Univerza
v Ljubljani
Fakulteta
za gradbeništvo
in geodezijo

Jamova 2
1000 Ljubljana, Slovenija
telefon (01) 47 68 500
faks (01) 42 50 681
fgg@fgg.uni-lj.si

Visokošolski program Gradbeništvo,
Smer operativno gradbeništvo

Kandidat:
Peter Muhvič

Projekt logističnega centra v jekleni izvedbi

Diplomska naloga št.: 419

Mentor:
prof. dr. Jože Korelc

Somentor:
asist. dr. Peter Skuber

Ljubljana, 27. 5. 2011

IZJAVA O AVTORSTVU

Skladno s 27. členom Pravilnika o diplomskem delu UL Fakultete za gradbeništvo in geodezijo,

Podpisani PETER MUHVIČ izjavljam, da sem avtor diplomske naloge z naslovom:

PROJEKT LOGISTIČNEGA CENTRA V JEKLENI IZVEDBI

Izjavljam, da prenašam vse materialne avtorske pravice v zvezi z diplomsko nalogo na UL, Fakulteto za gradbeništvo in geodezijo.

Noben del tega zaključnega dela ni bil uporabljen za pridobitev strokovnega naziva ali druge strokovne kvalifikacije na tej ali na drugi univerzi ali izobraževalni inštituciji.

Ljubljana, 11.5.2011

____

IZJAVE O PREGLEDU NALOGE

BIBLIOGRAFSKO – DOKUMENTACIJSKA STRAN Z IZVLEČKOM

UDK:	**624.014.2:725.3(043.2)**
Avtor:	**Peter Muhvič**
Mentor:	**prof. dr. Jože Korelc**
Somentor:	**asist. dr. Peter Skuber**
Naslov:	**Projekt logističnega centra v jekleni izvedbi**
Obseg in oprema:	**88 strani, 15 preglednic, 87 slik**
Ključne besede:	**jeklene konstrukcije, logistični center, dimenzioniranje**

Izvleček

Diplomska naloga obravnava statični izračun logističnega centra v jekleni izvedbi. Prvi del računa obsega globalno statično analizo konstrukcije, ki je narejena po elastični analizi drugega reda z upoštevanjem geometrijske nepopolnosti. Za izračun notranjih statičnih količin in dimenzioniranje sem uporabil računalniški program SCIA ENGINEER 2010. Vplive na konstrukcijo sem določil glede na veljavne slovenske standarde SIST EN 1991-1998. Za določitev potresne obtežbe sem uporabil metodo ekvivalentne statične obremenitve. Velikost te sile sem določil s projektnim spektrom za elastično analizo. V okviru diplomske naloge sem izračunal tudi tipične spoje in temelje ter zrisal pozicijske načrte.

BIBLIOGRAPHIC – DOCUMENTALISTIC INFORMATION

UDC:	**624.014.2:725.3(043.2)**
Author:	**Peter Muhvič**
Supervisor:	**Prof. Ph. D. Jože Korelc**
Co-supervisor:	**Asist. Ph. D. Peter Skuber**
Title:	**Design project of logistics center in steel construction**
Notes:	**88 p., 15 tab., 87 fig.**
Key words:	**steel construction, logistics center, design structure**

Abstract

A dissertation deals with a static calculation, for the design of logistics center in steel construction. First part of the calculatinons covers a global construction analysis, which takes in to accaunt second-order elastic analysis and geometrical imperferections of the construction. For the calculation of internal static quantities and design structure a computer program SCIA ENGENEER 2010 was used. The effect on construction were obtained from valid Slovenian standards SIST EN 1991-1998. To establish the seismic load of the construction I used the method of the equivalent static load. The magnitude of the force is set by the help of the design spectrum for elastic analysis. Dissertation also involves the calculation of typical joints, foundations and positional schemes.

ZAHVALA

Zahvaljujem se mentorju prof. dr. Jožetu Korelcu in somentorju asist. dr. Petru Skuberju za pomoč pri nastajanju diplomske naloge.

Posebna zahvala gre tudi staršem, ki so mi omogočili študij ter punci Vesni za podporo in pozitivne misli.

KAZALO VSEBINE

KAZALO PREGLEDNIC

KAZALO SLIK

1 UVOD

1.1 Namen naloge

Cilj diplomske naloge je izdelava načrta gradbenih konstrukcij, na nivoju PGD, logističnega centra v jekleni izvedbi. Upošteval sem pravila projektiranja in dimenzioniranja po EVROKOD standardih. Analiza konstrukcije je narejena po elastični analizi II. reda z upoštevanjem začetnih geometrijskih nepopolnosti konstrukcije. Za analizo sem uporabil računalniški program Scia Engineer 2010.1, za izdelavo načrtov pa program AutoCAD.

1.2 Opis naloge

Na osnovi projektne naloge in arhitekturne zasnove sem naredil statično analizo logističnega centra. Objekt je 60 m dolg, 40 m širok in visok 7.2 m. Nosilno konstrukcijo sem računal kot niz ravninskih okvirjev. Za primarno nosilno konstrukcijo sem izbral okvirje s paličnimi nosilci, ki so momentno pritrjeni na stebre v obeh glavnih smereh. Razpon paličnih nosilcev je 15 m v smeri x in 10 m v smeri y. V notranjosti objekta so križni stebri, po obodu fasade pa so dodani fasadni stebri.

Cilj naloge je bil poiskati čim bolj optimalno rešitev jeklene konstrukcije logističnega centra, ob upoštevanju EVROKOD standardov in izdelati načrt gradbenih konstrukcij na nivoju PGD.

1.3 Upoštevanje nepopolnosti

Ločimo:
- globalno nepopolnost konstrukcije
- lokalno nepopolnost konstrukcije
- globalno + lokalno nepopolnost konstrukcije

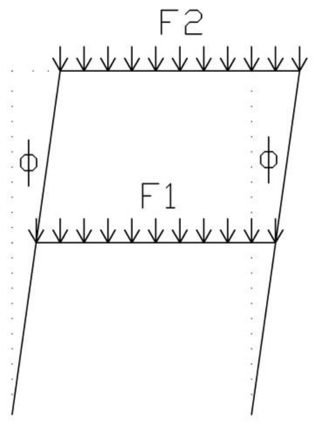
Pri računski analizi konstrukcije je potrebno na primeren način upoštevati vse pomembne nepopolnosti, ki se lahko pojavijo pri izdelavi in montaži:

- zaostale napetosti in deformacije
- odstopanje od vertikale
- neravnost elementov

- netočno naleganje
- manjše ekscentričnosti v stikih
- nehomogenost materiala

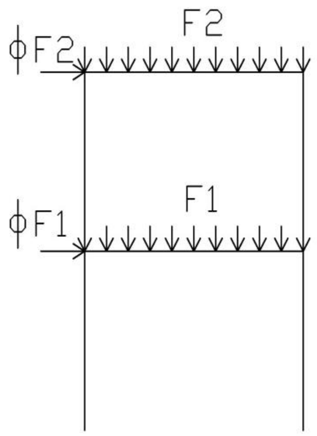
Naštete nepopolnosti lahko upoštevamo z nadomestnimi geometrijskimi nepopolnostmi pri globalni analizi konstrukcije. To lahko storimo na dva načina:

1. Pri geometriji konstrukcije (pri pripravi vhodnih podatkov programa) z vpeljavo kota Φ, ki predstavlja nagib stebrov nepopolnega okvirja od vertikale.



Slika 1: Nadomestna geometrijska nepopolnost Φ

2. Nadomestna horizontalna obtežba, ki deluje na okvir z idealno geometrijo.



Slika 2: Nadomestne horizontalne sile

Manj obremenjenih stebrov (z osno silo manjšo od polovice povprečne vrednosti) ne upoštevamo v n_c. Stebrov, ki se ne raztezajo skozi vse etaže, in prečk, ki niso priključene na vse stebre vključene v n_c ne upoštevamo.
Nadomestne geometrijske nepopolnosti Φ uporabimo pri globalni analizi okvirjev, izračunane notranje sile pa pri dimenzioniranju posameznih elementov.

Nepopolnost okvirjev je odvisna od:

$\Phi = k_c \cdot k_s \cdot \Phi_0$

Pri tem je:

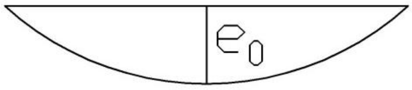
n_c… št. etaž $k_c = \sqrt{0.5 + \frac{1}{nc}} \leq 1.0$

n_s… št. etaž $k_s = \sqrt{0.5 + \frac{1}{ns}} \leq 1.0$

$\Phi_0 = \frac{1}{200}$

$H_{Sd} \geq 0.15\ V_{Sd}$ … če to velja.potem globalne nepopolnosti ni potrebno upoštevati.

Lokalna nepopolnost:



Slika 3: Lokalna nepopolnost

$e_0 = \alpha(\lambda\text{-}0.2)\frac{Wel}{A}k_y$ … elastična analiza
$e_0 = \alpha(\lambda\text{-}0.2)\frac{Wpl}{A}k_y$

λ … primerjalna vitkost
α, k_γ … faktorji po EC3

1.4 Odpornost okvirjev proti horizontalni obtežbi

Pri projektiranju konstrukcij moramo zagotoviti, da so dovolj odporne proti horizontalni obtežbi. Odpornost lahko zagotavljajo okvirji sami s togimi stiki prečka – steber, ki so sposobni prevzeti momentne obremenitve in s tem horizontalno obtežbo, ali z dodatnimi konstrukcijskimi sistemi, ki namesto okvirja prevzemajo horizontalno obtežbo (povezja, betonske stene in jedra).

1.5 Razvrstitev okvirjev na nepomične in pomične

Okvir razvrstimo med pomične okvirje, kadar ne moremo zanemariti povečanja upogibnih momentov zaradi horizontalnih pomikov vozlišč.

$V_{Sd} / V_{cr} \leq 0.1$ … nepomičen okvir

V_{Sd} … projektna vrednost skupne vertikalne obtežbe
V_{cr} … elastična kritična obtežba

1.6 Razvrstitev okvirjev na podprte in nepodprte

Okvir je podprt, če je togost podpore glede na horizontalno obtežbo (povezje, betonsko jedro) vsaj petkrat večja od togosti okvirja samega. Podprti okvirji so vedno nepomični, nepodprti okvirji pa so lahko pomični ali nepomični. Pri podprtih okvirjih lahko predpostavimo, da vso horizontalno obtežbo prevzame povezje, ki ga dimenzioniramo glede na:

- horizontalno obtežbo, ki deluje na podpirani okvir,
- horizontalno vertikalno obtežbo, ki deluje neposredno na povezje,
- horizontalno obtežbo zaradi nadomestnih geometrijskih nepopolnosti podprtih okvirjev in povezja samega.

Podprte okvirje dimenzioniramo samo na vertikalno obtežbo.

1.7 Stabilnost pomičnih okvirjev

Elastična analiza pomičnih okvirjev

Pomične okvirje je potrebno analizirati po teoriji drugega reda ob upoštevanju začetnih geometrijskih nepopolnosti. Pri dimenzioniranju posameznih elementov privzamemo za uklonske dolžine v ravnini okvirja (pri ravninskih paličjih) kar sistemske dolžine elementov. S tem v fazi dimenzioniranja upoštevamo tudi vpliv lokalnih geometrijskih nepopolnosti elementov. Vpliv globalnih geometrijskih nepopolnosti je zajet v globalni analizi po TDR. Uklonske dolžine za bočno zvrnitev in uklon izven ravnine okvirja je potrebno določiti glede na način podpiranja v smeri izven ravnine okvirja. Običajno lahko za te uklonske dolžine z zadovoljivo natančnostjo privzamemo razdalje med bočnimi podporami.
Globalno analizo pomičnih okvirjev lahko opravimo tudi po teoriji prvega reda in vplive teorije drugega reda upoštevamo na poenostavljen način:
- upogibne momente po teoriji drugega reda izračunamo tako, da pri rezultatih linearne analize delež upogibnih momentov, ki so posledica horizontalnega pomika vozlišč okvirja

povečamo s faktorjem $k_\delta = \frac{1}{1\text{-}V_{Sd}/V_{cr}}$. To metodo lahko uporabljamo, dokler V_{sd}/V_{cr} ne preseže vrednosti 0.25. Pri dimenzioniranju posameznih elementov privzamemo za uklonske dolžine v ravnini okvirja sistemske dolžine elementov.
- notranje sile izračunamo po teoriji prvega reda, v postopku dimenzioniranja posameznih elementov pa uporabimo dejanske uklonske dolžine. V tem primeru je potrebno delež momentov, ki so posledica horizontalnih pomikov vozlišč, v prečkah in stikih prečka – steber pomnožiti s faktorjem 1.2.

2 TEHNIČNO POROČILO

2.1 Zasnova

Objekt je logistični center, ki se nahaja v Ljubljani. Tlorisna površina je 40 m × 60 m. Raster notranjih stebrov primarnih okvirjev v smeri x je 15 m, v smeri y pa 10 m. Okvirji so momentno priključeni s paličnimi nosilci na stebre v obeh glavnih smereh. Po zunanjem obodu so dodani fasadni stebri, na katere so pritrjeni sekundarni nosilci. Raster fasadnih stebrov v smeri x je 3.75 m, v smeri y pa 5.0 m. Na fasadne stebre je horizontalo pritrjena fasada iz lahkih montažnih sendvič panelov SNV 150 Trimo. Višina objekta je 7.20 m. Streha je ravna, s 5 % naklonom za odvod meteorne vode, sestavljena iz visoko profilirane trapezne pločevine, toplotne izolacije in SIKA folije.

2.2 Material

Nosilna konstrukcija, sekundarni nosilci, zavarovalne konstrukcije in bočna podpiranja se izvedejo v materialu kvalitete S 235. Spoji na montaži se izvedejo z visokovrednimi vijaki kvalitete 10.9. Za vezne in čelne pločevine se uporabi jeklo kvalitete S 235. Za temelje se uporabi beton kvalitete C25/30 in armaturne palice S 400.

2.3 Obtežba

Poleg lastne teže konstrukcije in stalne obremenitve sem upošteval še naslednje obremenitve:

- sneg 1.21 kN/m^2
- inštalacije 0.20 kN/m^2
- veter cona I
- potres, kategorija tal B (dobro nosilna tla), 0.25ag

2.4 Računanje notranjih sil in pomikov

Konstrukcija je bila računana kot niz ravninskih okvirjev v x in y smeri. V vsaki smeri je bil okvir izbran kot najbolj neugoden in kot takšen preračunan s programom Scia Engineer po elastični teoriji drugega reda ob upoštevanju začetnih geometrijskih nepopolnosti. Pri okvirjih v ravnini fasade je v obeh smereh vzeto samo eno polje z zavetrovanjem, za kar je bila primerno reducirana tudi potresna obtežba. Horizontalno zavetrovanje je bilo računano kot paličje, pri čemer so izključene tlačne diagonale. Sekundarni nosilci so računani kot prostoležeči nosilci, katerih reakcije so vzete v nadaljnji račun primarnih okvirjev.
Dimenzioniranje ostalih elementov, temeljev in vijačenih oz. varjenih stikov je bilo opravljeno v skladu s standardi EC.
Kontrola pomikov pri mejnem stanju uporabnosti:
Vertikalni pomiki: L / 250
Horizontalni pomiki: h / 300 oz. h / 500 za celotno stavbo

2.5 Dinamična analiza

Potresne sile so določene s spektrom odziva za elastično analizo s faktorjem obnašanja q = 1.5. Vso potresno obtežbo prevzamejo primarni okvirji in fasadni okvirji s centričnim povezjem in jo prenašajo preko temeljev na temeljna tla. Sekundarna konstrukcija ne prevzame nobene obtežbe. Pri izračunu potresne sile je upoštevana tudi slučajna torzija.

2.6 Statični sistem

Nosilna konstrukcija je jeklena in po statičnem sistemu prostorski okvir, sestavljen iz dveh med seboj povezanih nizov ravninskih okvirjev. Palični nosilci so momentno priključeni na stebre v obeh smereh.. Okvirna konstrukcija prevzame vso vertikalno in horizontalno obremenitev in jo prenaša na temelje. V smereh x in y so trije notranji primarni okvirji, na zunanjem obodu v obeh smereh pa okvirji s centričnim povezjem. V obeh smereh so dodani fasadni stebri.

2.7 Streha

Streha je ravna in nepohodna, s 3° naklonom za odvod meteorne vode. Na sekundarne nosilce je pritrjena visokoprofilirana trapezna pločevina 85/280 d=0.75 mm, na kateri je položena toplotna izolacija iz kamene volne. Zaključni sloj strehe je SIKA folija SIKAPLAN – 20 G (2.0 mm).

2.8 Zavetrovanje

Vertikalno zavetrovanje je načrtovano v obeh glavnih smereh v ravnini fasade. V smeri x so 4 zavetrovanja z nateznimi diagonalami RD 22, v smeri y pa 2 zavetrovanji z nateznimi diagonalami RD 30. Pri računu so bile izključene tlačne diagonale.

Horizontalno zavetrovanje v smeri x sestavljajo 4 enakomerno porazdeljeni nizi okvirjev s centričnim povezjem z nateznimi palicami RD 10. Smer y je zavarovana z dvema okvirjema na robu objekta s palicami RD 26 in RD 16. Spodnji pas paličnih nosilcev je pridržan s palicami RD 8.

2.9 Fasada

Na objektu so kot fasada predvideni montažni sendvič paneli TRIMOTERM SNV 150, ki so horizontalno pritrjeni na fasadne stebre. Maksimalni razmak med vijaki je 35 cm. Fasadni paneli so zaščiteni z zaščitnim in dekorativnim premazom.
Detajlno pritrjevanje fasadnih panelov na fasadne stebre ni obdelano v tej diplomski nalogi.

2.10 Spoji

Sekundarni nosilci so pritrjeni na primarni nosilec s členkastim spojem preko vezne pločevine z dvema vijakoma M12 10.9. Primarni palični nosilci so momentno priključeni na stebre z momentnim spojem preko čelne pločevine s štirimi vijaki M22 10.9. Diagonale vertikalnega zavetrovanja imajo členkast spoj, ki je izveden preko vezne pločevine in tremi vijaki M16 10.9. Fasadni stebri so členkasto priključeni na temeljni nosilec s štirimi vijaki M12, ki so sidrani s HILTI maso. Minimalna globina sidranja vijakov je 15 cm.

2.11 Temeljenje

Temelji križnih stebrov so točkovni in podpirajo jeklene stebre z momentnim stikom v obeh smereh. Temelji fasadnih stebrov, ki so del primarnih okvirjev v smeri x, so prav tako točkovni. Stebri so na njih členkasto stikovani. Po obodu objekta je temeljni nosilec širine 0.4 m in globine 1.0 m, ki podpira fasadne stebre in parapetni zid okoli objekta. Tla so dobro nosilna s parametri: γ = 22 kN/m^3, φ = 23°, c = 22 kPa, cu = 100 kPa.

2.12 Izdelava in montaža jeklene konstrukcije

Pri izdelavi konstrukcije je potrebno posebno pozornost posvetiti izdelavi volišč steber – palični nosilec. Z ustrezno kontrolo je potrebno zagotoviti, da bo celotna konstrukcija narejena po predpisanih standardih.

Vsi čelni zvari, narejeni v delavnici ali montaži, morajo biti 1. kvalitete (SIST EN 1090-1).

Jeklena konstrukcija mora biti izdelana in montirana v skladu s projektno dokumentacijo, veljavnimi predpisi in standardi.

Pri montaži je potrebno s pravim vrstnim redom montaže zagotoviti stabilnost konstrukcije v času montaže. Nujna je prisotnost nadzornega organa. Pri izdelavi posameznih elementov jeklene konstrukcije je potrebno pozornost posvetiti dimenzijski kontroli in pripravi zvarnih žlebov.

Med izdelavo in montažo jeklene konstrukcije morata biti zagotovljena stalna merska kontrola in strokovni nadzor, ki ga izvaja strokovnjak za jeklene konstrukcije. Ob vsaki izvedeni spremembi je potrebno pridobiti pisnosoglasje projektanta in strokovnega nadzora.

2.13 Protikorozijska zaščita

Konstrukcijo je potrebno protikorozijsko zaščititi. Predlagam uporabo enega temeljnega in dveh prekrivnih premazov v skupni debelini suhega filma 0.15 – 0.20 mm. Po montaži je potrebno vsa poškodovana mesta očistiti in ponovno zaščititi. Pred nanosom temeljnega sloja protikorozijske zaščite, morajo biti vsi elementi očiščeni s peskanjem.

2.14 Seznam uporabljenih standardov

SIST-EN 1990: **Osnove projektiranja**
SIST-EN 1990: Osnove projektiranja

SIST-EN 1991: **Vplivi na konstrukcijo**
SIST-EN 1991-1-1: Prostorninska teža, lastna teža, koristne obtežbe stavb
SIST-EN 1991-1-3: Obtežba snega
SIST-EN 1991-1-4: Obtežba vetra

SIST-EN 1993: **Projektiranje jeklenih stavb**

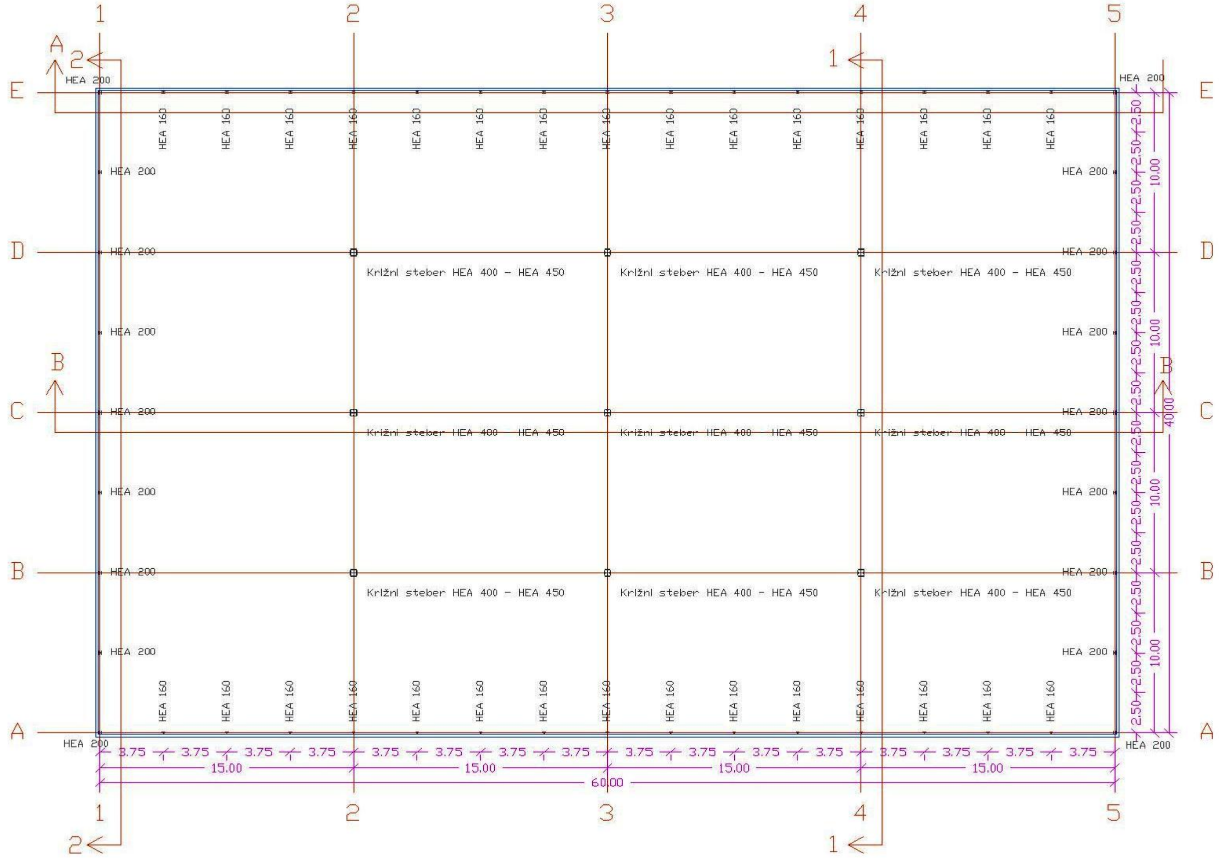
SIST-EN 1993-1-1: Splošna pravila in pravila za stavbe
SIST-EN 1993-1-8: Projektiranje spojev

SIST-EN 1997: Geotehnično projektiranje
SIST-EN 1997-1: Splošna pravila

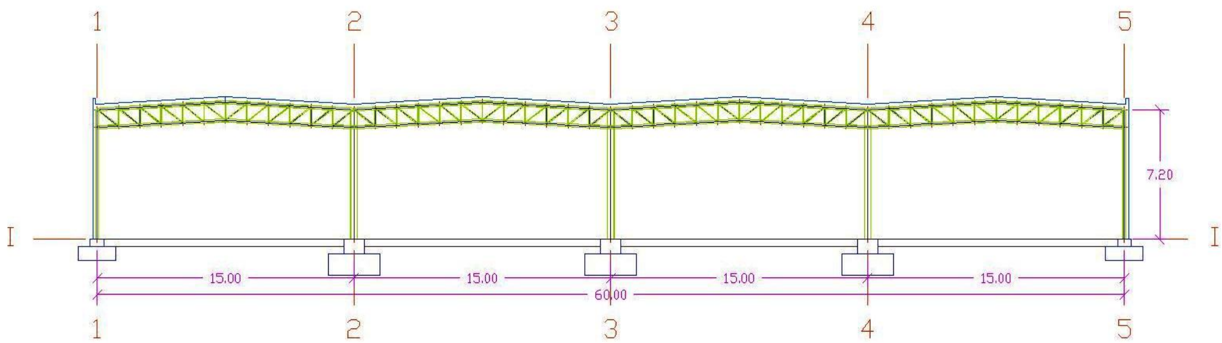
SIST-EN 1998: Projektiranje potresnoodpornih konstrukcij
SIST-EN 1998-1: Splošna pravila, potresna obtežba in pravila za stavbe

3 ZASNOVA OBJEKTA

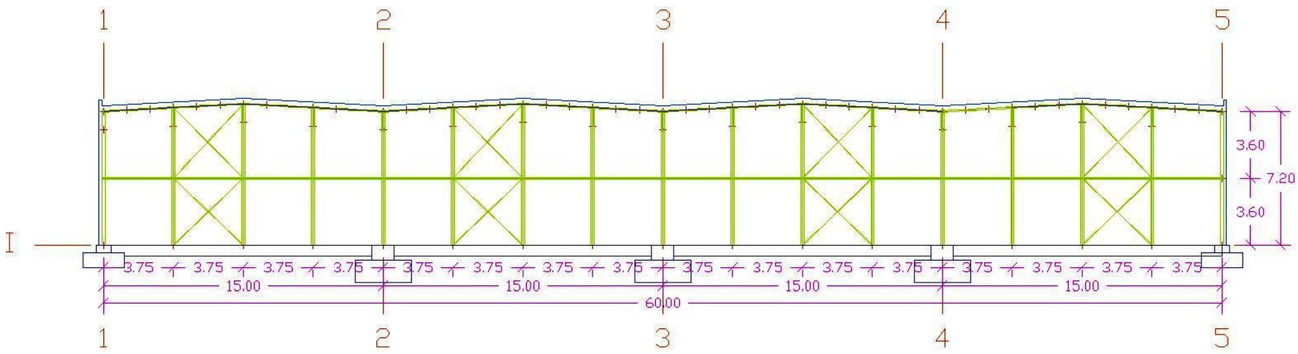
3.1 Zasnova



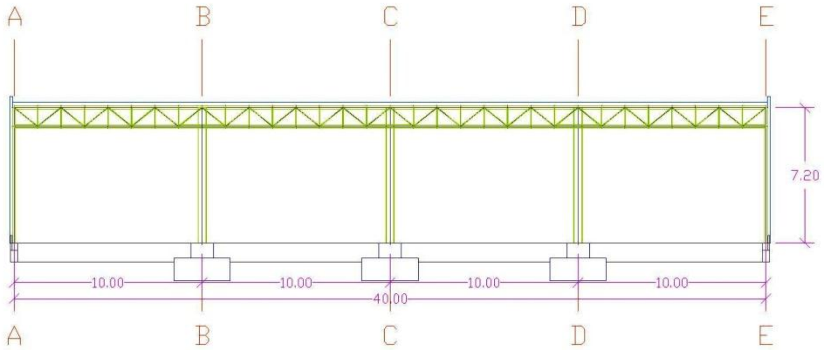
Slika 4: Tloris objekta na koti + 1.00 m



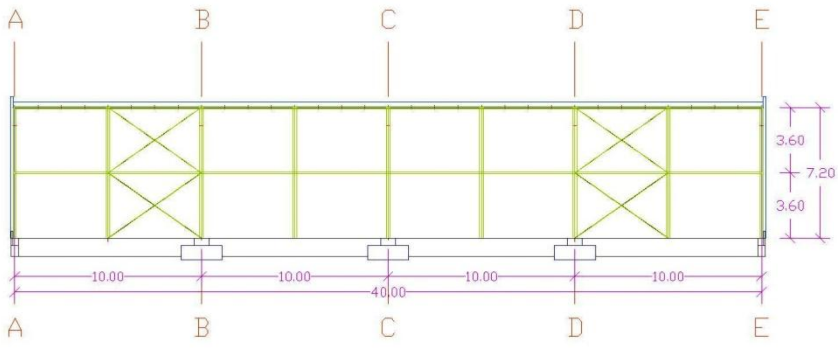
Slika 5: Vzdolžni prerez B-B



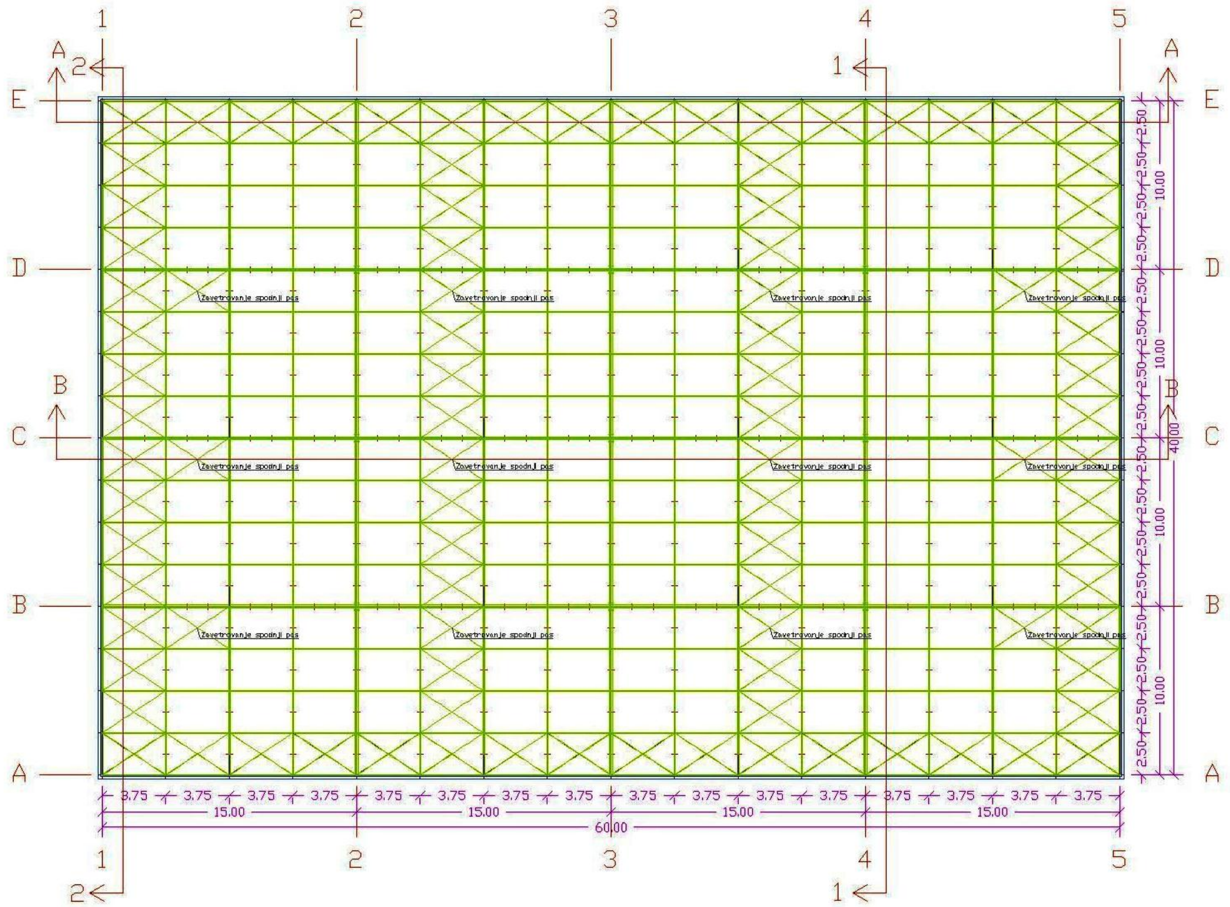
Slika 6: Vzdolžni prerez A-A



Slika 7: Prečni prerez 1-1



Slika 8: Prečni prerez 2-2



Slika 9: Tloris strehe

3.2 Globalna geometrijska nepopolnost

Upošteval sem geometrijsko nepopolnost, ki se lahko pojavi pri izdelavi in montaži konstrukcije logističnega centra.

$\Phi = 1/240 = 0.004167$

4 VPLIVI NA KONSTRUKCIJO

4.1 Lastna teža in stalna obtežba

Lastno in stalno obtežbo konstrukcije logističnega centra sestavljajo stalni nepomični vplivi, ki predvidoma delujejo na konstrukcijo ves čas njene življenjske dobe.

4.1.1 Obtežba strehe

- SIKA folija SIKAPLAN – 20 G (2.0 mm) :	0.024 kN/m^2
- toplotna izolacija (20 cm):	0.070 kN/m^2
- visokoprofilirana pločevina 85/280 d=0.75 mm:	0.079 kN/m^2
- inštalacije:	0.200 kN/m^2
	$\sum g$ = 0.373 kN/m^2

4.1.2 Fasadna konstrukcija

Fasadno konstrukcijo predstavlja TRIMO fasadni panel, ki je horizontalno pritrjen na fasadne stebre na razmaku 3.75 m in 5.00 m.

TRIMO fasadni panel g = 0.30 kN/m^2

4.2 Koristna obtežba

Ker je streha nepohodna, in razen osnovne funkcije ne opravlja nobene druge, na konstrukcijo ne deluje nobena koristna obtežba.

4.3 Obtežba snega

Karakteristična vrednost obtežbe snega: $s_k=1.293\left[1+\left(\frac{A}{728}\right)^2\right]=1.51$ kN/m^2

Obtežba snega: $S = \mu\, C_e\, C_t\, s_k = 0.8 \cdot 1.0 \cdot 1.0 \cdot 1.51 = 1.21$ kN/m^2

A … nadmorska višina objekta
A = 300 m (Ljubljana)

μ … oblikovni koeficient (za ravne strehe in primer simetrične obtežbe je μ=0.8, za primer nesimetrične obtežbe pa se μ zmanjša za polovico)
C_e … koeficient izpostavljenosti (=1.0)
C_t … termični koeficient (=1.0)

4.4 Vpliv vetra

Na karti za veter s tremi conami izberemo cono, v kateri leži naš objekt.

Ljubljana → cona 1 pod 800 m → $v_{b,0} = 20$ m/s

Temeljna vrednost osnovne hitrosti vetra: $v_{b,0} = 20$ m/s, gostota zrak: $\rho = 1.25$ kg/m^3
Kategorija terena III: višina hrapavosti oz. neravnine: $z_0 = 0.3$ m, minimalna višina nad tlemi, kjer je hitrost vetra konstantna: $z_{min} = 5.0$ m.

Sile vetra na objekt

Osnovna predpostavka:
- površine, na katere učinkujejo sile vetra, morajo biti dovolj toge, da se lahko zanemarijo njihova resonančna nihanja, ki nastanejo zaradi delovanja vetra,
- če so lastne nihajne frekvence omenjenih površin < 5Hz, lahko ta nihanja postanejo pomembna in jih je zato potrebno upoštevati v računu.

Sile vetra se izračunajo z izrazom:

$F_W = c_s\, c_d \sum c_f\, q_p\, A_{ref}$

$c_s\, c_d$ … konstrukcijski faktor, ki upošteva vpliv raznočasnega nastopa koničnih vetrnih tlakov in nihanj konstrukcije zaradi turbolence. Za objekte, ki so nižji od 15 m in imajo lastno frekvenco > 5 Hz je faktor 1,
c_f … koeficient tlaka za zunanje, notranje ali trenjske sile,
q_p … karakteristični konični tlak,
A_{ref}… referenčna površina konstrukcijskega dela (trenjske sile lahko zanemarimo, če je celotna površina vseh površin vzporednih z vetrom enaka ali manjša od štirikratne površine vseh zunanjih površin, pravokotnih na veter – privetrna in zavetrna stran).

4.4.1 Tlak na zunanje površine objekta

Tlak vetra na zunanje površine izračunamo z izrazom:

$W_e = c_{pe}\, q_p$

c_{pe} … koeficient tlaka za zunanji tlak in je podan v obliki tabel, ločeno za navpične stene in strehe,

q_p … karakteristični konični tlak: $q_p = q_p(z_e)$,

z_e … referenčna višina za zunanji tlak:

$z_e = h$, če $h \leq b \rightarrow q_p$ je konstanten po višini

b … širina objekta, pravokotno na veter

h … višina objekta

Karakteristični konični tlak q_p:

$q_p = c_e\, q_b$ → $q_p = 2.1212 \cdot 0.25$ kN/m^2 = 0.53 kN/m^2

c_e … faktor izpostavljenosti,

q_b … osnovni tlak,

(i) faktor izpostavljenosti:

Iz tabele: C_e (5 m) = 1.93 , C_e (10 m) = 2.35

→ interpolacija C_e (7.2 m) = 2.1212

(ii) osnovni tlak:

$q_b = \frac{1}{2}\rho\, v_b^2 \rightarrow q_b = \frac{1}{2} \cdot 1.25 \cdot 20^2$ = 250 N/m^2 = 0.25 kN/m^2

v_b … osnovna hitrost vetra: $v_b = c_{dir}\, c_{season}\, v_{b,0}$

c_{dir} = 1.0 (smerni faktor),

c_{season} = 1.0 (faktor letnega časa)

Veter v prečni smeri

$e = \min\begin{cases} b \\ 2h \end{cases} \rightarrow e = 15.6$ m

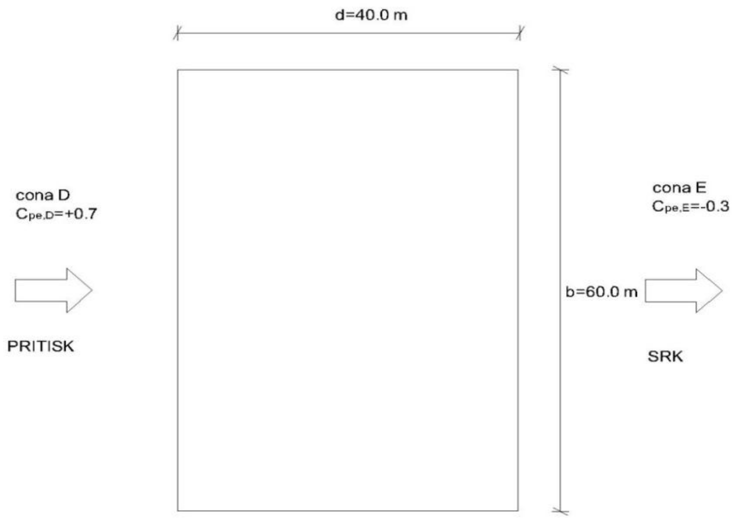
$c_{pe} = c_{pe10}$ … dejanska površina je večja od 10 m^2

$c_{pe} = c_{pe1}$ … dejanska površina je med 1 m^2 in 10 m^2

Privetrna in zavetrna stran objekta:

$h / d = 0.13 < 0.25$

d … širina objekta vzporedna z vetrom



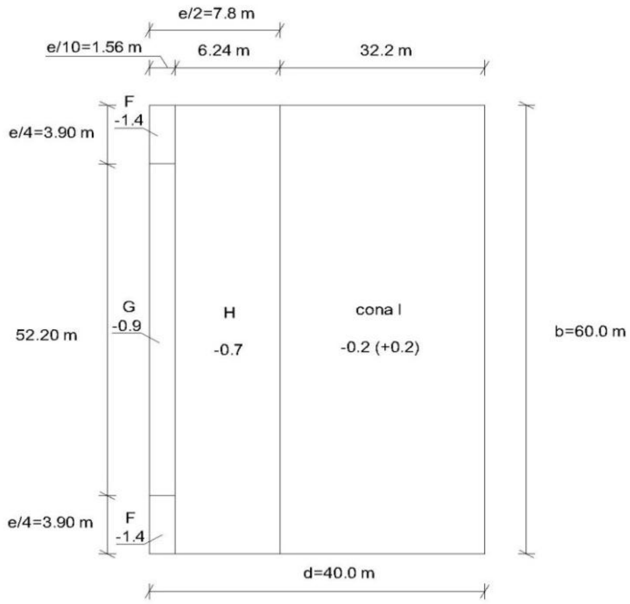
Slika 10: Razdelitev sten na področja v prečni smeri

$W_e^D = 0.7 \cdot 0.53 = 0.371$ kN/m^2
$W_e^E = - 0.3 \cdot 0.53 = - 0.159$ kN/m^2

- ravna streha

$h_p / h = 0.05$

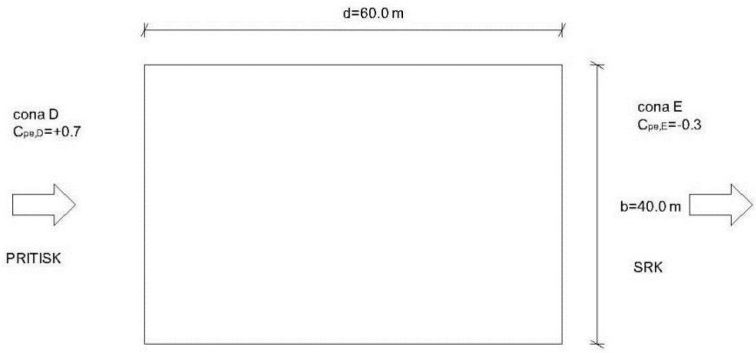
h_p … višina parapeta
h … višina objekta med parapetom in tlemi



Slika 11: Razdelitev strehe na področja v prečni smeri

W_e^G = - 0.9 · 0.53 kN/m^2 = - 0.477 kN/m^2
W_e^H = - 0.7 · 0.53 kN/m^2 = - 0.371 kN/m^2
W_e^I = ± 0.2 · 0.53 kN/m^2 = ± 0.106 kN/m^2

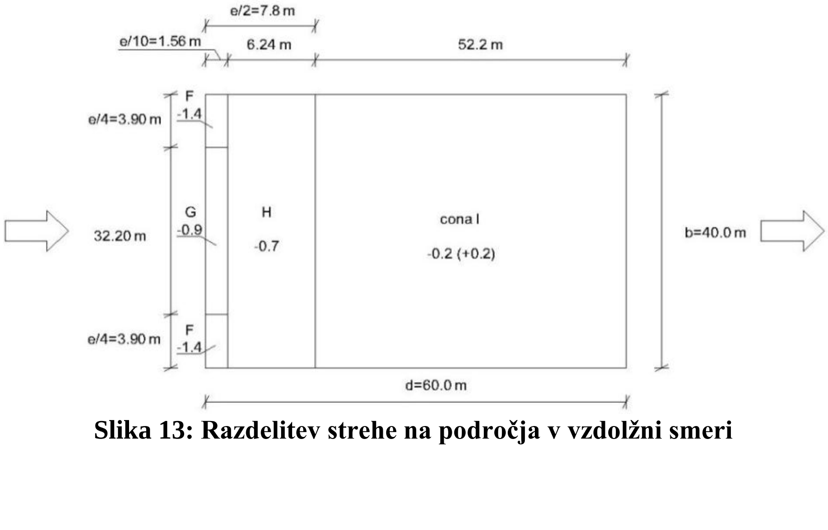
Veter v vzdolžni smeri



Slika 12: Razdelitev sten na področja v vzdolžni smeri

W_e^D = 0.7 · 0.53 kN/m^2 = 0.371 kN/m^2
W_e^E = - 0.3 · 0.53 kN/m^2 = - 0.159 kN/m^2

- ravna streha



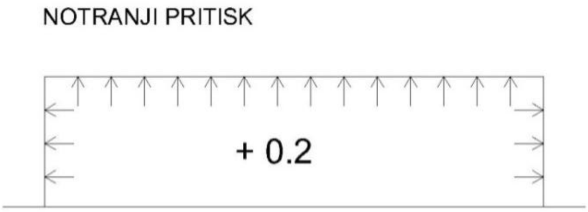
Slika 13: Razdelitev strehe na področja v vzdolžni smeri

$W_e^G = - 0.9 \cdot 0.53\ kN/m^2 = - 0.477\ kN/m^2$
$W_e^H = - 0.7 \cdot 0.53\ kN/m^2 = - 0.371\ kN/m^2$
$W_e^I = \pm 0.2 \cdot 0.53\ kN/m^2 = \pm 0.106\ kN/m^2$

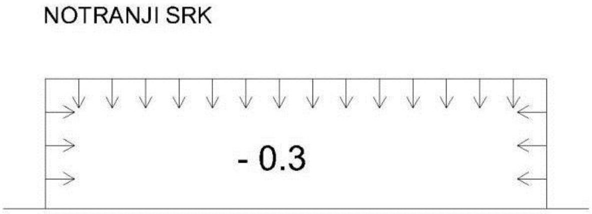
4.4.2 Notranji vpliv vetra

$W_i = c_{pi} \cdot q_p$

Glede na EN 1991-1-4:2005 (E), poglavje 7.2.9, 6. člen (opomba 2), sem določil vrednosti c_{pi}:



Slika 14: Notranji pritisk vetra



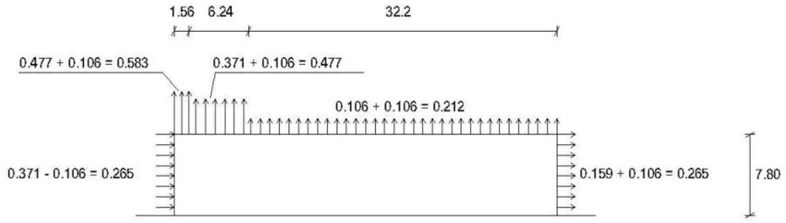
Slika 15: Notranji srk

- notranji pritisk: $W_i = 0.2 \cdot 0.53\ kN/m^2 = 0.106\ kN/m^2$
- notranji srk: $W_i = - 0.3 \cdot 0.53\ kN/m^2 = - 0.159\ kN/m^2$

4.4.3 Skupni vpliv vetra

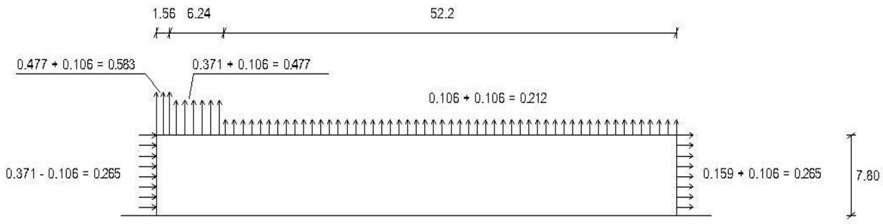
Zunanji vpliv + notranji pritisk

- prečna smer



Slika 16: Zunanji vpliv + notranji pritisk vetra v prečni smeri v kN/m²

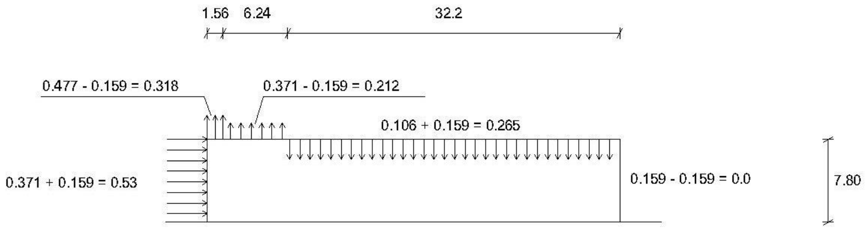
- vzdolžna smer



Slika 17: Zunanji vpliv + notranji pritisk vetra v vzdolžni smeri v kN/m²

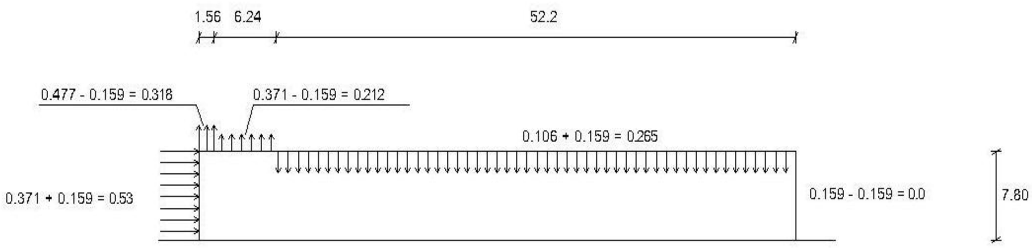
Zunanji vpliv + notranji srk

- prečna smer



Slika 18: Zunanji vpliv vetra + notranji srk v prečni smeri v kN/m²

- vzdolžna smer



Slika 19: Zunanji vpliv vetra + notranji srk v vzdolžni smeri v kN/m²

4.5 Potresna obtežba

Objekt se nahaja v Ljubljani:
Pričakovana intenziteta potresa: Ljubljana → $a_g = 0.25$

Kategorija tal – tip tal B (zelo gost pesek, prod ali zelo toga glina):
→ parameter tal S = 1.2,
→ karakteristični nihajni časi spektra: $T_B = 0.15$ s
$T_C = 0.5$ s
$T_D = 2.0$ s

Faktor obnašanja (elastični spekter) q = 1.5

4.5.1 Primarni okvir smer – X

4.5.1.1 Izračun nihajnega časa

$T_1 = c_t \cdot H^{3/4}$

T_1 (Scia Engineer) $= \frac{1}{\nu} = \frac{1}{2.28} = 0.44$ s

$c_t = 0.085$

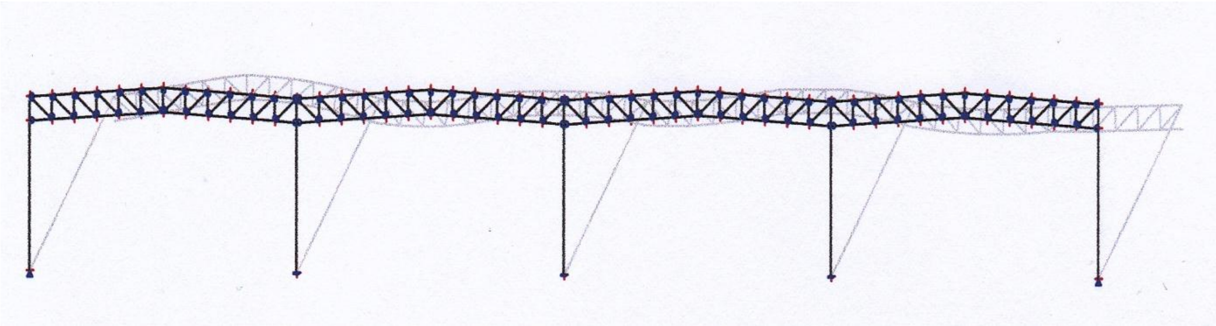
$T_1 = 0.085 \cdot (7.2\ \text{m})^{3/4} = 0.3736$ s

V nadaljnjem računu upoštevam nihajni čas izračunan s programom Scia Engineer.

Preglednica 1: Frekvence in nihajni časi primarnega okvirja – smer X

Eigen frequencies

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Mass combination : CM1				
1	2,30	14,44	208,38	0,44
2	5,33	33,46	1119,72	0,19
3	5,56	34,96	1222,22	0,18
4	6,44	40,48	1638,86	0,16



Slika 20: Prva nihajna oblika primarnega okvirja v smeri x

4.5.1.2 Določitev mas in potresne sile

Lastna obtežba:

Rezultanta R_z [lastna teža] (Scia Engineer): R_z =96.34 kN
∑ = 96.34 kN

Stalna obtežba:
- streha: 0.373 kN/m^2 · 10.0 m · 60.0 m = 223.80 kN
- sekundarni nosilci: 2,92 kN · 12 + 0.98 kN · 2 = 37.00 kN
- fasada: 0.30 kN/m^2 · (5.0 m · 3.6 m) · 2 = 10.80 kN

∑ = 271.60 kN

Sneg:
1.21 kN/m^2 · (10.0 m · 60 m) · 0.2 =145.2 kN

∑ m = 513.14 kN

Preglednica 2: Rezultati modalne analize primarnega okvirja – smer X

Calculation protocol

Calc protokol

Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu

Solution of Free Vibration

Number of 2D elements	0
Number of 1D elements	198
Number of mesh nodes	103
Number of equations	618

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

Combination of mass groups	MC 1 CM1
Number of frequencies	4
Start of calculation	28.04.2011 13:48
End of calculation	28.04.2011 13:48

Sum of masses

[kg]	X	Y	Z
Combination of mass groups 1	48345.96	0.00	48345.96

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

Modal participation factors

Mode	Omega	Period	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
1	14.4359	0.4352	2.2975	0.9475	0.0000	0.0000
2	33.4632	0.1878	5.3258	0.0022	0.0000	0.0000
3	34.9613	0.1797	5.5643	0.0000	0.0000	0.1557
4	40.4841	0.1552	6.4432	0.0008	0.0000	0.0000
				0.9505	0.0000	0.1557

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

Projektni spekter:

$S_d\,(T_1) = a_g \cdot S \cdot \frac{2,5}{q}$ $\quad T_B \leq T_1 \leq T_C \quad$ $T_B \leq T_1 = 0.5$ s

$S_d\,(T_1) = 0.25 \cdot 1.2 \cdot \frac{2,5}{1.5}$

$S_d\,(T_1) = 0.5$

Faktor obnašanja (elastični spekter) q = 1.5

Potresna sila F_b:

$F_b = S_d \cdot m \cdot \lambda$

$F_b = 0.5 \cdot 513.14\ \text{kN} \cdot 1.0 = 256.57\ \text{kN}$

4.5.1.3 Vpliv slučajne torzije

$\delta = 1 + 1.2 \cdot x/L_e = 1 + 1.2 \cdot 10\ m / 60\ m = 1.2$

Potresna obtežba:

$F = \delta \cdot F_b = 1.2 \cdot 256.57\ kN = 307.88\ kN$

4.5.1.4 Vpliv teorije drugega reda

$P_{tot} = 513.14\ kN$
$u_i = 46.76\ mm$
$d_r = 70.14\ mm$
$V_{tot} = 307.88\ kN$
$h = 7200\ mm$

$\theta = P_{tot} \cdot d_r / V_{tot} \cdot h$ $0.1 \leq \theta \leq 0.25$; $k_\delta = 1 / 1 - \theta$

$\theta = 513.14\ kN \cdot 70.14\ mm / 307.88\ kN \cdot 7200\ mm = 0.0162$

→ okvir je pomičen

$k_\delta = 1.0165$

4.5.2 Primarni okvir smer – Y

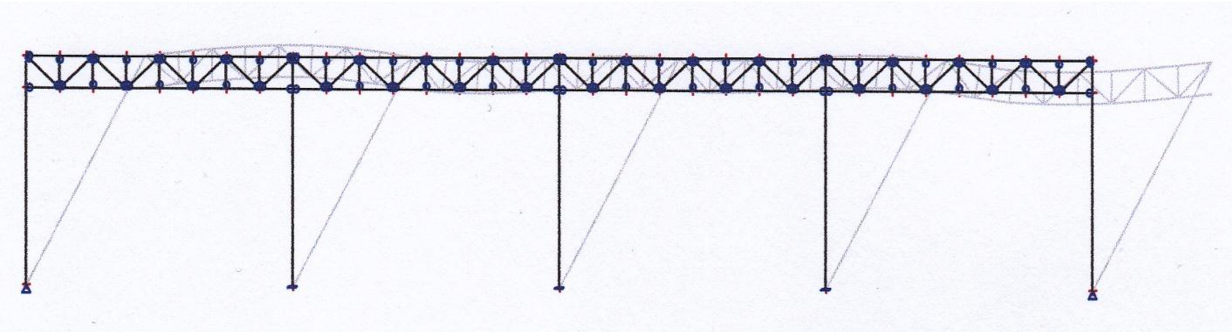
4.5.2.1 Izračun nihajnega časa

T_1 (Scia Engineer) $= \frac{1}{\nu} = \frac{1}{2.46} = 0.41\ s$

Preglednica 3: Frekvence in nihajni časi primarnega okvirja – smer Y

Eigen frequencies

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Student version *Student version* *Student version* *Student version* *Student version* *Student ver				
Mass combination : CM1				
1	2,44	15,33	235,06	0,41
2	7,50	47,15	2222,84	0,13
3	7,62	47,89	2292,99	0,13
4	8,38	52,66	2772,88	0,12



Slika 21: Prva nihajna oblika primarnega okvirja v smeri y

4.5.2.2 Določitev mas in potresne sile

Projektni spekter:

$S_d\,(T_1) = a_g \cdot S \cdot \frac{2,5}{q}$ $\quad T_B \leq T_1 \leq T_C$ $\quad T_B \leq T_1 = 0.5$ s

$S_d\,(T_1) = 0.25 \cdot 1.2 \cdot \frac{2,5}{1.5}$

$S_d\,(T_1) = 0.5$

Lastna obtežba:

Rezultanta R_z [lastna teža] (Scia Engineer): R_z =67.47 kN
∑ = 67.47 kN

Stalna obtežba:
- streha: 0.373 kN/m^2 · 3.75 m · 40.0 m = 55.95 kN
- fasada: 0.30 kN/m^2 · (3.75 m · 3.6 m) · 2 = 8.10 kN

∑ = 64.05 kN

Sneg:
1.21 kN/m^2 · (3.75 m · 40.0 m) · 0.2 =36.30 kN

∑ m_{okY} = 167.82 kN

Okvir Y mora prevzeti tudi horizontalno potresno obtežbo sekundarnih elementov konstrukcije.

Lastna teža sekundarne konstrukcije:

- sekundarni nosilci: 2.92 kN · 12 = 35.04 kN
- fasadni stebri: 0.304 kN/m · 3.6 m ·6 = 6.57 kN

∑ = 41.61 kN

Stalna obtežba:
- streha: 0.373 kN/m^2 · 3.75 m · 40.0 m · 3 = 167.85 kN
- fasada: 0.30 kN/m^2 · (3.75 m · 3.6 m) · 2 · 3 = 24.30 kN

∑ = 192.15 kN

Sneg:
1.21 kN/m^2 · (3.75 m · 40.0 m) · 0.2 · 3 =108.90 kN

∑ m_{sek} = 342.66 kN

Potresna sila primarnega okvirja v smeri Y in sekundarne konstrukcije:

∑ m = 167.82 kN + 342.66 kN = 510.48 kN

Preglednica 4: Rezultati modalne analize primarnega okvirja – smer Y

Calculation protocol

Calc protokol

Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu

Solution of Free Vibration

Number of 2D elements	0
Number of 1D elements	134
Number of mesh nodes	71
Number of equations	426
Student version *Student version* *Student version* *Student version* *Stude	
Combination of mass groups	MC 1 CM1
Number of frequencies	4
Start of calculation	29.04.2011 19:57
End of calculation	29.04.2011 19:57

Sum of masses

[kg]	X	Y	Z
Student version *Student version* *Student version* *Student version* *Student version* *Student ve			
Combination of mass groups 1	51324.39	0.00	51324.39

Modal participation factors

Mode	Omega	Period	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
Student version *Student version* *Student version* *Student version* *Student version* *Student version*						
1	15.3320	0.4098	2.4402	0.9731	0.0000	0.0000
2	47.1484	0.1333	7.5039	0.0013	0.0000	0.0000
3	47.8866	0.1312	7.6214	0.0000	0.0000	0.1628
4	52.6597	0.1193	8.3811	0.0004	0.0000	0.0000
				0.9748	0.0000	0.1628

Potresna sila F_b:

$F_b = S_d \cdot m \cdot \lambda$

$F_b = 0.5 \cdot 510.48\ kN \cdot 1.0 = 255.24\ kN$

4.5.2.3 Vpliv slučajne torzije

$\delta = 1 + 1.2 \cdot x/L_e = 1 + 1.2 \cdot 15/40 = 1.45$

Potresna obtežba:

$F = \delta \cdot F_b = 1.45 \cdot 255.24\ kN = 370.10\ kN$

4.5.2.4 Vpliv teorije drugega reda

$P_{tot} = 510.48\ kN$
$u_i = 44.43\ mm$
$d_r = 66.65\ mm$
$V_{tot} = 370.10\ kN$
$h = 7200\ mm$

$\theta = P_{tot} \cdot d_r / V_{tot} \cdot h$ $\qquad 0.1 \leq \theta \leq 0.25; \quad k_\delta = 1 / 1 - \theta$

$\theta = 510.48\ kN \cdot 66.65\ mm / 370.10\ kN \cdot 7200\ mm = 0.0128$
→ okvir je pomičen

$k_\delta = 1.0129$

4.5.3 Okvir s centričnim povezjem – smer X

4.5.3.1 Izračun nihajnega časa

$T_1 = c_t \cdot H^{3/4}$ $\qquad T_1\ (\text{Scia Engineer}) = \frac{1}{\nu} = \frac{1}{2.95} = 0.34\ s$

$c_t = 0.085$

$T_1 = 0.085 \cdot (7.2\ m)^{3/4} = 0.3736\ s$

Preglednica 5: Frekvence in nihajni časi okvirja s centričnim povezjem – smer X

Eigen frequencies

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Student version *Student version* *Student version* *Student version* *Student version* *Student versio				
Mass combination : CM1				
1	2,95	18,55	344,09	0,34
2	24,61	154,63	23909,08	0,04
3	24,97	156,87	24606,83	0,04
4	28,40	178,41	31831,85	0,04

4.5.3.2 Določitev mas in potresne sile

Lastna obtežba:

Rezultanta R_z [lastna teža] (Scia Engineer): R_z =5.31 kN
$\sum$ = 5.31 kN

Stalna obtežba:
- streha: 0.373 kN/m^2 · 5.0 m · 3.75 m = 6.99 kN
- sekundarni nosilci: 2,92 kN · 0.5 · 2 = 2.92 kN
- fasada: 0.30 kN/m^2 · (3.75 m · 3.6 m) = 4.05 kN

$\sum$ = 13.96 kN

Sneg:
1.21 kN/m^2 · (5.0 m · 3.75 m) · 0.2 =4.54 kN

Masa enega okvirja:
$\sum m_{m.\ okvir}$ = 23.81 kN

$m = 1 / n_{povezij} \cdot (n_{m.\ okvir} - 1) \cdot m_{m.\ okvir} = 1 / 4 \cdot (16 - 1) \cdot 23.81$ kN = 89.29 kN

Preglednica 6: Rezultati modalne analize okvirja s centričnim povezjem – smer X

Calculation protocol

Calc protokol

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

Solution of Free Vibration

Number of 2D elements	0
Number of 1D elements	8
Number of mesh nodes	6
Number of equations	36

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

Combination of mass groups	MC 1 CM1
Number of frequencies	4
Start of calculation	11.04.2011 11:19
End of calculation	11.04.2011 11:19

Sum of masses

Student version *Student version* *Student version* *Student version* *Student version* *Studen

[kg]	X	Y	Z
Combination of mass groups 1	9374.74	0.00	9374.74

Modal participation factors

Student version *Student version* *Student version* *Student version* *Student version* *Student version* *St

Mode	Omega	Period	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
1	18.5502	0.3387	2.9524	0.9897	0.0000	0.0002
2	154.6302	0.0406	24.6102	0.0000	0.0000	0.7440
3	156.8703	0.0401	24.9667	0.0014	0.0000	0.2443
4	178.4201	0.0352	28.3964	0.0016	0.0000	0.0034
				0.9927	0.0000	0.9920

Projektni spekter:

$S_d\,(T_1) = a_g \cdot S \cdot \frac{2{,}5}{q}$ $\qquad T_B \leq T_1 \leq T_C$ $\qquad T_B \leq 0.34 = 0.5$ s

$S_d\,(T_1) = 0.25 \cdot 1.2 \cdot \frac{2{,}5}{1.5}$

$S_d\,(T_1) = 0.5$

Faktor obnašanja (elastični spekter) q = 1.5

Potresna sila F_b:

$F_b = S_d \cdot m \cdot \lambda$

$F_b = 0.5 \cdot 89.29$ kN $\cdot\, 1.0 = 44.64$ kN

4.5.3.3 Vpliv slučajne torzije

$\delta = 1 + 1.2 \cdot x/L_e = 1 + 1.2 \cdot 20/60 = 1.4$

Potresna obtežba:

$F = \delta \cdot F_b = 1.4 \cdot 44.64\ kN = 62.50\ kN$

4.5.3.4 Vpliv teorije drugega reda

$P_{tot} = 89.29\ kN$
$u_i = 18.90\ mm$
$d_r = 28.35\ mm$
$V_{tot} = 62.50\ kN$
$h = 7200\ mm$

$\theta = P_{tot} \cdot d_r / V_{tot} \cdot h$ $\quad 0.1 \leq \theta \leq 0.25; \quad k_\delta = 1 / 1 - \theta$

$\theta = 89.29\ kN \cdot 28.35\ mm / 62.50\ kN \cdot 7200\ mm = 0.0056$

→ okvir ni pomičen

4.5.4 Okvir s centričnim povezjem – smer Y

4.5.4.1 Izračun nihajnega časa

$T_1 = c_t \cdot H^{3/4}$ $\quad T_1\ (\text{Scia Engineer}) = \frac{1}{\nu} = \frac{1}{2.95} = 0.31\ s$

$c_t = 0.085$

$T_1 = 0.085 \cdot (7.2\ m)^{3/4} = 0.3736\ s$

Preglednica 7: Frekvence in nihajni časi okvirja s centričnim povezjem – smer Y

Eigen frequencies

N	f [Hz]	omega [1/sec]	omega^2 [1/sec^2]	T [sec]
Student version *Student version* *Student version* *Student version* *Student version* *Student versio				
Mass combination : CM1				
1	3,36	21,10	445,35	0,30
2	23,10	145,12	21061,10	0,04
3	23,71	148,97	22191,70	0,04
4	30,09	189,04	35735,24	0,03

4.5.4.2 Določitev mas in potresne sile

Lastna obtežba:

Rezultanta R_z [lastna teža] (Scia Engineer): R_z =8.59 kN
∑ = 8.59 kN

Stalna obtežba:
- streha: 0.373 kN/m^2 · 7.50 m · 5.00 m = 13.99 kN
- sekundarni nosilci: 2,92 kN · 1.5 = 4.38 kN
- fasada: 0.30 kN/m^2 · (5.00 m · 3.6 m) = 5.40 kN

∑ = 13.96 kN

Sneg:
1.21 kN/m^2 · (7.50 m · 5.00) · 0.2 =9.08 kN

Masa enega okvirja:
$\sum m_{m.\ okvir}$ = 41.44 kN

$m = 1 / n_{povezij} \cdot (n_{m.\ okvir} - 1) \cdot m_{m.\ okvir} = 1 / 2 \cdot (8 - 1) \cdot 41.44$ kN = 145.04 kN

Preglednica 8: Rezultati modalne analize okvirja s centričnim povezjem – smer Y

Calculation protocol

Calc protokol

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

Solution of Free Vibration

Number of 2D elements	0
Number of 1D elements	8
Number of mesh nodes	6
Number of equations	36
Combination of mass groups	MC 1 CM1
Number of frequencies	4
Start of calculation	13.04.2011 20:21
End of calculation	13.04.2011 20:21

Sum of masses

[kg]	X	Y	Z
Combination of mass groups 1	15208.41	0.00	15208.41

Modal participation factors

Mode	Omega	Period	Freq. [Hz]	Wxi / Wxtot	Wyi / Wytot	Wzi / Wztot
1	21.1039	0.2977	3.3588	0.9915	0.0000	0.0002
2	145.1287	0.0433	23.0979	0.0000	0.0000	0.7788
3	148.9732	0.0422	23.7098	0.0016	0.0000	0.2136
4	189.0432	0.0332	30.0872	0.0007	0.0000	0.0006
				0.9937	0.0000	0.9933

Projektni spekter:

$S_d\,(T_1) = a_g \cdot S \cdot \frac{2{,}5}{q}$ $\quad T_B \leq T_1 \leq T_C \quad T_B \leq 0.34 = 0.5$ s

$S_d\,(T_1) = 0.25 \cdot 1.2 \cdot \frac{2{,}5}{1.5}$

$S_d\,(T_1) = 0.5$

Faktor obnašanja (elastični spekter) q = 1.5

Potresna sila F_b:

$F_b = S_d \cdot m \cdot \lambda$

$F_b = 0.5 \cdot 145.04$ kN $\cdot\ 1.0 = 72.52$ kN

4.5.4.3 Vpliv slučajne torzije

$\delta = 1 + 1.2 \cdot x/L_e = 1 + 1.2 \cdot 30/40 = 1.9$

Potresna obtežba:

$F = \delta \cdot F_b = 1.9 \cdot 72.52$ kN = 137.79 kN

4.5.4.4 Vpliv teorije drugega reda

P_{tot} = 145.04 kN
u_i = 20.4 mm
d_r = 30.6 mm
V_{tot} = 137.79 kN
h = 7200 mm

$\theta = P_{tot} \cdot d_r / V_{tot} \cdot h$ $\quad 0.1 \leq \theta \leq 0.25;\quad k_\delta = 1 / 1 - \theta$

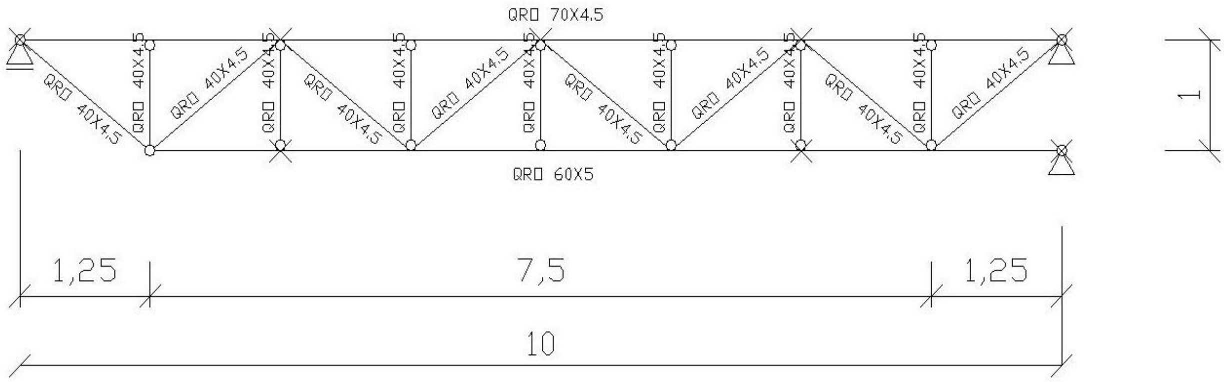
$\theta = 145.04$ kN $\cdot$ 30.6 mm / 137.79 kN $\cdot$ 7200 mm = 0.0045

→ okvir ni pomičen

5 STATIČNA ANALIZA

5.1 Sekundarni palični nosilec 1 – POZ 1

5.1.1 Računski model



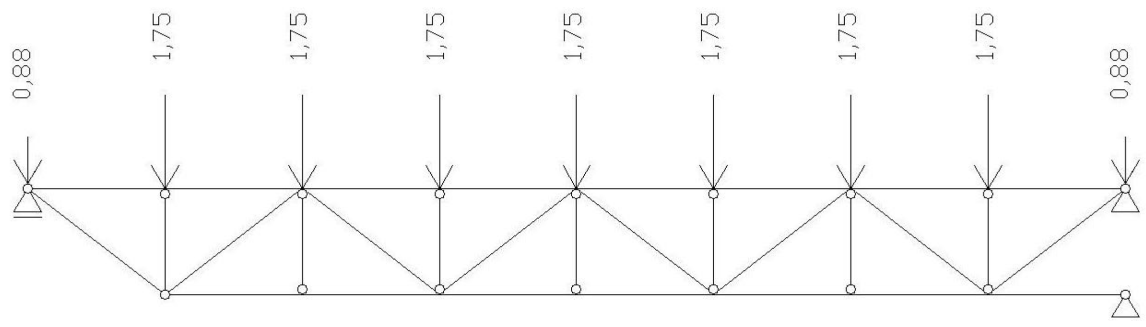
Slika 22: Zasnova sekundarnega paličnega nosilca 1

5.1.2 Obtežne sheme

5.1.2.1 Lastna in stalna obtežba [G]

Lastna teža je avtomatično upoštevana v programu. To velja za vse nadaljnje izračune.

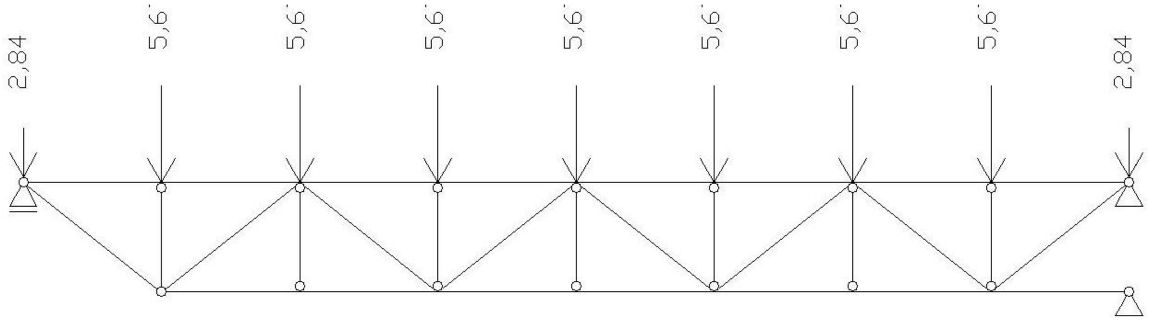
- streha: $0.373\ kN/m^2 \times 3.75\ m \times 1.25\ m = 1.75\ kN$
$0.373\ kN/m^2 \times 3.75\ m \times 0.625\ m = 0.88\ kN$



Slika 23: Obtežna shema sekundarnega paličnega nosilca 1 – stalna obtežba v kN

5.1.2.2 Sneg [S]

- sneg: 1.21 kN/m^2 × 3.75 m × 1.25 m = 5.67 kN
  1.21 kN/m^2 × 3.75 m × 0.625 m = 2.84 kN

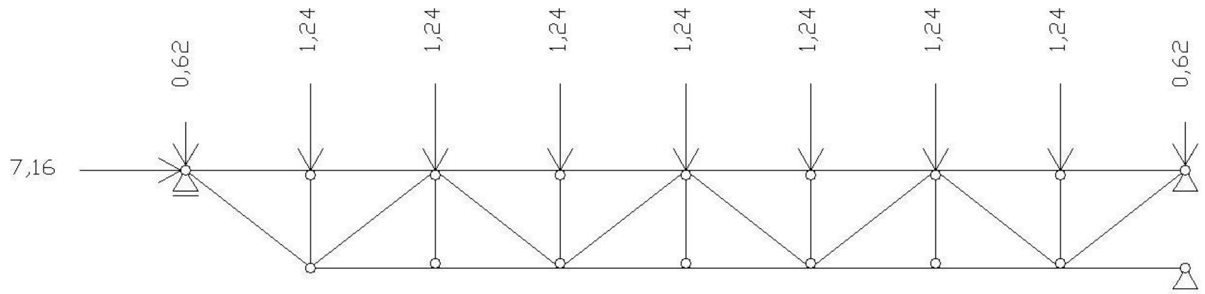


Slika 24: Obtežna shema sekundarnega paličnega nosilca 1 – sneg v kN

5.1.2.3 Veter [W]

- vertikalna obtežba: 0.265 kN/m^2 × 3.75 m × 1.25 m = 1.24 kN
  0.265 kN/m^2 × 3.75 m × 0.625 m = 0.62 kN

- horizontalna obtežba: 0.53 kN/m^2 × 3.75 m × 3.6 m = 7.16 kN



Slika 25: Obtežna shema sekundarnega paličnega nosilca 1 – veter v kN

5.1.3 Obtežne kombinacije

5.1.3.1 MSN

C1) 1.35·G + 1.5·S + 1.5·W · 0.6
C2) 1.35·G + 1.5·S · 0.6 + 1.5·W

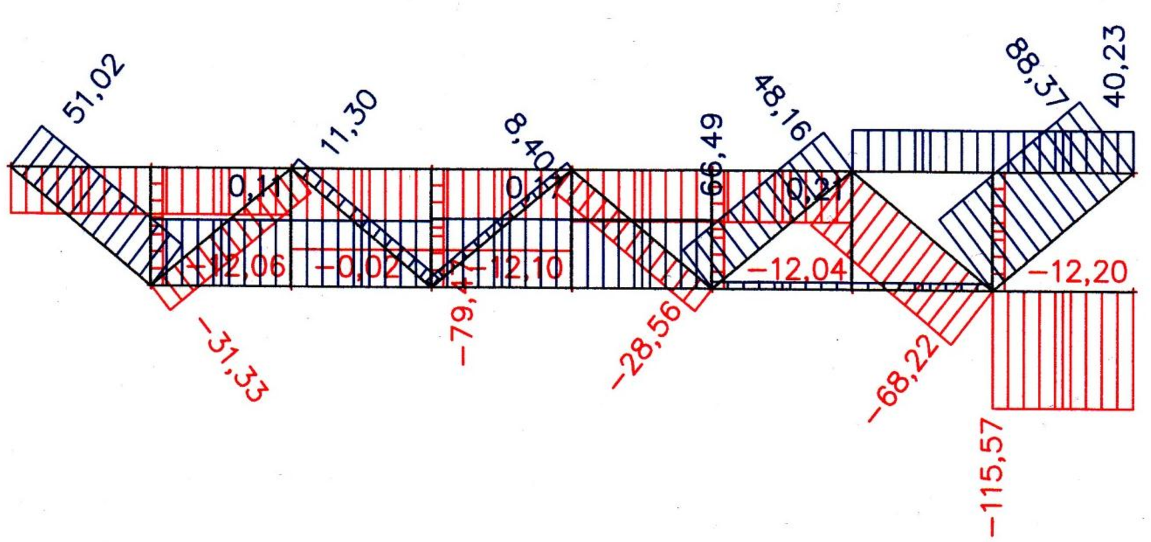
5.1.3.2 MSU

C1) $1.0 \cdot G + 0.9 \cdot S + 0.9 \cdot W$

5.1.4 Rezultati

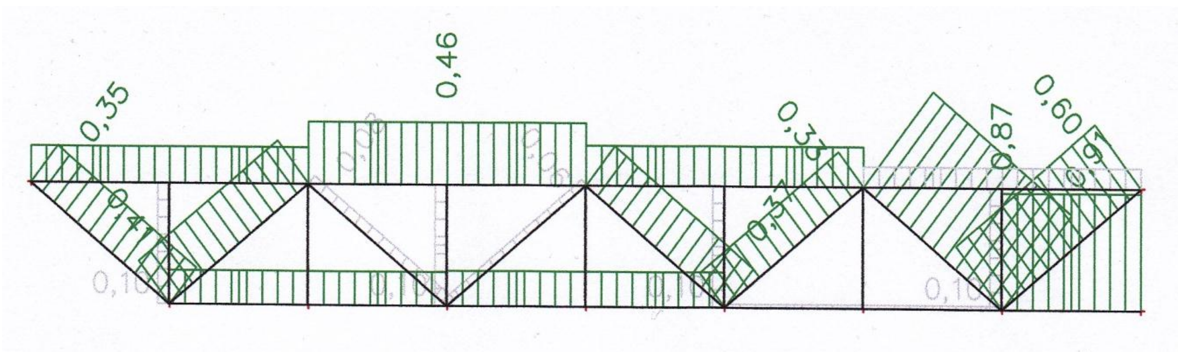
5.1.4.1 MSN

5.1.4.1.1 Notranje sile



Slika 26: Diagram osnih sil sekundarnega paličnega nosilca 1 v kN

5.1.4.1.2 Izkoriščenost elementov paličnega nosilca

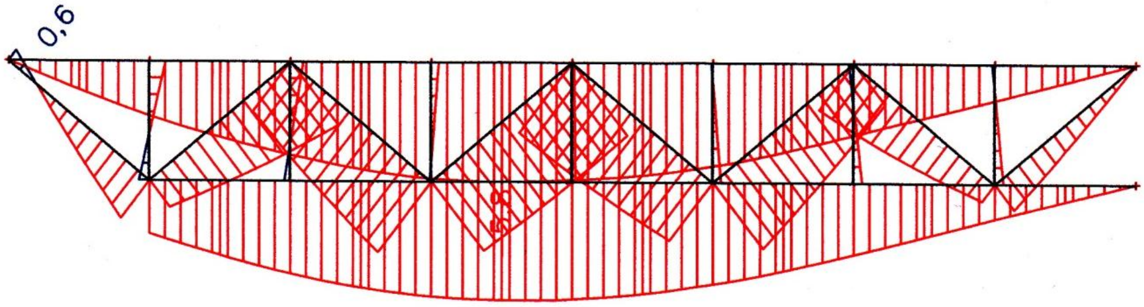


Slika 27: Diagram izkoriščenosti elementov sekundarnega paličnega nosilca 1

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 1.

5.1.4.2 5.1.4.2 MSU

5.1.4.2.1 Kontrola pomikov



Slika 28: Vertikalni pomiki sekundarnega paličnega nosilca 1 v mm

Kontrola vertikalnih pomikov:

$\delta_{max} = \delta_1 + \delta_2 \leq \frac{L}{250}$

$\delta_2 \leq \frac{L}{300}$

δ_1… upogibek nosilca zaradi stalne obtežbe takoj po nanosu obtežbe
δ_2… upogibek zaradi spremnljive obtežbe in upogibki zaradi časovno odvisnih pojavov pod vplivom stalne obtežbe

Tabela: Vertikalni pomik notranjega polja

$\delta_1 + \delta_2$ [mm]	≤	L/250 [mm]
5,8	≤	40

5.1.4.2.2 Kontrola reakcij

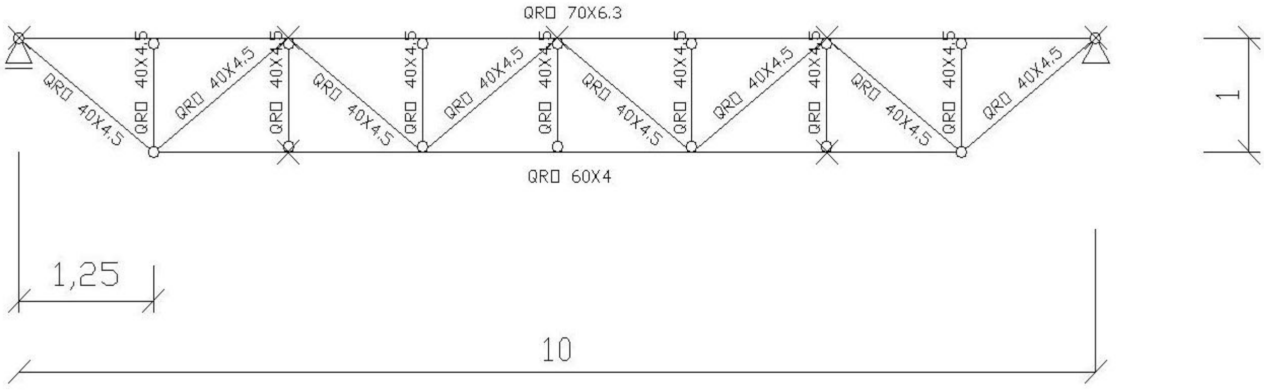
$\sum q_{Vi} = \sum V_i$

Račun reakcij glede na podane vertikalne obtežbe:
$\sum q_{Vi} = 1.35 \cdot (\sum G) + 1.5 \cdot S + 1.5 \cdot 0.6 \cdot W$
$\sum q_{Vi} = 1.35 \cdot 16.48 \text{ kN} + 1.5 \cdot 45.38 \text{ kN} + 0.9 \cdot 9.94 = 99.25 \text{ kN}$

Reakcije so rezultat programa Scia Engineer:
$\sum V_i = 99.34 \text{ kN}$

5.2 Sekundarni palični nosilec 2 – POZ 2

5.2.1 Računski model



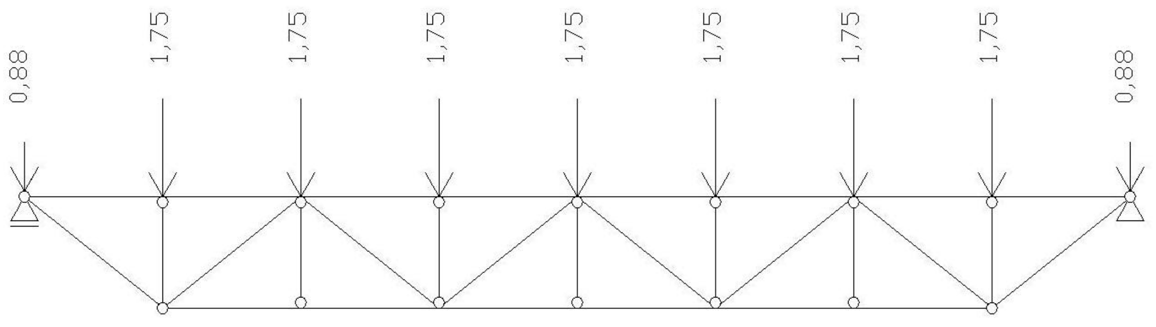
Slika 29: Zasnova sekundarnega paličnega nosilca 2

5.2.2 Obtežne sheme

5.2.2.1 Lastna in stalna obtežba [G]

Lastna teža je avtomatično upoštevana v programu. To velja za vse nadaljnje izračune.

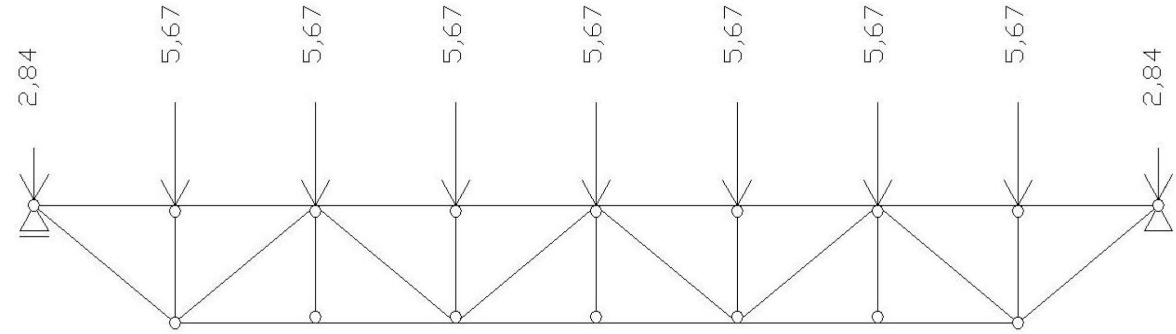
- streha: $0.373\ kN/m^2 \times 3.75\ m \times 1.25\ m = 1.75\ kN$
  $0.373\ kN/m^2 \times 3.75\ m \times 0.625\ m = 0.88\ kN$



Slika 30: Obtežna shema sekundarnega paličnega nosilca 2 – stalna obtežba v kN

5.2.2.2 Sneg [S]

- sneg: $1.21\ kN/m^2 \times 3.75\ m \times 1.25\ m = 5.67\ kN$
  $1.21\ kN/m^2 \times 3.75\ m \times 0.625\ m = 2.84\ kN$

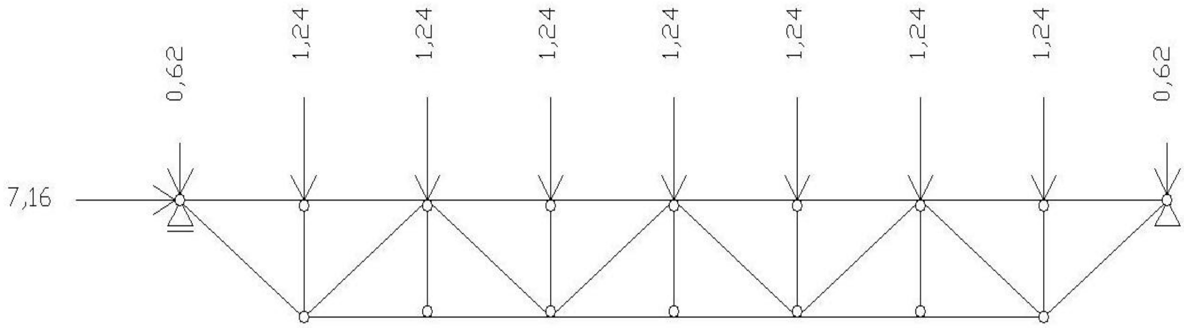


Slika 31: Obtežna shema sekundarnega paličnega nosilca 2 – sneg v kN

5.2.2.3 Veter [W]

- vertikalna obtežba: 0.265 kN/m^2 × 3.75 m × 1.25 m = 1.24 kN
0.265 kN/m^2 × 3.75 m × 0.625 m = 0.62 kN

- horizontalna obtežba: 0.53 kN/m^2 × 3.75 m × 3.6 m = 7.16 kN



Slika 32: Obtežna shema sekundarnega paličnega nosilca 2 – veter v kN

5.2.3 Obtežne kombinacije

5.2.3.1 MSN

C1) 1.35·G + 1.5·S + 1.5·W · 0.6
C2) 1.35·G + 1.5·S · 0.6 + 1.5·W

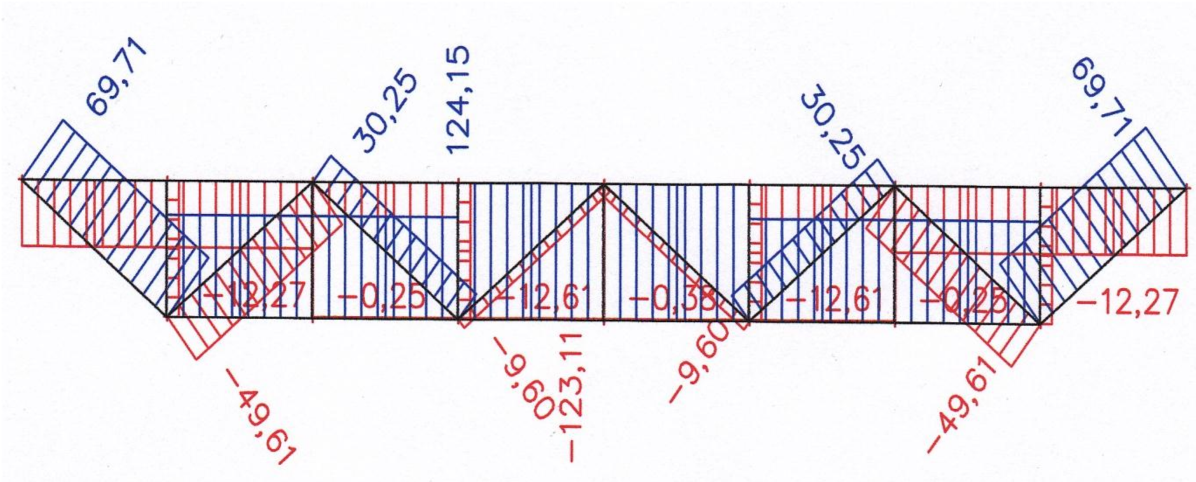
5.2.3.2 MSU

C1) 1.0 · G + 0.9 · S + 0.9 · W

5.2.4 Rezultati

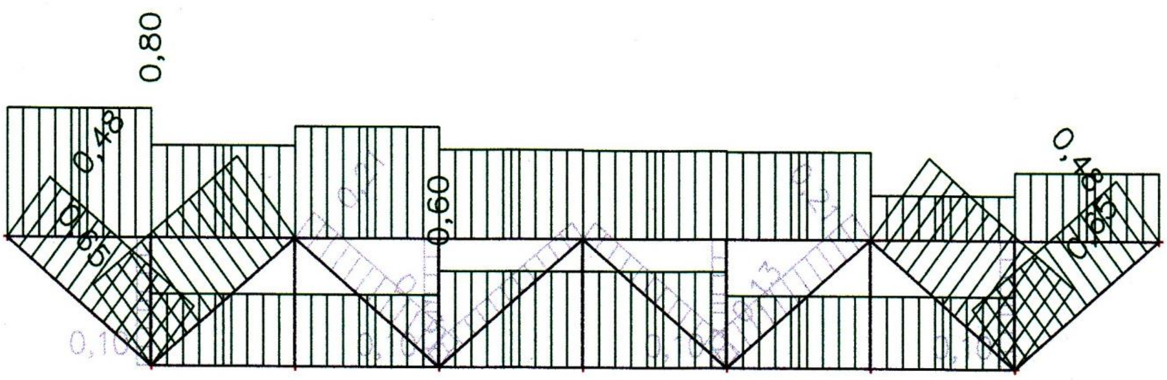
5.2.4.1 MSN

5.2.4.1.1 Notranje sile



Slika 33: Diagram osnih sil sekundarnega paličnega nosilca 2 v kN

5.2.4.1.2 Izkoriščenost elementov paličnega nosilca

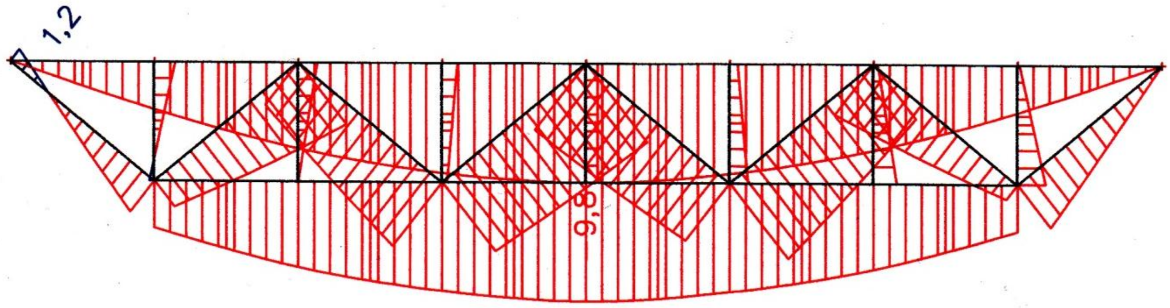


Slika 34: Diagram izkoriščenosti elementov sekundarnega paličnega nosilca 2

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 2.

5.2.4.2 MSU

5.2.4.2.1 Kontrola pomikov



Slika 35: Vertikalni pomiki sekundarnega paličnega nosilca 2 v mm

Kontrola vertikalnih pomikov:

Tabela: Vertikalni pomik notranjega polja

$\delta_1 + \delta_2$ [mm]	≤	L/250 [mm]
9,8	≤	40

5.2.4.2.2 Kontrola reakcij

Kontrola reakcij:

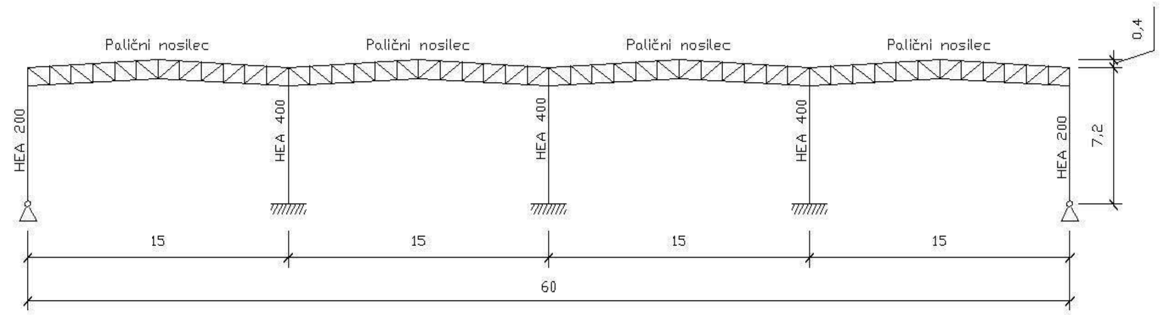
$\sum q_{Vi} = \sum V_i$

Račun reakcij glede na podane vertikalne obtežbe:
$\sum q_{Vi} = 1.35 \cdot (\sum G) + 1.5 \cdot S + 1.5 \cdot 0.6 \cdot W$
$\sum q_{Vi} = 1.35 \cdot 16.65$ kN $+ 1.5 \cdot 45.38$ kN $+ 0.9 \cdot 9.94 = 99.49$ kN

Reakcije so rezultat programa Scia Engineer:
$\sum V_i = 99.47$ kN

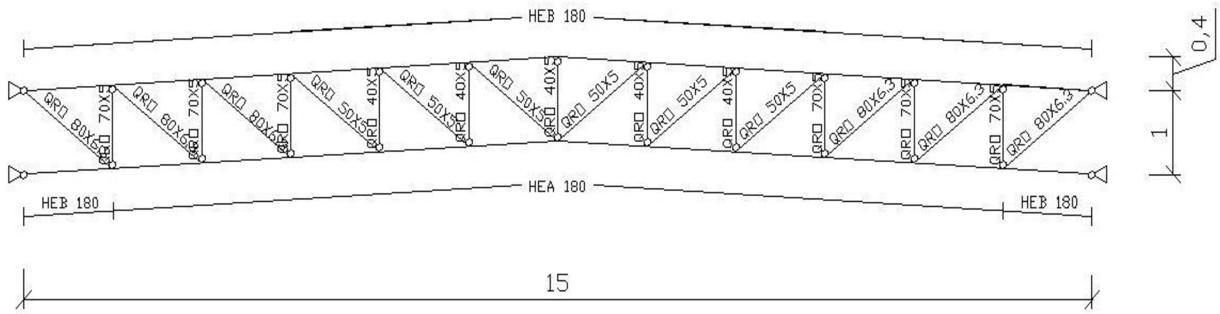
5.3 Primarni okvir smer X – POZ 3

5.3.1 Računski model



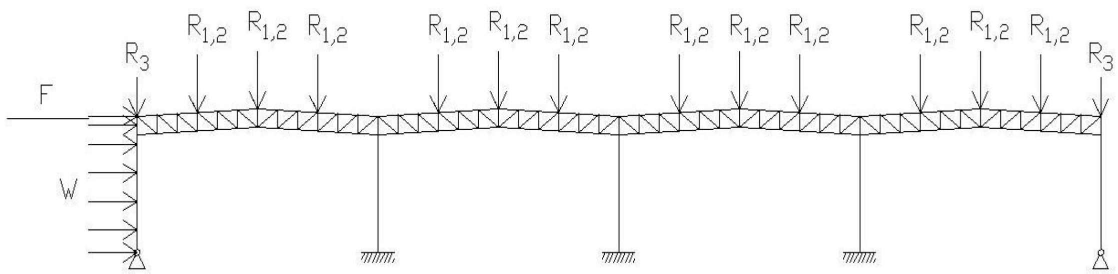
Slika 36: Zasnova primarnega okvirja – smer X

Palični nosilec:



Slika 37: Zasnova primarnega paličnega nosilca – smer X

5.4.2 Obtežne sheme



Slika 38: Obtežna shema primarnega okvirja – smer X

5.3.1.1 Lastna in stalna obtežba [G]

- fasada: $0.30\ kN/m^2 \times 5.0\ m = 1.50\ kN/m$

5.3.1.2 Reakcije sekundarnih nosilcev [R]

Reakcije so izračunane za vsako obtežno kombinacijo posebej:

Za MSN:

C1: $R_{1,2} = (61.48\ kN + 49.74\ kN) = 111.22\ kN$ $R_3 = 2 \cdot 11.63\ kN = 23.26\ kN$

C2: $R_{1,2} = (48.67\ kN + 39.10\ kN) = 87.77\ kN$ $R_3 = 2 \cdot 8.13\ kN = 16.26\ kN$

C3: $R_{1,2} = 25.99\ kN$ $R_3 = 6.77\ kN$

Za MSU:

C1: $R_{1,2} = (41.14\ kN + 33.21\ kN) = 74.35\ kN$ $R_3 = 2 \cdot 7.34\ kN = 14.68\ kN$

$R_{1,2}$ … vsota reakcij sekundarnih paličnih nosilcev 1 in 2
R_3… vsota reakcij dveh povezovalnih palic HEA 120 na okvirju s centričnim povezjem smer y

5.3.1.3 Veter [W]

Samo pritisk na fasado, saj so vse ostale kombinacije zajete v reakcijah.

$0.53\ kN/m^2 \times 10.0\ m = 5.3\ kN/m$

5.3.1.4 Potresna obtežba [A]

F = 307.88 kN

5.3.2 Obtežne kombinacije

5.3.2.1 MSN

C1) $1.35 \cdot G + 1.0\ R_{C1} + 1.5 \cdot W \cdot 0.6$
C2) $1.35 \cdot G + 1.0\ R_{C2} + 1.5 \cdot W$
C3) $1.00 \cdot G + 1.0\ R_{C3} + 1.0 \cdot A$

5.3.2.2 MSU

C1) $1.0 \cdot G + 1.0\ R_{C1} + 0.9 \cdot W$

5.3.3 Rezultati

5.3.3.1 MSN

5.3.3.1.1 Notranje sile

- nosilci

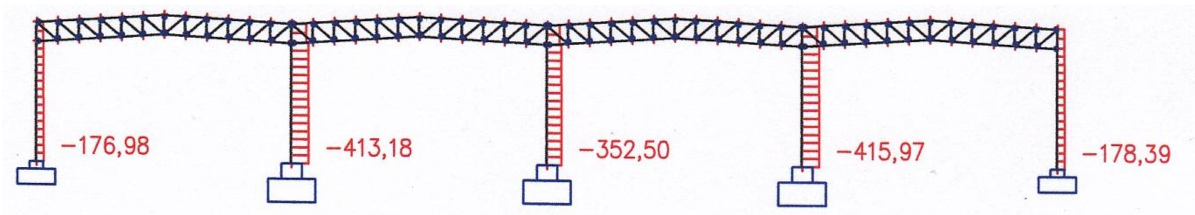
Preglednica 9: Notranje sile v primarnem nosilcu – smer X

Internal forces on member

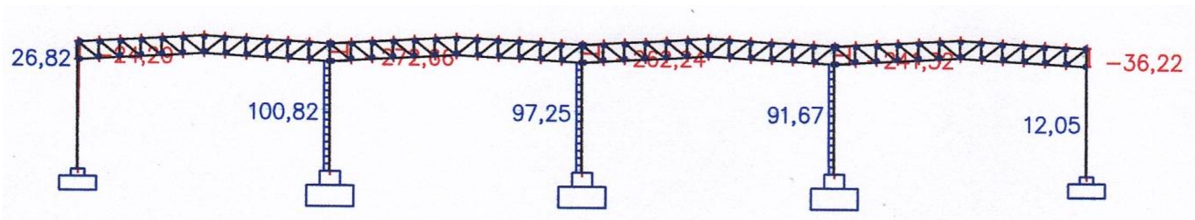
Nonlinear calculation, Extreme : Global, System : LCS
Selection : B83..B107,B114,B115,B58..B82,B112,B113,B33..B57,B110,B111,B2..B12,B14..B27,B108,B109
Class : MSN

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student versio
B109	NC1	1,252	**-668,66**	6,16	0,00
B114	NC1	6,259	**502,46**	-7,34	14,01
B56	NC1	8,762	-279,16	**-12,67**	3,04
B81	NC1	6,259	-273,65	**12,79**	2,94
B108	NC1	12,518	-384,87	-6,12	**-8,12**
B106	NC1	7,511	-507,92	7,85	**19,27**

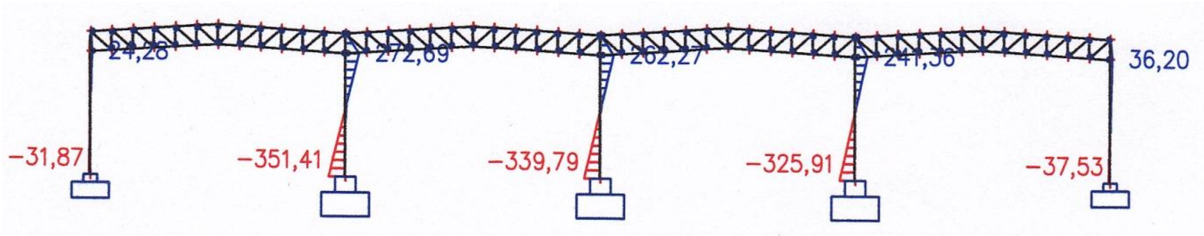
- stebri



Slika 39: Osne sile v stebrih primarnega okvirja – smer X v kN



Slika 40: Prečne sile v stebrih primarnega okvirja – smer X v kN



Slika 41: Momenti v stebrih primarnega okvirja – smer X v kNm

5.3.3.1.2 Izkoriščenost elementov konstrukcije

Preglednica 10: Izkoriščenost elementov primarnega okvirja – smer X

Check of steel

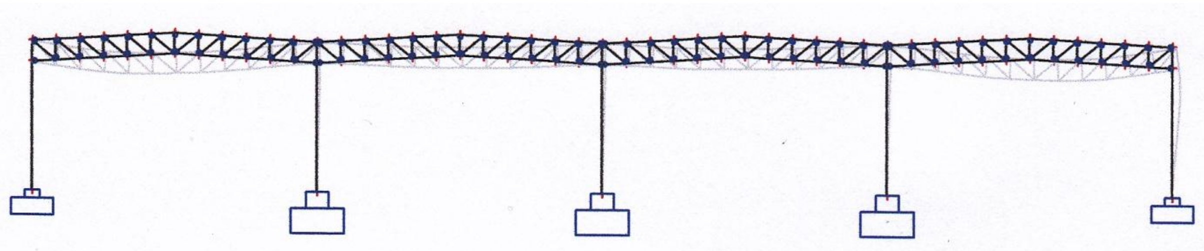
Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

Case	Member	css	mat	dx [m]	un.check [-]	sec.check [-]	stab.check [-]
NC1	B12	CS8 - QRO70X5	S 235	0,000	0,75	0,71	0,75
NC1	B25	CS9 - QRO80X6.3	S 235	0,000	0,83	0,83	0,00
NC1	B9	CS6 - QRO40X5	S 235	0,000	0,75	0,62	0,75
NC1	B22	CS5 - QRO50X5	S 235	0,000	0,74	0,74	0,00
NC1	B81	CS4 - HEB180	S 235	6,259	0,86	0,18	0,86
NC1	B109	CS7 - HEB180	S 235	1,252	0,92	0,44	0,92
NC4	B30	CS1 - HEA400	S 235	0,000	0,71	0,58	0,71
NC1	B108	CS3 - HEA180	S 235	12,518	0,57	0,36	0,57
NC1	B116	CS2 - HEA200	S 235	0,000	0,87	0,14	0,87

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 3.

5.3.3.2 MSU

5.3.3.2.1 Kontrola pomikov



Slika 42: Začetna in deformirana lega primernega okvirja – smer X

Kontrola horizontalnih pomikov:

Tabela: Horizontalni pomik celotne stavbe

δ [mm]	$\leq$	H/500 [mm]
6.8	$\leq$	14.4

Kontrola vertikalnih pomikov:

Tabela: Vertikalni pomik notranjega polja

$\delta_1 + \delta_2$ [mm]	$\leq$	L/250 [mm]
19.8	$\leq$	60

5.3.3.2.2 Kontrola reakcij

Kontrola reakcij:

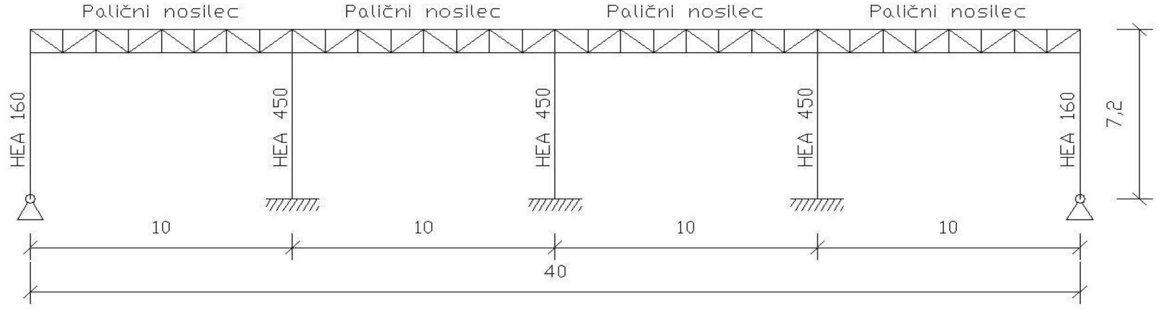
$\sum q_{Vi} = \sum V_i$

Račun reakcij glede na podane vertikalne obtežbe:
$\sum q_{Vi} = 1.35 \cdot (\sum G) + 1.0 \cdot (\sum R)$
$\sum q_{Vi} = 1.35 \cdot 110.47 + 1.0 \cdot 1381.16 = 1530.3$ kN

Reakcije so rezultat programa Scia Engineer:
$\sum V_i = 1530.30$ kN

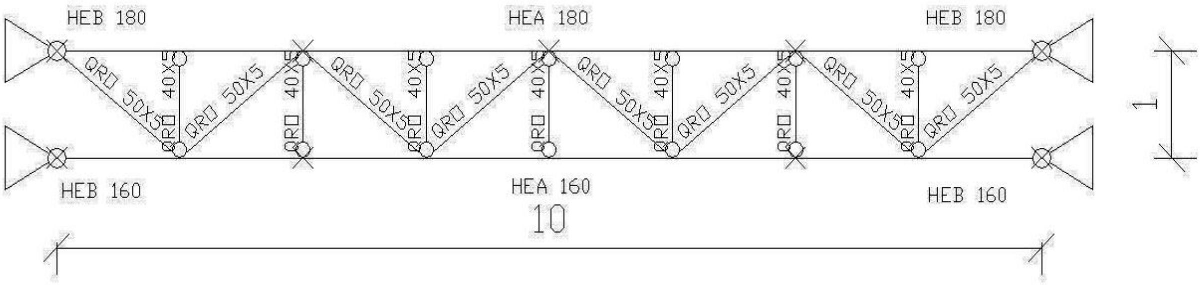
5.4 Primarni okvir smer Y – POZ 4

5.4.1 Računski model



Slika 43: Zasnova primarnega okvirja – smer Y

Palični nosilec:



Slika 44: Zasnova primarnega paličnega nosilca – smer Y

5.4.2 Obtežne sheme

5.4.2.1 Lastna in stalna obtežba [G]

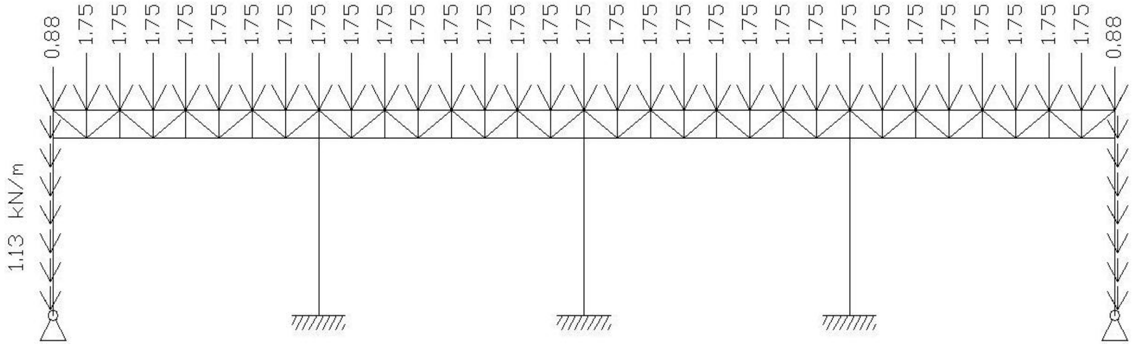
Točkovna obtežba:

- streha: $0.373\ kN/m^2 \cdot 3.75\ m \cdot 1.25\ m = 1.75\ kN$

  $0.373\ kN/m^2 \cdot 3.75\ m \cdot 0.625\ m = 0.88\ kN$

Linijska obtežba:

- fasada: $0.30\ kN/m^2 \cdot 3.75\ m = 1.13\ kN/m$

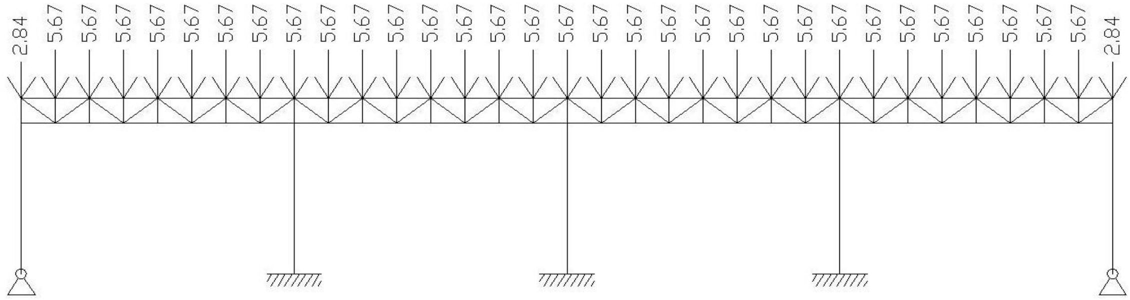


Slika 45: Obtežna shema primarnega okvirja – smer Y z lastno obtežbo v kN

5.4.2.2 Sneg [S]

$1.21\ kN/m^2 \cdot 3.75\ m \cdot 1.25\ m = 5.67\ kN$

$1.21\ kN/m^2 \cdot 3.75\ m \cdot 0.625\ m = 2.84\ kN$



Slika 46: Obtežna shema primarnega okvirja – smer Y s snegom v kN

5.4.2.3 Veter [W]

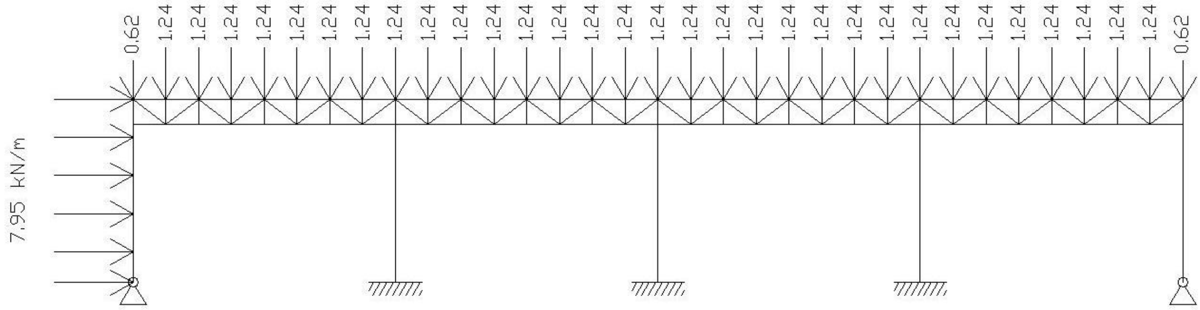
Točkovna obtežba:

- vertikalna smer: 0.265 kN/m^2 · 3.75 m · 1.25 m= 1.24 kN

  0.265 kN/m^2 · 3.75 m · 0.625 m= 0.62 kN

Linijska obtežba:

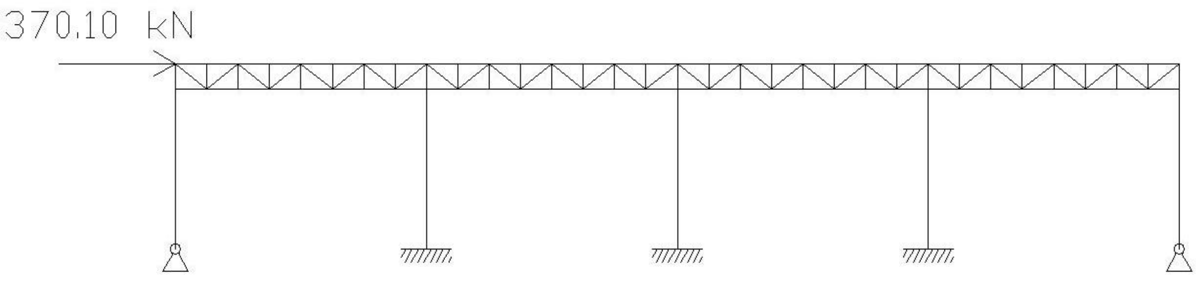
- horizontalna smer: 0.53 kN/m^2 · 15.00 m = 7.95 kN/m



Slika 47: Obtežna shema primarnega okvirja – smer Y z vetrom v kN

5.4.2.4 Potresna obtežba [A]

Nadomestna potresna sila: F = 370.10 kN



Slika 48: Obtežba primarnega okvirja – smer Y z nadomestno potresno silo F

5.4.3 Obtežne kombinacije

5.4.3.1 MSN

C1) 1.35 · G + 1.5 · S + 1.5 · W · 0.6
C2) 1.35 · G + 1.5 · 0.6 · S + 1.5 · W
C3) 1.00 · G + 0.2 · S + 1.0 A

5.4.3.2 MSU

C1) 1.0 · G + 0.9 · S + 0.9 · W

5.4.4 Rezultati

5.4.4.1 MSN

5.4.4.1.1 Notranje sile

- nosilci:

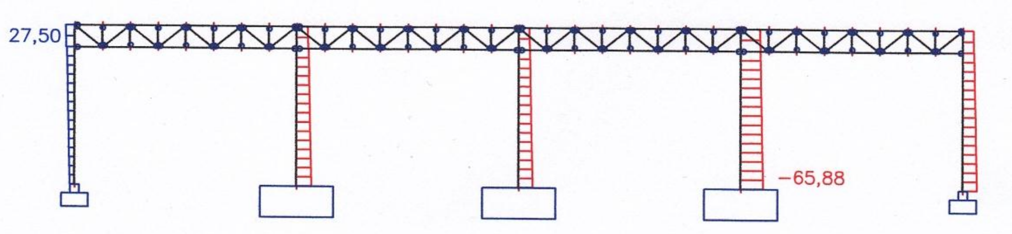
Preglednica 11: Notranje sile v paličnih nosilcih primarnega okvirja Y

Internal forces on member

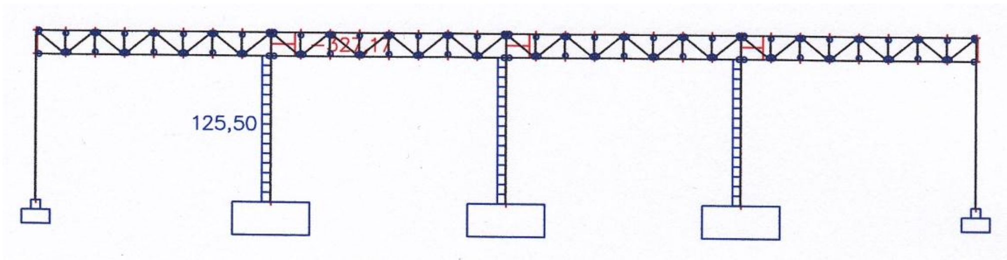
Nonlinear calculation, Extreme : Global, System : LCS
Selection : B7..B13,B15..B24,B76..B79,B25..B41,B80..B83,B42..B58,B84..B87,B59..B75,B88..B91
Class : MSN - potresna analiza

Member	Case	dx [m]	N [kN]	Vz [kN]	My [kNm]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student versio
B79	Potres	0,000	-392,57	-0,14	0,53
B75	Potres	0,000	130,20	1,21	0,00
B76	Potres	6,250	-159,87	-5,80	-3,49
B76	Potres	6,250	-40,39	4,87	-3,49
B23	Potres	1,250	-341,50	1,13	3,72

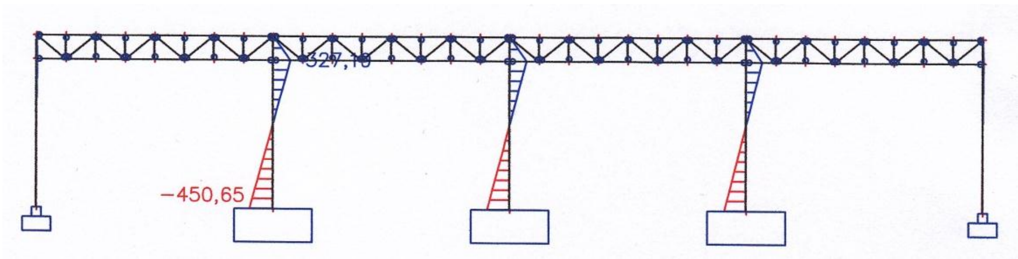
- stebri:



Slika 49: Osne sile v stebrih primarnega okvirja – smer Y v kN



Slika 50: Prečne sile v stebrih primarnega okvirja – smer Y v kN



Slika 51: Momenti v stebrih primarnega okvirja – smer Y v kNm

5.4.4.1.2 Izkoriščenost elementov konstrukcije

Preglednica 12: Izkoriščenost elementov primarnega okvirja – smer Y

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

Case	Member	css	mat	dx [m]	un.check [-]	sec.check [-]	stab.check [-]
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*
Potres	B5	CS8 - HEA160	S 235	0,000	0,55	0,25	0,55
Potres	B92	CS3 - HEA450	S 235	0,000	0,69	0,60	0,69
NC1	B48	CS9 - QRO40X5	S 235	0,000	0,09	0,07	0,09
Potres	B18	CS1 - QRO50X5	S 235	1,601	0,62	0,43	0,62
Potres	B23	CS2 - HEB180	S 235	1,250	0,87	0,22	0,87
Potres	B79	CS7 - HEB160	S 235	0,000	0,81	0,31	0,81
Potres	B76	CS6 - HEA180	S 235	0,000	0,51	0,32	0,51
Potres	B77	CS5 - HEA160	S 235	6,250	0,40	0,28	0,40

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 4.

5.4.4.2 MSN

5.4.4.2.1 Kontrola pomikov

Kontrola horizontalnih pomikov:

Tabela: Horizontalni pomik celotne stavbe

δ [mm]	≤	H/500 [mm]
11.7	≤	14.4

Kontrola vertikalnih pomikov:

Tabela: Vertikalni pomik notranjega polja

$\delta_1 + \delta_2$ [mm]	≤	L/250 [mm]
4.7	≤	40

5.4.4.2.2 Kontrola reakcij

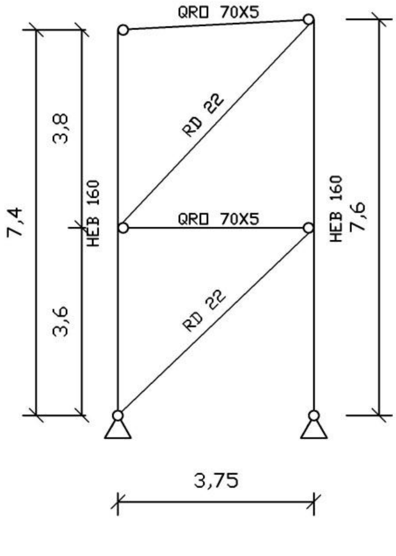
$\sum q_{Vi} = \sum V_i$

Račun reakcij glede na podane vertikalne obtežbe:
$\sum q_{Vi} = 1.35 \cdot (\sum G) + 1.5 \cdot S + 1.5 \cdot 0.6 \cdot W$
$\sum q_{Vi} = 1.35 \cdot 109.26\ kN + 1.5 \cdot 181.5\ kN + 0.9 \cdot 39.75\ kN = 455.53\ kN$

Reakcije so rezultat programa Scia Engineer:
$\sum V_i = 456.80\ kN$

5.5 Okvir s centričnim povezjem smer X – POZ 5

5.5.1 Računski model



Slika 52: Zasnova okvirja s centričnim povezjem – smer X

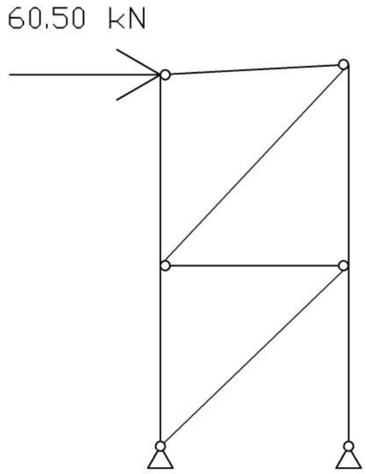
5.5.2 Primerjava med silo vetra in potresno silo

$F_w = 0.53\ kN/m^2 \cdot 5.0\ m \cdot 3.6\ m \cdot 1.5 = 14.31\ kN$

$F_b = 62.50\ kN$

$F_w \leq F_b \rightarrow$ potres je merodajna obtežba

5.5.2.1 Obtežna shema

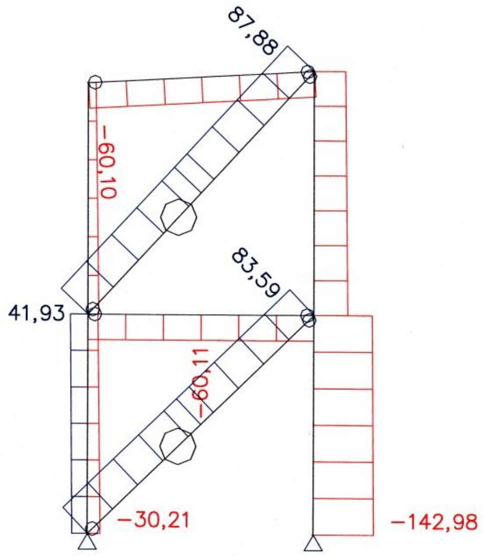


Slika 53: Obtežba okvirja s centričnim povezjem – smer X z nadomestno potresno silo F

5.5.3 Rezultati

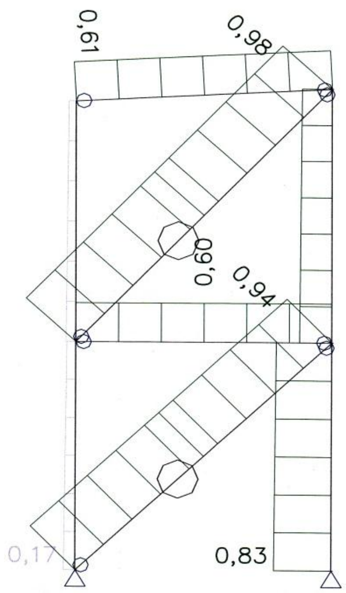
5.5.3.1 MSN

5.5.3.1.1 Notranje sile



Slika 54: Osne sile okvirja s centričnim povezjem – smer X v kN

5.5.3.1.2 Izkoriščenost elementov konstrukcije



Slika 55: Izkoriščenost elementov okvirja s centričnim povezjem – smer X

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 5.

5.5.3.2 MSU

5.5.3.2.1 Kontrola pomikov

$d_r \cdot \nu \leq 0.01\ h$

$28.35\ mm \cdot 0.5 \leq 0{,}01 \cdot 7200\ mm$

14.18 mm ≤ 72 mm

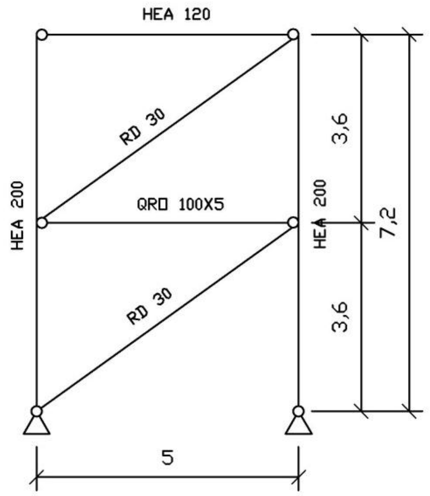
$d_r = d_s \cdot q = 18.90 \text{ mm} \cdot 1.5 = 28.35 \text{ mm}$

$d_s = (u_i - u_{i-1}) = 18.90 \text{ mm}$

ν = 0.5
d_s … medetažni pomik pri potresni kombinaciji
q … faktor obnašanja pri potresu
h … etažna višina

5.6 Okvir s centričnim povezjem smer Y – POZ 6

5.6.1 Računski model



Slika 56: Zasnova okvirja s centričnim povezjem – smer Y

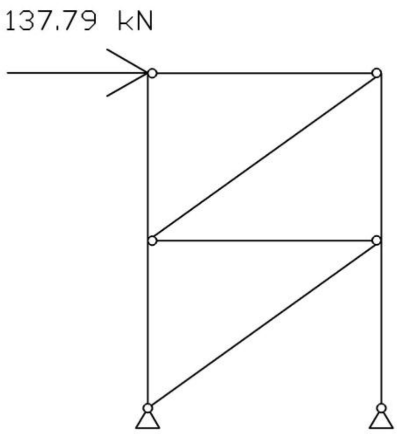
5.6.2 Primerjava med silo vetra in potresno silo

$F_w = 0.53 \text{ kN/m}^2 \cdot 7.5 \text{ m} \cdot 3.6 \text{ m} \cdot 1.5 = 21.47 \text{ kN}$

$F_b = 137.79 \text{ kN}$

$F_w \leq F_b$ → potres je merodajna obtežba

5.6.3 Obtežna shema

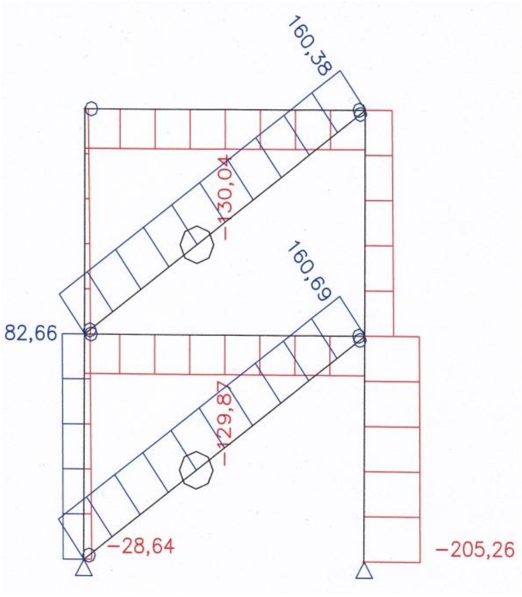


Slika 57: Obtežba okvirja s centričnim povezjem – smer Y z nadomestno potresno silo F

5.6.4 Rezultati

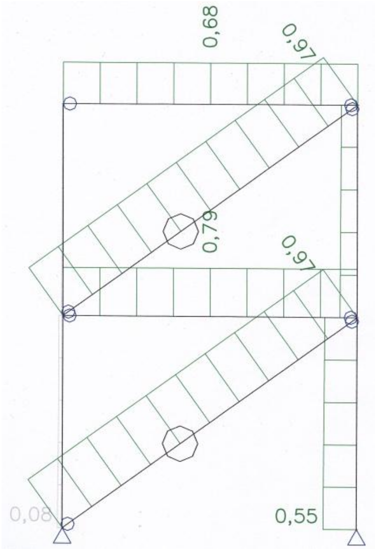
5.6.4.1 MSN

5.6.4.1.1 Notranje sile



Slika 58: Osne sile okvirja s centričnim povezjem – smer Y v kN

5.6.4.1.2 Izkoriščenost elementov konstrukcije



Slika 59: Izkoriščenost elementov okvirja s centričnim povezjem – smer Y

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 6.

5.6.4.2 MSU

5.6.4.2.1 Kontrola pomikov

$d_r \cdot \nu \leq 0.01\ h$

$30.6\ mm \cdot 0.5 \leq 0{,}01 \cdot 7200\ mm$

$15.3\ mm \leq 72\ mm$

$d_r = d_s \cdot q = 20.4\ mm \cdot 1.5 = 28.35\ mm$

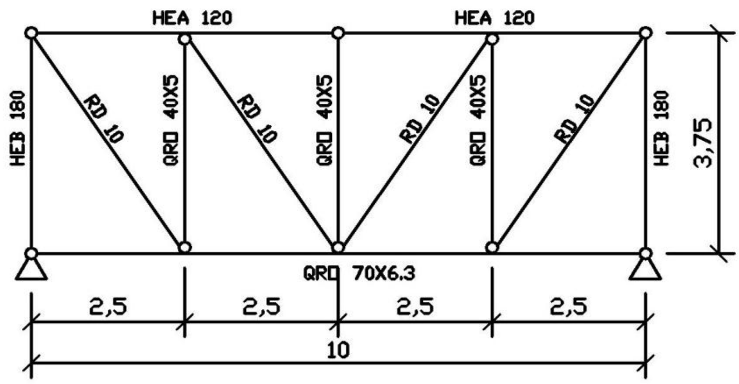
$d_s = (u_i - u_{i-1}) = 20.4\ mm$

$\nu = 0.5$
d_s … medetažni pomik pri potresni kombinaciji
q … faktor obnašanja pri potresu
h … etažna višina

5.7 Horizontalno zavetrovanje

5.7.1 Smer X – zgornji pas – POZ 7

5.7.1.1 Zasnova



Slika 60: Zasnova horizontalnega zavetrovanja v smeri X – zgornji pas

5.7.1.2 Obtežba

Zgornji pas zavetrovanja strehe v smeri X prevzema izbočne sile paličnih nosilcev primarnih okvirjev Y in sekundarnih paličnih nosilcev, ter silo vetra na fasadne stebre, ki niso del primarnih okvirjev.

5.7.1.2.1 Izbočne sile

$\sum N_{sd} = 3 \cdot N(\text{okvir Y}) + 12 \cdot N\ (\text{sekundarni nosilec})$

$\sum N_{sd} = 3 \cdot 336.49\ kN + 12 \cdot 123.11\ kN = 2486.79\ kN$

$\sum q = \beta \cdot \sum N_{sd} / L \cdot n$

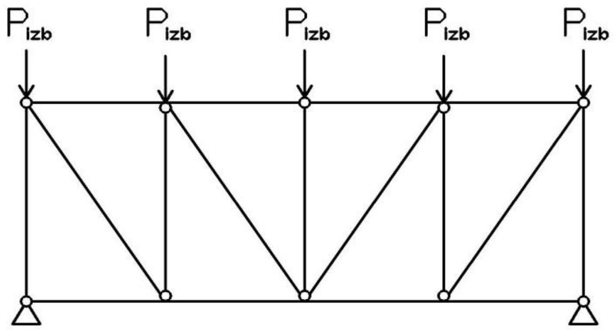
$\sum q = 1/62.2 \cdot\ kN / 10\ m \cdot 4 = 1.0\ kN/m$

$\beta = 1 / 62.2$

$L = 10\ m$

$n = 4$ … število povezij

$P_{izb} = \sum q \cdot 2.5\ m = 1.0\ kN/m \cdot 2.5\ m = 2.5\ kN$

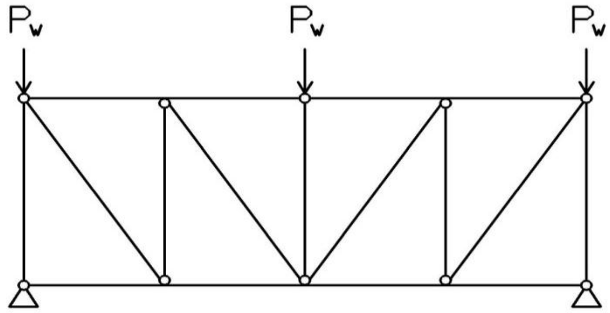


Slika 61: Obtežna shema horizontalnega zavetrovanja v smeri X – zgornji pas z izbočnimi silami

5.7.1.2.2 Veter

$P_W = A_{eff} \cdot w = 18.0\ m^2 \cdot 0.53\ kN/m^2 = 9.54\ kN$

$A_{eff} = 3.6\ m \cdot 5.0\ m = 18.0\ m^2$



Slika 62: Obtežna shema horizontalnega zavetrovanja v smeri X – zgornji pas s silo vetra

5.7.1.3 Obtežna kombinacija

5.7.1.3.1 MSN

$1.0 \cdot P_{izb} + 1.5 \cdot P_W$

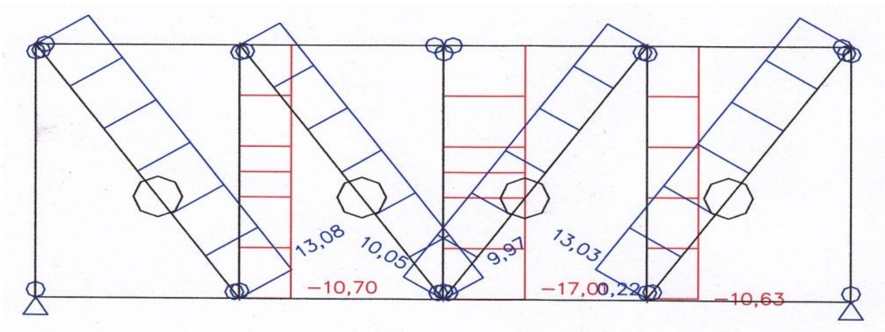
5.7.1.3.2 MSU

$1.0 \cdot P_{izb} + 1.0 \cdot P_W$

5.7.1.4 Rezultati

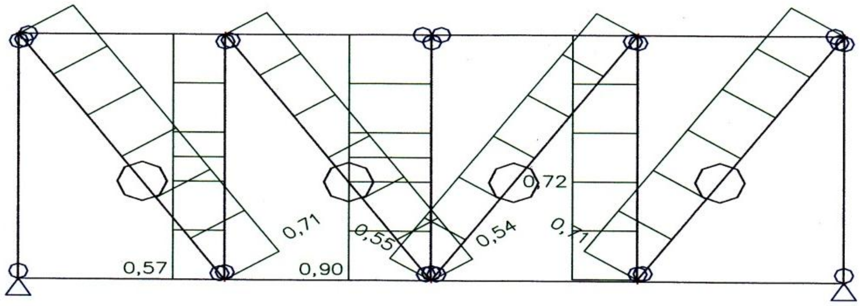
5.7.1.4.1 MSN

Osne sile:



Slika 63: Osne sile horizontalnega zavetrovanja v smeri X – zgornji pas v kN

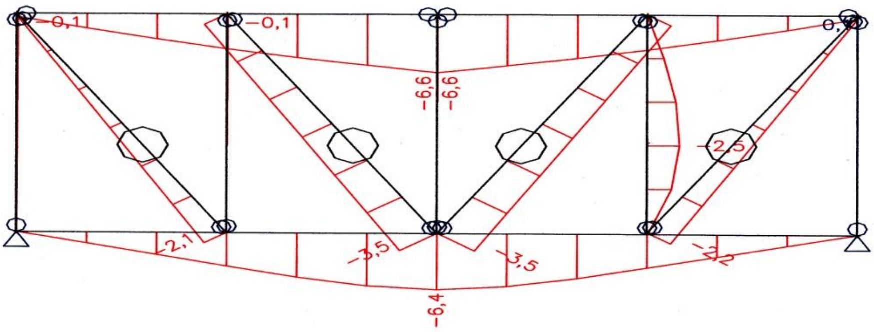
Izkoriščenost elementov:



Slika 64: Izkoriščenost elementov horizontalnega zavetrovanja v smeri X – zgornji pas

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 7.

5.7.1.4.2 MSU



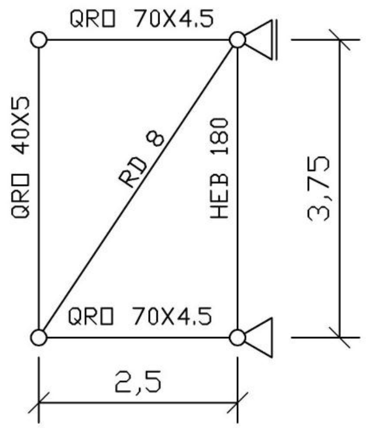
Slika 65:Pomiki horizontalnega zavetrovanja v smeri X – zgornji pas v mm

Tabela: Horizontalni pomik

δ [mm]	≤	L/1500 [mm]
6.6	≤	6.67

5.7.2 Smer X – spodnji pas – POZ 8

5.7.2.1 Zasnova



Slika 66: Zasnova horizontalnega zavetrovanja v smeri X – spodnji pas

5.7.2.2 Obtežba

Spodnji pas zavetrovanja strehe prevzame samo izbočne sile paličnih nosilcev primarnih okvirjev in sekundarnih nosilev.

5.7.2.2.1 Izbočne sile

$\sum N_{sd} = 3 \cdot N(\text{okvir Y}) + 12 \cdot N\ (\text{sekundarni nosilec})$

$\sum N_{sd} = 3 \cdot 260.29\ kN + 12 \cdot 115.57\ kN = 2167.71\ kN$

$\sum q = \beta \cdot \sum N_{sd} / L \cdot n$

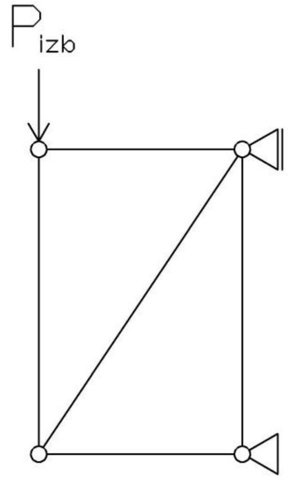
$\sum q = 1/62.2 \cdot\ \ kN / 10\ m \cdot 4 = 0.87\ kN/m$

$\beta = 1 / 62.2$

$L = 10\ m$

$n = 4$ … število povezij

$P_{izb} = \sum q \cdot 5.0\ m = 0.87\ kN/m \cdot 5.0\ m = 4.35\ kN$

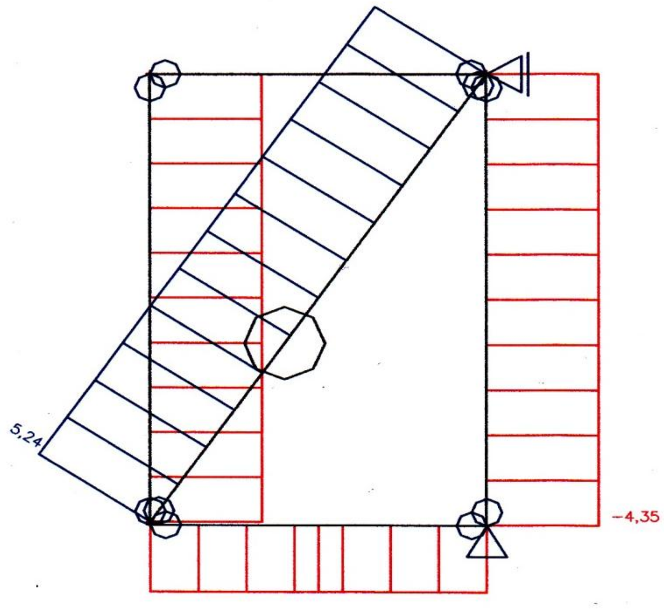


Slika 67: Obtežna shema horizontalnega zavetrovanja v smeri X – spodnji pas z izbočnimi silami

5.7.2.3 Rezultati

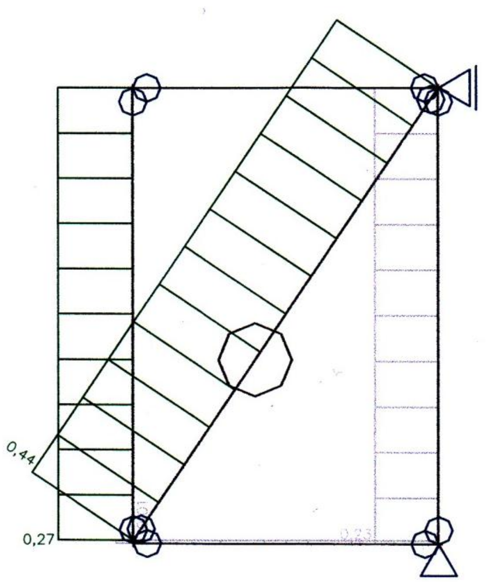
5.7.2.3.1 MSN

Osne sile:



Slika 68: Osne sile horizontalnega zavetrovanja v smeri X – spodnji pas v kN

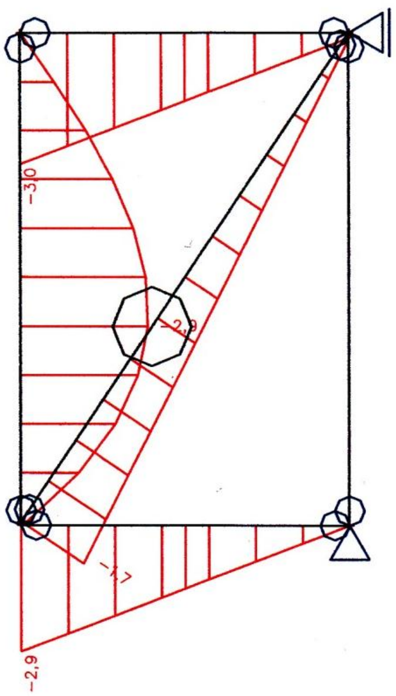
Izkoriščenost:



Slika 69: Izkoriščenost elementov horizontalnega zavetrovanja v smeri X – spodnji pas

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 8.

5.7.2.3.2 MSU



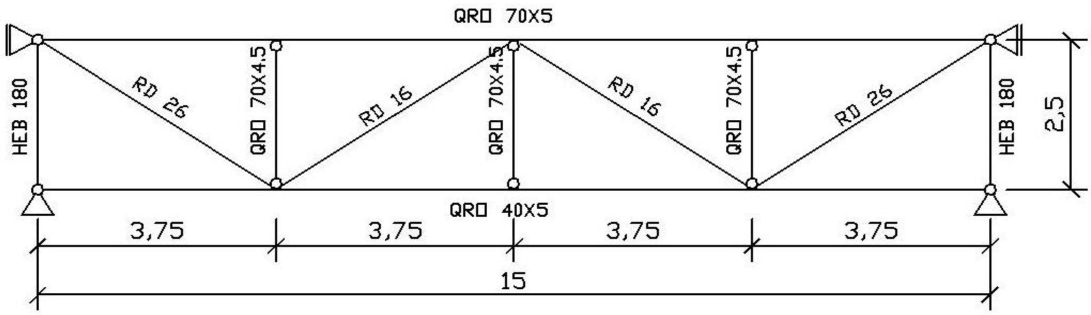
Slika 70: Pomiki horizontalnega zavetrovanja v smeri X – spodnji pas v mm

Tabela: Horizontalni pomik

δ [mm]	≤	L/1500 [mm]
3.0	≤	6.67

5.7.3 Smer Y – POZ 9

5.7.3.1 Zasnova



Slika 71: Zasnova horizontalnega zavetrovanja v smeri Y

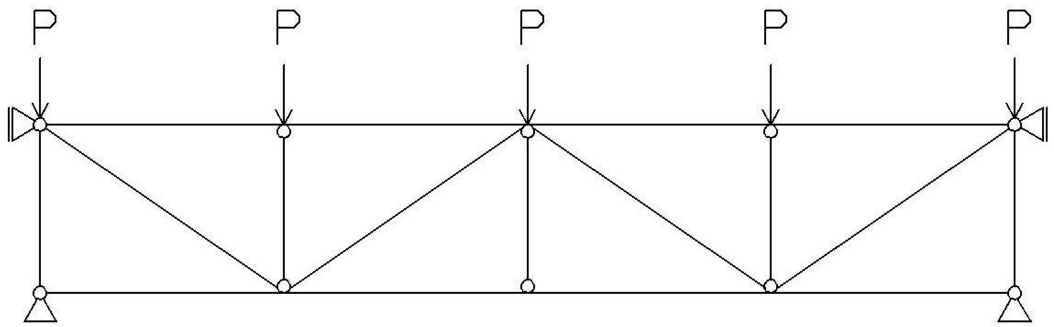
5.7.3.2 Obtežba

Horizontalno zavetrovanje v smeri Y prevzame potresno silo sekundarne konstrukcije (sekundarni nosilci in fasadni stebri) in jo prenaša na primarni okvir Y. Potresna sila P je izračunana kot delež celotne potresne sile, ki odpade na en primarni okvir in je posledica obtežbe sekundarne konstrukcije (glej poglavje 4.5.2):

$P = (\sum m_{sek} / \sum m) \cdot F_b / m \cdot n = (342.66 \text{ kN} / 510.48 \text{ kN}) \cdot 370.10 \text{ kN} / 3 \cdot 2 = 41.40 \text{ kN}$

m = 3 … število sekundarnih nosilcev, katerih potresno silo prevzame en primarni okvir Y

n = 2 … število povezij

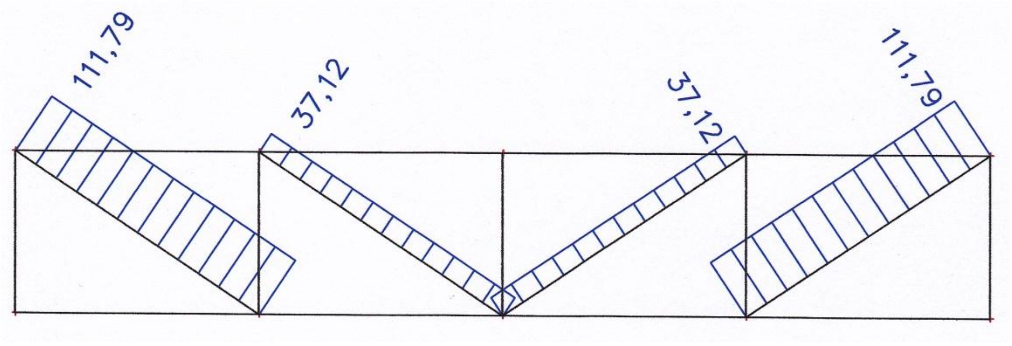


Slika 72: Obtežna shema horizontalnega zavetrovanja v smeri Y

5.7.3.3 Rezultati

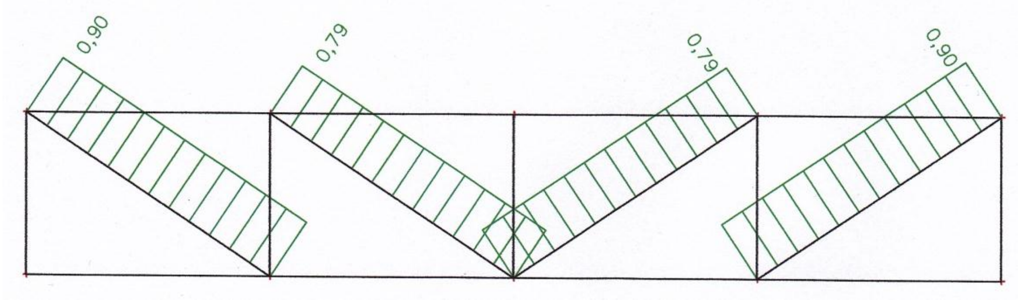
5.7.3.3.1 MSN

Osne sile:



Slika 73: Osne sile horizontalnega zavetrovanja v smeri Y

Izkoriščenost:



Slika 74: Izkoriščenost elementov horizontalnega zavetrovanja v smeri Y

Detajlno dimenzioniranje posameznih elementov je predstavljeno v Prilogi 9.

5.7.3.3.2 MSU

Kontrola pomikov:

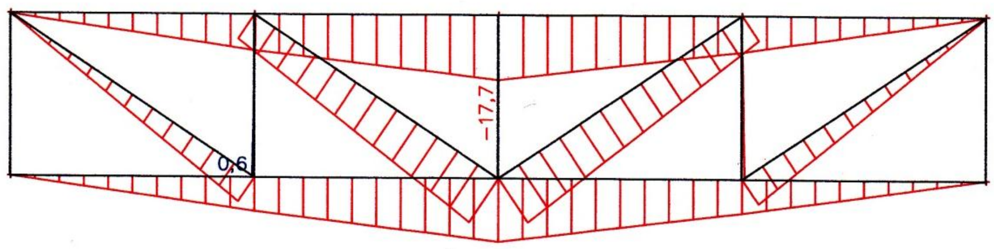
$d_r \cdot \nu \leq 0.01$ h

26.55 mm · 0.5 ≤ 0,01 · 2500 mm

13.28 mm ≤ 25 mm

$d_r = d_s \cdot q$ = 17.7 mm · 1.5 = 26.55 mm

$d_s = (u_i - u_{i-1})$ = 17.70 mm



Slika 75: Pomiki horizontalnega zavetrovanja v smeri Y

6 DRUGI SEKUNDARNI NOSILNI ELEMENTI

6.1 Račun nosilnosti strešne visokoprofilirane trapezne pločevine

Obtežba:

- stalna in lastna obtežba [G]: 0.373 kN/m^2
- sneg [S]: 1.21 kN/m^2
- veter [W]: 0.265 kN/m^2

Obtežba skupaj:

$q = 1.35 \cdot G + 1.5 \cdot S + 0.9 \cdot W$

$q = 1.35 \cdot 0.373$ kN/m^2 $+ 1.5 \cdot 1.21$ kN/m^2 $+ 0.9 \cdot 0.265$ kN/m^2 = 2.56 kN

Kontrola nosilnosti glede na zahteve proizvajalca za enopoljni nosilec:
$q_{dej} = 2.56 \text{ kN/m}^2$, $L_{dej} = 3.75$ m

$q_{dop} = 2.60 \text{ kN/m}^2$ pri $L_{max} = 3.78$ m

→ pogoj je izpolnjen

Preglednica 13: Dopustna obremenitev profilirane pločevine glede na razpon med podporami

85/280 BELASTUNGSTABELLE Positivlage

EINFELDTRÄGER **Belastung:** gleichmäßig verteilte Auflast
Endauflagerbreite: b_A = 40 mm

Dicke (mm)	Gewicht (kN/m²)	Zeile	Zulässige Flächenlast q_{zul} (kN/m²) bei einer Stützweite l in m:																	
			2,60	2,80	3,00	3,20	3,40	3,60	3,80	4,00	4,20	4,40	4,60	4,80	5,00	5,20	5,40	5,60	5,80	6,00
0,75	0,0789	1	3,78	3,26	2,84	2,50	2,21	1,97	1,77	1,60	1,45	1,32	1,21	1,11	1,02	0,94	0,88	0,81	0,76	0,71
		2	3,78	3,26	2,84	2,50	2,21	1,97	1,72	1,47	1,27	1,11	0,97	0,85	0,75	0,67	0,60	0,54	0,48	0,44
		3	3,78	3,22	2,62	2,16	1,80	1,51	1,29	1,10	0,95	0,83	0,73	0,64	0,57	0,50	0,45	0,40	0,36	0,33
		4	2,68	2,15	1,74	1,44	1,20	1,01	0,86	0,74	0,64	0,55	0,48	0,43	0,38	0,34	0,30	0,27	0,24	0,22
0,88	0,0925	1	5,14	4,43	3,86	3,39	3,00	2,68	2,40	2,17	1,97	1,79	1,64	1,51	1,39	1,28	1,19	1,11	1,03	0,96
		2	5,14	4,43	3,86	3,39	2,92	2,46	2,09	1,79	1,55	1,35	1,18	1,04	0,92	0,82	0,73	0,65	0,59	0,53
		3	4,90	3,92	3,19	2,63	2,19	1,84	1,57	1,34	1,16	1,01	0,88	0,78	0,69	0,61	0,55	0,49	0,44	0,40
		4	3,26	2,61	2,12	1,75	1,46	1,23	1,05	0,90	0,77	0,67	0,59	0,52	0,46	0,41	0,36	0,33	0,29	0,27
1,00	0,1051	1	6,31	5,44	4,74	4,17	3,69	3,29	2,95	2,67	2,42	2,20	2,02	1,85	1,71	1,58	1,46	1,36	1,27	1,19
		2	6,31	5,44	4,74	4,10	3,42	2,88	2,45	2,10	1,81	1,58	1,38	1,21	1,07	0,96	0,85	0,76	0,69	0,62
		3	5,73	4,59	3,73	3,07	2,56	2,16	1,84	1,57	1,36	1,18	1,03	0,91	0,81	0,72	0,64	0,57	0,52	0,47
		4	3,82	3,06	2,49	2,05	1,71	1,44	1,22	1,05	0,91	0,79	0,69	0,61	0,54	0,48	0,43	0,38	0,34	0,31
1,25	0,1314	1	8,61	7,42	6,46	5,68	5,03	4,49	4,03	3,64	3,30	3,01	2,75	2,53	2,33	2,15	2,00	1,86	1,73	1,62
		2	8,61	7,42	6,30	5,19	4,33	3,65	3,10	2,66	2,30	2,00	1,75	1,54	1,36	1,21	1,08	0,97	0,87	0,79
		3	7,26	5,82	4,73	3,90	3,25	2,74	2,33	1,99	1,72	1,50	1,31	1,15	1,02	0,91	0,81	0,73	0,65	0,59
		4	4,84	3,88	3,15	2,60	2,17	1,82	1,55	1,33	1,15	1,00	0,87	0,77	0,68	0,61	0,54	0,48	0,44	0,39

6.2 Račun nosilnosti fasadnega panela na obremenitev vetra

Izračun za najbolj neugoden fasadni okvir, ki je v smeri y:

Obtežba vetra: $q_{wk} = 0.53 \text{ kN/m}^2$
$q_{wd} = 0.53 \text{ kN/m}^2 \cdot 1.5 = 0.795 \text{ kN/m}^2$

h / a = 7.2 m / 40 m = 0.18
$q_{dej} = 0.795 \text{ kN/m}^2$, $L_{dej} = 5.0$ m

$q_{dop} = 0.80 \text{ kN/m}^2$ pri L = 5.02 m
→ pogoj je izpolnjen

Preglednica 14: Dopustne razdalje med podporami fasadnih panelov

Dopustne razdalje med podporami za sendvič panele FTV_{ss}, d=150 mm (fasadni panel)

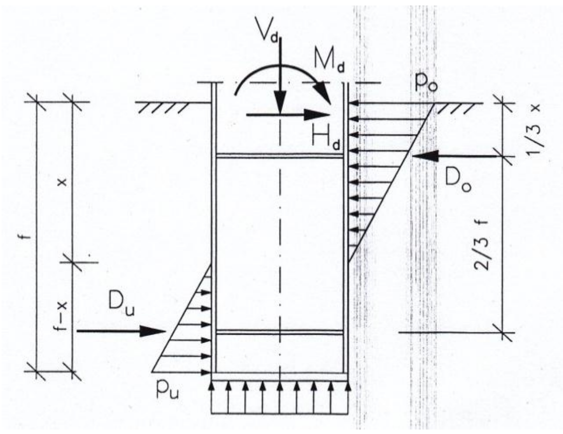
Zunanja jeklena obloga: profilirana t_K = 0,55 mm
Notranja jeklena obloga: linirana t_K = 0,55 mm

Fasadna plošča FTV_{ss}, d= 150 mm, t_K = 0,55 / 0,55 mm													
Statični sistem oz. število polj	Barvna skupina	Kapna višina / Širina objekta = h/a ≤ 0,25 Višina nad terenom						Kapna višina / Širina objekta = h/a ≥ 0,5 Višina nad terenom					
		0,50 (kN/m²)[1)]		0,80 (kN/m²)[1)]		1,10 (kN/m²)[1)]		0,50 (kN/m²)[1)]		0,80 (kN/m²)[1)]		1,10 (kN/m²)[1)]	
		0 < h < 8 m		8 < h < 20 m		20 < h < 100 m		0 < h < 8 m		8 < h < 20 m		20 < h < 100 m	
Enopoljni nosilec	I, II, III	6,35	6,35	5,02	5,02	4,28	4,28	6,35	6,35	5,02	5,02	4,28	4,28
Dvopoljni nosilec	I (zelo svetla)	4,09	4,09	4,18	4,18	3,87	3,87	4,09	4,09	3,97	3,97	3,76	3,76
	II (svetla)	3,07	3,07	3,01	3,01	2,96	2,96	3,03	3,03	2,95	2,95	2,88	2,88
	III (temna)	2,26	2,26	2,24	2,24	2,23	2,23	2,25	2,25	2,23	2,23	2,21	2,21
Tropoljni nosilec	I (zelo svetla)	5,33	5,33	4,49	4,49	4,03	4,03	4,85	4,85	4,25	4,25	3,90	3,90
	II (svetla)	2,79	2,79	2,72	2,72	2,65	2,65	2,74	2,74	2,65	2,65	2,58	2,58
	III (temna)	1,80	1,80	1,79	1,79	1,78	1,78	1,79	1,79	1,78	1,78	1,77	1,77

7 RAČUN ZNAČILNIH SPOJEV

7.1 Izračun globine vpetja križnega stebra v točkovni temelj

Material
Jeklo: S235
Beton: C25/30



Slika 76: Skica vpetja križnega stebra v točkovni temelj

Križni steber je varjen iz dveh standardnih profilov. V smeri x je profil HEA 400, v smeri y pa profil HEA 450. V izračunu globine vpetja ju obravnavam ločeno.

HEA 400:
$H_d = 100.33$ kN
$M_d = 355.27$ kNm = 35527 kNcm
b = 30 cm
$f_{ck} = 2.5$ kN/cm^2
$\alpha_{cc} = 1.0$
$f_{cd} = 1.67$ kN/cm^2

Potrebna globina vpetja stebra:

$f = (2 \cdot H_d / (f_{cd} \cdot b)) \cdot (1 + (1 + 1.5 \cdot (M_d \cdot f_{cd} \cdot b) / H_d^2)^{1/2})$

$f = (2 \cdot 100.33 \text{ kN} / (1.67 \text{ kN/cm}^2 \cdot 30 \text{ cm}) \cdot (1 + (1 + 1.5 \cdot (35527 \text{ kNcm} \cdot 1.67 \text{ kN/cm}^2 \cdot 30 \text{ cm}) / 100.33^2 \text{ kN}^2)^{1/2}) = 69.36 \text{ cm}$

HEA 450:
$H_d = 127.56$ kN
$M_d = 462.13$ kNm = 46113 kNcm
b = 30 cm
$f_{ck} = 2.5$ kN/cm^2
$\alpha_{cc} = 1.0$
$f_{cd} = 1.67$ kN/cm^2

Potrebna globina vpetja stebra:

$f = (2 \cdot H_d / (f_{cd} \cdot b)) \cdot (1 + (1 + 1.5 \cdot (M_d \cdot f_{cd} \cdot b) / H_d^2)^{1/2})$

$f = (2 \cdot 127.56 \text{ kN} / (1.67 \text{ kN/cm}^2 \cdot 30 \text{ cm}) \cdot (1 + (1 + 1.5 \cdot (46213 \text{ kNcm} \cdot 1.67 \text{ kN/cm}^2 \cdot 30 \text{ cm}) / 127.56^2 \text{ kN}^2)^{1/2}) = 79.66 \text{ cm}$

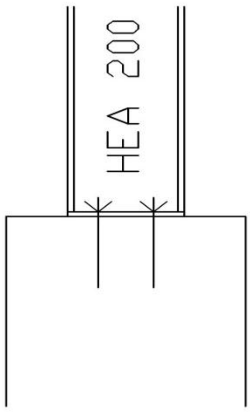
→ izberem globino vpetja križnih stebrov f = 80 cm

7.2 Spoj fasadnega stebra na temelj

Material:

- jeklo S 235
- visokovredni vijaki 10.9

Geometrija:



Slika 77: Skica vpetja fasadnega stebra stebra na temelj

Obremenitev:

$V_{Ed} = R_x = 9.82$ kN

Dimenzioniranje:

Izberem vijake M12 10.9
$d_0 = d + 1$ mm
$d_0 = 12$ mm + 1 mm = 13 mm

Podložna pločevina
$t_p = t_f = 10$ mm

Razporeditev vijakov:
$e_1 = 40$ mm
$e_2 = 50$ mm
$p_1 = 90$ mm
$p_2 = 100$ mm

Kontrola strižne obremenitve:

$F_{v,Sd} \leq F_{v,Rd} = 0.5\ f_{ub}\ A/\gamma_{Mb}$

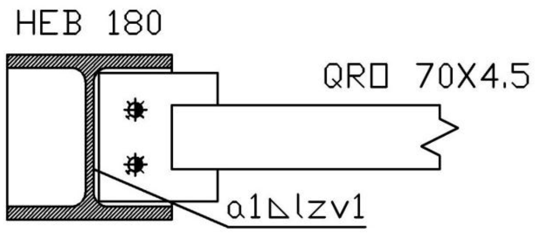
$9.82\ kN / 4 = 2.46\ kN \leq 0.5 \cdot 100\ kN/cm^2 \cdot 0.843\ cm^2 / 1.25 = 33.72\ kN$

7.3 Spoj sekundarnega nosilca na primarni nosilec

Material:

- jeklo S 235
- visokovredni vijaki 10.9

Geometrija:



Slika 78: Skica spoja sekundarnega nosilca na primarni nosilec

Obremenitev:

N_{Ed} = 6.44 kN
V_{Ed} = 49.74 kN

Dimenzioniranje:

Izberem vijake M16 10.9
$d_0 = d + 2$ mm
$d_0 = 16$ mm + 2 mm = 18 mm

Vezna pločevina:
$t_v = 10$ mm
$h_v = 140$ mm

Razporeditev vijakov:
$e_1 = 40$ mm
$e_2 = 40$ mm
$p_1 = 60$ mm

- stik v ravnini I
″dejanski členek je med ravnino II in zunanjim robom vezne pločevine v ravnini I.″

$M^{I\text{-}I} = V_{ed} \cdot 2 \cdot e = 49.74 \text{ kN} \cdot 2 \cdot 5.0 \text{ cm} = 497.40 \text{ kNcm}$

$e = \Delta + 2 \cdot e_2 = 10 \text{ mm} + 40 \text{ mm} = 50 \text{ mm} = 5.0 \text{ cm}$

Zvar med vezno pločevino in primarnim nosilcem:

$a \approx 0.4 \cdot t = 0.4 \cdot 10 \text{ mm} = 4.0 \text{ mm}$

Upoštevam samo zvar med stojino primarnega nosilca in vezno pločevino.
$l_{zv} = h_w = 15.2$ cm

Izberem $a \triangle l_{zv} = 4\ \text{mm} \triangle 152\ \text{mm}$

Kontrola zvara:

$\sqrt{n^2 + v_{\parallel}^2 + v_{\perp}^2} \leq f_{vw,d}$ $\qquad f_{vw,d} = \frac{f_u}{\sqrt{3}\beta_w\gamma_w} = \frac{36\ \text{kN/cm}^2}{\sqrt{3} \cdot 0.8 \cdot 1.25} = 20.78\ \text{kN/cm}^2$

$\sqrt{(16.14\ \text{kN/cm}^2)^2 + (4.09\ \text{kN/cm}^2)^2 + (0.53\ \text{kN/cm}_2)^2} \leq 20.78\ \text{kN/cm}^2$

$16.66\ \text{kN/cm}^2 \leq 20.78\ \text{kN/cm}^2$

$n = \frac{M_{Ed}}{W_{zv}} = \frac{497.4\ \text{kN/cm}^2}{30.81\ \text{cm}^3} = 16.14\ \text{kN/cm}^2$

$W_{zv} = 2 \cdot l_{zv}^2 \cdot a / 6 = 2 \cdot (15.2\ \text{cm})^2 \cdot 0.4\ \text{cm} / 6 = 30.81\ \text{cm}^3$

$v_{\parallel} = \frac{VEd}{2 \cdot a \cdot lzv} = \frac{49.74\ \text{kN}}{2 \cdot 0.4\ \text{cm} \cdot 15.2\ \text{cm}} = 4.09\ \text{kN/cm}^2$

$v_{\perp} = \frac{NEd}{2 \cdot a \cdot lzv} = \frac{6.44\ \text{kN}}{2 \cdot 0.4\ \text{cm} \cdot 15.2\ \text{cm}} = 0.53\ \text{kN/cm}^2$

Vijaki:

Kontrola strižne nosilnosti vijakov:

$F_m = r_{max} \cdot M_{Ed} / \sum r_i^2 = p_1/2 \cdot M_{Ed} / p_1^2 = 6.0\ \text{cm} / 2 \cdot 497.40\ \text{kNcm} / (6\ \text{cm})^2 = 41.45\ \text{kN}$

Strižna obremenitev, ki odpade na en vijak:

$F_{v,Ed} = \sqrt{F_m^2 + \left(\frac{V_{ed}}{2}\right)^2 + \left(\frac{N_{ed}}{2}\right)^2} = \sqrt{41.45^2 + \left(\frac{49.74}{2}\right)^2 + \left(\frac{6.44}{2}\right)^2} = 48.44\ \text{kN}$

$F_{v,Ed} \leq F_{v,Rd} = 0.6 \cdot f_{ub} \cdot A / \gamma_{Mb}$
$48.44 \leq 0.6 \cdot 100\ \text{kN/cm}^2 \cdot 2.01\ \text{cm}^2 / 1.25$
$48.44\ \text{kN} \leq 120.60\ \text{kN}$

Kontrola bočnih pritiskov:

$F_{v,Sd} \leq F_{b,Rd} = 2.5\alpha \cdot d \cdot t \cdot f_u / \gamma_{Mb}$

$49.74\ \text{kN} \leq 2.5 \cdot 0.62 \cdot 1.6\ \text{cm} \cdot 1.0\ \text{cm} \cdot 36.0\ \text{kN/cm}^2 = 89.28\ \text{kN}$

α = min: $e_1 / 3d_0 = 40$ mm / 3 · 16 mm = 0.83
$p_1 / 3d_0 - ¼ = 60$ mm / 3 · 16 mm – ¼ = 0.62
$f_{ub} / f_u = 100$ kN/cm^2 / 36 kN/cm^2 = 2.78
1.0

Kontrola proti pretrganju roba pločevine:

$V_{Ed} \leq V_{eff,Rd} = t_v \cdot L_{v,eff} \cdot f_y/\sqrt{3} \cdot \gamma_{M0}$
49.74 kN ≤ 1.0 cm · 10 cm · 23.5 kN/cm^2 / $\sqrt{3}$ · 1.0
49.74 kN ≤ 135.68 kN

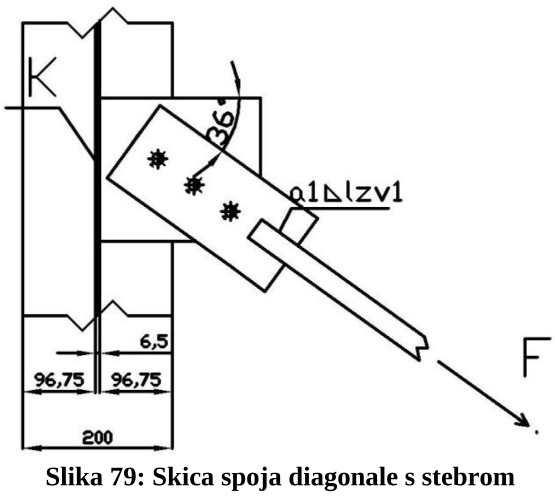
$L_{v,eff} = L_1 + L_v$= 4.0 cm + 6.0 cm = 10 cm
$L_1 = e_1$ = 4.0 cm
$L_v = p_1$ = 6.0 cm

7.4 Stik diagonale s stebrom

MATERIAL

- jeklo S235
- visokovredni vijaki 10.9

GEOMETRIJA



Slika 79: Skica spoja diagonale s stebrom

OBTEŽBA / OBREMENITEV

$F = N_{pl,Rd}$ = 166.15 kN

$N_{pl,Rd} = A \cdot f_y / \gamma_{M1} = 7.07\ cm^2 \cdot 23.5\ kN/cm^2 / 1.0 = 166.15\ kN$

DIMENZIONIRANJE

Zvar med diagonalo in vezno pločevino

$\sqrt{v_{II}^2} = 13.85\ kN/cm^2 \leq f_{v,w,d} = 20.78\ kN/cm^2$

$v_{II} = F / A_{zv} = 166.15\ kN / 12\ cm^2 = 13.85\ kN/cm^2$

$A_{zv} = 4 \cdot a_1 \cdot l_{zv1} = 4 \cdot 0.5\ cm \cdot 6.0\ cm = 12\ cm^2$

$a_1 \approx 0.4\ t = 0.4 \cdot 10\ mm = 4\ mm$; izberem $a_1 = 5\ mm$

Kontrola: $3\ mm \leq a_1 = 5\ mm \leq 0.7\ t = 0.7 \cdot 10 = 7\ mm$

$l_{zv1} = 60\ mm$

Kontrola: $\max(6a, 40\ mm) \leq l_{zv} \leq 150\ a$
$\max(30\ mm, 40\ mm) \leq 60 \leq 750\ mm$

Zvar med vezno pločevino in stebrom
Čelni zvar

Nosilnost vezne pločevine 1

- brutto:

$N_{sd} = 166.15\ kN \leq N_{pl,Rd} = A \cdot f_y / \gamma_{M1} = 12\ cm^2 \cdot 23.5\ kN/cm^2 / 1.0 = 282\ kN$

- neto:

$N_{sd} = 166.15\ kN \leq N_{u,Rd} = 0.9 \cdot A_{net} \cdot f_u / \gamma_{M2} = 0.9 \cdot 10.2\ cm^2 \cdot 36\ kN/cm^2 / 1.0 = 330.48\ kN$
$A_{net} = (12\ cm - 1.8\ cm) \cdot 1.0\ cm = 10.2\ cm^2$

Vijaki

Izberem vijake M16 10.9

$d_0 = d + 2\ mm = 16\ mm + 2\ mm = 18\ mm$

- število vijakov: $n = 3$

Razporeditev vijakov: e_1 = 40 mm
p_1 = 60 mm
e_2 = 60 mm

$F_{v,Sd} \leq F_{v,Rd} = 0.5\ f_{ub}\ A/\gamma_{Mb}$

$166.15\ kN / 3 = 55.38\ kN \leq 0.5 \cdot 100\ kN/cm^2 \cdot 1.57\ cm^2 / 1.25 = 62.8\ kN$

$F_{v,Sd} \leq F_{b,Rd} = 2.5\alpha \cdot d \cdot t \cdot f_u / \gamma_{Mb}$

$55.38\ kN \leq 2.5 \cdot 0.74 \cdot 1.8\ cm \cdot 1.0\ cm \cdot 36.0\ kN/cm^2 = 66.6\ kN$

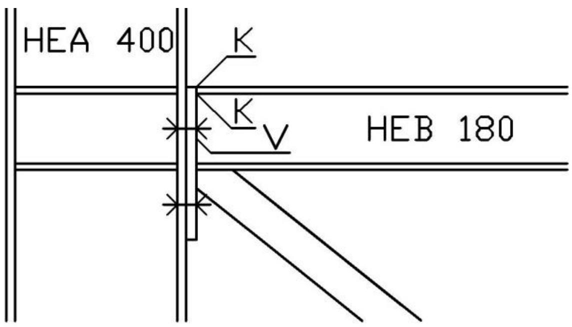
α = min: $e_1 / 3d_0 = 40\ mm / 3 \cdot 18\ mm = 0.74$
$p_1 / 3d_0 - ¼ = 60\ mm / 3 \cdot 18\ mm - ¼ = 0.86$
$f_{ub} / f_u = 100\ kN/cm^2 / 36\ kN/cm^2 = 2.78$
1.0

7.5 Spoj primarnega nosilca na steber

MATERIAL

- jeklo S235
- visokovredni vijaki 10.9

GEOMETRIJA



Slika 80: Skica spoja primarnega nosilca na steber

OBTEŽBA/OBREMENITEV

V_{ed} = 5.01 kN + sin38.66° · 305.01 kN = 195.55 kN
N_{ed} = 389.69 kN + cos38.66° · 305.01 kN = 627.86 kN

Dimenzioniranje spoja

Zvar med nosilcem in čelno pločevino: čelni zvar

Vijaki M22 10.9:
d_0 = d + 2 mm = 22 mm + 2 mm = 24 mm

Izberem debelino čelne pločevine
$t_{čp}$ = 22 mm ≥ d = 22 mm

e_1 = 76 mm
e_2 = 40 mm
p_2 = 100 mm

Kontrola natezne nosilnosti vijakov:

$F_{t,Sd} \leq F_{t,Rd} = 0.9 \cdot f_{ub} \cdot A_s / \gamma_{Mb}$
$627.86\ kN / 4 \leq 0.9 \cdot 100\ kN/cm^2 \cdot 3.03\ cm^2 / 1.25$
156.97 kN ≤ 218.16 kN

Kontrola strižne nosilnosti vijakov:

$F_{v,Sd} \leq F_{v,Rd} = 0.6 \cdot f_{ub} \cdot A / \gamma_{Mb}$
$195.55\ kN / 4 \leq 0.6 \cdot 100\ kN/cm^2 \cdot 3.8\ cm^2 / 1.25$
48.89 kN ≤ 182.40 kN

Interakcija striga in natega:

$F_{v,Sd} / F_{v,Rd} + F_{t,Sd} / 1.4 \cdot F_{t,Rd} \leq 1.0$
156.97 kN / 218.16 kN + 48.89 / 1.4 · 182.40 ≤ 1.0
0.91 ≤ 1.0

Kontrola nosilnosti na preboj pločevine:

$F_{t,Sd} \leq B_{p,Rd} = (0.6 \cdot \pi \cdot d_m \cdot f_u / \gamma_{Mb}) \cdot t_p$ $\quad t_p = \min(t_{čp}, t_f)$ = min (22 mm, 19 mm)
$156.97\ kN \leq (0.6 \cdot \pi \cdot 3.728\ cm \cdot 36.0\ kN/cm^2 / 1.25) \cdot 1.9\ cm$
156.97 kN ≤ 122.40 kN
→ ker se kontrola ne izide, dodam podložne ploščice 80/80/10 mm

Kontrola bočnih pritiskov:

$F_{v,Sd} \leq F_{b,Rd} = 2.5\alpha \cdot d \cdot t \cdot f_u / \gamma_{Mb}$

$48.89\ kN \leq 2.5 \cdot 1.0 \cdot 2.4\ cm \cdot 1.9\ cm \cdot 36.0\ kN/cm^2 = 328.32\ kN$

α = min:
$e_1 / 3d_0 = 76\ mm / 3 \cdot 24\ mm = 1.06$
$p_1 / 3d_0 - ¼ = 166\ mm / 3 \cdot 24\ mm - ¼ = 2.06$
$f_{ub} / f_u = 100\ kN/cm^2 / 36\ kN/cm^2 = 2.78$
1.0

Kontrola nosilnosti stebra v področju stika:

- čelna pločevina:

$t_{čp} = 22\ mm \geq d = 22\ mm$

- pasnica stebra v območju natezne obremenitve:

$t_f = 1.9\ cm \geq 0.5 \cdot t_{čp} = 0.5 \cdot 2.2\ cm = 1.1\ cm$
$t_f = 1.9\ cm \geq 0.8 \cdot d = 0.8 \cdot 2.2\ cm = 1.76\ cm$

- stojina stebra v tlaku:

$b_s = t_f^{nosilca} + 2 \cdot t_{čp} + 5 \cdot K = 1.4\ cm + 2 \cdot 2.2\ cm + 2.11\ cm = 7.91\ cm$

$K = t_f + \sqrt{2} \cdot a = 1.4\ cm + \sqrt{2} \cdot 0.5\ cm = 2.11\ cm$
$a \approx 0.5 \cdot t_w = 0.5 \cdot 8.5\ mm = 4.25\ mm$; $a = 5.0\ mm$

- prerez, ki prevzame koncentrirano tlačno silo $F_{c,Sd}$:

Sila, ki jo prevzame sodelujoči del nosilca:
$N_{Rd1} = b_s \cdot t_w \cdot f_y/\gamma_{M0} = 7.91\ cm \cdot 1.1\ cm \cdot 23.5\ kN/cm^2/1.0 = 204.47\ kN$

Sila, ki jo mora prevzeti prečna ojačitev:
$N_{Sd} = F_{c,Sd} - N_{Rd1} = 627.86\ kN - 204.47\ kN = 423.37\ kN$

$F_{c,Sd} = 627.86\ kN$

Kontrola nosilnosti prečnih ojačitev:

$b_{po} \geq N_{Sd} \cdot \gamma_{M0} / t_{po} \cdot f_y = 423.37\ kN \cdot 1.0 / 1.4\ cm \cdot 23.5\ kN/cm^2 = 12.87\ cm$
$15\ cm \geq 12.87\ cm$

$t_{po} = t_f = 14$ mm
$b_{po} = 150$ mm $\leq b = 300$ mm

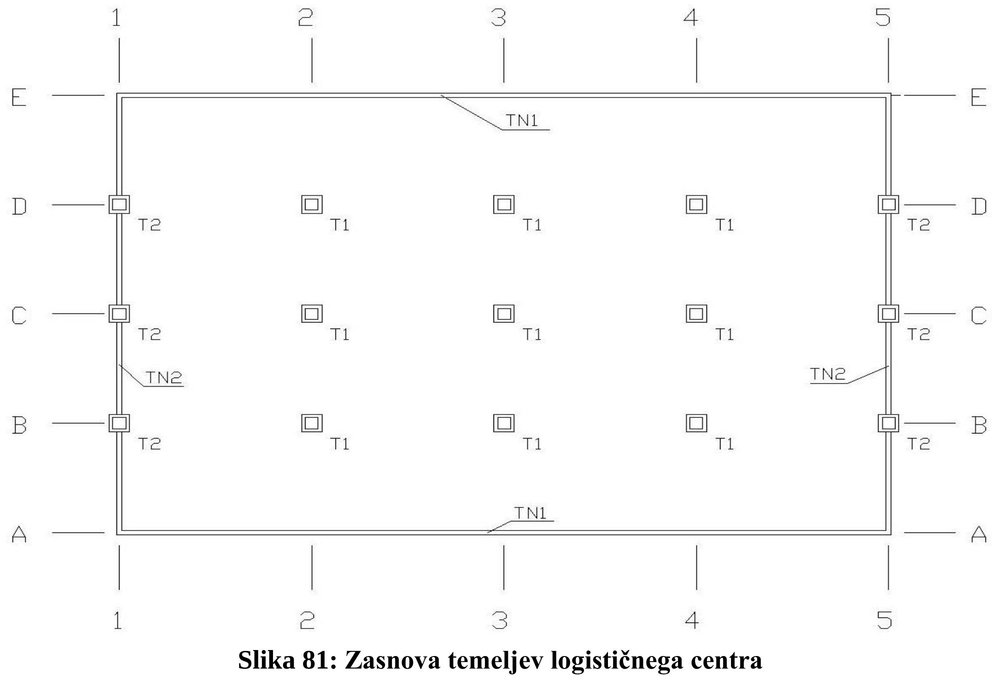
Stojina stebra v strigu:

$V_{Sd} = F_{c,Sd} \leq V_{pl,Rd} = h_w \cdot t_w \cdot f_y / \gamma_{M0} \cdot \sqrt{3}$
195.55 kN ≤ 35.2 cm $\cdot 1.1$ cm $\cdot 23.5$ kN/cm^2 $/ 1.0 \cdot \sqrt{3}$
195.55 kN ≤ 525.34 kN
→ diagonalna prečna ojačitev ni potrebna

8 OCENA NOSILNOSTI TEMELJEV

8.1 Zasnova

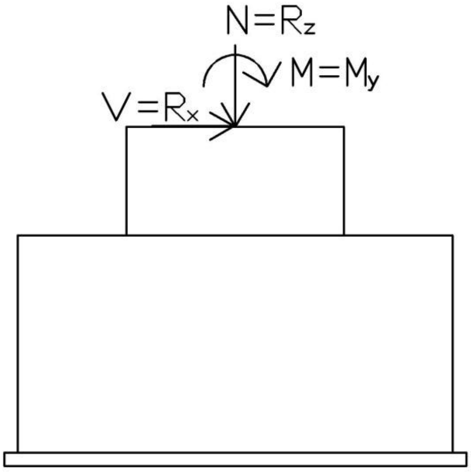
Obtežba primarnih okvirjev v oseh B,C in D se na temeljna tla prenaša preko točkovnih temeljev, obtežba primarnih okvirjev 2,3 in 4 ter fasadnih stebrov pa preko temeljnih nosilcev.



Slika 81: Zasnova temeljev logističnega centra

8.2 Statična obtežba na temelje

Obtežbo temeljev predstavljajo reakcije sil v podporah. Računalniški program jih označuje z drugačnimi oznakami, kot je navedeno v nadaljnjem računu. Obrazložitev označb je na spodnji sliki.



Slika 82: Obrazložitev označb pri točkovnih temeljih

Obtežba točkovnih temeljev:
V tabeli so vrednosti najbolj neugodnih kombinacij, ki lahko delujejo na temelje.

	N [kN]	M [kNm]	V [kN]
T1	161.16	-459.77	-127.45
T2	143.34	0.0	- 8.06

Obtežba temeljnih nosilcev:

TN1: Temeljni nosilec je obremenjen z reakcijami v podporah primarnih okvirjev 2,3,4 ter fasadnih stebrov na razdalji 3.75 m.

$N_1 = R_1 = 55.45$ kN
$N_2 = R_2 = 40.53$ kN

Varnostni faktorji za obtežne kombinacije:

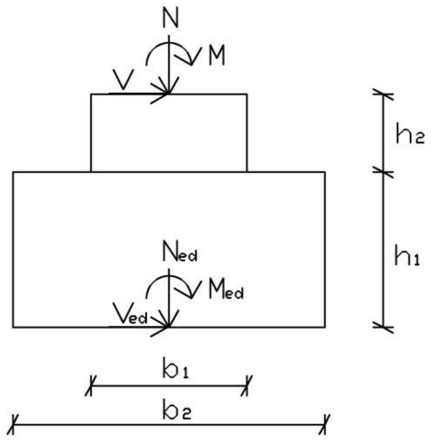
Trajni vplivi: - neugodni $\gamma_G = 1.1$
- ugodni $\gamma_G = 0.9$

Spremenljivi vplivi: - neugodni $\gamma_Q = 1,5$
- ugodni $\gamma_Q = 0.0$

8.3 Kontrola nosilnosti temeljnih tal

8.3.1 Točkovni temelji

8.3.1.1 Točkovni temelj T1



Slika 83: Sile, ki delujejo na točkovni temelj T1

Izberem temelj:

$h_1 = 1.4$ m
$h_2 = 0.8$ m
$b_1 = 3.8$ m
$b_2 = 1.4$ m

Obremenitev:

N = 161,16 kN · γ_G (vpliva ugodno) = 161.16 kN · 0.9 = 145.04 kN
V = 127.45 kN · γ_Q (neugoden vpliv) = 127.45 kN · 1.5 = 191.18 kN
M = 459.77 kNm · γ_Q (neugoden vpliv) = 459.77 kNm · 1.5 = 689.66 kN

G_b = ((3.8 m · 3.8 m · 1.4 m) + (1.4 m · 1.4 m · 0.8 m)) · 25 kN/m^3 = 544,60 kN
G_z = ((3.8 m · 3.8 m · 0.8 m) - (1.4 m · 1.4 m · 0.8 m)) · 19 kN/m^3 = 189.70 kN

Obremenitev temeljnih tal:

$N_{ed} = N + G_b + G_z = 879.34$ kN

$V_{ed} = V = 191.18$ kN

$M_{ed} = M + H \cdot V = 689.66$ kNm $+ 2.2$ m $\cdot$ 191.18 kN = 1110.26 kNm

Vpliv ekscentričnosti

$e = M_{ed} / N_{ed} = 1110.26$ kN m / 879.34 kN = 1.26 m

$e = 1.26$ m $\geq L/6 = 0.633$ m

$A' = b' \cdot l' = 1.28$ m $\cdot$ 3.8 m = 4.864 m^2

$b' = b - 2 \cdot e = 3.8$ m $- 2 \cdot 1.26$ m = 1.28 m ; $l' = l = 3.8$ m

$\sigma_{max} = 2 \cdot N_{ed} / 3 \cdot c \cdot b = 2 \cdot 879.34$ kN / $3 \cdot 0.64$ m $\cdot$ 3.8 m = 241.05 kN/m^2

$c = L/2 - e = 3.8$ m / 2 – 1.26 m = 0.64 m $\geq L/5 = 0.62$ m

σ_{max} = 241.05 kN/m^2

Karakteristike zemljine:

$c = 22$ kPa
$\varphi = 23^{\circ}$
$\gamma = 22.5$ kN/m^3
$c_u = 100$ kPa

$c_d = 17.6$ kPa
$\varphi_d = 18.76^{\circ}$
$c_{ud} = 71.43$ kPa

Materialni varnostni faktorji:

$\gamma_{\varphi'} = 1.25$
$\gamma_{c'} = 1.25$
$\gamma_{cu} = 1.40$
$\gamma_{\gamma} = 1.00$

Račun nosilnosti temeljnih tal:

Nosilnost v nedreniranih pogojih

$R/A' = (\pi+2) \cdot c_u \cdot b_c \cdot s_c \cdot i_c + q$

q … navpični tlak ob temelju na globini temeljne ploskve
c_u … nedrenirana strižna trdnost
b_c, s_c, i_c … koeficienti nagiba in oblike temelja ter nagib rezultante

$\alpha = 0^{\circ}$ … odklon temeljne ploskve od horizontale

$b_c = 1 - (2\alpha/(\pi+2)) = 1.0$
$s_c = 1 + 0.2(b'/l') = 1.067$
$i_c = 1.0$

$q = \gamma_z \cdot h = 19.0\ kN/m^3 \cdot 2.2\ m = 41.8\ kN/m^2$

$R/A' = 433.67\ kN/m^2$ > $\sigma_{max} = 241.05\ kN/m^2$ → pogoj je izpolnjen

Nosilnost v dreniranih pogojih

$R/A' = c' \cdot N_c \cdot b_c \cdot s_c \cdot i_c + q' \cdot N_q \cdot b_q \cdot s_q \cdot i_q + 0.5 \cdot \gamma' \cdot B' \cdot N_y \cdot b_y \cdot s_y \cdot i_y$

q … efektivni navpični tlak ob temelju na globini temeljne ploskve
c' … efektivna kohezija
N_c, N_q, N_y … koeficienti nosilnosti v odvisnosti os strižnega kota
b, s, i … koeficienti nagiba, oblike temelja in nagiba rezultante

- nosilnost tal

$N_q = e^{\pi \tan\varphi'} \tan^2 (45 + \varphi/2) = 5.66$

$N_c = (N_q - 1) \cot\varphi' = 13.72$

$N_y = 2(N_q - 1) \tan\varphi' = 3.165$

- naklon temeljne ploskve

$b_c = b_q - (1 - b_q) / (N_c \tan \varphi') = 1.0$

$b_q = b_\gamma = (1 - \alpha \tan\varphi')^2 = 1.0$

- oblika temelja
$s_q = 1 + \sin \varphi' = 1.32$

$s_\gamma = 0.7$

$s_c = (s_q N_q - 1) / (N_q - 1) = 1.39$

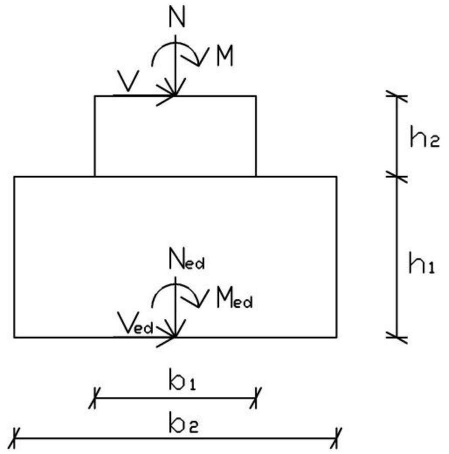
- nagib obtežbe, ki ga povzroča horizontalna sila V

$i_c = 1.0$
$i_q = 1.0$

$i_y = 1.0$

R / A' = 727.93 kN/m^2 > σ_{max} → pogoj je izpolnjen

8.3.1.2 Točkovni temelj T2



Slika 84: Sile, ki delujejo na točkovni temelj T2

Izberem temelj:

$h_1 = 0.4$ m
$h_2 = 0.8$ m
$b_1 = 1.4$ m
$b_2 = 0.6$ m

Obremenitev

N = 143.34 kN · γ_G (vpliva ugodno) = 143.34 kN · 0.9 = 129.01 kN
V = 8.06 kN · γ_Q (neugoden vpliv) = 8.06 kN · 1.5 = 12.09 kN
M = 0

G_b = ((1.4 m · 1.4 m · 0.8 m) + (0.6 m · 0.6 m · 0.4 m)) · 25 kN/m^3 = 42.8 kN
G_z = ((1.4 m · 1.4 m · 0.4 m) - (0.6 m · 0.6 m · 0.4 m)) · 19 kN/m^3 = 12.16 kN

Obremenitev temeljnih tal:

$N_{ed} = N + G_b + G_z = 129.01$ kN + 42.8 kN + 12.16 kN = 183.97 kN

$V_{ed} = V = 12.09$ kN

$M_{ed} = M + H \cdot V = 0 + 1.2$ m $\cdot$ 12.09 kN = 14.51 kNm

Vpliv ekscentričnosti

$e = M_{ed} / N_{ed} = 0.08$ m

$e = 0.08$ m $\leq L/6 = 0.23$ m

$A' = b' \cdot l' = 1.74$ m^2

$W = b^2 \cdot l/6 = 0.457$ m^3

$\sigma_{1,2} = N_{ed}/A' \pm M_{ed}/W$ → $\sigma_{max} = 137.48$ kN/m^2

Karakteristike zemljine:

$c = 22$ kPa
$\varphi = 23^{\circ}$
$\gamma = 22.5$ kN/m^3
$c_u = 100$ kPa

$c_d = 17.6$ kPa
$\varphi_d = 18.76^{\circ}$
$c_{ud} = 71.43$ kPa

Materialni varnostni faktorji:

$\gamma_{\varphi'} = 1.25$
$\gamma_{c'} = 1.25$
$\gamma_{cu} = 1.40$
$\gamma_{\gamma} = 1.00$

Račun nosilnosti temeljnih tal:

Nosilnost v nedreniranih pogojih

$R/A' = (\pi+2) \cdot c_u \cdot b_c \cdot s_c \cdot i_c + q$

q … navpični tlak ob temelju na globini temeljne ploskve
c_u … nedrenirana strižna trdnost
b_c, s_c, i_c … koeficienti nagiba in oblike temelja ter nagib rezultante

$\alpha = 0^{\circ}$ … odklon temeljne ploskve od horizontale

$b_c = 1 - (2\alpha/(\pi+2)) = 1.0$
$s_c = 1 + 0.2(b'/l) = 1.2$
$i_c = 1.0$

$q = \gamma_z \cdot h = 19.0\ kN/m^3 \cdot 1.2\ m = 22.8\ kN/m^2$

$R/A' = 463.38\ kN/m^2 > \sigma_{max}$ → pogoj je izpolnjen

Nosilnost v dreniranih pogojih

$R/A' = c' \cdot N_c \cdot b_c \cdot s_c \cdot i_c + q' \cdot N_q \cdot b_q \cdot s_q \cdot i_q + 0.5 \cdot \gamma' \cdot B' \cdot N_y \cdot b_y \cdot s_y \cdot i_y$

q … efektivni navpični tlak ob temelju na globini temeljne ploskve
c' … efektivna kohezija
N_c, N_q, N_y … koeficienti nosilnosti v odvisnosti os strižnega kota
b, s, i … koeficienti nagiba, oblike temelja in nagiba rezultante

- nosilnost tal

$N_q = e^{\pi \tan\varphi'} \tan^2 (45 + \varphi/2) = 5.66$

$N_c = (N_q – 1) \cot\varphi' = 13.72$

$N_y = 2(N_q – 1) \tan\varphi' = 3.165$

- naklon temeljne ploskve

$b_c = b_q – (1 – b_q) / (N_c \tan \varphi') = 1.0$

$b_q = b_\gamma= (1 – \alpha \tan\varphi')^2 = 1.0$

- oblika temelja

$s_q = 1 + \sin \varphi' = 1.32$

$s_\gamma = 0.7$

$s_c = (s_q N_q – 1) / (N_q – 1) = 1.39$

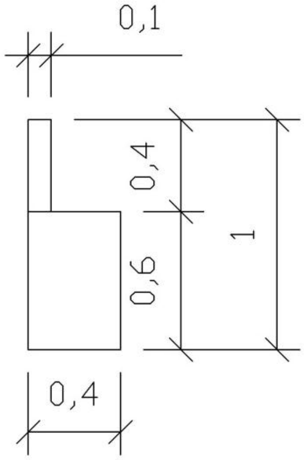
- nagib obtežbe, ki ga povzroča horizontalna sila V

$i_c = 1.0$
$i_q = 1.0$
$i_y = 1.0$

$R / A' = 560.48\ kN/m^2 > \sigma_{max}$ → pogoj je izpolnjen

8.3.1.3 Temeljni nosilec TN1

Izberem temeljni nosilec:



Slika 85: Skica prereza temeljnega nosilca

B = 0.4 m
D = 1.0 m
L = 60 m

Karakteristike zemljine:

c = 22 kPa
$\varphi = 23^{\circ}$
$\gamma = 22.5\ kN/m^3$
$c_u = 100$ kPa

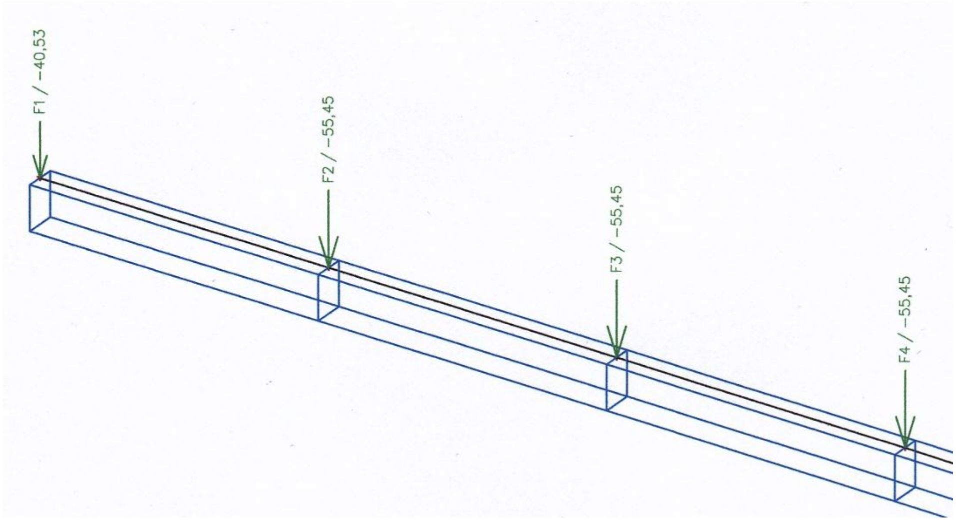
$c_d = 17.6$ kPa
$\varphi_d = 18.76^{\circ}$
$c_{ud} = 71.43$ kPa

Materialni varnostni faktorji:

$\gamma_{\varphi'} = 1.25$
$\gamma_{c'} = 1.25$
$\gamma_{cu} = 1.40$
$\gamma_{\gamma} = 1.00$

Obtežba:

Točkovna obtežba: R_1 (reakcije fasadnih stebrov v smer X na vsake 3.75 m) = -55.45 kN
R_2 (krajni reakciji fasadnih stebrov v smeri Y) = - 40.53 kN



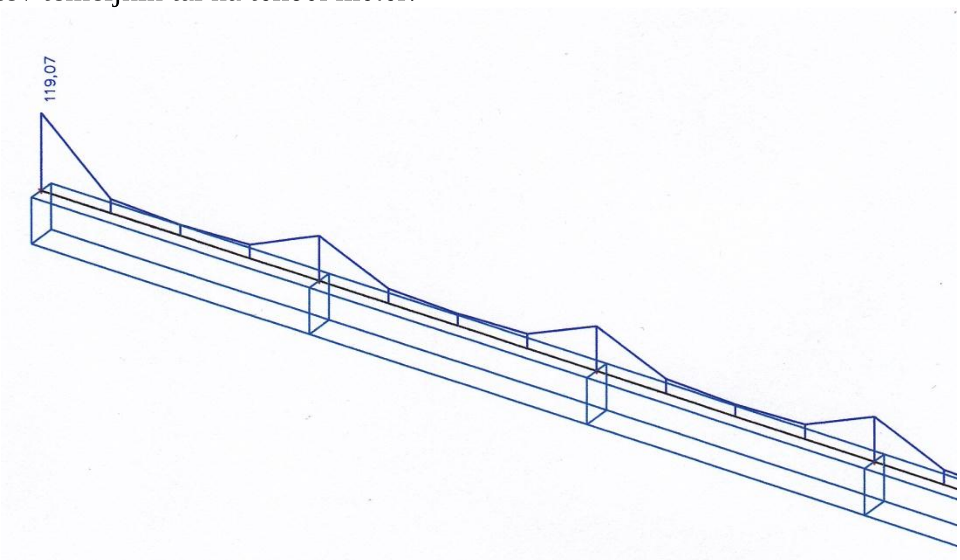
Slika 86: Točkovna obremenitev temeljnega nosilca TN 1

Linijska obtežba:

-parapetni zid: 0.1m · 0.8 m · 25 kN/m^3 = 2.0 kN/m

Obremenitev temeljnih tal:

Obremenitev temeljnih tal sem izračunal s programom SCIA Engineer, ki izračuna obremenitev temeljnih tal na tekoči meter.



Slika 87: Obremenitev temeljnih tal v kN/m

σ_{max} = 119.07 kN/m / 0.4 m = 297.68 kN/m^2

Nosilnost v dreniranih pogojih

$p_f = \gamma \cdot B \cdot N_\gamma + c \cdot N_c + q \cdot N_q =$
$= 22.5\ kN/m^3 \cdot 0.4\ m \cdot 3.17 + 17.6\ kN/m^2 \cdot 13.72 + 22.5\ kN/m^2 \cdot 5.66 = 397.35\ kN/m^2$

$N_q = e^{\pi \cdot tan\varphi d} \cdot tan^2(45 + \varphi_d/2) = e^{\pi \cdot tan18.76} \cdot tan^2(45 + 18.76 / 2) = 5.66$

$N_\gamma = 2 \cdot (N_q - 1) \cdot tan\varphi_d = 2 \cdot (5.66 - 1) \cdot tan18.76 = 3.17$

$N_c = (N_q - 1) / tan\varphi_d = (5.66 - 1) / tan18.76 = 13.72$

$q = \gamma \cdot D = 22.5\ kN/m^2 \cdot 1.0\ m = 22.5\ kN/m^2$

$\mathbf{p_f = 397.35\ kN/m^2} > \boldsymbol{\sigma_{max}} \rightarrow$ **pogoj je izpolnjen**

Nosilnost v nedreniranih pogojih

$p_f = \gamma \cdot B \cdot N_\gamma + c \cdot N_c + q \cdot N_q =$
$= 22.5\ kN/m^3 \cdot 0.4\ m \cdot 2.25 + 15.71\ kN/m^2 \cdot 12.23 + 22.5\ kN/m^2 \cdot 4.71 = 318.36\ kN/m^2$

$N_q = e^{\pi \cdot tan\varphi d} \cdot tan^2(45 + \varphi_d/2) = e^{\pi \cdot tan16.87} \cdot tan^2(45 + 16.87 / 2) = 4.71$

$N_\gamma = 2 \cdot (N_q - 1) \cdot tan\varphi_d = 2 \cdot (4.71 - 1) \cdot tan16.87 = 2.25$

$N_c = (N_q - 1) / tan\varphi_d = (4.71 - 1) / tan16.87 = 12.23$

$q = \gamma \cdot D = 22.5\ kN/m^2 \cdot 1.0\ m = 22.5\ kN/m^2$

$\mathbf{p_f = 318.36\ kN/m^2} > \boldsymbol{\sigma_{max}} \rightarrow$ **pogoj je izpolnjen**

8.3.1.4 TN 2

Ker ima temeljni nosilec TN2 enake geometrijske karakteristike kot TN2, hkrati pa je bistveno manj obremenjen, ga nisem posebej računsko preverjal.

9 IZVLEČEK MATERIALA

Preglednica 15: Izvleček materiala

Bill of material

Name	Mass [kg]	Surface [m²]	Volume [m³]
Student version *Student version* *Student version* *Student version* *Studer			
Total results :	83976,5	2045,371	1,0698e+01

CSS	Material	Unit mass [kg/m]	Length [m]	Mass [kg]	Surface [m²]	Unit volume mass [kg/m³]	Volume [m³]
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student ve							
CS1 - HEB180	S 235	51,2	240,299	12308,4	249,220	7850,0	1,5679e+00
CS2 - HEA180	S 235	35,6	240,213	8542,1	246,010	7850,0	1,0882e+00
CS3 - HEA200	S 235	42,2	129,600	5473,4	147,220	7850,0	6,9725e-01
CS4 - HEA400	S 235	124,8	64,800	8088,0	123,861	7850,0	1,0303e+00
CS5 - QRO40X5	S 235	5,3	1022,745	5443,4	154,819	7850,0	6,9342e-01
CS6 - QRO50X5	S 235	6,9	265,995	1835,4	50,905	7850,0	2,3381e-01
CS7 - QRO70X5	S 235	10,0	312,171	3136,7	84,716	7850,0	3,9958e-01
CS8 - QRO80X6.3	S 235	14,3	112,320	1604,7	34,722	7850,0	2,0442e-01
CS9 - HEA160	S 235	30,5	312,400	9515,1	283,075	7850,0	1,2121e+00
CS10 - HEA450	S 235	139,7	64,800	9054,5	130,276	7850,0	1,1534e+00
CS11 - HEB160	S 235	42,6	30,000	1277,6	27,544	7850,0	1,6275e-01
CS12 - QRO60X5	S 235	8,5	315,000	2670,6	72,883	7850,0	3,4020e-01
CS13 - QRO40X4.5	S 235	4,9	950,697	4642,0	144,732	7850,0	5,9134e-01
CS14 - QRO70X4.5	S 235	9,1	360,000	3278,2	98,006	7850,0	4,1760e-01
CS15 - QRO70X6.3	S 235	12,3	120,000	1478,9	32,296	7850,0	1,8840e-01
CS16 - QRO60X4	S 235	6,9	90,000	623,1	20,979	7850,0	7,9380e-02
CS17 - HEA120	S 235	19,9	79,941	1587,7	54,145	7850,0	2,0225e-01
CS18 - QRO100X5	S 235	14,8	80,000	1180,6	31,302	7850,0	1,5040e-01
CS19 - RD30	S 235	5,5	98,579	546,7	9,290	7850,0	6,9646e-02
CS20 - RD22	S 235	3,0	169,747	506,3	11,731	7850,0	6,4494e-02
CS21 - RD8	S 235	0,4	108,273	42,7	2,721	7850,0	5,4396e-03
CS22 - RD10	S 235	0,6	505,237	311,3	15,872	7850,0	3,9661e-02
CS23 - RD16	S 235	1,6	144,364	227,7	7,256	7850,0	2,9011e-02
CS24 - RD26	S 235	4,2	144,364	601,4	11,791	7850,0	7,6608e-02

CELOTNA KONSTRUKCIJA:	∑:	83.976,5 kg
	Zvari (1,5 %):	1.259,6 kg
	Vezne pločevine (15 %):	12.596,5 kg
	SKUPAJ:	**97.832,6 kg**

10 ZAKLJUČEK

V diplomski nalogi sem naredil statično analizo logističnega centra iz jekla kvalitete S 235. Primarna nosilna konstrukcija so okvirji s paličnimi nosilci, ki so v obeh smereh momentno priključeni na stebre. Po obodu objekta so dodani fasadni stebri z zavetrovanjem. Togost strešne konstrukcije zagotavlja horizontalno zavetrovanje. Vplive na konstrukcijo sem določil po standardih EVROKOD. Za analizo sem uporabil računalniški program SCIA Engineer 2010. V okviru diplomskega dela sem izračunal tudi značilne spoje in temelje ter zrisal načrte.

Med diplomskim delom sem se seznanil s projektiranjem jeklenih konstrukcij in se naučil uporabljati standarde ter računalniški program, ki se v inženirski praksi pogosto uporablja. Pri reševanju problemov sem utrdil znanje, ki sem ga pridobil med študijem in ga nadgradil s področja konstrukcijske smeri. Spoznal sem, da je pri dimenzioniranju konstrukcije zelo pomembno modeliranje, saj je potrebno narediti več variant in izbrati najbolj ugodno. Kriteriji glede katerega se odločimo je največkrat cena konstrukcije, ki je odvisna od teže in kvalitete materiala ter načina vgradnje.

Čeprav je diplomska naloga omejena na projekt logističnega centra, sem moral preučiti standarde in literaturo tudi za drugačne primere, da sem lahko prišel do rezultata. Delo na diplomski nalogi mi je kljub veliko vloženega truda, vztrajnosti in raziskovalnega dela predstavljalo velik izziv.

VIRI

Beg, D. 1999. Projektiranje jeklenih konstrukcij po evropskem predstandardu ENV 1993-1-1. Ljubljana, Univerza v Ljubljani, Fakulteta za gradbeništvo in geodezijo: 219 strani

Beg, D., Pogačnik, A. 2009. Priročnik za projektiranje gradbenih konstrukcij po evrokod standardih. Ljubljana, Inženirska zbornica Slovenije: loč. pog.

Scia Campus for Students and Professors, www.scia-online.com, maj 2011

SIST-EN 1990: Evrokod: Osnove projektiranja konstrukcij (istoveten EN 1990:2000), september 2004

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-1 del: Splošni vplivi – Prostorninske teže, lastna teža, koristne obtežbe stavb, september 2004

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-1 del: Splošni vplivi – Prostorninske teže, lastna teža, koristne obtežbe stavb - Nacionalni dodatek, september 2004/A101

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-3 del: Splošni vplivi – Obtežba snega, september 2004

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-3 del: Splošni vplivi – Obtežba snega – Nacionalni dodatek, september 2004/A101

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-4 del: Splošni vplivi – Vplivi vetra, oktober 2005

SIST-EN 1991: Evrokod 1: Vplivi na konstrukcije – 1-4 del: Splošni vplivi – Vplivi vetra – Nacionalni dodatek, oktober 2005/A101

SIST-EN 1993: Evrokod 3: Projektiranje jeklenih konstrukcij – 1-1 del: Splošna pravila in pravila za stavbe, oktober 2005

SIST-EN 1993: Evrokod 3: Projektiranje jeklenih konstrukcij – 1-8 del: Projektiranje spojev, oktober 2005

SIST-EN 1997: Evrokod 7: Geotehnično projektiranje – 1. del: Splošna pravila, maj 2005

SIST-EN 1998: Evrokod 8: Projektiranje potresnoodpornih konstrukcij – 1. del: Splošna pravila, potresni vplivi in pravila za stavbe, maj 2005

Trimo.si, www.trimo.si, maj 2011

KAZALO PRILOG

Priloga 1: Dimenzioniranje sekundarnega paličnega nosilca 1

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B13	**QRO40X4.5**	**S 235**	**NC1**	**0.91**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 5.89 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 1.601 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-68.22	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.10	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	146.17	kN
Unity check	0.47	-

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	42.20	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	1.31	kNm
MNVz.Rd	1.31	kNm

alfa 2.20 beta 2.20
Unity check 0.00 -
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* *St			
Sway type	sway	non-sway	
System Length L	1.601	1.601	m
Buckling factor k	1.00	1.00	
Student version *Student version* *Student version* *Student version* *Student version* *St			

Buckling parameters	yy	zz	
Buckling length Lcr	1.601	1.601	m
Critical Euler load Ncr	105.15	105.15	kN
Slenderness	110.73	110.73	
Relative slenderness Lambda	1.18	1.18	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.54	0.54	
Buckling resistance Nb,Rd	79.42	79.42	kN

Table of values		
A	6.2200e-04	m^2
Buckling resistance Nb,Rd	79.42	kN
Unity check	0.86	-

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		
kyy	1.898	
kyz	2.259	
kzy	1.989	
kzz	2.259	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.2200e-04	m^2
Wy	8.2221e-06	m^3
Wz	8.2221e-06	m^3
NRk	146.17	kN
My,Rk	1.93	kNm
Mz,Rk	1.93	kNm
My,Ed	0.05	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	41.86	kNm
reduced slenderness 0	0.21	
Cmy,0	1.019	
Cmz,0	1.156	
Cmy	1.019	
Cmz	1.156	
CmLT	1.000	
muy	0.542	
muz	0.542	
wy	1.265	
wz	1.265	
npl	0.467	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.830	
Cyz	0.474	
Czy	0.475	
Czz	0.791	

Unity check (6.61) = 0.86 + 0.05 + 0.00 = 0.91
Unity check (6.62) = 0.86 + 0.05 + 0.00 = 0.91
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B18	QRO70X4.5	S 235	NC1	0.46

Basic data EC3 : EN 1993	
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		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

...::SECTION CHECK::...
Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio 12.56 on position 2.500 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.88

==> Class cross-section 1

The critical check is on position 3.750 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-79.46	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.02	kN
TEd	0.00	kNm
My,Ed	0.19	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	272.60	kN
Unity check	0.29	-

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	78.69	kN
Unity check	0.00	-

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	6.68	kNm
Unity check	0.03	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	6.13	kNm
MNVz.Rd	6.13	kNm

alfa 1.84 beta 1.84
Unity check 0.03 -
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* *St			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	1.34	1.00	
Buckling length Lcr	1.671	2.500	m
Critical Euler load Ncr	613.55	274.25	kN
Slenderness	62.60	93.63	
Relative slenderness Lambda	0.67	1.00	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.86	0.67	
Buckling resistance Nb,Rd	235.22	182.02	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	1.1600e-03	m^2
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
Buckling resistance Nb,Rd	182.02	kN
Unity check	0.44	-

Lateral Torsional Buckling Check

Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.

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	1.175	
kyz	1.190	
kzy	0.771	
kzz	1.413	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.1600e-03	m^2
Wy	2.8414e-05	m^3
Wz	2.8414e-05	m^3
NRk	272.60	kN
My,Rk	6.68	kNm
Mz,Rk	6.68	kNm
My,Ed	0.19	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	168.55	kNm
reduced slenderness 0	0.20	
Cmy,0	1.003	
Cmz,0	1.070	
Cmy	1.003	
Cmz	1.070	
CmLT	1.000	
muy	0.980	
muz	0.881	
wy	1.204	
wz	1.204	
npl	0.292	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.961	
Cyz	0.745	
Czy	0.790	
Czz	0.939	

Unity check (6.61) = 0.34 + 0.03 + 0.00 = 0.37
Unity check (6.62) = 0.44 + 0.02 + 0.00 = 0.46
Element satisfies the stability check !

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

EN 1993-1-1 Code Check

Member B20	**QRO60X5**	**S 235**	**NC1**	**0.87**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 9.00 on position 7.500 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.44

==> Class cross-section 1

The critical check is on position 7.500 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-115.57	kN
Vy,Ed	0.00	kN
Vz,Ed	0.09	kN
TEd	0.00	kNm
My,Ed	-0.04	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	253.80	kN
Unity check	0.46	-

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	73.27	kN
Unity check	0.00	-

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	5.20	kNm
Unity check	0.01	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	3.64	kNm
MNVz.Rd	3.64	kNm

alfa	2.17	beta	2.17
Unity check	0.01	-	

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* *St			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	2.02	1.00	
Buckling length Lcr	2.531	2.500	m
Critical Euler load Ncr	175.10	179.41	kN
Slenderness	113.07	111.70	
Relative slenderness Lambda	1.20	1.19	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.53	0.54	
Buckling resistance Nb,Rd	133.88	136.22	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	1.0800e-03	m^2
Buckling resistance Nb,Rd	133.88	kN
Unity check	0.86	-

Lateral Torsional Buckling Check
Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.

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	0.585	
kyz	2.082	
kzy	0.391	
kzz	2.171	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.0800e-03	m^2
Wy	2.2130e-05	m^3
Wz	2.2130e-05	m^3
NRk	253.80	kN
My,Rk	5.20	kNm
Mz,Rk	5.20	kNm
My,Ed	-0.04	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	110.74	kNm
reduced slenderness 0	0.22	
Cmy,0	0.435	
Cmz,0	1.155	
Cmy	0.435	
Cmz	1.155	
CmLT	1.000	
muy	0.522	
muz	0.544	
wy	1.229	
wz	1.229	
npl	0.455	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	1.141	
Cyz	0.488	
Czy	1.066	
Czz	0.813	

Unity check (6.61) = 0.86 + 0.00 + 0.00 = 0.87
Unity check (6.62) = 0.85 + 0.00 + 0.00 = 0.85
Element satisfies the stability check !

Priloga 2: Dimenzioniranje sekundarnega paličnega nosilca 2

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B13	**QRO40X4.5**	**S 235**	**NC1**	**0.65**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 5.89 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 1.601 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-49.61	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.07	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	146.17	kN
Unity check	0.34	-

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	42.20	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	1.62	kNm
MNVz.Rd	1.62	kNm

alfa 1.91 beta 1.91
Unity check 0.00 -
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* *St			
Sway type	sway	non-sway	
System Length L	1.601	1.601	m
Buckling factor k	1.00	1.00	
Student version *Student version* *Student version* *Student version* *Student version* *St			

Buckling parameters	yy	zz	
Student version *Student version* *Student version* *Student version* *Student version* *St			
Buckling length Lcr	1.601	1.601	m
Critical Euler load Ncr	105.15	105.15	kN
Slenderness	110.73	110.73	
Relative slenderness Lambda	1.18	1.18	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.54	0.54	
Buckling resistance Nb,Rd	79.42	79.42	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.2200e-04	m^2
Buckling resistance Nb,Rd	79.42	kN
Unity check	0.62	-

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	1.551	
kyz	1.764	
kzy	1.311	
kzz	1.833	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.2200e-04	m^2
Wy	8.2221e-06	m^3
Wz	8.2221e-06	m^3
NRk	146.17	kN
My,Rk	1.93	kNm
Mz,Rk	1.93	kNm
My,Ed	0.03	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	41.86	kNm
reduced slenderness 0	0.21	
Cmy,0	1.014	
Cmz,0	1.114	
Cmy	1.014	
Cmz	1.114	
CmLT	1.000	
muy	0.710	
muz	0.710	
wy	1.265	
wz	1.265	
npl	0.339	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.879	
Cyz	0.509	
Czy	0.624	
Czz	0.817	

Unity check (6.61) = 0.62 + 0.03 + 0.00 = 0.65
Unity check (6.62) = 0.62 + 0.02 + 0.00 = 0.65
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B18	QRO70X6.3	S 235	NC1	0.80

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio	8.11	on position	0.000	m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 1.250 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-60.68	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.01	kN
TEd	0.00	kNm
My,Ed	0.15	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	368.95	kN
Unity check	0.16	-

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	106.51	kN
Unity check	0.00	-

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	8.77	kNm
Unity check	0.02	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	8.77	kNm
MNVz.Rd	8.77	kNm

alfa	1.71	beta	1.71
Unity check	0.02	-	

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* *St			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	4.03	1.00	
Buckling length Lcr	5.037	2.500	m
Critical Euler load Ncr	86.61	351.52	kN
Slenderness	193.83	96.21	
Relative slenderness Lambda	2.06	1.02	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.21	0.65	
Buckling resistance Nb,Rd	77.58	239.25	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	1.5700e-03	m^2
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Buckling resistance Nb,Rd	77.58	kN
Unity check	0.78	-

Lateral Torsional Buckling Check

Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.

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		
kyy	1.335	
kyz	0.546	
kzy	3.542	
kzz	1.450	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.5700e-03	m^2
Wy	3.7326e-05	m^3
Wz	3.7326e-05	m^3
NRk	368.95	kN
My,Rk	8.77	kNm
Mz,Rk	8.77	kNm
My,Ed	0.15	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	217.33	kNm
reduced slenderness 0	0.20	
Cmy,0	0.921	
Cmz,0	1.042	
Cmy	0.921	
Cmz	1.042	
CmLT	1.000	
muy	0.351	
muz	0.932	
wy	1.236	
wz	1.236	
npl	0.164	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.809	
Cyz	0.485	
Czy	0.485	
Czz	0.809	

Unity check (6.61) = 0.78 + 0.02 + 0.00 = 0.80
Unity check (6.62) = 0.25 + 0.06 + 0.00 = 0.31
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B20	QRO60X4	S 235	NC1	0.60

Basic data EC3 : EN 1993	
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		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

The critical check is on position 2.500 m

Internal forces		
NEd	124.15	kN
Vy,Ed	0.00	kN
Vz,Ed	0.10	kN
TEd	0.00	kNm
My,Ed	0.06	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version* *		
Nt.Rd	207.27	kN
Unity check	0.60	-

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	59.83	kN
Unity check	0.00	-

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	4.34	kNm
Unity check	0.01	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	2.25	kNm
MNVz.Rd	2.25	kNm

alfa	2.79	beta	2.79
Unity check	0.03	-	

Element satisfies the section check !

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

Lateral Torsional Buckling Check
Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.
Element satisfies the stability check !

Priloga 3: Dimenzioniranje primarnega okvirja – smer X

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B12	**QRO70X5**	**S 235**	**NC1**	**0.75**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 11.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-214.12	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	300.80	kN
Unity check	0.71	-

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	86.83	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	2.72	kNm
MNVz.Rd	2.72	kNm

alfa 3.88 beta 3.88
Unity check 0.00 -
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* *Stu			
Sway type	sway	non-sway	
System Length L	1.000	1.000	m
Buckling factor k	1.00	1.00	
Student version *Student version* *Student version* *Student version* *Student version* *Stu			

Buckling parameters	yy	zz	
Buckling length Lcr	1.000	1.000	m
Critical Euler load Ncr	1857.07	1857.07	kN
Slenderness	37.80	37.80	
Relative slenderness Lambda	0.40	0.40	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.95	0.95	
Buckling resistance Nb,Rd	286.40	286.40	kN

Table of values		
A	1.2800e-03	m^2
Buckling resistance Nb,Rd	286.40	kN
Unity check	0.75	-

Element satisfies the stability check!

EN 1993-1-1 Code Check

Member B25	**QRO80X6.3**	**S 235**	**NC1**	**0.83**

Basic data EC3 : EN 1993	
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		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

The critical check is on position 0.000 m

Internal forces		
NEd	354.75	kN
Vy,Ed	0.00	kN
Vz,Ed	0.10	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check

According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Nt.Rd	427.70	kN
Unity check	0.83	-

Shear check (Vz)

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

Table of values		
Vc,Rd	123.47	kN
Unity check	0.00	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
MNVy.Rd	2.59	kNm
MNVz.Rd	2.59	kNm

alfa	6.00	beta	6.00
Unity check	0.00	-	

Element satisfies the section check !

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

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B9	QRO40X5	S 235	NC1	0.75

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio 5.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-98.10	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	159.33	kN
Unity check	0.62	-

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	45.99	kN
Unity check	0.00	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	1.00	kNm
MNVz.Rd	1.00	kNm

alfa 2.90 beta 2.90

Unity check 0.00 -

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* *St			
Sway type	sway	non-sway	
System Length L	1.000	1.000	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	1.000	1.000	m
Critical Euler load Ncr	286.02	286.02	kN
Slenderness	70.09	70.09	
Relative slenderness Lambda	0.75	0.75	
Student version *Student version* *Student version* *Student version* *Student version* *St			

Buckling parameters	yy	zz	
Student version *Student version* *Student version* *Student version* *Student version* *St			
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.82	0.82	
Buckling resistance Nb,Rd	131.43	131.43	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.7800e-04	m^2
Buckling resistance Nb,Rd	131.43	kN
Unity check	0.75	-

Element satisfies the stability check!

EN 1993-1-1 Code Check

Member B22	QRO50X5	S 235	NC1	0.74

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *		
NEd	153.11	kN
Vy,Ed	0.00	kN
Vz,Ed	0.04	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check

According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version* *		
Nt.Rd	206.57	kN
Unity check	0.74	-

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	59.63	kN
Unity check	0.00	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	1.14	kNm
MNVz.Rd	1.14	kNm

alfa	4.38	beta	4.38
Unity check	0.00	-	

Element satisfies the section check !

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

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B81	HEB180	S 235	NC1	0.86

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
partial safety factor Gamma M0 for resistance of cross-sections	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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio 14.35 on position 6.259 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	44.98

==> Class cross-section 1

Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).

ratio 5.05 on position 6.259 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 6.259 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-273.65	kN
Vy,Ed	0.00	kN
Vz,Ed	12.79	kN
TEd	0.00	kNm
My,Ed	2.94	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1533.38	kN
Unity check	0.18	-

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	274.61	kN
Unity check	0.05	-

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* *St		
Mc,Rd	113.27	kNm
Unity check	0.03	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
MNVy.Rd	105.00	kNm
MNVz.Rd	54.52	kNm

alfa 2.00 beta 1.00

Unity check 0.03 -

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 version* *St			
Sway type	sway	non-sway	
System Length L	1.252	3.755	m
Buckling factor k	10.00	1.00	
Buckling length Lcr	12.518	3.755	m
Critical Euler load Ncr	506.73	2003.17	kN
Slenderness	163.37	82.17	
Relative slenderness Lambda	1.74	0.87	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.27	0.62	
Buckling resistance Nb,Rd	409.94	943.52	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.5250e-03	m^2
Buckling resistance Nb,Rd	409.94	kN
Unity check	0.67	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	4.8200e-04	m^3
Elastic critical moment Mcr	536.82	kNm
Relative slenderness Lambda,LT	0.46	
Limit slenderness Lambda,LT,0	0.40	

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	1.191	
kyz	0.751	
kzy	1.696	
kzz	1.679	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.5250e-03	m^2
Wy	4.8200e-04	m^3
Wz	2.3200e-04	m^3
NRk	1533.38	kN
My,Rk	113.27	kNm
Mz,Rk	54.52	kNm
My,Ed	18.24	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	309.66	kNm
reduced slenderness 0	0.60	
Cmy,0	0.856	
Cmz,0	1.033	
Cmy	0.928	
Cmz	1.033	
CmLT	1.000	
muy	0.538	
muz	0.943	
wy	1.132	
wz	1.500	
npl	0.178	
aLT	0.989	
bLT	0.000	
cLT	0.112	
dLT	0.000	
eLT	0.257	
Cyy	0.910	
Cyz	0.591	
Czy	0.584	
Czz	0.672	

Unity check (6.61) = 0.67 + 0.19 + 0.00 = 0.86

Unity check (6.62) = 0.29 + 0.27 + 0.00 = 0.56

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	17.882

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

EN 1993-1-1 Code Check

Member B109	**HEB180**	**S 235**	**NC1**	**0.92**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

...::SECTION CHECK::...
Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 14.35 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	45.35

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 5.05 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1
The critical check is on position 1.252 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-668.66	kN
Vy,Ed	0.00	kN
Vz,Ed	6.16	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1533.38	kN
Unity check	0.44	-

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	274.61	kN
Unity check	0.02	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	72.08	kNm
MNVz.Rd	50.55	kNm

alfa 2.00 beta 2.18
Unity check 0.00 -
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* *Stu			
Sway type	sway	non-sway	
System Length L	1.252	1.252	m
Buckling factor k	6.45	1.00	
Buckling length Lcr	8.077	1.252	m
Critical Euler load Ncr	1217.03	18028.57	kN
Slenderness	105.41	27.39	
Relative slenderness Lambda	1.12	0.29	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.52	0.95	
Buckling resistance Nb,Rd	800.31	1461.94	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.5250e-03	m^2
Buckling resistance Nb,Rd	800.31	kN
Unity check	0.84	-

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	1.218	
kyz	0.500	
kzy	1.354	
kzz	1.312	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.5250e-03	m^2
Wy	4.8200e-04	m^3
Wz	2.3200e-04	m^3
NRk	1533.38	kN
My,Rk	113.27	kNm
Mz,Rk	54.52	kNm
My,Ed	-8.12	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	1689.91	kNm
reduced slenderness 0	0.26	
Cmy,0	0.782	
Cmz,0	1.009	
Cmy	0.848	
Cmz	1.009	
CmLT	1.000	
muy	0.632	
muz	0.998	
wy	1.132	
wz	1.500	
npl	0.436	
aLT	0.989	
bLT	0.000	
cLT	0.011	
dLT	0.000	
eLT	0.343	
Cyy	0.976	
Cyz	0.915	
Czy	0.723	
Czz	0.797	

Unity check (6.61) = 0.84 + 0.09 + 0.00 = 0.92
Unity check (6.62) = 0.46 + 0.10 + 0.00 = 0.55

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	
hw t	17.882

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

EN 1993-1-1 Code Check

Member B30	HEA400	S 235	NC1	0.24

Basic data EC3 : EN 1993	
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		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 27.09 on position 0.000 m

ratio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	52.90

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 6.18 on position 0.000 m

ratio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
NEd	-413.18	kN
Vy,Ed	0.00	kN
Vz,Ed	12.80	kN
TEd	0.00	kNm
My,Ed	-35.72	kNm
Mz,Ed	0.00	kNm

Compression check

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

Table of values		
Nc.Rd	3736.50	kN
Unity check	0.11	-

Shear check (Vz)

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

Table of values		
Vc,Rd	778.11	kN
Unity check	0.02	-

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* *St		
Mc,Rd	601.60	kNm
Unity check	0.06	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
MNVy.Rd	601.60	kNm
MNVz.Rd	205.39	kNm

alfa 2.00 beta 1.00
Unity check 0.06 -
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* *Stu			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	2.02	1.00	
Buckling length Lcr	14.576	7.200	m
Critical Euler load Ncr	4399.67	3422.38	kN
Slenderness	86.55	98.13	
Relative slenderness Lambda	0.92	1.04	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	b	
Imperfection Alpha	0.21	0.34	
Reduction factor Chi	0.72	0.57	
Buckling resistance Nb,Rd	2688.78	2125.41	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	1.5900e-02	m^2
Buckling resistance Nb,Rd	2125.41	kN
Unity check	0.19	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	2.5600e-03	m^3
Elastic critical moment Mcr	1680.41	kNm
Relative slenderness Lambda,LT	0.60	
Limit slenderness Lambda,LT,0	0.40	

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	1.081	
kyz	0.832	
kzy	0.582	
kzz	1.136	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.5900e-02	m^2
Wy	2.5600e-03	m^3
Wz	8.7400e-04	m^3
NRk	3736.50	kN
My,Rk	601.60	kNm
Mz,Rk	205.39	kNm
My,Ed	44.48	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	962.60	kNm
reduced slenderness 0	0.79	
Cmy,0	0.946	
Cmz,0	1.029	
Cmy	0.971	
Cmz	1.029	
CmLT	1.027	
Student version *Student version* *Student version* *Student version*		

Table of values		
Student version *Student version* *Student version* *Student version*		
muy	0.972	
muz	0.944	
wy	1.108	
wz	1.500	
npl	0.111	
aLT	0.996	
bLT	0.000	
cLT	0.077	
dLT	0.000	
eLT	0.079	
Cyy	0.989	
Cyz	0.954	
Czy	0.921	
Czz	0.973	

Unity check (6.61) = 0.15 + 0.08 + 0.00 = 0.23
Unity check (6.62) = 0.19 + 0.04 + 0.00 = 0.24

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	32.000

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

EN 1993-1-1 Code Check

Member B108	**HEA180**	**S 235**	**NC1**	**0.57**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 20.33 on position 11.266 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.38

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 7.58 on position 11.266 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 12.518 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-384.87	kN
Vy,Ed	0.00	kN
Vz,Ed	-6.12	kN
TEd	0.00	kNm
My,Ed	-8.12	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1064.55	kN
Unity check	0.36	-

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	197.00	kN
Unity check	0.03	-

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	76.14	kNm
Unity check	0.11	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	55.40	kNm
MNVz.Rd	35.79	kNm

alfa	2.00	beta	1.81
Unity check	0.15	-	

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* *Stu			
Sway type	sway	non-sway	
System Length L	1.252	2.504	m
Buckling factor k	3.77	1.00	
Buckling length Lcr	4.715	2.504	m
Critical Euler load Ncr	2340.01	3058.77	kN
Slenderness	63.34	55.40	
Relative slenderness Lambda	0.67	0.59	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.80	0.79	
Buckling resistance Nb,Rd	849.43	842.41	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	4.5300e-03	m^2
Buckling resistance Nb,Rd	842.41	kN
Unity check	0.46	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	3.2400e-04	m^3
Elastic critical moment Mcr	621.30	kNm
Relative slenderness Lambda,LT	0.35	
Limit slenderness Lambda,LT,0	0.40	

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	1.127
Student version *Student version* *Student version* *Student version*	

Table of values		
Student version *Student version* *Student version* *Student version*		
kyz	0.676	
kzy	0.633	
kzz	1.085	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	4.5300e-03	m^2
Wy	3.2400e-04	m^3
Wz	1.5600e-04	m^3
NRk	1064.55	kN
My,Rk	76.14	kNm
Mz,Rk	36.66	kNm
My,Ed	-8.12	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	312.47	kNm
reduced slenderness 0	0.49	
Cmy,0	0.942	
Cmz,0	1.030	
Cmy	0.963	
Cmz	1.030	
CmLT	1.034	
muy	0.962	
muz	0.971	
wy	1.102	
wz	1.500	
npl	0.362	
aLT	0.994	
bLT	0.000	
cLT	0.052	
dLT	0.000	
eLT	0.418	
Cyy	1.018	
Cyz	1.174	
Czy	0.940	
Czz	1.055	

Unity check (6.61) = 0.45 + 0.12 + 0.00 = 0.57
Unity check (6.62) = 0.46 + 0.07 + 0.00 = 0.52

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	25.333

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

EN 1993-1-1 Code Check

Member B116	HEA200	S 235	NC1	0.87

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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* *Stu		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 20.62 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	46.36

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 7.88 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-176.98	kN
Vy,Ed	0.00	kN
Vz,Ed	2.81	kN
TEd	0.00	kNm
My,Ed	3.01	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1264.30	kN
Unity check	0.14	-

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	244.90	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* *St		
Mc,Rd	101.05	kNm
Unity check	0.03	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	99.69	kNm
MNVz.Rd	47.94	kNm

alfa 2.00 beta 1.00

Unity check 0.03 -

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* *St			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	2.02	1.00	
Buckling length Lcr	14.576	7.200	m
Critical Euler load Ncr	359.97	535.75	kN
Slenderness	176.00	144.27	
Relative slenderness Lambda	1.87	1.54	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.23	0.30	
Buckling resistance Nb,Rd	297.05	383.19	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	5.3800e-03	m^2
Buckling resistance Nb,Rd	297.05	kN
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Unity check	0.60	-

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

LTB Parameters		
Method for LTB curve	Art. 6.3.2.2.	
Wy	4.3000e-04	m^3
Elastic critical moment Mcr	200.79	kNm
Relative slenderness Lambda,LT	0.71	
Limit slenderness Lambda,LT,0	0.40	

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		
kyy	1.071	
kyz	1.339	
kzy	0.982	
kzz	1.803	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	5.3800e-03	m^2
Wy	4.3000e-04	m^3
Wz	2.0400e-04	m^3
NRk	1264.30	kN
My,Rk	101.05	kNm
Mz,Rk	47.94	kNm
My,Ed	-25.84	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	106.80	kNm
reduced slenderness 0	0.97	
Cmy,0	0.732	
Cmz,0	1.080	
Cmy	0.889	
Cmz	1.080	
CmLT	1.000	
muy	0.575	
muz	0.744	
wy	1.105	
wz	1.500	
npl	0.140	
aLT	0.994	
bLT	0.000	
cLT	0.256	
dLT	0.000	
eLT	0.083	
Cyy	0.939	
Cyz	0.484	
Czy	0.682	
Czz	0.665	

Unity check (6.61) = 0.60 + 0.27 + 0.00 = 0.87
Unity check (6.62) = 0.46 + 0.25 + 0.00 = 0.71

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	
hw t	26.154

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

Priloga 4: Dimenzioniranje primarnega okvirja – smer Y

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B1	HEA160	S 235	NC2	0.49

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 17.33 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 6.89 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1

The critical check is on position 2.067 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-41.64	kN
Vy,Ed	0.00	kN
Vz,Ed	1.23	kN
TEd	0.00	kNm
My,Ed	9.10	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	911.80	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* *		
Vc,Rd	179.64	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	57.81	kNm
Unity check	0.16	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	57.81	kNm
MNVz.Rd	27.73	kNm

alfa 2.00 beta 1.00
Unity check 0.16 -

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* *St			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	7.200	7.200	m
Critical Euler load Ncr	667.68	246.28	kN
Slenderness	109.75	180.70	
Relative slenderness Lambda	1.17	1.92	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.50	0.21	
Buckling resistance Nb,Rd	451.76	191.11	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	3.8800e-03	m^2
Buckling resistance Nb,Rd	191.11	kN
Unity check	0.22	-

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	2.4600e-04	m^3
Elastic critical moment Mcr	52.32	kNm
Relative slenderness Lambda,LT	1.05	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	a	
Imperfection Alpha,LT	0.21	
Reduction factor Chi,LT	0.63	
Buckling resistance Mb.Rd	36.41	kNm
Unity check	0.25	-

Mcr Parameters		
Student version *Student version* *Student version*		
LTB length	7.200	m
k	1.00	
kw	1.00	
C1	1.00	
C2	0.00	
C3	1.00	

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	1.192	
kyz	1.079	
kzy	0.626	
kzz	1.204	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	3.8800e-03	m^2
Wy	2.4600e-04	m^3
Wz	1.1800e-04	m^3
NRk	911.80	kN
My,Rk	57.81	kNm
Mz,Rk	27.73	kNm
My,Ed	-12.00	kNm
Mz,Ed	0.00	kNm
Student version *Student version* *Student version* *Student version*		

Table of values		
Student version *Student version* *Student version* *Student version*		
Interaction Method 1		
Mcr0	52.32	kNm
reduced slenderness 0	1.05	
Cmy,0	1.015	
Cmz,0	1.041	
Cmy	1.005	
Cmz	1.041	
CmLT	1.112	
muy	0.968	
muz	0.861	
wy	1.118	
wz	1.500	
npl	0.046	
aLT	0.993	
bLT	0.000	
cLT	0.192	
dLT	0.000	
eLT	0.042	
Cyy	0.967	
Cyz	0.781	
Czy	0.849	
Czz	0.896	

Unity check (6.61) = 0.09 + 0.39 + 0.00 = 0.49
Unity check (6.62) = 0.22 + 0.21 + 0.00 = 0.42

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	22.333

The web slenderness is such that the Shear Buckling Check is not re uired.

Element satisfies the stability check !

EN 1993-1-1 Code Check

EN 1993-1-1 Code Check

The critical check is on position 0.000 m

SECTION CHECK		
Student version *Student version* *Student version* *Student vers		
Compression check	0.01	1
Shear check (Vz)	0.14	1
Bending moment check (My)	0.61	1
M	0.61	1

STABILITY CHECK		
Student version *Student version* *Student version* *Stud		
LTB	0.68	1
Compression + Moment	0.70	1
Compression + Moment	0.37	1

Member B92	HEA450	S 235	Potres	0.70

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio 29.91 on position 0.000 m

ratio		
Student version *Student version* *Student version		
maximum ratio	1	68.33
maximum ratio	2	78.69
maximum ratio	3	119.19

==> Class cross-section 1

Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).

ratio 5.58 on position 0.000 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-42.22	kN
Vy,Ed	0.00	kN
Vz,Ed	127.46	kN
TEd	0.00	kNm
My,Ed	-459.77	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	4183.00	kN
Unity check	0.01	-

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	892.15	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.

Table of values		
Student version *Student version* *Student version* *St		
Mc,Rd	756.70	kNm
Unity check	0.61	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *St		
MNVy.Rd	756.70	kNm
MNVz.Rd	227.01	kNm

alfa 2.00 beta 1.00

Unity check 0.61 -

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* *Stu			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	2.02	1.00	
Buckling length Lcr	14.576	7.200	m
Critical Euler load Ncr	6214.17	3786.20	kN
Slenderness	77.05	98.71	
Relative slenderness Lambda	0.82	1.05	
Limit slenderness Lambda,0	0.20	0.20	

The slenderness or compression force is such that lexural 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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	3.2200e-03	m^3
Elastic critical moment Mcr	2123.68	kNm
Relative slenderness Lambda,LT	0.60	
Limit slenderness Lambda,LT,0	0.40	
LTB curve	a	
Imperfection Alpha,LT	0.21	
Reduction factor Chi,LT	0.89	
Buckling resistance Mb.Rd	674.34	kNm
Unity check	0.68	-

Mcr Parameters		
Student version *Student version* *Student version*		
LTB length	7.200	m
k	1.00	
kw	1.00	
C1	1.81	
C2	0.31	
C3	2.64	

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	1.010	
kyz	1.092	
kzy	0.525	
kzz	1.019	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.7800e-02	m^2
Wy	3.2200e-03	m^3
Wz	9.6600e-04	m^3
NRk	4183.00	kN
My,Rk	756.70	kNm
Mz,Rk	227.01	kNm
My,Ed	-459.77	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	1173.80	kNm
reduced slenderness 0	0.80	
Cmy,0	0.994	
Cmz,0	1.003	
Cmy	0.999	
Cmz	1.003	
CmLT	1.003	
muy	1.000	
muz	1.000	
wy	1.110	
wz	1.500	
npl	0.010	
aLT	0.996	
bLT	0.000	
cLT	0.704	
dLT	0.000	
eLT	0.702	
Cyy	0.999	
Cyz	0.648	
Czy	0.992	
Czz	0.995	

Unity check (6.61) = 0.01 + 0.69 + 0.00 = 0.70

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

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	34.609

The web slenderness is such that the Shear Buckling Check is not re uired.

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B48	**QRO40X5**	**S 235**	**NC1**	**0.09**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Stude	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 5.00 on position 0.000 m

ratio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
NEd	-11.64	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Compression check

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

Table of values		
Nc.Rd	159.33	kN
Unity check	0.07	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
MNVy.Rd	2.08	kNm
MNVz.Rd	2.08	kNm

alfa 1.67 beta 1.67
Unity check 0.00 -

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	
Sway type	sway	non-sway	
System Length L	1.000	1.000	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	1.000	1.000	m
Critical Euler load Ncr	286.02	286.02	kN
Slenderness	70.09	70.09	
Relative slenderness Lambda	0.75	0.75	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.82	0.82	
Buckling resistance Nb,Rd	131.43	131.43	kN

Table of values		
A	6.7800e-04	m^2
Buckling resistance Nb,Rd	131.43	kN
Unity check	0.09	-

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B18	QRO50X5	S 235	Potres	0.61

Basic data EC3 : EN 1993	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 7.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 1.601 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-88.52	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.06	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	206.57	kN
Unity check	0.43	-

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	59.63	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	2.52	kNm
MNVz.Rd	2.52	kNm

alfa 2.09 beta 2.09
Unity check 0.00 -

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* *St			
Sway type	sway	non-sway	
System Length L	1.601	1.601	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	1.601	1.601	m
Critical Euler load Ncr	238.60	238.60	kN
Slenderness	87.38	87.38	
Relative slenderness Lambda	0.93	0.93	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.71	0.71	
Buckling resistance Nb,Rd	147.41	147.41	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	8.7900e-04	m^2
Buckling resistance Nb,Rd	147.41	kN
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
Unity check	0.60	-

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	1.429	
kyz	1.255	
kzy	1.060	
kzz	1.607	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	8.7900e-04	m^2
Wy	1.4737e-05	m^3
Wz	1.4737e-05	m^3
NRk	206.57	kN
My,Rk	3.46	kNm
Mz,Rk	3.46	kNm
My,Ed	0.03	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	94.69	kNm
reduced slenderness 0	0.19	
Cmy,0	1.011	
Cmz,0	1.089	
Cmy	1.011	
Cmz	1.089	
CmLT	1.000	
muy	0.856	
muz	0.856	
wy	1.249	
wz	1.249	
npl	0.429	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.962	
Cyz	0.708	
Czy	0.778	
Czz	0.922	

Unity check (6.61) = 0.60 + 0.01 + 0.00 = 0.61
Unity check (6.62) = 0.60 + 0.01 + 0.00 = 0.61
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B23	HEB180	S 235	Potres	0.86

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

...::SECTION CHECK::...
Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 14.35 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 5.05 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1

The critical check is on position 1.250 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-336.54	kN
Vy,Ed	0.00	kN
Vz,Ed	1.09	kN
TEd	0.00	kNm
My,Ed	3.67	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1533.38	kN
Unity check	0.22	-

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	274.61	kN
Unity check	0.00	-

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* *St		
Mc,Rd	113.27	kNm
Unity check	0.03	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	99.76	kNm
MNVz.Rd	54.52	kNm

alfa	2.00	beta	1.10
Unity check	0.04	-	

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* *St			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	10.00	1.00	
Buckling length Lcr	12.500	2.500	m
Critical Euler load Ncr	508.17	4519.96	kN
Slenderness	163.13	54.70	
Relative slenderness Lambda	1.74	0.58	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.27	0.80	
Buckling resistance Nb,Rd	410.94	1220.17	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.5250e-03	m^2
Buckling resistance Nb,Rd	410.94	kN
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
Unity check	0.82	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	4.8200e-04	m^3
Elastic critical moment Mcr	838.45	kNm
Relative slenderness Lambda,LT	0.37	
Limit slenderness Lambda,LT,0	0.40	

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	1.271	
kyz	0.538	
kzy	2.891	
kzz	1.658	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.5250e-03	m^2
Wy	4.8200e-04	m^3
Wz	2.3200e-04	m^3
NRk	1533.38	kN
My,Rk	113.27	kNm
Mz,Rk	54.52	kNm
My,Ed	3.67	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	542.98	kNm
reduced slenderness 0	0.46	
Cmy,0	0.901	
Cmz,0	1.018	
Cmy	0.930	
Cmz	1.018	
CmLT	1.000	
muy	0.411	
muz	0.984	
wy	1.132	
wz	1.500	
npl	0.219	
aLT	0.989	
bLT	0.000	
cLT	0.014	
dLT	0.000	
eLT	0.124	
Cyy	0.889	
Cyz	0.580	
Czy	0.488	
Czz	0.653	

Unity check (6.61) = 0.82 + 0.04 + 0.00 = 0.86
Unity check (6.62) = 0.28 + 0.09 + 0.00 = 0.37
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	17.882

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

EN 1993-1-1 Code Check

Member B79	HEB160	S 235	Potres	0.87

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 13.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.41

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 4.69 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-396.16	kN
Vy,Ed	0.00	kN
Vz,Ed	-0.14	kN
TEd	0.00	kNm
My,Ed	0.52	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1274.88	kN
Unity check	0.31	-

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	238.66	kN
Unity check	0.00	-

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	83.19	kNm
Unity check	0.01	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	64.91	kNm
MNVz.Rd	39.54	kNm

alfa 2.00 beta 1.55
Unity check 0.01 -
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* *St			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	7.40	1.00	
Buckling length Lcr	9.249	2.500	m
Critical Euler load Ncr	603.72	2948.75	kN
Slenderness	136.47	61.75	
Relative slenderness Lambda	1.45	0.66	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.36	0.75	
Buckling resistance Nb,Rd	459.00	957.16	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	5.4250e-03	m^2
Buckling resistance Nb,Rd	459.00	kN
Unity check	0.86	-

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 versior		
Method for LTB curve	Art. 6.3.2.2.	
Wy	3.5400e-04	m^3
Elastic critical moment Mcr	633.07	kNm
Relative slenderness Lambda,LT	0.36	
Limit slenderness Lambda,LT,0	0.40	

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	1.320	
kyz	0.557	
kzy	2.515	
kzz	1.694	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	5.4250e-03	m^2
Wy	3.5400e-04	m^3
Wz	1.7000e-04	m^3
NRk	1274.88	kN
My,Rk	83.19	kNm
Mz,Rk	39.95	kNm
My,Ed	0.52	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	348.45	kNm
reduced slenderness 0	0.49	
Cmy,0	0.902	
Cmz,0	1.032	
Cmy	0.914	
Cmz	1.032	
CmLT	1.000	
muy	0.450	
muz	0.963	
wy	1.136	
wz	1.500	
npl	0.311	
aLT	0.987	
bLT	0.000	
cLT	0.003	
dLT	0.000	
eLT	0.020	
Cyy	0.907	
Cyz	0.664	
Czy	0.532	
Czz	0.678	

Unity check (6.61) = 0.86 + 0.01 + 0.00 = 0.87
Unity check (6.62) = 0.41 + 0.02 + 0.00 = 0.43

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	16.750

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

EN 1993-1-1 Code Check

Member B76	HEA180	S 235	Potres	0.48

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 20.33 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	45.19

==> Class cross-section 1

Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 7.58 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-336.53	kN
Vy,Ed	0.00	kN
Vz,Ed	-1.88	kN
TEd	0.00	kNm
My,Ed	3.67	kNm
Mz,Ed	0.00	kNm

Compression check

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1064.55	kN
Unity check	0.32	-

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	197.00	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	76.14	kNm
Unity check	0.05	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	59.34	kNm
MNVz.Rd	36.33	kNm

alfa	2.00	beta	1.58
Unity check	0.06	-	

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* *Stu			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	4.33	1.00	
Buckling length Lcr	5.412	2.500	m
Critical Euler load Ncr	1776.21	3067.47	kN
Slenderness	72.70	55.32	
Relative slenderness Lambda	0.77	0.59	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.74	0.79	
Buckling resistance Nb,Rd	788.03	842.94	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	4.5300e-03	m^2
Buckling resistance Nb,Rd	788.03	kN
Unity check	0.43	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	3.2400e-04	m^3
Elastic critical moment Mcr	483.62	kNm
Relative slenderness Lambda,LT	0.40	
Limit slenderness Lambda,LT,0	0.40	

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	1.115	
kyz	0.679	
kzy	0.654	
kzz	1.079	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	4.5300e-03	m^2
Wy	3.2400e-04	m^3
Wz	1.5600e-04	m^3
NRk	1064.55	kN
My,Rk	76.14	kNm
Mz,Rk	36.66	kNm
My,Ed	3.67	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	313.19	kNm
reduced slenderness 0	0.49	
Cmy,0	0.940	
Cmz,0	1.026	
Cmy	0.957	
Cmz	1.026	
CmLT	1.007	
Student version *Student version* *Student version* *Student version*		

Table of values		
Student version *Student version* *Student version* *Student version*		
muy	0.943	
muz	0.975	
wy	1.102	
wz	1.500	
npl	0.316	
aLT	0.994	
bLT	0.000	
cLT	0.024	
dLT	0.000	
eLT	0.190	
Cyy	1.006	
Cyz	1.120	
Czy	0.912	
Czz	1.042	

Unity check (6.61) = 0.43 + 0.05 + 0.00 = 0.48
Unity check (6.62) = 0.40 + 0.03 + 0.00 = 0.43

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	25.333

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

EN 1993-1-1 Code Check

Member B77	**HEA160**	**S 235**	**Potres**	**0.40**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 17.33 on position 6.250 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	44.64

==> Class cross-section 1

Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 6.89 on position 6.250 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	13.77

==> Class cross-section 1

The critical check is on position 6.250 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-260.64	kN
Vy,Ed	0.00	kN
Vz,Ed	2.24	kN
TEd	0.00	kNm
My,Ed	-2.13	kNm
Mz,Ed	0.00	kNm

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

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	911.80	kN
Unity check	0.29	-

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	179.64	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	57.81	kNm
Unity check	0.04	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	47.39	kNm
MNVz.Rd	27.69	kNm

alfa	2.00	beta	1.43
Unity check	0.04	-	

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* *Stu			
Sway type	sway	non-sway	
System Length L	1.250	2.500	m
Buckling factor k	3.11	1.00	
Buckling length Lcr	3.883	2.500	m
Critical Euler load Ncr	2295.97	2042.77	kN
Slenderness	59.18	62.74	
Relative slenderness Lambda	0.63	0.67	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.82	0.74	
Buckling resistance Nb,Rd	749.16	678.68	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	3.8800e-03	m^2
Buckling resistance Nb,Rd	678.68	kN
Unity check	0.38	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	2.4600e-04	m^3
Elastic critical moment Mcr	369.97	kNm
Relative slenderness Lambda,LT	0.40	
Limit slenderness Lambda,LT,0	0.40	

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	1.042	
Student version *Student version* *Student version* *Student version*		

Table of values		
Student version *Student version* *Student version* *Student version*		
kyz	0.698	
kzy	0.566	
kzz	1.046	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	3.8800e-03	m^2
Wy	2.4600e-04	m^3
Wz	1.1800e-04	m^3
NRk	911.80	kN
My,Rk	57.81	kNm
Mz,Rk	27.73	kNm
My,Ed	-2.13	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	203.63	kNm
reduced slenderness 0	0.53	
Cmy,0	0.938	
Cmz,0	1.031	
Cmy	0.955	
Cmz	1.031	
CmLT	1.008	
muy	0.978	
muz	0.964	
wy	1.118	
wz	1.500	
npl	0.286	
aLT	0.993	
bLT	0.000	
cLT	0.021	
dLT	0.000	
eLT	0.116	
Cyy	1.018	
Cyz	1.150	
Czy	0.957	
Czz	1.089	

Unity check (6.61) = 0.35 + 0.04 + 0.00 = 0.39
Unity check (6.62) = 0.38 + 0.02 + 0.00 = 0.40

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	22.333

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

Priloga 5: Dimenzioniranje okvirja s centričnim povezjem – smer X

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B2	HEA160	S 235	NC4	0.83

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 17.33 on position 0.000 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 6.89 on position 0.000 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-142.98	kN
Vy,Ed	-0.07	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	911.80	kN
Unity check	0.16	-

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	417.34	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	55.96	kNm
MNVz.Rd	27.73	kNm

alfa 2.00 beta 1.00
Unity check 0.00 -

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	
Sway type	sway	non-sway	
System Length L	7.600	7.600	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	7.600	7.600	m
Critical Euler load Ncr	599.25	221.04	kN
Slenderness	115.84	190.74	
Relative slenderness Lambda	1.23	2.03	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.46	0.19	
Buckling resistance Nb,Rd	419.68	174.20	kN

Table of values		
A	3.8800e-03	m^2
Buckling resistance Nb,Rd	174.20	kN
Unity check	0.82	-

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		
kyy	2.583	
kyz	2.151	
kzy	1.217	
kzz	1.336	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	3.8800e-03	m^2
Wy	2.4600e-04	m^3
Wz	1.1800e-04	m^3
NRk	911.80	kN
My,Rk	57.81	kNm
Mz,Rk	27.73	kNm
My,Ed	0.00	kNm
Mz,Ed	-0.22	kNm
Interaction Method 1		
Mcr0	49.27	kNm
reduced slenderness 0	1.08	
Cmy,0	1.058	
Cmz,0	0.884	
Cmy	1.058	
Cmz	0.884	
CmLT	1.944	
muy	0.855	
muz	0.403	
wy	1.118	
wz	1.500	
npl	0.157	
aLT	0.993	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.894	
Cyz	0.691	
Czy	0.463	
Czz	0.755	

Unity check (6.61) = 0.34 + 0.00 + 0.02 = 0.36

Unity check (6.62) = 0.82 + 0.00 + 0.01 = 0.83

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B3	**QRO70X5**	**S 235**	**NC4**	**0.61**

Basic data EC3 : EN 1993	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 11.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-60.10	kN
Vy,Ed	0.00	kN
Vz,Ed	0.31	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	300.80	kN
Unity check	0.20	-

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	86.83	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	7.29	kNm
MNVz.Rd	7.29	kNm

alfa 1.74 beta 1.74
Unity check 0.00 -
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* *St			
Sway type	sway	non-sway	
System Length L	3.755	3.755	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	3.755	3.755	m
Critical Euler load Ncr	131.68	131.68	kN
Slenderness	141.94	141.94	
Relative slenderness Lambda	1.51	1.51	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.37	0.37	
Buckling resistance Nb,Rd	110.60	110.60	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	1.2800e-03	m^2
Buckling resistance Nb,Rd	110.60	kN
Student version *Student version* *Student version* *Student version* *Stu		

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
Unity check	0.54	-

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	1.405	
kyz	1.616	
kzy	1.323	
kzz	1.616	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.2800e-03	m^2
Wy	3.1023e-05	m^3
Wz	3.1023e-05	m^3
NRk	300.80	kN
My,Rk	7.29	kNm
Mz,Rk	7.29	kNm
My,Ed	0.32	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	121.64	kNm
reduced slenderness 0	0.24	
Cmy,0	1.014	
Cmz,0	1.110	
Cmy	1.014	
Cmz	1.110	
CmLT	1.000	
muy	0.653	
muz	0.653	
wy	1.212	
wz	1.212	
npl	0.200	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.867	
Cyz	0.495	
Czy	0.552	
Czz	0.825	

Unity check (6.61) = 0.54 + 0.06 + 0.00 = 0.61
Unity check (6.62) = 0.54 + 0.06 + 0.00 = 0.60
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B5	RD22	S 235	NC4	0.94

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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 5.198 m

Internal forces		
Student version *Student version* *Student version*		
NEd	83.59	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version*		
Nt.Rd	89.29	kN
Unity check	0.94	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-220.0	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro 0.00 place 20
Unity check 0.94 -

Element satisfies the section check !

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

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B6	RD22	S 235	NC4	0.98

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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 5.483 m

Internal forces		
Student version *Student version* *Student version*		
NEd	87.88	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version*		
Nt.Rd	89.29	kN
Unity check	0.98	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-231.3	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro 0.00 place 20
Unity check 0.98 -

Element satisfies the section check !

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

Priloga 6: Dimenzioniranje okvirja s centričnim povezjem – smer Y

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : All
Class : MSN

EN 1993-1-1 Code Check

Member B1	HEA200	S 235	NC1	0.08

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

...::SECTION CHECK::...
Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 20.62 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 7.88 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1
The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-28.64	kN
Vy,Ed	0.05	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1264.30	kN
Unity check	0.02	-

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	580.02	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *S		
MNVy.Rd	101.05	kNm
MNVz.Rd	47.94	kNm

alfa 2.00 beta 1.00
Unity check 0.00 -

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* *Stu			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	7.200	7.200	m
Critical Euler load Ncr	1475.30	535.75	kN
Slenderness	86.94	144.27	
Relative slenderness Lambda	0.93	1.54	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.64	0.30	
Buckling resistance Nb,Rd	814.99	383.19	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	5.3800e-03	m^2
Buckling resistance Nb,Rd	383.19	kN
Unity check	0.07	-

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	1.066	
kyz	0.745	
kzy	0.551	
kzz	1.031	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	5.3800e-03	m^2
Wy	4.3000e-04	m^3
Wz	2.0400e-04	m^3
NRk	1264.30	kN
My,Rk	101.05	kNm
Mz,Rk	47.94	kNm
My,Ed	0.00	kNm
Mz,Ed	0.16	kNm
Interaction Method 1		
Mcr0	106.80	kNm
reduced slenderness 0	0.97	
Cmy,0	1.005	
Cmz,0	0.990	
Cmy	1.005	
Cmz	0.990	
CmLT	1.038	
muy	0.993	
muz	0.962	
wy	1.105	
wz	1.500	
npl	0.023	
aLT	0.994	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.991	
Cyz	0.974	
Czy	0.957	
Czz	0.976	

Unity check (6.61) = 0.04 + 0.00 + 0.00 = 0.04

Unity check (6.62) = 0.07 + 0.00 + 0.00 = 0.08

Element satisfies the stability check !

EN 1993-1-1 Code Check

EN 1993-1-1 Code Check

The critical check is on position 0.000 m

SECTION CHECK		
Student version *Student version* *Student version		
Compression check	0.16	1
Shear check (Vy)	0.00	1

STABILITY CHECK		
Student version *Student version* *Student version* *Stud		
Buckling	0.54	1
Compression + Moment	0.27	1
Compression + Moment	0.55	1

Member B2	HEA200	S 235	Potres	0.55

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

...::SECTION CHECK::...
Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 20.62 on position 0.000 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 7.88 on position 0.000 m

ratio		
Student version *Student version* *Student versic		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1
The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-205.26	kN
Vy,Ed	-0.20	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *St		
Nc.Rd	1264.30	kN
Unity check	0.16	-

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	580.02	kN
Unity check	0.00	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	97.10	kNm
MNVz.Rd	47.94	kNm

alfa 2.00 beta 1.00
Unity check 0.00 -
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* *Stu			
Sway type	sway	non-sway	
System Length L	7.200	7.200	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	7.200	7.200	m
Critical Euler load Ncr	1475.30	535.75	kN
Slenderness	86.94	144.27	
Relative slenderness Lambda	0.93	1.54	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.64	0.30	
Buckling resistance Nb,Rd	814.99	383.19	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	5.3800e-03	m^2
Buckling resistance Nb,Rd	383.19	kN
Unity check	0.54	-

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	1.729	
kyz	1.165	
kzy	0.916	
kzz	1.211	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	5.3800e-03	m^2
Wy	4.3000e-04	m^3
Wz	2.0400e-04	m^3
NRk	1264.30	kN
My,Rk	101.05	kNm
Mz,Rk	47.94	kNm
My,Ed	0.00	kNm
Mz,Ed	-0.63	kNm
Interaction Method 1		
Mcr0	106.80	kNm
reduced slenderness 0	0.97	
Cmy,0	1.034	
Cmz,0	0.931	
Cmy	1.034	
Cmz	0.931	
CmLT	1.418	
muy	0.946	
muz	0.698	
wy	1.105	
wz	1.500	
npl	0.162	
aLT	0.994	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.931	
Cyz	0.856	
Czy	0.668	
Czz	0.870	

Unity check (6.61) = 0.25 + 0.00 + 0.02 = 0.27
Unity check (6.62) = 0.54 + 0.00 + 0.02 = 0.55
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member	HEA140	S	Potres	0.68
B3		235		

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Stude	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 16.73 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1
Width-to-thickness ratio for outstand flanges (EN 1993-1-1 : Tab.5.2. sheet 2).
ratio 6.50 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	9.00
maximum ratio	2	10.00
maximum ratio	3	14.00

==> Class cross-section 1

The critical check is on position 2.500 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-130.04	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	5.18	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	737.90	kN
Unity check	0.18	-

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	40.89	kNm
Unity check	0.13	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	38.32	kNm
MNVz.Rd	19.93	kNm

alfa 2.00 beta 1.00
Unity check 0.14 -
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* *St			
Sway type	sway	non-sway	
System Length L	5.000	5.000	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	5.000	5.000	m
Critical Euler load Ncr	853.92	322.50	kN
Slenderness	87.30	142.06	
Student version *Student version* *Student version* *Student version* *Student version* *St			

Buckling parameters	yy	zz	
Student version *Student version* *Student version* *Student version* *Student version* *St			
Relative slenderness Lambda	0.93	1.51	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	b	c	
Imperfection Alpha	0.34	0.49	
Reduction factor Chi	0.64	0.31	
Buckling resistance Nb,Rd	473.83	229.10	kN

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	3.1400e-03	m^2
Buckling resistance Nb,Rd	229.10	kN
Unity check	0.57	-

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 versio		
Method for LTB curve	Art. 6.3.2.2.	
Wy	1.7400e-04	m^3
Elastic critical moment Mcr	56.74	kNm
Relative slenderness Lambda,LT	0.85	
Limit slenderness Lambda,LT,0	0.40	

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	1.611	
kyz	1.765	
kzy	0.860	
kzz	1.688	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	3.1400e-03	m^2
Wy	1.7400e-04	m^3
Wz	8.4800e-05	m^3
NRk	737.90	kN
My,Rk	40.89	kNm
Mz,Rk	19.93	kNm
My,Ed	5.18	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	50.21	kNm
reduced slenderness 0	0.90	
Cmy,0	1.005	
Cmz,0	1.097	
Cmy	1.002	
Cmz	1.097	
CmLT	1.342	
muy	0.940	
muz	0.682	
wy	1.123	
wz	1.500	
npl	0.176	
aLT	0.992	
bLT	0.000	
cLT	0.100	
dLT	0.000	
eLT	0.036	
Cyy	0.926	
Cyz	0.679	
Czy	0.653	
Czz	0.743	

Unity check (6.61) = 0.27 + 0.20 + 0.00 = 0.48
Unity check (6.62) = 0.57 + 0.11 + 0.00 = 0.68
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B4	QRO100X5	S 235	Potres	0.79

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

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
partial safety factor Gamma M2 for resistance of net sections	1.25

Material data		
Student version *Student version* *Student version* *Stu		
yield strength fy	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio 17.00 on position 0.000 m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 2.500 m

Internal forces		
Student version *Student version* *Student version* *S		
NEd	-129.87	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	1.04	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	441.80	kN
Unity check	0.29	-

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	15.67	kNm
Unity check	0.07	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
MNVy.Rd	14.45	kNm
MNVz.Rd	14.45	kNm

alfa 1.84 beta 1.84

Unity check 0.07 -

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* *St			
Sway type	sway	non-sway	
System Length L	5.000	5.000	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	5.000	5.000	m
Critical Euler load Ncr	232.96	232.96	kN
Slenderness	129.33	129.33	
Relative slenderness Lambda	1.38	1.38	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.43	0.43	
Buckling resistance Nb,Rd	189.65	189.65	kN

Table of values		
A	1.8800e-03	m^2
Buckling resistance Nb,Rd	189.65	kN
Unity check	0.68	-

Lateral Torsional Buckling Check

Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.

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		
kyy	1.553	
kyz	1.767	
kzy	1.584	
kzz	1.767	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	1.8800e-03	m^2
Wy	6.6701e-05	m^3
Wz	6.6701e-05	m^3
NRk	441.80	kN
My,Rk	15.67	kNm
Mz,Rk	15.67	kNm
My,Ed	1.04	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	285.57	kNm
reduced slenderness 0	0.23	
Cmy,0	1.017	
Cmz,0	1.134	
Cmy	1.017	
Cmz	1.134	
CmLT	1.000	
muy	0.582	
muz	0.582	
wy	1.185	
wz	1.185	
npl	0.294	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.860	
Cyz	0.506	
Czy	0.506	
Czz	0.844	

Unity check (6.61) = 0.68 + 0.10 + 0.00 = 0.79
Unity check (6.62) = 0.68 + 0.11 + 0.00 = 0.79
Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B5	RD30	S 235	Potres	0.97

Basic data EC3 : EN 1993	
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		
yield strength fy	235.0	MPa
tension strength fu	360.0	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 6.161 m

Internal forces		
NEd	160.38	kN

Internal forces		
Student version *Student version* *Student version* *		
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version* *		
Nt.Rd	166.03	kN
Unity check	0.97	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-227.0	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.97	-	

Element satisfies the section check !
...::STABILITY CHECK::...
Element satisfies the stability check !
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student versi
EN 1993-1-1 Code Check

Member B6	RD30	S 235	Potres	0.97

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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 6.161 m

Internal forces		
Student version *Student version* *Student version* *		
NEd	160.69	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version* *		
Nt.Rd	166.03	kN
Unity check	0.97	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-227.4	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.97	-	

Element satisfies the section check !

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

Element satisfies the stability check !

Priloga 7: Dimenzioniranje horizontalnega zavetrovanja – smer X (spodnji pas)

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : B8, B4, B12, B7, B13, B5, B11
Class : MSN

EN 1993-1-1 Code Check

Member B8	**RD10**	**S 235**	**NC1**	**0.71**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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*		
NEd	13.08	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check

According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version*		
Nt.Rd	18.45	kN
Unity check	0.71	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-166.7	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.71	-	

Element satisfies the section check !

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

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B7	**QRO40X5**	**S 235**	**NC1**	**0.90**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).

ratio	5.00	on position	0.000	m

ratio		
Student version *Student version* *Student versio		
maximum ratio	1	33.00
maximum ratio	2	38.00
maximum ratio	3	42.00

==> Class cross-section 1

The critical check is on position 0.000 m

Internal forces		
Student version *Student version* *Student version*		
NEd	-17.02	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Compression check

According to article EN 1993-1-1 : 6.2.4 and formula (6.9)

Section classification is 1.

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	159.33	kN
Unity check	0.11	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)

Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	2.08	kNm
MNVz.Rd	2.08	kNm

alfa 1.68 beta 1.68

Unity check 0.00 -

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* *St			
Sway type	sway	non-sway	
System Length L	3.750	3.750	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	3.750	3.750	m
Critical Euler load Ncr	20.34	20.34	kN
Slenderness	262.85	262.85	
Relative slenderness Lambda	2.80	2.80	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.12	0.12	
Buckling resistance Nb,Rd	18.85	18.85	kN

Warning: slenderness 262.85 is larger then 200.00 !

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.7800e-04	m^2
Buckling resistance Nb,Rd	18.85	kN
Unity check	0.90	-

Element satisfies the stability check !

Priloga 8: Dimenzioniranje horizontalnega zavetrovanja – smer X (zgornji pas)

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : B5, B11
Nonlinear combinations : NC1

EN 1993-1-1 Code Check

Member B5	**QRO40X5**	**S 235**	**NC1**	**0.27**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	MPa
fabrication	rolled	

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

Width-to-thickness ratio for internal compression parts (EN 1993-1-1 : Tab.5.2. sheet 1).
ratio 5.00 on position 0.025 m

ratio		
Student version *Student version* *Student version		
maximum ratio	1	72.22
maximum ratio	2	83.26
maximum ratio	3	124.00

==> Class cross-section 1

The critical check is on position 0.025 m

Internal forces		
Student version *Student version* *Student version		
NEd	-4.35	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.07	kNm
Mz,Ed	0.00	kNm

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

Table of values		
Student version *Student version* *Student version* *		
Nc.Rd	159.33	kN
Unity check	0.03	-

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	45.99	kN
Unity check	0.00	-

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	2.08	kNm
Unity check	0.04	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1 : 6.2.9.1. and formula (6.31)
Section classification is 1.

Table of values		
Student version *Student version* *Student version*		
MNVy.Rd	2.08	kNm
MNVz.Rd	2.08	kNm

alfa 1.66 beta 1.66
Unity check 0.04 -
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* *St			
Sway type	sway	non-sway	
System Length L	3.750	3.750	m
Buckling factor k	1.00	1.00	
Buckling length Lcr	3.750	3.750	m
Critical Euler load Ncr	20.34	20.34	kN
Slenderness	262.85	262.85	
Relative slenderness Lambda	2.80	2.80	
Limit slenderness Lambda,0	0.20	0.20	
Buckling curve	a	a	
Imperfection Alpha	0.21	0.21	
Reduction factor Chi	0.12	0.12	
Buckling resistance Nb,Rd	18.85	18.85	kN

Warning: slenderness 262.85 is larger then 200.00 !

Table of values		
Student version *Student version* *Student version* *Student version* *Stu		
A	6.7800e-04	m^2
Buckling resistance Nb,Rd	18.85	kN
Unity check	0.23	-

Lateral Torsional Buckling Check

Note: The cross-section concerns an R S section with h b 10 Lambda,red,z .
This section is thus not susceptible to Lateral Torsional Buckling.

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	1.195	
kyz	0.868	
kzy	0.868	
kzz	1.195	
Delta My	0.00	kNm
Delta Mz	0.00	kNm
A	6.7800e-04	m^2
Wy	8.8448e-06	m^3
Wz	8.8448e-06	m^3
NRk	159.33	kN
My,Rk	2.08	kNm
Mz,Rk	2.08	kNm
My,Ed	0.07	kNm
Mz,Ed	0.00	kNm
Interaction Method 1		
Mcr0	18.97	kNm
reduced slenderness 0	0.33	
Cmy,0	1.052	
Cmz,0	1.052	
Cmy	1.052	
Cmz	1.052	
CmLT	1.000	
muy	0.807	
muz	0.807	
wy	1.280	
wz	1.280	
npl	0.027	
aLT	0.000	
bLT	0.000	
cLT	0.000	
dLT	0.000	
eLT	0.000	
Cyy	0.903	
Cyz	0.745	
Czy	0.745	
Czz	0.903	

Unity check (6.61) = 0.23 + 0.04 + 0.00 = 0.27
Unity check (6.62) = 0.23 + 0.03 + 0.00 = 0.26

Element satisfies the stability check !

EN 1993-1-1 Code Check

Member B11	**RD8**	**S 235**	**NC1**	**0.44**

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
partial safety factor Gamma M0 for resistance of cross-sections	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	235.0	MPa
tension strength fu	360.0	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 versio		
NEd	5.24	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version*		
Nt.Rd	11.81	kN
Unity check	0.44	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-104.3	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.44	-	

Element satisfies the section check !

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

Element satisfies the stability check !

Priloga 9: Dimenzioniranje horizontalnega zavetrovanja – smer Y

Check of steel

Nonlinear calculation, Extreme : Cross-section
Selection : B14, B15, B16, B17
Nonlinear combinations : NC1

EN 1993-1-1 Code Check

Member B14	RD26	S 235	NC1	0.90

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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* *		
NEd	111.79	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check
According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version* *		
Nt.Rd	124.71	kN
Unity check	0.90	-

Combined bending, axial force and shear force check
According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-210.7	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.90	-	

Element satisfies the section check !
...::STABILITY CHECK::...
Element satisfies the stability check !
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *Student version* *
EN 1993-1-1 Code Check

Member B15	RD16	S 235	NC1	0.79

Basic data EC3 : EN 1993	
Student version *Student version* *Student version* *Student version* *Student version* *Student version* *Stu	
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	235.0	MPa
tension strength fu	360.0	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*		
NEd	37.12	kN
Vy,Ed	0.00	kN
Vz,Ed	0.00	kN
TEd	0.00	kNm
My,Ed	0.00	kNm
Mz,Ed	0.00	kNm

Normal force check

According to article EN 1993-1-1 : 6.2.3. and formula (6.5)

Table of values		
Student version *Student version* *Student version*		
Nt.Rd	47.23	kN
Unity check	0.79	-

Combined bending, axial force and shear force check

According to article EN 1993-1-1: 6.2.9.2.& 6.2.10 and formula (6.42)
Section classification is 3.

Table of values		
Student version *Student version* *Student version* *S		
sigma N	-184.7	MPa
sigma Myy	0.0	MPa
sigma Mzz	0.0	MPa

ro	0.00	place	20
Unity check	0.79	-	

Element satisfies the section check !

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

Element satisfies the stability check !

Priloga 10: Dimenzioniranje točkovnega temelja T1 – drenirano stanje

Pad foundation check

Linear calculation, Extreme : Global
Selection : Sn6
Class : GE
Pad foundation check

EN 1997-1 Stability check

Sn6/N81	Temelji_1/1	0,98

...::Input & Loading::...

Design data

Design approach	1 (Combination 1)
Partial factor sets	M1 + R1
Gamma i	1,00
Gamma c	1,00
Gamma cu	1,00
Gamma u	1,00
Gamma gamma	1,00
Gamma R v	1,00
Gamma R h	1,00

Pad foundation data

Name	T1
Material	C25 30
Type	Prismatic
Cast condition	Insitu

Pad foundation geometry

A m	B m	h1 m	h2 m	h3 m	a m	b m	ex m	ey m
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Student version*	*Stud
3,800	3,800	1,400	0,800	0,050	1,400	1,400	0,000	0,000

Subsoil data

Name	Sub1	
Type	Drained	
Density	2050,0	kg m^3
i	18,76	deg
Sigma oc	0,0	MPa
c	0,0	MPa
cu	0,1	MPa

Backfill material

Density	1900,0	kg m^3
eight	0,000	m

Water table

Level	No influence

Loading

Reaction		Elimination factor	Loading		
Student version	*Student version*	*Student version*	*Student version*	*Student version*	*Student version* *
Rx	-190,79	1,00	x	-190,79	kN
Ry	0,00	1,00	y	0,00	kN
Rz	149,63	1,00	P	149,63	kN
Mx	0,00	1,00	Mx	0,00	kNm
My	-687,71	1,00	My	-687,71	kNm

...::ULS Stability Check::...

Determination of Effective Geometry
According to EN 1997-1 Annex D

Table of values		
Student version *Student version* *Student version* *Student version*	*Student version*	*Student vers
Weight of backfill material	189,70	kN
Weight of pad foundation	544,60	kN
Partial safety factor	1,00	
Design weight of pad foundation and backfill G	734,30	kN
gx	0,000	m
gy	0,000	m
px	0,000	m
Student version *Student version* *Student version* *Student version*	*Student version*	*Student vers

Table of values		
Student version *Student version* *Student version* *Student version* *Student version* *Student vers		
py	0,000	m
h	2,200	m
Design value of the vertical load Vd	883,93	kN
Design value of the horizontal load d	190,79	kN
Eccentricity ex	-1,253	m
Eccentricity ey	0,000	m
Effective foundation width B	1,294	m
Effective foundation length L	3,800	m
Effective foundation area A	4,918	m^2

Bearing Resistance Check
According to EN 1997-1 article 6.5.2.1 and Annex D

Table of values		
Student version *Student version* *Student version* *Student version* *Student version* *Student version*		
Bearing resistance factor N	5,66	
Bearing resistance factor Nc	13,73	
Bearing resistance factor N gamma	3,17	
Pad foundation base inclination factor b	1,00	
Pad foundation base inclination factor bc	1,00	
Pad foundation base inclination factor bgamma	1,00	
Shape factor s	1,11	
Shape factor sc	1,13	
Shape factor sgamma	0,90	
Angle theta	90,00	deg
Exponent mB	1,75	
Exponent mL	1,25	
Exponent m	1,75	
Load inclination factor i	0,73	
Load inclination factor ic	0,95	
Load inclination factor i gamma	0,60	
Effective backfill density	19,0	kN m^3
Design effective overburden	41,80	kN m^2
Effective subsoil density	20,5	kN m^3
Design bearing resistance Rd	2326,69	kN
Unity check (6.1)	0,38	

Sliding Resistance Check
According to EN 1997-1 article 6.5.3

Table of values		
Student version *Student version* *Student version* *Student version* *Student versio		
Design friction angle delta	18,76	deg
Design earth pressure resistance Rpd	0,00	kN
Design shear resistance Rd	300,22	kN
Unity check (6.2)	0,64	

Check of Maximal Eccentricity
According to EN 1997-1 article 6.5.4 &
Bautabellen fur Ingenieure, 13. Auflage, Werner Verlag, 1998

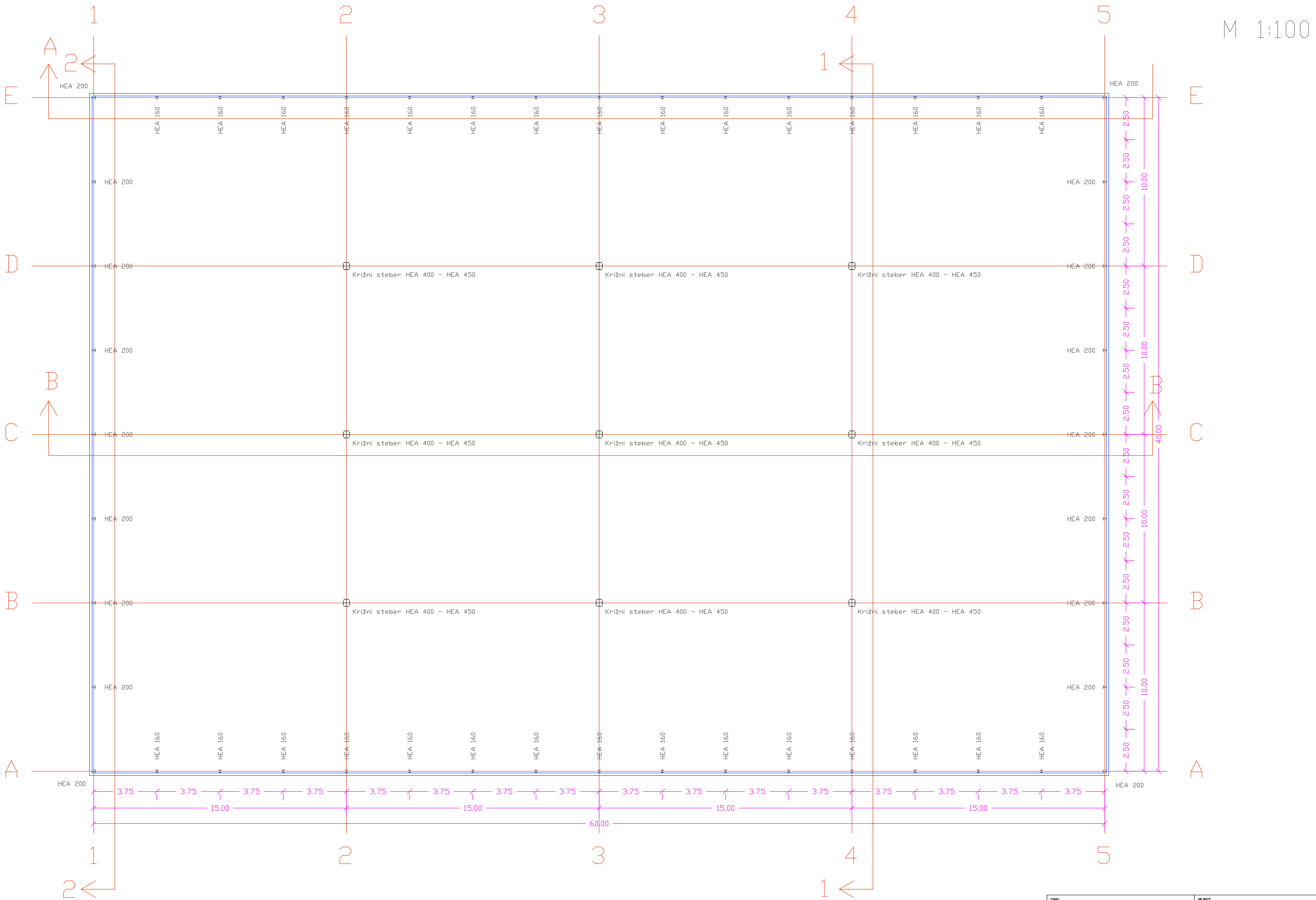
Table of values	
Student version *Student version* *Student version* *Stud	
Maximal value of eccentricity	1 3
Unity check	0,98

Priloga 11: Risbe

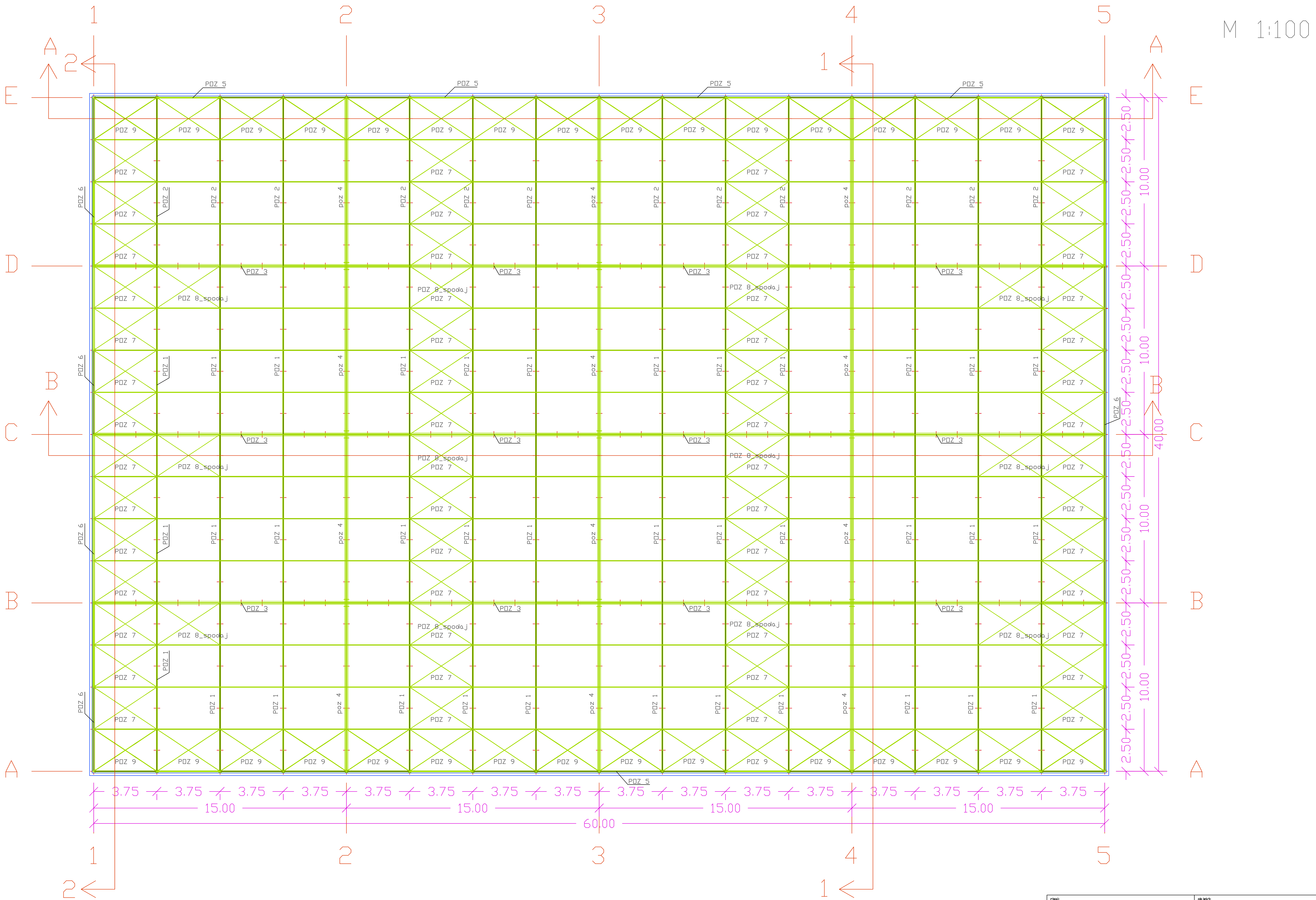
Diplomski nalogi prilagam naslednje risbe:

1. Tloris temeljev
2. Tloris objekta na koti + 1.0 m
3. Tloris strešne konstrukcije – dispozicijski načrt
4. Vzdolžni prerezi
5. Prečni prerezi
6. Detajli spojev

risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: Tloris temeljev	
odobril: prof. dr. Jože Korelc			
datum: maj 2011	merilo: 1:100	št. risbe: 1	list: 1 od: 1



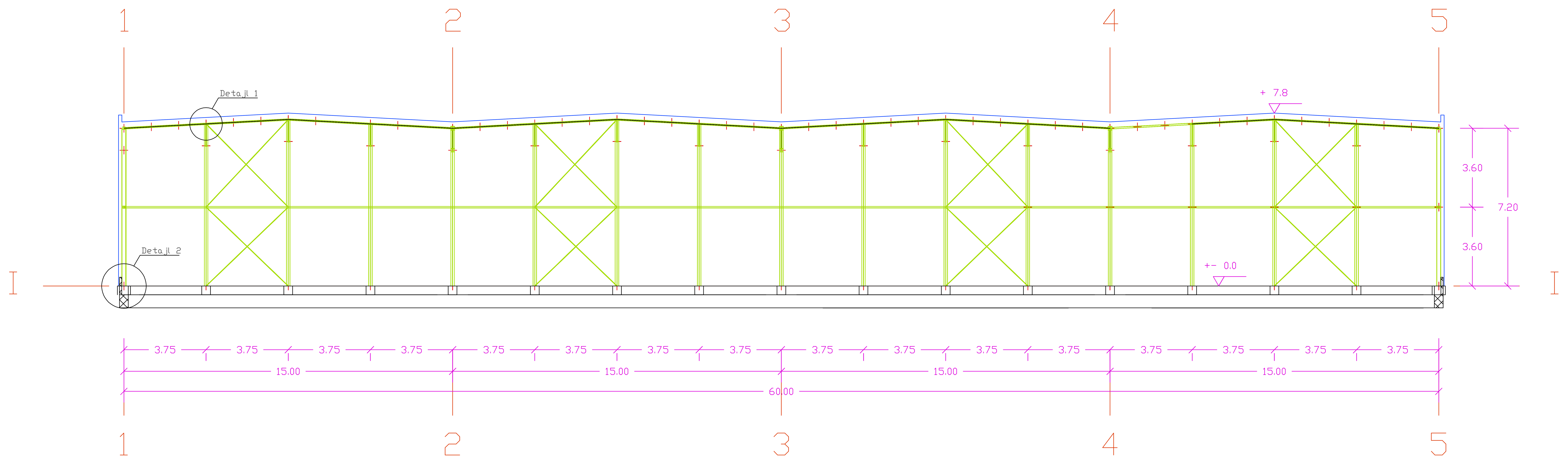
risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: Tloris objekta na koti + 1.00	
odobril: prof. dr. Jože Korelc			
datum: maj 2011	merilo: 1:100	št. risbe: 2	list: 1 od 1



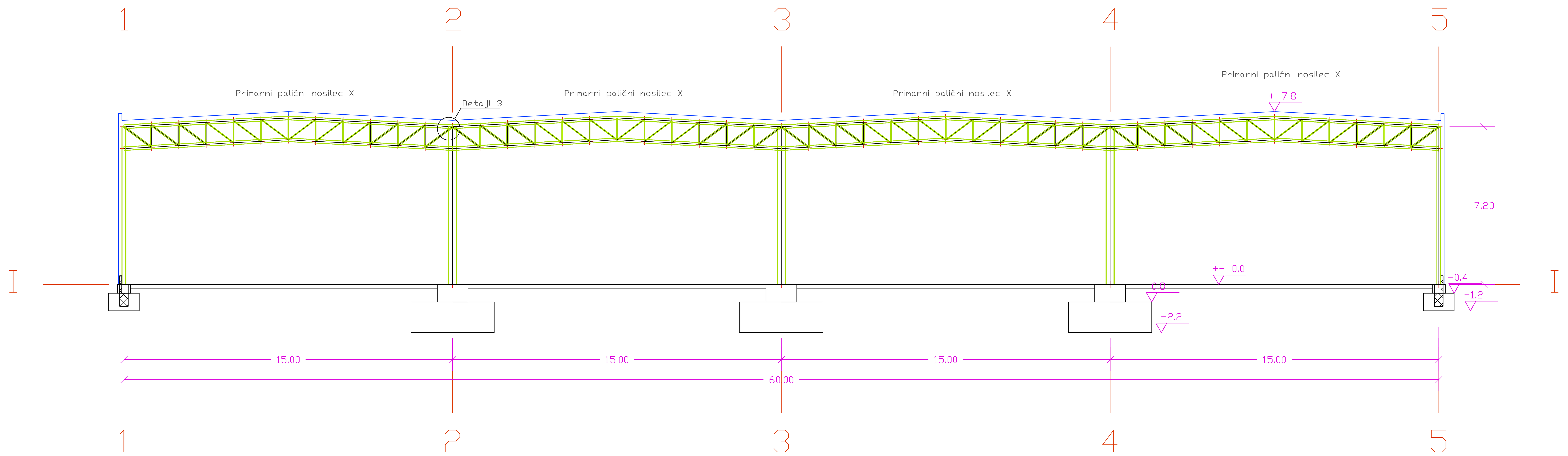
risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: DISPOZICIJSKI NAČRT Tloris strešne konstrukcije	
odobril: prof. dr. Jože Korelc			
datum: maj 2011	merilo: 1:100	št. risbe: 3	list: 1 od: 1

PREREZ A-A

M 1:100



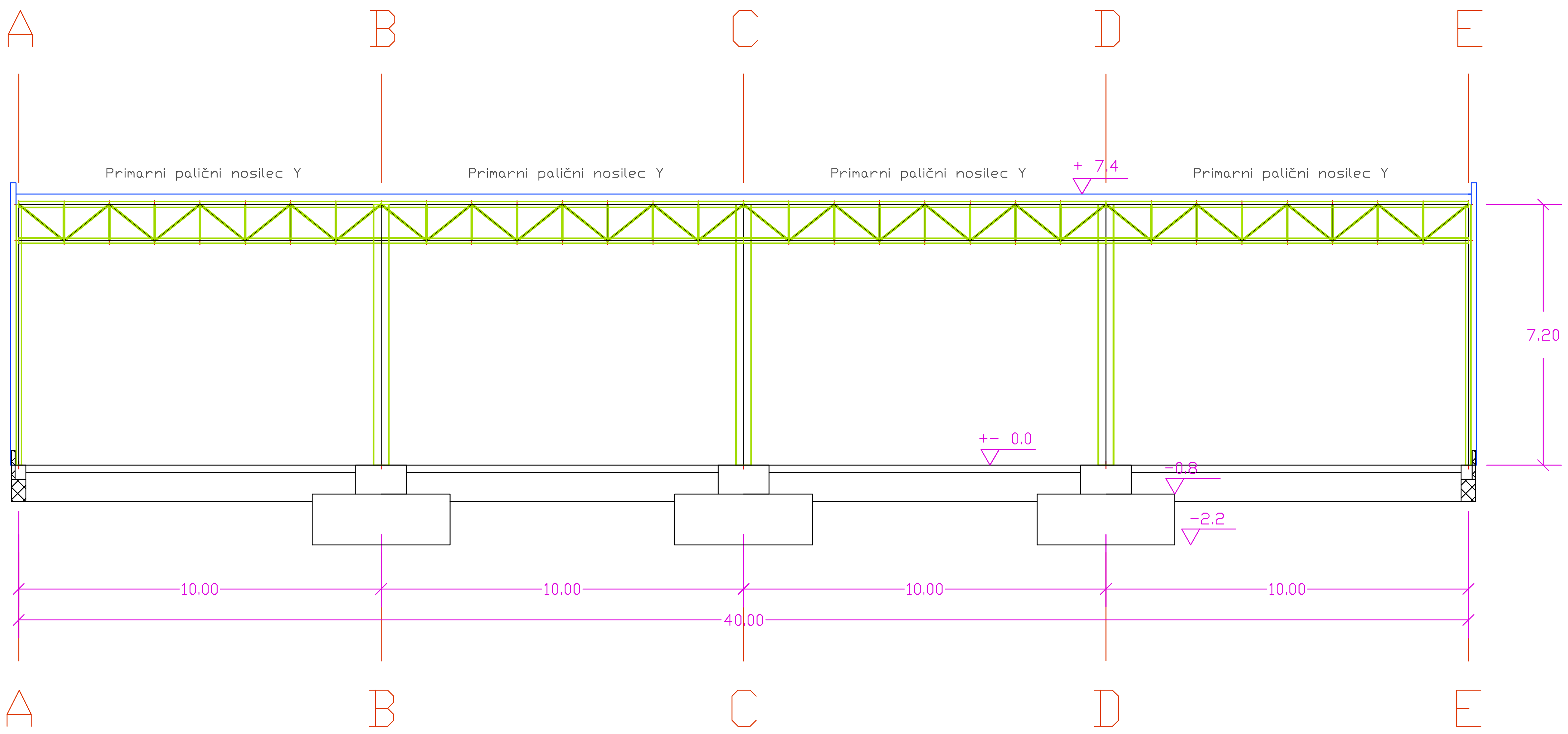
PREREZ B-B



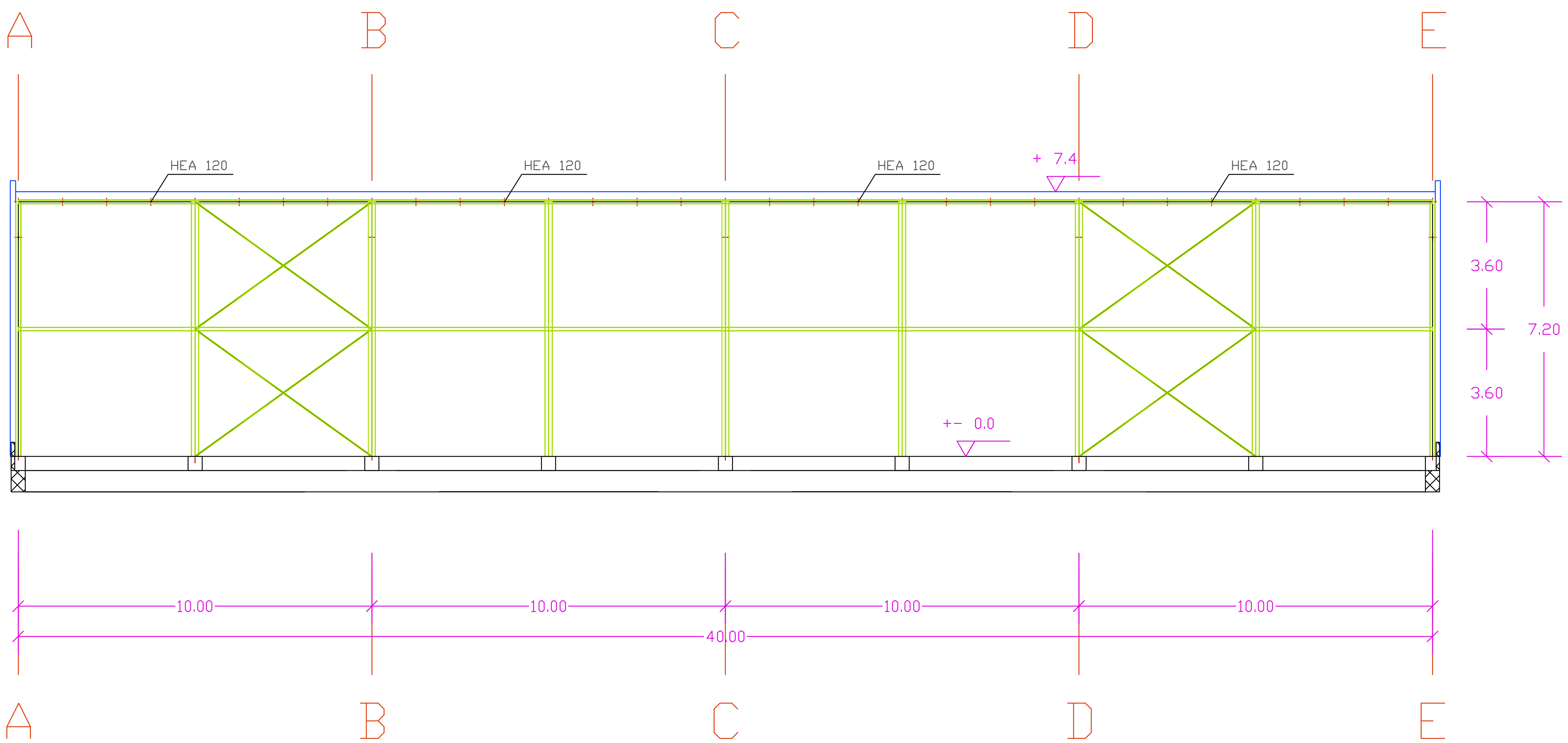
risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: Vzdolžni prerezi	
odobril: prof. dr. Jože Korelc			
datum: maj 2011	merilo: 1:100	št. risbe: 4	list: 1 od 1

PREREZ 1-1

M 1:100

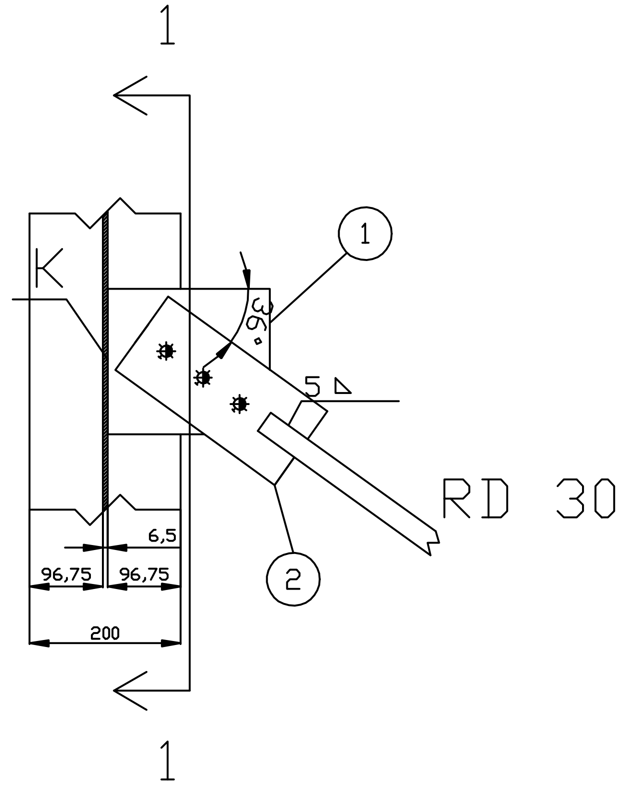


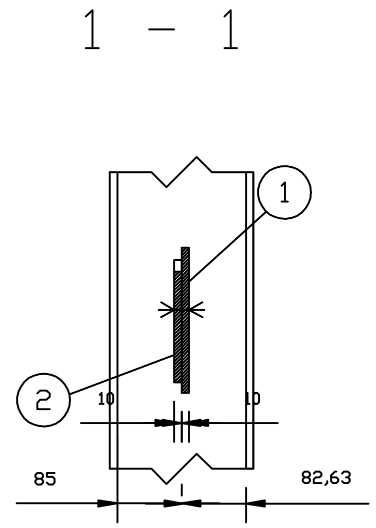
PREREZ 2-2



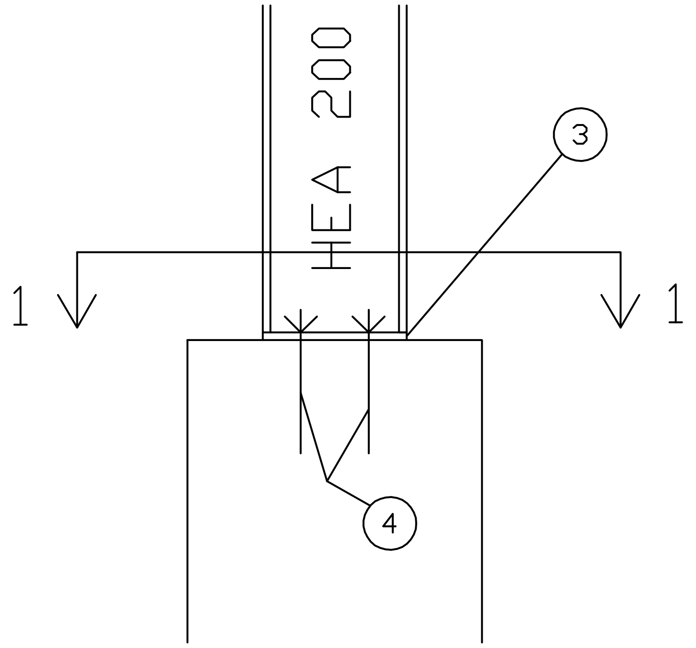
risal: Peter Muhvič	objekt: LOGISTIČNI CENTER
pregledal: asist. dr. Peter Skuber	načrt/naslov risbe: Prečni prerezi
odobril: prof. dr. Jože Korelc	
datum: maj 2011 / merilo: 1:100	št. risbe: 5 / list: 1 od: 1

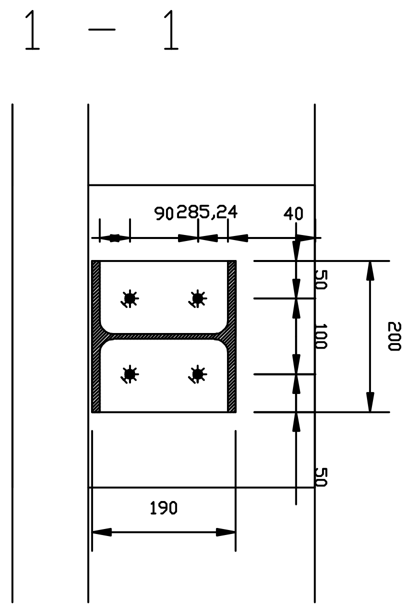
DETAJL 1: Stik diagonale s stebrom





DETAJL 2: Spoj fasadnega stebra na temeljni nosilec



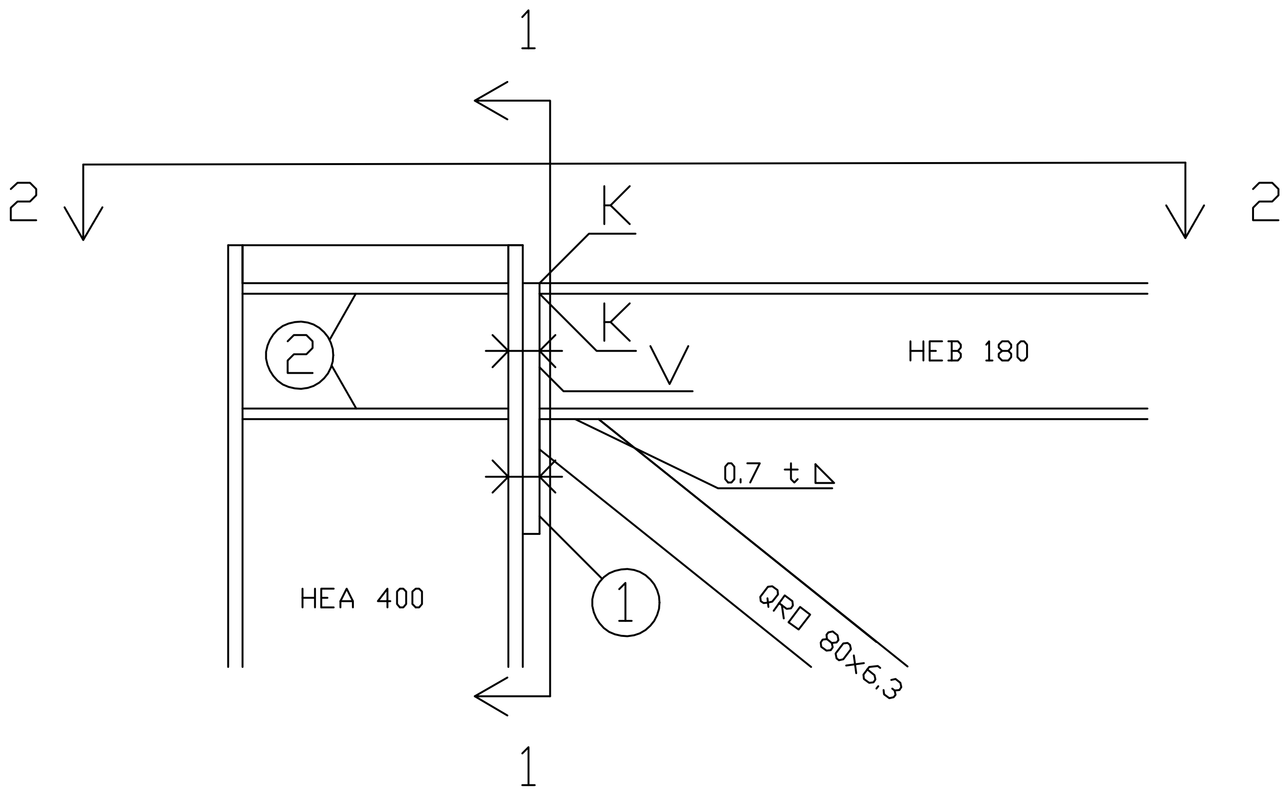


LEGENDA:

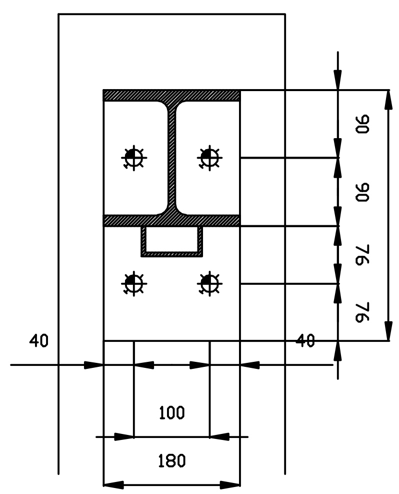
- vijaki M16 10.9
- vijaki M12 10.9
- (1) vezna ploščica 220/190/10 mm
- (2) vezna ploščica 260/120/10 mm
- (3) vezna ploščica 200/190/10 mm
- (4) vijaki M12 10.9, v HILTI masi, globina vpetja 150 mm

risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: DETAJLI ZNAČILNIH SPOJEV	
odobril: prof. dr. Jože Korelc			
datum: maj 2011	merilo: 1:10	št. risbe: 6	list: 1 od: 2

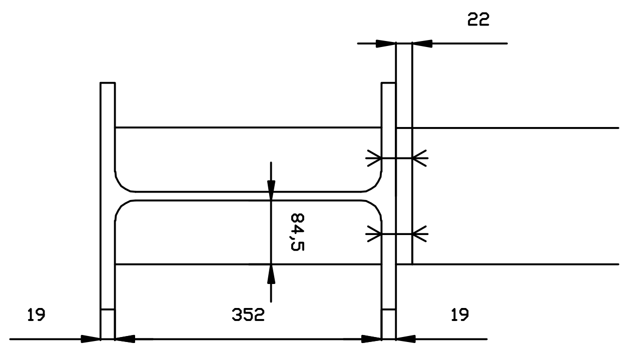
DETAJL 3: Spoj primarnega paličnega nosilca na križni steber



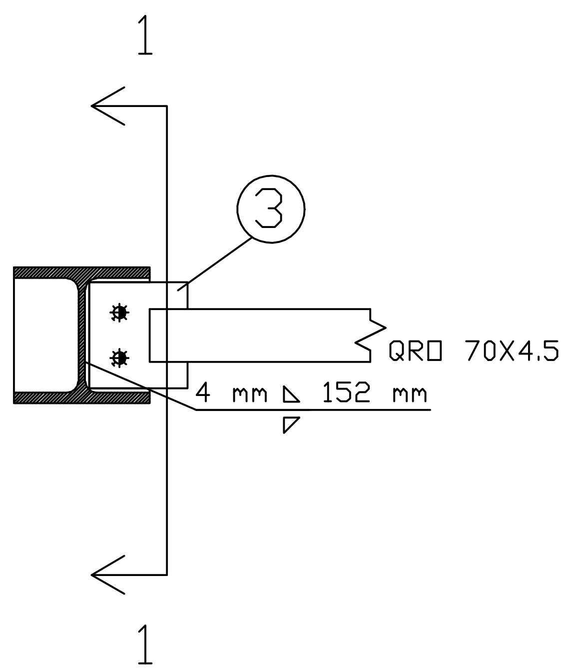
1 - 1

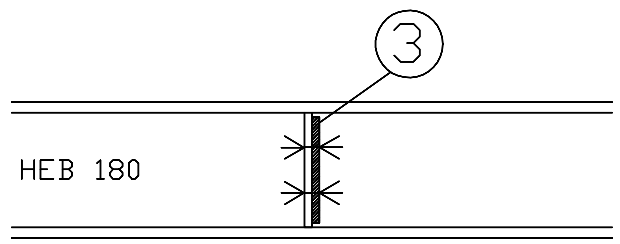


2 - 2



DETAJL 4: Spoj sekundarnega nosilca na primarni nosilec





LEGENDA:

- vijaki M22 10.9
- vijaki M16 10.9
- (1) vezna ploščica 332/180/22 mm
- (2) ojačitvene lamele d=10 mm
- (3) vezna ploščica 140/130/10 mm

risal: Peter Muhvič		objekt: LOGISTIČNI CENTER	
pregledal: asist. dr. Peter Skuber		načrt/naslov risbe: DETAJLI ZNAČILNIH SPOJEV	
odobril: prof. dr. Jože Korelc			
datum: april 2011	merilo: 1:10	št. risbe: 6	list: 2 od: 2