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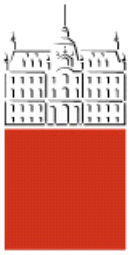

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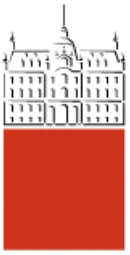

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UNIVERZITETNI ŠTUDIJ
PRVE STOPNJE
GRADBENIŠTVA

Kandidat:

ŽIGA FRANTAR

PROJEKT JEKLENE INDUSTRIJSKE HALE

Diplomska naloga št.: 22/B-GR

PROJECT OF STEEL INDUSTRIAL BUILDING

Graduation thesis No.: 22/B-GR

Mentor:
prof. dr. Darko Beg

Somentor:
viš. pred. dr. Primož Može

Predsednik komisije:
izr. prof. dr. Janko Logar

Ljubljana, 02. 07. 2013

STRAN ZA POPRAVKE

Stran z napako	Vrstica z napako	Namesto	Naj bo

IZJAVA O AVTORSTVU

Podpisani Žiga Frantar izjavljam, da sem avtor diplomskega dela z naslovom Projekt jeklene industrijske hale.

Izjavljam, da je elektronska različica v vsem enaka tiskani različici.

Izjavljam, da dovoljujem objavo elektronske različice v repozitoriju UL FGG.

Ljubljana, 11.9.2012

Podpis:

_____

BIBLIOGRAFSKO – DOKUMENTACIJSKA STRAN IN IZVLEČEK

UDK: 624.014.2:725(043.2)

Avtor: Žiga Frantar

Mentor: prof. dr. Darko Beg, univ. dipl. ing. grad.

Somentor: assist. dr. Primož Može, univ. dipl. ing. grad.

Naslov: Projekt jeklene industrijske hale

Obseg in oprema: 36 str., 9 pregl., 28 sl.

Ključne besede: jeklena hala, konstrukcijska zasnova, statična analiza

Izvleček:

Diplomska naloga v prvem delu zajema določitev zunanjih obtežb, ki poleg lastne teže konstrukcije delujejo nanjo. V izračunih so bili upoštevani vplivi stalne teže, vetra, snega in potresna obtežba. V nadaljevanju je narejen statični izračun in primerjava različnih konstrukcijskih zasnov okvirov jeklene industrijske skladiščne hale. Za nadalnjo podrobnejšo obravnavo je bila izbrana konstrukcijska zasnova torčlenskega okvira, na katerem je bila narejena tudi natančnejša analiza in dimenzioniranje posameznih elementov. V izračunih tročlenskega okvira je upoštevana globalna geometrijska nepopolnost. Diplomsko delo zajema tudi izračune vseh podkonstrukcij in izračun potrebnih temeljev.

BIBLIOGRAPHIC – DOCUMENTALISTIC INFORMATION AND ABSTRACT

UDC: 624.014.2:725(043.2)

Author: Žiga Frantar

Supervisor: prof. Darko Beg, Ph. D.

Cosupervisor: assist. Primož Može, Ph. D.

Title: Project of steel industrial building

Contents: 36 p., 9 tab., 28 fig.

Key words: steel hall, construction design, static analysis

Abstract:

The first part of my thesis determines the external loads that, in addition to its own weight, act on the structure. The calculations took into account self weight, wind, snow and earthquake loading. Hereinafter I made the static calculations and comparison of different structural concepts of frames for the steel industrial shed. For further detailed analysis I chose structural design of the frame with three hinges, and a detailed analysis and design of elements was conducted. In the calculations of the frame global geometrical imperfection was considered. The thesis also includes calculations of all secondary structures and foundations.

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1 UVOD

V okviru diplomske naloge je bila narejena primerjava različnih konstrukcijskih zasnov jeklene skladiščne hale. Za nadaljnje izračune je bil za osnovni okvir izbran tročlenski lok. Jeklena hala je locirana v Radovljici, sestavljena je iz enoladijskih okvirov z razponom 26 metrov. Nadmorska višina Radovljice je 491 metra, nahaja se v vetrovni coni I in snežni coni A3. Za izračun potresne obremenitve objekta so bila uporabljena tla tipa B.

Tla na katerih je objekt temeljen, so dobro nosilna z mejno nosilnostjo 300 kN/m^2.

V diplomski nalogi je narejena statična analiza, na poudarku dimenzioniranja in iskanja optimalnih prerezov različnih konstrukcijskih variant okvirov.

2 TEHNIČNO POROČILO

2.1 Zasnova

Jeklena skladiščna hala je pravokotne tlorisne oblike. Zunanje dimenzije objekta so 48m dolžine, 26m širine in 7m višine v slemenu strehe. Streha je dvokapna z naklonom 9°. Glavna nosilna konstrukcija je sestavljena iz 9-ih tročlenskih okvirov v oseh od A do I. Stebri in prečke so izvedeni iz varjenih profilov spremenljive višine (slika 1).

2. 2 Konstrukcijski elementi

2. 2. 1 Stebri in prečke

Stebri in prečke so izdelani iz varjenih profilov. Zaradi velikih razponov in posledično velikih obremenitev so prerezi spremenljivi tako, da sledimo momentni liniji. Tako dobimo optimalno izkoriščenost posameznega prereza. Stebri so členkasto priključeni na temelje, da se izognemo momentni obremenitvi temelja, spoj med prečko in stebrom je momentni, v slemenu členkast. Za izdelavo stebrov in prečk se uporabi jeklo kvalitete S 355.

Stebre predstavljajo varjeni profili naslednjih geometrijskih karakteristik:

- ob vpetju v temelj: $b_f/t_f = 310/22$ mm; $h_w/t_w = 350/13$ mm
- v vrhu stebra: $b_f/t_f = 310/22$ mm; $h_w/t_w = 680/13$ mm

Prečke predstavljajo varjeni profili z vuto dolžine 8 metrov naslednjih geometrijskih karakteristik:

- v slemenu strehe: $b_f/t_f = 250/16$ mm; $h_w/t_w = 308/10$ mm
- v stiku s stebrom: $b_f/t_f = 280/20$ mm: $h_w/t_w = 960/12$ mm

Stebri so bočno podprti na sredini svetle višine, prečke so 6 krat bočno podprte.

2. 2. 2 Strešne lege

Pod konstrukcijo strešni panelov predstavljajo strešne lege IPE 200 v rastru 2,63 metra. Podprte so s prečkami tročlenskega loka izvedejo se tudi bočne podpore z zategami. Uporabljeno je jeklo kvalitete S 275.

2. 2. 3 Horizontalno povezje

Horizontalno povezje predstavlja sistem nateznih diagonal. Horizontalni povezji sta locirani med osmi B in C ter G in H in služita za prevzem horizontalne obtežbe in za bočno podporo prečk. Profili

tlačenih palic povezja so kvadratne cevi SHS 100/100/4mm, natezni diagonalni elementi so palice premera 22mm. Vsi priključki so izvedeni členkasto. Uporabi se jeklo S 275.

2. 2 . 4 Vertikalno povezje

V vzdolžni smeri sta v oseh 1 in 2 okvirja s centričnim »V« povezjem. »V« povezje služi za prevzem horizontalne obtežbe vetra in potresa ter bočno podpira stebre. Horizontalni elementi-prečke povezja so kvadratne cevi SHS. Diagonale so tako tlačene kot tudi natezne sestavljajo jih kvadratne cevi SHS. Vsi priključki so izvedeni členkasto. Izbrano jeklo za izdelavo je S 275.

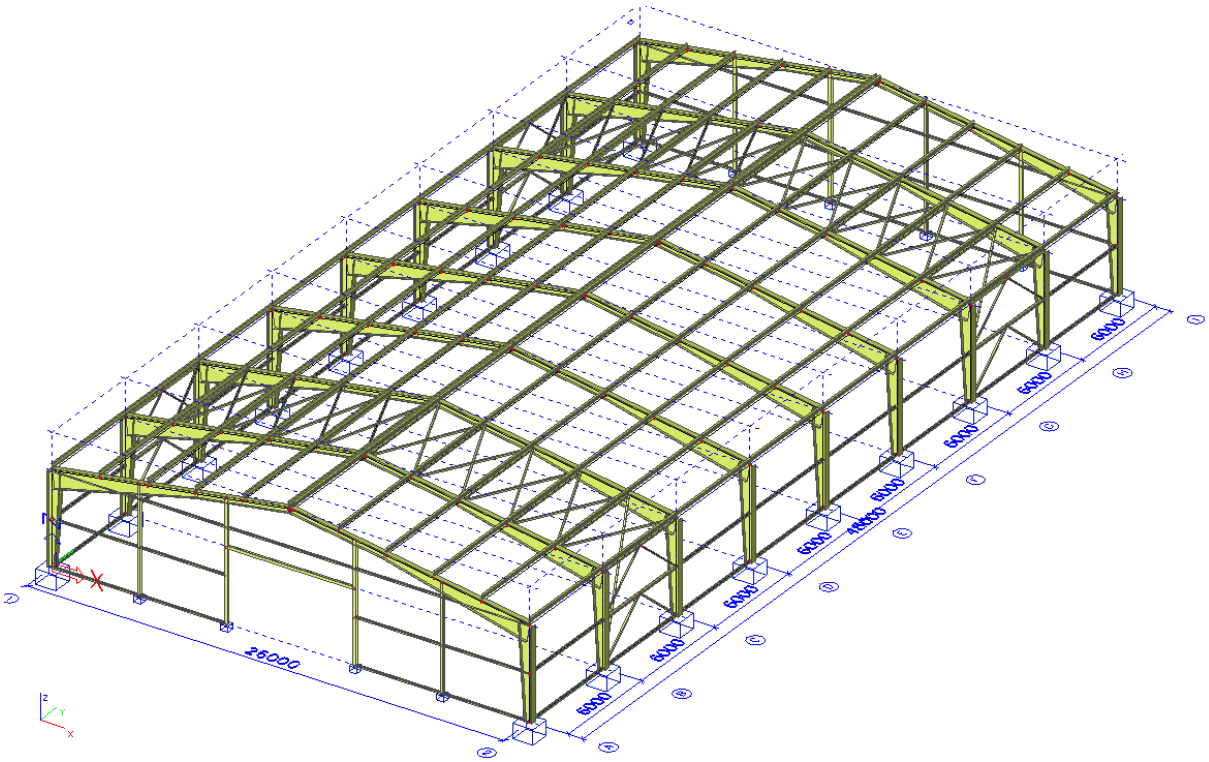
2. 2. 5 Fasadna podkonstrukcija

Pod konstrukcijo fasadnih panelov predstavljajo U profili v rastru 2,5 metra, ki so na stranskih fasadah bočno podprti v dveh krajnih poljih na vsaki strani ter dodatno nad vsemi podporami – stebri. Bočno podpiranje se izvede z zategami. Na čelnih fasadah se dodatno postavijo stebri HEA 140, na katere se pritrdijo U profili. Fasadni paneli so na objekt postavljeni vertikalno, celotna lastna teža panelov se prenese v tla, kjer se izvede ustrezen temelj.

Objekt ima vhod v čelni fasadi v izmeri 4 x 7 metrov izveden z dvižnimi vrati. Stebri pod konstrukcije so HEA 140, nosilec nad vratno odprtino HEA 140 dolžine 7 metrov. Uporabljeno jeklo za izdelavo je S 275.

2. 2. 6 Temelji

Temeljenje se izvede s plitkimi točkovnimi temelji dimenzij 1, 20 / 1, 20 / 0, 70 metra, za prevzem prečne sile ob podporah se izvede natezna vez, ki jo predstavlja L kotnik 75x7mm. Uporabljen je beton kvalitete C25 / 30 in jeklo za armiranje S 500.



Slika 1: Zasnova hale

3 DOLOČITEV OBTEŽB

3.1 Stalna teža

3.1.1 Sestava strehe

- strešni paneli Trimoterm SNV ts 100: $g_p = 0{,}237 KN/m^2$

- inštalacije: $g_i = 0{,}20 KN/m^2$

$g = 0{,}437 KN/m^2$

- strešne lege, IPE 200 (e = 2,63 m): $g_l = 0{,}224 KN/m$

3.1.2 Fasada

- fasadni paneli Trimoterm FTV ms 100: $g_p = 0{,}223 KN/m^2$

3. 2 Obtežba snega

(SIST EN 1991-1-3:2004)

Jeklena industrijska hala se bo nahajala v Radovljici na nadmorski višini 491 m v snežni coni A3.

Obtežbo snega na tleh na tleh:

$$s_k = 1{,}935 \cdot \left[1 + \left(\frac{A}{728}\right)^2\right] = 1{,}935 \cdot \left[1 + \left(\frac{491}{728}\right)^2\right] = 2{,}82 kN/m^2$$

Oblikovni koeficient strehe μ:

μ = 0,80 za: 0° ≤ α ≤ 30° (α = 10°)

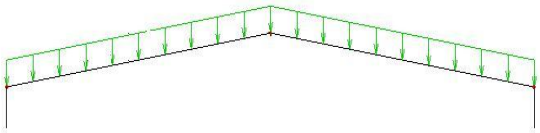
Koeficienta toplote in :

- faktor terena: $C_t = 1$ (običajen teren)

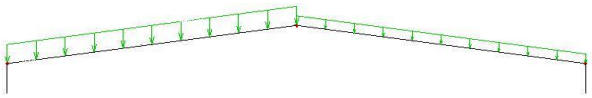
- koeficient toplote: $C_e = 1$ (streha ima toplotno izolacijo)

Obtežba snega na streho:

$$q_s = C_t \cdot C_e \cdot s_k \cdot \mu = 1 \cdot 1 \cdot 2{,}82 \cdot 0{,}80 = 2{,}26 kN/m^2$$



Slika 2: Enakomerno razporejen sneg



Slika 3: Neenakomerno razporejen sneg

3. 3 Obtežba vetra

(SIST EN 1991-1-4:2005)

Objekt se nahaja v vetrovni coni 1. Temeljna vrednost osnovne hitrosti vetra za objekte pod 800 metri nadmorske višine $v_{b,0} = 20 m/s$.

Osnovni pritisk vetra:

$$q_b = \frac{1}{2} \cdot \rho \cdot {v_{b,0}}^2 = \frac{1}{2} \cdot 1{,}25 kg/m^3 \cdot (20 m/s)^2 = 250 N/m^2$$

Faktor izpostavljenosti $C_e(z)$: Višina objekta je 7m, kategorija terena III (področje z običajnim rastlinjem, stavbami in posameznimi ovirami).

$$C_e(z = 7m) = \left(1{,}28 + \frac{7-5}{10-5} \cdot (1{,}71 - 1{,}28)\right) = 1{,}452$$

Največji pritisk pri sunkih vetra:

$$q_p(z) = q_b \cdot C_e(z) = 250N/m^2 \cdot 1{,}452 = 363N/m^2 = 0{,}363kN/m^2$$

Razporeditev obtežbe vetra po višini objekta je konstantna, saj je višina manjša od širine objekta (h ≤ b).

3. 3. 1 Obtežba vetra v prečni smeri (x smeri)

Objekt razdelim na cone, tako kot je to prikazana na slikah v standardu SIST EN 1991-1-4.

Koeficienti zunanjega pritiska v prečni smeri na objekt so prikazani v naslednji preglednici.

Podatki o hali:

e = 14m

d = 26m

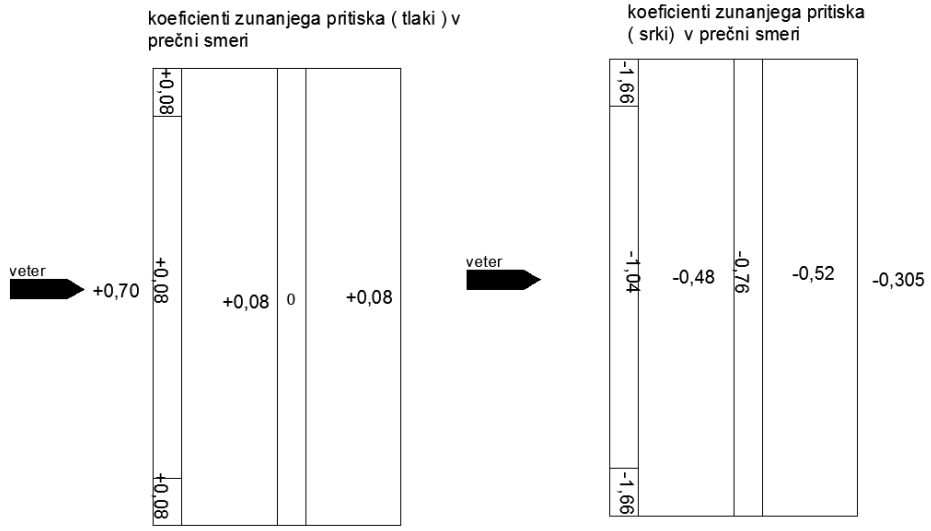
h = 7m

h/d = 0,27

$z_e = 7m$

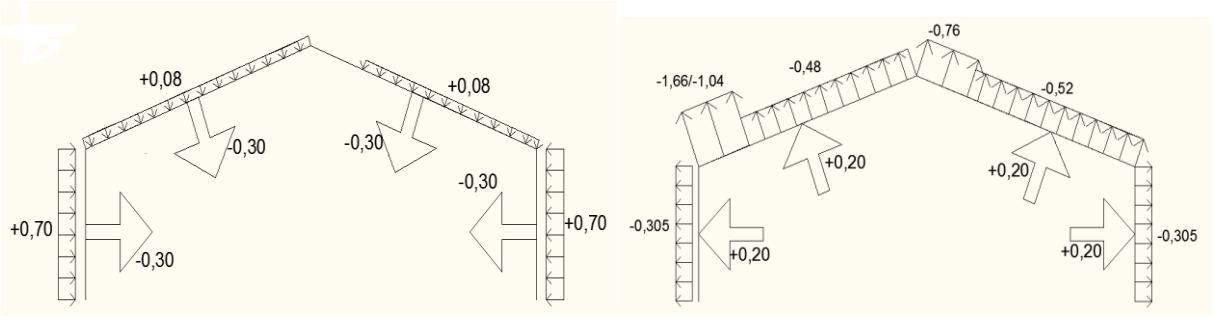
Preglednica 1: Koeficienti zunanjega pritiska v prečni smeri

cona	D	E	F	G	H	I	J
C_{pe}(-)	0	-0,30	-1,66	-1,04	-0,48	-0,52	-0,76
C_{pe} (+)	0,7	0	0,08	0,08	0,08	0	0,08



Slika 4: Koeficienti zunanjega pritiska v prečni smeri

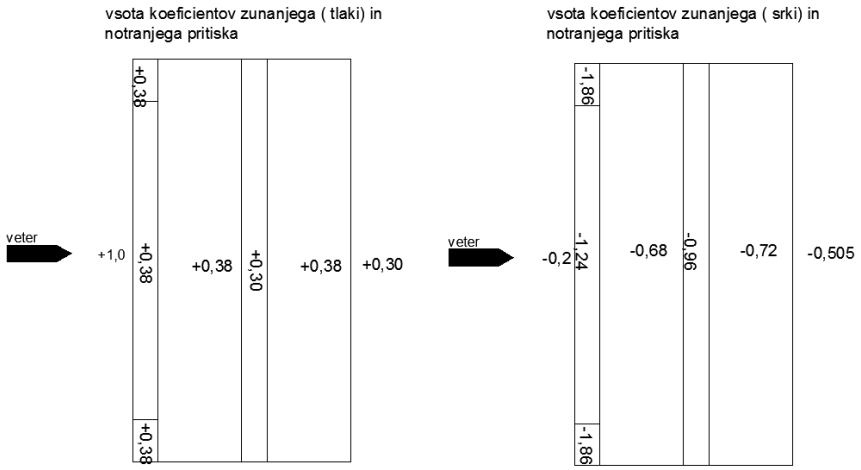
Za koeficient notranjega pritiska C_{pi} se izbere bolj neugodna vrednost med 0,2 in -0,3.



Slika 5: zunanji in notranji pritiski

Preglednica 2: Vsota koeficientov zunanjih in notranjih pritiskov v prečni smeri

cona	D	E	F	G	H	I	J
C_p	-0,505	-0,505	-1,86	-1,24	-0,68	-0,72	-0,96
C_p	1	0	0,38	0,38	0,38	0,3	0,38



Slika 6: Vsota koeficientov zunanjih in notranjih pritiskov v prečni smeri

Pritiski vetra v prečni smeri v [kN/m^2]:

$w_e = C_p \cdot q_p(z)$[kN/m^2]

Preglednica 3: Pritiski vetra v prečni smeri

cona	D	E	F	G	H	I	J
$w_e\left[kN/m^2\right]$	0,1815	-0,183	-0,675	-0,450	-0,247	-0,261	-0,348
$w_e\left[kN/m^2\right]$	0,363	0	0,138	0,138	0,138	0,109	0,138

3. 3. 2 Obtežba vetra v vzdolžni smeri (y smeri)

Objekt razdelim na cone, tako kot je to prikazana na slikah v standardu SIST EN 1991-1-4. Koeficienti zunanjega pritiska v prečni smeri na objekt so prikazani v naslednji preglednici.

Podatki o hali:

e = 14m

d = 48m

h = 7m

h/d = 0,15

$z_e = 7m$

Preglednica 4: Koeficienti zunanjega pritiska v vzdolžni smeri

cona	D	E	F	G	H	I
C_{pe}	0,7	-0,5	-1,77	-1,3	-0,66	-0,56

Slika 7: Koeficienti zunanjega pritiska v vzdolžni smeri

Za koeficient notranjega pritiska C_{pi} se izbere bolj neugodna vrednost med 0,2 in -0,3.

Preglednica 5: Vsota zunanjih in notranjih pritiskov

cona	D	E	F	G	H	I
C_{pe}	1	-0,7	-1,97	-1,5	-0,86	-0,76
C_{pe}	0,50	-0,20	-1,47	-1,0	-0,36	-0,26

Slika 8: Vsota koeficientov zunanjega in notranjega pritiska v vzdolžni smeri

Pritiski vetra v vzdolžni smeri v [kN/m^2]:

$w_e = C_p \cdot q_p(z)$[kN/m^2]

Preglednica 6: Pritiski vetra v vzdolžni smeri

cona	D	E	F	G	H	I
$w_e\left[kN/m^2\right]$	0,363	-0,254	-0,715	-0,545	-0,312	-0,276
	0,1815	-0,073	-0,554	-0,363	-0,131	-0,094

3. 4 Potresna obtežba

(SIST EN 1991-1-4:2005)

Konstrukcije morajo biti projektirane tako, da med delovanjem potresa ne pride do njihove porušitve, dopuščamo pa predvidene poškodbe. Konstrukcije načrtujemo tako, da so med delovanjem potresa sposobne sipati energijo kar se kaže s faktorjem obnašanja q. Bolj kot je konstrukcija duktilna, ustrezno duktilnost moramo dokazati in zagotoviti bolj je sposobna sipati energijo, večji je faktor obnašanja q in posledično manjša je potresna sila. Pri jeklenih enoetažnih konstrukcijah, katere imajo majhno maso se lahko za faktor obnašanje vzame najnižjo vrednost 1,5, saj potresne sile niso velike. Potresna obtežba je bila narejena le za tročlenski okvir.

3. 4. 1 Določitev potresne obtežbe

Podatki za izračun potresne sile:

- faktor obnašanja q = 1,5 (v obe smeri enak)
- Tip Tal B
- projektni pospešek tal $a_g = 0{,}20g$
- višina H = 5m
- C_t = 0,05

Izračun nihajnih časov:

Nihajna časa sta v X in Y smeri približno enaka in imata vrednost:

$T = C_t \cdot H^{\frac{3}{4}} = 0{,}05 \cdot 5^{\frac{3}{4}} = 0{,}17s$

Nihajni čas mora zadostiti pogoju:

$$\mathrm{T} \leq \min \begin{cases} 4 \cdot \mathrm{T_c} = 2{,}0\mathrm{s} \\ 2{,}0\mathrm{s} \end{cases}$$

Objekt se nahaja na tleh tipa B, tla opisujejo parametri za elastični spekter odziva 1.

S = 1,20

$T_B = 0{,}15\mathrm{s}$

$T_C = 0{,}5s$

$T_D = 2{,}0\mathrm{s}$

Nihajni čas konstrukcije se nahaja med $\mathrm{T_B}$ in $\mathrm{T_C}$, projektni pospešek tal izračunam z enačbo:

$$\mathrm{S_d(t)} = \mathrm{a_g} \cdot \mathrm{S} \cdot \frac{2{,}5}{\mathrm{q}} = 0{,}20\mathrm{g} \cdot 1{,}2 \cdot \frac{2{,}5}{1{,}2} = 0{,}40\mathrm{g}$$

Teža konstrukcije

Teža konstrukcije je sestavljena iz:

- lastna teža okvirjev: 453 kN
- lege : 129kN
- fasadna podkonstrukcija: 65kN
- strešni paneli in inštalacije: 545kN

SKUPNA TEŽA KONSTRUKCIJA :1192kN

Potresna sila

$F_d = S_d(t) \cdot m \cdot \lambda = 0{,}4 \cdot 1192 \cdot 1 = 477kN$

Potresna sila se v vzdolžni smeri prenese preko štirih povezji, v prečni smeri se preneša preko 9 okvirjev.

Vpliv naključne torzije

Vpliv torzije je izračunan le za torčlenska loka v oseh B in H ter za vertikalna povezja.

$\delta = 1 + 1{,}2 \cdot \frac{x}{L}$

x….oddaljenost masnega središča do središča obravnavanega elementa

L….dolžina (širina) objekta

- tročlenski okvir v oseh B in H:

$\delta = 1 + 1{,}2 \cdot \frac{x}{L} = 1 + 1{,}2 \cdot \frac{18m}{48m} = 1{,}45$

$F_b^* = \delta \cdot F_d = 1{,}45 \cdot 477kN = 692kN$

Sila se prenese na 9 okvirjev. Na najbolj obremenjene okvirje odpade sile 88 kN, na krajna okvirja pa sila 38 kN.

- povezja v oseh 1 in 2:

$\delta = 1 + 1{,}2 \cdot \frac{x}{L} = 1 + 1{,}2 \cdot \frac{13m}{26m} = 1{,}6$

$F_b^* = \delta \cdot F_d = 1{,}6 \cdot 477kN = 763kN$

Sila se prenese na štiri povezja. Na eno povezje odpade sila 191kN.

3. 5 Kombinacije vplivov

3. 5. 1 Mejno stanje nosilnosti

Kombinacije za mejno stanje nosilnosti (MSN) formiramo tako, da imajo vplivi na konstrukcije čim bolj neugoden učinek. V mejnih stanjih nosilnosti preverjamo kombinacije vplivov za stalna, začasna in potresna projektna stanja. Vplive za stalna in začasna projektna stanja se zajame v skladu s standardom SIST EN 1990 z naslednjo enačbo:

$$\sum_{j \geq 1} \gamma_{G,j} \cdot G_{k,j}" + "\gamma_{Q,1} \cdot Q_{k,1}" + "\sum_{i \geq 1} \gamma_{Q,1} \cdot \psi_{0,i} \cdot Q_{k,i}$$

Preglednica 7: Merodajne kombinacije vplivov za MSN

kombinacija	G	g	q_s	q_w^+	q_w^-
1	1,35	1,35	1,5	0,6*1,5	0
2	1,35	1,35	0,5*1,5	1,5	0
3	1,0	1,0	0	0	1,5

Ostale kombinacije se nahajajo v PRILOGI 1.

3. 5. 2 Mejno stanje uporabnosti

V mejnem stanju uporabnosti (MSU) moramo zagotoviti, da konstrukcija, ki je izpostavljena zunanjim vplivom ne prekorači kriterijev vezanih na uporabnost konstrukcije. Ti kriteriji so pomiki, razpoke, vibracije in poškodbe nekonstruktivnih delov. V diplomskem delu sem za preverjanje mejnega stanja uporabnosti uporabljal pogosto kombinacijo v skladu s SIST EN 1990:

$$\sum_{j\geq 1} G_{k,j}" + "\psi_{1,1} \cdot Q_{k,1}" + " \sum_{i\geq 1} \psi_{2,i} \cdot Q_{k,i}$$

Preglednica 8: Merodajne kombinacije vplivov za MSU

kombinacija	G	g	q_s	q_w^+	q_w^-
1	1,0	1,0	0,2	0	0
2	1,0	1,0	0	0,2	0
3	1,0	1,0	0	0	0,2

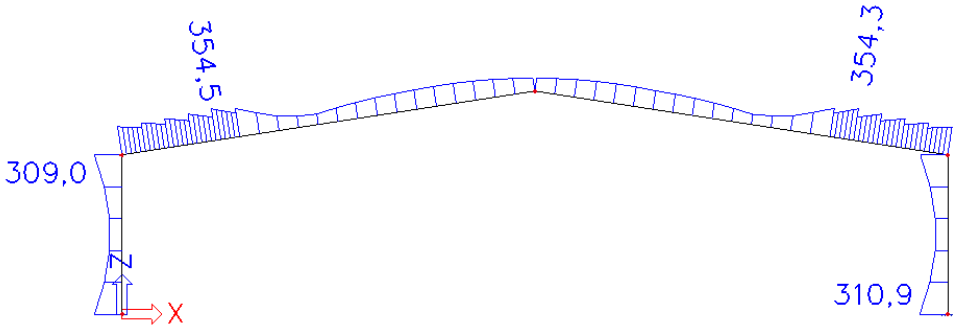
4 STATIČNA ANALIZA RAZLIČNIH KONSTRUKCIJSKIH VARIANT

Statična analiza različni konstrukcijskih variant zajema dimenzioniranje prerezov in preverjanje pomikov ob delovanju različnih kombinacij obtežb. Na koncu sem naredil primerjalno tabelo, kjer so razvidne dobre in slabe lastnosti posameznih okvirjev.

Za določevanje potrebnih prerezov sem okvirje obtežil z obtežnimi kombinacijami v skladu z MSN. Kot rezultat sem dobil ovojnice notranjih sil za posamezen okvir. Dimenzije prečnih prerezov sem določil tako, da sem preverjal napetosti po von Missesovem pogoju. Napetost v prerezu mora znašati manj kot 35,5kN/cm^2. V tem poglavju pri določanju potrebnih prečnih prerezov za prevzem obtežbe nisem upošteval stabilnosti.

Pomike sem dobil na podlagi dveh sil. Horizontalni pomik sem določil z horizontalno silo v vrhu stebra velikosti v velikosti 20 kN. Vertikalni pomik strešnih nosilcev z vertikalno silo v slemenu velikosti 20 kN. Vsi izpisi notranjih sil se nahajajo v PRILOGI 1.

4. 1 Momentni okvir



Slika 9: Ovojnica napetosti- von Misses [Mpa]

Kontrola napetosti:

a) stebri: $M_{Ed,\max} = -1213{,}08 kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1213{,}08 \cdot 100 kNcm \cdot 1}{35{,}5 kN/cm^2} = 3428 cm^3$$

Izberem profil HEA 550.

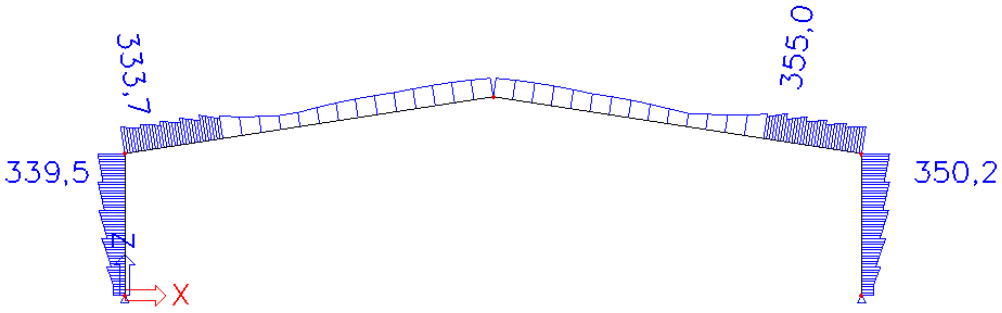
b) strešni nosilci: $M_{Ed,\max} = 1087{,}42 kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1087{,}42 \cdot 100 kNcm \cdot 1}{35{,}5 kN/cm^2} = 3103 cm^3$$

Izberem profil: - v slemenu: $b_f / t_f = 220/16[mm]; h_w / t_w = 318/12[mm]$

- pri stebru: $b_f / t_f = 220/16[mm]; h_w / t_w = 818/12[mm]$

4. 2 Dvočlenski okvir



Slika 10: Ovojnica napestosti- von Misses [Mpa]

Kontrola napetosti:

a) stebri: $M_{Ed,\max} = -1339{,}98 kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1339.98 \cdot 100 kNcm \cdot 1}{35{,}5 kN/cm^2} = 3775 cm^3$$

Izberem profil: - ob vpetju: $b_f / t_f = 200/18[mm]; h_w / t_w = 300/10[mm]$

-v vrhu stebra: $b_f / t_f = 260/20[mm]; h_w / t_w = 710/10[mm]$

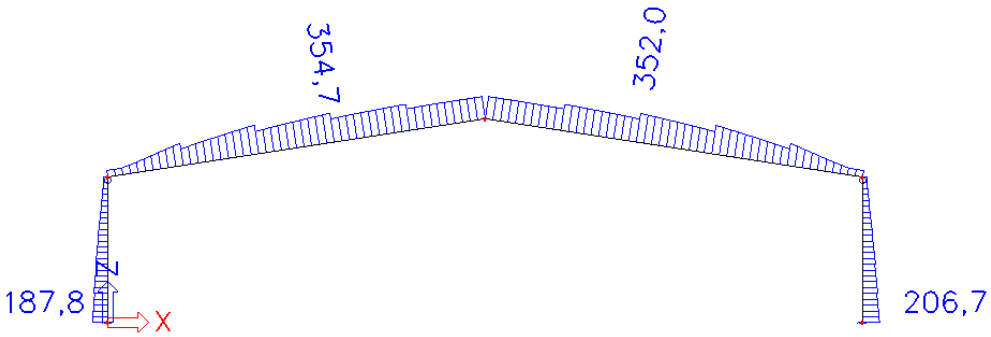
b) strešni nosilci: $M_{Ed,\max} = 1349{,}61 kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1349{,}61 \cdot 100 kNcm \cdot 1}{35{,}5 kN/cm^2} = 3802 cm^3$$

Izberem profil: - v slemenu: $b_f / t_f = 220/18[mm]; h_w / t_w = 364/16[mm]$

- ob stebru: $b_f / t_f = 250/18[mm]; h_w / t_w = 740/13[mm]$

4. 3 Dvočlenski togo vpeti okvir



Slika 11: Ovojnica napetosti- von Misses [Mpa]

Kontrola napetosti:

a) stebri: $M_{Ed,\max} = 399{,}65 kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{399{,}65 \cdot 100 kNcm \cdot 1}{35{,}5 kN/cm^2} = 1126 cm^3$$

Izberem profil : - ob vpetju: $b_f / t_f = 230/18[mm]; h_w / t_w = 480/10[mm]$

- v vrhu stebra: $b_f / t_f = 230/18[mm]; h_w / t_w = 300/10[mm]$

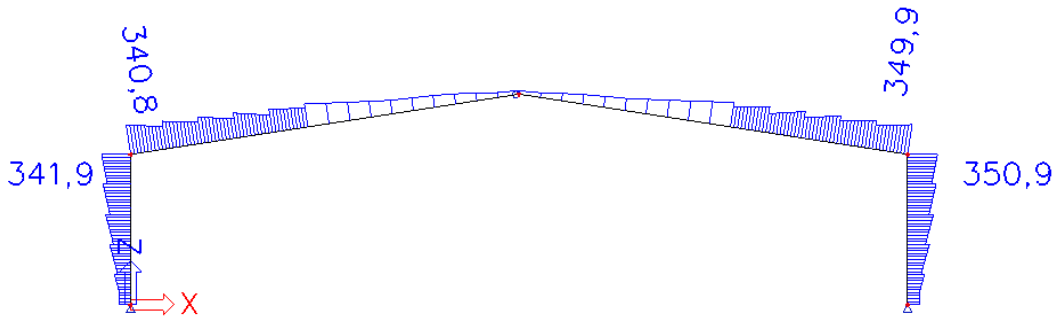
b) strešni nosilci: $M_{Ed,\max} = 2297{,}55kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{2297{,}55 \cdot 100kNcm \cdot 1}{35{,}5kN/cm^2} = 6472cm^3$$

Izberem profil: - v slemenu: $b_f / t_f = 250/20[mm]; h_w / t_w = 1160/16[mm]$

- ob stebru: $b_f / t_f = 250/20[mm]; h_w / t_w = 430/16[mm]$

4. 4 Tročlenski okvir



Slika 12: Ovojnica napetosti-von Misses [Mpa]

Kontrola napetosti:

a) stebri: $M_{Ed,\max} = -1610{,}18kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1610{,}18 \cdot 100kNcm \cdot 1}{35{,}5kN/cm^2} = 4536cm^3$$

Izberem profil: - ob vpetju: $b_f / t_f = 300/20[mm]; h_w / t_w = 314/12[mm]$

- v vrhu stebra: $b_f / t_f = 300/20[mm]; h_w / t_w = 710/12[mm]$

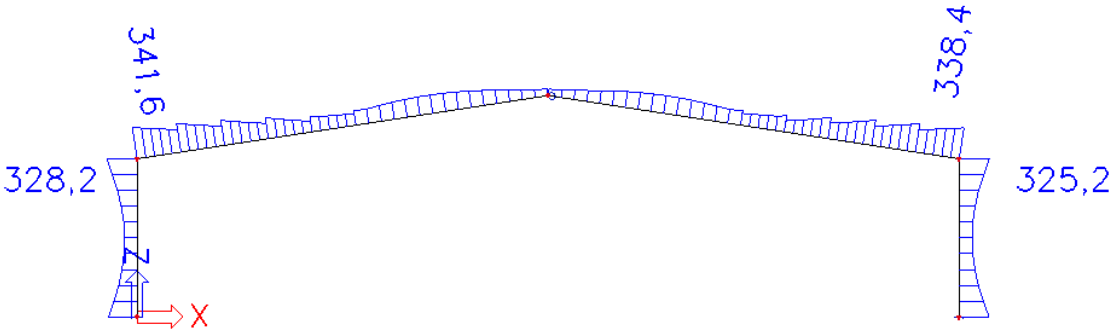
b) strešni nosilci: $M_{Ed,\max} = -1586{,}46kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1586{,}46 \cdot 100kNcm \cdot 1}{35{,}5kN/cm^2} = 4469cm^3$$

Izberem profil: - v slemenu: $b_f / t_f = 220/20[mm]; h_w / t_w = 310/15[mm]$

- ob stebru: $b_f / t_f = 220/20[mm]; h_w / t_w = 840/15[mm]$

4. 5 Enočlenski okvir



Slika 13:Ovojnica napetosti-von Misses [Mpa]

Kontrola napetosti:

a) stebri: $M_{Ed,\max} = -1285{,}70kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1285{,}70 \cdot 100kNcm \cdot 1}{35{,}5kN/cm^2} = 3622cm^3$$

Izberem profil HEA 550.

b) strešni nosilci: $M_{Ed,\max} = 1161{,}76kNm$

$$M_{Ed} \le M_{el,Rd} = \frac{W_{el} \cdot f_y}{\gamma_{M0}} \rightarrow W_{el} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{1161{,}76 \cdot 100kNcm \cdot 1}{35{,}5kN/cm^2} = 3273cm^3$$

Izberem profil: - v slemenu: $b_f / t_f = 200/18[mm]; h_w / t_w = 264/10[mm]$

- ob stebru: $b_f / t_f = 200/18[mm]; h_w / t_w = 764/15[mm]$

5 PRIMERJAVA KONSTRUKCIJSKIH VARIANT

Preglednica 9: Primerjava konstrukcijskih variant

OKVIR	**momentni**	**dvočlenski**	**dvočlenski-togo vpet**	**tročlenski**	**enočlenski**
Notranje sile in teža okvirja	a)steber: M_{max} = 1213,08kNm b)streha: M_{max} =1087,42kNm M_{min} =241,37kNm Teža: 40,06kN	a)steber: M_{max} = 1339,48kNm M_{min} =0kNm b)streha: M_{max} =1349,61kNm M_{min} =446,97kNm Teža: 38kN	a)steber: M_{max} = 399,65kNm M_{min} =0kNm b)streha: M_{max} =2297,55kNm M_{min} =0kNm Teža: 55,4kN	a)steber: M_{max} = 1610,18Nm M_{min} =0kNm b)streha: M_{max} =1586,46kNm M_{min} =0kNm Teža: 44kN	a)steber: M_{max} = 1285,7kNm b)streha: M_{max} =1161,76kNm M_{min} =0kNm Teža: 40,56kN
Pomiki	a) horizontalen: 1,8 mm b) vertikalen: -12,7 mm	a)horizontalen: 12,3mm b) vertikalen: 14,4mm	a) horizontalen: 4,4mm b) vertikalen: -10,4mm	a) horizontalen: 10,mm b) vertikalen: -31 mm	a) horizontalen: 2,0mm b) vertikalen: -24,2 mm
+	-majhni pomiki -majhna teža konstrukcije	-majhen vertikalen pomik -ni momenta ob vpetju→manjši temelj -optimalno izkoriščen steber -majhna teža	-zelo majhen horizontalen pomik	- ugoden horizontalen pomik - optimalna izkoriščenost vseh prerezov -ni momenta ob vpetju→manjši temelj -ugodna prečna sila v slemenu	- majhen horizontalen pomik - optimalna izkoriščenost strešnega nosilca -majhna teža
-	- neoptimalna izkoriščenost stebra -velik moment ob vpetju→večji temelj -velika obremenitev spoja steber – strešni nosilec	-velik horizontalen pomik -velik moment v vrhu stebra→ velika obremenitev spoja	-velik vertikalen pomik -zelo velik moment ob vpetju→velik temelj -velika teža -velik prerez strešnega nosilca	- velik prerez strešnega nosilca ob stebru -velika prečna sila v temelju	- največji vertikalen pomik - velik moment ob vpetju→večji temelj

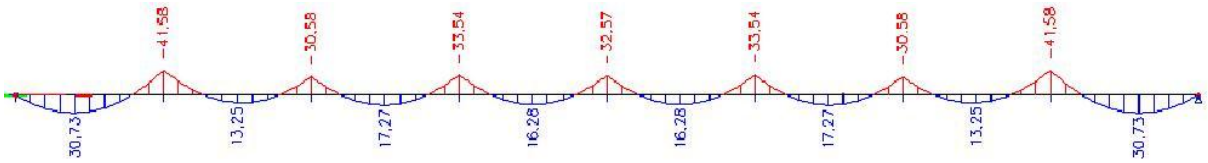
Rezultati tež okvirjev iz primerjalne tabele, niso povsem točni saj potrebni prečni prerezi niso preverjeni na kontrolo stabilnosti. Tako teže posameznih okvirjev niso idealne, vendar vseeno v grobem kažejo kateri okvirji so lažji od drugih.

6 STATIČNA ANALIZA PODKONSTRUKCIJ

6.1 Lege

Strešno lego dimenzioniram v skladu s kombinacijami za MSN. Kot najbolj neugodna kombinacija za določitev dimenzij leg se izkaže kombinacija, pri kateri je sneg prevladujoča spremenljiva obtežba, veter upoštevam kot tlak.

$$q_{Ed} = 1{,}35 \cdot g + 1{,}5 \cdot q_s + 0{,}6 \cdot 1{,}5 \cdot q_w^+$$



Slika 14: Momenti v legi [kNm]

$$M_{\max} = \left| -41{,}58 kNm \right|$$

$$M_{Ed} \le M_{Rd} = \frac{W_{potr.} \cdot f_y}{\gamma_{M0}} \rightarrow W_{potr.} \ge \frac{M_{Ed} \cdot \gamma_{M0}}{f_y} = \frac{41{,}58 \cdot 100 kNcm \cdot 1}{27{,}5 kN/cm^2} = 151{,}2 cm^3$$

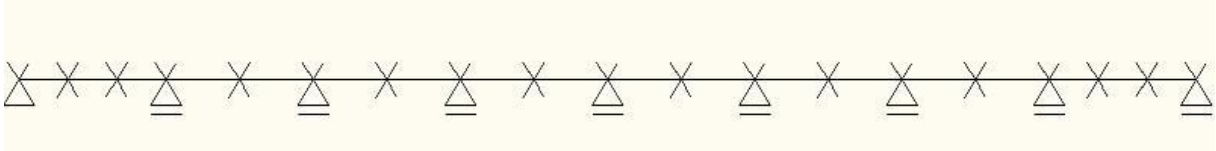
Izberem profil IPE 200.

Kontrola bočne zvrnitve se nahaja v PRILOGI 2.

6.1.1 Bočno podpiranje leg

Strešno lego predstavlja nosilec IPE 200. Število strešnih leg je 6 za vsako polovico strehe. Prvo in zadnje polje lege sta bočno podprti štirikrat, na mestu podpor ter na tretjini razpona. Ostala polja so podprta trikrat, nad podporami ter na sredini razpona.

Bočne podpore se izvede s pomočjo zateg.



Slika 15: Bočne podpore

Izračun dimenzij zateg:

a) Prvo in zadnje polje

Račun obremenitev:

število bočno podprtih elementov m = 6

$$N_{Ed} = \frac{M_{Ed}}{h} = \frac{4158}{20} = 207{,}9kN$$

$$\delta_d = \frac{L}{1000} \Rightarrow \beta^* = \frac{1}{51{,}8}$$

Nadomestna obtežba:

$$q_d = \beta \frac{\sum_{i=1}^{m} N_{Ed,i}}{L} = \frac{1}{51{,}8} \cdot \frac{6 \cdot 207{,}9}{6} = 4{,}0kN/m$$

Dimenzioniranje zatege:

$$\frac{Z_{Ed}}{A} \le \frac{f_y}{\gamma_{M0}}; A \ge \frac{Z_{Ed}\gamma_{M0}}{f_y} = \frac{8{,}40kN}{35{,}5kN/cm^2} = 0{,}24cm^2$$

$$A = \frac{\pi d^2}{4} \ge 0{,}24cm^2; d \ge \sqrt{\frac{0{,}24 \cdot 4}{\pi}} = 0{,}56cm$$

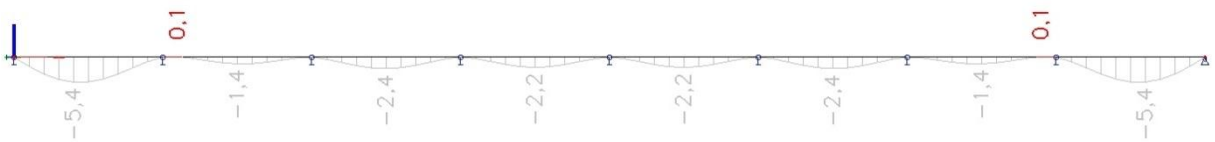
Izberem zatego ϕ8.

b) Vmesna polja

Računa sta identična zgornjemu, le ga je število bočnih podpor različno. Izberem zatego ϕ8. Krajna zatega sidrana v podporo je ϕ10.

6.1.2 Kontrola MSU

V mejnem stanju uporabnosti preverjam vertikalne pomike leg. Za preverjanje uporabim pogosto obtežno kombinacijo:



Slika 16: Vertikalen pomik strešne lege v MSU [mm]

$$\delta = 5{,}4mm \le \frac{L}{250} = \frac{6000}{250} = 24mm$$

6.2 Fasadna podkonstrukcija

Slika 17: Pozicije fasadnih podkonstrukcij

Fasadno pod konstrukcijo dimenzioniram v skladu z kombinacijami za MSN. Obtežba ki deluje na pod konstrukcijo je sila vetra in lastna teža profilov. Lastne teže panelov ne upoštevam saj se prenese preko temelja v tla. Merodajna obtežna kombinacija za določitev dimenzij fasadne pod konstrukcije je naslednja:

$$q_{Ed} = 1{,}35 \cdot g + 1{,}5 \cdot q_w^+$$

6. 2. 1 Pozicija F1 in F2

Nosilno konstrukcijo fasadnih panelov predstavljajo U160 profili, ki so povsod bočno podprti nad podporami, dodatno so podprti na sredini razpona v prvih dveh poljih. Razponi polj znašajo 6 metrov. Vrednosti notranjih sil in pomikov se nahajajo v PRILOGI 2.

Slika 18: Računski model

Izračun dimenzij zateg:

a) Prvo in drugo polje

Račun obremenitev:

število bočno podprtih elementov m = 2

$$N_{Ed} = \frac{M_{Ed}}{h} = \frac{318}{16} = 19.88kN$$

$$\delta_d = \frac{L}{1000} \Rightarrow \beta^* = \frac{1}{51{,}8}$$

Nadomestna obtežba:

$$q_d = \beta \frac{\sum_{i=1}^{m} N_{Ed,i}}{L} = \frac{1}{51{,}8} \cdot \frac{2 \cdot 19{,}88}{6} = 0{,}13kN/m$$

Dimenzioniranje zatege:

$$\frac{Z_{Ed}}{A} \le \frac{f_y}{\gamma_{M0}}; A \ge \frac{Z_{Ed}\gamma_{M0}}{f_y} = \frac{0{,}31KN}{23{,}5KN/cm^2} = 0{,}015cm^2$$

$$A = \frac{\pi d^2}{4} \ge 0{,}03cm^2; d \ge \sqrt{\frac{0{,}015 \cdot 4}{\pi}} = 0{,}13cm$$

Izberem zatego $\phi 8$.

Kontrola pomikov:

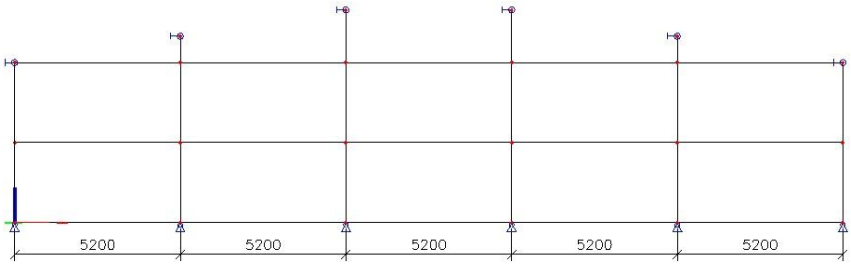
Merodajna kombinacija za preverjanje pomika $1{,}0 \cdot G + 1{,}0 \cdot g_p + 0{,}20 \cdot q_w$

$$u_y = 8{,}4mm \le \frac{L}{250} = \frac{6000}{250} = 24mm$$

$$u_y = 3{,}2mm \le \frac{L/2}{250} = \frac{3000}{250} = 12mm$$

6. 2. 2 Pozicija F3

Nosilno konstrukcijo fasadnih panelov predstavljajo U140 profili. Razponi polj znašajo 5,2 metra. Računski model predstavlja prostorska brana, sestavljena iz vzdolžnih U profilov in stebričkov. Zunanja obtežba je veter. Vrednosti notranjih sil in pomikov se nahajajo v PRILOGI 2.



Slika 19: Računski model fasadne podkonstrukcije

Kontrola pomikov:

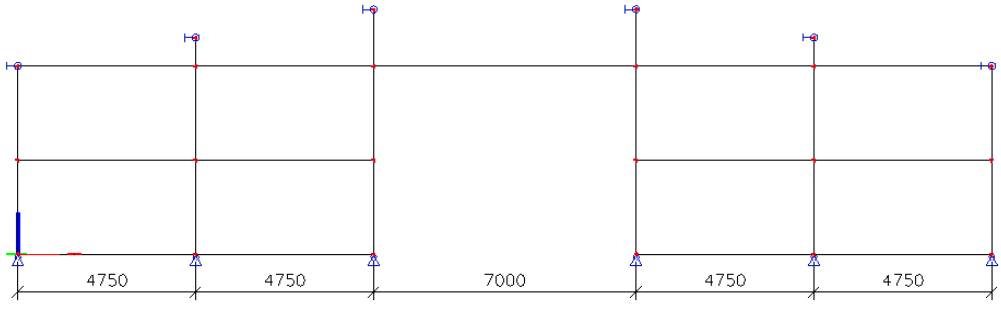
Merodajna kombinacija za preverjanje pomika $1{,}0 \cdot G + 1{,}0 \cdot g_p + 0{,}20 \cdot q_w$

$$u_y = 2{,}8mm \le \frac{L}{250} = \frac{5200}{250} = 20{,}8mm$$

$$u_z = 2{,}3mm \le \frac{L/2}{250} = \frac{2600}{250} = 10{,}4mm$$

6. 2. 3 Pozicija F4

Nosilno konstrukcijo fasadnih panelov predstavljajo U120 profili, stebri so HEA 140. Razponi polj znašajo 4,75 metra, nad vhodnimi 7 metrov. Računski model predstavlja prostorska brana, sestavljena iz vzdolžnih U profilov in stebričkov. Zunanja obtežba je veter. Vrednosti notranjih sil in pomikov se nahajajo v PRILOGI 2.



Slika 20: Računski model fasadne podkonstrukcije

Kontrola pomikov:

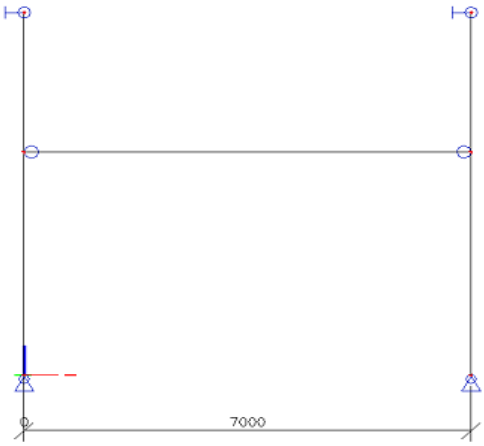
Merodajna kombinacija za preverjanje pomika $1{,}0 \cdot G + 1{,}0 \cdot g_p + 0{,}20 \cdot q_w$

$$u_y = 16{,}1mm \le \frac{L}{250} = \frac{7000}{250} = 28mm$$

$$u_z = 1{,}0mm \le \frac{L}{250} = \frac{7000}{250} = 28mm$$

6. 3 Dimenzioniranje konstrukcije dvižnih vrat

Računski model predstavlja okvir, sestavljen iz dveh stebrov in vodoravnega nosilca dvižnih vrat. Slike notranjih statičnih količin se nahajajo v prilogi. Vrednosti notranjih sil in pomikov se nahajajo v PRILOGI 2.



Slika 21: Računski model

Obtežba nosilca vrat: - teža vrat $0{,}70kN/m$

- teža panelov: $0{,}51kN/m$
- veter: $0{,}363kN/m^2$

Obtežba stebrov: - reakcije nosilca vrat

- veter: $0{,}363kN/m^2$

Obtežna kombinacija: $1{,}35 \cdot g_v + 1{,}35 \cdot g_p + 1{,}5 \cdot q_w$

Za nosilec dvižni vrat izberem profil HEA 140, za stebre profil HEA 140.

Kontrola pomikov:

Merodajna kombinacija za preverjanje pomika $1{,}0 \cdot G + 1{,}0 \cdot g_p + 0{,}20 \cdot q_w$

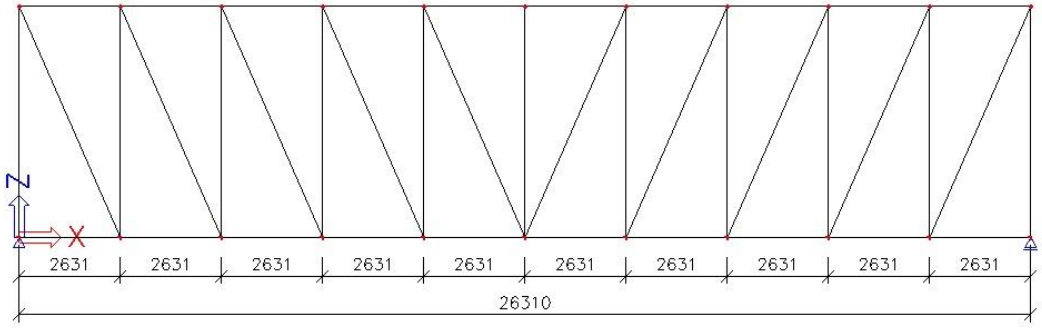
$$u_y = 12{,}2mm \le \frac{L}{250} = \frac{7000}{250} = 28mm$$

$$u_y = 20{,}6mm \le \frac{L}{250} = \frac{7000}{250} = 28mm$$

7 GLAVNE NOSILNE KONSTRUKCIJE

7. 1 Horizontalno povezje

Vrednosti notranjih sil in slike pomikov se nahajajo v PRILOGI 3.



Slika 22: Računski model horizontalnega povezja

<u>Dimenzioniranje elementov:</u>

1. obtežba vetra:

- sodelujoča površina fasade = 91m^2

- pritisk vetra w_e=0,363kN/m^2

- linijska obtežba na povezje : $p_w = \frac{S \cdot w_e}{L} = \frac{91 \cdot 0{,}363}{26{,}31} = 1{,}26kN/m^2$

2. izbočne sile:

- $N_{Ed} = \frac{M_{Ed}}{h} = \frac{1608{,}44}{1{,}0} = 1608{,}44kN$

- izberem δ_q=L/1000 → β^*=1/48,4 (za m=4)

-$q_d = \beta \frac{\sum_{i=1}^{m} N_{Ed,i}}{L} = \frac{1}{48{,}4} \cdot \frac{4 \cdot 1608{,}44}{26{,}31} = 5{,}05kN/m$

Kritična obtežna kombinacija: $q_{Ed} = 1{,}0q_d + 1{,}5p_w$

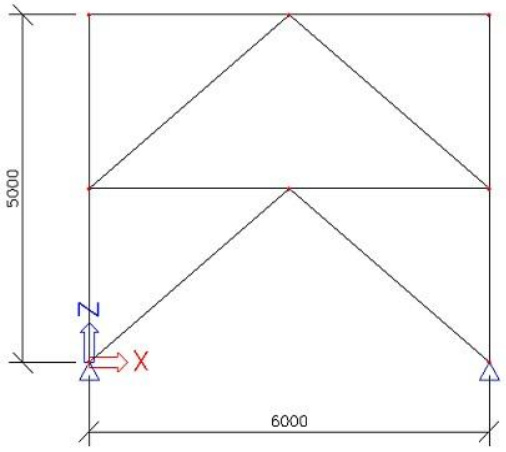
Dimenzije tlačenih in nateznih elementov določim s programom SCIA, tako da je zadoščeno pogoju stabilnosti in napetosti. Tlačeni elementi so kvadratne cevi SHS 100/100/4, natezne diagonale so palice ϕ 22.

Kontrola pomika:

$$u = 26{,}0 \text{ mm} < \frac{L}{1000} = 26{,}31\text{mm}$$

7. 2 Vertikalno V povezje

Vrednosti notranjih sil in slike pomikov se nahajajo v PRILOGI 3.



Slika 23: Računski model vertikalnega V povezja

Dimenzioniranje elementov:

1. obtežba vetra:

- sodelujoča površina fasade = 45,5m^2
- pritisk vetra w_e=0,363kN/m^2
- linijska obtežba na povezje : $p_w = \frac{S \cdot w_e}{L} = \frac{45{,}5 \cdot 0{,}363}{2{,}5} = 6{,}61 kN/m^2$

2. izbočne sile:

- $N_{Ed} = \frac{M_{Ed}}{h} + N = \frac{1679{,}42}{0{,}724} + 365{,}05 = 2684{,}7 kN$
- izberem δ_q=L/1000 → β^*=1/48,4 (za m=4)
- $q_d = \beta \frac{\sum_{i=1}^{m} N_{Ed,i}}{L} = \frac{1}{48{,}4} \cdot \frac{4 \cdot 2684{,}7}{5} = 44{,}38 kN/m$

Kritična obtežna kombinacija: $q_{Ed} = 1{,}0q_d + 1{,}5p_w$

Za diagonale izberem kvadratne cevi SHS 100/100/4, tlačene palice v povezju so kvadratne cevi SHS 140/140/5.

- Diagonale SHS 100/100/4

A = 15,2cm^2

i = 3,91cm

Nosilnost v tlaku:

$$\bar{\lambda} = \frac{l_u}{\lambda_1} = \frac{391cm}{3{,}91 \cdot 93{,}9 \cdot 0{,}92} = 1{,}16 \rightarrow \chi = 0{,}55 \ (uklonska\ krivulja\ a)$$

$$N_{Ed} = 122{,}99kN \leq N_{b,Rd} = \frac{\chi \cdot A \cdot f_y}{\gamma_{M1}} = \frac{0{,}55 \cdot 15{,}2 \cdot 27{,}5}{1{,}0} = 229{,}9kN$$

Nosilnost v nategu:

$$N_{Ed} = 122{,}99 \leq N_{pl,Rd} = \frac{A \cdot f_y}{\gamma_{M0}} = \frac{15{,}2 \cdot 27{,}5}{1{,}0} = 418kN$$

- Tlačene palice SHS 140/140/5

A = 26,3cm^2

i = 5,47cm

Nosilnost v tlaku:

$$\bar{\lambda} = \frac{l_u}{\lambda_1} = \frac{600cm}{5{,}47 \cdot 93{,}9 \cdot 0{,}92} = 1{,}27 \rightarrow \chi = 0{,}49 \ (uklonska\ krivulja\ a)$$

$$N_{Ed} = 165{,}9kN \leq N_{b,Rd} = \frac{\chi \cdot A \cdot f_y}{\gamma_{M1}} = \frac{0{,}49 \cdot 26{,}3 \cdot 27{,}5}{1{,}0} = 354{,}4kN$$

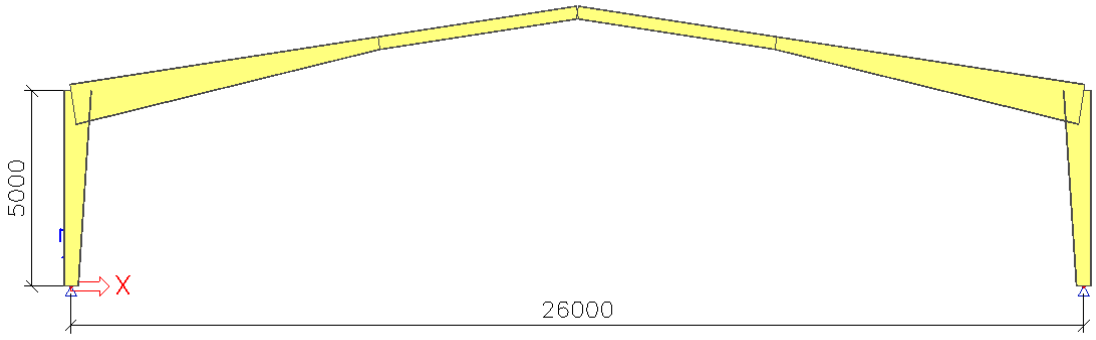
Kontrola pomika:

$$\mathrm{u} = 3{,}8\mathrm{mm} < \frac{\mathrm{H}}{150} = 33{,}33\mathrm{mm}$$

8 STATIČNA ANALIZA TROČLENSKEGA LOKA

Statična analiza tročlenskega okvira je bila narejena v programu SCIA Engineer 2011.1. Izračuni in s tem pridobljene notranje statične količine so bili narejeni na linijskem modelu po teoriji II reda z upoštevanjem globalne geometrijske nepopolnosti.

Vrednosti notranjih sil in kontrola nosilnosti elementa se nahajajo v PRILOGI 3.

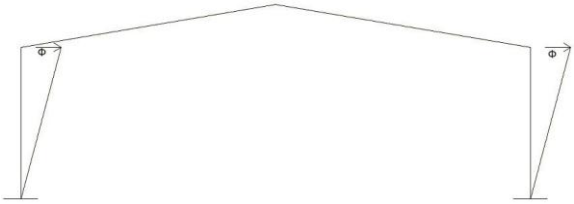


Slika 24: Model tročlenskega okvira

8. 1 Globalna geometrijska nepopolnost

Začetna globalna geometrijska nepopolnost:

$$\phi = \phi_0 \cdot \alpha_h \cdot \alpha_m = \frac{1}{200} \cdot \frac{2}{\sqrt{5}} \cdot \sqrt{0{,}5\left(1+\frac{1}{2}\right)} = 3{,}87 mm/m$$



Slika 25: Začetna globalna geometrijska nepopolnost

8. 2 Dimenzioniranje MSN

Potrebne prečne prereze za prevzem zunanje obtežbe sem določil na podlagi ovojnic nelinearnih kombinacij v skladu z mejnim stanjem nosilnosti. Dimenzioniral sem tako, da sem v celoti upogibni moment prevzel s pasnicama. Izpisi in slike notranjih statičnih količin se nahajajo v PRILOGI 3.

8. 2. 1 Stebri

Prečni prerezi stebrov:

- ob vpetju v temelj: $b_f/t_f = 310/22$ mm; $h_w/t_w = 350/13$ mm
- v vrhu stebra: $b_f/t_f = 310/22$ mm; $h_w/t_w = 680/13$ mm

Kontrola kompaktnosti:

1. upogib stojina: ε = 0,81

- $\frac{350}{13} = 26{,}9 \leq 72\varepsilon = 58{,}32$….1. R. K.

- $\frac{680}{13} = 52{,}31 \leq 72\varepsilon = 58{,}32$….1. R. K.

2. tlak pasnica: ε = 0,81

- $\frac{310}{44} = 7{,}05 \leq 9\varepsilon = 7{,}29$….1. R. K.

Prerez je v 1. razredu kompaktnosti.

3. Strig stojina: $^{h_w}/_{t_w} \leq 72\frac{\varepsilon}{\eta} = 72\frac{0{,}81}{1{,}2} = 48{,}6$

- $\frac{350}{13} = 26{,}9 \leq 48{,}6$
- $\frac{680}{13} = 52{,}3 > 48{,}6$…..vitka stojina glede strižnih napetosti

Kontrola strižnega izbočenja

Panel steber - prečka

$$\alpha = \frac{a}{h_w} = \frac{105}{68} = 1{,}54$$

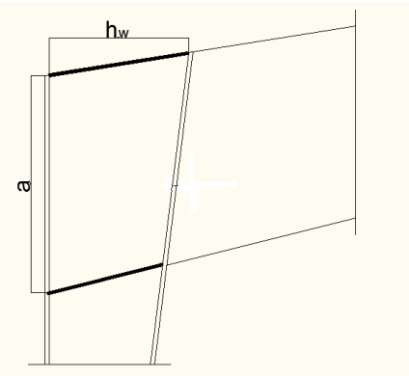
$k_\tau = 5{,}34 + \frac{4{,}0}{\alpha^2}$=7,03 – koeficient strižnega izbočenja

$\overline{\lambda_w} = \frac{h_w}{37{,}4 \cdot t_w \cdot \varepsilon \cdot \sqrt{k_\tau}}$ = 0,65 – vitkost stojine

χ_w = 0,83 / λ_w = 1,28

$$V_{b,Rd} = \frac{\chi_w \cdot f_y \cdot h_w \cdot t_w}{\sqrt{3} \cdot \gamma_{M1}} = \frac{1{,}28 \cdot \frac{35{,}5kN}{cm^2} \cdot 68cm \cdot 1{,}3cm}{\sqrt{3} \cdot 1} = 2319{,}16kN > V_{Ed} = 351{,}24kN$$

Prečne ojačitve se nahajajo na mestu spoja prečka steber zaradi vnosa koncentrirane sile.



Slika 26: Prečne ojačitve stebra

Kontrola nosilnosti prereza

1. Kontrola tlačne osne nosilnosti:

$$\frac{N_{Ed}}{N_{pl,Rd}} = \frac{N_{Ed} \cdot \gamma_{M0}}{A \cdot f_y} = \frac{365{,}05 \cdot 1{,}0}{181{,}9 \cdot 35{,}5} = 0{,}06 \leq 1{,}0$$

2. Kontrola upogiba:

$$\frac{M_{Ed}}{M_{pl,Rd}} = \frac{M_{Ed} \cdot \gamma_{M0}}{W_{pl} \cdot f_y} = \frac{1679{,}42 \cdot 100 \cdot 1{,}0}{6290{,}4 \cdot 35{,}5} = 0{,}75 \leq 1{,}0$$

Kontrola nosilnosti elementa: Izpis se nahaja v PRILOGI 3.

M_{Ed} = 1679,42kNm

N_{Ed} = 365,05kN (tlak)

W_y = 5584,7 cm^3

A = 224,8 cm^2

I_t = 269,9cm^4

I_w =13473015cm^6

I_z = 10935,8cm^4

Račun relativnih vitkosti: Stebre podpiram na polovici višine.

$$-\ \bar{\lambda}_y = \frac{l_u}{i_y \cdot \lambda_1} = \frac{500cm}{29{,}99cm \cdot 93{,}9 \cdot 0{,}81} = 0{,}22 \rightarrow \chi_y = 0{,}99 \text{ (uklonska krivulja b)}$$

$$-\ \bar{\lambda}_z = \frac{l_u}{i_z \cdot \lambda_1} = \frac{250cm}{7{,}0cm \cdot 93{,}9 \cdot 0{,}81} = 0{,}47 \rightarrow \chi_z = 0{,}86 \text{ (uklonska krivulja c)}$$

Račun kritičnega momenta M_{cr} in vitkosti $\bar{\lambda}_{LT}$:

C_1 = 1,77

k_z = 1

k_ω = 1

$$M_{Cr} = C_1 \cdot \frac{\pi}{k_z \cdot L} \cdot \sqrt{E \cdot I_z \cdot G \cdot I_t + \frac{\pi^2 \cdot E \cdot I_z \cdot E \cdot I_\omega}{(k_\omega \cdot L)^2}} =$$

$$= 1{,}77 \cdot \frac{\pi}{1 \cdot 250} \cdot \sqrt{21000 \cdot 10935{,}8 \cdot 8070 \cdot 269{,}9 + \frac{\pi^2 \cdot 21000 \cdot 10935{,}8 \cdot 21000 \cdot 13473015}{(1 \cdot 250)^2}} =$$

= 23073kNm

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y \cdot f_y}{Mcr}} = \sqrt{\frac{5584{,}7 \cdot 35{,}5}{2307300}} = 0{,}29 \rightarrow \bar{\chi}_{LT} = 0{,}92 \text{ (uklonska krivulja d)}$$

Interakcija osne sile in momenta:

- y os :

C_{my}=0,9 (pomični okvir)

$$k_{yy} = C_{my}(1 + 0{,}6 \cdot \bar{\lambda}_y \frac{N_{Ed}}{\chi_y \cdot A_i \cdot \frac{f_y}{\gamma_{M1}}} = 0{,}9\left(1 + 0{,}6 \cdot 0{,}22 \frac{365{,}05}{0{,}99 \cdot 224{,}8 \cdot 35{,}5}\right) = 0{,}905$$

$$\mathbf{\frac{365,05}{0,99 \cdot 224,8 \cdot 35,5/1} + 0,905 \frac{167942}{0,92 \cdot 5584,7 \cdot 35,5/1} = 0,88 < 1,0}$$

-z os:

$C_{mLT} = 0,6$ ($\psi = 0$)

$$k_{zy} = \left(1 - \frac{0,05 \cdot \bar{\lambda}_z}{(C_{mLT} - 0,25)} \frac{N_{Ed}}{\chi_z \cdot A_i \cdot \frac{f_y}{\gamma_{M1}}}\right) = \left(1 - \frac{0,05 \cdot 0,47}{0,6 - 0,25} \frac{365,05}{0,86 \cdot 224,8 \cdot \frac{35,5}{1}}\right) = 0,997$$

$$\mathbf{\frac{365,05}{0,86 \cdot 224,8 \cdot 35,5/1} + 0,997 \frac{167942}{0,92 \cdot 5584,7 \cdot 35,5/1} = 0,97 < 1,0}$$

Dobljene rezultate sem primerjal s tistimi, ki mi jih je podal program in se nahajajo v prilogi.

Odstopanja so zelo majhna, približno 5%.

7. 2. 2 Prečke

Prečni prerezi prečk:

- ob vpetju v steber: $b_f/t_f = 280/20$ mm; $h_w/t_w = 960/12$ mm
- v slemenu: $b_f/t_f = 250/16$ mm; $h_w/t_w = 308/10$ mm

Kontrola kompaktnosti:

1. upogib stojina: ε = 0,81

- $\frac{308}{10} = 30,8 \leq 72 \cdot \varepsilon = 72 \cdot 0,81 = 58,32$…. 1. R. K.
- $\frac{1010}{14} = 72,1 \leq 124 \cdot \varepsilon = 124 \cdot 0,81 = 100,44$….3 . R.K.

2. tlak pasnica: ε = 0,81

- $\frac{250}{32} = 7,81 \leq 10 \cdot \varepsilon = 10 \cdot 0,81 = 8,1$…. 2. R. K.

Prerez je v 3. razredu kompaktnosti.

3. Strig stojina: $^{h_w}/_{t_w} \leq 72\frac{\varepsilon}{\eta} = 72\frac{0,81}{1,2} = 48,6$

- $\frac{308}{10} = 30,8 \leq 48,6$
- $\frac{960}{12} = 80 > 48,6$…..vitka stojina glede strižnih napetosti

Kontrola strižnega izbočenja

$\alpha = \frac{a}{h_w} = \frac{460cm}{96cm} = 4,80$

$k_\tau = 5,34 + \frac{4,0}{4,80^2} = 5,51$ koeficient strižnega izbočenja

$\overline{\lambda_w} = \frac{h_w}{37,4 \cdot t_w \cdot \varepsilon \cdot \sqrt{k_\tau}} = 1,13$ – vitkost stojine

χ_w = 0,83 / λ_w = 0,73

$$V_{b,Rd} = \frac{\chi_w \cdot f_y \cdot h_w \cdot t_w}{\sqrt{3} \cdot \gamma_{M1}} = \frac{0{,}73 \cdot \frac{35{,}5kN}{cm^2} \cdot 96cm \cdot 1{,}2cm}{\sqrt{3} \cdot 1} = 11723{,}63kN \; > \; V_{Ed} = 302{,}67kN$$

Prečne ojačitve prereza se namesti od spoja steber- prečka proti slemenu, na razdalji 460 cm.

Kontrola nosilnosti prereza

1. Kontrola tlačne osne nosilnosti:

$$\frac{N_{Ed}}{N_{pl,Rd}} = \frac{N_{Ed} \cdot \gamma_{M0}}{A \cdot f_y} = \frac{389{,}7 \cdot 1{,}0}{110{,}8 \cdot 35{,}5} = 0{,}10 \leq 1{,}0$$

2. Kontrola upogiba:

$$\frac{M_{Ed}}{M_{el,Rd}} = \frac{M_{Ed} \cdot \gamma_{M0}}{W_{el} \cdot f_y} = \frac{1616{,}21 \cdot 100 \cdot 1{,}0}{7158{,}5 \cdot 35{,}5} = 0{,}64 \leq 1{,}0$$

Kontrola nosilnosti elementa: Izpis se nahaja v PRILOGI 3.

M_{Ed} = 1616,21kNm

N_{Ed} = 389,7kN

W_y = 7148,5cm^3

A = 227,2cm^2

I_t = 219,64cm^4

I_w =17602211cm^6

I_z = 7331,2cm^4

Račun relativnih vitkosti:

$$-\bar{\lambda}_y = \frac{l_u}{i_y \cdot \lambda_1} = \frac{1315{,}3cm}{39{,}663cm \cdot 93{,}9 \cdot 0{,}81} = 0{,}44 \rightarrow \chi_y = 0{,}905 \text{ (uklonska krivulja b)}$$

$$-\bar{\lambda}_z = \frac{l_u}{i_z \cdot \lambda_1} = \frac{263{,}1cm}{5{,}68cm \cdot 93{,}9 \cdot 0{,}81} = 0{,}61 \rightarrow \chi_z = 0{,}78 \text{ (uklonska krivulja c)}$$

Račun kritičnega momenta M_{cr} in vitkosti $\bar{\lambda}_{LT}$:

C_1 = 1,31

k_z = 1

k_ω = 1

$$M_{Cr} = C_1 \cdot \frac{\pi}{k_z \cdot L} \cdot \sqrt{E \cdot I_z \cdot G \cdot I_t + \frac{\pi^2 \cdot E \cdot I_z \cdot E \cdot I_\omega}{(k_\omega \cdot L)^2}} =$$

$$= 1{,}31 \cdot \frac{\pi}{1 \cdot 263{,}1} \cdot \sqrt{21000 \cdot 7331{,}2 \cdot 8070 \cdot 219{,}64 + \frac{\pi^2 \cdot 21000 \cdot 7331{,}2 \cdot 21000 \cdot 17602211}{(1 \cdot 263{,}1)^2}} =$$

= 14325kNm

$$\bar{\lambda}_{LT} = \sqrt{\frac{W_y \cdot f_y}{Mcr}} = \sqrt{\frac{7148{,}5 \cdot 35{,}5}{1432500}} = 0{,}42 \rightarrow \bar{\chi}_{LT} = 0{,}84 \text{ (uklonska krivulja d)}$$

Interakcija osne sile in momenta:

- y os :

C_{my}=0,9 (pomični okvir)

$$k_{yy} = C_{my}(1 + 0{,}6 \cdot \bar{\lambda}_y \frac{N_{Ed}}{\chi_y \cdot A_i \cdot \frac{f_y}{\gamma_{M1}}} = 0{,}9\left(1 + 0{,}6 \cdot 0{,}44 \frac{389{,}7}{0{,}905 \cdot 227{,}2 \cdot 35{,}5}\right) = 0{,}913$$

$$\mathbf{\frac{389,7}{0,905 \cdot 227,2 \cdot 35,5/1} + 0,913 \frac{161621}{0,84 \cdot 7148,5 \cdot 35,5/1} = 0,75 < 1,0}$$

-z os:

C_{mLT} = 0,84 (ψ = 0,6)

$$k_{zy} = \left(1 - \frac{0{,}05 \cdot \bar{\lambda}_z}{(C_{mLT} - 0{,}25)} \frac{N_{Ed}}{\chi_z \cdot A_i \cdot \frac{f_y}{\gamma_{M1}}}\right) = \left(1 - \frac{0{,}05 \cdot 0{,}61}{0{,}84 - 0{,}25} \frac{389{,}7}{0{,}78 \cdot 227{,}2 \cdot \frac{35{,}5}{1}}\right) = 1{,}0$$

$$\mathbf{\frac{389,7}{0,78 \cdot 227,2 \cdot 35,5/1} + 1 \frac{161621}{0,84 \cdot 7148,5 \cdot 35,5/1} = 0,82 < 1,0}$$

8. 3 Potresna obtežba

Potresna sila, ki deluje na okvir in centrično povezje je izračunana v poglavju 3. 4.

Kombinacija vplivov za potresno projektno stanje:

$G_k + \gamma_I \cdot A_{Ed} + \psi_2 \cdot Q_k$

$\psi_2 = 0$

$\gamma_I = 0{,}8$ objekt služi kot skladišče→kategorija namembnosi I

8. 3. 1 Potres v prečni smeri

Obtežbo razdelim na gravitacijski del in seizmični del in ju seštejem. V nalogi navajam le vrednosti seštevkov posamezne količine. Vrednosti notranjih sil se nahajajo v PRILOGI 3.

$M_{y,Ed} = 58{,}04 + 233{,}1 = 291{,}14\text{kN}$

$N_{Ed} = 22{,}90 + 13{,}54 = 36{,}44\text{kN}$

$V_{Ed} = 12{,}19 + 45{,}26 = 57{,}45\text{kN}$

Vpliv teorije drugega reda

P_{tot}= 69,43kN

V_{tot}= 70,4kN

de= 2,59cm

$\mathrm{dr} = \mathrm{de} \cdot \mathrm{q} = 2{,}59 \cdot 1{,}5 = 3{,}90\text{cm}$

$\vartheta = \frac{\mathrm{P_{tot}}}{\mathrm{V_{tot}}} \cdot \frac{\mathrm{dr}}{\mathrm{h}} = \frac{69{,}43}{70{,}4}\frac{3{,}90}{500} = 0{,}008 < 0{,}1 \rightarrow$ TDR ni potrebno upoštevati

8. 3. 2 Potres v vzdolžni smeri

Potres v vzdolžni smeri deluje na centrično V povezje, ki je obravnavano v poglavju 6. 5.. Diagrami notranjih sil se nahajajo v PRILOGI 3.

Osne sile v diagonalah povezja:

- spodnja diagonala D1: D1=99,32kN
- zgornja diagonala D2: D2 = 98,5kN

Osne sile v tlačenih prečkah:

- spodnja prečka P1: P1 = -77,87kN
- zgornja prečka P2: P2 = -150,72kN

Osne sile v stebrih:

- N1: N1 = 63,92kN
- N2: N2 = -63,75kN

Dimenzioniranje diagonal:

$A_1 \geq \frac{\mathrm{D1}}{\frac{\mathrm{f_y}}{\gamma_{\mathrm{Mo}}}} = \frac{99{,}32}{27{,}5}$=3,61cm^2 →ustreza profil U50 določen v poglavju 6. 5

$A_2 \geq \frac{\mathrm{D2}}{\frac{\mathrm{f_y}}{\gamma_{\mathrm{Mo}}}} = \frac{98{,}5}{27{,}5}$=3,58cm^2 →ustreza profil U50 določen v poglavju 6. 5

Omejitev glede vitkosti:

$$\bar{\lambda} = \frac{lu}{i \cdot \lambda_1} = \frac{391}{3{,}91 \cdot 93{,}9 \cdot 0{,}92} = 1{,}16 < 2$$

Vpliv teorije drugega reda

P_{tot}= 35,04kN

V_{tot}= 152,8kN

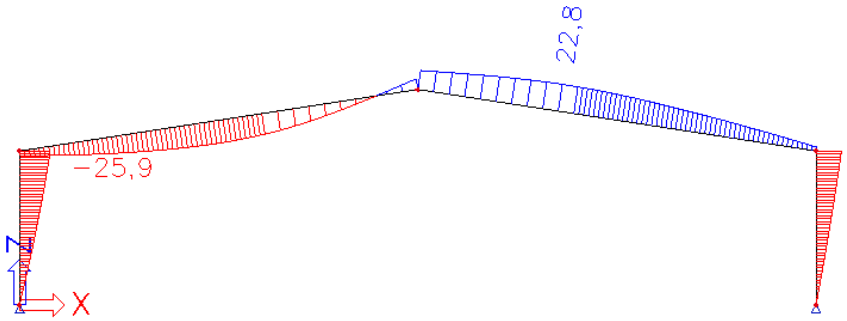
de= 1,06cm

$dr = de \cdot q = 0{,}44 \cdot 1{,}5 = 0{,}66cm$

$$\vartheta = \frac{P_{tot}}{V_{tot}} \cdot \frac{dr}{h} = \frac{35{,}04}{152{,}8}\frac{0{,}66}{500} = 0{,}0003 < 0{,}1 \rightarrow \text{TDR ni potrebno upoštevati}$$

Kontrola pomikov

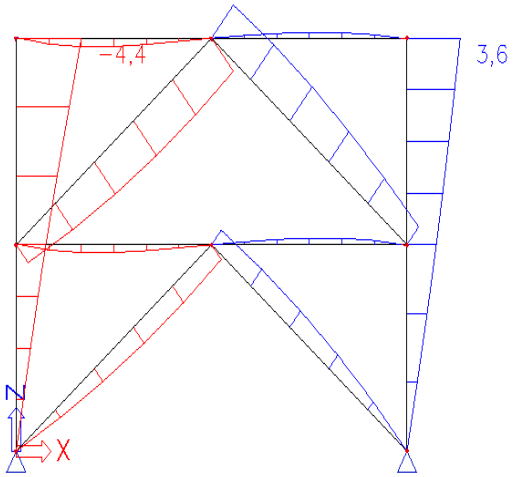
- X smer:



Slika 27: Pomiki zaradi potresa [mm]

$u = d_e \cdot q \cdot \nu = 25{,}9 \cdot 1{,}5 \cdot 0{,}5 = 19{,}4\ mm < 0{,}0075 \cdot h = 37{,}5mm$

- Y smer:



Slika 28: Pomiki zaradi potresa [mm]

$dr \cdot \nu \leq 0{,}0075 \cdot h$

de= 0,44cm

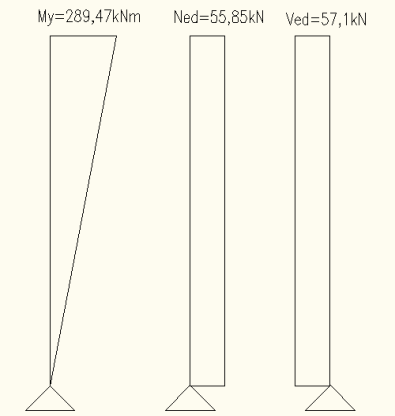
$dr = de \cdot q = 0{,}98 \cdot 1{,}5 = 0{,}44cm$

$\nu = 0{,}5$

$0{,}44 \cdot 0{,}5 = 0{,}22cm \leq 0{,}0075 \cdot 500 = 3{,}75cm$

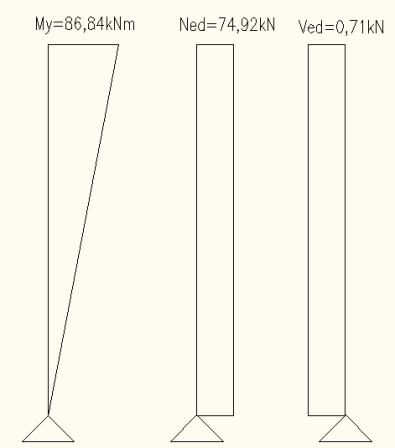
Kombinacija delovanja potresa v obe smeri

1. $E_{Edx} + 0{,}30E_{Edy}$



Slika 29: Notranje statične količine v prečni x smeri – v stebru [kNm]

2. $E_{Edy} + 0{,}30E_{Edx}$



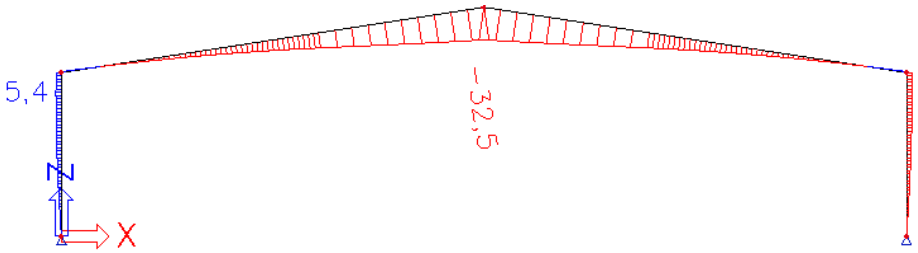
Slika 30: Notranje statične količina v vzdolžni y smeri – v stebru [kNm]

V MSN so obremenitve stebrov večje, tako da potres ni merodajen za dimenzioniranje.

8. 4 Kontrola pomikov MSU

Preverjal sem tako horizontalne pomike stebrov okvirja kot tudi vertikalne pomike prečk.

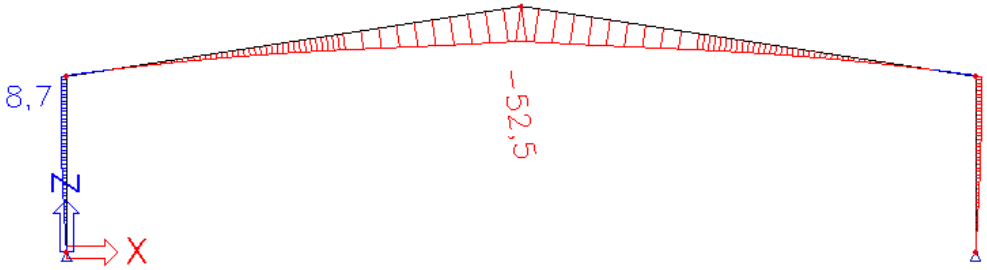
Horizontalni pomiki



Slika 31: Horizontalni pomiki [mm]

$$u = 5{,}4 \text{ mm} < \frac{H}{150} = 33{,}33\text{mm}$$

Vertikalni pomiki



Slika 32: Vertikalni pomiki [mm]

$$u = 52{,}5 \text{ mm} < \frac{L}{200} = 131{,}6\text{mm}$$

9 TEMELJI

Natezna vez

Zaradi velike prečne sile v dnu stebra je potrebno namestiti horizontalno vez. Vez se namesti v vseh oseh od A do I. Natezno vez dimenzioniram na največjo prečno silo v podpori.

Vz = 351,24kN → N_{Ed} = 351,24kN

$$N_{Ed} \leq N_{pl,Rd} = \frac{A \cdot f_y}{\gamma_{M0}} \rightarrow A \geq \frac{N_{Ed} \cdot \gamma_{M0}}{f_y} = 9{,}90 cm^2$$

Izberem L kotnik dimenzij 75x7 mm, A= 10,1cm^2.

Temelj

Objekt je temeljen na plitvih točkovnih temeljih, nosilnost tal znaša 300kN/m^2. Temelj je obremenjen le z tlačno silo.

$$\frac{N_{Ed}}{A_{temelja}} \leq R_d = 300kN/m^2 \rightarrow A \geq \frac{N_{Ed}}{R_d} = \frac{365{,}05}{300} = 1{,}22m^2$$

$A=a^2 \rightarrow a = \sqrt{1{,}22} = 1{,}10\ m$

Izberem temelj kvadratne tlorisne oblike z dimenzijo stranice 1,20m. Višina temelja se določi z raznosom obremenitve pod kotom 30 ° in znaša 70cm.

10. ZAKLJUČEK

V diplomski nalogi sem analiziral različne konstrukcijske možnosti izvedbe osnovnega okvira jeklene industrijske hale. Največjo težavo je predstavljal razpon 26 metrov in obtežba snega. Navadno se za tak razpon uporabljajo palični nosilci, vendar je bila moja naloga zastavljena tako, da sem bil primoran izbrati in ustrezno dimenzionirati varjene profile. V strešnem nosilcu in posledično tudi stebrih sem imel tako zelo velike upogibne momente za katere sem potreboval velike prečne prereze elementov. Vsi okvirji so imeli prečke spremenljive višine, saj sem tako prihranil na teži konstrukcije in izkoriščenost prereza je bila bistveno ugodnejša. Vsaka izvedba okvira ima svoje slabe in dobre lastnosti, ki sem jih zapisal v tabelo.

V nadaljevanju naloge sem se odločil za izvedbo tročlenskega okvira, kateri poleg ugodne teže nima momenta ob vpetju, kar je ugodno za prenos obtežbe v temeljna tla. V dnu stebra se nam pojavi le velika prečna sila, ki se jo prevzame z natezno vezjo, tako da je na koncu temelj obremenjen le s tlačno silo. Pomiki sicer niso bili med najmanjšimi vendar so ustrezali kriterijem mejnega stanja uporabnosti.

Diplomska naloga zaradi omejitve dolžine ne vsebuje vseh kontrol in natančnejših analiz ter dimenzioniranja tipičnih spojev konstrukcije.

VIRI

Beg, D. (ur.), Pogačnik, A. (ur.) 2009. Priročnik za projektiranje gradbenih konstrukcij po standardih
Evrokod. Ljubljana, Inženirska Zbornica Slovenije: 1077 str.

Študijsko gradivo Katedre za metalne konstrukcije
http://www.fgg.uni-lj.si/kmk/

Standardi:

SIST EN1992-1-4/2004: Evrokod 1: Vplivi na konstrukcije -1-4. del: Splošni vplivi - Vplivi vetra

SIST EN1992-1-4/2004: Evrokod 1: Vplivi na konstrukcije -1-3. del: Splošni vplivi – Obtežba snega

SIST EN1998-1/2005: Evrokod 8: Projektiranje potresno odpornih konstrukcij 1. del: Splošna pravila, potresni vplivi in pravila za stavbe

PRILOGE

PRILOGA 1: Izpisi iz programa SCIA za posamezne konstrukcijske variante okvirjev

PRILOGA 2: Izpisi iz programa SCIA vseh pod konstrukcij

PRILOGA 3: Izpisi iz programa SCIA glavnih nosilnih konstrukcij

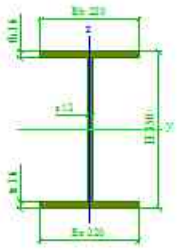
PRILOGA 1

NEMETSCHEK Scia

Project	-
Part	-
Description	-
Author	-

1. Prečni prerezi-momentni

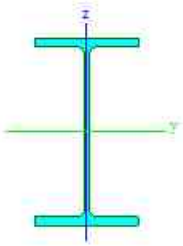
Name	prečke	
Type	I ng	
Detailed	350; 220; 220; 16; 16; 12	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis	×	



A [m²]	1,0856e-02	
A y, z [m²]	1,0856e-02	1,0856e-02
I y, z [m⁴]	2,2865e-04	2,8440e-05
I w [m⁶], t [m⁴]	0,0000e+00	1,5070e-06
Wel y, z [m³]	1,3065e-03	2,5855e-04
Wpl y, z [m³]	1,4791e-03	3,9865e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	110	175
alpha [deg]	0,00	
AL [m²/m]	1,5560e+00	

Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *

Name	stebri	
Type	HEA550	
Source description	Profil Arbed / Structural shapes / Edition ctobre 1995	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z	a	b



A [m²]	2,1200e-02	
A y, z [m²]	1,2393e-02	6,3018e-03
I y, z [m⁴]	1,1200e-03	1,0800e-04
I w [m⁶], t [m⁴]	7,2451e-06	3,5200e-06
Wel y, z [m³]	4,1500e-03	7,2100e-04
Wpl y, z [m³]	4,6200e-03	1,1080e-03
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	150	270
alpha [deg]	0,00	
AL [m²/m]	2,2083e+00	

2. Vute

Name	Member	Cross-section	Position	Alignment	Length x [m]	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student versi						
H3	B2	prečke - I ng (350; 220; 220; 16; 16; 12)	Begin	top surface	3,750	Abso
H4	B3	prečke - I ng (350; 220; 220; 16; 16; 12)	End	top surface	3,750	Abso

NEMETSCHEK Scia

Project -
Part -
Description -
Author -

3. Elementi

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student								
B2	prečke - I ng (350; 220; 220; 16; 16; 12)	13,153	Line	N2	N3	general (0)	standard	Layer1
B3	prečke - I ng (350; 220; 220; 16; 16; 12)	13,153	Line	N3	N4	general (0)	standard	Layer1
B5	stebri - HEA550	5,000	Line	N5	N4	general (0)	standard	Layer1
B6	stebri - HEA550	5,000	Line	N1	N2	general (0)	standard	Layer1

4. Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Stu			
1	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
2	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
3	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
4	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
5	Linear - ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
6	Linear - ultimate	veter6	0,90
		sneg6	1,50
		g6	1,00
7	Linear - ultimate	veter6	1,50
		sneg6	0,75
		g6	1,00
8	Linear - ultimate	veter6	0,90
		g6	1,00
		sneg6.1	1,50
9	Linear - ultimate	veter6	1,50
		g6	1,00
		sneg6.1	0,75
10	Linear - ultimate	sneg11	1,50
		veter11	0,90
		g11	1,00
11	Linear - ultimate	sneg11	0,75
		veter11	1,50
		g11	1,00
12	Linear - ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
13	Linear - ultimate	veter11	1,50
		g11	1,00
		sneg11.1	0,75
MSU-streha	Linear - serviceability	lastna t	1,00
		g	1,00
		sneg	0,20
MSU-steber	Linear -	lastna t	1,00
		g	1,00
		Student version *Student v	*Student version

NEMETSCHEK Scia

Project	-
Part	-
Description	-
Author	-

Name	Type	Load cases	Coeff. [-]
Student version	*Student version*	*Student version*	*Student version* *Student version* *Stu
MSU-steber	serviceability	veter-ms	0,20

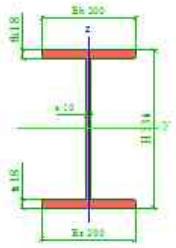
5. Notranje sile

Linear calculation, Extreme : Member, System : LCS
Selection : All
Class : ovo nica 1

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student versio
B2	1/1	0,000	**-527,99**	**278,28**	**-1087,42**
B2	5/2	13,153	**-32,45**	-5,80	11,25
B2	10/3	13,153	-238,82	**-96,16**	67,23
B2	10/3	9,392	-253,21	0,19	**247,72**
B3	1/1	13,153	**-528,41**	**-272,29**	**-1072,32**
B3	5/2	0,000	**-32,69**	4,22	11,25
B3	6/4	0,000	-234,53	**93,61**	68,46
B3	6/4	3,761	-248,92	-1,01	**241,37**
B5	1/1	0,000	**-360,49**	**480,86**	**-1213,08**
B5	5/2	5,000	**-27,93**	37,84	93,86
B5	5/2	0,000	-36,09	**37,84**	-95,32
B5	1/1	5,000	-349,47	480,86	**1191,21**
B6	1/1	0,000	**-366,35**	**-479,53**	**1191,45**
B6	5/2	5,000	**-23,69**	-38,24	-94,78
B6	5/2	0,000	-31,85	**-38,24**	96,43
B6	1/1	5,000	-355,33	-479,53	**-1206,22**

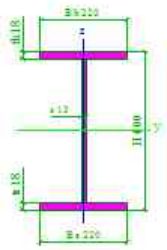
1.Prečni prerezi-dvočlenski

Name	stebri	
Type	I ng	
Detailed	336; 200; 200; 18; 18; 10	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis		



A [m²]	1,0200e-02	
A y, z [m²]	6,5161e-03	3,3188e-03
I y, z [m⁴]	2,0472e-04	2,4025e-05
I w [m⁶], t [m⁴]	6,0521e-07	8,0205e-07
Wel y, z [m³]	1,2186e-03	2,4025e-04
Wpl y, z [m³]	1,3698e-03	3,6750e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	100	168
alpha [deg]	0,00	
AL [m²/m]	1,4520e+00	

Name	prečke	
Type	I ng	
Detailed	400; 220; 220; 18; 18; 13	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z		b
FEM analysis		



A [m²]	1,2652e-02	
A y, z [m²]	1,2652e-02	1,2652e-02
I y, z [m⁴]	3,4139e-04	3,2011e-05
I w [m⁶], t [m⁴]	0,0000e+00	1,8682e-06
Wel y, z [m³]	1,7070e-03	2,9101e-04
Wpl y, z [m³]	1,9433e-03	4,5098e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	110	200
alpha [deg]	0,00	
AL [m²/m]	1,6540e+00	

2.Vute

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H1	B1	stebri - I ng (336; 200; 200; 18; 18; 10)	End	top surface	1,000	Rela
H2	B4	stebri - I ng (336; 200; 200; 18; 18; 10)	Begin	top surface	1,000	Rela
H3	B3	prečke - I ng (400; 220; 220; 18; 18; 13)	End	top surface	3,500	Abso
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H4	B2	prečke - I ng (400; 220; 220; 18; 18; 13)	Begin	top surface	3,500	Abso

3.Elementi

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version*								
B1	stebri - I ng (336; 200; 200; 18; 18; 10)	5,000	Line	N1	N2	general (0)	standard	Layer1
B2	prečke - I ng (400; 220; 220; 18; 18; 13)	13,153	Line	N2	N3	general (0)	standard	Layer1
B3	prečke - I ng (400; 220; 220; 18; 18; 13)	13,153	Line	N3	N4	general (0)	standard	Layer1
B4	stebri - I ng (336; 200; 200; 18; 18; 10)	5,000	Line	N4	N5	general (0)	standard	Layer1

4.Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student v			
1	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
2	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
3	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
4	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
5	Linear - ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
6	Linear - ultimate	veter6	0,90
		sneg6	1,50
		g6	1,00
7	Linear - ultimate	veter6	1,50
		sneg6	0,75
		g6	1,00
8	Linear - ultimate	veter6	0,90
		g6	1,00
		sneg6.1	1,50
9	Linear - ultimate	veter6	1,50
		g6	1,00
		sneg6.1	0,75
10	Linear - ultimate	sneg11	1,50
		veter11	0,90
		g11	1,00
11	Linear - ultimate	sneg11	0,75
		veter11	1,50
		g11	1,00
12	Linear - ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student v			
13	Linear - ultimate	veter11	1,50
		g11	1,00
		Student version *Student ver	*Student version*

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student v			
13	Ultimate	sneg11.1	0,75
MSU-streha	Linear - serviceability	lastna t	1,00
		g	1,00
		sneg	0,20
MSU-stber	Linear - serviceability	lastna t	1,00
		g	1,00
		veter-ms	0,20

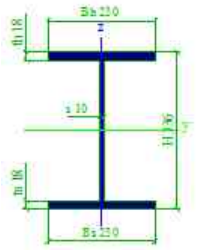
5.Notranje sile

Linear calculation, Extreme : Member, System : LCS
Selection : All
Class : ovo nica 1

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version *Student version* *Student version* *Student version* *Student version* *St					
B1	1/1	0,000	**-362,63**	-267,74	**7,51**
B1	5/2	5,000	**-23,12**	-25,06	-79,53
B1	1/1	5,000	-355,45	**-277,55**	**-1296,21**
B1	5/2	0,000	-28,44	**-8,71**	0,59
B2	1/1	0,000	**-328,37**	**309,11**	**-1306,87**
B2	5/2	13,153	**-19,07**	-6,09	29,94
B2	10/3	13,153	-130,43	**-101,83**	187,78
B2	1/1	11,774	-280,80	-8,89	**401,26**
B3	1/1	13,153	**-329,48**	**-307,58**	**-1349,61**
B3	5/2	0,000	**-20,02**	-0,08	29,94
B3	6/4	0,000	-128,07	**95,89**	187,48
B3	1/1	1,379	-281,90	1,73	**391,38**
B4	1/1	5,000	**-361,28**	**283,83**	**7,48**
B4	5/2	0,000	**-32,01**	**24,66**	-137,34
B4	1/1	0,000	-354,10	278,88	**-1339,98**

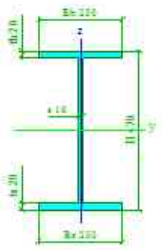
1. Prečni prerezi - dvočlenski togo vpet

Name	stebri	
Type	I ng	
Detailed	336; 230; 230; 18; 18; 10	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis		



A [m²]	1,1280e-02	
A y, z [m²]	1,1280e-02	1,1280e-02
I y, z [m⁴]	2,3205e-04	3,6526e-05
I w [m⁶], t [m⁴]	0,0000e+00	1,7230e-06
Wel y, z [m³]	1,3813e-03	3,1762e-04
Wpl y, z [m³]	1,5415e-03	4,8360e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	115	168
alpha [deg]	0,00	
AL [m²/m]	1,5720e+00	

Name	prečke	
Type	I ng	
Detailed	470; 250; 250; 20; 20; 16	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z		b
FEM analysis		



A [m²]	1,6880e-02	
A y, z [m²]	1,6880e-02	1,6880e-02
I y, z [m⁴]	6,1259e-04	5,2230e-05
I w [m⁶], t [m⁴]	0,0000e+00	3,3013e-06
Wel y, z [m³]	2,6068e-03	4,1784e-04
Wpl y, z [m³]	2,9896e-03	6,5252e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	125	235
alpha [deg]	0,00	
AL [m²/m]	1,9080e+00	

2.Vute

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H1	B1	stebri - I ng (336; 230; 230; 18; 18; 10)	Begin	top surface	1,000	Rela
H2	B4	stebri - I ng (336; 230; 230; 18; 18; 10)	End	top surface	1,000	Rela
H3	B3	prečke - I ng (470; 250; 250; 20; 20; 16)	Begin	top surface	1,000	Rela
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*S
H4	B2	prečke - I ng (470; 250; 250; 20; 20; 16)	End	top surface	1,000	Rela

3.Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version	*Student version*	*Student version*	*Student version*	*Stude
1	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
2	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
3	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
4	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
5	Linear - ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
6	Linear - ultimate	veter6	0,90
		sneg6	1,50
		g6	1,00
7	Linear - ultimate	veter6	1,50
		sneg6	0,75
		g6	1,00
8	Linear - ultimate	veter6	0,90
		g6	1,00
		sneg6.1	1,50
9	Linear - ultimate	veter6	1,50
		g6	1,00
		sneg6.1	0,75
10	Linear - ultimate	sneg11	1,50
		veter11	0,90
		g11	1,00
11	Linear - ultimate	sneg11	0,75
		veter11	1,50
		g11	1,00
12	Linear - ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
13	Linear - ultimate	veter11	1,50
		g11	1,00
		sneg11.1	0,75
MSU-streha	Linear - serviceability	lastna t	1,00
		g	1,00
		sneg	0,20
MSU-steber	Linear - serviceability	lastna t	1,00
		g	1,00
		veter-ms	0,20

4. Member 1D

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*
B1	stebri - I ng (336; 230; 230; 18; 18; 10)	5,000	Line	N1	N2	general (0)	standard	Layer1
B2	prečke - I ng (470; 250; 250; 20; 20; 16)	13,153	Line	N2	N3	general (0)	standard	Layer1
B3	prečke - I ng (470; 250; 250; 20; 20; 16)	13,153	Line	N3	N4	general (0)	standard	Layer1
B4	stebri - I ng (336; 230; 230; 18; 18; 10)	5,000	Line	N4	N5	general (0)	standard	Layer1

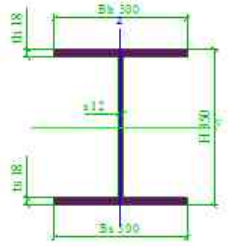
5.Notranje sile

Linear calculation, Extreme : Member, System : LCS
Selection : All
Class : ovo nica 1

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*S
B1	1/1	0,000	**-376,14**	-61,02	**356,47**
B1	5/2	5,000	**-34,80**	-9,44	0,00
B1	1/1	5,000	-369,80	**-70,83**	**0,00**
B1	5/2	0,000	-39,49	**6,91**	9,00
B2	1/1	0,000	**-126,24**	**354,73**	1,28
B2	5/2	13,153	**-3,98**	-1,46	255,12
B2	10/3	13,153	-22,94	**-83,21**	1135,80
B2	13/4	0,000	-29,14	106,18	**0,08**
B2	1/1	12,627	-73,43	2,04	**2297,55**
B3	1/1	13,153	**-126,83**	**-349,88**	1,34
B3	5/2	0,000	**-4,23**	-0,19	255,20
B3	6/5	0,000	-21,97	**80,56**	1119,22
B3	9/6	13,153	-27,52	-96,04	**0,11**
B3	1/1	0,263	-72,90	1,59	**2296,28**
B4	1/1	5,000	**-371,43**	**77,10**	**399,65**
B4	5/2	0,000	**-39,11**	**9,04**	0,00
B4	1/1	0,000	-365,10	72,15	**0,00**

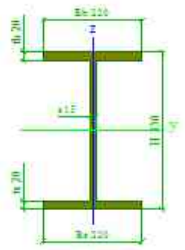
1.Prečni prerezi-tročlenski

Name	stebri	
Type	I ng	
Detailed	350; 300; 300; 18; 18; 12	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis		



A [m²]	1,4568e-02	
A y, z [m²]	1,4568e-02	1,4568e-02
I y, z [m⁴]	3,2886e-04	8,1045e-05
I w [m⁶], t [m⁴]	0,0000e+00	3,3245e-06
Wel y, z [m³]	1,8792e-03	5,4030e-04
Wpl y, z [m³]	2,0886e-03	8,2130e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	150	175
alpha [deg]	0,00	
AL [m²/m]	1,8760e+00	

Name	prečke	
Type	I ng	
Detailed	350; 220; 220; 20; 20; 15	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z		b
FEM analysis		



A [m²]	1,3450e-02	
A y, z [m²]	1,3450e-02	1,3450e-02
I y, z [m⁴]	2,7711e-04	3,5581e-05
I w [m⁶], t [m⁴]	0,0000e+00	2,9284e-06
Wel y, z [m³]	1,5835e-03	3,2346e-04
Wpl y, z [m³]	1,8124e-03	5,0144e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	110	175
alpha [deg]	0,00	
AL [m²/m]	1,5500e+00	

2.Vute

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H1	B1	stebri - I ng (350; 300; 300; 18; 18; 12)	End	top surface	1,000	Rela
H2	B4	stebri - I ng (350; 300; 300; 18; 18; 12)	Begin	top surface	1,000	Rela
H3	B2	prečke - I ng (350; 220; 220; 20; 20; 15)	Begin	top surface	6,000	Abso
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						

Name	Member	Cross-section	Position	Alignment	Length x	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H4	B3	prečke - I ng (350; 220; 220; 20; 20; 15)	End	top surface	6,000	Abso

3.Elementi

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version								
B1	stebri - I ng (350; 300; 300; 18; 18; 12)	5,000	Line	N1	N2	general (0)	standard	Layer1
B2	prečke - I ng (350; 220; 220; 20; 20; 15)	13,153	Line	N2	N3	general (0)	standard	Layer1
B3	prečke - I ng (350; 220; 220; 20; 20; 15)	13,153	Line	N3	N4	general (0)	standard	Layer1
B4	stebri - I ng (350; 300; 300; 18; 18; 12)	5,000	Line	N4	N5	general (0)	standard	Layer1

4.Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student v			
1	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
2	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
3	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
4	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
5	Linear - ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
6	Linear - ultimate	veter6	0,90
		sneg6	1,50
		g6	1,00
7	Linear - ultimate	veter6	1,50
		sneg6	0,75
		g6	1,00
8	Linear - ultimate	veter6	0,90
		g6	1,00
		sneg6.1	1,50
9	Linear - ultimate	veter6	1,50
		g6	1,00
		sneg6.1	0,75
10	Linear - ultimate	sneg11	1,50
		veter11	0,90
		g11	1,00
11	Linear - ultimate	sneg11	0,75
		veter11	1,50
		g11	1,00
12	Linear - ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student v			
13	Linear - ultimate	veter11	1,50
		g11	1,00
		Student version *Student ver	*Student version*

Name	Type	Load cases	Coeff. [-]
Student version	*Student version*	*Student version*	*Student version* *Student version* *Student v
13	Ultimate	sneg11.1	0,75
MSU-streha	Linear - serviceability	lastna t	1,00
		g	1,00
		sneg	0,20
MSU-steber	Linear - serviceability	lastna t	1,00
		g	1,00
		veter-ms	0,20

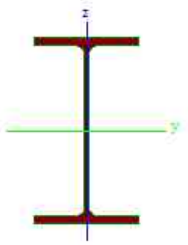
5. Notranje sile

Linear calculation, Extreme : Member, System : LCS
Selection : All
Class : ovo nica 1

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*St
B1	1/1	0,000	**-366,96**	-321,45	**7,34**
B1	5/2	5,000	**-24,89**	-30,53	-106,57
B1	1/1	5,000	-357,84	**-331,26**	**-1566,41**
B1	5/2	0,000	-31,65	**-14,18**	0,63
B2	1/1	0,000	**-381,82**	**303,31**	**-1543,20**
B2	5/2	13,153	**-24,47**	-6,92	0,00
B2	10/3	13,153	-157,07	**-105,98**	0,00
B2	10/3	8,861	-173,49	3,96	**218,93**
B3	1/1	13,153	**-382,92**	**-301,77**	**-1586,46**
B3	5/2	0,000	**-25,42**	0,75	0,00
B3	6/4	0,000	-154,66	**100,04**	0,00
B3	6/4	4,292	-171,08	-7,78	**196,43**
B4	1/1	5,000	**-365,60**	**337,54**	**7,31**
B4	5/2	0,000	**-33,78**	**30,12**	-164,44
B4	1/1	0,000	-356,48	332,59	**-1610,18**

1.Prečni prerezi-enočlenski

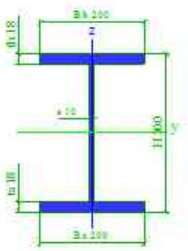
Name	stebri	
Type	HEA550	
Source description	Profil Arbed / Structural shapes / Edition ctobre 1995	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z		b



A [m²]	2,1200e-02	
A y, z [m²]	1,2393e-02	6,3018e-03
I y, z [m⁴]	1,1200e-03	1,0800e-04
I w [m⁶], t [m⁴]	7,2451e-06	3,5200e-06
Wel y, z [m³]	4,1500e-03	7,2100e-04
Wpl y, z [m³]	4,6200e-03	1,1080e-03
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	150	270
alpha [deg]	0,00	
AL [m²/m]	2,2083e+00	

Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Stude

Name	prečke	
Type	I ng	
Detailed	300; 200; 200; 18; 18; 10	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z		b
FEM analysis		



A [m²]	9,8400e-03	
A y, z [m²]	9,8400e-03	9,8400e-03
I y, z [m⁴]	1,5867e-04	2,4022e-05
I w [m⁶], t [m⁴]	0,0000e+00	1,4605e-06
Wel y, z [m³]	1,0578e-03	2,4022e-04
Wpl y, z [m³]	1,1894e-03	3,6660e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	100	150
alpha [deg]	0,00	
AL [m²/m]	1,3800e+00	

2. Haunch

Name	Member	Cross-section	Position	Alignment	Length x [m]	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *S						
H1	B2	prečke - I ng (300; 200; 200; 18; 18; 10)	Begin	top surface	7,000	Abso
H2	B3	prečke - I ng (300; 200; 200; 18; 18; 10)	End	top surface	7,000	Abso

3.Elementi

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*
B1	stebri - HEA550	5,000	Line	N1	N2	general (0)	standard	Layer1
B2	prečke - I ng (300; 200; 200; 18; 18; 10)	13,153	Line	N2	N3	general (0)	standard	Layer1
B3	prečke - I ng (300; 200; 200; 18; 18; 10)	13,153	Line	N3	N4	general (0)	standard	Layer1
B4	stebri - HEA550	5,000	Line	N4	N5	general (0)	standard	Layer1

4.Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version	*Student version*	*Student version*	*Student version*
1	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
2	Linear - ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
3	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
4	Linear - ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
5	Linear - ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
6	Linear - ultimate	veter6	0,90
		sneg6	1,50
		g6	1,00
7	Linear - ultimate	veter6	1,50
		sneg6	0,75
		g6	1,00
8	Linear - ultimate	veter6	0,90
		g6	1,00
		sneg6.1	1,50
9	Linear - ultimate	veter6	1,50
		g6	1,00
		sneg6.1	0,75
10	Linear - ultimate	sneg11	1,50
		veter11	0,90
		g11	1,00
11	Linear - ultimate	sneg11	0,75
		veter11	1,50
		g11	1,00
12	Linear - ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
13	Linear - ultimate	veter11	1,50
		g11	1,00
		sneg11.1	0,75

5. Notranje sile

Linear calculation, Extreme : Member, System : LCS
Selection : All

Class : ovo nica 1

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version* *St
B1	1/1	0,000	**-366,56**	-492,84	**1203,00**
B1	5/2	5,000	**-23,70**	-40,33	-96,02
B1	1/1	5,000	-355,54	**-502,65**	**-1285,70**
B1	5/2	0,000	-31,86	**-23,98**	64,78
B2	1/1	0,000	**-550,86**	**274,98**	**-1161,76**
B2	5/2	13,153	**-34,48**	-6,36	0,00
B2	10/3	13,153	-251,49	**-96,89**	0,00
B2	10/3	9,461	-265,62	-2,32	**183,13**
B3	1/1	13,153	**-551,32**	**-269,23**	**-1149,86**
B3	5/2	0,000	**-34,80**	4,30	0,00
B3	6/4	0,000	-247,91	**94,18**	0,00
B3	6/4	3,692	-262,03	1,28	**175,01**
B4	1/1	5,000	**-360,95**	**508,92**	**1258,32**
B4	5/2	0,000	**-28,42**	**39,93**	-101,37
B4	1/1	0,000	-349,93	503,97	**-1273,91**

NEMETSCHEK Scia

Project	-
Part	-
Description	-
Author	-

1. Check of steel

Linear calculation, Extreme : Member
Selection : All
Combinations : dimenzi e

EN 1993-1-1 Code Check

Member B1	IPE200	S 355	dimenzije/1	0.91

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version*	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *S		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 28.39 on position 0.600 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	58.58
maximum ratio	2	67.53
maximum ratio	3	100.89

== Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 4.14 on position 0.600 m

ratio		
Student version *Student version* *Student vers		
maximum ratio	1	7.32
maximum ratio	2	8.14
maximum ratio	3	11.82

== Class cross-section 1
The critical check is on position 6.000 m

Internal forces		
Student version *Student version* *Student version		
NEd	0.00	kN
Vy,Ed	5.95	kN
Vz,Ed	-39.82	kN
T Ed	0.00	kNm
My,Ed	-41.58	kNm
Mz,Ed	6.23	kNm

Shear check (Vy)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version*		
Vc,Rd	374.09	kN
Unity check	0.02	-

Shear check (Vz)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version*		
Vc,Rd	287.27	kN
Unity check	0.14	-

Bending moment check (My)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 1.

NEMETSCHEK Scia

Project	-
Part	-
Description	-
Author	-

Table of values		
Student version	*Student version*	*Student version*
Mc,Rd	78.31	kNm
Unity check	0.53	-

Bending moment check (Mz)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 1.

Table of values		
Student version	*Student version*	*Student version*
Mc,Rd	15.84	kNm
Unity check	0.39	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.41)
Section classification is 1.

Table of values		
Student version	*Student version*	*Student version*
MNVy.Rd	78.31	kNm
MNVz.Rd	15.84	kNm

alfa	2.00	beta	1.00
Unity check	0.68	-	

Element satisfies the section check !

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

Lateral Torsional Buckling Check
According to article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version	*Student version*	*Student version* *Student version* *Student ver
Method for LTB curve	Art. 6.3.2.2.	
Wy	2.2060e-04	m^3
Elastic critical moment Mcr	158.79	kNm
Relative slenderness Lambda,LT	0.70	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	a	
Imperfection Alpha,LT	0.21	
Reduction factor Chi,LT	0.85	
Buckling resistance Mb.Rd	66.31	kNm
Unity check	0.63	-

Mcr Parameters		
Student version	*Student version*	*Student versior
LTB length	1.998	m
k	1.00	
kw	1.00	
C1	1.66	
C2	0.78	
C3	0.41	

Note: C Parameters according to ECCS 119 2006 / Galea 2002
load in center of gravity

Compression and bending check
According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version	*Student version*	*Student version* *Student versio
kyy	1.014	
kyz	0.701	
kzy	0.522	
kzz	1.000	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.8500e-03	m^2
Wy	2.2060e-04	m^3
Wz	4.4610e-05	m^3
NRk	1011.75	kN
Student version	*Student version*	*Student version* *Student versio

NEMETSCHEK Scia

Project -
Part -
Description -
Author -

Table of values		
Student version	*Student version*	*Student version
My,Rk	78.31	kNm
Mz,Rk	15.84	kNm
My,Ed	-41.58	kNm
Mz,Ed	6.23	kNm
Interaction Method 1		
Mcr0	95.68	kNm
reduced slenderness 0	0.90	
Psi y	0.000	
Psi z	0.000	
Cmy,0	1.000	
Cmz,0	1.000	
Cmy	1.000	
Cmz	1.000	
CmLT	1.000	
muy	1.000	
muz	1.000	
wy	1.135	
wz	1.500	
npl	-0.000	
aLT	0.996	
bLT	0.101	
cLT	0.033	
dLT	0.003	
eLT	0.006	
Cyy	0.986	
Cyz	0.984	
Czy	1.000	
Czz	1.000	

Unity check (6.61) = 0.00 + 0.64 + 0.28 = 0.91
Unity check (6.62) = 0.00 + 0.33 + 0.39 = 0.72

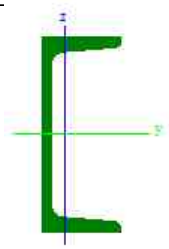
Shear buckling check
in buckling field 1
According to article EN 1993-1-5 : 5. 7.1. and formula (5.10) (7.1)

Table of values	
Student version	*Student version*
hw/t	32.679

The web slenderness is such that the Shear Buckling Check is not required.
Element satisfies the stability check !

1.Prečni prerez-stranska fasada

Name	CS3	
Type	U160	
Source description	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z		c



A [m²]	2,4000e-03	
A y, z [m²]	6,7635e-04	9,9291e-04
I y, z [m⁴]	9,2500e-06	8,5300e-07
I w [m⁶], t [m⁴]	3,2600e-09	7,3900e-08
Wel y, z [m³]	1,1600e-04	1,8300e-05
Wpl y, z [m³]	1,3760e-04	3,8800e-05
d y, z [mm]	-40	0
c YLCS, ZLCS [mm]	19	80
alpha [deg]	0,00	
AL [m²/m]	5,4468e-01	

2. Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student ve			
stranskavetrna-msn	linear - ultimate	lastna	1,35
		panel	1,35
		veter	1,50
stranskavetrna-msu	linear - serviceability	lastna	1,00
		panel	1,00
		veter	0,20

3. Notranje sile

Linear calculation, Extreme : Member, System : Principal
Selection : All
Combinations : stranskavetrna-msn

Member	Case	dx [m]	My [kNm]	Mz [kNm]
Student version *Student version* *Student version* *Student version* *Student version* *Stu				
B1	stranskavetrna-msn/1	6,000	**-3,81**	**5,18**
B1	stranskavetrna-msn/1	2,000	**2,74**	**-3,72**

4.Pomiki

Linear calculation, Extreme : Global, System : Principal
Selection : All
Combinations : stranskavetrna-msu

Case - combination	Member	dx [m]	uy [mm]	uz [mm]
Student version *Student version* *Student version* *Student version* *Student version* *Stu				
stranskavetrna-msu/2	B1	0,000	**0,0**	**0,0**
stranskavetrna-msu/2	B1	3,000	**8,4**	**-3,2**

5. Kontrola

Linear calculation, Extreme : Member
Selection : All
Combinations : stranskavetrna-msn

EN 1993-1-1 Code Check

Member B1	U160	S 355	stranskavetrna-	0.92

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 15.73 on position 14.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	26.85
maximum ratio	2	30.92
maximum ratio	3	35.28

== Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 4.48 on position 14.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	7.32
maximum ratio	2	8.14
maximum ratio	3	17.07

== Class cross-section 1
The critical check is on position 18.000 m

Internal forces		
Student version *Student version* *Student version*		
NEd	0.00	kN
Vy,Ed	4.15	kN
Vz,Ed	-3.05	kN
TEd	0.00	kNm
My,Ed	-3.07	kNm
Mz,Ed	4.17	kNm

Shear check (Vy)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version* *		
Vc,Rd	241.03	kN
Unity check	0.02	-

Shear check (Vz)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version* *		
Vc,Rd	250.87	kN
Unity check	0.01	-

Bending moment check (My)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 1.

Table of values		
Student version	*Student version*	*Student version* *
Mc,Rd	48.85	kNm
Unity check	0.06	-

Bending moment check (Mz)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 1.

Table of values		
Student version	*Student version*	*Student version* *
Mc,Rd	13.77	kNm
Unity check	0.30	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.41)
Section classification is 1.

Table of values		
Student version	*Student version*	*Student version* *
MNVy.Rd	48.85	kNm
MNVz.Rd	13.77	kNm

alfa	1.00	beta	1.00
Unity check	0.37	-	

Element satisfies the section check!

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

Lateral Torsional Buckling Check
According to article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version *Student version* *Student version*	*Student version*	*Student version
Method for LTB curve	Art. 6.3.2.2.	
Wy	1.1600e-04	m^3
Elastic critical moment Mcr	17.39	kNm
Relative slenderness Lambda,LT	1.54	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	d	
Imperfection Alpha,LT	0.76	
Reduction factor Chi,LT	0.27	
Buckling resistance Mb.Rd	10.97	kNm
Unity check	0.28	-

Mcr Parameters		
Student version	*Student version*	*Student version*
LTB length	6.000	m
k	1.00	
kw	1.00	
C1	2.51	
C2	1.48	
C3	0.41	

Note: C Parameters according to ECCS 119 2006 / Galea 2002
load in center of gravity

Compression and bending check
According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version	*Student version*	*Student version* *
kyy	1.000	
kyz	1.000	
kzy	1.000	
kzz	1.000	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.4000e-03	m^2
Wy	1.1600e-04	m^3
Wz	1.8300e-05	m^3
NRk	852.00	kN
Student version	*Student version*	*Student version* *

Table of values		
Student version	*Student version*	*Student version*
My,Rk	41.18	kNm
Mz,Rk	6.50	kNm
My,Ed	-3.07	kNm
Mz,Ed	4.17	kNm
Interaction Method 1		
Mcr0	17.39	kNm
reduced slenderness 0	1.54	
Psi y	0.910	
Psi z	0.909	
Cmy,0	1.000	
Cmz,0	1.000	
Cmy	1.000	
Cmz	1.000	
CmLT	1.000	
muy	1.000	
muz	1.000	
wy	1.186	
wz	1.500	
npl	-0.000	
aLT	0.992	
bLT	0.084	
cLT	0.018	
dLT	0.001	
eLT	0.002	
Cyy	0.984	
Cyz	0.991	
Czy	1.000	
Czz	1.000	

Unity check (6.61) = 0.00 + 0.28 + 0.64 = 0.92
Unity check (6.62) = 0.00 + 0.28 + 0.64 = 0.92

Shear buckling check
in buckling field 1
According to article EN 1993-1-5 : 5. 7.1. and formula (5.10) (7.1)

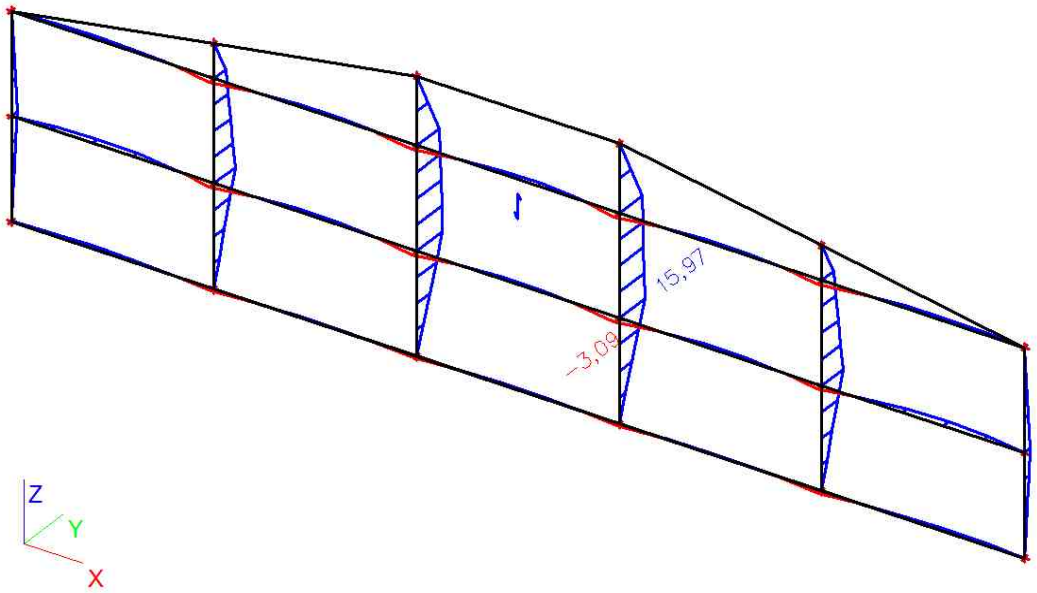
Table of values	
Student version	*Student version* *Student
hw/t	18.533

The web slenderness is such that the Shear Buckling Check is not re uired.
Element satisfies the stability check!

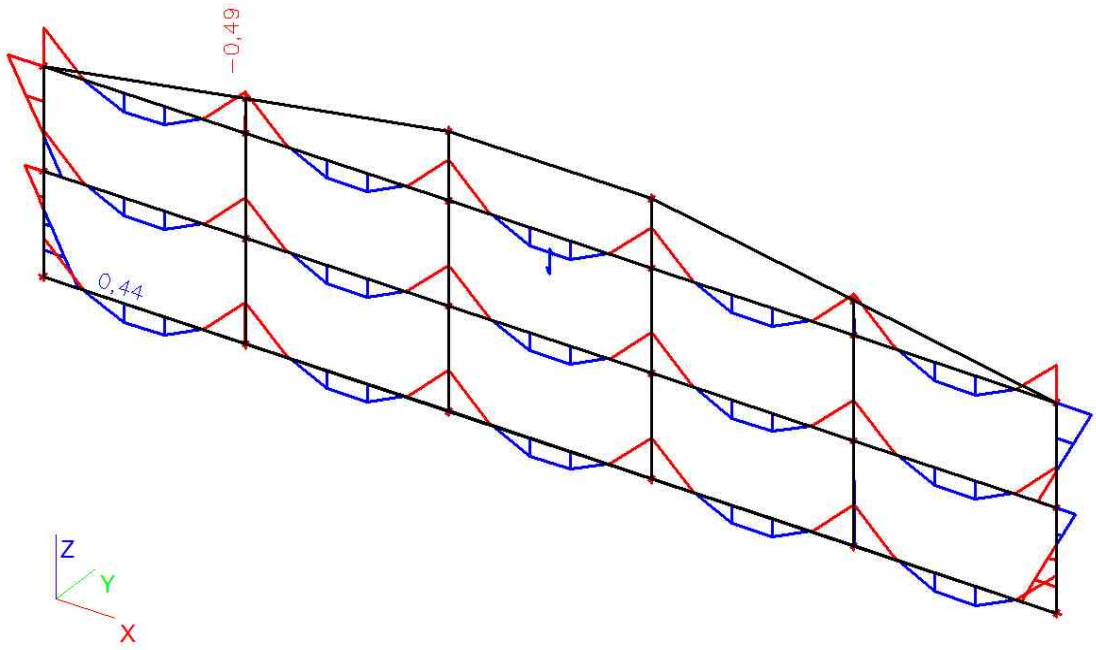
1. Kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version*		*Student version*	*Student version
msn	Linear - ultimate	LC1	1,35
		veter	1,50
msu	Linear - serviceability	LC1	1,00
		veter	0,20

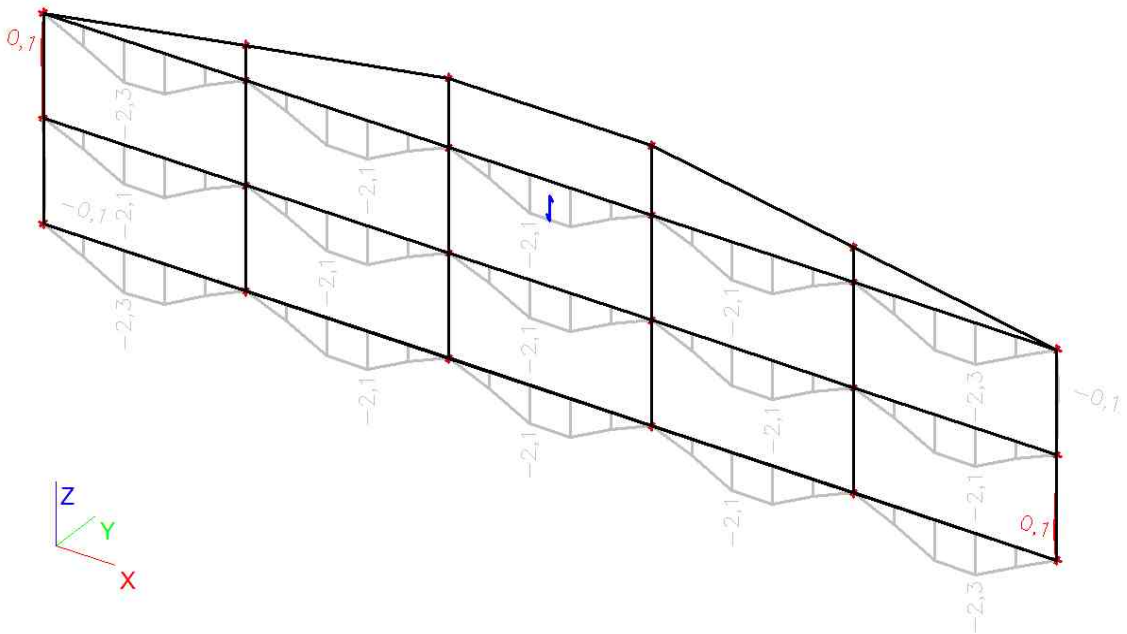
2. Mz



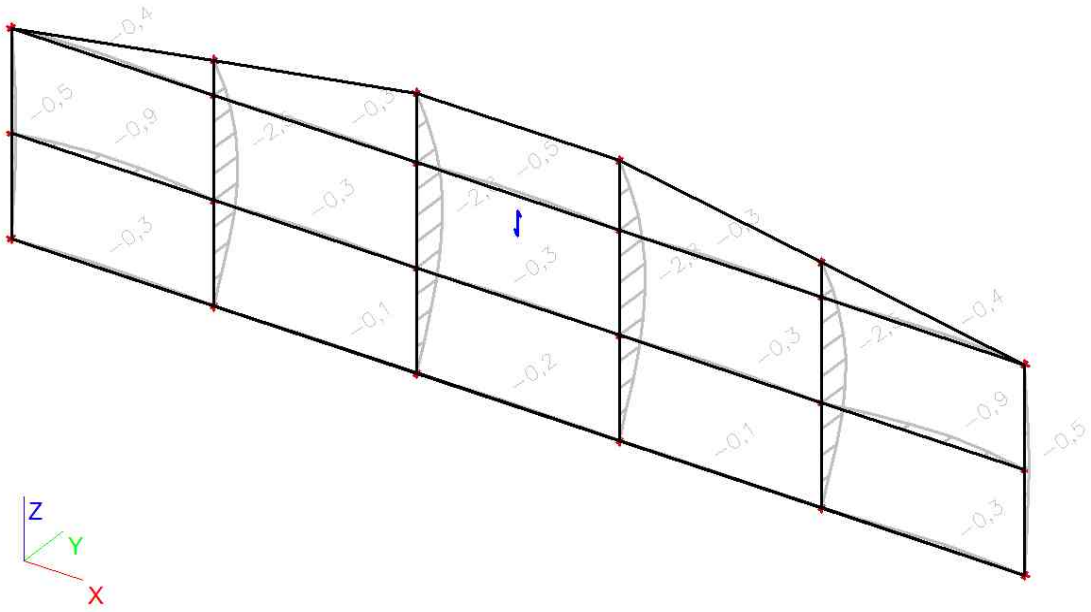
3. My



4. Mz

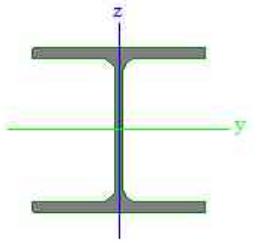


5. uy



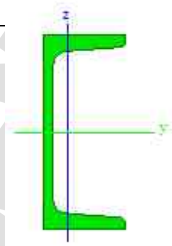
1.Prečni prerezi- fasada F4

Name	stebrički	
Type	HEA140	
Source description	Profil Arbed / Structural shapes / Edition ctobre 1995	
Item material	S 275	
Fabrication	rolled	
Buckling y-y, z-z		c



A [m²]	3,1400e-03	
A y, z [m²]	2,0441e-03	6,3677e-04
I y, z [m⁴]	1,0300e-05	3,8900e-06
I w [m⁶], t [m⁴]	1,5108e-08	8,1300e-08
Wel y, z [m³]	1,5500e-04	5,5600e-05
Wpl y, z [m³]	1,7400e-04	8,4800e-05
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	70	67
alpha [deg]	0,00	
AL [m²/m]	7,9430e-01	

Name	u profili	
Type	U140	
Source description	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z		c

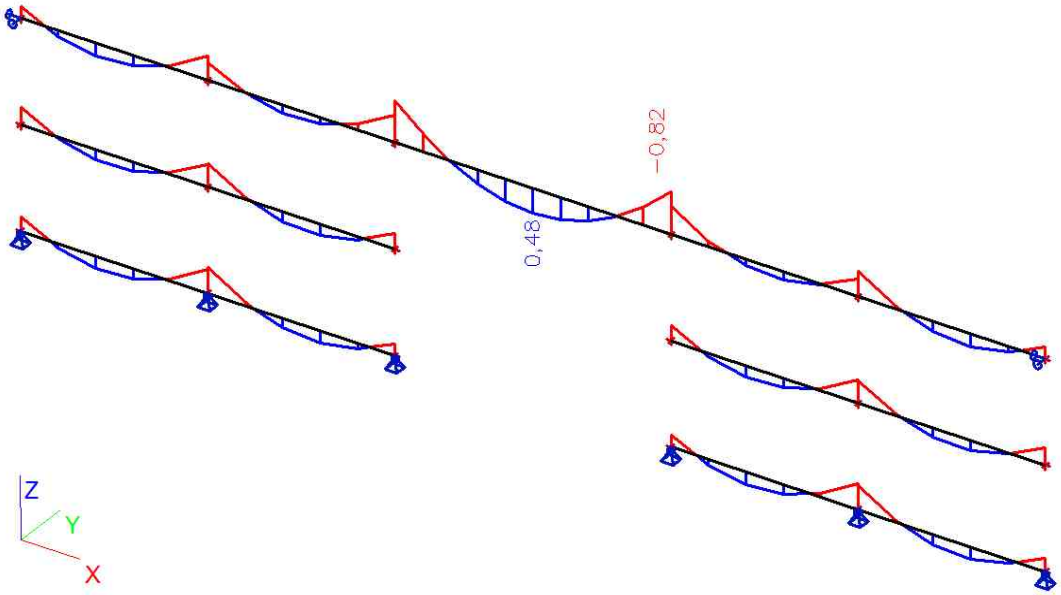


A [m²]	2,0400e-03	
A y, z [m²]	6,1502e-04	8,0274e-04
I y, z [m⁴]	6,0500e-06	6,2700e-07
I w [m⁶], t [m⁴]	1,8000e-09	5,6800e-08
Wel y, z [m³]	8,6400e-05	1,4800e-05
Wpl y, z [m³]	1,0280e-04	3,0800e-05
d y, z [mm]	-38	0
c YLCS, ZLCS [mm]	18	70
alpha [deg]	0,00	
AL [m²/m]	4,8709e-01	

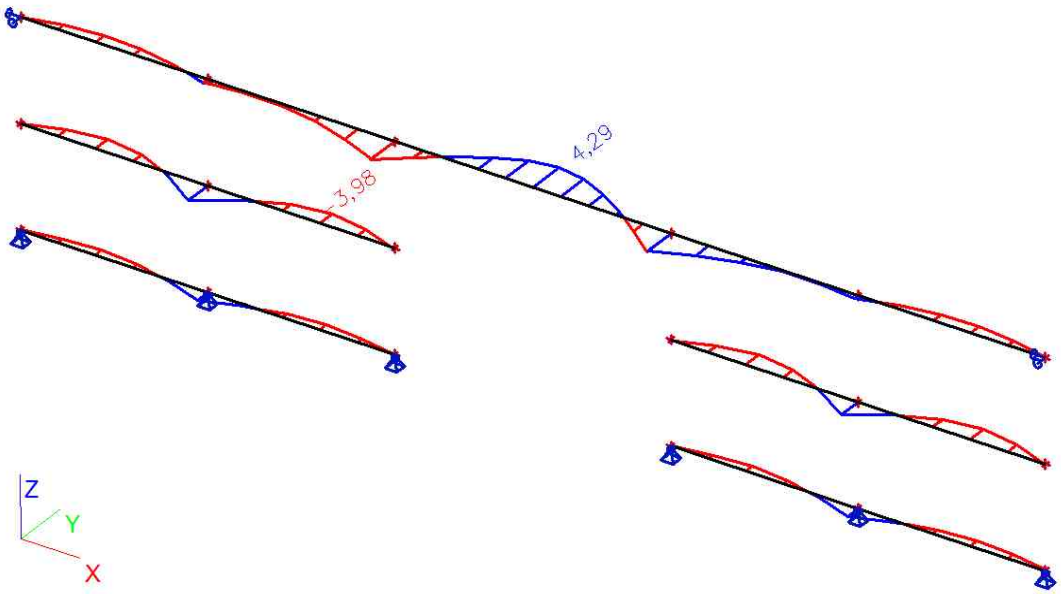
2.Kombinacije

Name	Type	Load cases	Coeff. [-]
msn	Linear - ultimate	LC1	1,35
		veter	1,50
msu	Linear - serviceability	LC1	1,00
		veter	0,20

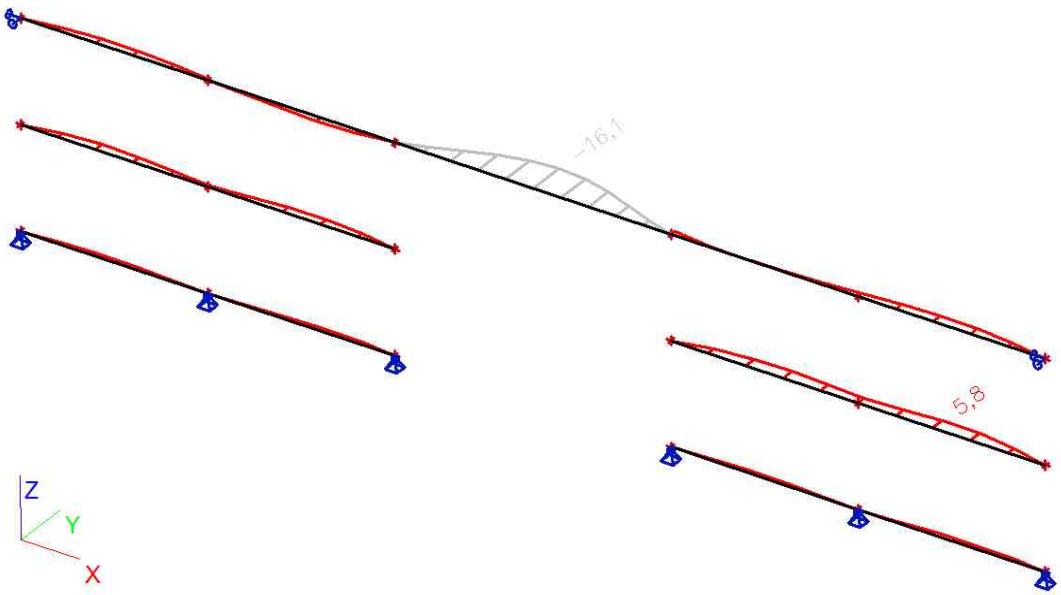
3.My



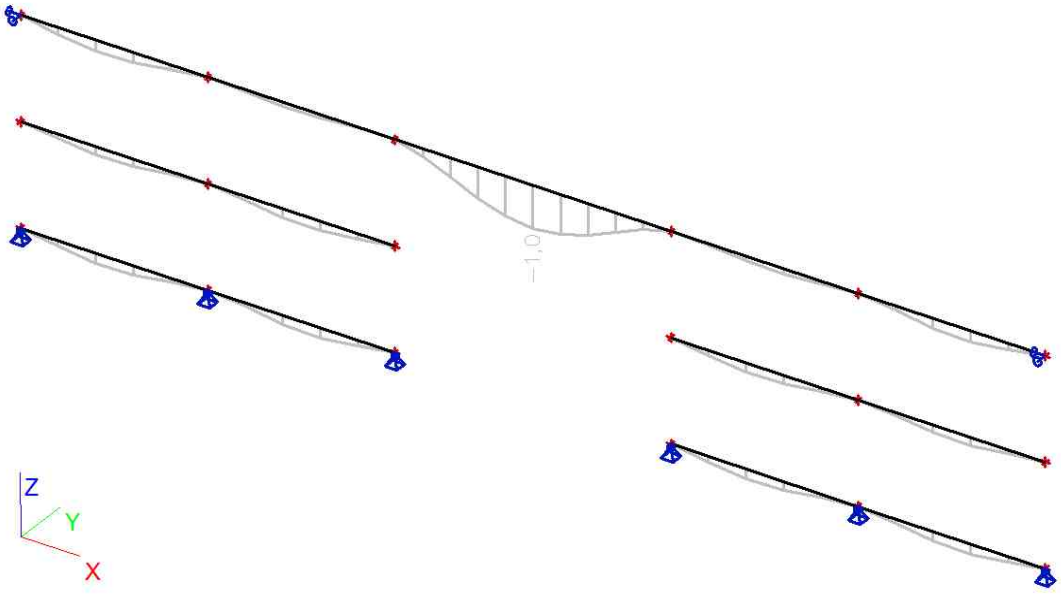
4.Mz



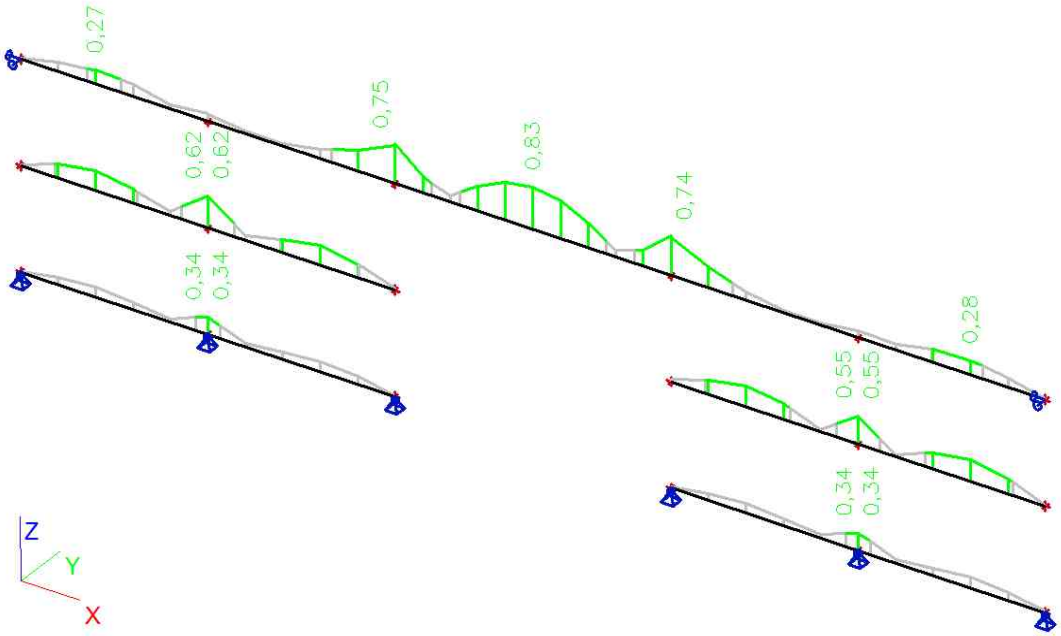
5.uy



6.uz

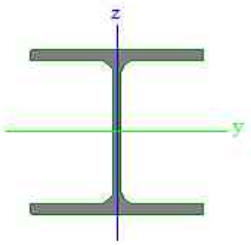


7.Kontrola prerezov



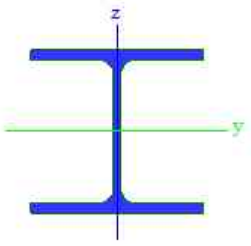
1.Prečni prerezi-okvir vrat

Name	stebri	
Type	HEA140	
Source description	Profil Arbed / Structural shapes / Edition ctobre 1995	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z		c



A [m²]	3,1400e-03	
A y, z [m²]	2,0441e-03	6,3677e-04
I y, z [m⁴]	1,0300e-05	3,8900e-06
I w [m⁶], t [m⁴]	1,5108e-08	8,1300e-08
Wel y, z [m³]	1,5500e-04	5,5600e-05
Wpl y, z [m³]	1,7400e-04	8,4800e-05
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	70	67
alpha [deg]	0,00	
AL [m²/m]	7,9430e-01	

Name	nosilec vrat	
Type	HEA140	
Source description	Profil Arbed / Structural shapes / Edition ctobre 1995	
Item material	S 355	
Fabrication	rolled	
Buckling y-y, z-z		c



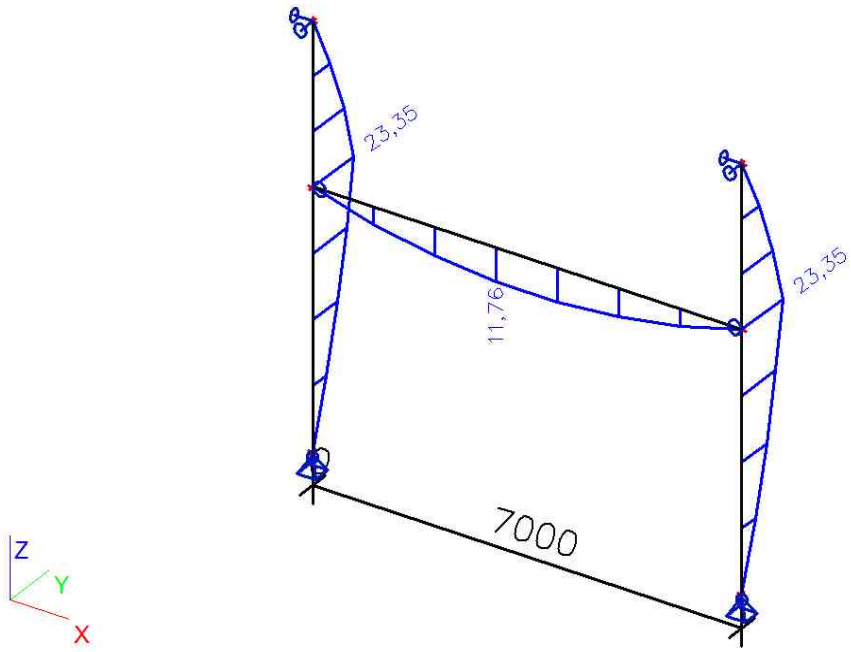
A [m²]	3,1400e-03	
A y, z [m²]	2,0441e-03	6,3677e-04
I y, z [m⁴]	1,0300e-05	3,8900e-06
I w [m⁶], t [m⁴]	1,5108e-08	8,1300e-08
Wel y, z [m³]	1,5500e-04	5,5600e-05
Wpl y, z [m³]	1,7400e-04	8,4800e-05
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	70	67
alpha [deg]	0,00	
AL [m²/m]	7,9430e-01	

2.Kombinacije

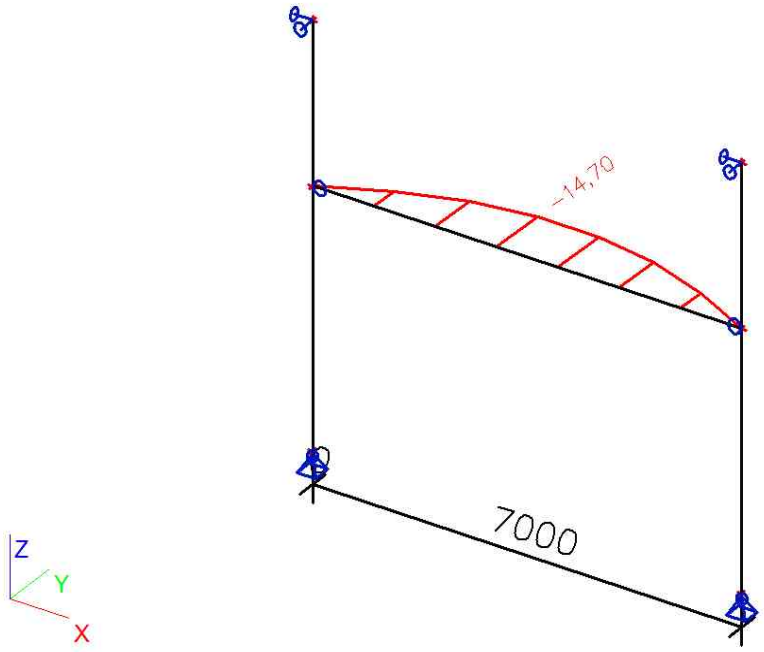
Name	Type	Load cases		Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu				
msn	Ultimate	LC1		1,35
		panel		1,35
		vrata		1,35
		veter		1,50

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu			
msu	Linear - serviceability	LC1	1,00
		panel	1,00
		vrata	1,00
		veter	0,20

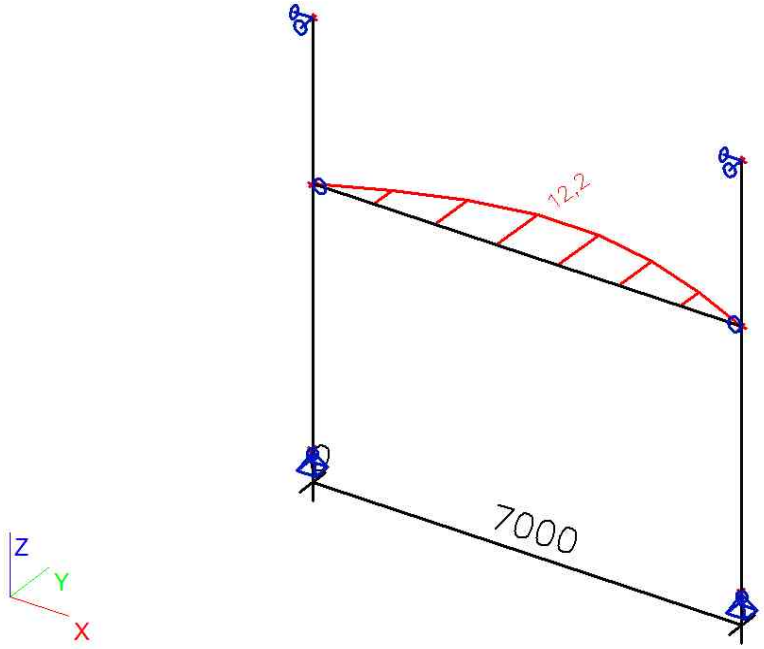
3.My



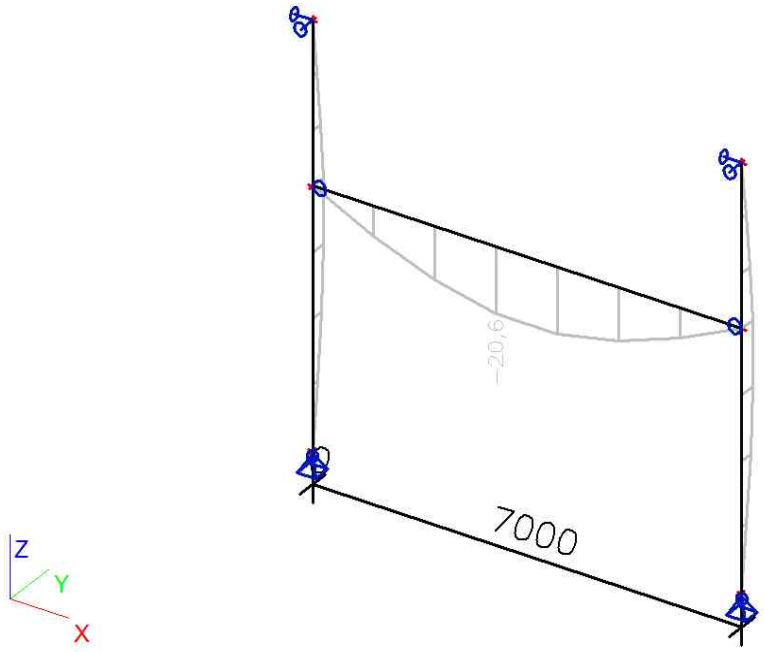
4.Mz



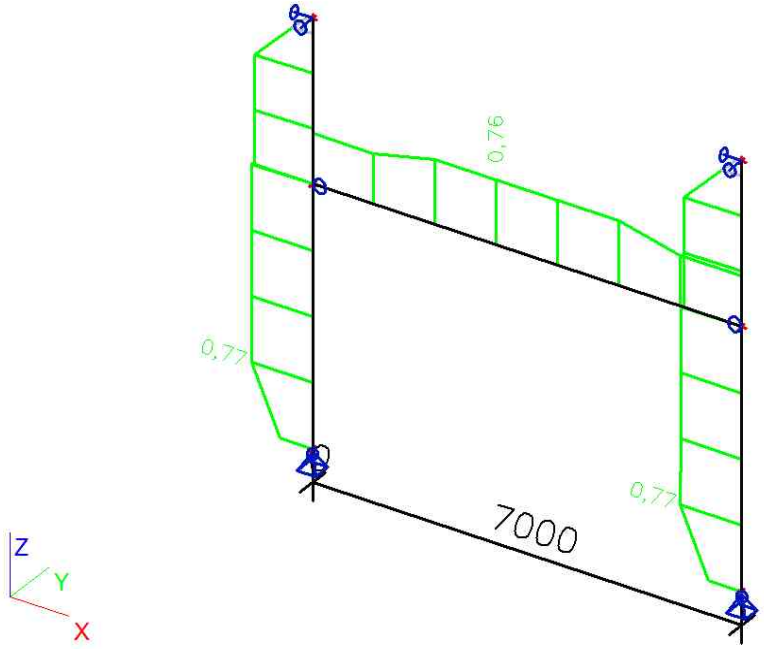
5.My



6.uz



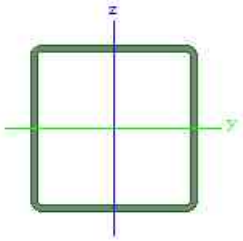
7 Kontrola prerezov



NEMETSCHEK Scia

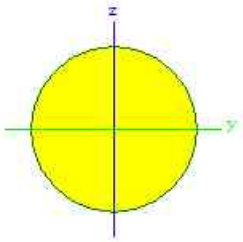
1. Cross-sections

Name	tlačene palice-notran e	
Type	SHS100/100/4.0	
Source description	British Standard / BS EN 10219-2:1997 / Part 2	
Item material	S 275	
Fabrication	cold formed	
Buckling y-y, z-z	c	c



A [m²]	1,5200e-03	
A y, z [m²]	7,6000e-04	7,6000e-04
I y, z [m⁴]	2,3200e-06	2,3200e-06
I w [m⁶], t [m⁴]	3,3333e-09	3,6100e-06
Wel y, z [m³]	4,6400e-05	4,6400e-05
Wpl y, z [m³]	5,3981e-05	5,3981e-05
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	50	50
alpha [deg]	0,00	
AL [m²/m]	3,8965e-01	

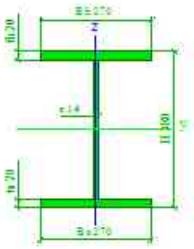
Name	diagonale	
Type	RD22	
Source description	Stahl im Hochbau / 14.Auflage Band I / Teil 1	
Item material	S 275	
Fabrication	rolled	
Buckling y-y, z-z	c	c
FEM analysis	×	



A [m²]	3,7994e-04	
A y, z [m²]	3,2295e-04	3,2295e-04
I y, z [m⁴]	1,1258e-08	1,1258e-08
I w [m⁶], t [m⁴]	0,0000e+00	2,2516e-08
Wel y, z [m³]	1,0235e-06	1,0235e-06
Wpl y, z [m³]	1,7467e-06	1,7467e-06
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	0	0
alpha [deg]	0,00	
AL [m²/m]	6,9112e-02	

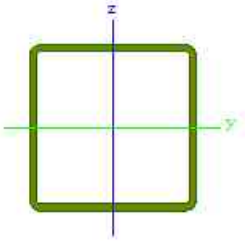
Name	CS3	
Type	I ng	
Detailed	380; 270; 270; 20; 20; 14	
Item material	S 275	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis	✓	

NEMETSCHEK Scia



A [m²]	1,5560e-02	
A y, z [m²]	9,8525e-03	5,2500e-03
I y, z [m⁴]	3,9613e-04	6,5688e-05
I w [m⁶], t [m⁴]	2,1192e-06	1,6237e-06
Wel y, z [m³]	2,0849e-03	4,8658e-04
Wpl y, z [m³]	2,3486e-03	7,4566e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	135	190
alpha [deg]	0,00	
AL [m²/m]	1,8120e+00	

Name	tlačene palice-zunan e	
Type	SHS120/120/5.0	
Source description	British Standard / BS 5950 part 1 : 1990 EN 10210-2	
Item material	S 275	
Fabrication	rolled	
Buckling y-y, z-z	a	a

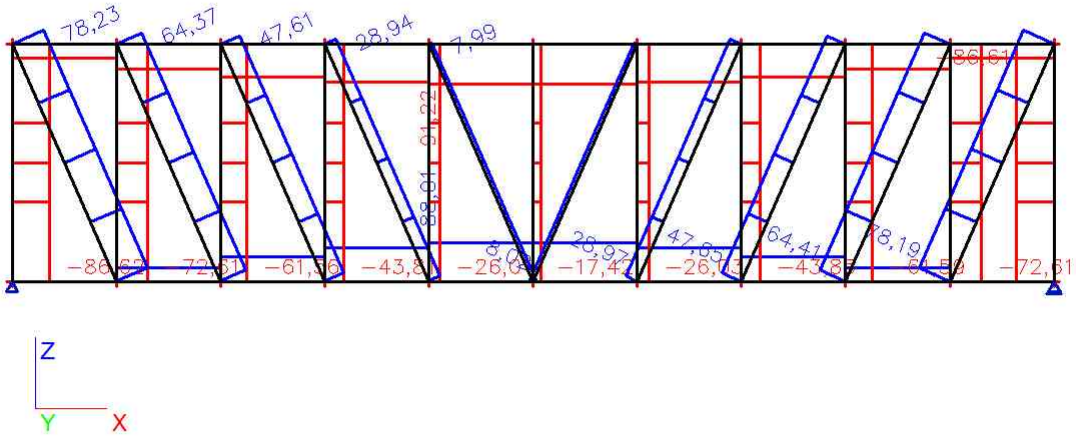


A [m²]	2,2700e-03	
A y, z [m²]	1,1350e-03	1,1350e-03
I y, z [m⁴]	4,9800e-06	4,9800e-06
I w [m⁶], t [m⁴]	1,0368e-08	7,7700e-06
Wel y, z [m³]	8,3000e-05	8,3000e-05
Wpl y, z [m³]	9,6726e-05	9,6726e-05
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	60	60
alpha [deg]	0,00	
AL [m²/m]	4,6706e-01	

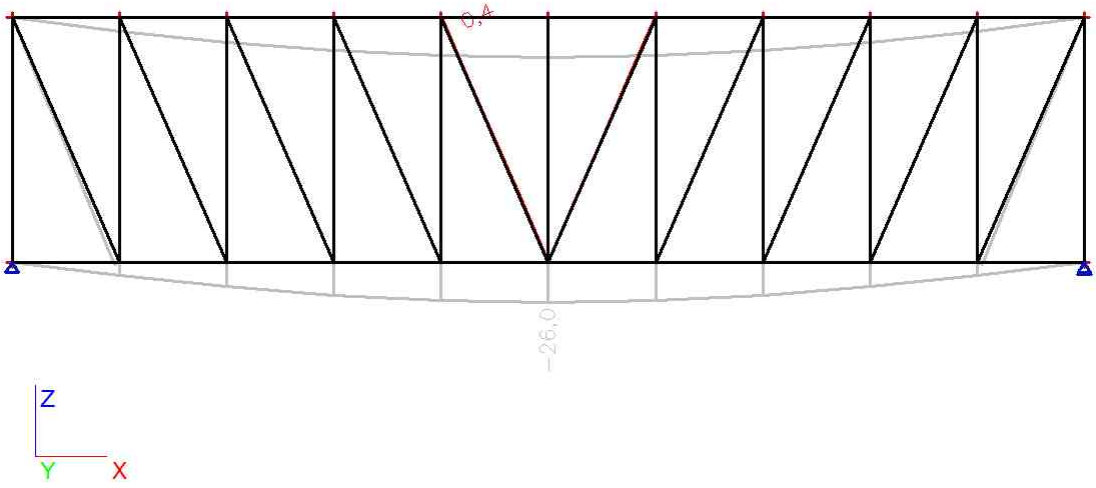
2. Combinations

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *			
L/1000	Linear - ultimate	veter	1,50
		izbočne/1000	1,00

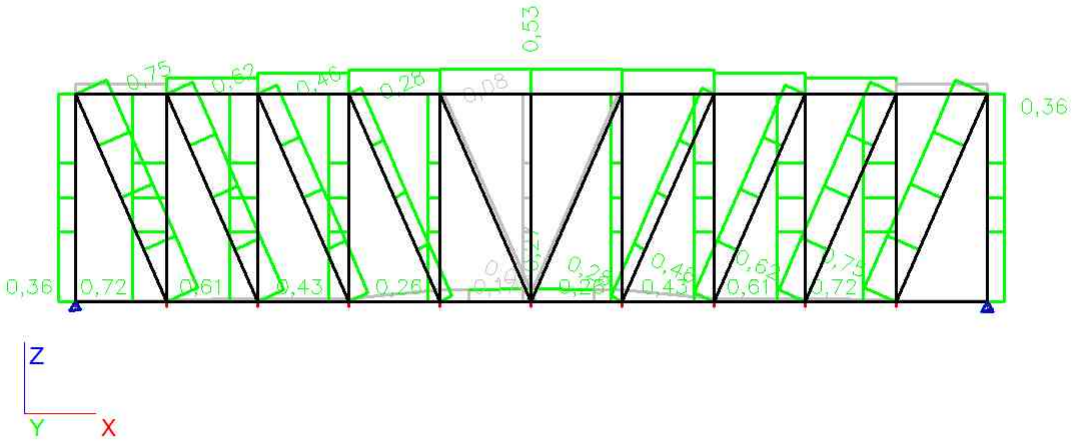
3. Osne sile



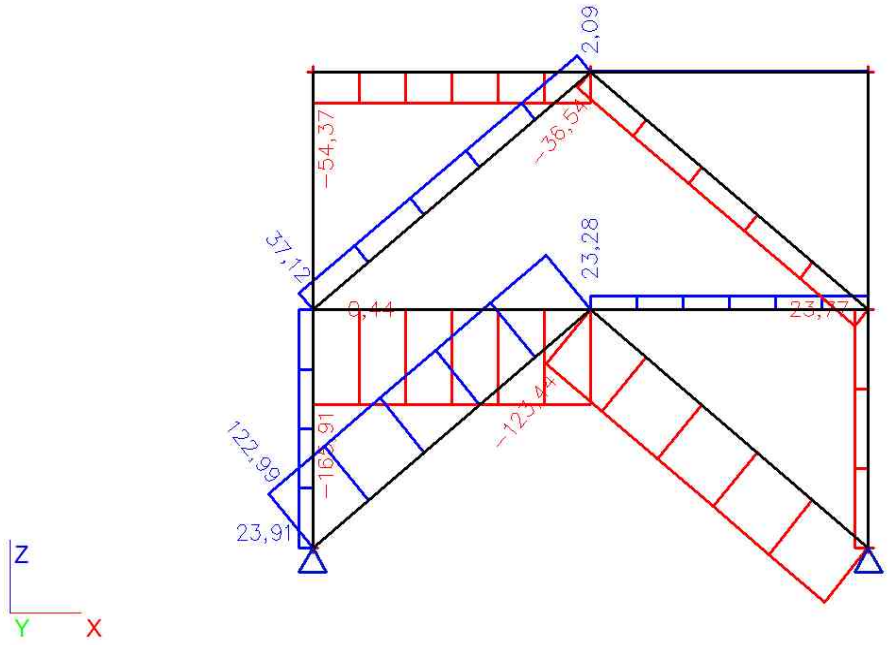
4. pomik povezja



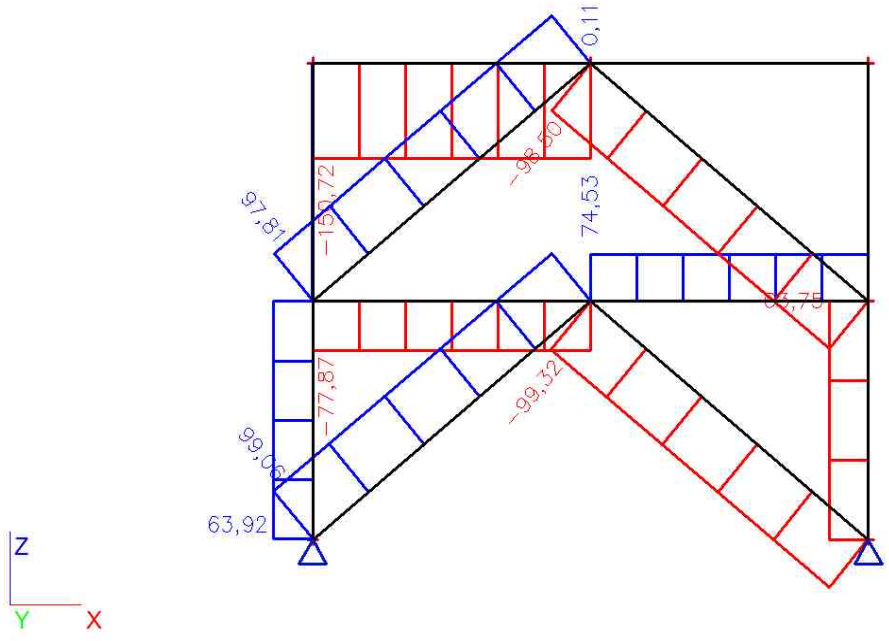
5. Kontrola prerezov



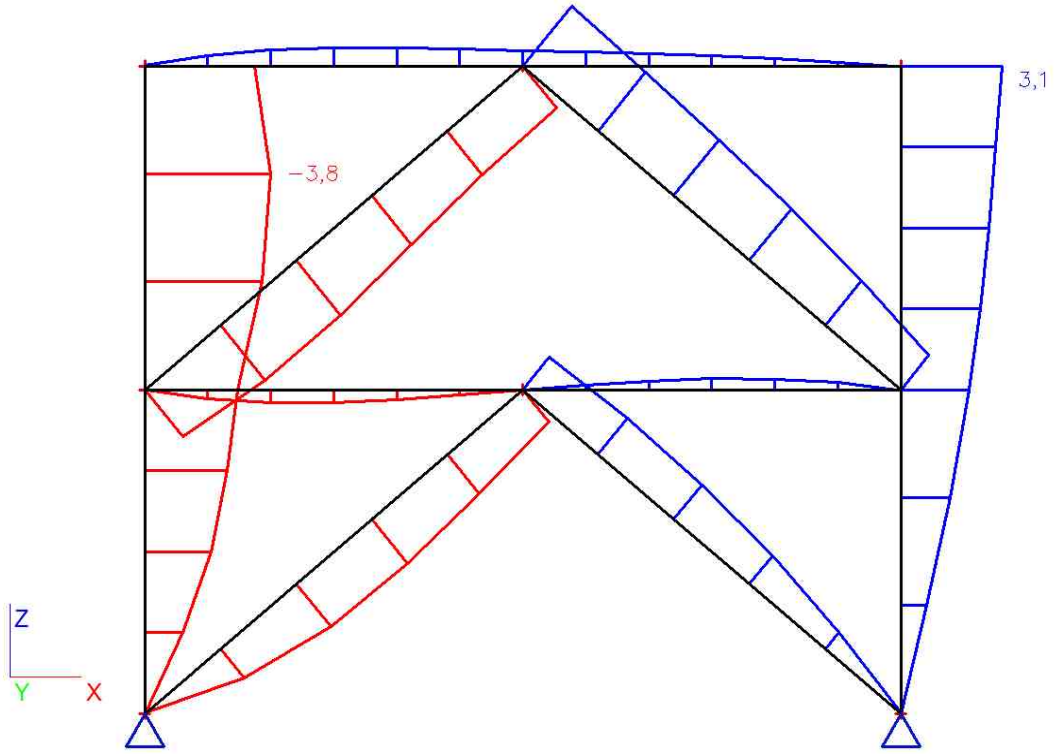
1. Osne sile-obtežba vetra in izbočne sile



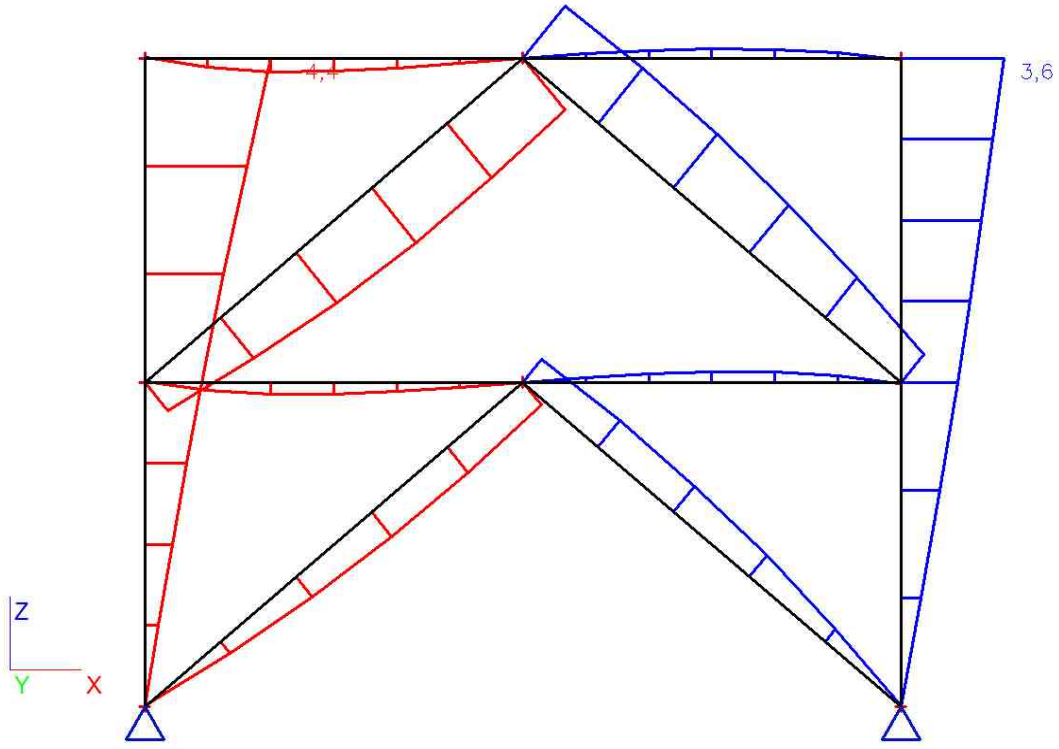
2. Osne sile - potresna obtežba



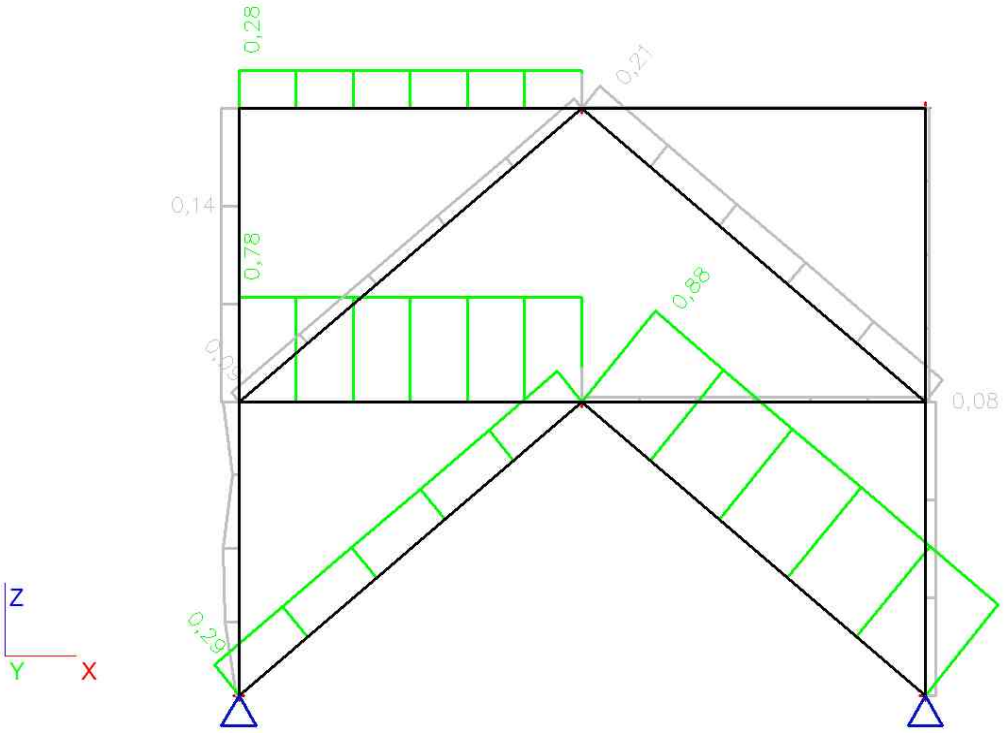
3. pomik - veter in izbočne sile



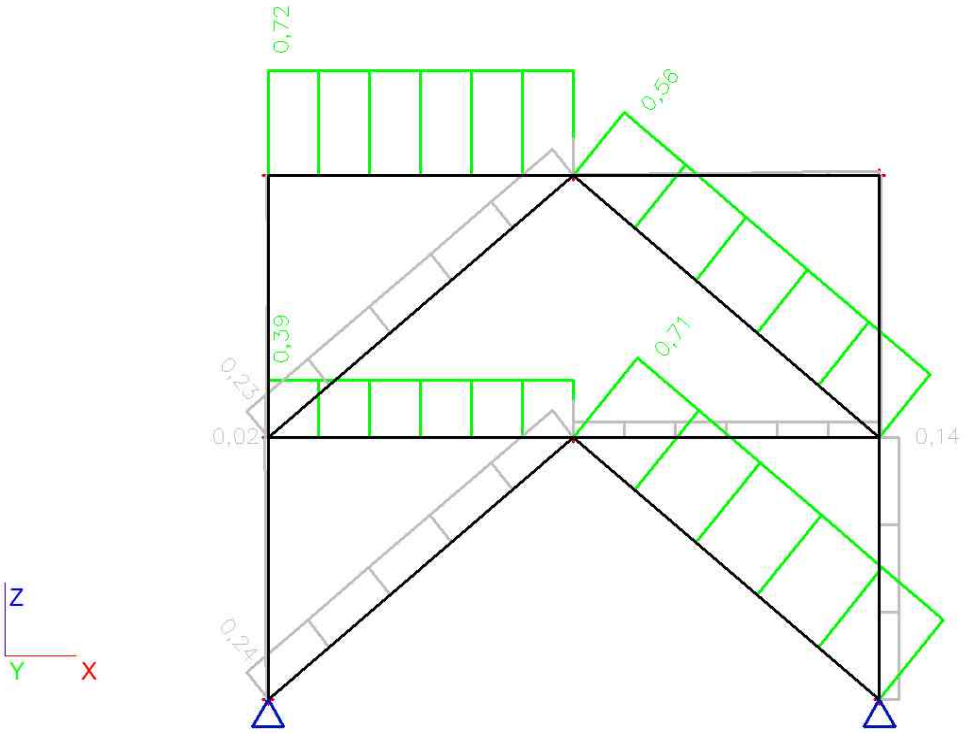
4. pomiki - potresna obtežba



5. Kontrola prereza - veter in izbočne sile

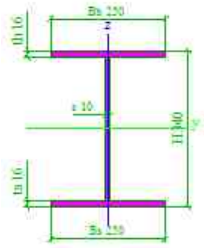


6. Kontrola prereza - potresna obtežba



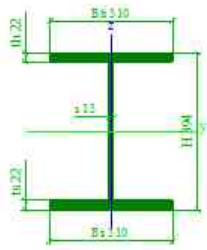
1. Prečni prerezi - tročlenski

Name	prečke	
Type	I ng	
Detailed	340; 250; 250; 16; 16; 10	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z	b	b
FEM analysis		



A [m²]	1,1080e-02	
A y, z [m²]	7,1598e-03	3,3649e-03
I y, z [m⁴]	2,3447e-04	4,1692e-05
I w [m⁶], t [m⁴]	1,0864e-06	6,0762e-07
Wel y, z [m³]	1,3792e-03	3,3354e-04
Wpl y, z [m³]	1,5332e-03	5,0770e-04
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	125	170
alpha [deg]	0,00	
AL [m²/m]	1,6600e+00	

Name	stebri	
Type	I ng	
Detailed	394; 310; 310; 22; 22; 13	
Item material	S 355	
Fabrication	general	
Buckling y-y, z-z		b
FEM analysis		



A [m²]	1,8190e-02	
A y, z [m²]	1,2115e-02	5,0767e-03
I y, z [m⁴]	5,1889e-04	1,0930e-04
I w [m⁶], t [m⁴]	3,7591e-06	2,0060e-06
Wel y, z [m³]	2,6339e-03	7,0515e-04
Wpl y, z [m³]	2,9352e-03	1,0719e-03
d y, z [mm]	0	0
c YLCS, ZLCS [mm]	155	197
alpha [deg]	0,00	
AL [m²/m]	2,0020e+00	

2. Elementi

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version*								
B1	stebri - I ng (394; 310; 310; 22; 22; 13)	5,000	Line	N5	N6	general (0)	standard	Layer1
B2	stebri - I ng (394; 310; 310; 22; 22; 13)	5,000	Line	N7	N8	general (0)	standard	Layer1
B3	prečke - I ng (340; 250; 250; 16; 16; 10)	13,153	Line	N6	N9	general (0)	standard	Layer1
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version*								

Name	CrossSection	Length [m]	Shape	Beg. node	End node	Type	FEM type	Layer
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version*								
B4	prečke - I ng (340; 250; 250; 16; 16; 10)	13,153	Line	N8	N9	general (0)	standard	Layer1

3. Vute

Name	Member	Cross-section	Position	Alignment	Length x [m]	Coor
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Studen						
H1	B1	stebri - I ng (394; 310; 310; 22; 22; 13)	End	top surface	5,000	Abso
H2	B2	stebri - I ng (394; 310; 310; 22; 22; 13)	End	bottom surface	5,000	Abso
H3	B3	prečke - I ng (340; 250; 250; 16; 16; 10)	Begin	top surface	9,000	Abso
H4	B4	prečke - I ng (340; 250; 250; 16; 16; 10)	Begin	top surface	9,000	Abso

4. Nelinearne kombinacije

Name	Type	Load cases	Coeff. [-]
Student version *Student version* *Student version* *Student version* *Student version* *Student ver			
NC1	Ultimate	lastna t	1,35
		g	1,35
		sneg	1,50
		veter	0,90
NC2	Ultimate	lastna t	1,35
		g	1,35
		sneg	0,75
		veter	1,50
NC3	Ultimate	lastna t	1,35
		g	1,35
		veter	0,90
		sneg2	1,50
NC4	Ultimate	lastna t	1,35
		g	1,35
		veter	1,50
		sneg2	0,75
NC5	Ultimate	lastna t	1,00
		g	1,00
		veter-	1,50
NC6	Ultimate	lastna t	1,00
		veter6	0,90
		sneg6	1,50
		g6	1,00
NC7	Ultimate	lastna t	1,00
		veter6	1,50
		sneg6	0,75
		g6	1,00
NC8	Ultimate	lastna t	1,00
		veter6	0,90
		g6	1,00
		sneg6.1	1,50
NC9	Ultimate	lastna t	1,00
		veter6	1,50
		g6	1,00
		sneg6.1	0,75
NC10	Ultimate	lastna t	1,00
		sneg11	1,50
		veter11	0,90
		g11	1,00
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student ver			
NC11	Ultimate	lastna t	1,00
		sneg11	0,75
		veter11	1,50
Student version *Student version* *Student version* *Student			

Name	Type	Load cases	Coeff. [-]
Student version	*Student version*	*Student version* *Student version* *Student version*	*Student ver
NC11	Ultimate		
		g11	1,00
NC12	Ultimate	veter11	0,90
		g11	1,00
		sneg11.1	1,50
NC13	Ultimate	veter11	1,50
		g11	1,00
		sneg11.1	0,75
NC14	Ultimate	lastna t	1,00
		g	1,00
NC16	Ultimate	lastna t	1,00
		g	1,00
		potres	0,80
NC17	Ultimate	lastna t	1,00
		g	1,00
		potres	0,80
		tlak ste	1,00

5. Notranje sile(nelinearna kombinacija)

Nonlinear calculation, Extreme : Member, System : LCS
Selection : All
Class : nelinearna

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*St
B1	NC1	0,000	**-365,05**	-331,61	**6,08**
B1	NC5	5,000	**-24,06**	-28,42	-96,95
B1	NC1	5,000	-359,42	**-336,07**	**-1618,46**
B1	NC5	0,000	-31,80	**-12,05**	0,52
B2	NC1	0,000	**-361,36**	**351,24**	**-6,04**
B2	NC5	5,000	**-33,57**	**29,62**	163,35
B2	NC1	5,000	-356,19	340,64	**1679,42**
B3	NC1	0,000	**-387,97**	**302,67**	**-1556,01**
B3	NC5	13,153	**-23,82**	-7,15	0,00
B3	NC10	13,153	-171,92	**-110,50**	0,00
B3	NC10	9,000	-188,98	1,77	**233,62**
B4	NC1	0,000	**-389,70**	**301,72**	**-1616,21**
B4	NC5	13,153	**-24,87**	-0,28	0,00
B4	NC6	13,153	-170,41	**-102,79**	0,00
B4	NC6	9,000	-187,18	7,13	**204,51**

6. Notranje sile (potres)

Linear calculation, Extreme : Member, System : LCS
Selection : All
Load cases : potres

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*
B1	potres	0,000	**13,54**	**45,26**	**-0,22**
B1	potres	5,000	13,54	45,26	**224,28**
B2	potres	0,000	**-13,54**	**25,14**	**-0,22**
B2	potres	5,000	-13,54	25,14	**123,70**
B3	potres	0,000	**-22,79**	**-17,20**	**233,05**
B3	potres	13,153	-22,79	-17,20	**0,00**
B4	potres	0,000	**-26,91**	**9,56**	**-117,72**
B4	potres	13,153	-26,91	9,56	**0,00**

7. Notranje sile(lastna teža)

Linear calculation, Extreme : Member, System : LCS
Selection : All
Load cases : lastna t

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*
B1	lastna t	0,000	**-22,90**	**-12,19**	**0,38**
B1	lastna t	5,000	**-15,07**	-12,19	**-58,04**
B2	lastna t	0,000	**-22,90**	**12,19**	**-0,38**
B2	lastna t	5,000	**-15,07**	12,19	**58,04**
B3	lastna t	0,000	**-14,34**	**13,05**	**-56,02**
B3	lastna t	13,153	**-12,05**	**-1,85**	0,00
B3	lastna t	11,076	-12,32	-0,10	**2,03**
B4	lastna t	0,000	**-14,34**	**13,05**	**-56,02**
B4	lastna t	13,153	**-12,05**	**-1,85**	0,00
B4	lastna t	11,076	-12,32	-0,10	**2,03**

8. Check of steel

Nonlinear calculation, Extreme : Member
Selection : All
Class : nelinearna

EN 1993-1-1 Code Check

Member B1	I ng	S 355	NC1	0.92

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

Warning: Strength reduction in function of the thickness is not supported for this type of cross-section.
...::SECTION CHECK::...
Note: Classification is not supported for this type of cross-section.
The section is checked as elastic, class 3.
The critical check is on position 5.000 m

Internal forces		
Student version *Student version* *Student version* *Stu		
NEd	-359.42	kN
Vy,Ed	0.00	kN
Vz,Ed	-336.07	kN
TEd	0.00	kNm
My,Ed	-1618.46	kNm
Mz,Ed	0.00	kNm

Section properties

A	2.205100e+004 mm^2		
Ay/A	0.552	Az/A	0.401
Iy	1.820143e+009 mm^4	Iz	1.093521e+008 mm^4
Iyz	0.000000e+000 mm^4	It	2.186562e+006 mm^4
Iw	1.217402e+013 mm^6		
Wely	5.268142e+006 mm^3	Welz	7.054976e+005 mm^3
Wply	5.923059e+006 mm^3	Wplz	1.084436e+006 mm^3
cy	345.50 mm	cz	155.00 mm
dy	0.00 mm	dz	-0.00 mm

Compression check
According to article EN 1993-1-1 : 6.2.4 and formula (6.9)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *St		
Nc,Rd	7828.11	kN
Unity check	0.05	-

Shear check (Vz)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version* *St		
Vc,Rd	1813.00	kN
Unity check	0.19	-

Bending moment check (My)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *Stu		
Mc,Rd	1870.19	kNm
Unity check	0.87	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2 and formula (6.1)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *		
sigma N	16.3	MPa
sigma Myy	307.2	MPa
sigma Mzz	0.0	MPa
Tau y	0.0	MPa
Tau z	0.0	MPa
Tau t	0.0	MPa

ro	0.00	place	15
Unity check	0.91	-	

Element satisfies the section check!

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

Flexural Buckling Check
According to article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Buckling parameters	yy	zz	
Student version *Student version* *Student version* *Student version* *Student version* *Student			
Sway type	sway	non-sway	
System Length L	5.000	5.000	m
Buckling factor k	1.00	0.50	
Buckling length Lcr	5.000	2.500	m
Critical Euler load Ncr	150898.38	36263.21	kN
Slenderness	17.40	35.50	
Relative slenderness Lambda	0.23	0.46	
Limit slenderness Lambda,0	0.20	0.20	

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 article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Table of values		
Student version *Student version* *Student version* *Student		
Torsional Buckling length	2.500	m
Ncr,T	48153.38	kN
Ncr,TF	36263.21	kN
Relative slenderness Lambda,T	0.46	
Limit slenderness Lambda,0	0.20	

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 article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version *Student version* *Student version*	*Student version* *Student version*	
Method for LTB curve	Art. 6.3.2.2.	
Wy	5.2681e-03	m^3
Elastic critical moment Mcr	12361.38	kNm
Relative slenderness Lambda,LT	0.39	
Limit slenderness Lambda,LT,0	0.40	

Mcr Parameters		
Student version *Student version* *Student version*		
LTB length	2.500	m
k	1.00	
kw	1.00	
C1	1.77	
C2	0.00	
C3	1.00	

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)

Compression and bending check

According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version *Student version* *Student version*	*Student version* *	
kyy	1.010	
kyz	0.796	
kzy	1.010	
kzz	0.796	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.2051e-02	m^2
Wy	5.2681e-03	m^3
Wz	7.0550e-04	m^3
NRk	7828.11	kN
My,Rk	1870.19	kNm
Mz,Rk	250.45	kNm
My,Ed	-1618.46	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	12361.38	kNm
reduced slenderness 0	0.39	
Psi y	-0.004	
Psi z	-0.004	
Cmy,0	1.000	
Cmz,0	0.788	
Cmy	1.000	
Cmz	0.788	
CmLT	1.008	
muy	1.000	
muz	1.000	
wy	1.124	
wz	1.500	
npl	0.046	
aLT	0.999	
bLT	0.000	
cLT	0.230	
dLT	0.000	
eLT	3.468	
Cyy	1.006	
Cyz	0.925	
Czy	1.002	
Czz	0.956	

Unity check (6.61) = 0.05 + 0.87 + 0.00 = 0.92
Unity check (6.62) = 0.05 + 0.87 + 0.00 = 0.92
Element satisfies the stability check!

EN 1993-1-1 Code Check

Member B2	I ng	S 355	NC1	0.95

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

Warning: Strength reduction in function of the thickness is not supported for this type of cross-section.

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

Note: Classification is not supported for this type of cross-section.
The section is checked as elastic, class 3.

The critical check is on position 5.000 m

Internal forces		
Student version *Student version* *Student version* *St		
NEd	-356.19	kN
Vy,Ed	0.00	kN
Vz,Ed	340.64	kN
TEd	0.00	kNm
My,Ed	1679.42	kNm
Mz,Ed	0.00	kNm

Section properties

A	2.205100e+004 mm^2		
Ay/A	0.552	Az/A	0.401
Iy	1.820143e+009 mm^4	Iz	1.093521e+008 mm^4
Iyz	0.000000e+000 mm^4	It	2.186562e+006 mm^4
Iw	1.217402e+013 mm^6		
Wely	5.268142e+006 mm^3	Welz	7.054976e+005 mm^3
Wply	5.923059e+006 mm^3	Wplz	1.084436e+006 mm^3
cy	345.50 mm	cz	155.00 mm
dy	0.00 mm	dz	-0.00 mm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	7828.11	kN
Unity check	0.05	-

Shear check (Vz)

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

Table of values		
Student version *Student version* *Student version* *St		
Vc,Rd	1813.00	kN
Unity check	0.19	-

Bending moment check (My)

According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *Stu		
Mc,Rd	1870.19	kNm
Unity check	0.90	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2 and formula (6.1)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *		
sigma N	16.2	MPa
sigma Myy	318.8	MPa
Student version *Student version* *Student version* *		

Table of values		
Student version	*Student version*	*Student version* *
sigma Mzz	0.0	MPa
Tau y	0.0	MPa
Tau z	0.0	MPa
Tau t	0.0	MPa

ro 0.00 place 7
Unity check 0.94 -
Element satisfies the section check!

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

Flexural Buckling Check

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

Buckling parameters	yy	zz	
Student version	*Student version*	*Student version*	*Student version* *Student
Sway type	sway	non-sway	
System Length L	5.000	5.000	m
Buckling factor k	1.00	0.50	
Buckling length Lcr	5.000	2.500	m
Critical Euler load Ncr	150898.38	36263.21	kN
Slenderness	17.40	35.50	
Relative slenderness Lambda	0.23	0.46	
Limit slenderness Lambda,0	0.20	0.20	

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 article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Table of values		
Student version	*Student version*	*Student version* *Student
Torsional Buckling length	2.500	m
Ncr,T	48153.38	kN
Ncr,TF	36263.21	kN
Relative slenderness Lambda,T	0.46	
Limit slenderness Lambda,0	0.20	

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 article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version	*Student version*	*Student version* *Student version
Method for LTB curve	Art. 6.3.2.2.	
Wy	5.2681e-03	m^3
Elastic critical moment Mcr	12361.38	kNm
Relative slenderness Lambda,LT	0.39	
Limit slenderness Lambda,LT,0	0.40	

Mcr Parameters		
Student version	*Student version*	*Student version* *
LTB length	2.500	m
k	1.00	
kw	1.00	
C1	1.76	
C2	0.00	
C3	1.00	

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)

Compression and bending check

According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version	*Student version*	*Student version* *Student version* *
kyy	1.010	
kyz	1.012	
kzy	1.010	
kzz	1.012	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.2051e-02	m^2
Wy	5.2681e-03	m^3
Student version	*Student version*	*Student version* *Student version* *

Table of values		
Student version *Student version* *Student version* *Student version* *		
Wz	7.0550e-04	m^3
NRk	7828.11	kN
My,Rk	1870.19	kNm
Mz,Rk	250.45	kNm
My,Ed	1679.42	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	12361.38	kNm
reduced slenderness 0	0.39	
Psi y	-0.004	
Psi z	1.000	
Cmy,0	1.000	
Cmz,0	1.002	
Cmy	1.000	
Cmz	1.002	
CmLT	1.007	
muy	1.000	
muz	1.000	
wy	1.124	
wz	1.500	
npl	0.046	
aLT	0.999	
bLT	0.000	
cLT	0.239	
dLT	0.000	
eLT	3.598	
Cyy	1.006	
Cyz	0.917	
Czy	1.002	
Czz	0.947	

Unity check (6.61) = 0.05 + 0.91 + 0.00 = 0.95
Unity check (6.62) = 0.05 + 0.91 + 0.00 = 0.95
Element satisfies the stability check!

EN 1993-1-1 Code Check

Member B3	I ng	S 355	NC1	0.94

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

Warning: Strength reduction in function of the thickness is not supported for this type of cross-section.
...::SECTION CHECK::...
Note: Classification is not supported for this type of cross-section.
The section is checked as elastic, class 3.
The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *Stu		
NEd	-387.97	kN
Vy,Ed	0.00	kN
Vz,Ed	302.67	kN
TEd	0.00	kNm
My,Ed	-1556.01	kNm
Mz,Ed	0.00	kNm

Section properties

A	2.141704e+004 mm^2		
Ay/A	0.448	Az/A	0.504
Iy	2.974595e+009 mm^4	Iz	6.955203e+007 mm^4
Iyz	-2.168404e-007 mm^4	It	1.570828e+006 mm^4
Iw	1.446092e+013 mm^6		

Student version *Student version* *Student version* *Student version* *Student version* *Student ve

Wely	6.369583e+006 mm^3	Welz	5.021807e+005 mm^3
Wply	7.326428e+006 mm^3	Wplz	7.830922e+005 mm^3
cy	467.00 mm	cz	138.50 mm
dy	0.00 mm	dz	-0.00 mm

Compression check
According to article EN 1993-1-1 : 6.2.4 and formula (6.9)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	7603.05	kN
Unity check	0.05	-

Shear check (Vz)
According to article EN 1993-1-1 : 6.2.6. and formula (6.17)

Table of values		
Student version *Student version* *Student version* *St		
Vc,Rd	2210.75	kN
Unity check	0.14	-

Bending moment check (My)
According to article EN 1993-1-1 : 6.2.5. and formula (6.12)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *Stu		
Mc,Rd	2261.20	kNm
Unity check	0.69	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2 and formula (6.1)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *		
sigma N	18.1	MPa
sigma Myy	244.3	MPa
sigma Mzz	0.0	MPa
Tau y	0.0	MPa
Tau z	0.0	MPa
Tau t	0.0	MPa

ro	0.00	place	15
Unity check	0.74	-	

Element satisfies the section check!

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

Flexural Buckling Check
According to article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Buckling parameters	yy	zz	
Student version *Student version* *Student version* *Student version* *Student version* *Studer			
Sway type	sway	non-sway	
System Length L	13.153	13.153	m
Buckling factor k	1.00	0.20	
Buckling length Lcr	13.153	2.631	m
Critical Euler load Ncr	35636.97	20831.61	kN
Slenderness	35.29	46.16	
Relative slenderness Lambda	0.46	0.60	
Limit slenderness Lambda,0	0.20	0.20	

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 article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Table of values		
Student version *Student version* *Student version* *Student		
Torsional Buckling length	2.631	m
Ncr,T	31362.87	kN
Ncr,TF	20831.61	kN
Student version *Student version* *Student version* *Student version* *Student		

Table of values		
Student version *Student version* *Student version* *Student version* *Student		
Relative slenderness Lambda,T	0.60	
Limit slenderness Lambda,0	0.20	

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 article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version *Student version* *Student version* *Student version* *Student version		
Method for LTB curve	Art. 6.3.2.2.	
Wy	6.3696e-03	m^3
Elastic critical moment Mcr	9636.85	kNm
Relative slenderness Lambda,LT	0.48	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	d	
Imperfection Alpha,LT	0.76	
Reduction factor Chi,LT	0.79	
Buckling resistance Mb.Rd	1787.02	kNm
Unity check	0.87	-

Mcr Parameters		
Student version *Student version* *Student version*		
LTB length	2.631	m
k	1.00	
kw	1.00	
C1	2.99	
C2	0.32	
C3	1.00	

Note: C Parameters according to ECCS 119 2006 / Galea 2002
load in center of gravity

Compression and bending check

According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version *Student version* *Student version* *Student version* *		
kyy	1.024	
kyz	0.803	
kzy	1.024	
kzz	0.803	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.1417e-02	m^2
Wy	6.3696e-03	m^3
Wz	5.0218e-04	m^3
NRk	7603.05	kN
My,Rk	2261.20	kNm
Mz,Rk	178.27	kNm
My,Ed	-1556.01	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	9636.85	kNm
reduced slenderness 0	0.48	
Psi y	0.000	
Psi z	0.000	
Cmy,0	0.996	
Cmz,0	0.788	
Cmy	0.999	
Cmz	0.788	
CmLT	1.014	
muy	1.000	
muz	1.000	
wy	1.150	
wz	1.500	
npl	0.051	
aLT	0.999	
bLT	0.000	
cLT	0.346	
dLT	0.000	
eLT	2.674	
Cyy	1.005	
Student version *Student version* *Student version* *Student version* *		

Table of values		
Student version *Student version* *Student version* *Student version* *		
Cyz	0.867	
Czy	0.996	
Czz	0.966	

Unity check (6.61) = 0.05 + 0.89 + 0.00 = 0.94
Unity check (6.62) = 0.05 + 0.89 + 0.00 = 0.94
Element satisfies the stability check!

EN 1993-1-1 Code Check

Member B4	I ng	S 355	NC1	0.98

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *S	
partial safety factor Gamma M0 for resistance of cross-sections	1.00
partial safety factor Gamma M1 for resistance to instability	1.00
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	355.0	MPa
tension strength fu	490.0	MPa
fabrication	rolled	

Warning: Strength reduction in function of the thickness is not supported for this type of cross-section.

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

Note: Classification is not supported for this type of cross-section.
The section is checked as elastic, class 3.

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *Stu		
NEd	-389.70	kN
Vy,Ed	0.00	kN
Vz,Ed	301.72	kN
TEd	0.00	kNm
My,Ed	-1616.21	kNm
Mz,Ed	0.00	kNm

Section properties

A	2.141704e+004 mm^2		
Ay/A	0.448	Az/A	0.504
Iy	2.974595e+009 mm^4	Iz	6.955203e+007 mm^4
Iyz	-2.168404e-007 mm^4	It	1.570828e+006 mm^4
Iw	1.446092e+013 mm^6		
Wely	6.369583e+006 mm^3	Welz	5.021807e+005 mm^3
Wply	7.326428e+006 mm^3	Wplz	7.830922e+005 mm^3
cy	467.00 mm	cz	138.50 mm
dy	0.00 mm	dz	-0.00 mm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	7603.05	kN
Unity check	0.05	-

Shear check (Vz)

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

Table of values		
Student version *Student version* *Student version* *St		
Vc,Rd	2210.75	kN
Unity check	0.14	-

Bending moment check (My)

According to article EN 1993-1-1 : 6.2.5. and formula (6.12)

Section classification is 3.

Table of values		
Student version	*Student version*	*Student version* *Stu
Mc,Rd	2261.20	kNm
Unity check	0.71	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2 and formula (6.1)
Section classification is 3.

Table of values		
Student version	*Student version*	*Student version* *
sigma N	18.2	MPa
sigma Myy	253.7	MPa
sigma Mzz	0.0	MPa
Tau y	0.0	MPa
Tau z	0.0	MPa
Tau t	0.0	MPa

ro 0.00 place 16
Unity check 0.77 -
Element satisfies the section check!

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

Flexural Buckling Check
According to article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Buckling parameters	yy	zz	
Student version	*Student version*	*Student version* *Student version*	*Student version* *Studer
Sway type	sway	non-sway	
System Length L	13.153	13.153	m
Buckling factor k	1.00	0.20	
Buckling length Lcr	13.153	2.631	m
Critical Euler load Ncr	35636.97	20831.61	kN
Slenderness	35.29	46.16	
Relative slenderness Lambda	0.46	0.60	
Limit slenderness Lambda,0	0.20	0.20	

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 article EN 1993-1-1 : 6.3.1.1. and formula (6.46)

Table of values		
Student version	*Student version* *Student version*	*Student version* *Student
Torsional Buckling length	2.631	m
Ncr,T	31362.87	kN
Ncr,TF	20831.61	kN
Relative slenderness Lambda,T	0.60	
Limit slenderness Lambda,0	0.20	

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 article EN 1993-1-1 : 6.3.2.1. and formula (6.54)

LTB Parameters		
Student version	*Student version* *Student version*	*Student version* *Student version
Method for LTB curve	Art. 6.3.2.2.	
Wy	6.3696e-03	m^3
Elastic critical moment Mcr	9636.85	kNm
Relative slenderness Lambda,LT	0.48	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	d	
Imperfection Alpha,LT	0.76	
Reduction factor Chi,LT	0.79	
Buckling resistance Mb.Rd	1787.02	kNm
Unity check	0.90	-

Mcr Parameters		
Student version	*Student version* *Student version*	*
LTB length	2.631	m
k	1.00	
Student version	*Student version* *Student version*	*

Mcr Parameters		
Student version	*Student version*	*Student version*
kw	1.00	
C1	2.88	
C2	0.29	
C3	1.00	

Note: C Parameters according to ECCS 119 2006 / Galea 2002
load in center of gravity

Compression and bending check

According to article EN 1993-1-1 : 6.3.3. and formula (6.61), (6.62)
Interaction Method 1

Table of values		
Student version	*Student version*	*Student version*
kyy	1.025	
kyz	1.024	
kzy	1.025	
kzz	1.024	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	2.1417e-02	m^2
Wy	6.3696e-03	m^3
Wz	5.0218e-04	m^3
NRk	7603.05	kN
My,Rk	2261.20	kNm
Mz,Rk	178.27	kNm
My,Ed	-1616.21	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	9636.85	kNm
reduced slenderness 0	0.48	
Psi y	0.000	
Psi z	1.000	
Cmy,0	0.998	
Cmz,0	1.005	
Cmy	0.999	
Cmz	1.005	
CmLT	1.014	
muy	1.000	
muz	1.000	
wy	1.150	
wz	1.500	
npl	0.051	
aLT	0.999	
bLT	0.000	
cLT	0.359	
dLT	0.000	
eLT	2.776	
Cyy	1.005	
Cyz	0.854	
Czy	0.996	
Czz	0.953	

Unity check (6.61) = 0.05 + 0.93 + 0.00 = 0.98
Unity check (6.62) = 0.05 + 0.93 + 0.00 = 0.98
Element satisfies the stability check!