

Projekt konstrukcije građevine Brownfield Dugi Rat

Vrdoljak, Antonio Dražen

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UNIVERSITY OF SPLIT



SVEUČILIŠTE U SPLITU
FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE

Diplomski rad

Antonio Dražen Vrdoljak

Split, 2023.

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Sažetak:

Prema arhitektonskim osnovnim projektnim podacima projekta Brownfield Dugi Rat izrađen je numerički model konstrukcije. Nakon proračuna čelične konstrukcije u računalnom programu, izvršena je provjera na granična stanja te provjera stabilnosti. Spojevi su proračunati nakon definiranja konačnih profila. Svi proračuni su izvedeni prema HRN EN 1991, HRN EN 1992, HRN EN 1993, HRN EN 1994.

Ključne riječi:

Brownfield Dugi Rat, čelik, konstrukcija, proračun

Construction project of BROWNFIELD Dugi Rat building

Abstract:

According to architectural basic design data of the project Brownfield Dugi Rat a numerical model of the structure was created. After calculating the steel structure in the computer program, a limit state check and a stability check were performed. Steel connections are calculated after defining the final profiles. All calculations were performed according to HRN EN 1991, HRN EN 1992, HRN EN 1993, HRN EN 1994.

Keywords:

Brownfield Dugi Rat, steel, structure, calculation

SVEUČILIŠTE U SPLITU

FAKULTET GRAĐEVINARSTVA, ARHITEKTURE I GEODEZIJE

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ZADATAK ZA DIPLOMSKI RAD

Tema: Projekt konstrukcije građevine BROWNFIELD Dugi Rat

Opis zadatka: Na temelju arhitektonskih podloga potrebno je izraditi projekt konstrukcije građevine BROWNFIELD Dugi Rat. U sklopu projekta potrebno je postaviti nosivu konstrukciju te dokazati mehaničku otpornost i stabilnost iste.

U Splitu, 15. ožujka 2023.

Voditelji Diplomskog rada:

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1. TEHNIČKI OPIS

1.1 Osnovni opis konstrukcije

Prema arhitektonskoj podlozi „Brownfield Dugi Rat“ konstruktorski je izveden glavni dio projekta čija je lokacija na području bivše tvornice Dalmacija u Dugom ratu.

Osnovni dio konstrukcije sastoji se od čeličnih profila (vruće valjani), a za komunikaciju je izabrana betonska konstrukcija. Međukatnu konstrukcija se sastoji od spregnutih IPE profila sa armirano betonskom pločom.

Namjena konstrukcije je proizvodnja jedrilica.

Konstrukcija je pravilna po tlocrtu s 2 karakteristična izreza te nepravilna po visini koja varira od 17 metara do 6 metara što će biti prikazano u modelu konstrukcije. Duljina konstrukcije iznosi 102,4 metra a širina 43,2 metra.

Za glavni vertikalni nosivi sustav izabrani su stupovi HEA profila koji su raspoređeni pravilno po tlocrtu za glavninu konstrukcije te su razmaknuti 14,40 metara po širini te 6,40 metara po dužini konstrukcije.

Za glavni horizontalni nosivi sustav izabrana je rešetka koja se sastoji od pojasa te vertikala i dijagonala. Vertikale i dijagonale su zamišljene kao šuplji CFCHS profili koji spojeni sa krovnim nosačima čine „SHED“ krov.

Za krovnu konstrukciju imamo 2 karakteristična krova i to:

- Ravni krov
- „SHED“ krov

„SHED“ krov je jednostrešni krov koji se ponavlja po duljini konstrukcije 12 puta te nije isti na svakom dijelu konstrukcije zbog izreza po tlocrtu. Ravni krov se uglavnom nalazi na dijelu konstrukcije betonske jezgre te na dijelu bliže moru tj. gdje izlaze proizvedene jedrilice.

Za svaki karakteristični krov izvedena je analiza opterećenja o čemu će se diskutirati u tom poglavlju.

Odvod vode na „SHED“ krovu će se riješiti postavljanjem žljebova na spoju kosine i vertikale krova.

Za prijenos sile na krovovima izabrana je sekundarna nosiva konstrukcija krovnih nosača HEA profila, a za bočne nosače izabrani su kvadratični šuplji profili CFRHS. Temelji stupova su izvedeni kao upeti temelji samci, a dodani su i spregovi RD profila za preuzimanje vlačnih sila.

Kad spojimo sekundarnu i glavnu nosivu konstrukciju sa vijčanim spojevima i spojevima zavarom, ona čini jednu stabilnu cjelinu na što ćemo obratiti pažnju u poglavlju pomaci konstrukcije.

1.2 Proračun konstrukcije i primijenjeni propisi

Za proračun mjerodavnih sila i deformacija konstrukcije korišten je računalni program SCIA Engineer 2019,a za potrebne radioničke nacрте korišten je AutoCAD 2018 i paket Parabuild kao dodatak za odabir čeličnih profila.

Kod rada u računalnom programu SCIA Engineer 2019 korišteni su takozvani „load paneli“ koji sa Accurate (FEM) metodom prenose nanešeno opterećenje na karakteristične nosače.

Accurate (FEM) metoda ili metoda konačnih elemenata diskretizira promatrani prostor u određenom broju konačnih elemenata koji su mjerodavni za rješenje, što znači da metoda konačnih elemenata ne daje u potpunosti točne rezultate, ali su isti dovoljno precizni i zadovoljavajući za praktičnu upotrebu.

Za proračun spojeva korišten je računalni program IDEA StatiCa 2023 gdje se po mjerodavnim silama proračunava broj potrebnih vijaka , debljina zavara i pločice.

Proračuni su izvedeni po Eurocodu i to: Eurocode 1, Eurocode 2, Eurocode 3 i Eurocode 4.

Za proračun konstrukcije bitno je reći da se izveo proračun na stalna, promjenjiva i dinamička opterećenja, te da je najzahtijevanije opterećenje upravo vjetar koji djeluje na konstrukciju iz više smjerova pa se njemu pridala najveća pažnja tokom analize opterećenja.

Kod spregnute ploče sa IPE profilima proračunavali su se čelični elementi odvojeno od betonske konstrukcije što je na strani sigurnosti.

Nakon dobivenih rezultata u računalnom programu , prvobitno su se kontrolirali progibi na GSU (Granično stanje uporabljivosti) pa onda mjerodavne sile na GSN (Granično stanje nosivosti) preko mjerodavnih kombinacija.

1.3 Materijal za izradu konstrukcije

Materijal za izradu čeličnih elemenata je čelik S275, a za betonske elemente odabran je beton klase C25/30.

Vijci za spojeve su M16 8.8, M20 8.8 i M27 8.8, a pločice od čelika S276.

1.4 Izvođenje konstrukcije

Kod izvođenja spregnutih ploča, trapezni lim ostaje kao izgubljena oplata te ne mora biti poduprt i kod njega se promatra djelovanje svježeg betona u fazi izgradnje te očvrstlog betona na kraju izvođenja.

Kod izvođenja čeličnog dijela konstrukcije koristimo montažni način izvođenja konstrukcije sa dizalicom i to redoslijedom:

1. Postavljanje glavne vertikalne konstrukcije
2. Postavljanje glavne horizontalne konstrukcije
3. Postavljanje sekundarne konstrukcije

1.5 Protupožarna i antikorozivna zaštita

Za protupožarnu zaštitu konstrukcije odlučeno je da se konstrukcija mora zaštititi sa posebnim premazima otpornim na visoke temperature do 120 minuta i to u 3 sloja:

- temeljni premaz
- ekspandirajući premaz
- završni premaz.

Premazi osim za požar djeluju i kao antikorozivna zaštita i odabrani su zbog:

- dostupni su dekorativni završni premazi
- bez vlakana, nema prašine
- jednostavno čišćenje i održavanje.

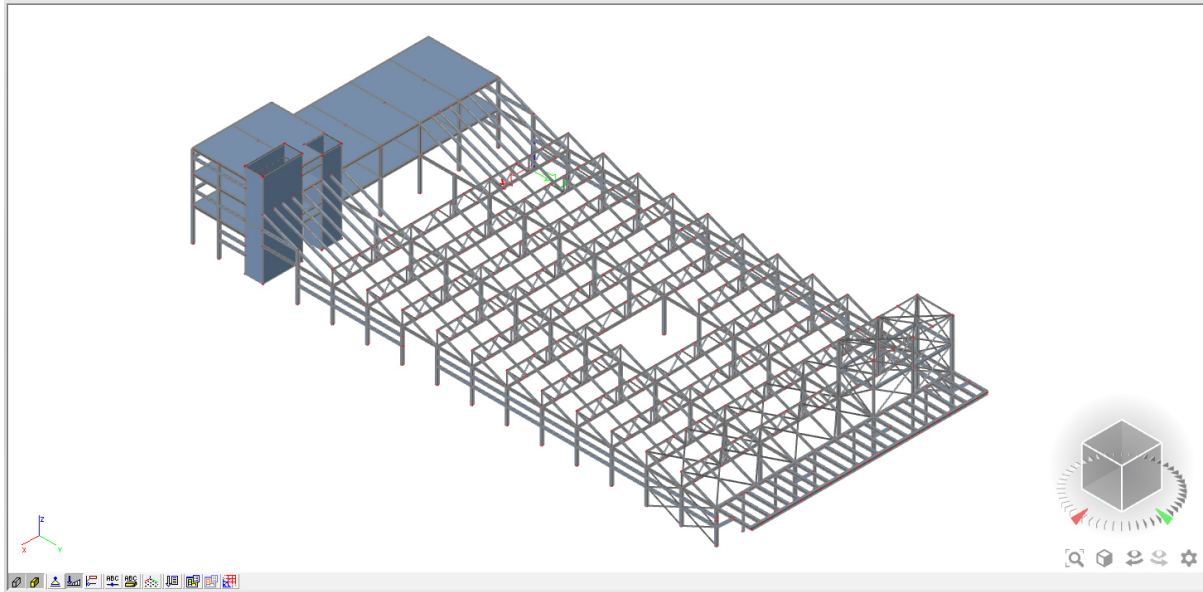
Temeljni premaz služi kao antikorozivna zaštita te se izvodi vrućim pocinčavanjem profila. Sva antikorozivna zaštita je izvedena prema pravilniku o tehničkim mjerama i uvjetima za zaštitu čeličnih konstrukcije od korozije.

1.6 Transport

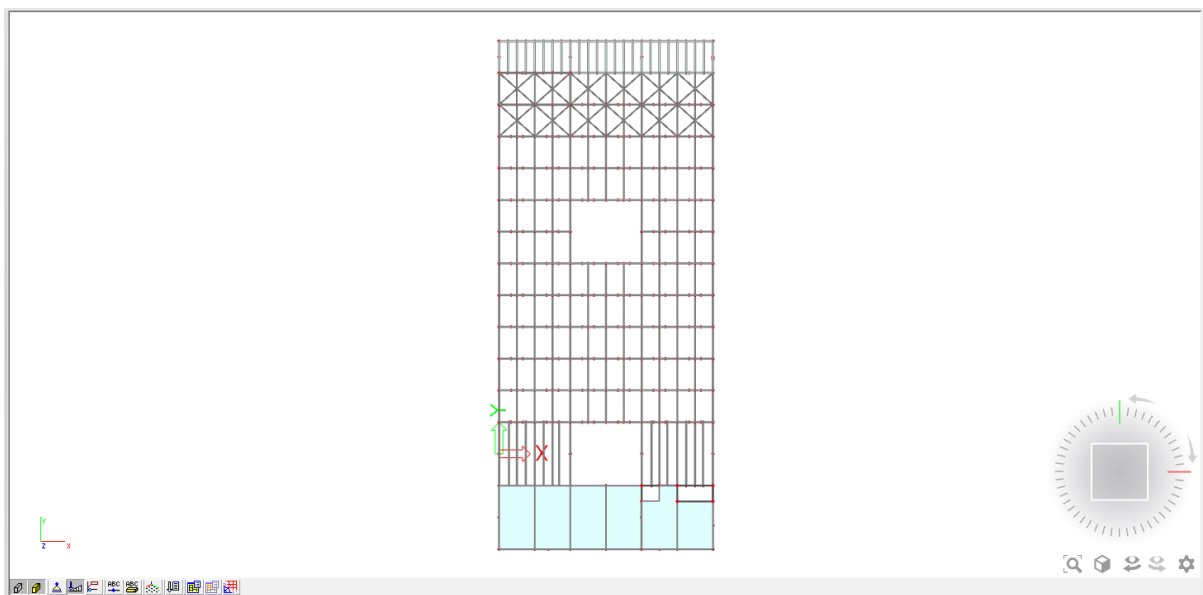
Svi čelični elementi izrezat će se u radionici do duljine 12 metara te transportirati direktno na gradilište.

2. NUMERIČKI MODEL KONSTRUKCIJE

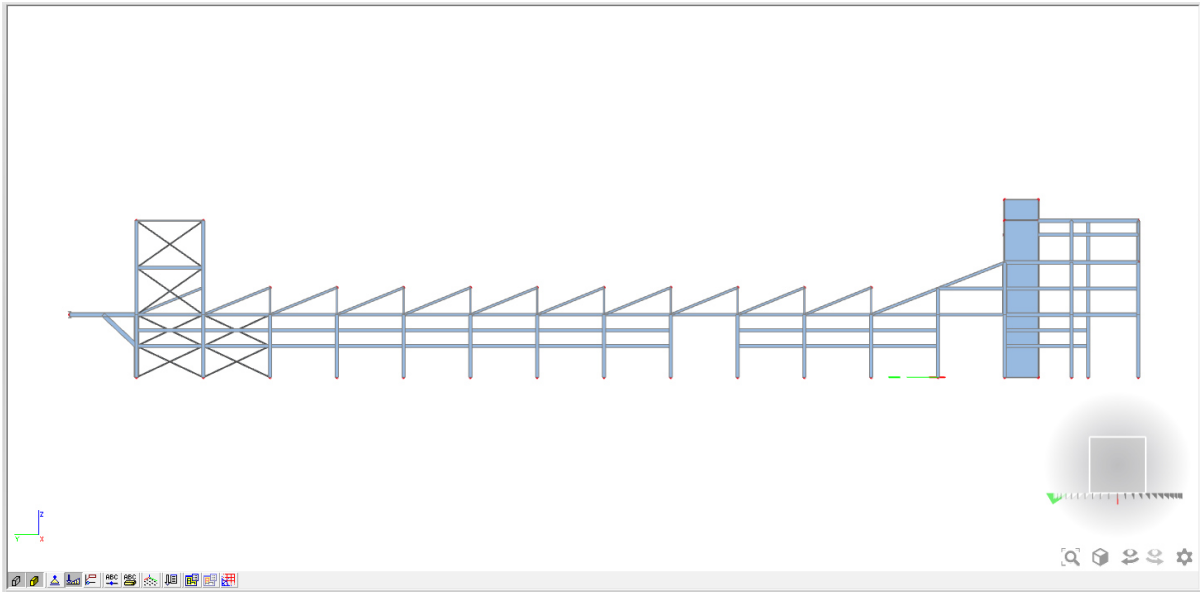
3D model konstrukcije je izrađen u računalnom programu Scia Engineer 2019.



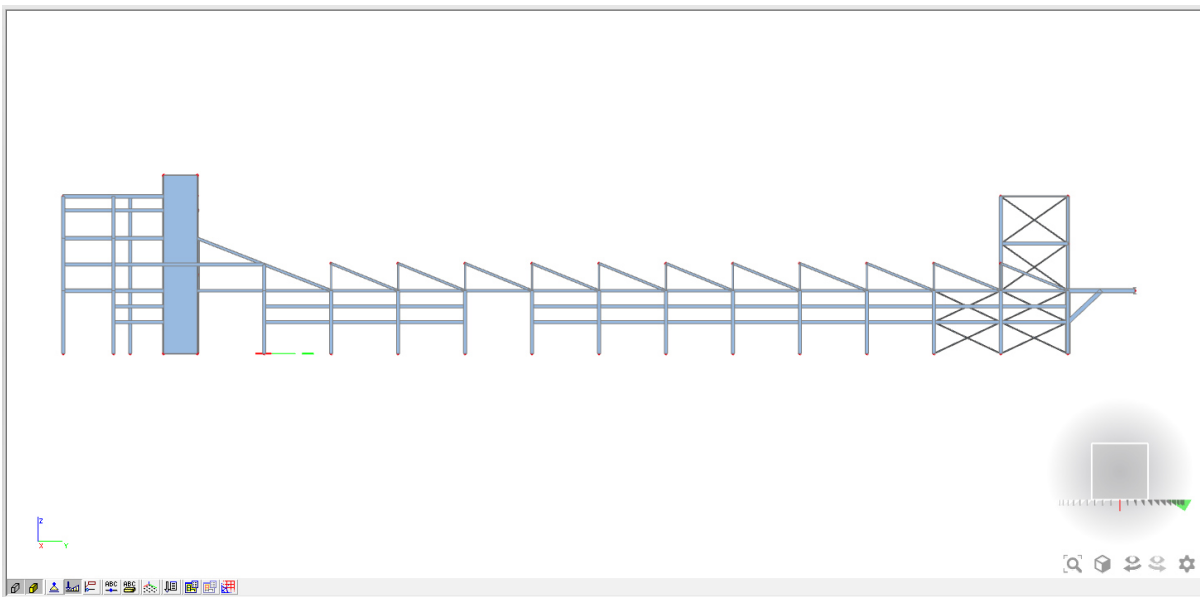
Slika 1. Izometrijski prikaz 3D modela



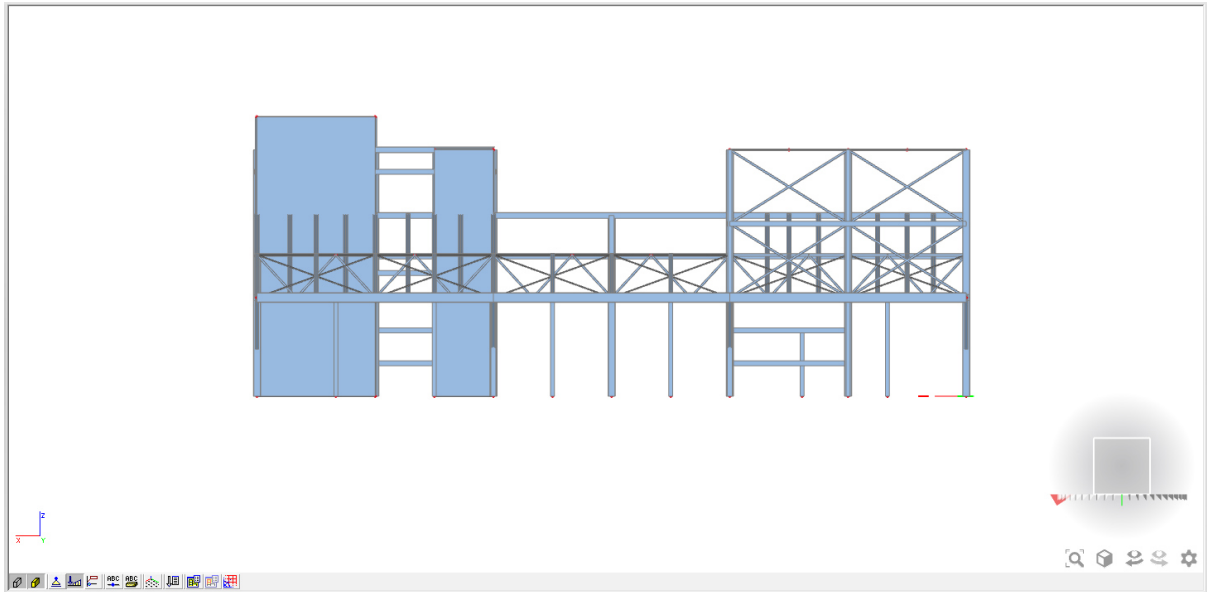
Slika 2. Tlocrtni prikaz modela



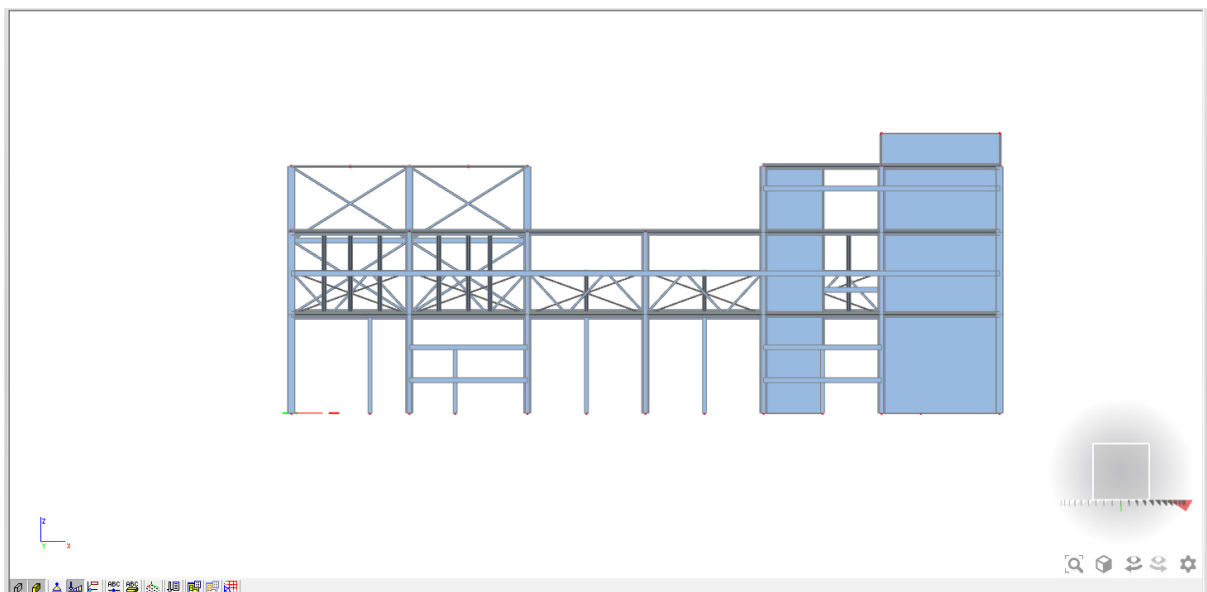
Slika 3. Prikaz zapadnog pročelja



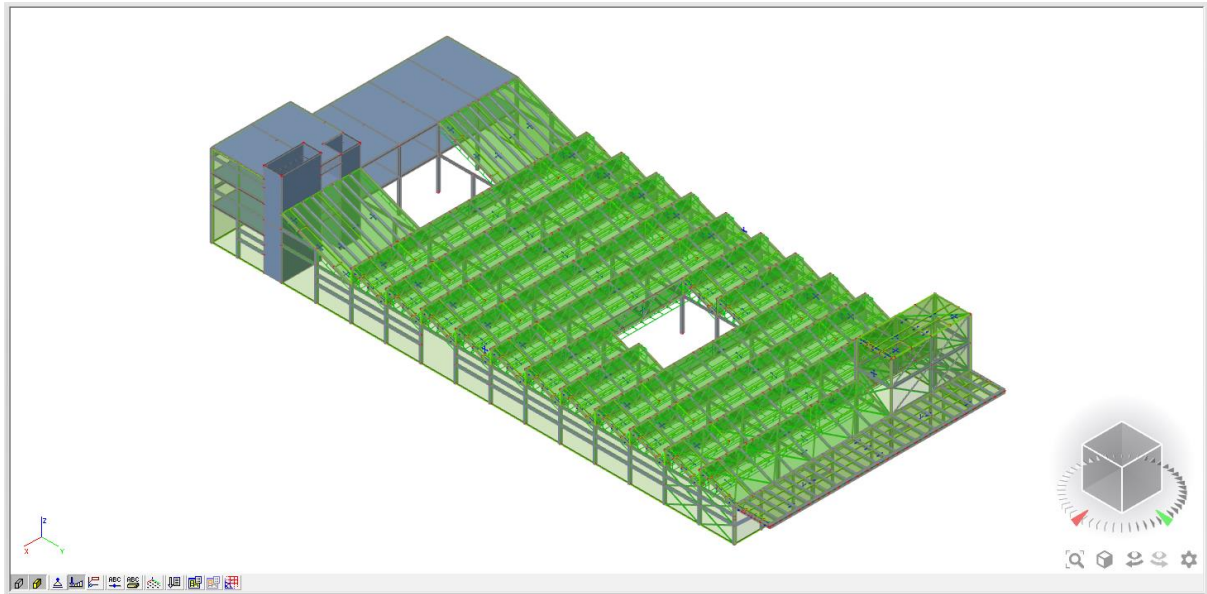
Slika 4. Prikaz istočnog pročelja



Slika 5. Prikaz sjevernog pročelja



Slika 6. Prikaz južnog pročelja



Slika 7. Prikaz 3D modela s load panelima

3. ANALIZA OPTEREĆENJA

3.1 Stalno opterećenje

Vlastita težina uračunata u programu SCIA.

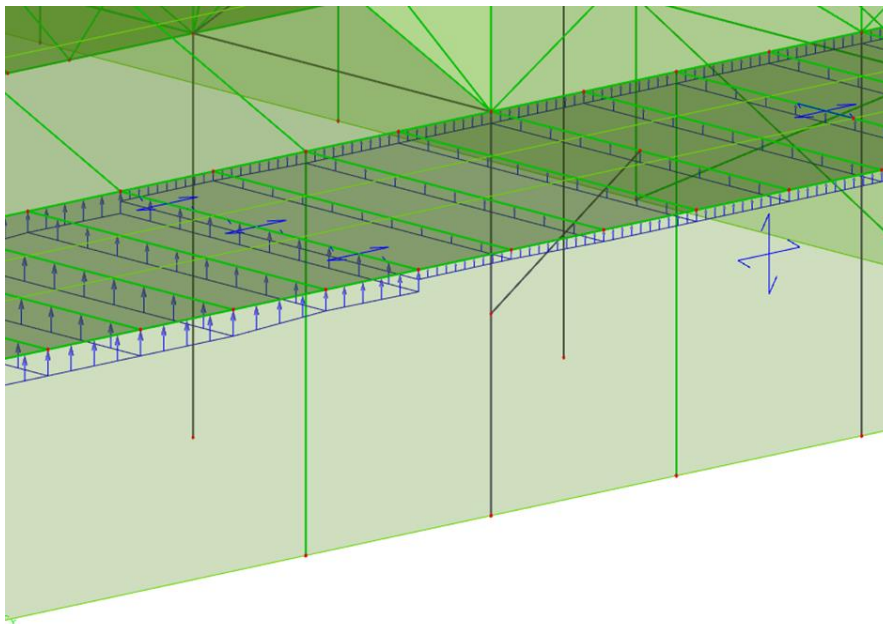
3.1.1 Dodatno stalno opterećenje

Opterećenje krovne konstrukcije:

- Paneli $g=0,20$ [kN/m²]
- Instalacije $g=0,10$ [kN/m²]

Opterećenje međukatne konstrukcije:

- Namještaj $g=0,10$ [kN/m²]
- Slojevi poda $g=0,10$ [kN/m²]



Slika 8. Prikaz jednog generiranog opterećenja s load panelima

3.2 Promjenjivo opterećenje – korisno opterećenje

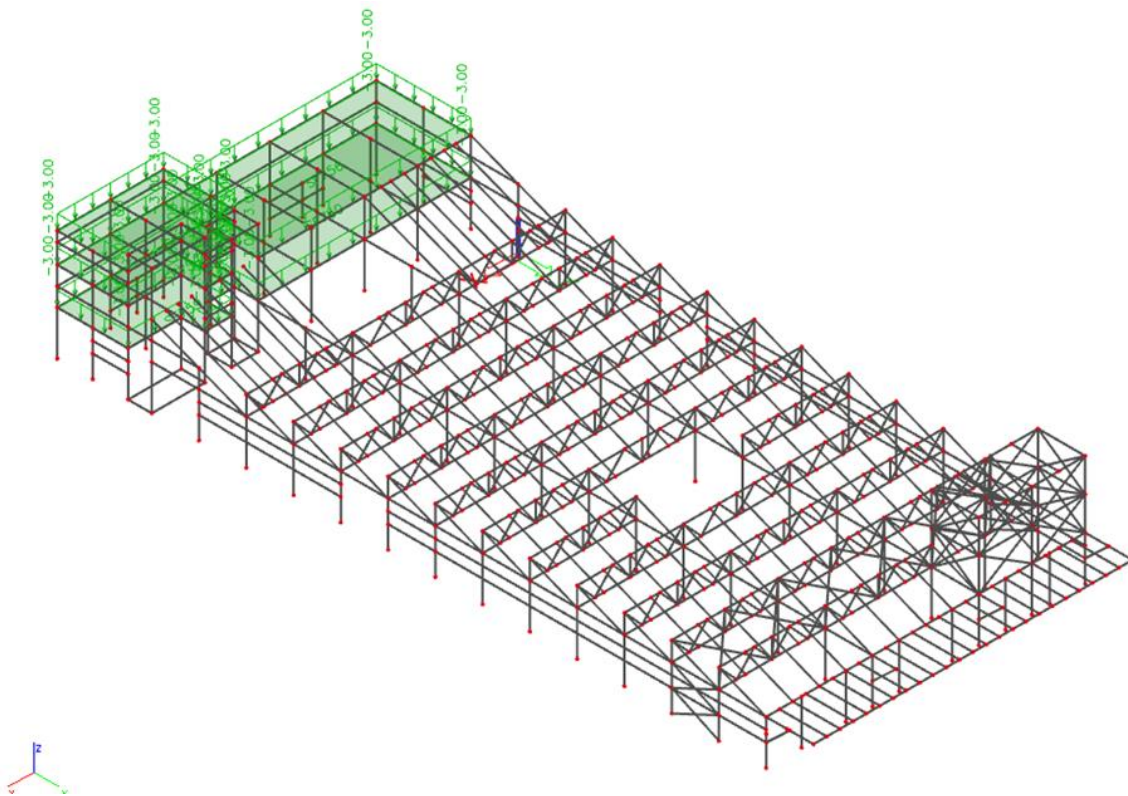
Tablica 1. Kategorije uporabnih opterećenja s obzirom na namjenu zgrade

Kategorija	Namjena	Primjer
A	Prostori za stanovanje i kućanske djelatnosti	Sobe u stambenim zgradama i kućama, sobe i odjeli u bolnicama; sobe u hotelima i prenoćištima, kuhinje i kupaonice
B	Uredski prostori	
C	Prostori gdje se mogu okupljati ljudi (osim prostora određenih u kategorijama A, B i D ¹⁾)	C1: Prostori sa stolovima i sl., primjerice u školama, kavanama, restoranima, blagovaonicama, čitaonicama, recepcijama
		C2: Prostori s nepomičnim sjedalima, primjerice u crkvama, kazalištima ili kinima, sobe za sastanke, dvorane za predavanje, dvorane za skupove, željezničke čekaonice i sl.
		C3: Prostori bez zapreka za kretanje ljudi, primjerice u muzejima, izložbenim prostorima i slično, te pristupi u javim i upravnim zgradama, hotelima, bolnicama i željezničkim stanicama
		C4: Prostori gdje su moguće fizičke aktivnosti, primjerice plesne dvorane, gimnastičke dvorane, pozornice
		C5: Prostori za velika okupljanja ljudi, primjerice u zgradama za javne priredbe kao što su koncertne dvorane, sportske dvorane uključujući gledališta, terase, prilaze i željezničke perone
D	Prodajni prostor	D1: Prostori u trgovinama
		D2: Prostori u robnim kućama
¹⁾ Obratiti pažnju na točku 6.3.1.1.(2), posebno za kategoriju C4 i C5. Kad se dinamički učinci trebaju uzeti u obzir, vidjeti normu EN 1990. Za kategoriju E, vidjeti tablicu 6.3.		
NAPOMENA 1: Ovisno o predviđenom načinu upotrebe, prostori koji bi mogli pripadati kategorijama C2, C3 i C4 smiju se odlukom investitora i/ili nacionalnim dodatkom svrstati u kategoriju C5.		
NAPOMENA 2: U nacionalnom dodatku smiju se odrediti potkategorije za A, B, C1 do C5, D1 i D2.		
NAPOMENA 3: Za proizvodne djelatnosti ili skladištenje, vidjeti točku 6.3.2		

Tablica 2. Vrijednosti uporabnih opterećenja s obzirom na kategoriju zgrade

Kategorija opterećenog prostora	q_k [kN/m ²]	Q_k [kN]
Kategorija A		
- stropovi	1,5 – 2,0	2,0 – 3,0
- stubišta	2,0 – 4,0	2,0 – 4,0
- balkoni	2,5 – 4,0	2,0 – 3,0
Kategorija B	2,0 – 3,0	1,5 – 4,5
Kategorija C		
- C1	2,0 – 3,0	3,0 – 4,0
- C2	3,0 – 4,0	2,5 – 7,0 (4,0)
- C3	3,0 – 5,0	4,0 – 7,0
- C4	4,5 – 5,0	3,5 – 7,0
- C5	5,0 – 7,5	3,5 – 4,5
Kategorija D		
- D1	4,0 – 5,0	3,5 – 7,0 (4,0)
- D2	4,0 – 5,0	3,5 – 7,0

Moguće okupljanje ljudi – kategorija C1 – $q=3$ [kN/m²]



Slika 10. Prikaz korisnog opterećenja na međukatnu konstrukciju

3.3 Promjenjivo opterećenje – opterećenje snijegom

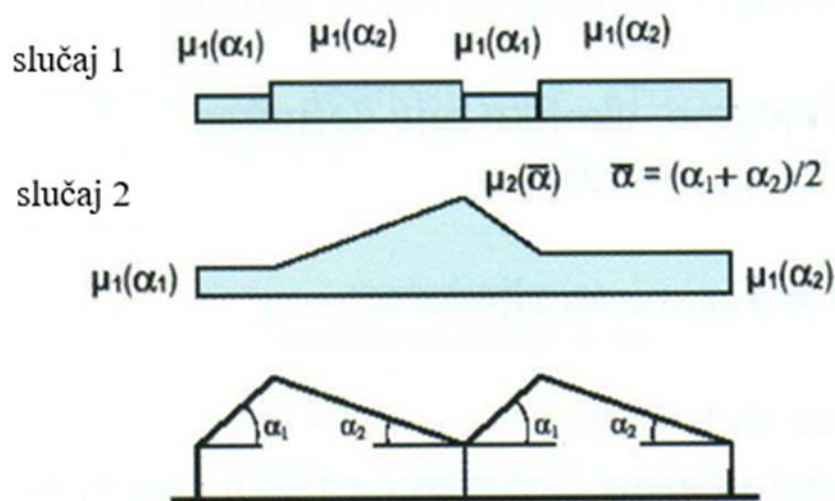
Jednostrešni „SHED“ krov

Opterećenje snijegom na krovnu površinu definiramo izrazom:

$$s = \mu_i * C_e * C_t * s_k \text{ [kN/m}^2\text{]} \quad (1)$$

gdje je:

- μ_i → koeficijent oblika za opterećenje snijegom
- C_e → 1,0
- C_t → 1,0
- s_k → karakteristična vrijednost za opterećenje na tlu [kN/m²]



Slika 11. Razmještaj opterećenja za višestrešne krovove

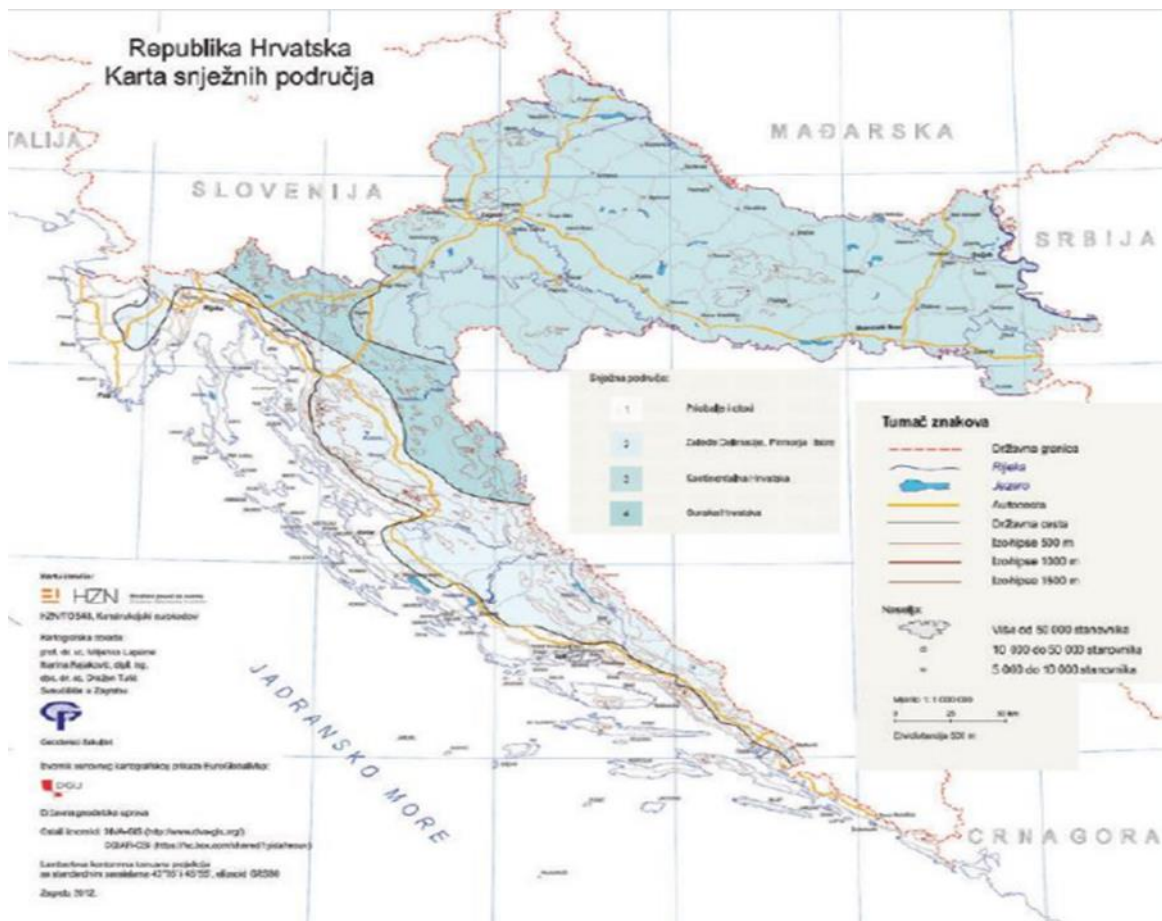
Tablica 3. Koeficijenti oblika za višestrešne krovove

Kut nagiba krova α	$0^\circ \leq \alpha \leq 30^\circ$	$30^\circ < \alpha \leq 60^\circ$	$\alpha \geq 60^\circ$
μ_1	0,8	$0,8 (60 - \alpha)/30$	0,0
μ_2	$0,8 + 0,8 \alpha/30$	1,6	–

$$\mu_1 = 0 \quad (2)$$

$$\mu_{1,2} = 0,8 + 0,8 * 28,6/30 = 1,56 \quad (3)$$

$$\mu_{2,1} = 1,6 \quad (4)$$



Slika 12. Karta opterećenja snijegom

Tablica 4. Karakteristične vrijednosti opterećenja S_k

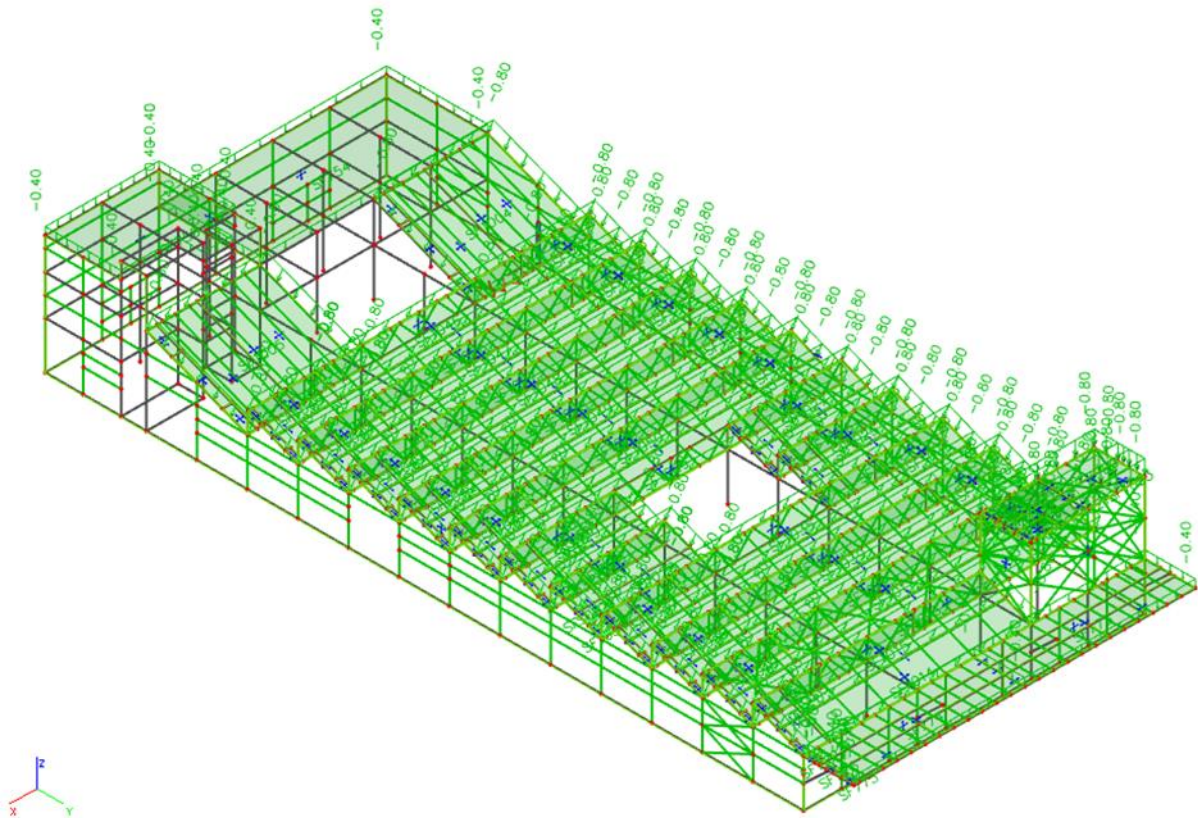
Nadmorska visina do [m]	1. područje priobalje i otoci [kN/m ²]	2. područje zaleđe Dalmacije, Primorja i Istre [kN/m ²]	3. područje Kontinentalna Hrvatska [kN/m ²]	4. područje Gorska Hrvatska [kN/m ²]
100	0,50	0,75	1,00	1,25
200	0,50	0,75	1,25	1,50
300	0,50	0,75	1,50	1,75
400	0,50	1,00	1,75	2,00
500	0,50	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
1000	2,00	4,00	3,50	5,00
1100	3,00	5,00	4,00	5,50
1200	4,00	6,00	4,50	6,00
1300	5,00	7,00		7,00
1400	6,00	8,00		8,00
1500		9,00		9,00
1600		10,00		10,00
1700		11,00		11,00
1800		12,00		

Zbog male razlike uzeto je jedno opterećenje snijegom i to sa koeficijentom 0,8!

Ravni krov

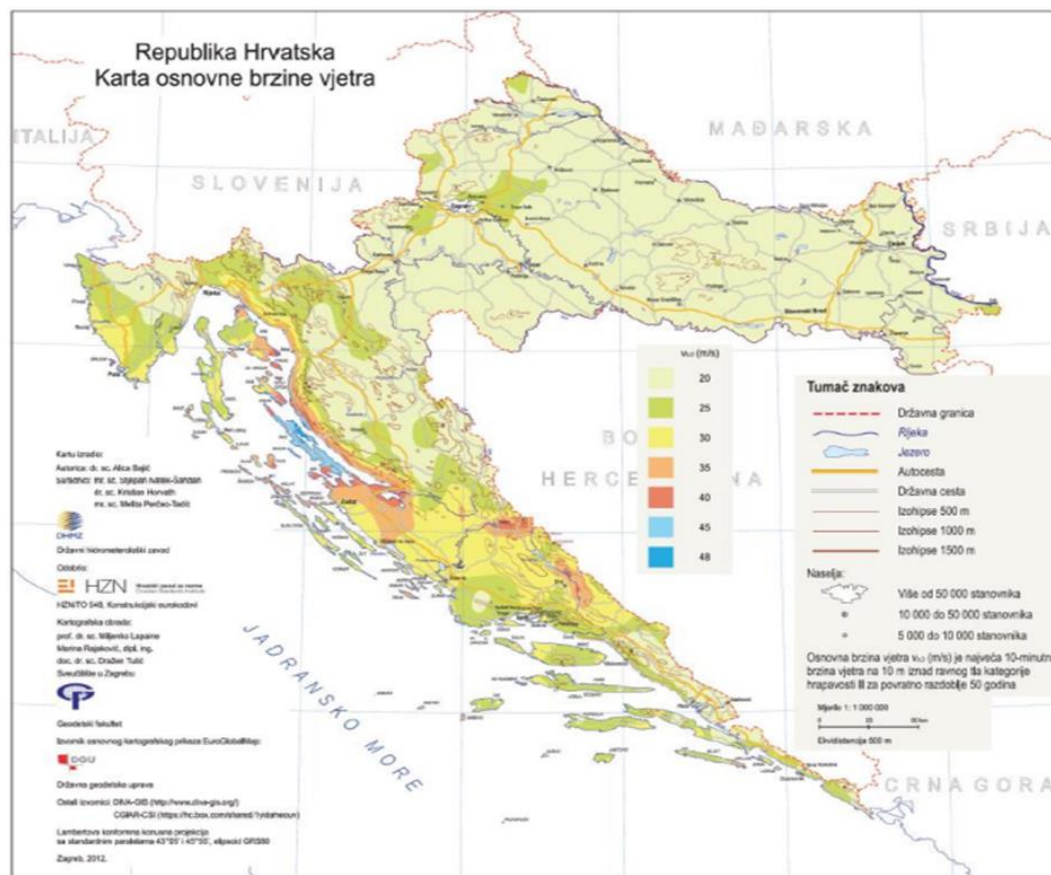
$$s_{1,2} = 0,8 * 1 * 1 * 0,5 = 0,4 \quad (5)$$

$$s_{2,1} = 0,8 * 1 * 1 * 0,5 = 0,4 \quad (6)$$



Slika 13. Prikaz snijega na konstrukciju

3.4 Promjenjivo opterećenje – opterećenje vjetrom



Slika 14. Zemljovid područja opterećenja vjetrom

Objekt se nalazi u III. vjetrovnoj zoni na 17 m n.m.

Osnovna brzina vjetra:

$$v_{b,0} = 35 \text{ [m/s]} \text{ (za III. zonu)} \quad (7)$$

Referentna brzina vjetra:

$$v_b = c_{DIR} * c_{TEM} * c_{ALT} * v_{b,0} \quad (8)$$

$$\begin{aligned} c_{DIR} &\rightarrow \text{koeficijent smjera vjetra} &&\rightarrow 1,0 \\ c_{TEM} &\rightarrow \text{koeficijent ovisan o godišnjem dobu} &&\rightarrow 1,0 \\ c_{ALT} &\rightarrow \text{koeficijent nadmorske visine} &&\rightarrow 1+0,000017*\alpha_s \\ &&&1+0,000017*100=1,01 \end{aligned}$$

$$v_b = 1,00 * 1,00 * 1,01 * 35 = 35,35 \text{ [m/s]} \quad (9)$$

$$z_e = 17 \text{ [m]} \quad (10)$$

Mjerodavna visina je veća od minimalne (17,00 m), pa je koeficijent hrapavosti:

$$c_{r(z)} = k_r * \ln\left(\frac{z_e}{z_0}\right) \quad (11)$$

Koeficijent terena k_r određuje se iz odgovarajuće tablice ovisno o kategoriji zemljišta.

Odabiremo III. kategoriju zemljišta.

Tablica 5. Kategorije terena i pripadni parametri

Kategorija terena	Opis	k_r	z_0 [m]	Z_{min} [m]
0	More ili područje uz more otvoreno prema moru	0,156	0,003	1
I	Uzburkano otvoreno more ili jezero, s najmanje 5 km dužine navjetrine i gladak ravan teren bez prepreka	0,170	0,01	1
II	Poljoprivredno zemljište s ogradama, povremenim malim poljoprivrednim objektima, kućama ili drvećem	1,190	0,05	2
III	Predgrađa ili industrijske zone i stalne šume	0,215	0,30	5
IV	Urbane zone u kojima je najmanje 15% površine pokriveno zgradama čija je srednja visina veća od 15 m	0,234	1,00	10

$$k_r = 0,215 \rightarrow c_{r(z)} = 0,215 * \ln\left(\frac{17}{0,30}\right) = 0,87 \quad (12)$$

Srednja brzina vjetra tako iznosi:

$$v_m = 0,87 * 1,0 * 35,35 = 30,68 \text{ [m/s]} \quad (13)$$

Turbulencija:

$$I_v(z) = \frac{1}{c_0(z) * \ln(z_e/z_0)} = \frac{1}{1,0 * \ln(17/0,30)} = 0,248 \quad (14)$$

Maksimalni tlak brzine vjetra $q_p(z_e)$:

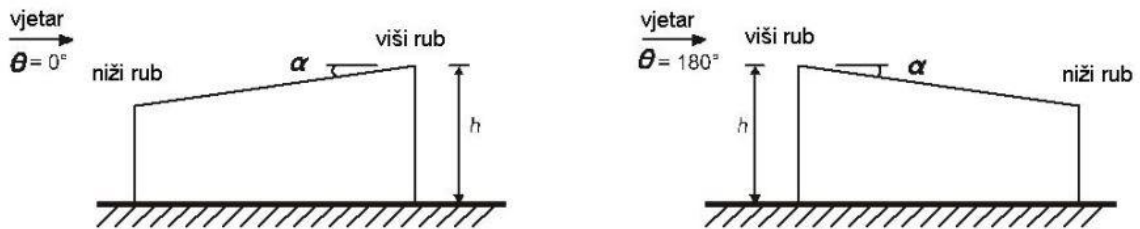
$$\rho_{zr} = 1,25 \text{ [kg/m}^3\text{]} \quad (15)$$

$$q_p(z) = [1 + 7 * I_v(z)] * \frac{\rho_{zr}}{2} * v_m^2(z) = c_e(z) * v_b(z) \quad (16)$$

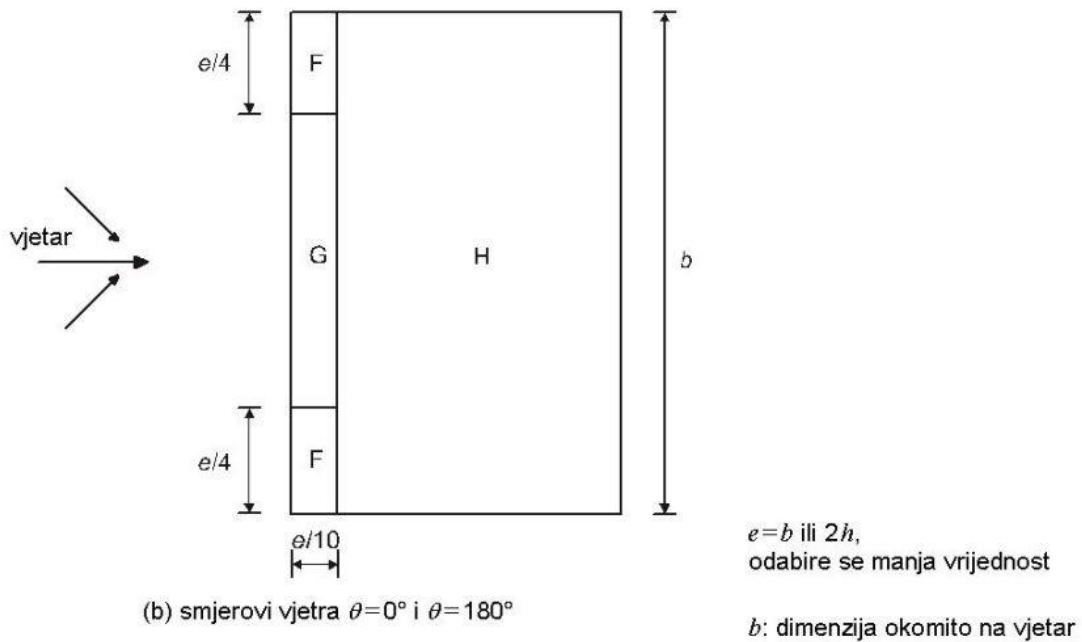
$$q_p(z) = [1 + 7 * 0,248] * \frac{1,25}{2} * 30,68^2 = 1609,56 \text{ [N/m}^2\text{]} = 1,61 \text{ [kN/m}^2\text{]} \quad (17)$$

3.4.1 Djelovanje vjetra na jednostrešni „SHED“ krov

Proračun koeficijenta pritiska c_{pe} , c_{pi} :

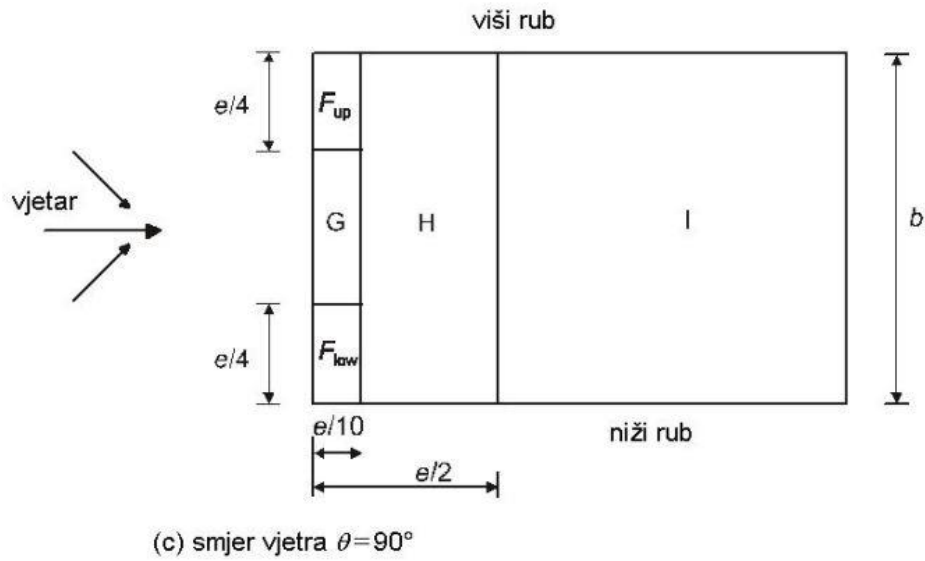


(a) općenito



Slika 15. Djelovanje vjetra na jednostrešne krovove (smjerovi 0° i 180°)

$$e = 2 * h = 2 * 17 = 34 \text{ [m]} \quad (18)$$

Slika 16. Djelovanje vjetra na jednostrešne krovove (smjer 90°)

$$e = b = 6,4 \text{ [m]} \quad (19)$$

Krov je nagiba $28,6^\circ$ te će se za proračun uzimati mjerodavna vrijednost od 30° .

Tablica 6. Preporučene vrijednosti vanjskih koeficijenata (smjerovi 0 i 180°)

Nagib α	Područje za smjer vjetra $\theta=0^\circ$						Područje za smjer vjetra $\theta=180^\circ$					
	F		G		H		F		G		H	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	-1,7	-2,5	-1,2	-2,0	-0,6	-1,2	-2,3	-2,5	-1,3	-2,0	-0,8	-1,2
	+0,0		+0,0		+0,0							
15°	-0,9	-2,0	-0,8	-1,5	-0,3		-2,5	-2,8	-1,3	-2,0	-0,9	-1,2
	+0,2		+0,2		+0,2							
30°	-0,5	-1,5	-0,5	-1,5	-0,2		-1,1	-2,3	-0,8	-1,5	-0,8	
	+0,7		+0,7		+0,4							
45°	-0,0		-0,0		-0,0		-0,6	-1,3	-0,5		-0,7	
	+0,7		+0,7		+0,6							
60°	+0,7		+0,7		+0,7		-0,5	-1,0	-0,5		-0,5	
75°	+0,8		+0,8		+0,8		-0,5	-1,0	-0,5		-0,5	

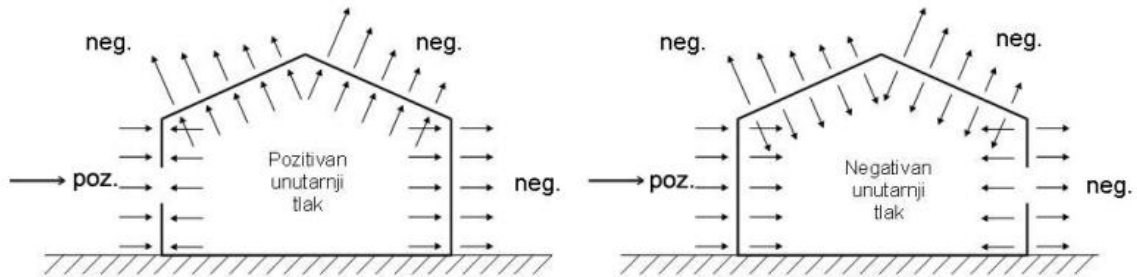
Tablica 7. Preporučene vrijednosti vanjskih koeficijenata (smjer 90°)

Nagib α	Područje za smjer vjetra $\theta=90^\circ$									
	F_{up}		F_{low}		G		H		I	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5°	-2,1	-2,6	-2,1	-2,4	-1,8	-2,0	-0,6	-1,2	-0,5	
15°	-2,4	-2,9	-1,6	-2,4	-1,9	-2,5	-0,8	-1,2	-0,7	-1,2
30°	-2,1	-2,9	-1,3	-2,0	-1,5	-2,0	-1,0	-1,3	-0,8	-1,2
45°	-1,5	-2,4	-1,3	-2,0	-1,4	-2,0	-1,0	-1,3	-0,9	-1,2
60°	-1,2	-2,0	-1,2	-2,0	-1,2	-2,0	-1,0	-1,3	-0,7	-1,2
75°	-1,2	-2,0	-1,2	-2,0	-1,2	-2,0	-1,0	-1,3	-0,5	

NAPOMENA 1: Pri $\theta=0^\circ$ (vidjeti tablicu (a)) tlak se naglo mijenja između pozitivnih i negativnih vrijednosti oko nagiba $\alpha=+5^\circ$ do $+45^\circ$, stoga su navedene i pozitivne i negativne vrijednosti. Za takve krovove treba uzeti u obzir dva slučaja: jedan sa svim pozitivnim vrijednostima i jedan sa svim negativnim vrijednostima. Ne dopušta se miješanje pozitivnih i negativnih vrijednosti na jednom pročelju.

NAPOMENA 2: Za međuvrijednosti nagiba smije se upotrebljavati linearna interpolacija između vrijednosti istog predznaka. Vrijednosti 0,0 dane su za potrebe interpolacije.

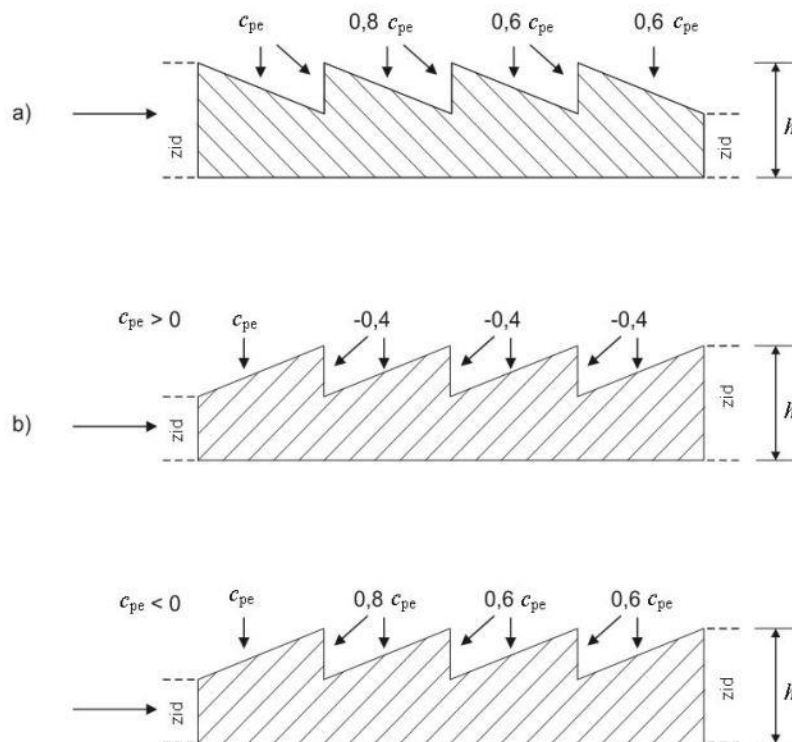
Za unutarnje koeficijente će se uzeti preporučene vrijednosti kako je vidljivo na slici u nastavku.



Slika 17. Unutarnji tlakovi vjetra

Za unutarnje tlakove c_{pi} se uzima $+0,2$ za pozitivni unutarnji tlak i $-0,3$ za negativni unutarnji tlak.

Za vanjske koeficijente tlakova potrebno je reducirati vrijednosti kod „SHED“ krovova po sljedećoj slici:



Slika 18. Redukcija vanjskih koeficijenata pritiska vjetra

3.4.2 Djelovanje vjetra na jednostrešni „SHED“ krov – vjetar u smjeru 180°

$$w = c_{pe,i} * q_p(z) \quad (20)$$

Sile vjetra na krov (vanjski pritisak vjetra – negativni):

Tablica 8. Negativni vanjski tlak vjetra (smjer 180°)

Područje	Odižući vjetar – vanjski tlak		
	$q_p(z)$	c_{pe}	w_{e1}
60 % F	1,61	– 0,66	– 1,06
60 % G	1,61	– 0,48	– 0,77
80 % F	1,61	– 0,88	– 1,42
80 % G	1,61	– 0,64	– 1,03
60 % H	1,61	– 0,48	– 0,77
80 % H	1,61	– 0,64	– 1,03
F	1,61	– 1,1	– 1,77
G	1,61	– 0,8	– 1,29
H	1,61	– 0,8	– 1,29
	kN/m ²		kN/m ²

Sile vjetra na krov (vanjski pritisak vjetra – pozitivni):

Nema pozitivnih vanjskih koeficijenata za smjer od 180°.

Unutarnji koeficijenti pritiska vjetra su + 0,2 i – 0,3, tako da za odižući vjetar pritisak je:

$$w_{i1} = c_{pi} * q_p(z) = 0,2 * 1,61 = 0,32 \text{ [kN/m}^2\text{]} \quad (21)$$

a za pritiskajući vjetar pritisak je:

$$w_{i1} = c_{pi} * q_p(z) = 0,3 * 1,61 = 0,48 \text{ [kN/m}^2\text{]} \quad (22)$$

Isto vrijedi za sve ostale smjerove vjetra što se tiče unutarnjih tlakova.

Rezultirajući vjetar za smjer od 180° – smjer odizanje:

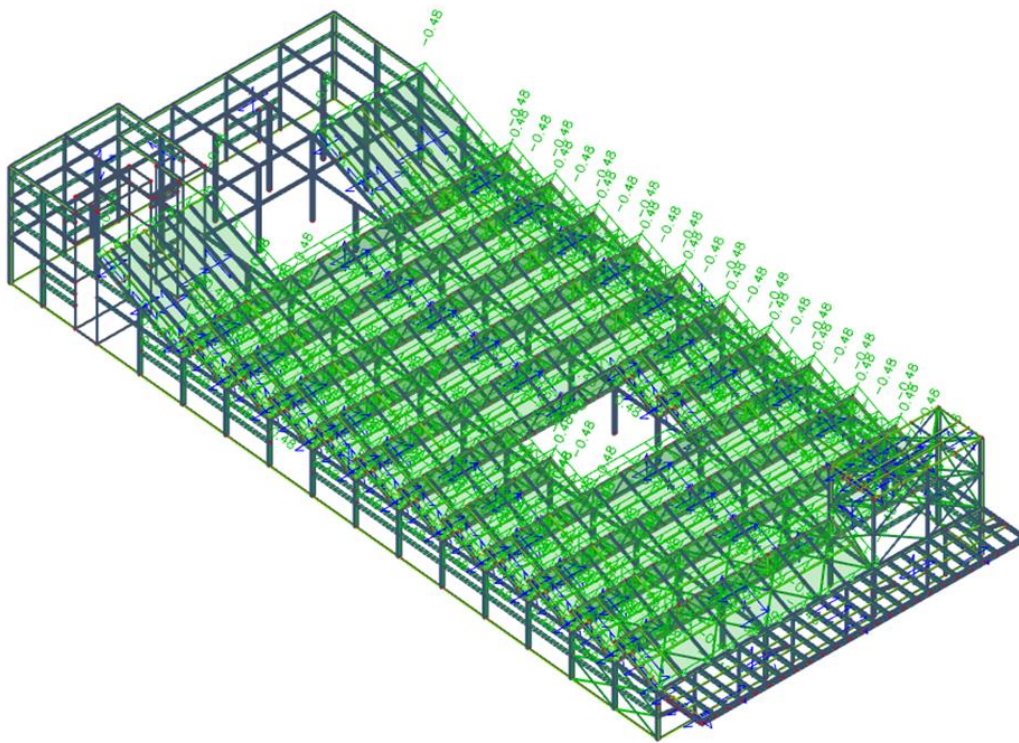
Tablica 9. Tlak vjetra (smjer 180°) – odizanje

Područje	$q_p(z)$	w $w=w_{el}+w_{il}$
60 % F	1,61	- 1,38
60 % G	1,61	- 1,10
80 % F	1,61	- 1,74
80 % G	1,61	- 1,35
60 % H	1,61	- 1,10
80 % H	1,61	- 1,35
F	1,61	- 2,09
G	1,61	- 1,61
H	1,61	- 1,61
	kN/m ²	kN/m ²

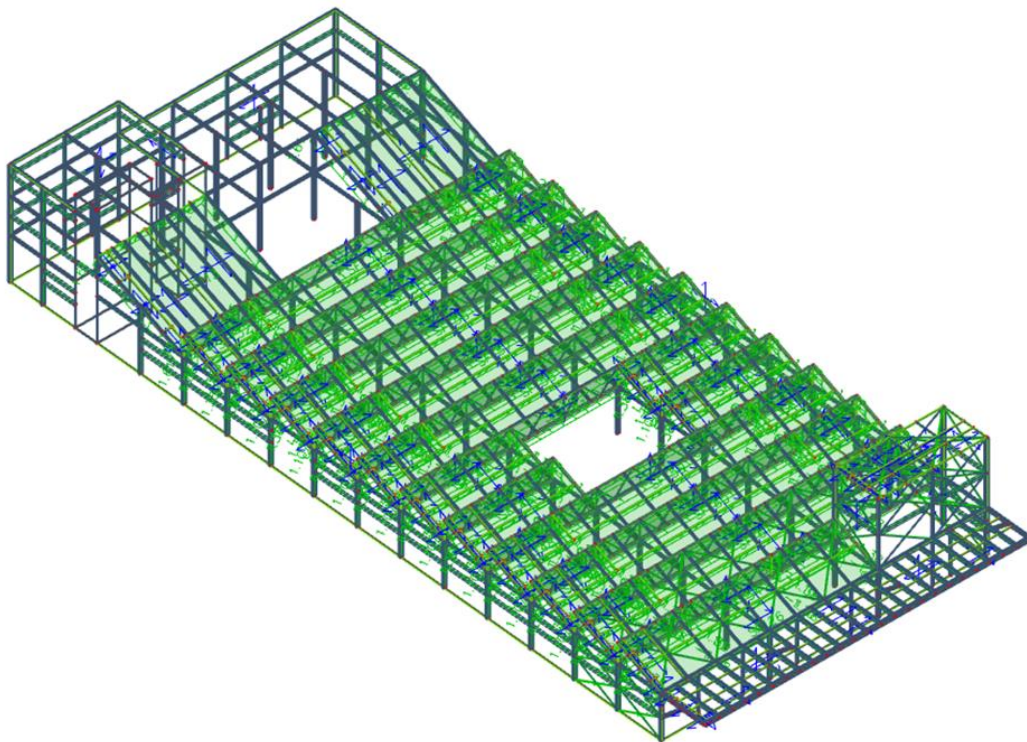
Rezultirajući vjetar za smjer od 180° – smjer pritisak:

Tablica 10. Tlak vjetra (smjer 180°) – pritisak

Područje	$q_p(z)$	w $w=w_{el}+w_{il}$
60 % F	1,61	0,48
60 % G	1,61	0,48
80 % F	1,61	0,48
80 % G	1,61	0,48
60 % H	1,61	0,48
80 % H	1,61	0,48
F	1,61	0,48
G	1,61	0,48
H	1,61	0,48
	kN/m ²	kN/m ²



Slika 19. Djelovanje vjetra na kosi krov (smjer 180°) – pritisak



Slika 20. Djelovanje vjetra na kosi krov (smjer 180°) – odizanje

3.4.3 Djelovanje vjetra na jednostrešni „SHED“ krov – vjetar u smjeru 0°

Sile vjetra na krov (vanjski pritisak vjetra – negativni):

Tablica 11. Negativni vanjski tlak vjetra (smjer 0°)

Područje	Odižući vjetar – vanjski tlak		
	$q_p(z)$	c_{pe}	w_{e2}
60 % F	1,61	-0,3	-0,48
60 % G	1,61	-0,3	-0,48
80 % F	1,61	-0,4	-0,64
80 % G	1,61	-0,4	-0,64
60 % H	1,61	-0,12	-0,20
80 % H	1,61	-0,16	-0,26
F	1,61	-0,5	-0,81
G	1,61	-0,5	-0,81
H	1,61	-0,2	-0,32
	kN/m ²		kN/m ²

Sile vjetra na krov (vanjski pritisak vjetra – pozitivni):

Tablica 12. Pozitivni vanjski tlak vjetra (smjer 0°)

Područje	Pritiskajući vjetar – vanjski tlak		
	$q_p(z)$	c_{pe}	w_{e2}
40 % F	1,61	–	0,4
40 % G	1,61	–	0,4
40 % H	1,61	–	0,4
F	1,61	0,7	1,13
G	1,61	0,7	1,13
H	1,61	0,4	0,64
	kN/m ²		kN/m ²

Rezultirajući vjetar za smjer od 0° – smjer odizanje:

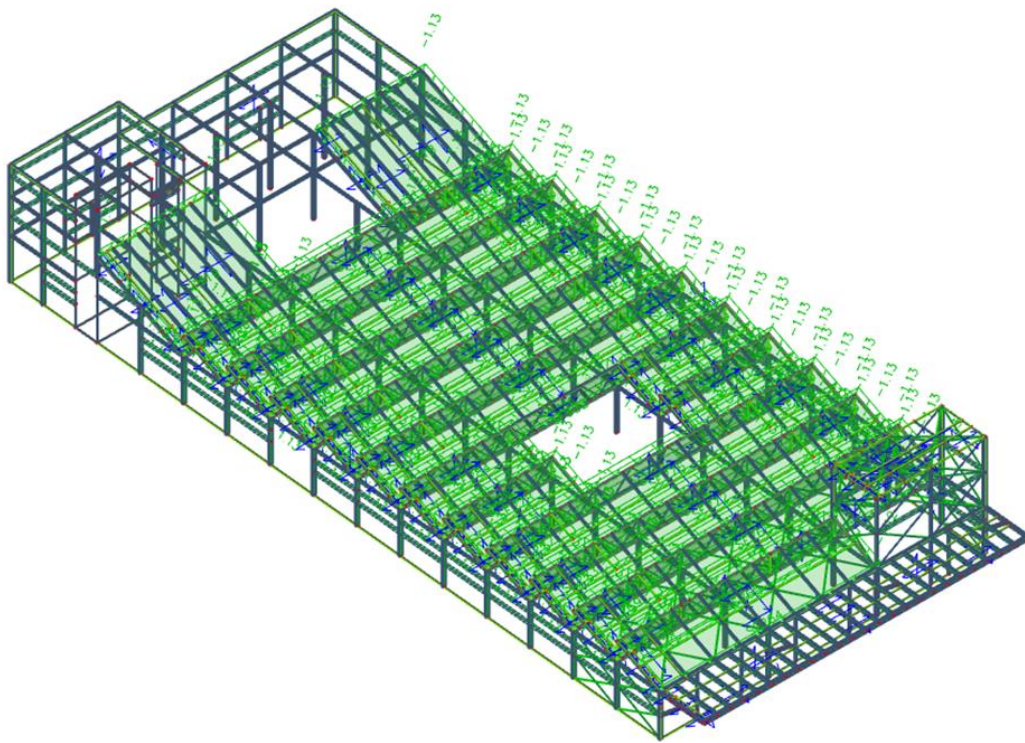
Tablica 13. Tlak vjetra (smjer 0°) – odizanje

Područje	$q_p(z)$	w $w=w_{e2}+w_{i2}$
60 % F	1,61	-0,80
60 % G	1,61	-0,80
80 % F	1,61	-0,96
80 % G	1,61	-0,96
60 % H	1,61	-0,52
80 % H	1,61	-0,58
F	1,61	-1,13
G	1,61	-1,13
H	1,61	-0,64
	kN/m ²	kN/m ²

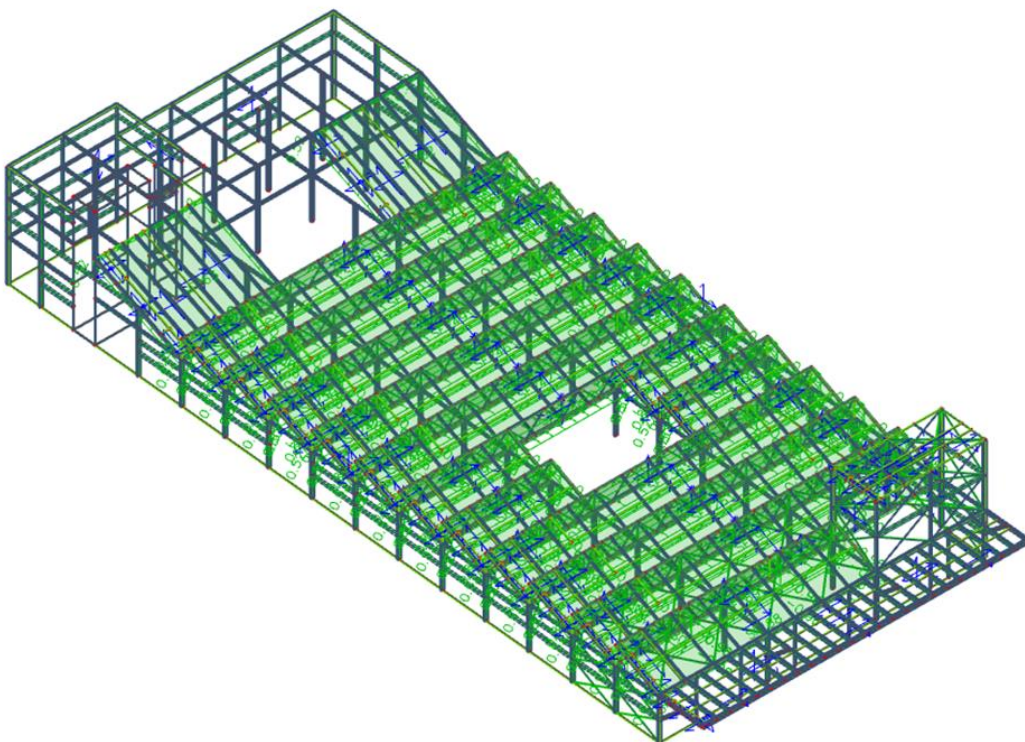
Rezultirajući vjetar za smjer od 0° – smjer pritisak:

Tablica 14. Tlak vjetra (smjer 0°) – pritisak

Područje	$q_p(z)$	w $w=w_{e2}+w_{i2}$
40 % F	1,61	1,13
40 % G	1,61	1,13
40 % H	1,61	1,13
F	1,61	1,61
G	1,61	1,61
H	1,61	1,12
	kN/m ²	kN/m ²



Slika 21. Djelovanje vjetra na kosi krov (smjer 0°) – pritisak



Slika 22. Djelovanje vjetra na kosi krov (smjer 0°) – odizanje

3.4.4 Djelovanje vjetra na jednostrešni „SHED“ krov – vjetar u smjeru 90°

Sile vjetra na krov (vanjski pritisak vjetra – negativni):

Tablica 15. Negativni vanjski tlak vjetra (smjer 90°)

Područje	Odižući vjetar – vanjski tlak		
	$q_p(z)$	c_{pe}	W_{e3}
60 % Fup	1,61	-1,74	-2,80
80 % Fup	1,61	-2,32	-3,74
60 % G	1,61	-1,20	-1,93
80 % G	1,61	-1,60	-2,58
60 % H	1,61	-0,60	-0,97
80 % H	1,61	-0,80	-1,29
Fup	1,61	-2,9	-4,67
Flow	1,61	-2,0	-3,22
G	1,61	-2,0	-3,22
H	1,61	-1,0	-1,61
I	1,61	-0,8	-1,29
	kN/m ²		kN/m ²

Sile vjetra na krov (vanjski pritisak vjetra – pozitivni):

Nema pozitivnih vanjskih koeficijenata za smjer od 90°.

Rezultirajući vjetar za smjer od 90° – smjer odizanje:

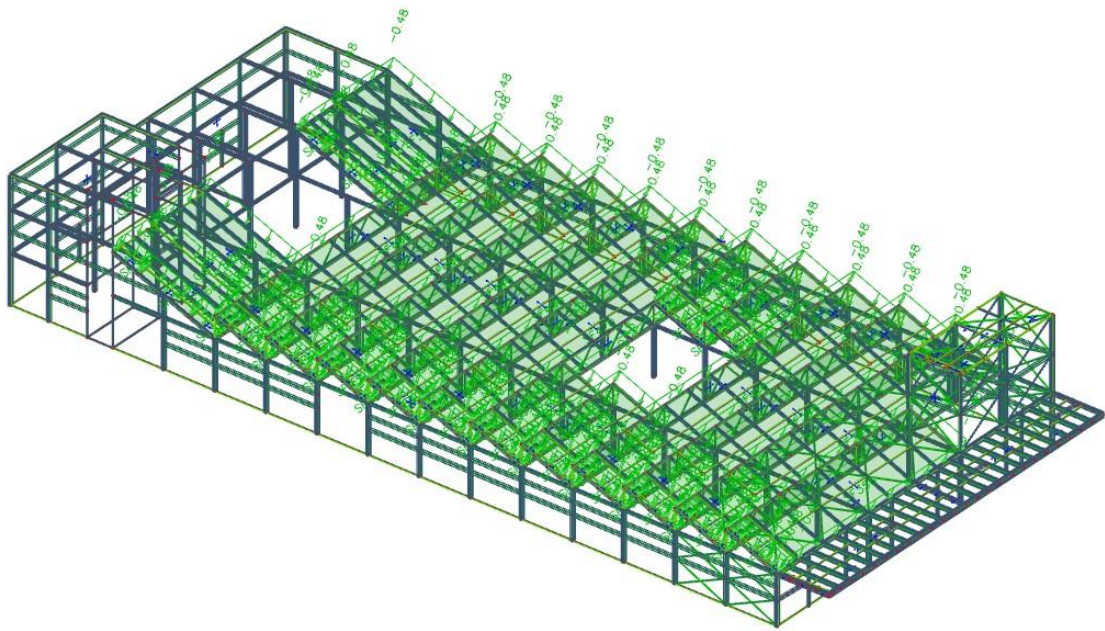
Tablica 16. Tlak vjetra (smjer 90°) – odizanje

Područje	$q_p(z)$	w $w=w_{e3}+w_{i3}$
60 % Fup	1,61	-3,12
80 % Fup	1,61	-4,06
60 % G	1,61	-2,25
80 % G	1,61	-2,90
60 % H	1,61	-1,29
80 % H	1,61	-1,61
Fup	1,61	-4,99
Flow	1,61	-3,54
G	1,61	-3,54
H	1,61	-1,93
I	1,61	-1,61
	kN/m ²	kN/m ²

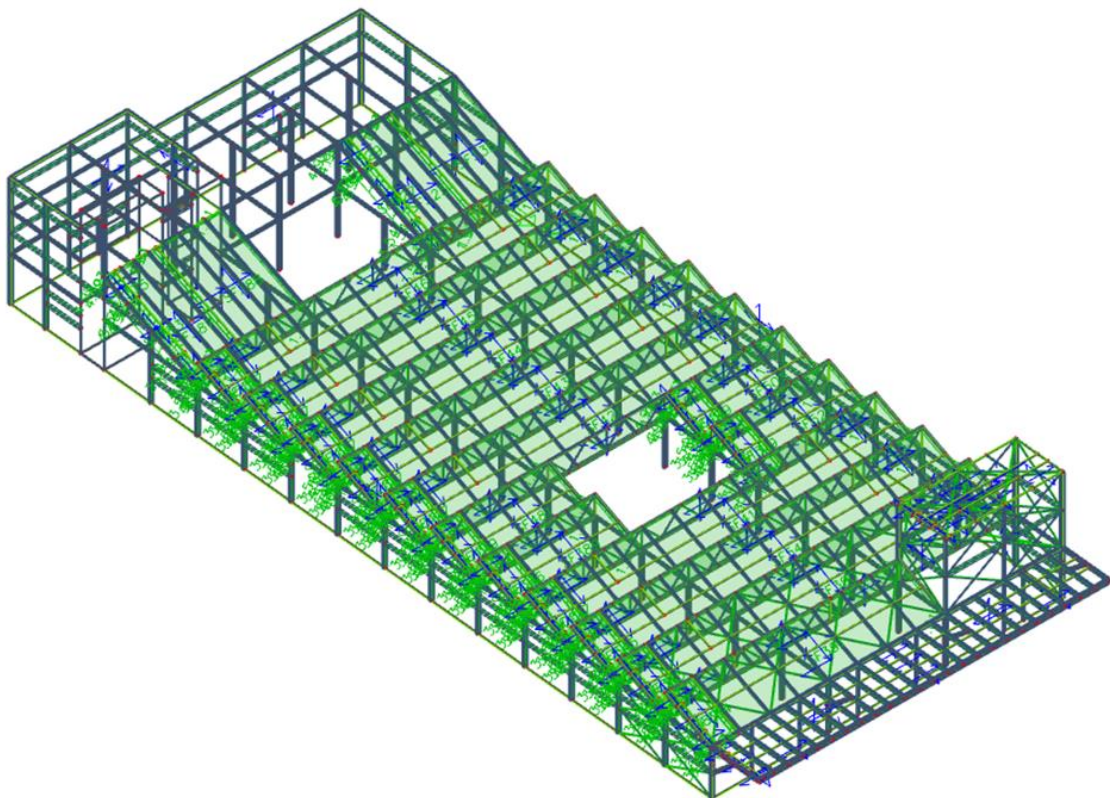
Rezultirajući vjetar za smjer od 90° – smjer pritisak:

Tablica 17. Tlak vjetra (smjer 90°) – pritisak

Područje	$q_p(z)$	w $w=w_{e3}+w_{i3}$
60 % Fup	1,61	0,48
80 % Fup	1,61	0,48
60 % G	1,61	0,48
80 % G	1,61	0,48
60 % H	1,61	0,48
80 % H	1,61	0,48
Fup	1,61	0,48
Flow	1,61	0,48
G	1,61	0,48
H	1,61	0,48
I	1,61	0,48
	kN/m ²	kN/m ²



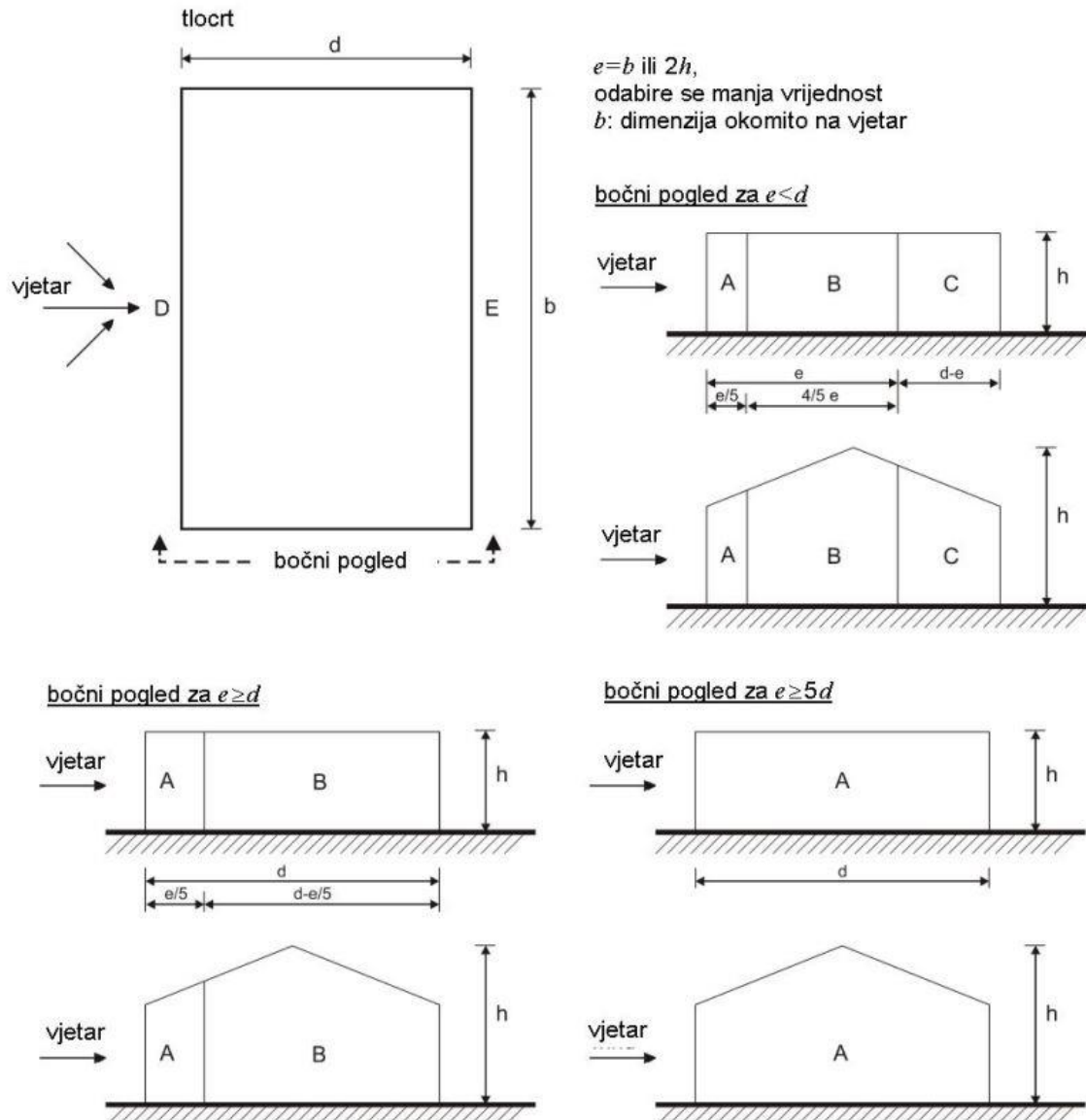
Slika 23. Djelovanje vjetra na kosi krov (smjer 90°) – pritisak



Slika 24. Djelovanje vjetra na kosi krov (smjer 90°) – odizanje

3.4.5 Djelovanje vjetra na zidove

Proračun koeficijenta pritiska c_{pe} , c_{pi} :



Slika 25. Djelovanje vjetra na zidove konstrukcije

$$e = 2 * h = 2 * 17 = 34 \text{ [m]} \quad (23)$$

$$d = 14,4 * 3 = 43,2 \text{ [m]} \quad (24)$$

$$h/d = 17/43,2 = 0,4 \text{ [m]} \quad (25)$$

$$e < d = 34 < 43,2 \text{ [m]} \quad (26)$$

Tablica 18. Koeficijenti vanjskih pritisaka za zidove konstrukcije

Područje	A		B		C		D		E	
	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
5	-1,2	-1,4	-0,8	-1,1	-0,5		+0,8	+1,0	-0,7	
1	-1,2	-1,4	-0,8	-1,1	-0,5		+0,8	+1,0	-0,5	
$\leq 0,25$	-1,2	-1,4	-0,8	-1,1	-0,5		+0,7	+1,0	-0,3	

Za omjer h/d koristit će se linearna interpolacija između vrijednosti 0,25 i 1,0 i to za zone E koja iznosi -0,34 i zonu D koja iznosi +0,72.

Unutarnji koeficijenti pritiska vjetra su +0,2 i -0,3, tako da za odižući vjetar pritisak je:

$$w_{i1} = c_{pi} * q_p(z) = 0,2 * 1,61 = 0,32 \text{ [kN/m}^2\text{]} \quad (27)$$

a za pritiskajući vjetar pritisak je :

$$w_{i1} = c_{pi} * q_p(z) = 0,3 * 1,61 = 0,48 \text{ [kN/m}^2\text{]} \quad (28)$$

Isto vrijedi za sve ostale smjerove vjetra što se tiče unutarnjih tlakova.

Tablica 19. Iznos $c_{pe,10}$ po zonama

Zona	c_{pe}
A	-1,2
B	-0,8
C	-0,5
D	+0,72
E	-0,34

Rezultirajući vjetar – smjer odizanje:

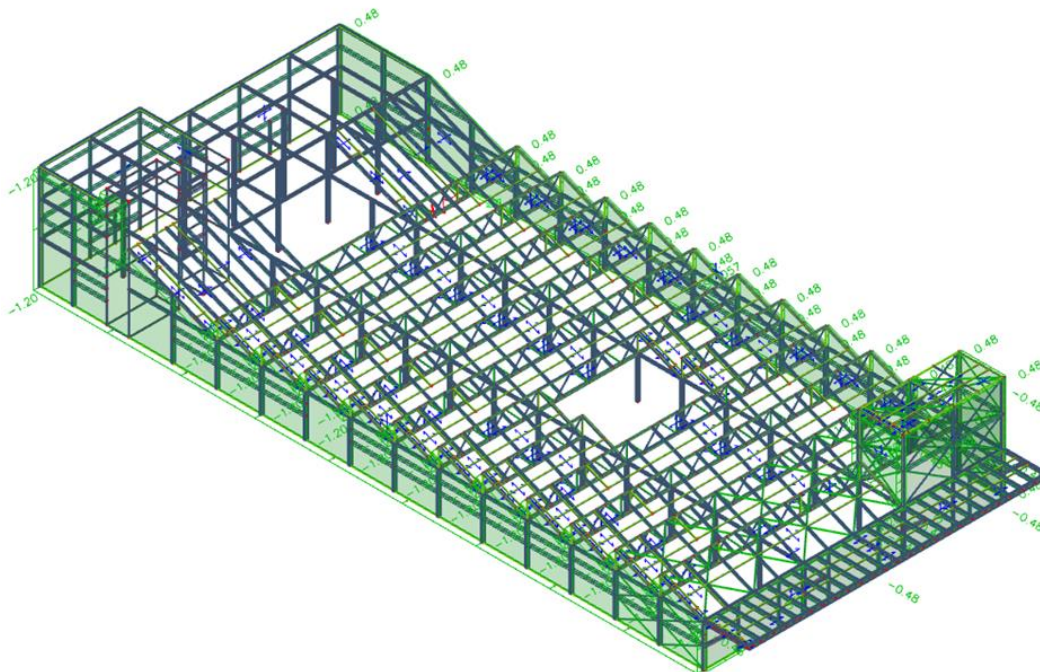
Tablica 20. Tlak vjetra – odizanje

Područje	$q_p(z)$	w $w = w_{el} + w_{i1}$
D	1,61	-0,32
A	1,61	-2,25
B	1,61	-1,61
C	1,61	-1,13
E	1,61	-0,86
	kN/m ²	kN/m ²

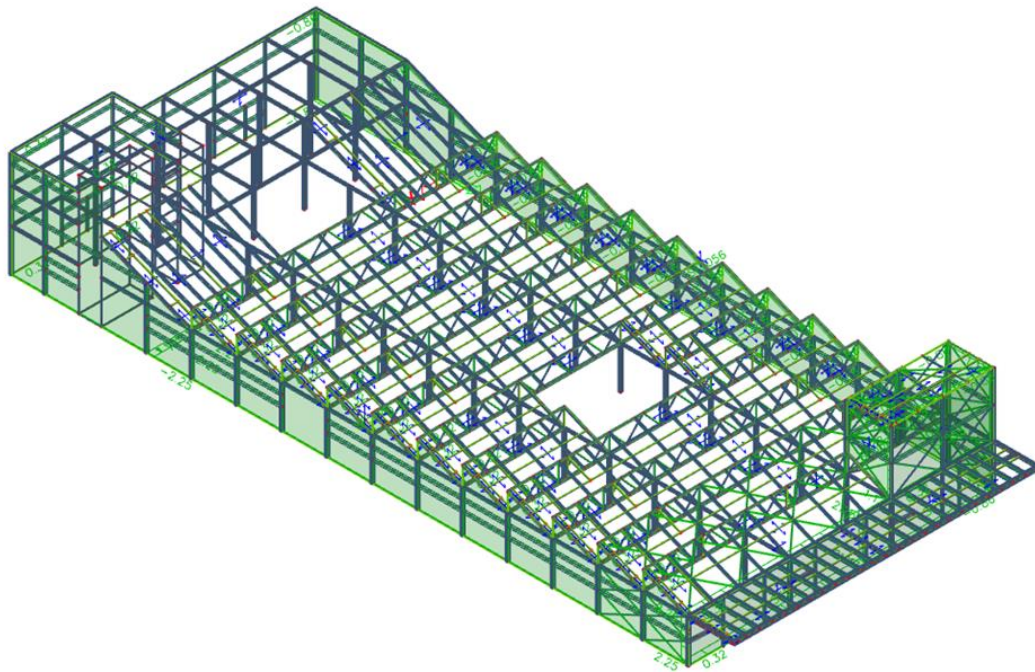
Rezultirajući vjetar – smjer pritisak:

Tablica 21. Tlak vjetra – pritisak

Područje	$q_p(z)$	w $w = w_{el} + w_{il}$
D	1,61	1,2
A	1,61	0,48
B	1,61	0,48
C	1,61	0,48
E	1,61	0,48
	kN/m ²	kN/m ²



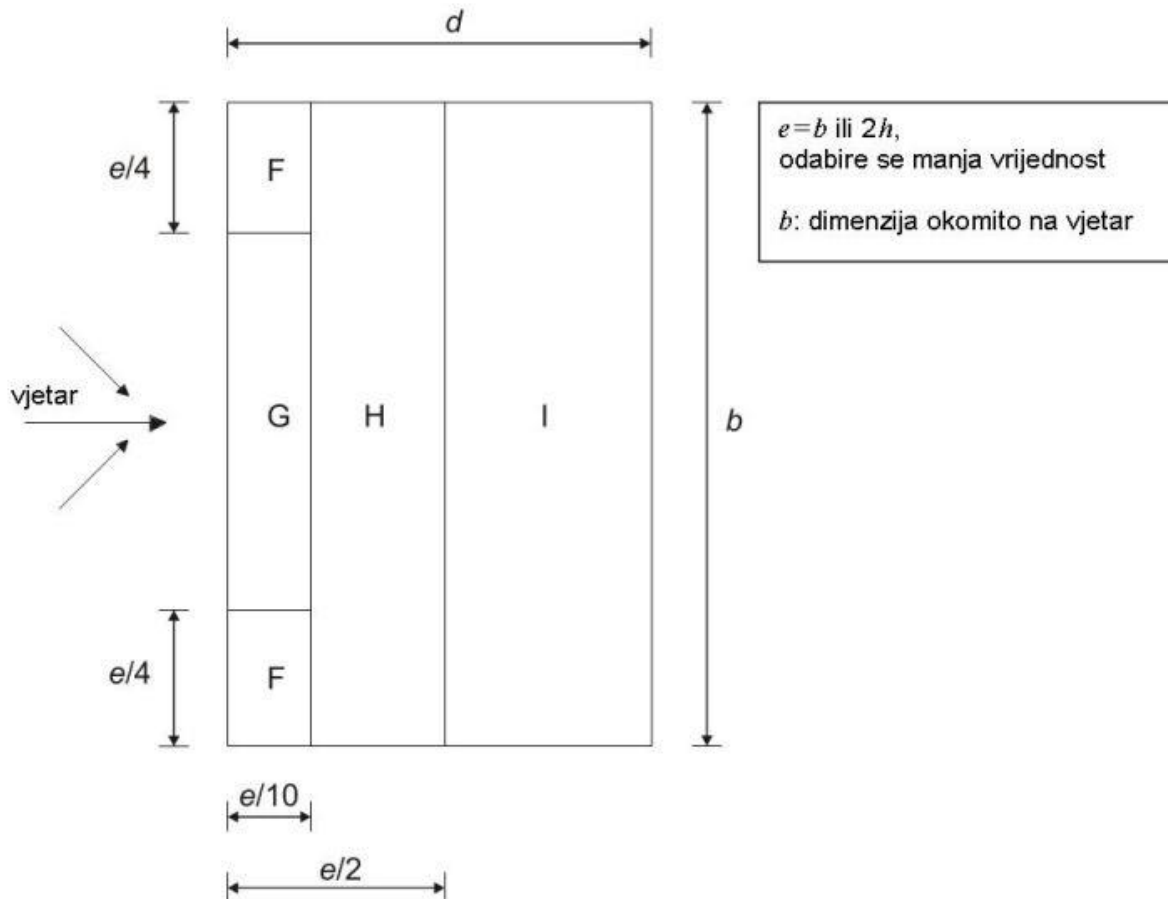
Slika 26. Djelovanje vjetra na zidove – pritisak



Slika 27. Djelovanje vjetra na zidove – odizanje

3.4.6 Djelovanje vjetra na ravni krov – vjetar u smjeru 180° i 0°

Proračun koeficijenata pritiska c_{pe} , c_{pi} :



Slika 28. Djelovanje vjetra na ravne krovne konstrukcije

$$e = 2 * h = 2 * 17 = 34 \text{ [m]} \quad (29)$$

Tablica 22. Iznos $c_{pe,10}$ po zonama

Zona	c_{pe}
F	- 1,8
G	- 1,2
H	- 0,7
I	+ 0,2
I	- 0,2

Tablica 23. Koeficijenti vanjskog tlaka vjetra

Vrsta krova		Područje							
		F		G		H		I	
		$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
Oštri zabati		-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2	-0,2
S nadozidima	$h_p/h = 0,025$	-1,6	-2,2	-1,1	-1,8	-0,7	-1,2	+0,2	-0,2
	$h_p/h = 0,05$	-1,4	-2,0	-0,9	-1,6	-0,7	-1,2	+0,2	-0,2
	$h_p/h = 0,10$	-1,2	-1,8	-0,8	-1,4	-0,7	-1,2	+0,2	-0,2
Zaobljeni zabati	$r/h = 0,05$	-1,0	-1,5	-1,2	-1,8	-0,4		+0,2	-0,2
	$r/h = 0,10$	-0,7	-1,2	-0,8	-1,4	-0,3		+0,2	-0,2
	$r/h = 0,20$	-0,5	-0,8	-0,5	-0,8	-0,3		+0,2	-0,2
Izlomljeni zabati	$\alpha = 30^\circ$	-1,0	-1,5	-1,0	-1,5	-0,3		+0,2	-0,2
	$\alpha = 45^\circ$	-1,2	-1,8	-1,3	-1,9	-0,4		+0,2	-0,2
	$\alpha = 60^\circ$	-1,3	-1,9	-1,3	-1,9	-0,5		+0,2	-0,2

NAPOMENA 1: Za krovove s nadozidima ili zaobljenim zabatima, smije se upotrebljavati linearna interpolacija za međuvrijednosti h_p/h i r/h .

NAPOMENA 2: Za krovove s izlomljenim zabatima, smije se upotrebljavati linearna interpolacija između vrijednosti za $\alpha = 30^\circ$, 45° i $\alpha = 60^\circ$. Za $\alpha > 60^\circ$ smije se upotrebljavati linearna interpolacija između vrijednosti za $\alpha = 60^\circ$ i vrijednosti za ravne krovove s oštrim (izlomljenim) zabatima.

NAPOMENA 3: U području I, gdje su dane i pozitivne i negativne vrijednosti, u obzir treba uzeti obje vrijednosti.

NAPOMENA 4: Za sami izlomljeni zabat, koeficijenti vanjskog tlaka dani su u tablici 7.4a „Koeficijenti vanjskog tlaka za dvostrešne krovove; smjer vjetra 0° “, područje F i G, ovisno o nagibu izlomljenog zabata.

NAPOMENA 5: Za sami zaobljeni zabat, koeficijenti vanjskog tlaka dani su linearnom interpolacijom duž krivulje, između vrijednosti na zidu i na krovu.

NAPOMENA 6: Za mansardne strehe čije su horizontalne dimenzije manje od $e/10$ treba uzeti vrijednosti za oštre strehe. Za definiciju e vidjeti sliku 7.6

Unutarnji koeficijenti pritiska vjetra su +0,2 i -0,3, tako da za odižući vjetar pritisak je:

$$w_{i1} = c_{pi} * q_p(z) = 0,2 * 1,61 = 0,32 \text{ [kN/m}^2\text{]} \quad (30)$$

a za pritiskajući vjetar pritisak je:

$$w_{i1} = c_{pi} * q_p(z) = 0,3 * 1,61 = 0,48 \text{ [kN/m}^2\text{]} \quad (31)$$

Isto vrijedi za sve ostale smjerove vjetra što se tiče unutarnjih tlakova.

Rezultirajući vjetar za vjetar 180° i 0° – smjer odizanje:

Tablica 24. Tlak vjetra (smjer 180° i 0°) – odizanje

Područje	$q_p(z)$	w w=we1“+“wi1
F	1,61	- 3,22
G	1,61	- 2,25
H	1,61	- 1,45
I	1,61	- 0,64
	kN/m ²	kN/m ²

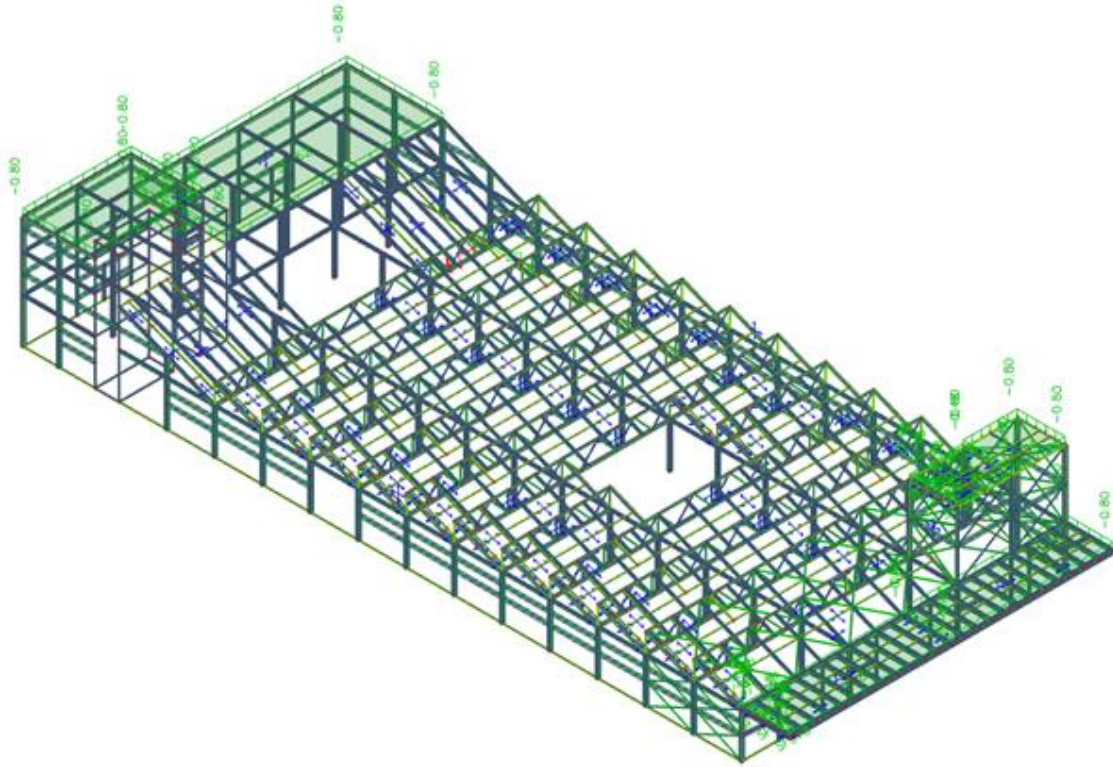
Rezultirajući vjetar za vjetar 180° i 0° – smjer pritisak:

Tablica 25. Tlak vjetra (smjer 180° i 0°) – pritisak

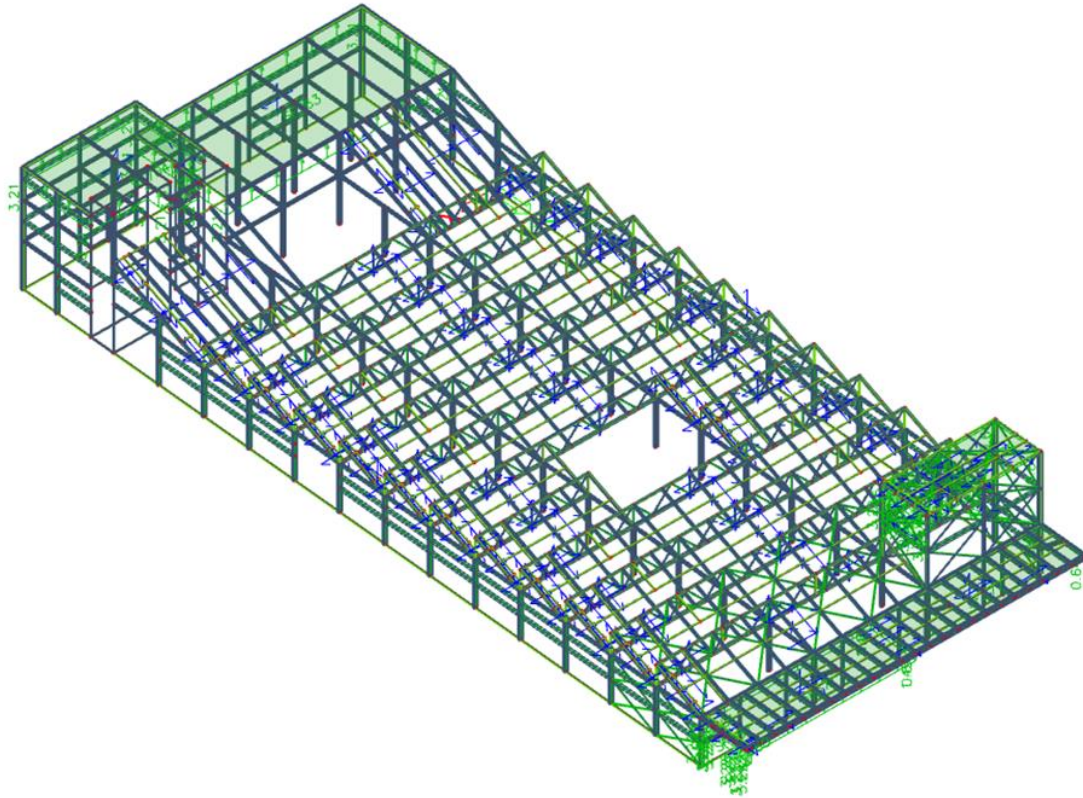
Područje	$q_p(z)$	w w=we1“+“wi1
F	1,61	0,48
G	1,61	0,48
H	1,61	0,48
I	1,61	0,48
	kN/m ²	kN/m ²

3.4.7 Djelovanje vjetra na ravni krov – vjetar u smjeru 90°

Iste vrijednosti kao i smjerovi 180° i 0°, samo drukčije zone pokrivanja koje će biti prikazane za svaki slučaj vjetra u nastavku.



Slika 33. Djelovanje vjetra na ravni krov (smjer 90°) – pritisak



Slika 34. Djelovanje vjetra na ravni krov (smjer 90°) – odizanje

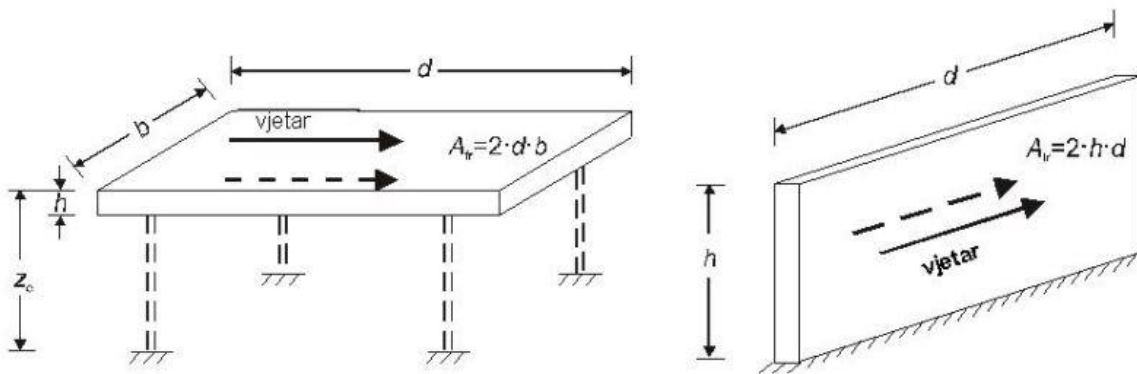
3.4.8 Djelovanja vjetra trenjem po krovu

Sila trenja:

$$F_F = c_{fr} * q_p(z) * A_f \quad (32)$$

gdje je:

- c_{fr} → 0,04 – koeficijent trenja za narebreni lim (vjerojatni pokrov)
- $q_p(z)$ → osnovni pritisak vjetra – 1,61 [kN/m²]
- A_f → površina usporedno sa smjerom vjetra

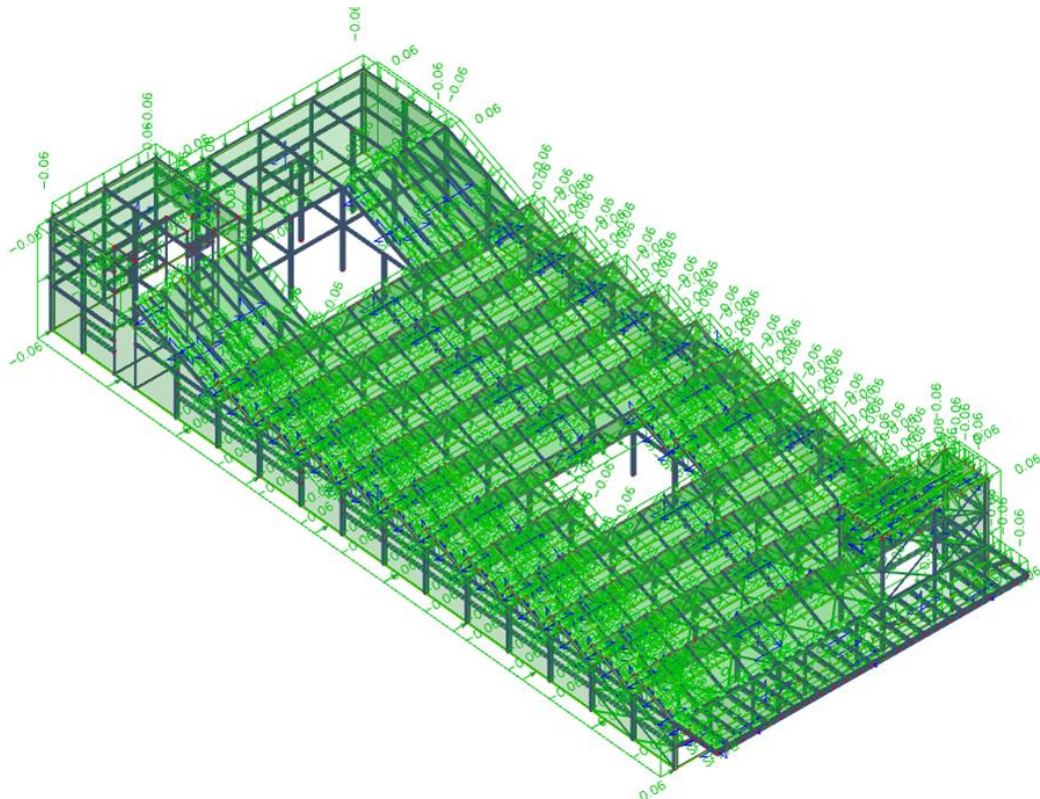


Slika 35. Prikaz referentne ploštine za trenje

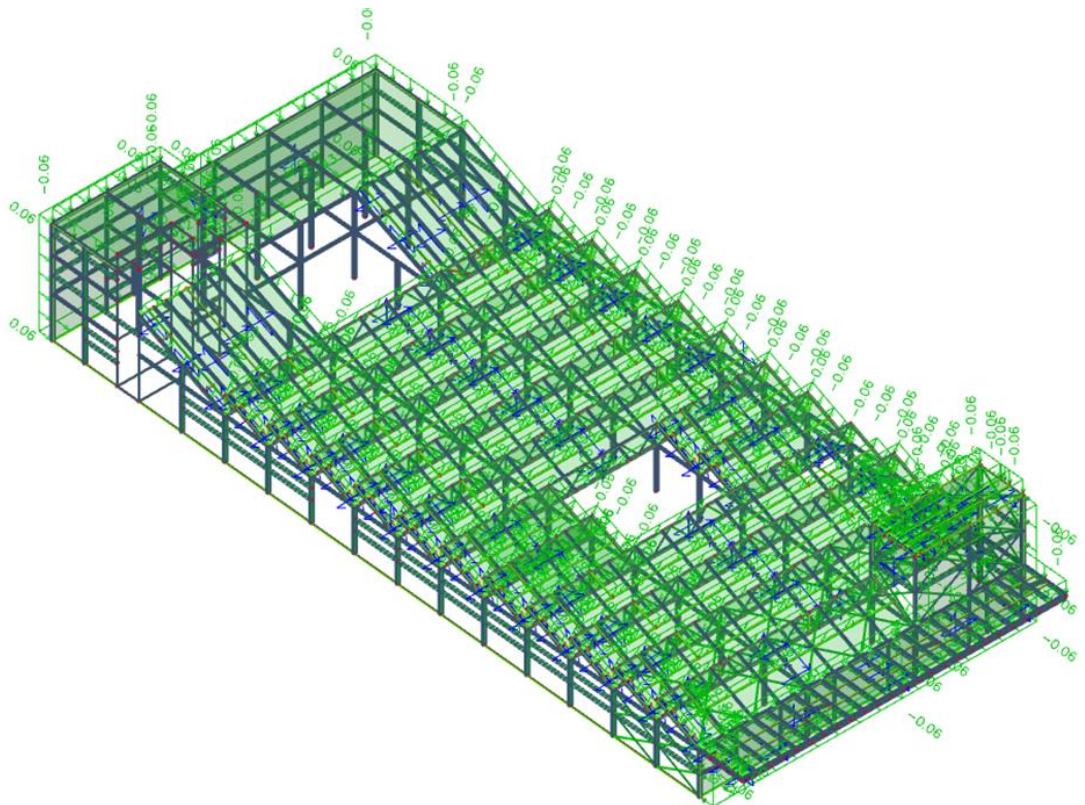
Izračunati ćemo silu trenja zanemarujući površinu jer nanosimo opterećenja na panele.

$$F_F = c_{fr} * q_p(z) = 0,04 * 1,61 = 0,064 \text{ [kN/m}^2\text{]} \quad (33)$$

Nanijeti ćemo silu trenja na svaki panel.



Slika 36. Trenje kod puhanja vjetra u jednom smjeru



Slika 37. Trenje kod puhanja vjetra u drugom smjeru

3.5 Izvanredno opterećenje – potresno djelovanje

U programi SCIA ENGINEER korištena je modalna analiza za proračun djelovanja potresa na konstrukciju. Tokom proračuna korištena je masa konstrukcije koja skupa s ubrzanjem koji djeluje kao potresno opterećenje na konstrukciju, a mase koje su analizirane su:

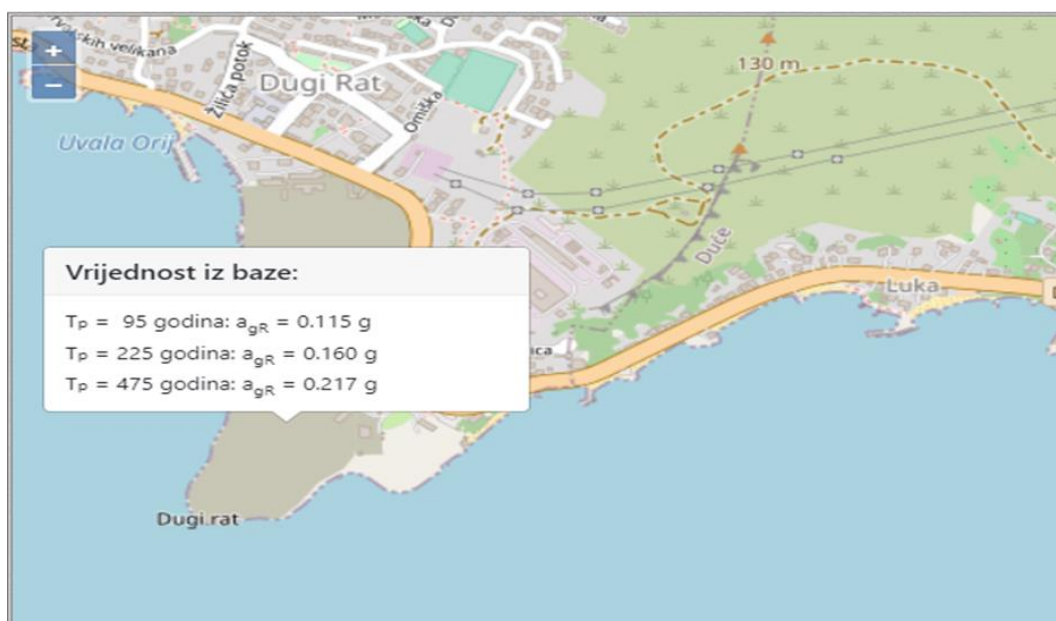
- vlastita težina
- dodatno stalno opterećenje
- korisno (promjenjivo) opterećenje

Potresno opterećenje na konstrukciju se dobiva u dva smjera s četiri sile i to:

- S_x – potres u smjeru x
- S_y – Potres u smjeru y
- S_{x_AE} – Slučajni utjecaj torzije za potresno opterećenje u smjeru x (sadrži i 30 % utjecaja od potresa u smjeru y)
- S_{y_AE} – Slučajni utjecaj torzije za potresno opterećenje u smjeru y (sadrži i 30 % utjecaja od potresa u smjeru x)

Ulazni podatci su:

- Računsko ubrzanje tla $a_g=0.217$ g



Slika 38. Prikaz računskog ubrzanja tla a_g

- Kategorija duktilnosti: DCM
- Kategorija tla: B

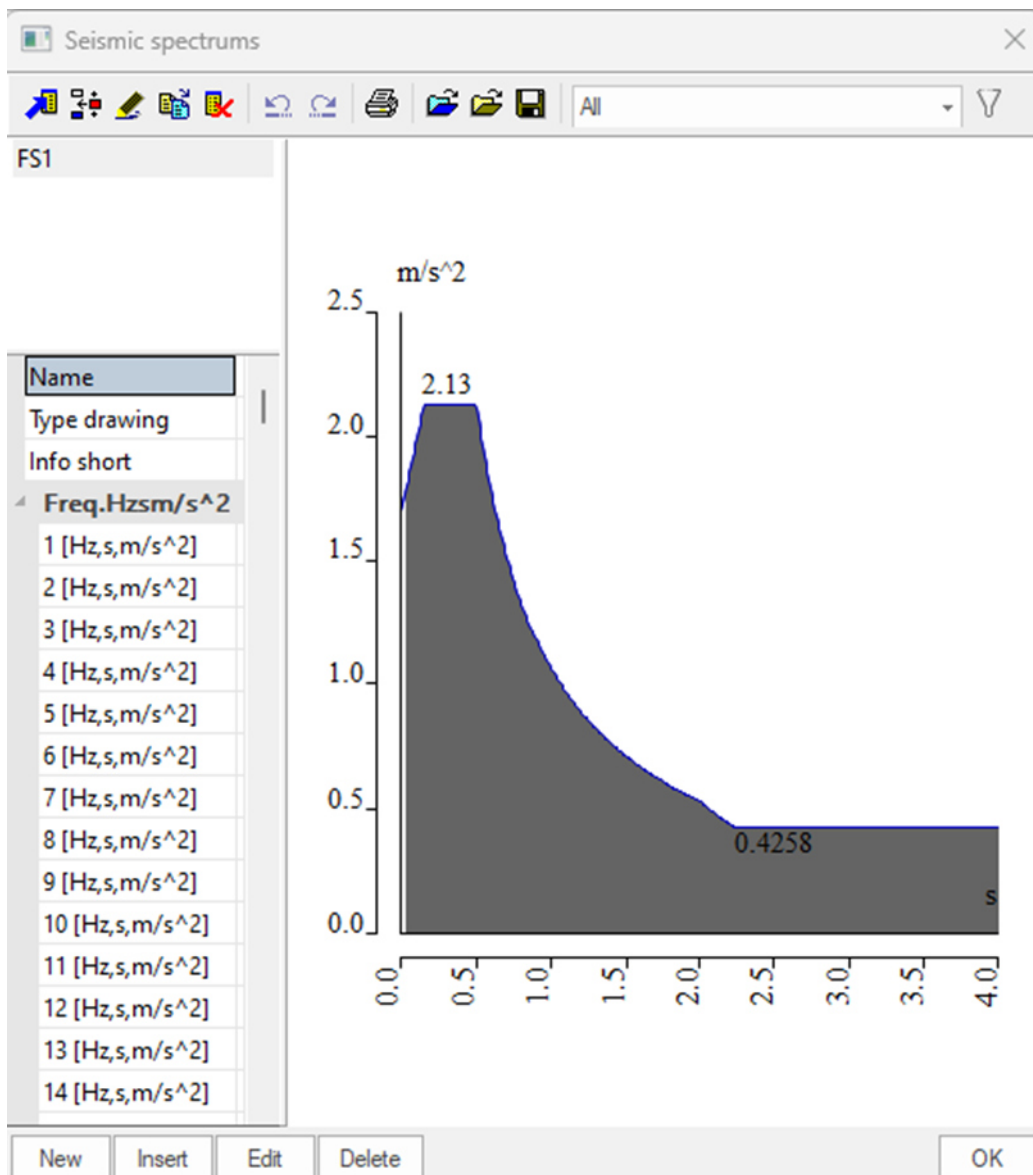
Tablica 26. Prikaz kategorija tla – EUROKOD

EC8 Tip tla	Litološka obilježja presjeka	Parametri		
		$V_{s,30}$ [m/s]	N_{SPT} [br. udaraca/ 30 cm]	c_u [kPa]
A	Stijena ili stjenovita masa, uključujući manje od 5 m slabijeg materijala na površini	> 800	–	–
B	Naslage gusto zbijenog pijeska, šljunka ili čvrstih glina, debele najmanje nekoliko desetaka metara, karakterizirane postepenim porastom mehaničkih karakteristika sa dubinom	360 – 800	> 50	> 250
C	Debele naslage rahlo zbijenih do srednje zbijenih pijesaka, šljunaka i polučvrstih glina, debljine od nekoliko desetaka do nekoliko stotina metara	180 – 360	15 – 50	70 – 250
D	Naslage vrlo rahlo do srednje zbijenih tala (sa ponekim lako gnječivim koherentnim slojem, ili bez njega), ili od pretežito lako do teško gnječivog koherentnog tla	< 180	< 15	< 70
E	Tip tla E sastoji se od površinskog aluvijalnog sloja sa $v_{s,30}$ vrijednostima klase C ili D i debljinom koja se kreće od 5 do 20 metara, sa čvrstom podlogom brzine $v_{s,30}$ većom od 800 m/s	–	–	–
S1	Naslage koje se sastoje od najmanje 10 metara debelih slojeva lako gnječive gline/praha sa indeksom plastičnosti (PI) većim od 40 i visokim sadržajem vode	< 100	–	10 – 20
S2	Naslage tala sklonih likvifakciji, glina osjetljivih na poremećaje, ili druga kategorija tla koje nije uključeno u kategorije A – E	–	–	–

- Faktor ponašanja $q=3$

Tablica 27. Prikaz osnovnog faktora ponašanja faktora q za sustave pravilne po tlocrtu

Vrsta konstrukcije	DCM	DCH
Okviri, dvostruki sustavi, povezani sustavi	$3,0 \cdot \alpha_0 / \alpha_1$	$4,5 \cdot \alpha_0 / \alpha_1$
Nezavisni zidni sustavi	3,0	$4,0 \cdot \alpha_0 / \alpha_1$
Sustavi ovisni o uvrtanju	2,0	3,0
Obrnuto njihalo, konzolni sustavi	1,5	2,0



Slika 39. Ulazni spektar odgovora

Nakon definiranog spektra odgovora slijedi kalkulacija za modalnu analizu gdje se aktivira masa konstrukcije.

Calculation protocol

Solution of Free vibration

Number of 2D elements	43612
Number of 1D elements	11312
Number of mesh nodes	53602
Number of equations	321612
Combination of mass groups	MC1 CM1
Number of frequencies	23
Method	Lanczos
Bending theory	Mindlin
Type of analysis model	Standard using improved reduced system (IRS)
Start of calculation	31.08.2023 10:08
End of calculation	31.08.2023 10:09

Sum of masses

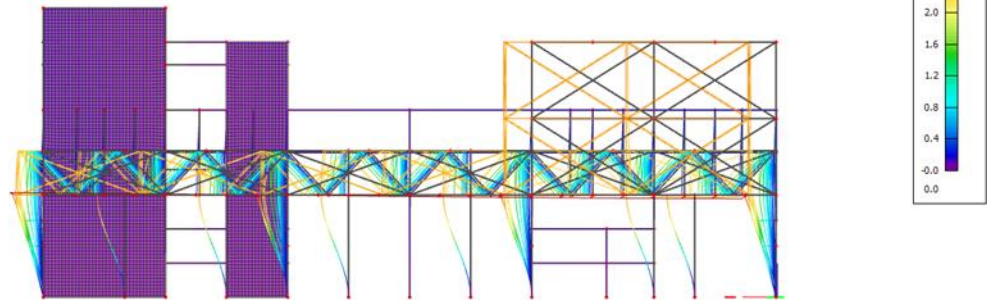
	Mass type	X [kg]	Y [kg]	Z [kg]
1	Moving mass	1387761.1	1387761.1	1378870.4
1	Total mass	1390857.8	1390857.8	1390857.8

Relative modal masses

Mode	omega [rad/s]	Period [s]	Freq. [Hz]	$W_{x1}/W_{x\text{tot}}$	$W_{y1}/W_{y\text{tot}}$	$W_{z1}/W_{z\text{tot}}$	$W_{x1_R}/W_{x\text{tot_R}}$	$W_{y1_R}/W_{y\text{tot_R}}$	$W_{z1_R}/W_{z\text{tot_R}}$
1	11.937	0.53	1.90	0.1633	0.0030	0.0000	0.0000	0.0020	0.6760
2	14.1769	0.44	2.26	0.1254	0.0503	0.0001	0.0006	0.0004	0.0066
3	15.1001	0.42	2.40	0.0002	0.4439	0.0010	0.0079	0.0011	0.0334
4	23.2332	0.27	3.70	0.0125	0.0071	0.0064	0.0431	0.0002	0.0453
5	26.8881	0.23	4.28	0.0011	0.0030	0.0011	0.0085	0.0000	0.0034
6	30.2513	0.21	4.81	0.0039	0.0177	0.0200	0.1438	0.0037	0.0033
7	37.5418	0.17	5.97	0.0517	0.2624	0.0012	0.0018	0.0013	0.0814
8	42.2457	0.15	6.72	0.0435	0.0117	0.0158	0.0087	0.2532	0.0100
9	44.7713	0.14	7.13	0.2868	0.0027	0.0209	0.0020	0.0194	0.0446
10	46.3825	0.14	7.38	0.0199	0.0014	0.1657	0.0620	0.0494	0.0028
11	49.3619	0.13	7.86	0.0023	0.0000	0.0987	0.0309	0.0236	0.0004
12	52.8687	0.12	8.41	0.0006	0.0003	0.1595	0.0305	0.0081	0.0001
13	55.0031	0.11	8.75	0.0011	0.0001	0.0057	0.0025	0.0706	0.0003
14	59.571	0.11	9.48	0.0003	0.0001	0.0032	0.0005	0.0005	0.0000
15	60.4109	0.10	9.61	0.0000	0.0001	0.0016	0.0006	0.0001	0.0000
16	70.6692	0.09	11.25	0.0294	0.0018	0.0005	0.0001	0.0013	0.0036
17	84.0736	0.07	13.38	0.0011	0.0010	0.0044	0.0084	0.0008	0.0000
18	98.0975	0.06	15.61	0.0220	0.0042	0.0000	0.0017	0.0008	0.0031
19	100.898	0.06	16.06	0.0077	0.0008	0.0005	0.0003	0.0011	0.0186
20	133.379	0.05	21.23	0.0052	0.0585	0.0000	0.0043	0.0000	0.0035
21	167.653	0.04	26.68	0.0328	0.0002	0.0000	0.0001	0.0018	0.0048
22	393.712	0.02	62.66	0.0006	0.0004	0.0544	0.2352	0.0459	0.0001
23	458.798	0.01	73.02	0.0077	0.0075	0.0254	0.1267	0.2324	0.0004
				0.8192	0.8783	0.5861	0.7203	0.7175	0.9418

3D displacement

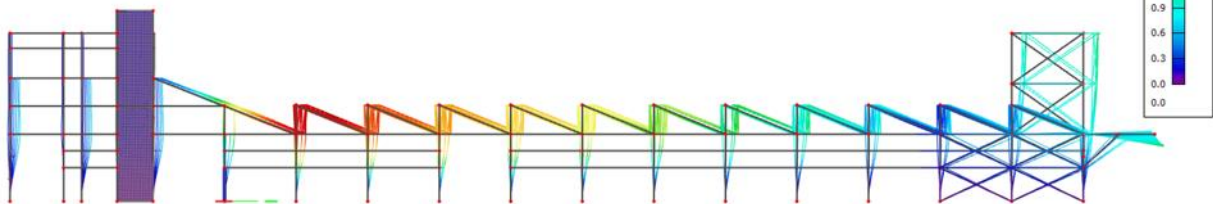
Values: Utotal
 Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.
 Mass combination: CM1/1 - 1.90
 Selection: All
 Location: In nodes avg., System: Global



Slika 40. Prvi vlastiti vektor konstrukcije smjer x

3D displacement

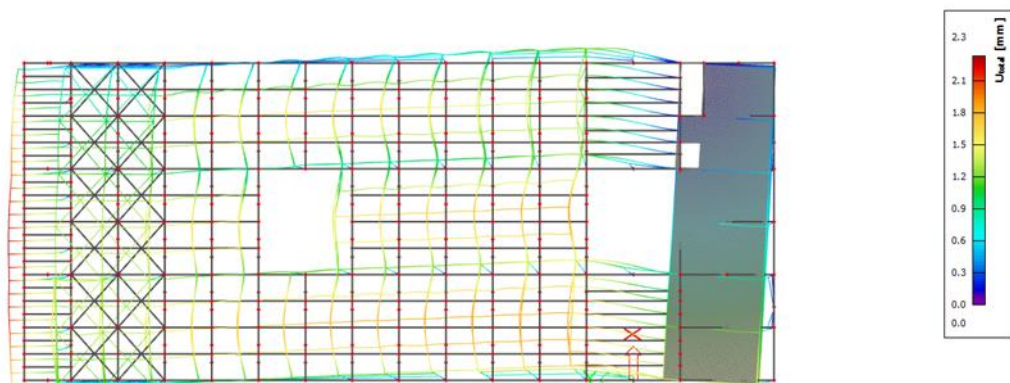
Values: Utotal
 Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.
 Mass combination: CM1/2 - 2.26
 Selection: All
 Location: In nodes avg., System: Global



Slika 41. Drugi vlastiti vektor konstrukcije smjer y

3D displacement

Values: Utotal
 Modal shapes are normalized, so that the generalized modal mass of each mode is equal to 1kg.
 Mass combination: CM1/3 - 2.40
 Selection: All
 Location: In nodes avg., System: Global



Slika 42. Treći vlastiti vektor konstrukcije (torzija) smjer xy

Nakon proračuna vidljivo je da je najveći pomak konstrukcije u smjeru x i to 3,2 [mm] maksimalna vrijednost, te nakon uvida u maksimalni pomak konstrukcije zaključujemo da je masa konstrukcije mala te potresno djelovanje nije mjerodavno za dimenzioniranje konstrukcije!

4. DIMENZIONIRANJE ELEMENATA KONSTRUKCIJE

4.1 Kombinacije djelovanja na konstrukciju

U Kombinacije GSN (granično stanje nosivosti) je upotrijebljen koeficijent smanjenja sila s koeficijentom 1,5*0,9, tako da su koeficijenti svih sila 1,35. Smanjenje je napravljeno zbog 3 ili više promjenjiva opterećenja sadržana u kombinaciji.

U Kombinacije GSU (Granično stanje uporabljivosti) korišteni su regularni koeficijenti 1,0.

Kombinacije:

Tablica 28. Prikaz kombinacija

Name	Type	Load cases	Coeff. [-]
GSU1	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC5_Vjetar "SHED" 0 –	1,00
		LC6_Vjetar "Zidovi –	1,00
		LC6_Vjetar "Ravni krov 0 –	1,00
		LC6_Vjetar "Trenje 0 i 180"	1,00
GSU2	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC6_Vjetar "SHED"180 –	1,00
		LC6_Vjetar "Zidovi –	1,00
		LC6_Vjetar "Ravni krov 180 –	1,00
		LC6_Vjetar "Trenje 0 i 180"	1,00
GSU3	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC3_Promjenjivo	1,00
		LC4_Snijeg	1,00
		LC6_Vjetar "SHED"180 +	1,00
		LC6_Vjetar "Zidovi +	1,00
		LC6_Vjetar "Ravni krov 180 +	1,00
		LC6_Vjetar "Trenje 0 i 180"	1,00

Name	Type	Load cases	Coeff. [-]
GSU4	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC3_Promjenjivo	1,00
		LC4_Snijeg	1,00
		LC6_Vjetar "SHED"0 +	1,00
		LC6_Vjetar "Zidovi +	1,00
		LC6_Vjetar "Ravni krov 0 +	1,00
		LC6_Vjetar "Trenje 0 i 180"	1,00
GSU5	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC6_Vjetar "SHED"90 –	1,00
		LC6_Vjetar "Zidovi –	1,00
		LC6_Vjetar "Ravni krov 90 –	1,00
		LC6_Vjetar "Trenje 90"	1,00
GSU6	Linear – serviceability	LC1 – Self weight	1,00
		LC2_Dodatno stalno	1,00
		LC3_Promjenjivo	1,00
		LC4_Snijeg	1,00
		LC6_Vjetar "SHED"90 +	1,00
		LC6_Vjetar "Zidovi +	1,00
		LC6_Vjetar "Ravni krov 90 +	1,00
		LC6_Vjetar "Trenje 90"	1,00
GSN1	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC5_Vjetar "SHED" 0 –	1,50
		LC6_Vjetar "Zidovi –	1,50x0.90
		LC6_Vjetar "Ravni krov 0 –	1,50x0.90
		LC6_Vjetar "Trenje 0 i 180"	1,50x0.90
GSN2	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC6_Vjetar "SHED"180 –	1,50
		LC6_Vjetar "Zidovi –	1,50x0.90
		LC6_Vjetar "Ravni krov 180 –	1,50x0.90
		LC6_Vjetar "Trenje 0 i 180"	1,50x0.90

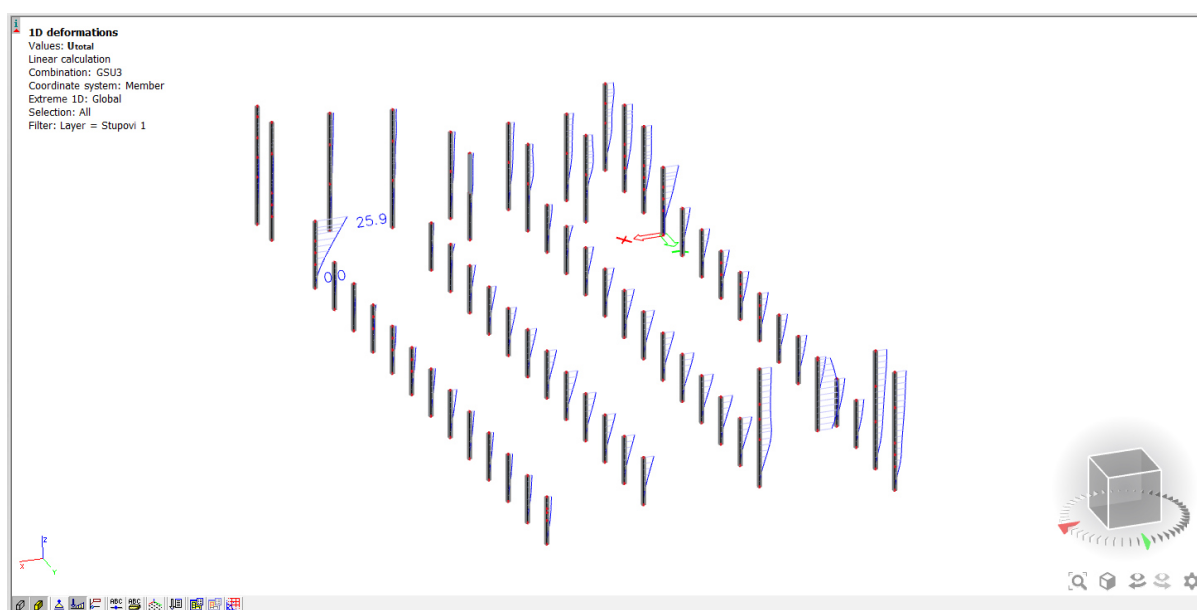
Name	Type	Load cases	Coeff. [-]
GSN3	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC3_Promjenjivo	1,50x0.90
		LC4_Snijeg	1,50x0.90
		LC6_Vjetar "SHED"180 +	1,50
		LC6_Vjetar "Zidovi +	1,50x0.90
		LC6_Vjetar "Ravni krov 180 +	1,50x0.90
		LC6_Vjetar "Trenje 0 i 180"	1,50x0.90
GSN4	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC3_Promjenjivo	1,50x0.90
		LC4_Snijeg	1,50x0.90
		LC6_Vjetar "SHED"0 +	1,50
		LC6_Vjetar "Zidovi +	1,50x0.90
		LC6_Vjetar "Ravni krov 0 +	1,50x0.90
		LC6_Vjetar "Trenje 0 i 180"	1,50x0.90
GSN5	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC6_Vjetar "SHED"90 –	1,50
		LC6_Vjetar "Zidovi –	1,50x0.90
		LC6_Vjetar "Ravni krov 90 –	1,50x0.90
		LC6_Vjetar "Trenje 90"	1,50x0.90
GSN6	Linear – ultimate	LC1 – Self weight	1,35
		LC2_Dodatno stalno	1,35
		LC3_Promjenjivo	1,50x0.90
		LC4_Snijeg	1,50x0.90
		LC6_Vjetar "SHED"90 +	1,50
		LC6_Vjetar "Zidovi +	1,50x0.90
		LC6_Vjetar "Ravni krov 90 +	1,50x0.90
		LC6_Vjetar "Trenje 90"	1,50x0.90

4.2 Pomaci konstrukcije mjerodavni za granično stanje uporabljivosti

Za sve rezultate korištene su mjerodavne kombinacije koje prikazuju najveći progib.

Za glavne elemente u vertikalnom i horizontalnom smjeru gledana je ukupna deformacija, a za sekundarne elemente gledana je relativna deformacija.

4.2.1 Deformacija stupova



Slika 43. Deformacija stupova

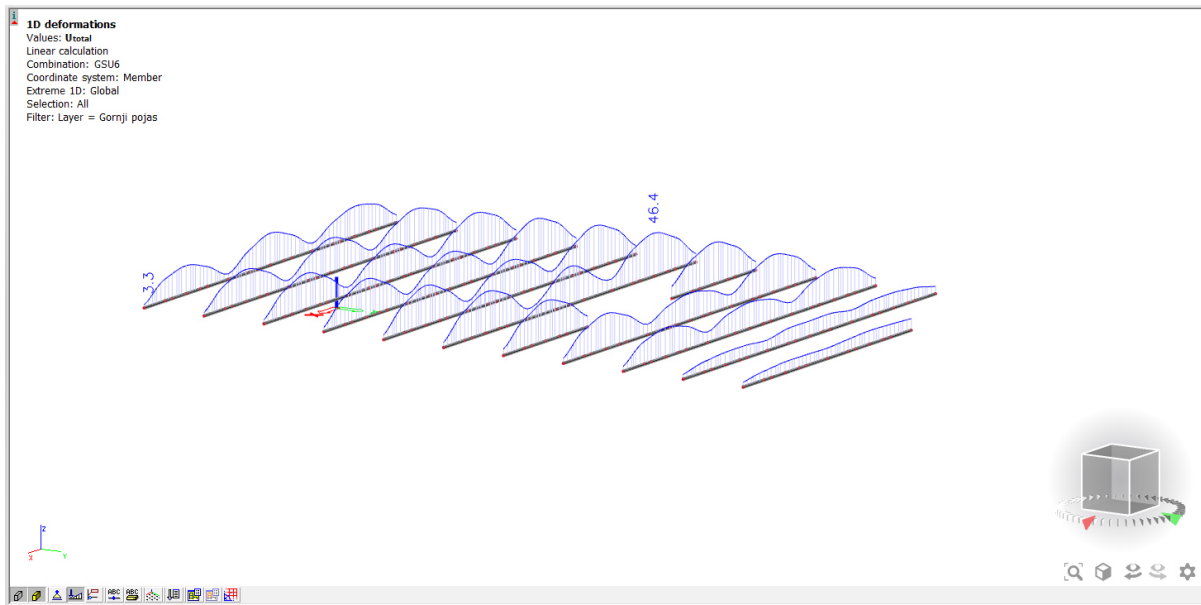
Dopušteni horizontalni pomak stupova:

$$u_{dop} = \frac{h}{200} = \frac{6000}{200} = 30,0 \text{ [mm]} \quad (34)$$

$$u_z = 25,9 < 30,0 \text{ [mm]} \quad (35)$$

Uvjet zadovoljen.

4.2.2 Deformacija gornjeg pojasa



Slika 44. Deformacija gornjeg pojasa

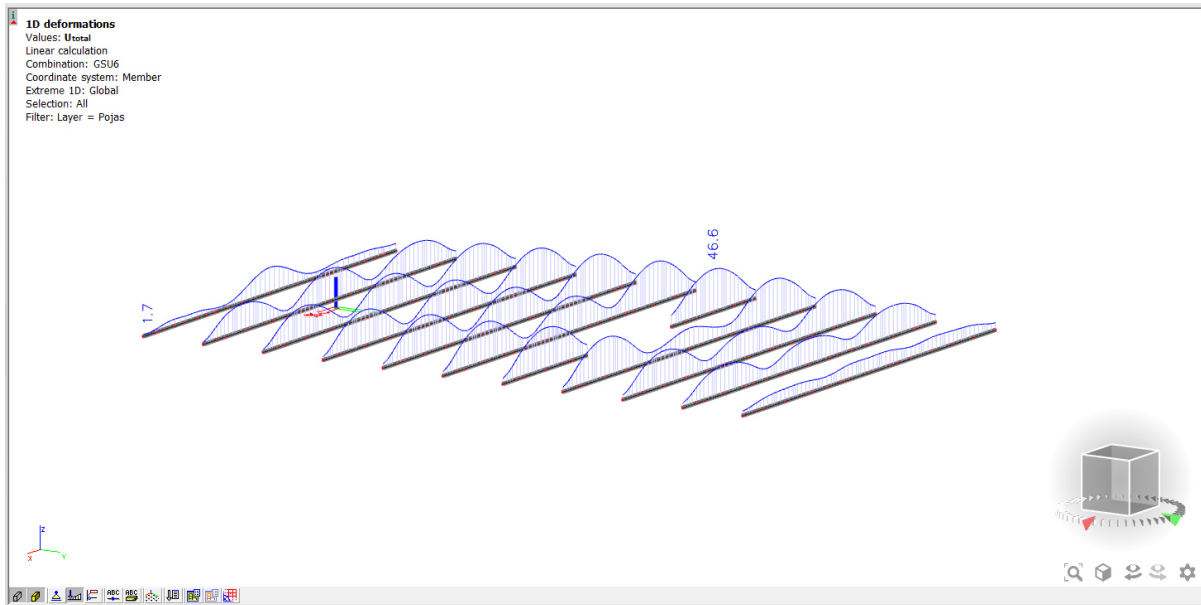
Dopušteni vertikalni pomak gornjeg pojasa:

$$u_{dop} = \frac{L}{300} = \frac{14400}{300} = 48,0 [mm] \quad (36)$$

$$u_z = 46,4 < 48,0 [mm] \quad (37)$$

Uvjet zadovoljen.

4.2.3 Deformacija donjeg pojasa



Slika 45. Deformacija donjeg pojasa

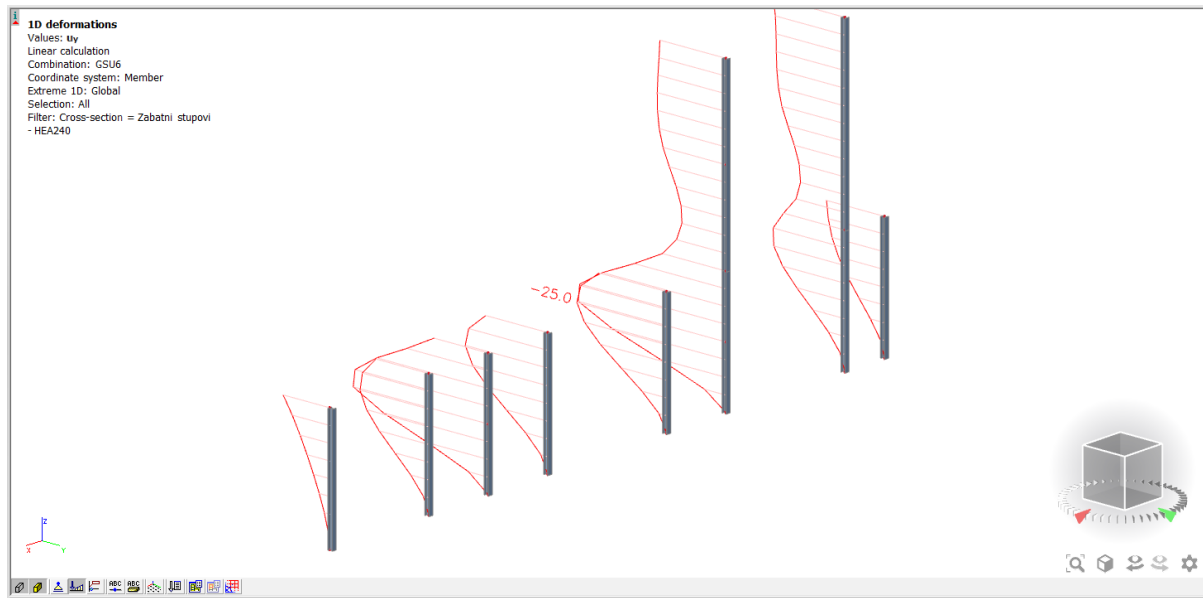
Dopušteni vertikalni pomak donjeg pojasa:

$$u_{dop} = \frac{L}{300} = \frac{14400}{300} = 48,0 \text{ [mm]} \quad (38)$$

$$u_z = 46,6 < 48,0 \text{ [mm]} \quad (39)$$

Uvjet zadovoljen.

4.2.4 Deformacija zabatnih stupova



Slika 46. Deformacija zabatnih stupova

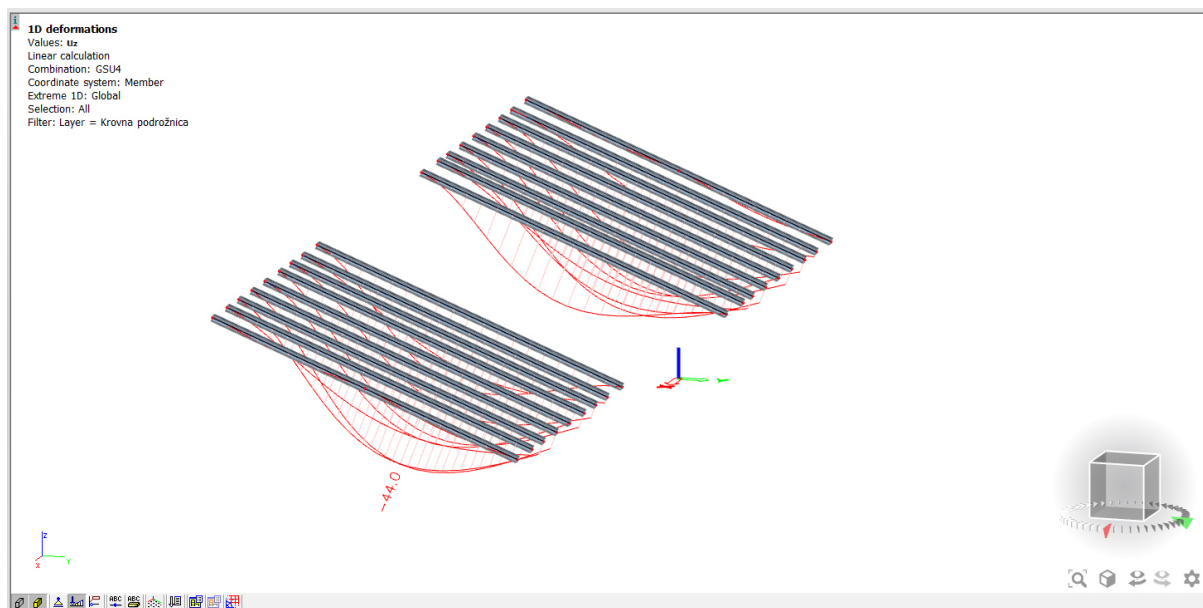
Dopušteni horizontalni pomak zabatnih stupova:

$$u_{dop} = \frac{h}{200} = \frac{6000}{200} = 30,0 \text{ [mm]} \quad (40)$$

$$u_z = 25,0 < 30,0 \text{ [mm]} \quad (41)$$

Uvjet zadovoljen.

4.2.5 Deformacija krovnih nosača – duži krovni nosač



Slika 47. Deformacija dužih krovnih nosača

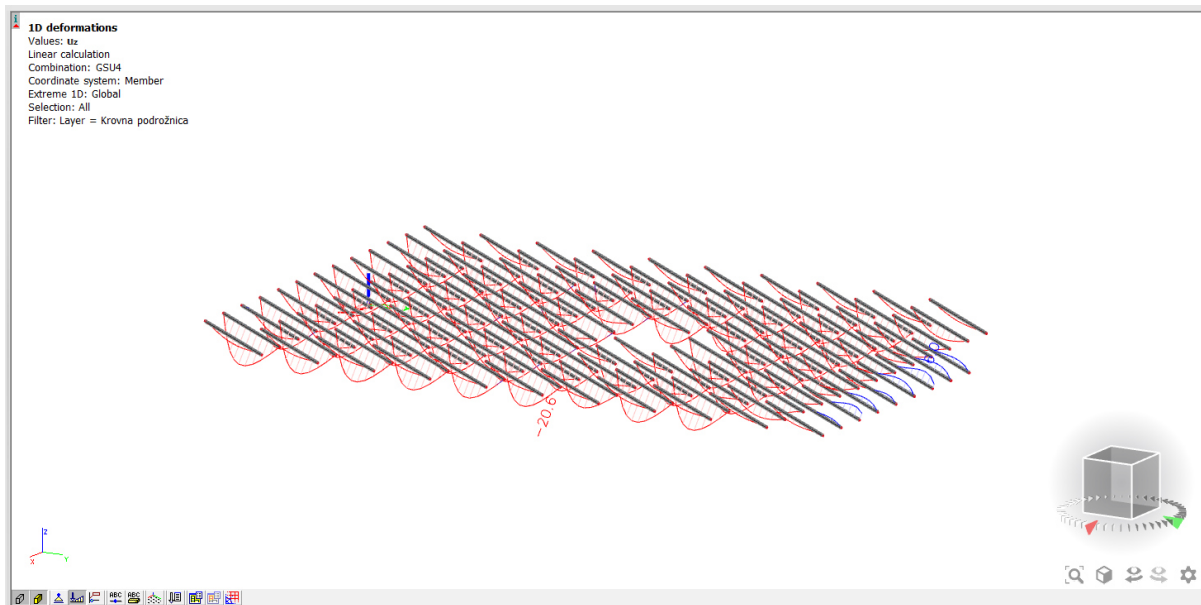
Dopušteni vertikalni pomak dužih krovnih nosača:

$$u_{dop} = \frac{L}{300} = \frac{13900}{300} = 46,33 \text{ [mm]} \quad (42)$$

$$u_z = 44,0 < 46,33 \text{ [mm]} \quad (43)$$

Uvjet zadovoljen.

4.2.6 Deformacija krovnih nosača – kraći krovni nosač



Slika 48. Deformacija kraćih krovnih nosača

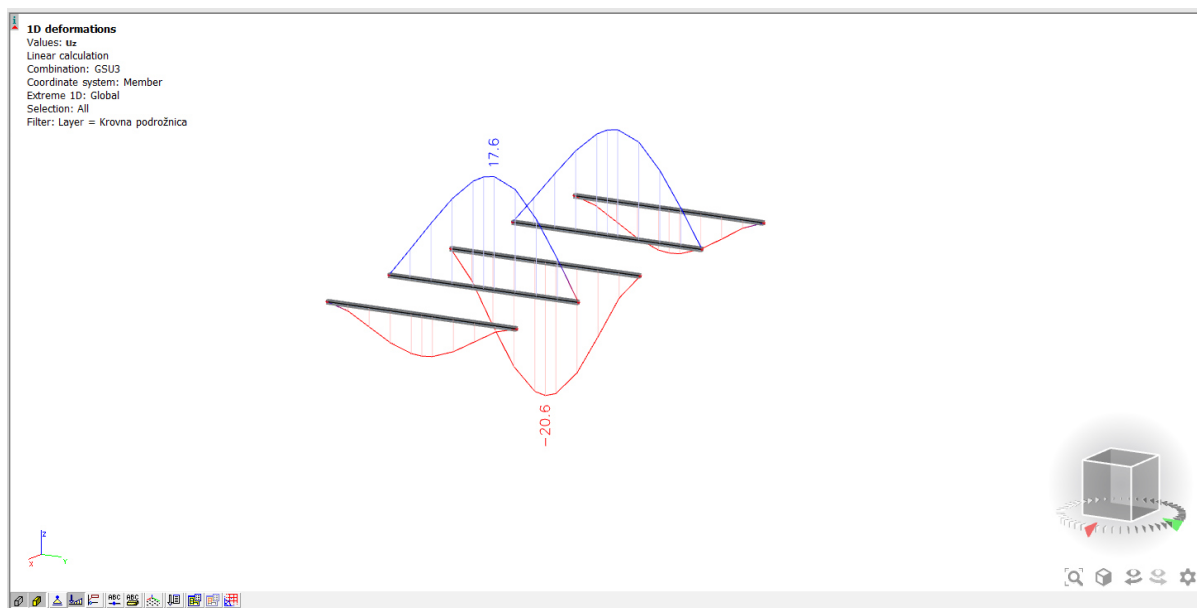
Dopušteni vertikalni pomak kraćih krovnih nosača:

$$u_{dop} = \frac{L}{300} = \frac{7000}{300} = 23,33 \text{ [mm]} \quad (44)$$

$$u_z = 20,6 < 23,33 \text{ [mm]} \quad (45)$$

Uvjet zadovoljen.

4.2.7 Deformacija krovnih nosača – krovni nosač na kućici



Slika 49. Deformacija krovnih nosača na kućici

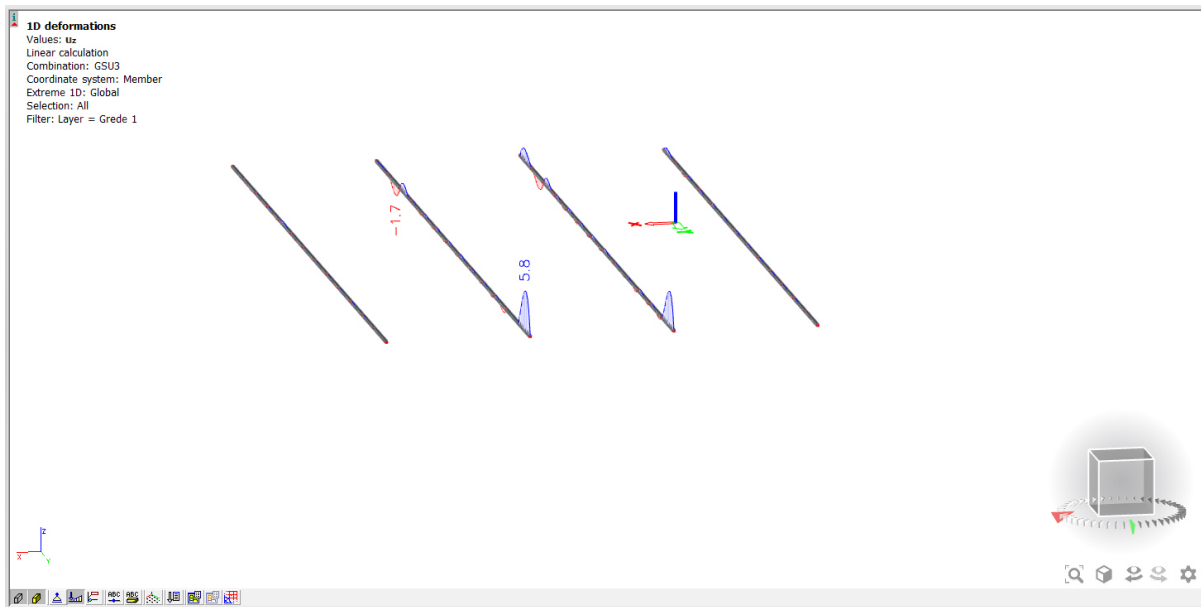
Dopušteni vertikalni pomak krovnih nosača na kućici:

$$u_{dop} = \frac{L}{300} = \frac{6400}{300} = 21,33 \text{ [mm]} \quad (46)$$

$$u_z = 20,60 < 21,33 \text{ [mm]} \quad (47)$$

Uvjet zadovoljen.

4.2.8 Deformacija greda



Slika 50. Deformacija greda

Dopušteni vertikalni pomak greda:

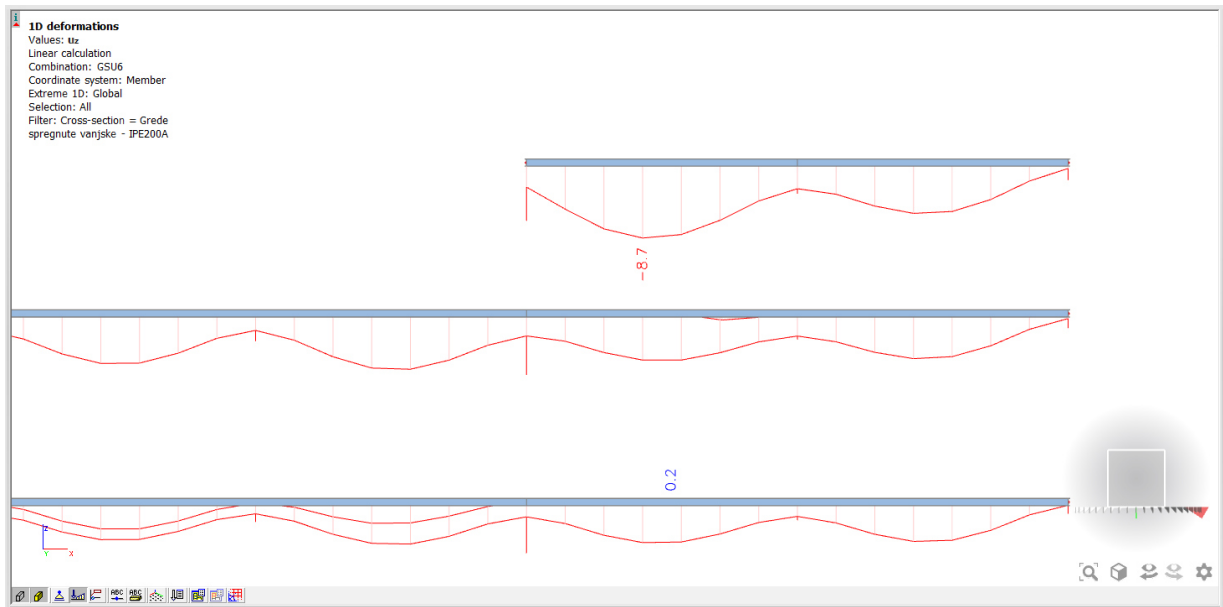
$$u_{dop} = \frac{L}{300} = \frac{6400}{300} = 21,33 \text{ [mm]} \quad (48)$$

$$u_z = 5,80 < 21,33 \text{ [mm]} \quad (49)$$

Uvjet zadovoljen.

Zbog nalijevanja krovnog nosača na gredu odabran je profil iste dimenzije – HEA 260.

4.2.9 Deformacija spregnutih greda



Slika 51. Deformacija spregnutih greda

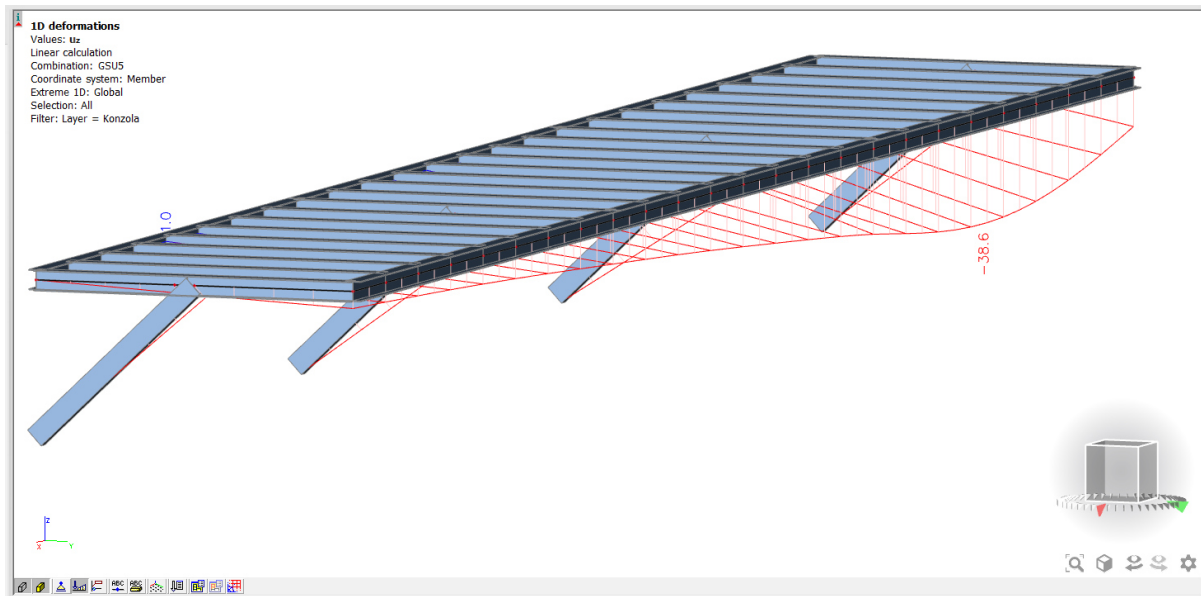
Dopušteni vertikalni pomak spregnutih greda:

$$u_{dop} = \frac{L}{300} = \frac{7200}{300} = 24,0 \text{ [mm]} \quad (50)$$

$$u_z = 8,7 < 24,0 \text{ [mm]} \quad (51)$$

Uvjet zadovoljen.

4.2.10 Deformacija konzole



Slika 52. Deformacija konzole

Dopušteni vertikalni pomak konzole:

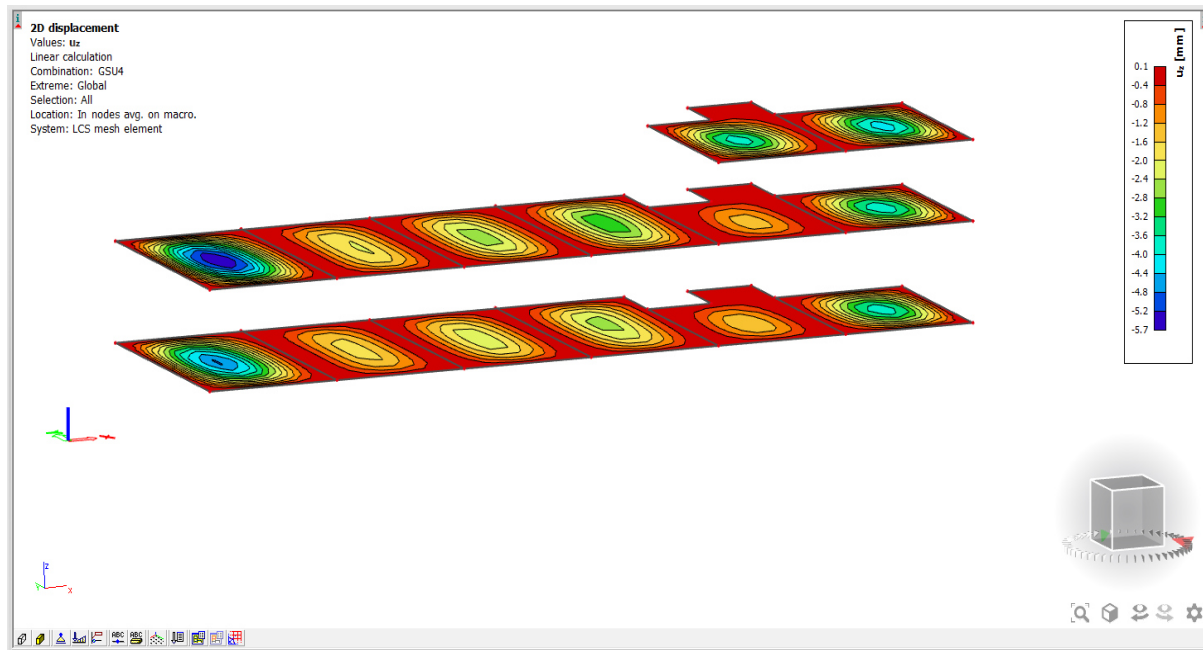
$$u_{dop} = \frac{L}{150} = \frac{6400}{150} = 42,6 \text{ [mm]} \quad (52)$$

$$u_z = 38,6 < 42,6 \text{ [mm]} \quad (53)$$

Uvjet zadovoljen.

Kod odabira geometrije cijele konzole paženo je da grede ne budu veće od profila stupova na koje će nalegnuti te da se kosnik može uspješno spojiti s stupom i karakterističnom gredom na konzoli.

4.2.11 Deformacija međukatne konstrukcije



Slika 53. Deformacija AB međukatne konstrukcije

Dopušteni vertikalni pomak međukatne konstrukcije:

$$u_{dop} = \frac{L_{min}}{1000} = \frac{7200}{1000} = 7,2 \text{ [mm]} \quad (54)$$

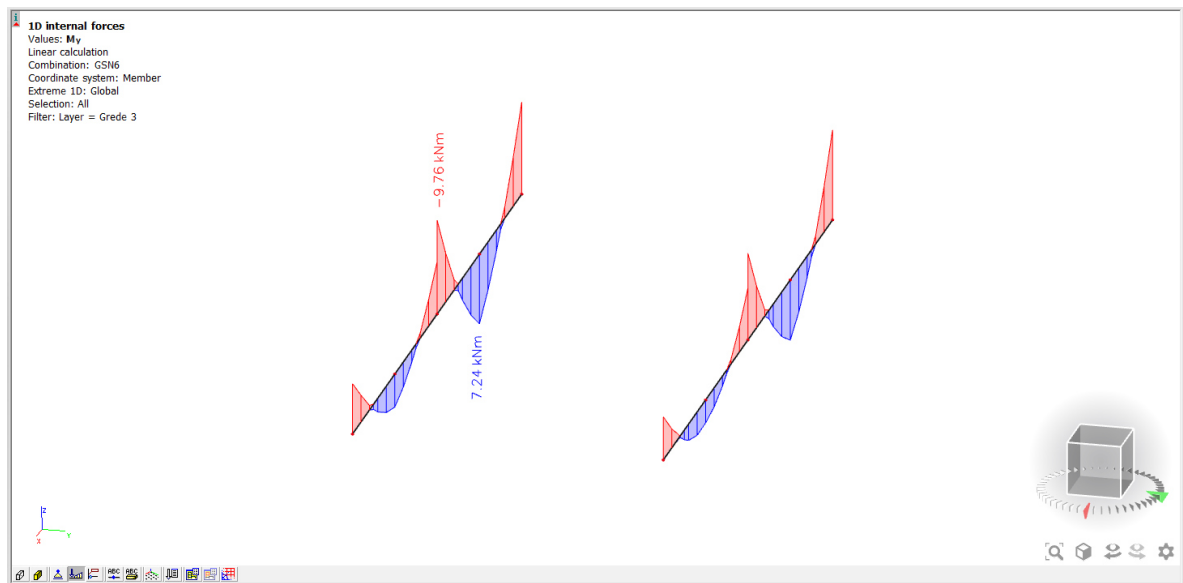
$$u_z = 5,7 < 7,2 \text{ [mm]} \quad (55)$$

Uvjet zadovoljen.

4.3 Granični uvjeti nosivosti i konačni profili

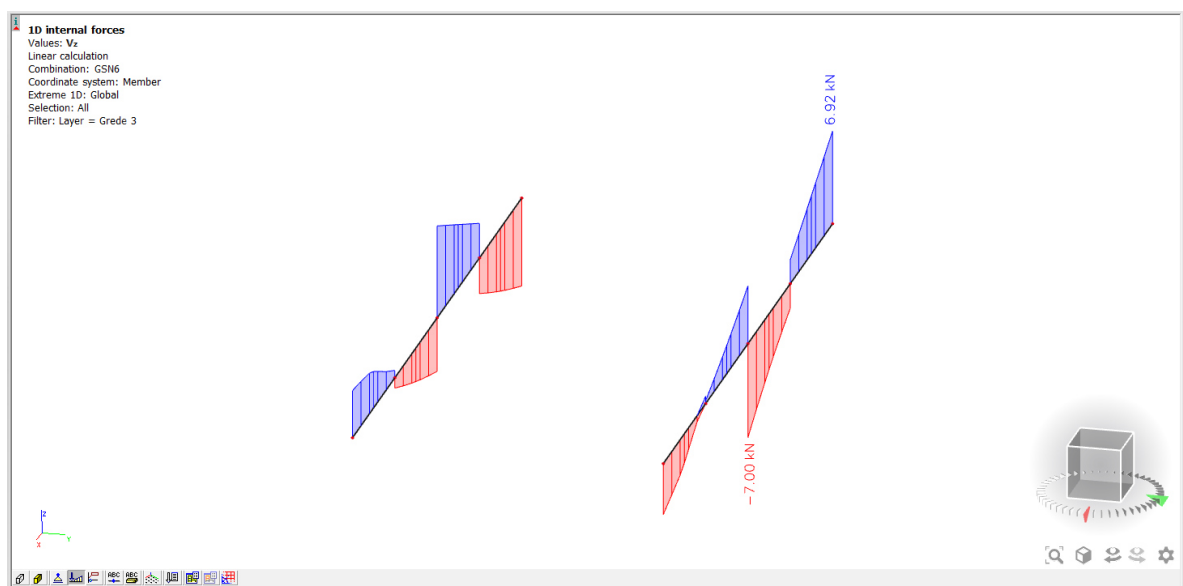
4.3.1 Dimenzioniranje krovnih greda – Pozicija 1

Moment savijanja M_y krovnih greda:



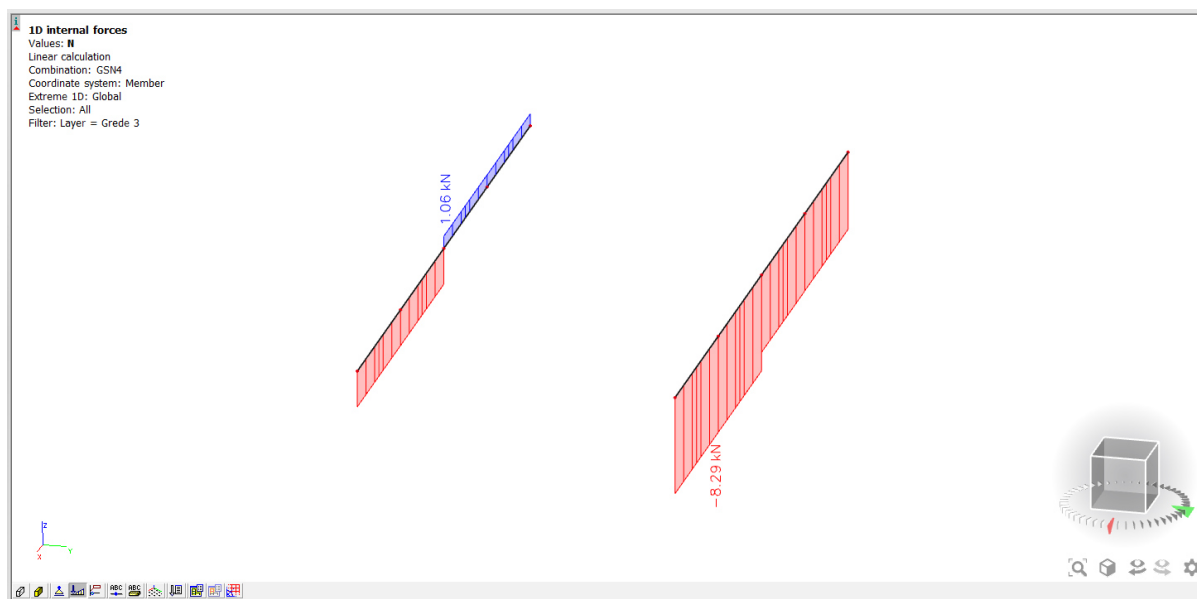
Slika 54. Prikaz momenta savijanja M_y krovnih greda

Poprečna sila V_z krovnih greda:



Slika 55. Prikaz poprečne sile V_z krovnih greda

Uzdužna sila N krovnih greda:



Slika 56. Prikaz uzdužne sile N krovnih greda

Proračun finalnog poprečnog presjeka krovnih greda u modulu Steel.

Odabran profil – HEA100

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Cross-section = Grede krov - HEA100

EN 1993-1-1 Code Check

National annex: Standard EN

Member B579	0.000 / 14.400 m	HEA100	S 275	GSN6	0.62 -
--------------------	-------------------------	---------------	--------------	-------------	---------------

Combination key
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

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

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-6.92	kN
$V_{y,Ed}$	0.93	kN
$V_{z,Ed}$	6.92	kN
T_{Ed}	-0.01	kNm
$M_{y,Ed}$	-9.34	kNm
$M_{z,Ed}$	-1.08	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	36	8	1.327e+05	1.613e+05	0.82	0.44	1.00	4.44	8.32	9.24	12.94	1
3	SO	36	8	1.093e+05	8.064e+04	0.74	0.54	1.00	4.44	8.32	9.24	14.22	1
4	I	56	5	7.817e+04	-7.165e+04	-0.92		0.54	11.20	58.32	67.93	104.88	1
5	SO	36	8	-1.262e+05	-1.548e+05								
7	SO	36	8	-1.028e+05	-7.412e+04								

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	2.1200e-03	m ²
$N_{c,Rd}$	583.00	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)

$W_{pl,y}$	8.2917e-05	m ³
$M_{pl,y,Rd}$	22.80	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)

$W_{pl,z}$	4.1125e-05	m ³
$M_{pl,z,Rd}$	11.31	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	1.6850e-03	m ²
$V_{pl,y,Rd}$	267.53	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	7.5200e-04	m ²
$V_{pl,z,Rd}$	119.40	kN
Unity check	0.06	-

Torsion check

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

Fibre	1	
T_{Ed}	1.3	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	22.80	kNm
α	2.00	
$M_{pl,z,Rd}$	11.31	kNm
β	1.00	

Unity check (6.41) = 0.17 + 0.10 = 0.26 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	36	8	1.327e+05	1.613e+05	0.82	0.44	1.00	4.44	8.32	9.24	12.94	1
3	SO	36	8	1.093e+05	8.064e+04	0.74	0.54	1.00	4.44	8.32	9.24	14.22	1
4	I	56	5	7.817e+04	-7.165e+04	-0.92		0.54	11.20	58.32	67.93	104.88	1
5	SO	36	8	-1.262e+05	-1.548e+05								
7	SO	36	8	-1.028e+05	-7.412e+04								

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	7.200	3.600	m
Buckling factor k	1.42	0.53	
Buckling length l_{cr}	10.253	1.920	m
Critical Euler load N_{cr}	68.81	753.36	kN
Slenderness λ	252.69	76.37	
Relative slenderness λ_{rel}	2.91	0.88	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	b	c	
Imperfection α	0.34	0.49	
Reduction factor χ	0.11	0.61	
Buckling resistance $N_{b,Rd}$	61.35	357.00	kN

Flexural Buckling verification		
Cross-section area A	2.1200e-03	m ²
Buckling resistance $N_{b,Rd}$	61.35	kN
Unity check	0.11	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	8.2917e-05	m ³
Elastic critical moment M_{cr}	93.09	kNm
Relative slenderness $\lambda_{rel,LT}$	0.49	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M _{cr} parameters		
LTB length l_{LT}	3.600	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.95	
LTB moment factor C_2	0.26	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

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	2.1200e-03	m ²
Plastic section modulus $W_{pl,y}$	8.2917e-05	m ³
Plastic section modulus $W_{pl,z}$	4.1125e-05	m ³
Design compression force N_{Ed}	6.92	kN
Design bending moment (maximum) $M_{y,Ed}$	-9.34	kNm
Design bending moment (maximum) $M_{z,Ed}$	-1.08	kNm
Characteristic compression resistance N_{Rk}	583.00	kN
Characteristic moment resistance $M_{y,Rk}$	22.80	kNm
Characteristic moment resistance $M_{z,Rk}$	11.31	kNm
Reduction factor χ_y	0.11	
Reduction factor χ_z	0.61	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.03	
Interaction factor k_{yz}	0.95	
Interaction factor k_{zy}	0.65	
Interaction factor k_{zz}	1.07	

Maximum moment $M_{y,Ed}$ is derived from beam B579 position 0.000 m.

Maximum moment $M_{z,Ed}$ is derived from beam B579 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	68.81	kN
Critical Euler load $N_{cr,z}$	753.36	kN
Elastic critical load $N_{cr,T}$	2038.85	kN
Plastic section modulus $W_{pl,y}$	8.2917e-05	m ³
Elastic section modulus $W_{el,y}$	7.2800e-05	m ³
Plastic section modulus $W_{pl,z}$	4.1125e-05	m ³
Elastic section modulus $W_{el,z}$	2.6800e-05	m ³
Second moment of area I_y	3.4900e-06	m ⁴
Second moment of area I_z	1.3400e-06	m ⁴
Torsional constant I_t	5.2400e-08	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-9.34	kNm
Maximum relative deflection δ_z	-23.8	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) $M_{z,Ed}$	-1.08	kNm
Maximum relative deflection δ_y	-0.6	mm
Equivalent moment factor $C_{mz,0}$	0.99	
Factor μ_y	0.91	
Factor μ_z	1.00	
Factor ϵ_y	39.32	
Factor a_{LT}	0.98	
Critical moment for uniform bending $M_{cr,0}$	31.55	kNm
Relative slenderness $\lambda_{rel,0}$	0.85	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.34	
Equivalent moment factor C_{my}	0.99	
Equivalent moment factor C_{mz}	0.99	
Equivalent moment factor C_{mLT}	1.00	

Interaction method 1 parameters		
Factor b_{LT}	0.01	
Factor c_{LT}	0.53	
Factor d_{LT}	0.10	
Factor e_{LT}	0.84	
Factor w_y	1.14	
Factor w_z	1.50	
Factor η_{pl}	0.01	
Maximum relative slenderness $\lambda_{rel,max}$	2.91	
Factor C_{yy}	0.98	
Factor C_{yz}	0.66	
Factor C_{zy}	0.89	
Factor C_{zz}	0.94	

Unity check (6.61) = 0.11 + 0.42 + 0.09 = 0.62 -

Unity check (6.62) = 0.02 + 0.26 + 0.10 = 0.39 -

Shear Buckling check

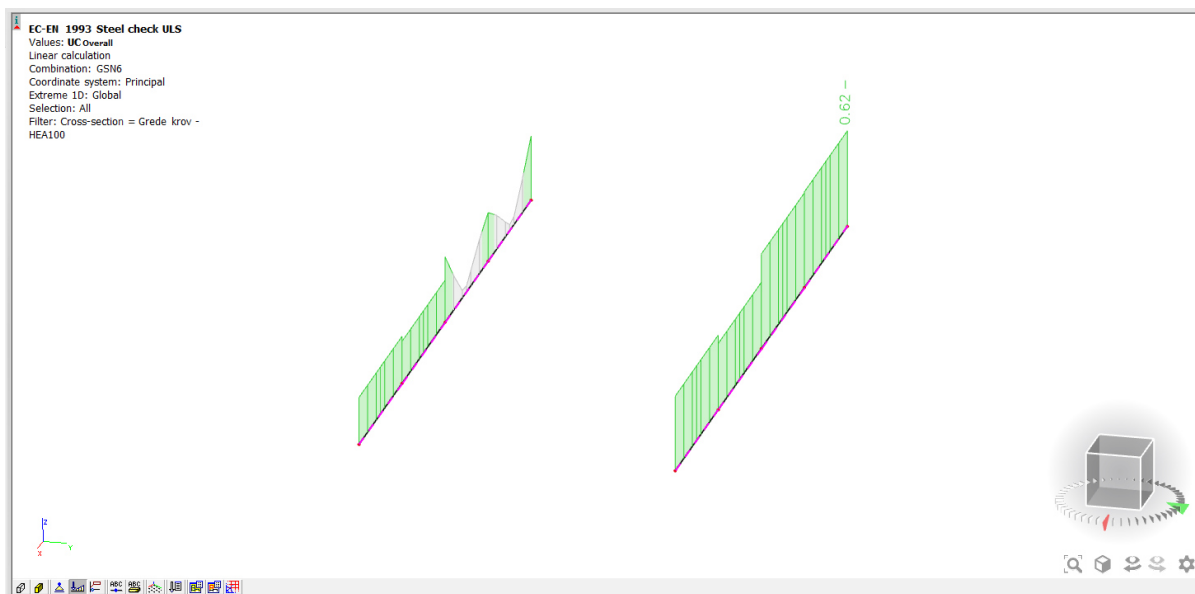
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	14,400	m
Web	unstiffened	
Web height h_w	80	mm
Web thickness t	5	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	16.00
Web slenderness limit	55.46

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

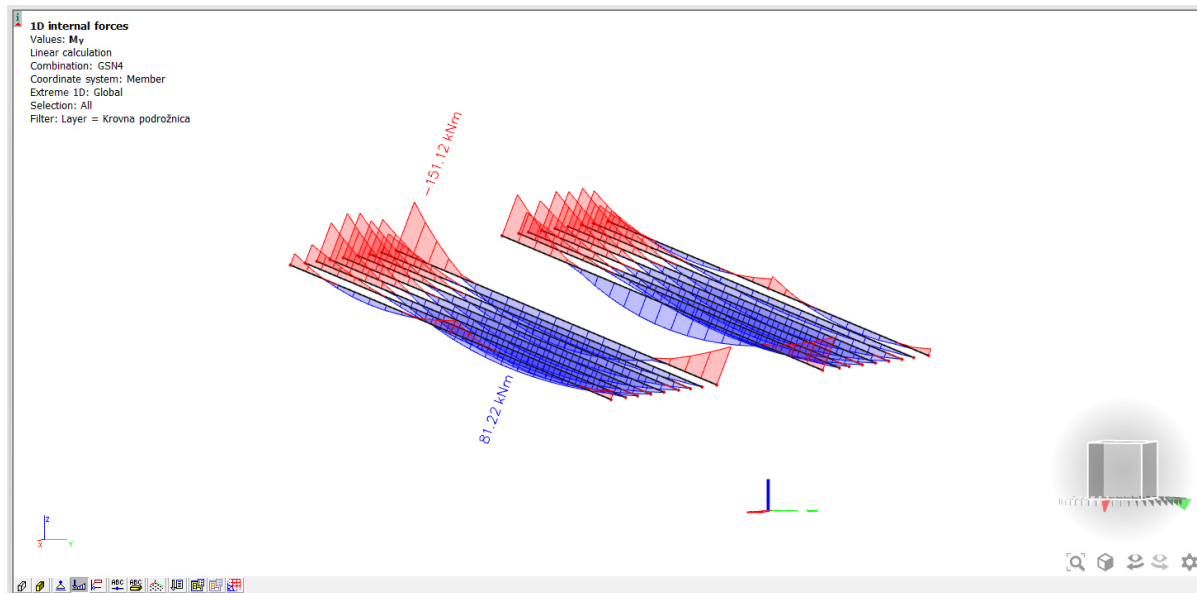
The member satisfies the stability check.



Slika 57. Prikaz iskoristivosti krovnih greda

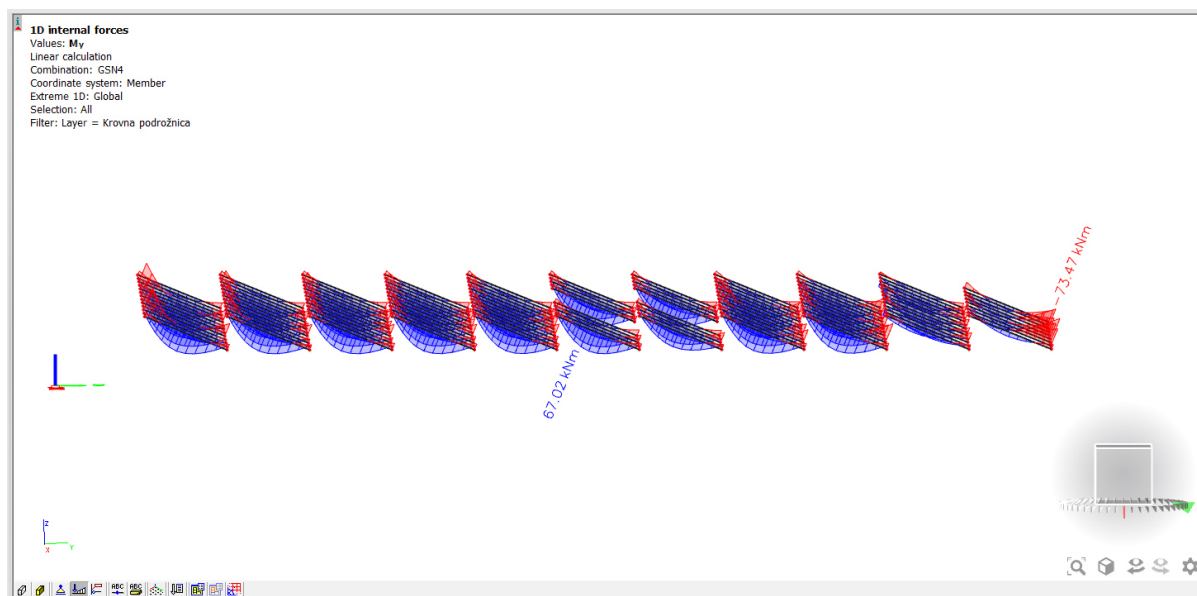
4.3.2 Dimenzioniranje krovnih nosača – Pozicija 2, 5, 15

Moment savijanja M_y dužih krovnih nosača:



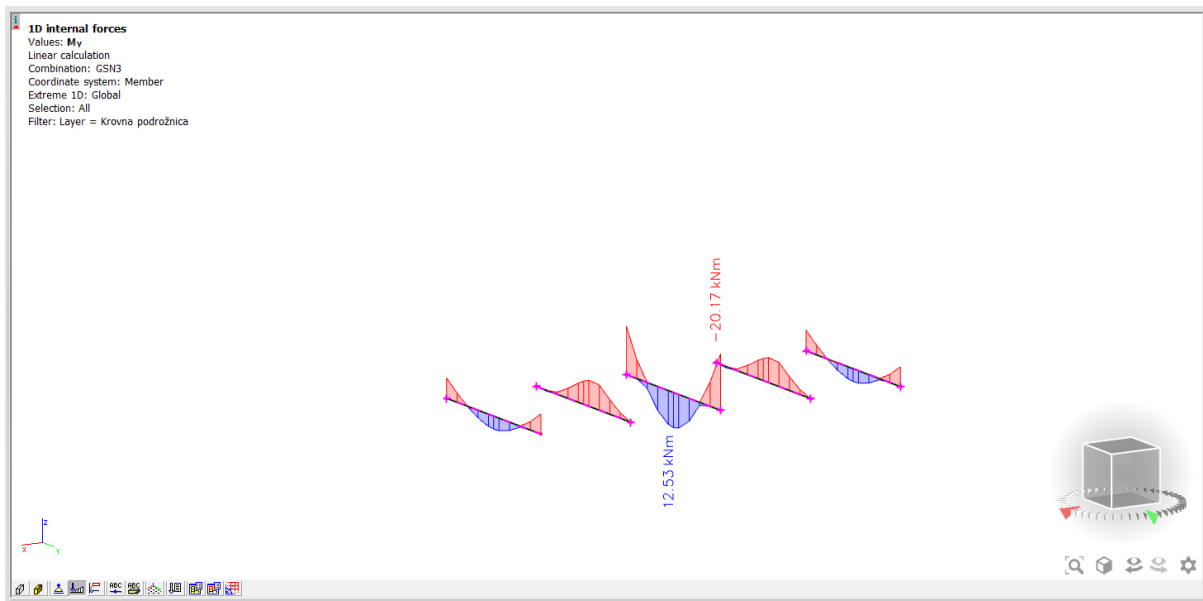
Slika 58. Prikaz momenta savijanja M_y dužih krovnih nosača

Moment savijanja M_y kraćih krovnih nosača:



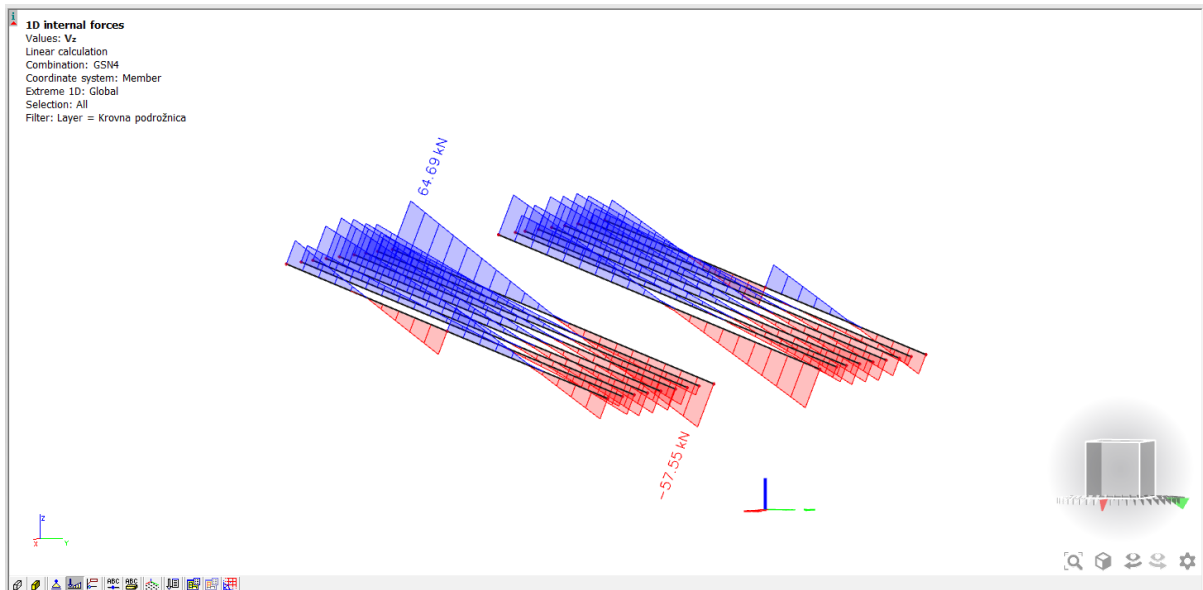
Slika 59. Prikaz momenta savijanja M_y kraćih krovnih nosača

Moment savijanja M_y krovnih nosača na kućici:



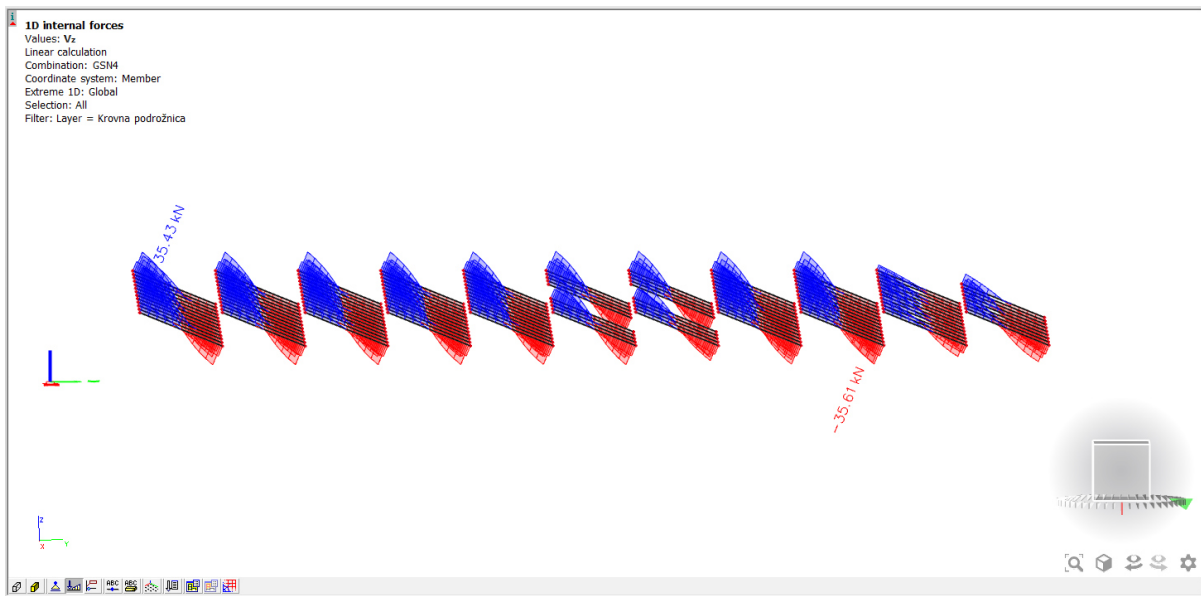
Slika 60. Prikaz momenta savijanja M_y krovnih nosača na kućici

Poprečna sila V_z dužih krovnih nosača:



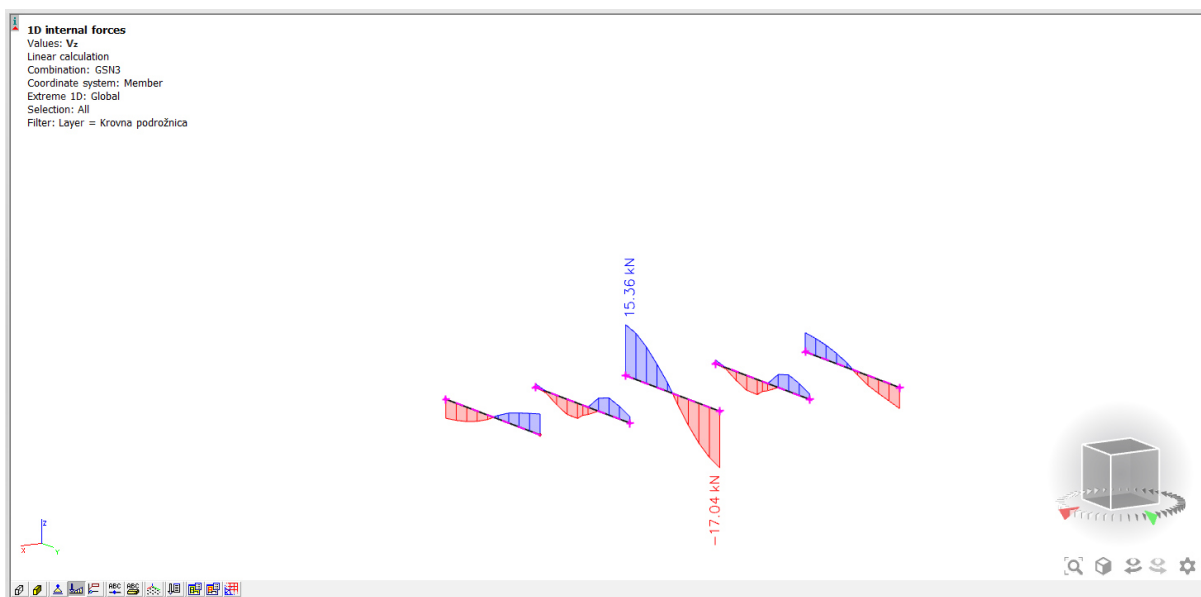
Slika 61. Prikaz poprečne sile V_z dužih krovnih nosača

Poprečna sila V_z kraćih krovnih nosača:



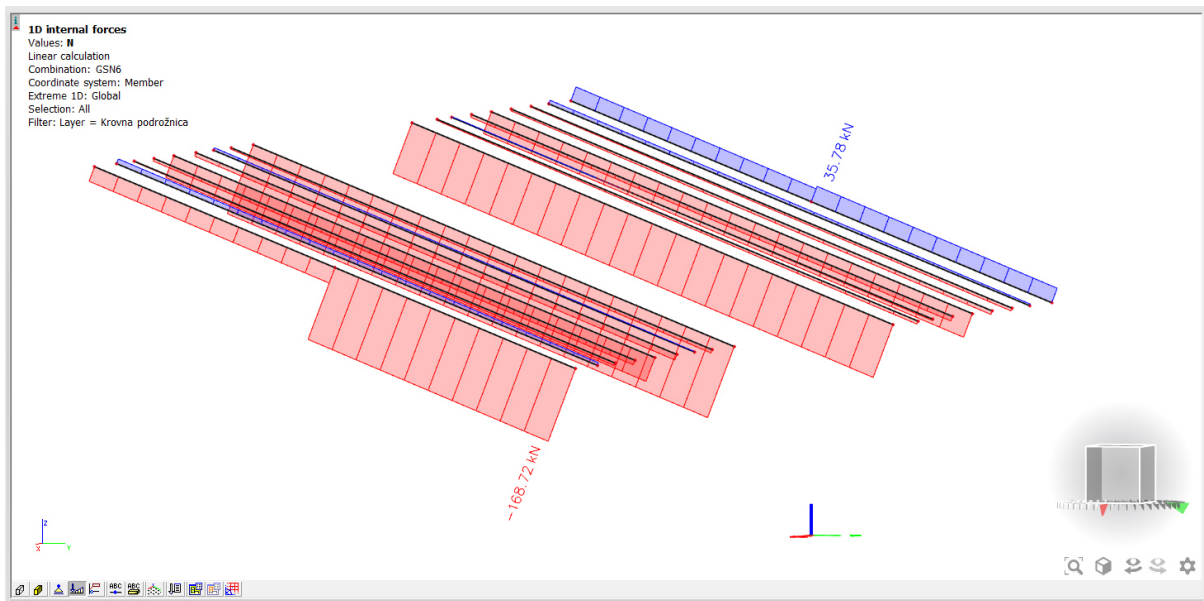
Slika 62. Prikaz poprečne sile V_z kraćih krovnih nosača

Poprečna sila V_z krovnih nosača na kućici:



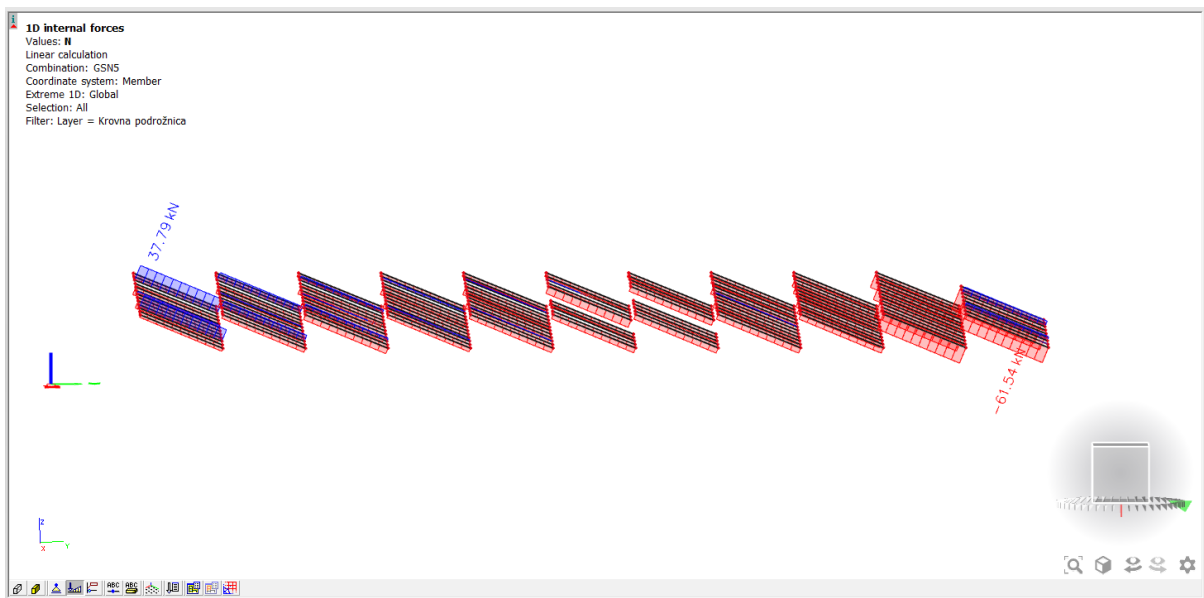
Slika 63. Prikaz poprečne sile V_z krovnih nosača na kućici

Uzdužna sila N dužih krovnih nosača:



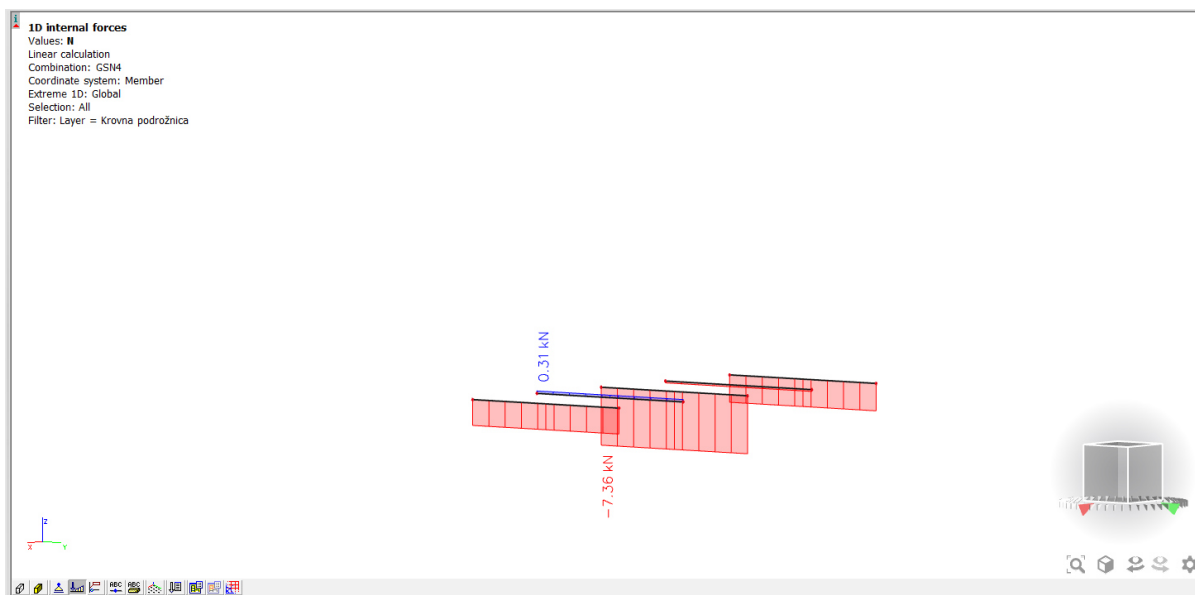
Slika 64. Prikaz uzdužne sile N dužih krovnih nosača

Uzdužna sila N kračih krovnih nosača:



Slika 65. Prikaz uzdužne sile N kračih krovnih nosača

Uzdužna sila N krovnih nosača na kućici:



Slika 66. Prikaz uzdužne sile N krovnih nosača na kućici

Provjera finalnog poprečnog presjeka krovnih nosača u modulu Steel.

Odabran profil za duži krovni nosač – HEA260

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN4
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Krovna področnica

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

Member B739	13.742 / 13.742 m	HEA260	S 275	GSN4	0.77 -
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Combination key	
GSN4 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"0+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 0+ + 1.35*LC6_Vjetar "Trenje 0 i 180 "	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 13.742 m

Internal forces	Calculated	Unit
N_{Ed}	-103.42	kN
$V_{y,Ed}$	-0.03	kN
$V_{z,Ed}$	-57.55	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-119.26	kNm
$M_{z,Ed}$	-0.16	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	1.475e+05	1.479e+05	1.00	0.43	1.00	8.18	8.32	9.24	12.73	1
3	SO	102	12	1.472e+05	1.468e+05	1.00	0.43	1.00	8.18	8.32	9.24	12.76	1
4	I	177	8	1.128e+05	-8.902e+04	-0.79		0.64	23.60	46.06	54.48	92.63	1
5	SO	102	12	-1.236e+05	-1.241e+05								
7	SO	102	12	-1.234e+05	-1.229e+05								

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	8.6800e-03	m ²
$N_{c,Rd}$	2387.00	kN
Unity check	0.04	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	9.2083e-04	m ³
$M_{pl,y,Rd}$	253.23	kNm
Unity check	0.47	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	4.2917e-04	m ³
$M_{pl,z,Rd}$	118.02	kNm
Unity check	0.00	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	6.7363e-03	m ²
$V_{pl,y,Rd}$	1069.52	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	2.8737e-03	m ²
$V_{pl,z,Rd}$	456.27	kN
Unity check	0.13	-

Torsion check

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

Fibre	2	
T_{Ed}	0.0	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	253.23	kNm
α	2.00	
$M_{pl,z,Rd}$	118.02	kNm
β	1.00	

Unity check (6.41) = 0.22 + 0.00 = 0.22 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	1.828e+05	1.821e+05	1.00	0.43	1.00	8.18	8.32	9.24	12.77	1
3	SO	102	12	1.832e+05	1.839e+05	1.00	0.43	1.00	8.18	8.32	9.24	12.73	1
4	I	177	8	1.393e+05	-1.165e+05	-0.84		0.64	23.60	46.68	55.18	96.84	1
5	SO	102	12	-1.600e+05	-1.593e+05								
7	SO	102	12	-1.604e+05	-1.612e+05								

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	13.742	13.742	m
Buckling factor k	1.03	0.51	
Buckling length l_{cr}	14.113	6.957	m
Critical Euler load N_{cr}	1092.61	1571.39	kN
Slenderness λ	128.32	107.00	
Relative slenderness λ_{rel}	1.48	1.23	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	b	c	
Imperfection α	0.34	0.49	
Reduction factor χ	0.35	0.42	
Buckling resistance $N_{b,Rd}$	836.47	999.10	kN

Flexural Buckling verification		
Cross-section area A	8.6800e-03	m ²
Buckling resistance $N_{b,Rd}$	836.47	kN
Unity check	0.12	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic critical moment M_{cr}	360.59	kNm
Relative slenderness $\lambda_{rel,LT}$	0.84	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	
LTB curve	b	
Imperfection α_{LT}	0.34	
LTB factor β	0.75	
Reduction factor χ_{LT}	0.80	
Correction factor k_c	0.62	
Correction factor f	0.81	
Modified reduction factor $\chi_{LT,mod}$	0.98	
Design buckling resistance $M_{b,Rd}$	248.51	kNm
Unity check	0.48	-

M _{cr} parameters		
LTB length l_{LT}	13.742	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.59	
LTB moment factor C_2	1.44	
LTB moment factor C_3	0.41	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECSS 119 2006 / Galea 2002.**Note:** The correction factor k_c is determined from C_1 .**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	8.6800e-03	m ²
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Design compression force N_{Ed}	103.42	kN
Design bending moment (maximum) $M_{y,Ed}$	-151.12	kNm
Design bending moment (maximum) $M_{z,Ed}$	0.26	kNm
Characteristic compression resistance N_{Rk}	2387.00	kN
Characteristic moment resistance $M_{y,Rk}$	253.23	kNm
Characteristic moment resistance $M_{z,Rk}$	118.02	kNm
Reduction factor χ_y	0.35	
Reduction factor χ_z	0.42	
Modified reduction factor $\chi_{LT,mod}$	0.98	
Interaction factor k_{yy}	1.06	
Interaction factor k_{yz}	0.98	
Interaction factor k_{zy}	0.59	
Interaction factor k_{zz}	0.66	

Maximum moment $M_{y,Ed}$ is derived from beam B739 position 0.000 m.Maximum moment $M_{z,Ed}$ is derived from beam B739 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	1092.61	kN
Critical Euler load $N_{cr,z}$	1571.39	kN
Elastic critical load $N_{cr,T}$	2939.70	kN
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic section modulus $W_{el,y}$	8.3600e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Elastic section modulus $W_{el,z}$	2.8200e-04	m ³
Second moment of area I_y	1.0500e-04	m ⁴
Second moment of area I_z	3.6700e-05	m ⁴
Torsional constant I_t	5.2400e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-151.12	kNm
Maximum relative deflection δ_z	-43.9	mm
Equivalent moment factor $C_{my,0}$	0.94	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments μ_z	-0.61	
Equivalent moment factor $C_{mz,0}$	0.64	
Factor μ_y	0.94	
Factor μ_z	0.96	
Factor ϵ_y	15.17	

Interaction method 1 parameters		
Factor a_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	139.03	kNm
Relative slenderness $\lambda_{rel,0}$	1.35	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.31	
Equivalent moment factor C_{my}	0.99	
Equivalent moment factor C_{mz}	0.64	
Equivalent moment factor C_{mLT}	1.02	
Factor b_{LT}	0.00	
Factor c_{LT}	1.53	
Factor d_{LT}	0.00	
Factor e_{LT}	0.58	
Factor w_y	1.10	
Factor w_z	1.50	
Factor n_{pl}	0.04	
Maximum relative slenderness $\lambda_{rel,max}$	1.48	
Factor C_{yy}	0.99	
Factor C_{yz}	0.46	
Factor C_{zy}	0.93	
Factor C_{zz}	1.00	

Unity check (6.61) = $0.12 + 0.64 + 0.00 = 0.77$ -

Unity check (6.62) = $0.10 + 0.36 + 0.00 = 0.47$ -

Shear Buckling check

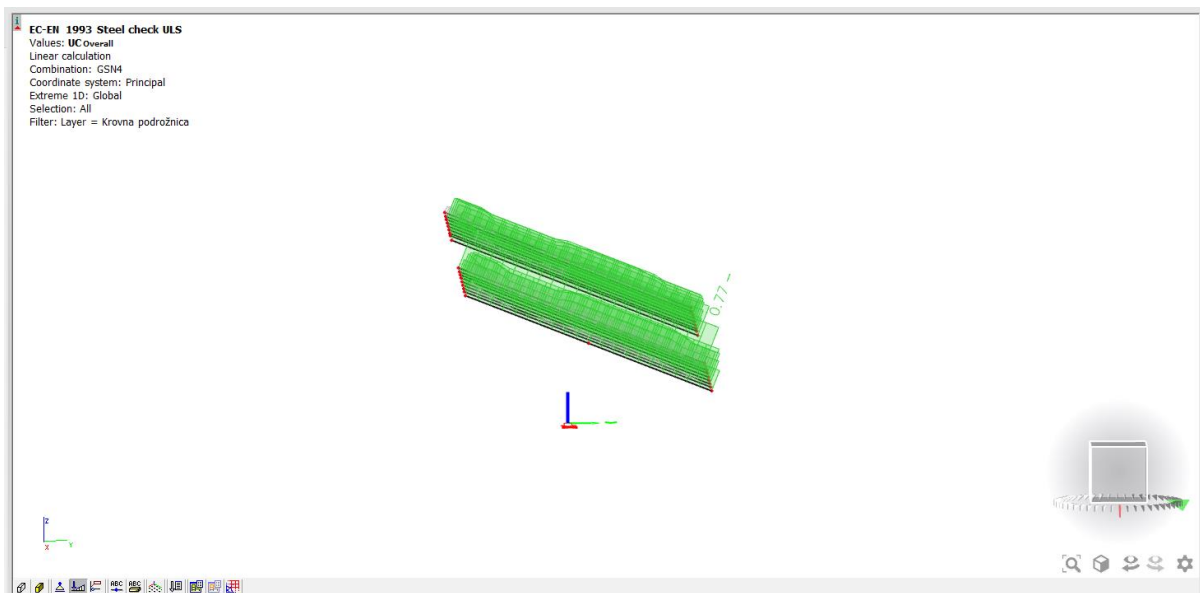
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	13.742	m
Web	unstiffened	
Web height h_w	225	mm
Web thickness t	8	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	30.00
Web slenderness limit	55.46

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.



Slika 67. Prikaz iskoristivosti dužih krovnih nosača

Odabran profil za kraći krovni nosač – HEA220

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavna sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN4
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Krovna podrožnica

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

Member B789	4.145 / 6.908 m	HEA220	S 275	GSN4	0.59 -
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Combination key	
GSN4 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"0+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 0+ + 1.35*LC6_Vjetar "Trenje 0 i 180 "	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

...:SECTION CHECK:...

The critical check is on position 4.145 m

Internal forces	Calculated	Unit
N_{Ed}	6.43	kN
$V_{y,Ed}$	-4.62	kN
$V_{z,Ed}$	-9.28	kN
T_{Ed}	-0.01	kNm
$M_{y,Ed}$	63.73	kNm
$M_{z,Ed}$	-4.45	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	88	11	-1.133e+05	-9.317e+04								
3	SO	88	11	-1.231e+05	-1.432e+05								
4	I	152	7	-9.051e+04	8.852e+04	-1.02		0.49	21.71	68.05	78.45	117.22	1
5	SO	88	11	1.113e+05	9.117e+04	0.82	0.50	1.00	8.05	8.32	9.24	13.71	1
7	SO	88	11	1.211e+05	1.412e+05	0.86	0.44	1.00	8.05	8.32	9.24	12.90	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	6.4300e-03	m ²
$N_{pl,Rd}$	1768.25	kN
$N_{u,Rd}$	1990.73	kN
$N_{t,Rd}$	1768.25	kN
Unity check	0.00	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	5.6667e-04	m ³
$M_{pl,y,Rd}$	155.83	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)

$W_{pl,z}$	2.7042e-04	m ³
$M_{pl,z,Rd}$	74.36	kNm
Unity check	0.06	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	5.0150e-03	m ²
$V_{pl,y,Rd}$	796.24	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	2.0630e-03	m ²
$V_{pl,z,Rd}$	327.55	kN
Unity check	0.03	-

Torsion check

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

Fibre	2	
T_{Ed}	0.5	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	155.83	kNm
α	2.00	
$M_{pl,z,Rd}$	74.36	kNm
β	1.00	

Unity check (6.41) = 0.17 + 0.06 = 0.23 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis is neglected.

The member satisfies the section check.

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

Classification for member buckling design

Decisive position for stability classification: 4.836 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	88	11	-9.276e+04	-5.819e+04								
3	SO	88	11	-1.096e+05	-1.441e+05								
4	I	152	7	-7.750e+04	7.556e+04	-1.03		0.49	21.71	68.01	78.40	117.59	1
5	SO	88	11	9.082e+04	5.624e+04	0.62	0.60	1.00	8.05	8.32	9.24	15.07	1
7	SO	88	11	1.076e+05	1.422e+05	0.76	0.45	1.00	8.05	8.32	9.24	13.04	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 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	5.6667e-04	m ³
Elastic critical moment M_{cr}	184.30	kNm
Relative slenderness $\lambda_{rel,LT}$	0.92	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	
LTB curve	b	
Imperfection α_{LT}	0.34	
LTB factor β	0.75	
Reduction factor χ_{LT}	0.75	
Correction factor k_c	0.94	
Correction factor f	0.97	
Modified reduction factor $\chi_{LT,mod}$	0.77	
Design buckling resistance $M_{b,Rd}$	120.01	kNm
Unity check	0.53	-

M _c parameters		
LTB length l_{LT}	6.908	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	1.13	
LTB moment factor C_2	0.45	
LTB moment factor C_3	0.53	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECSS 119 2006 / Galea 2002.

Note: The correction factor k_c is determined from C_1 .

Bending and axial tension check

According to EN 1993-1-3 article 6.3

Design tension force N_{Ed}	6.43	kN
Design bending moment $M_{y,Ed}$	63.73	kNm
Design bending moment $M_{z,Ed}$	-4.45	kNm
Tension resistance $N_{t,Rd}$	1768.25	kN
Bending resistance $M_{b,y,Rd}$	120.01	kNm
Bending resistance $M_{c,z,Rd,com}$	74.36	kNm

Unity check = $0.53 + 0.06 - 0.00 = 0.59$ -

Shear Buckling check

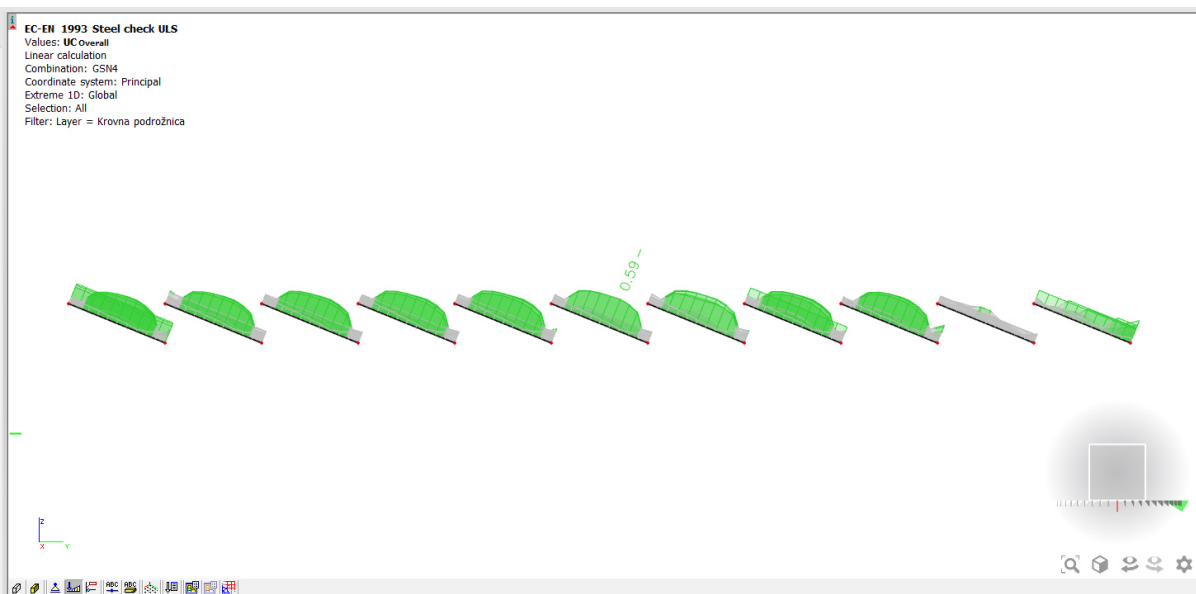
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	6.908	m
Web	unstiffened	
Web height h_w	188	mm
Web thickness t	7	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	26.86
Web slenderness limit	55.46

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.



Slika 68. Prikaz iskoristivosti kraćih krovnih nosača

Odabran profil za krovni nosač na kućici – HEA120

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavna sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN3
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Krovna podrožnica

EN 1993-1-1 Code Check

National annex: Standard EN

Member B582	6.400 / 6.400 m	HEA120	S 275	GSN3	0.68 -
-------------	-----------------	--------	-------	------	--------

Combination key
GSN3 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenljivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"180+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 180+ + 1.35*LC6_Vjetar "Trenje 0 i 180 "

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

...:SECTION CHECK:....

The critical check is on position 6.400 m

Internal forces	Calculated	Unit
N_{Ed}	-7.55	kN
$V_{y,Ed}$	-0.01	kN
$V_{z,Ed}$	-17.04	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-20.17	kNm
$M_{z,Ed}$	-0.05	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_{σ} [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	46	8	1.796e+05	1.806e+05	0.99	0.43	1.00	5.69	8.32	9.24	12.74	1
3	SO	46	8	1.790e+05	1.780e+05	0.99	0.43	1.00	5.69	8.32	9.24	12.78	1
4	I	74	5	1.261e+05	-1.201e+05	-0.95		0.54	14.80	59.60	69.31	108.95	1
5	SO	46	8	-1.736e+05	-1.746e+05								
7	SO	46	8	-1.730e+05	-1.720e+05								

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	2.5300e-03	m ²
$N_{c,Rd}$	695.75	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_{ply}	1.1958e-04	m ³
$M_{pl,y,Rd}$	32.89	kNm
Unity check	0.61	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	5.8750e-05	m ³
$M_{pl,z,Rd}$	16.16	kNm
Unity check	0.00	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	2.0050e-03	m ²
$V_{pl,y,Rd}$	318.34	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	8.4200e-04	m ²
$V_{pl,z,Rd}$	133.69	kN
Unity check	0.13	-

Torsion check

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

Fibre	2	
T_{Ed}	0.0	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	32.89	kNm
α	2.00	
$M_{pl,z,Rd}$	16.16	kNm
β	1.00	

Unity check (6.41) = 0.38 + 0.00 = 0.38 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis is neglected.

The member satisfies the section check.

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

Classification for member buckling design

Decisive position for stability classification: 6.400 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	46	8	1.796e+05	1.806e+05	0.99	0.43	1.00	5.69	8.32	9.24	12.74	1
3	SO	46	8	1.790e+05	1.780e+05	0.99	0.43	1.00	5.69	8.32	9.24	12.78	1
4	I	74	5	1.261e+05	-1.201e+05	-0.95		0.54	14.80	59.60	69.31	108.95	1
5	SO	46	8	-1.736e+05	-1.746e+05								
7	SO	46	8	-1.730e+05	-1.720e+05								

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	6.400	6.400	m
Buckling factor k	1.22	0.59	
Buckling length l_{cr}	7.778	3.793	m
Critical Euler load N_{cr}	207.64	332.76	kN
Slenderness λ	158.92	125.53	
Relative slenderness λ_{rel}	1.83	1.45	
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: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	1.1958e-04	m ³
Elastic critical moment M_{cr}	50.51	kNm
Relative slenderness $\lambda_{rel,LT}$	0.81	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	
LTB curve	b	
Imperfection α_{LT}	0.34	
LTB factor β	0.75	
Reduction factor χ_{LT}	0.81	
Correction factor k_c	0.70	
Correction factor f	0.85	
Modified reduction factor $\chi_{LT,mod}$	0.96	
Design buckling resistance $M_{b,Rd}$	31.51	kNm
Unity check	0.64	-

Mcr parameters		
LTB length l_{LT}	6.400	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.06	
LTB moment factor C_2	1.27	
LTB moment factor C_3	0.41	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_1	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

Note: The correction factor k_c is determined from C_1 .

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	2.5300e-03	m ²
Plastic section modulus $W_{pl,y}$	1.1958e-04	m ³
Plastic section modulus $W_{pl,z}$	5.8750e-05	m ³
Design compression force N_{Ed}	7.55	kN
Design bending moment (maximum) $M_{y,Ed}$	-20.17	kNm
Design bending moment (maximum) $M_{z,Ed}$	-0.05	kNm
Characteristic compression resistance N_{Rk}	695.75	kN
Characteristic moment resistance $M_{y,Rk}$	32.89	kNm
Characteristic moment resistance $M_{z,Rk}$	16.16	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	0.96	
Interaction factor k_{yy}	1.04	
Interaction factor k_{yz}	0.79	
Interaction factor k_{zy}	0.56	
Interaction factor k_{zz}	0.63	

Maximum moment $M_{y,Ed}$ is derived from beam B582 position 6.400 m.

Maximum moment $M_{z,Ed}$ is derived from beam B582 position 6.400 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	207.64	kN
Critical Euler load $N_{cr,z}$	332.76	kN
Elastic critical load $N_{cr,T}$	1561.39	kN
Plastic section modulus $W_{pl,y}$	1.1958e-04	m ³
Elastic section modulus $W_{el,y}$	1.0600e-04	m ³
Plastic section modulus $W_{pl,z}$	5.8750e-05	m ³
Elastic section modulus $W_{el,z}$	3.8500e-05	m ³
Second moment of area I_y	6.0600e-06	m ⁴
Second moment of area I_z	2.3100e-06	m ⁴
Torsional constant I_t	5.9900e-08	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-20.17	kNm
Maximum relative deflection δ_z	-27.4	mm
Equivalent moment factor $C_{my,0}$	0.98	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments ψ_z	-0.81	
Equivalent moment factor $C_{mz,0}$	0.61	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor E_y	63.72	
Factor α_{LT}	0.99	
Critical moment for uniform bending $M_{cr,0}$	24.57	kNm
Relative slenderness $\lambda_{rel,0}$	1.16	

Interaction method 1 parameters	
Limit relative slenderness $\lambda_{rel,\beta,lim}$	0.28
Equivalent moment factor C_{my}	1.00
Equivalent moment factor C_{mz}	0.61
Equivalent moment factor C_{mLT}	1.00
Factor b_{1T}	0.00
Factor c_{1T}	0.91
Factor d_{1T}	0.00
Factor e_{1T}	0.28
Factor w_y	1.13
Factor w_z	1.50
Factor n_{pl}	0.01
Maximum relative slenderness $\lambda_{rel,max}$	1.83
Factor C_{yy}	0.99
Factor C_{yz}	0.54
Factor C_{zy}	0.97
Factor C_{zz}	1.00

Unity check (6.61) = $0.01 + 0.67 + 0.00 = 0.68$ -

Unity check (6.62) = $0.01 + 0.36 + 0.00 = 0.37$ -

Shear Buckling check

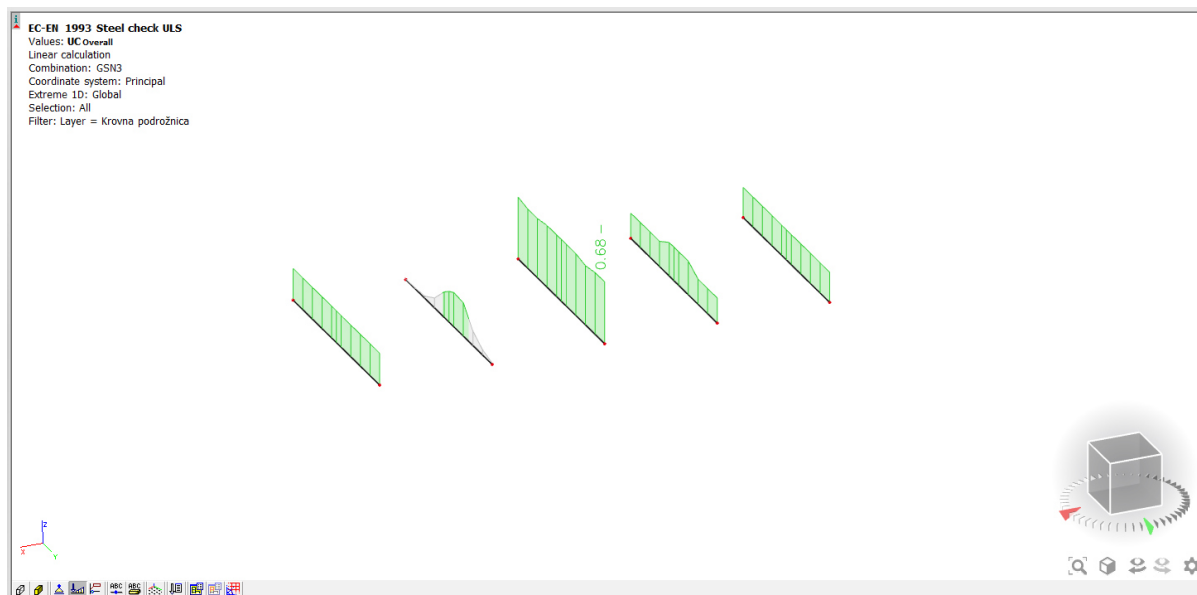
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters	
Buckling field length a	6.400 m
Web	unstiffened
Web height h_w	98 mm
Web thickness t	5 mm
Material coefficient ϵ	0.92
Shear correction factor η	1.20

Shear Buckling verification	
Web slenderness h_w/t	19.60
Web slenderness limit	55.46

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

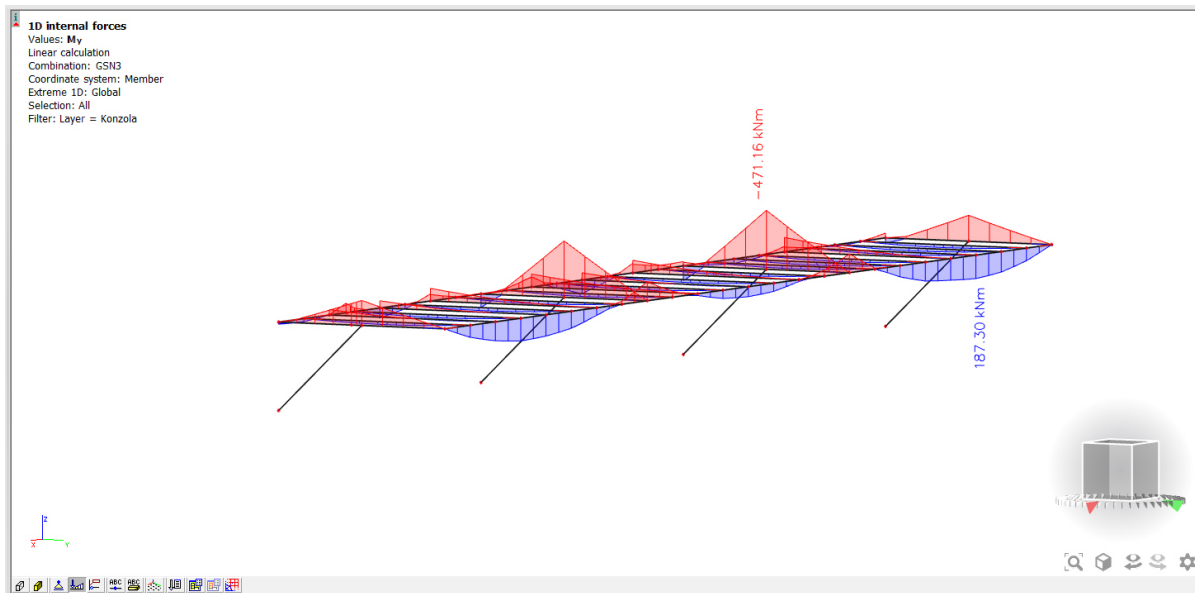
The member satisfies the stability check.



Slika 69. Prikaz iskoristivosti krovnih nosača na kućici

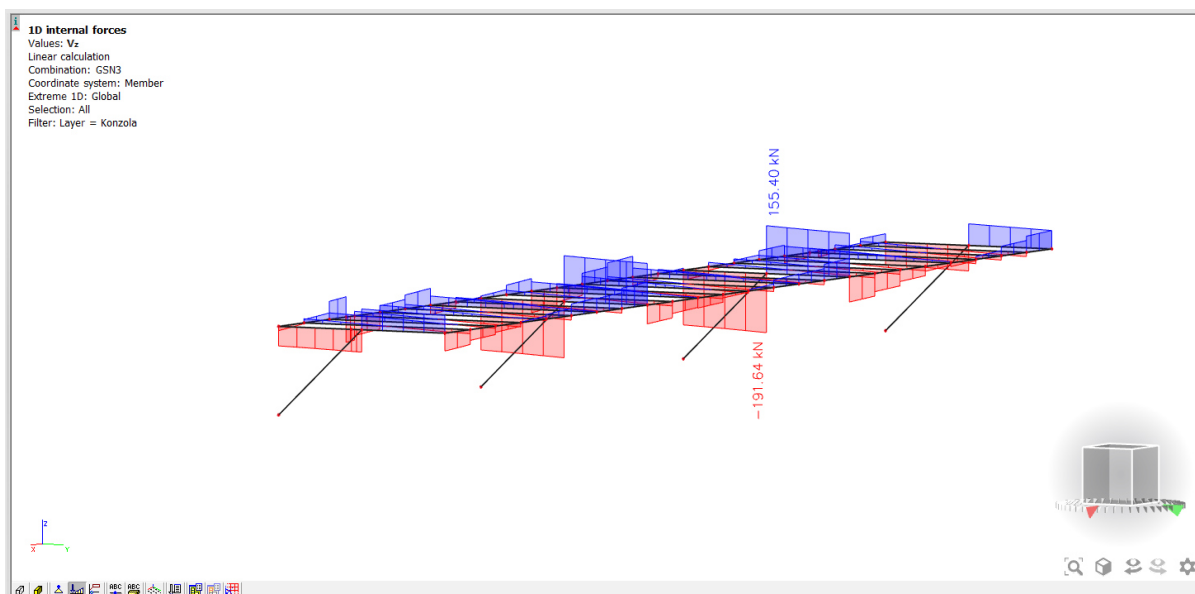
4.3.3 Dimenzioniranje konzole – Pozicija 3, 11, 12, 21

Moment savijanja M_y konzolnih greda:



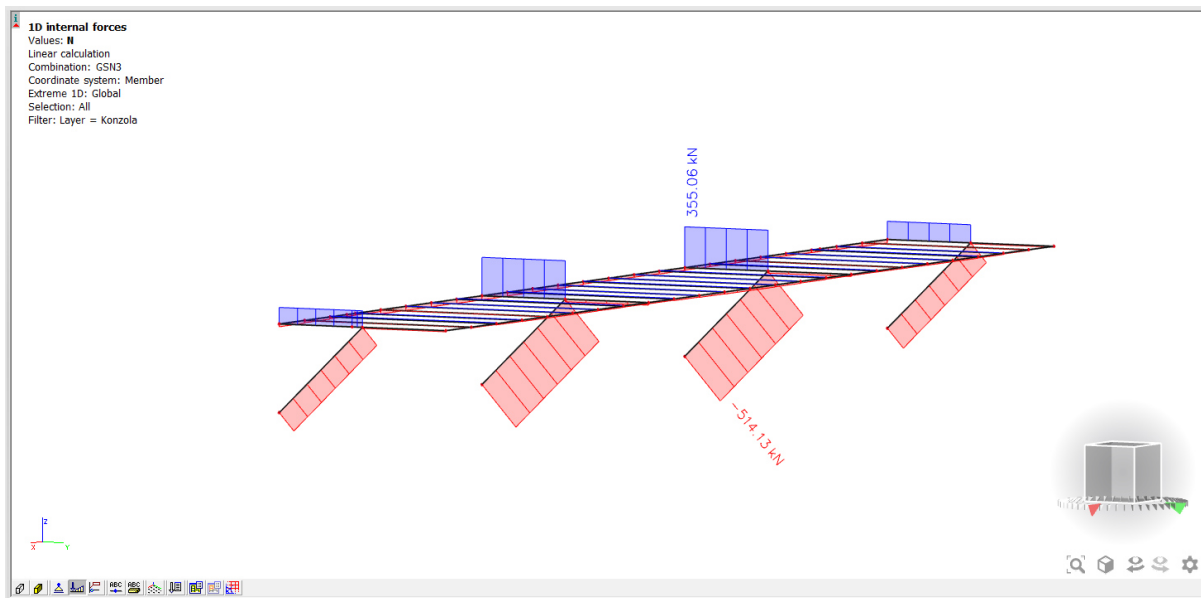
Slika 70. Prikaz momenta savijanja M_y konzolnih greda

Poprečna sila V_z konzolnih greda:



Slika 71. Prikaz poprečne sile V_z konzolnih greda

Uzdužna sila N konzolnih greda:



Slika 72. Prikaz uzdužne sile N konzolnih greda

Proračun finalnog poprečnog presjeka konzole u modulu Steel.

Odabrani profil kosnika – CFRHS 400X200X12.5

Odabrani profil grede na kraju – HEA 600

Odabrani profil grede na početku – HEA 400

Odabrani profil grede u kraćem smjeru – HEA 400

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN3
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Konzola

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

Member B350	3.200 / 6.400 m	HEA400	S 275	GSN3	0.72 -
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Combination key
GSN3 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"180+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 180+ + 1.35*LC6_Vjetar "Trenje 0 i 180 "

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

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

The critical check is on position 3.200 m

Internal forces	Calculated	Unit
N_{Ed}	-18.45	kN
$V_{y,Ed}$	-1.01	kN
$V_{z,Ed}$	155.40	kN
T_{Ed}	-0.01	kNm
$M_{y,Ed}$	-471.16	kNm
$M_{z,Ed}$	-0.10	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	117	19	1.951e+05	1.952e+05	1.00	0.43	1.00	6.18	8.32	9.24	12.73	1
3	SO	117	19	1.950e+05	1.949e+05	1.00	0.43	1.00	6.18	8.32	9.24	12.75	1
4	I	298	11	1.569e+05	-1.546e+05	-0.99		0.51	27.09	64.48	74.53	112.90	1
5	SO	117	19	-1.928e+05	-1.929e+05								
7	SO	117	19	-1.927e+05	-1.926e+05								

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	1.5900e-02	m ²
$N_{c,Rd}$	4372.50	kN
Unity check	0.00	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	2.5625e-03	m ³
$M_{pl,y,Rd}$	704.69	kNm
Unity check	0.67	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	8.7083e-04	m ³
$M_{pl,z,Rd}$	239.48	kNm
Unity check	0.00	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	1.1818e-02	m ²
$V_{pl,y,Rd}$	1876.36	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	5.7350e-03	m ²
$V_{pl,z,Rd}$	910.55	kN
Unity check	0.17	-

Torsion check

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

Fibre	2	
T_{Ed}	0.1	MPa
T_{Rd}	158.8	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)

$M_{rel,y,Rd}$	704.69	kNm
α	2.00	
$M_{pl,z,Rd}$	239.48	kNm
β	1.00	

Unity check (6.41) = 0.45 + 0.00 = 0.45 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis is neglected.

The member satisfies the section check.

...:STABILITY CHECK:...:**Classification for member buckling design**

Decisive position for stability classification: 6.400 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	117	19	1.257e+03	5.826e+03	0.22	0.53	1.00	6.18	8.32	9.24	14.11	1
3	SO	117	19	-1.271e+03	-5.841e+03								
4	I	298	11	2.224e+02	2.099e+03	0.11		1.00	27.09	25.88	31.43	50.93	2
5	SO	117	19	1.065e+03	-3.505e+03	-3.29	23.80	0.23	6.18	73.98	82.20	94.71	1
7	SO	117	19	3.593e+03	8.162e+03	0.44	0.49	1.00	6.18	8.32	9.24	13.60	1

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	6.400	6.400	m
Buckling factor k	2.16	0.52	
Buckling length l_{cr}	13.843	3.319	m
Critical Euler load N_{cr}	4878.13	16103.37	kN
Slenderness λ	82.19	45.24	
Relative slenderness λ_{rel}	0.95	0.52	
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: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	2.5625e-03	m ³
Elastic critical moment M_{cr}	1593.62	kNm
Relative slenderness $\lambda_{rel,LT}$	0.66	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	
LTB curve	b	
Imperfection α_{LT}	0.34	
LTB factor β	0.75	
Reduction factor χ_{LT}	0.89	
Correction factor k_c	0.85	
Correction factor f	0.93	
Modified reduction factor $\chi_{LT,mod}$	0.96	
Design buckling resistance $M_{b,Rd}$	674.72	kNm
Unity check	0.70	-

M _{cr} parameters		
LTB length l_{LT}	6.400	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	1.39	
LTB moment factor C_2	0.74	
LTB moment factor C_3	0.41	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

Note: The correction factor k_c is determined from C_1 .

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	1.5900e-02	m ²
Plastic section modulus $W_{pl,y}$	2.5625e-03	m ³
Plastic section modulus $W_{pl,z}$	8.7083e-04	m ³
Design compression force N_{Ed}	18.45	kN
Design bending moment (maximum) $M_{y,Ed}$	-471.16	kNm
Design bending moment (maximum) $M_{z,Ed}$	-3.33	kNm
Characteristic compression resistance N_{Rk}	4372.50	kN
Characteristic moment resistance $M_{y,Rk}$	704.69	kNm
Characteristic moment resistance $M_{z,Rk}$	239.48	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	0.96	
Interaction factor k_{yy}	1.00	
Interaction factor k_{yz}	0.71	
Interaction factor k_{zy}	0.53	
Interaction factor k_{zz}	0.60	

Maximum moment $M_{y,Ed}$ is derived from beam B350 position 3.200 m.

Maximum moment $M_{z,Ed}$ is derived from beam B350 position 6.400 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	4878.13	kN
Critical Euler load $N_{cr,z}$	16103.37	kN
Elastic critical load $N_{cr,T}$	8934.52	kN
Plastic section modulus $W_{pl,y}$	2.5625e-03	m ³
Elastic section modulus $W_{el,y}$	2.3100e-03	m ³
Plastic section modulus $W_{pl,z}$	8.7083e-04	m ³
Elastic section modulus $W_{el,z}$	5.7100e-04	m ³
Second moment of area I_y	4.5100e-04	m ⁴
Second moment of area I_z	8.5600e-05	m ⁴
Torsional constant I_t	1.8900e-06	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-471.16	kNm
Maximum relative deflection δ_z	-38.1	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 ψ_z	-0.94	
Equivalent moment factor $C_{mz,0}$	0.59	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor ϵ_y	175.73	
Factor α_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	1142.82	kNm
Relative slenderness $\lambda_{rel,0}$	0.79	

Interaction method 1 parameters	
Limit relative slenderness $\lambda_{rel,\beta,lim}$	0.24
Equivalent moment factor C_{my}	1.00
Equivalent moment factor C_{mz}	0.59
Equivalent moment factor C_{mLT}	1.00
Factor b_{LT}	0.00
Factor c_{LT}	0.84
Factor d_{LT}	0.15
Factor e_{LT}	5.34
Factor w_y	1.11
Factor w_z	1.50
Factor η_{pl}	0.00
Maximum relative slenderness $\lambda_{rel,max}$	0.95
Factor C_{yy}	1.00
Factor C_{yz}	0.58
Factor C_{zy}	0.98
Factor C_{zz}	0.99

Unity check (6.61) = 0.00 + 0.70 + 0.01 = 0.72 -
 Unity check (6.62) = 0.00 + 0.37 + 0.01 = 0.38 -

Shear Buckling check

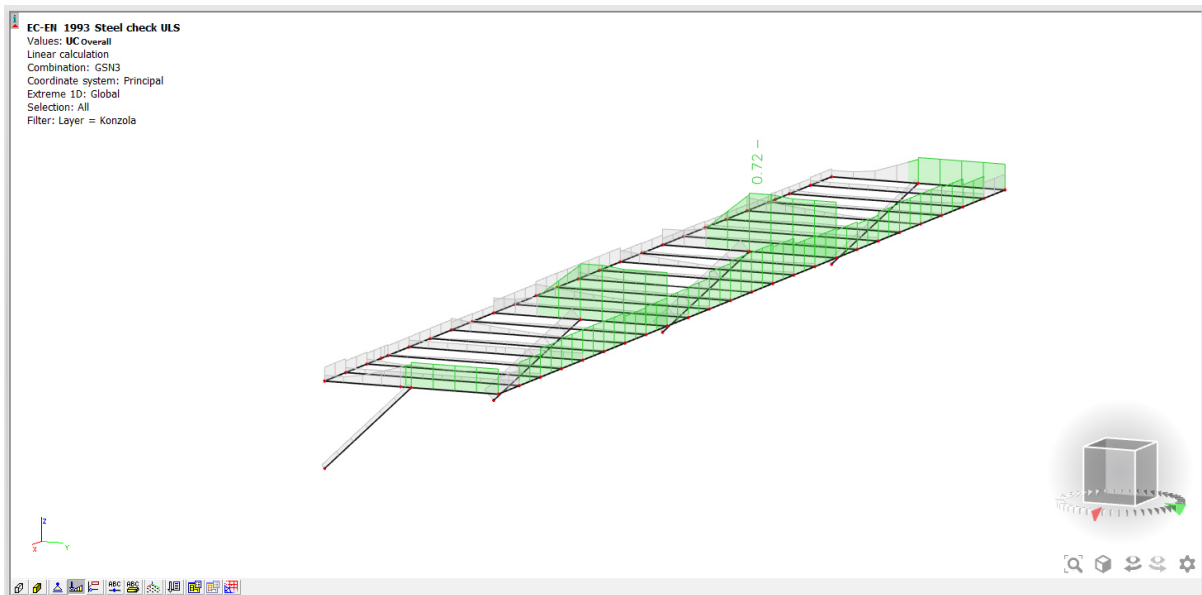
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	6,400	m
Web	unstiffened	
Web height h_w	352	mm
Web thickness t	11	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	32.00
Web slenderness limit	55.46

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

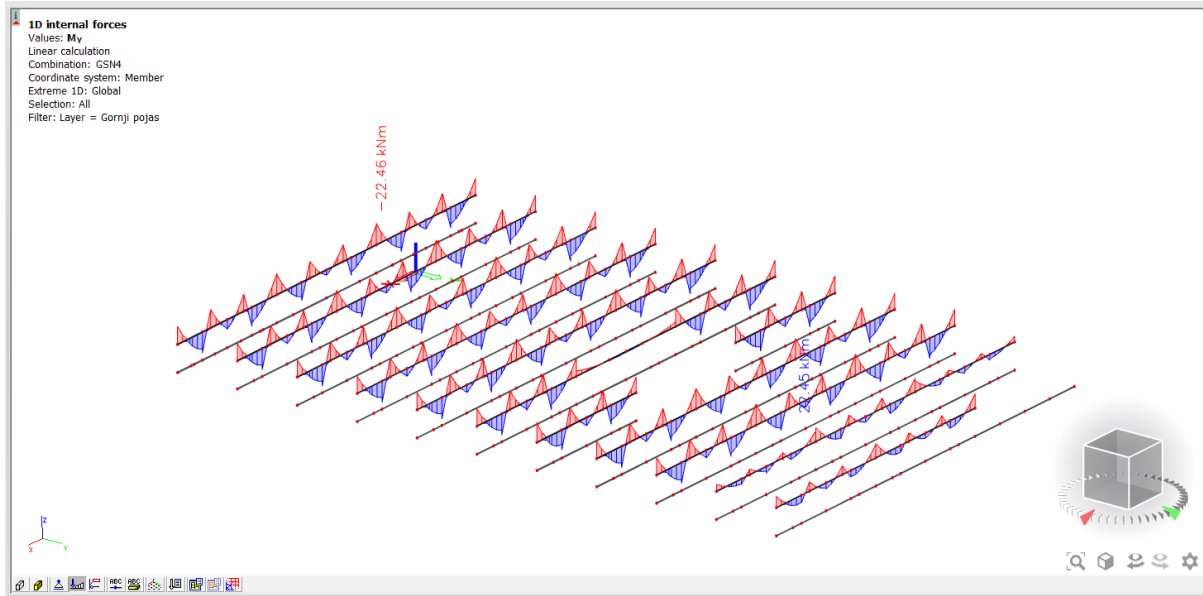
The member satisfies the stability check.



Slika 73. Prikaz iskoristivosti konzolnih greda

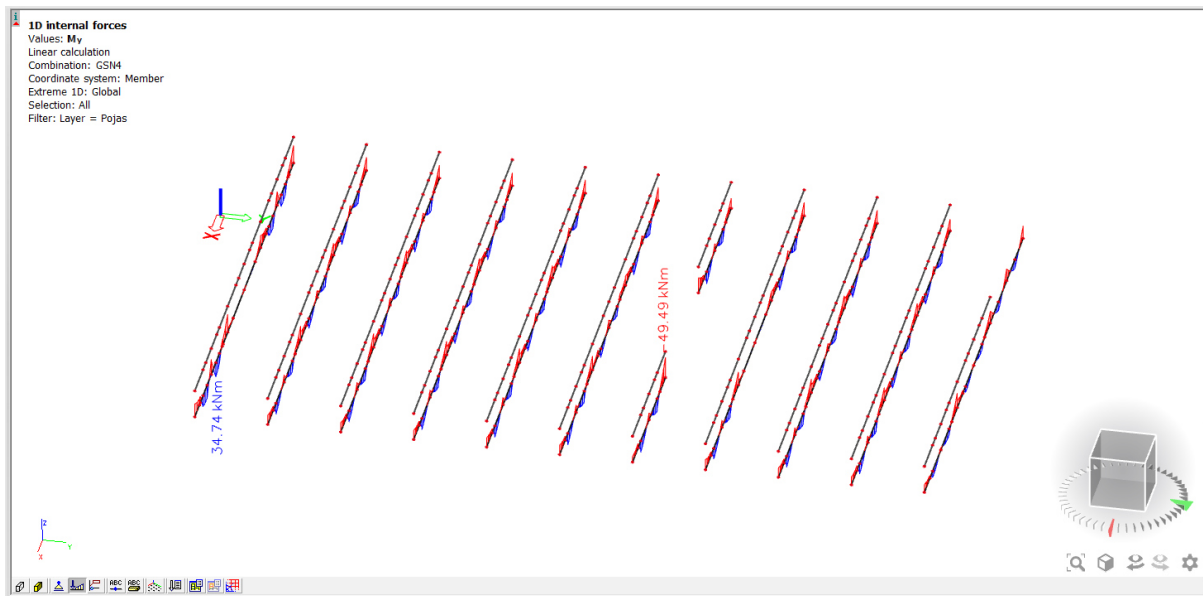
4.3.4 Dimenzioniranje pojasa – Pozicija 4, 16

Moment savijanja M_y u gornjem pojasu:



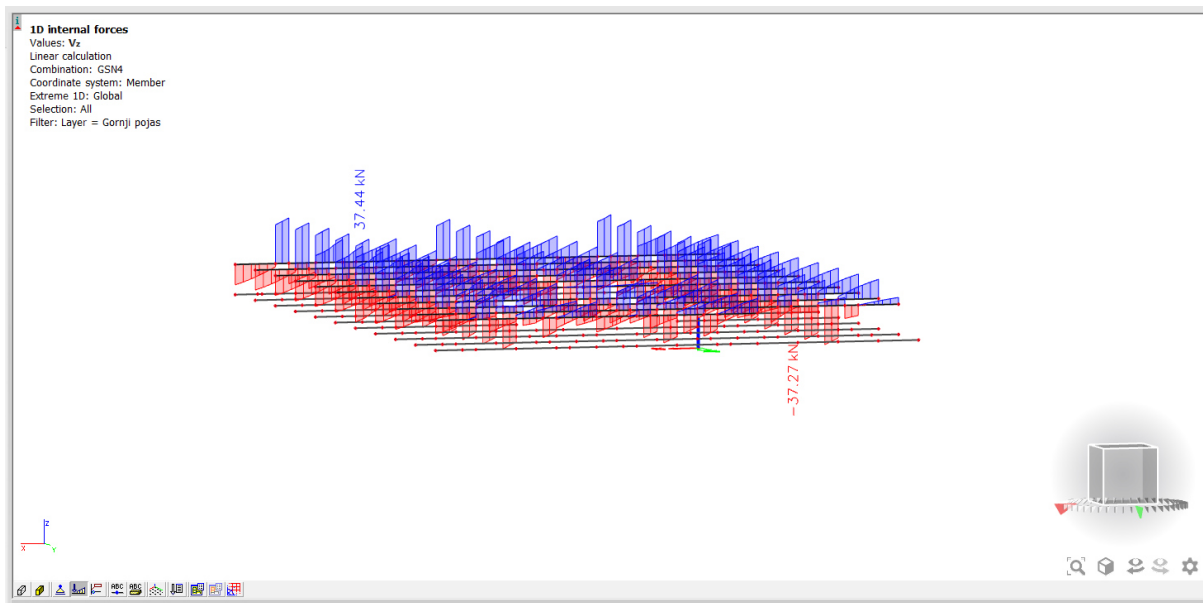
Slika 74. Prikaz momenta savijanja M_y u gornjem pojasu

Moment savijanja M_y u donjem pojasu:



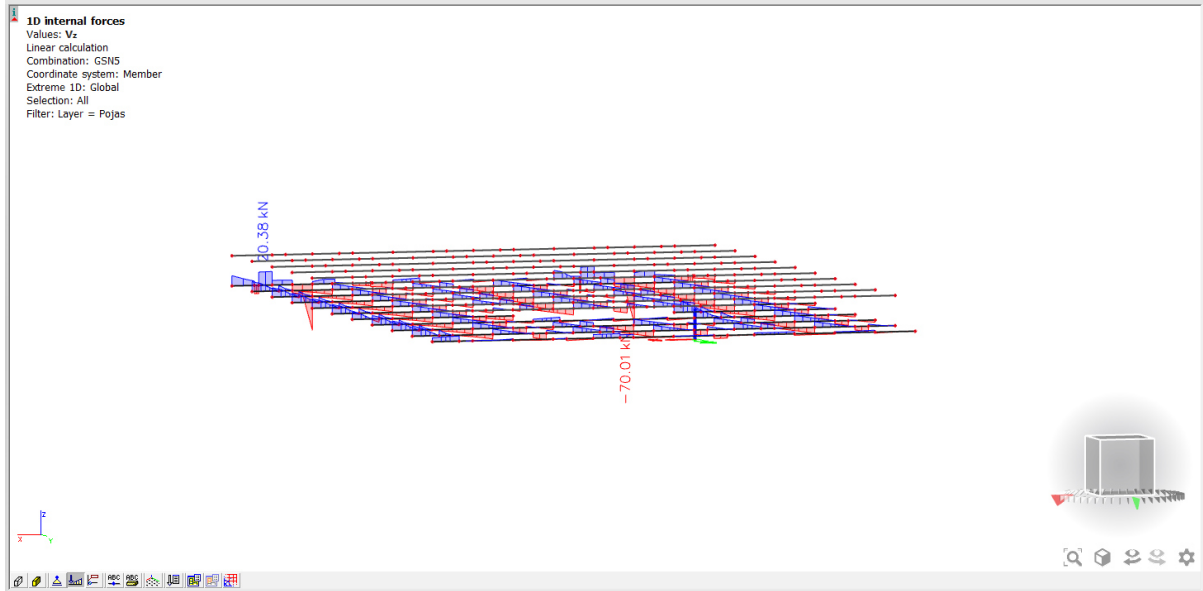
Slika 75. Prikaz momenta savijanja M_y u donjem pojasu

Poprečna sila V_z u gornjem pojasu:



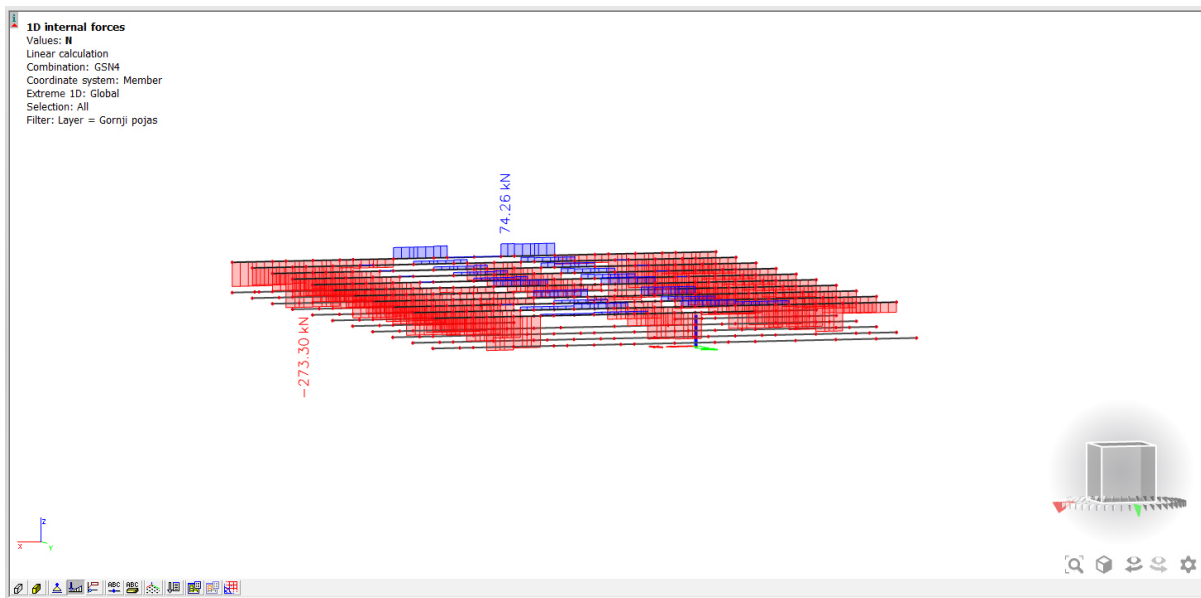
Slika 76. Prikaz poprečne sile V_z u gornjem pojasu

Poprečna sila V_z u donjem pojasu:



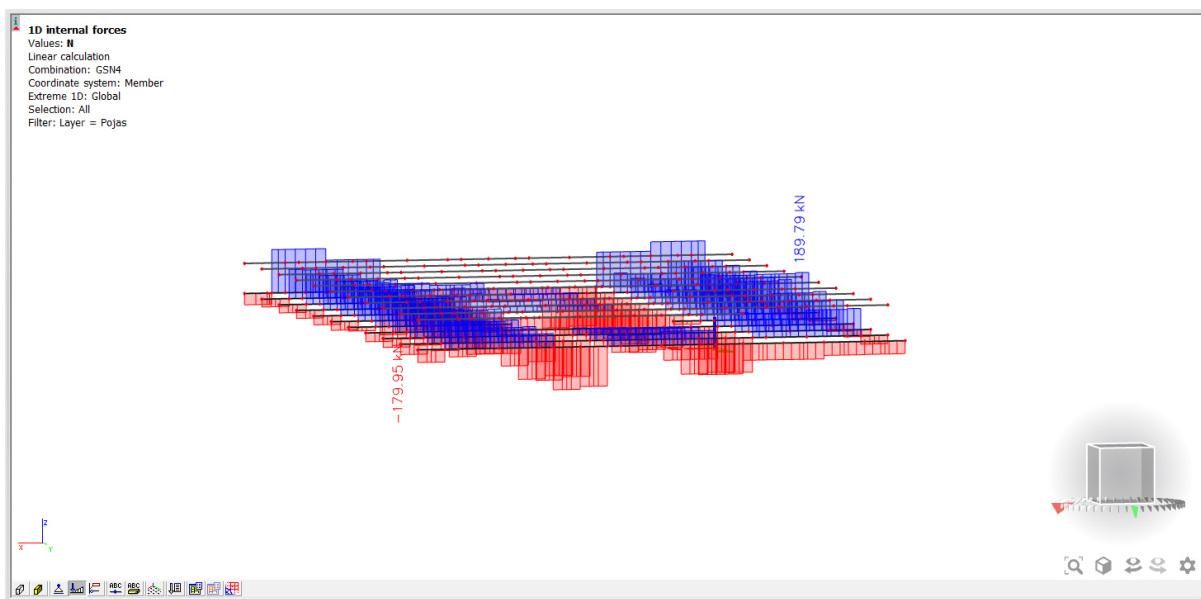
Slika 77. Prikaz poprečne sile V_z u donjem pojasu

Uzdužna sila N u gornjem pojasu:



Slika 78. Prikaz uzdužne sile N u gornjem pojasu

Uzdužna sila N u donjem pojasu



Slika 79. Prikaz uzdužne sile N u donjem pojasu

Provjera finalnog poprečnog presjeka gornjeg pojasa u modulu Steel.

Odabrani profil – HEA180

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Gornji pojas

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

Member B167	14.400 / 14.400 m	HEA180	S 275	GSN6	0.59 -
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Combination key	
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

...:SECTION CHECK:...

The critical check is on position 14.400 m

Internal forces	Calculated	Unit
N_{Ed}	-26.73	kN
$V_{y,Ed}$	-11.76	kN
$V_{z,Ed}$	-12.82	kN
T_{Ed}	-0.02	kNm
$M_{y,Ed}$	-14.52	kNm
$M_{z,Ed}$	-20.21	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	72	10	9.195e+04	2.494e+05	0.37	0.50	1.00	7.58	8.32	9.24	13.76	1
3	SO	72	10	1.324e+04	-1.442e+05	-10.89	23.80	0.08	7.58	340.98	378.87	94.71	1
4	I	122	6	4.117e+04	-2.936e+04	-0.71		0.57	20.33	55.07	64.40	86.62	1
5	SO	72	10	-8.014e+04	-2.375e+05								
7	SO	72	10	-1.431e+03	1.560e+05	-0.01	0.57	0.99	7.58	8.40	9.33	14.68	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	4.5300e-03	m ²
$N_{c,Rd}$	1245.75	kN
Unity check	0.02	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	3.2500e-04	m ³
$M_{pl,y,Rd}$	89.38	kNm
Unity check	0.16	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	1.5667e-04	m ³
$M_{pl,z,Rd}$	43.08	kNm
Unity check	0.47	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	3.5460e-03	m ²
$V_{pl,y,Rd}$	563.00	kN
Unity check	0.02	-

Shear check for V_z

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	1.4520e-03	m ²
$V_{pl,z,Rd}$	230.54	kN
Unity check	0.06	-

Torsion check

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

Fibre	2	
T_{Ed}	1.4	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	89.38	kNm
α	2.00	
$M_{pl,z,Rd}$	43.08	kNm
β	1.00	

Unity check (6.41) = 0.03 + 0.47 = 0.50 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis is neglected.

The member satisfies the section check.

...:STABILITY CHECK:...

Classification for member buckling design

Decisive position for stability classification: 14.400 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	72	10	9.195e+04	2.494e+05	0.37	0.50	1.00	7.58	8.32	9.24	13.76	1
3	SO	72	10	1.324e+04	-1.442e+05	-10.89	23.80	0.08	7.58	340.98	378.87	94.71	1
4	I	122	6	4.117e+04	-2.936e+04	-0.71		0.57	20.33	55.07	64.40	86.62	1
5	SO	72	10	-8.014e+04	-2.375e+05								
7	SO	72	10	-1.431e+03	1.560e+05	-0.01	0.57	0.99	7.58	8.40	9.33	14.68	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	4.800	3.600	m
Buckling factor k	1.00	0.50	
Buckling length l_{cr}	4.812	1.804	m
Critical Euler load N_{cr}	2246.84	5893.64	kN
Slenderness λ	64.64	39.91	
Relative slenderness λ_{rel}	0.74	0.46	
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: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	3.2500e-04	m ³
Elastic critical moment M_{cr}	465.70	kNm
Relative slenderness $\lambda_{rel,LT}$	0.44	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M _{cr} parameters		
LTB length l_{LT}	3.600	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.61	
LTB moment factor C_2	0.45	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_1	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

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	4.5300e-03	m ²
Plastic section modulus $W_{pl,y}$	3.2500e-04	m ³
Plastic section modulus $W_{pl,z}$	1.5667e-04	m ³
Design compression force N_{Ed}	26.73	kN
Design bending moment (maximum) $M_{y,Ed}$	-14.52	kNm
Design bending moment (maximum) $M_{z,Ed}$	-20.21	kNm
Characteristic compression resistance N_{Rk}	1245.75	kN
Characteristic moment resistance $M_{y,Rk}$	89.38	kNm
Characteristic moment resistance $M_{z,Rk}$	43.08	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.01	
Interaction factor k_{yz}	0.75	
Interaction factor k_{zy}	0.57	
Interaction factor k_{zz}	1.01	

Maximum moment $M_{y,Ed}$ is derived from beam B167 position 14.400 m.

Maximum moment $M_{z,Ed}$ is derived from beam B167 position 14.400 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	2246.84	kN
Critical Euler load $N_{cr,z}$	5893.64	kN
Elastic critical load $N_{cr,T}$	2846.32	kN
Plastic section modulus $W_{pl,y}$	3.2500e-04	m ³
Elastic section modulus $W_{el,y}$	2.9400e-04	m ³
Plastic section modulus $W_{pl,z}$	1.5667e-04	m ³
Elastic section modulus $W_{el,z}$	1.0300e-04	m ³
Second moment of area I_y	2.5100e-05	m ⁴
Second moment of area I_z	9.2500e-06	m ⁴
Torsional constant I_t	1.4800e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-14.52	kNm
Maximum relative deflection δ_z	-3.1	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) $M_{z,Ed}$	-20.21	kNm
Maximum relative deflection δ_y	2.5	mm
Equivalent moment factor $C_{mz,0}$	1.00	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor ϵ_y	8.37	
Factor a_{LT}	0.99	
Critical moment for uniform bending $M_{cr,0}$	178.68	kNm
Relative slenderness $\lambda_{rel,0}$	0.71	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.32	
Equivalent moment factor C_{my}	1.00	
Equivalent moment factor C_{mz}	1.00	
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.02	
Factor c_{LT}	0.16	

Interaction method 1 parameters		
Factor d_{LT}	0.74	
Factor $e_{1,T}$	1.34	
Factor w_y	1.11	
Factor w_z	1.50	
Factor n_{pl}	0.02	
Maximum relative slenderness $\lambda_{rel,max}$	0.74	
Factor C_{yy}	1.00	
Factor C_{yz}	0.93	
Factor C_{zy}	0.92	
Factor C_{zz}	0.99	

Unity check (6.61) = 0.02 + 0.16 + 0.35 = 0.54 -

Unity check (6.62) = 0.02 + 0.09 + 0.47 = 0.59 -

Shear Buckling check

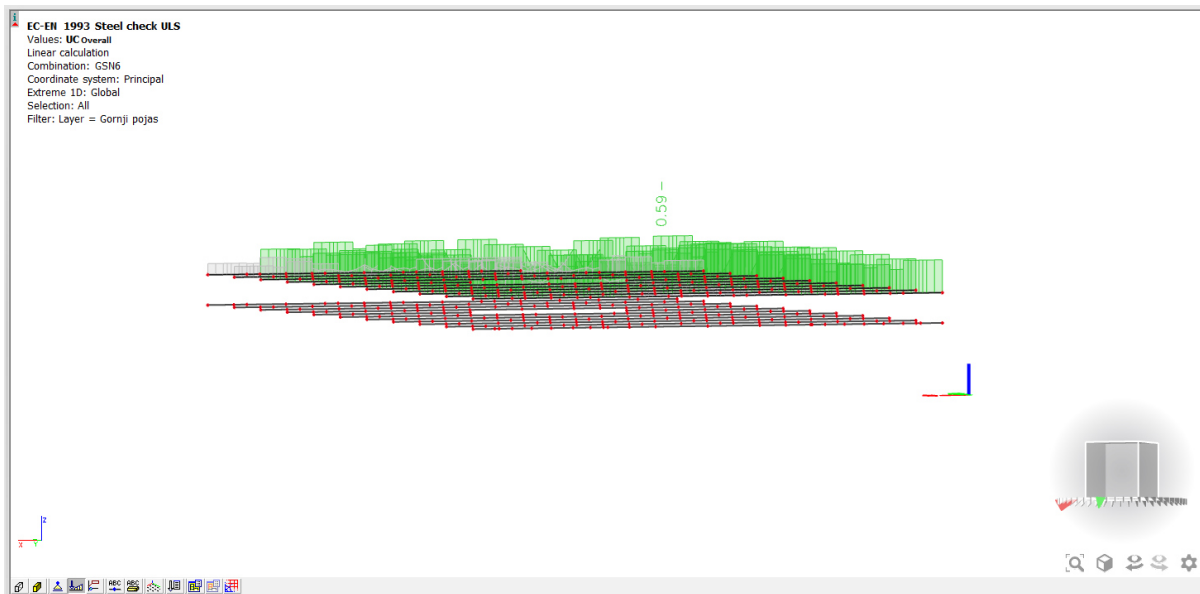
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	14.400	m
Web	unstiffened	
Web height h_w	152	mm
Web thickness t	6	mm
Material coefficient ε	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	25.33
Web slenderness limit	55.46

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.



Slika 80. Prikaz iskoristivosti gornjeg pojasa

Provjera finalnog poprečnog presjeka donjeg pojasa u modulu Steel.

Odabrani profil – HEA260

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavna sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Pojas

EN 1993-1-1 Code Check

National annex: Standard EN

Member B490	0.000 / 14.400 m	HEA260	S 275	GSN6	0.63 -
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Combination key	
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

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

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-110.42	kN
$V_{y,Ed}$	26.49	kN
$V_{z,Ed}$	12.87	kN
T_{Ed}	-0.08	kNm
$M_{y,Ed}$	-26.99	kNm
$M_{z,Ed}$	-63.13	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	9.113e+04	2.671e+05	0.34	0.51	1.00	8.18	8.32	9.24	13.82	1
3	SO	102	12	-4.407e+03	-1.804e+05								
4	I	177	8	3.555e+04	-1.012e+04	-0.28		0.65	23.60	45.12	53.43	63.39	1
5	SO	102	12	-6.570e+04	-2.417e+05								
7	SO	102	12	2.984e+04	2.058e+05	0.14	0.54	1.00	8.18	8.32	9.24	14.28	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	8.6800e-03	m ²
$N_{c,Rd}$	2387.00	kN
Unity check	0.05	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	9.2083e-04	m ³
$M_{pl,y,Rd}$	253.23	kNm
Unity check	0.11	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	4.2917e-04	m ³
$M_{pl,z,Rd}$	118.02	kNm
Unity check	0.53	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	6.7363e-03	m ²
$V_{pl,y,Rd}$	1069.52	kN
Unity check	0.02	-

Shear check for V_z

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	2.8737e-03	m ²
$V_{pl,z,Rd}$	456.27	kN
Unity check	0.03	-

Torsion check

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

Fibre	2	
T_{Ed}	1.9	MPa
T_{Rd}	158.8	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)

$M_{pl,y,Rd}$	253.23	kNm
α	2.00	
$M_{pl,z,Rd}$	118.02	kNm
β	1.00	

Unity check (6.41) = 0.01 + 0.53 = 0.55 -

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

Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	9.113e+04	2.671e+05	0.34	0.51	1.00	8.18	8.32	9.24	13.82	1
3	SO	102	12	-4.407e+03	-1.804e+05								
4	I	177	8	3.555e+04	-1.012e+04	-0.28		0.65	23.60	45.12	53.43	63.39	1
5	SO	102	12	-6.570e+04	-2.417e+05								
7	SO	102	12	2.984e+04	2.058e+05	0.14	0.54	1.00	8.18	8.32	9.24	14.28	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	2.400	3.600	m
Buckling factor k	1.30	0.61	
Buckling length l_{cr}	3.126	2.191	m
Critical Euler load N_{cr}	22267.17	15850.34	kN
Slenderness λ	28.42	33.69	
Relative slenderness λ_{rel}	0.33	0.39	
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)

Torsional buckling length l_{cr}	3.600	m
Elastic critical load $N_{cr,T}$	7650.91	kN
Relative slenderness $\lambda_{rel,T}$	0.56	
Limit slenderness $\lambda_{rel,0}$	0.20	

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

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic critical moment M_{cr}	1550.43	kNm
Relative slenderness $\lambda_{rel,LT}$	0.40	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M _{cr} parameters		
LTB length l_{LT}	3.600	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	1.81	
LTB moment factor C_2	0.12	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_0	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_1	0	mm

Note: C parameters are determined according to ECSS 119 2006 / Galea 2002.

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	8.6800e-03	m ²
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Design compression force N_{Ed}	110.42	kN
Design bending moment (maximum) $M_{y,Ed}$	-26.99	kNm
Design bending moment (maximum) $M_{z,Ed}$	-63.13	kNm
Characteristic compression resistance N_{Rk}	2387.00	kN
Characteristic moment resistance $M_{y,Rk}$	253.23	kNm
Characteristic moment resistance $M_{z,Rk}$	118.02	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.00	
Interaction factor k_{yz}	0.70	
Interaction factor k_{zy}	0.54	
Interaction factor k_{zz}	0.99	

Maximum moment $M_{y,Ed}$ is derived from beam B490 position 0.000 m.

Maximum moment $M_{z,Ed}$ is derived from beam B490 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	22267.17	kN
Critical Euler load $N_{cr,z}$	15850.34	kN
Elastic critical load $N_{cr,T}$	7650.91	kN
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic section modulus $W_{el,y}$	8.3600e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Elastic section modulus $W_{el,z}$	2.8200e-04	m ³
Second moment of area I_y	1.0500e-04	m ⁴
Second moment of area I_z	3.6700e-05	m ⁴
Torsional constant I_t	5.2400e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-26.99	kNm
Maximum relative deflection δ_z	0.5	mm
Equivalent moment factor $C_{my,0}$	1.00	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	-63.13	kNm
Maximum relative deflection δ_y	4.2	mm
Equivalent moment factor $C_{mz,0}$	1.00	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor ϵ_y	2.54	
Factor a_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	856.19	kNm
Relative slenderness $\lambda_{rel,0}$	0.54	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.27	
Equivalent moment factor C_{my}	1.00	
Equivalent moment factor C_{mz}	1.00	
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.01	
Factor c_{LT}	0.06	

Interaction method 1 parameters	
Factor $d_{L,T}$	0.51
Factor $e_{L,T}$	0.80
Factor w_y	1.10
Factor w_z	1.50
Factor n_{pl}	0.05
Maximum relative slenderness $\lambda_{rel,max}$	0.39
Factor C_{yy}	1.00
Factor C_{yz}	1.01
Factor C_{zy}	0.95
Factor C_{zz}	1.01

Unity check (6.61) = $0.05 + 0.11 + 0.37 = 0.53$ -

Unity check (6.62) = $0.05 + 0.06 + 0.53 = 0.63$ -

Shear Buckling check

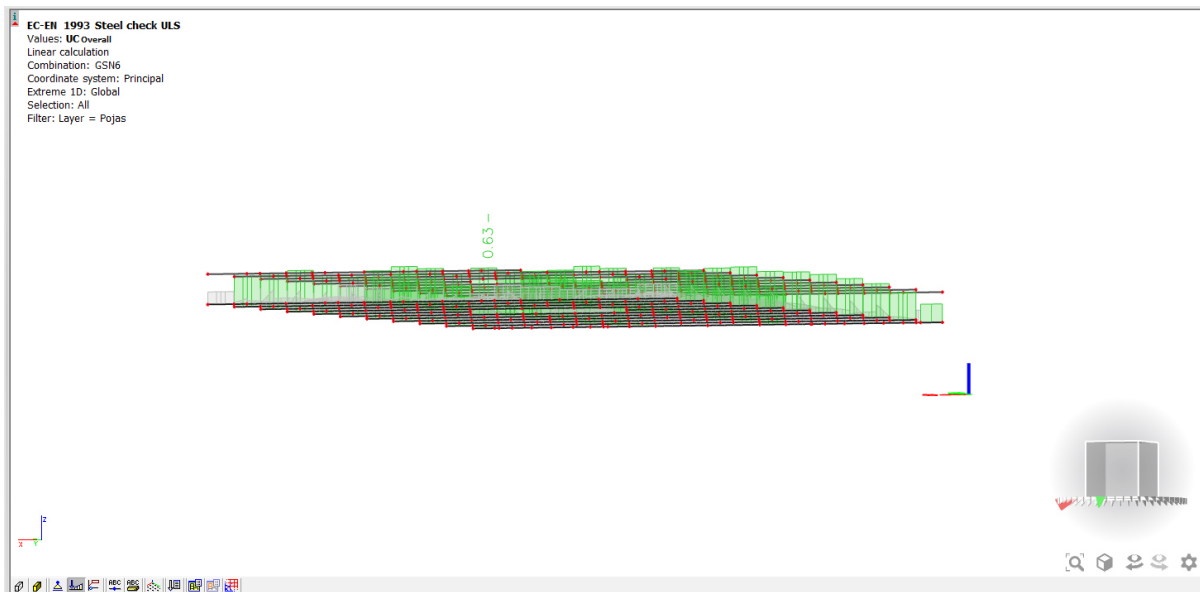
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters	
Buckling field length a	14.400 m
Web	unstiffened
Web height h_w	225 mm
Web thickness t	8 mm
Material coefficient ϵ	0.92
Shear correction factor η	1.20

Shear Buckling verification	
Web slenderness h_w/t	30.00
Web slenderness limit	55.46

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

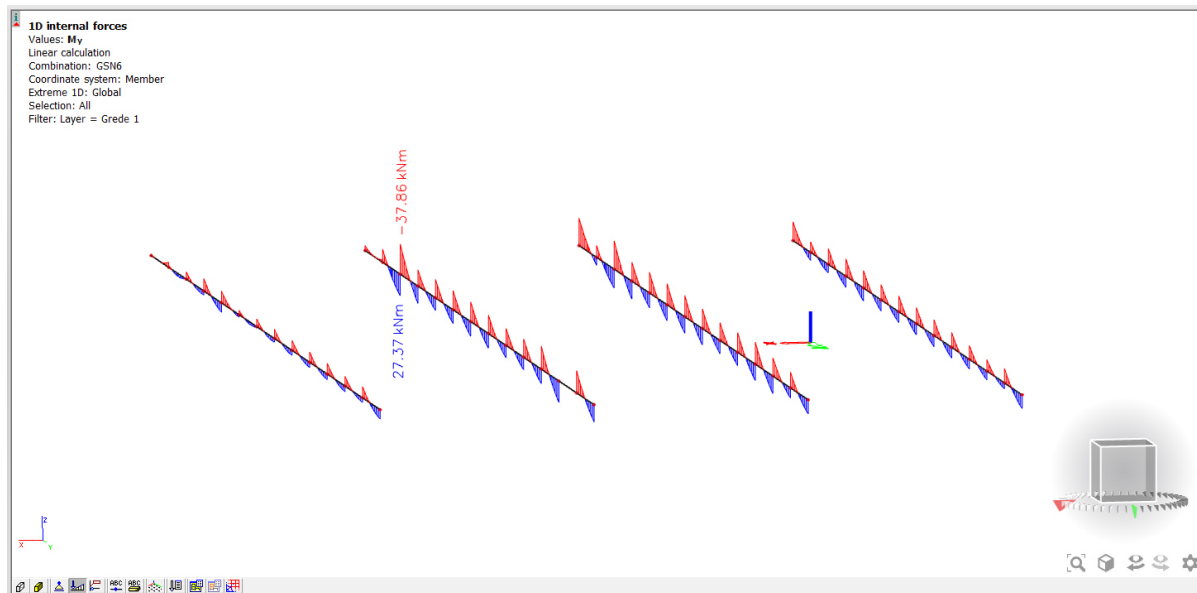
The member satisfies the stability check.



Slika 81. Prikaz iskoristivosti donjeg pojasa

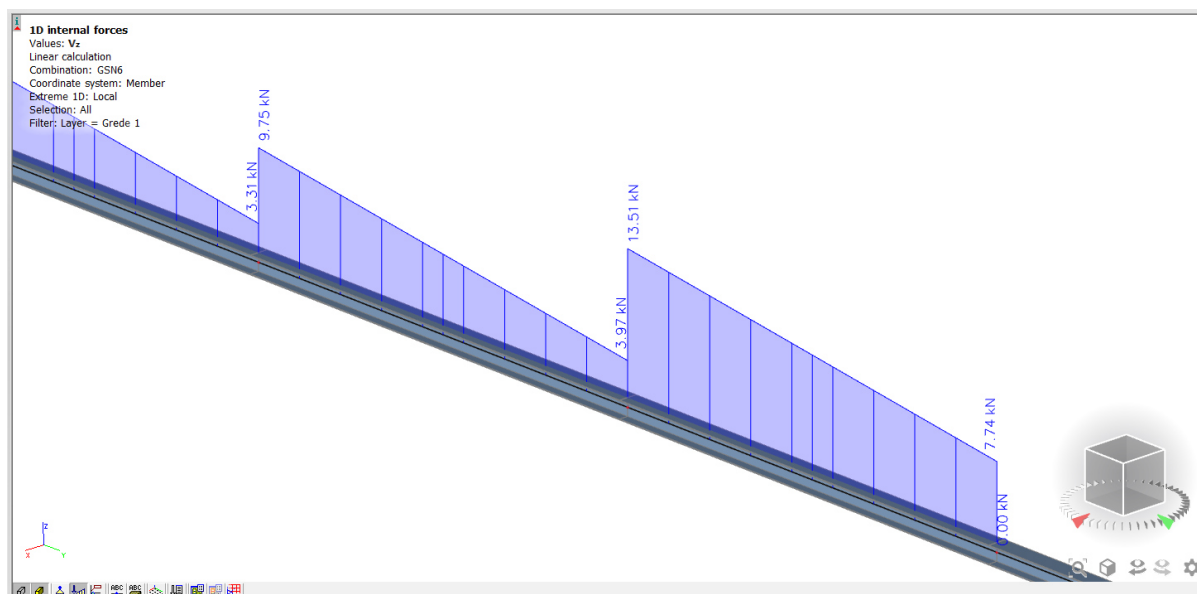
4.3.5 Dimenzioniranje greda – Pozicija 6

Moment savijanja M_y grede:



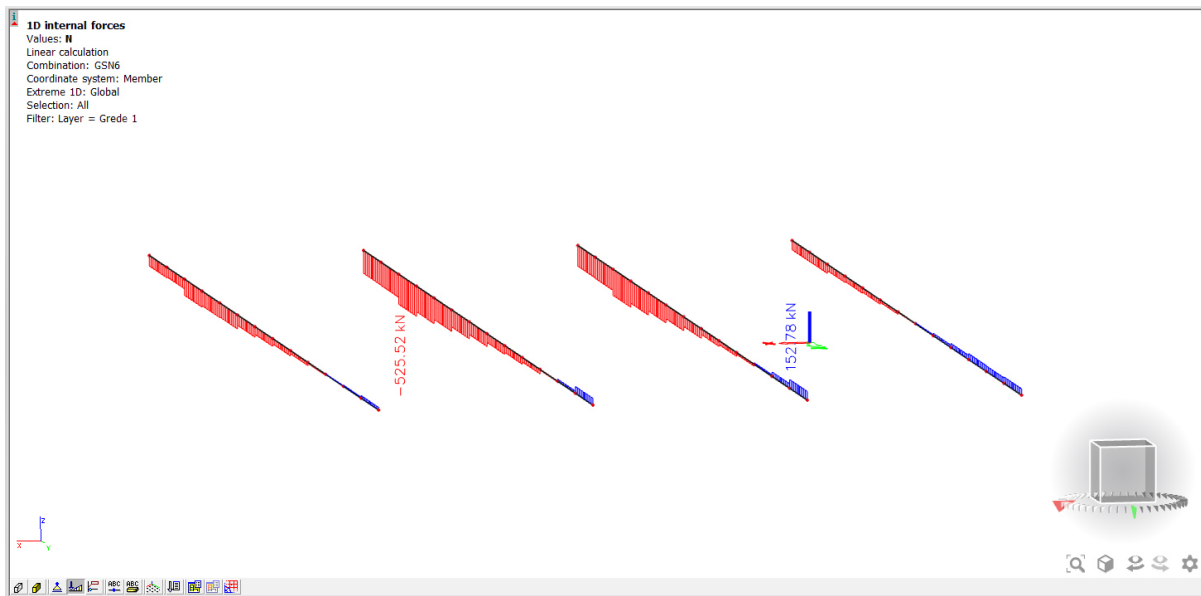
Slika 82. Prikaz momenta savijanja M_y grede

Poprečna sila V_z grede:



Slika 83. Prikaz poprečne sile V_z grede

Uzdužna sila N grede:



Slika 84. Prikaz uzdužne sile N grede

Proračun finalnog poprečnog presjeka grede u modulu Steel.

Odabran profil – HEA260

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Grede 1

EN 1993-1-1 Code Check

National annex: Standard EN

Member B650	0.000 / 6.400 m	HEA260	S 275	GSN6	0.48 -
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Combination key
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"

Partial safety factors		
γ_{M0} for resistance of cross-sections		1.00
γ_{M1} for resistance to instability		1.00
γ_{M2} for resistance of net sections		1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-404.55	kN
$V_{y,Ed}$	0.49	kN
$V_{z,Ed}$	9.77	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-16.68	kNm
$M_{z,Ed}$	0.12	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	6.543e+04	6.510e+04	0.99	0.43	1.00	8.18	8.32	9.24	12.77	1
3	SO	102	12	6.561e+04	6.594e+04	1.00	0.43	1.00	8.18	8.32	9.24	12.73	1
4	I	177	8	6.070e+04	3.247e+04	0.53		1.00	23.60	25.88	31.43	41.89	1
5	SO	102	12	2.774e+04	2.806e+04	0.99	0.43	1.00	8.18	8.32	9.24	12.74	1
7	SO	102	12	2.756e+04	2.723e+04	0.99	0.44	1.00	8.18	8.32	9.24	12.81	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	8.6800e-03	m ²
$N_{c,Rd}$	2387.00	kN
Unity check	0.17	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	9.2083e-04	m ³
$M_{pl,y,Rd}$	253.23	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)

$W_{pl,z}$	4.2917e-04	m ³
$M_{pl,z,Rd}$	118.02	kNm
Unity check	0.00	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	6.7363e-03	m ²
$V_{pl,y,Rd}$	1069.52	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	2.8737e-03	m ²
$V_{pl,z,Rd}$	456.27	kN
Unity check	0.02	-

Torsion check

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

Fibre	2	
T_{Ed}	0.0	MPa
T_{Rd}	158.8	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)

$M_{N,y,Rd}$	240.51	kNm
α	2.00	
$M_{pl,z,Rd}$	118.02	kNm
β	1.00	

Unity check (6.41) = 0.00 + 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.

Note: Since the axial force satisfies criteria (6.35) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the z-z axis is neglected.

The member satisfies the section check.

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

Classification for member buckling design

Decisive position for stability classification: 6.400 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	102	12	1.302e+04	3.876e+03	0.30	0.91	1.00	8.18	8.32	9.24	18.48	1
3	SO	102	12	1.798e+04	2.713e+04	0.66	0.46	1.00	8.18	8.32	9.24	13.19	1
4	I	177	8	2.342e+04	6.975e+04	0.34		1.00	23.60	25.88	31.43	45.65	1
5	SO	102	12	8.015e+04	8.929e+04	0.90	0.44	1.00	8.18	8.32	9.24	12.85	1
7	SO	102	12	7.519e+04	6.604e+04	0.88	0.47	1.00	8.18	8.32	9.24	13.37	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	6.400	12.800	m
Buckling factor k	1.29	0.53	
Buckling length l_{cr}	8.281	6.742	m
Critical Euler load N_{cr}	3173.75	1673.42	kN
Slenderness λ	75.29	103.69	
Relative slenderness λ_{rel}	0.87	1.19	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	b	c	
Imperfection α	0.34	0.49	
Reduction factor χ	0.68	0.44	
Buckling resistance $N_{b,Rd}$	1628.35	1041.89	kN

Flexural Buckling verification

Cross-section area A	8.6800e-03	m ²
Buckling resistance $N_{b,Rd}$	1041.89	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: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic critical moment M_{cr}	340.81	kNm
Relative slenderness $\lambda_{rel,LT}$	0.86	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M _{cr} parameters		
LTB length l_{LT}	12.800	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.26	
LTB moment factor C_2	1.05	
LTB moment factor C_3	0.41	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_1	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

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	8.6800e-03	m ²
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Design compression force N_{Ed}	404.55	kN
Design bending moment (maximum) $M_{y,Ed}$	27.37	kNm
Design bending moment (maximum) $M_{z,Ed}$	3.28	kNm
Characteristic compression resistance N_{Rk}	2387.00	kN
Characteristic moment resistance $M_{y,Rk}$	253.23	kNm
Characteristic moment resistance $M_{z,Rk}$	118.02	kNm
Reduction factor χ_y	0.68	
Reduction factor χ_z	0.44	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.23	
Interaction factor k_{yz}	0.82	
Interaction factor k_{zy}	0.65	
Interaction factor k_{zz}	0.92	

Maximum moment $M_{y,Ed}$ is derived from beam B650 position 6.400 m.

Maximum moment $M_{z,Ed}$ is derived from beam B650 position 6.400 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	3173.75	kN
Critical Euler load $N_{cr,z}$	1673.42	kN
Elastic critical load $N_{cr,T}$	2992.67	kN
Plastic section modulus $W_{pl,y}$	9.2083e-04	m ³
Elastic section modulus $W_{el,y}$	8.3600e-04	m ³
Plastic section modulus $W_{pl,z}$	4.2917e-04	m ³
Elastic section modulus $W_{el,z}$	2.8200e-04	m ³
Second moment of area I_y	1.0500e-04	m ⁴
Second moment of area I_z	3.6700e-05	m ⁴
Torsional constant I_t	5.2400e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	27.37	kNm
Maximum relative deflection δ_z	-2.4	mm
Equivalent moment factor $C_{my,0}$	0.93	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{z,Ed}$	3.28	kNm
Maximum relative deflection δ_y	-2.0	mm
Equivalent moment factor $C_{mz,0}$	0.83	
Factor μ_y	0.96	
Factor μ_z	0.85	
Factor ϵ_y	0.70	
Factor a_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	150.60	kNm
Relative slenderness $\lambda_{rel,0}$	1.30	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.27	
Equivalent moment factor C_{my}	0.96	
Equivalent moment factor C_{mz}	0.83	
Equivalent moment factor C_{mLT}	1.14	
Factor b_{LT}	0.00	
Factor c_{LT}	0.27	

Interaction method 1 parameters		
Factor d_{LT}	0.00	
Factor e_{LT}	0.12	
Factor w_y	1.10	
Factor w_z	1.50	
Factor η_{pl}	0.17	
Maximum relative slenderness $\lambda_{rel,max}$	1.19	
Factor C_{yy}	0.97	
Factor C_{yz}	0.88	
Factor C_{zy}	0.84	
Factor C_{zz}	1.00	

Unity check (6.61) = 0.25 + 0.13 + 0.02 = 0.40 -

Unity check (6.62) = 0.39 + 0.07 + 0.03 = 0.48 -

Shear Buckling check

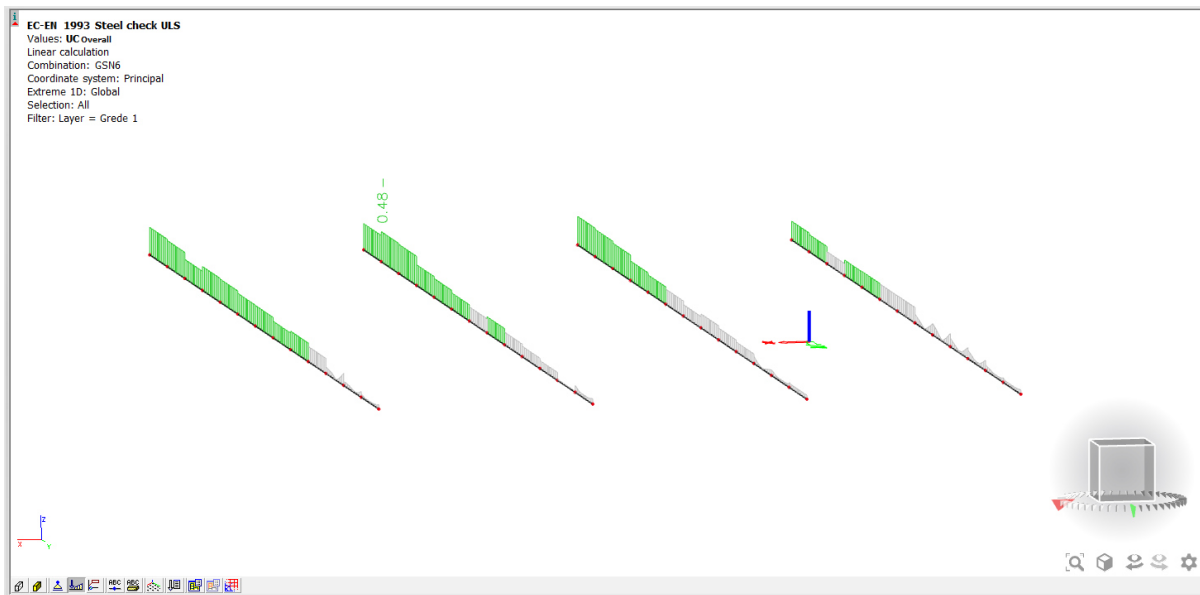
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	6.400	m
Web	unstiffened	
Web height h_w	225	mm
Web thickness t	8	mm
Material coefficient ε	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	30.00
Web slenderness limit	55.46

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

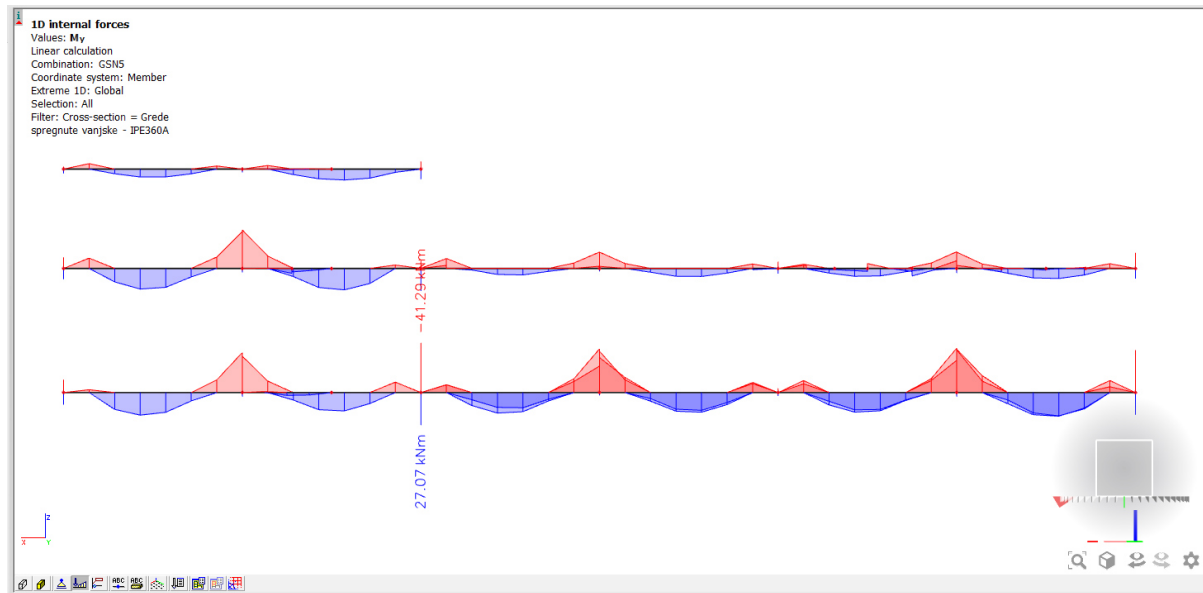
The member satisfies the stability check.



Slika 85. Prikaz iskoristivosti greda

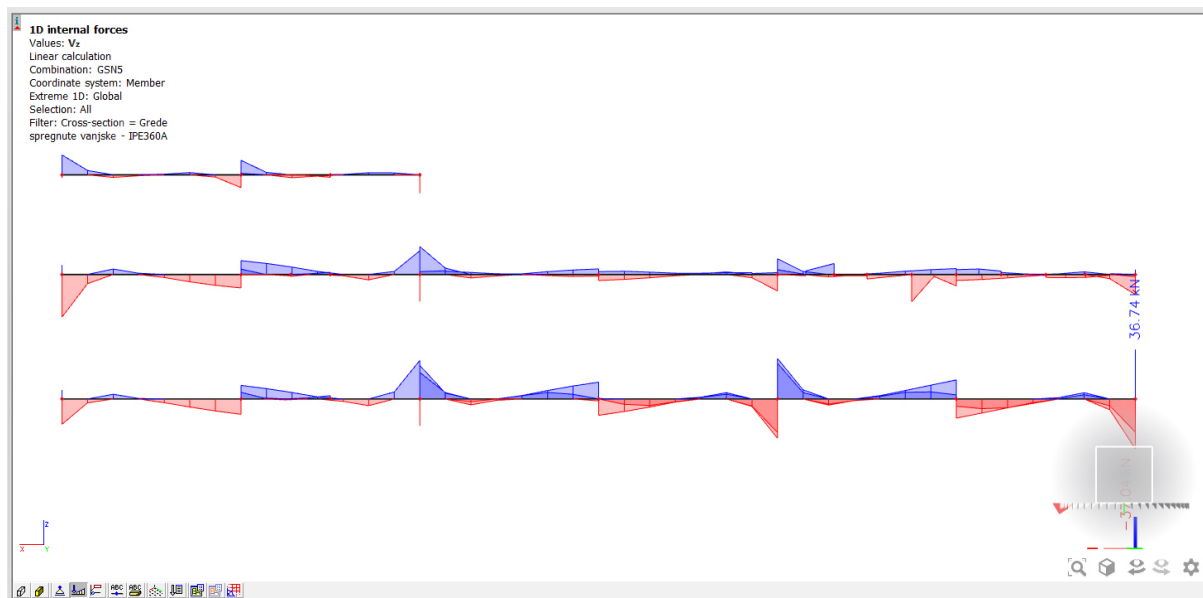
4.3.6 Dimenzioniranje spregnutih greda – Pozicija 7

Moment savijanja M_y spregnutih greda:



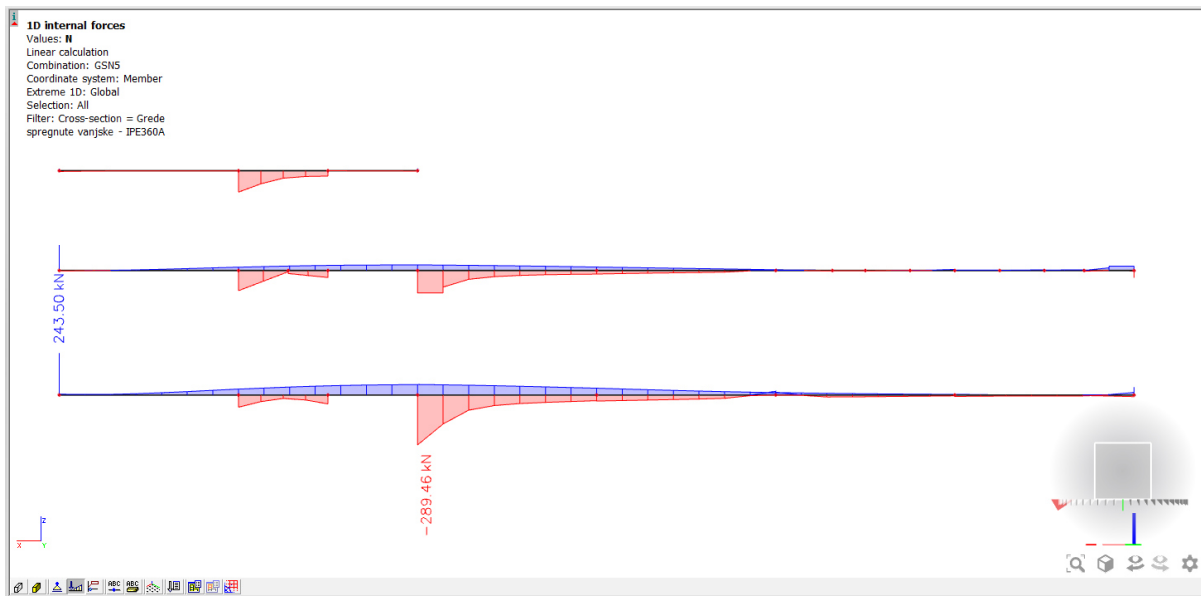
Slika 86. Prikaz momenta savijanja M_y spregnutih greda

Poprečna sila V_z spregnutih greda:



Slika 87. Prikaz poprečne sile V_z spregnutih greda

Uzdužna sila N spregnutih greda:



Slika 88. Prikaz uzdužne sile N spregnutih greda

Proračun finalnog poprečnog presjeka spregnutih greda u modulu Steel

Odabran profil – IPE360A

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation

Combination: GSN5

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = Grede spregnute vanjske - IPE360A

EN 1993-1-1 Code Check

National annex: Standard EN

Member B660	14.400 / 14.400 m	IPE360A	S 275	GSN5	0.91 -
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Combination key

GSN5 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.50*LC6_Vjetar "SHED"90- + 1.35*LC6_Vjetar "Zidovi - + 1.35*LC6_Vjetar "Ravni krov 90- + 1.35*LC6_Vjetar "Trenje 90"

Partial safety factors

γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material

Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

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

The critical check is on position 14.400 m

Internal forces	Calculated	Unit
N_{Ed}	-289.46	kN
$V_{y,Ed}$	-0.68	kN
$V_{z,Ed}$	19.79	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	0.00	kNm
$M_{z,Ed}$	0.00	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
3	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
4	I	299	7	4.524e+04	4.524e+04	1.00		1.00	45.24	25.88	31.43	35.13	4
5	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
7	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1

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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	λ_p [-]	ρ [-]	b_e [mm]	b_{e1} [mm]	b_{e2} [mm]
1	SO	64	2.750e+05	2.750e+05	1.00	0.43	0.32	1.00	64		
3	SO	64	2.750e+05	2.750e+05	1.00	0.43	0.32	1.00	64		
4	I	299	2.750e+05	2.750e+05	1.00	4.00	0.86	0.86	258	129	129
5	SO	64	2.750e+05	2.750e+05	1.00	0.43	0.32	1.00	64		
7	SO	64	2.750e+05	2.750e+05	1.00	0.43	0.32	1.00	64		

Effective properties

Effective area	A_{eff}	6.1302e-03	m ²				
Effective second moment of area	$I_{eff,y}$	1.4519e-04	m ⁴	$I_{eff,z}$	9.4428e-06	m ⁴	
Effective section modulus	$W_{eff,y}$	8.1201e-04	m ³	$W_{eff,z}$	1.1109e-04	m ³	
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}	6.1302e-03	m ²
$N_{c,Rd}$	1685.81	kN
Unity check	0.17	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	4.0724e-03	m ²
$V_{pl,y,Rd}$	646.57	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	2.9799e-03	m ²
$V_{pl,z,Rd}$	473.12	kN
Unity check	0.04	-

Torsion check

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

Fibre	2	
T_{Ed}	0.2	MPa
T_{Rd}	158.8	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.

The member satisfies the section check.

...:STABILITY CHECK:...:

Classification for member buckling design

Decisive position for stability classification: 14.400 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
3	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
4	I	299	7	4.524e+04	4.524e+04	1.00		1.00	45.24	25.88	31.43	35.13	4
5	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1
7	SO	64	12	4.524e+04	4.524e+04	1.00	0.43	1.00	5.54	8.32	9.24	12.94	1

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	7.200	7.200	m
Buckling factor k	2.04	0.96	
Buckling length l_{cr}	14.703	6.886	m
Critical Euler load N_{cr}	1392.03	412.58	kN
Slenderness λ	97.62	179.31	
Relative slenderness λ_{rel}	1.10	2.02	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	a	b	
Imperfection α	0.21	0.34	
Reduction factor χ	0.60	0.21	
Buckling resistance $N_{b,Rd}$	1004.21	346.48	kN

Flexural Buckling verification

Cross-section effective area A_{eff}	6.1302e-03	m ²
Buckling resistance $N_{b,Rd}$	346.48	kN
Unity check	0.84	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

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}	6.1302e-03	m ²
Effective section modulus $W_{eff,y}$	8.1201e-04	m ³
Effective section modulus $W_{eff,z}$	1.1109e-04	m ³
Design compression force N_{Ed}	289.46	kN
Design bending moment (maximum) $M_{y,Ed}$	-22.03	kNm
Design bending moment (maximum) $M_{z,Ed}$	0.28	kNm

Bending and axial compression check parameters		
Additional moment $\Delta M_{y,Ed}$	0.00	kNm
Additional moment $\Delta M_{z,Ed}$	0.00	kNm
Characteristic compression resistance N_{Rk}	1685.81	kN
Characteristic moment resistance $M_{y,Rk}$	223.30	kNm
Characteristic moment resistance $M_{z,Rk}$	30.55	kNm
Reduction factor χ_y	0.60	
Reduction factor χ_z	0.21	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.87	
Interaction factor k_{yz}	1.15	
Interaction factor k_{zy}	0.72	
Interaction factor k_{zz}	0.44	

Maximum moment $M_{y,Ed}$ is derived from beam B660 position 7.200 m.
 Maximum moment $M_{z,Ed}$ is derived from beam B660 position 13.371 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	1392.03	kN
Critical Euler load $N_{cr,z}$	412.58	kN
Elastic critical load $N_{cr,T}$	1352.45	kN
Effective section modulus $W_{eff,y}$	8.1201e-04	m ³
Second moment of area I_y	1.4520e-04	m ⁴
Second moment of area I_z	9.4400e-06	m ⁴
Torsional constant I_t	2.6500e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-22.03	kNm
Maximum relative deflection δ_z	-1.4	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) $M_{z,Ed}$	0.28	kNm
Maximum relative deflection δ_y	-0.1	mm
Equivalent moment factor $C_{mz,0}$	0.38	
Factor μ_y	0.90	
Factor μ_z	0.35	
Factor ϵ_y	0.57	
Factor a_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	111.06	kNm
Relative slenderness $\lambda_{rel,0}$	1.42	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.21	
Equivalent moment factor C_{my}	0.93	
Equivalent moment factor C_{mz}	0.38	
Equivalent moment factor C_{mLT}	1.77	

Unity check (6.61) = 0.29 + 0.18 + 0.01 = 0.48 -
 Unity check (6.62) = 0.84 + 0.07 + 0.00 = 0.91 -

Shear Buckling check

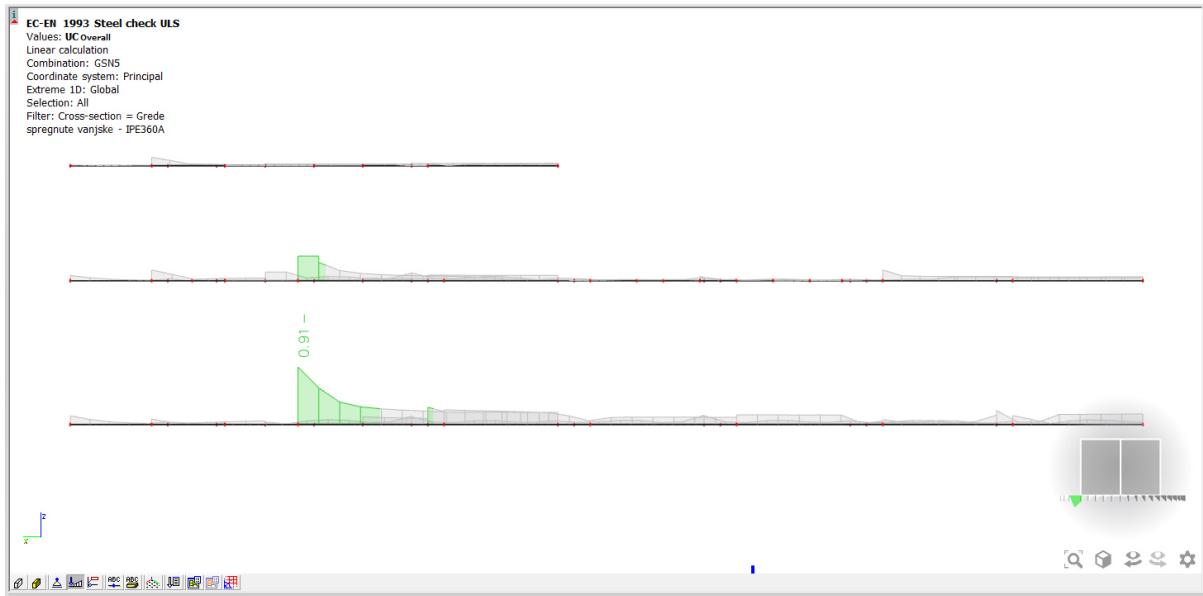
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	14.400	m
Web	unstiffened	
Web height h_w	335	mm
Web thickness t	7	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	50.70
Web slenderness limit	55.46

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

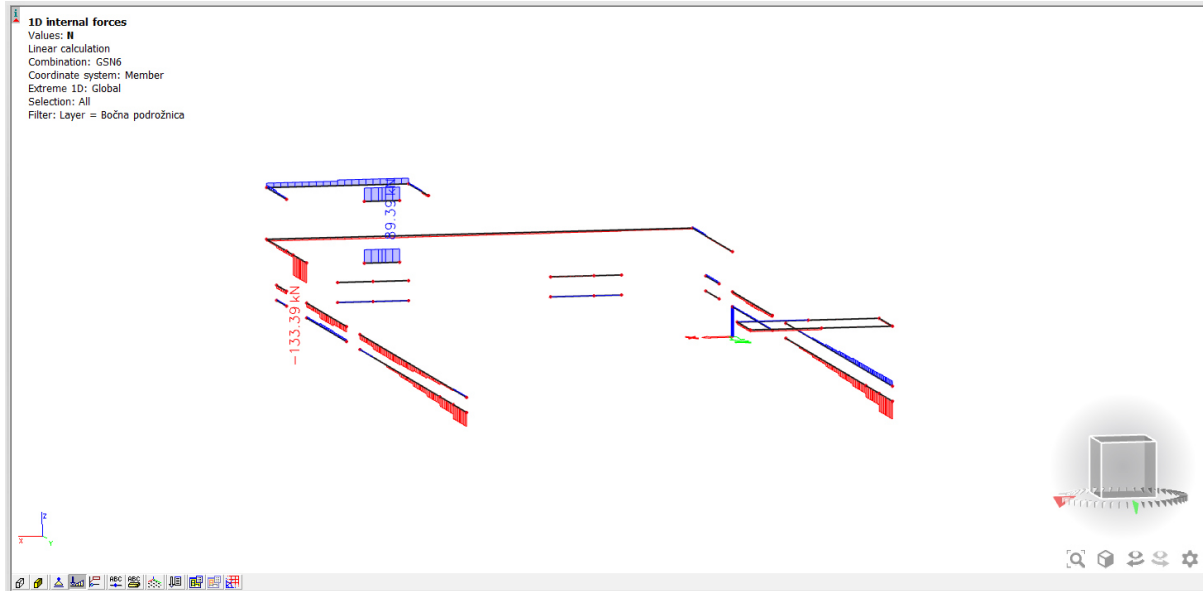
The member satisfies the stability check.



Slika 89. Prikaz iskoristivosti spregnutih greda

4.3.7 Dimenzioniranje bočne podrožnice – Pozicija 8

Uzdužna sila N bočne podrožnice:



Slika 90. Prikaz uzdužne sile N bočne podrožnice

Proračun finalnog poprečnog presjeka bočnih podrožnica u modulu Steel.

Odabran profil – CFRHS 300x300x12.5

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation

Combination: GSN6

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = Bočne podrožnice - CFRHS300X300X12.5

EN 1993-1-1 Code Check

National annex: Standard EN

Member B876	0.000 / 51.200 m	CFRHS300X300X12.5	S 275	GSN6	0.89 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key	
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Cold formed	

...:SECTION CHECK:...

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-118.45	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	0.00	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	0.00	kNm
$M_{z,Ed}$	0.00	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
3	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
5	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
7	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	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	1.3704e-02	m ²
N_{cRd}	3768.60	kN
Unity check	0.03	-

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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
3	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
5	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
7	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	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	51.200	6.400	m
Buckling factor k	1.00	1.00	
Buckling length l_{cr}	51.200	6.400	m
Critical Euler load N_{cr}	145.07	9284.79	kN
Slenderness λ	442.48	55.31	
Relative slenderness λ_{rel}	5.10	0.64	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	c	c	
Imperfection α	0.49	0.49	
Reduction factor χ	0.04	0.76	
Buckling resistance $N_{b,Rd}$	132.39	2876.14	kN

Flexural Buckling verification		
Cross-section area A	1.3704e-02	m ²
Buckling resistance $N_{b,Rd}$	132.39	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.

The member satisfies the stability check.

EC-EN 1993 Steel check ULS

Linear calculation

Combination: GSN6

Coordinate system: Principal

Extreme 1D: Global

Selection: All

Filter: Cross-section = Bočne podrožnice - CFRHS300X300X12.5

EN 1993-1-1 Code Check

National annex: Standard EN

Member B876	0.000 / 51.200 m	CFRHS300X300X12.5	S 275	GSN6	0.89 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Cold formed	

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

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-118.45	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	0.00	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	0.00	kNm
$M_{z,Ed}$	0.00	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
3	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
5	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
7	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	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	1.3704e-02	m ²
N _{c,Rd}	3768.60	kN
Unity check	0.03	-

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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
3	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
5	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	1
7	I	262	12	8.645e+03	8.645e+03	1.00		1.00	21.00	25.88	31.43	35.13	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	51.200	6.400	m
Buckling factor k	1.00	1.00	
Buckling length l _{cr}	51.200	6.400	m
Critical Euler load N _{cr}	145.07	9284.79	kN
Slenderness λ	442.48	55.31	
Relative slenderness λ_{rel}	5.10	0.64	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	c	c	
Imperfection α	0.49	0.49	
Reduction factor χ	0.04	0.76	
Buckling resistance N _{b,Rd}	132.39	2876.14	kN

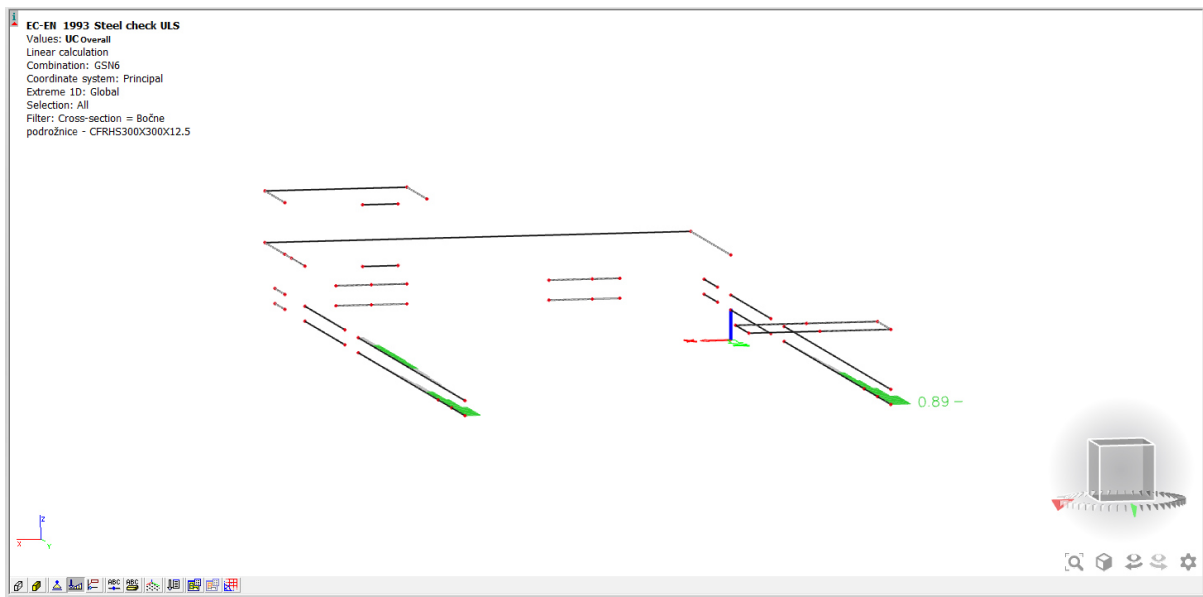
Flexural Buckling verification		
Cross-section area A	1.3704e-02	m ²
Buckling resistance N _{b,Rd}	132.39	kN
Unity check	0.89	-

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.

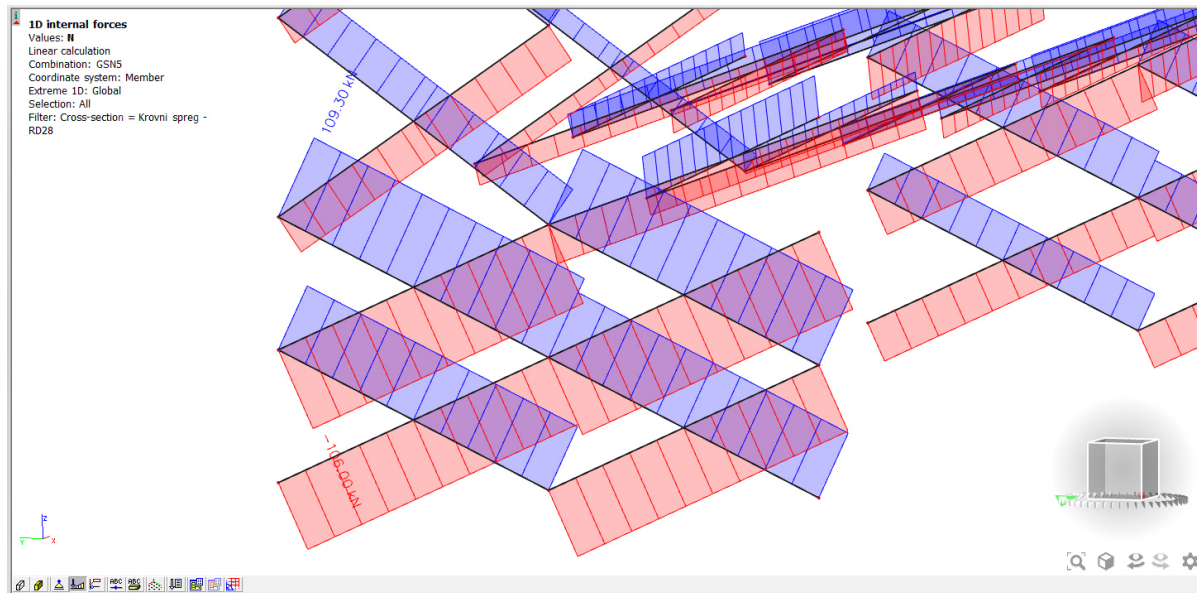
The member satisfies the stability check.



Slika 91. Prikaz iskoristivosti bočne področnice

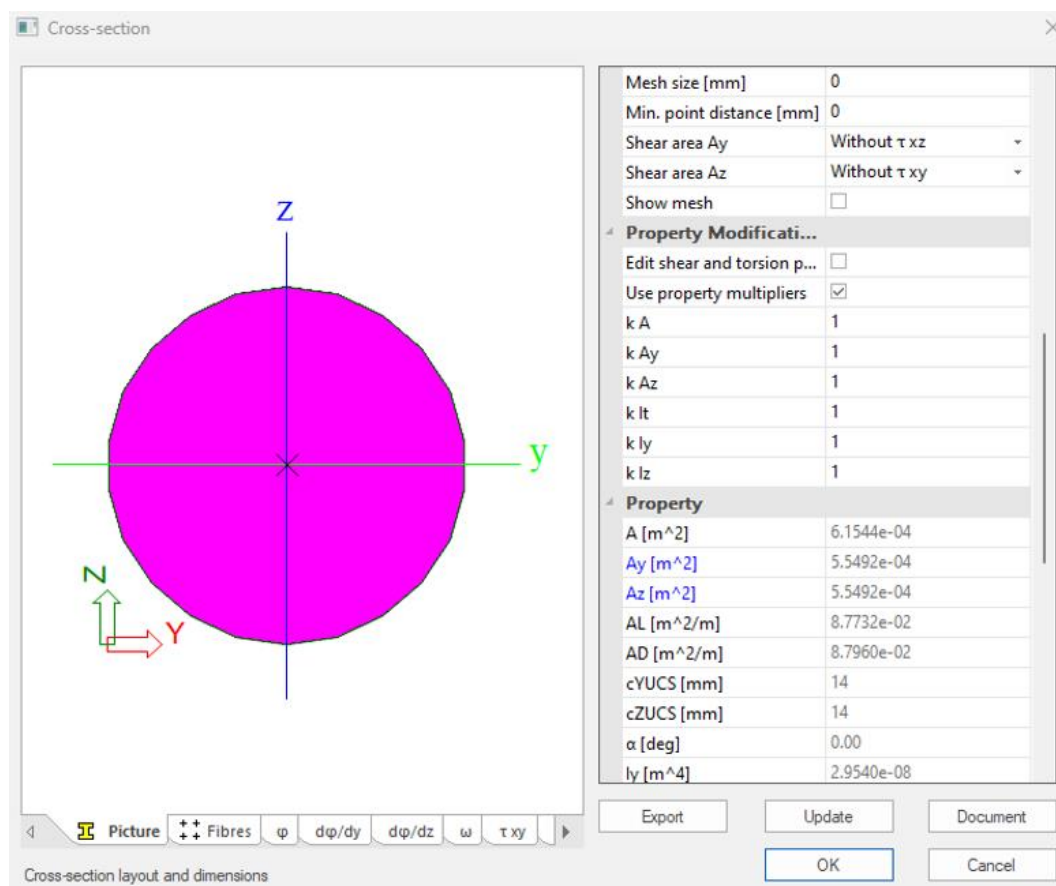
4.3.8 Dimenzioniranje spregova – Pozicija 9

Uzdužna sila N spregova:



Slika 92. Prikaz uzdužne sile N spregova

Proračun finalnog poprečnog presjeka spregova.



Slika 93. Prikaz finalnog poprečnog presjeka spregova

$$N_{c,Rd} = \frac{A_{fy}}{\gamma_{mo}} = \frac{6,15 \cdot 27,5}{1,25} = 135,3 \text{ [kN]} \quad (56)$$

$$N = 109,30 \text{ [kN]} \quad (57)$$

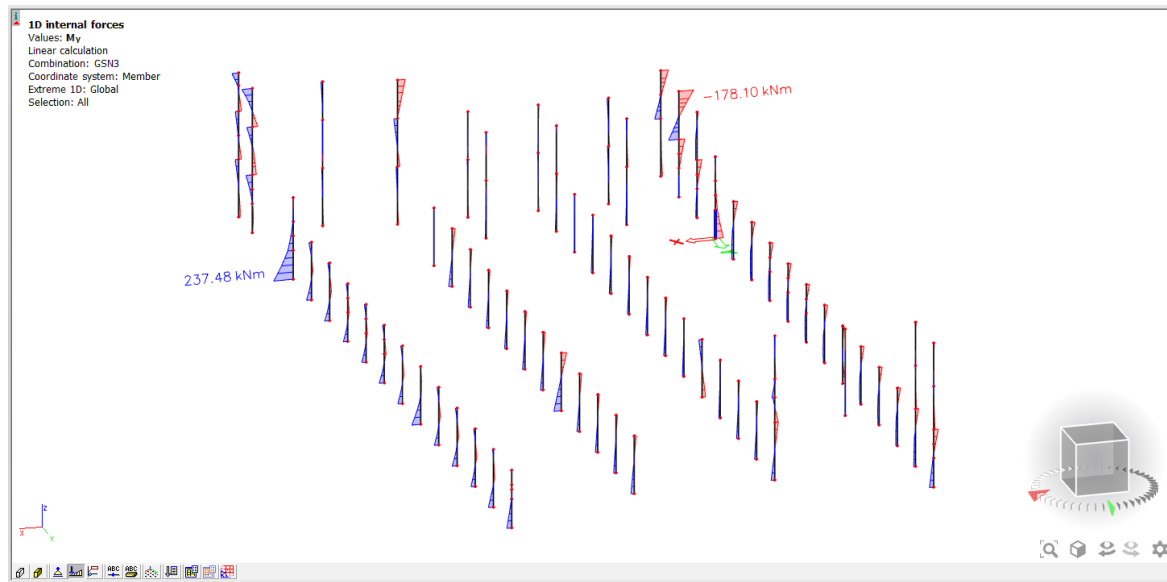
$$N = 109,30 < 135,3 \text{ [kN]} \quad (58)$$

$$\frac{109,30}{135,30} = 0,81 \quad (59)$$

Uvjet zadovoljen za profil RD28.

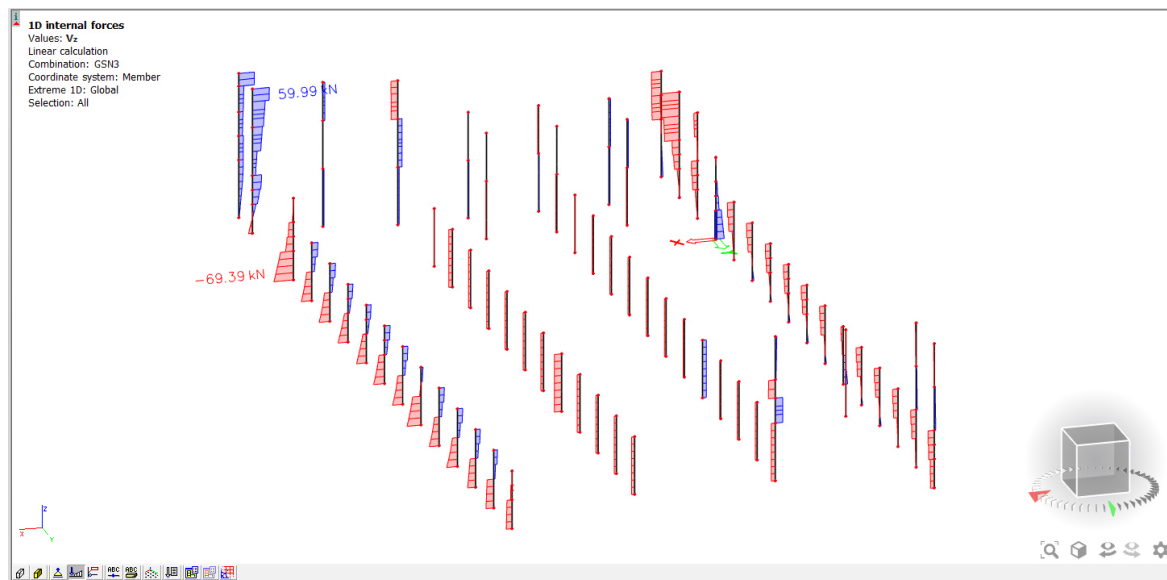
4.3.9 Dimenzioniranje stupova – Pozicija 10

Moment savijanja M_y u stupovima:



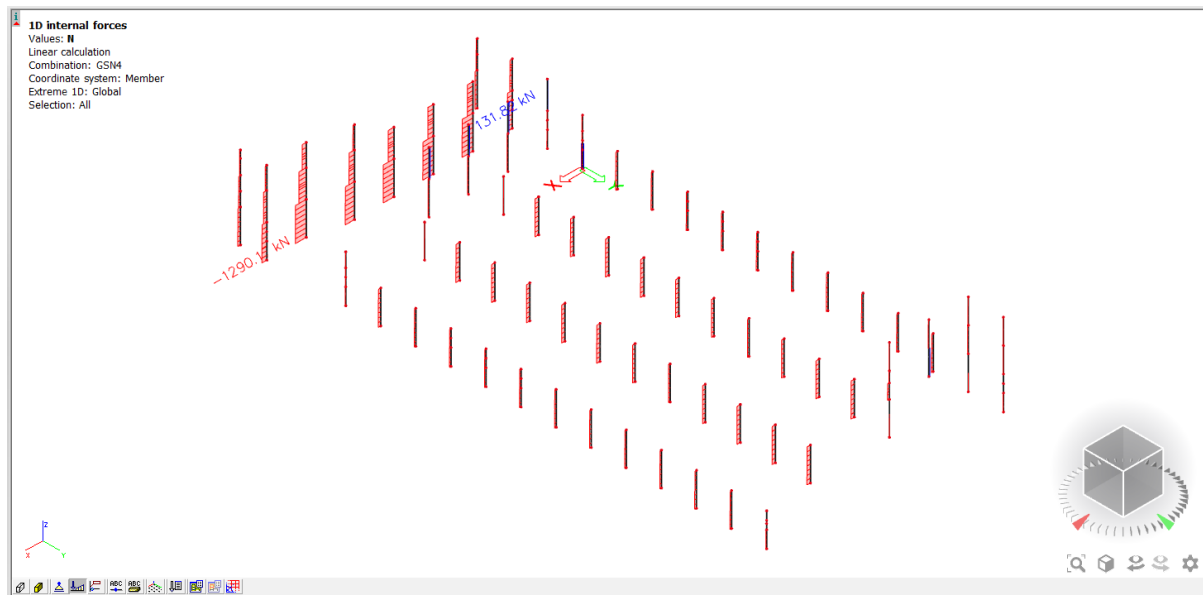
Slika 94. Prikaz momenta savijanja M_y u stupovima

Poprečna sila V_z u stupovima:



Slika 95. Prikaz poprečne sile V_z u stupovima

Uzdužna sila N u stupovima:



Slika 96. Prikaz uzdužne sile N u stupovima

Provjera finalnog poprečnog presjeka stupova u modulu Steel.

Odabrani profil – HEA450

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Stupovi 1

EN 1993-1-1 Code Check

National annex: Standard EN

Member B679	0.000 / 6.000 m	HEA450	S 275	GSN6	0.38 -
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Combination key	
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

....SECTION CHECK:....

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-1291.27	kN
$V_{y,Ed}$	7.33	kN
$V_{z,Ed}$	4.80	kN
T_{Ed}	-0.01	kNm
$M_{y,Ed}$	-13.93	kNm
$M_{z,Ed}$	-22.71	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	117	21	8.496e+04	1.131e+05	0.75	0.45	1.00	5.58	8.32	9.24	13.05	1
3	SO	117	21	6.924e+04	4.111e+04	0.59	0.62	1.00	5.58	8.32	9.24	15.27	1
4	I	344	12	7.628e+04	6.876e+04	0.90		1.00	29.91	25.88	31.43	36.37	2
5	SO	117	21	6.008e+04	3.195e+04	0.53	0.66	1.00	5.58	8.32	9.24	15.81	1
7	SO	117	21	7.580e+04	1.039e+05	0.73	0.45	1.00	5.58	8.32	9.24	13.08	1

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	1.7800e-02	m ²
$N_{c,Rd}$	4895.00	kN
Unity check	0.26	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

W_{ply}	3.2167e-03	m ³
$M_{ply,Rd}$	884.58	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)

$W_{pl,z}$	9.6667e-04	m ³
$M_{pl,z,Rd}$	265.83	kNm
Unity check	0.09	-

Shear check for V_y

According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	1.3043e-02	m ²
$V_{pl,y,Rd}$	2070.81	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	6.5755e-03	m ²
$V_{pl,z,Rd}$	1044.00	kN
Unity check	0.00	-

Torsion check

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

Fibre	2	
T_{Ed}	0.1	MPa
T_{Rd}	158.8	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)

$M_{N,v,Rd}$	762.63	kNm
α	2.00	
$M_{N,z,Rd}$	265.83	kNm
β	1.32	

Unity check (6.41) = 0.00 + 0.04 = 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: 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class [-]
1	SO	117	21	8.496e+04	1.131e+05	0.75	0.45	1.00	5.58	8.32	9.24	13.05	1
3	SO	117	21	6.924e+04	4.111e+04	0.59	0.62	1.00	5.58	8.32	9.24	15.27	1
4	I	344	12	7.628e+04	6.876e+04	0.90		1.00	29.91	25.88	31.43	36.37	2
5	SO	117	21	6.008e+04	3.195e+04	0.53	0.66	1.00	5.58	8.32	9.24	15.81	1
7	SO	117	21	7.580e+04	1.039e+05	0.73	0.45	1.00	5.58	8.32	9.24	13.08	1

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	6.000	6.000	m
Buckling factor k	1.01	0.51	
Buckling length l_{cr}	6.072	3.055	m
Critical Euler load N_{cr}	35805.39	21025.25	kN
Slenderness λ	32.10	41.89	
Relative slenderness λ_{rel}	0.37	0.48	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	a	b	
Imperfection α	0.21	0.34	
Reduction factor χ	0.96	0.89	
Buckling resistance $N_{b,Rd}$	4702.05	4365.76	kN

Flexural Buckling verification

Cross-section area A	1.7800e-02	m ²
Buckling resistance $N_{b,Rd}$	4365.76	kN
Unity check	0.30	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Torsional buckling length l_{cr}	6.000	m
Elastic critical load $N_{cr,T}$	10603.30	kN
Relative slenderness $\lambda_{rel,T}$	0.68	
Limit slenderness $\lambda_{rel,0}$	0.20	
Buckling curve	b	
Imperfection α	0.34	
Reduction factor χ	0.80	
Cross-section area A	1.7800e-02	m ²

Buckling resistance $N_{b,Rd}$	3892.45	kN
Unity check	0.33	-

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	3.2167e-03	m ³
Elastic critical moment M_{cr}	4008.05	kNm
Relative slenderness $\lambda_{rel,LT}$	0.47	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M_{cr} parameters		
LTB length l_{LT}	6.000	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.60	
LTB moment factor C_2	0.00	
LTB moment factor C_3	0.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

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	1.7800e-02	m ²
Plastic section modulus $W_{pl,y}$	3.2167e-03	m ³
Plastic section modulus $W_{pl,z}$	9.6667e-04	m ³
Design compression force N_{Ed}	1291.27	kN
Design bending moment (maximum) $M_{y,Ed}$	14.87	kNm
Design bending moment (maximum) $M_{z,Ed}$	-22.71	kNm
Characteristic compression resistance N_{Rk}	4895.00	kN
Characteristic moment resistance $M_{y,Rk}$	884.58	kNm
Characteristic moment resistance $M_{z,Rk}$	265.83	kNm
Reduction factor χ_y	0.96	
Reduction factor χ_z	0.80	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	0.66	
Interaction factor k_{yz}	0.34	
Interaction factor k_{zy}	0.34	
Interaction factor k_{zz}	0.50	

Maximum moment $M_{y,Ed}$ is derived from beam B679 position 6.000 m.

Maximum moment $M_{z,Ed}$ is derived from beam B679 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	35805.39	kN
Critical Euler load $N_{cr,z}$	21025.25	kN
Elastic critical load $N_{cr,T}$	10603.30	kN
Plastic section modulus $W_{pl,y}$	3.2167e-03	m ³
Elastic section modulus $W_{el,y}$	2.9000e-03	m ³
Plastic section modulus $W_{pl,z}$	9.6667e-04	m ³
Elastic section modulus $W_{el,z}$	6.3100e-04	m ³
Second moment of area I_y	6.3700e-04	m ⁴
Second moment of area I_z	9.4700e-05	m ⁴
Torsional constant I_t	2.4400e-06	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments ψ_y	-0.94	
Equivalent moment factor $C_{my,0}$	0.58	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments ψ_z	-0.94	
Equivalent moment factor $C_{mz,0}$	0.57	
Factor μ_y	1.00	
Factor μ_z	0.99	
Factor ϵ_y	0.07	
Factor a_{LT}	1.00	
Critical moment for uniform bending $M_{cr,0}$	1541.56	kNm
Relative slenderness $\lambda_{rel,0}$	0.76	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.31	
Equivalent moment factor C_{my}	0.67	
Equivalent moment factor C_{mz}	0.57	

Interaction method 1 parameters		
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.00	
Factor c_{LT}	0.03	
Factor d_{LT}	0.04	
Factor e_{LT}	0.21	
Factor w_y	1.11	
Factor w_z	1.50	
Factor n_{pl}	0.26	
Maximum relative slenderness $\lambda_{rel,max}$	0.48	
Factor C_{yy}	1.04	
Factor C_{yz}	1.23	
Factor C_{zy}	1.03	
Factor C_{zz}	1.20	

Unity check (6.61) = 0.27 + 0.01 + 0.03 = 0.31 -
 Unity check (6.62) = 0.33 + 0.01 + 0.04 = 0.38 -

Shear Buckling check

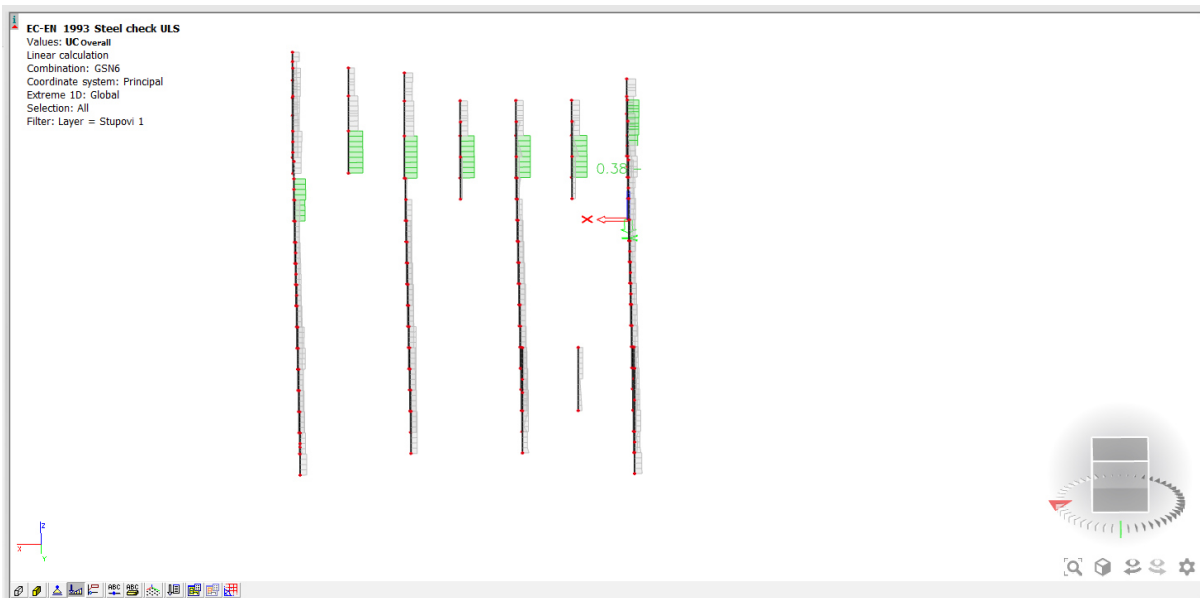
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	6.000	m
Web	unstiffened	
Web height h_w	398	mm
Web thickness t	12	mm
Material coefficient ϵ	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	34.61
Web slenderness limit	55.46

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

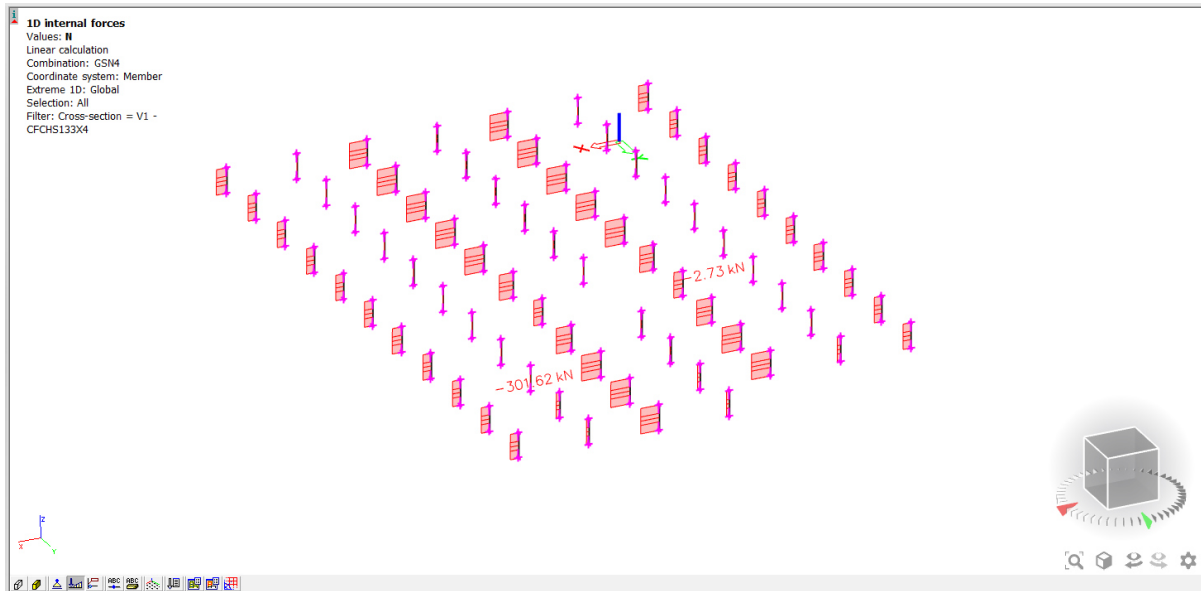
The member satisfies the stability check.



Slika 97. Prikaz iskoristivosti stupova

4.3.10 Dimenzioniranje vertikalala – Pozicija 13

Uzdužna sila N u vertikalama:



Slika 98. Prikaz uzdužne sile N u vertikalama

Proračun finalnog poprečnog presjeka vertikalala u modulu Steel.

Odabran profil – CHCHS133x4

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN4
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Cross-section = V1 - CFCHS133X4

EN 1993-1-1 Code Check

National annex: Standard EN

Member B248	0.000 / 2.600 m	CFCHS133X4	S 275	GSN4	0.90 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key	
GSN4 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"0+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 0+ + 1.35*LC6_Vjetar "Trenje 0 i 180 "	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Cold formed	

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

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-301.62	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	0.00	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	0.00	kNm
$M_{z,Ed}$	0.00	kNm

Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
133	4	33.25	42.73	59.82	76.91	1

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	1.6210e-03	m ²
$N_{c,Rd}$	445.77	kN
Unity check	0.68	-

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 Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
133	4	33.25	42.73	59.82	76.91	1

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	2.600	2.600	m
Buckling factor k	1.00	1.00	
Buckling length l_{cr}	2.600	2.600	m
Critical Euler load N_{cr}	1034.87	1034.92	kN
Slenderness λ	56.98	56.98	

Buckling parameters	yy	zz	
Relative slenderness λ_{rel}	0.66	0.66	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	c	c	
Imperfection α	0.49	0.49	
Reduction factor χ	0.75	0.75	
Buckling resistance $N_{b,Rd}$	335.01	335.02	kN

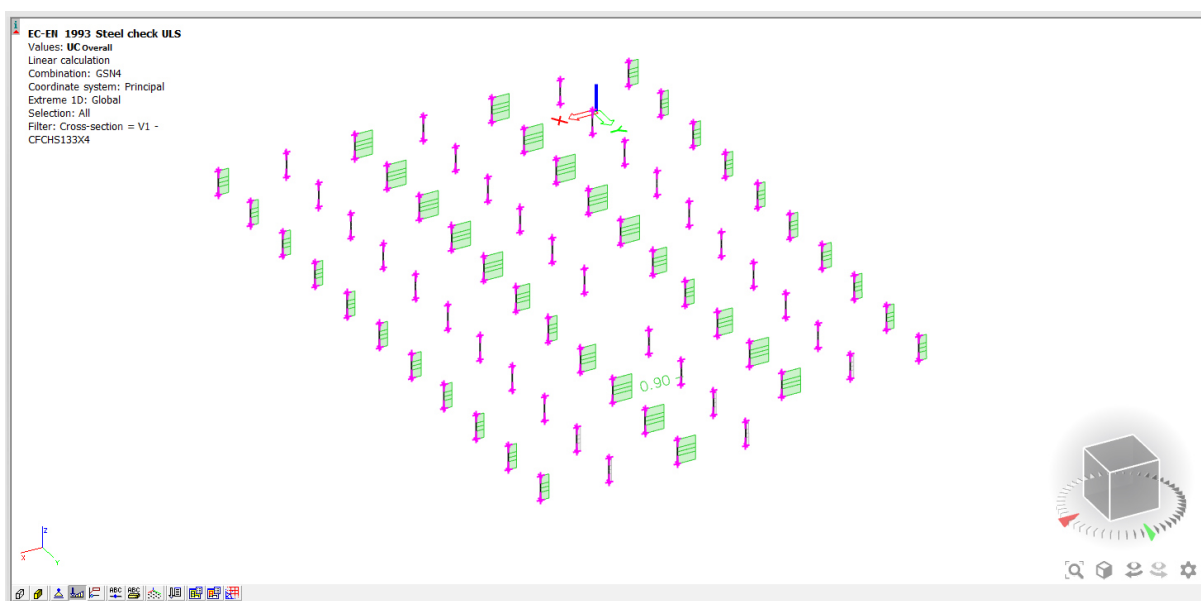
Flexural Buckling verification		
Cross-section area A	1.6210e-03	m ²
Buckling resistance $N_{b,Rd}$	335.01	kN
Unity check	0.90	-

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 CHS section which is not susceptible to Torsional(-Flexural) Buckling.

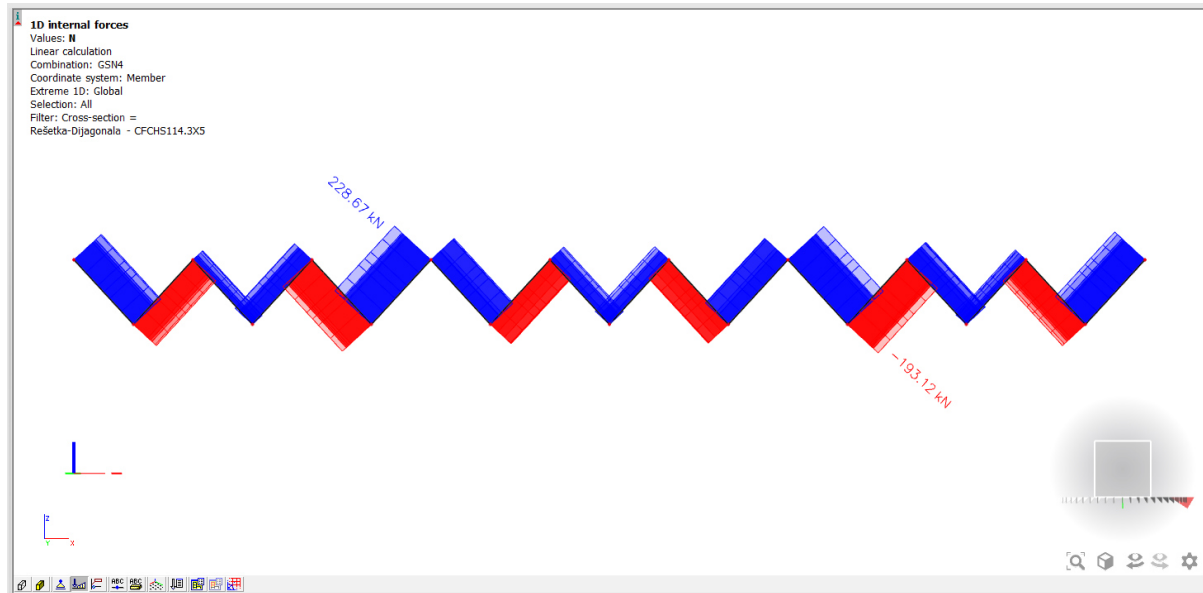
The member satisfies the stability check.



Slika 99. Prikaz iskoristivosti vertikalna

4.3.11 Dimenzioniranje dijagonala – Pozicija 14

Uzdužna sila N u dijagonalama:



Slika 100. Prikaz uzdužne sile N u dijagonalama

Proračun finalnog poprečnog presjeka dijagonala modulu Steel..

Odabran profil – CFCHS114.3x5

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavna sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN4
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Cross-section = Rešetka-Dijagonala - CFCHS114.3X5

EN 1993-1-1 Code Check

National annex: Standard EN

Member B443	3.538 / 3.538 m	CFCHS114.3X5	S 275	GSN4	0.80 -
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Note: EN 1993-1-3 article 1.1(3) specifies that this part does not apply to cold formed CHS and RHS sections. The default EN 1993-1-1 code check is executed instead of the EN 1993-1-3 code check.

Combination key

GSN4 / 1.35*LC1 + 1.35*LC2_Dodatno stalno +
 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg +
 1.50*LC6_Vjetar "SHED"0+ + 1.35*LC6_Vjetar "Zidovi+ +
 1.35*LC6_Vjetar "Ravni krov 0+ + 1.35*LC6_Vjetar "Trenje
 0 i 180 "

Partial safety factors

γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material

Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Cold formed	

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

The critical check is on position 3.538 m

Internal forces	Calculated	Unit
N_{Ed}	-193.12	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	0.00	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	0.00	kNm
$M_{z,Ed}$	0.00	kNm

Classification for cross-section design

Classification according to EN 1993-1-1 article 5.5.2

Classification of Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
114	5	22.86	42.73	59.82	76.91	1

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	1.7170e-03	m ²
$N_{cr,Rd}$	472.18	kN
Unity check	0.41	-

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 Tubular sections according to EN 1993-1-1 Table 5.2 Sheet 3

d [mm]	t [mm]	d/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
114	5	22.86	42.73	59.82	76.91	1

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	3.538	3.538	m
Buckling factor k	1.00	1.00	
Buckling length l_{cr}	3.538	3.538	m
Critical Euler load N_{cr}	425.32	425.34	kN
Slenderness λ	91.47	91.47	

Buckling parameters	yy	zz	
Relative slenderness λ_{rel}	1.05	1.05	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	c	c	
Imperfection α	0.49	0.49	
Reduction factor χ	0.51	0.51	
Buckling resistance $N_{b,Rd}$	240.55	240.56	kN

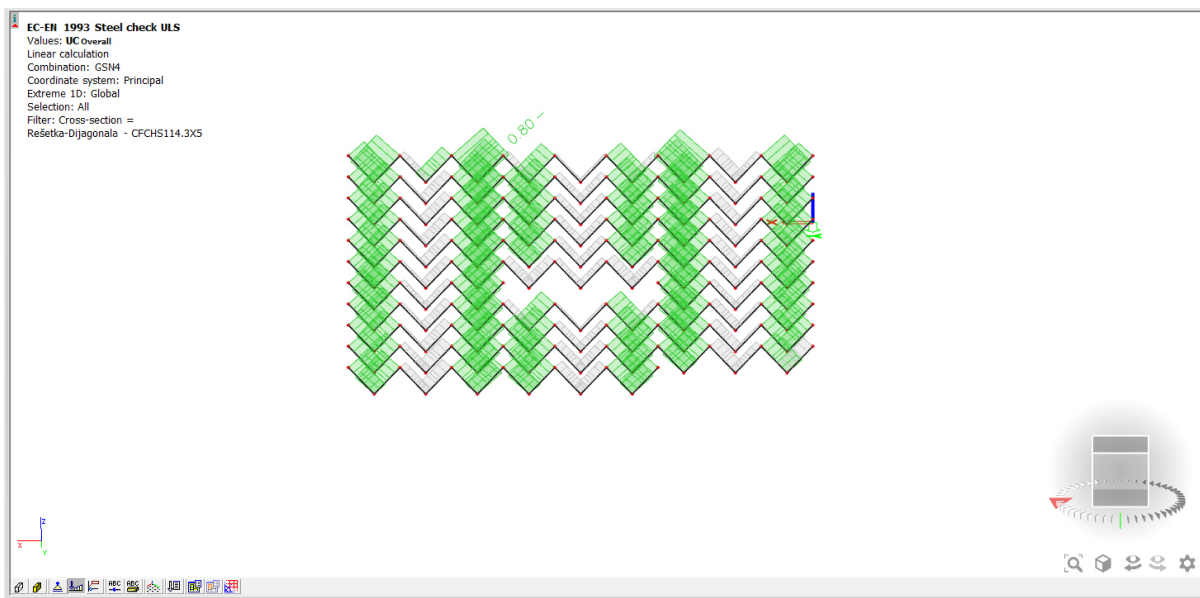
Flexural Buckling verification		
Cross-section area A	1.7170e-03	m ²
Buckling resistance $N_{b,Rd}$	240.55	kN
Unity check	0.80	-

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 CHS section which is not susceptible to Torsional(-Flexural) Buckling.

The member satisfies the stability check.

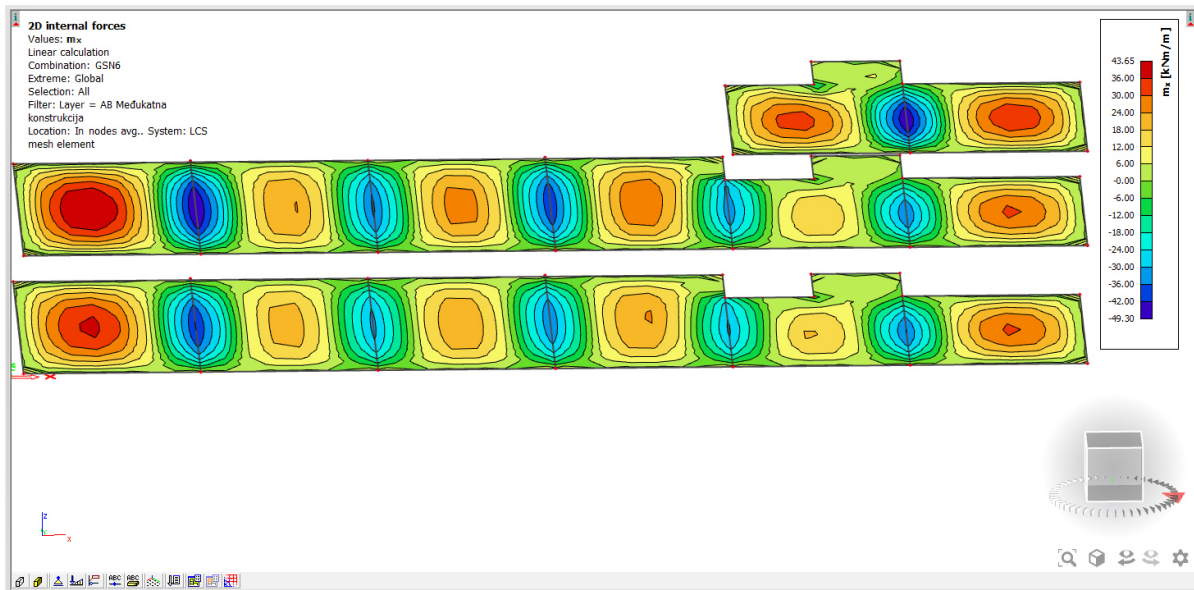


Slika 101. Prikaz iskoristivosti dijagonala

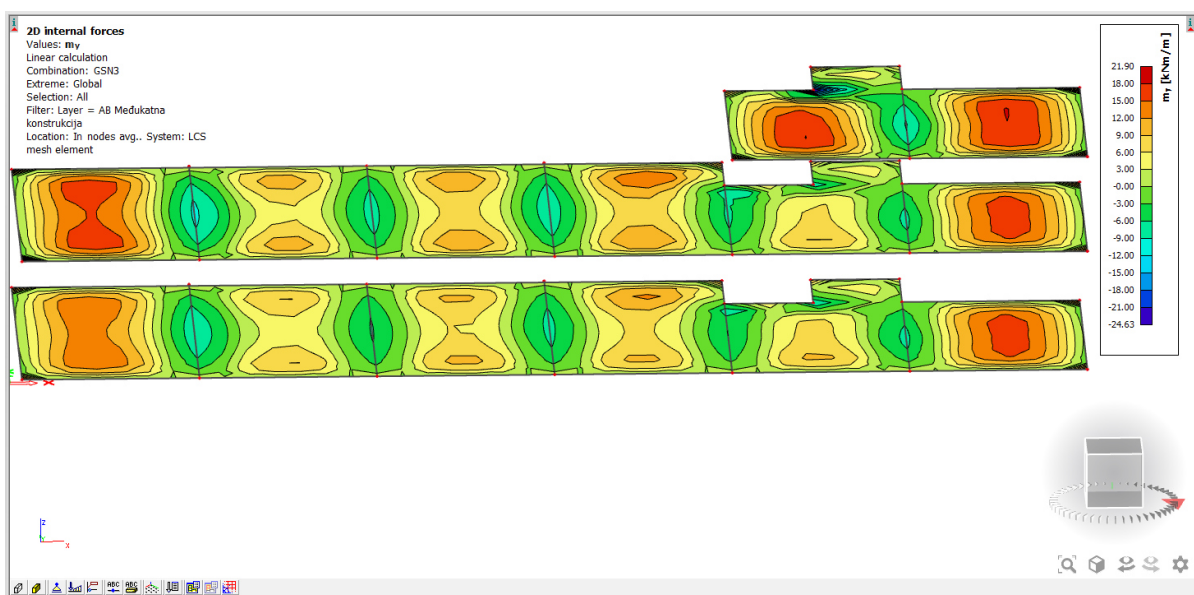
4.3.12 Dimenzioniranje spregnute konstrukcije – Pozicija 17

Kod dimenzioniranja AB dijela spregnute konstrukcije, proračunavamo samo gornju zonu, a donji dio potrebne armature će preuzeti trapezni lim sa rebrastom armaturom

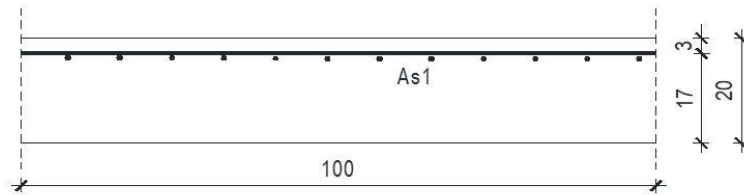
Mjerodavne kombinacije opterećenja



Slika 102. Prikaz mjerodavnog momenta u x smjeru

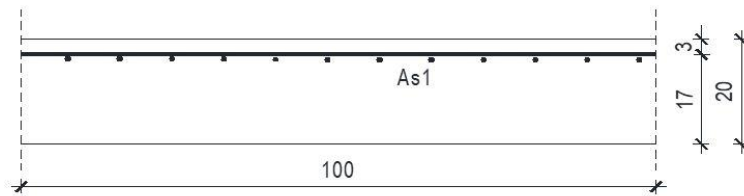


Slika 103. Prikaz mjerodavnog momenta u y smjeru

Dimenzioniranje pozicija 100Pozicija 101 – ležaj 101 – 102

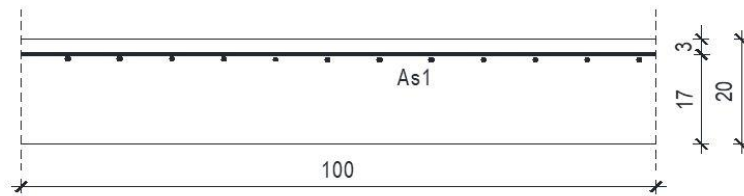
	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	‰	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

Pozicija 102 – ležaj 102 – 103



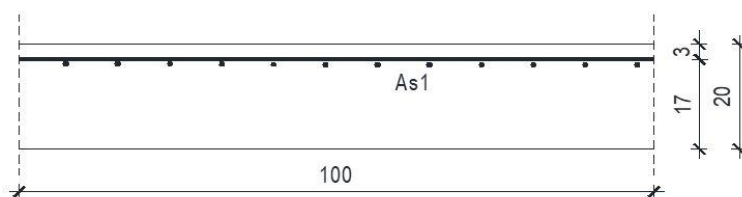
	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	%	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

Pozicija 103 – ležaj 103 – 104



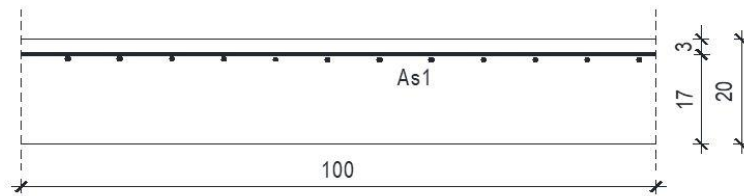
	b	100.00	cm					
	h	20.00	cm	C 25/30				
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²		
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²		
	M_{Ed}	42.00	kNm	Jednostruko armiranje				
B 500B	N_{Ed}	0.00	kN	w	10.879	%		
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.356	%		
	e_{c2}	2.0	‰	x	0.164		x =	2.80 cm
M _{Ed} =42,00 [kNm]	M_{sds}	42.00	kNm	z	0.938			
	M_{Rd,lim}	76.81	kNm	A_{s1}	6.05	cm ²		
N _{Ed} =0,00 [kN]	m_{sd}	0.087		A_{s2}	0.00	cm ²		
				A_{s,min}	2.00	cm ²		
	Odabrana mreža: Q 636 (6,36 [cm ² /m])							

Pozicija 104 – ležaj 104 – 105



	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	%	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

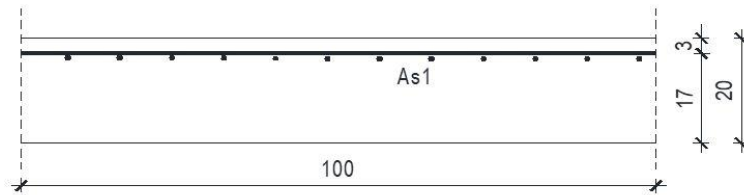
Pozicija 105 – ležaj 105 – 106



	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	42.00	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	10.879	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.356	%	
	e_{c2}	2.0	‰	x	0.164	x =	2.80 cm
M _{Ed} =42,00 [kNm]	M_{sds}	42.00	kNm	z	0.938		
	M_{Rd,lim}	76.81	kNm	A_{s1}	6.05	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.087		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 636 (6,36 [cm ² /m])						

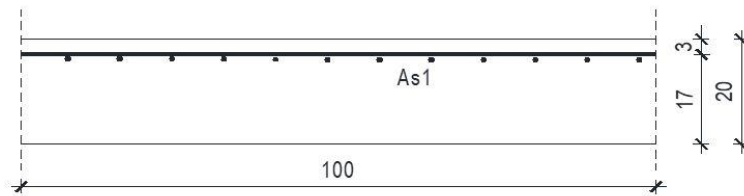
Dimenzioniranje pozicija 200

Pozicija 201 – ležaj 201 – 202



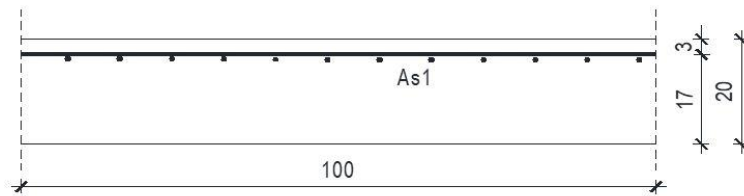
	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	%	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

Pozicija 202 – ležaj 202 – 203



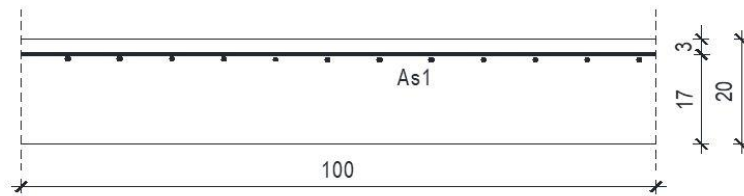
	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	%	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: : Q 785 (7,85 [cm ² /m])						

Pozicija 203 – ležaj 203 – 204



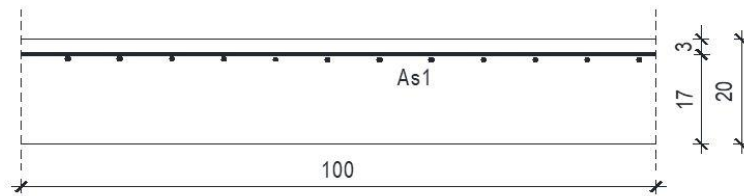
	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	42.00	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	10.879	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.356	%	
	e_{c2}	2.0	‰	x	0.164	x =	2.80 cm
M _{Ed} =42,00 [kNm]	M_{sds}	42.00	kNm	z	0.938		
	M_{Rd,lim}	76.81	kNm	A_{s1}	6.05	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.087		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 636 (6,36 [cm ² /m])						

Pozicija 204 – ležaj 204 – 205



	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	%	
	e_{c2}	2.2	‰	x	0.183	x =	3.11 cm
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

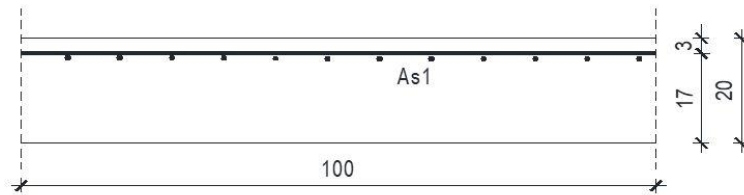
Pozicija 205 – ležaj 205 – 206



	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	42.00	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	10.879	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.356	%	
	e_{c2}	2.0	‰	x	0.164	x =	2.80 cm
M _{Ed} =42,00 [kNm]	M_{sds}	42.00	kNm	z	0.938		
	M_{Rd,lim}	76.81	kNm	A_{s1}	6.05	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.087		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 636 (6,36 [cm ² /m])						

Dimenzioniranje pozicija 300

Pozicija 301 – ležaj 301 – 302



	b	100.00	cm				
	h	20.00	cm	C 25/30			
C 25/30	d₁ (d₂)	3.00	cm	f_{cd}	1.67	kN/cm ²	
f _{cd} =25/1,5=16,67 [MPa]	d	17.00	cm	f_{yd}	43.48	kN/cm ²	
	M_{Ed}	49.30	kNm	Jednostruko armiranje			
B 500B	N_{Ed}	0.00	kN	w	12.870	%	
f _{yd} =500/1,15=434,8 [MPa]	e_{s1}	10.0	‰	r	0.422	‰	
	e_{c2}	2.2	‰	x	0.183	x = 3.11 cm	
M _{Ed} =49,30 [kNm]	M_{sds}	49.30	kNm	z	0.930		
	M_{Rd,lim}	76.81	kNm	A_{s1}	7.17	cm ²	
N _{Ed} =0,00 [kN]	m_{sd}	0.102		A_{s2}	0.00	cm ²	
				A_{s,min}	2.00	cm ²	
	Odabrana mreža: Q 785 (7,85 [cm ² /m])						

KONSTRUKTIVNA ARMATURA

Za sve presjeke konstruktivna armatura je odabrana Q226 (na ležaju gdje armatura nosi u jednom smjeru R226), zbog minimalne potrebne armature od 2 [cm²/m¹].

Kod donje zone spregnute konstrukcije, trapezni lim skupa s rebrastom armaturom mora pokriti mjerodavne momente savijanja i to:

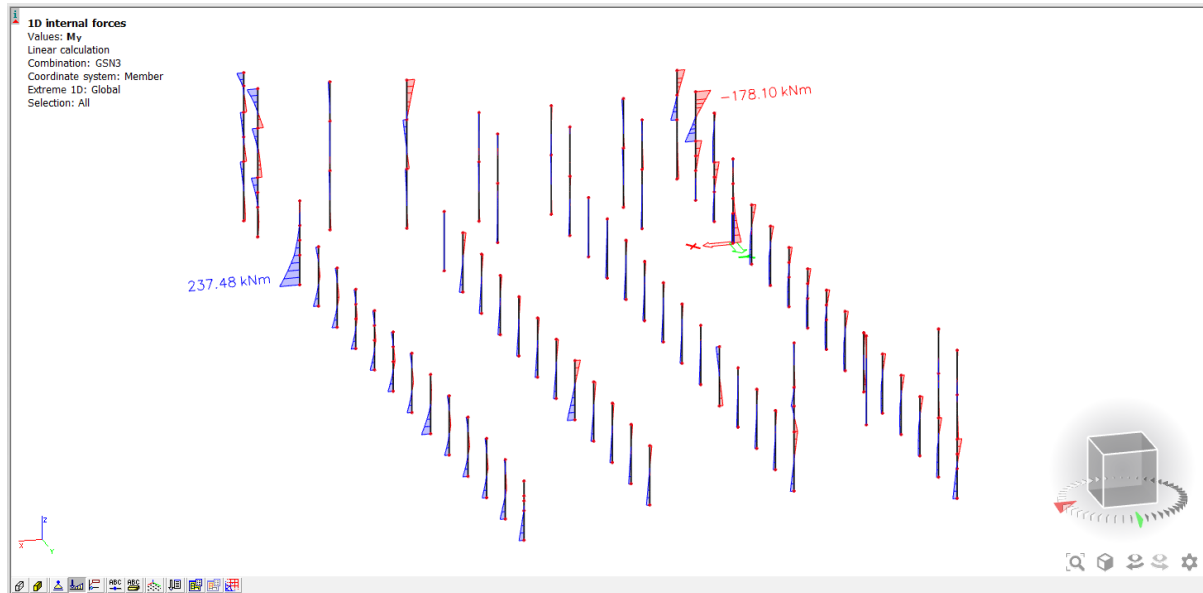
Tablica 29. Prikaz mjerodavnih momenata savijanja po pozicijama

Pozicija	Mjerodavni moment savijanja [kNm]
101	43,65
102	32,00
103	32,00
104	36,00
105	36,00
106	43,65
201	43,65
202	32,00
203	36,00
204	36,00
205	28,00
206	43,65
301	43,65
302	43,65

Proračun na pukotine nije potrebno izvršiti sa graničnim stanjem uporabljivosti jer ploča nije deblja od 20 [cm]!

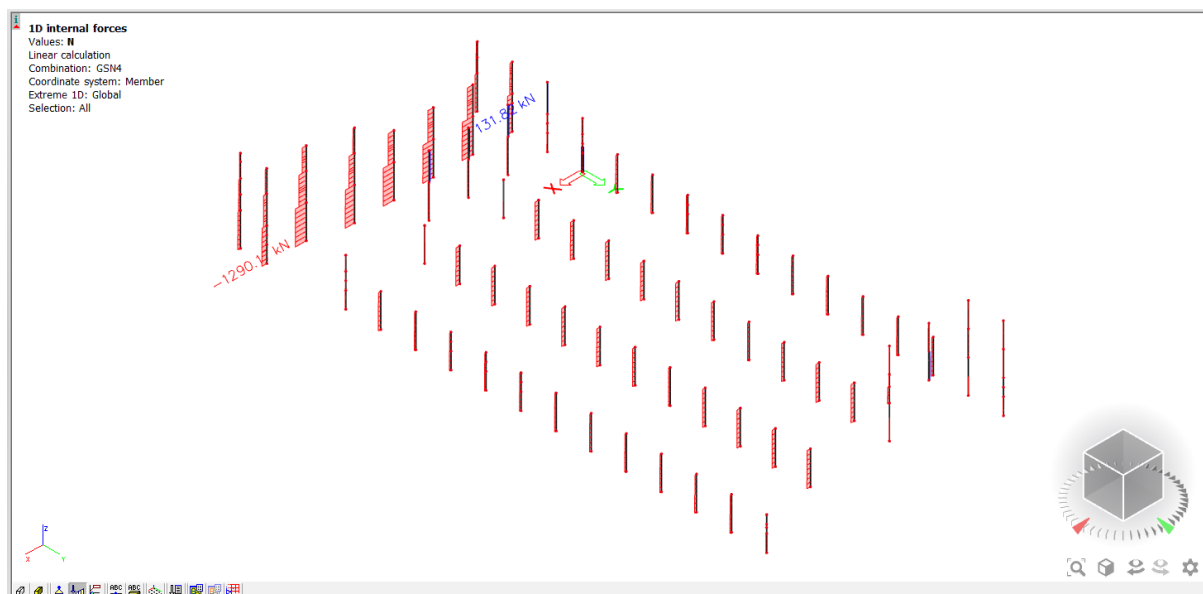
4.3.13 Odabir geometrije temelja samca – Pozicija 19

Moment savijanja M_y temelja samca:



Slika 104. Prikaz momenta savijanja M_y temelja samca

Uzdužna sila N temelja samca:



Slika 105. Prikaz uzdužne sile N temelja samca

$$\sigma_{1,2} = \frac{N_{Ed}}{A} \pm \frac{M_{Ed}}{W} \quad (60)$$

$$\sigma_{dop} = 500 \text{ [MPa]} \quad (61)$$

$$\sigma_{1,2} < \sigma_{dop} \quad (62)$$

Za najbolju iskoristivog presjeka stupa odabrana je geometrija 2000x2000x500 [mm].

$$A = 2,1 * 2,1 = 4,41 \text{ [m}^2\text{]} \quad (63)$$

$$W = \frac{a^3}{6} = \frac{2,1^3}{6} = 1,54 \text{ [m}^2\text{]} \quad (64)$$

$$\sigma_1 = \frac{N_{Ed}}{A} + \frac{M_{Ed}}{W} = \frac{1290,1}{4,41} + \frac{237,48}{1,54} = 446,75 \text{ [MPa]} \quad (65)$$

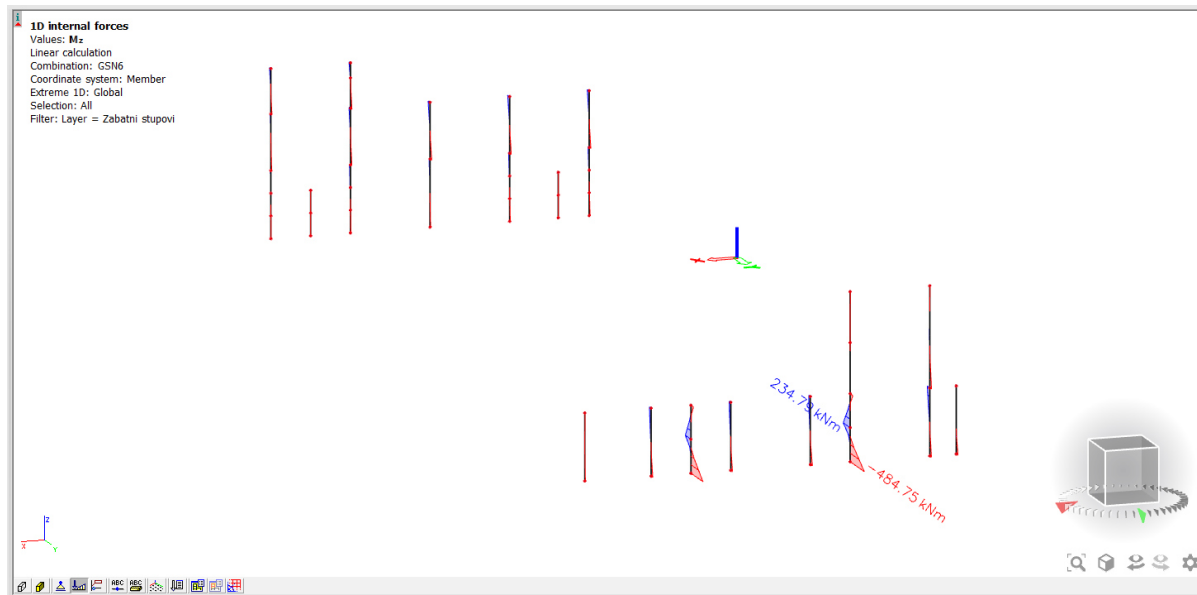
$$\sigma_2 = \frac{N_{Ed}}{A} - \frac{M_{Ed}}{W} = \frac{1290,1}{4,41} - \frac{237,48}{1,54} = 138,34 \text{ [MPa]} \quad (66)$$

$$\sigma_1 < \sigma_{dop} \quad (67)$$

$$\sigma_2 < \sigma_{dop} \quad (68)$$

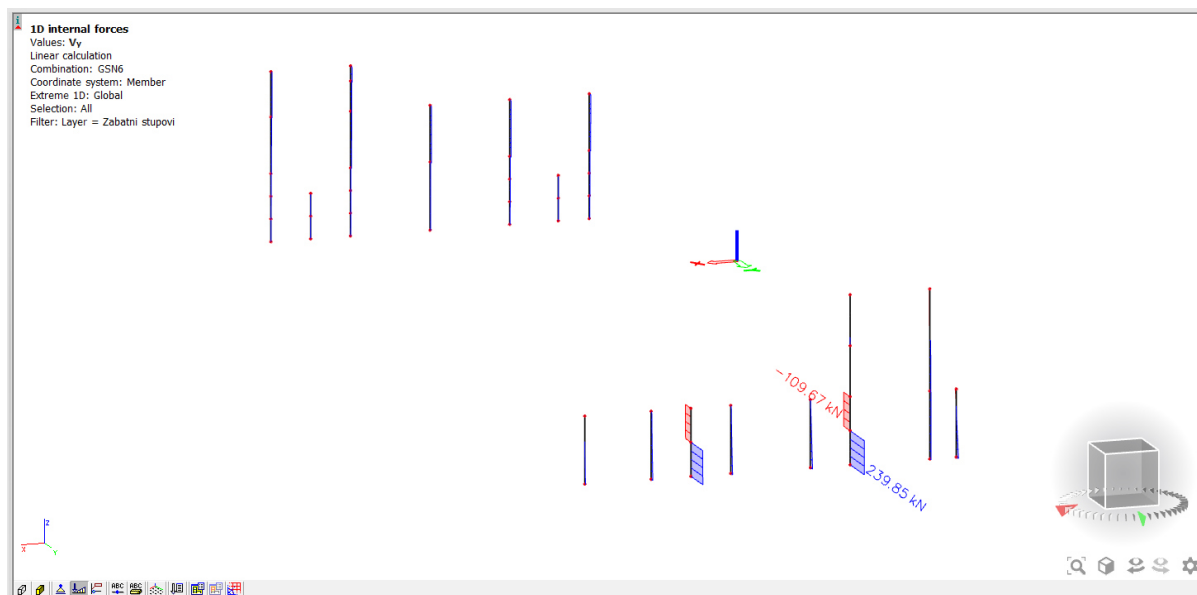
4.3.14 Dimenzioniranje zabatnih stupova – Pozicija 20

Moment savijanja M_y u zabatnim stupovima:



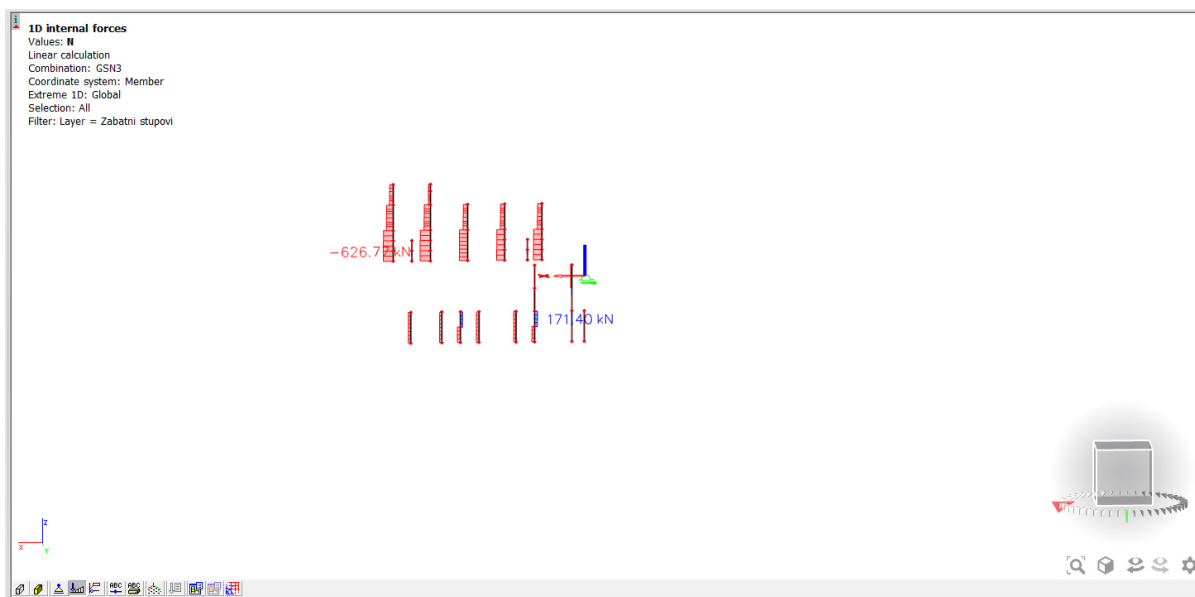
Slika 106. Prikaz momenta savijanja M_z u zabatnim stupovima

Poprečna sila V_z u zabatnim stupovima:



Slika 107. Prikaz poprečne sile V_y u zabatnim stupovima

Uzdužna sila N u zabatnim stupovima:



Slika 108. Prikaz uzdužne sile N u zabatnim stupovima

Provjera finalnog poprečnog presjeka donjeg pojasa u modulu Steel.

Odabrani profil – HEA240

U nastavku je dan prikaz proračuna odabranog presjeka na mjerodavne sile:

EC-EN 1993 Steel check ULS

Linear calculation
 Combination: GSN6
 Coordinate system: Principal
 Extreme 1D: Global
 Selection: All
 Filter: Layer = Zabatni stupovi

EN 1993-1-1 Code Check

National annex: Standard EN

Member B692	0.000 / 6.000 m	HEA240	S 275	GSN6	0.61 -
-------------	-----------------	--------	-------	------	--------

Combination key	
GSN6 / 1.35*LC1 + 1.35*LC2_Dodatno stalno + 1.35*LC3_Promjenjivo + 1.35*LC4_Snijeg + 1.50*LC6_Vjetar "SHED"90+ + 1.35*LC6_Vjetar "Zidovi+ + 1.35*LC6_Vjetar "Ravni krov 90+ + 1.35*LC6_Vjetar "Trenje 90"	

Partial safety factors	
γ_{M0} for resistance of cross-sections	1.00
γ_{M1} for resistance to instability	1.00
γ_{M2} for resistance of net sections	1.25

Material		
Yield strength f_y	275.0	MPa
Ultimate strength f_u	430.0	MPa
Fabrication	Rolled	

...:SECTION CHECK:...

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-489.96	kN
$V_{y,Ed}$	0.55	kN
$V_{z,Ed}$	-8.37	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	23.23	kNm
$M_{z,Ed}$	-2.06	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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1	Class 2	Class 3	Class
										Limit [-]	Limit [-]	Limit [-]	
1	SO	95	12	3.298e+04	4.006e+04	0.82	0.44	1.00	7.94	8.32	9.24	12.94	1
3	SO	95	12	2.930e+04	2.222e+04	0.76	0.53	1.00	7.94	8.32	9.24	14.08	1
4	I	164	8	3.922e+04	8.829e+04	0.44		1.00	21.87	25.88	31.43	43.52	1
5	SO	95	12	9.453e+04	8.745e+04	0.93	0.46	1.00	7.94	8.32	9.24	13.12	1
7	SO	95	12	9.821e+04	1.053e+05	0.93	0.44	1.00	7.94	8.32	9.24	12.80	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	7.6800e-03	m ²
$N_{c,Rd}$	2112.00	kN
Unity check	0.23	-

Bending moment check for M_y

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

W_{ply}	7.4583e-04	m ³
$M_{pl,y,Rd}$	205.10	kNm
Unity check	0.11	-

Bending moment check for M_z

According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,z}$	3.5167e-04	m ³
$M_{pl,z,Rd}$	96.71	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	5.9737e-03	m ²
$V_{pl,y,Rd}$	948.46	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	2.5140e-03	m ²
$V_{pl,z,Rd}$	399.15	kN
Unity check	0.02	-

Torsion check

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

Fibre	2	
T_{Ed}	0.0	MPa
T_{Rd}	158.8	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)

$M_{N,y,Rd}$	180.03	kNm
α	2.00	
$M_{N,z,Rd}$	96.71	kNm
β	1.16	

Unity check (6.41) = 0.02 + 0.01 = 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]	σ_1 [kN/m ²]	σ_2 [kN/m ²]	Ψ [-]	k_σ [-]	α [-]	c/t [-]	Class 1 Limit [-]	Class 2 Limit [-]	Class 3 Limit [-]	Class
1	SO	95	12	1.156e+05	1.099e+05	0.95	0.45	1.00	7.94	8.32	9.24	12.99	1
3	SO	95	12	1.186e+05	1.243e+05	0.95	0.43	1.00	7.94	8.32	9.24	12.78	1
4	I	164	8	1.035e+05	2.110e+04	0.20		1.00	21.87	25.88	31.43	48.54	1
5	SO	95	12	9.017e+03	1.475e+04	0.61	0.47	1.00	7.94	8.32	9.24	13.28	1
7	SO	95	12	6.038e+03	3.045e+02	0.05	1.48	1.00	7.94	8.32	9.24	23.62	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	6.000	2.000	m
Buckling factor k	1.49	0.64	
Buckling length l_{cr}	8.920	1.274	m
Critical Euler load N_{cr}	2021.37	35395.72	kN
Slenderness λ	88.74	21.21	
Relative slenderness λ_{rel}	1.02	0.24	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	b	c	
Imperfection α	0.34	0.49	
Reduction factor χ	0.58	0.98	
Buckling resistance $N_{b,Rd}$	1231.33	2064.44	kN

Flexural Buckling verification		
Cross-section area A	7.6800e-03	m ²
Buckling resistance $N_{b,Rd}$	1231.33	kN
Unity check	0.40	-

Torsional(-Flexural) Buckling check

According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check

According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	7.4583e-04	m ³
Elastic critical moment M_{cr}	2599.32	kNm
Relative slenderness $\lambda_{rel,LT}$	0.28	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

Note: The slenderness or bending moment is such that Lateral Torsional Buckling effects may be ignored according to EN 1993-1-1 article 6.3.2.2(4).

M _{cr} parameters		
LTB length l_{LT}	2.000	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_{yy}	1.00	
LTB moment factor C_1	1.52	
LTB moment factor C_2	0.01	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters are determined according to ECCS 119 2006 / Galea 2002.

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
Plastic section modulus $W_{pl,y}$	7.4583e-04	m ³
Plastic section modulus $W_{pl,z}$	3.5167e-04	m ³
Design compression force N_{Ed}	489.96	kN
Design bending moment (maximum) $M_{y,Ed}$	-39.03	kNm
Design bending moment (maximum) $M_{z,Ed}$	-2.06	kNm
Characteristic compression resistance N_{Rk}	2112.00	kN
Characteristic moment resistance $M_{y,Rk}$	205.10	kNm
Characteristic moment resistance $M_{z,Rk}$	96.71	kNm
Reduction factor χ_y	0.58	
Reduction factor χ_z	0.98	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.07	
Interaction factor k_{yz}	0.54	
Interaction factor k_{zy}	0.71	
Interaction factor k_{zz}	1.01	

Maximum moment $M_{y,Ed}$ is derived from beam B692 position 6.000 m.

Maximum moment $M_{z,Ed}$ is derived from beam B692 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	2021.37	kN
Critical Euler load $N_{cr,z}$	35395.72	kN
Elastic critical load $N_{cr,T}$	14864.51	kN
Plastic section modulus $W_{pl,y}$	7.4583e-04	m ³
Elastic section modulus $W_{el,y}$	6.7500e-04	m ³
Plastic section modulus $W_{pl,z}$	3.5167e-04	m ³
Elastic section modulus $W_{el,z}$	2.3100e-04	m ³
Second moment of area I_y	7.7600e-05	m ⁴
Second moment of area I_z	2.7700e-05	m ⁴
Torsional constant I_t	4.1600e-07	m ⁴
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-39.03	kNm
Maximum relative deflection δ_z	2.2	mm
Equivalent moment factor $C_{my,0}$	0.82	
Method for equivalent moment factor $C_{mz,0}$	Table A.2 Line 1 (Linear)	
Ratio of end moments ψ_z	0.47	
Equivalent moment factor $C_{mz,0}$	0.89	
Factor μ_y	0.88	
Factor μ_z	1.00	
Factor ϵ_y	0.91	
Factor a_{LT}	0.99	
Critical moment for uniform bending $M_{cr,0}$	1710.32	kNm
Relative slenderness $\lambda_{rel,0}$	0.35	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.24	
Equivalent moment factor C_{my}	0.91	
Equivalent moment factor C_{mz}	0.89	
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.00	
Factor c_{LT}	0.05	
Factor d_{LT}	0.03	

Interaction method 1 parameters		
Factor e_{LT}	1.19	
Factor w_y	1.10	
Factor w_z	1.50	
Factor n_{pl}	0.23	
Maximum relative slenderness $\lambda_{rel,max}$	1.02	
Factor C_{yy}	0.99	
Factor C_{yz}	1.03	
Factor C_{zy}	0.87	
Factor C_{zz}	0.89	

Unity check (6.61) = $0.40 + 0.20 + 0.01 = 0.61$ -

Unity check (6.62) = $0.24 + 0.14 + 0.02 = 0.39$ -

Shear Buckling check

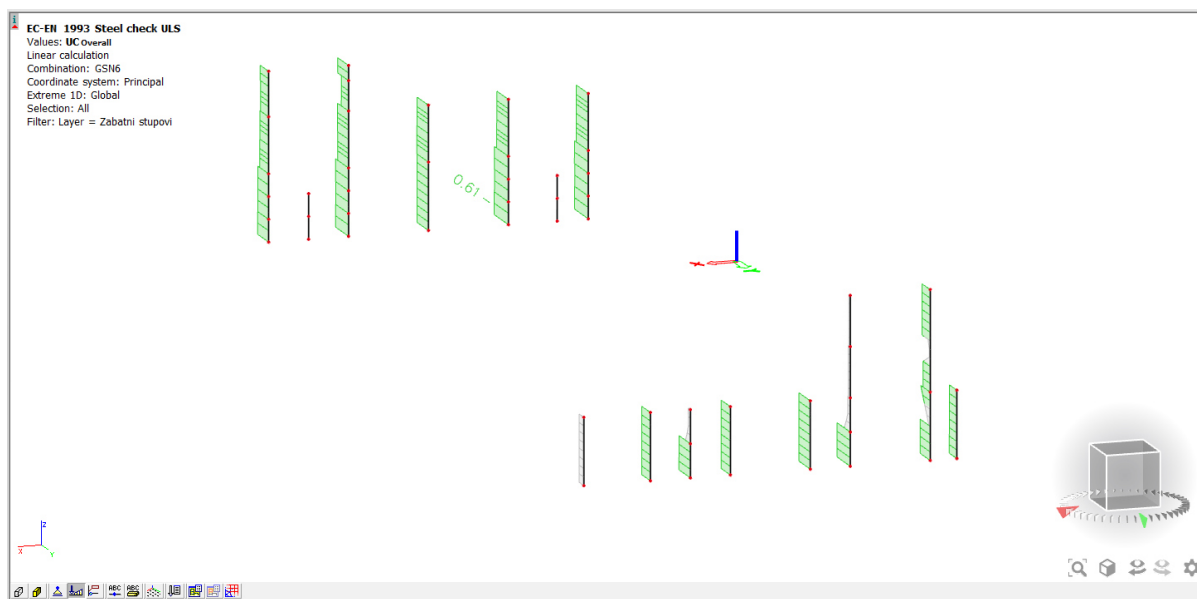
According to EN 1993-1-5 article 5 & 7.1 and formula (5.10) & (7.1)

Shear Buckling parameters		
Buckling field length a	6.000	m
Web	unstiffened	
Web height h_w	206	mm
Web thickness t	8	mm
Material coefficient ε	0.92	
Shear correction factor η	1.20	

Shear Buckling verification	
Web slenderness h_w/t	27.47
Web slenderness limit	55.46

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.

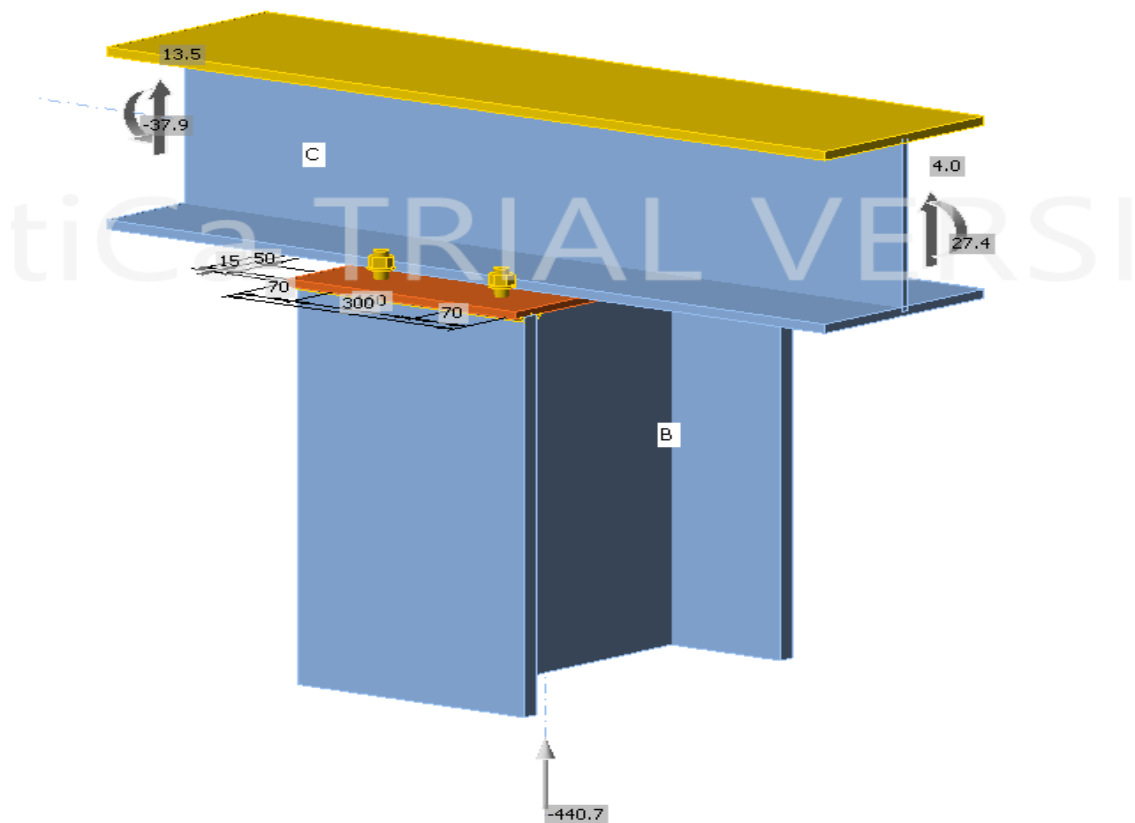


Slika 109. Prikaz iskoristivosti zabatnih stupova

5. SPOJEVI ČELIČNIH ELEMENATA

5.1 Spoj stup greda

- | | |
|---|----------------------|
| - Mjerodavni moment savijanja M_{y1} na gredi | $M_{y1}=37,86$ [kNm] |
| - Mjerodavni moment savijanja M_{y2} na gredi | $M_{y2}=27,37$ [kNm] |
| - Mjerodavna poprečna sila V_{z1} na gredi | $V_{z1}=13,51$ [kN] |
| - Mjerodavna poprečna sila V_{z2} na gredi | $V_{z2}=3,97$ [kN] |
| - Mjerodavna uzdužna sila N u stupu | $N=440,68$ [kN] |



Slika 110. Prikaz zadanih opterećenja u programu IdeaStatica – spoj stup greda

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/28/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item Spoj stup - greda

Design

Name Spoj stup - greda
Description
Analysis Stress, strain/ loads in equilibrium

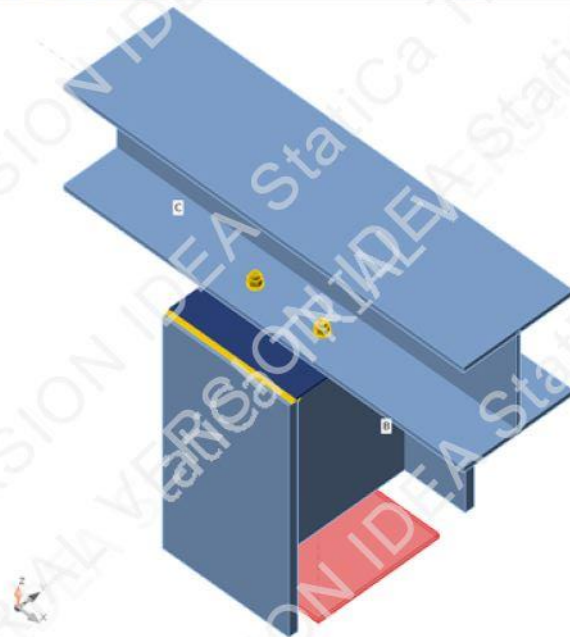
Members

Geometry

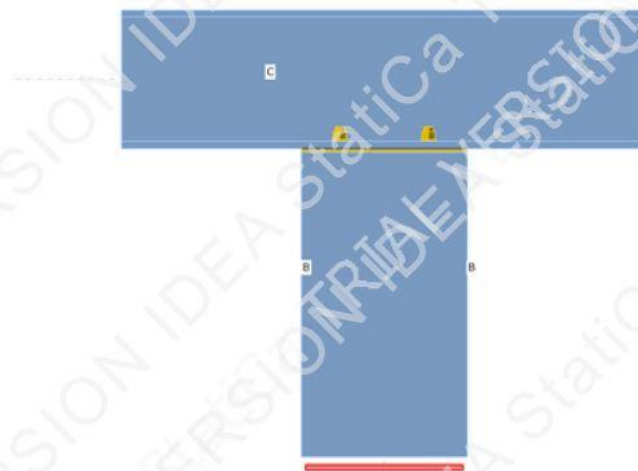
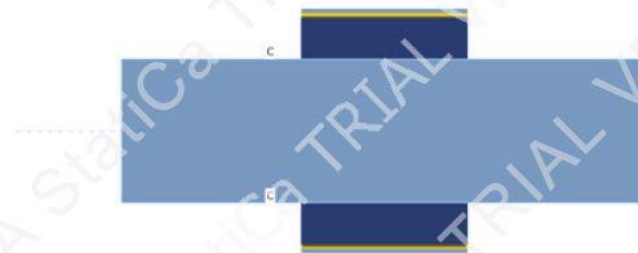
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
C	14 - Greda 1(HEA260)	0.0	0.0	0.0	0	0	0
B	15 - Stup1(HEA450)	0.0	-90.0	90.0	0	0	0

Supports and forces

Name	Support	Forces in	X [mm]
C / begin		Node	0
C / end		Node	0
B / end	N-Vy-Vz-Mx-My-Mz	Node	0



Project:
Project no:
Author:



Project:
Project no:
Author:



Cross-sections

Name	Material
14 - Greda 1(HEA260)	S 275
15 - Stup1(HEA450)	S 275

Project:
Project no:
Author:



Cross-sections

Name	Material	Drawing
14 - Greda 1(HEA260)	S 275	
15 - Stup 1(HEA450)	S 275	

Bolts

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M16 8.8	M16 8.8	16	800.0	201

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	C / Begin	0.0	0.0	13.5	0.0	-37.9	0.0
	C / End	0.0	0.0	4.0	0.0	27.4	0.0
	B / End	-440.7	0.0	0.0	0.0	0.0	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	0.0	0.0	458.2	0.0	-10.5	0.0

Project:
Project no:
Author:



Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	2.7 < 5.0%	OK
Bolts	81.9 < 100%	OK
Welds	98.4 < 100%	OK
Buckling	Not calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pI} [%]	$\sigma_{c,Ed}$ [MPa]	Status
C-bfl 1	12.5	LE1	275.2	0.1	243.5	OK
C-tfl 1	12.5	LE1	55.4	0.0	0.0	OK
C-w 1	7.5	LE1	84.0	0.0	0.0	OK
B-bfl 1	21.0	LE1	94.1	0.0	0.0	OK
B-tfl 1	21.0	LE1	94.0	0.0	0.0	OK
B-w 1	11.5	LE1	276.5	0.7	0.0	OK
EP1	8.0	LE1	280.7	2.7	243.5	OK

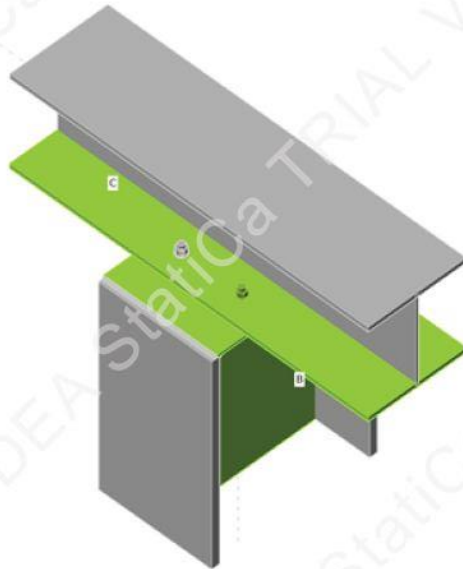
Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

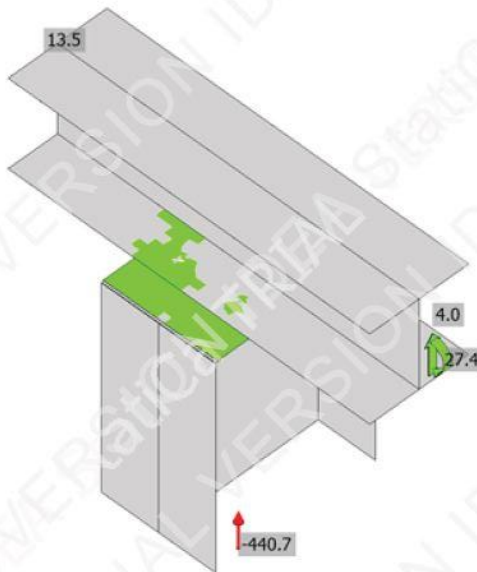
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pI}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

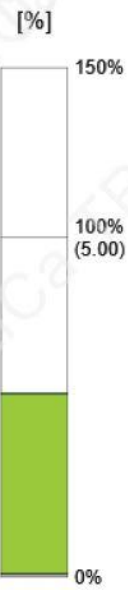
Project:
Project no:
Author:



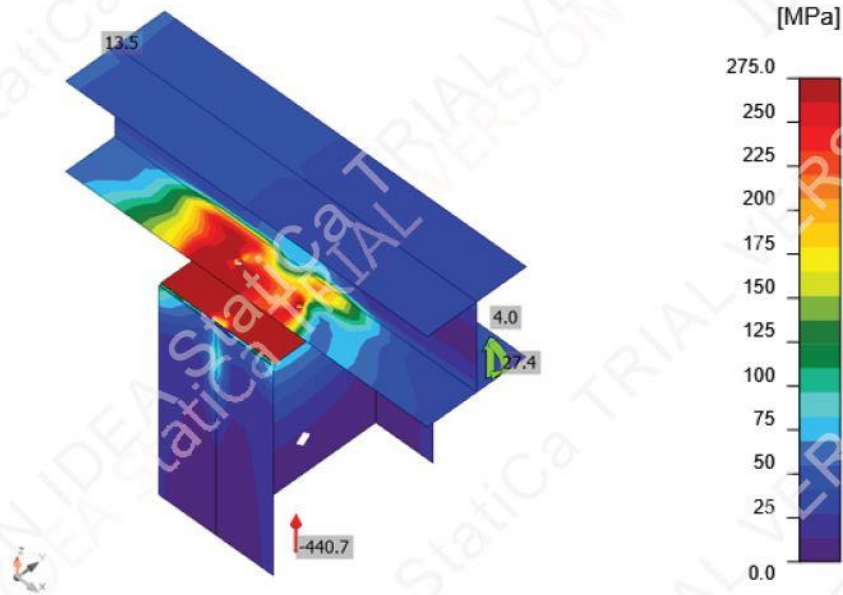
Overall check, LE1



Strain check, LE1



Project:
Project no:
Author:



Equivalent stress, LE1

Bolts

Shape	Item	Grade	Loads	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	$F_{b,Rd}$ [kN]	U_t [%]	U_s [%]	U_{ts} [%]	Status
	B1	M16 8.8 - 1	LE1	74.1	4.2	110.1	81.9	7.0	65.5	OK
	B2	M16 8.8 - 1	LE1	17.8	4.8	110.1	19.7	8.0	22.0	OK
	B3	M16 8.8 - 1	LE1	74.0	4.2	110.1	81.9	7.0	65.5	OK
	B4	M16 8.8 - 1	LE1	17.7	4.8	110.1	19.6	8.0	22.0	OK

Design data

Grade	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M16 8.8 - 1	90.4	131.6	60.3

Symbol explanation

- $F_{t,Ed}$ Tension force
- $F_{v,Ed}$ Resultant of bolt shear forces V_y and V_z in shear planes
- $F_{b,Rd}$ Plate bearing resistance EN 1993-1-8 – Tab. 3.4
- U_t Utilization in tension
- U_s Utilization in shear
- U_{ts} Interaction of tension and shear EN 1993-1-8 – Tab. 3.4
- $F_{t,Rd}$ Bolt tension resistance EN 1993-1-8 – Tab. 3.4
- $B_{p,Rd}$ Punching shear resistance EN 1993-1-8 – Tab. 3.4
- $F_{v,Rd}$ Bolt shear resistance EN 1993-1-8 – Tab. 3.4

Project:

Project no:

Author:

**Detailed result for B1****Tension resistance check (EN 1993-1-8 – Table 3.4)**

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 90.4 \text{ kN} \geq F_{t,Ed} = 74.1 \text{ kN}$$

Where:

- $k_2 = 0.90$ – Factor
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A_s = 157 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1.25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Table 3.4)

$$B_{p,Rd} = \frac{0.6 \pi d_m t_p f_u}{\gamma_{M2}} = 131.6 \text{ kN} \geq F_{t,Ed} = 74.1 \text{ kN}$$

Where:

- $d_m = 25 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 8 \text{ mm}$ – Plate thickness
- $f_u = 430.0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1.25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Table 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 60.3 \text{ kN} \geq F_{v,Ed} = 4.2 \text{ kN}$$

Where:

- $\beta_p = 1.00$ – Reduction factor for packing
- $\alpha_v = 0.60$ – Reduction factor for shear stress
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 157 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1.25$ – Safety factor

Project:

Project no:

Author:



Bearing resistance check (EN 1993-1-8 – Table 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 110.1 \text{ kN} \geq F_{b,Ed} = 4.2 \text{ kN}$$

Where:

$$k_1 = \min\left(2.8 \frac{e_2}{d_0} - 1.7, 1.4 \frac{p_2}{d_0} - 1.7, 2.5\right) = 2.50$$

– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer

$$\alpha_b = \min\left(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1\right) = 1.00$$

– Factor for end distance and bolt spacing in direction of load transfer

$$e_2 = 70 \text{ mm}$$

– Distance to the plate edge perpendicular to the shear force

$$p_2 = 160 \text{ mm}$$

– Distance between bolts perpendicular to the shear force

$$d_0 = 18 \text{ mm}$$

– Bolt hole diameter

$$e_1 = 275 \text{ mm}$$

– Distance to the plate edge in the direction of the shear force

$$p_1 = 140 \text{ mm}$$

– Distance between bolts in the direction of the shear force

$$f_{ub} = 800.0 \text{ MPa}$$

– Ultimate tensile strength of the bolt

$$f_u = 430.0 \text{ MPa}$$

– Ultimate strength of the plate

$$d = 16 \text{ mm}$$

– Nominal diameter of the fastener

$$t = 8 \text{ mm}$$

– Thickness of the plate

$$\gamma_{M2} = 1.25$$

– Safety factor

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0.82 \leq 1.0$$

Where:

$$F_{t,Ed} = 74.1 \text{ kN}$$

– Tensile force

$$F_{t,Rd} = 90.4 \text{ kN}$$

– Tension resistance

$$B_{p,Rd} = 131.6 \text{ kN}$$

– Punching resistance

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}, \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0.07 \leq 1.0$$

Where:

$$F_{v,Ed} = 4.2 \text{ kN}$$

– Shear force (in decisive shear plane)

$$F_{v,Rd} = 60.3 \text{ kN}$$

– Shear resistance

$$F_{b,Ed} = 4.2 \text{ kN}$$

– Bearing force (for decisive plate)

$$F_{b,Rd} = 110.1 \text{ kN}$$

– Bearing resistance

Project:

Project no:

Author:



Interaction of tension and shear (EN 1993-1-8 – Table 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 F_{t,Rd}} = 0.66 \leq 1.0$$

Where:

 $F_{v,Ed} = 4.2 \text{ kN}$ – Shear force (in decisive shear plane)

 $F_{v,Rd} = 60.3 \text{ kN}$ – Shear resistance

 $F_{t,Ed} = 74.1 \text{ kN}$ – Tensile force

 $F_{t,Rd} = 90.4 \text{ kN}$ – Tension resistance

Welds

Item	Edge	T_w [mm]	L [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{pl} [%]	σ_{\perp} [MPa]	τ_{\perp} [MPa]	τ_{\parallel} [MPa]	Ut [%]	Ut _c [%]	Status
EP1	B-bf 1	▲ 5.0 ▲	299	LE1	186.9	0.0	-139.6	-71.7	1.3	46.2	27.6	OK
		▲ 5.0 ▲	299	LE1	115.3	0.0	89.5	40.2	12.0	29.1	21.1	OK
EP1	B-tfl 1	▲ 5.0 ▲	299	LE1	115.7	0.0	90.1	-40.1	-12.0	29.2	21.1	OK
		▲ 5.0 ▲	299	LE1	186.2	0.0	-139.0	71.5	-1.2	46.0	27.5	OK
EP1	B-w 1	▲ 4.0 ▲	408	LE1	398.3	1.1	194.7	166.0	-112.6	98.4	88.2	OK
		▲ 4.0 ▲	408	LE1	397.4	0.5	-133.6	141.4	-163.4	98.2	85.9	OK

Design data

Material	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9σ [MPa]
S 275	0.85	404.7	309.6

Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{pl}	Strain
σ_{\perp}	Perpendicular stress
τ_{\perp}	Shear stress perpendicular to weld axis
τ_{\parallel}	Shear stress parallel to weld axis
Ut	Utilization
Ut _c	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9σ	Perpendicular stress resistance: $0.9 \cdot f_u / \gamma_{M2}$
▲	Fillet weld

Project:
Project no:
Author:



Detailed result for EP1 / B-w 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 398.3 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 252.3 \text{ MPa}$$

where:

$f_u = 430.0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0.85$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1.25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0.98 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 398.3 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7 \text{ MPa}$ – Equivalent stress resistance

$\sigma_{\perp} = 252.3 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6 \text{ MPa}$ – Perpendicular stress resistance

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]
S 275	7.72	2.00	15.45

Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]
M16 8.8	0.71	16.00	11.40

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Double fillet	5.0	7.1	0.24	40.00	9.42
Double fillet	4.0	5.7	0.10	40.00	4.12

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]
11.40	30.0	3.42

Project:
Project no:
Author:




Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	43.81

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
EP1	P8.0x300.0-410.0 (S 275)		1	Double fillet: a = 5.0 Double fillet: a = 4.0	600.0 410.0	M16 8.8	4

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 275	5.0	7.1	600.0
Double fillet	S 275	4.0	5.7	410.0

Bolts

Name	Grip length [mm]	Count
M16 8.8	20	4

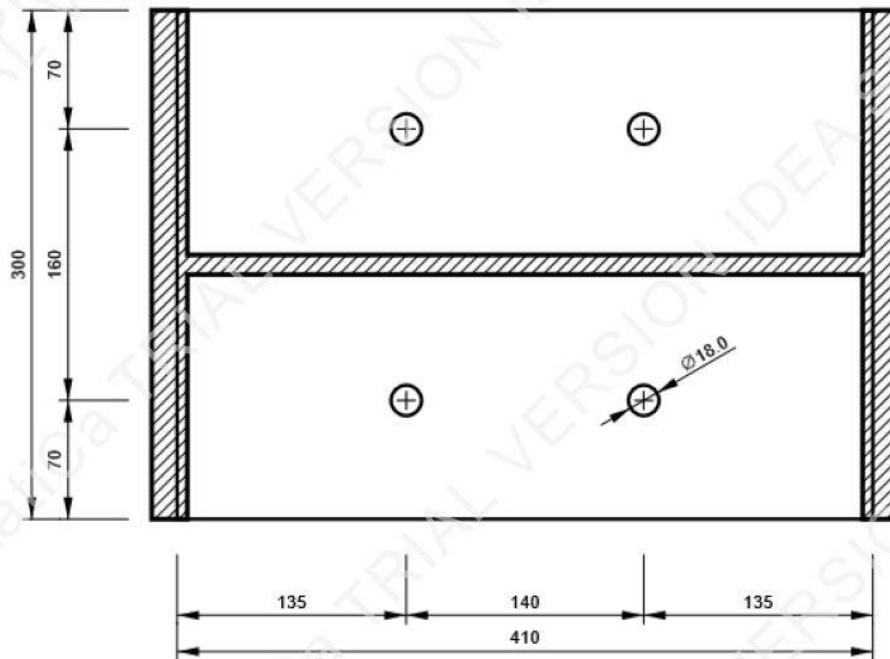
Drawing

EP1

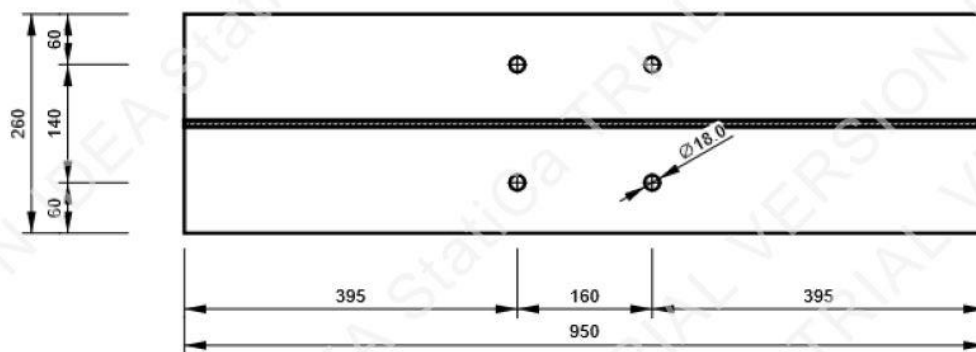
Project:
Project no:
Author:



P8.0x410-300 (S 275)



C, Greda 1(HEA260) - Bottom flange 1:



Project:
Project no:
Author:

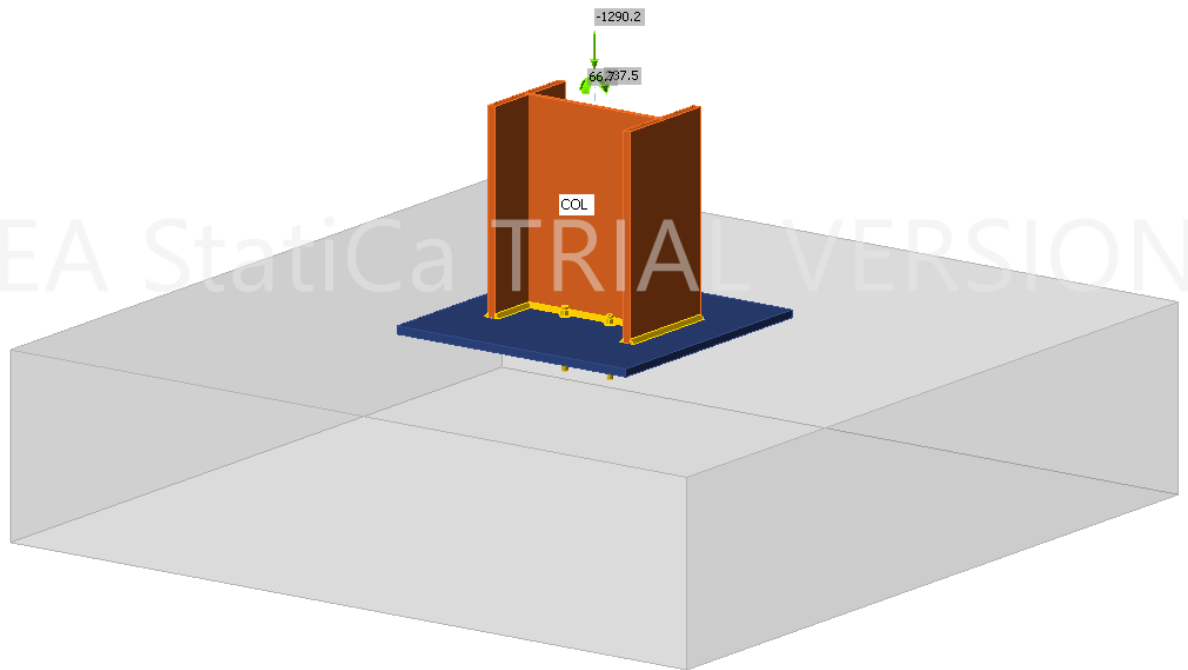


Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.2 Spoj stup temelj

- Mjerodavni moment savijanja M_y u stupu $M_y=237,48$ [kNm]
- Mjerodavni moment savijanja M_z u stupu $M_z=66,67$ [kNm]
- Mjerodavna uzdužna sila N u stupu $N=1290,18$ [kN]



Slika 111. Prikaz zadanih opterećenja u programu IdeaStatica – spoj stup temelj

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/28/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item STUP-TEMELJ

Design

Name: STUP-TEMELJ
Description:
Analysis: Stress, strain/ loads in equilibrium

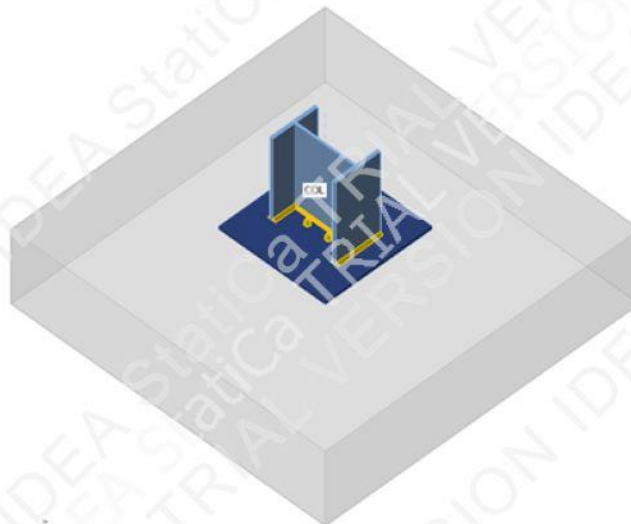
Members

Geometry

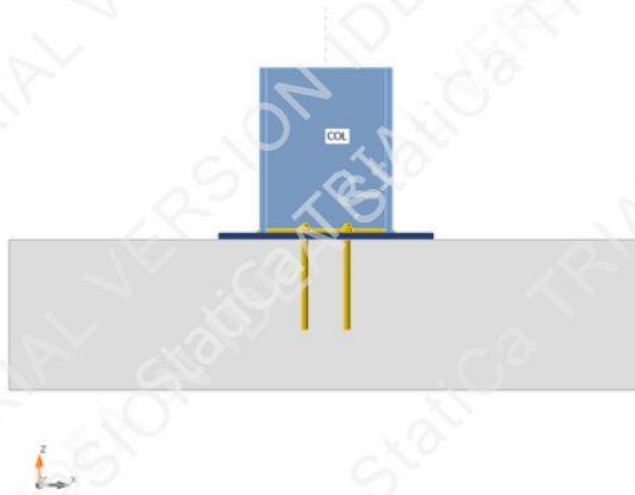
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
COL	8 - STUP(HEA450)	0.0	90.0	0.0	0	0	0

Supports and forces

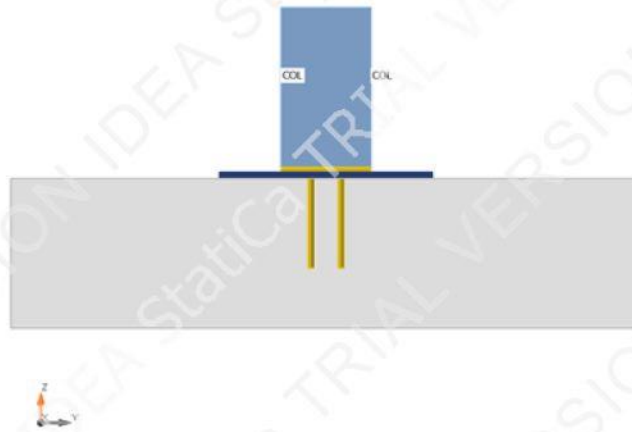
Name	Support	Forces in	X [mm]
COL / end		Node	0



Project:
Project no:
Author:



Project:
Project no:
Author:



Cross-sections

Name	Material
8 - STUP(HEA450)	S 275

Cross-sections

Name	Material	Drawing
8 - STUP(HEA450)	S 275	

Anchors

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M20 8.8	M20 8.8	20	800.0	314

Project:
Project no:
Author:



Load effects (forces in equilibrium)

Name	Member	N [kN]	V _y [kN]	V _z [kN]	M _x [kNm]	M _y [kNm]	M _z [kNm]
LE1	COL / End	-1290.2	0.0	0.0	0.0	237.5	66.7

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	M _x [kNm]	M _y [kNm]	M _z [kNm]
LE1	0.0	0.0	-1290.2	-66.7	237.5	0.0

Foundation block

Item	Value	Unit
CB 1		
Dimensions	2100 x 2100	mm
Depth	500	mm
Anchor	M20 8.8	
Anchoring length	300	mm
Shear force transfer	Friction	

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.7 < 5.0%	OK
Anchors	80.1 < 100%	OK
Welds	98.4 < 100%	OK
Concrete block	96.0 < 100%	OK
Shear	0.0 < 100%	OK
Buckling	Not calculated	

Plates

Name	t _p [mm]	Loads	σ _{Ed} [MPa]	ε _{pl} [%]	σ _{c,Ed} [MPa]	Status
COL-bfl 1	21.0	LE1	276.4	0.7	0.0	OK
COL-tfl 1	21.0	LE1	212.6	0.0	0.0	OK
COL-w 1	11.5	LE1	203.0	0.0	0.0	OK
BP1	20.0	LE1	275.6	0.3	0.0	OK

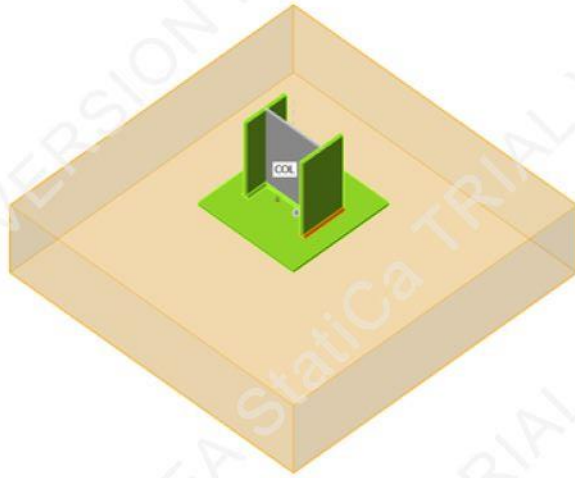
Design data

Material	f _y [MPa]	ε _{lim} [%]
S 275	275.0	5.0

Project:
Project no:
Author:

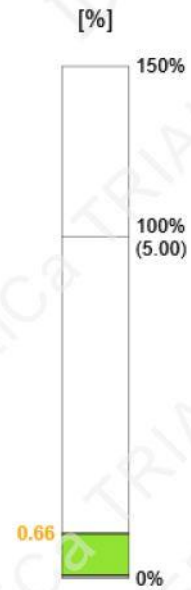
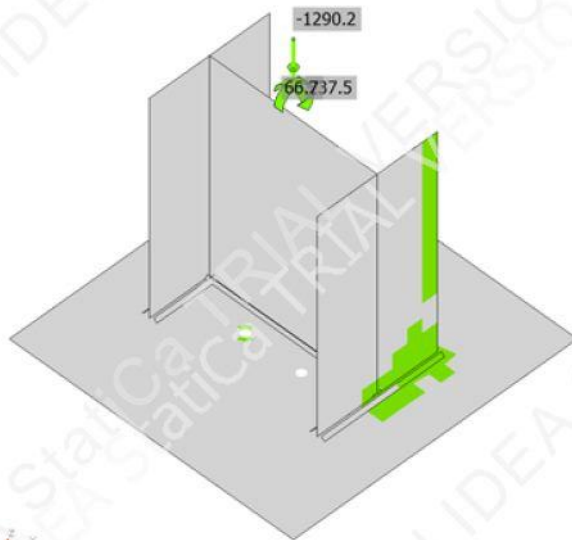
**Symbol explanation**

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

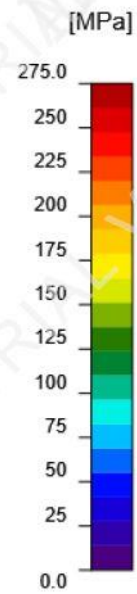
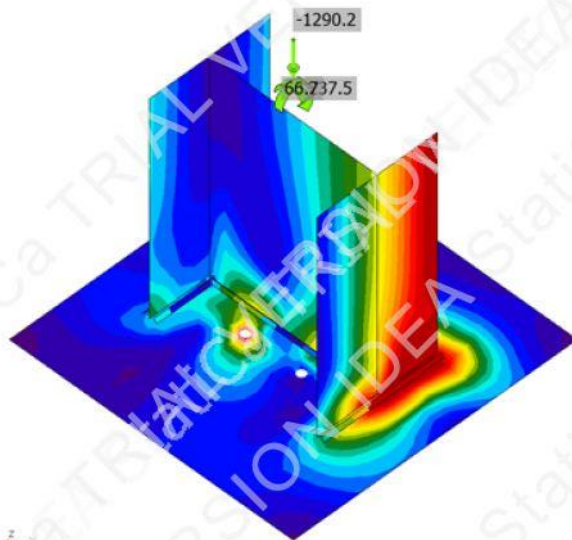


Overall check, LE1

Project:
Project no:
Author:



Strain check, LE1



Equivalent stress, LE1

Project:
Project no:
Author:



Anchors

Shape	Item	Loads	N_{Ed} [kN]	V_{Ed} [kN]	$N_{Rd,c}$ [kN]	$V_{Rd,cp}$ [kN]	U_t [%]	U_s [%]	U_{ts} [%]	Status
	A1	LE1	23.1	0.0	173.1	342.1	64.7	0.0	52.0	OK
	A2	LE1	88.9	0.0	173.1	342.1	80.1	0.0	64.1	OK
	A3	LE1	0.0	0.0	-	342.1	0.0	0.0	0.0	OK
	A4	LE1	0.0	0.0	-	342.1	0.0	0.0	0.0	OK

Design data

Grade	$N_{Rd,s}$ [kN]	$V_{Rd,s}$ [kN]
M20 8.8 - 1	111.1	78.4

Symbol explanation

N_{Ed}	Tension force
V_{Ed}	Resultant of bolt shear forces V_y and V_z in shear planes
$N_{Rd,c}$	Design resistance in case of concrete cone failure under tension load - EN 1992-4 – 7.2.1.4
$V_{Rd,cp}$	Design resistance in case of concrete pryout failure - EN 1992-4 – 7.2.2.4
U_t	Utilization in tension
U_s	Utilization in shear
U_{ts}	Utilization in tension and shear
$N_{Rd,s}$	Design tensile resistance of a fastener in case of steel failure - EN 1992-4 – 7.2.1.3
$V_{Rd,s}$	Design shear resistance of a fastener in case of steel failure - EN 1992-4 – 7.2.2.3.1

Detailed result for A2

Following checks of anchors loaded in tension are not provided and should be checked using information in relevant European Technical Product Specification:

- Pull-out failure of fastener (for post-installed mechanical anchors) - EN 1992-4 – 7.2.1.5
- Combined pull-out and concrete failure (for post-installed bonded anchors) - EN 1992-4 – 7.2.1.6
- Concrete splitting failure - EN 1992-4 – 7.2.1.7

Concrete blow-out failure is provided only for anchors with washer plates.

Project:

Project no:

Author:



Anchor tensile resistance (EN 1992-4 – 7.2.1.3)

$$N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}} = 111.1 \text{ kN} \geq N_{Ed} = 88.9 \text{ kN}$$

$$N_{Rk,s} = c \cdot A_s \cdot f_{uk} = 166.6 \text{ kN}$$

Where:

 $c = 0.85$ – reduction factor for cut thread $A_s = 245 \text{ mm}^2$ – tensile stress area $f_{uk} = 800.0 \text{ MPa}$ – minimum tensile strength of the bolt $\gamma_{Ms} = 1.50$ – safety factor for steel

- $\gamma_{Ms} = 1.2 \cdot \frac{f_{uk}}{f_{yk}} \geq 1.4$, where:
 - $f_{yk} = 640.0 \text{ MPa}$ – minimum yield strength of the bolt

Project:

Project no:

Author:

**Concrete breakout resistance of anchor in tension (EN 1992-4 – 7.2.1.4)**

The check is performed for group of anchors that form common tension breakout cone: A1, A2

$$N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}} = 173.1 \text{ kN} \geq N_{Ed,g} = 112.0 \text{ kN}$$

$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \psi_{s,N} \cdot \psi_{re,N} \cdot \psi_{ec,N} \cdot \psi_{M,N} = 311.6 \text{ kN}$$

Where:

$N_{Ed,g} = 112.0 \text{ kN}$ – sum of tension forces of anchors with common concrete breakout cone area

$N_{Rk,c}^0 = 200.1 \text{ kN}$ – characteristic strength of a fastener, remote from the effects of adjacent fasteners or edges of the concrete member

- $N_{Rk,c}^0 = k_1 \cdot \sqrt{f'_c} \cdot h_{ef}^{1.5}$, where:
 - $k_1 = 7.70$ – parameter accounting for anchor type and concrete condition
 - $f'_c = 25.0 \text{ MPa}$ – concrete compressive strength
 - $h_{ef} = \min(h_{emb}, \max(\frac{c_{a,max}}{1.5}, \frac{s_{max}}{3})) = 300 \text{ mm}$ – depth of embedment, where:
 - $h_{emb} = 300 \text{ mm}$ – anchor length embedded in concrete
 - $c_{a,max} = 1000 \text{ mm}$ – maximum distance from the anchor to one of the three closest edges
 - $s_{max} = 100 \text{ mm}$ – maximum spacing between anchors

$A_{c,N} = 898101 \text{ mm}^2$ – concrete breakout cone area for group of anchors

$A_{c,N}^0 = 810000 \text{ mm}^2$ – concrete breakout cone area for single anchor not influenced by edges

- $A_{c,N}^0 = (3 \cdot h_{ef})^2$, where:
 - $h_{ef} = 300 \text{ mm}$ – depth of embedment

$\psi_{s,N} = 1.00$ – parameter related to the distribution of stresses in the concrete due to the proximity of the fastener to an edge of the concrete member:

- $\psi_{s,N} = 0.7 + 0.3 \cdot \frac{c}{1.5 \cdot h_{ef}} \leq 1$, where:
 - $c = 930 \text{ mm}$ – minimum distance from the anchor to the edge
 - $h_{ef} = 300 \text{ mm}$ – depth of embedment

$\psi_{re,N} = 1.00$ – parameter accounting for the shell spalling:

- $\psi_{re,N} = 0.5 + \frac{h_{emb}}{200} \leq 1$, where:
 - $h_{emb} = 300 \text{ mm}$ – anchor length embedded in concrete

$\psi_{ec,N} = 0.94$ – modification factor for anchor groups loaded eccentrically in tension:

- $\psi_{ec,N} = \psi_{ecx,N} \cdot \psi_{ecy,N}$, where:
 - $\psi_{ecx,N} = \frac{1}{1 + \frac{2e_{x,N}}{3h_{ef}}} = 0.94$ – modification factor that depends on eccentricity in x-direction
 - $e_{x,N} = 29 \text{ mm}$ – tension load eccentricity in x-direction
 - $\psi_{ecy,N} = \frac{1}{1 + \frac{2e_{y,N}}{3h_{ef}}} = 1.00$ – modification factor that depends on eccentricity in y-direction
 - $e_{y,N} = 0 \text{ mm}$ – tension load eccentricity in y-direction
 - $h_{ef} = 300 \text{ mm}$ – depth of embedment

$\psi_{M,N} = 1.50$ – parameter accounting for the effect of a compression force between the fixture and concrete; this parameter is equal to 1 if $c < 1.5h_{ef}$ or the ratio of the compressive force (including the compression due to bending) to the sum of tensile forces in anchors is smaller than 0.8

Project:

Project no:

Author:



- $\psi_{M,N} = 2 - \frac{2 \cdot z}{3 \cdot h_{ef}} \geq 1$, where:
 - $z = 227$ mm – internal lever arm
 - $h_{ef} = 300$ mm – depth of embedment

$\gamma_{Mc} = 1.80$ – safety factor for concrete

Shear resistance (EN 1992-4 – 7.2.2.3.1)

$$V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}} = 78.4 \text{ kN} \geq V_{Ed} = 0.0 \text{ kN}$$

$$V_{Rk,s} = k_7 \cdot V_{Rk,s}^0 = 98.0 \text{ kN}$$

Where:

$k_7 = 1.00$ – coefficient for anchor steel ductility

- $k_7 = \begin{cases} 0.8, & A < 0.08 \\ 1.0, & A \geq 0.08 \end{cases}$, where:
 - $A = 0.12$ – bolt grade elongation at rupture

$V_{Rk,s}^0 = 98.0$ kN – the characteristic shear strength

- $V_{Rk,s}^0 = k_6 \cdot A_s \cdot f_{uk}$, where:
 - $k_6 = 0.50$ – coefficient for anchor resistance in shear
 - $A_s = 245$ mm² – tensile stress area
 - $f_{uk} = 800.0$ MPa – specified ultimate strength of anchor steel

$\gamma_{Ms} = 1.25$ – safety factor for steel

Concrete pryout resistance (EN 1992-4 – 7.2.2.4)

The check is performed for group of anchors on common base plate

$$V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}} = 342.1 \text{ kN} \geq V_{Ed,g} = 0.0 \text{ kN}$$

$$V_{Rk,cp} = k_8 \cdot N_{Rk,c} = 513.2 \text{ kN}$$

Where:

$k_8 = 2.00$ – factor taking into account fastener embedment depth

$N_{Rk,c} = 256.6$ kN – characteristic concrete cone failure of a fastener or a group of fasteners; all anchors are assumed to be in tension

$\gamma_{Mc} = 1.50$ – safety factor for concrete

Project:
Project no:
Author:



Interaction of tensile and shear forces in steel (EN 1992-4 – Table 7.3)

$$\left(\frac{N_{Ed}}{N_{Rd,s}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd,s}}\right)^2 = 0.64 \leq 1.0$$

Where:

- $N_{Ed} = 88.9$ kN – design tension force
 $N_{Rd,s} = 111.1$ kN – fastener tensile strength
 $V_{Ed} = 0.0$ kN – design shear force
 $V_{Rd,s} = 78.4$ kN – fastener shear strength

Interaction of tensile and shear forces in concrete (EN 1992-4 – Table 7.3)

$$\left(\frac{N_{Ed}}{N_{Rd,t}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,s}}\right)^{1.5} = 0.52 \leq 1.0$$

Where:

- $\frac{N_{Ed}}{N_{Rd,t}}$ – the largest utilization value for tension failure modes
 $\frac{V_{Ed}}{V_{Rd,s}}$ – the largest utilization value for shear failure modes
 $\frac{N_{Ed,c}}{N_{Rd,c}} = 64\%$ – concrete breakout failure of anchor in tension
 $\frac{N_{Ed}}{N_{Rd,p}} = 0\%$ – concrete pullout failure
 $\frac{N_{Ed}}{N_{Rd,cb}} = 0\%$ – concrete blowout failure
 $\frac{V_{Ed}}{V_{Rd,e}} = 0\%$ – concrete edge failure
 $\frac{V_{Ed}}{V_{Rd,cb}} = 0\%$ – concrete pryout failure

Welds

Item	Edge	T_w [mm]	L [mm]	Loads	$\sigma_{w,Ed}$ [MPa]	ϵ_{pl} [%]	σ_{\perp} [MPa]	τ_{\perp} [MPa]	τ_{\parallel} [MPa]	Ut [%]	Ut _c [%]	Status
BP1	COL-bfl 1	▲ 11.0 ▼	299	LE1	398.2	1.0	-166.2	-168.3	-123.8	98.4	55.8	OK
		▲ 11.0 ▼	299	LE1	398.4	1.1	-171.8	169.8	119.3	98.4	70.3	OK
BP1	COL-tfl 1	▲ 11.0 ▼	300	LE1	314.7	0.0	-108.4	-133.8	-105.8	77.8	28.0	OK
		▲ 11.0 ▼	300	LE1	373.9	0.0	-160.0	134.7	141.2	92.4	20.6	OK
BP1	COL-w 1	▲ 9.0 ▼	418	LE1	243.7	0.0	-89.9	-92.8	92.1	60.2	22.3	OK
		▲ 9.0 ▼	418	LE1	159.1	0.0	-77.1	74.1	-31.0	39.3	25.1	OK

Design data

Material	β_w [-]	$\sigma_{w,Rd}$ [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Project:
Project no:
Author:



Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{pl}	Strain
σ_{\perp}	Perpendicular stress
τ_{\perp}	Shear stress perpendicular to weld axis
τ_{\parallel}	Shear stress parallel to weld axis
U_t	Utilization
$U_{t,c}$	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9σ	Perpendicular stress resistance: $0.9 \cdot f_u / \gamma_{M2}$
▲	Fillet weld

Detailed result for BP1 / COL-bf1 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 398.4 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 217.5 \text{ MPa}$$

where:

$f_u = 430.0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0.85$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1.25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0.98 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 398.4 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7 \text{ MPa}$ – Equivalent stress resistance

$\sigma_{\perp} = -217.5 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6 \text{ MPa}$ – Perpendicular stress resistance

Concrete block

Item	Loads	c [mm]	A_{eff} [mm ²]	σ [MPa]	k_j [-]	f_{jd} [MPa]	U_t [%]	Status
CB 1	LE1	33	44606	32.2	3.00	33.5	96.0	OK

Project:
Project no:
Author:



Symbol explanation

c Bearing width
 A_{eff} Effective area
 σ Average stress in concrete
 k_j Concentration factor
 f_{jd} The ultimate bearing strength of the concrete block
 U_t Utilization

Detailed result for CB 1

Concrete block compressive resistance check (EN 1993-1-8 – 6.2.5)

$$f_{jd} = 33.5 \text{ MPa} \geq \sigma = 32.2 \text{ MPa}$$

Where:

f_{jd} – concrete block design bearing strength:

- $f_{jd} = \alpha_{cc} \beta_j k_j \frac{f_{ck}}{\gamma_c}$, where:
 - $\alpha_{cc} = 1.00$ – long term effects on compressive strength factor
 - $\beta_j = 0.67$ – grout quality factor
 - $k_j = 3.00$ – concentration factor
 - $f_{ck} = 25.0 \text{ MPa}$ – characteristic resistance of concrete in compression
 - $\gamma_c = 1.50$ – safety factor for concrete

σ – average compressive stress in concrete under base plate

- $\sigma = \frac{N}{A_{eff}}$, where:
 - $N = 1434.6 \text{ kN}$ – compressive normal force acting on concrete block
 - $A_{eff} = 44606 \text{ mm}^2$ – effective area on which normal force is distributed

Shear in contact plane

Name	Loads	V_y [kN]	V_z [kN]	$V_{Rd,y}$ [kN]	$V_{Rd,z}$ [kN]	U_t [%]	Status
BP1	LE1	0.0	0.0	358.7	358.7	0.0	OK

Symbol explanation

V_y Shear force in base plate V_y
 V_z Shear force in base plate V_z
 $V_{Rd,y}$ Shear resistance
 $V_{Rd,z}$ Shear resistance
 U_t Utilization

Project:
Project no:
Author:



Detailed result for BP1

Base plate shear resistance check (EN 1993-1-8 – 6.2.2)

$$V_{Rd,y} = NC_f = 358.7 \text{ kN}$$

$$V_{Rd,z} = NC_f = 358.7 \text{ kN}$$

Where:

$N = 1434.6 \text{ kN}$ – design normal force

$C_f = 0.25$ – friction coefficient

Utilization in shear

$$U_t = \max\left(\frac{\sqrt{V_y^2 + V_z^2}}{V_{Rd,y}}, \frac{\sqrt{V_y^2 + V_z^2}}{V_{Rd,z}}\right) = 0.00 \leq 1$$

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]
S 275	79.14	2.00	158.29

Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]
M20 8.8	1.23	16.00	19.72

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Double fillet	11.0	15.6	1.14	40.00	45.59
Double fillet	9.0	12.7	0.53	40.00	21.31

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]
19.72	30.0	5.92

Cost summary

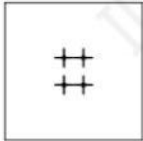
Cost estimation summary	Cost [€]
Total estimated cost	250.83

Project:
Project no:
Author:



Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
BP1	P20.0x710.0-710.0 (S 275)		1	Double fillet: a = 11.0 Double fillet: a = 9.0	600.0 419.0	M20 8.8	4

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 275	11.0	15.6	600.0
Double fillet	S 275	9.0	12.7	419.0

Anchors

Name	Length [mm]	Drill length [mm]	Count
M20 8.8	320	300	4

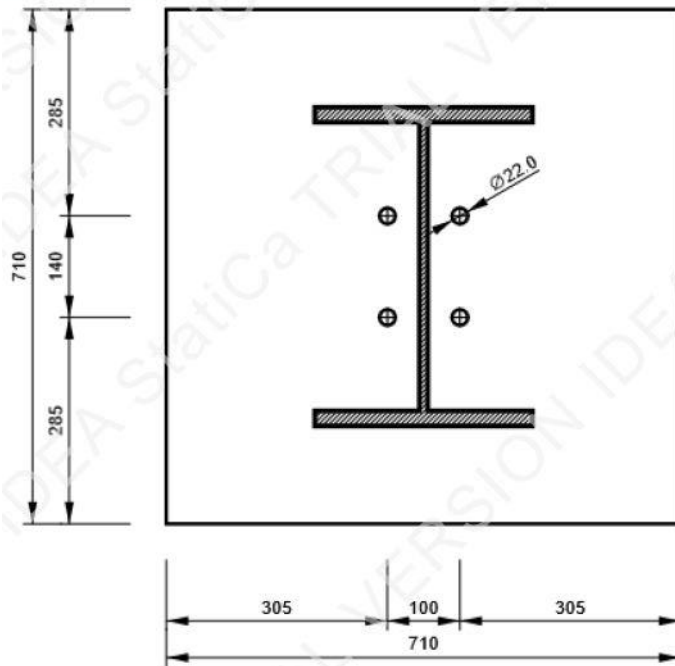
Drawing

BP1

Project:
Project no:
Author:



P20.0x710-710 (S 275)



Project:
Project no:
Author:

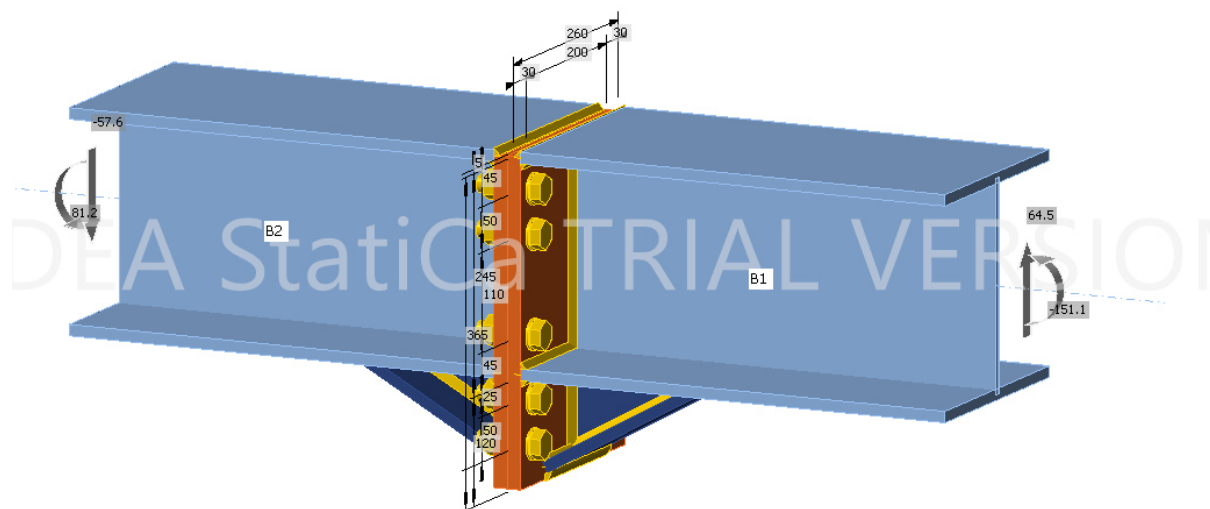


Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.3 Spoj nastavka krovnog nosača

- | | |
|--|--------------------------|
| - Mjerodavni moment savijanja M_{y1} na nosaču | $M_{y1} = -151,12$ [kNm] |
| - Mjerodavni moment savijanja M_{y2} na nosaču | $M_{y2} = 81,22$ [kNm] |
| - Mjerodavna poprečna sila V_{z1} na nosaču | $V_{z1} = 64,48$ [kN] |
| - Mjerodavna poprečna sila V_{z2} na nosaču | $V_{z2} = -57,55$ [kN] |



Slika 112. Prikaz zadanih opterećenja u programu IdeaStatica – spoj nastavka krovnog nosača

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/28/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item Spoj nastavak krovnog nosaca

Design

Name Spoj nastavak krovnog nosaca
Description
Analysis Stress, strain/ loads in equilibrium

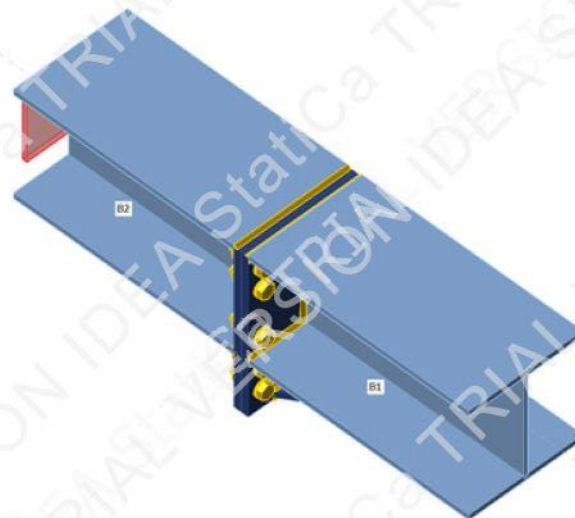
Members

Geometry

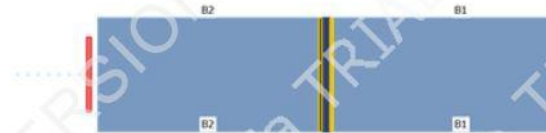
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
B1	16 - HEA260	0.0	0.0	0.0	0	0	0
B2	16 - HEA260	180.0	0.0	0.0	0	0	0

Supports and forces

Name	Support	Forces in	X [mm]
B1 / end		Node	0
B2 / end	N-Vy-Vz-Mx-My-Mz	Node	0



Project:
Project no:
Author:



Project:
Project no:
Author:



Cross-sections

Name	Material
16 - HEA260	S 275

Cross-sections

Name	Material	Drawing
16 - HEA260	S 275	

Bolts

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M20 8.8	M20 8.8	20	800.0	314

Project:
Project no:
Author:



Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	B1 / End	0.0	0.0	64.5	0.0	-151.1	0.0
	B2 / End	0.0	0.0	-57.6	0.0	81.2	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	0.0	0.0	6.9	0.0	-232.3	0.0

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.8 < 5.0%	OK
Bolts	85.6 < 100%	OK
Welds	99.7 < 100%	OK
Buckling	Not calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
B1-bfl 1	12.5	LE1	266.9	0.3	0.0	OK
B1-tfl 1	12.5	LE1	194.2	0.0	0.0	OK
B1-w 1	7.5	LE1	183.5	0.0	0.0	OK
B2-bfl 1	12.5	LE1	266.9	0.3	0.0	OK
B2-tfl 1	12.5	LE1	230.7	0.0	0.0	OK
B2-w 1	7.5	LE1	208.2	0.0	0.0	OK
PP1a	16.0	LE1	275.7	0.4	221.1	OK
PP1b	16.0	LE1	275.8	0.4	221.1	OK
WD1a	12.0	LE1	148.7	0.0	0.0	OK
WD1b	12.0	LE1	276.6	0.8	0.0	OK
WD2a	12.0	LE1	166.1	0.0	0.0	OK
WD2b	12.0	LE1	276.7	0.8	0.0	OK

Design data

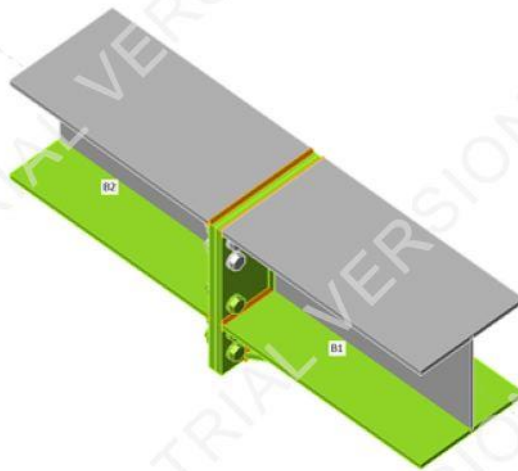
Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

Project:
Project no:
Author:



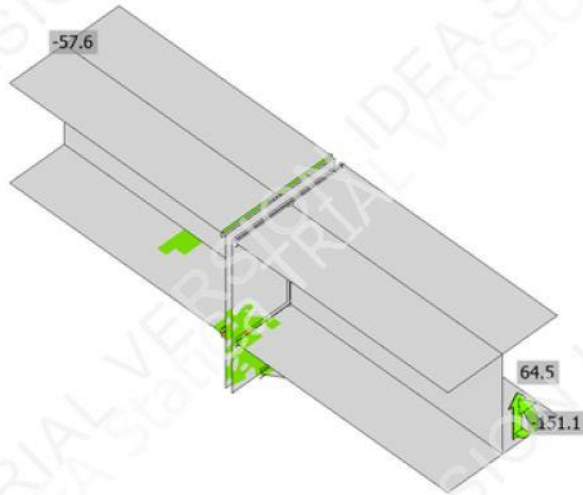
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

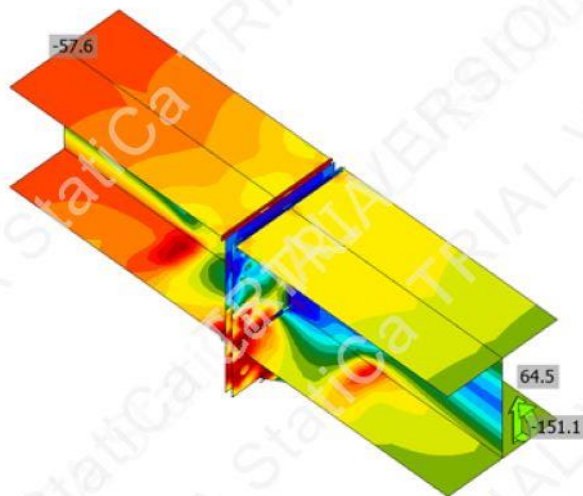


Overall check, LE1

Project:
Project no:
Author:



Strain check, LE1



Equivalent stress, LE1

Project:
Project no:
Author:

IDEA StatiCa®
Calculate yesterday's estimates

Bolts

Shape	Item	Grade	Loads	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	$F_{b,Rd}$ [kN]	U_t [%]	U_s [%]	U_{ts} [%]	Status
	B1	M20 8.8 - 1	LE1	4.3	7.9	118.4	3.1	8.4	10.6	OK
	B2	M20 8.8 - 1	LE1	4.1	7.9	118.4	2.9	8.4	10.5	OK
	B3	M20 8.8 - 1	LE1	23.2	8.1	118.4	16.4	8.7	20.4	OK
	B4	M20 8.8 - 1	LE1	23.2	8.2	118.4	16.4	8.7	20.4	OK
	B5	M20 8.8 - 1	LE1	118.5	6.0	189.0	84.0	6.4	66.4	OK
	B6	M20 8.8 - 1	LE1	118.5	6.0	189.0	84.0	6.4	66.4	OK
	B7	M20 8.8 - 1	LE1	120.8	4.7	118.4	85.6	5.0	66.2	OK
	B8	M20 8.8 - 1	LE1	120.8	4.7	118.4	85.6	5.0	66.2	OK
	B9	M20 8.8 - 1	LE1	117.0	5.5	118.4	82.9	5.9	65.1	OK
	B10	M20 8.8 - 1	LE1	117.0	5.5	118.4	82.9	5.8	65.1	OK

Design data

Grade	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M20 8.8 - 1	141.1	329.6	94.1

Symbol explanation

$F_{t,Ed}$	Tension force
$F_{v,Ed}$	Resultant of bolt shear forces V_y and V_z in shear planes
$F_{b,Rd}$	Plate bearing resistance EN 1993-1-8 – Tab. 3.4
U_t	Utilization in tension
U_s	Utilization in shear
U_{ts}	Interaction of tension and shear EN 1993-1-8 – Tab. 3.4
$F_{t,Rd}$	Bolt tension resistance EN 1993-1-8 – Tab. 3.4
$B_{p,Rd}$	Punching shear resistance EN 1993-1-8 – Tab. 3.4
$F_{v,Rd}$	Bolt shear resistance EN 1993-1-8 – Tab. 3.4

Detailed result for B8

Tension resistance check (EN 1993-1-8 – Table 3.4)

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 141.1 \text{ kN} \geq F_{t,Ed} = 120.8 \text{ kN}$$

Where:

$k_2 = 0.90$ – Factor

$f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt

$A_s = 245 \text{ mm}^2$ – Tensile stress area of the bolt

$\gamma_{M2} = 1.25$ – Safety factor

Project:

Project no:

Author:



Punching resistance check (EN 1993-1-8 – Table 3.4)

$$B_{p,Rd} = \frac{0.6 \pi d_m t_p f_u}{\gamma_{M2}} = 329.6 \text{ kN} \geq F_{t,Ed} = 120.8 \text{ kN}$$

Where:

- $d_m = 32 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 16 \text{ mm}$ – Plate thickness
- $f_u = 430.0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1.25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Table 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 94.1 \text{ kN} \geq F_{v,Ed} = 4.7 \text{ kN}$$

Where:

- $\beta_p = 1.00$ – Reduction factor for packing
- $\alpha_v = 0.60$ – Reduction factor for shear stress
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 245 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1.25$ – Safety factor

Bearing resistance check (EN 1993-1-8 – Table 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 118.4 \text{ kN} \geq F_{b,Ed} = 4.7 \text{ kN}$$

Where:

- $k_1 = \min(2.8 \frac{e_2}{d_0} - 1.7, 1.4 \frac{p_2}{d_0} - 1.7, 2.5) = 2.12$ – Factor for edge distance and bolt spacing perpendicular to the direction of load transfer
- $\alpha_b = \min(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1) = 0.51$ – Factor for end distance and bolt spacing in direction of load transfer
- $e_2 = 30 \text{ mm}$ – Distance to the plate edge perpendicular to the shear force
- $p_2 = 200 \text{ mm}$ – Distance between bolts perpendicular to the shear force
- $d_0 = 22 \text{ mm}$ – Bolt hole diameter
- $e_1 = 95 \text{ mm}$ – Distance to the plate edge in the direction of the shear force
- $p_1 = 50 \text{ mm}$ – Distance between bolts in the direction of the shear force
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $f_u = 430.0 \text{ MPa}$ – Ultimate strength of the plate
- $d = 20 \text{ mm}$ – Nominal diameter of the fastener
- $t = 16 \text{ mm}$ – Thickness of the plate
- $\gamma_{M2} = 1.25$ – Safety factor

Project:

Project no:

Author:



Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Ed})} = 0.86 \leq 1.0$$

Where:

 $F_{t,Ed} = 120.8 \text{ kN}$ – Tensile force

 $F_{t,Rd} = 141.1 \text{ kN}$ – Tension resistance

 $B_{p,Rd} = 329.6 \text{ kN}$ – Punching resistance

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}; \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0.05 \leq 1.0$$

Where:

 $F_{v,Ed} = 4.7 \text{ kN}$ – Shear force (in decisive shear plane)

 $F_{v,Rd} = 94.1 \text{ kN}$ – Shear resistance

 $F_{b,Ed} = 4.7 \text{ kN}$ – Bearing force (for decisive plate)

 $F_{b,Rd} = 118.4 \text{ kN}$ – Bearing resistance

Interaction of tension and shear (EN 1993-1-8 – Table 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 F_{t,Rd}} = 0.66 \leq 1.0$$

Where:

 $F_{v,Ed} = 4.7 \text{ kN}$ – Shear force (in decisive shear plane)

 $F_{v,Rd} = 94.1 \text{ kN}$ – Shear resistance

 $F_{t,Ed} = 120.8 \text{ kN}$ – Tensile force

 $F_{t,Rd} = 141.1 \text{ kN}$ – Tension resistance

Project:
Project no:
Author:



Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pI} [%]	σ _⊥ [MPa]	τ _⊥ [MPa]	τ [MPa]	U _t [%]	U _{t,c} [%]	Status
PP1a	B1-bfl 1	▲ 5.0 ▼	259	LE1	402.3	3.5	196.6	200.3	-30.3	99.4	72.2	OK
		▲ 5.0 ▼	259	LE1	403.4	4.2	202.0	-199.3	30.3	99.7	76.7	OK
PP1a	B1-tfl 1	▲ 5.0 ▼	259	LE1	396.9	0.2	-248.2	178.8	5.1	98.1	98.0	OK
		▲ 5.0 ▼	259	LE1	251.0	0.0	-70.1	139.1	4.1	62.0	56.1	OK
PP1a	B1-w 1	▲ 5.0 ▼	237	LE1	257.2	0.0	-121.8	-121.8	47.6	63.6	14.5	OK
		▲ 5.0 ▼	237	LE1	257.1	0.0	-121.8	121.8	-47.6	63.5	14.5	OK
PP1b	B2-bfl 1	▲ 5.0 ▼	259	LE1	402.5	3.7	197.3	200.5	28.8	99.5	71.9	OK
		▲ 5.0 ▼	259	LE1	403.5	4.2	202.2	-199.4	-29.5	99.7	74.4	OK
PP1b	B2-tfl 1	▲ 5.0 ▼	259	LE1	396.9	0.2	-245.8	179.8	5.0	98.1	98.0	OK
		▲ 5.0 ▼	259	LE1	259.0	0.0	-84.9	141.1	7.8	64.0	59.1	OK
PP1b	B2-w 1	▲ 5.0 ▼	237	LE1	209.0	0.0	-104.7	-104.2	7.2	51.6	28.1	OK
		▲ 5.0 ▼	237	LE1	209.8	0.0	-104.5	104.8	-7.3	51.8	28.2	OK
PP1a	WID1a	▲ 6.0 ▼	99	LE1	111.7	0.0	38.4	39.2	-46.1	27.6	16.6	OK
		▲ 6.0 ▼	99	LE1	114.2	0.0	39.7	-38.9	48.1	28.2	16.7	OK
B1-bfl 1	WID1a	▲ 6.0 ▼	179	LE1	79.2	0.0	-4.7	-4.6	45.4	19.6	5.6	OK
		▲ 6.0 ▼	179	LE1	79.2	0.0	-4.6	4.6	-45.4	19.6	5.6	OK
WID1b	WID1a	▲ 6.0 ▼	204	LE1	64.5	0.0	-25.1	-25.3	-23.2	15.9	6.6	OK
		▲ 6.0 ▼	204	LE1	64.2	0.0	-25.4	25.2	22.9	15.9	6.6	OK
PP1a	WID1b	▲ 6.0 ▼	149	LE1	398.1	0.9	190.1	159.1	-124.3	98.4	77.5	OK
		▲ 6.0 ▼	149	LE1	377.5	0.0	185.5	-119.8	-147.2	93.3	57.6	OK
B1-bfl 1	WID1b	▲ 6.0 ▼	149	LE1	360.1	0.0	57.4	205.3	0.1	89.0	51.7	OK
		▲ 6.0 ▼	149	LE1	139.3	0.0	55.2	-73.9	0.1	34.4	15.3	OK
PP1b	WID2a	▲ 6.0 ▼	99	LE1	108.2	0.0	38.5	37.7	-44.6	26.7	16.0	OK
		▲ 6.0 ▼	99	LE1	105.8	0.0	37.2	-38.0	42.7	26.1	16.0	OK
B2-bfl 1	WID2a	▲ 6.0 ▼	179	LE1	87.0	0.0	-6.9	-6.9	49.6	21.5	6.2	OK
		▲ 6.0 ▼	179	LE1	87.0	0.0	-6.9	6.9	-49.6	21.5	6.2	OK
WID2b	WID2a	▲ 6.0 ▼	204	LE1	68.1	0.0	-26.3	-26.1	-25.2	16.8	8.4	OK
		▲ 6.0 ▼	204	LE1	68.5	0.0	-26.0	26.2	25.5	16.9	8.4	OK
PP1b	WID2b	▲ 6.0 ▼	149	LE1	398.1	0.9	190.3	160.0	123.2	98.4	78.0	OK
		▲ 6.0 ▼	149	LE1	379.1	0.0	188.8	-116.5	149.9	93.7	57.3	OK
B2-bfl 1	WID2b	▲ 6.0 ▼	149	LE1	374.5	0.0	-14.3	196.2	90.5	92.5	57.0	OK
		▲ 6.0 ▼	149	LE1	143.9	0.0	55.4	-76.7	-0.1	35.6	17.5	OK

Design data

Material	β _w [-]	σ _{w,Rd} [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Project:
Project no:
Author:



Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{F1}	Strain
σ_{\perp}	Perpendicular stress
τ_{\perp}	Shear stress perpendicular to weld axis
τ_{\parallel}	Shear stress parallel to weld axis
U_t	Utilization
U_t^c	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9σ	Perpendicular stress resistance: $0.9 \cdot f_u / \gamma_{M2}$
▲	Filet weld

Detailed result for PP1b / B2-bfl 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 403.5 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 202.2 \text{ MPa}$$

where:

$f_u = 430.0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0.85$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1.25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 1.00 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 403.5 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7 \text{ MPa}$ – Equivalent stress resistance

$\sigma_{\perp} = 202.2 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6 \text{ MPa}$ – Perpendicular stress resistance

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]
S 275	25.53	2.00	51.07

Project:
Project no:
Author:



Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]
M20 8.8	3.31	16.00	52.95

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Double fillet	5.0	7.1	0.59	40.00	23.79
Double fillet	6.0	8.5	0.89	40.00	35.54

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]
52.95	30.0	15.89

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	179.23

Project:

Project no:

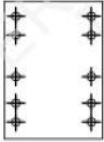
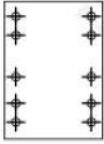




Author:



 Calculate yesterday's estimates

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
PP1	P16.0x260.0-365.0 (S 275)		1	Double fillet: a = 5.0	1515.0	M20 8.8	10
	P16.0x260.0-365.0 (S 275)		1				
WD1	P12.0x100.0-180.0 (S 275)		1	Double fillet: a = 6.0	785.9		
	P12.0x150.0-205.9 (S 275)		1				
WD2	P12.0x100.0-180.0 (S 275)		1	Double fillet: a = 6.0	785.9		
	P12.0x150.0-205.9 (S 275)		1				

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 275	5.0	7.1	1515.0
Double fillet	S 275	6.0	8.5	1571.8

Project:
Project no:
Author:



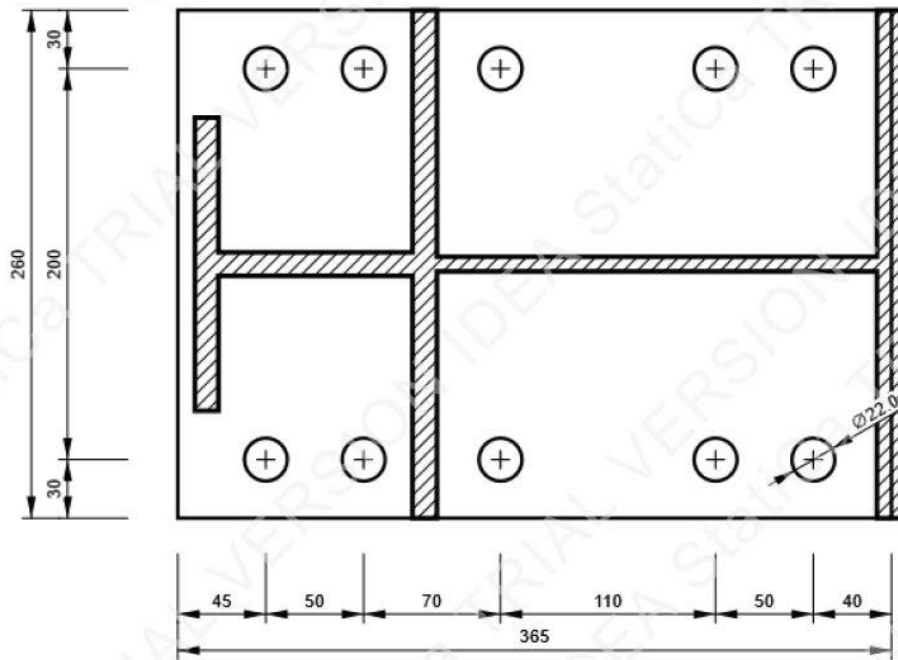
Bolts

Name	Grip length [mm]	Count
M20 8.8	32	10

Drawing

PP1 - PP1a

P16.0x365-260 (S 275)

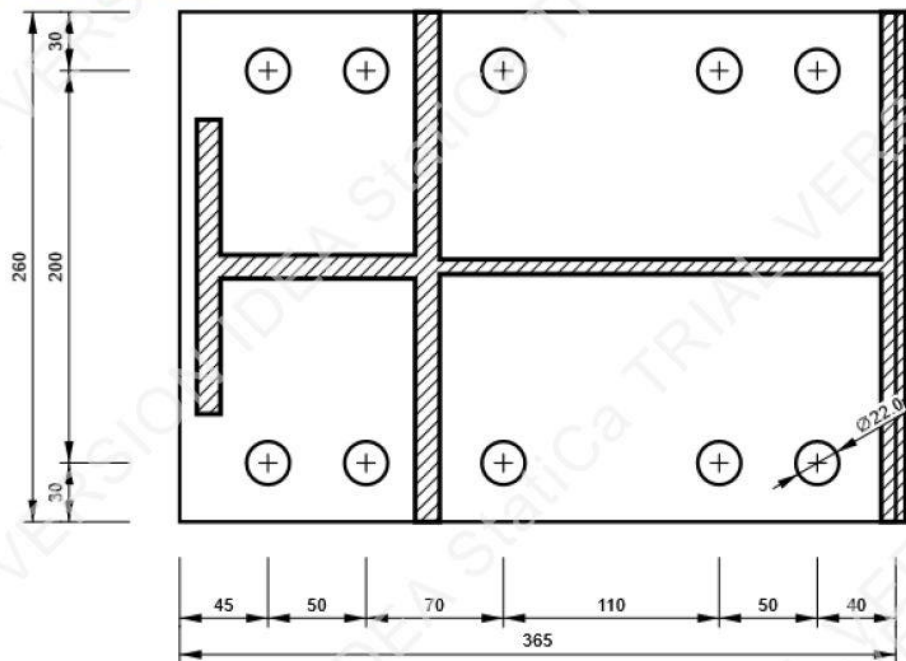


Project:
Project no:
Author:



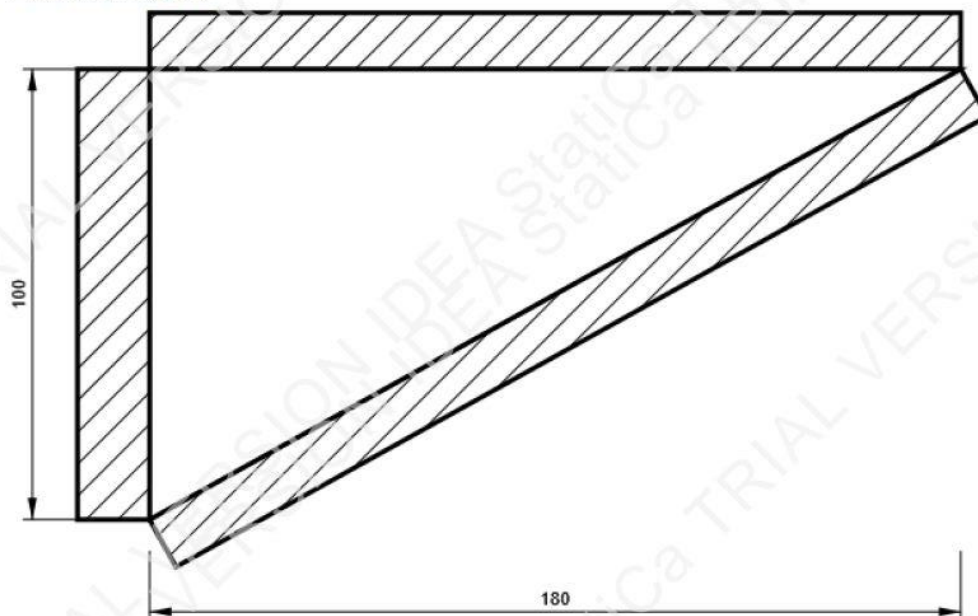
PP1 - PP1b

P16.0x365-260 (S 275)



WID1 - WID1a

P12.0x180-100 (S 275)

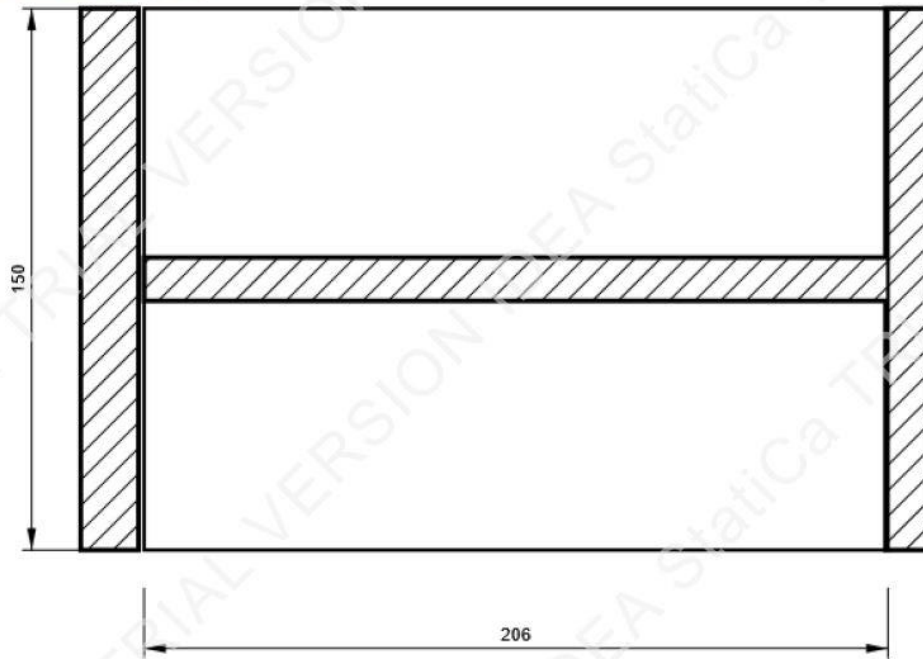


Project:
Project no:
Author:



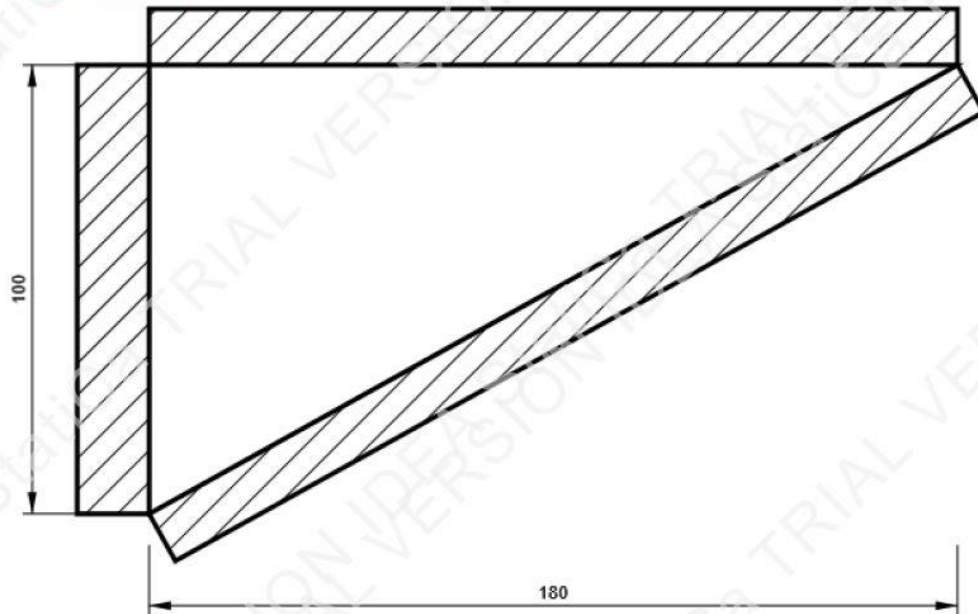
WID1 - WID1b

P12.0x206-150 (S 275)



WID2 - WID2a

P12.0x180-100 (S 275)

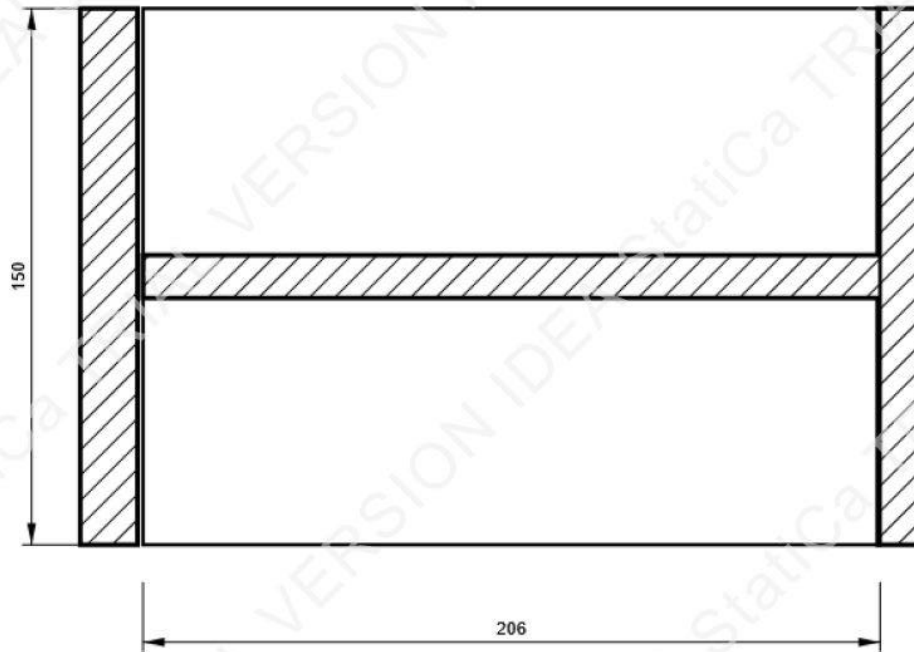


Project:
Project no:
Author:



WID2 - WID2b

P12.0x206-150 (S 275)



Project:
Project no:
Author:

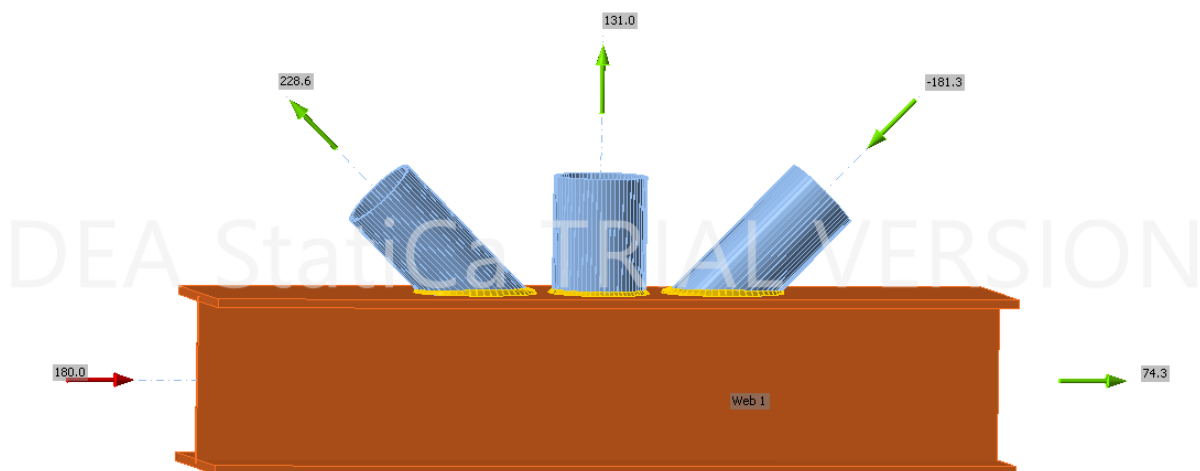


Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated q_b in bearing check	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.4 Spoj rešetka – greda

- Mjerodavna uzdužna sila N u dijagonali 1 N=228,63 [kNm]
- Mjerodavna uzdužna sila N u dijagonali 2 N= -181,30 [kNm]
- Mjerodavna uzdužna sila N u vertikali N=131,03 [kN]
- Mjerodavna uzdužna sila N u gredi N= -179,96 [kN]
N=74,24 [kN]



Slika 113. Prikaz zadanih opterećenja u programu IdeaStatica – spoj rešetka greda

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/29/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item Spoj resetka

Design

Name Spoj resetka
Description
Analysis Stress, strain/ loads in equilibrium

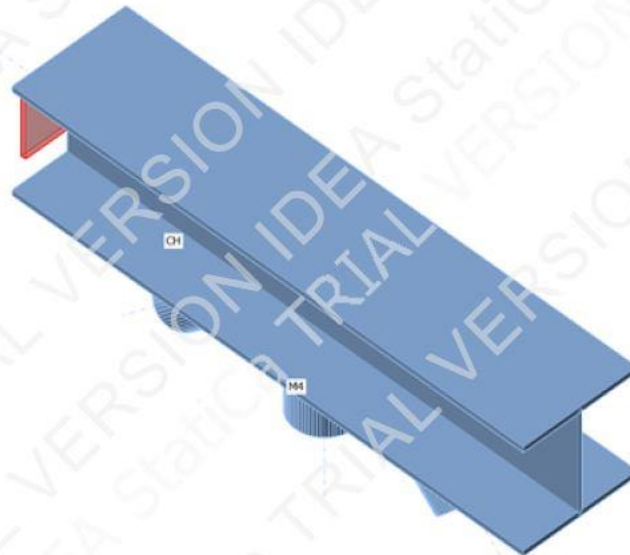
Members

Geometry

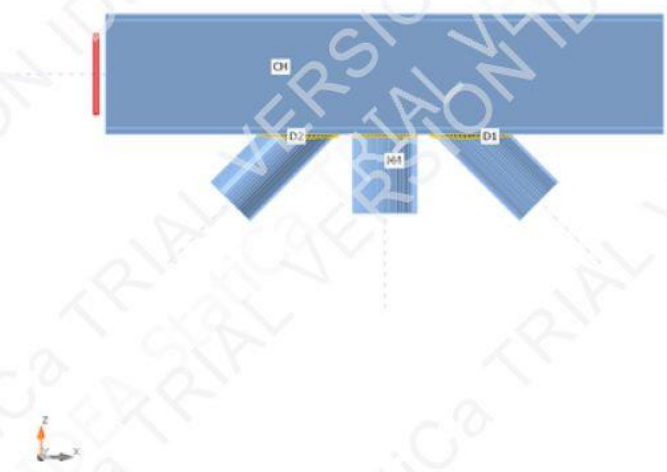
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
CH	28 - Greda(HEA260)	0.0	0.0	0.0	0	0	0
D1	31 - Dijagonala(CHS114.3,5)	0.0	-45.0	0.0	0	0	40
D2	32 - Dijagonala 2(CHS114.3,5)	180.0	-45.0	0.0	0	0	40
M4	33 - Vertikala(CHS133,4)	0.0	-90.0	-180.0	0	0	0

Supports and forces

Name	Support	Forces in	X [mm]
CH / begin	N-Vy-Vz-Mx-My-Mz	Node	0
CH / end		Node	0
D1 / end		Node	0
D2 / end		Node	0
M4 / end		Node	0

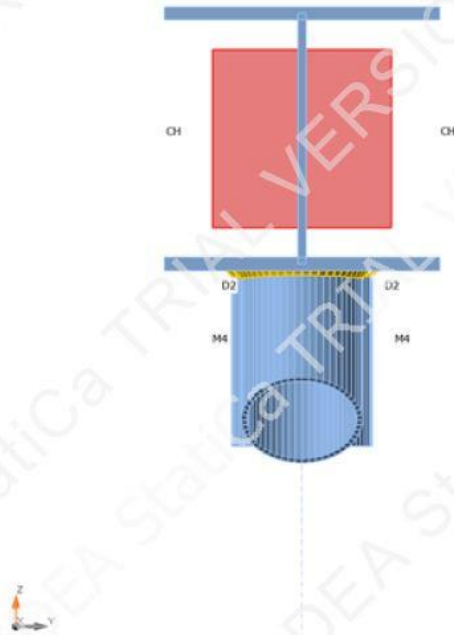


Project:
Project no:
Author:



Project:
Project no:
Author:

IDEA StatiCa[®]
Calculate yesterday's estimates



Cross-sections

Name	Material
28 - Greda(HEA260)	S 275
31 - Dijagonala(CHS114.3,5)	S 275
32 - Dijagonala 2(CHS114.3,5)	S 275
33 - Vertikala(CHS133,4)	S 275

Project:
Project no:
Author:

IDEA StatiCa[®]
Calculate yesterday's estimates

Cross-sections

Name	Material	Drawing
28 - Greda(HEA260)	S 275	
31 - Dijagonala(CHS114.3,5)	S 275	
32 - Dijagonala 2(CHS114.3,5)	S 275	
33 - Vertikala(CHS133,4)	S 275	

Project:
Project no:
Author:



Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	CH / Begin	180.0	0.0	0.0	0.0	0.0	0.0
	CH / End	74.3	0.0	0.0	0.0	0.0	0.0
	D1 / End	-181.3	0.0	0.0	0.0	0.0	0.0
	D2 / End	228.6	0.0	0.0	0.0	0.0	0.0
	M4 / End	131.0	0.0	0.0	0.0	0.0	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	-35.6	0.0	-164.5	0.0	-16.4	0.0

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.2 < 5.0%	OK
Welds	98.1 < 100%	OK
Buckling	Not calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
CH-bfl 1	12.5	LE1	205.1	0.0	0.0	OK
CH-tfl 1	12.5	LE1	82.0	0.0	0.0	OK
CH-w 1	7.5	LE1	194.8	0.0	0.0	OK
D1	5.0	LE1	275.1	0.0	0.0	OK
D2	5.0	LE1	275.4	0.2	0.0	OK
M4	4.0	LE1	275.3	0.1	0.0	OK

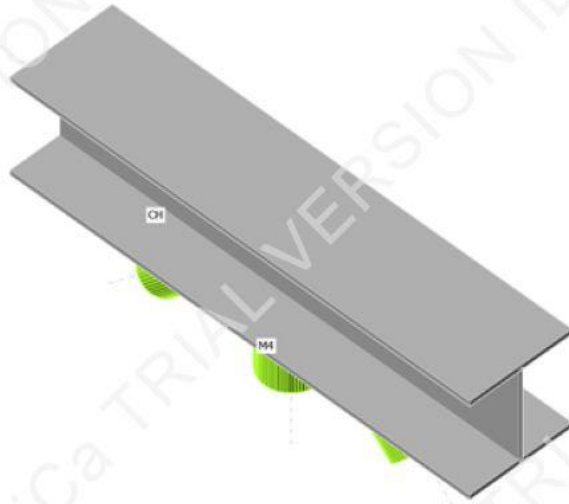
Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

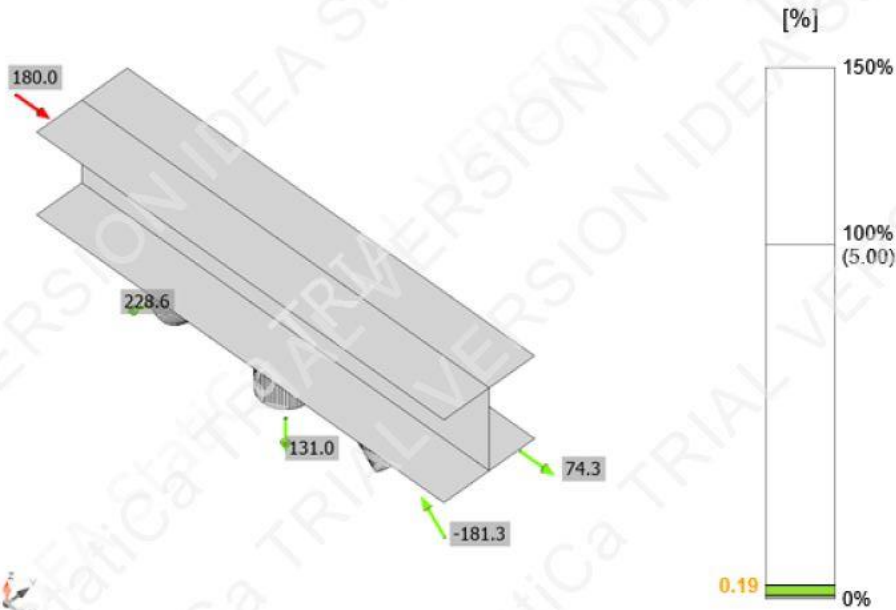
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

Project:
Project no:
Author:

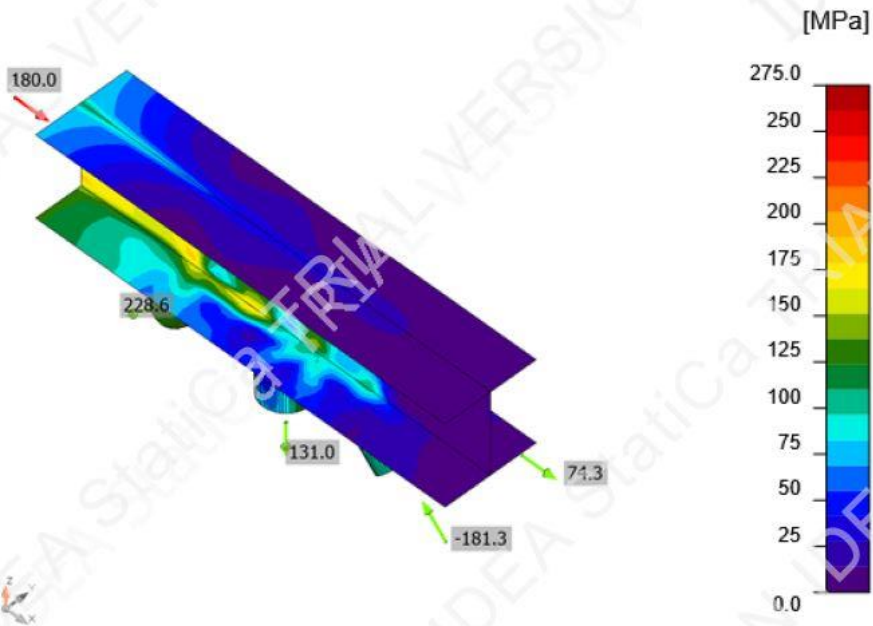


Overall check, LE1



Strain check, LE1

Project:
Project no:
Author:



Equivalent stress, LE1

Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pl} [%]	σ _⊥ [MPa]	τ _⊥ [MPa]	τ _∥ [MPa]	U _t [%]	U _{t,c} [%]	Status
CH-bfl 1	D1	▲ 6.0	417	LE1	380.7	0.0	-74.9	197.1	87.2	94.1	27.6	OK
CH-bfl 1	D2	▲ 6.0	417	LE1	396.7	0.0	78.8	-212.7	71.6	98.0	35.0	OK
CH-bfl 1	M4	▲ 4.0	405	LE1	397.2	0.4	163.5	-177.4	110.5	98.1	31.4	OK

Design data

Material	β _w [-]	σ _{w,Rd} [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Project:
Project no:
Author:



Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{pl}	Strain
σ_{\perp}	Perpendicular stress
τ_{\perp}	Shear stress perpendicular to weld axis
τ_{\parallel}	Shear stress parallel to weld axis
Ut	Utilization
Ut _c	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9 σ	Perpendicular stress resistance: 0.9*fu/γM2
▲	Fillet weld

Detailed result for CH-bfl 1 / M4

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 397.2 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 163.5 \text{ MPa}$$

where:

$f_u = 430.0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0.85$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1.25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0.98 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 397.2 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7 \text{ MPa}$ – Equivalent stress resistance

$\sigma_{\perp} = 163.5 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6 \text{ MPa}$ – Perpendicular stress resistance

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Project:
Project no:
Author:



Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Fillet rear	6.0	8.5	0.24	40.00	9.43
Fillet rear	4.0	5.7	0.05	40.00	2.04

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	11.47

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
CUT1				Fillet: a = 6.0	417.3		
CUT2				Fillet: a = 6.0	417.3		
CUT3				Fillet: a = 4.0	405.1		

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Fillet	S 275	6.0	8.5	834.6
Fillet	S 275	4.0	5.7	405.1

Project:
Project no:
Author:



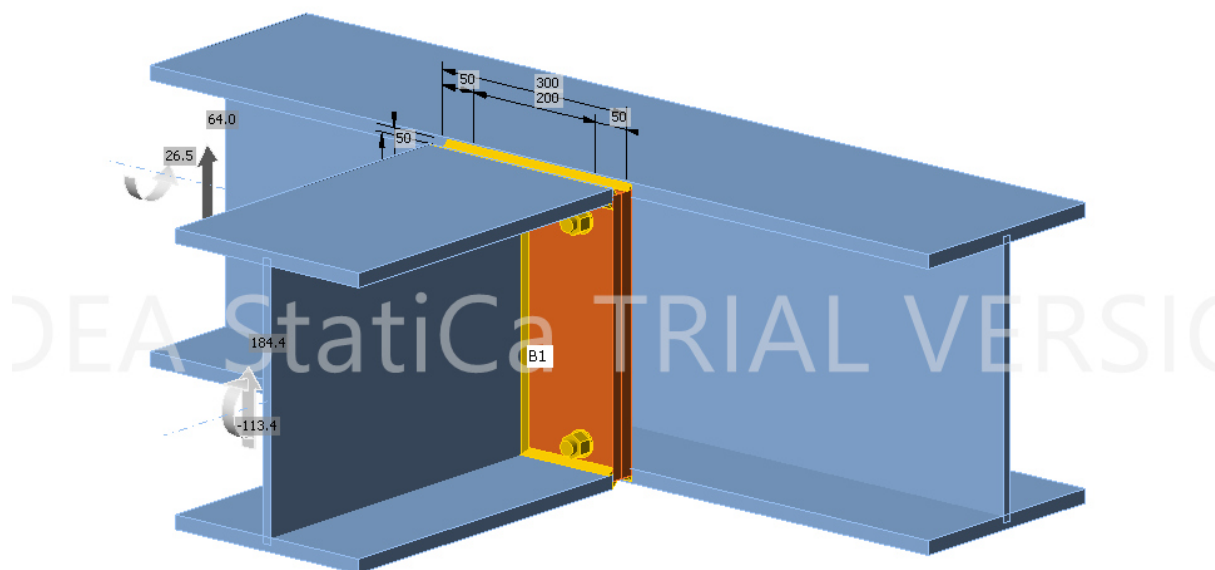
Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.5 Spoj konzolnih greda

- Mjerodavni moment savijanja M_z na gredi 2 $M_z=26,54$ [kNm]
- Mjerodavni moment savijanja M_y na gredi 1 $M_y=-113,42$ [kNm]
- Mjerodavna poprečna sila V_z na gredi 2 $V_z=63,96$ [kN]
- Mjerodavna poprečna sila V_z na gredi 1 $V_z=184,39$ [kN]

Produc



Slika 114. Prikaz zadanih opterećenja u programu IdeaStatica – spoj konzolnih greda

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/29/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item SPOJ KONZOLNE GREDE

Design

Name: SPOJ KONZOLNE GREDE
Description:
Analysis: Stress, strain/ loads in equilibrium

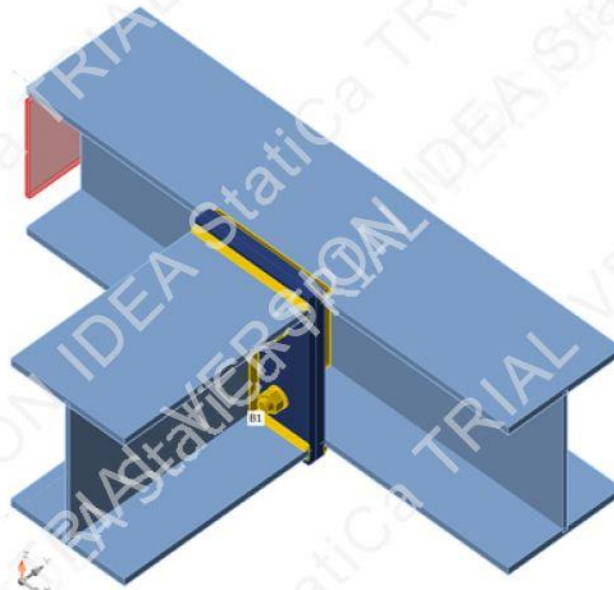
Members

Geometry

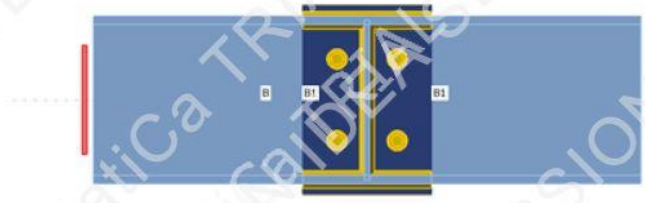
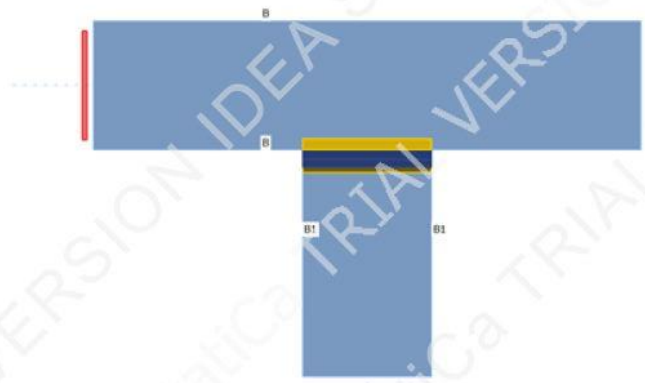
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
B	4 - Greda 2(HEA400)	0.0	0.0	0.0	0	0	0
B1	5 - Greda 1(HEA400)	-90.0	0.0	0.0	0	0	0

Supports and forces

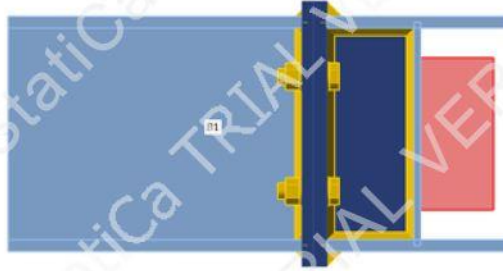
Name	Support	Forces in	X [mm]
B / begin	N-Vy-Vz-Mx-My-Mz	Node	0
B / end		Node	0
B1 / end		Node	0



Project:
Project no:
Author:



Project:
Project no:
Author:



Cross-sections

Name	Material
4 - Greda 2(HEA400)	S 275
5 - Greda 1(HEA400)	S 275

Project:
Project no:
Author:



Cross-sections

Name	Material	Drawing
4 - Greda 2(HEA400)	S 275	
5 - Greda 1(HEA400)	S 275	

Bolts

Name	Bolt assembly	Diameter [mm]	f_u [MPa]	Gross area [mm ²]
M27 8.8	M27 8.8	27	800.0	573

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	B / Begin	0.0	0.0	64.0	26.5	0.0	0.0
	B / End	0.0	0.0	0.0	0.0	0.0	0.0
	B1 / End	0.0	0.0	184.4	0.0	-113.4	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	0.0	0.0	248.4	-86.9	0.0	0.0

Project:
Project no:
Author:



Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	4.8 < 5.0%	OK
Bolts	94.1 < 100%	OK
Welds	99.8 < 100%	OK
Buckling	Not calculated	

Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
B-bfl 1	19.0	LE1	285.1	4.8	0.0	OK
B-tfl 1	19.0	LE1	283.6	4.1	0.0	OK
B-w 1	11.0	LE1	275.3	0.1	0.0	OK
B1-bfl 1	19.0	LE1	275.1	0.0	0.0	OK
B1-tfl 1	19.0	LE1	275.2	0.1	0.0	OK
B1-w 1	11.0	LE1	275.2	0.1	0.0	OK
SEP1a	22.0	LE1	279.4	2.1	189.5	OK
SEP1b	19.0	LE1	277.9	1.4	189.5	OK
STIFF	19.0	LE1	275.5	0.2	0.0	OK

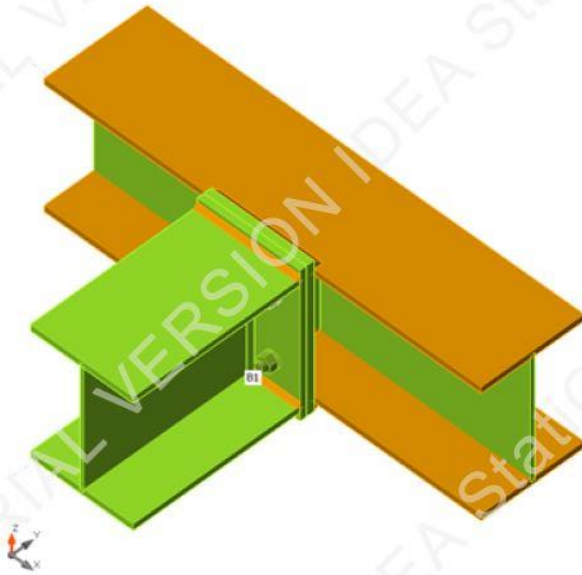
Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

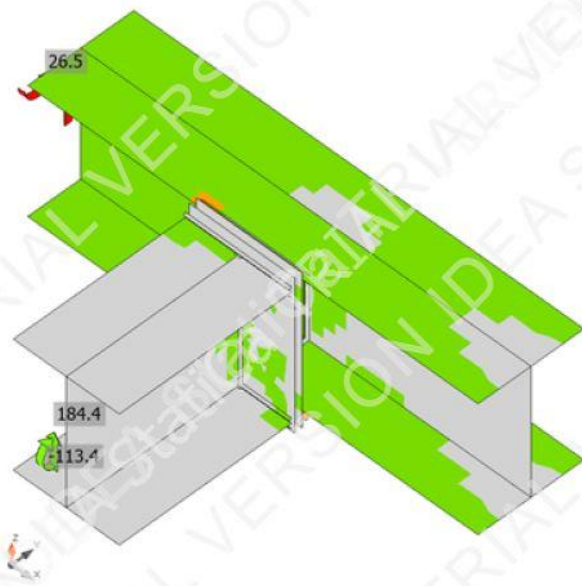
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

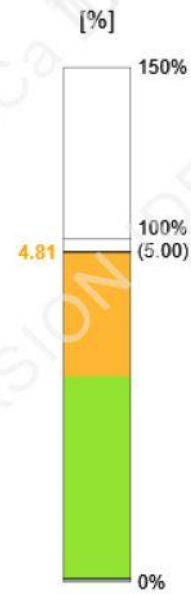
Project:
Project no:
Author:



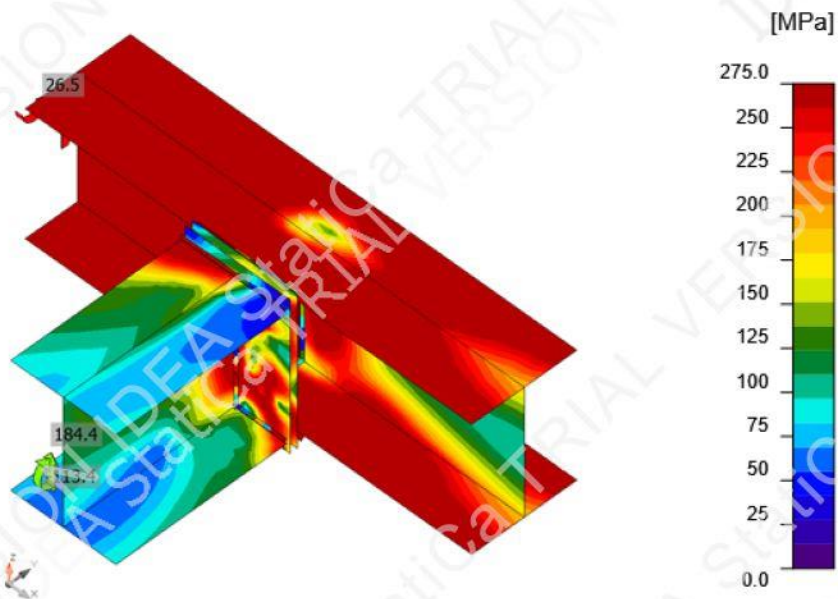
Overall check, LE1



Strain check, LE1



Project:
Project no:
Author:



Equivalent stress, LE1

Bolts

Shape	Item	Grade	Loads	$F_{t,Ed}$ [kN]	$F_{v,Ed}$ [kN]	$F_{b,Rd}$ [kN]	U_t [%]	U_s [%]	U_{ts} [%]	Status
	B1	M27 8.8 - 1	LE1	114.3	40.5	441.2	43.2	23.0	53.8	OK
	B2	M27 8.8 - 1	LE1	131.8	80.6	441.2	49.8	45.8	81.3	OK
	B3	M27 8.8 - 1	LE1	217.8	31.2	441.2	82.4	17.7	76.6	OK
	B4	M27 8.8 - 1	LE1	248.8	35.5	441.2	94.1	20.1	87.3	OK

Design data

Grade	$F_{t,Rd}$ [kN]	$B_{p,Rd}$ [kN]	$F_{v,Rd}$ [kN]
M27 8.8 - 1	264.4	531.0	176.3

Symbol explanation

- $F_{t,Ed}$ Tension force
- $F_{v,Ed}$ Resultant of bolt shear forces V_y and V_z in shear planes
- $F_{b,Rd}$ Plate bearing resistance EN 1993-1-8 – Tab. 3.4
- U_t Utilization in tension
- U_s Utilization in shear
- U_{ts} Interaction of tension and shear EN 1993-1-8 – Tab. 3.4
- $F_{t,Rd}$ Bolt tension resistance EN 1993-1-8 – Tab. 3.4
- $B_{p,Rd}$ Punching shear resistance EN 1993-1-8 – Tab. 3.4
- $F_{v,Rd}$ Bolt shear resistance EN 1993-1-8 – Tab. 3.4

Project:

Project no:

Author:

**Detailed result for B4****Tension resistance check (EN 1993-1-8 – Table 3.4)**

$$F_{t,Rd} = \frac{k_2 f_{ub} A_s}{\gamma_{M2}} = 264.4 \text{ kN} \geq F_{t,Ed} = 248.8 \text{ kN}$$

Where:

- $k_2 = 0.90$ – Factor
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A_s = 459 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1.25$ – Safety factor

Punching resistance check (EN 1993-1-8 – Table 3.4)

$$B_{p,Rd} = \frac{0.6 \pi d_m t_p f_u}{\gamma_{M2}} = 531.0 \text{ kN} \geq F_{t,Ed} = 248.8 \text{ kN}$$

Where:

- $d_m = 43 \text{ mm}$ – The mean of the across points and across flats dimensions of the bolt head or the nut, whichever is smaller
- $t_p = 19 \text{ mm}$ – Plate thickness
- $f_u = 430.0 \text{ MPa}$ – Ultimate strength
- $\gamma_{M2} = 1.25$ – Safety factor

Shear resistance check (EN 1993-1-8 – Table 3.4)

$$F_{v,Rd} = \frac{\beta_p \alpha_v f_{ub} A}{\gamma_{M2}} = 176.3 \text{ kN} \geq F_{v,Ed} = 35.5 \text{ kN}$$

Where:

- $\beta_p = 1.00$ – Reduction factor for packing
- $\alpha_v = 0.60$ – Reduction factor for shear stress
- $f_{ub} = 800.0 \text{ MPa}$ – Ultimate tensile strength of the bolt
- $A = 459 \text{ mm}^2$ – Tensile stress area of the bolt
- $\gamma_{M2} = 1.25$ – Safety factor

Project:

Project no:

Author:



Bearing resistance check (EN 1993-1-8 – Table 3.4)

$$F_{b,Rd} = \frac{k_1 \alpha_b f_u d t}{\gamma_{M2}} = 441.2 \text{ kN} \geq F_{b,Ed} = 35.5 \text{ kN}$$

Where:

$$k_1 = \min\left(2.8 \frac{e_2}{d_0} - 1.7, 1.4 \frac{p_2}{d_0} - 1.7, 2.5\right) = 2.50 \quad \text{– Factor for edge distance and bolt spacing perpendicular to the direction of load transfer}$$

$$\alpha_b = \min\left(\frac{e_1}{3d_0}, \frac{p_1}{3d_0} - \frac{1}{4}, \frac{f_{ub}}{f_u}, 1\right) = 1.00 \quad \text{– Factor for end distance and bolt spacing in direction of load transfer}$$

$$e_2 = 80 \text{ mm} \quad \text{– Distance to the plate edge perpendicular to the shear force}$$

$$p_2 = 140 \text{ mm} \quad \text{– Distance between bolts perpendicular to the shear force}$$

$$d_0 = 30 \text{ mm} \quad \text{– Bolt hole diameter}$$

$$e_1 = 122 \text{ mm} \quad \text{– Distance to the plate edge in the direction of the shear force}$$

$$p_1 = \infty \text{ mm} \quad \text{– Distance between bolts in the direction of the shear force}$$

$$f_{ub} = 800.0 \text{ MPa} \quad \text{– Ultimate tensile strength of the bolt}$$

$$f_u = 430.0 \text{ MPa} \quad \text{– Ultimate strength of the plate}$$

$$d = 27 \text{ mm} \quad \text{– Nominal diameter of the fastener}$$

$$t = 19 \text{ mm} \quad \text{– Thickness of the plate}$$

$$\gamma_{M2} = 1.25 \quad \text{– Safety factor}$$

Utilization in tension

$$\frac{F_{t,Ed}}{\min(F_{t,Rd}; B_{p,Rd})} = 0.94 \leq 1.0$$

Where:

$$F_{t,Ed} = 248.8 \text{ kN} \quad \text{– Tensile force}$$

$$F_{t,Rd} = 264.4 \text{ kN} \quad \text{– Tension resistance}$$

$$B_{p,Rd} = 531.0 \text{ kN} \quad \text{– Punching resistance}$$

Utilization in shear

$$\max\left(\frac{F_{v,Ed}}{F_{v,Rd}}, \frac{F_{b,Ed}}{F_{b,Rd}}\right) = 0.20 \leq 1.0$$

Where:

$$F_{v,Ed} = 35.5 \text{ kN} \quad \text{– Shear force (in decisive shear plane)}$$

$$F_{v,Rd} = 176.3 \text{ kN} \quad \text{– Shear resistance}$$

$$F_{b,Ed} = 35.5 \text{ kN} \quad \text{– Bearing force (for decisive plate)}$$

$$F_{b,Rd} = 441.2 \text{ kN} \quad \text{– Bearing resistance}$$

Project:
Project no:
Author:



Interaction of tension and shear (EN 1993-1-8 – Table 3.4)

$$\frac{F_{v,Ed}}{F_{v,Rd}} + \frac{F_{t,Ed}}{1.4 F_{t,Rd}} = 0.87 \leq 1.0$$

Where:

$F_{v,Ed} = 35.5$ kN – Shear force (in decisive shear plane)

$F_{v,Rd} = 176.3$ kN – Shear resistance

$F_{t,Ed} = 248.8$ kN – Tensile force

$F_{t,Rd} = 264.4$ kN – Tension resistance

Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pl} [%]	σ _⊥ [MPa]	τ _⊥ [MPa]	τ _∥ [MPa]	U _t [%]	U _{t,c} [%]	Status
SEP1a	B-tfl 1	▲ 18.0	299	LE1	403.8	4.5	-30.2	203.5	-112.4	99.8	56.9	OK
SEP1a	B-bfl 1	▲ 18.0	299	LE1	402.4	3.6	1.3	195.5	-125.5	99.4	65.6	OK
SEP1b	B1-bfl 1	▲ 8.0 ▼	299	LE1	399.1	1.5	-170.1	-163.5	-129.3	98.6	56.9	OK
		▲ 8.0 ▼	299	LE1	399.6	1.9	-172.6	178.2	107.5	98.7	59.2	OK
SEP1b	B1-tfl 1	▲ 8.0 ▼	299	LE1	388.9	0.0	-216.9	-165.9	85.0	96.1	53.3	OK
		▲ 8.0 ▼	299	LE1	165.9	0.0	-51.9	84.0	34.9	41.0	25.5	OK
SEP1b	B1-w 1	▲ 8.0 ▼	369	LE1	264.6	0.0	99.4	141.3	-8.9	65.4	32.4	OK
		▲ 8.0 ▼	369	LE1	380.9	0.0	119.4	-93.5	-186.7	94.1	54.5	OK
B-bfl 1	STIFF	▲ 9.0 ▼	144	LE1	397.1	0.3	-35.2	-34.1	225.8	98.1	95.6	OK
		▲ 9.0 ▼	144	LE1	396.6	0.0	115.8	151.6	-158.1	98.0	37.1	OK
B-w 1	STIFF	▲ 9.0 ▼	351	LE1	332.6	0.0	25.5	6.5	-191.4	82.2	59.3	OK
		▲ 9.0 ▼	351	LE1	259.2	0.0	29.4	-10.7	-148.3	64.1	40.0	OK
B-tfl 1	STIFF	▲ 9.0 ▼	144	LE1	284.3	0.0	-34.1	-6.0	162.8	70.2	47.1	OK
		▲ 9.0 ▼	144	LE1	396.7	0.1	35.3	-15.3	227.6	98.0	91.4	OK
SEP1a	STIFF	▲ 9.0 ▼	350	LE1	397.6	0.6	115.1	91.4	-199.8	98.2	83.5	OK
		▲ 9.0 ▼	350	LE1	355.5	0.0	62.8	-127.2	-157.0	87.9	56.2	OK

Design data

Material	β _w [-]	σ _{w,Rd} [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Project:
Project no:
Author:



Symbol explanation

T_w	Throat thickness a
L	Length
$\sigma_{w,Ed}$	Equivalent stress
ϵ_{pl}	Strain
σ_{\perp}	Perpendicular stress
τ_{\perp}	Shear stress perpendicular to weld axis
τ_{\parallel}	Shear stress parallel to weld axis
U_t	Utilization
$U_{t,c}$	Weld capacity utilization
β_w	Correlation factor EN 1993-1-8 – Tab. 4.1
$\sigma_{w,Rd}$	Equivalent stress resistance
0.9σ	Perpendicular stress resistance: $0.9 \cdot f_u / \gamma_{M2}$
▲	Fillet weld

Detailed result for SEP1a / B-tfl 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 403.8 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 227.1 \text{ MPa}$$

where:

$f_u = 430.0 \text{ MPa}$ – Ultimate strength

$\beta_w = 0.85$ – Correlation factor EN 1993-1-8 – Tab. 4.1

$\gamma_{M2} = 1.25$ – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 1.00 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 403.8 \text{ MPa}$ – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7 \text{ MPa}$ – Equivalent stress resistance

$\sigma_{\perp} = -227.1 \text{ MPa}$ – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6 \text{ MPa}$ – Perpendicular stress resistance

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]
S 275	50.07	2.00	100.14

Project:
Project no:
Author:



Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]
M27 8.8	3.24	5.00	16.19

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Fillet	18.0	25.5	1.53	40.00	61.04
Double fillet	8.0	11.3	0.98	40.00	39.03
Double fillet	9.0	12.7	1.26	40.00	50.51

Hole drilling




Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]
16.19	30.0	4.86

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	271.76

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
SEP1	P22.0x300.0-440.0 (S 275)		1	Double fillet: a = 9.0 Fillet: a = 18.0 Fillet: a = 18.0 Double fillet: a = 8.0	993.0 300.0 300.0 971.0	M27 8.8	4
	P19.0x300.0-440.0 (S 275)		1				
	P19.0x144.5-352.0 (S 275)		1				

Project:
Project no:
Author:



Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Fillet	S 275	18.0	25.5	300.0
Fillet	S 275	18.0	25.5	300.0
Double fillet	S 275	8.0	11.3	971.0
Double fillet	S 275	9.0	12.7	993.0

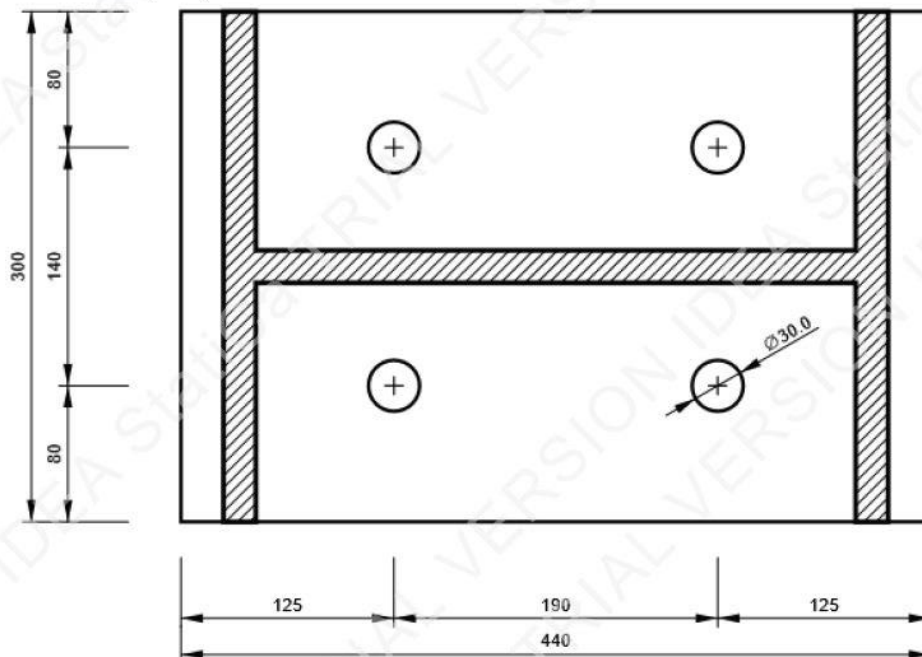
Bolts

Name	Grip length [mm]	Count
M27 8.8	41	4

Drawing

SEP1 - SEP1a

P22.0x440-300 (S 275)

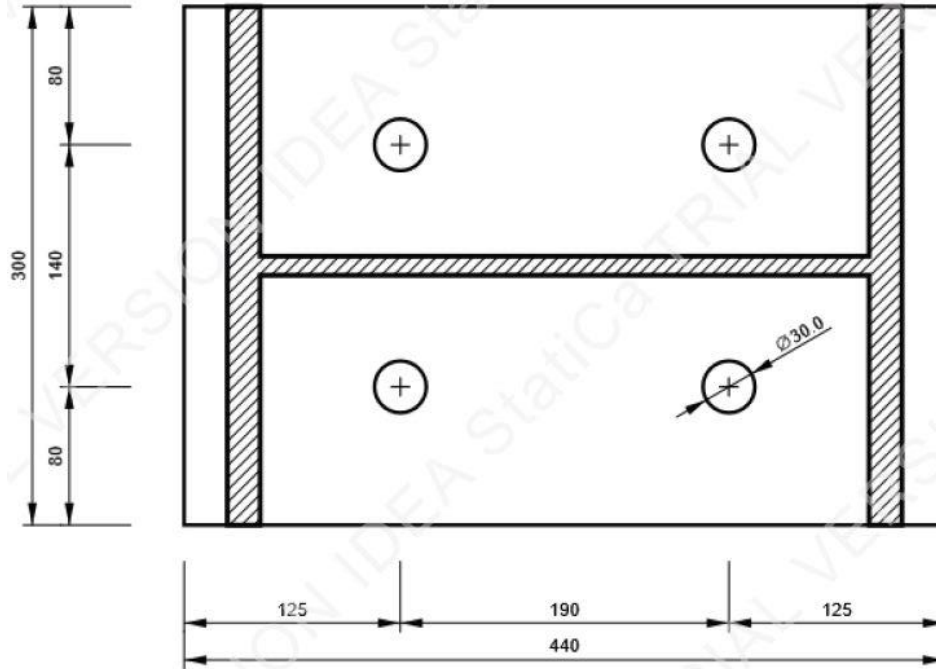


Project:
Project no:
Author:



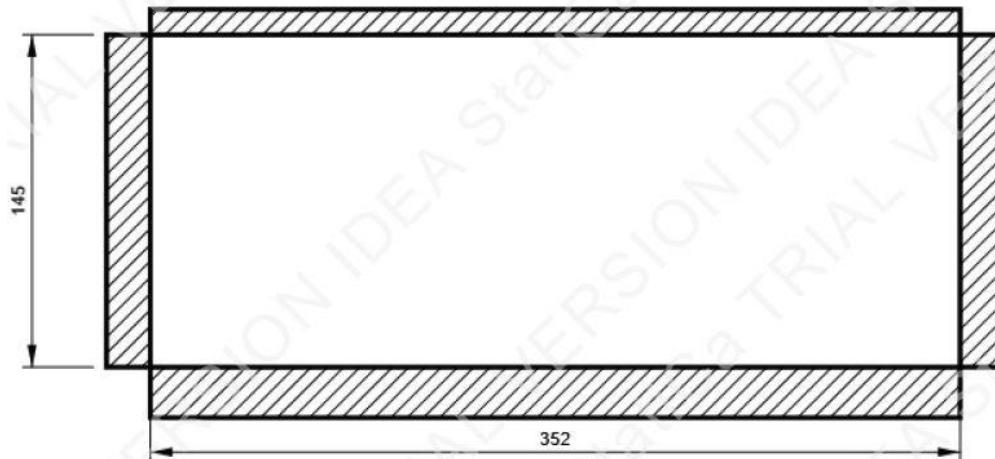
SEP1 - SEP1b

P19.0x440-300 (S 275)



SEP1 - STIFF

P19.0x352-145 (S 275)



Project:
Project no:
Author:

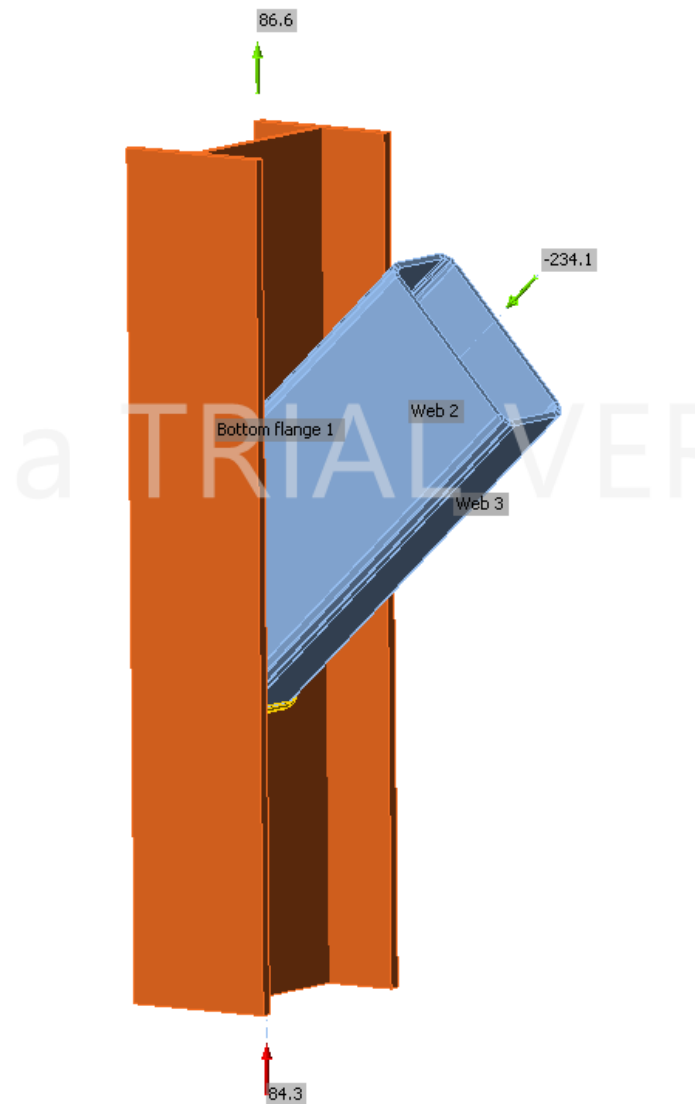


Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated q_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.6 Spoj stup – kosnik

- Mjerodavna uzdužna sila N u stupu $N = -84,29$ [kNm]
 $N = 86,57$ [kNm]
- Mjerodavna uzdužna sila N u kosniku $N = -234,10$ [kNm]



Slika 115. Prikaz zadanih opterećenja u programu IdeaStatica – spoj stup kosnik

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/29/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item Spoj kosnik -stup

Design

Name Spoj kosnik -stup
Description
Analysis Stress, strain/ loads in equilibrium

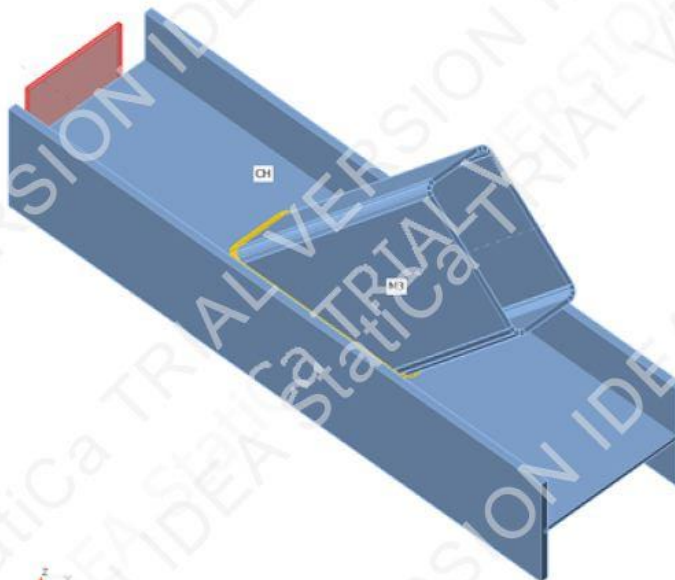
Members

Geometry

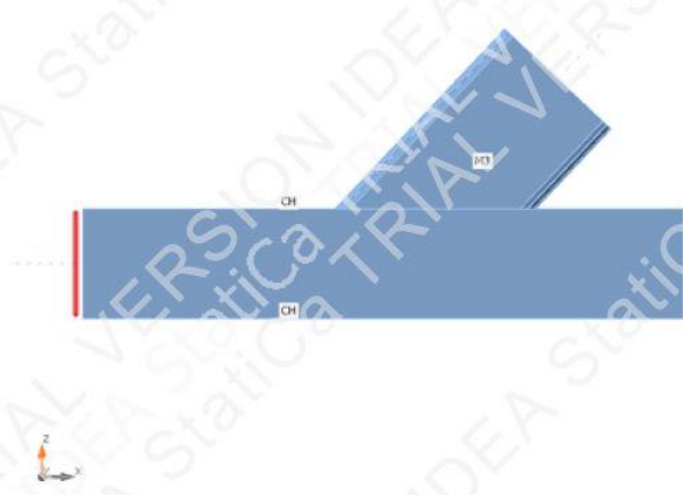
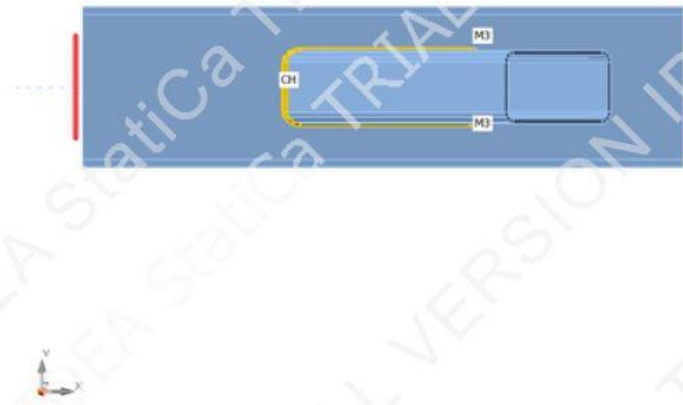
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
CH	15 - CON1(HEA450)	0.0	0.0	90.0	0	0	0
M3	16 - RHSCF400/200/12.5	0.0	46.7	0.0	0	0	0

Supports and forces

Name	Support	Forces in	X [mm]
CH / begin	N-Vy-Vz-Mx-My-Mz	Node	0
CH / end		Node	0
M3 / end		Node	0

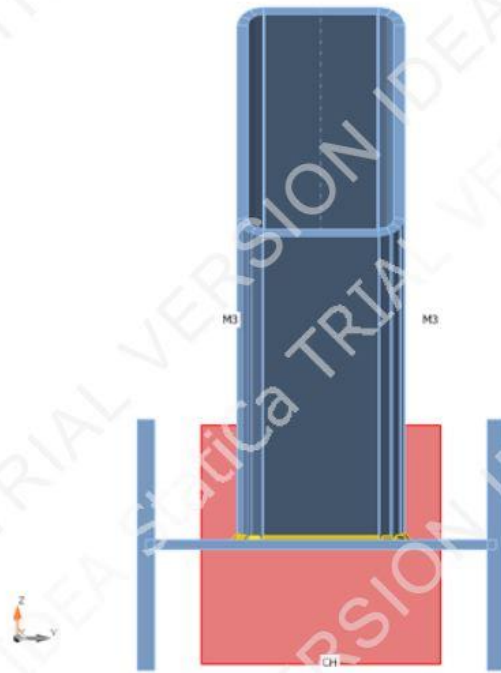


Project:
Project no:
Author:



Project:
Project no:
Author:

IDEA StatiCa[®]
Calculate yesterday's estimates



Cross-sections

Name	Material
15 - CON1 (HEA450)	S 275
16 - RHSCF400/200/12.5	S 275

Project:
Project no:
Author:



Cross-sections

Name	Material	Drawing
15 - CON1(HEA450)	S 275	
16 - RHSCF400/200/12.5	S 275	

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	CH / Begin	84.3	0.0	0.0	0.0	0.0	0.0
	CH / End	86.6	0.0	0.0	0.0	0.0	0.0
	M3 / End	-234.1	0.0	0.0	0.0	0.0	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	10.3	0.0	-170.4	0.0	0.0	0.0

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.1 < 5.0%	OK
Welds	98.1 < 100%	OK
Buckling	Not calculated	

Project:
Project no:
Author:

IDEA StatiCa®
Calculate yesterday's estimates

Plates

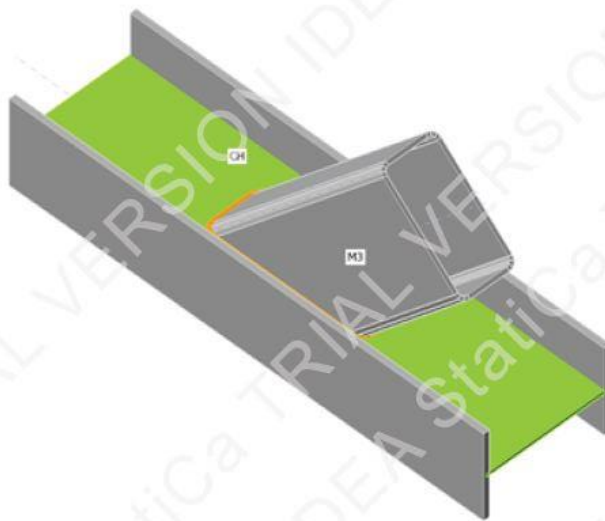
Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
CH-bfl 1	21.0	LE1	202.6	0.0	0.0	OK
CH-tfl 1	21.0	LE1	202.6	0.0	0.0	OK
CH-w 1	11.5	LE1	275.2	0.1	0.0	OK
M3	12.5	LE1	211.9	0.0	0.0	OK

Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

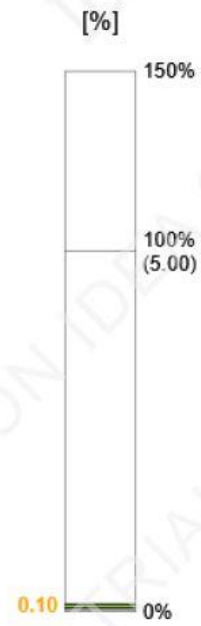
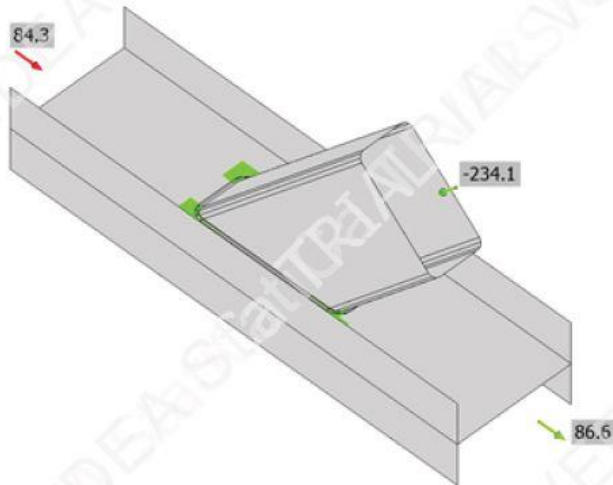
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

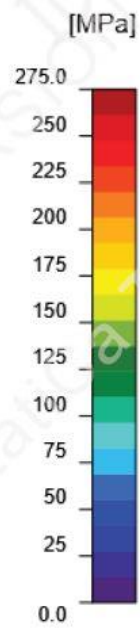
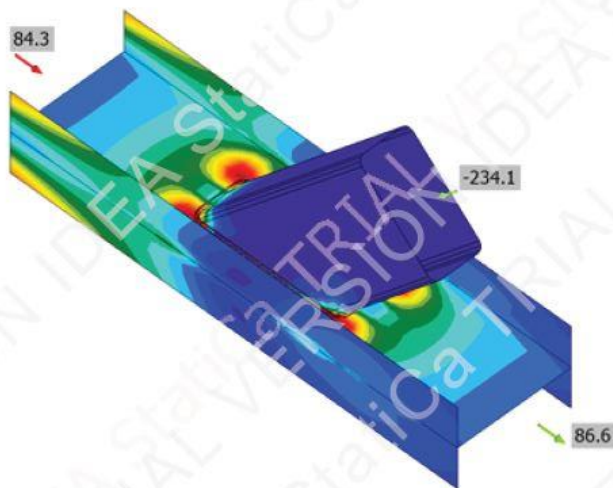


Overall check, LE1

Project:
Project no:
Author:



Strain check, LE1



Equivalent stress, LE1

Project:
Project no:
Author:



Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pl} [%]	σ _⊥ [MPa]	τ _⊥ [MPa]	τ _∥ [MPa]	Ut [%]	Ut _c [%]	Status
CH-w 1	M3	▲ 6.0	1385	LE1	397.0	0.2	-231.9	185.9	5.5	98.1	34.9	OK

Design data

Material	β _w [-]	σ _{w,Rd} [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Symbol explanation

T _w	Throat thickness a
L	Length
σ _{w,Ed}	Equivalent stress
ε _{pl}	Strain
σ _⊥	Perpendicular stress
τ _⊥	Shear stress perpendicular to weld axis
τ _∥	Shear stress parallel to weld axis
Ut	Utilization
Ut _c	Weld capacity utilization
β _w	Correlation factor EN 1993-1-8 – Tab. 4.1
σ _{w,Rd}	Equivalent stress resistance
0.9 σ	Perpendicular stress resistance: 0.9·f _u /γ _{M2}
▲	Fillet weld

Detailed result for CH-w 1 / M3

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 397.0 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 231.9 \text{ MPa}$$

where:

f_u = 430.0 MPa – Ultimate strength

β_w = 0.85 – Correlation factor EN 1993-1-8 – Tab. 4.1

γ_{M2} = 1.25 – Safety factor

Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0.98 \leq 1.0$$

Where:

σ_{w,Ed} = 397.0 MPa – Maximum normal stress transverse to the axis of the weld

σ_{w,Rd} = 404.7 MPa – Equivalent stress resistance

σ_⊥ = -231.9 MPa – Normal stress perpendicular to the throat

σ_{⊥,Rd} = 309.6 MPa – Perpendicular stress resistance

Project:
Project no:
Author:



Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Fillet rear	6.0	8.5	0.39	40.00	15.69

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	15.69

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
CUT2				Fillet: a = 6.0	1388.0		

Welds

Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Fillet	S 275	6.0	8.5	1388.0

Project:

Project no:

Author:



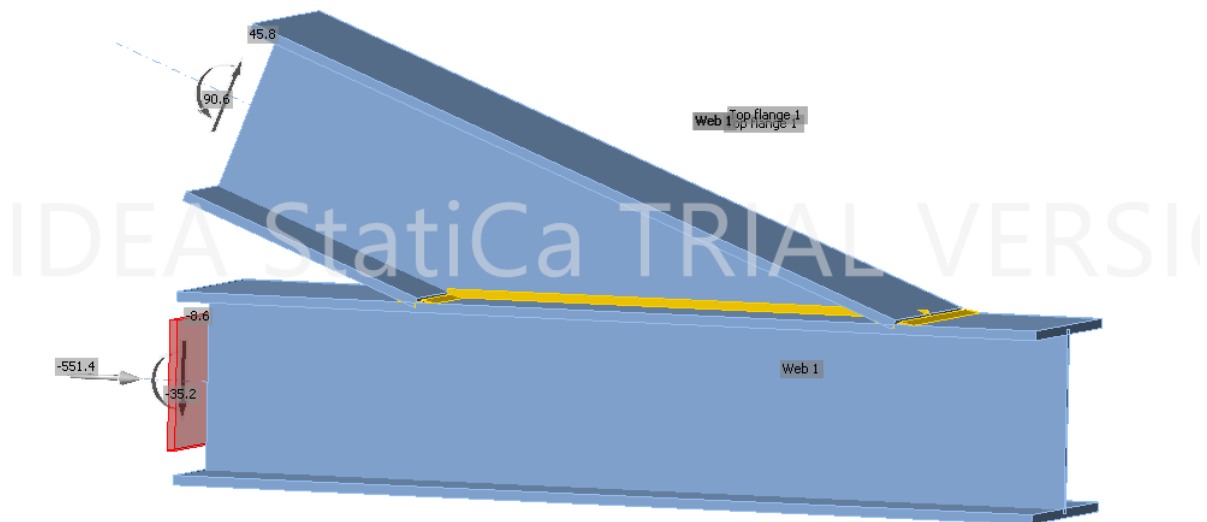
Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{Inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

5.7 Spoj krovni nosač – greda

- Mjerodavni moment savijanja M_y na krovnom nosaču $M_y=90,62$ [kNm]
- Mjerodavna poprečna sila V_z na krovnom nosaču $V_z=45,83$ [kNm]
- Mjerodavni moment savijanja M_y na gredi $M_y=-35,16$ [kNm]
- Mjerodavna poprečna sila V_z na gredi $V_z=-8,63$ [kN]
- Mjerodavna uzdužna sila N u gredi $N=-551,39$ [kN]

Prc



Slika 116. Prikaz zadanih opterećenja u programu IdeaStatica – spoj krovni nosač greda

Nakon nanošenja opterećenja slijedi dimenzioniranje s najvećem stupnjem iskoristivosti prema proračunu u računalnom programu IdeaStatiCa u nastavku:

Project:
Project no:
Author:



Project data

Project name
Project number
Author
Description
Date 8/29/2023
Code EN

Material

Steel S 275
Concrete C25/30

Project:
Project no:
Author:



Project item SPOJ KROVNI NOSAČ GREDA

Design

Name: SPOJ KROVNI NOSAČ GREDA
Description:
Analysis: Stress, strain/ loads in equilibrium

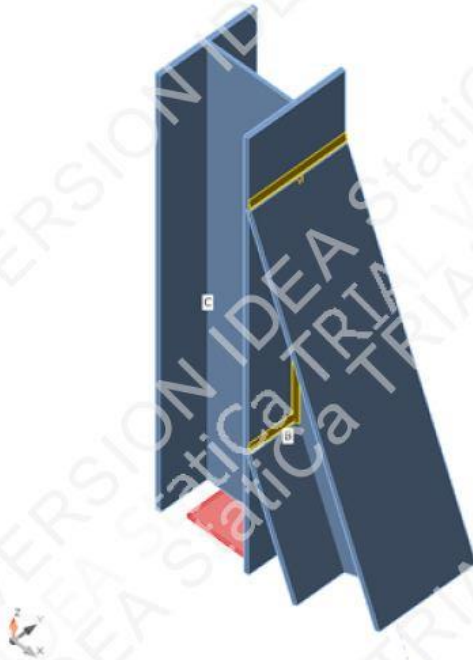
Members

Geometry

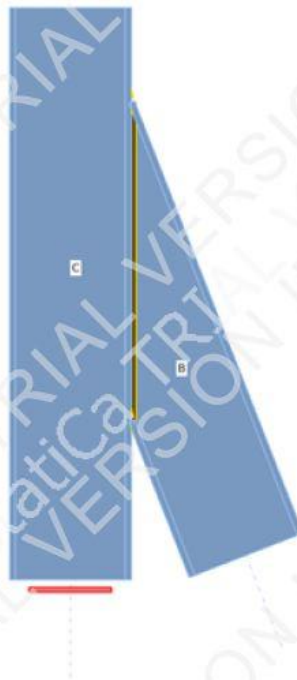
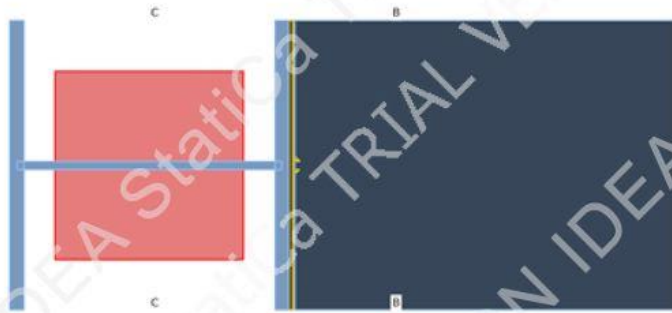
Name	Cross-section	β - Direction [°]	γ - Pitch [°]	α - Rotation [°]	Offset ex [mm]	Offset ey [mm]	Offset ez [mm]
C	9 - Greda(HEA260)	0.0	-90.0	0.0	-200	0	0
B	10 - Krovni nosač(HEA260)	0.0	-68.7	0.0	200	0	0

Supports and forces

Name	Support	Forces in	X [mm]
C / end	N-Vy-Vz-Mx-My-Mz	Node	0
B / end		Node	0



Project:
Project no:
Author:



Project:
Project no:
Author:

IDEA StatiCa[®]
Calculate yesterday's estimations



Cross-sections

Name	Material
9 - Greda(HEA260)	S 275
10 - Krovni nosač(HEA260)	S 275

Project:
Project no:
Author:



Cross-sections

Name	Material	Drawing
9 - Greda(HEA260)	S 275	
10 - Krovni nosač(HEA260)	S 275	

Load effects (forces in equilibrium)

Name	Member	N [kN]	Vy [kN]	Vz [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	C / End	-551.4	0.0	-8.6	0.0	-35.2	0.0
	B / End	0.0	0.0	45.8	0.0	90.6	0.0

Unbalanced forces

Name	X [kN]	Y [kN]	Z [kN]	Mx [kNm]	My [kNm]	Mz [kNm]
LE1	34.1	0.0	568.0	0.0	44.6	0.0

Check

Summary

Name	Value	Check status
Analysis	100.0%	OK
Plates	0.6 < 5.0%	OK
Welds	98.5 < 100%	OK
Buckling	Not calculated	

Project:
Project no:
Author:



Plates

Name	t_p [mm]	Loads	σ_{Ed} [MPa]	ϵ_{pl} [%]	$\sigma_{c,Ed}$ [MPa]	Status
C-bfl 1	12.5	LE1	168.1	0.0	0.0	OK
C-tfl 1	12.5	LE1	275.4	0.2	0.0	OK
C-w 1	7.5	LE1	276.2	0.6	0.0	OK
B-bfl 1	12.5	LE1	275.5	0.2	0.0	OK
B-tfl 1	12.5	LE1	162.2	0.0	0.0	OK
B-w 1	7.5	LE1	275.3	0.2	0.0	OK

Design data

Material	f_y [MPa]	ϵ_{lim} [%]
S 275	275.0	5.0

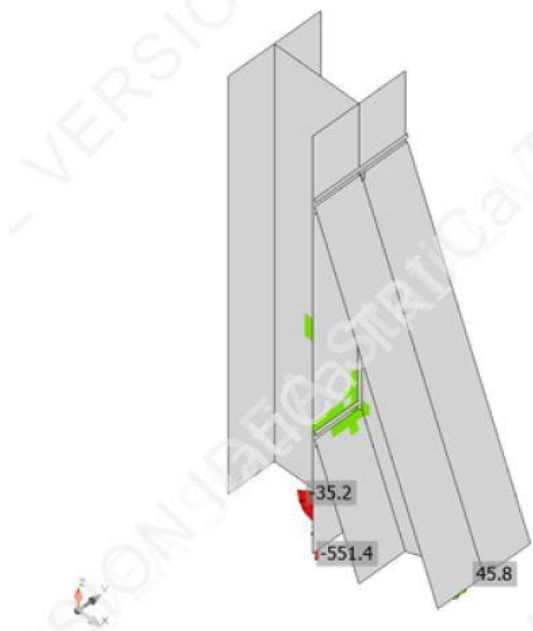
Symbol explanation

t_p	Plate thickness
σ_{Ed}	Equivalent stress
ϵ_{pl}	Plastic strain
$\sigma_{c,Ed}$	Contact stress
f_y	Yield strength
ϵ_{lim}	Limit of plastic strain

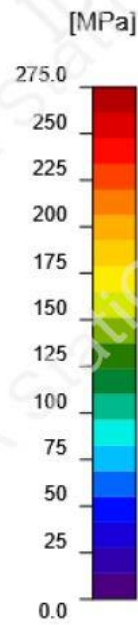


Overall check, LE1

Project:
Project no:
Author:



Strain check, LE1



Equivalent stress, LE1

Project:
Project no:
Author:



Welds

Item	Edge	T _w [mm]	L [mm]	Loads	σ _{w,Ed} [MPa]	ε _{pI} [%]	σ _⊥ [MPa]	τ _⊥ [MPa]	τ _∥ [MPa]	Ut [%]	Ut _c [%]	Status
C-tfl 1	B-bfl 1	▲ 7.0 ▲	259	LE1	329.0	0.0	-145.4	-148.7	-83.3	81.3	21.1	OK
		▲ 7.0 ▲	259	LE1	398.5	1.2	-237.9	167.4	-77.7	98.5	72.6	OK
C-tfl 1	B-tfl 1	▲ 7.0 ▲	259	LE1	69.5	0.0	15.9	27.0	28.2	17.2	6.9	OK
		▲ 7.0 ▲	259	LE1	160.9	0.0	19.0	-84.0	-38.2	39.8	21.2	OK
C-tfl 1	B-w 1	▲ 7.0 ▲	652	LE1	108.1	0.0	24.9	24.9	55.4	26.7	15.6	OK
		▲ 7.0 ▲	652	LE1	108.2	0.0	24.9	-24.9	-55.5	26.7	15.6	OK

Design data

Material	β _w [-]	σ _{w,Rd} [MPa]	0.9 σ [MPa]
S 275	0.85	404.7	309.6

Symbol explanation

T _w	Throat thickness a
L	Length
σ _{w,Ed}	Equivalent stress
ε _{pI}	Strain
σ _⊥	Perpendicular stress
τ _⊥	Shear stress perpendicular to weld axis
τ _∥	Shear stress parallel to weld axis
Ut	Utilization
Ut _c	Weld capacity utilization
β _w	Correlation factor EN 1993-1-8 – Tab. 4.1
σ _{w,Rd}	Equivalent stress resistance
0.9 σ	Perpendicular stress resistance: 0.9·f _u /γ _{M2}
▲	Fillet weld

Detailed result for C-tfl 1 / B-bfl 1

Weld resistance check (EN 1993-1-8 – Cl. 4.5.3.2)

$$\sigma_{w,Rd} = f_u / (\beta_w \gamma_{M2}) = 404.7 \text{ MPa} \geq \sigma_{w,Ed} = [\sigma_{\perp}^2 + 3(\tau_{\perp}^2 + \tau_{\parallel}^2)]^{0.5} = 398.5 \text{ MPa}$$

$$\sigma_{\perp,Rd} = 0.9 f_u / \gamma_{M2} = 309.6 \text{ MPa} \geq |\sigma_{\perp}| = 238.0 \text{ MPa}$$

where:

f_u = 430.0 MPa – Ultimate strength

β_w = 0.85 – Correlation factor EN 1993-1-8 – Tab. 4.1

γ_{M2} = 1.25 – Safety factor

Project:
Project no:
Author:



Stress utilization

$$U_t = \max\left(\frac{\sigma_{w,Ed}}{\sigma_{w,Rd}}; \frac{|\sigma_{\perp}|}{\sigma_{\perp,Rd}}\right) = 0.98 \leq 1.0$$

Where:

$\sigma_{w,Ed} = 398.5$ MPa – Maximum normal stress transverse to the axis of the weld

$\sigma_{w,Rd} = 404.7$ MPa – Equivalent stress resistance

$\sigma_{\perp} = -238.0$ MPa – Normal stress perpendicular to the throat

$\sigma_{\perp,Rd} = 309.6$ MPa – Perpendicular stress resistance

Buckling

Buckling analysis was not calculated.

Cost estimation

Steel

Steel grade	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Bolts

Bolt assembly	Total weight [kg]	Unit cost [€/kg]	Cost [€]

Welds

Weld type	Throat thickness [mm]	Leg size [mm]	Total weight [kg]	Unit cost [€/kg]	Cost [€]
Double fillet	7.0	9.9	0.90	40.00	36.12

Hole drilling

Bolt assembly cost [€]	Percentage of bolt assembly cost [%]	Cost [€]

Cost summary

Cost estimation summary	Cost [€]
Total estimated cost	36.12

Bill of material

Manufacturing operations

Name	Plates [mm]	Shape	Nr.	Welds [mm]	Length [mm]	Bolts	Nr.
CUT2				Double fillet: a = 7.0	1173.8		

Project:
Project no:
Author:



Welds

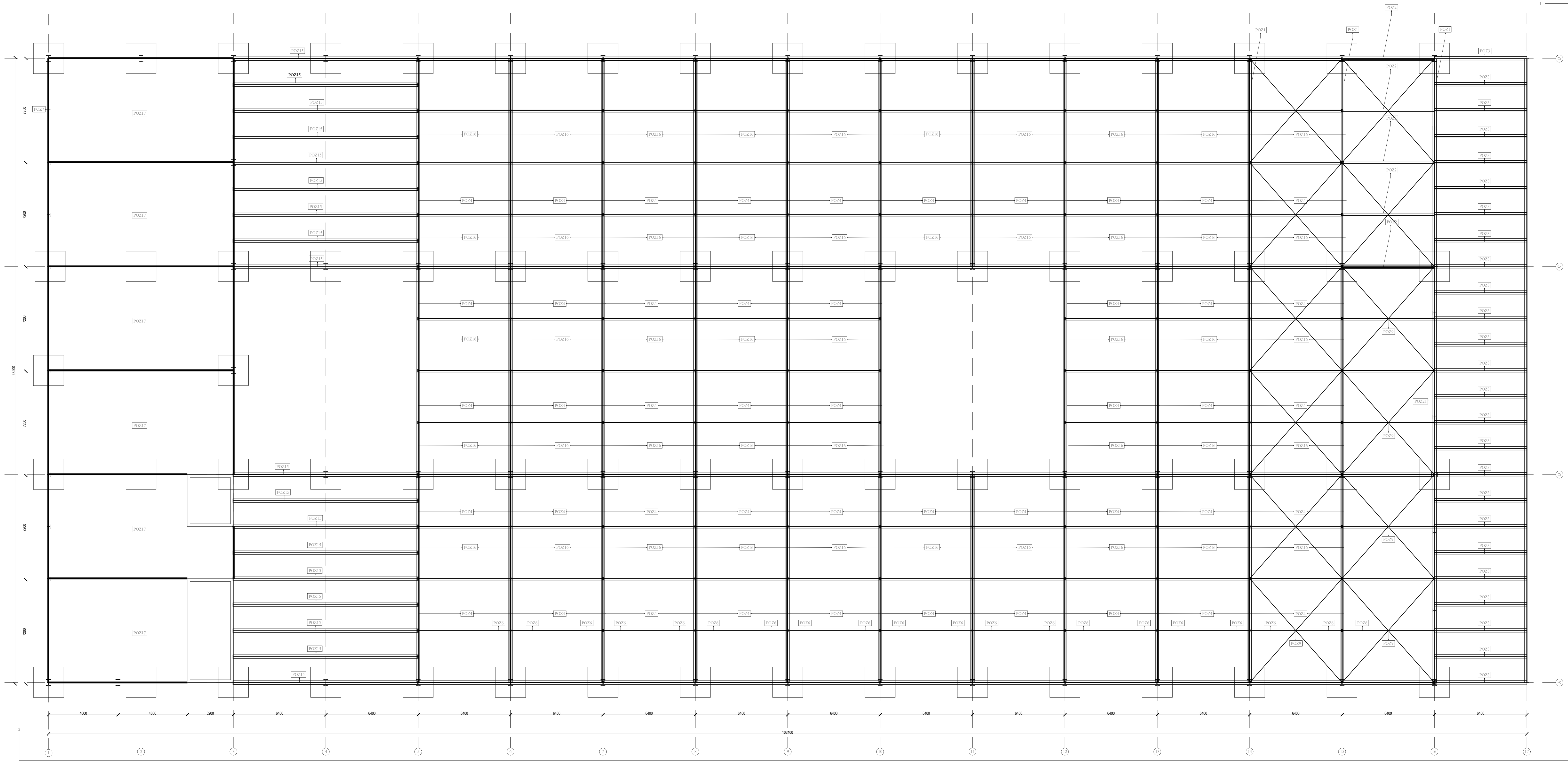
Type	Material	Throat thickness [mm]	Leg size [mm]	Length [mm]
Double fillet	S 275	7.0	9.9	1173.8


Code settings

Item	Value	Unit	Reference
Safety factor γ_{M0}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M1}	1.00	-	EN 1993-1-1: 6.1
Safety factor γ_{M2}	1.25	-	EN 1993-1-1: 6.1
Safety factor γ_{M3}	1.25	-	EN 1993-1-8: 2.2
Safety factor γ_C	1.50	-	EN 1992-1-1: 2.4.2.4
Safety factor γ_{inst}	1.20	-	EN 1992-4: Table 4.1
Joint coefficient β_j	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
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 check	Both		EN 1992-4: 7.2.1.4 and 7.2.2.5
Use calculated a_b in bearing check.	Yes		EN 1993-1-8: tab 3.4
Cracked concrete	Yes		EN 1992-4
Local deformation check	No		CIDECT DG 1, 3 - 1.1
Local deformation limit	0.03	-	CIDECT DG 1, 3 - 1.1
Geometrical nonlinearity (GMNA)	Yes		Analysis with large deformations for hollow section joints
Braced system	No		EN 1993-1-8: 5.2.2.5

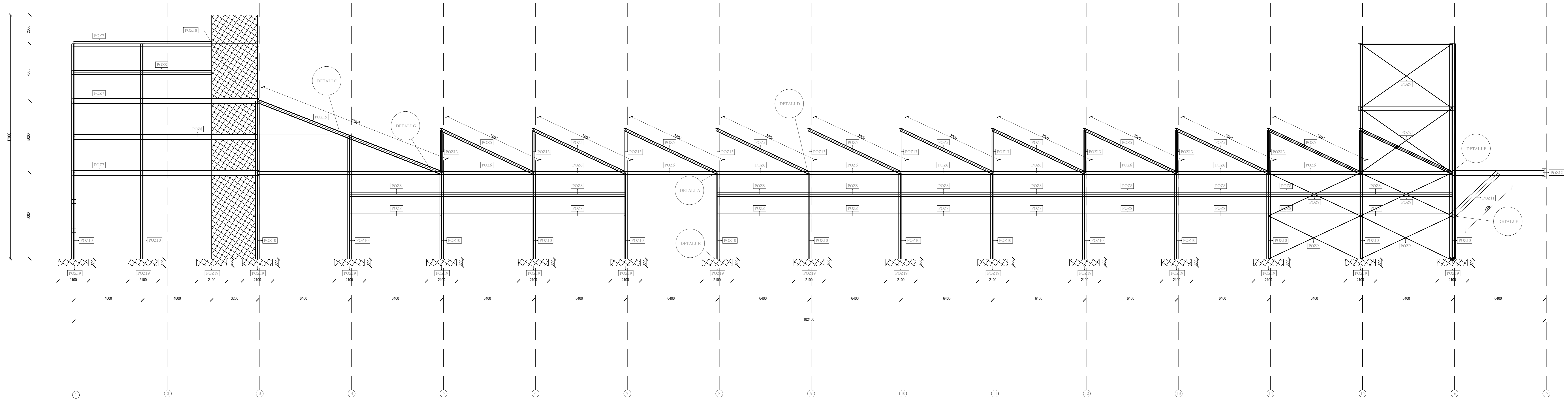
6. PRILOZI


1. Prilog 1–Tlocrt
2. Prilog 2–Pogled 1-1
3. Prilog 3–Pogled 2-2
4. Prilog 4–Plan pozicija
5. Prilog 5 – Detalj „A“
6. Prilog 6 – Detalj „B“
7. Prilog 7 – Detalj „C“
8. Prilog 8 – Detalj „D“
9. Prilog 9 – Detalj „E“
10. Prilog 10 – Detalj „F“
11. Prilog 11 – Detalj „G“



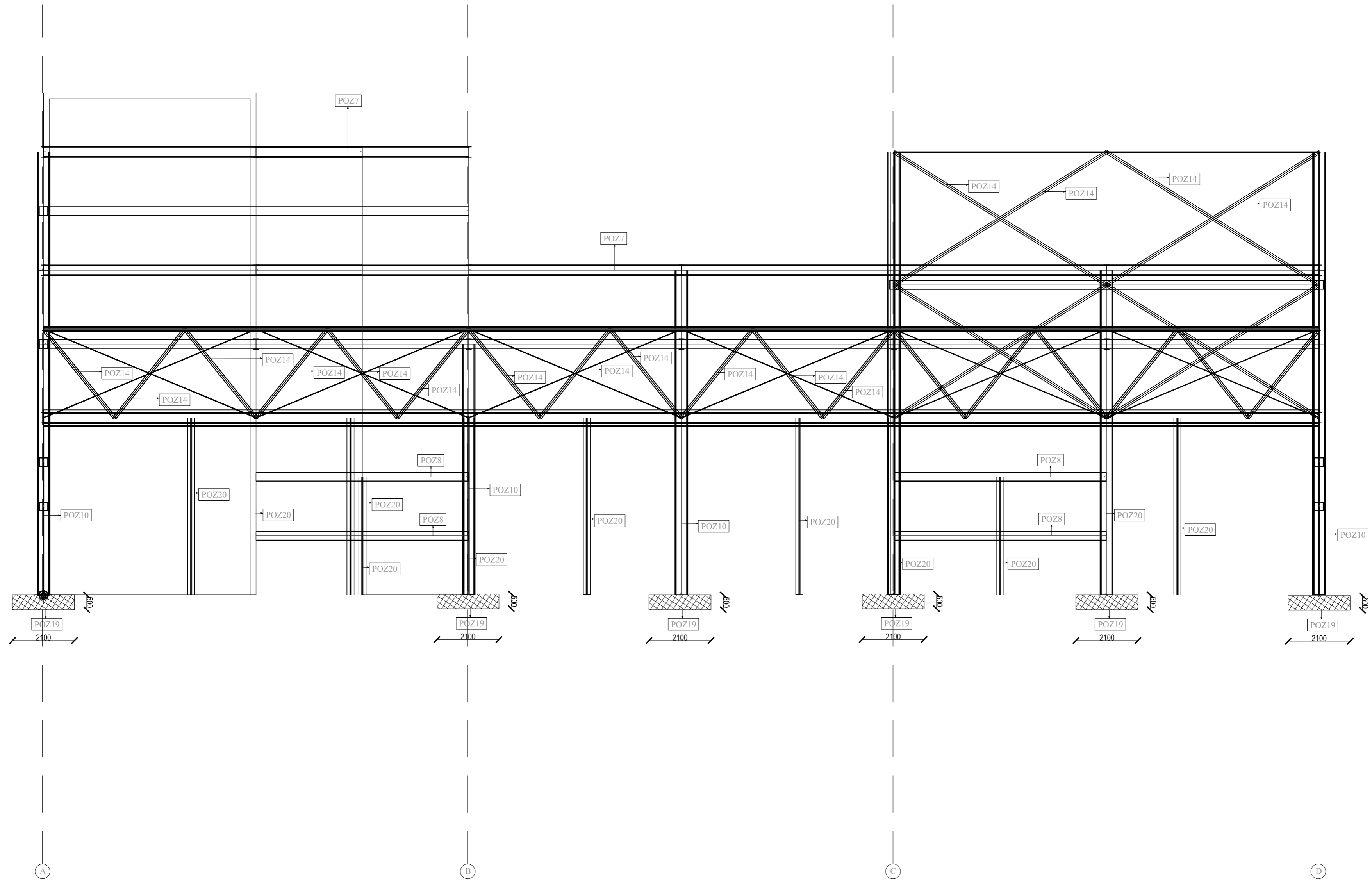
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	PROGRAM: PROJEKT KONSTRUKCIJE BROWNFIELD DUGH RAT	
	STUDENT: ANTONIO DRAŽEN VRDOLJAK	MENTOR: Dr. sc. Ivica Beko
	SERIJA: TLOCRT	MERLO: 1:100
DATUM: 2022./2023.	PRILOG: 1	


POGLED 2 - 2



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	PROGRAM: PROJEKT KONSTRUKCIJE BROWNFIELD DUGI RAT		
	STUDENT: ANTONIO DRAŽEN VRDOLJAK	MENTOR: Dr. sc. Ivica Boko	
	SADRŽAJ: POGLED 2-2	MERLO: 1:100	
	DATA: 2022/2023.	PRLO: 3	


POGLED 1-1



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	PROGRAM: PROJEKT KONSTRUKCIJE BROWNFIELD DUGI RAT		
	STUDENT: ANTONIO DRAŽEN VRDOLJAK	MENTOR:	Dr. sc. Ivica Boko
	SADRŽAJ: DATUM:	POGLED 1-1 2022./2023.	MERLO PRILOG

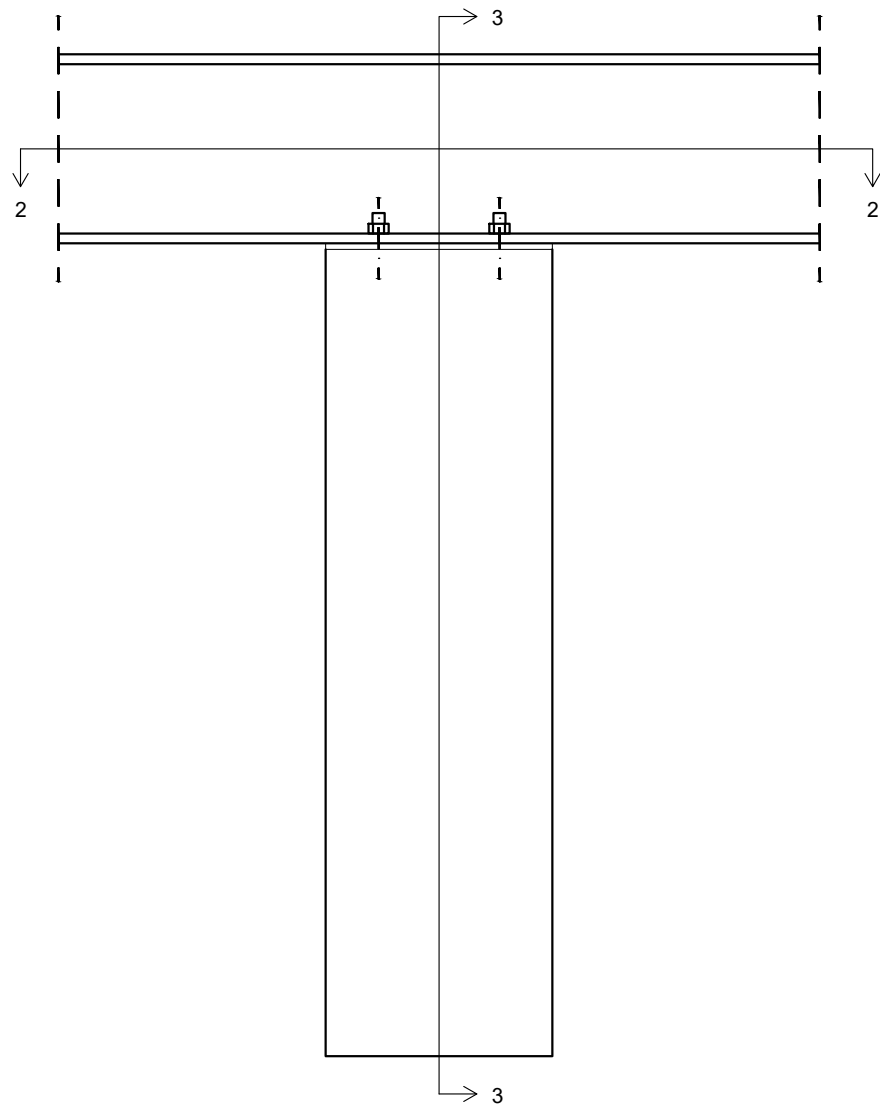
PLAN POZICIJA ČELIČNIH ELEMENATA				
POZICIJA	PROFIL	NAZIV	KOM	TEŽINA(KG)
POZ1	HEA100	KROVNA GREDA	3	720.3
POZ2	HEA120	PODROŽNICA-KUĆICA	5	636.5
POZ3	HEA400	KONZOLNA GREDA	25	19967.5
POZ4	HEA180	GORNJI POJAS	12	6138.4
POZ5	HEA220	KRAĆI KROVNI NOSAČ	79	15638.4
POZ6	HEA260	GREDE 1	4	58713.6
POZ7	IPE360A	SPREGNUTE GREDE	42	31452.6
POZ8	SHS300x300x12.5	BOČNA PODROŽNICA	55	49901.5
POZ9	RD28	SPREG	48	2008.4
POZ10	HEA450	STUP	66	64285.7
POZ11	RHS400x200x12.5	KOSNIK	4	1965.2
POZ12	HEA600	ZADNJA GREDA 2	1	7679.6
POZ13	CHS133x4	VERTIKALA	73	2788.6
POZ14	CHS114.3x5	DIJAGONALA	202	11465.5
POZ15	HEA260	DUŽI KROVNI NOSAČ	18	8757
POZ16	HEA260	DONJI POJAS	12	33026.4
POZ20	HEA240	ZABATNI STUPOVI	16	7539.4
POZ21	HEA400	ZADNJA GREDA 1	1	5486.4
Ukupno:				328171

PLAN POZICIJA BETONSKIH ELEMENATA	
POZICIJA	NAZIV
POZ17	SPREGNUTE PLOČE
POZ18	ZIDOVI
POZ19	TEMELJI

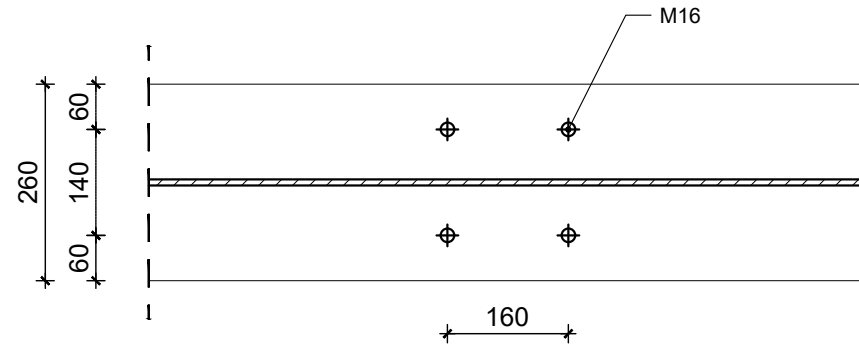
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	SADRŽAJ: DATUM:	PLAN POZICIJA 2022./2023.	MJERILO PRILOG
			1:100 4

DETALJ "A" - SPOJ STUP GREDA

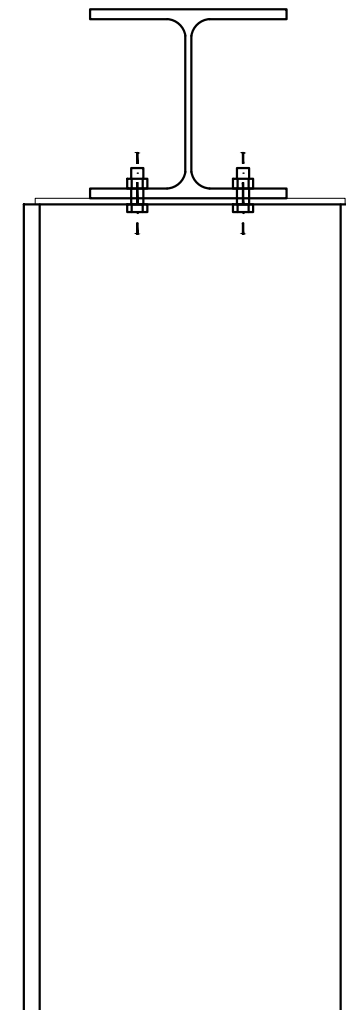
PRESJEK 1 - 1



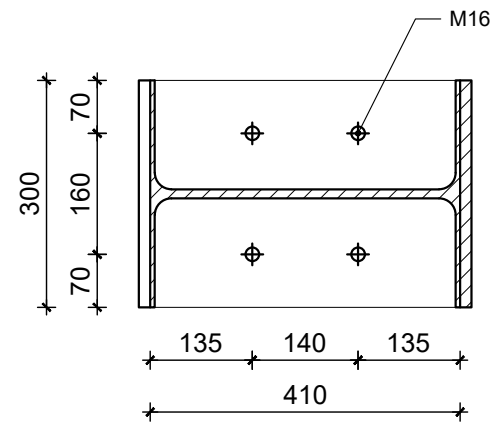
PRESJEK 2 - 2



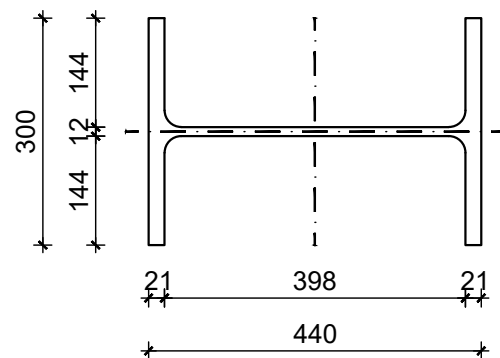
PRESJEK 3 - 3



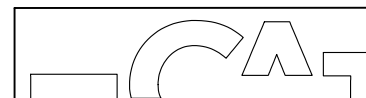
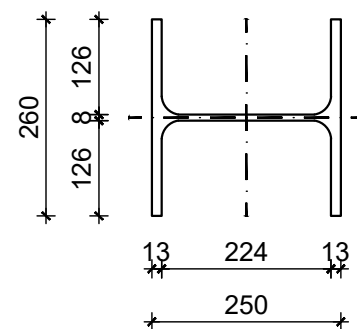
TLOCRT



POPREČNI PRESJEK - STUP



POPREČNI PRESJEK - GREDA



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STUDENT:
 ANTONIO DRAŽEN VRDOLJAK

MENTOR:
 Dr. sc. Ivica Boko

SADRŽAJ: DETALJ "A"

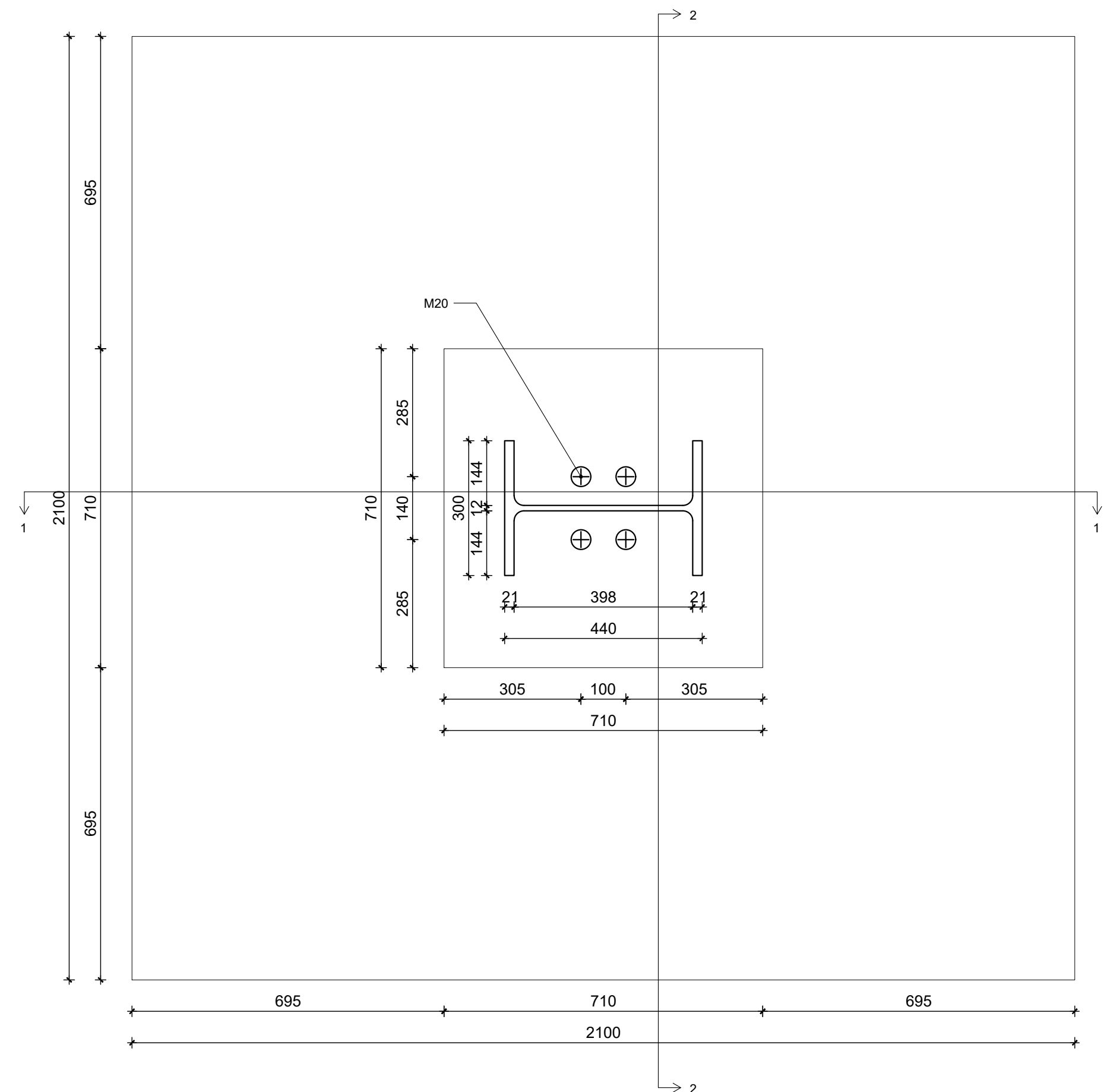
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DATUM: 2022./2023.

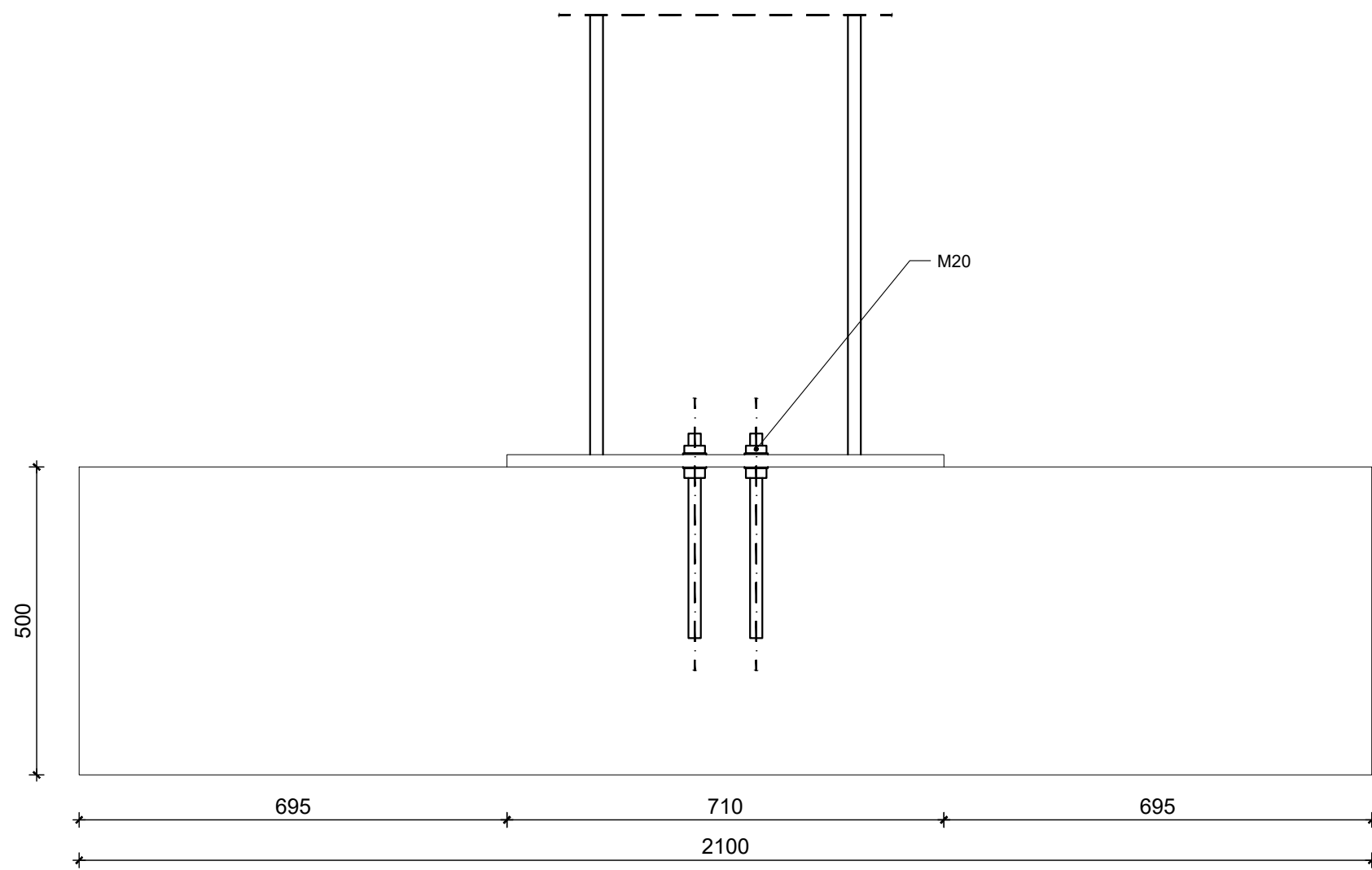
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DETALJ "B" - SPOJ STUP TEMELJ

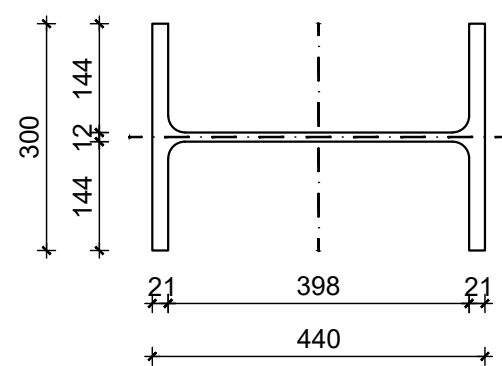
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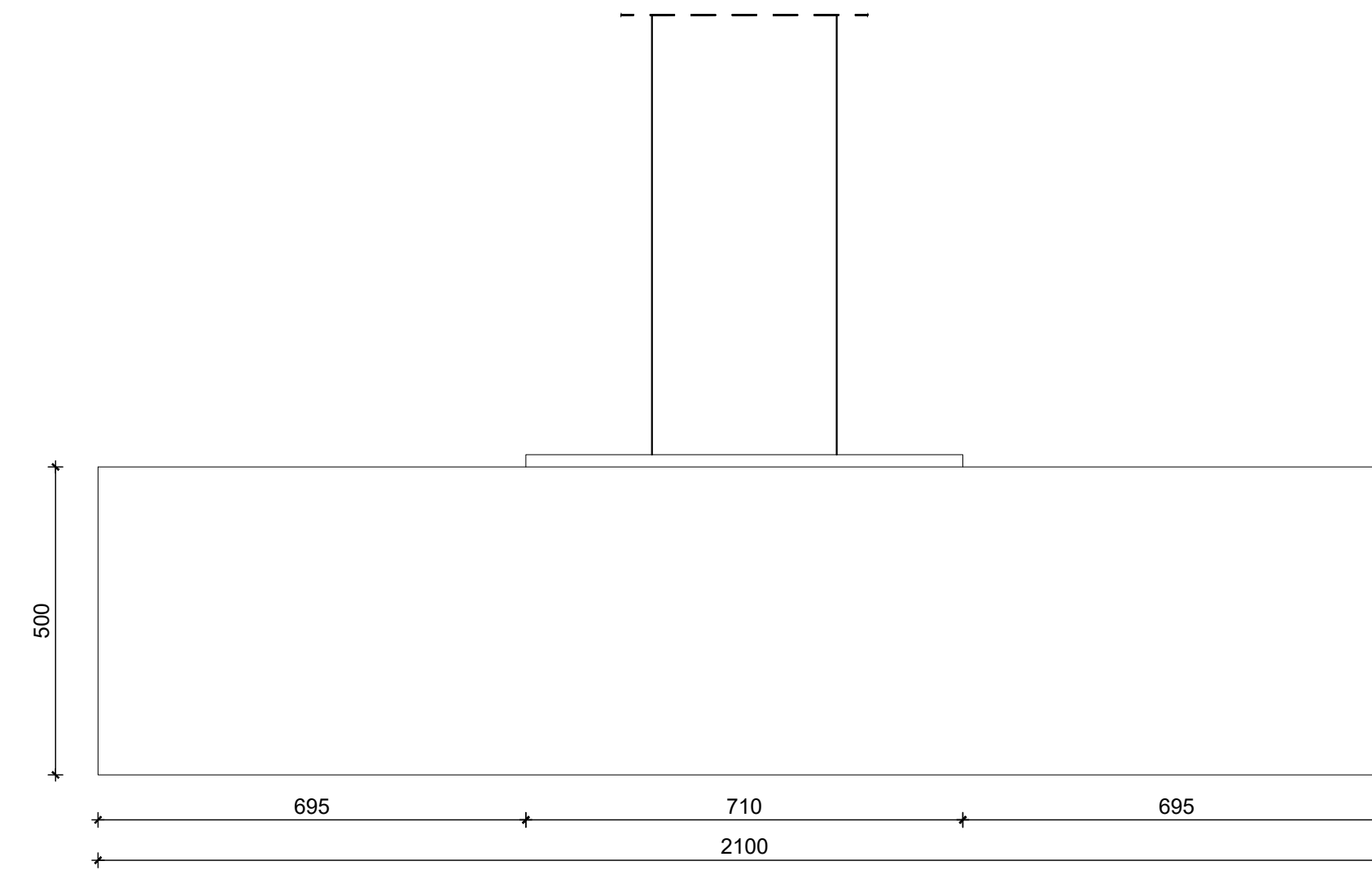
PRESJEK 1 - 1



POPREČNI PRESJEK - STUP



PRESJEK 2 - 2



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MENTOR:
Dr. sc. Ivica Boko

SADRŽAJ:
DETALJ "B"

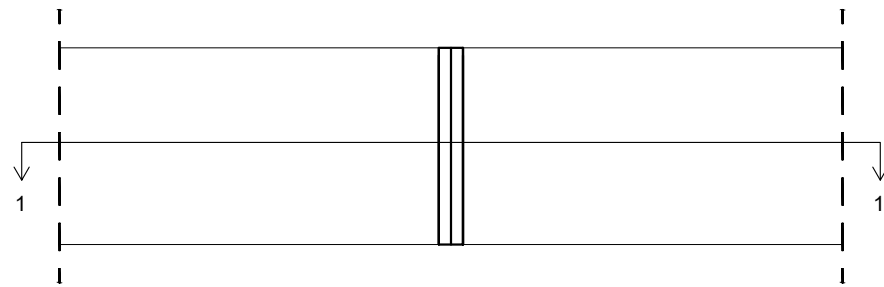
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DATUM:
2022./2023.

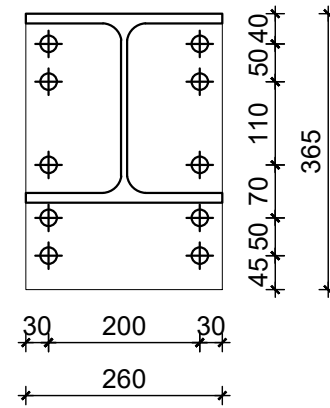
PRILOG:
6

DETALJ "C" - NASTAVAK KROVNOG NOSAČA

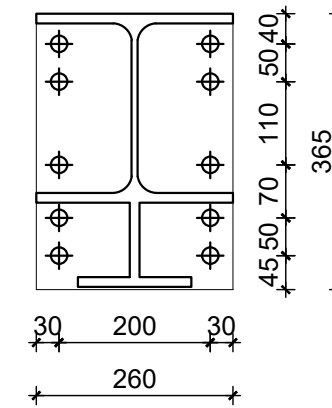
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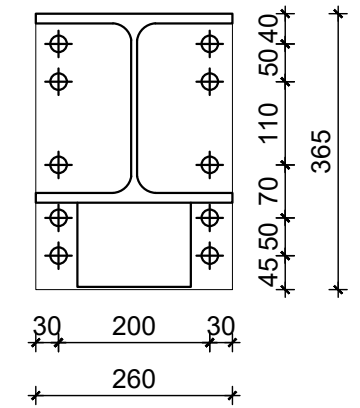
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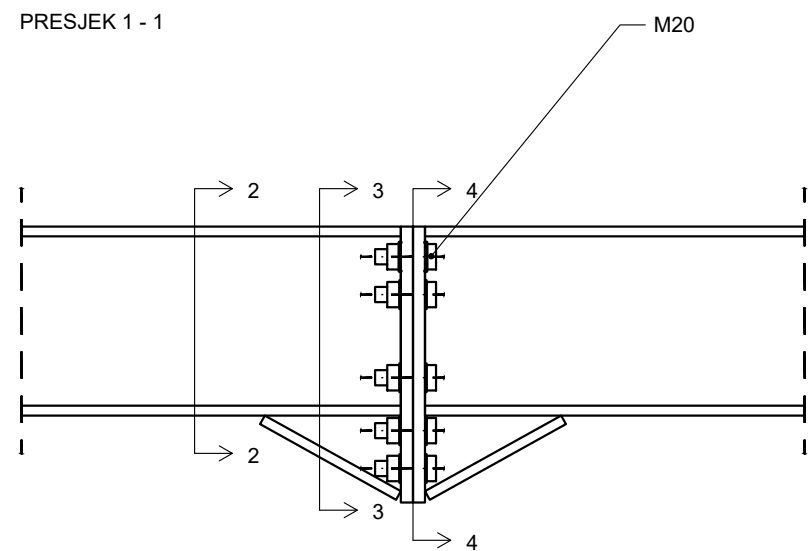
PRESJEK 3 - 3



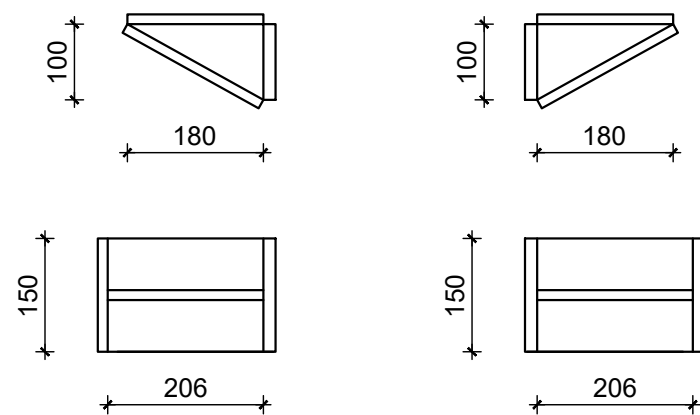
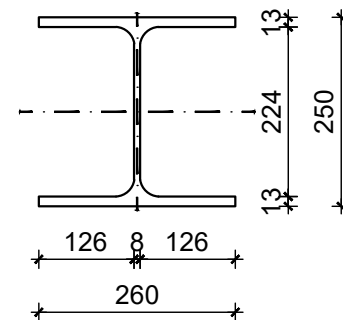
PRESJEK 4 - 4




PRESJEK 1 - 1



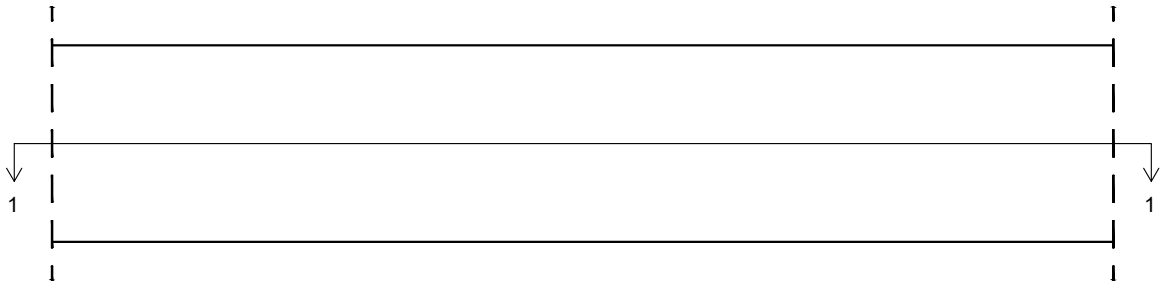
POPREČNI PRESJEK - KROVNI NOSAČ



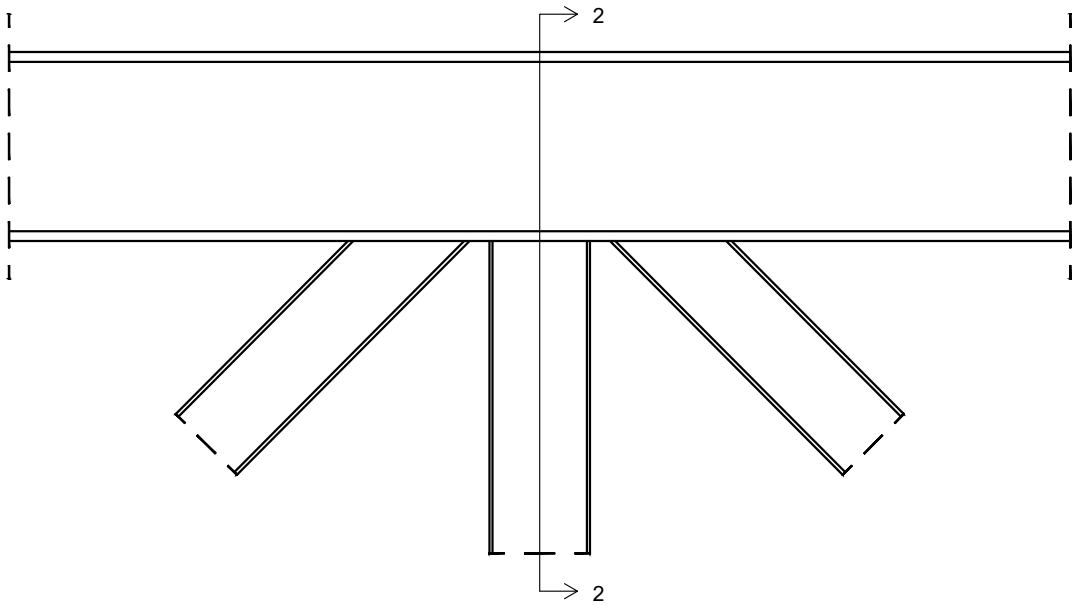
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	STUDENT: ANTONIO DRAŽEN VRDOLJAK	MENTOR: 	Dr. sc. Ivica Boko
	SADRŽAJ: DETALJ "C"	MJERILO 1:10	
	DATUM: 2022./2023.	PRILOG 7	

DETALJ "D" - SPOJ REŠETKA GREDA

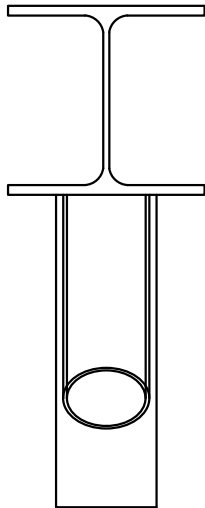
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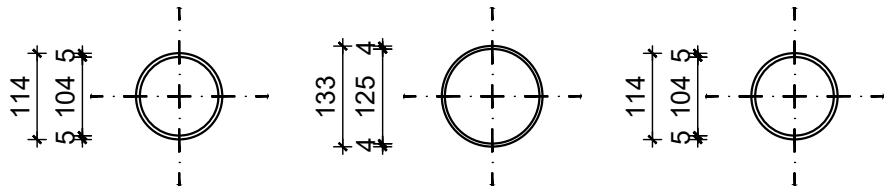
PRESJEK 1 - 1



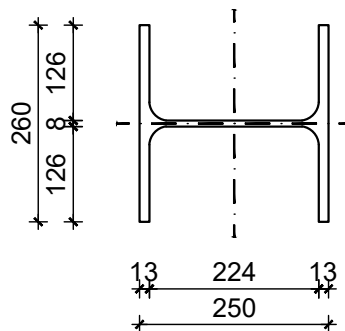
PRESJEK 2 - 2



POPREČNI PRESJEK - DIJAGONALE I VERTIKALA



POPREČNI PRESJEK - GREDA



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ARHITEKTURE I GEODEZIJE

UNIVERSITY OF SPLIT
FACULTY OF CIVIL ENGINEERING,
ARCHITECTURE AND GEODESY

DIPLOMSKI RAD

PROGRAM:

PROJEKT KONSTRUKCIJE BROWNFIELD DUGI RAT

STUDENT:

ANTONIO DRAŽEN VRDOLJAK

MENTOR:

Dr. sc. Ivica Boko

SADRŽAJ:

DETALJ "D"

MJERILO

1:10

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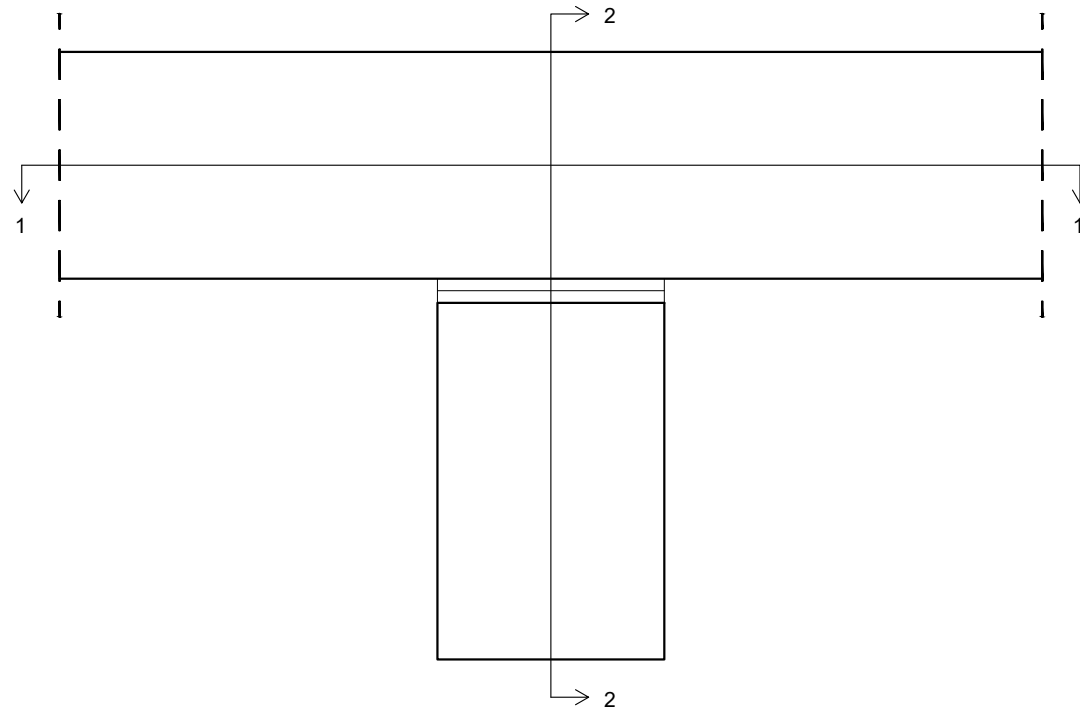
2022./2023.

PRILOG

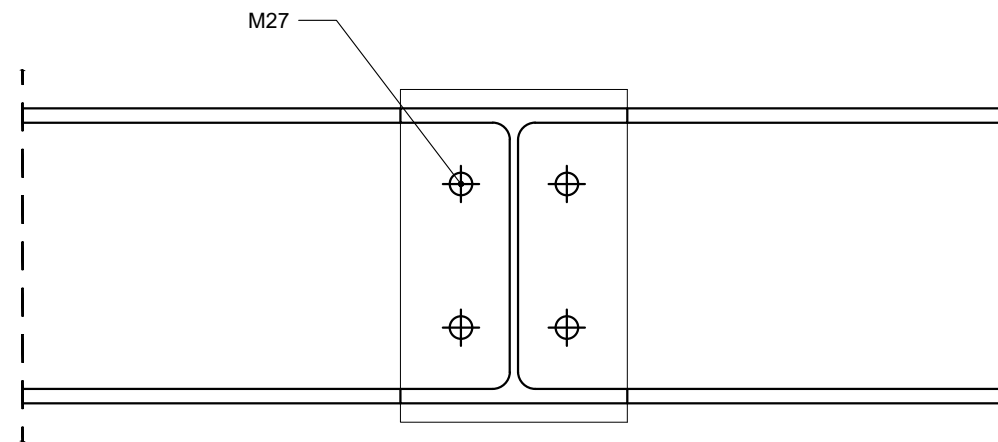
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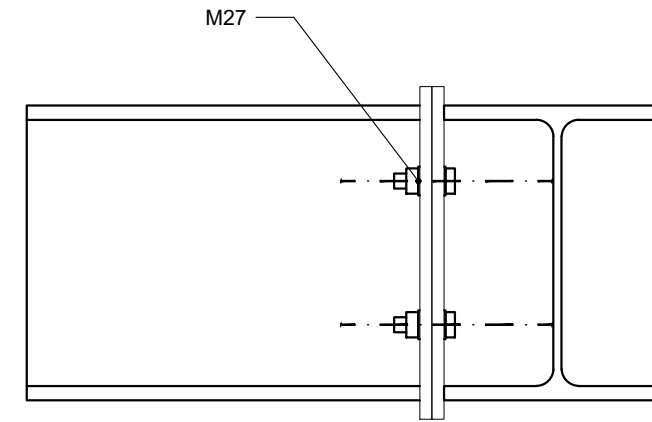
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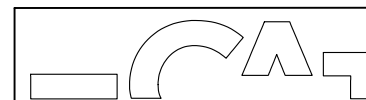
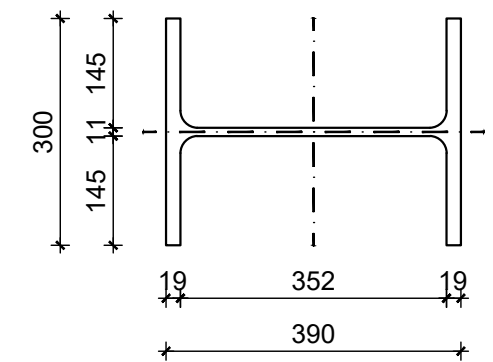
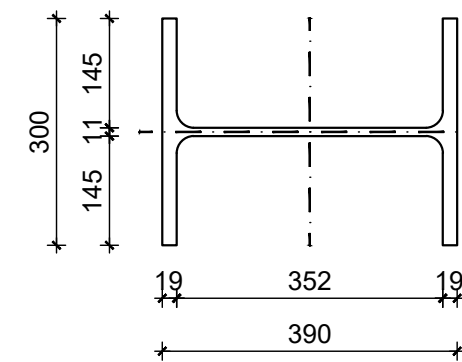
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PRESJEK 2 - 2



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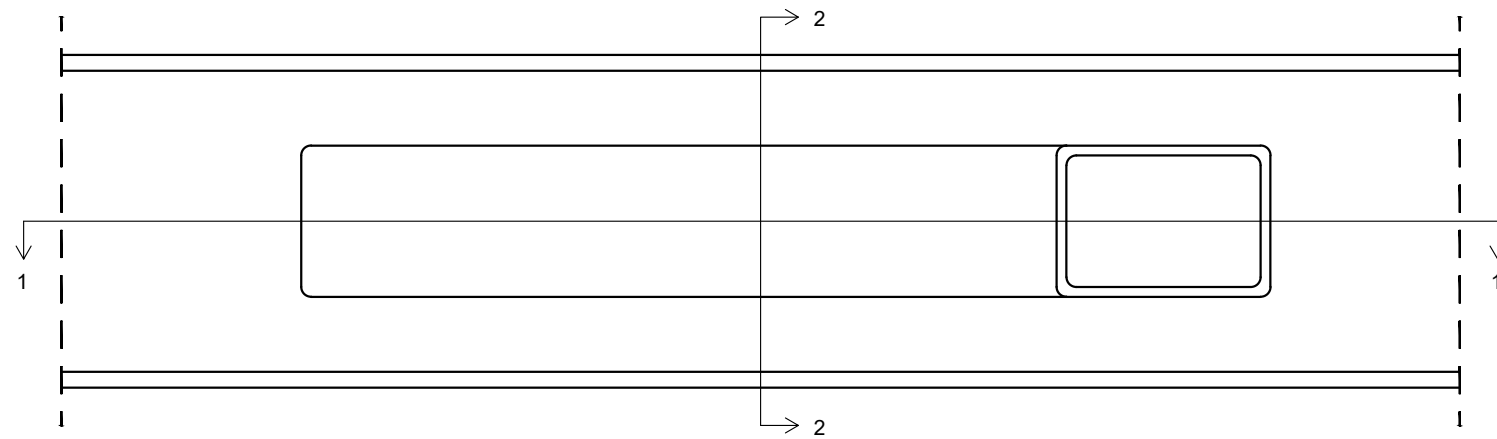


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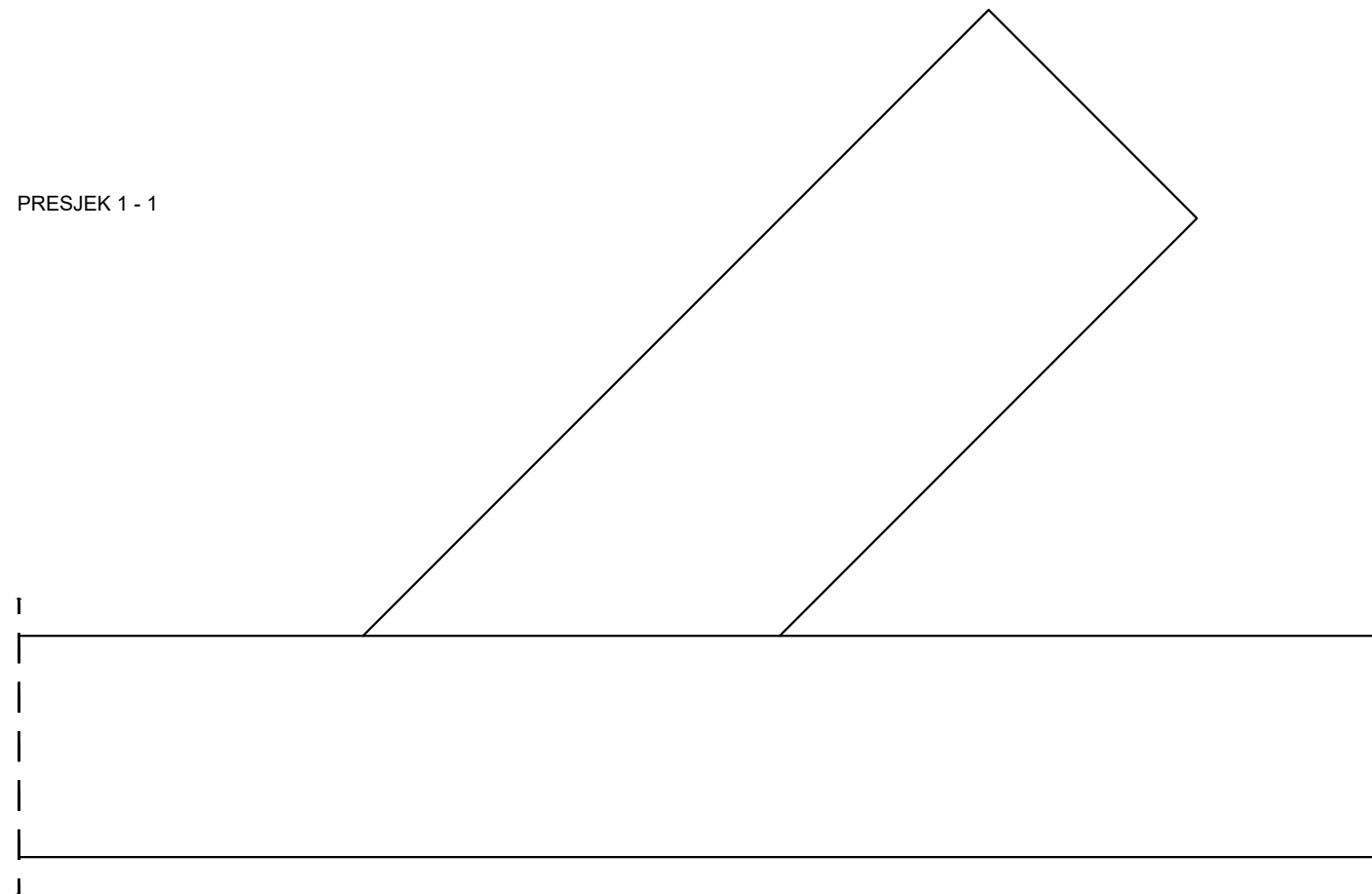
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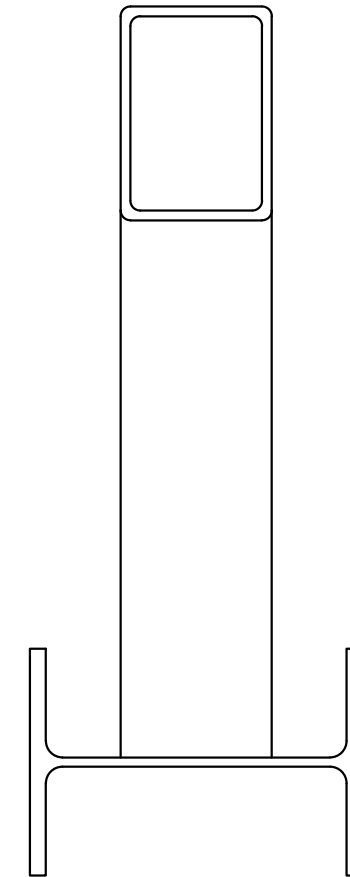
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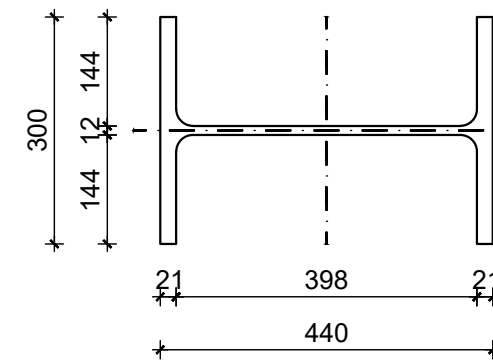
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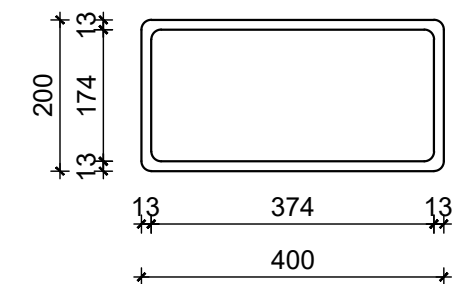
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POPREČNI PRESJEK - STUP



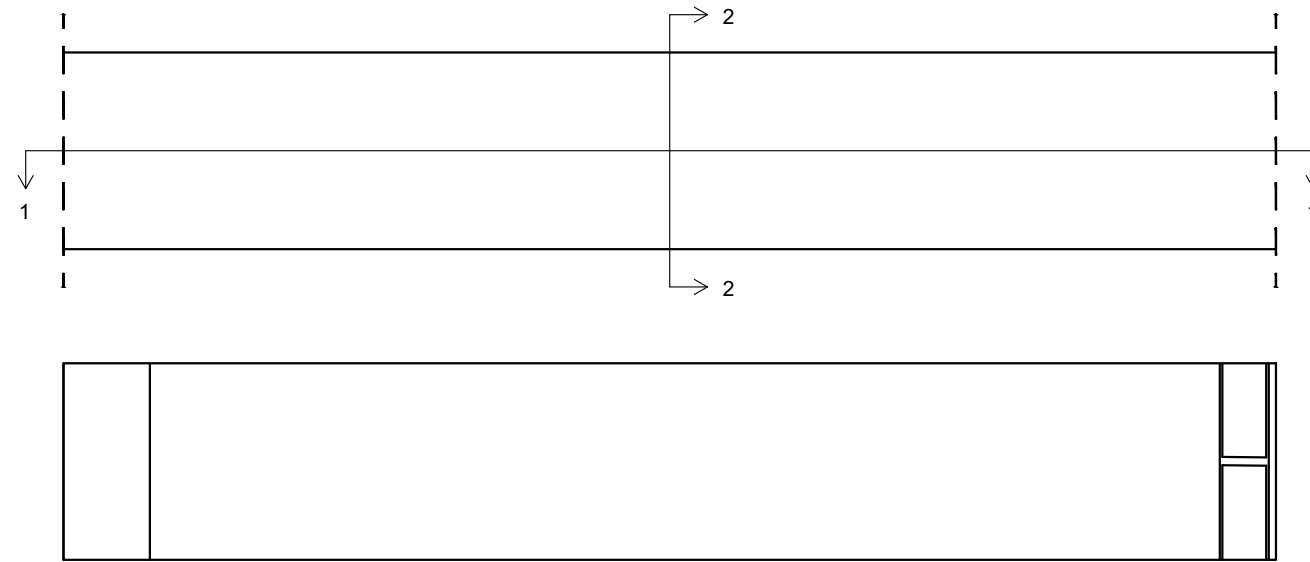
POPREČNI PRESJEK - KOSNIK



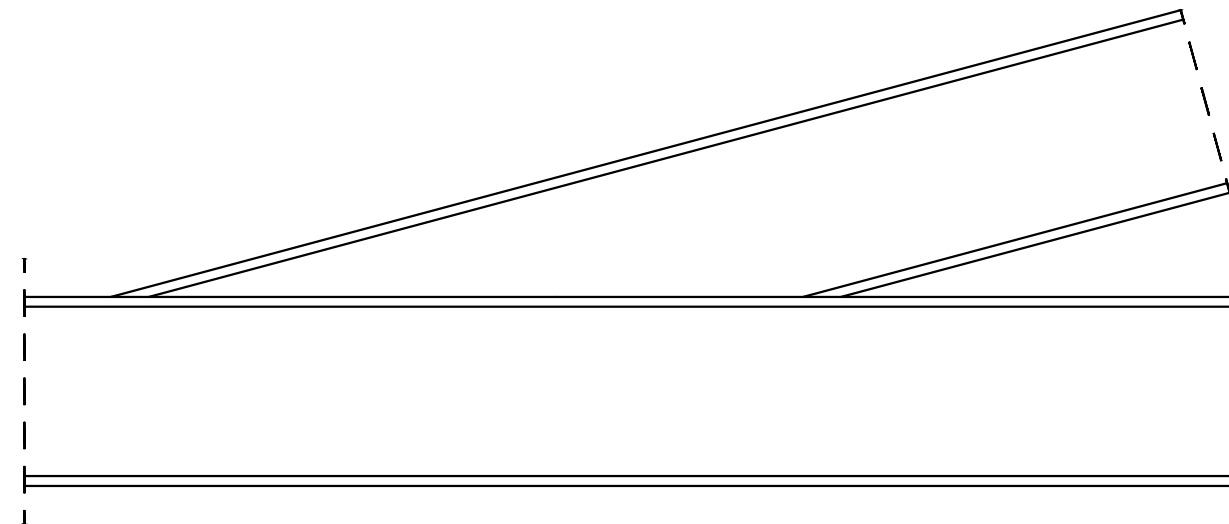
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	SADRŽAJ: DETALJ "F"	MJERILO 1:10	
	DATUM: 2022./2023.	PRILOG 10	

DETALJ "G" - SPOJ KROVNI NOSAČ GREDA

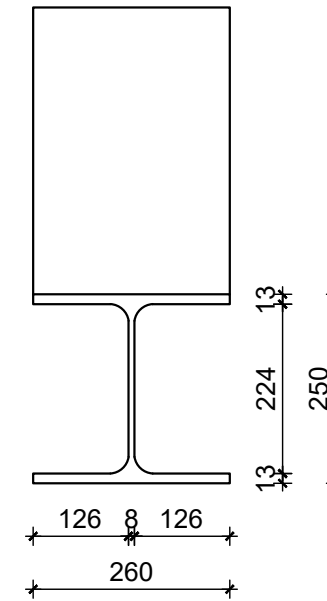
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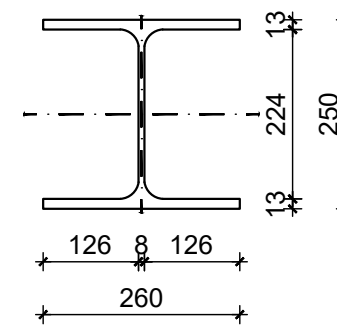
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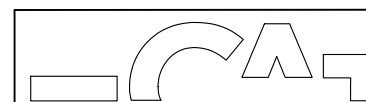
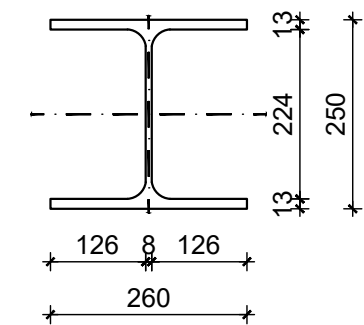
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SADRŽAJ: DETALJ "G"	MJERILO 1:10		
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