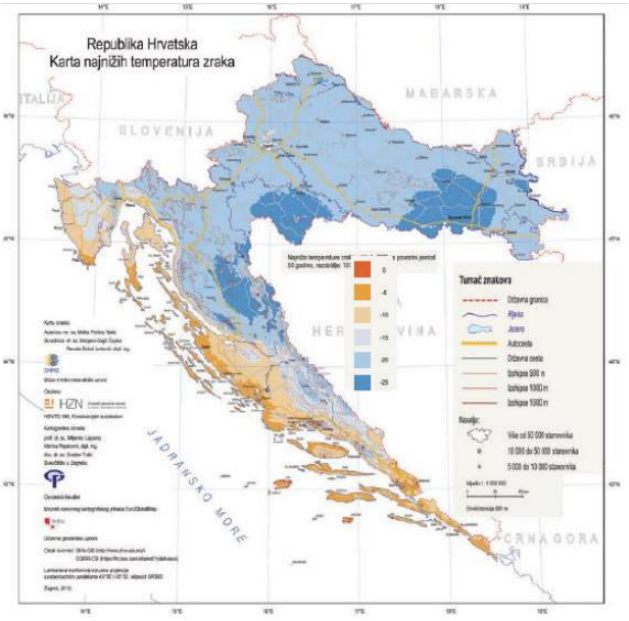
$$f_{tr} = \frac{1404,50}{18676,86}$$

$$f_{tr} = 0,0752\left(kN/m^2\right)$$

## 3.6. Djelovanje temeprature




***Slika 3.6*** *Karta najviših temperatura zraka u RH*




***Slika 3.7*** *Karta najnižih temperatura zraka u RH*

Za područje Zadra očitane su vrijednosti:

Najviše temperature zraka: $T_{max}$ = 40 °C

Najniže temperature zraka: $T_{min}$ = -5 °C

Pretpostavlja se djelovanje jednolike temperaturne promjene u svim presjecima.

Pretpostavljena temperatura pri montaži konstrukcije: T = 15 °C

Maksimalna pozitivna temperaturna promjena: $T_{max}$ = 40 °C-15 °C = 25 °C

Maksimalna negativna temperaturna promjena: $T_{min}$ = -5 °C-15 °C = -20 °C

## 3.7. Potres

Potresne sile proračunate su postupkom spektralne analize prema EC-8. Građevina je smještena u VIII potresnoj zoni prema važećoj seizmičkoj karti. Računsko projektno ubrzanje tla je a = 0.20 g.

Građevina je temeljena na nanosima vrlo zbijenog pijeska,šljunka ili vrlo krute gline debljine najmanje nekoliko desetaka metara, sa svojstvom postupnoga povećanja mehaničkih svojstava s dubina, što odgovara klasi tla B.

Proračun je izvršen za faktor ponašanja q=3

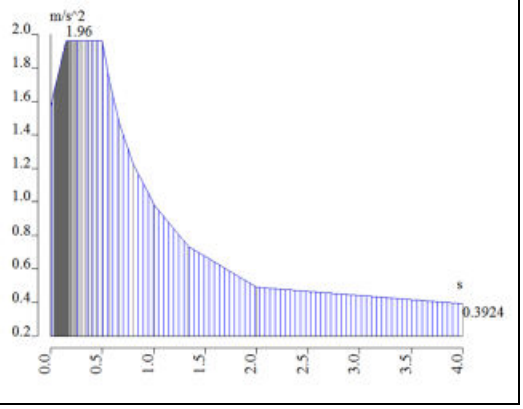
Koeficijenti za proračun ordinata spektra odgovora

Faktor važnosti ψ=1.2 ( građevine čija je potresna otpornost važna sa stajališta posljedica vezanih za rušenje, npr.škole, dvorane za skupove, kulturne institucije)

Faktor ponašanja q=3.0

Tlo klase "A": S=1.2, $T_B$=0.15 s, $T_C$=0.5 s, $T_D$=2.0 s

Računsko ubrzanje tla a = 0.20 g (VIII seizmička zona)

| Naziv | Način crtanja spektra | Informacija o seizmičkom djelovanju | Grafički prikaz |
|---|---|---|---|
| Projektni spektar za proračun seizmičkog djelovanja (za smjer x i y) | Uz pomoć perioda | Tip propisa – Eurocode 8<br>Tip tla - B<br>Djelovanje - Horizontalno<br>Tip spektra - tip 1<br>Koeficijent akceleracije. ag - 0,2<br>ag proračunska akceleracija – 1,961<br>beta - 0,2<br>q – faktor ponašanja – 3.0 (za smjer x i y) |  |

***Tablica 3.7.*** *Prikaz osnovnih informacija o proračunskom spektru*

-$S_x$-potresno opterećenje u smjeru x (zadan spektar odgovora za smjer x + 30% spektra odgovora za smjer y)

-$S_y$-potresno opterećenje u smjeru y (zadan spektar odgovora za smjer y + 30% spektra odgovora za smjer x)

Nakon provedene modalne analize vidljivo je da potres neće imati značajan utjecaj na konstrukciju.

# 4. KOMBINACIJE DJELOVANJA

## 4.1. Granično stanje nosivosti

(1) $1,35 \cdot (g + \Delta g) + 1,5 \cdot s$

(2) $1,35 \cdot (g + \Delta g) + 1,5 \cdot w_{pritisak}$

(3) $1,35 \cdot (g + \Delta g) + 1,80 \cdot q$

(4) $1,35 \cdot (g + \Delta g) + 0,9 \cdot (1,50s + 1,5w_{pritisak} + 1,8q)$

(5) $1,35 \cdot (g + \Delta g) + 0,9 \cdot (1,50s + 1,5w_{pritisak} + 1,8q + 1,5w_{trenje})$

(6) $1,35 \cdot (g + \Delta g) + 1,5w_{trenje}$

(7) $1,35 \cdot (g + \Delta g) + 0,9 \cdot (1,5w_{pritisak} + 1,8q + 1,5w_{trenje} + 1,5T_{\max})$

(8) $1,35 \cdot (g + \Delta g) + 0,9 \cdot (1,5s + 1,5w_{pritisak} + 1,8q + 1,5w_{trenje} + 1,5T_{\min})$

(9) $1,0 \cdot (g + \Delta g) + 1,5w_{odizanje}$

(10) $1,0 \cdot (g + \Delta g) + 1,5 \cdot 0,9(w_{odizanje} + T_{\min})$

(11) $1,0 \cdot (g + \Delta g) + 1,5 \cdot 0,9(w_{odizanje} + T_{\min} + w_{trenje})$

(12) $1,0 \cdot (g + \Delta g) + 0,5 \cdot q + 1,0 \cdot S_x$

(13) $1,0 \cdot (g + \Delta g) + 0,5 \cdot q + 1,0 \cdot S_y$

## 4.2. Granično stanje uporabivosti

Kombinacije za GSU su iste kao za GSN, s tim da su primjenjeni adekvatni koeficijenti za kombinacije djelovanja prema EN 1991.

- Parcijalni faktor za promjenjivo (pokretno) opterećenje – 1,5 × 1,2 =1,8 (nije vršena kombinacija opterećenja, tj. postavljanje pokretnog opterećenja u najkritičnije položaje, već je pokretno opterećenje uvećano za 20%)

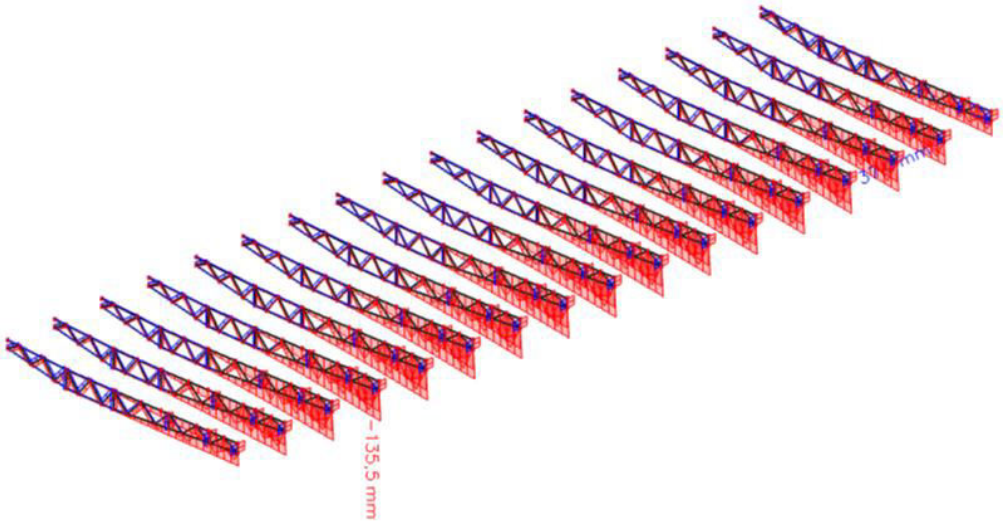
- Parcijalni faktor za djelovanje više promjenjivih opterećenja je – 0,9 × 1,5 = 1,35

# 5. DIMENZIONIRANJE ELEMENATA KONSTRUKCIJE

## 5.1. Pomaci konstrukcije

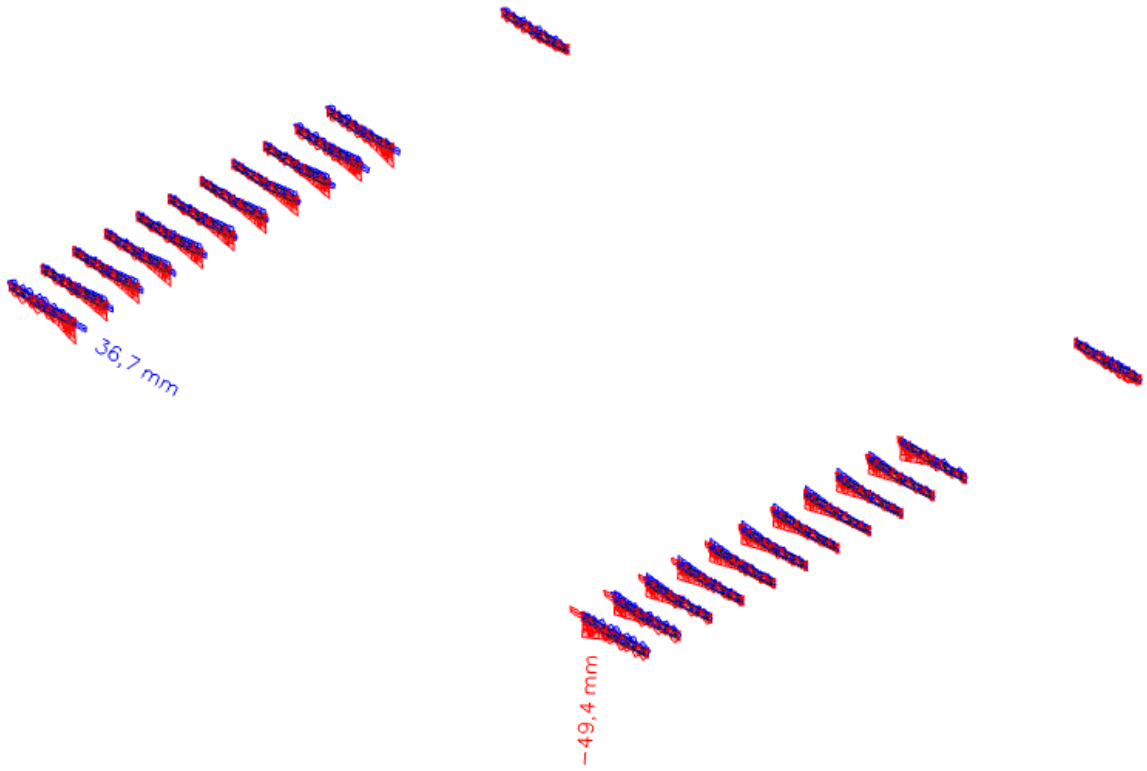
Vertikalni progib krovne rešetkaste konstrukcije:

- rešetka R1



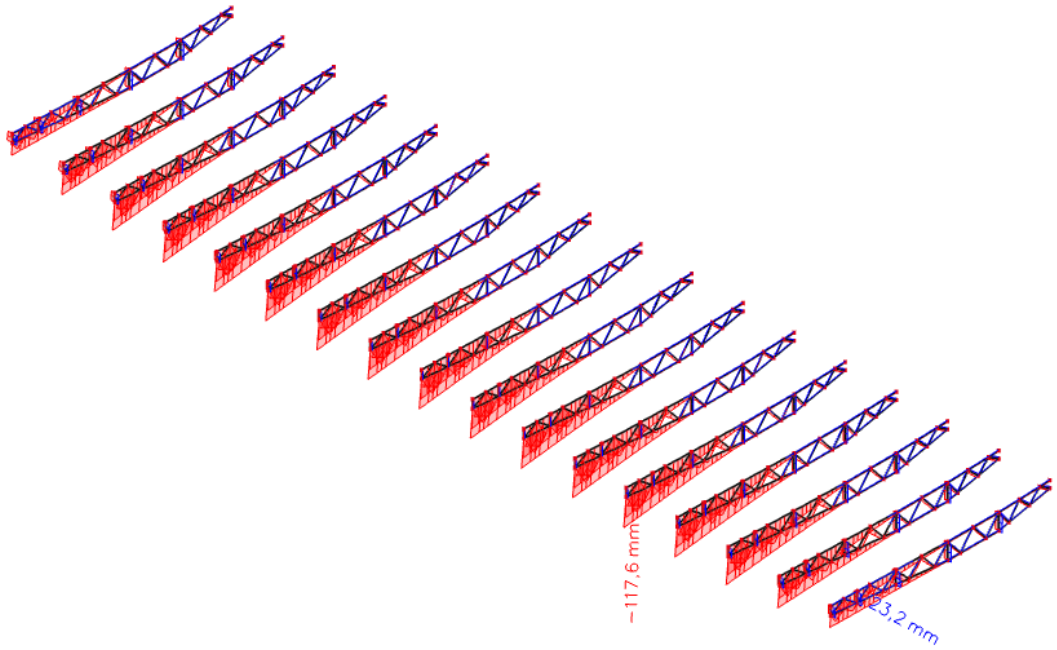

***Slika 5.1.*** *Vertikalni progib rešetke R1*

-rešetka R2



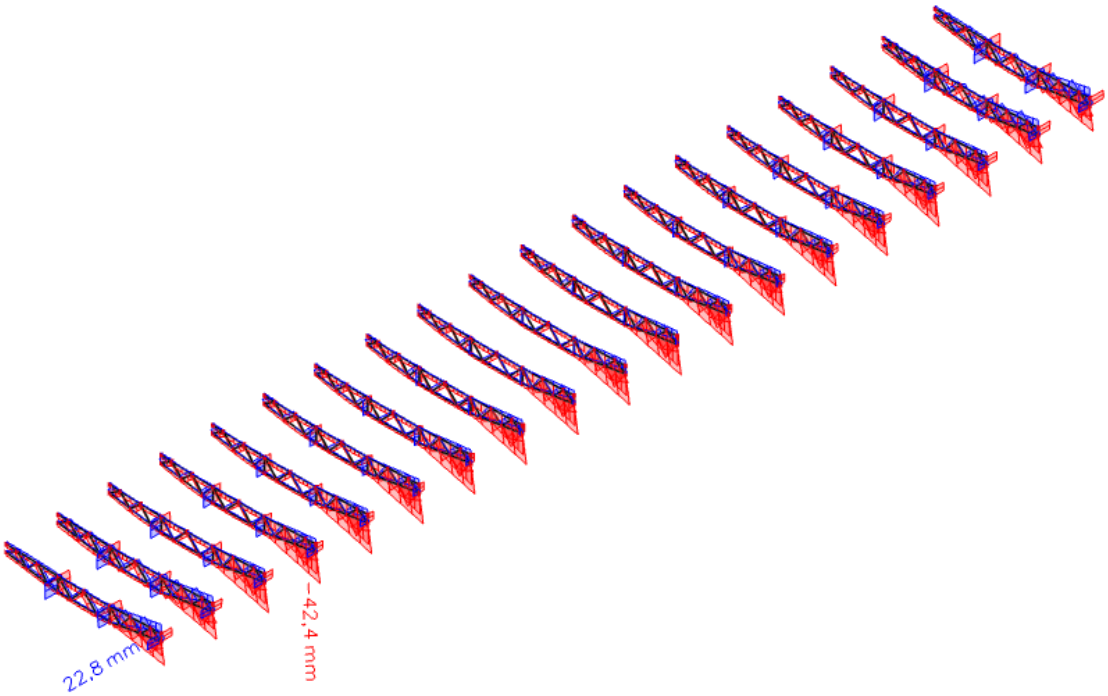
***Slika 5.2.*** *Vertikalni progib rešetke R2*

-rešetka R3




***Slika 5.3.*** *Vertikalni progib rešetke R3*

- rešetka R4




***Slika 5.4.*** *Vertikalni progib rešetke R4*

- rešetka R1:

Dopušteni vertikalni pomak:

$$u_{z,dop} = \frac{\mathrm{l}}{150} = \frac{21{,}061 \cdot 1000}{150} = 140{,}41\ mm$$

$u_z = 135{,}5\ \mathrm{mm} < u_{z,dop} = 140{,}41\ mm$; zadovoljava

- rešetka R2:

Dopušteni vertikalni pomak:

$$u_{z,dop} = \frac{\mathrm{l}}{150} = \frac{8{,}0 \cdot 1000}{150} = 53{,}33\ mm$$

$u_z = 49{,}4\ \mathrm{mm} < u_{z,dop} = 53{,}33\ mm$; zadovoljava

- rešetka R3:

Dopušteni vertikalni pomak:

$$u_{z,dop} = \frac{\mathrm{l}}{150} = \frac{18{,}276 \cdot 1000}{150} = 121{,}84\ mm$$

$u_z = 117{,}6\ \mathrm{mm} < u_{z,dop} = 121{,}84\ mm$; zadovoljava

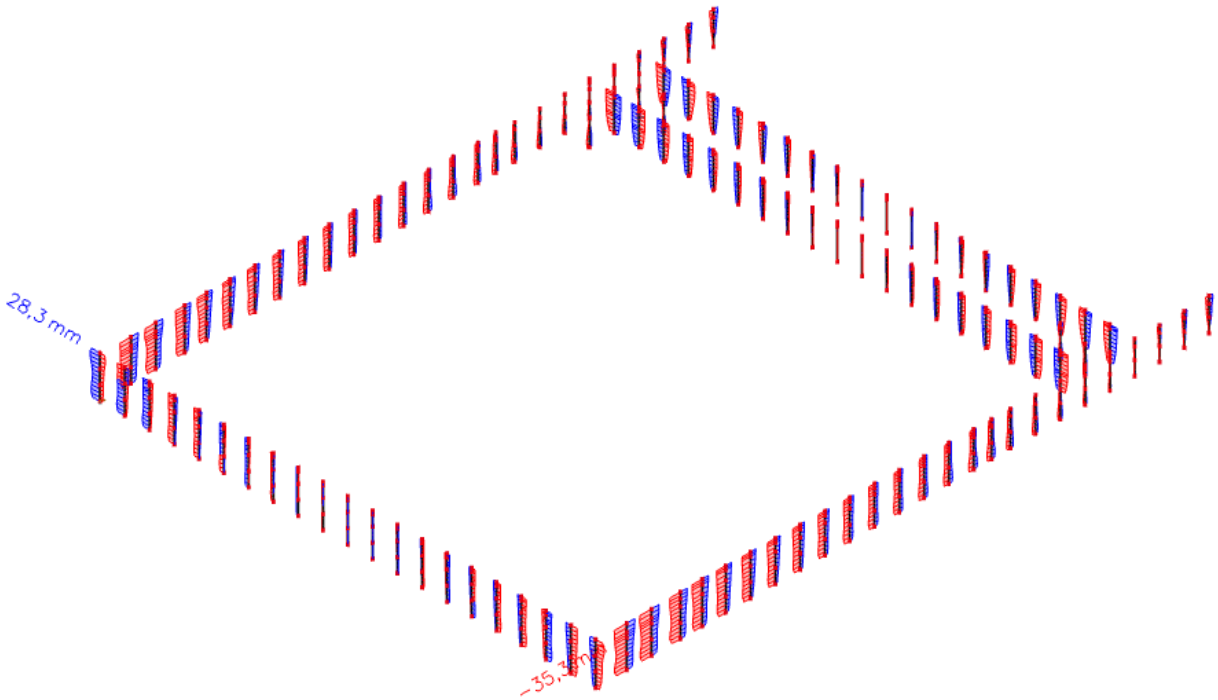
- rešetka R4:

Dopušteni vertikalni pomak:

$$u_{z,dop} = \frac{\mathrm{l}}{150} = \frac{8{,}006 \cdot 1000}{150} = 53{,}37\ mm$$

$u_z = 42{,}4\ \mathrm{mm} < u_{z,dop} = 53{,}37\ mm$; zadovoljava

Horizontalni pomak stupova:




***Slika 5.5.*** *Horizontalni pomaci stupova*

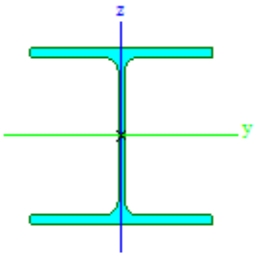
Dopušteni horizontalni pomak pomak:

$$u_{y,dop} = \frac{l}{150} = \frac{13{,}5 \cdot 1000}{150} = 90{,}0\ mm$$

$u_y = 35{,}3\ \text{mm} < u_{y,dop} = 90{,}0\ mm$; zadovoljava

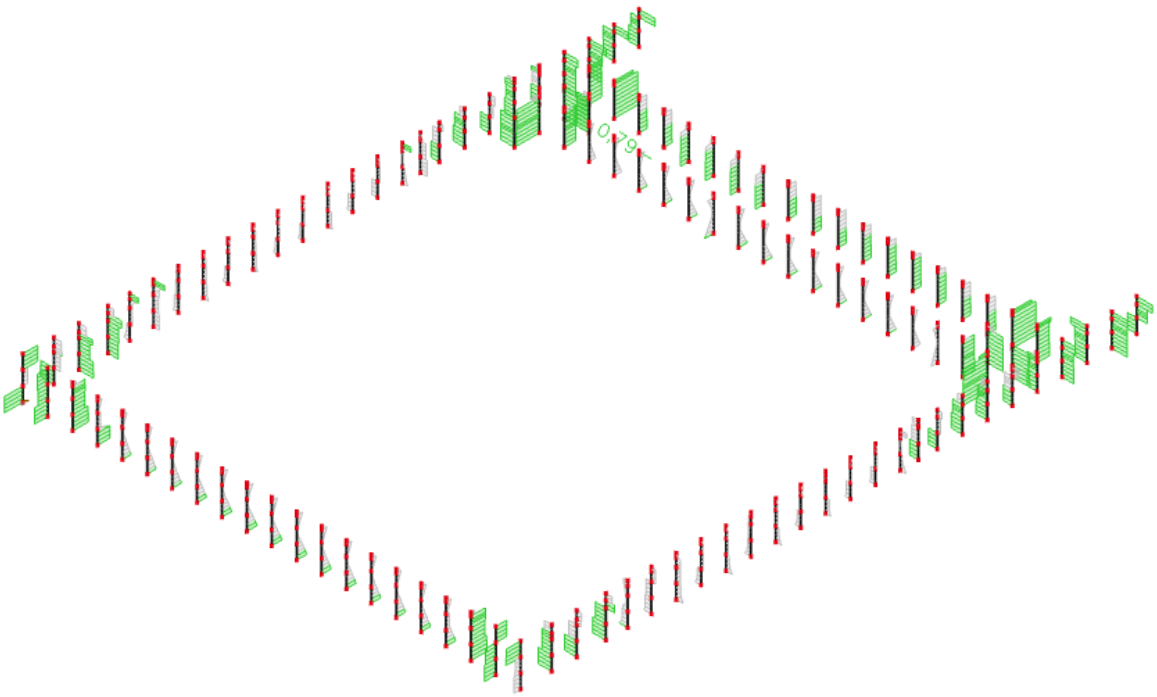
## 5.2. Dimenzioniranje stupa pozicije S1

| | |
|---|---|
| Name | S1 |
| Type | HEA280 |
| Source description | Profil Arbed / Structural shapes / Edition Octobre 1995 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | b |
| Flexural buckling z-z | c |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 9,7300e-03 | |
| A y, z [m²] | 7,0049e-03 | 2,3104e-03 |
| I y, z [m⁴] | 1,3700e-04 | 4,7600e-05 |
| I w [m⁶], t [m⁴] | 7,8537e-07 | 6,2100e-07 |
| $W_{el}$ y, z [m³] | 1,0100e-03 | 3,4000e-04 |
| $W_{pl}$ y, z [m³] | 1,1125e-03 | 5,1667e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 140 | 135 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,6000e+00 | 1,6026e+00 |
| $M_{ply}$ +, - [Nm] | 3,95e+05 | 3,95e+05 |
| $M_{plz}$ +, - [Nm] | 1,84e+05 | 1,84e+05 |

***Tablica 5.1.*** *Karakteristike poprečnog presjeka stupa pozicije S1*




***Slika 5.6.*** *Prikaz iskoristivosti stupa pozicije S1*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = S1 - HEA280

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp11975 | 9,000 / 9,000 m | HEA280 | S 355 | GSN | 0,79 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 9,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -484,74 | kN |
| $V_{y,Ed}$ | -2,76 | kN |
| $V_{z,Ed}$ | 0,31 | kN |
| $T_{Ed}$ | 0,00 | kNm |
| $M_{y,Ed}$ | -6,28 | kNm |
| $M_{z,Ed}$ | -13,92 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SO | 112 | 13 | 6,391e+04 | 9,666e+04 | 0,66 | 0,46 | 1,00 | 8,62 | 7,32 | 8,14 | 11,61 | 3 |
| 3 | SO | 112 | 13 | 4,754e+04 | 1,480e+04 | 0,31 | 0,89 | 1,00 | 8,62 | 7,32 | 8,14 | 16,10 | 3 |
| 4 | I | 196 | 8 | 5,433e+04 | 4,533e+04 | 0,83 | | 1,00 | 24,50 | 22,78 | 27,66 | 32,80 | 2 |
| 5 | SO | 112 | 13 | 3,574e+04 | 2,995e+03 | 0,08 | 1,36 | 1,00 | 8,62 | 7,32 | 8,14 | 19,95 | 3 |
| 7 | SO | 112 | 13 | 5,211e+04 | 8,485e+04 | 0,61 | 0,47 | 1,00 | 8,62 | 7,32 | 8,14 | 11,68 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient ε | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 8,14 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 11,39 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Flange class 2 slenderness limit $\beta_{2,z,f}$ | 8,14 | |
| Flange class 3 slenderness limit $\beta_{3,z,f}$ | 13,02 | |
| Web slenderness ratio $c/t_w$ | 24,50 | |
| Flange slenderness ratio $c/t_f$ | 8,62 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 0,15 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 0,10 | |
| Interpolated section modulus $W_{3,y}$ | 1,0974e-03 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 4,9932e-04 | $m^3$ |

**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 9,7300e-03 | $m^2$ |
| $N_{c,Rd}$ | 3454,15 | kN |
| Unity check | 0,14 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

Student version

| | | |
|---|---|---|
| $W_{3,y}$ | 1,0974e-03 | $m^3$ |
| $M_{3,y,Rd}$ | 389,58 | kNm |
| Unity check | 0,02 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,z}$ | 4,9932e-04 | $m^3$ |
| $M_{3,z,Rd}$ | 177,26 | kNm |
| Unity check | 0,08 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 7,5360e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 1544,57 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,1780e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 651,36 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 2 | |
| $\tau_{Ed}$ | 0,0 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,3,y,Rd}$ | 334,91 | kNm |
| α | 2,00 | |
| $M_{N,3,z,Rd}$ | 173,77 | kNm |
| β | 1,00 | |

Unity check (6.41) = 0,00 + 0,08 = 0,08 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 9,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SO | 112 | 13 | 6,391e+04 | 9,666e+04 | 0,66 | 0,46 | 1,00 | 8,62 | 7,32 | 8,14 | 11,61 | 3 |
| 3 | SO | 112 | 13 | 4,754e+04 | 1,480e+04 | 0,31 | 0,89 | 1,00 | 8,62 | 7,32 | 8,14 | 16,10 | 3 |
| 4 | I | 196 | 8 | 5,433e+04 | 4,533e+04 | 0,83 | | 1,00 | 24,50 | 22,78 | 27,66 | 32,80 | 2 |
| 5 | SO | 112 | 13 | 3,574e+04 | 2,995e+03 | 0,08 | 1,36 | 1,00 | 8,62 | 7,32 | 8,14 | 19,95 | 3 |
| 7 | SO | 112 | 13 | 5,211e+04 | 8,485e+04 | 0,61 | 0,47 | 1,00 | 8,62 | 7,32 | 8,14 | 11,68 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 9,000 | 10,800 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 9,000 | 10,800 | m |
| Critical Euler load $N_{cr}$ | 3505,65 | 845,84 | kN |
| Slenderness λ | 75,85 | 154,41 | |
| Relative slenderness $\lambda_{rel}$ | 0,99 | 2,02 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | b | c | |
| Imperfection α | 0,34 | 0,49 | |
| Reduction factor χ | 0,60 | 0,19 | |

Student version

| Interaction method 1 parameters | | |
|---|---|---|
| Maximum relative deflection $\delta_y$ | -3,3 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,54 | |
| Factor $\mu_y$ | 0,94 | |
| Factor $\mu_z$ | 0,48 | |
| Factor $\varepsilon_y$ | 0,12 | |
| Factor $a_{LT}$ | 1,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 232,87 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 1,29 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,17 | |
| Equivalent moment factor $C_{my}$ | 0,97 | |
| Equivalent moment factor $C_{mz}$ | 0,54 | |
| Equivalent moment factor $C_{mLT}$ | 1,53 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,01 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,09 | |
| Factor $w_z$ | 1,47 | |
| Factor $n_{pl}$ | 0,14 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 2,02 | |
| Factor $C_{yy}$ | 0,92 | |
| Factor $C_{yz}$ | 0,96 | |
| Factor $C_{zy}$ | 0,60 | |
| Factor $C_{zz}$ | 1,00 | |

Unity check (6.61) = 0,23 + 0,03 + 0,07 = 0,33 -
Unity check (6.62) = 0,73 + 0,01 + 0,05 = 0,79 -

**Shear Buckling check**
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

| Shear Buckling parameters | | |
|---|---|---|
| Buckling field length a | 9,000 | m |
| Web | unstiffened | |
| Web height $h_w$ | 244 | mm |
| Web thickness t | 8 | mm |
| Material coefficient ε | 0,81 | |
| Shear correction factor η | 1,20 | |

| Shear Buckling verification | |
|---|---|
| Web slenderness $h_w/t$ | 30,50 |
| Web slenderness limit | 48,82 |

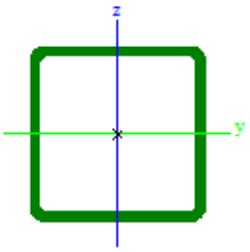
**Note:** The web slenderness is such that Shear Buckling effects may be ignored according to EN 1993-1-5 article 5.1(2).

The member satisfies the stability check.

Student version
Student version
Student version

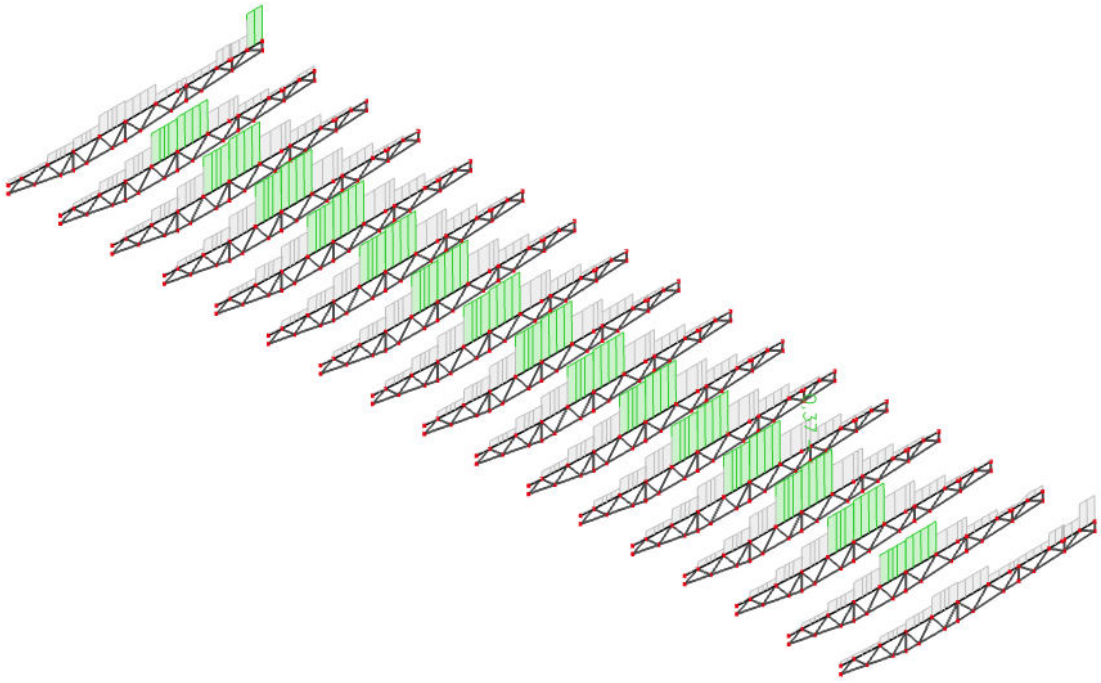
## 5.3. Dimenzioniranje gornjeg pojasa rešetke pozicije R1

| | |
|---|---|
| Name | R1-GP |
| Type | SHS400/400/20.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 3,0000e-02 | |
| A y, z [m²] | 1,4981e-02 | 1,4981e-02 |
| I y, z [m⁴] | 7,1540e-04 | 7,1540e-04 |
| I w [m⁶], t [m⁴] | 1,7067e-05 | 1,1250e-03 |
| $W_{el}$ y, z [m³] | 3,5770e-03 | 3,5770e-03 |
| $W_{pl}$ y, z [m³] | 4,2470e-03 | 4,2470e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 200 | 200 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,5500e+00 | 2,9538e+00 |
| $M_{ply}$ +, - [Nm] | 1,51e+06 | 1,51e+06 |
| $M_{plz}$ +, - [Nm] | 1,51e+06 | 1,51e+06 |

***Tablica 5.2.*** *Karakteristike poprečnog presjeka gornjeg pojasa rešetke pozicije R1*



***Slika 5.6.*** *Prikaz iskoristivosti gornjeg pojasa rešetke pozicije R1*

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,5000e-02 | $m^2$ |
| $V_{pl,z,Rd}$ | 3074,39 | kN |
| Unity check | 0,03 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 1236,11 | kNm |
| $\alpha$ | 1,97 | |
| $M_{N,z,Rd}$ | 1236,11 | kNm |
| $\beta$ | 1,97 | |

Unity check (6.41) = 0,06 + 0,00 = 0,06 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 18,721 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 340 | 20 | 1,303e+03 | -9,754e+03 | -7,49 | | 0,12 | 17,00 | 248,64 | 286,62 | 1171,81 | 1 |
| 3 | I | 340 | 20 | -1,002e+04 | -3,416e+03 | | | | | | | | |
| 5 | I | 340 | 20 | -2,377e+03 | 8,680e+03 | -0,27 | | 0,79 | 17,00 | 30,90 | 37,07 | 55,41 | 1 |
| 7 | I | 340 | 20 | 8,942e+03 | 2,341e+03 | 0,26 | | 1,00 | 17,00 | 22,78 | 27,66 | 41,56 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

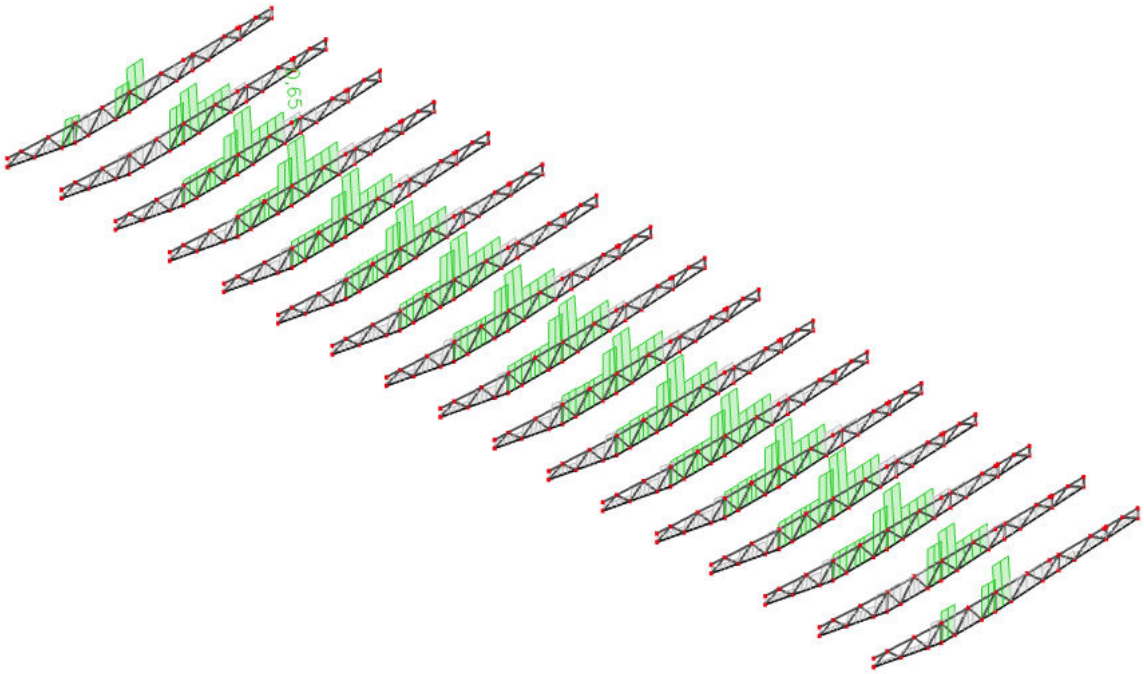
The member satisfies the stability check.

Student version

## 5.4. Dimenzioniranje donjeg pojasa rešetke pozicije R1

| | | |
|---|---|---|
| Name | R1-DP | |
| Type | SHS400/400/25.0 | |
| Source description | Corus Advance Sections | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
| A [m²] | 3,5900e-02 | |
| A y, z [m²] | 1,8204e-02 | 1,8204e-02 |
| I y, z [m⁴] | 8,2200e-04 | 8,2200e-04 |
| I w [m⁶], t [m⁴] | 2,1333e-05 | 1,3600e-03 |
| $W_{el}$ y, z [m³] | 4,1100e-03 | 4,1100e-03 |
| $W_{pl}$ y, z [m³] | 5,0693e-03 | 5,0693e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 200 | 200 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,5100e+00 | 2,9138e+00 |
| $M_{ply}$ +, - [Nm] | 1,80e+06 | 1,80e+06 |
| $M_{plz}$ +, - [Nm] | 1,80e+06 | 1,80e+06 |

***Tablica 5.3.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R1*



***Slika 5.7.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R1*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R1-DP - SHS400/400/25.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp143 | 21,110 / 21,110 m | SHS400/400/25.0 | S 355 | GSN | 0,65 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 21,110 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -4313,11 | kN |
| $V_{y,Ed}$ | -4,75 | kN |
| $V_{z,Ed}$ | -344,13 | kN |
| $T_{Ed}$ | -0,78 | kNm |
| $M_{y,Ed}$ | -749,92 | kNm |
| $M_{z,Ed}$ | -24,77 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 325 | 25 | 2,902e+05 | 2,806e+05 | 0,97 | | 1,00 | 13,00 | 22,78 | 27,66 | 31,27 | 1 |
| 3 | I | 325 | 25 | 2,576e+05 | -3,178e+04 | -0,12 | | 0,89 | 13,00 | 26,31 | 31,78 | 50,67 | 1 |
| 5 | I | 325 | 25 | -5,331e+04 | -4,375e+04 | | | | | | | | |
| 7 | I | 325 | 25 | -2,076e+04 | 2,686e+05 | -0,08 | | 0,93 | 13,00 | 24,97 | 30,22 | 49,37 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 3,5900e-02 | $m^2$ |
| $N_{c,Rd}$ | 12744,50 | kN |
| Unity check | 0,34 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 5,0693e-03 | $m^3$ |
| $M_{pl,y,Rd}$ | 1799,60 | kNm |
| Unity check | 0,42 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 5,0693e-03 | $m^3$ |
| $M_{pl,z,Rd}$ | 1799,60 | kNm |
| Unity check | 0,01 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,7950e-02 | $m^2$ |
| $V_{pl,y,Rd}$ | 3679,02 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,7950e-02 | $m^2$ |
| $V_{pl,z,Rd}$ | 3679,02 | kN |
| Unity check | 0,09 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,1 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 1529,20 | kNm |
| α | 1,91 | |
| $M_{N,z,Rd}$ | 1529,20 | kNm |
| β | 1,91 | |

Unity check (6.41) = 0,26 + 0,00 = 0,26 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 21,110 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 325 | 25 | 2,902e+05 | 2,806e+05 | 0,97 | | 1,00 | 13,00 | 22,78 | 27,66 | 31,27 | 1 |
| 3 | I | 325 | 25 | 2,576e+05 | -3,178e+04 | -0,12 | | 0,89 | 13,00 | 26,31 | 31,78 | 50,67 | 1 |
| 5 | I | 325 | 25 | -5,331e+04 | -4,375e+04 | | | | | | | | |
| 7 | I | 325 | 25 | -2,075e+04 | 2,686e+05 | -0,08 | | 0,93 | 13,00 | 24,97 | 30,22 | 49,37 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,346 | 9,382 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,346 | 9,382 | m |
| Critical Euler load $N_{cr}$ | 309674,37 | 19354,65 | kN |
| Slenderness λ | 15,50 | 62,00 | |
| Relative slenderness $\lambda_{rel}$ | 0,20 | 0,81 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 1,00 | 0,79 | |
| Buckling resistance $N_{b,Rd}$ | 12736,51 | 10056,52 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 3,5900e-02 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 10056,52 | kN |
| Unity check | 0,43 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 3,5900e-02 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 5,0693e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 5,0693e-03 | $m^3$ |
| Design compression force $N_{Ed}$ | 4313,11 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -749,92 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -24,77 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 12744,50 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 1799,60 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 1799,60 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 0,79 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,74 | |
| Interaction factor $k_{yz}$ | 0,66 | |
| Interaction factor $k_{zy}$ | 0,44 | |
| Interaction factor $k_{zz}$ | 0,97 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp143 position 21,110 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp143 position 21,110 m.

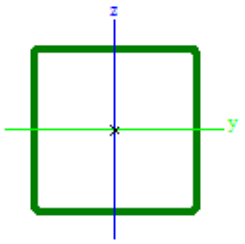
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 309674,37 | kN |
| Critical Euler load $N_{cr,z}$ | 19354,65 | kN |
| Elastic critical load $N_{cr,T}$ | 2409677,53 | kN |
| Plastic section modulus $W_{pl,y}$ | 5,0693e-03 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 4,1100e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 5,0693e-03 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 4,1100e-03 | $m^3$ |
| Second moment of area $I_y$ | 8,2200e-04 | $m^4$ |
| Second moment of area $I_z$ | 8,2200e-04 | $m^4$ |
| Torsional constant $I_t$ | 1,3600e-03 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,06 | |
| Equivalent moment factor $C_{my,0}$ | 0,77 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -24,77 | kNm |
| Maximum relative deflection $\delta_y$ | 0,4 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,84 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 0,94 | |
| Factor $\varepsilon_y$ | 1,52 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 46214,24 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,20 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,35 | |
| Equivalent moment factor $C_{my}$ | 0,77 | |
| Equivalent moment factor $C_{mz}$ | 0,84 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,23 | |
| Factor $w_z$ | 1,23 | |
| Factor $n_{pl}$ | 0,34 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,81 | |
| Factor $C_{yy}$ | 1,07 | |
| Factor $C_{yz}$ | 0,98 | |
| Factor $C_{zy}$ | 1,00 | |
| Factor $C_{zz}$ | 1,05 | |

Unity check (6.61) = 0,34 + 0,31 + 0,01 = 0,65 -
Unity check (6.62) = 0,43 + 0,18 + 0,01 = 0,63 -

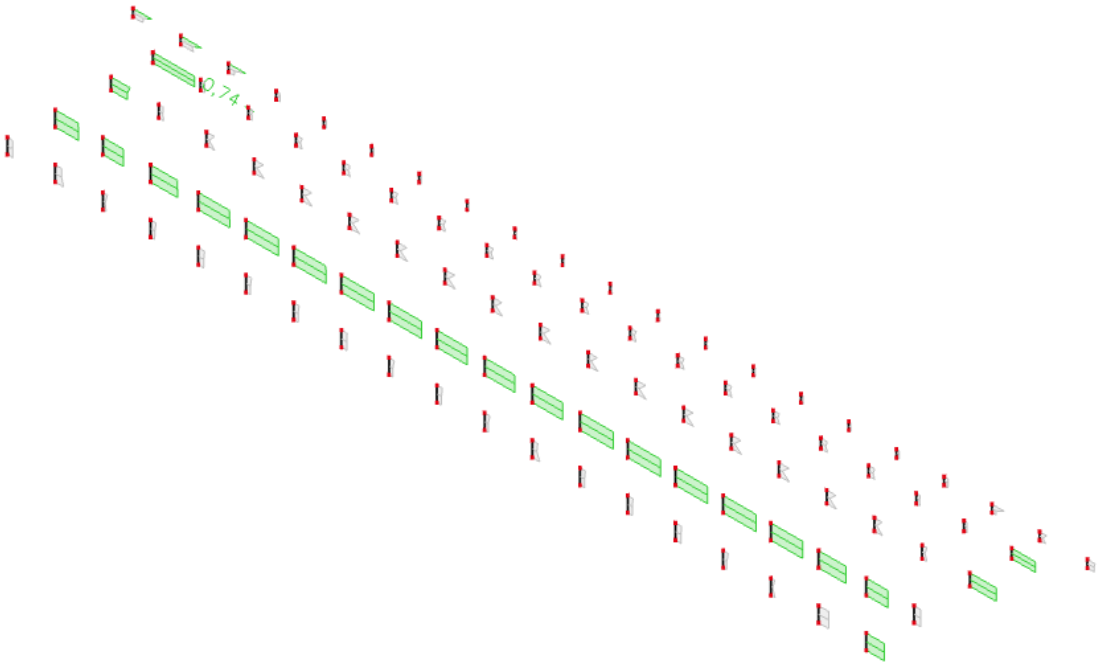
The member satisfies the stability check.

Student version

## 5.5. Dimenzioniranje vertikale rešetke pozicije R1

| | | |
|---|---|---|
| Name | | R1-V |
| Type | | SHS250/250/8.0 |
| Source description | | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | | S 355 |
| Fabrication | | rolled |
| Flexural buckling y-y | | a |
| Flexural buckling z-z | | a |
| Lateral torsional buckling | | Default |
| Use 2D FEM analysis | | x |
| |  | |
| A [m²] | 7,6800e-03 | |
| A y, z [m²] | 3,8370e-03 | 3,8370e-03 |
| I y, z [m⁴] | 7,4550e-05 | 7,4550e-05 |
| I w [m⁶], t [m⁴] | 6,5104e-07 | 1,1530e-04 |
| $W_{el}$ y, z [m³] | 5,9600e-04 | 5,9600e-04 |
| $W_{pl}$ y, z [m³] | 6,9400e-04 | 6,9400e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 125 | 125 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 9,7900e-01 | 1,9015e+00 |
| $M_{ply}$ +, - [Nm] | 2,46e+05 | 2,46e+05 |
| $M_{plz}$ +, - [Nm] | 2,46e+05 | 2,46e+05 |

***Tablica 5.4.*** *Karakteristike poprečnog presjeka vertikale rešetke pozicije R1*



***Slika 5.8.*** *Prikaz iskoristivosti vertikala rešetke pozicije R1*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R1-V - SHS250/250/8.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| | | | | | |
|---|---|---|---|---|---|
| **Member pp8971** | **1,527 / 1,527 m** | **SHS250/250/8.0** | **S 355** | **GSN** | **0,74 -** |

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 1,527 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -402,36 | kN |
| $V_{y,Ed}$ | -116,62 | kN |
| $V_{z,Ed}$ | 61,10 | kN |
| $T_{Ed}$ | 7,09 | kNm |
| $M_{y,Ed}$ | 71,02 | kNm |
| $M_{z,Ed}$ | -24,35 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 226 | 8 | -2,595e+04 | -9,977e+04 | | | | | | | | |
| 3 | I | 226 | 8 | -9,476e+04 | 1,206e+05 | -0,79 | | 0,56 | 28,25 | 49,30 | 57,59 | 81,31 | 1 |
| 5 | I | 226 | 8 | 1,308e+05 | 2,046e+05 | 0,64 | | 1,00 | 28,25 | 22,78 | 27,66 | 35,34 | 3 |
| 7 | I | 226 | 8 | 1,996e+05 | -1,571e+04 | -0,08 | | 0,93 | 28,25 | 25,01 | 30,27 | 49,41 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient ε | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 27,66 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 30,92 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Web class 2 slenderness limit $\beta_{2,z,w}$ | 27,66 | |
| Web class 3 slenderness limit $\beta_{3,z,w}$ | 30,92 | |
| Web slenderness ratio $c/t_w$ | 28,25 | |
| Flange slenderness ratio c/tf | 28,25 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 0,18 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 0,18 | |
| Interpolated section modulus $W_{3,y}$ | 6,7632e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 6,7632e-04 | $m^3$ |

**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 7,6800e-03 | $m^2$ |
| $N_{c,Rd}$ | 2726,40 | kN |
| Unity check | 0,15 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,y}$ | 6,7632e-04 | $m^3$ |
| $M_{3,y,Rd}$ | 240,09 | kNm |
| Unity check | 0,30 | - |

Student version

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,z}$ | 6,7632e-04 | $m^3$ |
| $M_{3,z,Rd}$ | 240,09 | kNm |
| Unity check | 0,10 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,8400e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 787,04 | kN |
| Unity check | 0,15 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,8400e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 787,04 | kN |
| Unity check | 0,08 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 7,6 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,04 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,3,y,Rd}$ | 204,66 | kNm |
| α | 1,70 | |
| $M_{N,3,z,Rd}$ | 204,66 | kNm |
| β | 1,70 | |

Unity check (6.41) = 0,17 + 0,03 = 0,19 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 226 | 8 | -1,446e+05 | 3,216e+05 | -0,45 | | 0,69 | 28,25 | 36,70 | 43,65 | 62,22 | 1 |
| 3 | I | 226 | 8 | 3,357e+05 | 2,681e+05 | 0,80 | | 1,00 | 28,25 | 22,78 | 27,66 | 33,24 | 3 |
| 5 | I | 226 | 8 | 2,492e+05 | -2,170e+05 | -0,87 | | 0,53 | 28,25 | 52,86 | 61,43 | 88,15 | 1 |
| 7 | I | 226 | 8 | -2,312e+05 | -1,635e+05 | | | | | | | | |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 1,527 | 1,527 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_\sigma$ | 1,527 | 1,527 | m |
| Critical Euler load $N_\sigma$ | 66229,52 | 66229,52 | kN |
| Slenderness λ | 15,50 | 15,50 | |
| Relative slenderness $\lambda_{rel}$ | 0,20 | 0,20 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

Student version

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 7,6800e-03 | $m^2$ |
| Interpolated section modulus $W_{3,y}$ | 6,7632e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 6,7632e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 402,36 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 71,02 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 153,77 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 2726,40 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 240,09 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 240,09 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,70 | |
| Interaction factor $k_{yz}$ | 0,44 | |
| Interaction factor $k_{zy}$ | 0,42 | |
| Interaction factor $k_{zz}$ | 0,73 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp8971 position 1,527 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp8971 position 0,000 m.

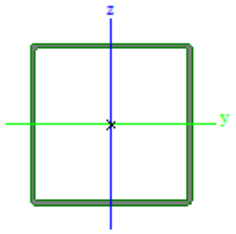
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 66229,52 | kN |
| Critical Euler load $N_{cr,z}$ | 66229,52 | kN |
| Elastic critical load $N_{cr,T}$ | 509479,74 | kN |
| Interpolated section modulus $W_{3,y}$ | 6,7632e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 5,9600e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 6,7632e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 5,9600e-04 | $m^3$ |
| Second moment of area $I_y$ | 7,4550e-05 | $m^4$ |
| Second moment of area $I_z$ | 7,4550e-05 | $m^4$ |
| Torsional constant $I_t$ | 1,1530e-04 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,31 | |
| Equivalent moment factor $C_{my,0}$ | 0,72 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,16 | |
| Equivalent moment factor $C_{mz,0}$ | 0,76 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 2,27 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 25594,55 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,10 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,29 | |
| Equivalent moment factor $C_{my}$ | 0,72 | |
| Equivalent moment factor $C_{mz}$ | 0,76 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,13 | |
| Factor $w_z$ | 1,13 | |
| Factor $n_{pl}$ | 0,15 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,20 | |
| Factor $C_{yy}$ | 1,04 | |
| Factor $C_{yz}$ | 1,04 | |
| Factor $C_{zy}$ | 1,04 | |
| Factor $C_{zz}$ | 1,04 | |

Unity check (6.61) = 0,15 + 0,21 + 0,28 = 0,64 -
Unity check (6.62) = 0,15 + 0,12 + 0,47 = 0,74 -

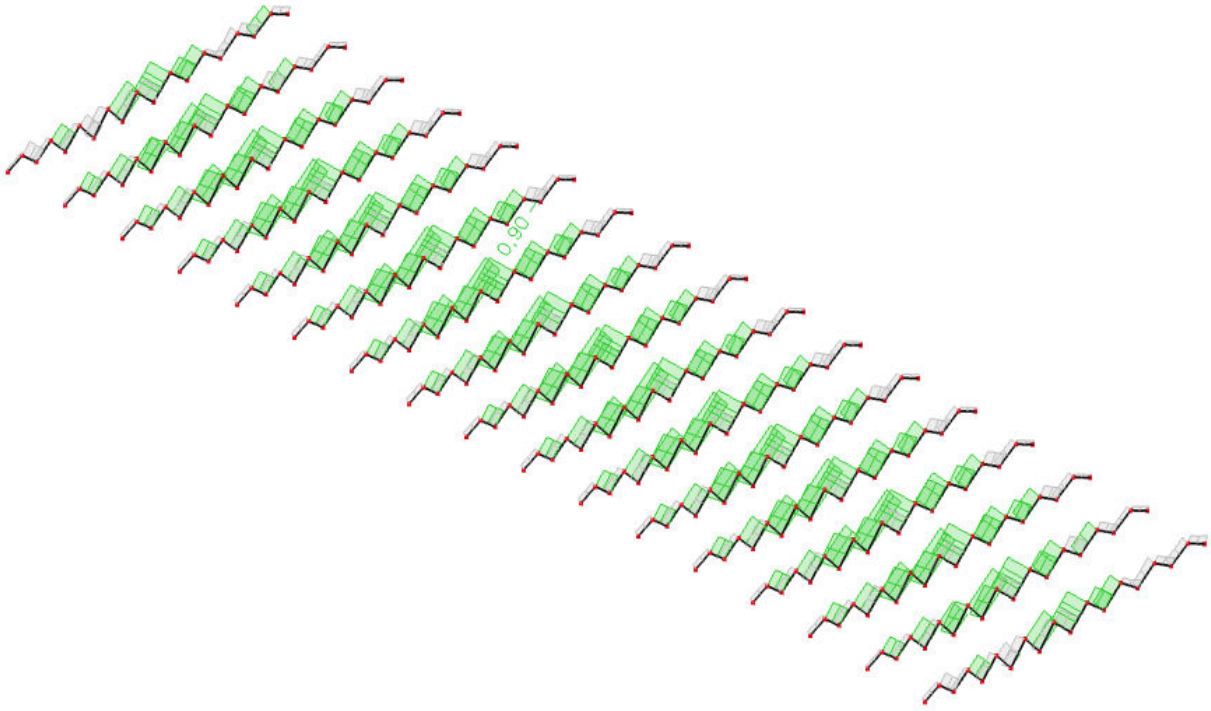
The member satisfies the stability check.

Student version
Student version
Student version

## 5.6. Dimenzioniranje ispune rešetke pozicije R1

| | | |
|---|---|---|
| Name | R1-I | |
| Type | SHS250/250/6.3 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | roled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 6,1000e-03 | |
| A y, z [m²] | 3,0489e-03 | 3,0489e-03 |
| I y, z [m⁴] | 6,0140e-05 | 6,0140e-05 |
| I w [m⁶], t [m⁴] | 5,1270e-07 | 9,2380e-05 |
| $W_{el}$ y, z [m³] | 4,8100e-04 | 4,8100e-04 |
| $W_{pl}$ y, z [m³] | 5,5600e-04 | 5,5600e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 125 | 125 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 9,8400e-01 | 1,9224e+00 |
| $M_{ply}$ +, - [Nm] | 1,97e+05 | 1,97e+05 |
| $M_{plz}$ +, - [Nm] | 1,97e+05 | 1,97e+05 |

***Tablica 5.5.*** *Karakteristike poprečnog presjeka vertikale rešetke pozicije R1*




***Slika 5.9.*** *Prikaz iskoristivosti ispune rešetke pozicije R1*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R1-I - SHS250/250/6.3

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp219 | 3,202 / 3,202 m | SHS250/250/6.3 | S 355 | GSN | 0,90 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 3,202 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -1307,12 | kN |
| $V_{y,Ed}$ | 1,90 | kN |
| $V_{z,Ed}$ | 18,09 | kN |
| $T_{Ed}$ | -0,28 | kNm |
| $M_{y,Ed}$ | 28,94 | kNm |
| $M_{z,Ed}$ | 4,12 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 231 | 6 | 1,478e+05 | 1,636e+05 | 0,90 | | 1,00 | 36,68 | 22,78 | 27,66 | 31,99 | 4 |
| 3 | I | 231 | 6 | 1,671e+05 | 2,783e+05 | 0,60 | | 1,00 | 36,68 | 22,78 | 27,66 | 35,89 | 4 |
| 5 | I | 231 | 6 | 2,809e+05 | 2,651e+05 | 0,94 | | 1,00 | 36,68 | 22,78 | 27,66 | 31,53 | 4 |
| 7 | I | 231 | 6 | 2,616e+05 | 1,504e+05 | 0,57 | | 1,00 | 36,68 | 22,78 | 27,66 | 36,27 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |
| 3 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |
| 5 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |
| 7 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |

**Effective section My+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 231 | -3,399e+05 | -3,399e+05 | | | | | | | |
| 3 | I | 231 | 3,370e+05 | -3,219e+05 | -0,96 | 22,74 | 0,33 | 1,00 | 118 | 47 | 71 |
| 5 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |
| 7 | I | 231 | 3,370e+05 | -3,219e+05 | -0,96 | 22,74 | 0,33 | 1,00 | 118 | 47 | 71 |

**Effective section Mz+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 231 | 3,370e+05 | -3,219e+05 | -0,96 | 22,74 | 0,33 | 1,00 | 118 | 47 | 71 |
| 3 | I | 231 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,79 | 0,91 | 210 | 105 | 105 |
| 5 | I | 231 | 3,370e+05 | -3,219e+05 | -0,96 | 22,74 | 0,33 | 1,00 | 118 | 47 | 71 |
| 7 | I | 231 | -3,399e+05 | -3,399e+05 | | | | | | | |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 5,5781e-03 | m² | | | |
| Effective second moment of area | $I_{eff,y}$ | 5,8162e-05 | m⁴ | $I_{eff,z}$ | 5,8162e-05 | m⁴ |
| Effective section modulus | $W_{eff,y}$ | 4,5562e-04 | m³ | $W_{eff,z}$ | 4,5562e-04 | m³ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| $A_{eff}$ | 5,5781e-03 | m² |
| $N_{c,Rd}$ | 1980,22 | kN |
| Unity check | 0,66 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,y,min}$ | 4,5562e-04 | m³ |
| $M_{c,y,Rd}$ | 161,74 | kNm |
| Unity check | 0,18 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,z,min}$ | 4,5562e-04 | m³ |
| $M_{c,z,Rd}$ | 161,74 | kNm |
| Unity check | 0,03 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 3,0500e-03 | m² |
| $V_{pl,y,Rd}$ | 625,13 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 3,0500e-03 | m² |
| $V_{pl,z,Rd}$ | 625,13 | kN |
| Unity check | 0,03 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,4 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.3 and formula (6.43)

| Effective properties | | |
|---|---|---|
| $A_{eff}$ | 5,5781e-03 | m² |
| $e_{N,y}$ | 0 | mm |
| $e_{N,z}$ | 0 | mm |
| $W_{eff,y}$ | 4,5562e-04 | m³ |
| $W_{eff,z}$ | 4,5562e-04 | m³ |

| Normal stresses | | |
|---|---|---|
| $\sigma_{N,Ed}$ | 234,3 | MPa |
| $\sigma_{My,Ed}$ | 63,5 | MPa |
| $\sigma_{Mz,Ed}$ | 9,0 | MPa |
| $\sigma_{tot,Ed}$ | 306,9 | MPa |
| Unity check | 0,86 | - |

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 3,202 m

Student version

Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 231 | 6 | 1,478e+05 | 1,636e+05 | 0,90 | | 1,00 | 36,68 | 22,78 | 27,66 | 31,99 | 4 |
| 3 | I | 231 | 6 | 1,671e+05 | 2,783e+05 | 0,60 | | 1,00 | 36,68 | 22,78 | 27,66 | 35,89 | 4 |
| 5 | I | 231 | 6 | 2,809e+05 | 2,651e+05 | 0,94 | | 1,00 | 36,68 | 22,78 | 27,66 | 31,53 | 4 |
| 7 | I | 231 | 6 | 2,616e+05 | 1,504e+05 | 0,57 | | 1,00 | 36,68 | 22,78 | 27,66 | 36,27 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 3,202 | 3,202 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 3,202 | 3,202 | m |
| Critical Euler load $N_{cr}$ | 12160,70 | 12160,70 | kN |
| Slenderness $\lambda$ | 32,24 | 32,24 | |
| Relative slenderness $\lambda_{rel}$ | 0,40 | 0,40 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection $\alpha$ | 0,21 | 0,21 | |
| Reduction factor $\chi$ | 0,95 | 0,95 | |
| Buckling resistance $N_{b,Rd}$ | 1884,88 | 1884,88 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section effective area $A_{eff}$ | 5,5781e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1884,88 | kN |
| Unity check | 0,69 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 5,5781e-03 | $m^2$ |
| Effective section modulus $W_{eff,y}$ | 4,5562e-04 | $m^3$ |
| Effective section modulus $W_{eff,z}$ | 4,5562e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 1307,12 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -31,02 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 4,12 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1980,22 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 161,74 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 161,74 | kNm |
| Reduction factor $\chi_y$ | 0,95 | |
| Reduction factor $\chi_z$ | 0,95 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,00 | |
| Interaction factor $k_{yz}$ | 0,73 | |
| Interaction factor $k_{zy}$ | 1,00 | |
| Interaction factor $k_{zz}$ | 0,73 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp219 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp219 position 3,202 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 12160,70 | kN |
| Critical Euler load $N_{cr,z}$ | 12160,70 | kN |
| Elastic critical load $N_{cr,T}$ | 383665,65 | kN |
| Effective section modulus $W_{eff,y}$ | 4,5562e-04 | $m^3$ |
| Second moment of area $I_y$ | 6,0140e-05 | $m^4$ |
| Second moment of area $I_z$ | 6,0140e-05 | $m^4$ |
| Torsional constant $I_t$ | 9,2380e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -31,02 | kNm |
| Maximum relative deflection $\delta_z$ | 0,1 | mm |

Student version

| Interaction method 1 parameters | | |
|---|---|---|
| Equivalent moment factor $C_{my,0}$ | 0,90 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,48 | |
| Equivalent moment factor $C_{mz,0}$ | 0,66 | |
| Factor $\mu_y$ | 0,99 | |
| Factor $\mu_z$ | 0,99 | |
| Factor $\varepsilon_y$ | 0,29 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 9591,52 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,13 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,31 | |
| Equivalent moment factor $C_{my}$ | 0,90 | |
| Equivalent moment factor $C_{mz}$ | 0,66 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

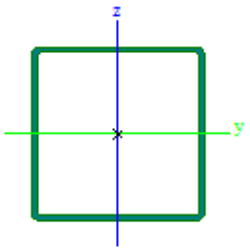
Unity check (6.61) = 0,69 + 0,19 + 0,02 = 0,90 -
Unity check (6.62) = 0,69 + 0,19 + 0,02 = 0,90 -

The member satisfies the stability check.

Student version
Student version
Student version

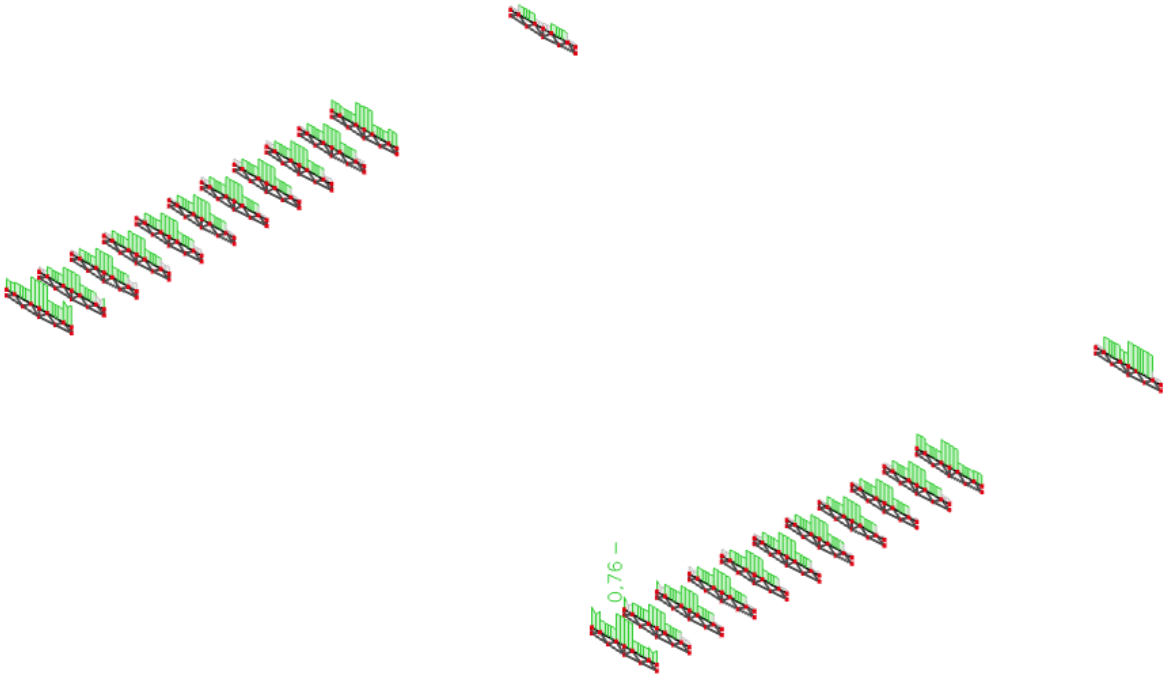
## 5.7. Dimenzioniranje gornjeg pojasa rešetke pozicije R2

| | |
|---|---|
| Name | R2-GP |
| Type | SHS200/200/6.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 4,6200e-03 | |
| A y, z [m²] | 2,3083e-03 | 2,3083e-03 |
| I y, z [m⁴] | 2,8830e-05 | 2,8830e-05 |
| I w [m⁶], t [m⁴] | 1,6000e-07 | 4,4490e-05 |
| $W_{el}$ y, z [m³] | 2,8800e-04 | 2,8800e-04 |
| $W_{pl}$ y, z [m³] | 3,3500e-04 | 3,3500e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,8500e-01 | 1,5261e+00 |
| $M_{ply}$ +, - [Nm] | 1,19e+05 | 1,19e+05 |
| $M_{plz}$ +, - [Nm] | 1,19e+05 | 1,19e+05 |

***Tablica 5.6.*** *Karakteristike poprečnog presjeka gornjeg pojasa rešetke pozicije R2*




***Slika 5.10.*** *Prikaz iskoristivosti gornjeg pojasa rešetke pozicije R2*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R2-GP - SHS200/200/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp670 | 0,000 / 8,000 m | SHS200/200/6.0 | S 355 | GSN | 0,76 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | 1241,94 | kN |
| $V_{y,Ed}$ | 11,08 | kN |
| $V_{z,Ed}$ | 11,60 | kN |
| $T_{Ed}$ | -3,72 | kNm |
| $M_{y,Ed}$ | -17,21 | kNm |
| $M_{z,Ed}$ | -9,10 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 182 | 6 | -1,824e+05 | -2,398e+05 | | | | | | | | |
| 3 | I | 182 | 6 | -2,453e+05 | -3,539e+05 | | | | | | | | |
| 5 | I | 182 | 6 | -3,556e+05 | -2,981e+05 | | | | | | | | |
| 7 | I | 182 | 6 | -2,927e+05 | -1,840e+05 | | | | | | | | |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Tension check**
According to EN 1993-1-1 article 6.2.3 and formula (6.5)

| | | |
|---|---|---|
| A | 4,6200e-03 | $m^2$ |
| $N_{pl,Rd}$ | 1640,10 | kN |
| $N_{u,Rd}$ | 1629,94 | kN |
| $N_{t,Rd}$ | 1629,94 | kN |
| Unity check | 0,76 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 3,3500e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 118,92 | kNm |
| Unity check | 0,14 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 3,3500e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 118,92 | kNm |
| Unity check | 0,08 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 2,3100e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 473,46 | kN |
| Unity check | 0,02 | - |

Student version

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_y$ | 2,3100e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 473,46 | kN |
| Unity check | 0,02 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 8,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,04 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 38,00 | kNm |
| $\alpha$ | 4,72 | |
| $M_{N,z,Rd}$ | 38,00 | kNm |
| $\beta$ | 4,72 | |

Unity check (6.41) = 0,02 + 0,00 = 0,03 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 6,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 182 | 6 | 8,408e+04 | 2,787e+04 | 0,33 | | 1,00 | 30,33 | 22,78 | 27,66 | 40,26 | 3 |
| 3 | I | 182 | 6 | 2,258e+04 | -8,171e+04 | -3,62 | | 0,22 | 30,33 | 135,30 | 155,97 | 443,28 | 1 |
| 5 | I | 182 | 6 | -8,330e+04 | -2,709e+04 | | | | | | | | |
| 7 | I | 182 | 6 | -2,180e+04 | 8,250e+04 | -0,26 | | 0,79 | 30,33 | 30,60 | 36,72 | 55,08 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient $\varepsilon$ | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 27,66 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 30,92 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Web class 2 slenderness limit $\beta_{2,z,w}$ | 27,66 | |
| Web class 3 slenderness limit $\beta_{3,z,w}$ | 30,92 | |
| Web slenderness ratio $c/t_w$ | 30,33 | |
| Flange slenderness ratio $c/t_f$ | 30,33 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 0,82 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 0,82 | |
| Interpolated section modulus $W_{3,y}$ | 2,9644e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 2,9644e-04 | $m^3$ |

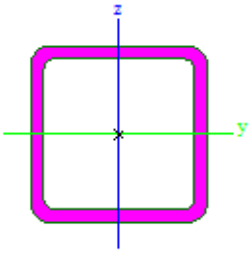
**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

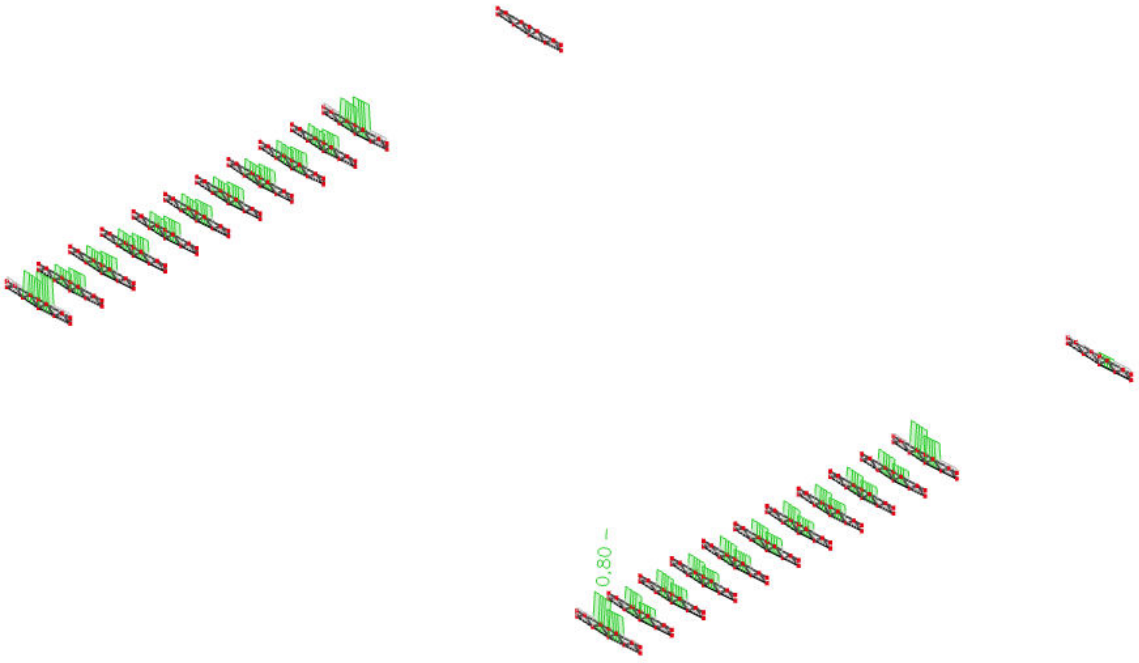
The member satisfies the stability check.

Student version

## 5.8. Dimenzioniranje donjeg pojasa rešetke pozicije R2

| | | |
|---|---|---|
| Name | R2-DP | |
| Type | SHS200/200/14.2 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|   | | |
| A [m²] | 1,0300e-02 | |
| A y, z [m²] | 5,1665e-03 | 5,1665e-03 |
| I y, z [m⁴] | 5,8720e-05 | 5,8720e-05 |
| I w [m⁶], t [m⁴] | 3,7867e-07 | 9,4170e-05 |
| $W_{el}$ y, z [m³] | 5,8700e-04 | 5,8700e-04 |
| $W_{pl}$ y, z [m³] | 7,1400e-04 | 7,1400e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,6300e-01 | 1,4252e+00 |
| $M_{ply}$ +, - [Nm] | 2,53e+05 | 2,53e+05 |
| $M_{plz}$ +, - [Nm] | 2,53e+05 | 2,53e+05 |

***Tablica 5.7.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R2*




***Slika 5.11.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R2*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R2-DP - SHS200/200/14.2

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp671 | 8,019 / 8,019 m | SHS200/200/14.2 | S 355 | GSN | 0,80 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 8,019 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -872,29 | kN |
| $V_{y,Ed}$ | 2,20 | kN |
| $V_{z,Ed}$ | -27,34 | kN |
| $T_{Ed}$ | 8,62 | kNm |
| $M_{y,Ed}$ | -81,89 | kNm |
| $M_{z,Ed}$ | 0,86 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 157 | 14 | 2,128e+05 | 2,151e+05 | 0,99 | | 1,00 | 11,08 | 22,78 | 27,66 | 31,03 | 1 |
| 3 | I | 157 | 14 | 1,955e+05 | -2,401e+04 | -0,12 | | 0,89 | 11,08 | 26,30 | 31,76 | 50,65 | 1 |
| 5 | I | 157 | 14 | -4,403e+04 | -4,635e+04 | | | | | | | | |
| 7 | I | 157 | 14 | -2,675e+04 | 1,928e+05 | -0,14 | | 0,88 | 11,08 | 26,77 | 32,31 | 51,12 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,0300e-02 | $m^2$ |
| $N_{c,Rd}$ | 3656,50 | kN |
| Unity check | 0,24 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 253,47 | kNm |
| Unity check | 0,32 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 253,47 | kNm |
| Unity check | 0,00 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 5,1500e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 1055,54 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 5,1500e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 1055,54 | kN |
| Unity check | 0,03 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 8,8 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,04 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 248,80 | kNm |
| α | 1,77 | |
| $M_{N,z,Rd}$ | 248,80 | kNm |
| β | 1,77 | |

Unity check (6.41) = 0,14 + 0,00 = 0,14 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,019 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 157 | 14 | 2,128e+05 | 2,151e+05 | 0,99 | | 1,00 | 11,08 | 22,78 | 27,66 | 31,03 | 1 |
| 3 | I | 157 | 14 | 1,955e+05 | -2,401e+04 | -0,12 | | 0,89 | 11,08 | 26,30 | 31,76 | 50,65 | 1 |
| 5 | I | 157 | 14 | -4,403e+04 | -4,635e+04 | | | | | | | | |
| 7 | I | 157 | 14 | -2,675e+04 | 1,928e+05 | -0,14 | | 0,88 | 11,08 | 26,77 | 32,31 | 51,12 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,009 | 8,019 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,009 | 8,019 | m |
| Critical Euler load $N_{cr}$ | 7570,72 | 1892,68 | kN |
| Slenderness λ | 53,10 | 106,20 | |
| Relative slenderness $\lambda_{rel}$ | 0,69 | 1,39 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,85 | 0,42 | |
| Buckling resistance $N_{b,Rd}$ | 3108,35 | 1546,16 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,0300e-02 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1546,16 | kN |
| Unity check | 0,56 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,0300e-02 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 872,29 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -81,89 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -5,01 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 3656,50 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 253,47 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 253,47 | kNm |
| Reduction factor $\chi_y$ | 0,85 | |
| Reduction factor $\chi_z$ | 0,42 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,15 | |
| Interaction factor $k_{yz}$ | 1,13 | |
| Interaction factor $k_{zy}$ | 0,67 | |
| Interaction factor $k_{zz}$ | 1,03 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp671 position 8,019 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp671 position 5,346 m.

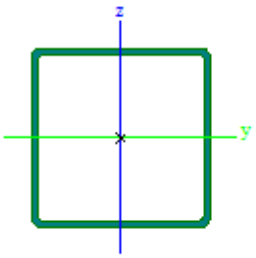
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 7570,72 | kN |
| Critical Euler load $N_{cr,z}$ | 1892,68 | kN |
| Elastic critical load $N_{cr,T}$ | 668153,19 | kN |
| Plastic section modulus $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 5,8700e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 5,8700e-04 | $m^3$ |
| Second moment of area $I_y$ | 5,8720e-05 | $m^4$ |
| Second moment of area $I_z$ | 5,8720e-05 | $m^4$ |
| Torsional constant $I_t$ | 9,4170e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -81,89 | kNm |
| Maximum relative deflection $\delta_z$ | 5,1 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,94 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -5,01 | kNm |
| Maximum relative deflection $\delta_y$ | 1,5 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,80 | |
| Factor $\mu_y$ | 0,98 | |
| Factor $\mu_z$ | 0,67 | |
| Factor $\varepsilon_y$ | 1,65 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 3797,22 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,26 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,31 | |
| Equivalent moment factor $C_{my}$ | 0,94 | |
| Equivalent moment factor $C_{mz}$ | 0,80 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,22 | |
| Factor $w_z$ | 1,22 | |
| Factor $n_{pl}$ | 0,24 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,39 | |
| Factor $C_{yy}$ | 0,90 | |
| Factor $C_{yz}$ | 0,77 | |
| Factor $C_{zy}$ | 0,64 | |
| Factor $C_{zz}$ | 0,96 | |

Unity check (6.61) = 0,28 + 0,37 + 0,02 = 0,67 -
Unity check (6.62) = 0,56 + 0,21 + 0,02 = 0,80 -

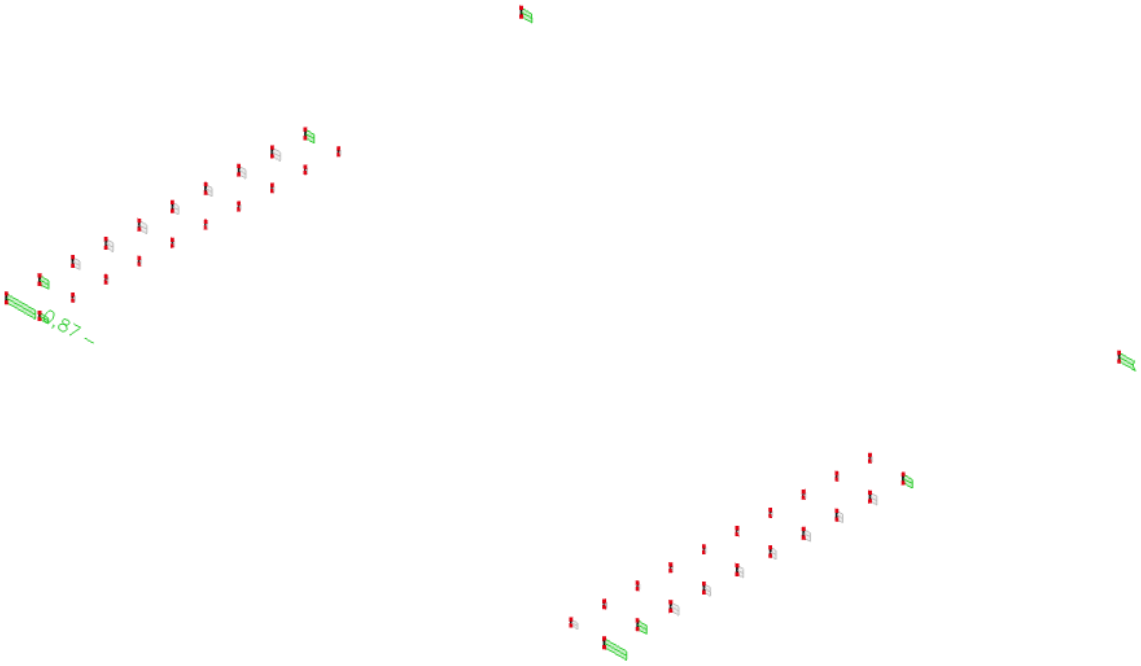
The member satisfies the stability check.

Student version
Student version
Student version

## 5.9. Dimenzioniranje vertikale rešetke pozicije R2

| | | |
|---|---|---|
| Name | R2-V | |
| Type | SHS180/180/6.3 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | roled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 4,3300e-03 | |
| A y, z [m²] | 2,1669e-03 | 2,1669e-03 |
| I y, z [m⁴] | 2,1680e-05 | 2,1680e-05 |
| I w [m⁸], t [m⁴] | 9,9202e-08 | 3,3610e-05 |
| $W_{el}$ y, z [m³] | 2,4100e-04 | 2,4100e-04 |
| $W_{pl}$ y, z [m³] | 2,8100e-04 | 2,8100e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 90 | 90 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,0400e-01 | 1,3624e+00 |
| $M_{ply}$ +, - [Nm] | 9,98e+04 | 9,98e+04 |
| $M_{plz}$ +, - [Nm] | 9,98e+04 | 9,98e+04 |

***Tablica 5.8.*** *Karakteristike poprečnog presjeka vertikale rešetke pozicije R2*



***Slika 5.12.*** *Prikaz iskoristivosti vertikale rešetke pozicije R2*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R2-V - SHS180/180/6.3

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp509 | 1,800 / 1,800 m | SHS180/180/6.3 | S 355 | GSN | 0,87 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 1,800 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -323,98 | kN |
| $V_{y,Ed}$ | 26,27 | kN |
| $V_{z,Ed}$ | 20,70 | kN |
| $T_{Ed}$ | 1,22 | kNm |
| $M_{y,Ed}$ | 26,78 | kNm |
| $M_{z,Ed}$ | -19,12 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 161 | 6 | 3,851e+04 | -1,036e+05 | -2,69 | | 0,27 | 25,57 | 108,07 | 124,59 | 305,26 | 1 |
| 3 | I | 161 | 6 | -1,013e+05 | 9,765e+04 | -1,04 | | 0,49 | 25,57 | 59,69 | 68,81 | 104,73 | 1 |
| 5 | I | 161 | 6 | 1,110e+05 | 2,531e+05 | 0,44 | | 1,00 | 25,57 | 22,78 | 27,66 | 38,40 | 2 |
| 7 | I | 161 | 6 | 2,508e+05 | 5,184e+04 | 0,21 | | 1,00 | 25,57 | 22,78 | 27,66 | 42,66 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 4,3300e-03 | $m^2$ |
| $N_{c,Rd}$ | 1537,15 | kN |
| Unity check | 0,21 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 99,75 | kNm |
| Unity check | 0,27 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 99,75 | kNm |
| Unity check | 0,19 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 2,1650e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 443,74 | kN |
| Unity check | 0,06 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 2,1650e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 443,74 | kN |
| Unity check | 0,05 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 3,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,02 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 99,75 | kNm |
| α | 1,75 | |
| $M_{N,z,Rd}$ | 99,75 | kNm |
| β | 1,75 | |

Unity check (6.41) = 0,10 + 0,06 = 0,16 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 161 | 6 | 3,634e+05 | -1,302e+05 | -0,36 | | 0,74 | 25,57 | 33,62 | 40,17 | 58,48 | 1 |
| 3 | I | 161 | 6 | -1,525e+05 | -2,305e+05 | | | | | | | | |
| 5 | I | 161 | 6 | -2,142e+05 | 2,793e+05 | -0,77 | | 0,57 | 25,57 | 48,53 | 56,75 | 79,92 | 1 |
| 7 | I | 161 | 6 | 3,017e+05 | 3,796e+05 | 0,79 | | 1,00 | 25,57 | 22,78 | 27,66 | 33,29 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 1,800 | 1,800 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 1,800 | 1,800 | m |
| Critical Euler load $N_{cr}$ | 13868,62 | 13868,62 | kN |
| Slenderness λ | 25,44 | 25,44 | |
| Relative slenderness $\lambda_{rel}$ | 0,33 | 0,33 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 4,3300e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 323,98 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 26,78 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -66,41 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1537,15 | kN |

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Characteristic moment resistance $M_{y,Rk}$ | 99,75 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 99,75 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,68 | |
| Interaction factor $k_{yz}$ | 0,50 | |
| Interaction factor $k_{zy}$ | 0,41 | |
| Interaction factor $k_{zz}$ | 0,83 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp509 position 1,800 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp509 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 13868,62 | kN |
| Critical Euler load $N_{cr,z}$ | 13868,62 | kN |
| Elastic critical load $N_{cr,T}$ | 277426,90 | kN |
| Plastic section modulus $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 2,4100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 2,4100e-04 | $m^3$ |
| Second moment of area $I_y$ | 2,1680e-05 | $m^4$ |
| Second moment of area $I_z$ | 2,1680e-05 | $m^4$ |
| Torsional constant $I_t$ | 3,3610e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,39 | |
| Equivalent moment factor $C_{my,0}$ | 0,70 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | 0,29 | |
| Equivalent moment factor $C_{mz,0}$ | 0,85 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 1,48 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 6207,14 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,13 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,30 | |
| Equivalent moment factor $C_{my}$ | 0,70 | |
| Equivalent moment factor $C_{mz}$ | 0,85 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,17 | |
| Factor $w_z$ | 1,17 | |
| Factor $n_{pl}$ | 0,21 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,33 | |
| Factor $C_{yy}$ | 1,06 | |
| Factor $C_{yz}$ | 1,05 | |
| Factor $C_{zy}$ | 1,06 | |
| Factor $C_{zz}$ | 1,05 | |

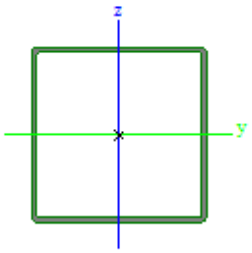
Unity check (6.61) = 0,21 + 0,18 + 0,33 = 0,72 -
Unity check (6.62) = 0,21 + 0,11 + 0,55 = 0,87 -

The member satisfies the stability check.

Student version
Student version
Student version

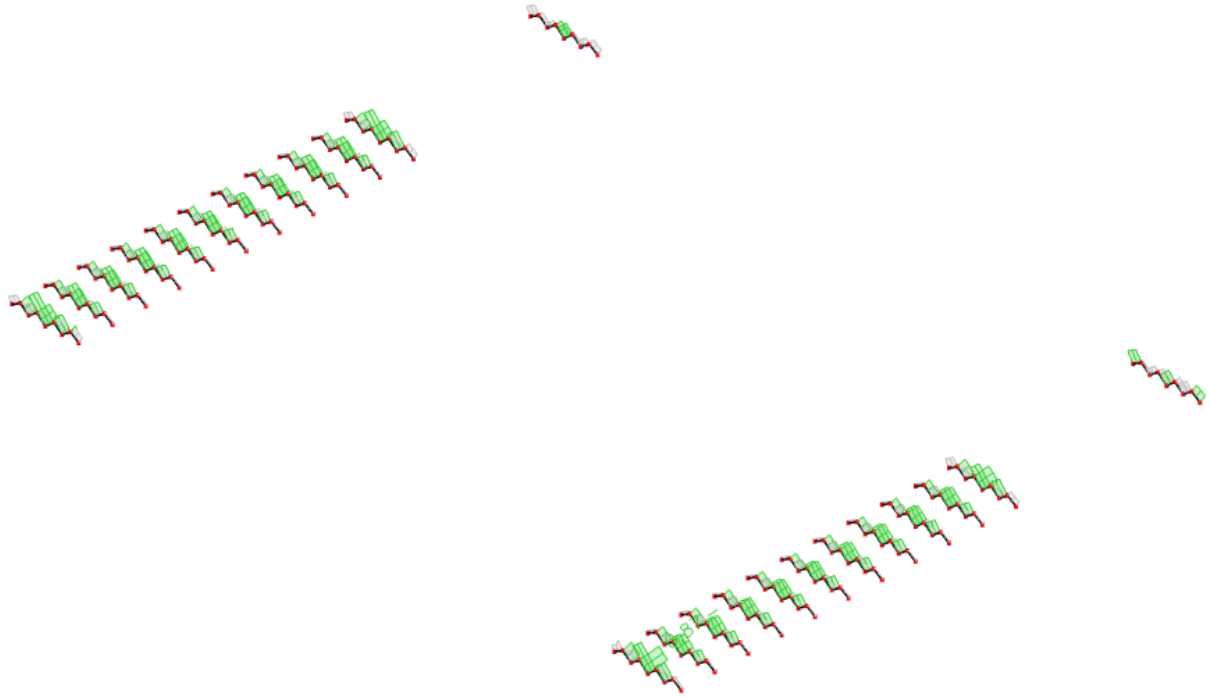
## 5.10. Dimenzioniranje ispune rešetke pozicije R2

| | |
|---|---|
| Name | R1-I |
| Type | SHS250/250/6.3 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 6,1000e-03 | |
| A y, z [m²] | 3,0489e-03 | 3,0489e-03 |
| I y, z [m⁴] | 6,0140e-05 | 6,0140e-05 |
| I w [m⁶], t [m⁴] | 5,1270e-07 | 9,2380e-05 |
| $W_{el}$ y, z [m³] | 4,8100e-04 | 4,8100e-04 |
| $W_{pl}$ y, z [m³] | 5,5600e-04 | 5,5600e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 125 | 125 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 9,8400e-01 | 1,9224e+00 |
| $M_{ply}$ +, - [Nm] | 1,97e+05 | 1,97e+05 |
| $M_{plz}$ +, - [Nm] | 1,97e+05 | 1,97e+05 |

***Tablica 5.9.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R2*



***Slika 5.13.*** *Prikaz iskoristivosti ispune rešetke pozicije R2*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R2-I - SHS180/180/6.3

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp679 | 2,691 / 2,691 m | SHS180/180/6.3 | S 355 | GSN | 0,87 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 2,691 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -559,38 | kN |
| $V_{y,Ed}$ | 2,41 | kN |
| $V_{z,Ed}$ | -19,86 | kN |
| $T_{Ed}$ | 5,20 | kNm |
| $M_{y,Ed}$ | -40,68 | kNm |
| $M_{z,Ed}$ | -7,18 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 161 | 6 | 3,187e+05 | 2,654e+05 | 0,83 | | 1,00 | 25,57 | 22,78 | 27,66 | 32,83 | 2 |
| 3 | I | 161 | 6 | 2,514e+05 | -5,090e+04 | -0,20 | | 0,83 | 25,57 | 28,68 | 34,52 | 53,05 | 1 |
| 5 | I | 161 | 6 | -6,064e+04 | -7,243e+03 | | | | | | | | |
| 7 | I | 161 | 6 | 6,668e+03 | 3,090e+05 | 0,02 | | 1,00 | 25,57 | 22,78 | 27,66 | 46,81 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 4,3300e-03 | $m^2$ |
| $N_{c,Rd}$ | 1537,15 | kN |
| Unity check | 0,36 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 99,75 | kNm |
| Unity check | 0,41 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 99,75 | kNm |
| Unity check | 0,07 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 2,1650e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 443,74 | kN |
| Unity check | 0,01 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 2,1650e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 443,74 | kN |
| Unity check | 0,04 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 13,7 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,07 | - |

**Combined Shear and Torsion check for $V_y$ and $\tau_{t,Ed}$**
According to EN 1993-1-1 article 6.2.6 & 6.2.7 and formula (6.25),(6.28)

| | | |
|---|---|---|
| $V_{pl,T,y,Rd}$ | 414,13 | kN |
| Unity check | 0,01 | - |

**Combined Shear and Torsion check for $V_z$ and $\tau_{t,Ed}$**
According to EN 1993-1-1 article 6.2.6 & 6.2.7 and formula (6.25),(6.28)

| | | |
|---|---|---|
| $V_{pl,T,z,Rd}$ | 414,13 | kN |
| Unity check | 0,05 | - |

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 83,28 | kNm |
| α | 1,95 | |
| $M_{N,z,Rd}$ | 83,28 | kNm |
| β | 1,95 | |

Unity check (6.41) = 0,25 + 0,01 = 0,26 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 2,691 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 161 | 6 | 3,187e+05 | 2,654e+05 | 0,83 | | 1,00 | 25,57 | 22,78 | 27,66 | 32,83 | 2 |
| 3 | I | 161 | 6 | 2,514e+05 | -5,090e+04 | -0,20 | | 0,83 | 25,57 | 28,68 | 34,52 | 53,05 | 1 |
| 5 | I | 161 | 6 | -6,064e+04 | -7,243e+03 | | | | | | | | |
| 7 | I | 161 | 6 | 6,668e+03 | 3,090e+05 | 0,02 | | 1,00 | 25,57 | 22,78 | 27,66 | 46,81 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,691 | 2,691 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,691 | 2,691 | m |
| Critical Euler load $N_{cr}$ | 6206,40 | 6206,40 | kN |
| Slenderness λ | 38,03 | 38,03 | |
| Relative slenderness $\lambda_{rel}$ | 0,50 | 0,50 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,92 | 0,92 | |
| Buckling resistance $N_{b,Rd}$ | 1421,86 | 1421,86 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 4,3300e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1421,86 | kN |
| Unity check | 0,39 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.

Student version

This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 4,3300e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 559,38 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -40,68 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -13,66 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1537,15 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 99,75 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 99,75 | kNm |
| Reduction factor $\chi_y$ | 0,92 | |
| Reduction factor $\chi_z$ | 0,92 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,97 | |
| Interaction factor $k_{yz}$ | 0,57 | |
| Interaction factor $k_{zy}$ | 0,60 | |
| Interaction factor $k_{zz}$ | 0,92 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp679 position 2,691 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp679 position 0,000 m.

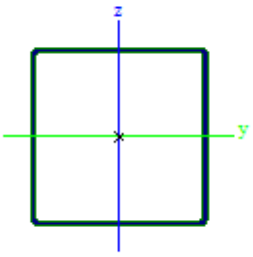
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 6206,40 | kN |
| Critical Euler load $N_{cr,z}$ | 6206,40 | kN |
| Elastic critical load $N_{cr,T}$ | 273925,71 | kN |
| Plastic section modulus $W_{pl,y}$ | 2,8100e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 2,4100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,8100e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 2,4100e-04 | $m^3$ |
| Second moment of area $I_y$ | 2,1680e-05 | $m^4$ |
| Second moment of area $I_z$ | 2,1680e-05 | $m^4$ |
| Torsional constant $I_t$ | 3,3610e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -40,68 | kNm |
| Maximum relative deflection $\delta_z$ | 2,8 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,95 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | 0,53 | |
| Equivalent moment factor $C_{mz,0}$ | 0,91 | |
| Factor $\mu_y$ | 0,99 | |
| Factor $\mu_z$ | 0,99 | |
| Factor $\varepsilon_y$ | 1,31 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 4126,07 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,16 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,28 | |
| Equivalent moment factor $C_{my}$ | 0,95 | |
| Equivalent moment factor $C_{mz}$ | 0,91 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,17 | |
| Factor $w_z$ | 1,17 | |
| Factor $n_{pl}$ | 0,36 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,50 | |
| Factor $C_{yy}$ | 1,07 | |
| Factor $C_{yz}$ | 1,04 | |
| Factor $C_{zy}$ | 1,03 | |
| Factor $C_{zz}$ | 1,07 | |

Unity check (6.61) = 0,39 + 0,40 + 0,08 = 0,87 -
Unity check (6.62) = 0,39 + 0,25 + 0,13 = 0,77 -

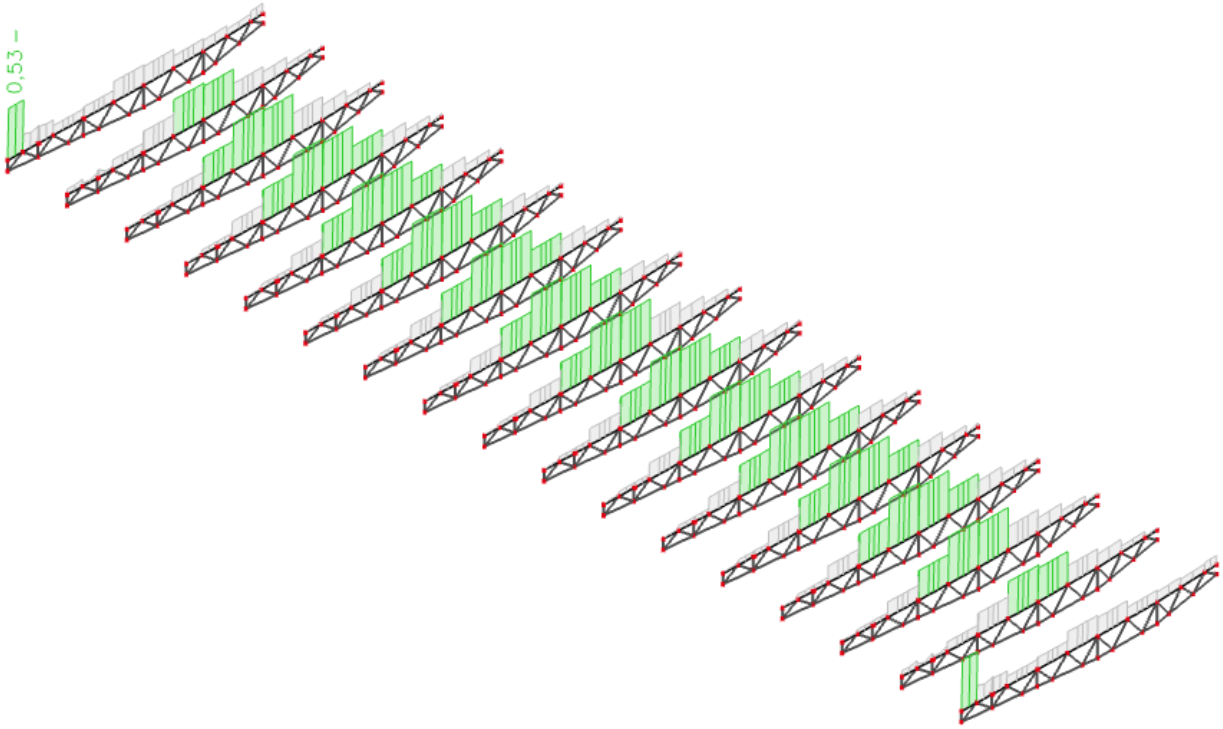
The member satisfies the stability check.

Student version

## 5.11. Dimenzioniranje gornjeg pojasa rešetke pozicije R3

| | | |
|---|---|---|
| Name | R3-GP | |
| Type | SHS400/400/10.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,5500e-02 | |
| A y, z [m²] | 7,7454e-03 | 7,7454e-03 |
| I y, z [m⁴] | 3,9130e-04 | 3,9130e-04 |
| I w [m⁶], t [m⁴] | 8,5333e-06 | 6,0090e-04 |
| $W_{el}$ y, z [m³] | 1,9560e-03 | 1,9560e-03 |
| $W_{pl}$ y, z [m³] | 2,2600e-03 | 2,2600e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 200 | 200 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,5700e+00 | 3,0769e+00 |
| $M_{ply}$ +, - [Nm] | 8,02e+05 | 8,02e+05 |
| $M_{plz}$ +, - [Nm] | 8,02e+05 | 8,02e+05 |

***Tablica 5.10.*** *Karakteristike poprečnog presjeka gornjeg pojasa rešetke pozicije R3*




***Slika 5.14.*** *Prikaz iskoristivosti gornjeg pojasa rešetke pozicije R3*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R3-GP - SHS400/400/10.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp834 | 2,031 / 18,276 m | SHS400/400/10.0 | S 355 | GSN | 0,53 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 2,031 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -707,54 | kN |
| $V_{y,Ed}$ | -22,37 | kN |
| $V_{z,Ed}$ | -109,58 | kN |
| $T_{Ed}$ | -0,85 | kNm |
| $M_{y,Ed}$ | 4,51 | kNm |
| $M_{z,Ed}$ | -47,99 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 370 | 10 | 6,611e+04 | 2,073e+04 | 0,31 | | 1,00 | 37,00 | 22,78 | 27,66 | 40,58 | 3 |
| 3 | I | 370 | 10 | 1,962e+04 | 2,389e+04 | 0,82 | | 1,00 | 37,00 | 22,78 | 27,66 | 32,96 | 4 |
| 5 | I | 370 | 10 | 2,523e+04 | 7,061e+04 | 0,36 | | 1,00 | 37,00 | 22,78 | 27,66 | 39,79 | 3 |
| 7 | I | 370 | 10 | 7,172e+04 | 6,746e+04 | 0,94 | | 1,00 | 37,00 | 22,78 | 27,66 | 31,57 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |
| 3 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |
| 5 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |
| 7 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |

**Effective section My+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 370 | -3,390e+05 | -3,390e+05 | | | | | | | |
| 3 | I | 370 | 3,372e+05 | -3,212e+05 | -0,95 | 22,68 | 0,34 | 1,00 | 189 | 76 | 114 |
| 5 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |
| 7 | I | 370 | 3,372e+05 | -3,212e+05 | -0,95 | 22,68 | 0,34 | 1,00 | 189 | 76 | 114 |

**Effective section Mz-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 370 | 3,372e+05 | -3,212e+05 | -0,95 | 22,68 | 0,34 | 1,00 | 189 | 76 | 114 |
| 3 | I | 370 | -3,390e+05 | -3,390e+05 | | | | | | | |
| 5 | I | 370 | 3,372e+05 | -3,212e+05 | -0,95 | 22,68 | 0,34 | 1,00 | 189 | 76 | 114 |
| 7 | I | 370 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,80 | 0,91 | 335 | 168 | 168 |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 1,4098e-02 | m² | | | |
| Effective second moment of area | $I_{eff,y}$ | 3,7770e-04 | m⁴ | $I_{eff,z}$ | 3,7770e-04 | m⁴ |
| Effective section modulus | $W_{eff,y}$ | 1,8470e-03 | m³ | $W_{eff,z}$ | 1,8470e-03 | m³ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| $A_{eff}$ | 1,4098e-02 | m² |
| $N_{c,Rd}$ | 5004,83 | kN |
| Unity check | 0,14 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,y,min}$ | 1,8470e-03 | m³ |
| $M_{c,y,Rd}$ | 655,70 | kNm |
| Unity check | 0,01 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,z,min}$ | 1,8470e-03 | m³ |
| $M_{c,z,Rd}$ | 655,70 | kNm |
| Unity check | 0,07 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 7,7500e-03 | m² |
| $V_{pl,y,Rd}$ | 1588,43 | kN |
| Unity check | 0,01 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 7,7500e-03 | m² |
| $V_{pl,z,Rd}$ | 1588,43 | kN |
| Unity check | 0,07 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,3 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.3 and formula (6.43)

| Effective properties | | |
|---|---|---|
| $A_{eff}$ | 1,4098e-02 | m² |
| $e_{N,y}$ | 0 | mm |
| $e_{N,z}$ | 0 | mm |
| $W_{eff,y}$ | 1,8470e-03 | m³ |
| $W_{eff,z}$ | 1,8470e-03 | m³ |

| Normal stresses | | |
|---|---|---|
| $\sigma_{N,Ed}$ | 50,2 | MPa |
| $\sigma_{My,Ed}$ | 2,4 | MPa |
| $\sigma_{Mz,Ed}$ | 26,0 | MPa |
| $\sigma_{tot,Ed}$ | 78,6 | MPa |
| Unity check | 0,22 | - |

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m

Student version

Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 370 | 10 | -5,950e+04 | -6,193e+04 | | | | | | | | |
| 3 | I | 370 | 10 | -5,654e+04 | 1,453e+05 | -0,39 | | 0,72 | 37,00 | 34,64 | 41,33 | 59,69 | 2 |
| 5 | I | 370 | 10 | 1,508e+05 | 1,532e+05 | 0,98 | | 1,00 | 37,00 | 22,78 | 27,66 | 31,09 | 4 |
| 7 | I | 370 | 10 | 1,479e+05 | -5,398e+04 | -0,37 | | 0,73 | 37,00 | 33,84 | 40,43 | 58,74 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,031 | 2,031 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,031 | 2,031 | m |
| Critical Euler load $N_{cr}$ | 196685,99 | 196685,99 | kN |
| Slenderness $\lambda$ | 12,78 | 12,78 | |
| Relative slenderness $\lambda_{rel}$ | 0,16 | 0,16 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 1,4098e-02 | $m^2$ |
| Effective section modulus $W_{eff,y}$ | 1,8470e-03 | $m^3$ |
| Effective section modulus $W_{eff,z}$ | 1,8470e-03 | $m^3$ |
| Design compression force $N_{Ed}$ | 707,54 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 213,42 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -47,99 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 5004,83 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 655,70 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 655,70 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,00 | |
| Interaction factor $k_{yz}$ | 0,80 | |
| Interaction factor $k_{zy}$ | 1,00 | |
| Interaction factor $k_{zz}$ | 0,80 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp834 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp834 position 2,031 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 196685,99 | kN |
| Critical Euler load $N_{cr,z}$ | 196685,99 | kN |
| Elastic critical load $N_{cr,T}$ | 1046210,19 | kN |
| Effective section modulus $W_{eff,y}$ | 1,8470e-03 | $m^3$ |
| Second moment of area $I_y$ | 3,9130e-04 | $m^4$ |
| Second moment of area $I_z$ | 3,9130e-04 | $m^4$ |
| Torsional constant $I_t$ | 6,0090e-04 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | 213,42 | kNm |
| Maximum relative deflection $\delta_z$ | -0,7 | mm |
| Equivalent moment factor $C_{my,0}$ | 1,00 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | 0,05 | |
| Equivalent moment factor $C_{mz,0}$ | 0,80 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |

Student version

| Interaction method 1 parameters | | |
|---|---|---|
| Factor $\varepsilon_y$ | 2,30 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 101929,58 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,08 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,26 | |
| Equivalent moment factor $C_{my}$ | 1,00 | |
| Equivalent moment factor $C_{mz}$ | 0,80 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

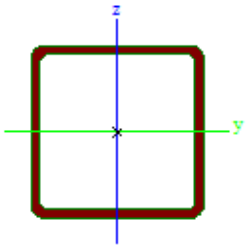
Unity check (6.61) = 0,14 + 0,33 + 0,06 = 0,53 -
Unity check (6.62) = 0,14 + 0,33 + 0,06 = 0,53 -

The member satisfies the stability check.

Student version
Student version
Student version

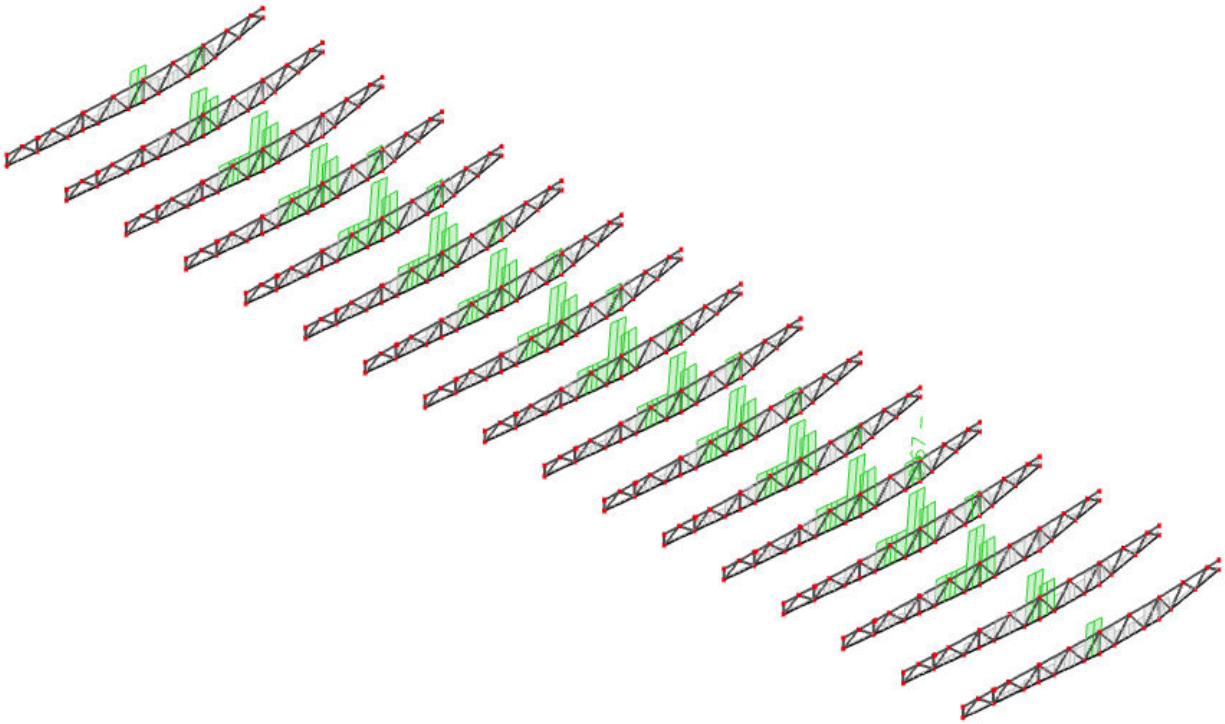
## 5.12. Dimenzioniranje donjeg pojasa rešetke pozicije R3

| | |
|---|---|
| Name | R3-DP |
| Type | SHS400/400/20.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 3,0000e-02 | |
| A y, z [m²] | 1,4981e-02 | 1,4981e-02 |
| I y, z [m⁴] | 7,1540e-04 | 7,1540e-04 |
| I w [m⁶], t [m⁴] | 1,7067e-05 | 1,1250e-03 |
| $W_{el}$ y, z [m³] | 3,5770e-03 | 3,5770e-03 |
| $W_{pl}$ y, z [m³] | 4,2470e-03 | 4,2470e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 200 | 200 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,5500e+00 | 2,9538e+00 |
| $M_{ply}$ +, - [Nm] | 1,51e+06 | 1,51e+06 |
| $M_{plz}$ +, - [Nm] | 1,51e+06 | 1,51e+06 |

***Tablica 5.11.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R3*



***Slika 5.15.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R3*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R3-DP - SHS400/400/20.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp1609 | 18,349 / 18,349 m | SHS400/400/20.0 | S 355 | GSN | 0,67 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 18,349 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -2981,75 | kN |
| $V_{y,Ed}$ | -5,54 | kN |
| $V_{z,Ed}$ | -393,33 | kN |
| $T_{Ed}$ | -5,30 | kNm |
| $M_{y,Ed}$ | -765,57 | kNm |
| $M_{z,Ed}$ | -27,65 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 340 | 20 | 3,094e+05 | 2,963e+05 | 0,96 | | 1,00 | 17,00 | 22,78 | 27,66 | 31,38 | 1 |
| 3 | I | 340 | 20 | 2,741e+05 | -8,981e+04 | -0,33 | | 0,75 | 17,00 | 32,62 | 39,04 | 57,33 | 1 |
| 5 | I | 340 | 20 | -1,104e+05 | -9,729e+04 | | | | | | | | |
| 7 | I | 340 | 20 | -7,511e+04 | 2,888e+05 | -0,26 | | 0,79 | 17,00 | 30,47 | 36,57 | 54,94 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 3,0000e-02 | $m^2$ |
| $N_{c,Rd}$ | 10650,00 | kN |
| Unity check | 0,28 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 4,2470e-03 | $m^3$ |
| $M_{pl,y,Rd}$ | 1507,68 | kNm |
| Unity check | 0,51 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 4,2470e-03 | $m^3$ |
| $M_{pl,z,Rd}$ | 1507,68 | kNm |
| Unity check | 0,02 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,5000e-02 | $m^2$ |
| $V_{pl,y,Rd}$ | 3074,39 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,5000e-02 | $m^2$ |
| $V_{pl,z,Rd}$ | 3074,39 | kN |
| Unity check | 0,13 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,9 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 1415,96 | kNm |
| α | 1,82 | |
| $M_{N,z,Rd}$ | 1415,96 | kNm |
| β | 1,82 | |

Unity check (6.41) = 0,33 + 0,00 = 0,33 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 18,349 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 340 | 20 | 3,094e+05 | 2,963e+05 | 0,96 | | 1,00 | 17,00 | 22,78 | 27,66 | 31,38 | 1 |
| 3 | I | 340 | 20 | 2,741e+05 | -8,981e+04 | -0,33 | | 0,75 | 17,00 | 32,62 | 39,04 | 57,33 | 1 |
| 5 | I | 340 | 20 | -1,104e+05 | -9,729e+04 | | | | | | | | |
| 7 | I | 340 | 20 | -7,511e+04 | 2,888e+05 | -0,26 | | 0,79 | 17,00 | 30,47 | 36,57 | 54,94 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,039 | 8,155 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,039 | 8,155 | m |
| Critical Euler load $N_{cr}$ | 356723,68 | 22295,23 | kN |
| Slenderness λ | 13,20 | 52,81 | |
| Relative slenderness $\lambda_{rel}$ | 0,17 | 0,69 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 1,00 | 0,85 | |
| Buckling resistance $N_{b,Rd}$ | 10650,00 | 9072,28 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 3,0000e-02 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 9072,28 | kN |
| Unity check | 0,33 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 3,0000e-02 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 4,2470e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,2470e-03 | $m^3$ |
| Design compression force $N_{Ed}$ | 2981,75 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -765,57 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -27,65 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 10650,00 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 1507,68 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 1507,68 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 0,85 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,75 | |
| Interaction factor $k_{yz}$ | 0,64 | |
| Interaction factor $k_{zy}$ | 0,46 | |
| Interaction factor $k_{zz}$ | 0,99 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp1609 position 18,349 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp1609 position 18,349 m.

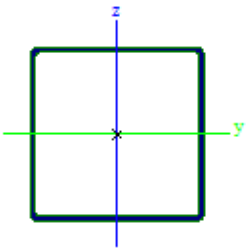
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 356723,68 | kN |
| Critical Euler load $N_{cr,z}$ | 22295,23 | kN |
| Elastic critical load $N_{cr,T}$ | 1916353,00 | kN |
| Plastic section modulus $W_{pl,y}$ | 4,2470e-03 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 3,5770e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,2470e-03 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 3,5770e-03 | $m^3$ |
| Second moment of area $I_y$ | 7,1540e-04 | $m^4$ |
| Second moment of area $I_z$ | 7,1540e-04 | $m^4$ |
| Torsional constant $I_t$ | 1,1250e-03 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,04 | |
| Equivalent moment factor $C_{my,0}$ | 0,78 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -27,65 | kNm |
| Maximum relative deflection $\delta_y$ | 0,4 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,91 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 0,98 | |
| Factor $\varepsilon_y$ | 2,15 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 45141,14 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,18 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,36 | |
| Equivalent moment factor $C_{my}$ | 0,78 | |
| Equivalent moment factor $C_{mz}$ | 0,91 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,19 | |
| Factor $w_z$ | 1,19 | |
| Factor $n_{pl}$ | 0,28 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,69 | |
| Factor $C_{yy}$ | 1,05 | |
| Factor $C_{yz}$ | 0,98 | |
| Factor $C_{zy}$ | 1,01 | |
| Factor $C_{zz}$ | 1,04 | |

Unity check (6.61) = 0,28 + 0,38 + 0,01 = 0,67 -
Unity check (6.62) = 0,33 + 0,23 + 0,02 = 0,58 -

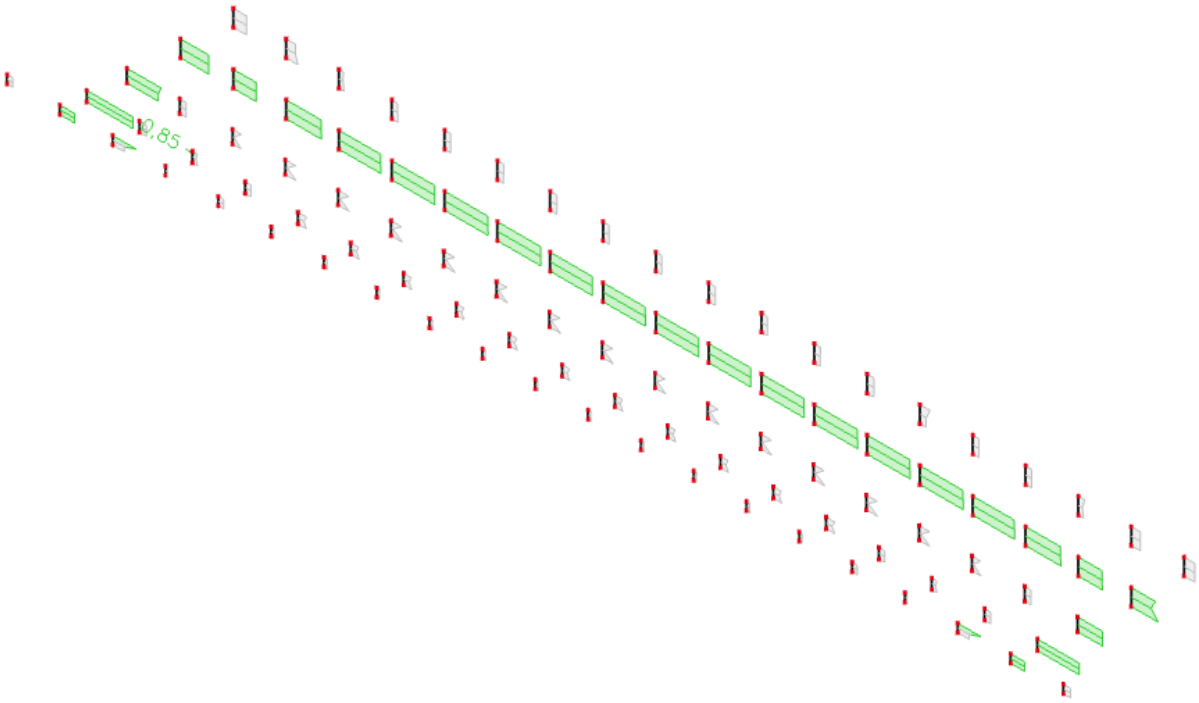
The member satisfies the stability check.

Student version
Student version
Student version

## 5.13. Dimenzioniranje vertikale rešetke pozicije R3

| | | |
|---|---|---|
| Name | R3-V | |
| Type | SHS180/180/5.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 3,4700e-03 | |
| A y, z [m²] | 1,7363e-03 | 1,7363e-03 |
| I y, z [m⁴] | 1,7650e-05 | 1,7650e-05 |
| I w [m⁶], t [m⁴] | 7,8732e-08 | 2,7180e-05 |
| $W_{el}$ y, z [m³] | 1,9600e-04 | 1,9600e-04 |
| $W_{pl}$ y, z [m³] | 2,2700e-04 | 2,2700e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 90 | 90 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,0700e-01 | 1,3784e+00 |
| $M_{ply}$ +, - [Nm] | 8,07e+04 | 8,07e+04 |
| $M_{plz}$ +, - [Nm] | 8,07e+04 | 8,07e+04 |

***Tablica 5.12.*** *Karakteristike poprečnog presjeka vertikale rešetke pozicije R3*




***Slika 5.16.*** *Prikaz iskoristivosti vertikale rešetke pozicije R3*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R3-V - SHS180/180/5.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp9153 | 1,528 / 1,528 m | SHS180/180/5.0 | S 355 | GSN | 0,85 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 1,528 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -308,71 | kN |
| $V_{y,Ed}$ | 32,91 | kN |
| $V_{z,Ed}$ | 15,11 | kN |
| $T_{Ed}$ | 1,24 | kNm |
| $M_{y,Ed}$ | 14,92 | kNm |
| $M_{z,Ed}$ | 10,18 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 165 | 5 | -3,263e+04 | 6,251e+04 | -0,52 | | 0,66 | 33,00 | 39,22 | 46,49 | 65,52 | 1 |
| 3 | I | 165 | 5 | 6,962e+04 | 2,091e+05 | 0,33 | | 1,00 | 33,00 | 22,78 | 27,66 | 40,23 | 3 |
| 5 | I | 165 | 5 | 2,104e+05 | 1,153e+05 | 0,55 | | 1,00 | 33,00 | 22,78 | 27,66 | 36,67 | 3 |
| 7 | I | 165 | 5 | 1,082e+05 | -3,129e+04 | -0,29 | | 0,78 | 33,00 | 31,39 | 37,63 | 55,95 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient ε | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 27,66 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 30,92 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Web class 2 slenderness limit $\beta_{2,z,w}$ | 27,66 | |
| Web class 3 slenderness limit $\beta_{3,z,w}$ | 30,92 | |
| Web slenderness ratio $c/t_w$ | 33,00 | |
| Flange slenderness ratio c/tf | 33,00 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 1,00 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 1,00 | |
| Interpolated section modulus $W_{3,y}$ | 1,9600e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 1,9600e-04 | $m^3$ |

**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 3,4700e-03 | $m^2$ |
| $N_{c,Rd}$ | 1231,85 | kN |
| Unity check | 0,25 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,y}$ | 1,9600e-04 | $m^3$ |
| $M_{3,y,Rd}$ | 69,58 | kNm |
| Unity check | 0,21 | - |

Student version

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,z}$ | 1,9600e-04 | $m^3$ |
| $M_{3,z,Rd}$ | 69,58 | kNm |
| Unity check | 0,15 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,7350e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 355,60 | kN |
| Unity check | 0,09 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,7350e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 355,60 | kN |
| Unity check | 0,04 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 4,0 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,02 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,3,y,Rd}$ | 52,14 | kNm |
| α | 1,79 | |
| $M_{N,3,z,Rd}$ | 52,14 | kNm |
| β | 1,79 | |

Unity check (6.41) = 0,11 + 0,05 = 0,16 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,764 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 165 | 5 | 1,420e+05 | 2,180e+03 | 0,02 | | 1,00 | 33,00 | 22,78 | 27,66 | 46,96 | 3 |
| 3 | I | 165 | 5 | -1,102e+03 | 3,042e+04 | -0,04 | | 0,97 | 33,00 | 23,80 | 28,85 | 48,28 | 3 |
| 5 | I | 165 | 5 | 3,562e+04 | 1,754e+05 | 0,20 | | 1,00 | 33,00 | 22,78 | 27,66 | 42,74 | 3 |
| 7 | I | 165 | 5 | 1,787e+05 | 1,472e+05 | 0,82 | | 1,00 | 33,00 | 22,78 | 27,66 | 32,93 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |
| 3 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |
| 5 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |
| 7 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |

**Effective section My+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 165 | -3,498e+05 | -3,498e+05 | | | | | | | |
| 3 | I | 165 | 3,349e+05 | -3,296e+05 | -0,98 | 23,48 | 0,29 | 1,00 | 83 | 33 | 50 |
| 5 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |
| 7 | I | 165 | 3,349e+05 | -3,296e+05 | -0,98 | 23,48 | 0,29 | 1,00 | 83 | 33 | 50 |

**Effective section Mz+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 165 | 3,349e+05 | -3,296e+05 | -0,98 | 23,48 | 0,29 | 1,00 | 83 | 33 | 50 |
| 3 | I | 165 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,71 | 0,97 | 160 | 80 | 80 |
| 5 | I | 165 | 3,349e+05 | -3,296e+05 | -0,98 | 23,48 | 0,29 | 1,00 | 83 | 33 | 50 |
| 7 | I | 165 | -3,498e+05 | -3,498e+05 | | | | | | | |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 3,3706e-03 | $m^2$ | | | |
| Effective second moment of area | $I_{eff,y}$ | 1,7455e-05 | $m^4$ | $I_{eff,z}$ | 1,7455e-05 | $m^4$ |
| Effective section modulus | $W_{eff,y}$ | 1,9255e-04 | $m^3$ | $W_{eff,z}$ | 1,9255e-04 | $m^3$ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 1,528 | 1,528 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 1,528 | 1,528 | m |
| Critical Euler load $N_{cr}$ | 15672,68 | 15672,68 | kN |
| Slenderness $\lambda$ | 21,42 | 21,42 | |
| Relative slenderness $\lambda_{rel}$ | 0,28 | 0,28 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 3,3706e-03 | $m^2$ |
| Effective section modulus $W_{eff,y}$ | 1,9255e-04 | $m^3$ |
| Effective section modulus $W_{eff,z}$ | 1,9255e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 308,71 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 14,92 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -40,09 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1196,56 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 68,36 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 68,36 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,68 | |
| Interaction factor $k_{yz}$ | 0,75 | |
| Interaction factor $k_{zy}$ | 0,68 | |
| Interaction factor $k_{zz}$ | 0,75 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp9153 position 1,528 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp9153 position 0,000 m.

Student version

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 15672,68 | kN |
| Critical Euler load $N_{cr,z}$ | 15672,68 | kN |
| Elastic critical load $N_{cr,T}$ | 222671,71 | kN |
| Effective section modulus $W_{eff,y}$ | 1,9255e-04 | $m^3$ |
| Second moment of area $I_y$ | 1,7650e-05 | $m^4$ |
| Second moment of area $I_z$ | 1,7650e-05 | $m^4$ |
| Torsional constant $I_t$ | 2,7180e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,55 | |
| Equivalent moment factor $C_{my,0}$ | 0,67 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,25 | |
| Equivalent moment factor $C_{mz,0}$ | 0,73 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 0,85 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 5958,36 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,11 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,31 | |
| Equivalent moment factor $C_{my}$ | 0,67 | |
| Equivalent moment factor $C_{mz}$ | 0,73 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

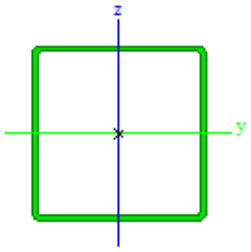
Unity check (6.61) = 0,26 + 0,15 + 0,44 = 0,85 -
Unity check (6.62) = 0,26 + 0,15 + 0,44 = 0,85 -

The member satisfies the stability check.

Student version
Student version

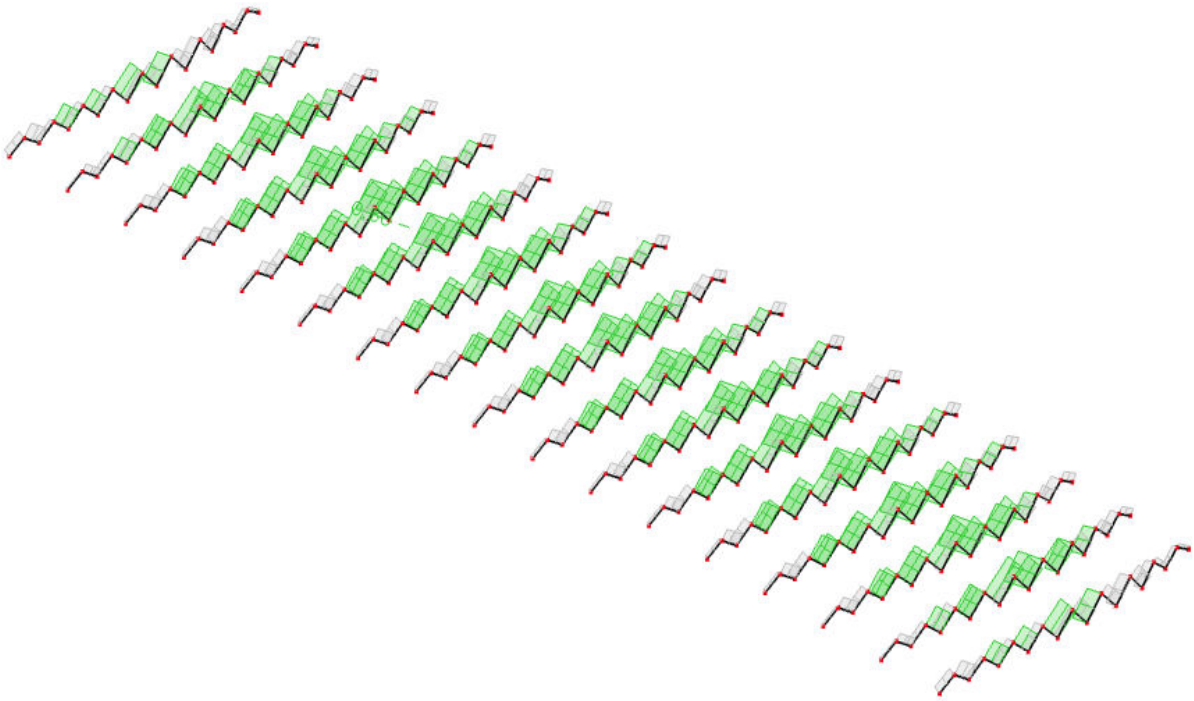
## 5.14. Dimenzioniranje ispune rešetke pozicije R3

| | |
|---|---|
| Name | R3-I |
| Type | SHS200/200/6.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | roled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 4,6200e-03 | |
| A y, z [m²] | 2,3083e-03 | 2,3083e-03 |
| I y, z [m⁴] | 2,8830e-05 | 2,8830e-05 |
| I w [m⁶], t [m⁴] | 1,6000e-07 | 4,4490e-05 |
| $W_{el}$ y, z [m³] | 2,8800e-04 | 2,8800e-04 |
| $W_{pl}$ y, z [m³] | 3,3500e-04 | 3,3500e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,8500e-01 | 1,5261e+00 |
| $M_{ply}$ +, - [Nm] | 1,19e+05 | 1,19e+05 |
| $M_{plz}$ +, - [Nm] | 1,19e+05 | 1,19e+05 |

***Tablica 5.13.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R3*



***Slika 5.17.*** *Prikaz iskoristivosti ispune rešetke pozicije R3*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R3-I - SHS200/200/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp1398 | 0,000 / 3,202 m | SHS200/200/6.0 | S 355 | GSN | 0,80 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -999,75 | kN |
| $V_{y,Ed}$ | -0,24 | kN |
| $V_{z,Ed}$ | -8,04 | kN |
| $T_{Ed}$ | 0,19 | kNm |
| $M_{y,Ed}$ | 13,34 | kNm |
| $M_{z,Ed}$ | 0,56 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 182 | 6 | 1,699e+05 | 1,734e+05 | 0,98 | | 1,00 | 30,33 | 22,78 | 27,66 | 31,14 | 3 |
| 3 | I | 182 | 6 | 1,763e+05 | 2,605e+05 | 0,68 | | 1,00 | 30,33 | 22,78 | 27,66 | 34,82 | 3 |
| 5 | I | 182 | 6 | 2,632e+05 | 2,597e+05 | 0,99 | | 1,00 | 30,33 | 22,78 | 27,66 | 31,06 | 3 |
| 7 | I | 182 | 6 | 2,568e+05 | 1,725e+05 | 0,67 | | 1,00 | 30,33 | 22,78 | 27,66 | 34,89 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient ε | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 27,66 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 30,92 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Web class 2 slenderness limit $\beta_{2,z,w}$ | 27,66 | |
| Web class 3 slenderness limit $\beta_{3,z,w}$ | 30,92 | |
| Web slenderness ratio $c/t_w$ | 30,33 | |
| Flange slenderness ratio c/tf | 30,33 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 0,82 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 0,82 | |
| Interpolated section modulus $W_{3,y}$ | 2,9644e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 2,9644e-04 | $m^3$ |

**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 4,6200e-03 | $m^2$ |
| $N_{c,Rd}$ | 1640,10 | kN |
| Unity check | 0,61 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,y}$ | 2,9644e-04 | $m^3$ |
| $M_{3,y,Rd}$ | 105,23 | kNm |
| Unity check | 0,13 | - |

Student version

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,z}$ | 2,9644e-04 | $m^3$ |
| $M_{3,z,Rd}$ | 105,23 | kNm |
| Unity check | 0,01 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 2,3100e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 473,46 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 2,3100e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 473,46 | kN |
| Unity check | 0,02 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,4 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,3,y,Rd}$ | 41,09 | kNm |
| α | 2,86 | |
| $M_{N,3,z,Rd}$ | 41,09 | kNm |
| β | 2,86 | |

Unity check (6.41) = 0,04 + 0,00 = 0,04 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 3,202 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 182 | 6 | 2,638e+05 | 2,626e+05 | 1,00 | | 1,00 | 30,33 | 22,78 | 27,66 | 30,97 | 3 |
| 3 | I | 182 | 6 | 2,596e+05 | 1,716e+05 | 0,66 | | 1,00 | 30,33 | 22,78 | 27,66 | 35,04 | 3 |
| 5 | I | 182 | 6 | 1,687e+05 | 1,700e+05 | 0,99 | | 1,00 | 30,33 | 22,78 | 27,66 | 31,00 | 3 |
| 7 | I | 182 | 6 | 1,729e+05 | 2,610e+05 | 0,66 | | 1,00 | 30,33 | 22,78 | 27,66 | 35,02 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 3,202 | 3,202 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_\sigma$ | 3,202 | 3,202 | m |
| Critical Euler load $N_\sigma$ | 5829,61 | 5829,61 | kN |
| Slenderness λ | 40,53 | 40,53 | |
| Relative slenderness $\lambda_{rel}$ | 0,53 | 0,53 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,91 | 0,91 | |
| Buckling resistance $N_{b,Rd}$ | 1499,97 | 1499,97 | kN |

Student version

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 4,6200e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1499,97 | kN |
| Unity check | 0,67 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 4,6200e-03 | $m^2$ |
| Interpolated section modulus $W_{3,y}$ | 2,9644e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 2,9644e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 999,75 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -13,95 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 0,56 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1640,10 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 105,23 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 105,23 | kNm |
| Reduction factor $\chi_y$ | 0,91 | |
| Reduction factor $\chi_z$ | 0,91 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,96 | |
| Interaction factor $k_{yz}$ | 0,48 | |
| Interaction factor $k_{zy}$ | 0,59 | |
| Interaction factor $k_{zz}$ | 0,78 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp1398 position 3,202 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp1398 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 5829,61 | kN |
| Critical Euler load $N_{cr,z}$ | 5829,61 | kN |
| Elastic critical load $N_{cr,T}$ | 290514,84 | kN |
| Interpolated section modulus $W_{3,y}$ | 2,9644e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 2,8800e-04 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 2,9644e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 2,8800e-04 | $m^3$ |
| Second moment of area $I_y$ | 2,8830e-05 | $m^4$ |
| Second moment of area $I_z$ | 2,8830e-05 | $m^4$ |
| Torsional constant $I_t$ | 4,4490e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -13,95 | kNm |
| Maximum relative deflection $\delta_z$ | 0,0 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,83 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,36 | |
| Equivalent moment factor $C_{mz,0}$ | 0,67 | |
| Factor $\mu_y$ | 0,98 | |
| Factor $\mu_z$ | 0,98 | |
| Factor $\varepsilon_y$ | 0,22 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 4597,49 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,15 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,31 | |
| Equivalent moment factor $C_{my}$ | 0,83 | |
| Equivalent moment factor $C_{mz}$ | 0,67 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,03 | |
| Factor $w_z$ | 1,03 | |
| Factor $n_{pl}$ | 0,61 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,53 | |
| Factor $C_{yy}$ | 1,02 | |
| Factor $C_{yz}$ | 1,01 | |
| Factor $C_{zy}$ | 0,99 | |
| Factor $C_{zz}$ | 1,03 | |

Student version

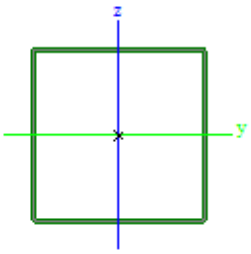
Unity check (6.61) = 0,67 + 0,13 + 0,00 = 0,80 -
Unity check (6.62) = 0,67 + 0,08 + 0,00 = 0,75 -

The member satisfies the stability check.

Student version
Student version
Student version

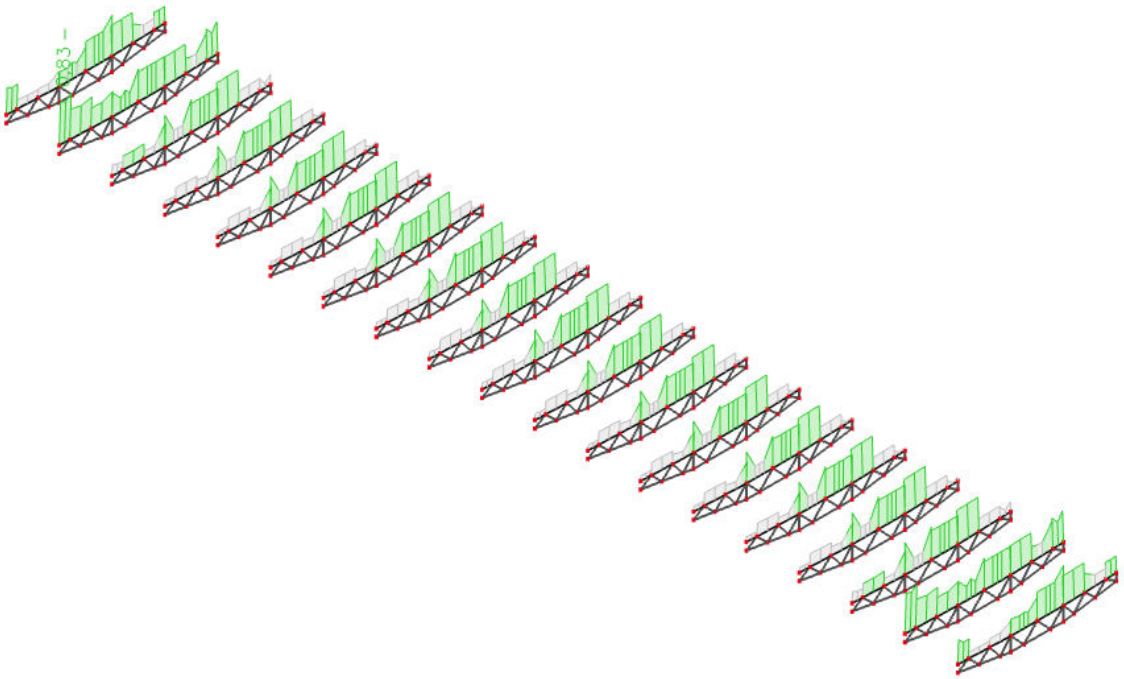
## 5.15. Dimenzioniranje gornjeg pojasa rešetke pozicije R4

| | |
|---|---|
| Name | R4-GP |
| Type | SHS200/200/4.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | roled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | x |




| | | |
|---|---|---|
| A [m²] | 3,1300e-03 | |
| A y, z [m²] | 1,5593e-03 | 1,5593e-03 |
| I y, z [m⁴] | 2,0000e-05 | 2,0000e-05 |
| I w [m⁶], t [m⁴] | 1,0667e-07 | 3,0410e-05 |
| $W_{el}$ y, z [m³] | 2,0000e-04 | 2,0000e-04 |
| $W_{pl}$ y, z [m³] | 2,2875e-04 | 2,2875e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,8965e-01 | 1,5508e+00 |
| $M_{ply}$ +, - [Nm] | 8,12e+04 | 8,12e+04 |
| $M_{plz}$ +, - [Nm] | 8,12e+04 | 8,12e+04 |

***Tablica 5.14.*** *Karakteristike poprečnog presjeka gornjeg pojasa rešetke pozicije R4*



***Slika 5.18.*** *Prikaz iskoristivosti gornjeg pojasa rešetke pozicije R4*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R4-GP - SHS200/200/4.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp886 | 1,601 / 8,006 m | SHS200/200/4.0 | S 355 | GSN | 0,83 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 1,601 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -410,96 | kN |
| $V_{y,Ed}$ | -21,74 | kN |
| $V_{z,Ed}$ | 1,24 | kN |
| $T_{Ed}$ | -8,44 | kNm |
| $M_{y,Ed}$ | 4,44 | kNm |
| $M_{z,Ed}$ | -17,03 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 188 | 4 | 1,904e+05 | 2,951e+04 | 0,16 | | 1,00 | 47,00 | 22,78 | 27,66 | 43,74 | 4 |
| 3 | I | 188 | 4 | 2,698e+04 | 6,886e+04 | 0,39 | | 1,00 | 47,00 | 22,78 | 27,66 | 39,19 | 4 |
| 5 | I | 188 | 4 | 7,318e+04 | 2,340e+05 | 0,31 | | 1,00 | 47,00 | 22,78 | 27,66 | 40,60 | 4 |
| 7 | I | 188 | 4 | 2,366e+05 | 1,947e+05 | 0,82 | | 1,00 | 47,00 | 22,78 | 27,66 | 32,94 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |
| 3 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |
| 5 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |
| 7 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |

**Effective section My+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 188 | -3,157e+05 | -3,157e+05 | | | | | | | |
| 3 | I | 188 | 3,413e+05 | -3,020e+05 | -0,88 | 21,03 | 0,44 | 1,00 | 100 | 40 | 60 |
| 5 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |
| 7 | I | 188 | 3,413e+05 | -3,020e+05 | -0,88 | 21,03 | 0,44 | 1,00 | 100 | 40 | 60 |

**Effective section Mz-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 188 | 3,413e+05 | -3,020e+05 | -0,88 | 21,03 | 0,44 | 1,00 | 100 | 40 | 60 |
| 3 | I | 188 | -3,157e+05 | -3,157e+05 | | | | | | | |
| 5 | I | 188 | 3,413e+05 | -3,020e+05 | -0,88 | 21,03 | 0,44 | 1,00 | 100 | 40 | 60 |
| 7 | I | 188 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 1,02 | 0,77 | 145 | 72 | 72 |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 2,4286e-03 | m² | | | |
| Effective second moment of area | $I_{eff,y}$ | 1,8155e-05 | m⁴ | $I_{eff,z}$ | 1,8155e-05 | m⁴ |
| Effective section modulus | $W_{eff,y}$ | 1,7170e-04 | m³ | $W_{eff,z}$ | 1,7170e-04 | m³ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| $A_{eff}$ | 2,4286e-03 | m² |
| $N_{c,Rd}$ | 862,16 | kN |
| Unity check | 0,48 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,y,min}$ | 1,7170e-04 | m³ |
| $M_{c,y,Rd}$ | 60,95 | kNm |
| Unity check | 0,07 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,z,min}$ | 1,7170e-04 | m³ |
| $M_{c,z,Rd}$ | 60,95 | kNm |
| Unity check | 0,28 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,5650e-03 | m² |
| $V_{pl,y,Rd}$ | 320,76 | kN |
| Unity check | 0,07 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,5650e-03 | m² |
| $V_{pl,z,Rd}$ | 320,76 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 27,5 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,13 | - |

**Combined Shear and Torsion check for $V_y$ and $\tau_{t,Ed}$**
According to EN 1993-1-1 article 6.2.6 & 6.2.7 and formula (6.25),(6.28)

| | | |
|---|---|---|
| $V_{pl,T,y,Rd}$ | 277,80 | kN |
| Unity check | 0,08 | - |

**Combined Shear and Torsion check for $V_z$ and $\tau_{t,Ed}$**
According to EN 1993-1-1 article 6.2.6 & 6.2.7 and formula (6.25),(6.28)

| | | |
|---|---|---|
| $V_{pl,T,z,Rd}$ | 277,80 | kN |
| Unity check | 0,00 | - |

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.3 and formula (6.43)

| Effective properties | | |
|---|---|---|
| $A_{eff}$ | 2,4286e-03 | m² |
| $e_{N,y}$ | 0 | mm |
| $e_{N,z}$ | 0 | mm |
| $W_{eff,y}$ | 1,7170e-04 | m³ |
| $W_{eff,z}$ | 1,7170e-04 | m³ |

Student version
Student version
Student version

| Normal stresses | | |
|---|---|---|
| $\sigma_{N,Ed}$ | 169,2 | MPa |
| $\sigma_{My,Ed}$ | 25,8 | MPa |
| $\sigma_{Mz,Ed}$ | 99,2 | MPa |
| $\sigma_{tot,Ed}$ | 294,3 | MPa |
| Unity check | 0,83 | - |

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 1,601 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 188 | 4 | 1,904e+05 | 2,951e+04 | 0,16 | | 1,00 | 47,00 | 22,78 | 27,66 | 43,74 | 4 |
| 3 | I | 188 | 4 | 2,698e+04 | 6,886e+04 | 0,39 | | 1,00 | 47,00 | 22,78 | 27,66 | 39,19 | 4 |
| 5 | I | 188 | 4 | 7,318e+04 | 2,340e+05 | 0,31 | | 1,00 | 47,00 | 22,78 | 27,66 | 40,60 | 4 |
| 7 | I | 188 | 4 | 2,366e+05 | 1,947e+05 | 0,82 | | 1,00 | 47,00 | 22,78 | 27,66 | 32,94 | 4 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 1,601 | 1,601 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 1,601 | 1,601 | m |
| Critical Euler load $N_{cr}$ | 16169,58 | 16169,58 | kN |
| Slenderness λ | 20,03 | 20,03 | |
| Relative slenderness $\lambda_{rel}$ | 0,23 | 0,23 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 2,4286e-03 | $m^2$ |
| Effective section modulus $W_{eff,y}$ | 1,7170e-04 | $m^3$ |
| Effective section modulus $W_{eff,z}$ | 1,7170e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 410,96 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 4,44 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 17,77 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 862,16 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 60,95 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 60,95 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,02 | |
| Interaction factor $k_{yz}$ | 0,59 | |
| Interaction factor $k_{zy}$ | 1,02 | |
| Interaction factor $k_{zz}$ | 0,59 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp886 position 1,601 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp886 position 0,000 m.

Student version

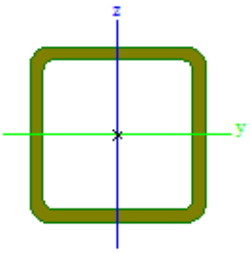
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 16169,58 | kN |
| Critical Euler load $N_{cr,z}$ | 16169,58 | kN |
| Elastic critical load $N_{cr,T}$ | 198945,15 | kN |
| Effective section modulus $W_{eff,y}$ | 1,7170e-04 | $m^3$ |
| Second moment of area $I_y$ | 2,0000e-05 | $m^4$ |
| Second moment of area $I_z$ | 2,0000e-05 | $m^4$ |
| Torsional constant $I_t$ | 3,0410e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | 4,44 | kNm |
| Maximum relative deflection $\delta_z$ | -0,2 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,99 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,96 | |
| Equivalent moment factor $C_{mz,0}$ | 0,58 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 0,15 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 6411,71 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,10 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,24 | |
| Equivalent moment factor $C_{my}$ | 0,99 | |
| Equivalent moment factor $C_{mz}$ | 0,58 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

Unity check (6.61) = 0,48 + 0,07 + 0,17 = 0,72 -
Unity check (6.62) = 0,48 + 0,07 + 0,17 = 0,72 -

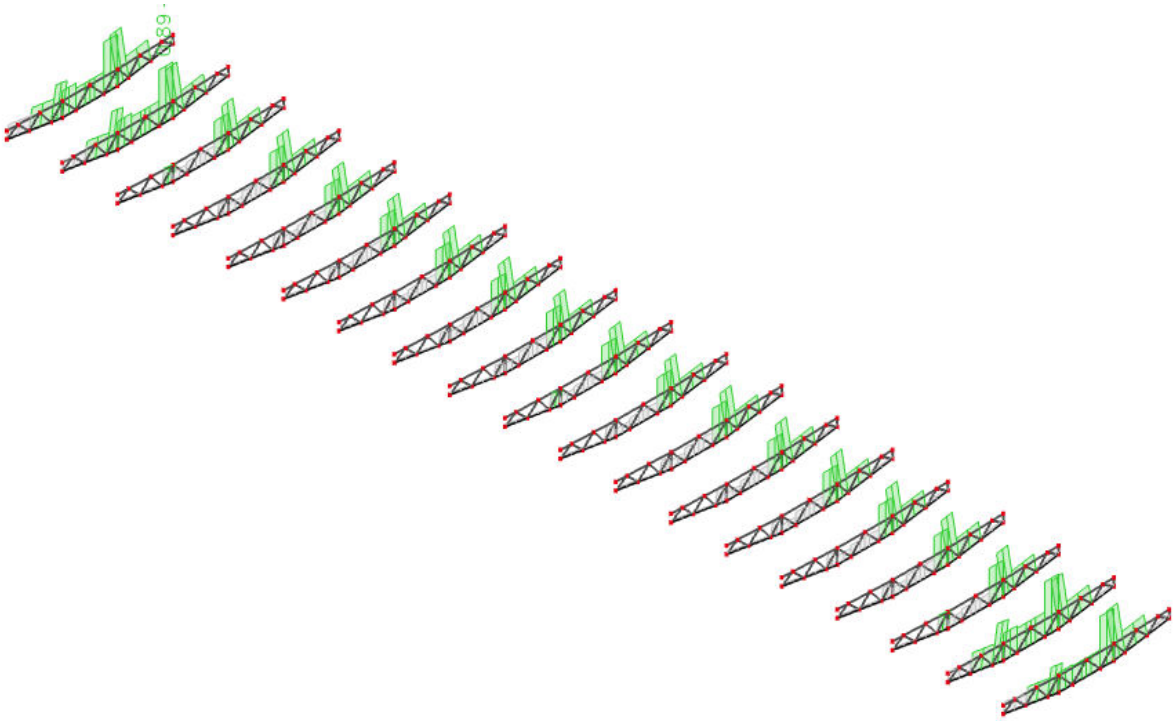
The member satisfies the stability check.

Student version
Student version
Student version

## 5.16. Dimenzioniranje donjeg pojasa rešetke pozicije R4

| | | |
|---|---|---|
| Name | R4-DP | |
| Type | SHS200/200/14.2 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | roled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,0300e-02 | |
| A y, z [m²] | 5,1665e-03 | 5,1665e-03 |
| I y, z [m⁴] | 5,8720e-05 | 5,8720e-05 |
| I w [m⁶], t [m⁴] | 3,7867e-07 | 9,4170e-05 |
| $W_{el}$ y, z [m³] | 5,8700e-04 | 5,8700e-04 |
| $W_{pl}$ y, z [m³] | 7,1400e-04 | 7,1400e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,6300e-01 | 1,4252e+00 |
| $M_{ply}$ +, - [Nm] | 2,53e+05 | 2,53e+05 |
| $M_{plz}$ +, - [Nm] | 2,53e+05 | 2,53e+05 |

***Tablica 5.15.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R4*



***Slika 5.19.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R4*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R4-DP - SHS200/200/14.2

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp899 | 8,000 / 8,000 m | SHS200/200/14.2 | S 355 | GSN | 0,89 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 8,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -1139,19 | kN |
| $V_{y,Ed}$ | 1,18 | kN |
| $V_{z,Ed}$ | -66,34 | kN |
| $T_{Ed}$ | 0,23 | kNm |
| $M_{y,Ed}$ | -107,75 | kNm |
| $M_{z,Ed}$ | 4,96 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 157 | 14 | 2,741e+05 | 2,874e+05 | 0,95 | | 1,00 | 11,08 | 22,78 | 27,66 | 31,42 | 1 |
| 3 | I | 157 | 14 | 2,625e+05 | -2,638e+04 | -0,10 | | 0,91 | 11,08 | 25,64 | 31,00 | 50,02 | 1 |
| 5 | I | 157 | 14 | -5,364e+04 | -6,693e+04 | | | | | | | | |
| 7 | I | 157 | 14 | -4,207e+04 | 2,468e+05 | -0,17 | | 0,85 | 11,08 | 27,71 | 33,40 | 52,06 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,0300e-02 | $m^2$ |
| $N_{c,Rd}$ | 3656,50 | kN |
| Unity check | 0,31 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 253,47 | kNm |
| Unity check | 0,43 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 253,47 | kNm |
| Unity check | 0,02 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 5,1500e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 1055,54 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 5,1500e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 1055,54 | kN |
| Unity check | 0,06 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 224,95 | kNm |
| $\alpha$ | 1,86 | |
| $M_{N,z,Rd}$ | 224,95 | kNm |
| $\beta$ | 1,86 | |

Unity check (6.41) = 0,25 + 0,00 = 0,25 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 157 | 14 | 2,741e+05 | 2,874e+05 | 0,95 | | 1,00 | 11,08 | 22,78 | 27,66 | 31,42 | 1 |
| 3 | I | 157 | 14 | 2,625e+05 | -2,638e+04 | -0,10 | | 0,91 | 11,08 | 25,64 | 31,00 | 50,02 | 1 |
| 5 | I | 157 | 14 | -5,364e+04 | -6,693e+04 | | | | | | | | |
| 7 | I | 157 | 14 | -4,207e+04 | 2,468e+05 | -0,17 | | 0,85 | 11,08 | 27,71 | 33,40 | 52,06 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,000 | 8,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,000 | 8,000 | m |
| Critical Euler load $N_{cr}$ | 30426,02 | 1901,63 | kN |
| Slenderness $\lambda$ | 26,49 | 105,95 | |
| Relative slenderness $\lambda_{rel}$ | 0,35 | 1,39 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection $\alpha$ | 0,21 | 0,21 | |
| Reduction factor $\chi$ | 0,97 | 0,42 | |
| Buckling resistance $N_{b,Rd}$ | 3533,37 | 1552,11 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,0300e-02 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1552,11 | kN |
| Unity check | 0,73 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,0300e-02 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 1139,19 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -107,75 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -5,26 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 3656,50 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 253,47 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 253,47 | kNm |
| Reduction factor $\chi_y$ | 0,97 | |
| Reduction factor $\chi_z$ | 0,42 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,79 | |
| Interaction factor $k_{yz}$ | 0,82 | |
| Interaction factor $k_{zy}$ | 0,32 | |
| Interaction factor $k_{zz}$ | 0,66 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp899 position 8,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp899 position 0,000 m.

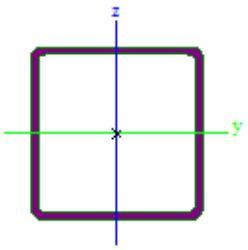
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 30426,02 | kN |
| Critical Euler load $N_{cr,z}$ | 1901,63 | kN |
| Elastic critical load $N_{cr,T}$ | 668158,25 | kN |
| Plastic section modulus $W_{pl,y}$ | 7,1400e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 5,8700e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 7,1400e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 5,8700e-04 | $m^3$ |
| Second moment of area $I_y$ | 5,8720e-05 | $m^4$ |
| Second moment of area $I_z$ | 5,8720e-05 | $m^4$ |
| Torsional constant $I_t$ | 9,4170e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,21 | |
| Equivalent moment factor $C_{my,0}$ | 0,74 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -5,26 | kNm |
| Maximum relative deflection $\delta_y$ | -0,6 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,52 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 0,54 | |
| Factor $\varepsilon_y$ | 1,66 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 3806,20 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,26 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,21 | |
| Equivalent moment factor $C_{my}$ | 0,74 | |
| Equivalent moment factor $C_{mz}$ | 0,52 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,22 | |
| Factor $w_z$ | 1,22 | |
| Factor $n_{pl}$ | 0,31 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,39 | |
| Factor $C_{yy}$ | 0,97 | |
| Factor $C_{yz}$ | 0,95 | |
| Factor $C_{zy}$ | 0,76 | |
| Factor $C_{zz}$ | 1,05 | |

Unity check (6.61) = 0,32 + 0,33 + 0,02 = 0,67 -
Unity check (6.62) = 0,73 + 0,14 + 0,01 = 0,89 -

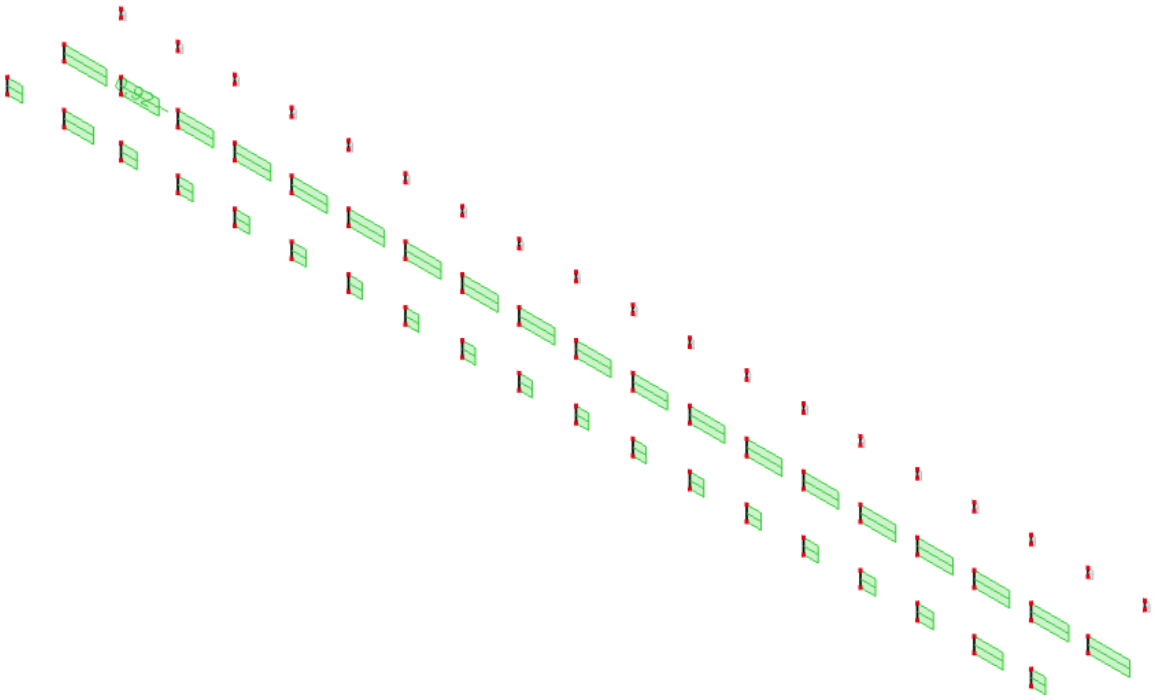
The member satisfies the stability check.

Student version

## 5.17. Dimenzioniranje vertikale rešetke pozicije R4

| | | |
|---|---|---|
| Name | R4-V | |
| Type | SHS140/140/6.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 3,1800e-03 | |
| A y, z [m²] | 1,5883e-03 | 1,5883e-03 |
| I y, z [m⁴] | 9,4400e-06 | 9,4400e-06 |
| I w [m⁶], t [m⁴] | 2,6891e-08 | 1,4750e-05 |
| $W_{el}$ y, z [m³] | 1,3500e-04 | 1,3500e-04 |
| $W_{pl}$ y, z [m³] | 1,5900e-04 | 1,5900e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 70 | 70 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 5,4500e-01 | 1,0461e+00 |
| $M_{ply}$ +, - [Nm] | 5,64e+04 | 5,64e+04 |
| $M_{plz}$ +, - [Nm] | 5,64e+04 | 5,64e+04 |

***Tablica 5.16.*** *Karakteristike poprečnog presjeka vertikale rešetke pozicije R4*



***Slika 5.20.*** *Prikaz iskoristivosti vertikale rešetke pozicije R4*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R4-V - SHS140/140/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp847 | 2,100 / 2,100 m | SHS140/140/6.0 | S 355 | GSN | 0,92 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 2,100 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -601,34 | kN |
| $V_{y,Ed}$ | 14,85 | kN |
| $V_{z,Ed}$ | -6,34 | kN |
| $T_{Ed}$ | -0,07 | kNm |
| $M_{y,Ed}$ | -13,17 | kNm |
| $M_{z,Ed}$ | 20,68 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 122 | 6 | 1,491e+05 | 4,163e+05 | 0,36 | | 1,00 | 20,33 | 22,78 | 27,66 | 39,78 | 1 |
| 3 | I | 122 | 6 | 4,211e+05 | 2,510e+05 | 0,60 | | 1,00 | 20,33 | 22,78 | 27,66 | 35,96 | 1 |
| 5 | I | 122 | 6 | 2,295e+05 | -3,778e+04 | -0,16 | | 0,86 | 20,33 | 27,54 | 33,20 | 51,89 | 1 |
| 7 | I | 122 | 6 | -4,256e+04 | 1,276e+05 | -0,33 | | 0,75 | 20,33 | 32,81 | 39,26 | 57,55 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 3,1800e-03 | $m^2$ |
| $N_{c,Rd}$ | 1128,90 | kN |
| Unity check | 0,53 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 1,5900e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 56,44 | kNm |
| Unity check | 0,23 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 1,5900e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 56,44 | kNm |
| Unity check | 0,37 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,5900e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 325,89 | kN |
| Unity check | 0,05 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,5900e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 325,89 | kN |
| Unity check | 0,02 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,3 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 34,52 | kNm |
| α | 2,44 | |
| $M_{N,z,Rd}$ | 34,52 | kNm |
| β | 2,44 | |

Unity check (6.41) = 0,09 + 0,29 = 0,38 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 2,100 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 122 | 6 | 1,491e+05 | 4,163e+05 | 0,36 | | 1,00 | 20,33 | 22,78 | 27,66 | 39,78 | 1 |
| 3 | I | 122 | 6 | 4,211e+05 | 2,510e+05 | 0,60 | | 1,00 | 20,33 | 22,78 | 27,66 | 35,96 | 1 |
| 5 | I | 122 | 6 | 2,295e+05 | -3,778e+04 | -0,16 | | 0,86 | 20,33 | 27,54 | 33,20 | 51,89 | 1 |
| 7 | I | 122 | 6 | -4,255e+04 | 1,276e+05 | -0,33 | | 0,75 | 20,33 | 32,81 | 39,26 | 57,55 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,100 | 2,100 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,100 | 2,100 | m |
| Critical Euler load $N_{cr}$ | 4436,62 | 4436,62 | kN |
| Slenderness λ | 38,54 | 38,54 | |
| Relative slenderness $\lambda_{rel}$ | 0,50 | 0,50 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,92 | 0,92 | |
| Buckling resistance $N_{b,Rd}$ | 1041,85 | 1041,85 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 3,1800e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1041,85 | kN |
| Unity check | 0,58 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 3,1800e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 1,5900e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 1,5900e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 601,34 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -13,17 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 20,68 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1128,90 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 56,44 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 56,44 | kNm |
| Reduction factor $\chi_y$ | 0,92 | |
| Reduction factor $\chi_z$ | 0,92 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,78 | |
| Interaction factor $k_{yz}$ | 0,39 | |
| Interaction factor $k_{zy}$ | 0,48 | |
| Interaction factor $k_{zz}$ | 0,64 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp847 position 2,100 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp847 position 2,100 m.

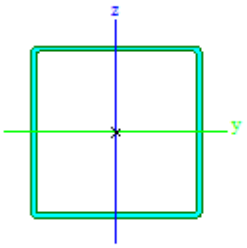
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 4436,62 | kN |
| Critical Euler load $N_{cr,z}$ | 4436,62 | kN |
| Elastic critical load $N_{cr,T}$ | 202789,76 | kN |
| Plastic section modulus $W_{pl,y}$ | 1,5900e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 1,3500e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 1,5900e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 1,3500e-04 | $m^3$ |
| Second moment of area $I_y$ | 9,4400e-06 | $m^4$ |
| Second moment of area $I_z$ | 9,4400e-06 | $m^4$ |
| Torsional constant $I_t$ | 1,4750e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_y$ | -0,01 | |
| Equivalent moment factor $C_{my,0}$ | 0,77 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,51 | |
| Equivalent moment factor $C_{mz,0}$ | 0,64 | |
| Factor $\mu_y$ | 0,99 | |
| Factor $\mu_z$ | 0,99 | |
| Factor $\varepsilon_y$ | 0,52 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 2311,20 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,16 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,26 | |
| Equivalent moment factor $C_{my}$ | 0,77 | |
| Equivalent moment factor $C_{mz}$ | 0,64 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,18 | |
| Factor $w_z$ | 1,18 | |
| Factor $n_{pl}$ | 0,53 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,50 | |
| Factor $C_{yy}$ | 1,13 | |
| Factor $C_{yz}$ | 1,13 | |
| Factor $C_{zy}$ | 1,10 | |
| Factor $C_{zz}$ | 1,15 | |

Unity check (6.61) = 0,58 + 0,18 + 0,14 = 0,90 -
Unity check (6.62) = 0,58 + 0,11 + 0,23 = 0,92 -

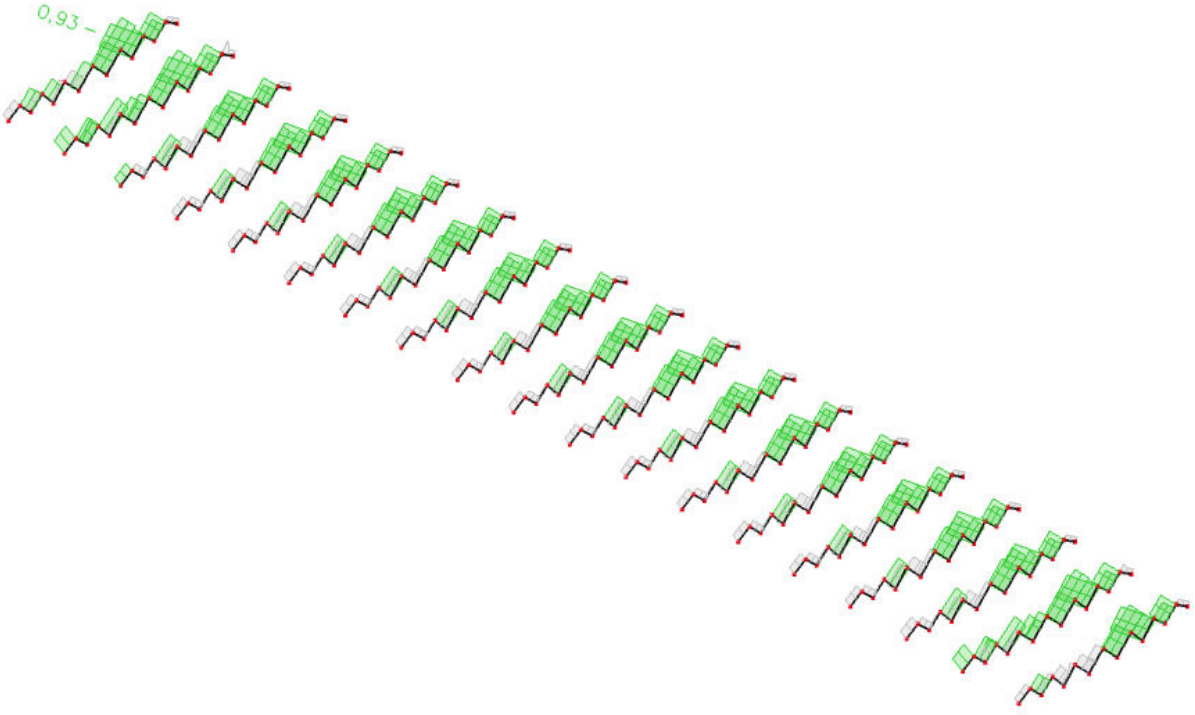
The member satisfies the stability check.

Student version

## 5.18. Dimenzioniranje ispune rešetke pozicije R4

| | | |
|---|---|---|
| Name | R4-I | |
| Type | SHS140/140/4.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 2,1760e-03 | |
| A y, z [m²] | 1,0793e-03 | 1,0793e-03 |
| I y, z [m⁴] | 6,7060e-06 | 6,7060e-06 |
| I w [m⁶], t [m⁴] | 1,7927e-08 | 1,0190e-05 |
| $W_{el}$ y, z [m³] | 9,5800e-05 | 9,5800e-05 |
| $W_{pl}$ y, z [m³] | 1,0976e-04 | 1,0976e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 70 | 70 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 5,4965e-01 | 1,0708e+00 |
| $M_{ply}$ +, - [Nm] | 3,90e+04 | 3,90e+04 |
| $M_{plz}$ +, - [Nm] | 3,90e+04 | 3,90e+04 |

***Tablica 5.17.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R4*




***Slika 5.21.*** *Prikaz iskoristivosti ispune rešetke pozicije R4*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R4-I - SHS140/140/4.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp882 | 0,000 / 2,530 m | SHS140/140/4.0 | S 355 | GSN | 0,93 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -457,62 | kN |
| $V_{y,Ed}$ | -1,49 | kN |
| $V_{z,Ed}$ | -3,04 | kN |
| $T_{Ed}$ | 0,92 | kNm |
| $M_{y,Ed}$ | 5,09 | kNm |
| $M_{z,Ed}$ | 3,41 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 128 | 4 | 1,269e+05 | 1,927e+05 | 0,66 | | 1,00 | 32,00 | 22,78 | 27,66 | 35,07 | 3 |
| 3 | I | 128 | 4 | 1,978e+05 | 2,961e+05 | 0,67 | | 1,00 | 32,00 | 22,78 | 27,66 | 34,94 | 3 |
| 5 | I | 128 | 4 | 2,971e+05 | 2,313e+05 | 0,78 | | 1,00 | 32,00 | 22,78 | 27,66 | 33,49 | 3 |
| 7 | I | 128 | 4 | 2,261e+05 | 1,279e+05 | 0,57 | | 1,00 | 32,00 | 22,78 | 27,66 | 36,41 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 3

| Semi-Comp+ properties | | |
|---|---|---|
| Material coefficient ε | 0,81 | |
| Flange class 2 slenderness limit $\beta_{2,y,f}$ | 27,66 | |
| Flange class 3 slenderness limit $\beta_{3,y,f}$ | 30,92 | |
| Web class 2 slenderness limit $\beta_{2,y,w}$ | 67,53 | |
| Web class 3 slenderness limit $\beta_{3,y,w}$ | 100,89 | |
| Web class 2 slenderness limit $\beta_{2,z,w}$ | 27,66 | |
| Web class 3 slenderness limit $\beta_{3,z,w}$ | 30,92 | |
| Web slenderness ratio $c/t_w$ | 32,00 | |
| Flange slenderness ratio c/tf | 32,00 | |
| Reference slenderness ratio $c/t_{ref,y}$ | 1,00 | |
| Reference slenderness ratio $c/t_{ref,z}$ | 1,00 | |
| Interpolated section modulus $W_{3,y}$ | 9,5800e-05 | $m^3$ |
| Interpolated section modulus $W_{3,z}$ | 9,5800e-05 | $m^3$ |

**Note:** The resistance for this semi-compact section has been calculated according to Semi-Comp+.

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 2,1760e-03 | $m^2$ |
| $N_{c,Rd}$ | 772,48 | kN |
| Unity check | 0,59 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,y}$ | 9,5800e-05 | $m^3$ |
| $M_{3,y,Rd}$ | 34,01 | kNm |
| Unity check | 0,15 | - |

Student version

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{3,z}$ | 9,5800e-05 | $m^3$ |
| $M_{3,z,Rd}$ | 34,01 | kNm |
| Unity check | 0,10 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,0880e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 223,00 | kN |
| Unity check | 0,01 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,0880e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 223,00 | kN |
| Unity check | 0,01 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 6,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,03 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,3,y,Rd}$ | 13,86 | kNm |
| α | 2,75 | |
| $M_{N,3,z,Rd}$ | 13,86 | kNm |
| β | 2,75 | |

Unity check (6.41) = 0,06 + 0,02 = 0,08 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 2,530 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 128 | 4 | 2,468e+05 | 2,396e+05 | 0,97 | | 1,00 | 32,00 | 22,78 | 27,66 | 31,23 | 4 |
| 3 | I | 128 | 4 | 2,375e+05 | 1,783e+05 | 0,75 | | 1,00 | 32,00 | 22,78 | 27,66 | 33,84 | 3 |
| 5 | I | 128 | 4 | 1,767e+05 | 1,839e+05 | 0,96 | | 1,00 | 32,00 | 22,78 | 27,66 | 31,34 | 4 |
| 7 | I | 128 | 4 | 1,860e+05 | 2,452e+05 | 0,76 | | 1,00 | 32,00 | 22,78 | 27,66 | 33,74 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | ψ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | ρ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |
| 3 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |
| 5 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |
| 7 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |

**Effective section My+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 128 | -3,525e+05 | -3,525e+05 | | | | | | | |
| 3 | I | 128 | 3,342e+05 | -3,317e+05 | -0,99 | 23,69 | 0,28 | 1,00 | 64 | 26 | 39 |
| 5 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |
| 7 | I | 128 | 3,342e+05 | -3,317e+05 | -0,99 | 23,69 | 0,28 | 1,00 | 64 | 26 | 39 |

**Effective section Mz+**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 128 | 3,342e+05 | -3,317e+05 | -0,99 | 23,69 | 0,28 | 1,00 | 64 | 26 | 39 |
| 3 | I | 128 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,69 | 0,99 | 126 | 63 | 63 |
| 5 | I | 128 | 3,342e+05 | -3,317e+05 | -0,99 | 23,69 | 0,28 | 1,00 | 64 | 26 | 39 |
| 7 | I | 128 | -3,525e+05 | -3,525e+05 | | | | | | | |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 2,1287e-03 | m² | | | |
| Effective second moment of area | $I_{eff,y}$ | 6,5909e-06 | m⁴ | $I_{eff,z}$ | 6,5909e-06 | m⁴ |
| Effective section modulus | $W_{eff,y}$ | 9,3838e-05 | m³ | $W_{eff,z}$ | 9,3838e-05 | m³ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,530 | 2,530 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,530 | 2,530 | m |
| Critical Euler load $N_{cr}$ | 2171,17 | 2171,17 | kN |
| Slenderness $\lambda$ | 45,58 | 45,58 | |
| Relative slenderness $\lambda_{rel}$ | 0,59 | 0,59 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection $\alpha$ | 0,21 | 0,21 | |
| Reduction factor $\chi$ | 0,89 | 0,89 | |
| Buckling resistance $N_{b,Rd}$ | 675,41 | 675,41 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section effective area $A_{eff}$ | 2,1287e-03 | m² |
| Buckling resistance $N_{b,Rd}$ | 675,41 | kN |
| Unity check | 0,68 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 2,1287e-03 | m² |
| Effective section modulus $W_{eff,y}$ | 9,3838e-05 | m³ |
| Effective section modulus $W_{eff,z}$ | 9,3838e-05 | m³ |
| Design compression force $N_{Ed}$ | 457,62 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | 5,09 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 3,41 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 755,69 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 33,31 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 33,31 | kNm |
| Reduction factor $\chi_y$ | 0,89 | |
| Reduction factor $\chi_z$ | 0,89 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,04 | |
| Interaction factor $k_{yz}$ | 0,90 | |
| Interaction factor $k_{zy}$ | 1,04 | |
| Interaction factor $k_{zz}$ | 0,90 | |

Student version

Maximum moment $M_{y,Ed}$ is derived from beam pp882 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp882 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 2171,17 | kN |
| Critical Euler load $N_{cr,z}$ | 2171,17 | kN |
| Elastic critical load $N_{cr,T}$ | 134473,74 | kN |
| Effective section modulus $W_{eff,y}$ | 9,3838e-05 | $m^3$ |
| Second moment of area $I_y$ | 6,7060e-06 | $m^4$ |
| Second moment of area $I_z$ | 6,7060e-06 | $m^4$ |
| Torsional constant $I_t$ | 1,0190e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | 5,09 | kNm |
| Maximum relative deflection $\delta_z$ | -0,6 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,85 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,11 | |
| Equivalent moment factor $C_{mz,0}$ | 0,73 | |
| Factor $\mu_y$ | 0,97 | |
| Factor $\mu_z$ | 0,97 | |
| Factor $\varepsilon_y$ | 0,25 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 1341,48 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,16 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,29 | |
| Equivalent moment factor $C_{my}$ | 0,85 | |
| Equivalent moment factor $C_{mz}$ | 0,73 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

Unity check (6.61) = 0,68 + 0,16 + 0,09 = 0,93 -
Unity check (6.62) = 0,68 + 0,16 + 0,09 = 0,93 -

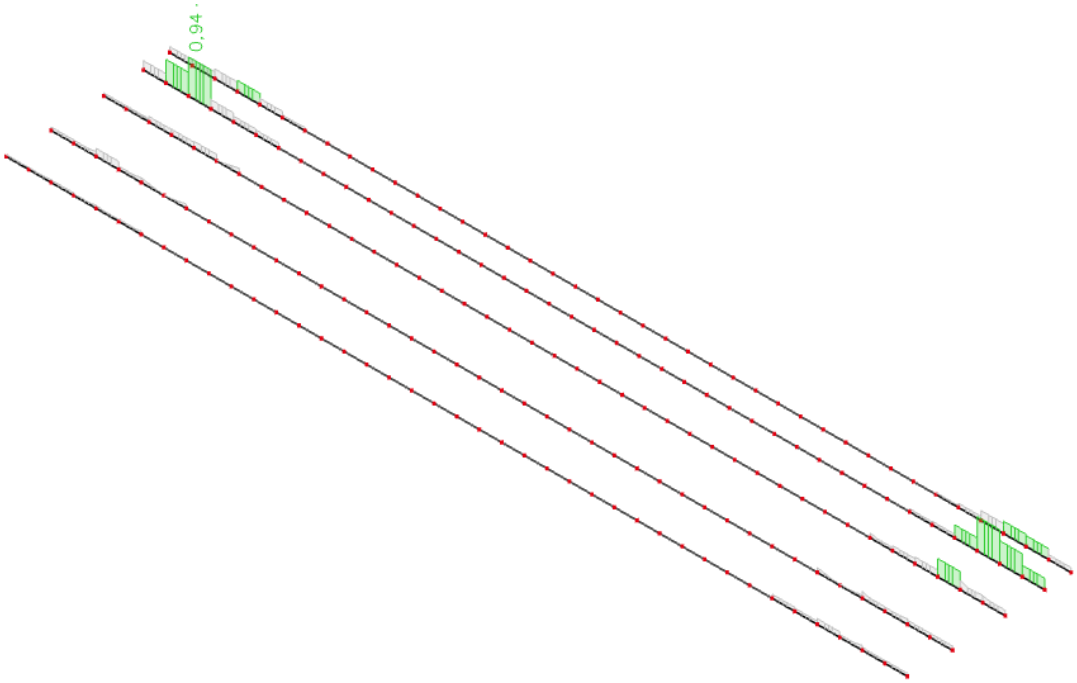
The member satisfies the stability check.

Student version
Student version
Student version

## 5.19. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 1)

| | | |
|---|---|---|
| Name | R5-DP1 | |
| Type | SHS350/350/16.0 | |
| Source description | Corus Advance Sections | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
| A [m²] | 2,1100e-02 | |
| A y, z [m²] | 1,0464e-02 | 1,0464e-02 |
| I y, z [m⁴] | 3,8900e-04 | 3,8900e-04 |
| I w [m⁶], t [m⁴] | 7,0029e-06 | 6,1000e-04 |
| $W_{el}$ y, z [m³] | 2,2300e-03 | 2,2300e-03 |
| $W_{pl}$ y, z [m³] | 2,6028e-03 | 2,6028e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 175 | 175 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,3600e+00 | 2,6168e+00 |
| $M_{ply}$ +, - [Nm] | 9,24e+05 | 9,24e+05 |
| $M_{plz}$ +, - [Nm] | 9,24e+05 | 9,24e+05 |

***Tablica 5.18.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R5 (segment 1)*




***Slika 5.22.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R5 (segment 1)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R5-DP1 - SHS350/350/16.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| | | | | | |
|---|---|---|---|---|---|
| **Member pp9002** | **8,000 / 8,000 m** | **SHS350/350/16.0** | **S 355** | **GSN** | **0,94 -** |

| **Combination key** |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| **Partial safety factors** | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| **Material** | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 8,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -1572,40 | kN |
| $V_{y,Ed}$ | 9,32 | kN |
| $V_{z,Ed}$ | -121,00 | kN |
| $T_{Ed}$ | 6,78 | kNm |
| $M_{y,Ed}$ | -420,79 | kNm |
| $M_{z,Ed}$ | 41,65 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 302 | 16 | 2,411e+05 | 2,738e+05 | 0,88 | | 1,00 | 18,87 | 22,78 | 27,66 | 32,25 | 1 |
| 3 | I | 302 | 16 | 2,580e+05 | -7,171e+04 | -0,28 | | 0,78 | 18,87 | 31,03 | 37,22 | 55,55 | 1 |
| 5 | I | 302 | 16 | -9,090e+04 | -1,235e+05 | | | | | | | | |
| 7 | I | 302 | 16 | -1,078e+05 | 2,219e+05 | -0,49 | | 0,67 | 18,87 | 37,94 | 45,05 | 63,82 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 2,1100e-02 | $m^2$ |
| $N_{c,Rd}$ | 7490,50 | kN |
| Unity check | 0,21 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 2,6028e-03 | $m^3$ |
| $M_{pl,y,Rd}$ | 923,99 | kNm |
| Unity check | 0,46 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 2,6028e-03 | $m^3$ |
| $M_{pl,z,Rd}$ | 923,99 | kNm |
| Unity check | 0,05 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,0550e-02 | $m^2$ |
| $V_{pl,y,Rd}$ | 2162,32 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,0550e-02 | $m^2$ |
| $V_{pl,z,Rd}$ | 2162,32 | kN |
| Unity check | 0,06 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 1,9 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,01 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 923,99 | kNm |
| α | 1,75 | |
| $M_{N,z,Rd}$ | 923,99 | kNm |
| β | 1,75 | |

Unity check (6.41) = 0,25 + 0,00 = 0,26 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 302 | 16 | 2,411e+05 | 2,738e+05 | 0,88 | | 1,00 | 18,87 | 22,78 | 27,66 | 32,25 | 1 |
| 3 | I | 302 | 16 | 2,580e+05 | -7,171e+04 | -0,28 | | 0,78 | 18,87 | 31,03 | 37,22 | 55,55 | 1 |
| 5 | I | 302 | 16 | -9,090e+04 | -1,235e+05 | | | | | | | | |
| 7 | I | 302 | 16 | -1,078e+05 | 2,219e+05 | -0,49 | | 0,67 | 18,87 | 37,94 | 45,05 | 63,82 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,000 | 16,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,000 | 16,000 | m |
| Critical Euler load $N_{cr}$ | 50390,50 | 3149,41 | kN |
| Slenderness λ | 29,46 | 117,84 | |
| Relative slenderness $\lambda_{rel}$ | 0,39 | 1,54 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,96 | 0,36 | |
| Buckling resistance $N_{b,Rd}$ | 7165,03 | 2660,45 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 2,1100e-02 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 2660,45 | kN |
| Unity check | 0,59 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 2,1100e-02 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 2,6028e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,6028e-03 | $m^3$ |
| Design compression force $N_{Ed}$ | 1572,40 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -420,79 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 41,65 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 7490,50 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 923,99 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 923,99 | kNm |
| Reduction factor $\chi_y$ | 0,96 | |
| Reduction factor $\chi_z$ | 0,36 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,15 | |
| Interaction factor $k_{yz}$ | 0,95 | |
| Interaction factor $k_{zy}$ | 0,68 | |
| Interaction factor $k_{zz}$ | 0,81 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp9002 position 8,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp9002 position 8,000 m.

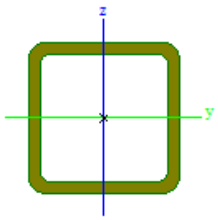
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 50390,50 | kN |
| Critical Euler load $N_{cr,z}$ | 3149,41 | kN |
| Elastic critical load $N_{cr,T}$ | 1337759,73 | kN |
| Plastic section modulus $W_{pl,y}$ | 2,6028e-03 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 2,2300e-03 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,6028e-03 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 2,2300e-03 | $m^3$ |
| Second moment of area $I_y$ | 3,8900e-04 | $m^4$ |
| Second moment of area $I_z$ | 3,8900e-04 | $m^4$ |
| Torsional constant $I_t$ | 6,1000e-04 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -420,79 | kNm |
| Maximum relative deflection $\delta_z$ | 4,6 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,99 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | 41,65 | kNm |
| Maximum relative deflection $\delta_y$ | -4,2 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,66 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 0,61 | |
| Factor $\varepsilon_y$ | 2,53 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 12463,84 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,27 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,20 | |
| Equivalent moment factor $C_{my}$ | 0,99 | |
| Equivalent moment factor $C_{mz}$ | 0,66 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,17 | |
| Factor $w_z$ | 1,17 | |
| Factor $n_{pl}$ | 0,21 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,54 | |
| Factor $C_{yy}$ | 0,89 | |
| Factor $C_{yz}$ | 0,83 | |
| Factor $C_{zy}$ | 0,55 | |
| Factor $C_{zz}$ | 0,99 | |

Unity check (6.61) = 0,22 + 0,52 + 0,04 = 0,78 -
Unity check (6.62) = 0,59 + 0,31 + 0,04 = 0,94 -

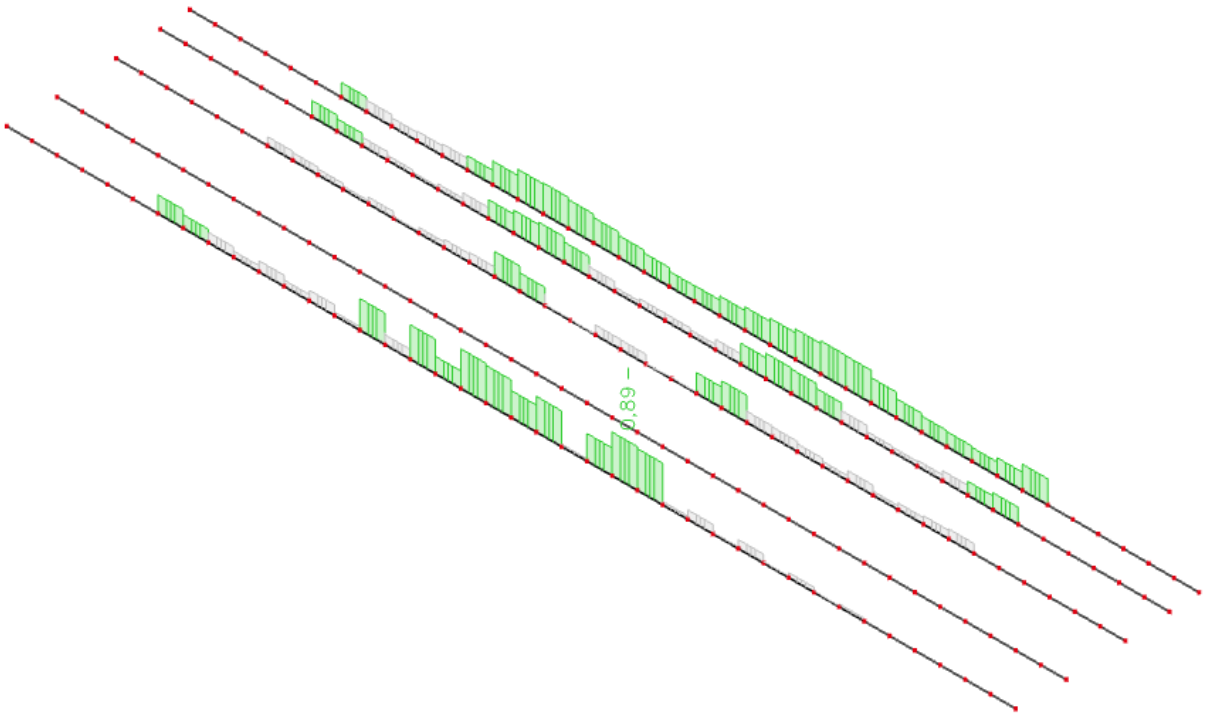
The member satisfies the stability check.

Student version
Student version
Student version

## 5.20. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 2)

| | | |
|---|---|---|
| Name | R5-DP2 | |
| Type | SHS80/80/6.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,7400e-03 | |
| A y, z [m²] | 8,6833e-04 | 8,6833e-04 |
| I y, z [m⁴] | 1,5600e-06 | 1,5600e-06 |
| I w [m⁶], t [m⁴] | 1,6384e-09 | 2,5200e-06 |
| $W_{el}$ y, z [m³] | 3,9100e-05 | 3,9100e-05 |
| $W_{pl}$ y, z [m³] | 4,7800e-05 | 4,7800e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 40 | 40 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 3,0500e-01 | 5,6613e-01 |
| $M_{ply}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |
| $M_{plz}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |

***Tablica 5.19.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R5 (segment 2)*




***Slika 5.23.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R5 (segment 2)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R5-DP2 - SHS80/80/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp7742 | 4,000 / 8,000 m | SHS80/80/6.0 | S 355 | GSN | 0,89 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 4,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -42,13 | kN |
| $V_{y,Ed}$ | -0,02 | kN |
| $V_{z,Ed}$ | 0,44 | kN |
| $T_{Ed}$ | 0,00 | kNm |
| $M_{y,Ed}$ | -0,27 | kNm |
| $M_{z,Ed}$ | 0,07 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 2,938e+04 | 3,207e+04 | 0,92 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,85 | 1 |
| 3 | I | 62 | 6 | 3,128e+04 | 2,044e+04 | 0,65 | | 1,00 | 10,33 | 22,78 | 27,66 | 35,15 | 1 |
| 5 | I | 62 | 6 | 1,913e+04 | 1,643e+04 | 0,86 | | 1,00 | 10,33 | 22,78 | 27,66 | 32,51 | 1 |
| 7 | I | 62 | 6 | 1,722e+04 | 2,806e+04 | 0,61 | | 1,00 | 10,33 | 22,78 | 27,66 | 35,71 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,7400e-03 | $m^2$ |
| $N_{c,Rd}$ | 617,70 | kN |
| Unity check | 0,07 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 16,97 | kNm |
| Unity check | 0,02 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 16,97 | kNm |
| Unity check | 0,00 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,y,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,z,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,0 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 16,97 | kNm |
| α | 1,67 | |
| $M_{N,z,Rd}$ | 16,97 | kNm |
| β | 1,67 | |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 3,653e+04 | 3,337e+04 | 0,91 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,87 | 1 |
| 3 | I | 62 | 6 | 3,114e+04 | 1,124e+04 | 0,36 | | 1,00 | 10,33 | 22,78 | 27,66 | 39,72 | 1 |
| 5 | I | 62 | 6 | 9,625e+03 | 1,279e+04 | 0,75 | | 1,00 | 10,33 | 22,78 | 27,66 | 33,82 | 1 |
| 7 | I | 62 | 6 | 1,502e+04 | 3,491e+04 | 0,43 | | 1,00 | 10,33 | 22,78 | 27,66 | 38,54 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,000 | 8,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,000 | 8,000 | m |
| Critical Euler load $N_{cr}$ | 202,08 | 50,52 | kN |
| Slenderness λ | 133,59 | 267,18 | |
| Relative slenderness $\lambda_{rel}$ | 1,75 | 3,50 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,28 | 0,08 | |
| Buckling resistance $N_{b,Rd}$ | 175,92 | 47,60 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 47,60 | kN |
| Unity check | 0,89 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 42,13 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,27 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,08 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 617,70 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 16,97 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 16,97 | kNm |
| Reduction factor $\chi_y$ | 0,28 | |
| Reduction factor $\chi_z$ | 0,08 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,26 | |
| Interaction factor $k_{yz}$ | 2,13 | |
| Interaction factor $k_{zy}$ | 0,27 | |
| Interaction factor $k_{zz}$ | 0,61 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp7742 position 4,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp7742 position 0,000 m.

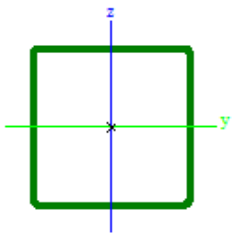
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 202,08 | kN |
| Critical Euler load $N_{cr,z}$ | 50,52 | kN |
| Elastic critical load $N_{cr,T}$ | 113541,42 | kN |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 3,9100e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 3,9100e-05 | $m^3$ |
| Second moment of area $I_y$ | 1,5600e-06 | $m^4$ |
| Second moment of area $I_z$ | 1,5600e-06 | $m^4$ |
| Torsional constant $I_t$ | 2,5200e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,27 | kNm |
| Maximum relative deflection $\delta_z$ | -1,2 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,97 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,08 | kNm |
| Maximum relative deflection $\delta_y$ | -0,7 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,53 | |
| Factor $\mu_y$ | 0,84 | |
| Factor $\mu_z$ | 0,18 | |
| Factor $\varepsilon_y$ | 0,29 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 101,42 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,41 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,21 | |
| Equivalent moment factor $C_{my}$ | 0,97 | |
| Equivalent moment factor $C_{mz}$ | 0,53 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,22 | |
| Factor $w_z$ | 1,22 | |
| Factor $n_{pl}$ | 0,07 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 3,50 | |
| Factor $C_{yy}$ | 0,82 | |
| Factor $C_{yz}$ | 0,76 | |
| Factor $C_{zy}$ | 0,49 | |
| Factor $C_{zz}$ | 0,94 | |

Unity check (6.61) = 0,24 + 0,02 + 0,01 = 0,27 -
Unity check (6.62) = 0,89 + 0,00 + 0,00 = 0,89 -

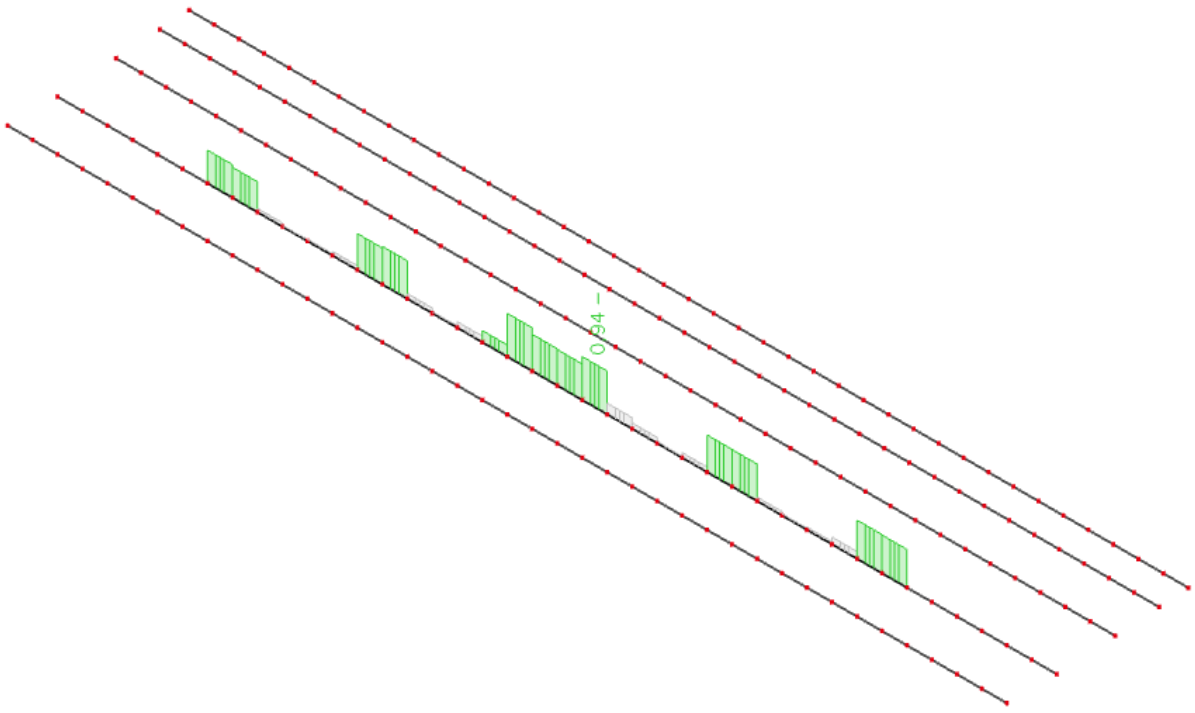
The member satisfies the stability check.

Student version
Student version
Student version

## 5.21. Dimenzioniranje donjeg pojasa rešetke pozicije R5 (segment 3)

| | | |
|---|---|---|
| Name | R5-DP3 | |
| Type | SHS150/150/5.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 2,8700e-03 | |
| A y, z [m²] | 1,4363e-03 | 1,4363e-03 |
| I y, z [m⁴] | 1,0020e-05 | 1,0020e-05 |
| I w [m⁶], t [m⁴] | 3,1641e-08 | 1,5500e-05 |
| $W_{el}$ y, z [m³] | 1,3400e-04 | 1,3400e-04 |
| $W_{pl}$ y, z [m³] | 1,5600e-04 | 1,5600e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 75 | 75 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 5,8700e-01 | 1,1384e+00 |
| $M_{ply}$ +, - [Nm] | 5,53e+04 | 5,53e+04 |
| $M_{plz}$ +, - [Nm] | 5,53e+04 | 5,53e+04 |

***Tablica 5.20.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R5 (segment 3)*




***Slika 5.24.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R5 (segment 3)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R5-DP3 - SHS150/150/5.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp7724 | 0,000 / 8,000 m | SHS150/150/5.0 | S 355 | GSN | 0,94 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -258,84 | kN |
| $V_{y,Ed}$ | 0,15 | kN |
| $V_{z,Ed}$ | 1,81 | kN |
| $T_{Ed}$ | -0,15 | kNm |
| $M_{y,Ed}$ | -3,75 | kNm |
| $M_{z,Ed}$ | -0,42 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 135 | 5 | 1,200e+05 | 1,144e+05 | 0,95 | | 1,00 | 27,00 | 22,78 | 27,66 | 31,43 | 2 |
| 3 | I | 135 | 5 | 1,123e+05 | 6,181e+04 | 0,55 | | 1,00 | 27,00 | 22,78 | 27,66 | 36,63 | 2 |
| 5 | I | 135 | 5 | 6,015e+04 | 6,579e+04 | 0,91 | | 1,00 | 27,00 | 22,78 | 27,66 | 31,86 | 2 |
| 7 | I | 135 | 5 | 6,787e+04 | 1,184e+05 | 0,57 | | 1,00 | 27,00 | 22,78 | 27,66 | 36,29 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 2,8700e-03 | $m^2$ |
| $N_{c,Rd}$ | 1018,85 | kN |
| Unity check | 0,25 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 1,5600e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 55,38 | kNm |
| Unity check | 0,07 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 1,5600e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 55,38 | kNm |
| Unity check | 0,01 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,4350e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 294,12 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,4350e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 294,12 | kN |
| Unity check | 0,01 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,7 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 54,26 | kNm |
| α | 1,79 | |
| $M_{N,z,Rd}$ | 54,26 | kNm |
| β | 1,79 | |

Unity check (6.41) = 0,01 + 0,00 = 0,01 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 135 | 5 | 1,200e+05 | 1,144e+05 | 0,95 | | 1,00 | 27,00 | 22,78 | 27,66 | 31,43 | 2 |
| 3 | I | 135 | 5 | 1,123e+05 | 6,181e+04 | 0,55 | | 1,00 | 27,00 | 22,78 | 27,66 | 36,63 | 2 |
| 5 | I | 135 | 5 | 6,015e+04 | 6,579e+04 | 0,91 | | 1,00 | 27,00 | 22,78 | 27,66 | 31,86 | 2 |
| 7 | I | 135 | 5 | 6,787e+04 | 1,184e+05 | 0,57 | | 1,00 | 27,00 | 22,78 | 27,66 | 36,29 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,000 | 8,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,000 | 8,000 | m |
| Critical Euler load $N_{cr}$ | 1297,98 | 324,49 | kN |
| Slenderness λ | 67,70 | 135,39 | |
| Relative slenderness $\lambda_{rel}$ | 0,89 | 1,77 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,74 | 0,28 | |
| Buckling resistance $N_{b,Rd}$ | 757,11 | 283,25 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 2,8700e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 283,25 | kN |
| Unity check | 0,91 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 2,8700e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 1,5600e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 1,5600e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 258,84 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -3,75 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,42 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 1018,85 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 55,38 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 55,38 | kNm |
| Reduction factor $\chi_y$ | 0,74 | |
| Reduction factor $\chi_z$ | 0,28 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,16 | |
| Interaction factor $k_{yz}$ | 0,88 | |
| Interaction factor $k_{zy}$ | 0,33 | |
| Interaction factor $k_{zz}$ | 0,38 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp7724 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp7724 position 0,000 m.

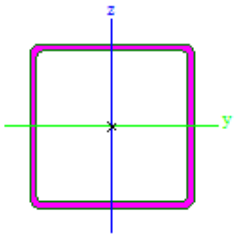
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 1297,98 | kN |
| Critical Euler load $N_{cr,z}$ | 324,49 | kN |
| Elastic critical load $N_{cr,T}$ | 179439,12 | kN |
| Plastic section modulus $W_{pl,y}$ | 1,5600e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 1,3400e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 1,5600e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 1,3400e-04 | $m^3$ |
| Second moment of area $I_y$ | 1,0020e-05 | $m^4$ |
| Second moment of area $I_z$ | 1,0020e-05 | $m^4$ |
| Torsional constant $I_t$ | 1,5500e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -3,75 | kNm |
| Maximum relative deflection $\delta_z$ | 0,9 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,87 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,42 | kNm |
| Maximum relative deflection $\delta_y$ | -0,2 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,32 | |
| Factor $\mu_y$ | 0,94 | |
| Factor $\mu_z$ | 0,26 | |
| Factor $\varepsilon_y$ | 0,31 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 637,63 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,29 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,27 | |
| Equivalent moment factor $C_{my}$ | 0,87 | |
| Equivalent moment factor $C_{mz}$ | 0,32 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,16 | |
| Factor $w_z$ | 1,16 | |
| Factor $n_{pl}$ | 0,25 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,77 | |
| Factor $C_{yy}$ | 0,87 | |
| Factor $C_{yz}$ | 1,00 | |
| Factor $C_{zy}$ | 0,52 | |
| Factor $C_{zz}$ | 1,06 | |

Unity check (6.61) = 0,34 + 0,08 + 0,01 = 0,43 -
Unity check (6.62) = 0,91 + 0,02 + 0,00 = 0,94 -

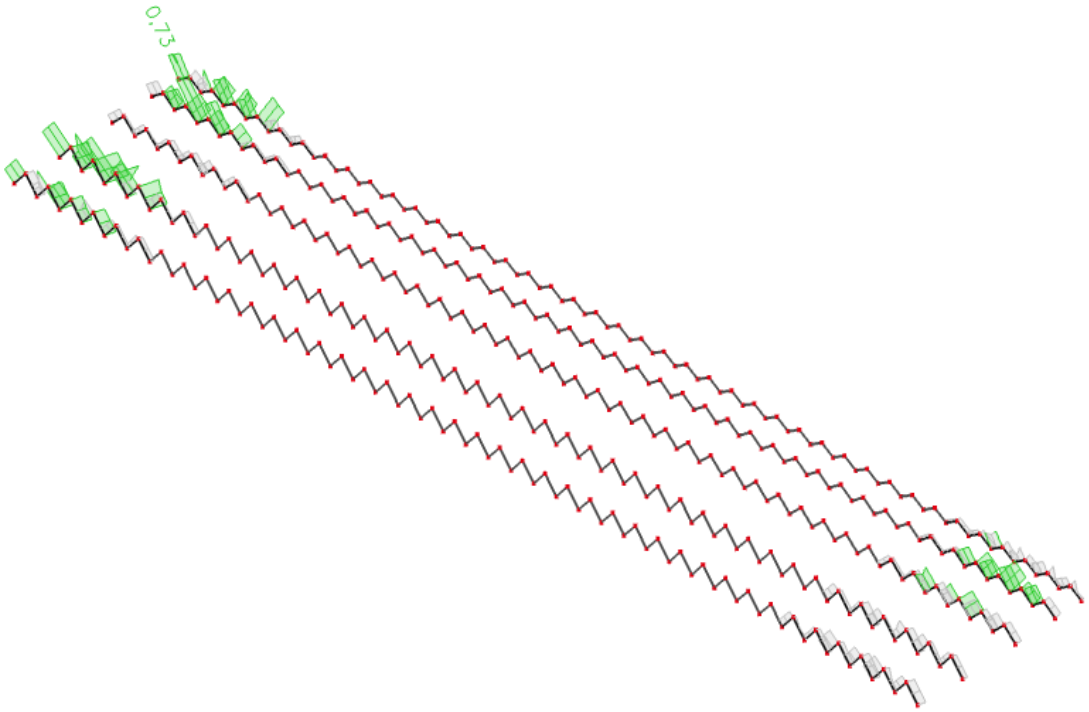
The member satisfies the stability check.

Student version

## 5.22. Dimenzioniranje ispune rešetke pozicije R5 (segment 1)

| | | |
|---|---|---|
| Name | R5-I1 | |
| Type | SHS200/200/8.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 6,0800e-03 | |
| A y, z [m²] | 3,0370e-03 | 3,0370e-03 |
| I y, z [m⁴] | 3,7090e-05 | 3,7090e-05 |
| I w [m⁶], t [m⁴] | 2,1333e-07 | 5,7780e-05 |
| $W_{el}$ y, z [m³] | 3,7100e-04 | 3,7100e-04 |
| $W_{pl}$ y, z [m³] | 4,3600e-04 | 4,3600e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,7900e-01 | 1,5015e+00 |
| $M_{ply}$ +, - [Nm] | 1,55e+05 | 1,55e+05 |
| $M_{plz}$ +, - [Nm] | 1,55e+05 | 1,55e+05 |

***Tablica 5.21.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R5 (segment 1)*




***Slika 5.25.*** *Prikaz iskoristivosti ispune rešetke pozicije R5 (segment 1)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R5-I1 - SHS200/200/8.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| | | | | | |
|---|---|---|---|---|---|
| **Member pp9087** | **2,517 / 2,517 m** | **SHS200/200/8.0** | **S 355** | **GSN** | **0,73 -** |

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 2,517 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -725,09 | kN |
| $V_{y,Ed}$ | -5,06 | kN |
| $V_{z,Ed}$ | -28,92 | kN |
| $T_{Ed}$ | 4,40 | kNm |
| $M_{y,Ed}$ | -58,20 | kNm |
| $M_{z,Ed}$ | -7,73 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 176 | 8 | 2,884e+05 | 2,517e+05 | 0,87 | | 1,00 | 22,00 | 22,78 | 27,66 | 32,34 | 1 |
| 3 | I | 176 | 8 | 2,375e+05 | -3,875e+04 | -0,16 | | 0,86 | 22,00 | 27,50 | 33,15 | 51,84 | 1 |
| 5 | I | 176 | 8 | -4,964e+04 | -1,297e+04 | | | | | | | | |
| 7 | I | 176 | 8 | 1,251e+03 | 2,775e+05 | 0,00 | | 1,00 | 22,00 | 22,78 | 27,66 | 47,23 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 6,0800e-03 | $m^2$ |
| $N_{c,Rd}$ | 2158,40 | kN |
| Unity check | 0,34 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 4,3600e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 154,78 | kNm |
| Unity check | 0,38 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 4,3600e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 154,78 | kNm |
| Unity check | 0,05 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 3,0400e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 623,08 | kN |
| Unity check | 0,01 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,0400e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 623,08 | kN |
| Unity check | 0,05 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 7,5 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,04 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 134,68 | kNm |
| α | 1,90 | |
| $M_{N,z,Rd}$ | 134,68 | kNm |
| β | 1,90 | |

Unity check (6.41) = 0,20 + 0,00 = 0,21 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 2,517 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 176 | 8 | 2,884e+05 | 2,517e+05 | 0,87 | | 1,00 | 22,00 | 22,78 | 27,66 | 32,34 | 1 |
| 3 | I | 176 | 8 | 2,375e+05 | -3,875e+04 | -0,16 | | 0,86 | 22,00 | 27,50 | 33,15 | 51,84 | 1 |
| 5 | I | 176 | 8 | -4,964e+04 | -1,297e+04 | | | | | | | | |
| 7 | I | 176 | 8 | 1,251e+03 | 2,775e+05 | 0,00 | | 1,00 | 22,00 | 22,78 | 27,66 | 47,23 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 2,517 | 2,517 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 2,517 | 2,517 | m |
| Critical Euler load $N_{cr}$ | 12138,53 | 12138,53 | kN |
| Slenderness λ | 32,22 | 32,22 | |
| Relative slenderness $\lambda_{rel}$ | 0,42 | 0,42 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,95 | 0,95 | |
| Buckling resistance $N_{b,Rd}$ | 2043,98 | 2043,98 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 6,0800e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 2043,98 | kN |
| Unity check | 0,35 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 6,0800e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 4,3600e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,3600e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 725,09 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -58,20 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -7,73 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 2158,40 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 154,78 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 154,78 | kNm |
| Reduction factor $\chi_y$ | 0,95 | |
| Reduction factor $\chi_z$ | 0,95 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,96 | |
| Interaction factor $k_{yz}$ | 0,37 | |
| Interaction factor $k_{zy}$ | 0,58 | |
| Interaction factor $k_{zz}$ | 0,61 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp9087 position 2,517 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp9087 position 2,517 m.

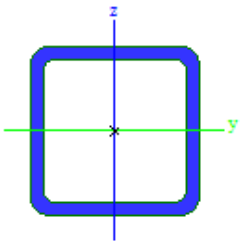
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 12138,53 | kN |
| Critical Euler load $N_{cr,z}$ | 12138,53 | kN |
| Elastic critical load $N_{cr,T}$ | 388230,23 | kN |
| Plastic section modulus $W_{pl,y}$ | 4,3600e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 3,7100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,3600e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 3,7100e-04 | $m^3$ |
| Second moment of area $I_y$ | 3,7090e-05 | $m^4$ |
| Second moment of area $I_z$ | 3,7090e-05 | $m^4$ |
| Torsional constant $I_t$ | 5,7780e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -58,20 | kNm |
| Maximum relative deflection $\delta_z$ | 2,3 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,97 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,65 | |
| Equivalent moment factor $C_{mz,0}$ | 0,63 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 1,32 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 7582,62 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,14 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,28 | |
| Equivalent moment factor $C_{my}$ | 0,97 | |
| Equivalent moment factor $C_{mz}$ | 0,63 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,18 | |
| Factor $w_z$ | 1,18 | |
| Factor $n_{pl}$ | 0,34 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,42 | |
| Factor $C_{yy}$ | 1,07 | |
| Factor $C_{yz}$ | 1,09 | |
| Factor $C_{zy}$ | 1,06 | |
| Factor $C_{zz}$ | 1,10 | |

Unity check (6.61) = 0,35 + 0,36 + 0,02 = 0,73 -
Unity check (6.62) = 0,35 + 0,22 + 0,03 = 0,60 -

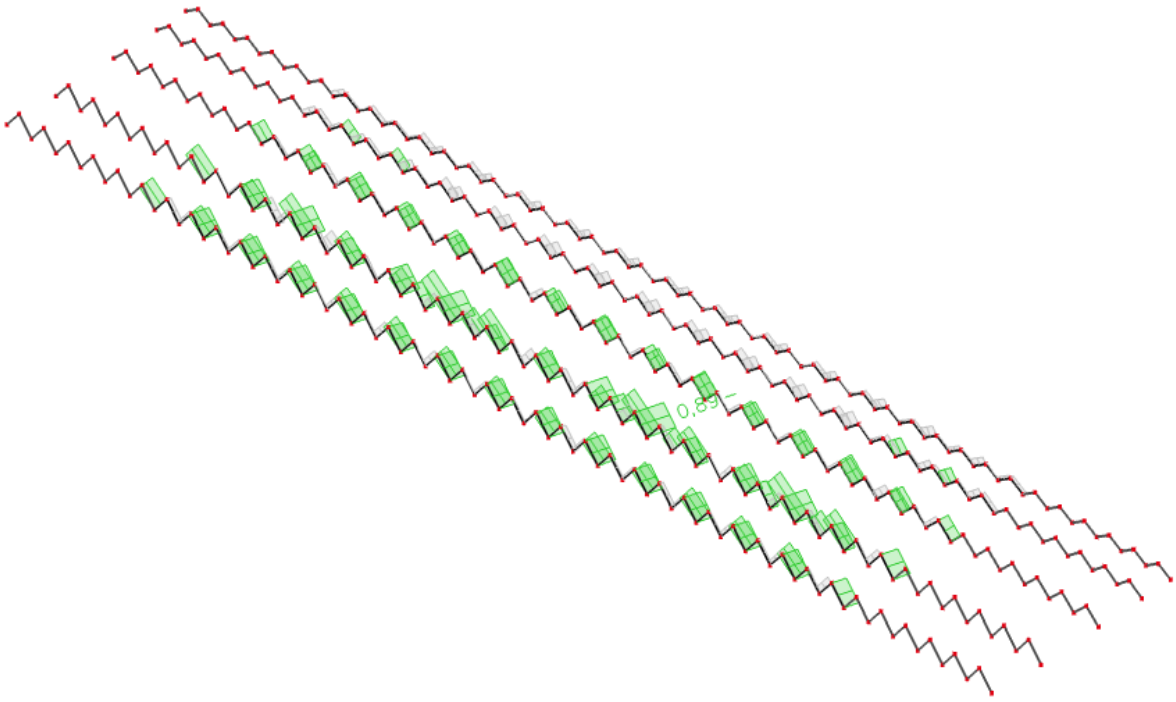
The member satisfies the stability check.

Student version

## 5.23. Dimenzioniranje ispune rešetke pozicije R5 (segment 2)

| | | |
|---|---|---|
| Name | | R5-I2 |
| Type | | SHS80/80/6.0 |
| Source description | | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | | S 355 |
| Fabrication | | rolled |
| Flexural buckling y-y | | a |
| Flexural buckling z-z | | a |
| Lateral torsional buckling | | Default |
| Use 2D FEM analysis | | × |
| |  | |
| A [m²] | 1,7400e-03 | |
| A y, z [m²] | 8,6833e-04 | 8,6833e-04 |
| I y, z [m⁴] | 1,5600e-06 | 1,5600e-06 |
| I w [m⁶], t [m⁴] | 1,6384e-09 | 2,5200e-06 |
| $W_{el}$ y, z [m³] | 3,9100e-05 | 3,9100e-05 |
| $W_{pl}$ y, z [m³] | 4,7800e-05 | 4,7800e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 40 | 40 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 3,0500e-01 | 5,6613e-01 |
| $M_{ply}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |
| $M_{plz}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |

***Tablica 5.22.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R5 (segment 2)*




***Slika 5.26.*** *Prikaz iskoristivosti ispune rešetke pozicije R5 (segment 2)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R5-I2 - SHS80/80/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp7799 | 0,000 / 3,202 m | SHS80/80/6.0 | S 355 | GSN | 0,89 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -220,58 | kN |
| $V_{y,Ed}$ | 0,25 | kN |
| $V_{z,Ed}$ | -0,08 | kN |
| $T_{Ed}$ | -0,01 | kNm |
| $M_{y,Ed}$ | 0,17 | kNm |
| $M_{z,Ed}$ | -0,57 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 1,343e+05 | 1,118e+05 | 0,83 | | 1,00 | 10,33 | 22,78 | 27,66 | 32,83 | 1 |
| 3 | I | 62 | 6 | 1,103e+05 | 1,168e+05 | 0,94 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,53 | 1 |
| 5 | I | 62 | 6 | 1,196e+05 | 1,421e+05 | 0,84 | | 1,00 | 10,33 | 22,78 | 27,66 | 32,72 | 1 |
| 7 | I | 62 | 6 | 1,437e+05 | 1,371e+05 | 0,95 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,41 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,7400e-03 | $m^2$ |
| $N_{c,Rd}$ | 617,70 | kN |
| Unity check | 0,36 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 16,97 | kNm |
| Unity check | 0,01 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 16,97 | kNm |
| Unity check | 0,03 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,y,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,z,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,1 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 14,06 | kNm |
| α | 1,94 | |
| $M_{N,z,Rd}$ | 14,06 | kNm |
| β | 1,94 | |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 3,202 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 1,377e+05 | 1,468e+05 | 0,94 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,60 | 1 |
| 3 | I | 62 | 6 | 1,451e+05 | 1,192e+05 | 0,82 | | 1,00 | 10,33 | 22,78 | 27,66 | 32,97 | 1 |
| 5 | I | 62 | 6 | 1,158e+05 | 1,066e+05 | 0,92 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,79 | 1 |
| 7 | I | 62 | 6 | 1,083e+05 | 1,343e+05 | 0,81 | | 1,00 | 10,33 | 22,78 | 27,66 | 33,14 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 3,202 | 3,202 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 3,202 | 3,202 | m |
| Critical Euler load $N_{cr}$ | 315,44 | 315,44 | kN |
| Slenderness λ | 106,92 | 106,92 | |
| Relative slenderness $\lambda_{rel}$ | 1,40 | 1,40 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,42 | 0,42 | |
| Buckling resistance $N_{b,Rd}$ | 258,33 | 258,33 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 258,33 | kN |
| Unity check | 0,85 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 220,58 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,66 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,57 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 617,70 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 16,97 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 16,97 | kNm |
| Reduction factor $\chi_y$ | 0,42 | |
| Reduction factor $\chi_z$ | 0,42 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,60 | |
| Interaction factor $k_{yz}$ | 0,47 | |
| Interaction factor $k_{zy}$ | 0,40 | |
| Interaction factor $k_{zz}$ | 0,69 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp7799 position 3,202 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp7799 position 0,000 m.

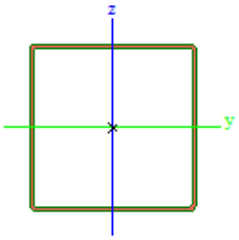
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 315,44 | kN |
| Critical Euler load $N_{cr,z}$ | 315,44 | kN |
| Elastic critical load $N_{cr,T}$ | 113696,60 | kN |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 3,9100e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 3,9100e-05 | $m^3$ |
| Second moment of area $I_y$ | 1,5600e-06 | $m^4$ |
| Second moment of area $I_z$ | 1,5600e-06 | $m^4$ |
| Torsional constant $I_t$ | 2,5200e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,66 | kNm |
| Maximum relative deflection $\delta_z$ | 0,5 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,46 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,40 | |
| Equivalent moment factor $C_{mz,0}$ | 0,52 | |
| Factor $\mu_y$ | 0,43 | |
| Factor $\mu_z$ | 0,43 | |
| Factor $\varepsilon_y$ | 0,13 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 253,59 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,26 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,24 | |
| Equivalent moment factor $C_{my}$ | 0,46 | |
| Equivalent moment factor $C_{mz}$ | 0,52 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,22 | |
| Factor $w_z$ | 1,22 | |
| Factor $n_{pl}$ | 0,36 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,40 | |
| Factor $C_{yy}$ | 1,08 | |
| Factor $C_{yz}$ | 0,94 | |
| Factor $C_{zy}$ | 0,99 | |
| Factor $C_{zz}$ | 1,06 | |

Unity check (6.61) = 0,85 + 0,02 + 0,02 = 0,89 -
Unity check (6.62) = 0,85 + 0,02 + 0,02 = 0,89 -

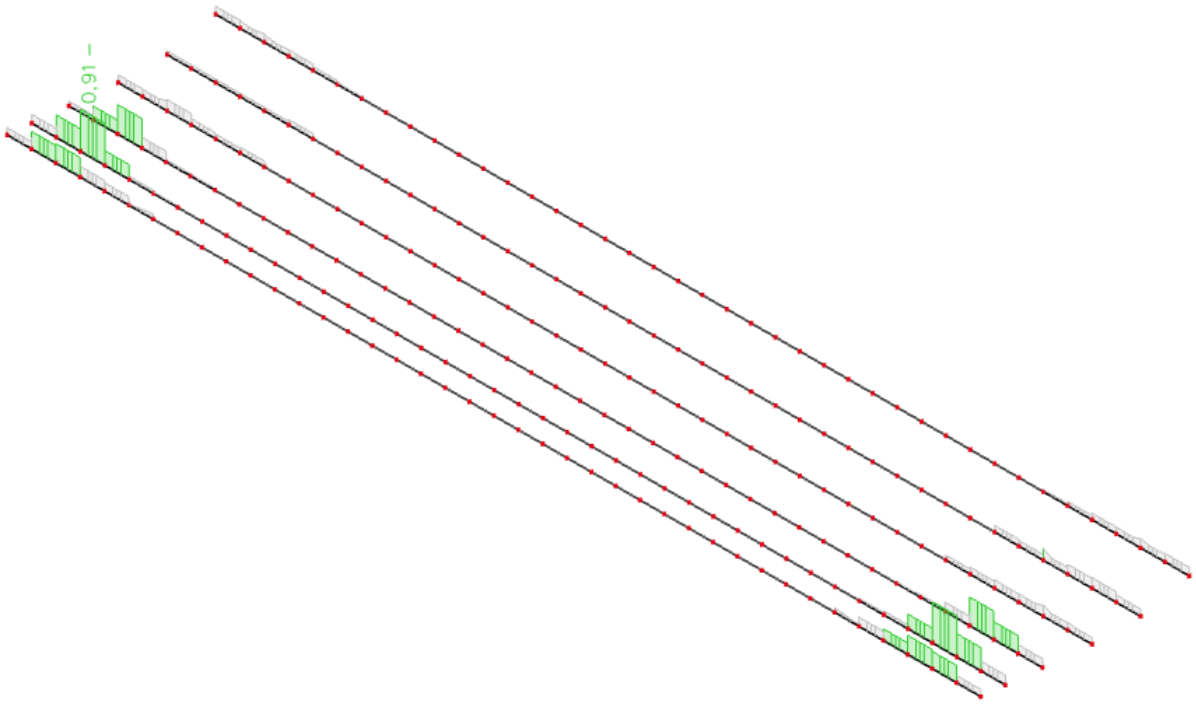
The member satisfies the stability check.

Student version

## 5.23. Dimenzioniranje donjeg pojasa rešetke pozicije R6 (segment 1)

| | | |
|---|---|---|
| Name | R6-DP1 | |
| Type | SHS350/350/8.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | roled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,0900e-02 | |
| A y, z [m²] | 5,4370e-03 | 5,4370e-03 |
| I y, z [m⁴] | 2,1130e-04 | 2,1130e-04 |
| I w [m⁶], t [m⁴] | 3,5015e-06 | 3,2380e-04 |
| $W_{el}$ y, z [m³] | 1,2070e-03 | 1,2070e-03 |
| $W_{pl}$ y, z [m³] | 1,3920e-03 | 1,3920e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 175 | 175 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,3800e+00 | 2,7015e+00 |
| $M_{ply}$ +, - [Nm] | 4,94e+05 | 4,94e+05 |
| $M_{plz}$ +, - [Nm] | 4,94e+05 | 4,94e+05 |

***Tablica 5.23.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R6 (segment 1)*




***Slika 5.27.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R6 (segment 1)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R6-DP1 - SHS350/350/8.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp9151 | 0,000 / 8,000 m | SHS350/350/8.0 | S 355 | GSN | 0,91 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -695,99 | kN |
| $V_{y,Ed}$ | 6,35 | kN |
| $V_{z,Ed}$ | 54,14 | kN |
| $T_{Ed}$ | -7,70 | kNm |
| $M_{y,Ed}$ | -188,97 | kNm |
| $M_{z,Ed}$ | -25,75 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 326 | 8 | 2,368e+05 | 1,971e+05 | 0,83 | | 1,00 | 40,75 | 22,78 | 27,66 | 32,83 | 4 |
| 3 | I | 326 | 8 | 1,889e+05 | -1,026e+05 | -0,54 | | 0,65 | 40,75 | 39,98 | 47,33 | 66,56 | 2 |
| 5 | I | 326 | 8 | -1,088e+05 | -6,908e+04 | | | | | | | | |
| 7 | I | 326 | 8 | -6,095e+04 | 2,306e+05 | -0,26 | | 0,79 | 40,75 | 30,60 | 36,72 | 55,08 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Effective section N-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |
| 3 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |
| 5 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |
| 7 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |

**Effective section My-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |
| 3 | I | 326 | 3,390e+05 | -3,136e+05 | -0,93 | 22,00 | 0,38 | 1,00 | 169 | 68 | 102 |
| 5 | I | 326 | -3,297e+05 | -3,297e+05 | | | | | | | |
| 7 | I | 326 | 3,390e+05 | -3,136e+05 | -0,93 | 22,00 | 0,38 | 1,00 | 169 | 68 | 102 |

**Effective section Mz-**
**Effective width calculation**
According to EN 1993-1-5 article 4.4

Student version

| Id | Type | $b_p$ [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\lambda_p$ [-] | $\rho$ [-] | $b_e$ [mm] | $b_{e1}$ [mm] | $b_{e2}$ [mm] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 326 | 3,390e+05 | -3,136e+05 | -0,93 | 22,00 | 0,38 | 1,00 | 169 | 68 | 102 |
| 3 | I | 326 | -3,297e+05 | -3,297e+05 | | | | | | | |
| 5 | I | 326 | 3,390e+05 | -3,136e+05 | -0,93 | 22,00 | 0,38 | 1,00 | 169 | 68 | 102 |
| 7 | I | 326 | 3,550e+05 | 3,550e+05 | 1,00 | 4,00 | 0,88 | 0,85 | 277 | 139 | 139 |

| Effective properties | | | | | | |
|---|---|---|---|---|---|---|
| Effective area | $A_{eff}$ | 9,3220e-03 | m² | | | |
| Effective second moment of area | $I_{eff,y}$ | 1,9950e-04 | m⁴ | $I_{eff,z}$ | 1,9950e-04 | m⁴ |
| Effective section modulus | $W_{eff,y}$ | 1,1002e-03 | m³ | $W_{eff,z}$ | 1,1002e-03 | m³ |
| Shift of the centroid | $e_{N,y}$ | 0 | mm | $e_{N,z}$ | 0 | mm |

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| $A_{eff}$ | 9,3220e-03 | m² |
| $N_{c,Rd}$ | 3309,29 | kN |
| Unity check | 0,21 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,y,min}$ | 1,1002e-03 | m³ |
| $M_{c,y,Rd}$ | 390,57 | kNm |
| Unity check | 0,48 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.15)

| | | |
|---|---|---|
| $W_{eff,z,min}$ | 1,1002e-03 | m³ |
| $M_{c,z,Rd}$ | 390,57 | kNm |
| Unity check | 0,07 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 5,4500e-03 | m² |
| $V_{pl,y,Rd}$ | 1117,03 | kN |
| Unity check | 0,01 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 5,4500e-03 | m² |
| $V_{pl,z,Rd}$ | 1117,03 | kN |
| Unity check | 0,05 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 4,1 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,02 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.3 and formula (6.43)

| Effective properties | | |
|---|---|---|
| $A_{eff}$ | 9,3220e-03 | m² |
| $e_{N,y}$ | 0 | mm |
| $e_{N,z}$ | 0 | mm |
| $W_{eff,y}$ | 1,1002e-03 | m³ |
| $W_{eff,z}$ | 1,1002e-03 | m³ |

| Normal stresses | | |
|---|---|---|
| $\sigma_{N,Ed}$ | 74,7 | MPa |
| $\sigma_{My,Ed}$ | 171,8 | MPa |
| $\sigma_{Mz,Ed}$ | 23,4 | MPa |
| $\sigma_{tot,Ed}$ | 269,8 | MPa |
| Unity check | 0,76 | - |

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m

Student version Student version Student version

Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 326 | 8 | 2,368e+05 | 1,971e+05 | 0,83 | | 1,00 | 40,75 | 22,78 | 27,66 | 32,83 | 4 |
| 3 | I | 326 | 8 | 1,889e+05 | -1,026e+05 | -0,54 | | 0,65 | 40,75 | 39,98 | 47,33 | 66,56 | 2 |
| 5 | I | 326 | 8 | -1,088e+05 | -6,908e+04 | | | | | | | | |
| 7 | I | 326 | 8 | -6,095e+04 | 2,306e+05 | -0,26 | | 0,79 | 40,75 | 30,60 | 36,72 | 55,08 | 3 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 4

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,000 | 16,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,000 | 16,000 | m |
| Critical Euler load $N_{cr}$ | 27371,50 | 1710,72 | kN |
| Slenderness $\lambda$ | 28,73 | 114,92 | |
| Relative slenderness $\lambda_{rel}$ | 0,35 | 1,39 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection $\alpha$ | 0,21 | 0,21 | |
| Reduction factor $\chi$ | 0,97 | 0,42 | |
| Buckling resistance $N_{b,Rd}$ | 3197,01 | 1397,86 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section effective area $A_{eff}$ | 9,3220e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 1397,86 | kN |
| Unity check | 0,50 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section effective area $A_{eff}$ | 9,3220e-03 | $m^2$ |
| Effective section modulus $W_{eff,y}$ | 1,1002e-03 | $m^3$ |
| Effective section modulus $W_{eff,z}$ | 1,1002e-03 | $m^3$ |
| Design compression force $N_{Ed}$ | 695,99 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -188,97 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -25,75 | kNm |
| Additional moment $\Delta M_{y,Ed}$ | 0,00 | kNm |
| Additional moment $\Delta M_{z,Ed}$ | 0,00 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 3309,29 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 390,57 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 390,57 | kNm |
| Reduction factor $\chi_y$ | 0,97 | |
| Reduction factor $\chi_z$ | 0,42 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,01 | |
| Interaction factor $k_{yz}$ | 1,38 | |
| Interaction factor $k_{zy}$ | 0,73 | |
| Interaction factor $k_{zz}$ | 0,99 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp9151 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp9151 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 27371,50 | kN |
| Critical Euler load $N_{cr,z}$ | 1710,72 | kN |
| Elastic critical load $N_{cr,T}$ | 675289,96 | kN |
| Effective section modulus $W_{eff,y}$ | 1,1002e-03 | $m^3$ |
| Second moment of area $I_y$ | 2,1130e-04 | $m^4$ |
| Second moment of area $I_z$ | 2,1130e-04 | $m^4$ |
| Torsional constant $I_t$ | 3,2380e-04 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -188,97 | kNm |
| Maximum relative deflection $\delta_z$ | 3,8 | mm |

Student version

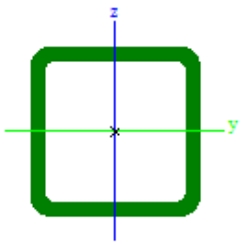
| Interaction method 1 parameters | | |
|---|---|---|
| Equivalent moment factor $C_{my,0}$ | 0,99 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | -25,75 | kNm |
| Maximum relative deflection $\delta_y$ | 8,4 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,82 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 0,72 | |
| Factor $\varepsilon_y$ | 2,30 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 6692,46 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,24 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,20 | |
| Equivalent moment factor $C_{my}$ | 0,99 | |
| Equivalent moment factor $C_{mz}$ | 0,82 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |

Unity check (6.61) = 0,22 + 0,49 + 0,09 = 0,80 -
Unity check (6.62) = 0,50 + 0,35 + 0,07 = 0,91 -

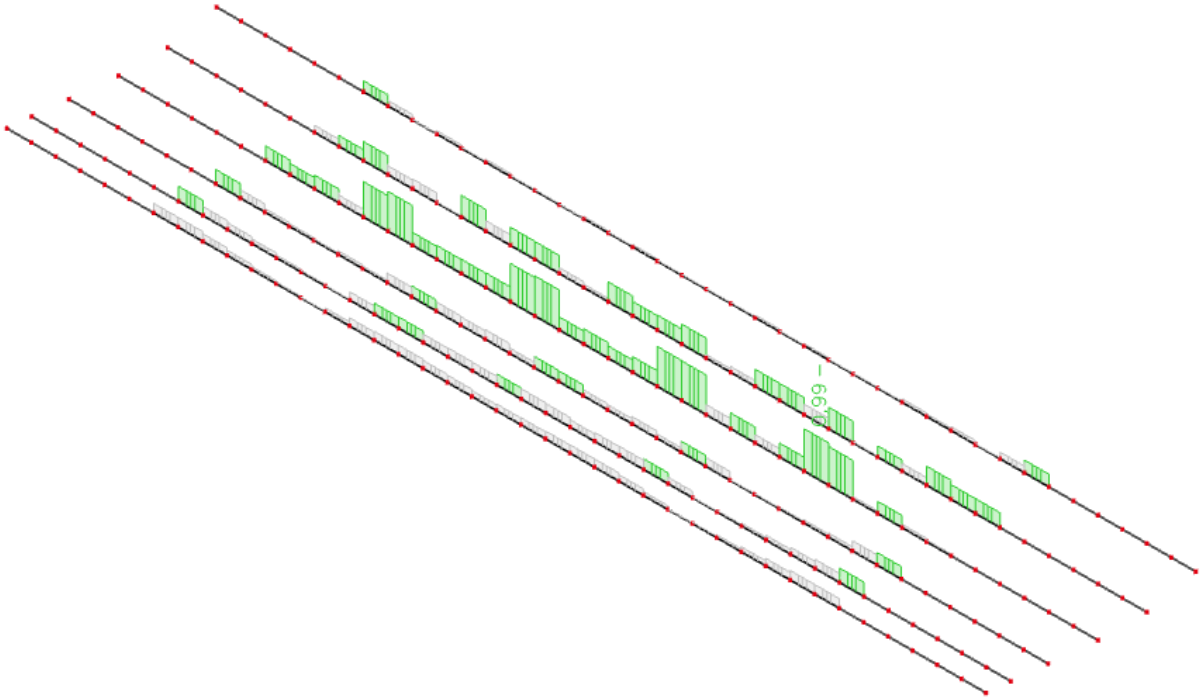
The member satisfies the stability check.

Student version
Student version
Student version

## 5.24. Dimenzioniranje donjeg pojasa rešetke pozicije R6 (segment 2)

| | | |
|---|---|---|
| Name | R6-DP2 | |
| Type | SHS80/80/6.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,7400e-03 | |
| A y, z [m²] | 8,6833e-04 | 8,6833e-04 |
| I y, z [m⁴] | 1,5600e-06 | 1,5600e-06 |
| I w [m⁶], t [m⁴] | 1,6384e-09 | 2,5200e-06 |
| $W_{el}$ y, z [m³] | 3,9100e-05 | 3,9100e-05 |
| $W_{pl}$ y, z [m³] | 4,7800e-05 | 4,7800e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 40 | 40 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 3,0500e-01 | 5,6613e-01 |
| $M_{ply}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |
| $M_{plz}$ +, - [Nm] | 1,69e+04 | 1,69e+04 |

***Tablica 5.24.*** *Karakteristike poprečnog presjeka donjeg pojasa rešetke pozicije R6 (segment 2)*




***Slika 5.28.*** *Prikaz iskoristivosti donjeg pojasa rešetke pozicije R6 (segment 2)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R6-DP2 - SHS80/80/6.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp8265 | 4,000 / 8,000 m | SHS80/80/6.0 | S 355 | GSN | 0,99 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 4,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -46,97 | kN |
| $V_{y,Ed}$ | 0,03 | kN |
| $V_{z,Ed}$ | 0,22 | kN |
| $T_{Ed}$ | -0,04 | kNm |
| $M_{y,Ed}$ | 0,01 | kNm |
| $M_{z,Ed}$ | -0,04 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 2,775e+04 | 2,606e+04 | 0,94 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,58 | 1 |
| 3 | I | 62 | 6 | 2,592e+04 | 2,615e+04 | 0,99 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,01 | 1 |
| 5 | I | 62 | 6 | 2,633e+04 | 2,802e+04 | 0,94 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,58 | 1 |
| 7 | I | 62 | 6 | 2,816e+04 | 2,793e+04 | 0,99 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,00 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,7400e-03 | $m^2$ |
| $N_{c,Rd}$ | 617,70 | kN |
| Unity check | 0,08 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 16,97 | kNm |
| Unity check | 0,00 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 16,97 | kNm |
| Unity check | 0,00 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,y,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,7000e-04 | $m^2$ |
| $V_{pl,z,Rd}$ | 178,31 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,6 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 16,97 | kNm |
| $\alpha$ | 1,67 | |
| $M_{N,z,Rd}$ | 16,97 | kNm |
| $\beta$ | 1,67 | |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 62 | 6 | 3,880e+04 | 4,224e+04 | 0,92 | | 1,00 | 10,33 | 22,78 | 27,66 | 31,82 | 1 |
| 3 | I | 62 | 6 | 4,039e+04 | 1,780e+04 | 0,44 | | 1,00 | 10,33 | 22,78 | 27,66 | 38,36 | 1 |
| 5 | I | 62 | 6 | 1,528e+04 | 1,184e+04 | 0,77 | | 1,00 | 10,33 | 22,78 | 27,66 | 33,54 | 1 |
| 7 | I | 62 | 6 | 1,369e+04 | 3,628e+04 | 0,38 | | 1,00 | 10,33 | 22,78 | 27,66 | 39,44 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 4,000 | 8,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 4,000 | 8,000 | m |
| Critical Euler load $N_{cr}$ | 202,08 | 50,52 | kN |
| Slenderness $\lambda$ | 133,59 | 267,18 | |
| Relative slenderness $\lambda_{rel}$ | 1,75 | 3,50 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection $\alpha$ | 0,21 | 0,21 | |
| Reduction factor $\chi$ | 0,28 | 0,08 | |
| Buckling resistance $N_{b,Rd}$ | 175,92 | 47,60 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 47,60 | kN |
| Unity check | 0,99 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,7400e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 46,97 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,57 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 0,09 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 617,70 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 16,97 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 16,97 | kNm |
| Reduction factor $\chi_y$ | 0,28 | |
| Reduction factor $\chi_z$ | 0,08 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,03 | |
| Interaction factor $k_{yz}$ | 1,09 | |
| Interaction factor $k_{zy}$ | 0,09 | |
| Interaction factor $k_{zz}$ | 0,16 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp8265 position 8,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp8265 position 8,000 m.

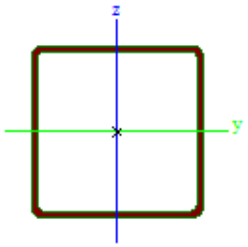
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 202,08 | kN |
| Critical Euler load $N_{cr,z}$ | 50,52 | kN |
| Elastic critical load $N_{cr,T}$ | 113541,42 | kN |
| Plastic section modulus $W_{pl,y}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 3,9100e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 4,7800e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 3,9100e-05 | $m^3$ |
| Second moment of area $I_y$ | 1,5600e-06 | $m^4$ |
| Second moment of area $I_z$ | 1,5600e-06 | $m^4$ |
| Torsional constant $I_t$ | 2,5200e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,57 | kNm |
| Maximum relative deflection $\delta_z$ | -0,2 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,79 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{z,Ed}$ | 0,09 | kNm |
| Maximum relative deflection $\delta_y$ | 0,2 | mm |
| Equivalent moment factor $C_{mz,0}$ | 0,16 | |
| Factor $\mu_y$ | 0,82 | |
| Factor $\mu_z$ | 0,08 | |
| Factor $\varepsilon_y$ | 0,54 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 101,42 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,41 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,22 | |
| Equivalent moment factor $C_{my}$ | 0,79 | |
| Equivalent moment factor $C_{mz}$ | 0,16 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,22 | |
| Factor $w_z$ | 1,22 | |
| Factor $n_{pl}$ | 0,08 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 3,50 | |
| Factor $C_{yy}$ | 0,82 | |
| Factor $C_{yz}$ | 1,01 | |
| Factor $C_{zy}$ | 0,49 | |
| Factor $C_{zz}$ | 1,03 | |

Unity check (6.61) = 0,27 + 0,03 + 0,01 = 0,31 -
Unity check (6.62) = 0,99 + 0,00 + 0,00 = 0,99 -

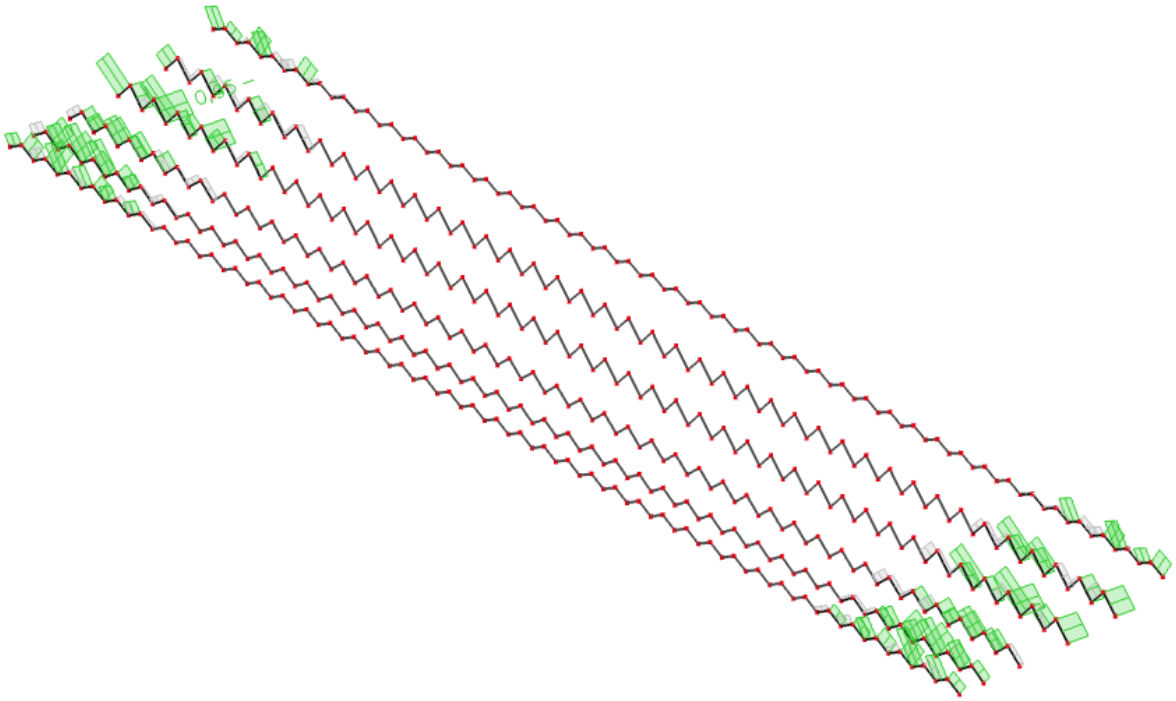
The member satisfies the stability check.

Student version

## 5.25. Dimenzioniranje ispune rešetke pozicije R6 (segment 1)

| | | |
|---|---|---|
| Name | R6-I1 | |
| Type | SHS110/110/4.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,6800e-03 | |
| A y, z [m²] | 8,3926e-04 | 8,3926e-04 |
| I y, z [m⁴] | 3,1300e-06 | 3,1300e-06 |
| I w [m⁶], t [m⁴] | 5,3684e-09 | 4,8500e-06 |
| $W_{el}$ y, z [m³] | 5,6800e-05 | 5,6800e-05 |
| $W_{pl}$ y, z [m³] | 6,6460e-05 | 6,6460e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 55 | 55 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 4,2965e-01 | 8,3075e-01 |
| $M_{ply}$ +, - [Nm] | 2,36e+04 | 2,36e+04 |
| $M_{plz}$ +, - [Nm] | 2,36e+04 | 2,36e+04 |

***Tablica 5.25.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R6 (segment 1)*



***Slika 5.29.*** *Prikaz iskoristivosti ispune rešetke pozicije R6 (segment 1)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R6-I1 - SHS110/110/4.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp8309 | 3,202 / 3,202 m | SHS110/110/4.0 | S 355 | GSN | 0,95 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 3,202 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -288,73 | kN |
| $V_{y,Ed}$ | 4,01 | kN |
| $V_{z,Ed}$ | 0,03 | kN |
| $T_{Ed}$ | 0,68 | kNm |
| $M_{y,Ed}$ | -0,19 | kNm |
| $M_{z,Ed}$ | 4,98 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 98 | 4 | 9,730e+04 | 2,533e+05 | 0,38 | | 1,00 | 24,50 | 22,78 | 27,66 | 39,32 | 2 |
| 3 | I | 98 | 4 | 2,594e+05 | 2,533e+05 | 0,98 | | 1,00 | 24,50 | 22,78 | 27,66 | 31,17 | 2 |
| 5 | I | 98 | 4 | 2,467e+05 | 9,070e+04 | 0,37 | | 1,00 | 24,50 | 22,78 | 27,66 | 39,61 | 2 |
| 7 | I | 98 | 4 | 8,458e+04 | 9,069e+04 | 0,93 | | 1,00 | 24,50 | 22,78 | 27,66 | 31,66 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,6800e-03 | $m^2$ |
| $N_{c,Rd}$ | 596,40 | kN |
| Unity check | 0,48 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 6,6460e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 23,59 | kNm |
| Unity check | 0,01 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 6,6460e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 23,59 | kNm |
| Unity check | 0,21 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,4000e-04 | $m^2$ |
| $V_{pl,y,Rd}$ | 172,17 | kN |
| Unity check | 0,02 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 8,4000e-04 | $m^2$ |
| $V_{pl,z,Rd}$ | 172,17 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 7,5 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,04 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 15,98 | kNm |
| α | 2,26 | |
| $M_{N,z,Rd}$ | 15,98 | kNm |
| β | 2,26 | |

Unity check (6.41) = 0,00 + 0,07 = 0,07 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 0,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 98 | 4 | 3,093e+05 | 6,315e+04 | 0,20 | | 1,00 | 24,50 | 22,78 | 27,66 | 42,71 | 2 |
| 3 | I | 98 | 4 | 5,201e+04 | 2,524e+04 | 0,49 | | 1,00 | 24,50 | 22,78 | 27,66 | 37,64 | 2 |
| 5 | I | 98 | 4 | 3,420e+04 | 2,803e+05 | 0,12 | | 1,00 | 24,50 | 22,78 | 27,66 | 44,46 | 2 |
| 7 | I | 98 | 4 | 2,914e+05 | 3,182e+05 | 0,92 | | 1,00 | 24,50 | 22,78 | 27,66 | 31,85 | 2 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 2

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 3,202 | 3,202 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 3,202 | 3,202 | m |
| Critical Euler load $N_{cr}$ | 632,91 | 632,91 | kN |
| Slenderness λ | 74,17 | 74,17 | |
| Relative slenderness $\lambda_{rel}$ | 0,97 | 0,97 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,69 | 0,69 | |
| Buckling resistance $N_{b,Rd}$ | 409,12 | 409,12 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,6800e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 409,12 | kN |
| Unity check | 0,71 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,6800e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 6,6460e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 6,6460e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 288,73 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,85 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -7,85 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 596,40 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 23,59 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 23,59 | kNm |
| Reduction factor $\chi_y$ | 0,69 | |
| Reduction factor $\chi_z$ | 0,69 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,16 | |
| Interaction factor $k_{yz}$ | 0,42 | |
| Interaction factor $k_{zy}$ | 0,85 | |
| Interaction factor $k_{zz}$ | 0,65 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp8309 position 0,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp8309 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 632,91 | kN |
| Critical Euler load $N_{cr,z}$ | 632,91 | kN |
| Elastic critical load $N_{cr,T}$ | 105420,35 | kN |
| Plastic section modulus $W_{pl,y}$ | 6,6460e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 5,6800e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 6,6460e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 5,6800e-05 | $m^3$ |
| Second moment of area $I_y$ | 3,1300e-06 | $m^4$ |
| Second moment of area $I_z$ | 3,1300e-06 | $m^4$ |
| Torsional constant $I_t$ | 4,8500e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,85 | kNm |
| Maximum relative deflection $\delta_z$ | 0,8 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,81 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,63 | |
| Equivalent moment factor $C_{mz,0}$ | 0,50 | |
| Factor $\mu_y$ | 0,79 | |
| Factor $\mu_z$ | 0,79 | |
| Factor $\varepsilon_y$ | 0,09 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 498,61 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,22 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,24 | |
| Equivalent moment factor $C_{my}$ | 0,81 | |
| Equivalent moment factor $C_{mz}$ | 0,50 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,17 | |
| Factor $w_z$ | 1,17 | |
| Factor $n_{pl}$ | 0,48 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 0,97 | |
| Factor $C_{yy}$ | 1,02 | |
| Factor $C_{yz}$ | 1,04 | |
| Factor $C_{zy}$ | 0,84 | |
| Factor $C_{zz}$ | 1,11 | |

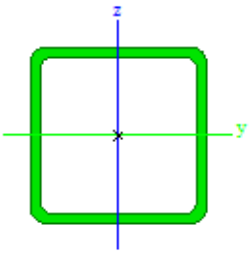
Unity check (6.61) = 0,71 + 0,04 + 0,14 = 0,89 -
Unity check (6.62) = 0,71 + 0,03 + 0,22 = 0,95 -

The member satisfies the stability check.

Student version

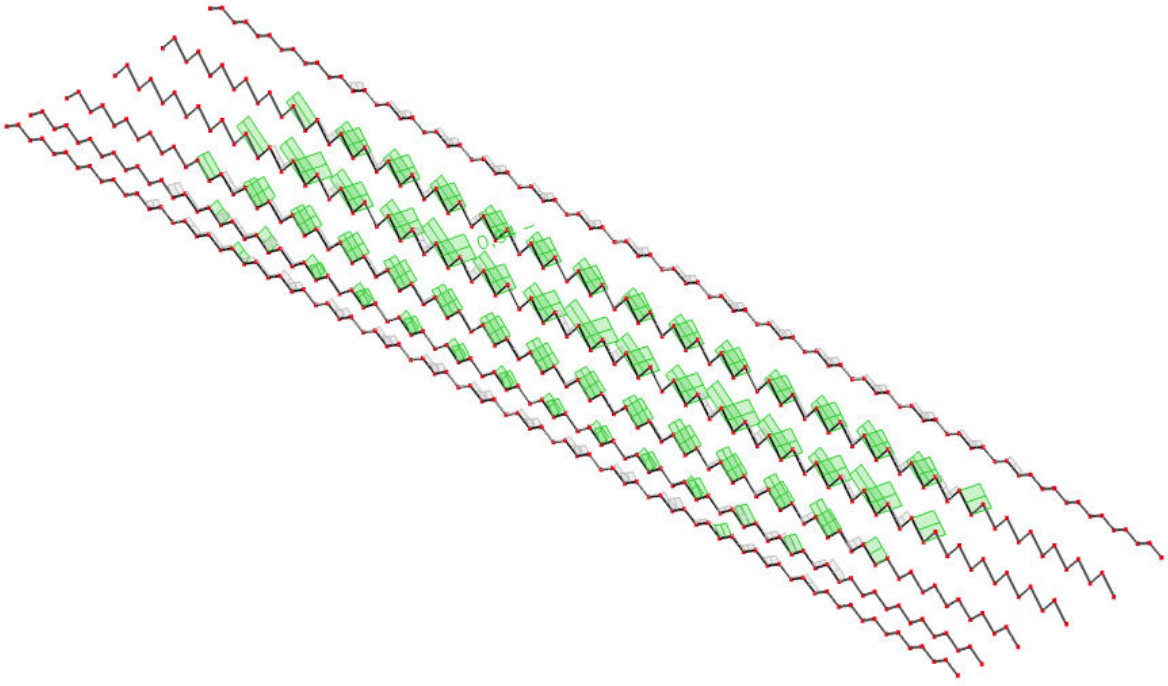
## 5.26. Dimenzioniranje ispune rešetke pozicije R6 (segment 2)

| | |
|---|---|
| Name | R6-I2 |
| Type | SHS70/70/4.0 |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 |
| Item material | S 355 |
| Fabrication | rolled |
| Flexural buckling y-y | a |
| Flexural buckling z-z | a |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | × |




| | | |
|---|---|---|
| A [m²] | 1,0400e-03 | |
| A y, z [m²] | 5,1926e-04 | 5,1926e-04 |
| I y, z [m⁴] | 7,4700e-07 | 7,4700e-07 |
| I w [m⁶], t [m⁴] | 5,6023e-10 | 1,1800e-06 |
| $W_{el}$ y, z [m³] | 2,1300e-05 | 2,1300e-05 |
| $W_{pl}$ y, z [m³] | 2,5500e-05 | 2,5500e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 35 | 35 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 2,7000e-01 | 5,1075e-01 |
| $M_{ply}$ +, - [Nm] | 9,06e+03 | 9,06e+03 |
| $M_{plz}$ +, - [Nm] | 9,06e+03 | 9,06e+03 |

***Tablica 5.26.*** *Karakteristike poprečnog presjeka ispune rešetke pozicije R6 (segment 2)*



***Slika 5.30.*** *Prikaz iskoristivosti ispune rešetke pozicije R6 (segment 2)*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = R6-I2 - SHS70/70/4.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp8357 | 3,202 / 3,202 m | SHS70/70/4.0 | S 355 | GSN | 0,94 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 3,202 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -117,68 | kN |
| $V_{y,Ed}$ | -0,11 | kN |
| $V_{z,Ed}$ | -0,13 | kN |
| $T_{Ed}$ | 0,01 | kNm |
| $M_{y,Ed}$ | -0,15 | kNm |
| $M_{z,Ed}$ | -0,21 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 58 | 4 | 1,280e+05 | 1,115e+05 | 0,87 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,37 | 1 |
| 3 | I | 58 | 4 | 1,096e+05 | 9,820e+04 | 0,90 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,07 | 1 |
| 5 | I | 58 | 4 | 9,856e+04 | 1,151e+05 | 0,86 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,54 | 1 |
| 7 | I | 58 | 4 | 1,170e+05 | 1,284e+05 | 0,91 | | 1,00 | 14,50 | 22,78 | 27,66 | 31,90 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 1,0400e-03 | $m^2$ |
| $N_{c,Rd}$ | 369,20 | kN |
| Unity check | 0,32 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 2,5500e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 9,05 | kNm |
| Unity check | 0,02 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 2,5500e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 9,05 | kNm |
| Unity check | 0,02 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 5,2000e-04 | $m^2$ |
| $V_{pl,y,Rd}$ | 106,58 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 5,2000e-04 | $m^2$ |
| $V_{pl,z,Rd}$ | 106,58 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,4 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 8,02 | kNm |
| α | 1,88 | |
| $M_{N,z,Rd}$ | 8,02 | kNm |
| β | 1,88 | |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 3,202 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 58 | 4 | 1,280e+05 | 1,115e+05 | 0,87 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,37 | 1 |
| 3 | I | 58 | 4 | 1,096e+05 | 9,820e+04 | 0,90 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,07 | 1 |
| 5 | I | 58 | 4 | 9,856e+04 | 1,151e+05 | 0,86 | | 1,00 | 14,50 | 22,78 | 27,66 | 32,54 | 1 |
| 7 | I | 58 | 4 | 1,170e+05 | 1,284e+05 | 0,91 | | 1,00 | 14,50 | 22,78 | 27,66 | 31,90 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 3,202 | 3,202 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 3,202 | 3,202 | m |
| Critical Euler load $N_{cr}$ | 151,05 | 151,05 | kN |
| Slenderness λ | 119,46 | 119,46 | |
| Relative slenderness $\lambda_{rel}$ | 1,56 | 1,56 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,35 | 0,35 | |
| Buckling resistance $N_{b,Rd}$ | 128,08 | 128,08 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 1,0400e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 128,08 | kN |
| Unity check | 0,92 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 1,0400e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 2,5500e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,5500e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 117,68 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,15 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | -0,21 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 369,20 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 9,05 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 9,05 | kNm |
| Reduction factor $\chi_y$ | 0,35 | |
| Reduction factor $\chi_z$ | 0,35 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,60 | |
| Interaction factor $k_{yz}$ | 0,32 | |
| Interaction factor $k_{zy}$ | 0,40 | |
| Interaction factor $k_{zz}$ | 0,50 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp8357 position 3,202 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp8357 position 3,202 m.

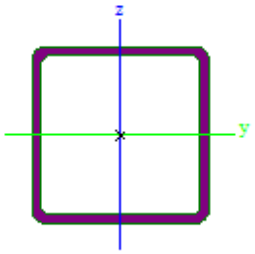
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 151,05 | kN |
| Critical Euler load $N_{cr,z}$ | 151,05 | kN |
| Elastic critical load $N_{cr,T}$ | 66424,24 | kN |
| Plastic section modulus $W_{pl,y}$ | 2,5500e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 2,1300e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 2,5500e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 2,1300e-05 | $m^3$ |
| Second moment of area $I_y$ | 7,4700e-07 | $m^4$ |
| Second moment of area $I_z$ | 7,4700e-07 | $m^4$ |
| Torsional constant $I_t$ | 1,1800e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -0,15 | kNm |
| Maximum relative deflection $\delta_z$ | 0,3 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,46 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,62 | |
| Equivalent moment factor $C_{mz,0}$ | 0,39 | |
| Factor $\mu_y$ | 0,30 | |
| Factor $\mu_z$ | 0,30 | |
| Factor $\varepsilon_y$ | 0,06 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 120,05 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,27 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,22 | |
| Equivalent moment factor $C_{my}$ | 0,46 | |
| Equivalent moment factor $C_{mz}$ | 0,39 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,20 | |
| Factor $w_z$ | 1,20 | |
| Factor $n_{pl}$ | 0,32 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,56 | |
| Factor $C_{yy}$ | 1,05 | |
| Factor $C_{yz}$ | 0,99 | |
| Factor $C_{zy}$ | 0,94 | |
| Factor $C_{zz}$ | 1,07 | |

Unity check (6.61) = 0,92 + 0,01 + 0,01 = 0,94 -
Unity check (6.62) = 0,92 + 0,01 + 0,01 = 0,94 -

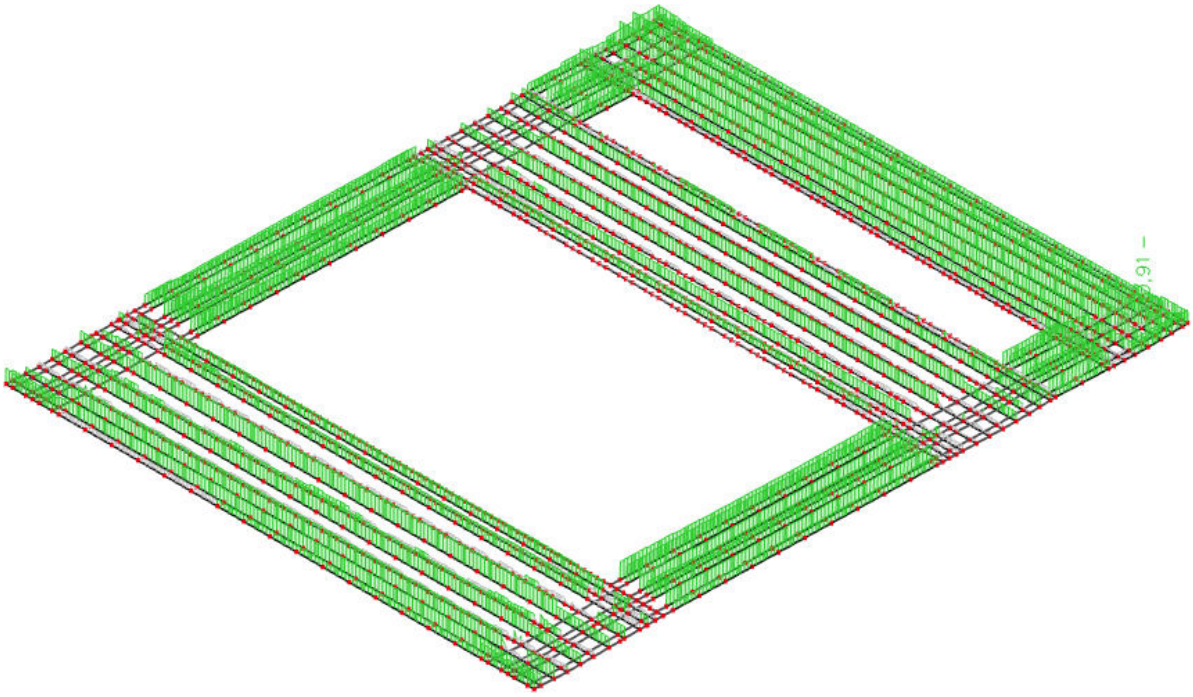
The member satisfies the stability check.

Student version

## 5.27. Dimenzioniranje krovne podrožnice pozicije KP1

| | | |
|---|---|---|
| Name | KP1 | |
| Type | SHS200/200/10.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 7,4900e-03 | |
| A y, z [m²] | 3,7454e-03 | 3,7454e-03 |
| I y, z [m⁴] | 4,4710e-05 | 4,4710e-05 |
| I w [m⁶], t [m⁴] | 2,6667e-07 | 7,0310e-05 |
| $W_{el}$ y, z [m³] | 4,4700e-04 | 4,4700e-04 |
| $W_{pl}$ y, z [m³] | 5,3100e-04 | 5,3100e-04 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 100 | 100 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 7,7400e-01 | 1,4769e+00 |
| $M_{ply}$ +, - [Nm] | 1,88e+05 | 1,88e+05 |
| $M_{plz}$ +, - [Nm] | 1,88e+05 | 1,88e+05 |

***Tablica 5.27.*** *Karakteristike poprečnog presjeka krovne podrožnice pozicije KP1*



***Slika 5.30.*** *Prikaz iskoristivosti krovne podrožnie pozicije KP1*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = KP1 - SHS200/200/10.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp2090 | 8,000 / 8,000 m | SHS200/200/10.0 | S 355 | GSN | 0,91 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.35*dodatno stalno opterećenje + 1.50*vjetar pritisak |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 8,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -19,07 | kN |
| $V_{y,Ed}$ | 14,19 | kN |
| $V_{z,Ed}$ | -107,77 | kN |
| $T_{Ed}$ | -2,94 | kNm |
| $M_{y,Ed}$ | -164,28 | kNm |
| $M_{z,Ed}$ | 14,56 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 170 | 10 | 3,240e+05 | 3,793e+05 | 0,85 | | 1,00 | 17,00 | 22,78 | 27,66 | 32,57 | 1 |
| 3 | I | 170 | 10 | 3,459e+05 | -2,789e+05 | -0,81 | | 0,55 | 17,00 | 50,13 | 58,49 | 82,84 | 1 |
| 5 | I | 170 | 10 | -3,189e+05 | -3,743e+05 | | | | | | | | |
| 7 | I | 170 | 10 | -3,408e+05 | 2,840e+05 | -1,20 | | 0,45 | 17,00 | 64,44 | 74,28 | 121,58 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 7,4900e-03 | $m^2$ |
| $N_{c,Rd}$ | 2658,95 | kN |
| Unity check | 0,01 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 5,3100e-04 | $m^3$ |
| $M_{pl,y,Rd}$ | 188,50 | kNm |
| Unity check | 0,87 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 5,3100e-04 | $m^3$ |
| $M_{pl,z,Rd}$ | 188,50 | kNm |
| Unity check | 0,08 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,7450e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 767,57 | kN |
| Unity check | 0,02 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 3,7450e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 767,57 | kN |
| Unity check | 0,14 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 4,1 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,02 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 188,50 | kNm |
| α | 1,66 | |
| $M_{N,z,Rd}$ | 188,50 | kNm |
| β | 1,66 | |

Unity check (6.41) = 0,80 + 0,01 = 0,81 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 170 | 10 | 3,240e+05 | 3,793e+05 | 0,85 | | 1,00 | 17,00 | 22,78 | 27,66 | 32,57 | 1 |
| 3 | I | 170 | 10 | 3,459e+05 | -2,789e+05 | -0,81 | | 0,55 | 17,00 | 50,13 | 58,49 | 82,84 | 1 |
| 5 | I | 170 | 10 | -3,189e+05 | -3,743e+05 | | | | | | | | |
| 7 | I | 170 | 10 | -3,403e+05 | 2,840e+05 | -1,20 | | 0,45 | 17,00 | 64,44 | 74,28 | 121,58 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | non-sway | |
| System length L | 8,000 | 2,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 8,000 | 2,000 | m |
| Critical Euler load $N_{cr}$ | 1447,92 | 23166,68 | kN |
| Slenderness λ | 103,54 | 25,89 | |
| Relative slenderness $\lambda_{rel}$ | 1,36 | 0,34 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |

**Note:** The slenderness or compression force is such that Flexural Buckling effects may be ignored according to EN 1993-1-1 article 6.3.1.2(4).

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 7,4900e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 5,3100e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 5,3100e-04 | $m^3$ |
| Design compression force $N_{Ed}$ | 19,07 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -164,28 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 14,56 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 2658,95 | kN |

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Characteristic moment resistance $M_{y,Rk}$ | 188,50 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 188,50 | kNm |
| Reduction factor $\chi_y$ | 1,00 | |
| Reduction factor $\chi_z$ | 1,00 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 1,01 | |
| Interaction factor $k_{yz}$ | 0,35 | |
| Interaction factor $k_{zy}$ | 0,61 | |
| Interaction factor $k_{zz}$ | 0,59 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp2090 position 8,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp2090 position 8,000 m.

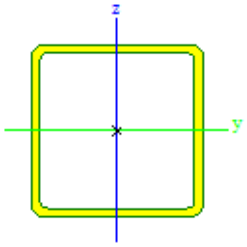
| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 1447,92 | kN |
| Critical Euler load $N_{cr,z}$ | 23166,68 | kN |
| Elastic critical load $N_{cr,T}$ | 487248,63 | kN |
| Plastic section modulus $W_{pl,y}$ | 5,3100e-04 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 4,4700e-04 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 5,3100e-04 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 4,4700e-04 | $m^3$ |
| Second moment of area $I_y$ | 4,4710e-05 | $m^4$ |
| Second moment of area $I_z$ | 4,4710e-05 | $m^4$ |
| Torsional constant $I_t$ | 7,0310e-05 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -164,28 | kNm |
| Maximum relative deflection $\delta_z$ | -50,7 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,99 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | -0,97 | |
| Equivalent moment factor $C_{mz,0}$ | 0,59 | |
| Factor $\mu_y$ | 1,00 | |
| Factor $\mu_z$ | 1,00 | |
| Factor $\varepsilon_y$ | 144,35 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 11608,70 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,13 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,29 | |
| Equivalent moment factor $C_{my}$ | 0,99 | |
| Equivalent moment factor $C_{mz}$ | 0,59 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,19 | |
| Factor $w_z$ | 1,19 | |
| Factor $n_{pl}$ | 0,01 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 1,36 | |
| Factor $C_{yy}$ | 1,00 | |
| Factor $C_{yz}$ | 1,00 | |
| Factor $C_{zy}$ | 0,99 | |
| Factor $C_{zz}$ | 1,00 | |

Unity check (6.61) = 0,01 + 0,88 + 0,03 = 0,91 -
Unity check (6.62) = 0,01 + 0,53 + 0,05 = 0,58 -

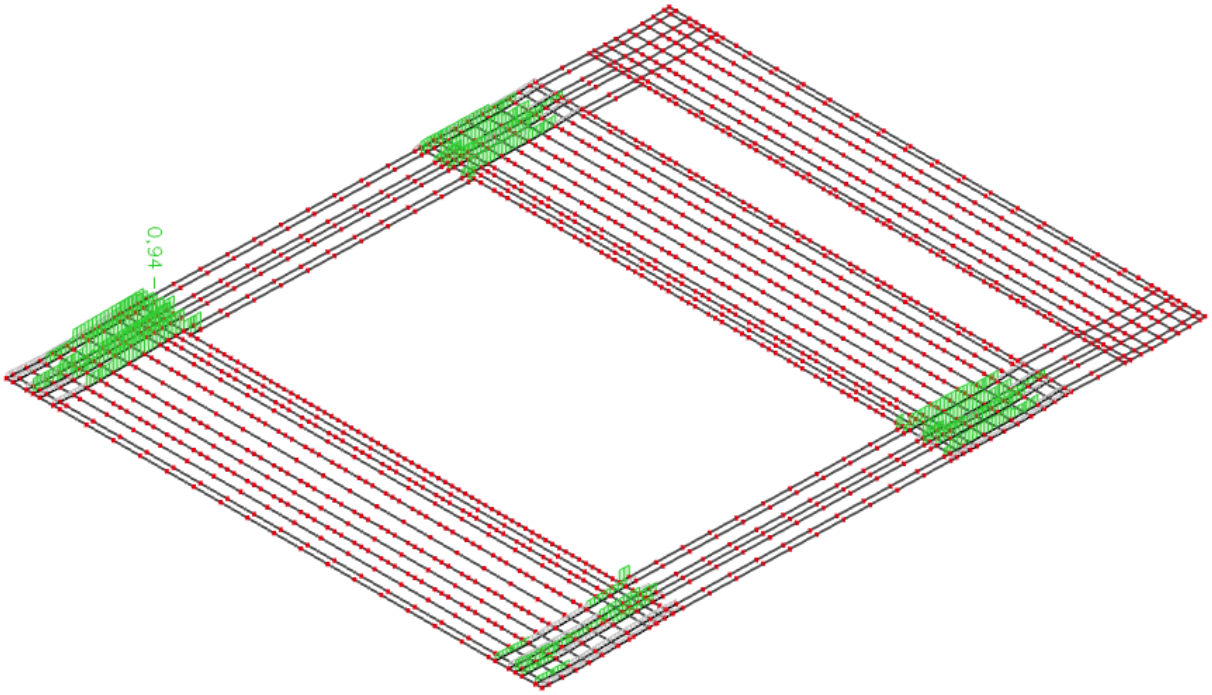
The member satisfies the stability check.

Student version
Student version
Student version

## 5.28. Dimenzioniranje krovne podrožnice pozicije KP2

| | | |
|---|---|---|
| Name | KP2 | |
| Type | SHS300/300/14.2 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | rolled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [m²] | 1,6000e-02 | |
| A y, z [m²] | 8,0065e-03 | 8,0065e-03 |
| I y, z [m⁴] | 2,1640e-04 | 2,1640e-04 |
| I w [m⁶], t [m⁴] | 2,8755e-06 | 3,3940e-04 |
| $W_{el}$ y, z [m³] | 1,4420e-03 | 1,4420e-03 |
| $W_{pl}$ y, z [m³] | 1,7080e-03 | 1,7080e-03 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 150 | 150 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 1,1600e+00 | 2,2252e+00 |
| $M_{ply}$ +, - [Nm] | 6,06e+05 | 6,06e+05 |
| $M_{plz}$ +, - [Nm] | 6,06e+05 | 6,06e+05 |

***Tablica 5.28.*** *Karakteristike poprečnog presjeka krovne podrožnice pozicije KP2*




***Slika 5.31.*** *Prikaz iskoristivosti krovne podrožnie pozicije KP2*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = KP2 - SHS300/300/14.2

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp7250 | 21,061 / 21,061 m | SHS300/300/14.2 | S 355 | GSN | 0,94 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*snijeg + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmin |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 21,061 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | 186,80 | kN |
| $V_{y,Ed}$ | -17,67 | kN |
| $V_{z,Ed}$ | 158,62 | kN |
| $T_{Ed}$ | -1,04 | kNm |
| $M_{y,Ed}$ | 568,64 | kNm |
| $M_{z,Ed}$ | -19,62 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 257 | 14 | -3,756e+05 | -3,989e+05 | | | | | | | | |
| 3 | I | 257 | 14 | -3,629e+05 | 3,137e+05 | -1,16 | | 0,46 | 18,13 | 63,18 | 72,83 | 117,04 | 1 |
| 5 | I | 257 | 14 | 3,523e+05 | 3,756e+05 | 0,94 | | 1,00 | 18,13 | 22,78 | 27,66 | 31,60 | 1 |
| 7 | I | 257 | 14 | 3,396e+05 | -3,370e+05 | -0,99 | | 0,50 | 18,13 | 58,23 | 67,16 | 100,17 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Tension check**
According to EN 1993-1-1 article 6.2.3 and formula (6.5)

| | | |
|---|---|---|
| A | 1,6000e-02 | $m^2$ |
| $N_{pl,Rd}$ | 5680,00 | kN |
| $N_{u,Rd}$ | 5644,80 | kN |
| $N_{t,Rd}$ | 5644,80 | kN |
| Unity check | 0,03 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 1,7080e-03 | $m^3$ |
| $M_{pl,y,Rd}$ | 606,34 | kNm |
| Unity check | 0,94 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 1,7080e-03 | $m^3$ |
| $M_{pl,z,Rd}$ | 606,34 | kNm |
| Unity check | 0,03 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,0000e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 1639,67 | kN |
| Unity check | 0,01 | - |

Student version

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 8,0000e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 1639,67 | kN |
| Unity check | 0,10 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,4 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 606,34 | kNm |
| $\alpha$ | 1,66 | |
| $M_{N,z,Rd}$ | 606,34 | kNm |
| $\beta$ | 1,66 | |

Unity check (6.41) = 0,90 + 0,00 = 0,90 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 21,061 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\Psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 257 | 14 | -3,755e+05 | -3,989e+05 | | | | | | | | |
| 3 | I | 257 | 14 | -3,629e+05 | 3,137e+05 | -1,16 | | 0,46 | 18,13 | 63,18 | 72,83 | 117,04 | 1 |
| 5 | I | 257 | 14 | 3,523e+05 | 3,756e+05 | 0,94 | | 1,00 | 18,13 | 22,78 | 27,66 | 31,60 | 1 |
| 7 | I | 257 | 14 | 3,396e+05 | -3,370e+05 | -0,99 | | 0,50 | 18,13 | 58,23 | 67,16 | 100,17 | 1 |

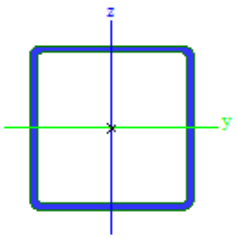
**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with '$h / b < 10 / \lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

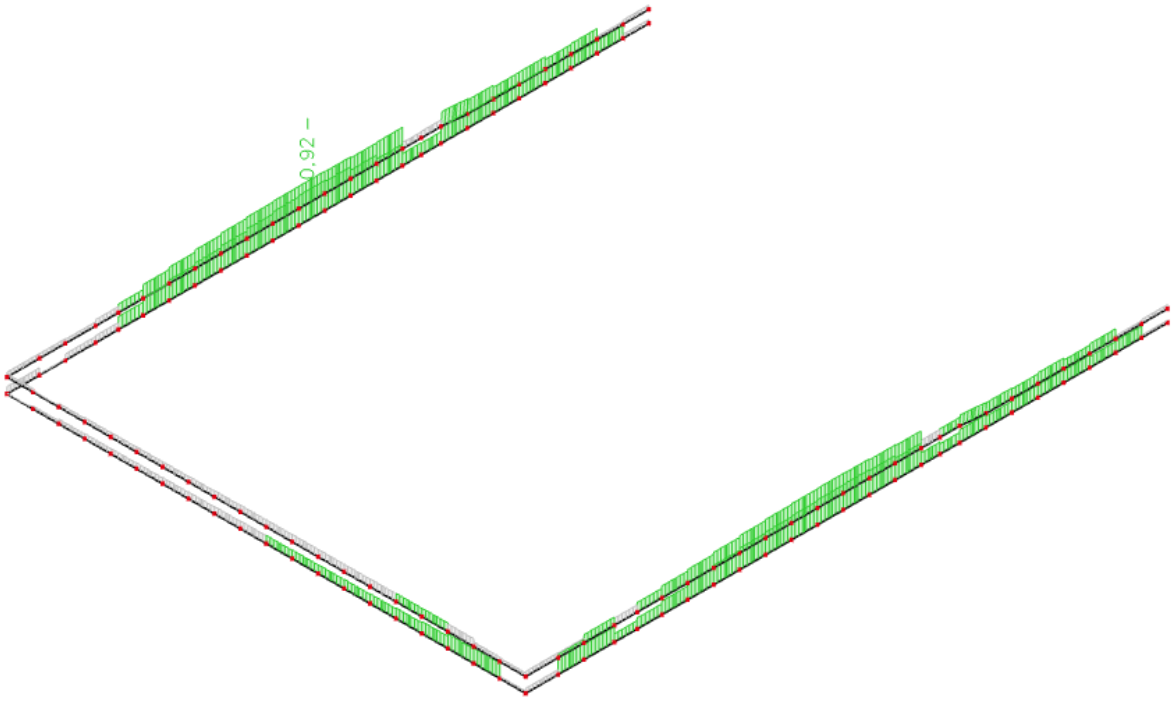
The member satisfies the stability check.

Student version

## 5.29. Dimenzioniranje bočne podrožnice pozicije BP

| | | |
|---|---|---|
| Name | BP | |
| Type | SHS120/120/5.0 | |
| Source description | British Standard / BS 5950 part 1 : 1990 & EN 10210-2 | |
| Item material | S 355 | |
| Fabrication | roled | |
| Flexural buckling y-y | a | |
| Flexural buckling z-z | a | |
| Lateral torsional buckling | Default | |
| Use 2D FEM analysis | × | |
|  | | |
| A [$m^2$] | 2,2700e-03 | |
| A y, z [$m^2$] | 1,1363e-03 | 1,1363e-03 |
| I y, z [$m^4$] | 4,9800e-06 | 4,9800e-06 |
| I w [$m^6$], t [$m^4$] | 1,0368e-08 | 7,7700e-06 |
| $W_{el}$ y, z [$m^3$] | 8,3000e-05 | 8,3000e-05 |
| $W_{pl}$ y, z [$m^3$] | 9,7600e-05 | 9,7600e-05 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 60 | 60 |
| α [deg] | 0,00 | |
| A L, D [$m^2$/m] | 4,6700e-01 | 8,9844e-01 |
| $M_{ply}$ +, - [Nm] | 3,46e+04 | 3,46e+04 |
| $M_{plz}$ +, - [Nm] | 3,46e+04 | 3,46e+04 |

***Tablica 5.29.*** *Karakteristike poprečnog presjeka bočne podrožnice pozicije BP*




***Slika 5.32.*** *Prikaz iskoristivosti bočne podrožnice BP*

## EC-EN 1993 Steel check ULS

Linear calculation
Class: GSN
Coordinate system: Principal
Extreme 1D: Global
Selection: All
Filter: Cross-section = BP - SHS120/120/5.0

**EN 1993-1-1 Code Check**
National annex: Standard EN

| Member pp12607 | 0,000 / 8,000 m | SHS120/120/5.0 | S 355 | GSN | 0,92 - |
|---|---|---|---|---|---|

| Combination key |
|---|
| GSN / 1.35*vlastita težina + 1.62*korisno opterećenje + 1.35*dodatno stalno opterećenje + 1.35*vjetar pritisak + 1.35*trenje po krovu + 1.35*Tmax |

| Partial safety factors | |
|---|---|
| $\gamma_{M0}$ for resistance of cross-sections | 1,00 |
| $\gamma_{M1}$ for resistance to instability | 1,00 |
| $\gamma_{M2}$ for resistance of net sections | 1,25 |

| Material | | |
|---|---|---|
| Yield strength $f_y$ | 355,0 | MPa |
| Ultimate strength $f_u$ | 490,0 | MPa |
| Fabrication | Rolled | |

**...::SECTION CHECK::...**

**The critical check is on position 0,000 m**

| Internal forces | Calculated | Unit |
|---|---|---|
| $N_{Ed}$ | -131,29 | kN |
| $V_{y,Ed}$ | -0,01 | kN |
| $V_{z,Ed}$ | 0,79 | kN |
| $T_{Ed}$ | 0,02 | kNm |
| $M_{y,Ed}$ | -0,68 | kNm |
| $M_{z,Ed}$ | 0,08 | kNm |

**Classification for cross-section design**
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | $\psi$ [-] | $k_\sigma$ [-] | $\alpha$ [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 105 | 5 | 6,482e+04 | 6,642e+04 | 0,98 | | 1,00 | 21,00 | 22,78 | 27,66 | 31,18 | 1 |
| 3 | I | 105 | 5 | 6,581e+04 | 5,146e+04 | 0,78 | | 1,00 | 21,00 | 22,78 | 27,66 | 33,45 | 1 |
| 5 | I | 105 | 5 | 5,070e+04 | 4,910e+04 | 0,97 | | 1,00 | 21,00 | 22,78 | 27,66 | 31,26 | 1 |
| 7 | I | 105 | 5 | 4,971e+04 | 6,406e+04 | 0,78 | | 1,00 | 21,00 | 22,78 | 27,66 | 33,52 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Compression check**
According to EN 1993-1-1 article 6.2.4 and formula (6.9)

| | | |
|---|---|---|
| A | 2,2700e-03 | $m^2$ |
| $N_{c,Rd}$ | 805,85 | kN |
| Unity check | 0,16 | - |

**Bending moment check for $M_y$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,y}$ | 9,7600e-05 | $m^3$ |
| $M_{pl,y,Rd}$ | 34,65 | kNm |
| Unity check | 0,02 | - |

**Bending moment check for $M_z$**
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

| | | |
|---|---|---|
| $W_{pl,z}$ | 9,7600e-05 | $m^3$ |
| $M_{pl,z,Rd}$ | 34,65 | kNm |
| Unity check | 0,00 | - |

**Shear check for $V_y$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

| | | |
|---|---|---|
| $\eta$ | 1,20 | |
| $A_v$ | 1,1350e-03 | $m^2$ |
| $V_{pl,y,Rd}$ | 232,63 | kN |
| Unity check | 0,00 | - |

**Shear check for $V_z$**
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

Student version

| | | |
|---|---|---|
| η | 1,20 | |
| $A_v$ | 1,1350e-03 | $m^2$ |
| $V_{pl,z,Rd}$ | 232,63 | kN |
| Unity check | 0,00 | - |

**Torsion check**
According to EN 1993-1-1 article 6.2.7 and formula (6.23)

| | | |
|---|---|---|
| Fibre | 1 | |
| $\tau_{Ed}$ | 0,2 | MPa |
| $\tau_{Rd}$ | 205,0 | MPa |
| Unity check | 0,00 | - |

**Note:** The unity check for torsion is lower than the limit value of 0,05. Therefore torsion is considered as insignificant and is ignored in the combined checks.

**Combined bending, axial force and shear force check**
According to EN 1993-1-1 article 6.2.9.1 and formula (6.41)

| | | |
|---|---|---|
| $M_{N,y,Rd}$ | 34,65 | kNm |
| α | 1,71 | |
| $M_{N,z,Rd}$ | 34,65 | kNm |
| β | 1,71 | |

Unity check (6.41) = 0,00 + 0,00 = 0,00 -

**Note:** Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.

The member satisfies the section check.

**...::STABILITY CHECK::...**

**Classification for member buckling design**
Decisive position for stability classification: 8,000 m
Classification according to EN 1993-1-1 article 5.5.2
Classification of Internal and Outstand parts according to EN 1993-1-1 Table 5.2 Sheet 1 & 2

| Id | Type | c [mm] | t [mm] | $\sigma_1$ [kN/m²] | $\sigma_2$ [kN/m²] | Ψ [-] | $k_\sigma$ [-] | α [-] | c/t [-] | Class 1 Limit [-] | Class 2 Limit [-] | Class 3 Limit [-] | Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 105 | 5 | 7,923e+04 | 7,986e+04 | 0,99 | | 1,00 | 21,00 | 22,78 | 27,66 | 31,00 | 1 |
| 3 | I | 105 | 5 | 7,800e+04 | 3,821e+04 | 0,49 | | 1,00 | 21,00 | 22,78 | 27,66 | 37,57 | 1 |
| 5 | I | 105 | 5 | 3,629e+04 | 3,566e+04 | 0,98 | | 1,00 | 21,00 | 22,78 | 27,66 | 31,10 | 1 |
| 7 | I | 105 | 5 | 3,752e+04 | 7,731e+04 | 0,49 | | 1,00 | 21,00 | 22,78 | 27,66 | 37,64 | 1 |

**Note:** The Classification limits have been set according to Semi-Comp+.
The cross-section is classified as Class 1

**Flexural Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

| Buckling parameters | yy | zz | |
|---|---|---|---|
| Sway type | sway | sway | |
| System length L | 8,000 | 8,000 | m |
| Buckling factor k | 1,00 | 1,00 | |
| Buckling length $l_{cr}$ | 8,000 | 8,000 | m |
| Critical Euler load $N_{cr}$ | 161,28 | 161,28 | kN |
| Slenderness λ | 170,80 | 170,80 | |
| Relative slenderness $\lambda_{rel}$ | 2,24 | 2,24 | |
| Limit slenderness $\lambda_{rel,0}$ | 0,20 | 0,20 | |
| Buckling curve | a | a | |
| Imperfection α | 0,21 | 0,21 | |
| Reduction factor χ | 0,18 | 0,18 | |
| Buckling resistance $N_{b,Rd}$ | 146,02 | 146,02 | kN |

| Flexural Buckling verification | | |
|---|---|---|
| Cross-section area A | 2,2700e-03 | $m^2$ |
| Buckling resistance $N_{b,Rd}$ | 146,02 | kN |
| Unity check | 0,90 | - |

**Torsional(-Flexural) Buckling check**
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
**Note:** The cross-section concerns a RHS section which is not susceptible to Torsional(-Flexural) Buckling.

**Lateral Torsional Buckling check**
According to EN 1993-1-1 article 6.3.2.1
**Note:** The cross-section concerns an RHS section with 'h / b < 10 / $\lambda_{rel,z}$'.
This section is thus not susceptible to Lateral Torsional Buckling.

**Bending and axial compression check**
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Student version

| Bending and axial compression check parameters | | |
|---|---|---|
| Interaction method | alternative method 1 | |
| Cross-section area A | 2,2700e-03 | $m^2$ |
| Plastic section modulus $W_{pl,y}$ | 9,7600e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 9,7600e-05 | $m^3$ |
| Design compression force $N_{Ed}$ | 131,29 | kN |
| Design bending moment (maximum) $M_{y,Ed}$ | -1,89 | kNm |
| Design bending moment (maximum) $M_{z,Ed}$ | 0,08 | kNm |
| Characteristic compression resistance $N_{Rk}$ | 805,85 | kN |
| Characteristic moment resistance $M_{y,Rk}$ | 34,65 | kNm |
| Characteristic moment resistance $M_{z,Rk}$ | 34,65 | kNm |
| Reduction factor $\chi_y$ | 0,18 | |
| Reduction factor $\chi_z$ | 0,18 | |
| Reduction factor $\chi_{LT}$ | 1,00 | |
| Interaction factor $k_{yy}$ | 0,40 | |
| Interaction factor $k_{yz}$ | 1,23 | |
| Interaction factor $k_{zy}$ | 0,26 | |
| Interaction factor $k_{zz}$ | 1,23 | |

Maximum moment $M_{y,Ed}$ is derived from beam pp12607 position 8,000 m.
Maximum moment $M_{z,Ed}$ is derived from beam pp12607 position 0,000 m.

| Interaction method 1 parameters | | |
|---|---|---|
| Critical Euler load $N_{cr,y}$ | 161,28 | kN |
| Critical Euler load $N_{cr,z}$ | 161,28 | kN |
| Elastic critical load $N_{cr,T}$ | 143108,61 | kN |
| Plastic section modulus $W_{pl,y}$ | 9,7600e-05 | $m^3$ |
| Elastic section modulus $W_{el,y}$ | 8,3000e-05 | $m^3$ |
| Plastic section modulus $W_{pl,z}$ | 9,7600e-05 | $m^3$ |
| Elastic section modulus $W_{el,z}$ | 8,3000e-05 | $m^3$ |
| Second moment of area $I_y$ | 4,9800e-06 | $m^4$ |
| Second moment of area $I_z$ | 4,9800e-06 | $m^4$ |
| Torsional constant $I_t$ | 7,7700e-06 | $m^4$ |
| Method for equivalent moment factor $C_{my,0}$ | Table A.2 Line 2 (General) | |
| Design bending moment (maximum) $M_{y,Ed}$ | -1,89 | kNm |
| Maximum relative deflection $\delta_z$ | -2,4 | mm |
| Equivalent moment factor $C_{my,0}$ | 0,35 | |
| Method for equivalent moment factor $C_{mz,0}$ | Table A.2 Line 1 (Linear) | |
| Ratio of end moments $\psi_z$ | 0,39 | |
| Equivalent moment factor $C_{mz,0}$ | 0,89 | |
| Factor $\mu_y$ | 0,22 | |
| Factor $\mu_z$ | 0,22 | |
| Factor $\varepsilon_y$ | 0,39 | |
| Factor $a_{LT}$ | 0,00 | |
| Critical moment for uniform bending $M_{cr,0}$ | 318,22 | kNm |
| Relative slenderness $\lambda_{rel,0}$ | 0,33 | |
| Limit relative slenderness $\lambda_{rel,0,lim}$ | 0,25 | |
| Equivalent moment factor $C_{my}$ | 0,35 | |
| Equivalent moment factor $C_{mz}$ | 0,89 | |
| Equivalent moment factor $C_{mLT}$ | 1,00 | |
| Factor $b_{LT}$ | 0,00 | |
| Factor $c_{LT}$ | 0,00 | |
| Factor $d_{LT}$ | 0,00 | |
| Factor $e_{LT}$ | 0,00 | |
| Factor $w_y$ | 1,18 | |
| Factor $w_z$ | 1,18 | |
| Factor $n_{pl}$ | 0,16 | |
| Maximum relative slenderness $\lambda_{rel,max}$ | 2,24 | |
| Factor $C_{yy}$ | 1,02 | |
| Factor $C_{yz}$ | 0,51 | |
| Factor $C_{zy}$ | 0,95 | |
| Factor $C_{zz}$ | 0,85 | |

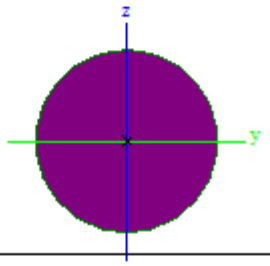
Unity check (6.61) = 0,90 + 0,02 + 0,00 = 0,92 -
Unity check (6.62) = 0,90 + 0,01 + 0,00 = 0,92 -

The member satisfies the stability check.

Student version

## 5.30. Dimenzioniranje bočnog sprega pozicije BS

| | |
|---|---|
| Name | KP4 |
| Type | RD27 |
| Source description | Stahl im Hochbau / 14.Auflage Band I / Teil 1 |
| Item material | S 355 |
| Fabrication | roled |
| Flexural buckling y-y | c |
| Flexural buckling z-z | c |
| Lateral torsional buckling | Default |
| Use 2D FEM analysis | ✓ |




| | | |
|---|---|---|
| A [m²] | 5,7226e-04 | |
| A y, z [m²] | 5,1431e-04 | 5,1431e-04 |
| I y, z [m⁴] | 2,5540e-08 | 2,5540e-08 |
| I w [m⁶], t [m⁴] | 3,1923e-26 | 5,2251e-08 |
| $W_{el}$ y, z [m³] | 1,8919e-06 | 1,8919e-06 |
| $W_{pl}$ y, z [m³] | 3,2288e-06 | 3,2288e-06 |
| d y, z [mm] | 0 | 0 |
| c YUCS, ZUCS [mm] | 14 | 14 |
| α [deg] | 0,00 | |
| A L, D [m²/m] | 8,4599e-02 | 8,4819e-02 |
| $M_{ply}$ +, - [Nm] | 1,16e+03 | 1,16e+03 |
| $M_{plz}$ +, - [Nm] | 1,16e+03 | 1,16e+03 |

***Tablica 5.30.*** *Karakteristike poprečnog presjeka bočnog sprega pozicije BS*

Dimenzioniranje elementa

$$\mathrm{N}_{c,Rd} = \mathrm{N}_{pl,Rd} = \frac{A \cdot f_y}{\gamma_{M_0}} = \frac{5{,}72 \cdot 35{,}5}{1{,}25} = 162{,}45(kN)$$

Uvjet nosivosti:

$$\mathrm{N}_{c,Rd} > N_{Ed}$$

$$162{,}45\ (\mathrm{kN}) \geq 158{,}06(kN)$$

uvjet zadovoljen

# 6. SPOJEVI

## 6.1. Spoj stupa s pločom

### Steel connection

| | |
|---|---|
| Name | spoj stupa s pločom |
| Node | N1510 |
| Connection type | Frame bolted |
| Connection geometry | Column base |
| Calculation type | Internal forces |
| Lc/Combi | GSN7 |

Student version

Connected beams

| Name | Cross-section | Material | Length [m] | Beg. node | End node | Type |
|---|---|---|---|---|---|---|
| pp12790 | S1 - HEA280 | S 355 | 4,500 | N1510 | N10202 | beam (80) |

**Parts of connection**

Bolts

| M24 - 5.6 (ISO 4014, ISO 4032, ISO 7089) | | | |
|---|---|---|---|
| Name | | Bolt pattern | 4 bolts/row |
| Internal bolts distance [mm] | 110 | External bolts distance [mm] | 80 |
| Length [mm] | 820 | Reference | Bottom of the beam |
| 1.Location [mm] | 330 | 2.Location [mm] | |
| 5.Location [mm] | -60 | 6.Location [mm] | |

End-plate

| EP1 | | | |
|---|---|---|---|
| Material | S 355 | Left extension [mm] | 80 |
| Thickness[mm] | 25 | Right extension [mm] | 80 |
| Input | Top/Bottom/Left/Right | Total width [mm] | 440 |
| Top extension [mm] | 100 | Total height [mm] | 470 |
| Bottom extension [mm] | 100 | | |

**Connection analysis: Side [pp12790]**

**According to EN 1993-1-8**
National annex: Standard EN

Student version

| Partial safety factors | |
|---|---|
| Gamma_M0 | 1.00 |
| Gamma_M1 | 1.00 |
| Gamma_M2 | 1.25 |
| Gamma_M3 | 1.25 |
| Gamma_c | 1.50 |

**1. Internal forces**

| GSN7 | | |
|---|---|---|
| NEd | -200.40 | kN |
| Vz,Ed | 37.94 | kN |
| My,Ed | -145.93 | kNm |

Left side in Tension, Right side in Compression.

**...::STRONG-AXIS CALCULATION::..**

**2. T-stub in compression**
According to EN 1993-1-8 Article 6.2.5

| Bearing width data | | |
|---|---|---|
| α | 1.50 | - |
| βj | 0.60 | - |
| fcd | 26.67 | MPa |
| fj | 24.00 | MPa |
| c | 55.51 | mm |

**3. Design moment resistance Mj,y,Rd**
**3.1. Design resistance of basic components**
**3.1.1. Column flange and web in compression - Right side**
According to EN 1993-1-8 Article 6.2.6.7

| Fc,fb,Rd data | | |
|---|---|---|
| Section class | 3 | |
| Mc,Rd | 358.55 | kNm |
| hb-tfb | 257.00 | mm |
| Fc,fb,Rd | 1395.14 | kN |

Student version

**3.1.2. Concrete in compression under the right column flange**
According to EN 1993-1-8 Article 6.2.6.9

| Fc,pl,Rd data | | |
|---|---|---|
| beff | 124.02 | mm |
| leff | 391.02 | mm |
| Aeff | 48496.50 | $mm^2$ |
| Fc,pl,Rd | 1163.92 | kN |

Student version

**3.1.3. Design tension resistance of anchor row**
(effective lengths in mm, resistance in kN)

| Ft,Rd data | | |
|---|---|---|
| fub | 500.00 | MPa |
| As | 353.00 | $mm^2$ |
| k2 | 0.90 | - |
| Beta | 0.85 | - |
| Ft,Rd | 108.02 | kN |
| Lb | 261.75 | mm |

Note: The bolt-rows are numbered starting from the bolt-row farthest from the centre of compression as given by EN 1993-1-8 Article 6.2.7.2 (1).

Note: The effective lengths and resistances of bolt-rows are calculated considering 4 bolts per row.

Note: The Alternative method for FT,1,Rd according to EN 1993-1-8 Article 6.2.4, Table 6.2 is used.

**3.1.4. Base plate under the left column flange**
According to EN 1993-1-8 Article 6.2.6.11, 6.2.6.8
(effective lengths in mm, resistance in kN)

| row | m2U | m2L | limit | near flange U | near flange L | Classification |
|---|---|---|---|---|---|---|
| 1 | - | - | - | - | - | Bolt-row outside of beam |

| row | p (p1+p2) | e | ex | m | mx | n | λ1U | λ2U | αU | λ1L | λ2L | αL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.00+0.00 | 85.00 | 40.00 | - | 50.95 | 40.00 | - | - | - | - | - | - |

| row | leff,cp,i | leff,nc,i |
|---|---|---|
| 1 | 255.03 | 220.00 |

For individual anchor row:

| row | leff,1 | leff,2 | Lb* | Prying forces | FT,1,Rd | FT,2,Rd | FT,3,Rd | Ft,ep,Rd,i |
|---|---|---|---|---|---|---|---|---|
| 1 | 220.00 | 220.00 | 119.79 | X | 479.03 | 479.03 | 432.07 | 432.07 |

| row | beff,t,wb | Ft,wb,Rd,i |
|---|---|---|
| 1 | - | - |

Student version

**3.1.4.1. Base plate in bending under the left column flange**

| row | Ft,pl,Rd,i | Ft,pl,Rd,g | Ft,pl,Rd,r |
|---|---|---|---|
| 1 | 432.07 | - | 432.07 |

Ft,pl,Rd = 432.07 kN

**3.1.4.2. Column web in tension under the left column flange**

| row | Ft,wc,Rd,i | Ft,wc,Rd,g | Ft,wc,Rd,r |
|---|---|---|---|
| 1 | - | - | - |

**3.2. Determination of Mj,y,Rd**
According to EN 1993-1-8 Article 6.2.8.3 Table 6.7

| Mj,Rd data | | |
|---|---|---|
| FT,l,Rd | 432.07 | kN |
| zT,l | 195.00 | mm |
| FC,r,Rd | 1163.92 | kN |
| zC,r | 128.50 | mm |
| z | 323.50 | mm |
| e | -728.21 | mm |

**Mj,y,Rd = 169.72 kNm**

**4. Design shear resistance VRd**

| Vz,Rd data | | |
|---|---|---|
| Vz,Rd | 395.36 | kN |
| Fv,Rd | 49.42 | kN |
| e1,ep | 40.00 | mm |
| p1 | 390.00 | mm |
| Alfa_d plate | 0.51 | |
| Alfa_b plate | 0.51 | |
| Fb,ep,Rd | 301.54 | kN |
| Alfa_b (6.2) plate | 0.35 | |
| F1,vb,Rd | 84.72 | kN |
| F2,vb,Rd | 49.42 | kN |

Student version

**5. Stiffness caiculation**

**5.1. Design rotational stiffness**
According to EN 1993-1-8 Article 6.3.4
Bolt-rows under the left column flange

| row | k15[mm] | k16[mm] | keff[mm] |
|---|---|---|---|
| 1 | 11.05 | 2.16 | 1.81 |

| Sj data | | |
|---|---|---|
| kT,l | 1.81 | mm |
| zT,l | 195.00 | mm |
| kC,r | 21.15 | mm |
| zC,r | 128.50 | mm |
| z | 323.50 | mm |
| ek | 103.06 | mm |
| e | -728.21 | mm |
| Sj,ini | 42.58 | MNm/rad |
| mu | 1.99 | |
| Sj | 21.42 | MNm/rad |

**5.2. Stiffness classification**
According to EN 1993-1-8 Article 5.2.2.5 (2)

| Stiffness data | | |
|---|---|---|
| frame type | braced | |
| E | 210000.00 | MPa |
| Ic | 137000000.00 | $mm^4$ |
| Lc | 4500.14 | mm |
| λ0,rel | 0.50 | - |

System RIGID

**5.3. Ductility classification**
In the endplate we have the following :
t > 0.53 sqrt(fub/fy) d
This results in a non-ductile classification for ductility : class 3.

**6. Design Calculations.**
**6.1. Anchorage length**
According to EN 1992-1-1 Article 8.4

| Anchorage data | | |
|---|---|---|
| fctd | 1.64 | MPa |
| good bond condition | no | - |
| μ1 | 0.70 | - |
| μ2 | 1.00 | - |
| fbd | 2.58 | MPa |
| Ft,bolt | 108.02 | kN |
| As,prov | 353.00 | $mm^2$ |
| As,req | 360.06 | $mm^2$ |
| σ,sd | 306.00 | MPa |
| lb,rqd | 711.91 | mm |
| bar shape | Straight | - |
| α1 | 1.00 | - |
| lbd | 711.91 | mm |

| Anchorage data - straight | | |
|---|---|---|
| d | 24.00 | mm |
| lbd,c | 555.50 | mm |

| Anchorage data | | |
|---|---|---|
| lbd | 711.91 | mm |
| lbd,c | 555.50 | mm |
| lb,min | 240.00 | mm |
| lbd | 711.91 | mm |

**6.2. Calculation weldsize**
**6.2.1. Calculation af**

| data | | |
|---|---|---|
| Mj,y,Rd | 69.75 | kNm |
| α | 1.40 | |
| h | 257.00 | mm |
| FRd | 379.98 | kN |
| Nt,Rd | 1292.20 | kN |
| fu | 490.00 | MPa |
| $\beta_w$ | 0.90 | |
| minimum af | 7.49 | mm |
| af | 8.00 | mm |

**6.2.2. Calculation aw**

Student version

| data | | |
|---|---|---|
| M | 69.75 | kNm |
| N | 200.40 | kN |
| V | 37.94 | kN |
| fu | 490.00 | MPa |
| $\beta_w$ | 0.90 | |
| a1 | 8.00 | mm |
| a3 | 8.00 | mm |
| l1 | 280.00 | mm |
| l2 | 183.00 | mm |
| l3 | 112.00 | mm |
| A | 8430.00 | $mm^2$ |
| I | 136013670.50 | $mm^4$ |
| minimum aw (a2) | 4.61 | mm |
| aw | 5.00 | mm |

Student version

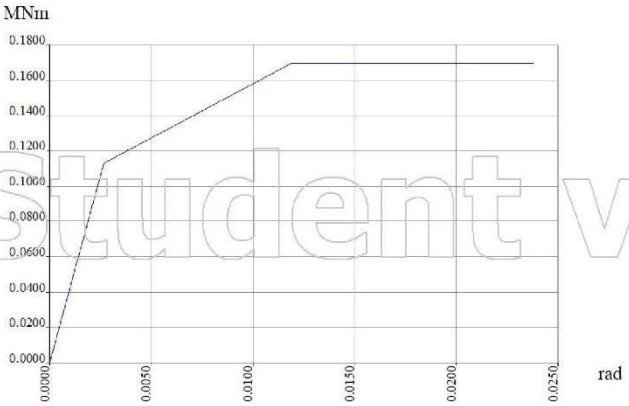
**...::RESULTS::...**

**7. Unity checks**

| Unity checks | |
|---|---|
| My,Ed/Mj,y,Rd | 0.86 |
| Vz,Ed/Vz,Rd | 0.10 |

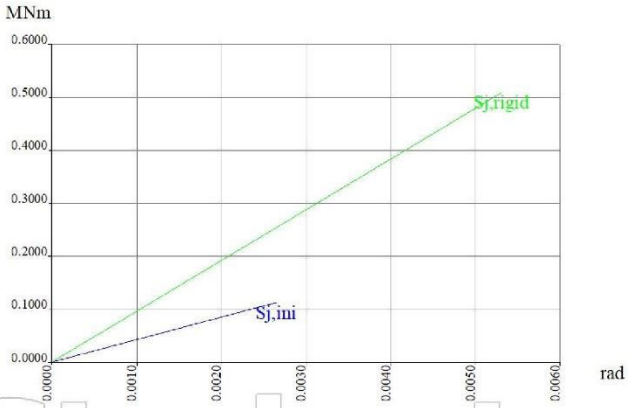
**The connection satisfies.**

**Moment-rotation diagram: Side [pp12790] - Strong axis**




Student version

**Stiffness classification: Side [pp12790] - Strong axis**




Student version

## 6.2. Montažni nastavak donjeg pojasa

**Project:** **Montažni nastavak donjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Montažni nastavak donjeg pojasa |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Montažni nastavak donjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

# Project item Con N102

## Design

| | |
|---|---|
| Name | Con N102 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp47 | 8 - SHS400/400/25.0 | 90,0 | -3,9 | 0,0 | 0 | 0 | 0 | Position |
| pp48 | 10 - SHS400/400/25.0 | -90,0 | 3,9 | 0,0 | 0 | 0 | 0 | Position |

### Cross-sections

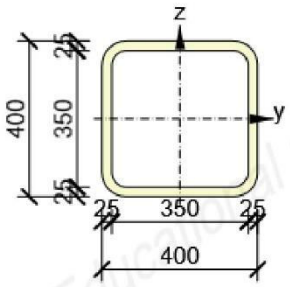
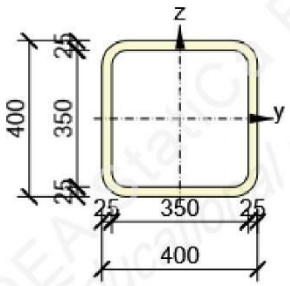
| Name | Material |
|---|---|
| 8 - SHS400/400/25.0 | S 355 |
| 10 - SHS400/400/25.0 | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 8 - SHS400/400/25.0 | S 355 |   |
| 10 - SHS400/400/25.0 | S 355 |   |

### Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M22 5.6 | M22 5.6 | 22 | 500,0 | 380 |

### Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| LE | pp47 | 342,8 | -46,9 | 38,4 | -57,9 | 39,7 | -70,6 |
| | pp48 | 342,8 | -46,9 | -38,4 | -57,9 | 39,7 | 70,6 |

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,3 < 5% | OK |
| Bolts | 95,0 < 100% | OK |
| Welds | 98,4 < 100% | OK |
| Buckling | Not calculated | |

3 / 10

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Plates

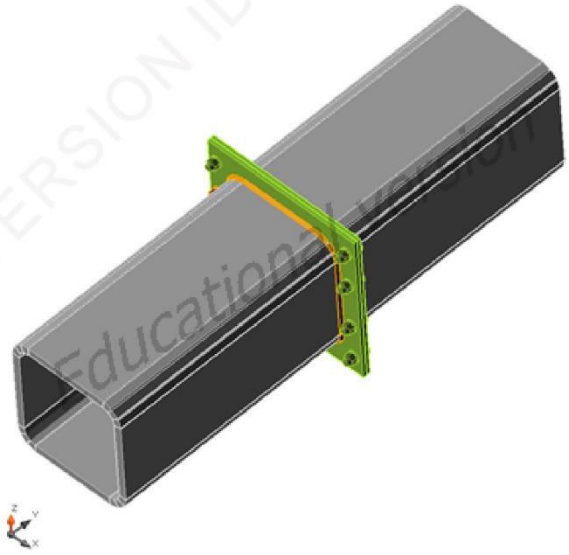
| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp47 | 25,0 | LE | 296,4 | 0,0 | OK |
| pp48 | 25,0 | LE | 300,1 | 0,0 | OK |
| PP1a | 12,0 | LE | 355,7 | 0,3 | OK |
| PP1b | 12,0 | LE | 355,6 | 0,3 | OK |

**Design data**

| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |

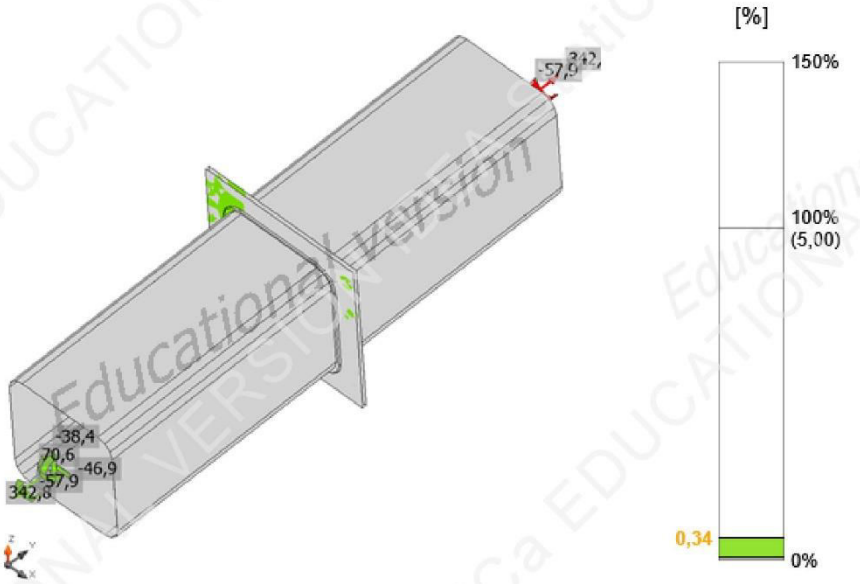


*Overall check, LE*

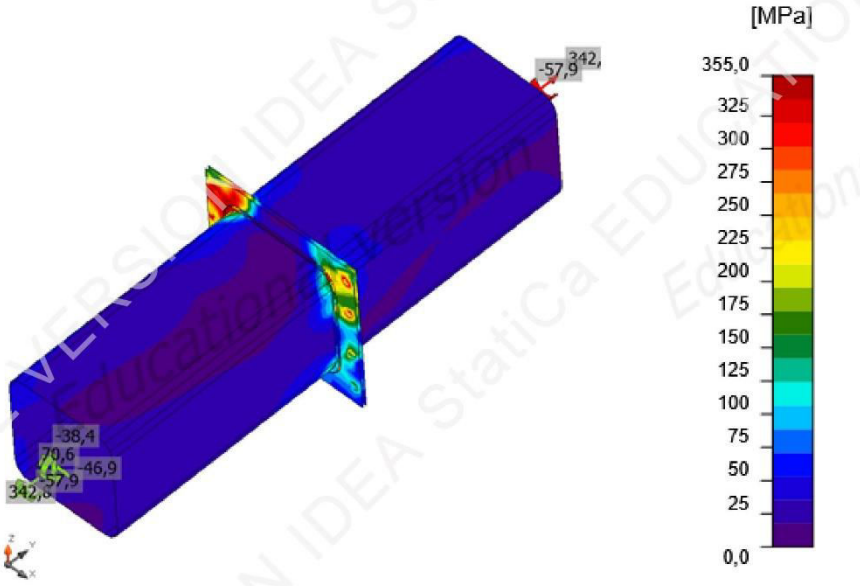
VERSION IDEA StatiCa EDUCATIONAL VERSION
Educational version

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates




*Strain check, LE*




*Equivalent stress, LE*

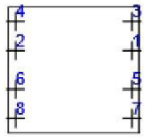
EDUCATIONAL VERSION IDEA StatiCa Educational version

5 / 10

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Bolts




| Name | Loads | $F_{t,Ed}$ [kN] | V [kN] | $Ut_t$ [%] | $F_{b,Rd}$ [kN] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|
| B1 | LE | 103,7 | 13,7 | 95,0 | 189,1 | 18,8 | 86,7 | OK |
| B2 | LE | 68,9 | 23,0 | 63,2 | 190,0 | 31,6 | 76,7 | OK |
| B3 | LE | 91,6 | 19,0 | 84,0 | 197,2 | 26,1 | 86,1 | OK |
| B4 | LE | 67,0 | 24,7 | 61,4 | 189,8 | 33,9 | 77,8 | OK |
| B5 | LE | 93,1 | 18,2 | 85,4 | 215,9 | 25,0 | 86,0 | OK |
| B6 | LE | 32,6 | 35,2 | 29,9 | 207,8 | 48,4 | 69,8 | OK |
| B7 | LE | 67,3 | 27,1 | 61,7 | 152,2 | 37,3 | 81,3 | OK |
| B8 | LE | 0,8 | 43,6 | 0,7 | 145,6 | 59,9 | 60,4 | OK |

**Design data**

| Name | $F_{t,Rd}$ [kN] | $B_{p,Rd}$ [kN] | $F_{v,Rd}$ [kN] |
|---|---|---|---|
| M22 5.6 - 1 | 109,1 | 305,9 | 72,7 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Montažni nastavak donjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Detailed result for B1**

**Tension resistance check** (EN 1993-1-8 Table 3.4)

$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} =$ 109,1 kN ≥ $F_t =$ 103,7 kN

where:

$k_2 =$ 0,90 – Factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A_s =$ 303 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Punching resistance check** (EN 1993-1-8 Table 3.4)

$B_{p,Rd} = \frac{0,6\pi d_m t_p f_u}{\gamma_{M2}} =$ 305,9 kN ≥ $F_t =$ 103,7 kN

where:

$d_m =$ 35 mm – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p =$ 12 mm – Thickness

$f_u =$ 490,0 MPa – Ultimate strength

$\gamma_{M2} =$ 1,25 – Safety factor

**Shear resistance check** (EN 1993-1-8 Table 3.4)

$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} =$ 72,7 kN ≥ $V =$ 13,7 kN

where:

$\beta_p =$ 1,00 – Reducing factor

$\alpha_v =$ 0,60 – Reducing factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A =$ 303 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Montažni nastavak donjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Bearing resistance check** (EN 1993-1-8 Table 3.4)

$F_{b,Rd} = \frac{k_1 \alpha_b f_u dt}{\gamma_{M2}} =$ 189,1 kN ≥ $V =$ 13,7 kN

where:

$k_1 =$ 1,83 – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b =$ 1,00 – Factor
$f_u =$ 490,0 MPa – Ultimate strength
$d =$ 22 mm – Nominal diameter of the fastener
$t =$ 12 mm – Thickness
$\gamma_{M2} =$ 1,25 – Safety factor

**Interaction of tension and shear** (EN 1993-1-8 Table 3.4)

$U_{tts} = \frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4F_{t,Rd}} =$ 86,7 %

**Utilization in tension**

$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd};B_{p,Rd})} =$ 95,0 %

**Utilization in shear**

$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd};F_{b,Rd})} =$ 18,8 %

**Symbol explanation**

| | |
|---|---|
| $F_{t,Rd}$ | Bolt tension resistance EN 1993-1-8 tab. 3.4 |
| $F_{t,Ed}$ | Tension force |
| $B_{p,Rd}$ | Punching shear resistance |
| V | Resultant of shear forces Vy, Vz in bolt |
| $F_{v,Rd}$ | Bolt shear resistance EN_1993-1-8 table 3.4 |
| $F_{b,Rd}$ | Plate bearing resistance EN 1993-1-8 tab. 3.4 |
| $Ut_t$ | Utilization in tension |
| $Ut_s$ | Utilization in shear |
| $Ut_{ts}$ | Utilization in tension and shear EN 1993-1-8 table 3.4 |

VERSION IDEA StatiCa EDUCATIONAL

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢6,0◣ | 1411 | LE | 415,5 | 0,0 | -222,6 | 89,5 | -181,7 | 95,4 | 26,8 | OK |
| PP1a | pp47 | ◢6,0◣ | 1411 | LE | 428,5 | 1,0 | 252,1 | 31,1 | 197,6 | 98,4 | 36,0 | OK |
| | | ◢6,0◣ | 1411 | LE | 428,5 | 1,0 | 249,3 | -44,3 | -196,3 | 98,4 | 37,8 | OK |
| PP1b | pp48 | ◢6,0◣ | 1411 | LE | 422,0 | 0,0 | -240,6 | -47,3 | 194,5 | 96,9 | 28,0 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Detailed result for PP1a pp47**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} =$ 428,5 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_{\perp}| =$ 249,3 MPa

where:

$f_u =$ 490,0 MPa – Ultimate strength

$\beta_w =$ 0,90 – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} =$ 1,25 – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}) =$ 98,4 %

## Buckling

**Buckling analysis was not calculated.**

**Project:** Montažni nastavak donjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.3. Montažni nastavak gornjeg pojasa

**Project:** **Montažni nastavak gornjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Montažni nastavak gornjeg pojasa |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

VERSION IDEA StatiCa EDUCATIONAL VERSION

1 / 10

**Project:** **Montažni nastavak gornjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

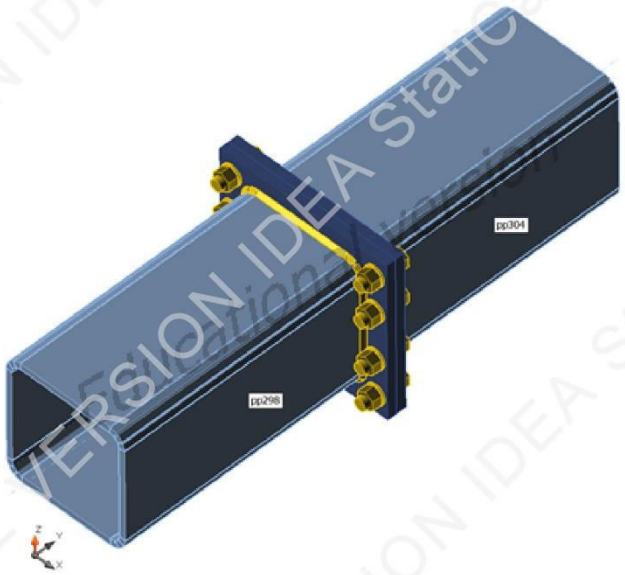
# Project item Con N314

## Design

| | |
|---|---|
| Name | Con N314 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp304 | 6 - SHS400/400/20.0 | 90,0 | -0,5 | 0,0 | 0 | 0 | 0 | Position |
| pp298 | 5 - SHS400/400/20.0 | -90,0 | 0,5 | 0,0 | 0 | 0 | 0 | Position |




### Cross-sections

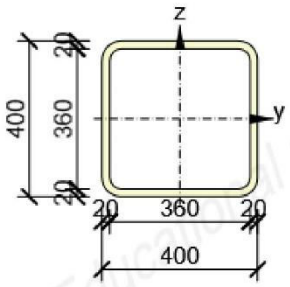
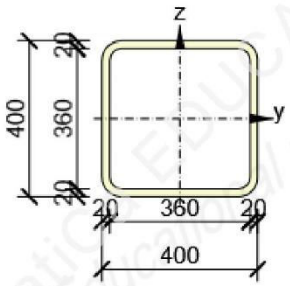
| Name | Material |
|---|---|
| 6 - SHS400/400/20.0 | S 355 |
| 5 - SHS400/400/20.0 | S 355 |

VERSION IDEA StatiCa EDUCATIONAL

**Project:** Montažni nastavak gornjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 6 - SHS400/400/20.0 | S 355 |   |
| 5 - SHS400/400/20.0 | S 355 |   |

## Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M36 5.6 | M36 5.6 | 36 | 500,0 | 1018 |

## Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| LE | pp304 | 2180,1 | -6,3 | -26,5 | -0,5 | -5,6 | -3,5 |
| | pp298 | 2180,1 | -6,3 | 26,5 | -0,5 | -5,6 | 3,5 |

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,2 < 5% | OK |
| Bolts | 97,1 < 100% | OK |
| Welds | 99,7 < 100% | OK |
| Buckling | Not calculated | |

**Project:** Montažni nastavak gornjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Plates

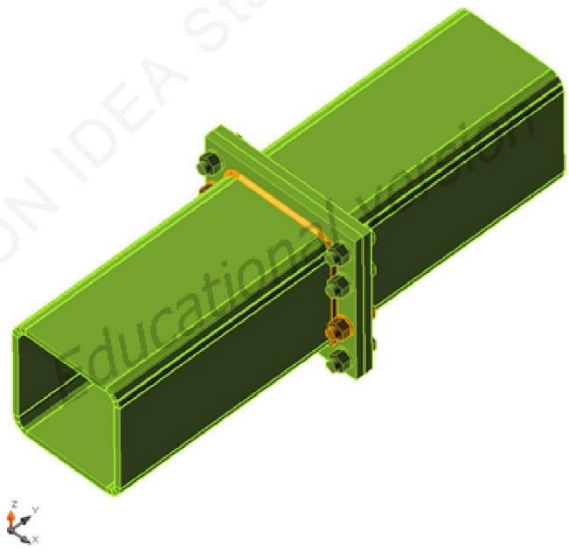
| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp304 | 20,0 | LE | 355,2 | 0,1 | OK |
| pp298 | 20,0 | LE | 355,2 | 0,1 | OK |
| PP1a | 30,0 | LE | 355,4 | 0,2 | OK |
| PP1b | 30,0 | LE | 355,4 | 0,2 | OK |

**Design data**

| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

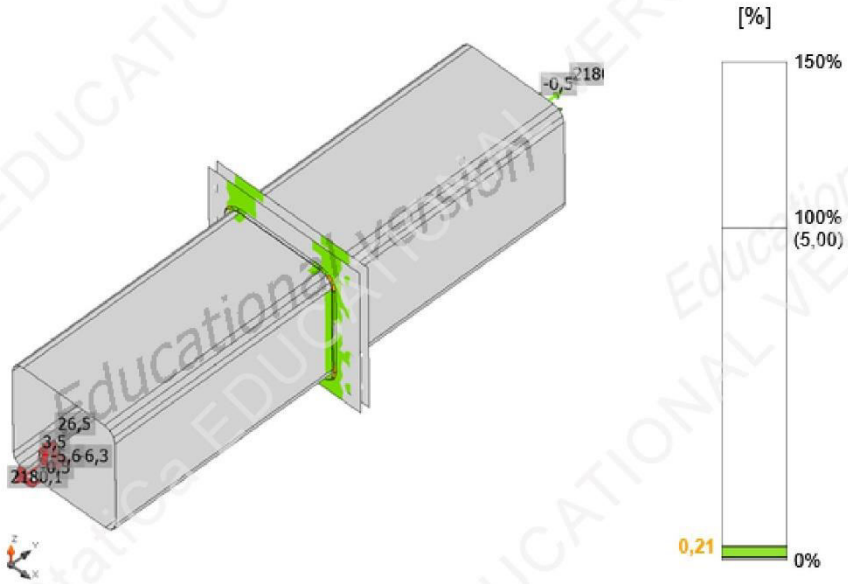
| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |



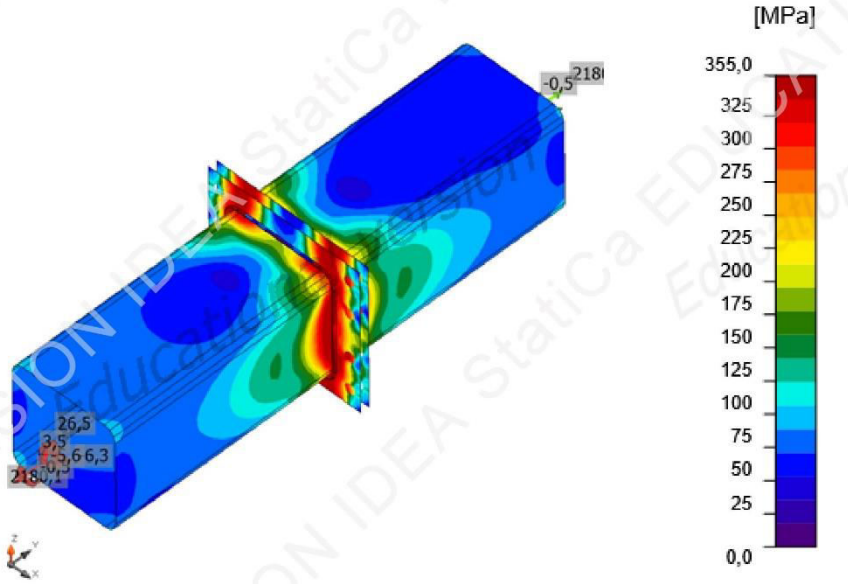
*Overall check, LE*

**Project:** Montažni nastavak gornjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates




*Strain check, LE*



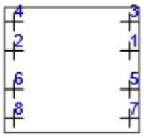

*Equivalent stress, LE*

5 / 10

**Project:** Montažni nastavak gornjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Bolts

| | Name | Loads | $F_{t,Ed}$ [kN] | V [kN] | $Ut_t$ [%] | $F_{b,Rd}$ [kN] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
|  | B1 | LE | 282,1 | 3,2 | 95,9 | 523,9 | 1,6 | 70,1 | OK |
| | B2 | LE | 278,3 | 2,9 | 94,6 | 529,8 | 1,5 | 69,0 | OK |
| | B3 | LE | 243,3 | 3,8 | 82,7 | 260,9 | 1,9 | 61,0 | OK |
| | B4 | LE | 241,1 | 3,5 | 82,0 | 284,9 | 1,8 | 60,4 | OK |
| | B5 | LE | 285,6 | 3,1 | 97,1 | 534,3 | 1,6 | 70,9 | OK |
| | B6 | LE | 281,8 | 2,8 | 95,8 | 545,8 | 1,4 | 69,8 | OK |
| | B7 | LE | 249,1 | 4,0 | 84,7 | 302,4 | 2,0 | 62,5 | OK |
| | B8 | LE | 247,0 | 3,3 | 84,0 | 281,8 | 1,7 | 61,7 | OK |



### Design data

| Name | $F_{t,Rd}$ [kN] | $B_{p,Rd}$ [kN] | $F_{v,Rd}$ [kN] |
|---|---|---|---|
| M36 5.6 - 1 | 294,1 | 1285,7 | 196,1 |

IDEA StatiCa EDUCATIONAL VERSION

**Project:** **Montažni nastavak gornjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Detailed result for B5**

**Tension resistance check** (EN 1993-1-8 Table 3.4)

$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} =$ 294,1 kN ≥ $F_t =$ 285,6 kN

where:

$k_2 =$ 0,90 – Factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A_s =$ 817 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Punching resistance check** (EN 1993-1-8 Table 3.4)

$B_{p,Rd} = \frac{0,6\pi d_m t_p f_u}{\gamma_{M2}} =$ 1285,7 kN ≥ $F_t =$ 285,6 kN

where:

$d_m =$ 58 mm – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p =$ 30 mm – Thickness

$f_u =$ 490,0 MPa – Ultimate strength

$\gamma_{M2} =$ 1,25 – Safety factor

**Shear resistance check** (EN 1993-1-8 Table 3.4)

$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} =$ 196,1 kN ≥ $V =$ 3,1 kN

where:

$\beta_p =$ 1,00 – Reducing factor

$\alpha_v =$ 0,60 – Reducing factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A =$ 817 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

IDEA StatiCa EDUCATIONAL VERSION

**Project:** **Montažni nastavak gornjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Bearing resistance check** (EN 1993-1-8 Table 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u dt}{\gamma_{M2}} = \quad 534,3 \quad \text{kN} \quad \geq \quad V = \quad 3,1 \quad \text{kN}$$

where:

$k_1 = 1,26$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer

$\alpha_b = 1,00$ – Factor

$f_u = 490,0$ MPa – Ultimate strength

$d = 36$ mm – Nominal diameter of the fastener

$t = 30$ mm – Thickness

$\gamma_{M2} = 1,25$ – Safety factor

**Interaction of tension and shear** (EN 1993-1-8 Table 3.4)

$$U_{tts} = \frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1,4F_{t,Rd}} = \quad 70,9 \quad \%$$

**Utilization in tension**

$$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = \quad 97,1 \quad \%$$

**Utilization in shear**

$$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd}; F_{b,Rd})} = \quad 1,6 \quad \%$$

**Symbol explanation**

| | |
|---|---|
| $F_{t,Rd}$ | Bolt tension resistance EN 1993-1-8 tab. 3.4 |
| $F_{t,Ed}$ | Tension force |
| $B_{p,Rd}$ | Punching shear resistance |
| V | Resultant of shear forces Vy, Vz in bolt |
| $F_{v,Rd}$ | Bolt shear resistance EN_1993-1-8 table 3.4 |
| $F_{b,Rd}$ | Plate bearing resistance EN 1993-1-8 tab. 3.4 |
| $Ut_t$ | Utilization in tension |
| $Ut_s$ | Utilization in shear |
| $Ut_{ts}$ | Utilization in tension and shear EN 1993-1-8 table 3.4 |

**Project:** Montažni nastavak gornjeg pojasa
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢8,0◣ | 1448 | LE | 434,2 | 4,2 | 279,5 | -26,8 | -190,0 | 99,7 | 67,2 | OK |
| PP1a | pp304 | ◢8,0◣ | 1448 | LE | 429,9 | 1,7 | 29,2 | 54,4 | 241,6 | 98,7 | 58,0 | OK |
| | | ◢8,0◣ | 1448 | LE | 429,8 | 1,7 | 28,5 | -52,4 | -242,0 | 98,7 | 58,0 | OK |
| PP1b | pp298 | ◢8,0◣ | 1448 | LE | 434,1 | 4,2 | 279,2 | 25,3 | 190,3 | 99,7 | 67,2 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) = \quad 435,6 \quad \text{MPa} \quad \geq \quad \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} = \quad 434,2 \quad \text{MPa}$$

$$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} = \quad 352,8 \quad \text{MPa} \quad \geq \quad |\sigma_{\perp}| = \quad 279,5 \quad \text{MPa}$$

where:

$f_u = 490,0$ MPa – Ultimate strength

$\beta_w = 0,90$ – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} = 1,25$ – Safety factor

**Stress utilization**

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = \quad 99,7 \quad \%$$

## Buckling

**Buckling analysis was not calculated.**

## Code settings

**Project:** **Montažni nastavak gornjeg pojasa**
**Project no:**
**Author:**

IDEA StatiCa®
Calculate yesterday's estimates

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.4. Montažni nastavak ispune

**Project:** **Montažni nastavak ispune**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Montažni nastavak ispune |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

1 / 10

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

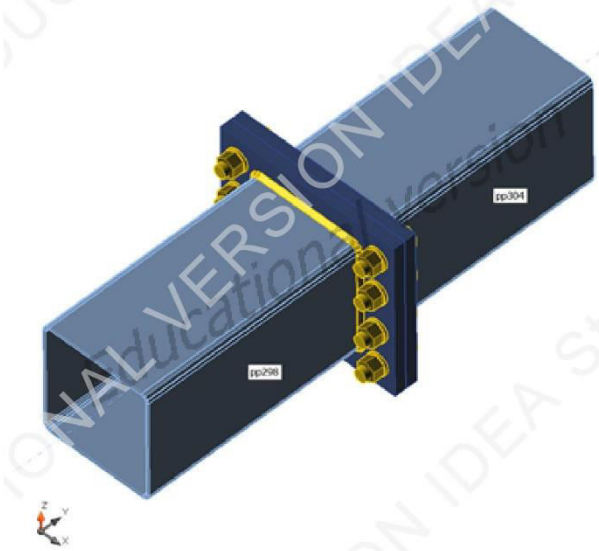
# Project item Con N314

## Design

| | |
|---|---|
| Name | Con N314 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp304 | 8 - SHS250/250/6.3 | 90,0 | -0,5 | 0,0 | 0 | 0 | 0 | Position |
| pp298 | 7 - SHS250/250/6.3 | -90,0 | 0,5 | 0,0 | 0 | 0 | 0 | Position |




### Cross-sections

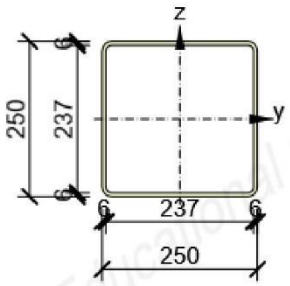
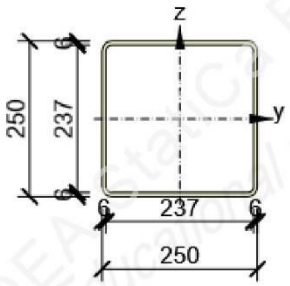
| Name | Material |
|---|---|
| 8 - SHS250/250/6.3 | S 355 |
| 7 - SHS250/250/6.3 | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 8 - SHS250/250/6.3 | S 355 |   |
| 7 - SHS250/250/6.3 | S 355 |   |

## Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M27 5.6 | M27 5.6 | 27 | 500,0 | 573 |

## Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| LE | pp304 | 1101,0 | 1,0 | 17,2 | -0,7 | -28,3 | -2,8 |
| | pp298 | 1101,0 | 1,0 | -17,2 | -0,7 | -28,3 | -2,8 |

# Check

## Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 4,5 < 5% | OK |
| Bolts | 99,7 < 100% | OK |
| Welds | 98,7 < 100% | OK |
| Buckling | Not calculated | |

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Plates

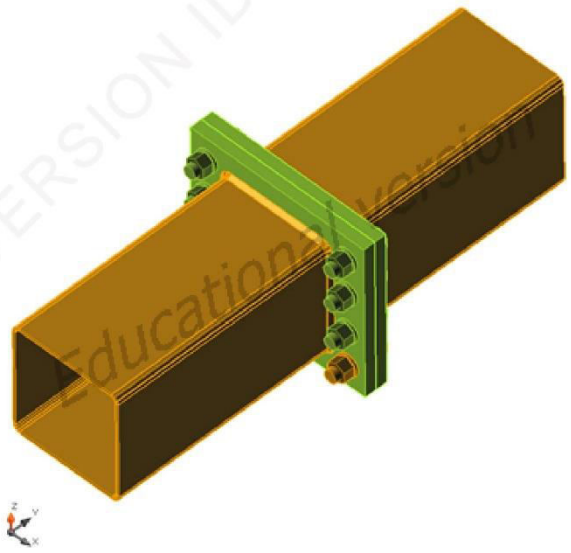
| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp304 | 6,3 | LE | 364,4 | 4,5 | OK |
| pp298 | 6,3 | LE | 364,5 | 4,5 | OK |
| PP1a | 26,0 | LE | 355,7 | 0,4 | OK |
| PP1b | 26,0 | LE | 355,8 | 0,4 | OK |

**Design data**

| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

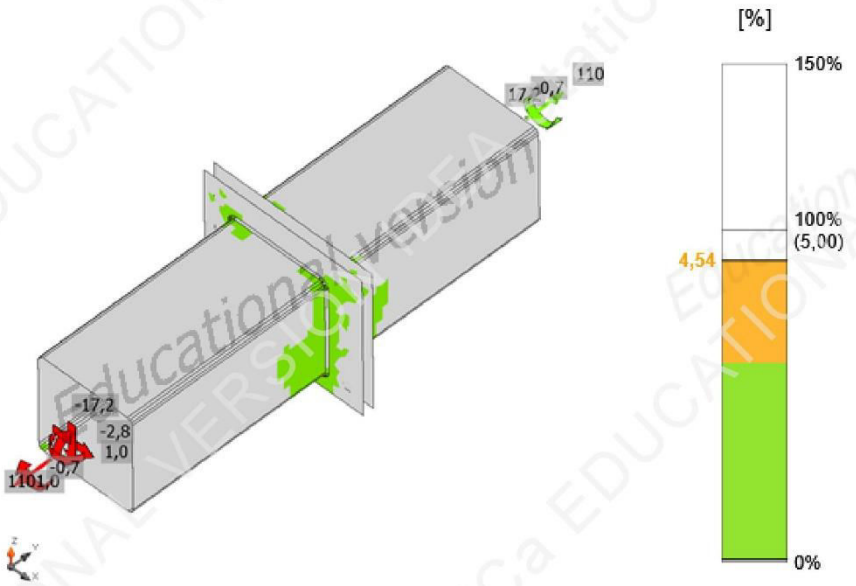
| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |



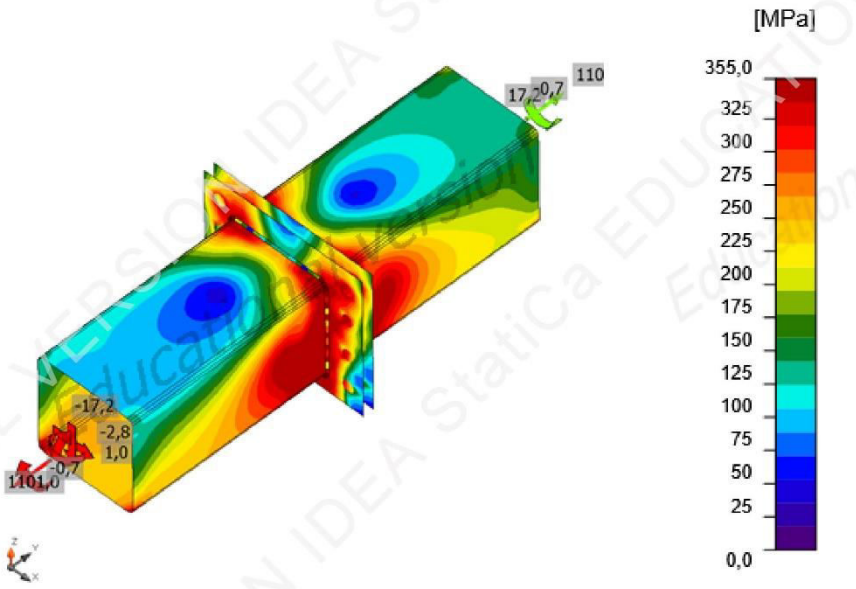
*Overall check, LE*

VERSION IDEA StatiCa EDUCATIONAL VERSION
Educational version

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**




*Strain check, LE*

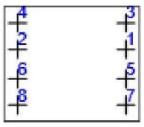



*Equivalent stress, LE*

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Bolts

| | Name | Loads | $F_{t,Ed}$ [kN] | V [kN] | $Ut_t$ [%] | $F_{b,Rd}$ [kN] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
|  | B1 | LE | 138,8 | 1,8 | 84,0 | 363,5 | 1,7 | 61,7 | OK |
| | B2 | LE | 135,7 | 2,6 | 82,1 | 358,0 | 2,4 | 61,0 | OK |
| | B3 | LE | 118,6 | 2,5 | 71,8 | 322,3 | 2,3 | 53,6 | OK |
| | B4 | LE | 116,4 | 3,6 | 70,4 | 320,7 | 3,2 | 53,6 | OK |
| | B5 | LE | 155,7 | 1,6 | 94,2 | 358,7 | 1,4 | 68,7 | OK |
| | B6 | LE | 153,3 | 2,1 | 92,8 | 358,5 | 2,0 | 68,2 | OK |
| | B7 | LE | 164,7 | 1,5 | 99,7 | 311,5 | 1,4 | 72,6 | OK |
| | B8 | LE | 163,3 | 2,0 | 98,8 | 323,2 | 1,9 | 72,4 | OK |

### Design data

| Name | $F_{t,Rd}$ [kN] | $B_{p,Rd}$ [kN] | $F_{v,Rd}$ [kN] |
|---|---|---|---|
| M27 5.6 - 1 | 165,2 | 826,1 | 110,2 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Montažni nastavak ispune**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Detailed result for B7**

**Tension resistance check** (EN 1993-1-8 Table 3.4)

$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} =$ 165,2 kN ≥ $F_t =$ 164,7 kN

where:

$k_2 =$ 0,90 – Factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A_s =$ 459 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Punching resistance check** (EN 1993-1-8 Table 3.4)

$B_{p,Rd} = \frac{0,6\pi d_m t_p f_u}{\gamma_{M2}} =$ 826,1 kN ≥ $F_t =$ 164,7 kN

where:

$d_m =$ 43 mm – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p =$ 26 mm – Thickness

$f_u =$ 490,0 MPa – Ultimate strength

$\gamma_{M2} =$ 1,25 – Safety factor

**Shear resistance check** (EN 1993-1-8 Table 3.4)

$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} =$ 110,2 kN ≥ $V =$ 1,5 kN

where:

$\beta_p =$ 1,00 – Reducing factor

$\alpha_v =$ 0,60 – Reducing factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A =$ 459 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

IDEA StatiCa EDUCATIONAL VERSION

**Project:** **Montažni nastavak ispune**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Bearing resistance check** (EN 1993-1-8 Table 3.4)

$F_{b,Rd} = \frac{k_1 \alpha_b f_u dt}{\gamma_{M2}} =$ 311,5 kN ≥ $V =$ 1,5 kN

where:

$k_1 = 2{,}04$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b = 0{,}56$ – Factor
$f_u = 490{,}0$ MPa – Ultimate strength
$d = 27$ mm – Nominal diameter of the fastener
$t = 26$ mm – Thickness
$\gamma_{M2} = 1{,}25$ – Safety factor

**Interaction of tension and shear** (EN 1993-1-8 Table 3.4)

$U_{tts} = \frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4F_{t,Rd}} =$ 72,6 %

**Utilization in tension**

$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd};B_{p,Rd})} =$ 99,7 %

**Utilization in shear**

$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd};F_{b,Rd})} =$ 1,4 %

**Symbol explanation**

| | |
|---|---|
| $F_{t,Rd}$ | Bolt tension resistance EN 1993-1-8 tab. 3.4 |
| $F_{t,Ed}$ | Tension force |
| $B_{p,Rd}$ | Punching shear resistance |
| V | Resultant of shear forces Vy, Vz in bolt |
| $F_{v,Rd}$ | Bolt shear resistance EN_1993-1-8 table 3.4 |
| $F_{b,Rd}$ | Plate bearing resistance EN 1993-1-8 tab. 3.4 |
| $Ut_t$ | Utilization in tension |
| $Ut_s$ | Utilization in shear |
| $Ut_{ts}$ | Utilization in tension and shear EN 1993-1-8 table 3.4 |

8 / 10

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢6,0◣ | 952 | LE | 429,1 | 1,3 | 261,8 | -20,6 | -195,2 | 98,5 | 64,8 | OK |
| PP1a | pp304 | ◢6,0◣ | 952 | LE | 429,8 | 1,7 | 129,5 | 82,7 | 221,7 | 98,7 | 62,1 | OK |
| | | ◢6,0◣ | 952 | LE | 429,9 | 1,7 | 130,1 | -82,2 | -221,8 | 98,7 | 62,9 | OK |
| PP1b | pp298 | ◢6,0◣ | 952 | LE | 429,0 | 1,3 | 260,9 | 22,3 | 195,3 | 98,5 | 64,9 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Detailed result for PP1a pp304**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} =$ 429,9 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_{\perp}| =$ 130,1 MPa

where:

$f_u =$ 490,0 MPa – Ultimate strength

$\beta_w =$ 0,90 – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} =$ 1,25 – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}) =$ 98,7 %

## Buckling

**Buckling analysis was not calculated.**

**Project:** Montažni nastavak ispune
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.5. Spoj donjeg pojasa i ispune rešetke sa stupom

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Spoj donjeg pojasa i ispune rešetke sa stupom |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** Spoj donjeg pojasa i ispune rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

# Project item Con N468

## Design

| | |
|---|---|
| Name | Con N468 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp11781 | 3 - HEA280 | 0,0 | -90,0 | 270,0 | 0 | 0 | 0 | Position |
| pp478 | 1 - SHS(Ju)400/400/25.0(RHS400x400) | 90,0 | 10,8 | 0,0 | 0 | 0 | 0 | Position |
| pp3073 | 2 - SHS250/250/6.3 | 90,0 | -26,6 | 0,0 | 0 | 0 | 0 | Position |

### Cross-sections

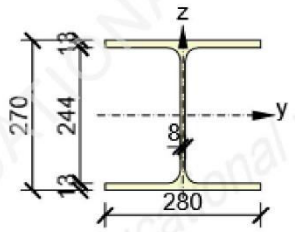
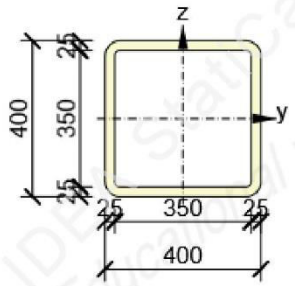
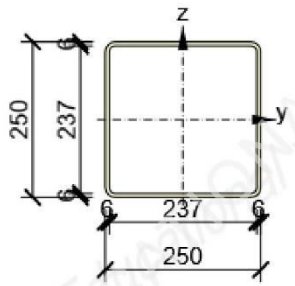
| Name | Material |
|---|---|
| 3 - HEA280 | S 355 |
| 1 - SHS(Ju)400/400/25.0(RHS400x400) | S 355 |
| 2 - SHS250/250/6.3 | S 355 |

StatiCa EDUCATIONAL VERSION IDEA StatiCa

**Project:** Spoj donjeg pojasa i ispune rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 3 - HEA280 | S 355 |   |
| 1 - SHS(Ju)400/400/25.0(RHS400x400) | S 355 |   |
| 2 - SHS250/250/6.3 | S 355 |   |

## Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M16 5.6 | M16 5.6 | 16 | 500,0 | 201 |

**Project:** Spoj donjeg pojasa i ispune rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| GSN9(1) | pp11781 | -70,0 | -2,0 | -3,2 | 0,0 | -16,6 | 5,0 |
| | pp11781 | 37,3 | 2,4 | 1,3 | 0,0 | 3,6 | -5,0 |
| | pp478 | -43,5 | -0,2 | 0,7 | 1,9 | -10,3 | -0,4 |
| | pp3073 | 50,4 | 0,6 | 1,5 | -1,3 | -2,7 | 1,5 |
| GSN7(2) | pp11781 | 173,8 | 2,0 | -14,3 | -0,1 | -58,4 | -3,3 |
| | pp11781 | -87,3 | -9,9 | -32,9 | 0,0 | 21,6 | -1,1 |
| | pp478 | 162,0 | -2,7 | -2,1 | 1,5 | -33,6 | 5,2 |
| | pp3073 | -124,1 | -5,1 | 1,4 | -0,4 | -3,2 | -5,1 |
| GSN8(3) | pp11781 | 72,1 | 0,7 | 0,2 | 0,0 | -4,6 | -1,7 |
| | pp11781 | -102,7 | 3,1 | 9,9 | 0,0 | -8,3 | 9,7 |
| | pp478 | -62,6 | 1,6 | -4,0 | -5,8 | -15,4 | -4,9 |
| | pp3073 | 56,8 | 2,1 | -2,9 | 0,4 | 2,5 | 3,9 |
| GSN11(4) | pp11781 | -115,3 | -2,3 | 3,1 | 0,0 | 5,9 | 5,1 |
| | pp11781 | 28,1 | 8,0 | 20,5 | 0,0 | -9,8 | 0,5 |
| | pp478 | -146,4 | 1,8 | 0,2 | -1,6 | -3,6 | -4,9 |
| | pp3073 | 134,2 | 3,9 | -0,4 | -0,8 | -0,3 | 5,4 |
| GSN10(5) | pp11781 | -109,6 | -2,3 | 3,3 | 0,0 | 7,4 | 5,0 |
| | pp11781 | 27,8 | 8,0 | 19,7 | 0,0 | -9,5 | 0,5 |
| | pp478 | -138,9 | 1,9 | -0,4 | -1,6 | -2,0 | -4,9 |
| | pp3073 | 126,6 | 3,8 | -0,5 | -0,8 | -0,2 | 5,3 |
| GSN3(6) | pp11781 | 19,2 | 1,3 | -6,3 | 0,0 | -30,6 | -2,5 |
| | pp11781 | -23,6 | 0,2 | -7,1 | 0,0 | 7,4 | 3,9 |
| | pp478 | 4,2 | 1,1 | -0,5 | -2,1 | -20,7 | -0,7 |
| | pp3073 | 10,9 | 0,4 | 0,9 | 0,8 | -2,5 | 0,0 |
| GSN2(7) | pp11781 | 131,0 | 1,1 | -4,1 | 0,0 | -17,5 | -2,2 |
| | pp11781 | -99,8 | -3,1 | -8,0 | 0,0 | 2,8 | 4,3 |
| | pp478 | 44,5 | -0,6 | -5,9 | -2,2 | -15,7 | -0,1 |
| | pp3073 | -35,0 | -1,4 | -1,7 | -0,1 | 1,1 | -0,2 |
| GSN12(8) | pp11781 | 11,7 | 1,3 | -3,6 | 0,0 | -17,4 | -2,8 |
| | pp11781 | -17,2 | -0,1 | -4,5 | 0,0 | 3,9 | 2,8 |
| | pp478 | 5,0 | -0,3 | -1,1 | -1,8 | -12,7 | -1,3 |
| | pp3073 | 12,7 | -0,4 | 0,4 | 0,5 | -1,4 | 0,8 |
| GSN12(9) | pp11781 | 17,3 | 0,4 | -3,8 | 0,0 | -18,2 | -0,6 |
| | pp11781 | -17,4 | 0,1 | -3,4 | 0,0 | 4,5 | 2,4 |
| | pp478 | -4,0 | 1,6 | -1,6 | -0,9 | -11,7 | 0,5 |
| | pp3073 | 4,3 | 0,8 | 0,4 | 0,6 | -1,3 | -1,0 |

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,1 < 5% | OK |
| Bolts | 95,7 < 100% | OK |
| Welds | 95,6 < 100% | OK |
| Buckling | Not calculated | |

### Plates

| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp11781-bfl 1 | 13,0 | GSN7(2) | 82,1 | 0,0 | OK |
| pp11781-tfl 1 | 13,0 | GSN7(2) | 355,2 | 0,1 | OK |
| pp11781-w 1 | 8,0 | GSN7(2) | 183,4 | 0,0 | OK |
| pp478 | 25,0 | GSN7(2) | 158,5 | 0,0 | OK |
| pp3073 | 6,3 | GSN7(2) | 286,1 | 0,1 | OK |
| EP1 | 10,0 | GSN7(2) | 355,3 | 0,1 | OK |

**Design data**

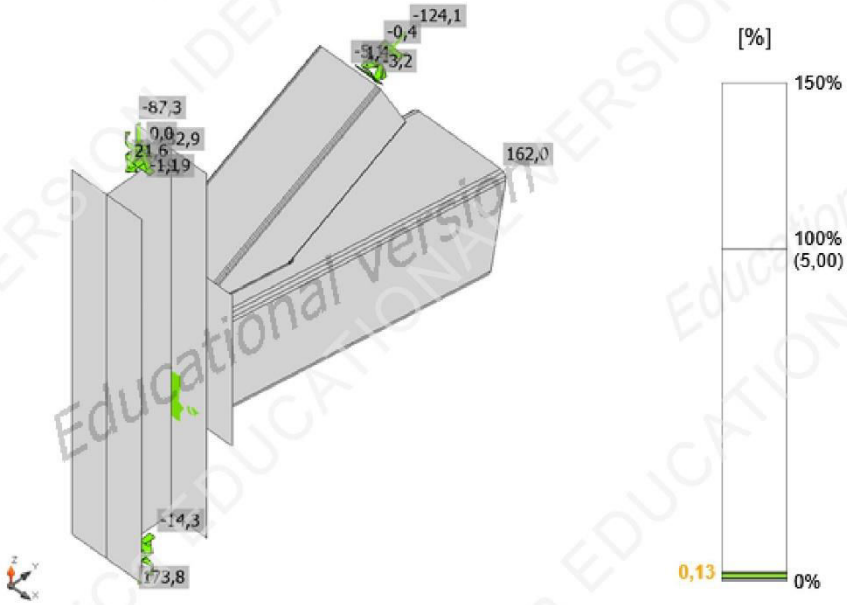
| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |

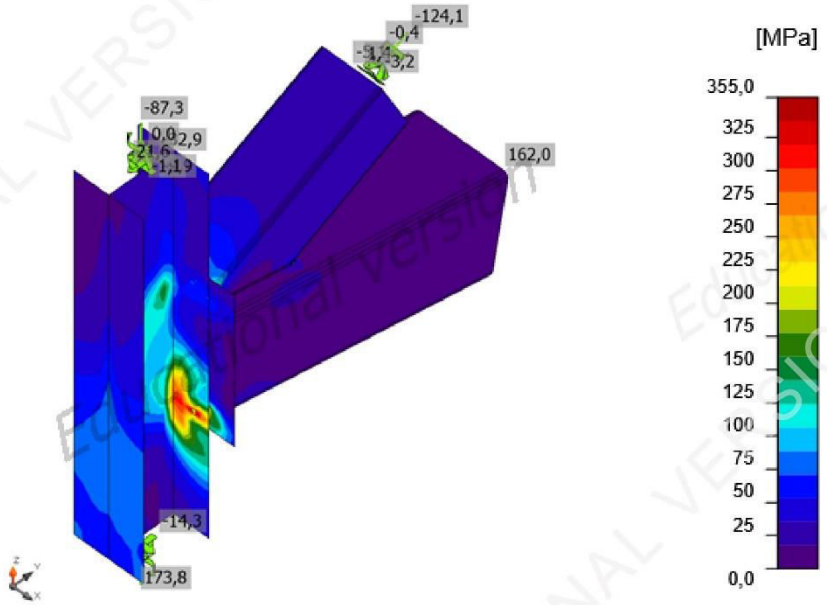
**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

*Overall check, GSN7(2)*



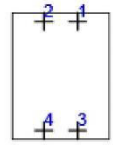

*Strain check, GSN7(2)*

**Project:** Spoj donjeg pojasa i ispune rešetke sa stupom
**Project no:**
**Author:**




*Equivalent stress, GSN7(2)*

## Bolts

| | Name | Loads | $F_{t,Ed}$ [kN] | V [kN] | $Ut_t$ [%] | $F_{b,Rd}$ [kN] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
|  | B1 | GSN11(4) | 1,5 | 2,8 | 2,7 | 156,8 | 7,5 | 9,4 | OK |
| | B2 | GSN11(4) | 1,9 | 4,1 | 3,3 | 156,8 | 10,8 | 13,2 | OK |
| | B3 | GSN7(2) | 50,6 | 2,6 | 89,6 | 156,8 | 7,0 | 71,0 | OK |
| | B4 | GSN7(2) | 54,1 | 0,3 | 95,7 | 156,8 | 0,9 | 69,3 | OK |



**Design data**

| Name | $F_{t,Rd}$ [kN] | $B_{p,Rd}$ [kN] | $F_{v,Rd}$ [kN] |
|---|---|---|---|
| M16 5.6 - 1 | 56,5 | 188,4 | 37,7 |

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Detailed result for B4**

**Tension resistance check** (EN 1993-1-8 Table 3.4)

$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} =$ 56,5 kN ≥ $F_t =$ 54,1 kN

where:

$k_2 =$ 0,90 – Factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A_s =$ 157 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Punching resistance check** (EN 1993-1-8 Table 3.4)

$B_{p,Rd} = \frac{0{,}6\pi d_m t_p f_u}{\gamma_{M2}} =$ 188,4 kN ≥ $F_t =$ 54,1 kN

where:

$d_m =$ 26 mm – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p =$ 10 mm – Thickness

$f_u =$ 490,0 MPa – Ultimate strength

$\gamma_{M2} =$ 1,25 – Safety factor

**Shear resistance check** (EN 1993-1-8 Table 3.4)

$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} =$ 37,7 kN ≥ $V =$ 0,3 kN

where:

$\beta_p =$ 1,00 – Reducing factor

$\alpha_v =$ 0,60 – Reducing factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A =$ 157 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Bearing resistance check** (EN 1993-1-8 Table 3.4)

$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} =$ 156,8 kN ≥ $V =$ 0,3 kN

where:

$k_1 = 2{,}50$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b = 1{,}00$ – Factor
$f_u = 490{,}0$ MPa – Ultimate strength
$d = 16$ mm – Nominal diameter of the fastener
$t = 10$ mm – Thickness
$\gamma_{M2} = 1{,}25$ – Safety factor

**Interaction of tension and shear** (EN 1993-1-8 Table 3.4)

$U_{tts} = \frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4F_{t,Rd}} =$ 69,3 %

**Utilization in tension**

$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} =$ 95,7 %

**Utilization in shear**

$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd}; F_{b,Rd})} =$ 0,9 %

**Symbol explanation**

| | |
|---|---|
| $F_{t,Rd}$ | Bolt tension resistance EN 1993-1-8 tab. 3.4 |
| $F_{t,Ed}$ | Tension force |
| $B_{p,Rd}$ | Punching shear resistance |
| V | Resultant of shear forces Vy, Vz in bolt |
| $F_{v,Rd}$ | Bolt shear resistance EN_1993-1-8 table 3.4 |
| $F_{b,Rd}$ | Plate bearing resistance EN 1993-1-8 tab. 3.4 |
| $Ut_t$ | Utilization in tension |
| $Ut_s$ | Utilization in shear |
| $Ut_{ts}$ | Utilization in tension and shear EN 1993-1-8 table 3.4 |

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢4,0◣ | 1468 | GSN7(2) | 141,6 | 0,0 | -55,4 | -33,9 | 67,2 | 32,5 | 12,5 | OK |
| EP1 | pp478 | ◢4,0◣ | 1468 | GSN7(2) | 386,2 | 0,0 | 257,7 | -53,4 | 157,3 | 88,7 | 17,0 | OK |
| | | ◢4,0◣ | 932 | GSN7(2) | 293,9 | 0,0 | 112,5 | 121,4 | 99,2 | 67,5 | 7,7 | OK |
| pp478-w 3 | pp3073 | ◢4,0◣ | 932 | GSN7(2) | 212,7 | 0,0 | 79,0 | 80,1 | -81,2 | 48,8 | 5,6 | OK |
| | | ◢4,0◣ | 283 | GSN7(2) | 416,2 | 0,0 | 126,5 | 222,2 | -55,3 | 95,6 | 45,1 | OK |
| pp11781-tfl 1 | pp3073 | ◢4,0◣ | 283 | GSN11(4) | 361,2 | 0,0 | 87,6 | 184,3 | 83,4 | 82,9 | 15,6 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Detailed result for pp478-w 3 pp3073**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} =$ 416,2 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_{\perp}| =$ 126,5 MPa

where:
$f_u = 490,0$ MPa – Ultimate strength
$\beta_w = 0,90$ – appropriate correlation factor taken from Table 4.1
$\gamma_{M2} = 1,25$ – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}) =$ 95,6 %

**Project:** **Spoj donjeg pojasa i ispune rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Buckling

**Buckling analysis was not calculated.**

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.6. Spoj gonjeg pojasa rešetke sa stupom

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Spoj gornjeg pojasa rešetke sa stupom |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355, BS |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

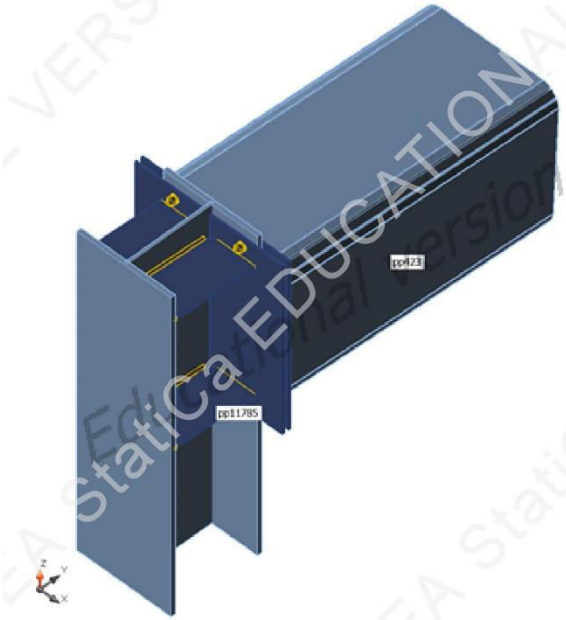
# Project item Con N419

## Design

| | |
|---|---|
| Name | Con N419 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp11785 | 3 - HEA280 | 0,0 | 90,0 | 270,0 | -270 | 0 | 0 | Position |
| pp423 | 1 - SHS400/400/20.0 | 90,0 | 2,9 | 0,0 | 0 | 0 | 0 | Position |




### Cross-sections

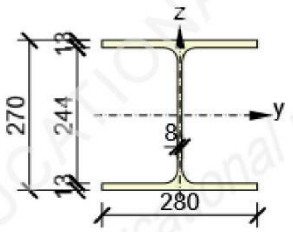
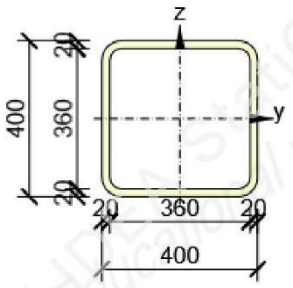
| Name | Material |
|---|---|
| 3 - HEA280 | S 355 |
| 1 - SHS400/400/20.0 | S 355 |

IDEA StatiCa EDUCATIONAL VERSION

**Project:** Spoj gornjeg pojasa rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 3 - HEA280 | S 355 |   |
| 1 - SHS400/400/20.0 | S 355 |   |

## Bolts

| Name | Bolt assembly | Diameter [mm] | fu [MPa] | Gross area [mm$^2$] |
|---|---|---|---|---|
| M12 5.6 | M12 5.6 | 12 | 500,0 | 113 |

IDEA StatiCa EDUCATIONAL VERSION

**Project:** Spoj gornjeg pojasa rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| GSN8(1) | pp11785 | -70,0 | 4,8 | -39,4 | 0,0 | 20,5 | 0,0 |
| | pp423 | 41,0 | 17,0 | 2,3 | -2,1 | -20,6 | 5,1 |
| GSN9(2) | pp11785 | 16,6 | 0,7 | -4,7 | 0,0 | 6,3 | -0,2 |
| | pp423 | 3,3 | 0,7 | 5,8 | -0,3 | -6,3 | -2,2 |
| GSN7(3) | pp11785 | -48,7 | -2,8 | -18,9 | 0,0 | 15,7 | -1,2 |
| | pp423 | 20,3 | -14,1 | -2,1 | 1,2 | -15,7 | -11,9 |
| GSN12(4) | pp11785 | -9,9 | 0,5 | -8,8 | 0,0 | 6,7 | -0,3 |
| | pp423 | 8,8 | -3,2 | 1,5 | -0,7 | -7,4 | 4,3 |
| GSN12(5) | pp11785 | -10,4 | 1,1 | -7,5 | 0,0 | 7,4 | -0,4 |
| | pp423 | 7,5 | 5,5 | 2,1 | -0,1 | -6,7 | -8,9 |
| GSN2(6) | pp11785 | -62,5 | 1,0 | -30,0 | 0,0 | 16,7 | -0,3 |
| | pp423 | 32,6 | 2,8 | -1,0 | -0,5 | -16,8 | -1,1 |
| GSN5(7) | pp11785 | -62,2 | 1,4 | -31,7 | 0,0 | 19,1 | -0,5 |
| | pp423 | 33,4 | 3,2 | 0,6 | -0,6 | -19,1 | -2,4 |
| GSN11(8) | pp11785 | 6,4 | 4,1 | -13,4 | 0,0 | 8,3 | 0,3 |
| | pp423 | 11,4 | 14,5 | 7,5 | -1,7 | -8,3 | 5,4 |
| GSN10(9) | pp11785 | 6,2 | 4,1 | -12,7 | 0,0 | 7,7 | 0,3 |
| | pp423 | 11,4 | 14,4 | 7,1 | -1,8 | -7,7 | 5,3 |
| GSN3(10) | pp11785 | -14,5 | 1,4 | -10,7 | 0,0 | 10,1 | -0,6 |
| | pp423 | 10,6 | 1,8 | 2,7 | -0,6 | -10,1 | -4,1 |
| GSN4(11) | pp11785 | -62,5 | 1,5 | -31,0 | 0,0 | 18,5 | -0,5 |
| | pp423 | 33,4 | 3,2 | 0,2 | -0,7 | -18,6 | -2,5 |
| GSN1(12) | pp11785 | -17,4 | 0,9 | -15,0 | 0,0 | 10,9 | -0,4 |
| | pp423 | 15,2 | 1,6 | 2,7 | -0,4 | -10,9 | -2,3 |

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,3 < 5% | OK |
| Bolts | 86,9 < 100% | OK |
| Welds | 80,8 < 100% | OK |
| Buckling | Not calculated | |

**Project:** Spoj gornjeg pojasa rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Plates

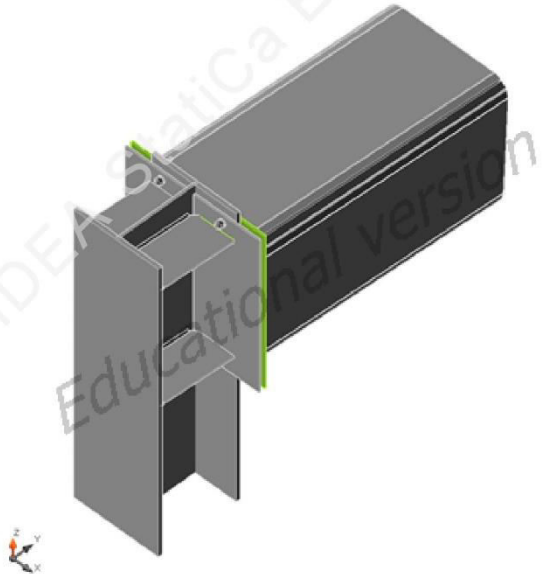
| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp11785-bfl 1 | 13,0 | GSN7(3) | 164,5 | 0,0 | OK |
| pp11785-tfl 1 | 13,0 | GSN7(3) | 260,4 | 0,0 | OK |
| pp11785-w 1 | 8,0 | GSN7(3) | 52,3 | 0,0 | OK |
| pp423 | 20,0 | GSN7(3) | 111,9 | 0,0 | OK |
| EP1a | 6,0 | GSN7(3) | 355,6 | 0,3 | OK |
| EP1b | 6,0 | GSN7(3) | 152,8 | 0,0 | OK |
| EP1c | 6,0 | GSN8(1) | 148,5 | 0,0 | OK |
| STIFF1a | 5,0 | GSN8(1) | 107,0 | 0,0 | OK |
| STIFF1b | 5,0 | GSN12(5) | 138,4 | 0,0 | OK |
| STIFF1c | 5,0 | GSN8(1) | 109,7 | 0,0 | OK |
| STIFF1d | 5,0 | GSN7(3) | 246,9 | 0,0 | OK |

**Design data**

| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

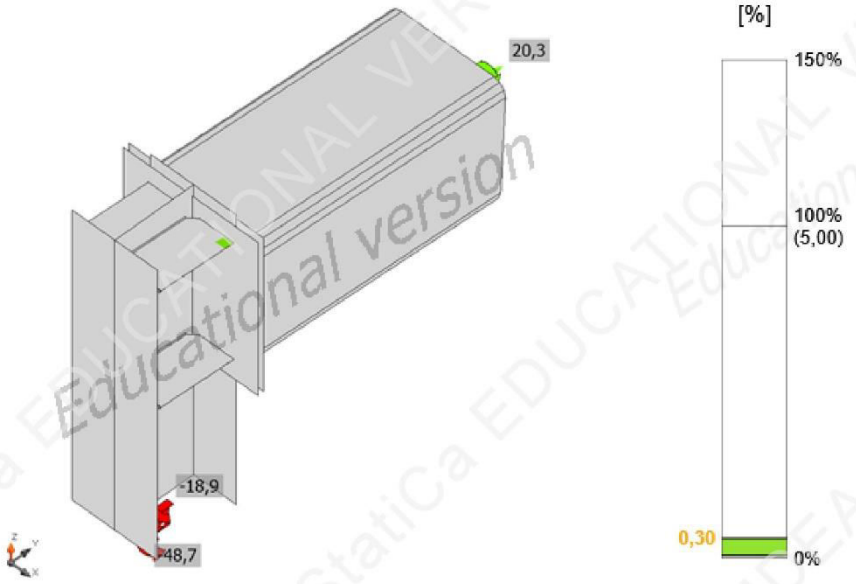
| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |



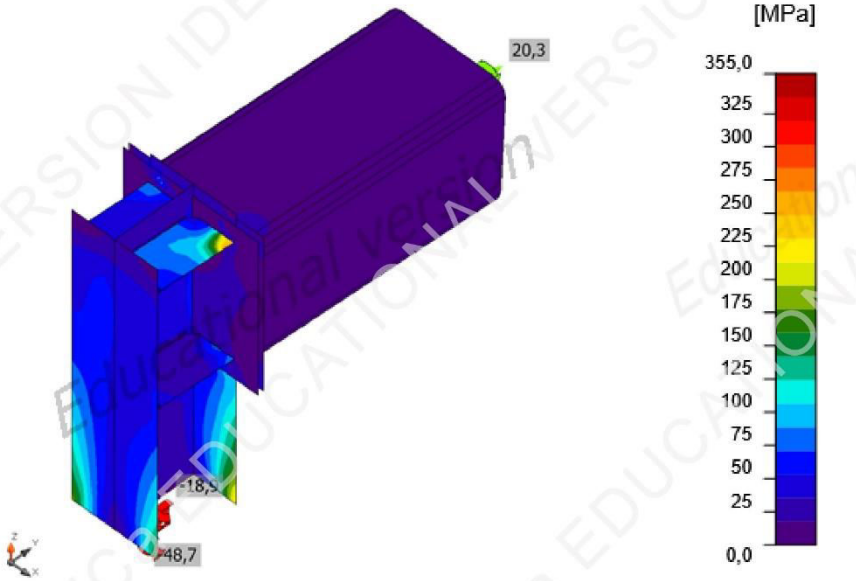
*Overall check, GSN7(3)*

5 / 12

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**




*Strain check, GSN7(3)*

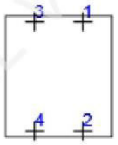



*Equivalent stress, GSN7(3)*

**Project:** Spoj gornjeg pojasa rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Bolts

| | Name | Loads | $F_{t,Ed}$ [kN] | V [kN] | $Ut_t$ [%] | $F_{b,Rd}$ [kN] | $Ut_s$ [%] | $Ut_{ts}$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|
|  | B1 | GSN7(3) | 16,1 | 4,4 | 52,7 | 70,6 | 21,6 | 59,2 | OK |
| | B2 | GSN7(3) | 26,6 | 2,1 | 86,9 | 70,6 | 10,1 | 72,2 | OK |
| | B3 | GSN8(1) | 1,5 | 6,3 | 4,9 | 70,6 | 31,0 | 34,5 | OK |
| | B4 | GSN8(1) | 26,4 | 2,3 | 86,2 | 70,6 | 11,2 | 72,8 | OK |



### Design data

| Name | $F_{t,Rd}$ [kN] | $B_{p,Rd}$ [kN] | $F_{v,Rd}$ [kN] |
|---|---|---|---|
| M12 5.6 - 1 | 30,6 | 86,5 | 20,4 |

IDEA StatiCa EDUCATIONAL VERSION

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

**Detailed result for B2**

**Tension resistance check** (EN 1993-1-8 Table 3.4)

$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} =$ 30,6 kN ≥ $F_t =$ 26,6 kN

where:

$k_2 =$ 0,90 – Factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A_s =$ 85 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Punching resistance check** (EN 1993-1-8 Table 3.4)

$B_{p,Rd} = \frac{0{,}6\pi d_m t_p f_u}{\gamma_{M2}} =$ 86,5 kN ≥ $F_t =$ 26,6 kN

where:

$d_m =$ 20 mm – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller

$t_p =$ 6 mm – Thickness

$f_u =$ 490,0 MPa – Ultimate strength

$\gamma_{M2} =$ 1,25 – Safety factor

**Shear resistance check** (EN 1993-1-8 Table 3.4)

$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} =$ 20,4 kN ≥ $V =$ 2,1 kN

where:

$\beta_p =$ 1,00 – Reducing factor

$\alpha_v =$ 0,60 – Reducing factor

$f_{ub} =$ 500,0 MPa – Ultimate tensile strength of the bolt

$A =$ 85 mm$^2$ – Tensile stress area of the bolt

$\gamma_{M2} =$ 1,25 – Safety factor

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Bearing resistance check** (EN 1993-1-8 Table 3.4)

$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} =$ 70,6 kN ≥ $V =$ 2,1 kN

where:

$k_1 = 2{,}50$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
$\alpha_b = 1{,}00$ – Factor
$f_u = 490{,}0$ MPa – Ultimate strength
$d = 12$ mm – Nominal diameter of the fastener
$t = 6$ mm – Thickness
$\gamma_{M2} = 1{,}25$ – Safety factor

**Interaction of tension and shear** (EN 1993-1-8 Table 3.4)

$U_{tts} = \frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1{,}4F_{t,Rd}} =$ 72,2 %

**Utilization in tension**

$U_{tt} = \frac{F_{t,Ed}}{\min(F_{t,Rd};B_{p,Rd})} =$ 86,9 %

**Utilization in shear**

$U_{ts} = \frac{V_{Ed}}{\min(F_{v,Rd};F_{b,Rd})} =$ 10,1 %

**Symbol explanation**

| | |
|---|---|
| $F_{t,Rd}$ | Bolt tension resistance EN 1993-1-8 tab. 3.4 |
| $F_{t,Ed}$ | Tension force |
| $B_{p,Rd}$ | Punching shear resistance |
| V | Resultant of shear forces Vy, Vz in bolt |
| $F_{v,Rd}$ | Bolt shear resistance EN_1993-1-8 table 3.4 |
| $F_{b,Rd}$ | Plate bearing resistance EN 1993-1-8 tab. 3.4 |
| $Ut_t$ | Utilization in tension |
| $Ut_s$ | Utilization in shear |
| $Ut_{ts}$ | Utilization in tension and shear EN 1993-1-8 table 3.4 |

IDEA StatiCa EDUCATIONAL VERSION

**Project:** Spoj gornjeg pojasa rešetke sa stupom
**Project no:**
**Author:**

IDEA StatiCa®
Calculate yesterday's estimates

## Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pp11785-bfl 1 | STIFF1a | ◢4,0◣ | 112 | GSN7(3) | 45,9 | 0,0 | 3,8 | 22,6 | 13,7 | 10,5 | 5,2 | OK |
| | | ◢4,0◣ | 112 | GSN7(3) | 52,9 | 0,0 | 4,6 | -30,1 | 4,5 | 12,1 | 7,8 | OK |
| pp11785-w 1 | STIFF1a | ◢4,0◣ | 196 | GSN7(3) | 49,8 | 0,0 | 3,4 | -28,4 | -4,0 | 11,4 | 10,3 | OK |
| | | ◢4,0◣ | 196 | GSN7(3) | 40,6 | 0,0 | 3,0 | 20,9 | -10,3 | 9,3 | 4,9 | OK |
| pp11785-tfl 1 | STIFF1a | ◢4,0◣ | 112 | GSN8(1) | 124,0 | 0,0 | 33,2 | 56,8 | 39,1 | 28,5 | 15,3 | OK |
| | | ◢4,0◣ | 112 | GSN7(3) | 103,4 | 0,0 | 41,5 | 0,6 | -54,7 | 23,7 | 15,2 | OK |
| pp11785-bfl 1 | STIFF1b | ◢4,0◣ | 112 | GSN12(5) | 37,5 | 0,0 | 0,3 | -20,9 | 5,8 | 8,6 | 6,2 | OK |
| | | ◢4,0◣ | 112 | GSN8(1) | 34,5 | 0,0 | 5,6 | -16,7 | -10,4 | 7,9 | 3,2 | OK |
| pp11785-w 1 | STIFF1b | ◢4,0◣ | 196 | GSN8(1) | 37,3 | 0,0 | 4,2 | -21,4 | -0,7 | 8,6 | 5,5 | OK |
| | | ◢4,0◣ | 196 | GSN8(1) | 45,3 | 0,0 | -1,2 | 25,9 | -3,6 | 10,4 | 7,9 | OK |
| pp11785-tfl 1 | STIFF1b | ◢4,0◣ | 112 | GSN12(5) | 203,7 | 0,0 | -83,5 | -67,9 | -83,1 | 46,8 | 17,9 | OK |
| | | ◢4,0◣ | 112 | GSN12(5) | 179,9 | 0,0 | -73,8 | 59,3 | 73,9 | 41,3 | 17,4 | OK |
| pp11785-bfl 1 | STIFF1c | ◢4,0◣ | 112 | GSN7(3) | 30,3 | 0,0 | -0,7 | 16,6 | 5,5 | 7,0 | 4,0 | OK |
| | | ◢4,0◣ | 112 | GSN7(3) | 40,0 | 0,0 | -2,2 | -21,6 | 8,1 | 9,2 | 6,1 | OK |
| pp11785-w 1 | STIFF1c | ◢4,0◣ | 196 | GSN7(3) | 47,4 | 0,0 | -7,5 | -21,1 | -16,9 | 10,9 | 7,9 | OK |
| | | ◢4,0◣ | 196 | GSN8(1) | 25,3 | 0,0 | -2,0 | -13,3 | 6,0 | 5,8 | 3,1 | OK |
| pp11785-tfl 1 | STIFF1c | ◢4,0◣ | 112 | GSN12(4) | 95,1 | 0,0 | -41,9 | -26,4 | -41,6 | 21,8 | 8,5 | OK |
| | | ◢4,0◣ | 112 | GSN8(1) | 106,6 | 0,0 | -55,0 | 30,2 | 43,2 | 24,5 | 13,3 | OK |
| pp11785-bfl 1 | STIFF1d | ◢4,0◣ | 112 | GSN7(3) | 62,9 | 0,0 | -3,2 | -36,1 | 3,5 | 14,4 | 8,9 | OK |
| | | ◢4,0◣ | 112 | GSN7(3) | 59,5 | 0,0 | -6,3 | 31,4 | 13,5 | 13,7 | 6,5 | OK |
| pp11785-w 1 | STIFF1d | ◢4,0◣ | 196 | GSN7(3) | 59,2 | 0,0 | -0,3 | 32,9 | -9,0 | 13,6 | 7,0 | OK |
| | | ◢4,0◣ | 196 | GSN7(3) | 74,2 | 0,0 | -0,6 | -42,1 | -8,1 | 17,0 | 13,7 | OK |
| pp11785-tfl 1 | STIFF1d | ◢4,0◣ | 112 | GSN7(3) | 351,9 | 0,0 | -155,2 | -99,6 | -152,7 | 80,8 | 30,0 | OK |
| | | ◢4,0◣ | 112 | GSN7(3) | 308,2 | 0,0 | -133,5 | 85,6 | 135,6 | 70,8 | 26,9 | OK |
| | | ◢4,0◣ | 1449 | GSN7(3) | 233,8 | 0,0 | 152,2 | 23,4 | -99,8 | 53,7 | 9,4 | OK |
| EP1a | pp423 | ◢4,0◣ | 1449 | GSN7(3) | 156,3 | 0,0 | -69,0 | 19,1 | -78,7 | 35,9 | 6,8 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

EDUCATIONAL VERSION IDEA StatiCa EDUCATIONAL VERSION

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Detailed result for pp11785-tfl 1 STIFF1d**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0,5} =$ 351,9 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_{\perp}| =$ 155,2 MPa

where:

$f_u = 490,0$ MPa – Ultimate strength

$\beta_w = 0,90$ – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} = 1,25$ – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}) =$ 80,8 %

### Buckling

**Buckling analysis was not calculated.**

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |

**Project:** **Spoj gornjeg pojasa rešetke sa stupom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

| Item | Value | Unit | Reference |
|---|---|---|---|
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.7. Spoj ispune s donjim pojasom

**Project:** **Spoj ispune s donjim pojasom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Spoj ispune s donjim pojasom |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

1 / 8

**Project:** **Spoj ispune s donjim pojasom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

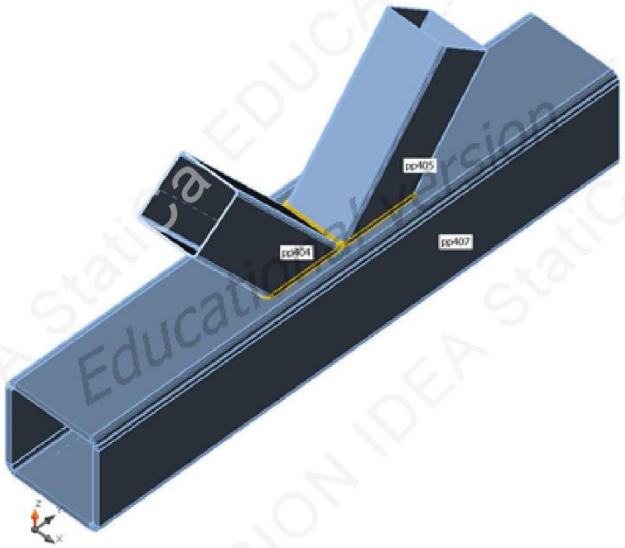
# Project item Con N404

## Design

| | |
|---|---|
| Name | Con N404 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp407 | 2 - SHS(Ju)400/400/25.0(RHS400x400) | -90,0 | 0,0 | 0,0 | 0 | 0 | 0 | Position |
| pp405 | 1 - SHS250/250/6.3 | 90,0 | -51,3 | 0,0 | 0 | 0 | 0 | Position |
| pp404 | 1 - SHS250/250/6.3 | -90,0 | -51,3 | 0,0 | 0 | 0 | 0 | Position |



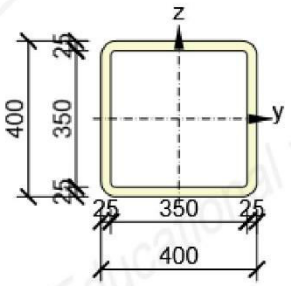
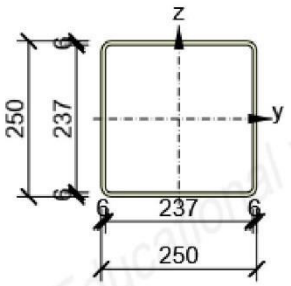

### Cross-sections

| Name | Material |
|---|---|
| 2 - SHS(Ju)400/400/25.0(RHS400x400) | S 355 |
| 1 - SHS250/250/6.3 | S 355 |

**Project:** Spoj ispune s donjim pojasom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 2 - SHS(Ju)400/400/25.0(RHS400x400) | S 355 |   |
| 1 - SHS250/250/6.3 | S 355 |   |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** Spoj ispune s donjim pojasom
**Project no:**
**Author:**

IDEA StatiCa® Calculate yesterday's estimates

## Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| GSN9(1) | pp407 | 87,1 | -0,7 | -6,7 | -2,2 | -9,9 | 0,2 |
| | pp407 | -26,2 | -0,1 | -26,4 | 3,9 | 11,9 | -0,1 |
| | pp405 | 69,6 | -0,3 | -0,7 | 0,2 | 0,9 | -0,9 |
| | pp404 | -26,8 | 0,5 | 0,1 | -0,2 | -1,0 | 1,0 |
| GSN5(2) | pp407 | 2795,2 | -1,5 | -23,0 | -3,7 | -60,5 | -0,1 |
| | pp407 | -1581,2 | 0,3 | -199,7 | 6,2 | 108,0 | 0,1 |
| | pp405 | 1099,4 | -0,5 | -17,2 | 0,2 | 28,3 | -1,3 |
| | pp404 | -809,1 | 0,7 | 10,7 | -0,3 | -19,2 | 1,5 |
| GSN7(3) | pp407 | 2579,8 | -3,6 | -22,5 | -2,2 | -56,7 | 2,9 |
| | pp407 | -1440,2 | 4,1 | -194,8 | 0,3 | 101,5 | -2,2 |
| | pp405 | 1037,3 | 0,1 | -16,1 | -0,3 | 26,4 | 0,6 |
| | pp404 | -754,2 | -0,5 | 10,1 | 0,1 | -18,3 | -1,5 |
| GSN8(4) | pp407 | 2790,4 | 0,2 | -22,4 | -5,0 | -59,6 | -2,6 |
| | pp407 | -1596,9 | -2,7 | -190,9 | 11,0 | 106,1 | 2,0 |
| | pp405 | 1077,4 | -0,9 | -17,0 | 0,6 | 27,8 | -2,8 |
| | pp404 | -799,0 | 1,6 | 10,4 | -0,7 | -18,7 | 3,8 |
| GSN10(5) | pp407 | 142,7 | 1,0 | -6,4 | -3,5 | -9,8 | -2,3 |
| | pp407 | -78,2 | -3,1 | -20,4 | 8,7 | 11,7 | 1,8 |
| | pp405 | 68,6 | -0,8 | -0,8 | 0,5 | 1,1 | -2,4 |
| | pp404 | -33,6 | 1,4 | 0,0 | -0,6 | -0,8 | 3,3 |
| GSN12(6) | pp407 | 715,4 | -6,1 | -9,8 | -10,1 | -18,5 | 0,9 |
| | pp407 | -404,1 | 6,1 | -53,1 | 8,5 | 30,2 | -1,3 |
| | pp405 | 280,3 | 0,3 | -4,3 | 0,6 | 6,9 | -2,6 |
| | pp404 | -201,7 | 1,2 | 2,3 | 0,0 | -4,6 | 3,1 |
| GSN11(7) | pp407 | 152,0 | 1,0 | -6,9 | -3,5 | -11,0 | -2,5 |
| | pp407 | -76,7 | -3,2 | -31,2 | 8,7 | 13,7 | 2,0 |
| | pp405 | 84,1 | -0,8 | -1,0 | 0,5 | 1,4 | -2,4 |
| | pp404 | -34,8 | 1,4 | 0,3 | -0,6 | -1,3 | 3,3 |
| GSN4(8) | pp407 | 2785,9 | -1,6 | -22,5 | -3,7 | -59,3 | 0,1 |
| | pp407 | -1582,7 | 0,4 | -188,8 | 6,2 | 106,0 | -0,1 |
| | pp405 | 1083,8 | -0,5 | -17,0 | 0,2 | 27,9 | -1,3 |
| | pp404 | -808,0 | 0,7 | 10,4 | -0,3 | -18,8 | 1,5 |
| GSN12(9) | pp407 | 701,1 | 4,4 | -9,6 | 5,3 | -17,9 | -0,8 |
| | pp407 | -397,2 | -6,1 | -57,7 | -0,3 | 29,2 | 1,1 |
| | pp405 | 288,7 | -1,0 | -4,4 | -0,3 | 6,7 | 0,8 |
| | pp404 | -197,4 | -0,2 | 2,4 | -0,4 | -4,8 | -1,1 |
| GSN3(10) | pp407 | 995,6 | -1,4 | -13,4 | -4,1 | -25,5 | 0,2 |
| | pp407 | -568,4 | 0,1 | -78,3 | 7,0 | 41,5 | -0,2 |
| | pp405 | 395,9 | -0,6 | -6,0 | 0,3 | 9,4 | -1,6 |
| | pp404 | -276,4 | 0,8 | 3,3 | -0,4 | -6,6 | 1,7 |
| GSN2(11) | pp407 | 2682,9 | -1,2 | -21,7 | -2,5 | -56,4 | 0,0 |
| | pp407 | -1521,4 | 0,4 | -178,8 | 4,1 | 101,3 | 0,0 |

**Project:** **Spoj ispune s donjim pojasom**
**Project no:**
**Author:**

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| | pp405 | 1044,0 | -0,3 | -16,6 | 0,1 | 27,1 | -0,8 |
| | pp404 | -782,0 | 0,5 | 10,0 | -0,2 | -17,9 | 1,0 |

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,2 < 5% | OK |
| Welds | 98,1 < 100% | OK |
| Buckling | Not calculated | |

### Plates

| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp407 | 25,0 | GSN5(2) | 223,8 | 0,0 | OK |
| pp405 | 6,3 | GSN5(2) | 355,4 | 0,2 | OK |
| pp404 | 6,3 | GSN8(4) | 355,1 | 0,1 | OK |

**Design data**

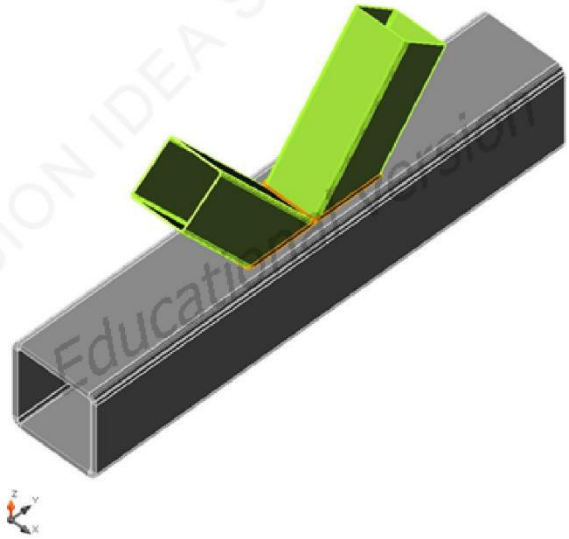
| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

**Symbol explanation**

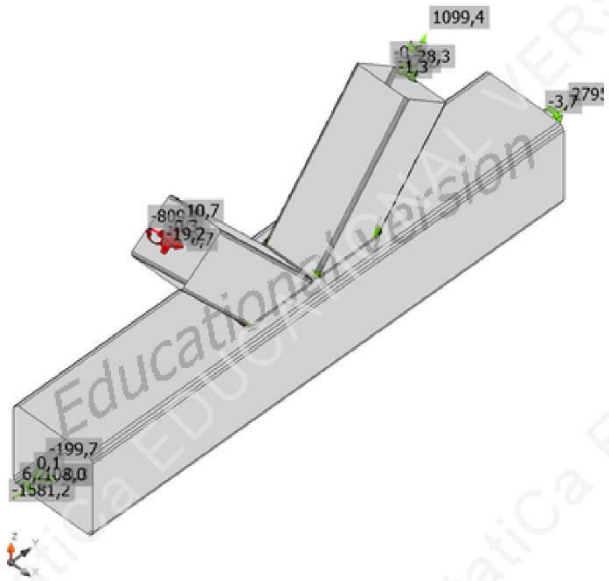
| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** **Spoj ispune s donjim pojasom**
**Project no:**
**Author:**

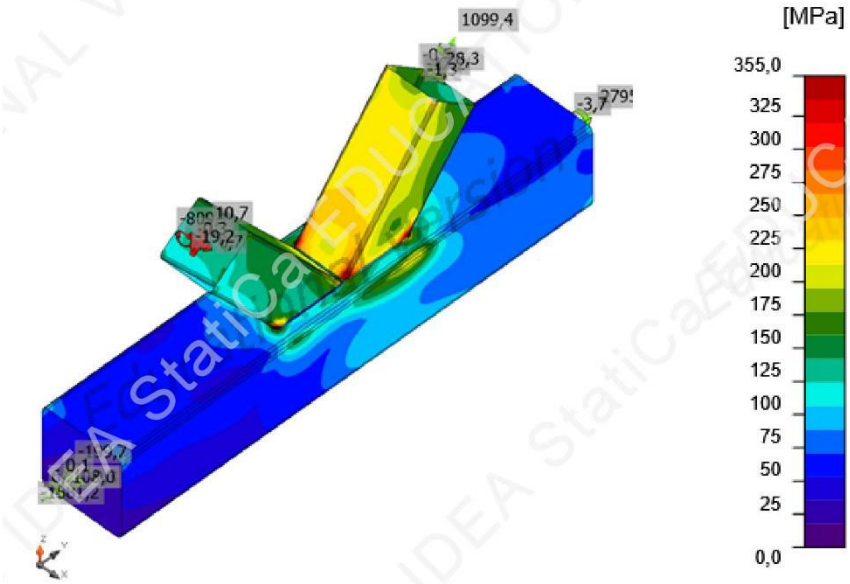


*Overall check, GSN5(2)*




*Strain check, GSN5(2)*

**Project:** Spoj ispune s donjim pojasom
**Project no:**
**Author:**




*Equivalent stress, GSN5(2)*

### Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢6,0◣ | 1086 | GSN5(2) | 426,9 | 0,1 | -130,1 | -140,5 | 188,1 | 98,0 | 25,5 | OK |
| pp407-w 3 | pp404 | ◢6,0◣ | 1086 | GSN8(4) | 427,0 | 0,1 | -252,6 | 163,3 | -113,3 | 98,0 | 21,0 | OK |
| | | ◢6,0◣ | 1086 | GSN5(2) | 427,1 | 0,2 | 204,7 | 186,0 | -110,8 | 98,1 | 33,1 | OK |
| pp407-w 3 | pp405 | ◢6,0◣ | 1086 | GSN5(2) | 427,1 | 0,2 | 56,5 | -72,6 | 233,4 | 98,1 | 33,0 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Project:** **Spoj ispune s donjim pojasom**
**Project no:**
**Author:**

**Detailed result for pp407-w 3 pp405**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_\perp^2 + 3(\tau_\perp^2 + \tau_\parallel^2)]^{0,5} =$ 427,1 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_\perp| =$ 56,5 MPa

where:

$f_u = 490,0$ MPa – Ultimate strength

$\beta_w = 0,90$ – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} = 1,25$ – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_\perp|}{\sigma_{\perp,Rd}}) =$ 98,1 %

### Buckling

**Buckling analysis was not calculated.**

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

## 6.8. Spoj ispune sa gornjim pojasom

**Project:** **Spoj ispune s gornjim pojasom**
**Project no:**
**Author:**

IDEA StatiCa®
Calculate yesterday's estimates

### Project data

| | |
|---|---|
| Project name | Spoj ispune s gornjim pojasom |
| Project number | |
| Author | |
| Description | |
| Date | 22.6.2019. |
| Design code | EN |

### Material

| | |
|---|---|
| Steel | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

1 / 8

**Project:** **Spoj ispune s gornjim pojasom**
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

# Project item Con N405

## Design

| | |
|---|---|
| Name | Con N405 |
| Description | |
| Analysis | Stress, strain/ loads in equilibrium |

### Beams and columns

| Name | Cross-section | β – Direction [°] | γ - Pitch [°] | α - Rotation [°] | Offset ex [mm] | Offset ey [mm] | Offset ez [mm] | Forces in |
|---|---|---|---|---|---|---|---|---|
| pp406 | 2 - SHS400/400/20.0 | 90,0 | 0,0 | 0,0 | 0 | 0 | 0 | Position |
| pp405 | 1 - SHS250/250/6.3 | -90,0 | 51,3 | 0,0 | 0 | 0 | 0 | Position |
| pp408 | 1 - SHS250/250/6.3 | 90,0 | 51,3 | 0,0 | 0 | 0 | 0 | Position |

### Cross-sections

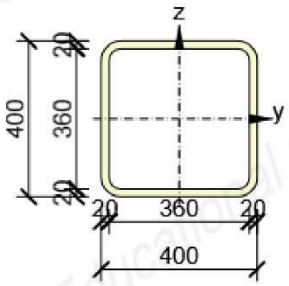
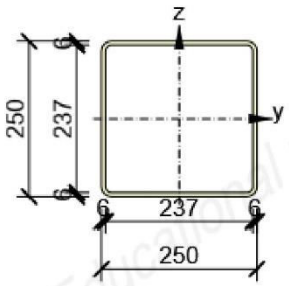
| Name | Material |
|---|---|
| 2 - SHS400/400/20.0 | S 355 |
| 1 - SHS250/250/6.3 | S 355 |

EDUCATIONAL VERSION IDEA StatiCa

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**

IDEA StatiCa
Calculate yesterday's estimates

## Cross-sections

| Name | Material | Drawing |
|---|---|---|
| 2 - SHS400/400/20.0 | S 355 |   |
| 1 - SHS250/250/6.3 | S 355 |   |

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**

IDEA StatiCa®
Calculate yesterday's estimates

## Load effects (forces in equilibrium)

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| GSN5(1) | pp406 | -2162,0 | -3,3 | -44,9 | -0,1 | -48,5 | 5,2 |
| | pp406 | 3696,4 | 0,5 | 47,8 | 0,1 | -8,2 | -5,4 |
| | pp405 | 1101,0 | -0,5 | 15,9 | 0,2 | -24,8 | -0,2 |
| | pp408 | -1316,2 | -0,2 | -19,6 | 0,1 | 31,6 | -0,5 |
| GSN10(2) | pp406 | -50,5 | -4,6 | -0,7 | 0,0 | -6,4 | 8,8 |
| | pp406 | 96,7 | -4,5 | 1,6 | 0,8 | 4,8 | -9,5 |
| | pp405 | 69,7 | -0,8 | -0,1 | 0,5 | -0,1 | 0,0 |
| | pp408 | -3,6 | 0,0 | -1,1 | -0,4 | 1,4 | -0,8 |
| GSN12(3) | pp406 | -503,7 | 2,0 | -11,5 | 0,3 | -14,5 | -4,5 |
| | pp406 | 886,1 | -7,1 | 10,5 | -0,2 | 0,9 | 5,3 |
| | pp405 | 289,9 | -1,0 | 3,4 | -0,3 | -5,6 | -0,6 |
| | pp408 | -304,5 | -2,1 | -5,3 | -1,1 | 7,9 | 1,6 |
| GSN12(4) | pp406 | -493,0 | -5,7 | -11,7 | -0,5 | -14,8 | 9,8 |
| | pp406 | 865,6 | 8,2 | 10,8 | 0,7 | 1,0 | -11,3 |
| | pp405 | 281,5 | 0,3 | 3,3 | 0,6 | -5,4 | 0,3 |
| | pp408 | -312,7 | 1,9 | -5,2 | 1,1 | 8,1 | -2,3 |
| GSN9(5) | pp406 | 18,4 | -1,7 | -0,4 | -0,1 | -6,7 | 2,3 |
| | pp406 | 23,3 | 0,5 | 1,0 | 0,2 | 5,6 | -2,6 |
| | pp405 | 70,8 | -0,3 | -0,2 | 0,2 | 0,2 | -0,2 |
| | pp408 | 4,3 | -0,1 | -1,0 | 0,0 | 1,1 | -0,3 |
| GSN7(6) | pp406 | -1961,6 | 0,4 | -42,7 | -0,2 | -46,0 | -3,0 |
| | pp406 | 3407,7 | 6,7 | 43,8 | -0,7 | -7,0 | 3,3 |
| | pp405 | 1038,9 | 0,1 | 14,8 | -0,3 | -23,1 | -0,4 |
| | pp408 | -1239,8 | -0,3 | -18,5 | 0,5 | 29,6 | 0,1 |
| GSN8(7) | pp406 | -2179,5 | -6,2 | -44,1 | 0,0 | -47,5 | 11,8 |
| | pp406 | 3685,6 | -4,4 | 47,5 | 0,7 | -8,4 | -12,3 |
| | pp405 | 1079,0 | -0,9 | 15,7 | 0,6 | -24,5 | -0,1 |
| | pp408 | -1293,5 | -0,1 | -19,3 | -0,3 | 31,2 | -1,0 |
| GSN2(8) | pp406 | -2110,0 | -2,5 | -43,5 | 0,0 | -45,3 | 4,0 |
| | pp406 | 3578,6 | 0,3 | 46,1 | 0,0 | -9,3 | -3,9 |
| | pp405 | 1045,6 | -0,3 | 15,3 | 0,1 | -24,0 | -0,1 |
| | pp408 | -1263,3 | -0,1 | -18,9 | 0,1 | 30,5 | -0,3 |
| GSN11(9) | pp406 | -56,1 | -4,5 | -0,9 | 0,0 | -6,8 | 8,9 |
| | pp406 | 119,2 | -4,6 | 2,0 | 0,8 | 4,7 | -9,6 |
| | pp405 | 85,3 | -0,8 | 0,1 | 0,5 | -0,3 | 0,0 |
| | pp408 | -19,1 | 0,0 | -1,3 | -0,4 | 1,6 | -0,8 |
| GSN13(10) | pp406 | -501,1 | -0,5 | -11,5 | 0,0 | -14,6 | -0,6 |
| | pp406 | 881,7 | -2,1 | 10,5 | 0,1 | 0,9 | 0,5 |
| | pp405 | 290,2 | -0,6 | 3,4 | -0,1 | -5,6 | -0,4 |
| | pp408 | -304,1 | -0,8 | -5,3 | -0,4 | 8,0 | 0,4 |
| GSN13(11) | pp406 | -495,6 | -3,2 | -11,6 | -0,3 | -14,8 | 5,9 |
| | pp406 | 870,0 | 3,2 | 10,7 | 0,4 | 1,0 | -6,5 |

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**

| Name | Member | N [kN] | Vy [kN] | Vz [kN] | Mx [kNm] | My [kNm] | Mz [kNm] |
|---|---|---|---|---|---|---|---|
| | pp405 | 281,2 | 0,0 | 3,4 | 0,4 | -5,5 | 0,1 |
| | pp408 | -313,0 | 0,6 | -5,2 | 0,4 | 8,1 | -1,1 |
| GSN6(12) | pp406 | -673,9 | -2,1 | -15,6 | -0,2 | -19,5 | 3,2 |
| | pp406 | 1193,1 | 0,5 | 14,7 | 0,3 | 0,7 | -3,6 |
| | pp405 | 395,9 | -0,4 | 4,7 | 0,2 | -7,6 | -0,1 |
| | pp408 | -426,2 | -0,1 | -7,1 | 0,0 | 10,9 | -0,4 |
| GSN3(13) | pp406 | -681,2 | -3,2 | -16,2 | -0,2 | -21,0 | 4,4 |
| | pp406 | 1206,2 | 1,0 | 14,5 | 0,4 | 2,1 | -5,0 |
| | pp405 | 397,5 | -0,6 | 4,7 | 0,3 | -7,6 | -0,3 |
| | pp408 | -429,2 | -0,2 | -7,2 | 0,0 | 11,1 | -0,6 |
| GSN4(14) | pp406 | -2156,4 | -3,4 | -44,7 | -0,1 | -48,1 | 5,2 |
| | pp406 | 3673,9 | 0,6 | 47,4 | 0,1 | -8,1 | -5,3 |
| | pp405 | 1085,4 | -0,5 | 15,8 | 0,2 | -24,6 | -0,2 |
| | pp408 | -1300,8 | -0,2 | -19,5 | 0,1 | 31,4 | -0,5 |

## Check

### Summary

| Name | Value | Status |
|---|---|---|
| Analysis | 100,0% | OK |
| Plates | 0,7 < 5% | OK |
| Welds | 98,6 < 100% | OK |
| Buckling | Not calculated | |

### Plates

| Name | Thickness [mm] | Loads | $\sigma_{Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | Status |
|---|---|---|---|---|---|
| pp406 | 20,0 | GSN5(1) | 355,1 | 0,1 | OK |
| pp405 | 6,3 | GSN5(1) | 355,9 | 0,4 | OK |
| pp408 | 6,3 | GSN5(1) | 356,5 | 0,7 | OK |

**Design data**

| Material | $f_y$ [MPa] | $\varepsilon_{lim}$ [%] |
|---|---|---|
| S 355 | 355,0 | 5,0 |

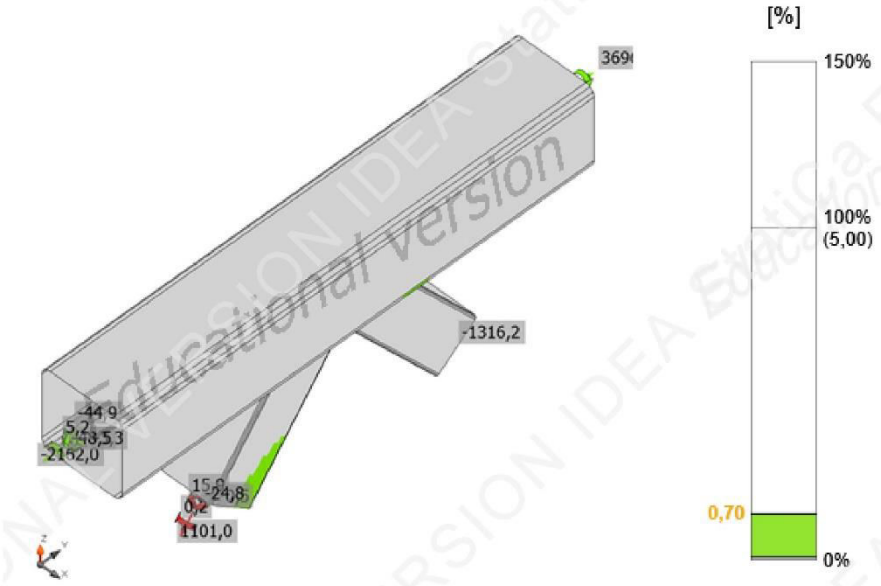
**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{Ed}$ | Eq. stress |
| $f_y$ | Yield strength |
| $\varepsilon_{lim}$ | Limit of plastic strain |

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**

IDEA StatiCa®
Calculate yesterday's estimates

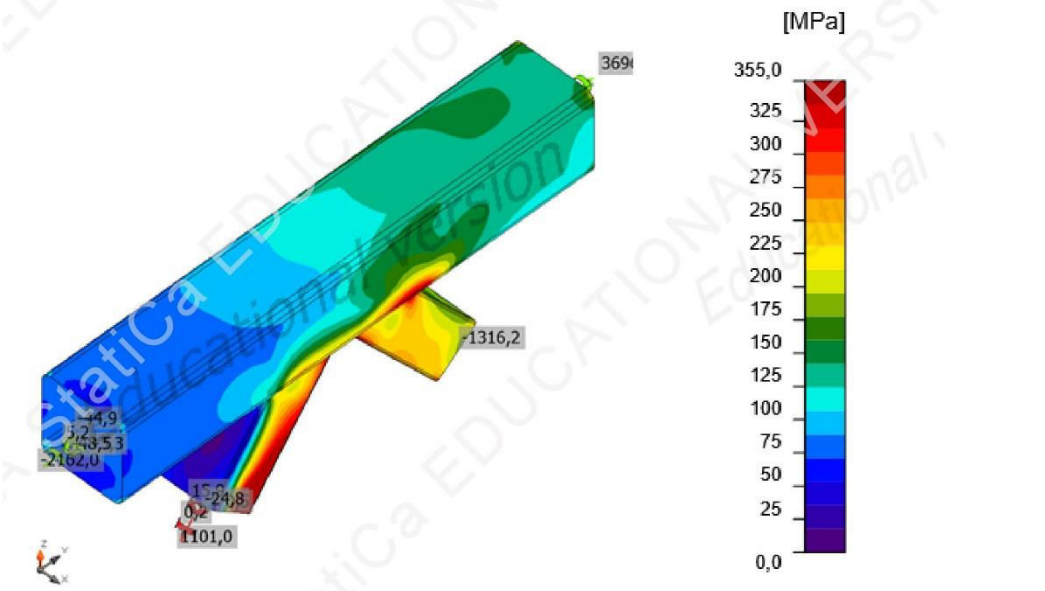
*Overall check, GSN5(1)*




*Strain check, GSN5(1)*

Educational version
IDEA StatiCa EDUCATIONAL VERSION

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**




*Equivalent stress, GSN5(1)*

### Welds (Plastic redistribution)

| Item | Edge | Throat th. [mm] | Length [mm] | Loads | $\sigma_{w,Ed}$ [MPa] | $\varepsilon_{Pl}$ [%] | $\sigma_{\perp}$ [MPa] | $\tau_{\parallel}$ [MPa] | $\tau_{\perp}$ [MPa] | Ut [%] | $Ut_c$ [%] | Status |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ◢6,0◣ | 1086 | GSN5(1) | 428,3 | 0,8 | 115,5 | 116,8 | -207,5 | 98,3 | 40,5 | OK |
| pp406-w 1 | pp405 | ◢6,0◣ | 1086 | GSN5(1) | 428,9 | 1,2 | 274,6 | -99,3 | 162,3 | 98,5 | 42,4 | OK |
| | | ◢6,0◣ | 1086 | GSN5(1) | 429,7 | 1,6 | -246,3 | 96,1 | 179,1 | 98,6 | 38,9 | OK |
| pp406-w 1 | pp408 | ◢6,0◣ | 1086 | GSN5(1) | 427,5 | 0,4 | -140,1 | -167,8 | -162,0 | 98,2 | 48,9 | OK |

**Design data**

| | $\beta_w$ [-] | $\sigma_{w,Rd}$ [MPa] | 0.9 σ [MPa] |
|---|---|---|---|
| S 355 | 0,90 | 435,6 | 352,8 |

**Symbol explanation**

| | |
|---|---|
| $\varepsilon_{Pl}$ | Strain |
| $\sigma_{w,Ed}$ | Equivalent stress |
| $\sigma_{w,Rd}$ | Equivalent stress resistance |
| $\sigma_{\perp}$ | Perpendicular stress |
| $\tau_{\parallel}$ | Shear stress parallel to weld axis |
| $\tau_{\perp}$ | Shear stress perpendicular to weld axis |
| 0.9 σ | Perpendicular stress resistance - 0.9*fu/γM2 |
| $\beta_w$ | Corelation factor EN 1993-1-8 tab. 4.1 |
| Ut | Utilization |
| Utc | Weld capacity utilization |

**Project:** Spoj ispune s gornjim pojasom
**Project no:**
**Author:**

**Detailed result for pp406-w 1 pp405**

**Weld resistance check** (EN 1993-1-8 4.5.3.2)

$\sigma_{w,Rd} = f_u/(\beta_w \gamma_{M2}) =$ 435,6 MPa ≥ $\sigma_{w,Ed} = [\sigma_\perp^2 + 3(\tau_\perp^2 + \tau_\parallel^2)]^{0,5} =$ 429,7 MPa

$\sigma_{\perp,Rd} = 0,9 f_u/\gamma_{M2} =$ 352,8 MPa ≥ $|\sigma_\perp| =$ 246,3 MPa

where:

$f_u =$ 490,0 MPa – Ultimate strength

$\beta_w =$ 0,90 – appropriate correlation factor taken from Table 4.1

$\gamma_{M2} =$ 1,25 – Safety factor

**Stress utilization**

$U_t = \max(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_\perp|}{\sigma_{\perp,Rd}}) =$ 98,6 %

### Buckling

**Buckling analysis was not calculated.**

## Code settings

| Item | Value | Unit | Reference |
|---|---|---|---|
| $\gamma_{M0}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M1}$ | 1,00 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M2}$ | 1,25 | - | EN 1993-1-1: 6.1 |
| $\gamma_{M3}$ | 1,25 | - | EN 1993-1-8: 2.2 |
| $\gamma_C$ | 1,50 | - | EN 1992-1-1: 2.4.2.4 |
| $\gamma_{Inst}$ | 1,20 | - | ETAG 001-C: 3.2.1 |
| Joint coefficient βj | 0,67 | - | EN 1993-1-8: 6.2.5 |
| Effective area - influence of mesh size | 0,10 | - | |
| Friction coefficient - concrete | 0,25 | - | EN 1993-1-8 |
| Friction coefficient in slip-resistance | 0,30 | - | EN 1993-1-8 tab 3.7 |
| Limit plastic strain | 0,05 | - | EN 1993-1-5 |
| Weld stress evaluation | Plastic redistribution | | |
| Detailing | No | | |
| Distance between bolts [d] | 2,20 | - | EN 1993-1-8: tab 3.3 |
| Distance between bolts and edge [d] | 1,20 | - | EN 1993-1-8: tab 3.3 |
| Concrete breakout resistance | Yes | | ETAG 001-C |
| Use calculated αb in bearing check. | Yes | | EN 1993-1-8: tab 3.4 |
| Cracked concrete | Yes | | |
| Local deformation check | No | | |
| Local deformation limit | 0,03 | - | CIDECT DG 1, 3 - 1.1 |

# 7. TEŽINA KONSTRUKCIJE

Težina konstrukcije je izračunata u programu SCIA Engineer 2019.

Student version

**Bill of material**

Selection: All
Type of sorting: Material

**Summary**

| Material | Mass [kg] | Surface [m²] | Volume [m³] |
|---|---|---|---|
| Steel | 1536199,4 | 19306,638 | 1,9835e+02 |
| Total | 1536199,4 | 19306,638 | 1,9835e+02 |

Note: Value 'Surface' represents for 1D members the total exposed surface area, while for 2D members it corresponds only to the surface area of the centroidal plane.

**Steel (1D)**

| Material | Density [kg/m³] | Mass [kg] | Surface [m²] | Volume [m³] |
|---|---|---|---|---|
| S 355 | 7850,0 | 1536196,7 | 18951,831 | 1,9569e+02 |
| BS | 1,0 | 2,7 | 354,807 | 2,6606e+00 |
| Total | | 1536199,4 | 19306,638 | 1,9835e+02 |

***Slika 7.1.*** *Ukupna težina čelične konstrukcije*

Program daje vrijednost ukupne težine svih štapova rešetke.

Dijeljenjem vrijednosti sa tlocrtnom površinom čelične konstrukcije dobije se kilaža po metru kvadratnom:

$\frac{1536199{,}4\ \text{kg}}{19306{,}638\ \text{m}^2} = 79{,}57\ [kg/m^2]$ – težina čelične konstrukcije po $\text{m}^2$

# 8. DIMENZIONIRANJE TEMELJA SAMCA

## 8.1. Proračun dimenzija temlja samca

Dimenzije temelja: 4200×4200×1250 mm

Dopušteno naprezanje: σ=500 MPa

$M_{sd}$=131,35 kNm

$N_{sd}$=-7961,76 kN

h=1,25m

$$a = \sqrt{\frac{P}{\sigma}} = \sqrt{\frac{7961,76}{500}} = 3,99\ m\ \rightarrow odabrano\ a = 4,2\ m$$

Maksimalno djelovanje na temelj:

$N_{Ed,max}$=-7961,76 kN – tlak

Težina temelja:

$N_t$=4,2·4,2·1,25·25=551,25 kN

$N_{Ed}$=$N_{Ed}$'+$N_t$=7961,76+551,25=8513,01 Kn

Naprezanje ispod temelja:

$$\sigma_{1,2} \leq \sigma_{dop.tla} = 500\left(\frac{kN}{m^2}\right)$$

$$\sigma_{1,2} \leq \frac{N_{Ed}}{A} \pm \frac{M_{Ed}}{W}$$

A=4,2·4,2=17,64 $m^2$

$$W \leq \frac{b \cdot a^2}{6} = \frac{4,2^3}{6} = 12,35\ m^2$$

$$\sigma_1 = 493,24\frac{kN}{m^2} < 500\frac{kN}{m^2}$$

$$\sigma_2 = 471,96\frac{kN}{m^2} < 500\frac{kN}{m^2}$$

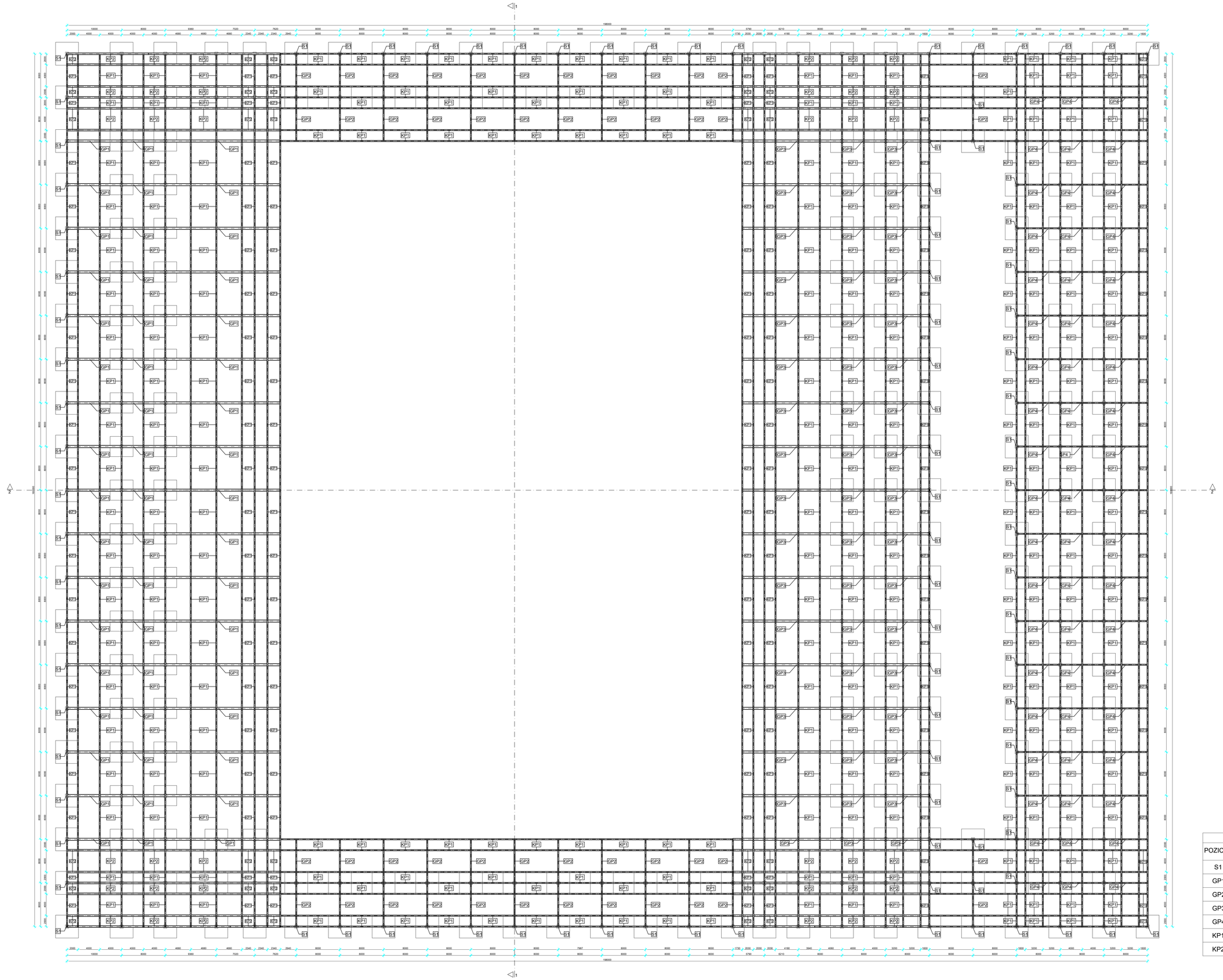
# 9. GRAFIČKI PRILOZI

Prilog 1: Plan pozicija nosive konstrukcije - tlocrt, M 1:250
Prilog 2: Plan pozicija nosive konstrukcije - presjek 1-1; M 1:100
Prilog 3: Plan pozicija nosive konstrukcije – presjek 2-2; M 1:100
Prilog 4: Radionički nacrt rešetke; M 1:50
Prilog 5: Spoj stupa s pločom; M 1:10
Prilog 6: Montažni nastavak donjeg pojasa; M 1:10
Prilog 7: Montažni nastavak gornjeg pojasa; M 1:10
Prilog 8: Montažni nastavak ispune; M 1:10
Prilog 9: Spoj donjeg pojasa i ispune rešetke sa stupom; M 1:10
Prilog 10: Spoj donjeg pojasa sa stupom; M 1:10
Prilog 11: Spoj ispune s donjim i gornjim pojasom; M 1:10

# 10. LITERATURA

[**1**] Androić B., Dujmović D., Džeba I., Metalne konstrukcije 1, IGH Zagreb, 1994
[**2**] Androić B., Dujmović D., Džeba I, Čelične konstrukcije 1, IA Projektiranje, Zagreb, 2009
[3] Prof. dr. sc. Ivica Boko, Predavanja

TLOCRT



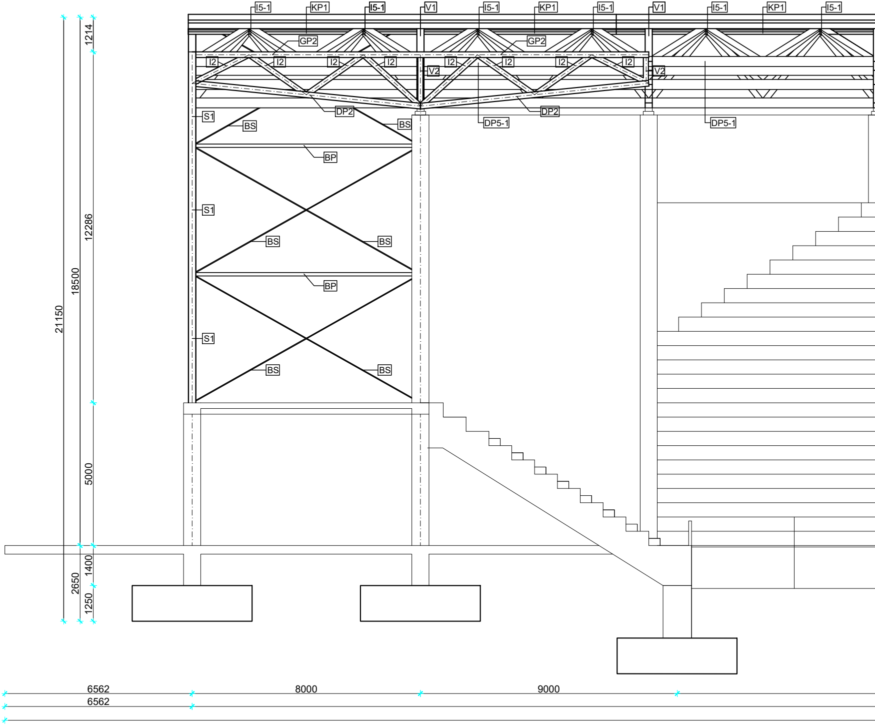

# PLAN POZICIJA
# NOSIVE KONSTRUKCIJE
# TLOCRT
# M 1:250
# ČELIK S355
# BETON C40/50

| PRIKAZ I OPIS POZICIJA | | |
|---|---|---|
| POZICIJA | PROFIL | NAZIV |
| S1 | HEA280 | Stup |
| GP1 | SHS400/400/20.0 | Gornji pojas rešetke R1 |
| GP2 | SHS200/200/6.0 | Gornji pojas rešetke R2 |
| GP3 | SHS400/400/10.0 | Gornji pojas rešetke R3 |
| GP4 | SHS200/200/4.0 | Gornji pojas rešetke R4 |
| KP1 | SHS200/200/10 | Krovna podrožnica segmenta 1 |
| KP2 | SHS300/300/14.2 | Krovna podrožnica segmenta 2 |

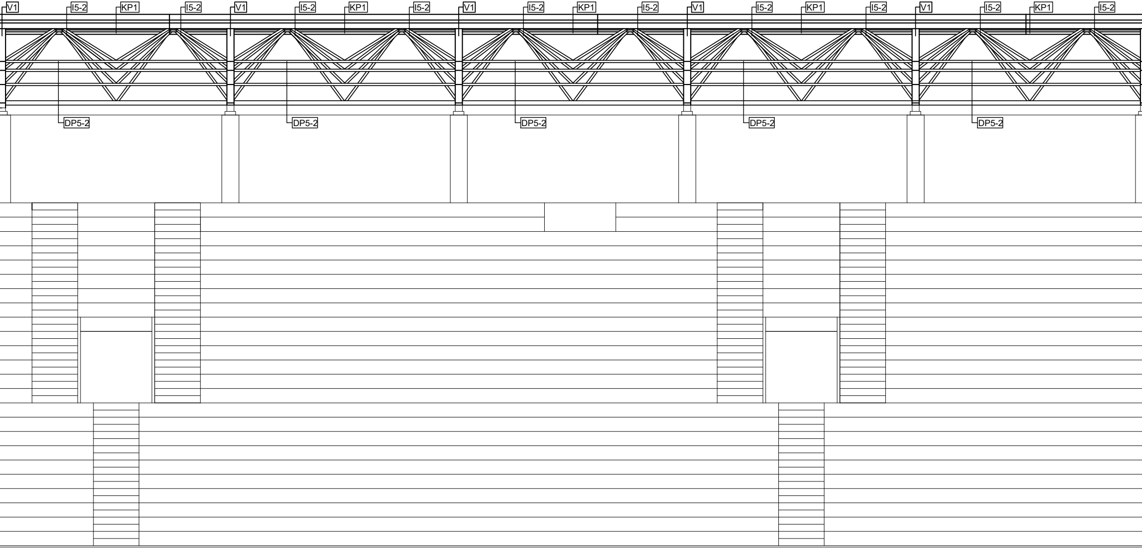

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

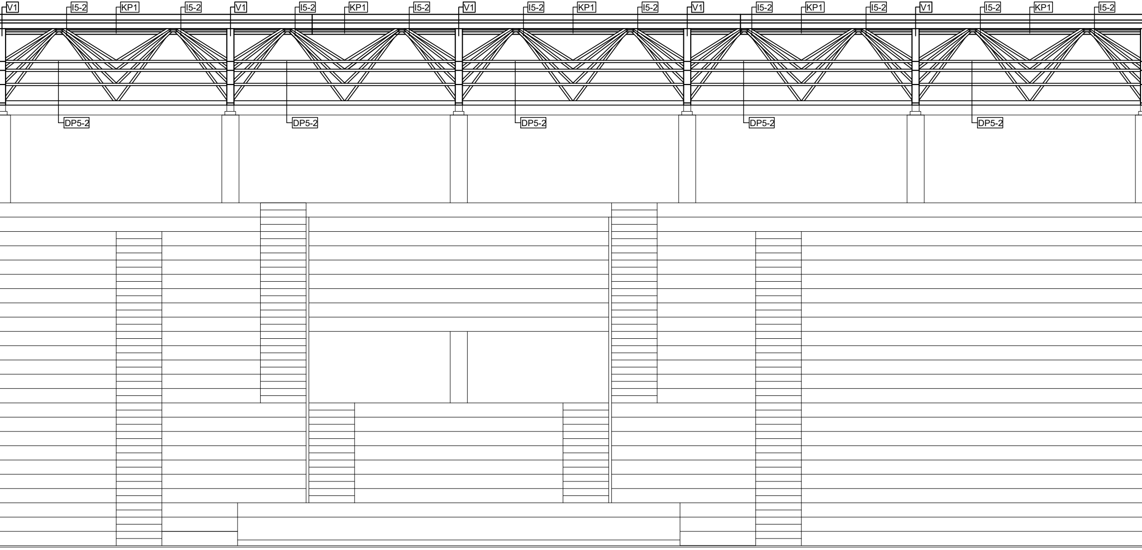

| | |
|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK |
| STUDENT: | Monika Ćosić, 685 |
| MENTOR: | Prof. dr. sc. Ivica Boko |
| SADRŽAJ: | PLAN POZICIJA - TLOCRT |
| MJERILO | 1:250 |
| DATUM | srpanj 2019. |
| PRILOG | 1 |

# PRESJEK 1-1



I5-1
KP1
I5-1
V1
I5-1
KP1
I5-1
V1
I5-1
KP1
I5-1
GP2
GP2
I2
I2
I2
I2
I2
I2
I2
I2
V2
V2
DP2
DP2
DP5-1
DP5-1
S1
BS
BS
BP
S1
BS
BS
BP
S1
BS
BS
1214
12286
18500
21150
5000
1400
2650
1250
6562
6562
8000
9000

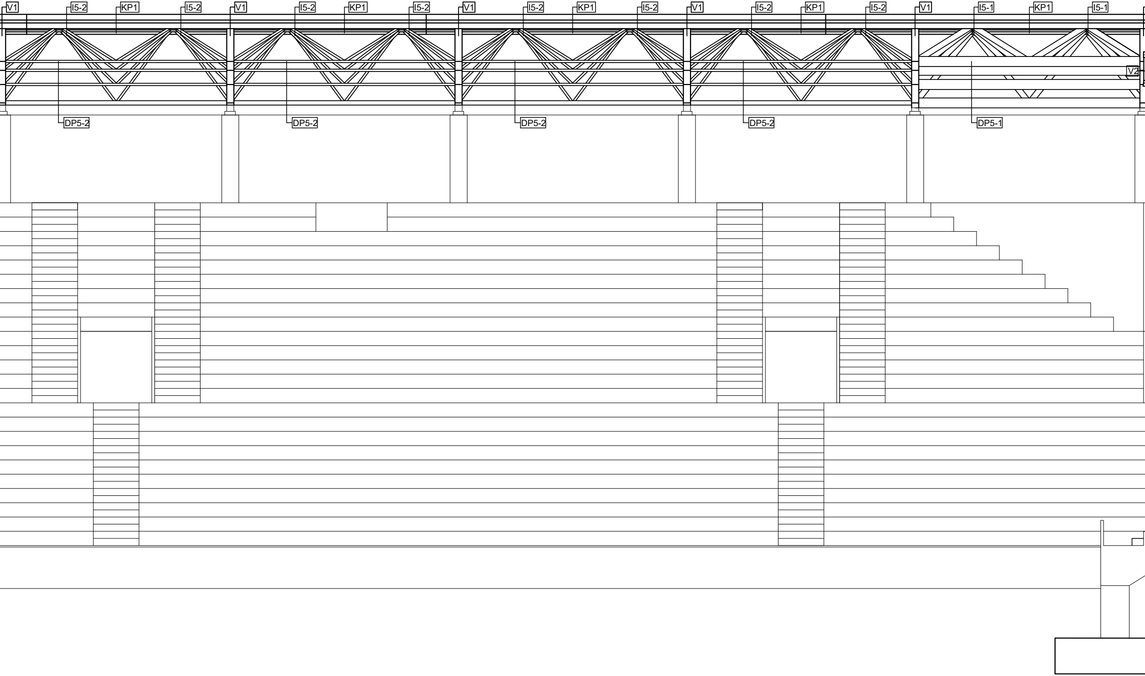

V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
DP5-2
DP5-2
DP5-2
DP5-2
DP5-2

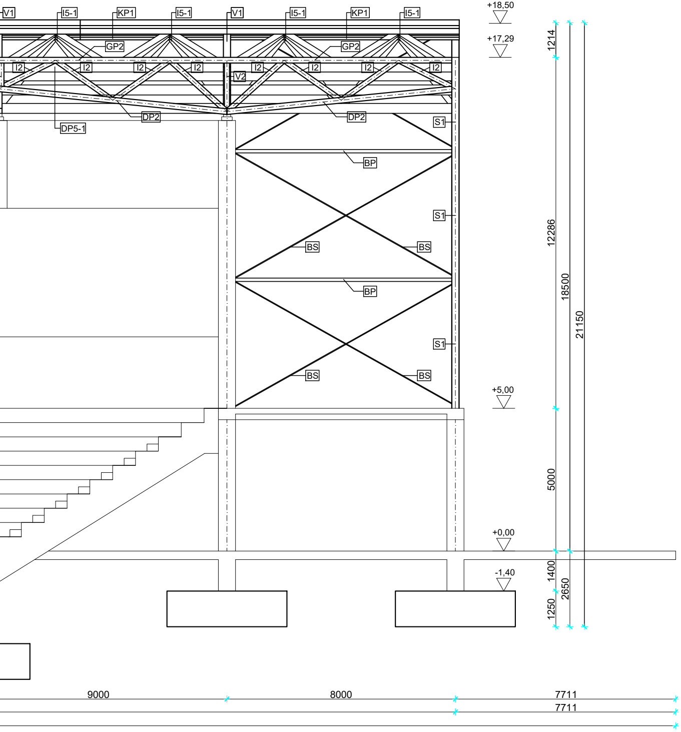

V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
DP5-2
DP5-2
DP5-2
DP5-2
DP5-2

126000

160000

174274


V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-2
KP1
I5-2
V1
I5-1
KP1
I5-1
V2
DP5-2
DP5-2
DP5-2
DP5-2
DP5-1


V1
I5-1
KP1
I5-1
V1
I5-1
KP1
I5-1
+18,50
+17,29
GP2
GP2
I2
I2
I2
I2
I2
I2
I2
I2
V2
DP2
DP2
DP5-1
S1
BP
S1
BS
BS
BP
S1
BS
BS
+5,00
+0,00
-1,40
1214
12286
18500
21150
5000
1400
2650
1250
9000
8000
7711
7711

## PRIKAZ I OPIS POZICIJA

| POZICIJA | PROFIL | NAZIV |
|---|---|---|
| S1 | HEA280 | Stup |
| GP2 | SHS200/200/6.0 | Gornji pojas rešetke R2 |
| DP2 | SHS200/200/14.2 | Donji pojas rešetke R2 |
| V2 | SHS180/180/6.3 | Vertikala rešetke R2 |
| I2 | SHS180/180/6.3 | Ispuna rešetke R2 |
| DP5-1 | SHS350/350/16 | Donji pojas sekundarne rešetke R5 segmenta 1 |
| DP5-2 | SHS80/80/6.0 | Donji pojas sekundarne rešetke R5 segmenta 2 |
| I5-1 | SHS200/200/8.0 | Ispuna sekundarne rešetke R5 segmenta 1 |
| I5-2 | SHS80/80/6.0 | Ispuna sekundarne rešetke R5 segmenta 2 |
| KP1 | SHS200/200/10 | Krovna podrožnica segmenta 1 |
| BP | SHS120/120/5.0 | Bočna podrožnica |
| BS | RD30 | Bočni spreg |

# PLAN POZICIJA
# NOSIVE KONSTRUKCIJE
# PRESJEK 1-1
# M 1:100
# ČELIK S355
# BETON C40/50

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

PROGRAM: PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK

STUDENT: Monika Ćosić, 685

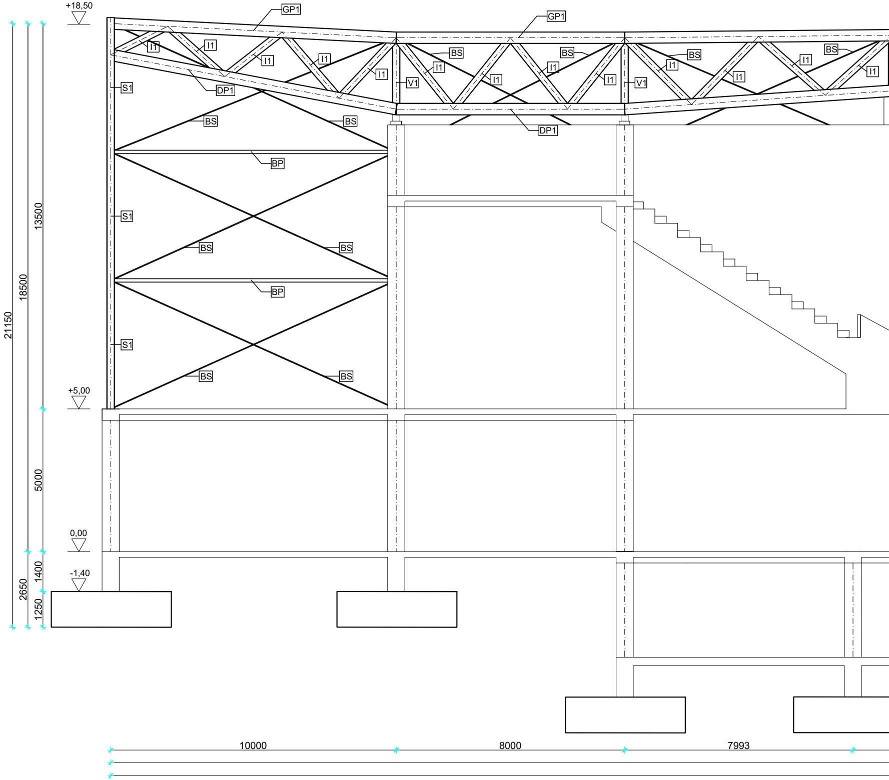
MENTOR: Prof. dr. sc. Ivica Boko

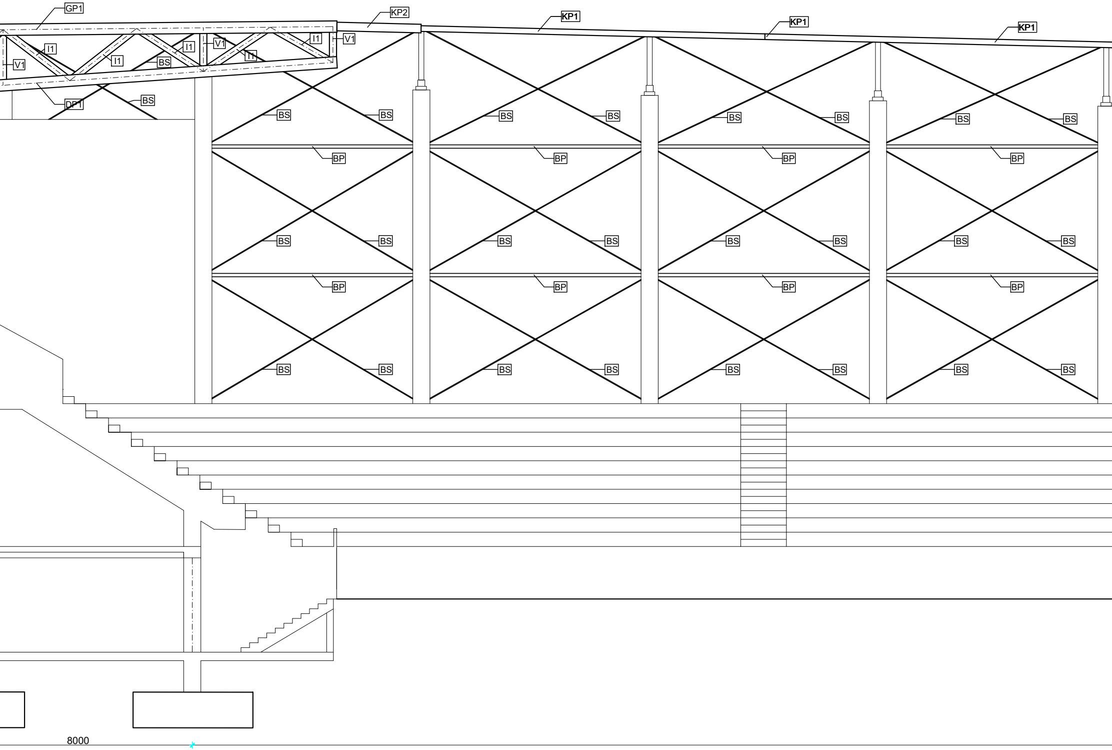
SADRŽAJ: PLAN POZICIJA - PRESJEK 1-1

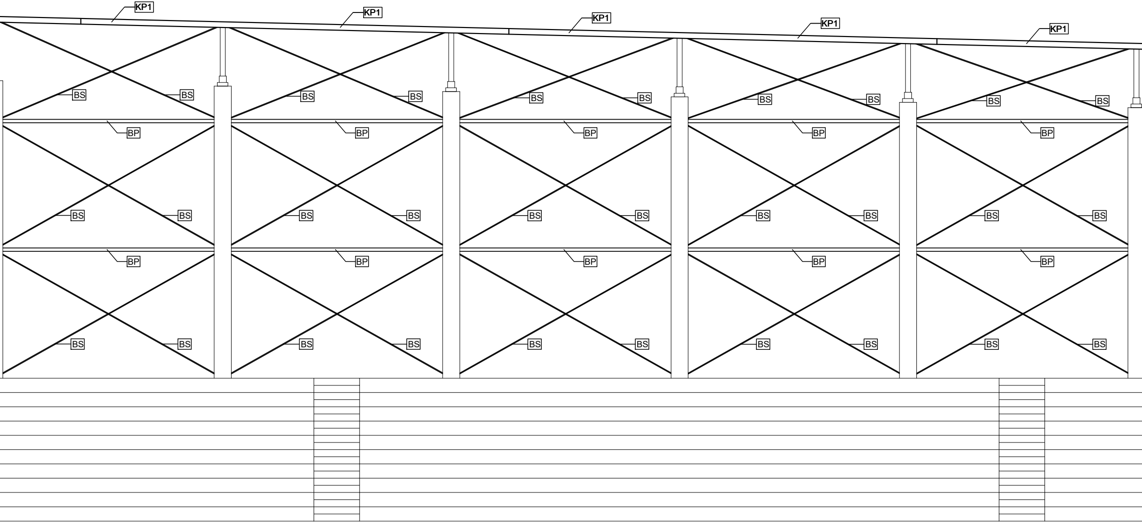
MJERILO 1:100

DATUM srpanj 2019.

PRILOG 2

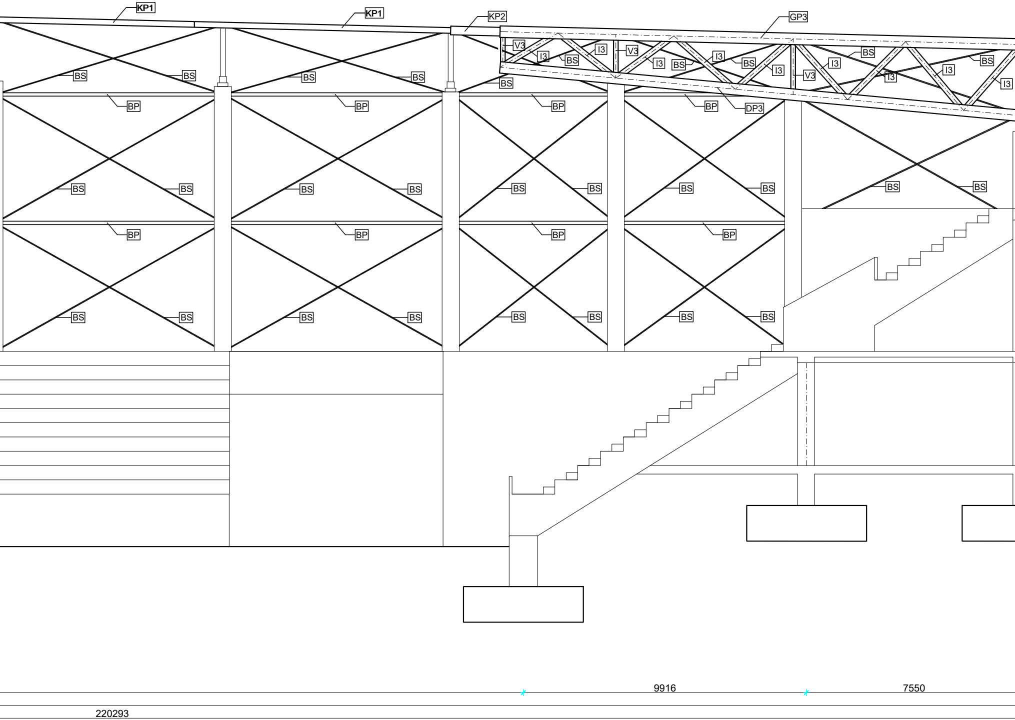

+18,50
GP1
GP1
I1
I1
I1
I1
I1
I1
BS
BS
BS
BS
I1
I1
I1
I1
I1
I1
I1
V1
V1
S1
DP1
BS
BS
DP1
BP
S1
BS
BS
BP
S1
BS
BS
+5,00
0,00
-1,40
21150
18500
13500
5000
2650
1400
1250
10000
8000
7993

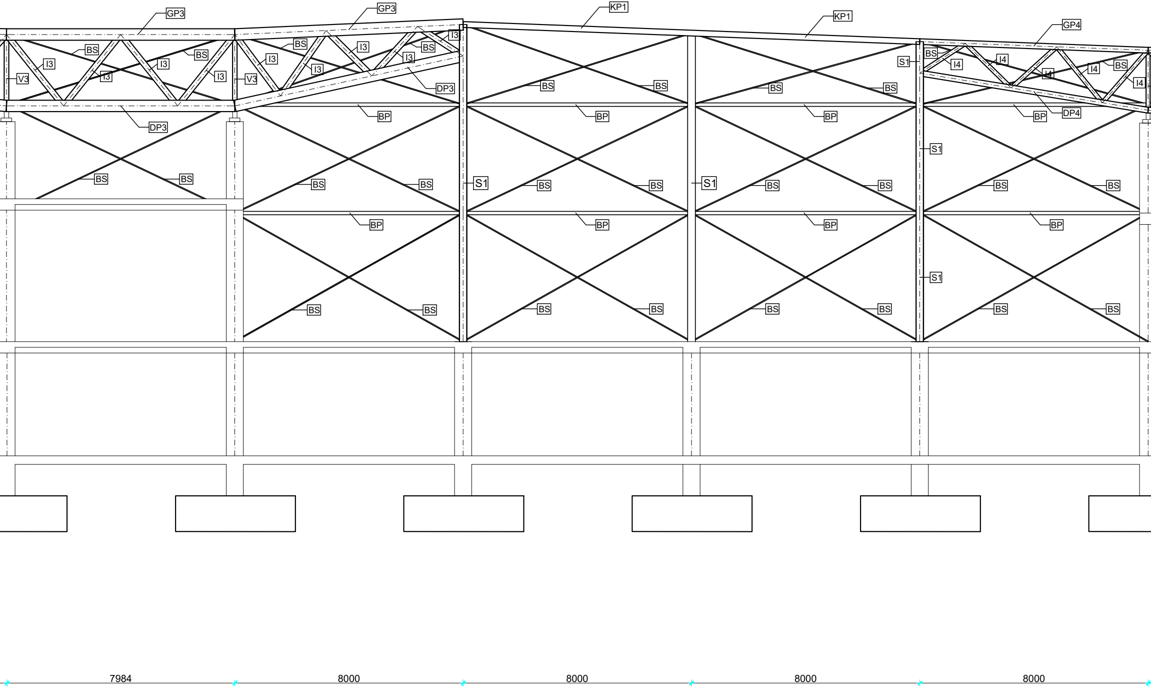

GP1
KP2
KP1
KP1
KP1
V1
I1
I1
I1
V1
I1
I1
V1
BS
DP1
BS
BP
8000

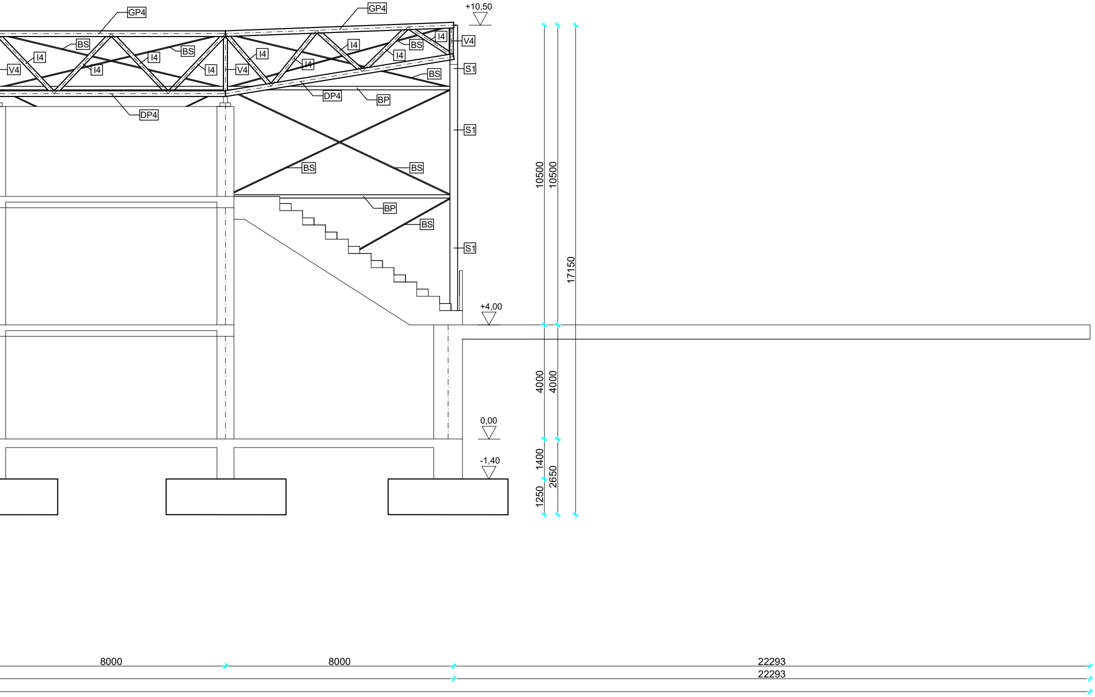

KP1
KP1
KP1
KP1
KP1
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BP
BP
BP
BP
BP
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BP
BP
BP
BP
BP
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS

90557

198000


KP1
KP1
KP2
GP3
V3
I3
BS
I3
V3
I3
BS
I3
BS
I3
V3
I3
BS
I3
I3
BS
I3
BS
BS
BS
BS
BS
BP
BP
BP
BP
DP3
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BP
BP
BP
BP
BS
BS
BS
BS
BS
BS
BS
BS
9916
7550
220293


GP3
GP3
KP1
KP1
GP4
BS
BS
BS
BS
BS
I3
I3
I3
I3
I3
I3
I3
I3
I3
V3
V3
DP3
DP3
S1
BS
I4
I4
I4
I4
I4
BS
DP4
BP
BP
BP
BP
BP
BP
BP
BP
BS
BS
BS
BS
BS
BS
BS
BS
S1
S1
S1
S1
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
BS
7984
8000
8000
8000
8000


GP4
GP4
+10,50
BS
I4
BS
I4
V4
I4
I4
I4
V4
I4
I4
BS
I4
I4
V4
S1
BS
DP4
BP
DP4
S1
BS
BS
BP
BS
S1
+4,00
0,00
-1,40
10500
10500
17150
4000
4000
1400
2650
1250
8000
8000
22293
22293

PRIKAZ I OPIS POZICIJA		
POZICIJA	PROFIL	NAZIV
S1	HEA280	Stup
GP1	SHS400/400/20	Gornji pojas rešetke R1
DP1	SHS400/400/25	Donji pojas rešetke R1
V1	SHS250/250/8.0	Vertikala rešetke R1
I1	SHS250/250/6.3	Ispuna rešetke R1
GP3	SHS400/400/10	Gornji pojas rešetke R3
DP3	SHS400/400/20	Donji pojas rešetke R3
V3	SHS180/180/5.0	Vertikala rešetke R3
I3	SHS200/200/6.0	Ispuna rešetke R3
GP4	SHS200/200/4.0	Gornji pojas rešetke R4
DP4	SHS200/200/14.2	Donji pojas rešetke R4
V4	SHS140/140/6.0	Vertikala rešetke R4
I4	SHS140/140/4.0	Ispuna rešetke R4
KP1	SHS200/200/10	Krovna podrožnica segmenta 1
BP	SHS120/120/5.0	Bočna podrožnica
BS	RD30	Bočni spreg

PLAN POZICIJA
PRESJEK 2-2
M 1:100
ČELIK S355
BETON C40/50

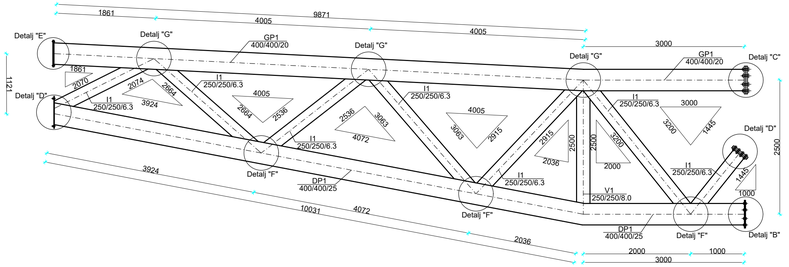
SVEUČILIŠTE U SPLITU

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

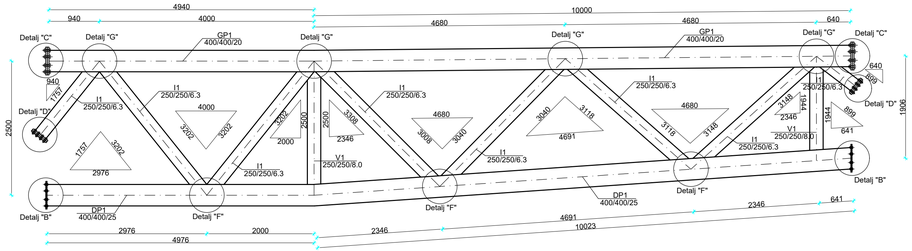
PROGRAM:	PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK		
STUDENT:	Monika Ćosić, 685	MENTOR:	Prof. dr. sc. Ivica Boko
SADRŽAJ:	PRESJEK 2-2	MJERILO	1:100
DATUM	srpanj 2019.	PRILOG	3

RADIONIČKI NACRT REŠETKE R1

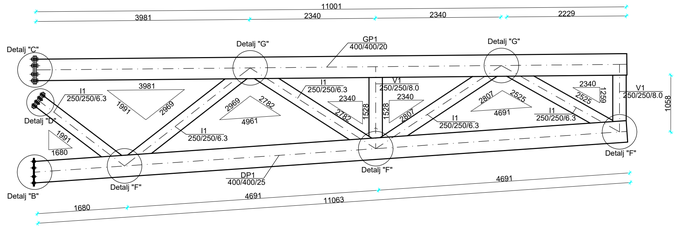
SEGMENT 1




SEGMENT 2

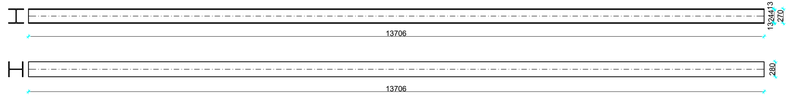



SEGMENT 3




RADIONIČKI NACRT STUPA S1

STUP HEA280




# RADIONIČKI NACRT
MJ 1:50
ČELIK S355


FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15


| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: | Monika Ćosić, 685 | MENTOR: | Prof. dr. sc. Ivica Boko |
| SADRŽAJ: | RADIONIČKI NACRT | MJERILO | 1:50 |
| DATUM | srpanj 2019. | PRILOG | 4 |

| ISKAZ MATERIJALA REŠETKE R1 - SEGMENT 1 | | | | | |
|---|---|---|---|---|---|
| POZICIJA | PROFIL | DUŽINA (mm) | KOMADA | JED. MASA (kg/m) | UKUPNA MASA (kg) |
| DP1-1 | SHS400/400/25 | 10031 | 1 | 294,38 | 2952,92 |
| DP1-2 | SHS400/400/25 | 3000 | 1 | 294,38 | 883,14 |
| GP1-1 | SHS400/400/20 | 9871 | 1 | 238,64 | 2355,62 |
| GP1-2 | SHS400/400/20 | 3000 | 1 | 238,64 | 715,92 |
| I1-1 | SHS250/250/6.3 | 2074 | 1 | 48,21 | 99,99 |
| I1-2 | SHS250/250/6.3 | 2664 | 1 | 48,21 | 128,43 |
| I1-3 | SHS250/250/6.3 | 2536 | 1 | 48,21 | 122,26 |
| I1-4 | SHS250/250/6.3 | 3063 | 1 | 48,21 | 147,67 |
| I1-5 | SHS250/250/6.3 | 2915 | 1 | 48,21 | 140,53 |
| I1-6 | SHS250/250/6.3 | 3200 | 1 | 48,21 | 154,27 |
| I1-7 | SHS250/250/6.3 | 1445 | 1 | 48,21 | 69,66 |
| V1-1 | SHS250/250/8.0 | 2500 | 1 | 60,79 | 151,98 |
| | | | | UKUPNO | 7922,39 |

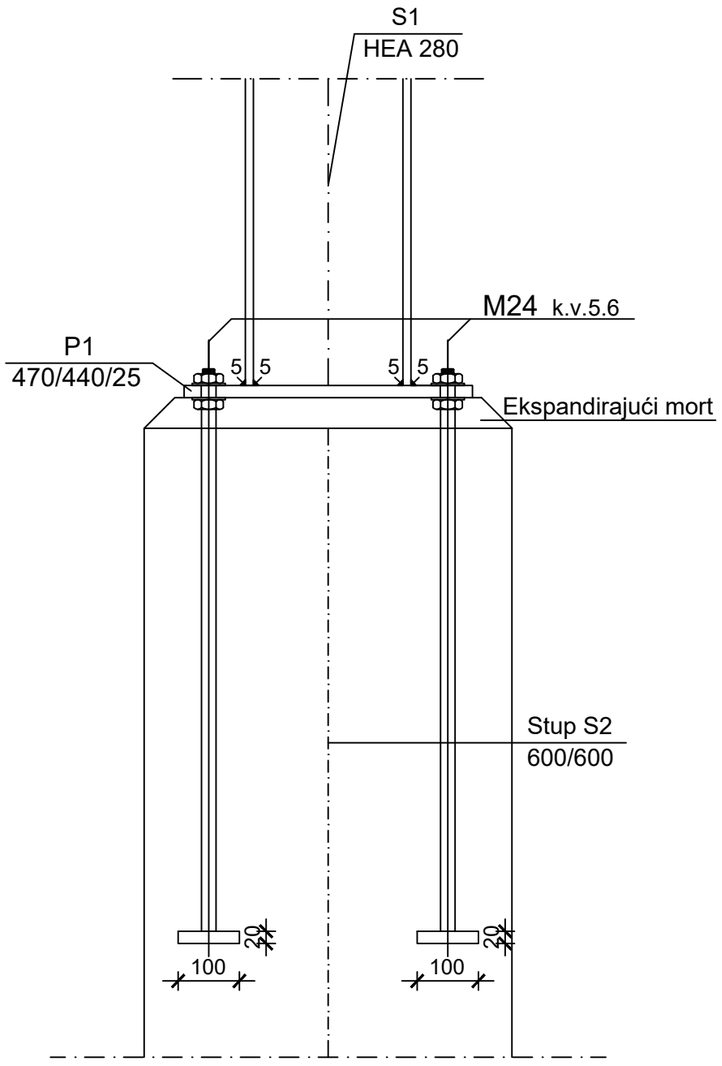
| ISKAZ MATERIJALA REŠETKE R1 - SEGMENT 2 | | | | | |
|---|---|---|---|---|---|
| POZICIJA | PROFIL | DUŽINA (mm) | KOMADA | JED. MASA (kg/m) | UKUPNA MASA (kg) |
| DP1-3 | SHS400/400/25 | 4976 | 1 | 294,38 | 1464,83 |
| DP1-4 | SHS400/400/25 | 10023 | 1 | 294,38 | 2950,57 |
| GP1-3 | SHS400/400/20 | 4940 | 1 | 238,64 | 1178,88 |
| GP1-4 | SHS400/400/20 | 10000 | 1 | 238,64 | 238,64 |
| I1-8 | SHS250/250/6.3 | 1757 | 1 | 48,21 | 84,70 |
| I1-9 | SHS250/250/6.3 | 3202 | 1 | 48,21 | 154,37 |
| I1-10 | SHS250/250/6.3 | 3202 | 1 | 48,21 | 154,37 |
| I1-11 | SHS250/250/6.3 | 3308 | 1 | 48,21 | 159,48 |
| I1-12 | SHS250/250/6.3 | 3040 | 1 | 48,21 | 146,56 |
| I1-13 | SHS250/250/6.3 | 3118 | 1 | 48,21 | 150,32 |
| I1-14 | SHS250/250/6.3 | 3148 | 1 | 48,21 | 151,77 |
| I1-15 | SHS250/250/6.3 | 899 | 1 | 48,21 | 43,34 |
| V1-2 | SHS250/250/8.0 | 2500 | 1 | 60,79 | 151,98 |
| V1-3 | SHS250/250/8.0 | 1944 | 1 | 60,79 | 118,18 |
| | | | | UKUPNO | 7147,99 |

| ISKAZ MATERIJALA REŠETKE R1 - SEGMENT 3 | | | | | |
|---|---|---|---|---|---|
| POZICIJA | PROFIL | DUŽINA (mm) | KOMADA | JED. MASA (kg/m) | UKUPNA MASA (kg) |
| DP1-5 | SHS400/400/25 | 11063 | 1 | 294,38 | 3256,73 |
| GP1-5 | SHS400/400/20 | 11001 | 1 | 238,64 | 2625,28 |
| I1-16 | SHS250/250/6.3 | 1991 | 1 | 48,21 | 95,99 |
| I1-17 | SHS250/250/6.3 | 2969 | 1 | 48,21 | 143,14 |
| I1-18 | SHS250/250/6.3 | 2782 | 1 | 48,21 | 134,12 |
| I1-19 | SHS250/250/6.3 | 2807 | 1 | 48,21 | 135,33 |
| I1-20 | SHS250/250/6.3 | 2525 | 1 | 48,21 | 121,73 |
| V1-4 | SHS250/250/8.0 | 1528 | 1 | 60,79 | 92,89 |
| V1-5 | SHS250/250/8.0 | 1259 | 1 | 60,79 | 76,53 |
| | | | | UKUPNO | 6681,74 |

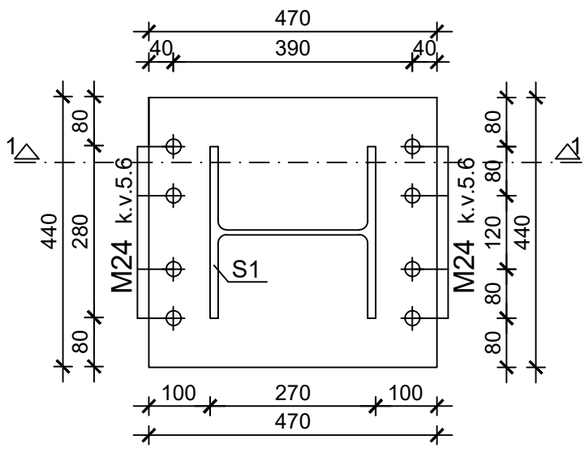
| ISKAZ MATERIJALA STUPA S1 | | | | | |
|---|---|---|---|---|---|
| POZICIJA | PROFIL | DUŽINA (mm) | KOMADA | JED. MASA (kg/m) | UKUPNA MASA (kg) |
| S1 | HEA280 | 13706 | 1 | 46,76 | 640,89 |

# Detalj "A"
# Spoj stupa s pločom
# MJ 1:10

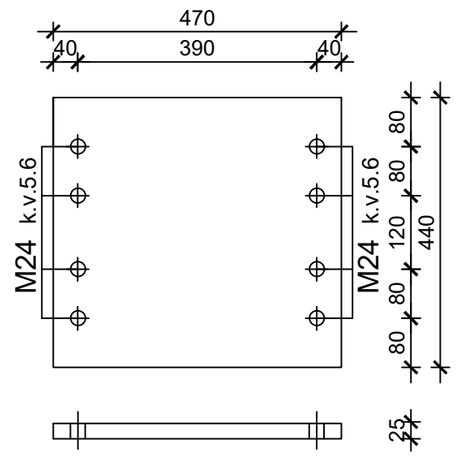
## Presjek 1-1




## Tlocrt




P1
470/440/25





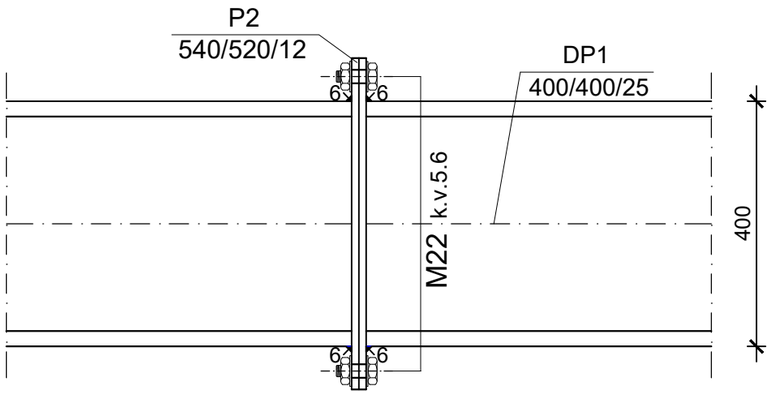
SVEUČILIŠTE U SPLITU

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

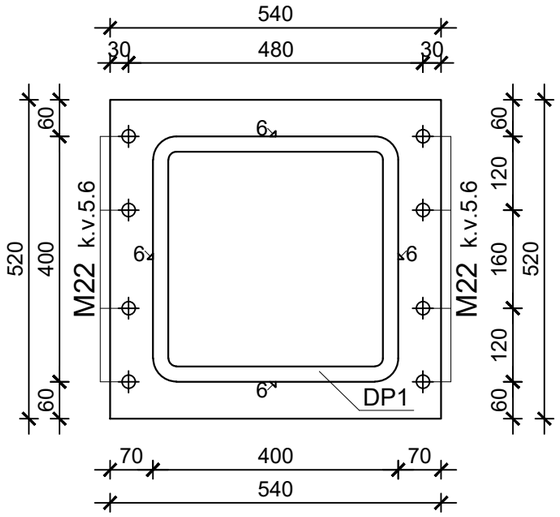

| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: | Monika Ćosić, 685 | MENTOR: | Prof. dr. sc. Ivica Boko |
| SADRŽAJ: | SPOJ STUPA S PLOČOM | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 5 |

# Detalj "B"
# Montažni nastavak donjeg pojasa
# MJ 1:10

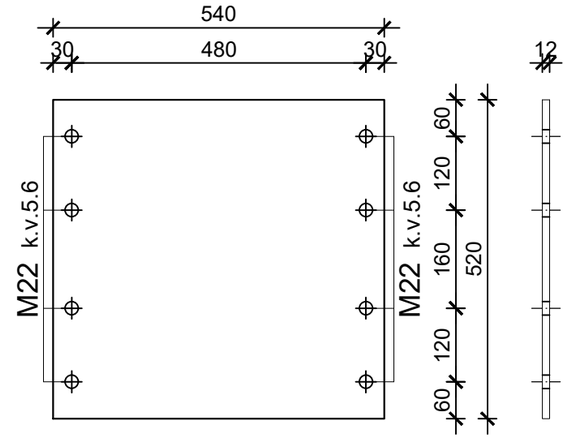
## Tlocrt



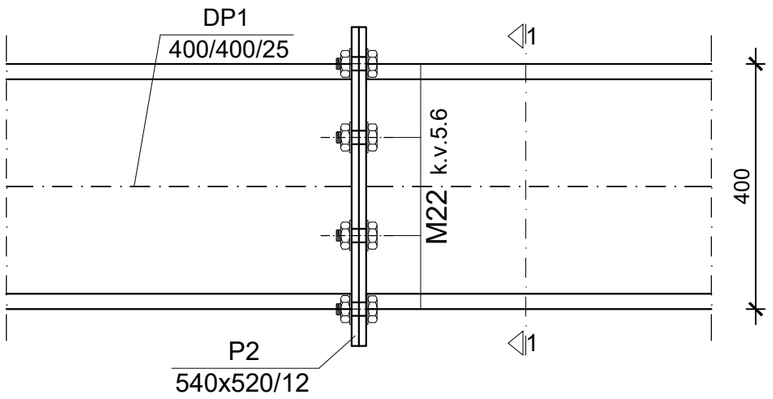

## Presjek 1-1




## P2
## 540/520/12




## Pogled





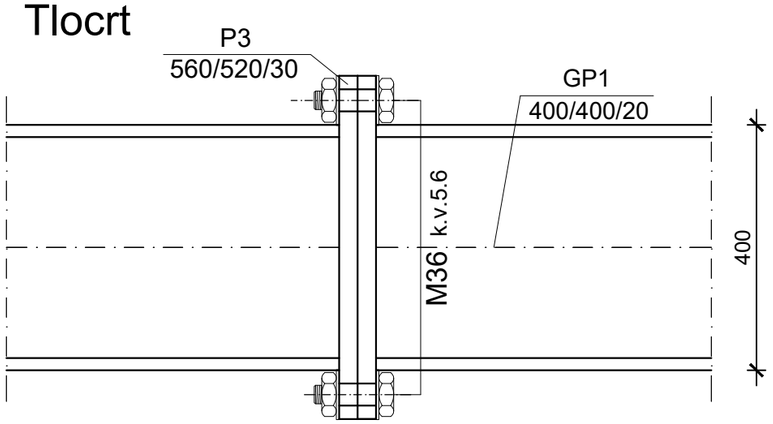
SVEUČILIŠTE U SPLITU

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

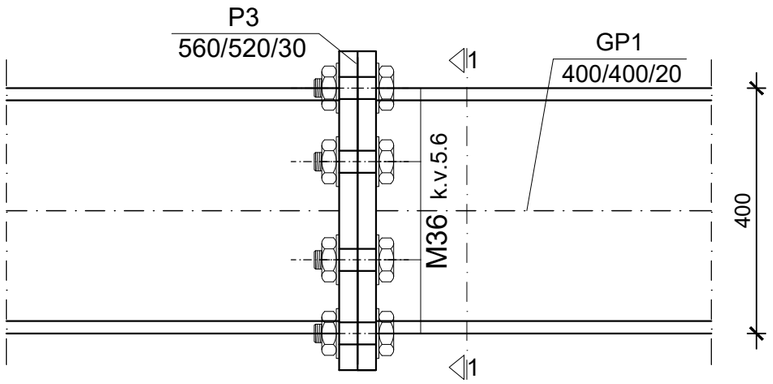

| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: Monika Ćosić, 685 | | MENTOR: Prof. dr. sc. Ivica Boko | |
| SADRŽAJ: | MONTAŽNI NASTAVAK DONJEG POJASA | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 6 |

# Detalj "C"
# Montažni nastavak gornjeg pojasa
# MJ 1:10

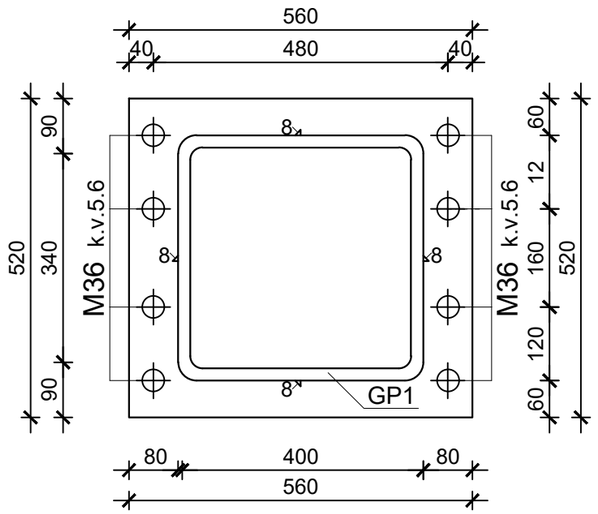
## Tlocrt



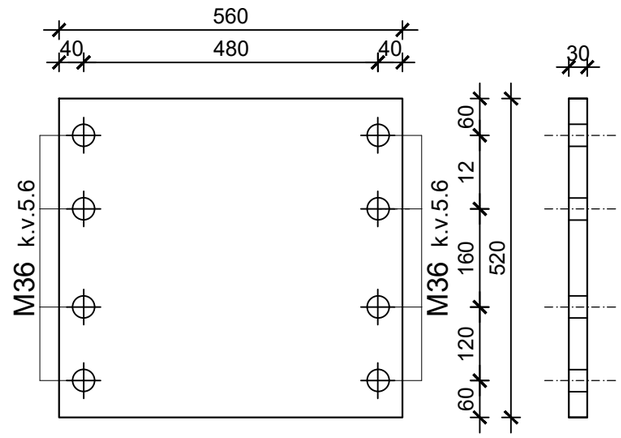

## Pogled




## Presjek 1-1




P3
560/520/30

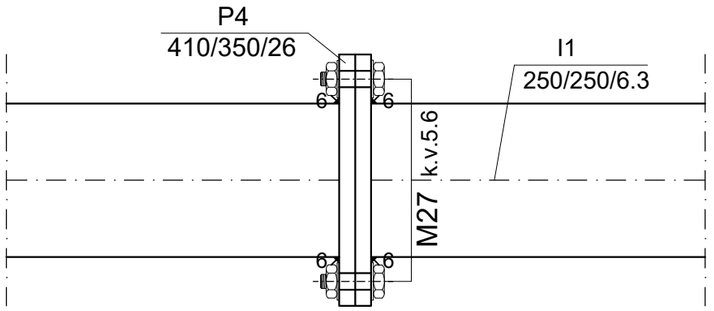


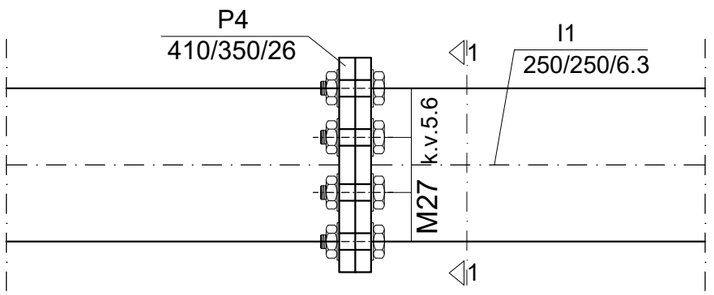

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: Monika Ćosić, 685 | | MENTOR: Prof. dr. sc. Ivica Boko | |
| SADRŽAJ: | MONTAŽNI NASTAVAK GORNJEG POJASA | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 7 |

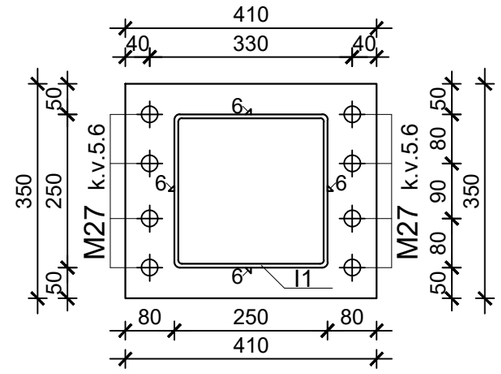
# Detalj "D"
# Montažni nastavak ispune

## Tlocrt

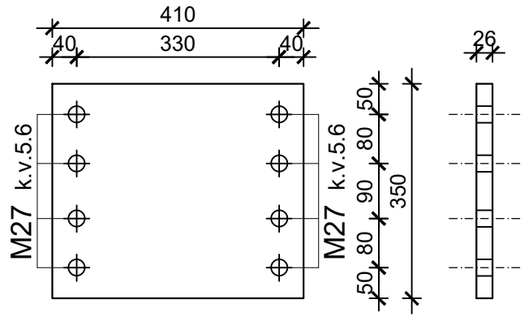



## Presjek 1-1




P4
410/350/26




FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

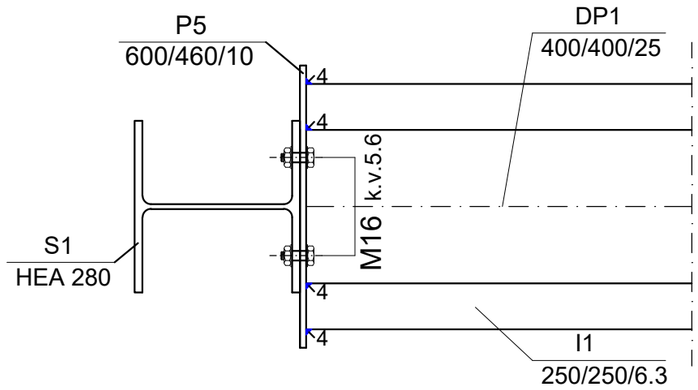
| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: Monika Ćosić, 685 | | MENTOR: Prof. dr. sc. Ivica Boko | |
| SADRŽAJ: | MONTAŽNI NASTAVAK ISPUNE | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 8 |

# Detalj "E"

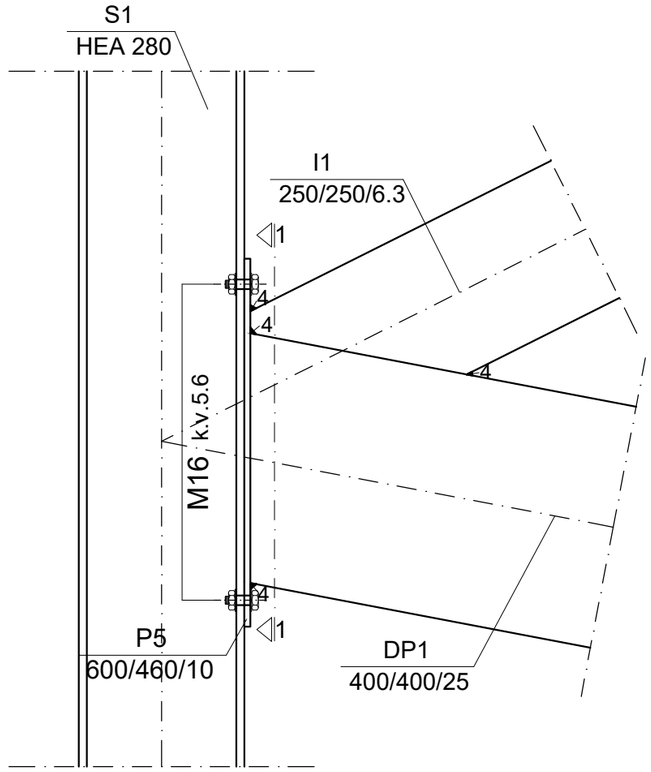
# Spoj donjeg pojasa i ispune sa stupom

# MJ 1:10

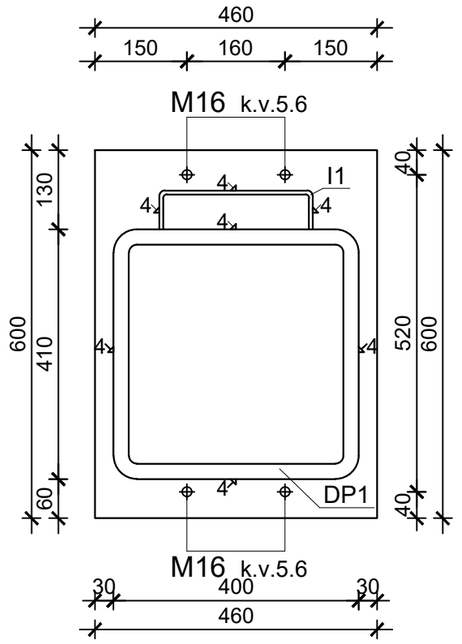
## Tlocrt

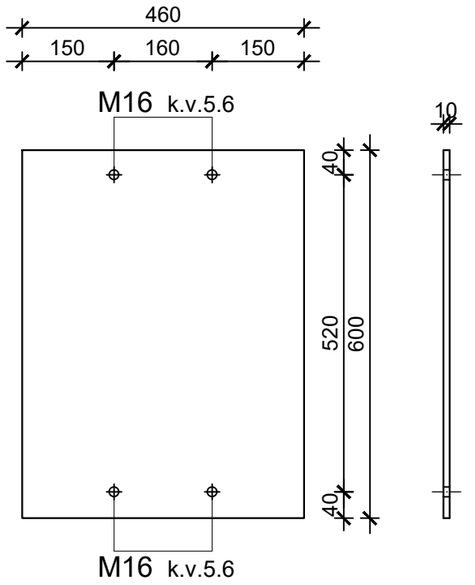



## Pogled




## Presjek 1-1



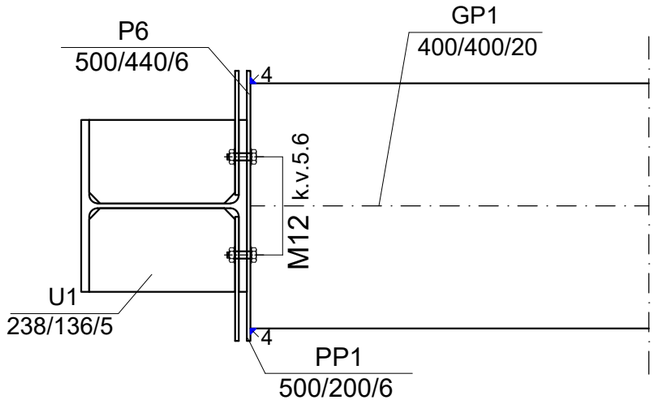




FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15

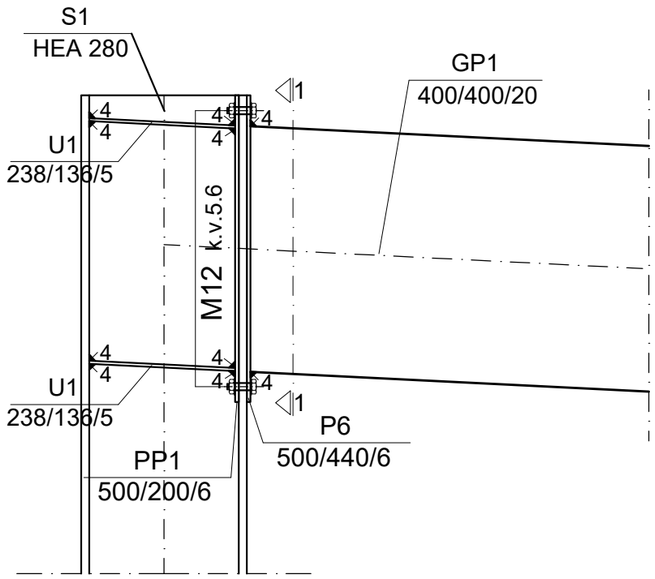
| | |
|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK |
| STUDENT: Monika Ćosić, 685 | MENTOR: Prof. dr. sc. Ivica Boko |
| SADRŽAJ: SPOJ DONJEG POJASA I ISPUNE SA STUPOM | MJERILO 1:10 |
| DATUM srpanj 2019. | PRILOG 9 |

# Detalj "F"
# Spoj gornjeg pojasa sa stupom
# MJ 1:10

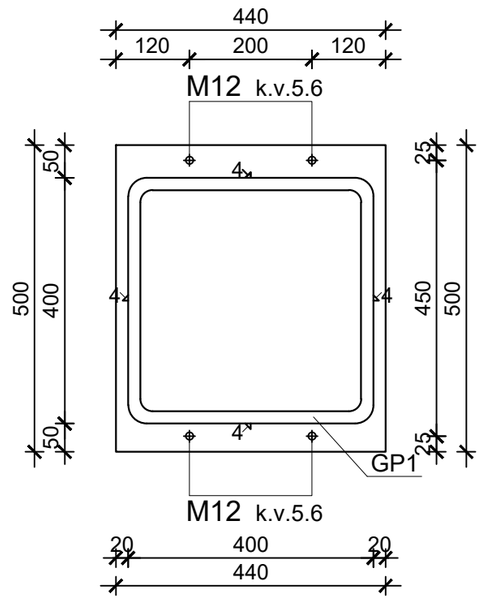
## Tlocrt



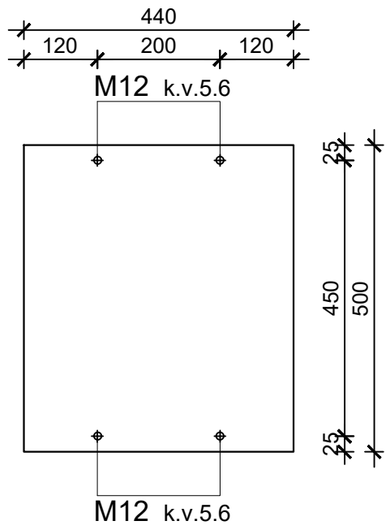

## Pogled



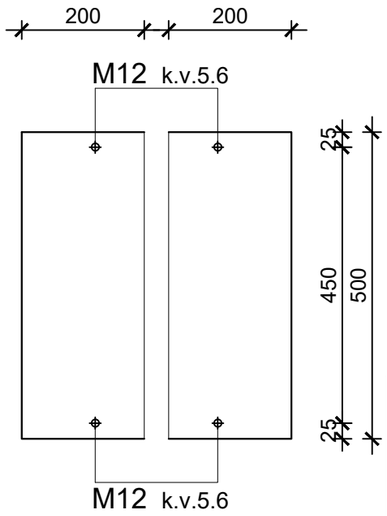

## Presjek 1-1



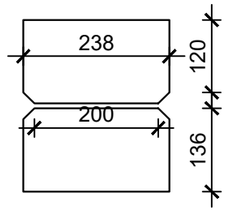

P6
500/440/6




PP1
500/200/6




U1
238/136/5

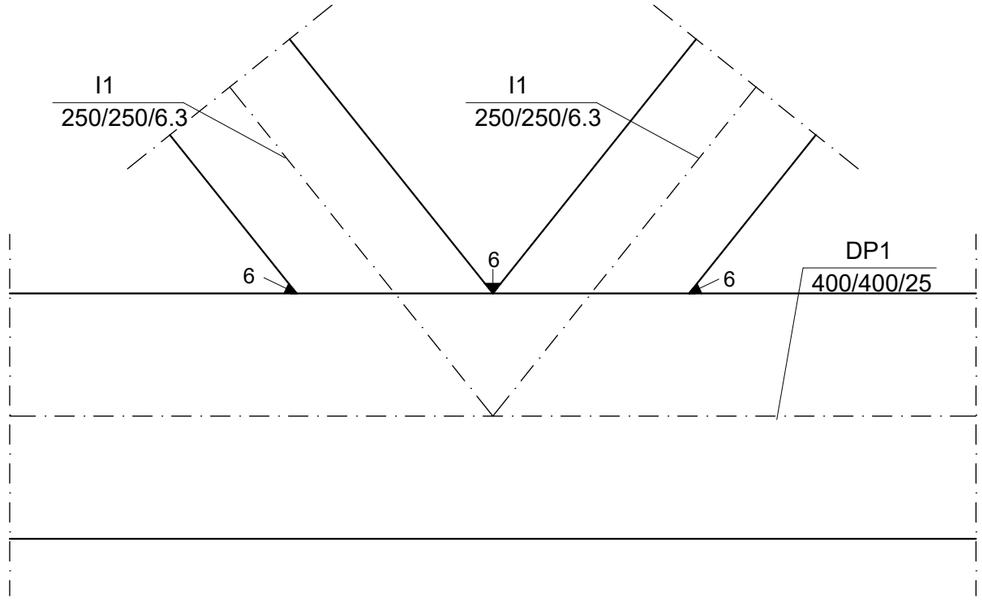




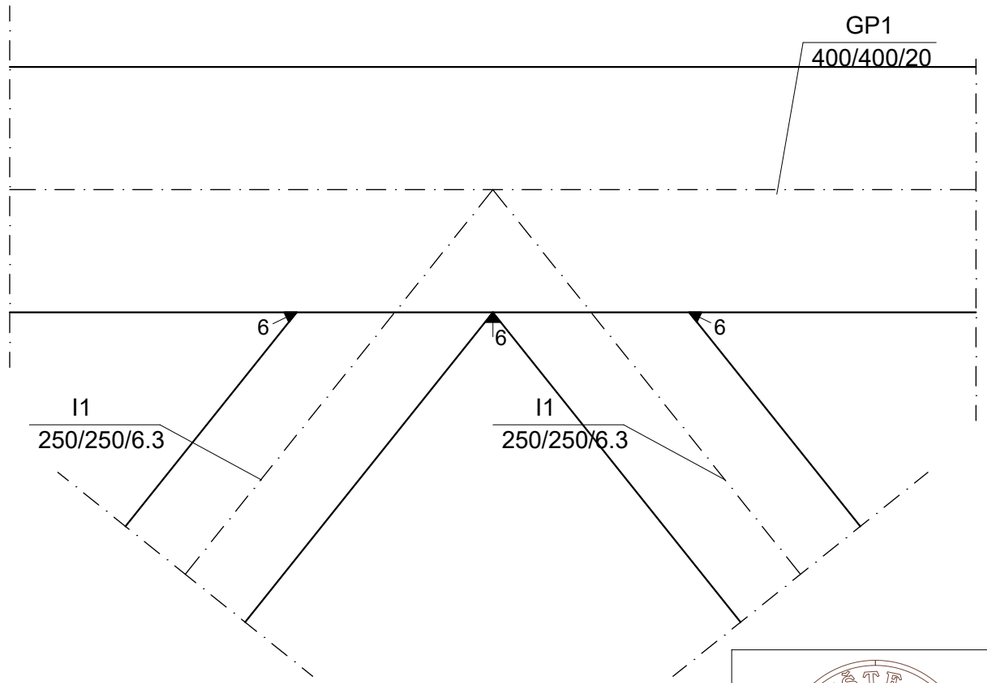
SVEUČILIŠTE U SPLITU
FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15


| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: | Monika Ćosić, 685 | MENTOR: | Prof. dr. sc. Ivica Boko |
| SADRŽAJ: | SPOJ GORNJEG POJASA SA STUPOM | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 10 |

# Detalj "G"
# Spoj ispune s donjim pojasom
# MJ 1:10




# Detalj "H"
# Spoj ispune s gornjim pojasom
# MJ 1:10





SVEUČILIŠTE U SPLITU

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE
KATEDRA ZA METALNE I DRVENE KONSTRUKCIJE
21000 SPLIT, MATICE HRVATSKE 15


| | | | |
|---|---|---|---|
| PROGRAM: | PROJEKT ČELIČNE KONSTRUKCIJE STADIONA VIŠNJIK | | |
| STUDENT: | Monika Ćosić, 685 | MENTOR: | Prof. dr. sc. Ivica Boko |
| SADRŽAJ: | SPOJ ISPUNE S GORNJIM I DONJIM POJASOM | MJERILO | 1:10 |
| DATUM | srpanj 2019. | PRILOG | 11 |