

**URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**

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**GLAVNI PROJEKT**

**- Građevinski projekt-**

**Za ishođenje građevinske dozvole**

**MAPA. 2/4**

**Broj projekta: 60/19-GP**

OVAJ GLAVNI PROJEKT JE PRILOG I SASTAVNI DIO  
GRAĐEVINSKE DOZVOLE  
KLASA: UP/I-361-03/19-01/000261,  
URBROJ: 2189/1-08/08-20-0012,  
OD 22.04.2020. GODINE

**ZOP: 17/19**

INVESTITOR: **Grad Slatina, Trg Svetog Josipa 10, Slatina,  
OIB: 68254459599**

GRAĐEVINA: **Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina**

LOKACIJA GRAĐEVINE: **Slatina, Bana Jelačića 25, k.o. Podravska Slatina,  
k.č.br. 3616**

GLAVNI PROJEKTANT: **Samanta Rešetar mag.ing.arch., A4562**

PROJEKTANT GRAĐEVINSKOG  
PROJEKTA: **Željko Šaponja dipl.ing.građ., G2032**

ODGOVORNA OSOBA UREDA: **Željko Šaponja dipl.ing.građ., G2032**

**Slatina, lipanj, 2019.**

**URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**, Slatina, M. Gupca 159

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INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
FAZA PROJEKTA:	Glavni projekt – građevinski projekt
BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

**SADRŽAJ:**

- Popis svih projekata koje tehnička dokumentacija sadrži
- Rješenje o registraciji ureda
- Rješenje o upisu u imenik ovlaštenih inženjera
- Rješenje o imenovanju projektanta
- Ugovor o poslovno tehničkoj suradnji
- Posebni uvjeti građenja
- Izjava projektanta građevinskog projekta
  
- Građevinski projekt konstrukcije
  - \* Tehnički opis
  - \* Proračun mehaničke otpornosti i stabilnosti
  - \* Plan pozicija
  
- Projekt vodovoda i kanalizacije



**URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**, Slatina, M. Gupca 159

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INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
FAZA PROJEKTA:	Glavni projekt – građevinski projekt
BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

**POPIS SVIH PROJEKATA KOJE TEHNIČKA DOKUMENTACIJA SADRŽI:**

<b>MAPA 1</b>	<b>ARHITEKTONSKI PROJEKT</b> “MODELARCH” d.o.o., A. K. Zrinske 26, Slatina OIB: 94732757958 Gl. projektant Samanta Rešetar, mag.ing.arch., A 4562 Projektant suradnik: Domagoj Klement, mag.ing.arch.	<b>T.D. 17/19-AP</b>
<b>MAPA 2</b>	<b>GRAĐEVINSKI PROJEKT</b> Ured ovlaštenog inženjera građevinarstva Šaponja Željko, Matije Gupca 159, Slatina OIB: 92755191271 Projektant Željko Šaponja dipl.ing.građ., G 2032	<b>T.D. 60/19-GP</b>
<b>MAPA 3</b>	<b>ELEKTROTEHNIČKI PROJEKT</b> MFT PROJEKT j.d.o.o., P. Svačića 1, Čačinci OIB: 66662330721 Projektant Danijel Bartolović, struč.spec.ing.el., E 2836	<b>T.D. 37/19-EL</b>
<b>MAPA 4</b>	<b>STROJARSKI PROJEKT</b> REŠETAR d.o.o., Cvjetna 1/3, Slatina OIB: 18254316188 Projektant Branko Rešetar, dipl.ing.stroj., S 1400	<b>T.D. 160/19-ST</b>

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**2. POPIS ELABORATA**

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<b>ELABORAT 1</b>	<b>GEODETSKI ELABORAT</b> GEOSOFT d.o.o., P. Preradovića 8, Orahovica OIB: 05092130559 Projektant Šimo Sudarić dipl.ing.geod., Geo 1460	<b>T.D. 168/2019</b>
<b>ELABORAT 2</b>	<b>ELABORAT ZAŠTITE OD POŽARA</b> ZAGREBINSPEKT d.o.o., Draškovićeva 29, 10 000 Zagreb OIB: 82752153530 Projektant : Dario Rogina, mag.ing.el., upisni broj: 292	<b>22-397-ZOP/19</b>



**REPUBLIKA HRVATSKA**

**HRVATSKA KOMORA ARHITEKATA  
I INŽENJERA U GRADITELJSTVU**

Klasa: UP/I-311-01/07-01/541  
Urbroj: 314-02-07-3  
Zagreb, 24. kolovoza 2007. godine

Na temelju članka 24. Zakona o Hrvatskoj komori arhitekata i inženjera u graditeljstvu (Narodne novine, broj 47/98), a u svezi s člancima 50. i 52. Zakona o gradnji (Narodne novine, broj 175/03 i 100/04), rješavajući po zahtjevu koji je podnio ŽELJKO ŠAPONJA, dipl.ing.građ., SLATINA, M. GUPCA 159, za upis u Upisnik ureda za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja Hrvatske komore arhitekata i inženjera u graditeljstvu, predsjednik Komore donosi

**RJEŠENJE**

o osnivanju Ureda za samostalno obavljanje poslova  
projektiranja i stručnog nadzora građenja  
ovlaštenog inženjera građevinarstva

1. U Upisnik ureda za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja Hrvatske komore arhitekata i inženjera u graditeljstvu, upisuje se Ured za samostalno obavljanje poslova projektiranja i stručnog nadzora građenja ovlaštenog inženjera građevinarstva ŽELJKO ŠAPONJA, dipl.ing.građ., SLATINA, pod rednim brojem **541**, s danom upisa **03.09.2007.** godine.
2. Ured za samostalno obavljanje poslova projektiranja i stručnog nadzora građenja ovlaštenog inženjera građevinarstva ŽELJKO ŠAPONJA, dipl.ing.građ., SLATINA, osniva se danom upisa u Upisnik ureda za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja Hrvatske komore arhitekata i inženjera u graditeljstvu, a s radom započinje **03.09.2007.** godine.
3. Poslovno sjedište Ureda za samostalno obavljanje poslova projektiranja i stručnog nadzora građenja ovlaštenog inženjera građevinarstva ŽELJKO ŠAPONJA, dipl.ing.građ., je na adresi **SLATINA, MATIJE GUPCA 159.**
4. Ured mora imati natpisnu ploču koja se postavlja pored ulaza u zgradu u kojoj je smješten ured. Naziv ureda ispisuje se na natpisnoj ploči četverokutnog oblika, širine 50 cm i visine 30 cm, u materijalu eloksirani aluminij sa folijom. Logotip (znak) Komore tiska se u foliji u dvije boje na svijetlo sivoj podlozi. Tekst natpisne ploče mora biti tiskan u srebrno sivoj boji na antracit podlozi, a tip slova je helvetica.
5. Komora izdaje natpisnu ploču, a ŽELJKO ŠAPONJA, dipl.ing.građ. snosi trošak korištenja natpisne ploče, koji jednokratno uplaćuje u korist osnovnog računa Komore.
6. Matični broj Ureda: **80370187**
7. Šifra djelatnosti Ureda je: **74.20.0 - Arhitektonske djelatnosti i inženjerstvo te s njima povezano tehničko savjetovanje.**

8. Skraćeni naziv Ureda je: **URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**

**Obrazloženje**

ŽELJKO ŠAPONJA, dipl.ing.građ., podnio je Hrvatskoj komori arhitekata i inženjera u graditeljstvu aktom od 26.07.2007. godine, Zahtjev za osnivanje Ureda za samostalno obavljanje poslova projektiranja i stručnog nadzora građenja ovlaštenog inženjera građevinarstva.

Sukladno članku 50. Zakona o gradnji ("Narodne novine", br. 175/03 i 100/04), ovlašteni arhitekt i ovlašteni inženjer mogu obavljati poslove projektiranja i/ili stručnog nadzora građenja samostalno u vlastitom uredu, zajedničkom uredu, projektantskom društvu ili drugoj pravnoj osobi registriranoj za tu djelatnost (u daljnjem tekstu: osoba registrirana za djelatnost projektiranja i/ili stručnog nadzora).

Osoba registrirana za djelatnost projektiranja i/ili stručnog nadzora dužna je u obavljanju tih poslova poštivati odredbe Zakona o gradnji i posebnih zakona, te osigurati da obavljanje poslova projektiranja i/ili stručnog nadzora bude u skladu s temeljnim načelima i pravilima koja trebaju poštivati ovlašteni arhitekti i ovlašteni inženjeri. Osoba registrirana za djelatnost projektiranja odgovorna je da projekt ili dio projekta kojeg je izradila odgovara propisanim zahtjevima.

U članku 52. Zakona o gradnji propisano je da ovlašteni arhitekt odnosno ovlašteni inženjer stječe pravo na samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja upisom u Imenik ovlaštenih arhitekata, odnosno Imenike ovlaštenih inženjera Hrvatske komore arhitekata i inženjera u graditeljstvu.

Ured za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja, osniva se upisom u Upisnik ureda za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja Hrvatske komore arhitekata i inženjera u graditeljstvu.

Uvidom u službenu evidenciju Hrvatske komore arhitekata i inženjera u graditeljstvu utvrđeno je da je ŽELJKO ŠAPONJA, dipl.ing.građ. upisan u Imenik ovlaštenih inženjera građevinarstva Hrvatske komore arhitekata i inženjera u graditeljstvu pod rednim brojem 2032, s danom upisa 15.10.1999. godine, te je s tog osnova stekao pravo na samostalno obavljanje poslova projektiranja i stručnog nadzora građenja.

Ured za samostalno obavljanje poslova projektiranja i stručnog nadzora građenja ovlaštenog inženjera građevinarstva, osnovan je upisom u Upisnik ureda za samostalno obavljanje poslova projektiranja i/ili stručnog nadzora građenja Hrvatske komore arhitekata i inženjera u graditeljstvu, s danom 03.09.2007. godine, pod rednim brojem 541.

Uredu je Državni zavod za statistiku dodijelio Matični broj ureda, u skladu s Odlukom o sadržaju i načinu vođenja registra ovlaštenih organizacija.

Uredu je u skladu s Nacionalnom klasifikacijom djelatnosti dodjeljena pripadajuća šifra djelatnosti, za samostalnu djelatnost arhitekata i inženjera u graditeljstvu 74.20.0 – Arhitektonske djelatnosti i inženjerstvo te s njima povezano tehničko savjetovanje.

Ured će poslovati pod skraćenim nazivom: **URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**, te će se isti upisati u "inženjersku iskaznicu" i "pečat" koje izdaje Hrvatska komora arhitekata i inženjera u graditeljstvu.

U članku 38. Statuta Hrvatske komore arhitekata i inženjera u graditeljstvu propisano je da ovlaštene arhitekti i ovlaštene inženjeri koji poslove projektiranja i/ili stručnog nadzora građenja obavljaju samostalno u vlastitom uredu, zajedničkom uredu ili projektantskom društvu, dužni su imati ploču ureda odnosno društva istaknutu pored ulaza u zgradu u kojem je smješten ured.

Upravni odbor Komore je temeljem ovlaštenja iz članka 38. stavka 3. Statuta Komore propisao obvezatni sadržaj ploče, na sjednici održanoj 14. lipnja 2007. godine donošenjem Pravilnika o obliku i sadržaju natpisne ploče ovlaštenih arhitekata i ovlaštenih inženjera.

Time su se stekli uvjeti koji su propisani u točki 4. dispozitiva ovog rješenja. Trošak korištenja natpisne ploče snosi ŽELJKO ŠAPONJA, dipl.ing.građ., koji jednokratno uplaćuje iznos od 850,00 kn (slovima: osamstopeideset kuna) u korist osnovnog računa Komore broj: 2360000-1101366566.

U skladu s člankom 52. stavcima 3. i 4. Zakona o gradnji, "propisano je da ovlaštene arhitekt, odnosno ovlaštene inženjer koji samostalno obavlja poslove projektiranja i/ili stručnog nadzora građenja može obavljati te poslove pod uvjetom da nije u radnom odnosu i može imati samo jedan ured".

Uvidom u dostavljenu dokumentaciju imenovanog, razvidno je da nije u radnom odnosu i da Izjavom potvrđuje da će raditi samo u jednom Uredu.

Sukladno svemu prethodno iznesenom, riješeno je kao u izreci ovoga Rješenja.

#### Pouka o pravnom lijeku

Protiv ovog Rješenja žalba nije dopuštena, ali se može pokrenuti upravni spor podnošenjem tužbe Upravnom sudu Republike Hrvatske, u roku 30 dana od dana primitka ovog Rješenja.



Dostaviti:

1. ŽELJKO ŠAPONJA, 33520 SLATINA, M. GUPCA 159
2. Područna služba HZMO Virovitica, Ispostava Slatina, Šet. Julija Bisigera 3, 33520 SLATINA
3. HZZO Područni ured Virovitica, Ispostava Slatina, Šet. Julija Burgera 3, 33520 SLATINA
4. Područni ured Porezne uprave Slatina, Braće Radića 7, 33520 SLATINA
5. U Zbirku isprava Komore
6. Pismohrana Komore
7. Povrat potvrde o izvršenoj dostavi uz točke 1. do 4.



REPUBLIKA HRVATSKA  
HRVATSKA KOMORA ARHITEKATA  
I INŽENJERA U GRADITELJSTVU

Klasa: UP/I-360-01/99-01/2032  
Urbroj: 314-01-991  
Zagreb, 14. listopada 1999.

Na temelju članka 24. i 50. Zakona o Hrvatskoj komori arhitekata i inženjera u graditeljstvu (Narodne novine, broj 47/98), Odbor za upise razreda inženjera građevinarstva, rješavajući po zahtjevu koji je podnio ŠAPONJA ŽELJKO, dipl.ing.građ., SLATINA, M. GUPCA 159, za upis u Imenik ovlaštenih inženjera građevinarstva, donio je sljedeće

RJEŠENJE

1. U Imenik ovlaštenih inženjera građevinarstva upisuje se ŠAPONJA ŽELJKO, dipl.ing.građ., SLATINA, pod rednim brojem 2032, s danom upisa 15.10.1999. godine.
2. Upisom u Imenik ovlaštenih inženjera građevinarstva, ŠAPONJA ŽELJKO, dipl.ing.građ., stječe pravo na uporabu strukovnog naziva "ovlašteni inženjer građevinarstva" i pravo na obavljanje poslova temeljem članka 25. Zakona o Hrvatskoj komori arhitekata i inženjera u graditeljstvu, a u svezi s člankom 4. stavkom 1. Statuta Hrvatske komore arhitekata i inženjera u graditeljstvu, te ostala prava i dužnosti sukladno posebnim propisima.
3. Ovlaštenom inženjeru izdaje se "inženjerska iskaznica" i stječe pravo na uporabu "pečata".

Obrazloženje

ŠAPONJA ŽELJKO, dipl.ing.građ., podnio je Zahtjev za upis u Imenik ovlaštenih inženjera građevinarstva.

Odbor za upise razreda inženjera građevinarstva proveo je postupak u povodu dostavljenog Zahtjeva, te je temeljem članka 24. stavka 2. Zakona o Hrvatskoj komori arhitekata i inženjera u graditeljstvu (Narodne novine, broj 47/98), a u svezi s člankom 5. stavkom 4. i člankom 20. Statuta Hrvatske komore arhitekata i inženjera u graditeljstvu (Narodne novine, broj 40/99), riješeno kao u izreci.

Upisom u Imenik ovlaštenih inženjera građevinarstva imenovani stječe pravo na izradu i uporabu pečata, sukladno članku 35. Statuta Hrvatske komore arhitekata i inženjera u graditeljstvu i na izdavanje "inženjerske iskaznice".

Na temelju članka 141. stavka 1. točke 1. Zakona o općem upravnom postupku (Narodne novine, broj 53/91), predmet je riješen po skraćenom postupku.

Pouka o pravnom lijeku

Protiv ovog Rješenja žalba nije dopuštena, ali se može pokrenuti upravni spor podnošenjem tužbe Upravnom sudu Republike Hrvatske, u roku od 30 dana od primitka ovog Rješenja.



Dostaviti:

1. ŽELJKO ŠAPONJA, 33520 SLATINA, M. GUPCA 159
2. U Zbirku isprava Komore
3. Pismohrana Komore

Zabilješka:

Istovjetnost ovog otpavka s izvornikom ovjerava

Tajnica Komore:  
  
 Sunčana Rudić, dipl.iur.

Broj. 04-02/04  
 Zagreb, 22.01.2004. godine

Na temelju članka 51. Zakona o gradnji ("Narodne novine" broj 153/13, 20/17 i 39/19) izdajem  
slijedeće

**IMENOVANJE br. 1- 60/19-GP**  
o imenovanju projektanta Građevinskog projekta

INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA GRAĐEVINE:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
BROJ PROJEKTA:	60/19-GP

**Za projektanta Građevinskog projekta imenuje se:**

ŽELJKO ŠAPONJA dipl.ing.građ., ovlašteni inženjer građevinarstva

Rješenje o upisu u imenik ovlaštenih inženjera građevinarstva Klasa UP/I-360-01/99-01/2032,  
Urbroj: 314-01-991 od 14 listopada 1999.g.

Imenovani projektant je osoba ovlaštena za projektiranje sukladno posebnom zakonu i propisima donesenim na temelju tog zakona i odgovoran je da projekti koje izrađuje zadovoljavaju uvjete iz Zakona o prostornom uređenju i gradnji i posebnih zakona i drugih propisa

U Slatini, lipanj.2019.g.

Odgovorna osoba ureda:

Željko Šaponja dipl.inž.građ.

INVESTITOR: Grad Slatina, Trg Svetog Josipa 10, Slatina  
GRAĐEVINA: Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina  
LOKACIJA: Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616  
FAZA PROJEKTA: Glavni projekt – građevinski projekt  
BROJ PROJEKTA: 60/19-GP  
GLAVNI PROJEKTANT: Željko Šaponja dipl.ing.građ.

Na temelju članka 108. stavak 2. podstavak 2. Zakona o gradnji (NN 153/13, 20/17 19/19), donosi se:

### **IZJAVA PROJEKTANTA GRAĐEVINSKOG PROJEKTA br. 58/19 –IZ**

Ovaj Glavni projekt, izrađen je u skladu sa odredbama Prostornog plana i drugim propisima u skladu s kojima mora biti izrađen, a to su:

- Zakon o prostornom uređenju (NN 153/13, 65/17)
- Zakon o gradnji (NN 153/13, 20/17)
- Zakon o poslovima i djelatnostima prostornog uređenja i gradnje (NN 78/15)
- Zakon o zaštiti od požara (NN 92/10)
- Zakon o zaštiti okoliša (NN 80/13, 153/13)
- Zakon o zaštiti na radu (NN 71/14)
- Zakon o zaštiti od buke (NN 30/09, 55/13, 153/13, 41/16)
- Pravilnik o djelatnostima za koje je potrebno utvrditi provedbu mjera za zaštitu od buke (NN 91/07)
- Direktiva 2002/49/EZ
- Pravilnik o najvišim dopuštenim razinama buke u sredini u kojoj ljudi rade i borave (NN 145/04)
- Pravilnik o zaštiti na radu za radne i pomoćne prostorije (NN br. 6/84, 42/05)
- Zakon o građevnim proizvodima (30/14)
- Pravilnik o načinu obračuna površine i obujma u projektima zgrada (NN 90/10, 111/10)
- Pravilnik o obračunu i naplati vodnog doprinosa (NN 107/14)
- Tehnički propis za betonske konstrukcije (NN br. 139/09, 14/10, 125/10)
- Tehnički propis o izmjenama i dopunama Tehničkog propisa za betonske konstrukcije (NN 136/12)
- Tehnički propis za drvene konstrukcije (NN 121/07, 58/09, 125/10)
- Tehnički propis o izmjenama i dopunama Tehničkog propisa za drvene konstrukcije (NN 136/12)
- Tehnički propis za čelične konstrukcije (NN 112/08, 125/10, 73/12)
- Tehnički propis o izmjenama i dopunama Tehničkog propisa za čelične konstrukcije (NN 136/12)
- Tehnički propis za zidane konstrukcije (NN 01/07)
- Tehnički propis za aluminijske konstrukcije (NN 80/13)
- Tehnički propis za dimnjake u građevinama (NN 3/07)
- Tehnički propis o građevnim proizvodima (NN 33/10, 87/10, 146/10, 81/11, 100/11, 130/12)
- Tehnički propis o izmjenama i dopunama Tehničkog propisa o građevnim proizvodima (NN 81/13)
- Tehnički propis o racionalnoj uporabi energije i toplinskoj zaštiti u zgradama (NN 97/14)
- Zakon o normizaciji (NN 80/13)
- Pravilnik o osiguranju pristupačnosti građevina osobama s invaliditetom i smanjene pokretljivosti (NN 78/13)
- Zakon o hrani (NN 81/13, 14/14)
- Zakon o higijeni hrane i mikrobiološkim kriterijima za hranu (NN 81/13)
- Zakon o zaštiti pučanstva od zaraznih bolesti (NN 79/07, 113/08, 43/09, 130/17)
- Pravilnik o načinu provedbe obvezatne dezinfekcije, dezinsekcije i deratizacije (NN 35/07, 76/12)

Slatina, lipanj 2019.g.

Projektant:

Željko Šaponja dipl.ing.građ.



**URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**, Slatina, M. Gupca 159

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INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
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BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

## PROJEKT KONSTRUKCIJE

- Plan pozicija
- Tehnički opis
- Dokaz mehaničke otpornosti i stabilnosti

Slatina, lipanj 2019.g.

PROJEKTANT:

Željko Šaponja dipl.ing.građ.

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## **TEHNIČKI OPIS I PROGRAM KONTROLE**

### **1. OPĆENITO**

Investitor je dužan tijekom građenja osigurati stručni nadzor izvedbe za građevinu u cijelosti i pojedinim segmentima.

Izvoditelj je dužan prije početka radova proučiti projektnu dokumentaciju i o svim eventualnim primjedbama i uočenim nedostacima obavijestiti Investitora ili nadzornog inženjera. Ukoliko se tokom gradnje ukaže opravdana potreba za manjim odstupanjima od projekta ili njegovim izmjenama, izvoditelj je dužan prethodno pribaviti suglasnost projektanta i nadzornog inženjera.

Izvoditelj je obavezan putem dnevnika registrirati sve izmjene i eventualna odstupanja od projekta, a po dovršetku gradnje obavezan je predati Investitoru projekt izvedenog stanja objekta koji se sastoji od svih projekata u kojima je došlo do izmjene.

Sav materijal koji se upotrijebi mora odgovarati hrvatskim standardima.

Pri dovoženju materijala na gradilište pregled materijala izvršit će nadzorni inženjer i njegovo stanje konstatirati u građevinski dnevnik. Ukoliko izvoditelj upotrijebi neodgovarajući materijal, na zahtjev nadzornog inženjera mora ga ukloniti i upotrijebiti drugi koji odgovara propisima.

Svi radovi moraju biti kvalitetno izvedeni. Sve nedostatke uočene u toku ili nakon radova izvoditelj je dužan ispraviti o svom trošku.

Svi ugrađeni materijali moraju biti kvalitetni i atestirani prema važećim propisima, a prema Zakonu o preuzimanju Zakona o standardizaciji NN RH br.53/91.

### **2. BETONSKI I ARMIRANO BETONSKI RADOVI**

Izvoditelj je dužan sustavno pratiti izvedbu konstrukcije geodetskom kontrolom vertikalnosti i horizontalnosti elemenata, ponašanje konstrukcije spram slijeganja, te o svim pojavama koje nisu u skladu sa predviđenima u projektu odmah obavijestiti projektanta i nadzornog inženjera.

Izvoditelj je obavezan posjedovati atest o kvaliteti svih ugrađenih materijala.

Kvaliteta betona i čelika treba odgovarati Tehničkim propisima za betonske konstrukcije.

Ispitivanje betonskih uzoraka provesti kod nadležne institucije, prema odredbama pravilnika Tehnički propis za betonske konstrukcije (NN br. 139/09, 14/10).

Sukladno Tehničkom propisu za betonske konstrukcije (NN br. 139/09, 14/10) donosi se ovaj program kontrole i osiguranja kvalitete za betonske konstrukcije.

Sukladno članku 8. gore navedenog tehničkog propisa, tehnička svojstva betonske konstrukcije moraju biti takova da na građevini ne prouzroče:

- rušenje građevine ili njezinog djela
- deformacije nedopuštena stupnja
- nerazmjerno velika oštećenja građevine ili njezinog djela u odnosu na uzrok zbog kojih su nastala
- da se u slučaju požara očuva nosivost konstrukcije ili njezinog djela tijekom određenog vremena

Beton koji će se ugrađivati je obični beton gustoće 2400 kg/m<sup>3</sup>. Specifikacija, svojstva, proizvodnja i sukladnost betona je prema HRN EN 206-1. Beton će se proizvoditi na betonari.

Izvršiti ispitivanje tlačne čvrstoće betona sukladno HRN EN 12390-1, 12390-2 i 12390-3. Uzeti uzorke svježeg betona oblika valjaka dimenzija d/h=150/300 mm i kocke stranice a=500 mm.

- Beton će se izraditi od prirodnog agregata sukladno HRN EN 12620. Najveće zrno 31,5 mm.
- Koristiti vodu iz gradskog vodovoda koja zadovoljava zahtjeve HRN EN 1008
- Tlačna čvrstoća treba zadovoljiti zahtjev  $f_{c,m} > f_{ck} + (6 \text{ do } 12) \text{ N/mm}^2$ .
- Razred izloženosti XC1
- Razred tlačne čvrstoće svih elemenata je 25/30, a temelja 20/25
- Može se koristiti cement razreda CEM 32,5 gustoće 3,00kg/dm<sup>3</sup> sukladno HRN EN 197-1
- Najveći v/c je 0,65

- Neće se dodavati dodaci betonu
- Udio zraka u betonu je 2,5%

Kontrola betona:

- Kontrolu betona u tvornici betona mora biti u skladu sa zahtjevima 9. točke norme HRN 206-1
- Kontrolu betona na gradilištu obavlja izvođač radova od vremena preuzimanja betona od proizvođača do završetka njege ugrađenog betona. Kontrola se vrši pregledom svake otpremnice, vizualnom kontrolom konzistencije betona kod svake dopreme betona, mjerenjem konzistencije betona, ispitivanja sadržaja zračnih pora, mjerenje temperature svježeg betona.

Nadzorni inženjer treba nadzirati:

- oplatu i stabilnost oplata
- geometrijska svojstva oplata
- nepropusnost oplata i njenih dijelova
- uklanjanje nečistoća iz presjeka koji će se betonirati
- obradu lica radnih spojnica
- uklanjanje vode s dna oplata
- pripremu površine oplata
- postavu armature prema projektu
- armatura ne smije sadržavati slobodnu hrđu i štetne tvari
- armatura ne smije biti zagađena uljima, mastima, ili drugim štetnim tvarima
- armatura mora biti ispravno učvršćena i osigurana od pomaka tijekom ugradnje
- razmak između šipki mora biti dovoljan za ugradnju betona
- svježi beton prije ugradnje, kao i popratne dokumente uz njega
- sve radnje prije ugradnje betona
- njegu i zaštitu beton
- temperaturu betona koja nesmije biti manja od 5° niti veća od 25°

### **3. ZIDARSKI RADOVI**

Svi materijali koji se koriste za izvođenje zidarskih radova moraju biti u skladu sa uvjetima propisanim HRN. Dobavljači materijala dužni su isporučiti odgovarajuće ateste za sve tipove opeke koji se ugrađuju, a isto tako za cement, vapno, agregat za zidanje, pijesak za žbukanje i glazure. Primijeniti tehnički propis za zidane konstrukcije NN 34/2007.

### **4. DRVENE KONSTRUKCIJE**

Drvena konstrukcija se izvodi sa građom II klase.

Primijenjeni su sljedeći propisi:

- za opterećenje HRN U.C7.123
- za drvenu konstrukciju HRN U D0.001 – materijal za izradu drvenih konstrukcija i tehnički

uvjeti

HRN U.C9.400 – drvene skele i oplata

HRN U C.9.500 – zaštita drveta u konstrukcijama

### **5. ISPITIVANJE NOSIVOSTI TLA**

Neće se raditi geomehanički elaborat. Kod izrade ovog statičkog računa uzeta je pretpostavljena minimalna nosivost tla od 15 N/cm<sup>2</sup>. Ukoliko se prilikom iskopa za temelje ustanovi drugačije stanje, investitor je o tome obavezan obavijestiti nadzornog inženjera i projektanta, koji će izvršiti kontrolu statičkog proračuna temeljne konstrukcije.

Slatina, lipanj 2019.g.

Projektant:

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## **DOKAZ MEHANIČKE OTPORNOSTI I STABILNOSTI**

- plan pozicija
- krovište
- furt strop
- a.b. elementi zgrade
- vertikalna konstrukcija zgrade
- temelji

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## - **KROVIŠTE**

### **Odstupanje od projektne dokumentacije**

- Bilo kakve promjene i odstupanja od projektne dokumentacije izvoditelj može izvesti jedino uz pismenu suglasnost nadzornog inženjera, koji procjenjuje u kojim je slučajevima potrebno pribaviti pisanu suglasnost projektanta, odnosno ishoditi izmjenu i dopunu projektne dokumentacije.

### **Kontrole svih materijala prije ugradnje**

- Svi materijali, građevinski proizvodi i oprema mogu se ugrađivati ukoliko je njihova kvaliteta dokazana certifikatom sukladno posebnim propisima ili ispravama proizvođača - atestna dokumentacija.
- Atesti, mjerenja i ispitivanja koja je izvoditelj dužan posjedovati na gradilištu to priložiti uz Zahtjev za Tehnički pregled i Uporabnu dozvolu jesu ATESTI SVIH UGRADENIH MATERIJALA I OPREME.
- Kontrole se vrše osim preko navedenih proizvođačkih dokaza i vizualno priručnim probama, kontrolom oznake u pakiranju i drugim načinima.
- Kod dopreme materijala na gradilište nadzorni inženjer će ga pregledati i upisom u dnevnik izvijestiti o njegovom stanju. Ako se pri tome utvrdi da materijal ne udovoljava zahtjevima projekta i nije u skladu s odgovarajućim Hrvatskim normama, na zahtjev nadzornog inženjera izvoditelj je dužan otkloniti nedostatke ili nabaviti drugi odgovarajući materijal.
- Puno drvo potrebno je nakon sušenja pravilno skladištiti. Projektant konstrukcije u glavnom projektu propisuje dimenzije i klasu punog drva.
- Klasificiranje drva izvodi se vizualnom metodom prema normi HRN EN 14081-1.
- Klasifikaciju provodi osoba koja je educirana i osposobljena za provođenje radne operacije.
- Prilikom klasifikacije identificiraju se greške drva, mjere dimenzije drva i vlažnost drva te se nakon toga drvo razvrstava u pripadajući razred čvrstoće.
- Pri klasifikaciji vode se potrebni zapisi prema normi HRN EN 14081-1
- Prije izvođenja zaštite građevinskog drveta mora se svaki element potpuno završiti (bez okova), a poslije provedene zaštite nije dozvoljena nikakva dodatna obrada. Obavezno prije premazivanja očistiti građu od prašine, masnoća, prljavštine do stupnja da bude potpuno čist. Ukoliko je drvo ispucalo treba pukotine naročito dobro natopiti zaštitnim sredstvom. Premazivanje čelnih strana drveta dozvoljeno je samo sredstvima koja ne sprečavaju cirkulaciju zraka. Vrsta zaštitnog sredstva u pravilu se ne propisuje ali isti mora imati tražena svojstva. Drveni elementi iznad otvorene terase i krovne emplate dodatno de se zaštititi i mehanički kako elementi konstrukcije ne bi direktno bili izloženi utjecaju atmosferilija. Način zaštite propisat će se izvedbenim projektom. Oslanjanje drvenih nosača na zidove i stupove izvest će se preko podmetača (tvrdo drvo), a sve ostale površine su ventilirane.

### **Održavanje drvene konstrukcije**

- Održavanje drvene konstrukcije mora biti takvo da se tijekom trajanja građevine očuvaju njezina tehnička svojstva i ispunjavaju zahtjevi određeni ovim projektom i u njemu primijenjenim Propisima.

U okviru održavanja drvenu konstrukciju treba:

- a) redovito pregledati svakih deset godina
- b) izvanredno pregledati nakon kakvog izvanrednog događaja ili po zahtjevu inspekcije
- c) na konstrukciji izvoditi radove kojima se drvena konstrukcija zadržava ili vraća u stanje određeno projektom.

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## **A.B. ELEMENTI**

### **BETON**

Beton je građevni proizvod izrađen od cementa, agregata, dodataka betonu i vode. TPBK propisuje tehnička svojstva i druge zahtjeve za beton koji se ugrađuje u betonsku konstrukciju te način potvrđivanja sukladnosti betona.

Tehnička svojstva betona i materijala o kojih se beton proizvodi moraju biti specificirana prema TPBK i normi HRN EN 206-1, te normama i specifikacijama za materijale.

Svojstva svježeg betona specificira izvođač radova, ili su prema potrebi specificirana u projektu betonske konstrukcije. Proizvođač je odgovoran za proizvodnju i transport, a izvođač za ugradnju, zbijanje i njegu svježeg betona. Postupak njege betona provodi se prema HRN ENV 13670-1.

Najčešći pojmovi kojima se definiraju i mjere svojstva svježeg betona jesu: konzistencija, izdvajanje vode, segregacija, vrijeme vezivanja, homogenost, temperatura, količina pora.

Osnovni je cilj pri projektiranju sastava betona ostvariti takvu konzistenciju svježeg betona, da se beton uz raspoloživa transportna sredstva i sredstva za zbijanje, može uspješno ugraditi do propisane gustoće.

Ispitivanja svježeg betona trebaju biti učestala u početku proizvodnje određenog betona. Redovita kontrolna ispitivanja obuhvaćaju sljedeća svojstva: konzistencija, gustoća, temperatura, količina zraka. Analizom svježeg betona provjerava se stvarni sastav betona nakon miješanja u miješalici ili nakon dopreme do gradilišta, a sastoji se od provjere:

- količine vode u uzorku
- količine cementa

Svojstva očvrslog betona specificiraju se u projektu betonske konstrukcije. Obavezno se specificira razred tlačne čvrstoće te ostala svojstva po potrebi (otpornost na cikluse smrzavanja i odmrzavanja, vodonepropusnost itd.)

Tlačna čvrstoća betona je obavezno svojstvo koje se definira kod očvrsnulog betona. Za razvrstavanje se mogu upotrijebiti čvrstoća valjka promjera 150 mm i visine 300 mm ( $f_{ck,cyl}$ ) starosti 28 dana ili karakteristična čvrstoća kocke brida 150 mm ( $f_{ck,cube}$ ) starosti 28 dana. Proizvođač treba prije početka betoniranja odrediti prihvaća li se tlačna čvrstoća na osnovi ispitivanja kocaka ili valjaka. Ukoliko je predviđen drugačiji postupak, trebaju se usuglasiti uvjetovatelj (sastavljač specifikacije) i proizvođač. U posebnim slučajevima može se zahtijevati tlačna čvrstoća betona pri starosti betona manjoj ili većoj od 28 dana.

Za predviđenu betonsku konstrukciju i njene dijelove beton mora biti razreda tlačne čvrstoće: - C25/30.

Prema TPBK i normi HRN EN 206-1 zaštita armature od korozije u betonu postiže se izvedbom zahtijevanog zaštitnog sloja betona, izborom vrste cementa i ograničenjem maksimalne količine kloridnih iona u betonu. Jedna je od glavnih mjera zaštite armature od korozije, ali i povećanja trajnosti ostvarivanje kvalitetnog betona u području zaštitnog sloja, te projektiranje i izvedba debljine zaštitnog sloja.

Minimalna debljina zaštitnog sloja betona utvrđuje se u ovisnosti o razredu izloženosti te načinu armiranja elementa.

Djelovanje okoliša na konstrukciju, odnosno njene dijelove svrstava se u sedam razreda izloženosti (prema HRN EN 206-1). Zahtjevi za svaki razred izloženosti određuju se:

- dopuštenim tipom i razredom sastavnog materijala
- najvećim omjerom v/c
- najmanjim sadržajem cementa
- najmanjom tlačnom čvrstoćom betona

Za svaki pojedini razred izloženosti dane su preporuke za izbor graničnih vrijednosti sastava za predviđeni uporabni vijek konstrukcije od 50 godina te odgovaraju cementu tipa CEM I agregatu

nazivnog najvećeg zrna od 20 do 32 mm. Najmanji razredi čvrstoće su izvedeni iz odnosa omjera v/c i razreda čvrstoće betona proizvedenog s cementom razreda 32,50.

S obzirom na uvjete okoliša u kojima će se nalaziti betonska konstrukcija i njeni dijelovi svrstavamo je u razred izloženosti XC1 (zatvorena građevina).

Na osnovu razreda izloženosti određujemo i nazivnu veličinu zaštitnog sloja betona ( $c_{nom}$ ) prema izrazu:

$$c_{nom} = c_{min} + \Delta c \text{ (mm)}$$

gdje je:  $c_{min}$  – najmanja debljina zaštitnog sloja ovisna o razredu agresivnog djelovanja iz okoliša

$\Delta c$  – dopušteno odstupanje zaštitnog sloja

- debljina zaštitnog sloja betona  $c_{nom}$ :

- betonska konstrukcija iznad zemlje 3 cm

- beton temelja 5 cm

Potvrđivanje sukladnosti sastoji se od kontrole proizvodnje koju provodi proizvođač betona uz ovlašteno tijelo. Potvrđivanje sukladnosti je postupak kojim se potvrđuje da proizvedeni beton ima svojstva prema tehničkoj specifikaciji HRN EN 206-1, prema Prilogu "A" TPBK što je potrebno dokumentirati.

Za betone i betonske proizvode proizvedene na gradilištu, a u skladu sa projektom betonske konstrukcije, potrebno je dokazati uporabljivost u skladu sa projektom betonske konstrukcije i TPBK.

Osim isprave o sukladnosti isporučeni građevni proizvod mora pratiti otpremnica koja sadrži podatke propisane u Prilogu "A". Uzimanje uzoraka, priprema ispitnih uzoraka i ispitivanje svojstava svježeg betona provodi se prema normama niza HRN EN 12350, a ispitivanje svojstava očvrslog betona prema normama niza HRN EN 12390.

Kada se betonara nalazi na gradilištu pri uzimanju uzoraka i potvrđivanju sukladnosti betona u gradilišnoj dokumentaciji i ostaloj dokumentaciji ispitivanja navodi se obavezno oznaka pojedinačnog elementa betonske konstrukcije i mjesta u elementu betonske konstrukcije na kojem je ugrađen beton iz kojeg je uzet uzorak.

Označavanje betona u projektnim specifikacijama proizvođačevim izjavama i sličnim dokumentima treba provoditi prema uputama poglavlja 11 norme HRN EN 206-1 koje se svode na obavezno navođenje norme HRN EN 206-1 i skraćenica specificiranih svojstava (razred tlačne čvrstoće, granične vrijednosti prema razredima izloženosti, najveće količine klorida, najveće nazivne gornje veličine zrna agregata, gustoće, konzistencije itd.).

Izvođenje i održavanje betonskih konstrukcija obuhvaćeno je Prilogom "J" TPBK-a.

Pri izvođenju betonske konstrukcije izvođač je dužan pridržavati se projekta betonske konstrukcije i tehničkih uputa za ugradnju i uporabu građevnih proizvoda i odredaba TPBK-a.

Postignuta propisana svojstva i uporabljivost građevnog proizvoda izrađenog na gradilištu izvođač treba zapisivati sukladno posebnim propisima o vođenju građevinskog dnevnika.

Zabranjena je ugradnja građevnog proizvoda koji je isporučen bez oznake s posebnim propisom, bez tehničke upute za ugradnju i uporabu i koji nema svojstva zahtijevana projektom ili mu je istekao rok uporabe, odnosno čiji podaci značajni za ugradnju, uporabu i utjecaj na svojstva i trajnost betonske konstrukcije nisu sukladni podacima određenim glavnim projektom.

Ugradnju građevnog proizvoda mora odobriti nadzorni inženjer što zapisuje u skladu s posebnim propisom o načinu vođenja građevinskog dnevnika.

## ARMATURA I ČELIK ZA ARMIRANJE

Tehnička svojstva i drugi zahtjevi, te dokazivanje uporabljivosti armature provodi se prema projektu betonske konstrukcije.

Tehnička svojstva i drugi zahtjevi, te potvrđivanje sukladnosti armature proizvedene prema tehničkoj specifikaciji (normi ili tehničkom dopuštenju) provodi se prema toj specifikaciji, prema normama iz Priloga "B" TPBK-a i normama na koje one upućuju, te u skladu s odredbama posebnog propisa.

Tehnička svojstva armature moraju ispunjavati opće i posebne zahtjeve bitne za krajnju namjenu i ovisno o vrsti čelika moraju biti specificirana prema normama nizova nHRN EN 10080 odnosno nHRN EN:10138 i odredbama Priloga "B" TPBK-a.

Armatura se izrađuje odnosno proizvodi kao armatura za armirane betonske konstrukcije, od čelika za armiranje.

Tehnička svojstva armature, čelika za armiranje specificiraju se u projektu betonske konstrukcije odnosno u tehničkoj specifikaciji za taj proizvod.

Dokazivanje uporabljivosti armature izrađene prema projektu betonske konstrukcije provodi se prema tom projektu te odredbama Priloga "B" TPBK-a, i uključuje zahtjeve za:

- a) izvođačevom kontrolom izrade i ispitivanja armature
- b) nadzorom proizvodnog pogona i nadzorom izvođačeve kontrole izrade armature, na način primjeren postizanju tehničkih svojstava betonske konstrukcije, a u skladu s ovim TPBK

Potvrđivanje sukladnosti armature proizvedene prema tehničkoj specifikaciji provodi se prema odredbama te specifikacije, te odredbama Priloga "B" TPBK-a i posebnog propisa. Potvrđivanje sukladnosti čelika za armiranje provodi se prema sustavu ocjenjivanja 1+ te prema normi HRN EN 10080.

Armatura proizvedena prema tehničkoj specifikaciji označava na otpremnici i na oznaci prema odredbama te specifikacije. Oznaka mora obvezno sadržavati upućivanje na tu specifikaciju, a u skladu s posebnim propisom.

Čelik za armiranje označava se na otpremnici i na oznaci prema odgovarajućim normama. Oznaka mora obvezno sadržavati upućivanje na tu normu, a u skladu s posebnim propisom.

Uzimanje uzoraka, priprema ispitnih uzoraka i ispitivanje svojstava čelika za armiranje provodi se prema odgovarajućim normama. Ako je armatura sklop čelika za armiranje i drugog čeličnog proizvoda (čelični lim, čelični profil, čelična cijev i sl.) uzimanje uzoraka i priprema ispitnih uzoraka za mehanička ispitivanja tih čeličnih proizvoda provodi se prema odgovarajućim normama.

- Pri ugradnji armature treba odgovarajuće primijeniti pravila određena Prilogom »J« TPBK-a te:
- pojedinosti koje se odnose na ugradnju armature,
  - pojedinosti koje se odnose na sastavne materijale od kojih se armatura izrađuje te norme kojima se potvrđuje sukladnost tih proizvoda,
  - pojedinosti koje se odnose na uporabu i održavanje, dane projektom betonske konstrukcije i/ili tehničkom uputom za ugradnju i uporabu.

Pri izradi ili proizvodnji armature treba poštivati pravila armiranja prema Prilogu »I« TPBK-a.

Armatura od čelika za armiranje ima nastavke u obliku prijeklopa, zavara ili mehaničkog spoja. Oni se proizvode i potvrđuje im se sukladnost prema tehničkoj specifikaciji ili se izrađuju prema projektu betonske konstrukcije.

Armatura izrađena prema projektu betonske konstrukcije smije se ugraditi u betonsku konstrukciju ako je sukladnost čelika, zavara, mehaničkih spojeva, spojki potvrđena ili ispitana na način određen Prilogom "B" TPBK-a i ako ispunjava zahtjeve projekta betonske konstrukcije.

Prije ugradnje armature provode se odgovarajuće nadzorne radnje određene normom HRN ENV 13670-1, te druge kontrolne radnje određene Prilogom »J« TPBK-a.

## CEMENT

Tehnička svojstva i drugi zahtjevi, te potvrđivanje sukladnosti cementa, određuje se odnosno provodi prilogu "C" TPBK.

Tehnička svojstva cementa specificiraju se u projektu betonske konstrukcije.

## AGREGAT

Agregat je granulirani materijal koji se upotrebljava za izradu betona. Agregat može biti prirodni, umjetni (industrijski proizveden) ili recikliran od materijala prethodno upotrijebljenih u građevni.

Tehnička svojstva i drugi zahtjevi, te potvrđivanje sukladnosti agregata određuje se odnosno provodi, prema normama na koje upućuje prilog "D" TPBK-a.

Odredbe Priloga "D" TPBK-a primjenjuju se na agregat koji je sastavni dio betona iz Priloga "A" TPBK-a. Obični agregat je agregat za beton gustoće čestica veće od 2000 kg/m<sup>3</sup>. Lagani agregat je agregat gustoće zrna ne veće od 2000 kg/m<sup>3</sup> ili nasipom gustoćom ne većom od 1200 kg/m<sup>3</sup> proizveden preradom prirodnih, industrijski proizvedenih ili recikliranih materijala.

Tehnička svojstva agregata za beton moraju ispunjavati, ovisno o podrijetlu agregata, opće i posebne zahtjeve bitne za krajnju namjenu u betonu i moraju biti specificirana prema normama priloga "D" TPBK-a.

Potvrđivanje sukladnosti agregata za beton provodi se prema odredbama Dodatka ZA norme HRN EN 12620 i odredbama posebnog propisa ako Prilogom "D" TPBK-a nije drugačije određeno.

Potvrđivanje sukladnosti laganog agregata za beton provodi se prema odredbama Dodatka ZA norme HRN EN 13055-1 te odredbama Priloga "D" TPBK-a i posebnog propisa.

Agregat za beton označava se na otpremnici i na pakovini prema normi HRN EN 12620. Oznaka mora obvezno sadržavati upućivanje na tu normu, a u skladu s posebnim propisom.



Lagani agregat za beton označava se na otpremnici i na pakovini prema normi HRN EN 13055-1. Oznaka mora obvezno sadržavati upućivanje na tu normu, a u skladu s posebnim propisom.

Ispitivanje svojstava, ovisno o vrsti agregata za beton i laganog agregata za beton, provodi se prema normama niza HRN EN 932, HRN EN 933, HRN EN 1097, HRN EN 1367 i HRN EN 1744, i odredbama Priloga "D" TPBK-a

Uzimanje i priprema uzoraka za ispitivanje svojstava, ovisno o vrsti agregata za beton i laganog agregata za beton, provodi se prema normama niza HRN EN 932, HRN EN 933, HRN EN 1097, HRN EN 1367 i HRN EN 1744, i odredbama Priloga "D" TPBK-a.

Kontrola agregata provodi se u centralnoj betonari (tvornici betona), u betonari pogona za predgotovljene betonske elemente i u betonari na gradilištu prema normi HRN EN 206-1. Kontrola agregata provodi se odgovarajućom primjenom normi iz točke D.3.1. Priloga "D" TPBK-a.

Proizvođač i distributer agregata te proizvođač betona dužni su poduzeti odgovarajuće mjere u cilju održavanja svojstava agregata tijekom rukovanja, prijevoza, pretovara i skladištenja prema Dodatku "H" norme HRN EN 12620, odnosno Dodatku "F" norme HRN EN 13055-1.

## VODA

Tehnička svojstva i drugi zahtjevi, te potvrđivanje prikladnosti vode određuju se odnosno provodi prema normi HRN EN 1008:2002.

Tehnička svojstva vode za primjenu u betonu moraju ispunjavati opće i posebne zahtjeve bitne za svojstva betona i moraju se specificirati prema normi HRN EN 1008, normama na koje ta norma upućuje i odredbama Priloga "F" TPBK-a.

Potvrđivanje prikladnosti provodi se u skladu s odredbama norme HRN EN 1008, i odredbama Priloga "F" TPBK-a. Za pitku vodu iz vodovoda nije potrebno provoditi potvrđivanje prikladnosti za pripremu betona. Morska i bočata voda nisu prikladne za pripremu betona za armirane betonske konstrukcije. Ispitivanje sadržaja i granične količine štetnih tvari u vodi i utjecaja tih voda na svojstva svježeg i očvrsnulog betona provodi se i određuje prema normi HRN EN 1008 i normama na koje ta norma upućuje, te odredbama Priloga "F" TPBK-a.

Ispitivanje uporabivosti prikladnosti vode provodi se prije prve uporabe, te u slučaju kada je došlo do promjene u koncentraciji štetnih tvari u vodi u slučaju kada postoji sumnja da je došlo do promjene u njenom sastavu.

Kontrola vode provodi se u centralnoj betonari (tvornici betona), betonari na gradilištu prije prve uporabe te u slučaju kada postoji sumnja da je došlo do promjene njezinih svojstava.

Kontrola u slučaju kada postoji sumnja da je došlo do promjene svojstava vode provodi se odgovarajućom primjenom norme HRN EN 1008 i normama na koje ta norma upućuje.

## IZVOĐENJE BETONSKIH KONSTRUKCIJA

Izvođenje betonskih konstrukcija, nadzorne radnje i kontrolni postupci na gradilištu treba provoditi sukladno Prilogu "J".

## PRIMJENA ZAKONSKIH ZAHTJEVA NA IZVEDBU BETONSKIH RADOVA

Izvođač betonskih radova sukladno odredbama važećeg Zakona o gradnji i odredbama TPBK dužan je provoditi sljedeće:

- ugrađivati beton u skladu sa Zakonom (prema TPBK-u – Prilog "J", normi HRN EN 13670-1, normi HRN EN 206-1 i tehničkoj uputi proizvođača betona)
- osigurati dokaze o uporabivosti ugrađenih betona (pribaviti proizvođačevu izjavu o sukladnosti betona i tehničku uputu za ugradnju i uporabu)
- provjeravati sadržavaju li dostavnice za isporučeni beton, oznaku i sve podatke o tehničkim svojstvima isporučenog betona prema TPBK-u, normi HRN EN 206-1 i pravilniku o ocjenjivanju sukladnosti, ispravama o sukladnosti i označavanju građevnih proizvoda te jesu li ti podaci u skladu s podacima o specifikaciji narudžbe betona
- podatke o isporuci i preuzimanju betona zapisivati u građevinski dnevnik
- izjave o sukladnosti betona, tehničke upute za ugradnju i uporabu, specifikacije narudžbi betona i dostavnice isporučenog betona pohranjivati među dokaze o sukladnosti građevnih proizvoda koje proizvođač treba imati na gradilištu
- osigurati isprave o sukladnosti betonske konstrukcije s bitnim zahtjevima za građevinu (izvještaj o ispitivanju mehaničke otpornosti i stabilnosti konstrukcije pokusnim opterećenjem za konstrukcije za koje je to propisano tehničkim propisom)

- osigurati dokaze kvalitete betona tijekom izvođenja betonskih radova (zapis rezultata, ispitivanja svježeg i očvrslog betona na mjestu ugradnje te zapise o provedenim procedurama kontrole kvalitete betona, najmanje u skladu s TPBK-om Prilog "J", točka J.2.1, ako projektom konstrukcije nisu određeni drugi zahtjevi za učestalost ispitivanja i/ili dodatna ispitivanja)

- sastaviti pisanu izjavu o izvedenim betonskim radovima (uz ostale vrste radova) i o uvjetima održavanja betonske konstrukcije

Obzirom da se radi o jednostavnoj građevini (< 2 kata) prema normi HRN EN 206-1 svrstavamo je u razred nadzora 1

Za jednostavne građevine u razredu nadzora 1 norma HRN ENV 13670-1 dodatak G predviđa provjeru otpremnice i vizualni pregled.

Prema zahtjevima Prilog "J" TPBK-a propisan je najmanji opseg kontrolnih postupaka utvrđivanja svojstava betona na gradilištu:

- pregled podataka na dostavnici, vizualni pregled isporučenog betona i ovjera dostavnice, neposredno prije ugradnje

- uzorkovanja i ispitivanja potrebna za utvrđivanje svojstava svježeg betona na mjestu ugradnje (u slučaju sumnje, konzistencija i količina zraka, uključujući zapis)

- uzorkovanja na mjestu ugradnje potrebna za laboratorijska ispitivanja tlačne čvrstoće betona (uključujući i zapis o uzorkovanju)

- laboratorijska ispitivanja tlačne čvrstoće betona

Kontrolni postupak utvrđivanja tlačne čvrstoće betona na gradilištu provodi se primjenom kriterija za utvrđivanja istovjetnosti tlačne čvrstoće prema prilogu J TPBK.

Kontrola kvalitete betona obuhvaća:

- kontrolu proizvodnje betona u tvornici betona koja se obavlja u skladu sa zahtjevima 9. točke norme HRN 206-1, prema planu uzorkovanja, a obavlja je proizvođač betona do vremena predaje betona izvođaču radova

- kontrola kvalitete na gradilištu obavlja izvođač radova od vremena preuzimanja betona od proizvođača do završetka njega ugrađenog betona. U okviru ove kontrole uključeno je i mjerenje konzistencije svježeg betona i kontrola istovjetnosti tlačne čvrstoće u skladu s normom HRN EN 206-1.

Kontrola svojstava svježeg betona na mjestu ugradnje obuhvaća sljedeće radnje:

- pregled svake otpremnice

- vizualna kontrola konzistencije kod svake dopreme betona

- u slučaju opravdane sumnje ispitivanje konzistencije prema normi HRN EN 12350-2 (ispitivanje svježeg betona slijeganjem) o čemu treba voditi evidenciju

o Ispitivanje očvrsnulog betona sastoji se:

- tlačne čvrstoće prema normi HRN EN 12390-2 (uzorci će se uzimati i njegovati u skladu s normom HRN EN 12390-2, oblika 15x15x15 cm, ispitivanja će se evidentirati redoslijedom uzimanja uzoraka)

- minimalni broj uzoraka je za svaku vrstu betona 1 uzorak na 100 m<sup>3</sup> betona

Njega betona je jedan od najvažnijih koraka u izradi betona. To je međutim često jedan od najzanemarljivijih koraka. Nepravilna ili nezadovoljavajuća njega može rezultirati sa sniženjem čvrstoće betona i otpornosti na abraziju i atmosferilije.

Zaštita betona od naglog površinskog isušivanja mora započeti već u prvim satima nakon ugradbe. Intenzivna njega mora trajati najmanje sedam dana. Ako se njega provodi vodom onda njena temperatura ne smije biti niža od temperature betona jer će u suprotnom doći do stvaranja termičkih pukotina po površini.

Ako se zaštita provodi kemijskim premazima koji su obično na bazi voskova, onda se mora prethodno provjeriti njihovo djelovanje na beton i ako na taj beton dolaze neki novi slojevi ili ostaje vidljiv, da li i za koje vrijeme taj premaz razgrađuje beton.

## Oplata

Oplata se mora projektirati i konstruirati (prema normi HRN ENV 13670-1) tako da je:

- |  |
|--|
| <p><b>1. otporna na svako djelovanje tijekom izvedbe</b></p> <p><b>2. dovoljno čvrsta da osigurava zadovoljenje dopuštenih odstupanja specificiranih za konstrukciju i da ne utječe na cjelovitost zadanog konstruktivnog elementa</b></p> |
|--|

Oplata mora držati beton u zahtijevanom obliku sve dok ne očvrsne. Spojevi između dasaka ili panela moraju dovoljno brtviti kako bi spriječili gubitak finog morta. Unutarnja površina oplate mora biti čista. Oplatu treba prije betoniranja navlažiti kako bi se spriječio gubitak vode iz betona

## Armatura

Čelik za armiranje i armatura koja se od njega izrađuje moraju zadovoljavati niz normi na koje upućuje Prilog "B" TPBK-a.

Prilikom transporta i uskladištenja čelika ne smije doći do mehaničkih oštećenja, lomova na mjestu zavarivanja i prljavštine koja može smanjiti adheziju, kao i do gubitka oznaka i smanjenja presjeka zbog korozije. Armatura se savija u hladnom stanju i nastavlja na način određen projektom konstrukcije. Prije postavljanja, armatura se mora očistiti od prljavštine i masnoća.

Nastavljanje armature zavarivanjem dozvoljeno je samo na ravnim dijelovima. Udaljenost zavara od početka krivine mora iznositi najmanje 10 Ø presjeka.

Ako se armatura postavlja na tlo, postavlja se izravnavajući sloj betona debljine najmanje 10cm. Pri ugrađivanju pocinčanih elemenata ne smije doći do kontakta tih elemenata s armaturom. Prije početka betoniranja mora se zapisnički utvrditi da li montirana armatura zadovoljava uvijete u pogledu:

- Presjeka, broja šipki i geometrije ugrađene armature predviđene projektom konstrukcije
- Učvršćivanja armature u oplati
- Mehaničkih karakteristika (granica razvlačenja i granica kidanja)

Armaturu koja je umazana cementnim malterom ili betonom potrebno je prije ugradnje betona očistiti.

### Ugradnja betona

Ako se ugrađivanje betona prekida zbog nepredviđenih prilika, moraju se poduzeti mjere da takav prekid ugrađivanja betona ne utječe štetno na nosivost i ostala svojstva konstrukcije, odnosno elemenata. Ako prekid ugrađivanja nije izveden na način predviđen u projektu, izvođač radova mora na mjestu prekida očistiti površinu betona, a po potrebi i ukloniti beton kako bi se dobila površina pogodna za nastavljivanje daljnjeg ugrađivanja betona. Početna temperatura svježeg betona u fazi ugradnje ne smije biti niža od 5°C. Najviša temperatura svježeg betona koji se ne ugrađuje posebnim postupcima predviđenim za temperirane betone ne smije biti viša od 30°C.

Beton se mora transportirati i ubacivati u oplatu na način i pod uvjetima koji sprečavaju segregaciju betona i promjene u sastavu i svojstvima betona.

U konstrukciju se mora ugrađivati beton takove konzistencije da se može kvalitetno ugraditi do zahtijevane zapreminske mase i zbijati predviđenim mehaničkim sredstvima za ugrađivanje. Svježem betonu se ne smije naknadno dodavati voda.

Visina slobodnog pada betona ne smije biti veća od 1.50m, ako nisu poduzete potrebne mjere za sprječavanje segregacije betona.

Beton se unosi u slojevima ne višim od 70 cm. Naredni sloj mora se ugraditi u vremenu koje osigurava spajanje betona s prethodnim slojem. Ugrađivanje betona u više slojeva izvodi se tako da gornji sloj vibrira, a donji sloj revibrira.

### Nadzor

Provođenje nadzora provodi se sukladno Zakonu o prostornom uređenju i gradnji NN 76/07, normom HRN ENV 13670-1 – izvedba betonskih konstrukcija, TPBK-om i svim ostalim normama i zakonima te pravilnicima koji su vezani uz građenje.

Norma HRN ENV 13670-1 definira:

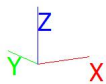
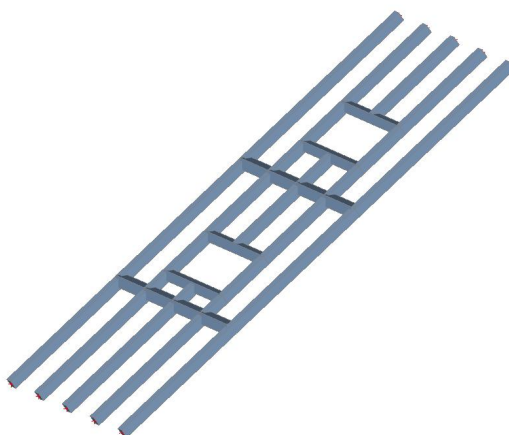
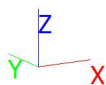
- razred nadzora
- nadzor materijala i proizvoda
- područje nadzora izvedbe
- nadzor skele i oplata
- nadzor armature
- nadzor prije betoniranja
- nadzor predgotovljenih elemenata
- djelovanje u slučaju nesukladnosti

### PROJEKTIRANI VIJEK I ODRŽAVANJE ARMIRANO BETONSKE KONSTRUKCIJE


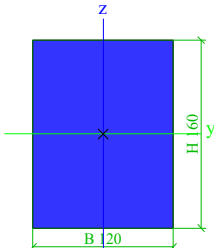

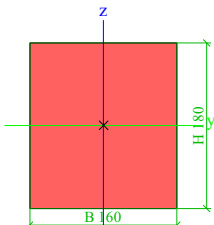
Sukladno normi HRN ENV 1991-1:2005 projektirani vijek konstrukcije u ovisnosti o tlačnoj čvrstoći (C25/30) i razredu izloženosti (XC1) iznosi 50 godina.

INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
FAZA PROJEKTA:	Glavni projekt – građevinski projekt
BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

## 1. Model krovišta




## 2. Poprečni-presjeci

Rogovi		
Vrsta	RECT	
Detaljno	120; 160	
Vrsta oblika	Masivni	
materijal predmeta	C24 (EN 338)	
Proizvodnja	drvo	
Boja		
A [m <sup>2</sup> ]	1,9200e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	1,6025e-02	1,6014e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	5,6000e-01	5,6000e-01
C <sub>Y,UCS</sub> [mm], C <sub>Z,UCS</sub> [mm]	60	80
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	4,0960e-05	2,3040e-05
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	46	35
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	5,1200e-04	3,8400e-04
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	6,2738e-04	4,7054e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	1,32e+04	1,32e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	9,88e+03	9,88e+03
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	4,9814e-05	4,5711e-09
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Slika		
Podgrožnice		
Vrsta	RECT	
Detaljno	160; 180	
Vrsta oblika	Masivni	
materijal predmeta	C24 (EN 338)	
Proizvodnja	drvo	
Boja		
A [m <sup>2</sup> ]	2,8800e-02	
A <sub>y</sub> [m <sup>2</sup> ], A <sub>z</sub> [m <sup>2</sup> ]	2,4026e-02	2,4021e-02
A <sub>L</sub> [m <sup>2</sup> /m], A <sub>D</sub> [m <sup>2</sup> /m]	6,8000e-01	6,8000e-01
C <sub>Y,UCS</sub> [mm], C <sub>Z,UCS</sub> [mm]	80	90
α [deg]	0,00	
I <sub>y</sub> [m <sup>4</sup> ], I <sub>z</sub> [m <sup>4</sup> ]	7,7760e-05	6,1440e-05
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	52	46
W <sub>el,y</sub> [m <sup>3</sup> ], W <sub>el,z</sub> [m <sup>3</sup> ]	8,6400e-04	7,6800e-04
W <sub>pl,y</sub> [m <sup>3</sup> ], W <sub>pl,z</sub> [m <sup>3</sup> ]	1,0587e-03	9,4107e-04
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	2,22e+04	2,22e+04
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	1,98e+04	1,98e+04
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0
I <sub>t</sub> [m <sup>4</sup> ], I <sub>w</sub> [m <sup>6</sup> ]	1,1571e-04	5,2152e-09
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0
Slika		

Objašnjenja simbola	
A	Površina
A <sub>y</sub>	Površina posmika u glavnom y-smjeru - Proračunato po 2D MKE analizi
A <sub>z</sub>	Površina posmika u glavnom z-smjeru - Proračunato po 2D MKE analizi
A <sub>L</sub>	Opseg po jedinici duljine
A <sub>D</sub>	Površina Sušenje po jedinici duljine
C <sub>Y.UCS</sub>	Težište koordinirata u Y-smjeru unosa
C <sub>Z.UCS</sub>	Težište koordinirata u Z-smjeru unosa
I <sub>Y.LCS</sub>	Drugi moment površine oko YLKS osi
I <sub>Z.LCS</sub>	Drugi moment površine oko ZLKS osi
I <sub>YZ.LCS</sub>	Trenutak Proizvod prostora u LCS sustav
α	Kut zakretanja glavne osi sustava
I <sub>y</sub>	Drugi moment površine oko glavne y-osi
I <sub>z</sub>	Drugi moment površine oko glavne z-osi
i <sub>y</sub>	Radius giracije o glavnoj osi y
i <sub>z</sub>	Radius giracije o glavnoj osi z
W <sub>el,y</sub>	Modula elastičnosti sekcije o glavnoj osi y
W <sub>el,z</sub>	Modula elastičnosti sekcije o glavnoj osi z
W <sub>pl,y</sub>	Plastika Moment otpora o glavnoj osi y
W <sub>pl,z</sub>	Plastika Moment otpora o glavnoj osi z
M <sub>pl,y,+</sub>	Plastični trenutak o glavnoj osi y za pozitivan moj trenutak
M <sub>pl,y,-</sub>	Plastični trenutak o glavnoj osi y za negativnu moj trenutak
M <sub>pl,z,+</sub>	Plastični trenutak o glavnom z-osi za pozitivan MZ trenutku
M <sub>pl,z,-</sub>	Plastični trenutak o glavnom z-osi za negativnu MZ trenutku
d <sub>y</sub>	Koordinata središta posmika u glavnom y-smjeru mjereno iz težišta - Proračunato po 2D MKE analizi
d <sub>z</sub>	Koordinata središta posmika u glavnom z-smjeru mjereno iz težišta - Proračunato po 2D MKE analizi
I <sub>t</sub>	Konstanta torzije - Proračunato po 2D MKE analizi
I <sub>w</sub>	Konstanta vitoperenja - Proračunato po 2D MKE analizi
β <sub>y</sub>	Mono-simetrija stalna o glavnoj osi y
β <sub>z</sub>	Mono-simetrija stalna o glavnoj osi z

### 3. Materijali

Drvo EC5

Naziv	Vrsta drveta	μ	E <sub>mod</sub> [MPa]	f <sub>m,k</sub> [MPa]	f <sub>t,0,k</sub> [MPa]	f <sub>t,90,k</sub> [MPa]	f <sub>c,0,k</sub> [MPa]	f <sub>c,90,k</sub> [MPa]	f <sub>v,k</sub> [MPa]	Boja
	ρ [kg/m³]	α [m/mK]	G <sub>mod</sub> [MPa]							
C24 (EN 338)	Čvrst	0	1,1000e+04	24,0	14,5	0,4	21,0	2,5	4,0	
	420,0	0,00	6,9000e+02							

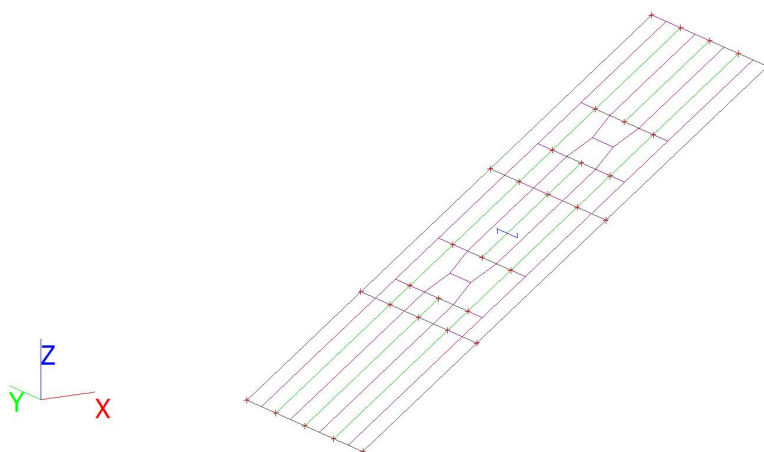
## 4. Opterećenje

### 4.1. Opterećenje - LC1

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Smjer
	Spec	Vrsta opterećenja		
LC1	Self weight	Trajno Vlastita težina	LG1	-Z

#### 4.1.

##### 4.1.1. LC2 / Tot. value

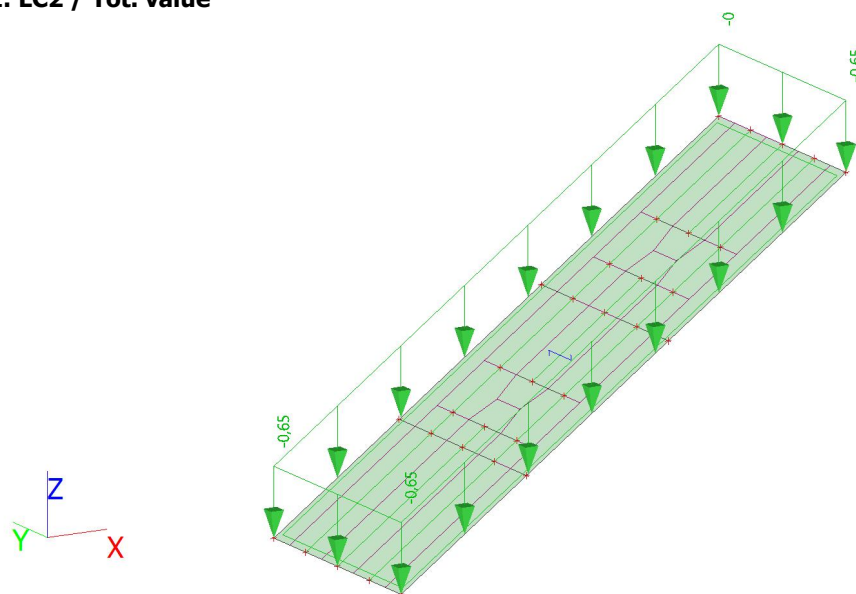


### 4.2. Opterećenje - LC2

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja
	Spec	Vrsta opterećenja	
LC2	Dodatno stalno opterećenje	Trajno	LG1
		Standardno	

#### 4.2.

##### 4.2.1. LC2 / Tot. value

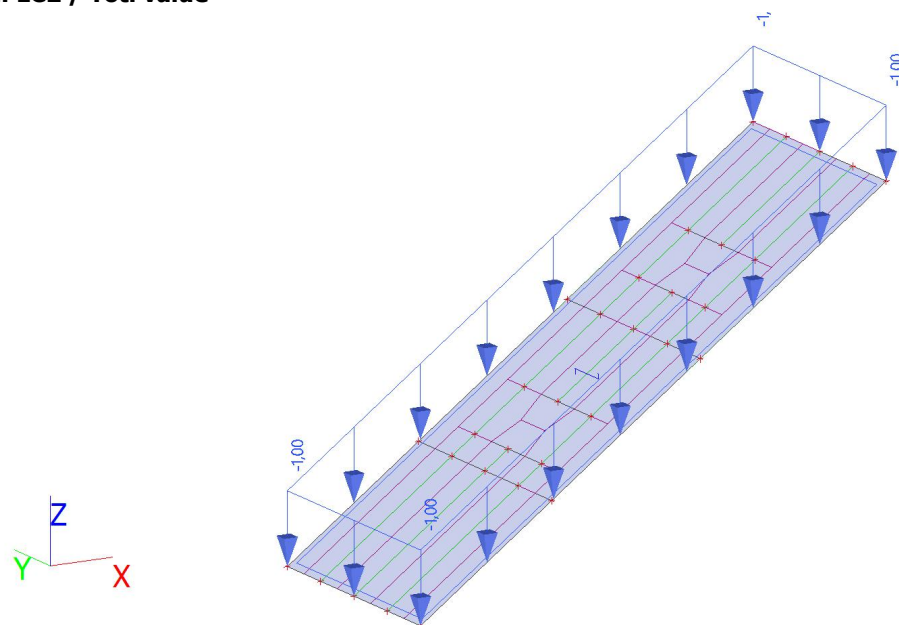


### 4.3. Opterećenje - LC3

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC3	Snijeg	Varijabla	LG2	Ne postoji
	Snijeg	Stat.		

### 4.3.

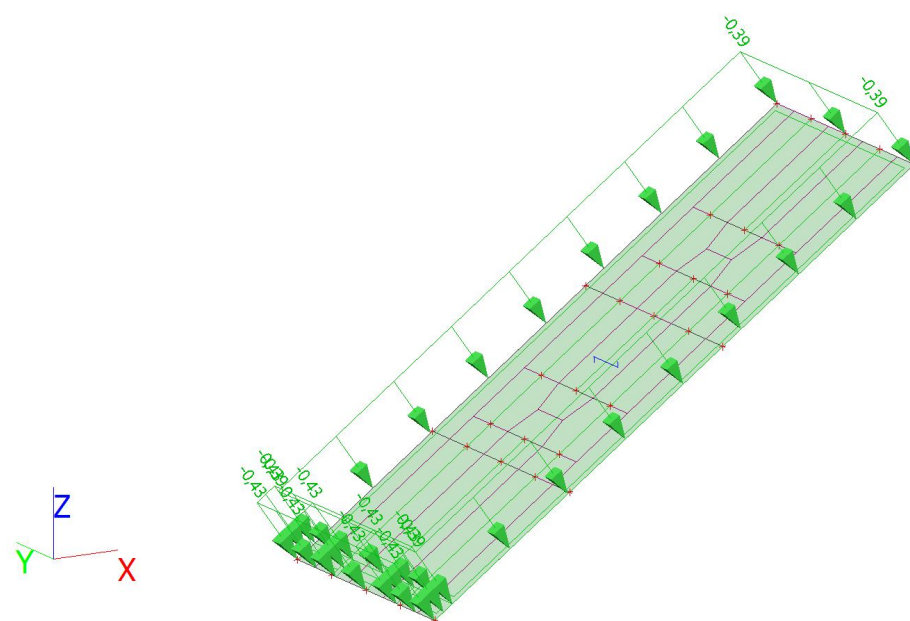
#### 4.3.1. LC2 / Tot. value



### 4.4. Opterećenje - LC4

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC4	Vjetar	Varijabla	LG3	Ne postoji
	Statički vjetar	Stat.		

#### 4.4.1. LC2 / Tot. value





## 5. Unutarnje sile

### 5.1. Unutarnje sile - LC1

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Smjer
	<b>Spec</b>	<b>Vrsta opterećenja</b>		
LC1	Self weight	Trajno Vlastita težina	LG1	-Z

#### 5.1.

##### 5.1.1. 1D internal forces; $M_y$

Values:  $M_y$

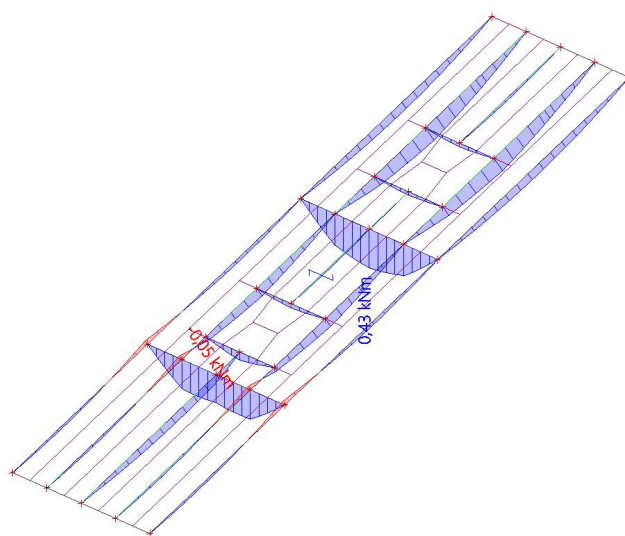
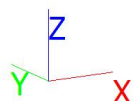
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



##### 5.1.2. 1D internal forces; $N$

Values:  $N$

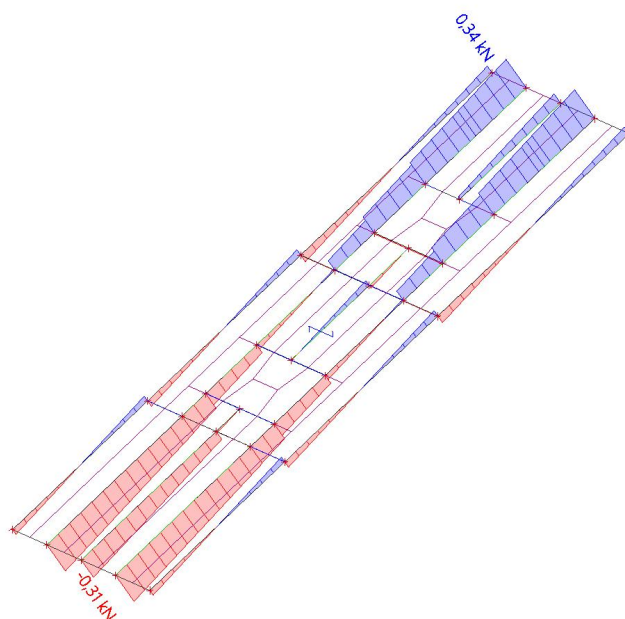
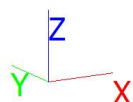
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.1.3. 1D internal forces; $V_z$

Values:  $V_z$

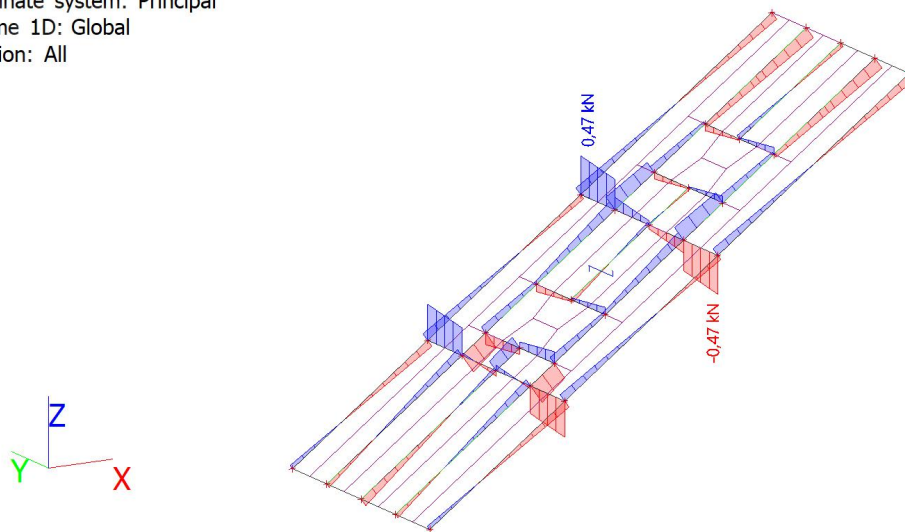
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 5.2. Unutarnje sile - LC2

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja
	<b>Spec</b>	<b>Vrsta opterećenja</b>	
LC2	Dodatno stalno opterećenje	Trajno	LG1
		Standardno	

## 5.2.

### 5.2.1. 1D internal forces; $M_y$

Values:  $M_y$

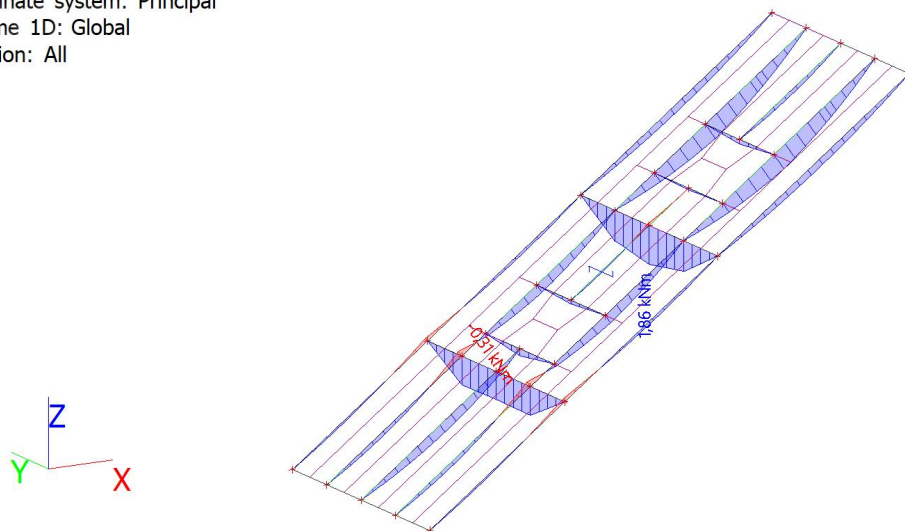
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.2.2. 1D internal forces; N

Values: **N**

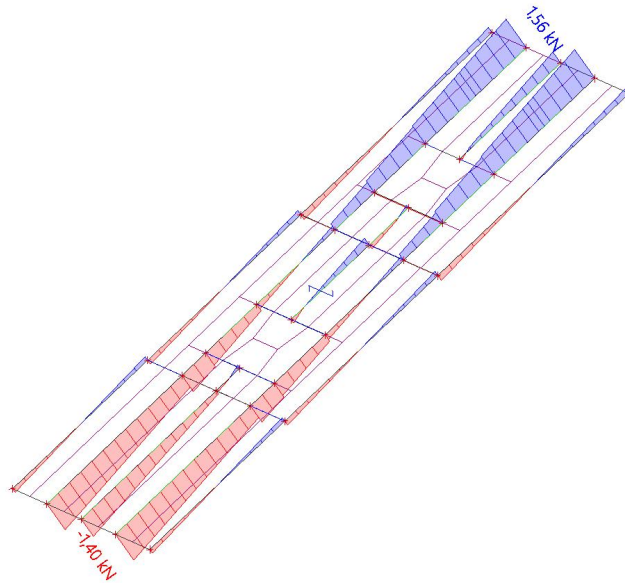
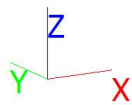
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.2.3. 1D internal forces; V<sub>z</sub>

Values: **V<sub>z</sub>**

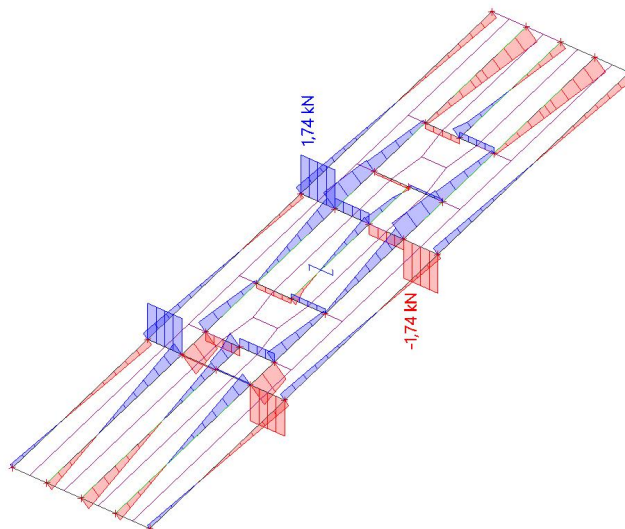
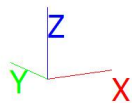
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.3. Unutarnje sile - LC3

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC3	Snijeg	Varijabla	LG2	Ne postoji
	Snijeg	Stat.		

### 5.3.

#### 5.3.1. 1D internal forces; $M_y$

Values:  $M_y$

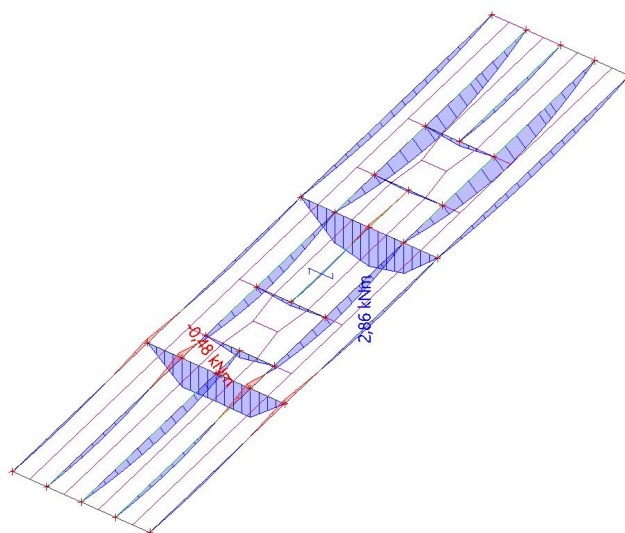
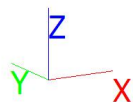
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 5.3.2. 1D internal forces; $N$

Values:  $N$

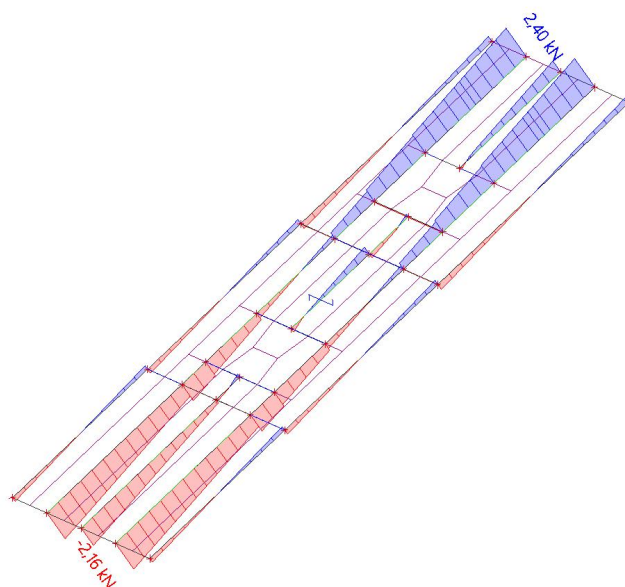
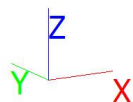
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.3.3. 1D internal forces; $V_z$

Values:  $V_z$

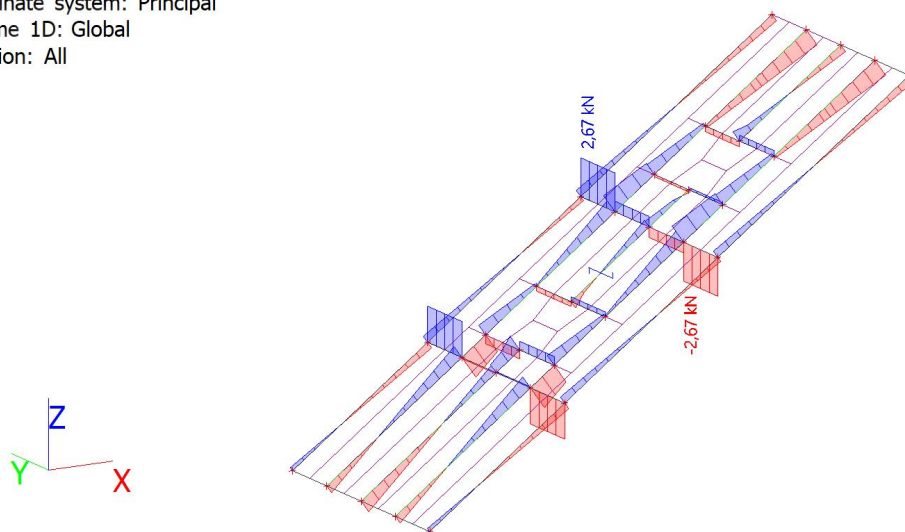
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.4. Unutarnje sile - LC4

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC4	Vjetar	Varijabla	LG3	Ne postoji
	Statički vjetar	Stat.		

### 5.4.

#### 5.4.1. 1D internal forces; $M_y$

Values:  $M_y$

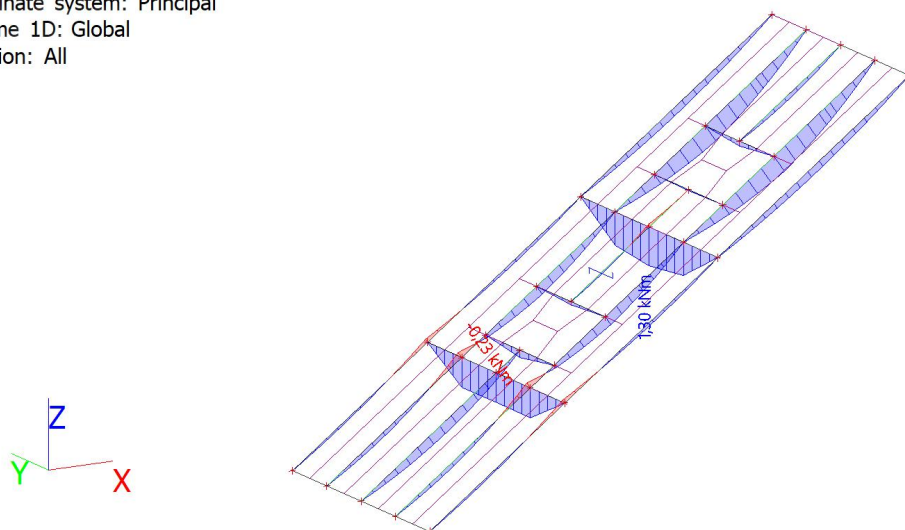
Linear calculation

Load case: LC4

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.4.2. 1D internal forces; N

Values: **N**

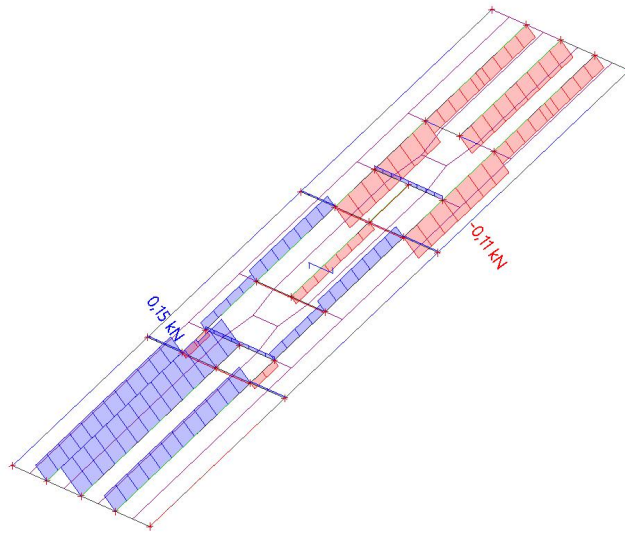
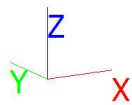
Linear calculation

Load case: LC4

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 5.4.3. 1D internal forces; V<sub>z</sub>

Values: **V<sub>z</sub>**

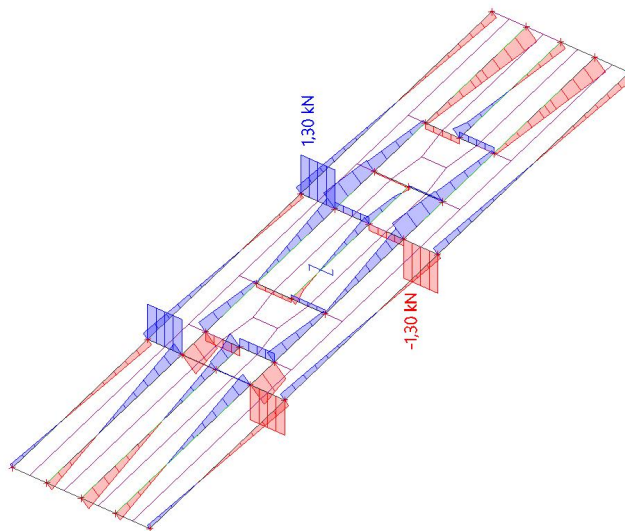
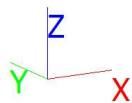
Linear calculation

Load case: LC4

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 6. Dimenzioniranje rogova

Linearni proračun, Ekstrem : Globalni

Odabir : Svi

Kombinacije : ULS-Set B (auto)

Poprečni presjek : Rogovi - RECT (120; 160)

HR 1995/01/01 kod Check

<b>Greda B36</b>	<b>1,788 m</b>	<b>Rogovi - RECT (120; 160)</b>	<b>C24 (EN 338)</b>	<b>ULS-Set B (auto)</b>	<b>0,51 -</b>
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### Kombinacijski ključ

ULS-Set B (auto) / 1.35\*LC1 + 1.35\*LC2 + 1.50\*LC3 + 0.75\*LC4

### Osnovni podaci

Djelomična faktor sigurnosti  $\gamma_{f1}$  gamma\_M za Solid drva 1,30

### Materijal podataka

Savijanje (fm,k)	24,0	MPa
Vlak (ft,0,k)	14,5	MPa
Vlak (ft,90,k)	0,4	MPa
Kompresija (F_c, 0, k)	21,0	MPa
Kompresija (F_c, 90, k)	2,5	MPa
Posmik (fv,k)	4,0	MPa
Vrsta drveta	Čvrst	

Provjera kritičnog je na poziciji **0,000** m.

### Unutarnje sile

NEd	3,88	kN
Vy,Ed	0,00	kN
Vz,Ed	-0,55	kN
TEd	0,00	kNm
My,Ed	4,14	kNm
Mz,Ed	0,00	kNm

### faktor modifikacija

Uporabna klasa	1
trajanje opterećenja	Kratkotrajno
Modifikacija faktor k_mod	0,90

...: PROVJERA PRESJEKA ...:

### Vlak paralelno sa vlaknima

Prema EN 1995-1-1 članak 6.1.2 i formula (6.1)

$\sigma_{t,0,d}$	0,2	MPa
kh	1,00	
$f_{t,0,d}$	10,0	MPa
Provjera jedinica	0,02	-

### Kompresija okomito na zrnu

Prema EN 1995-1-1 članak 6.1.5 i formula (6.3)

Fc,90,d	0,55	kN
Element - geometrija	100	mm
lef	130	mm
b	120	mm
Aef	15600	mm <sup>2</sup>
$\sigma_{c,90,d}$	0,0	MPa
Uvjet oslonca	Diskretna	
h	160	mm
kc,90	1,50	-
$f_{c,90,d}$	1,7	MPa
Provjera jedinica	0,01	-

### Savijanje

Prema EN 1995-1-1 članak 6.1.6 i formula (6.11),(6.12)

$\sigma_{m,y,d}$	8,1	MPa
$k_{h,y}$	1,00	
$f_{m,y,d}$	16,6	MPa
$k_m$	0,70	

Provjera cjelovitosti (6.11) =  $0,49 + 0,00 = 0,49$  -

Provjera cjelovitosti (6.12) =  $0,34 + 0,00 = 0,34$  -

### Posmik

Prema EN 1995-1-1 članak 6.1.7 i formula (6.13)

$k_{cr}$	0,67	
$\tau_{z,d}$	0,1	MPa
$f_{v,d}$	2,8	MPa
Provjera cjelovitosti $\tau_z$	0,02	-

### Kombinirano savijanje i aksijalno Napetost

Prema EN 1995-1-1 članak 6.2.3 i formula (6.17),(6.18)

$f_{t,0,d}$	10,0	MPa
$f_{m,y,d}$	16,6	MPa
$k_m$	0,70	

Provjera cjelovitosti (6.17) =  $0,02 + 0,49 + 0,00 = 0,51$  -

Provjera cjelovitosti (6.18) =  $0,02 + 0,34 + 0,00 = 0,36$  -

Element zadovoljava provjeru presjeka.

### ...: PROVJERA STABILNOSTI :...

### Nosači izloženi savijanju ili savijanju i tlaku

Prema EN 1995-1-1 članak 6.3.3 i formula (6.33),(6.35)

LTB Parametri		
Elastična kritični trenutak $M_{y, krit}$	122,37	kNm
Kritična stres savijanje $\sigma_{m, krit}$	239,0	MPa
Relativna vitkost $\lambda_{rel,m}$	0,32	-
Redukcijski faktor $k_{krit}$	1,00	-

Provjera cjelovitosti (6.33) =  $0,49$  -

My,crit Parametri		
G0,05	462,5	MPa
LTB duljina L	1,788	m
$L_{ef}/L$	0,90	
Efektivna duljina $L_{ef}$	1,609	m
Utjecaj položaja opterećenja	bez utjecaja	

Element zadovoljava provjeru stabilnosti.



## 7. Dimenzioniranje drvenih greda

Linearni proračun, Ekstrem : Globalni

Odabir : Svi

Kombinacije : ULS-Set B (auto)

HR 1995/01/01 kod Check

Greda B26	0,850 m	Podgrožnice - RECT (160; 180)	C24 (EN 338)	ULS-Set B (auto)	0,81 -
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### Kombinacijski ključ

ULS-Set B (auto) / 1.35\*LC1 + 1.35\*LC2 + 1.50\*LC3 + 0.75\*LC4

### Osnovni podaci

Djelomična faktor sigurnosti  $\gamma_{f1}$   $\gamma_{M}$  za Solid drva 1,30

### Materijal podataka

Savijanje (fm,k)	24,0	MPa
Vlak (ft,0,k)	14,5	MPa
Vlak (ft,90,k)	0,4	MPa
Kompresija (F <sub>c</sub> , 0, k)	21,0	MPa
Kompresija (F <sub>c</sub> , 90, k)	2,5	MPa
Posmik (fv,k)	4,0	MPa
Vrsta drveta	Čvrst	

Provjera kritičnog je na poziciji **0,850** m.

### Unutarnje sile

NEd	0,05	kN
Vy,Ed	-0,06	kN
Vz,Ed	1,96	kN
TEd	0,00	kNm
My,Ed	8,36	kNm
Mz,Ed	-4,19	kNm

### faktor modifikacija

Uporabna klasa	1
trajanje opterećenja	Kratkotrajno
Modifikacija faktor k <sub>mod</sub>	0,90

...: PROVJERA PRESJEKA ...:

### Vlak paralelno sa vlaknima

Prema EN 1995-1-1 članak 6.1.2 i formula (6.1)

$\sigma_{t,0,d}$	0,0	MPa
kh	1,00	
$f_{t,0,d}$	10,0	MPa
Provjera jedinica	0,00	-

### Kompresija okomito na zrnu

Prema EN 1995-1-1 članak 6.1.5 i formula (6.3)

F <sub>c,90,d</sub>	1,96	kN
Element - geometrija	100	mm
l <sub>ef</sub>	130	mm
b	160	mm
A <sub>ef</sub>	20800	mm <sup>2</sup>
$\sigma_{c,90,d}$	0,1	MPa
Uvjet oslonca	Diskretna	
h	180	mm
k <sub>c,90</sub>	1,50	-
f <sub>c,90,d</sub>	1,7	MPa

Provjera jedinica	0,04	-
-------------------	------	---

### Savijanje

Prema EN 1995-1-1 članak 6.1.6 i formula (6.11),(6.12)

$\sigma_{m,y,d}$	9,7	MPa
$k_{h,y}$	1,00	
$f_{m,y,d}$	16,6	MPa
$\sigma_{m,z,d}$	5,5	MPa
$k_{h,z}$	1,00	
$f_{m,z,d}$	16,6	MPa
$k_m$	0,70	

Provjera cjelovitosti (6.11) =  $0,58 + 0,23 = 0,81$  -

Provjera cjelovitosti (6.12) =  $0,41 + 0,33 = 0,74$  -

### Posmik

Prema EN 1995-1-1 članak 6.1.7 i formula (6.13)

$k_{cr}$	0,67	
$\tau_{y,d}$	0,0	MPa
$\tau_{z,d}$	0,2	MPa
$f_{v,d}$	2,8	MPa
Provjera cjelovitosti $\tau_y$	0,00	-
Provjera cjelovitosti $\tau_z$	0,06	-
Provjera cjelovitosti Interakcija	0,00	-

Napomena: Jednadžba interakcija je dodan kao NCCI.

### Kombinirano savijanje i aksijalno Napetost

Prema EN 1995-1-1 članak 6.2.3 i formula (6.17),(6.18)

$f_{t,0,d}$	10,0	MPa
$f_{m,y,d}$	16,6	MPa
$f_{m,z,d}$	16,6	MPa
$k_m$	0,70	

Provjera cjelovitosti (6.17) =  $0,00 + 0,58 + 0,23 = 0,81$  -

Provjera cjelovitosti (6.18) =  $0,00 + 0,41 + 0,33 = 0,74$  -

Element zadovoljava provjeru presjeka.

### ...: PROVJERA STABILNOSTI :...

### Nosači izloženi savijanju ili savijanju i tlaku

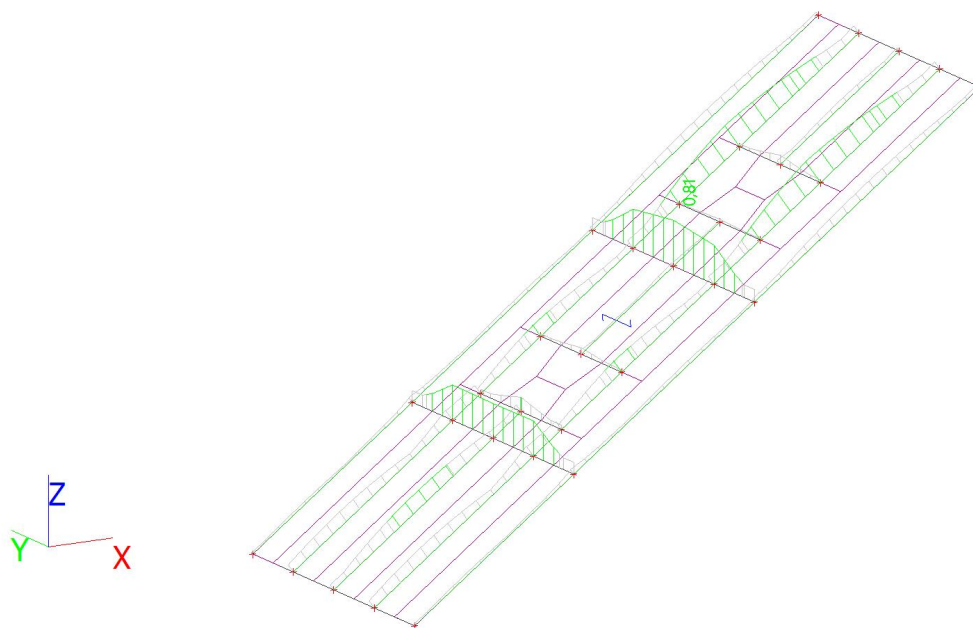
Prema EN 1995-1-1 članak 6.3.3 i formula (6.33),(6.35)

LTB Parametri		
Elastična kritični trenutak $M_{y, \text{krit}}$	576,51	kNm
Kritična stres savijanje $\sigma_{m, \text{krit}}$	667,3	MPa
Relativna vitkost $\lambda_{rel,m}$	0,19	-
Redukcijski faktor $k_{\text{krit}}$	1,00	-

Provjera cjelovitosti (6.33) =  $0,58$  -

My,crit Parametri		
G0,05	462,5	MPa
LTB duljina L	0,850	m
$L_{ef}/L$	1,00	
Efektivna duljina $L_{ef}$	0,850	m
Utjecaj položaja opterećenja	bez utjecaja	

Element zadovoljava provjeru stabilnosti.



## 8. Slučajevi opterećenja

### 8.1. Slučajevi opterećenja - LC1

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Smjer
	Spec	Vrsta opterećenja		
LC1	Self weight	Trajno Vlastita težina	LG1	-Z

### 8.1.

#### 8.1.1. Reactions; R\_x

Values:  $R_x$

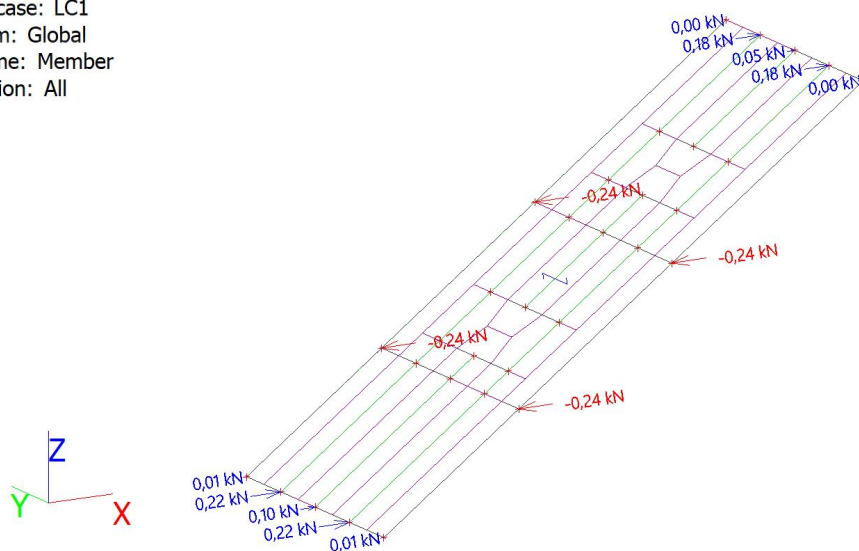
Linear calculation

Load case: LC1

System: Global

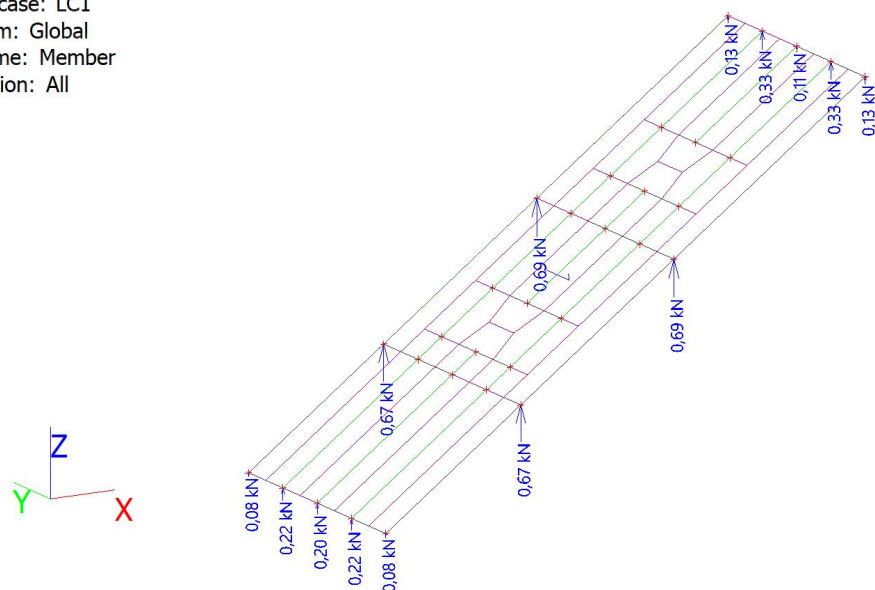
Extreme: Member

Selection: All



### 8.1.2. Reactions; $R_z$

Values:  $R_z$   
 Linear calculation  
 Load case: LC1  
 System: Global  
 Extreme: Member  
 Selection: All



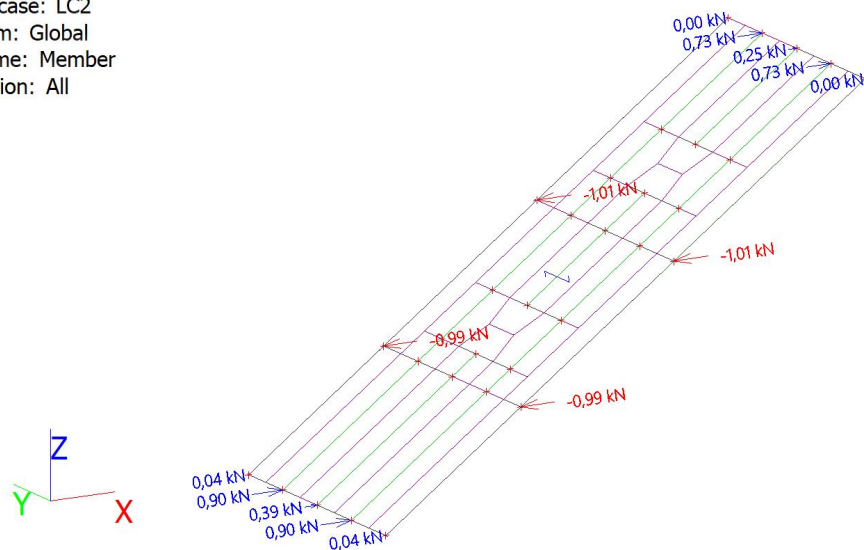
## 8.2. Slučajevi opterećenja - LC2

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja
	Spec	Vrsta opterećenja	
LC2	Dodatno stalno opterećenje	Trajno	LG1
		Standardno	

## 8.2.

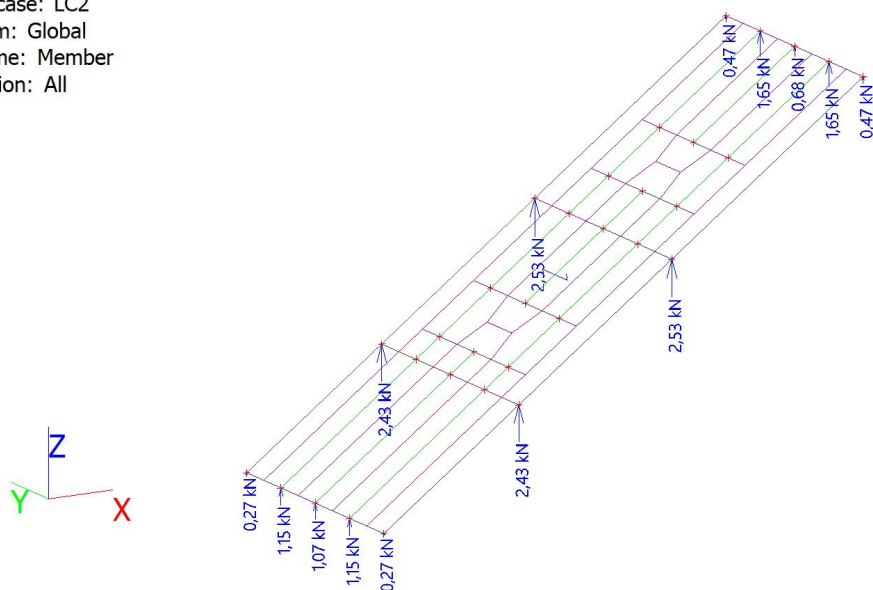
### 8.2.1. Reactions; $R_x$

Values:  $R_x$   
 Linear calculation  
 Load case: LC2  
 System: Global  
 Extreme: Member  
 Selection: All



### 8.2.2. Reactions; $R_z$

Values:  $R_z$   
 Linear calculation  
 Load case: LC2  
 System: Global  
 Extreme: Member  
 Selection: All



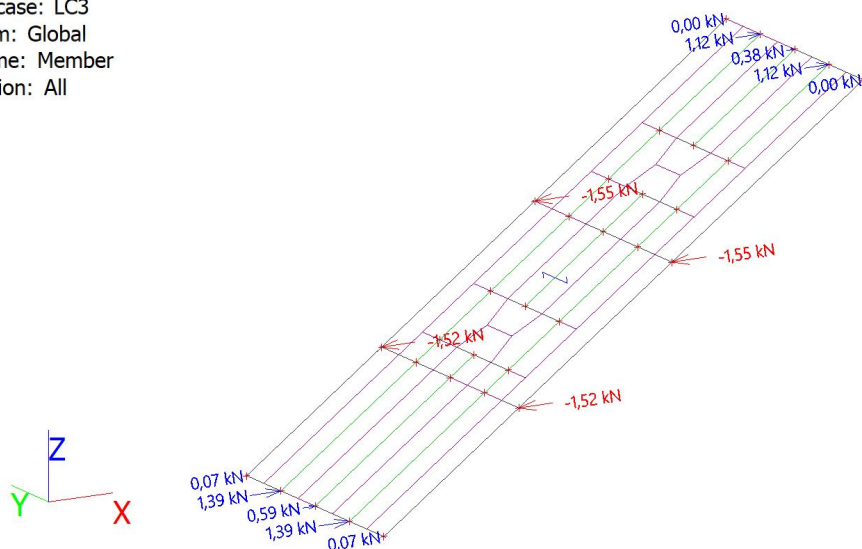
### 8.3. Slučajevi opterećenja - LC3

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC3	Snijeg	Varijabla	LG2	Ne postoji
	Snijeg	Stat.		

### 8.3.

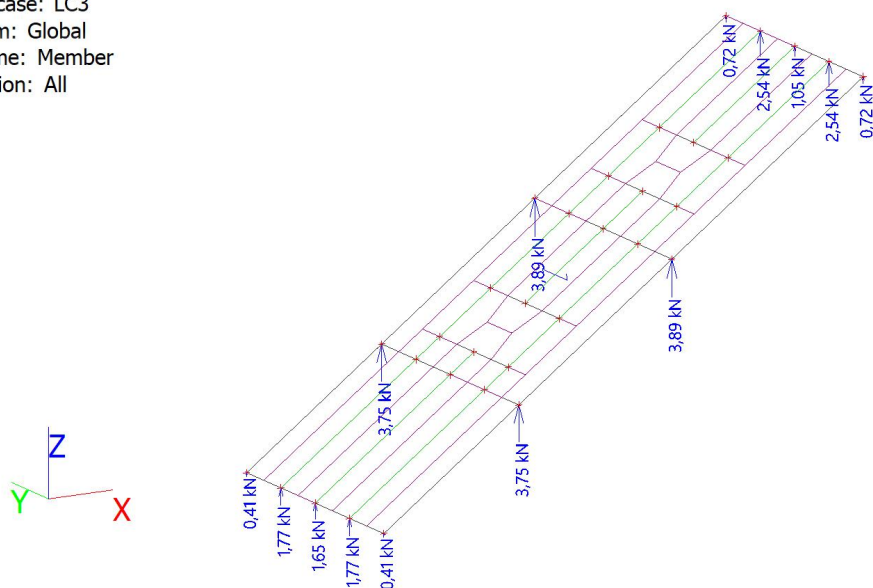
#### 8.3.1. Reactions; $R_x$

Values:  $R_x$   
 Linear calculation  
 Load case: LC3  
 System: Global  
 Extreme: Member  
 Selection: All



### 8.3.2. Reactions; $R_z$

Values:  $R_z$   
 Linear calculation  
 Load case: LC3  
 System: Global  
 Extreme: Member  
 Selection: All



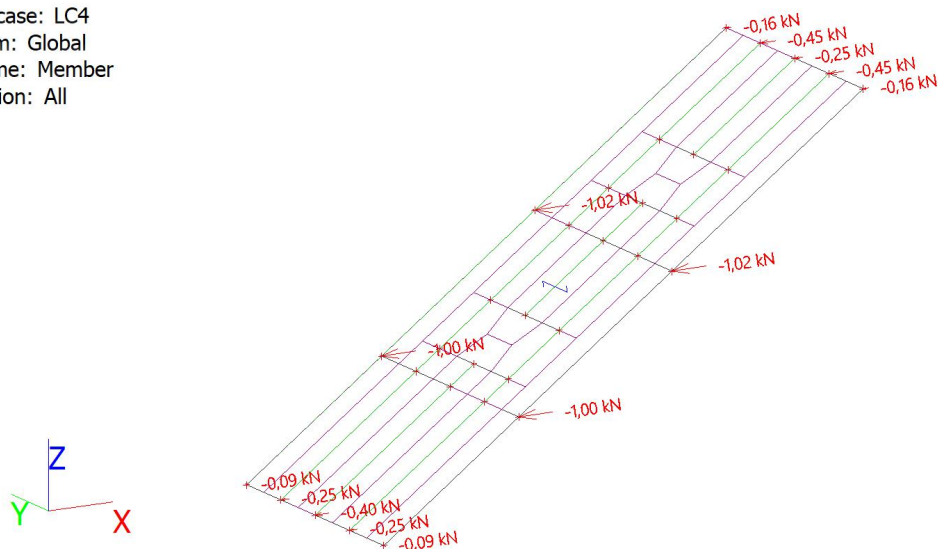
### 8.4. Slučajevi opterećenja - LC4

Naziv	Opis	Vrsta aktivnosti	Grupa opterećenja	Glavni slučaj opterećenja
	Spec	Vrsta opterećenja		
LC4	Vjetar	Varijabla	LG3	Ne postoji
	Statički vjetar	Stat.		

### 8.4.

#### 8.4.1. Reactions; $R_x$

Values:  $R_x$   
 Linear calculation  
 Load case: LC4  
 System: Global  
 Extreme: Member  
 Selection: All



### 8.4.2. Reactions; $R_z$

Values:  $R_z$

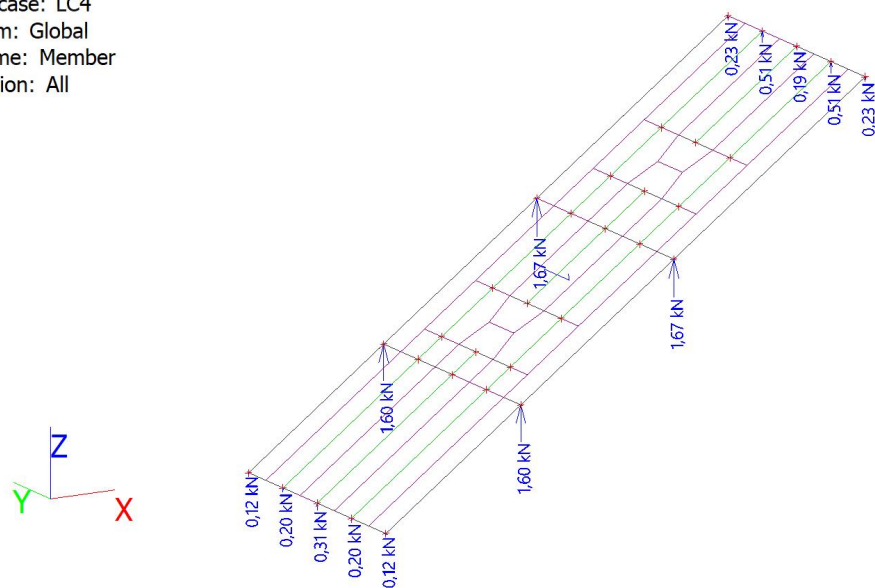
Linear calculation

Load case: LC4

System: Global

Extreme: Member

Selection: All



Grede iznad FERT stropa osloniti i sidriti svakih metar u stropnu konstrukciju. Dimenzije gređa su 12/18 cm.

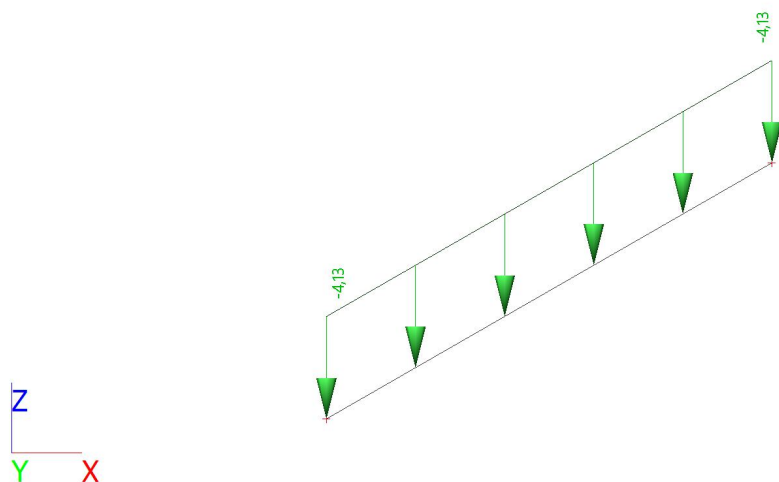
## 9. FERT strop

### 9.1.1. Opterećenje - LC1

Name	Description Spec	Action type Load type	Load group
LC1	Stalno opterećenje	Permanent Standard	LG1

#### 9.1.1.

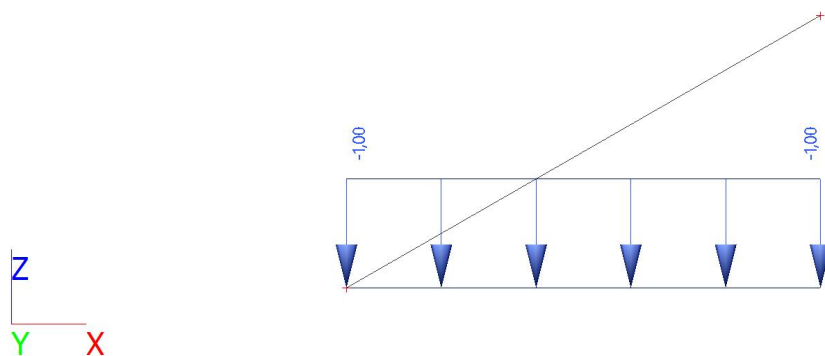
##### 9.1.1.1. LC1 / Tot. value



### 9.1.2. Opterećenje - LC2

Name	Description Spec	Action type Load type	Load group	Master load case
LC2	Snijeg Snow	Variable Static	LG2	None

#### 9.1.2.1. LC1 / Tot. value





## 9.2. Unutarnje sile

### 9.2.1. Unutarnje sile - LC1

Name	Description	Action type	Load group
	Spec	Load type	
LC1	Stalno opterećenje	Permanent	LG1
		Standard	

#### 9.2.1.

##### 9.2.1.1. 1D internal forces; $M_y$

Values:  $M_y$

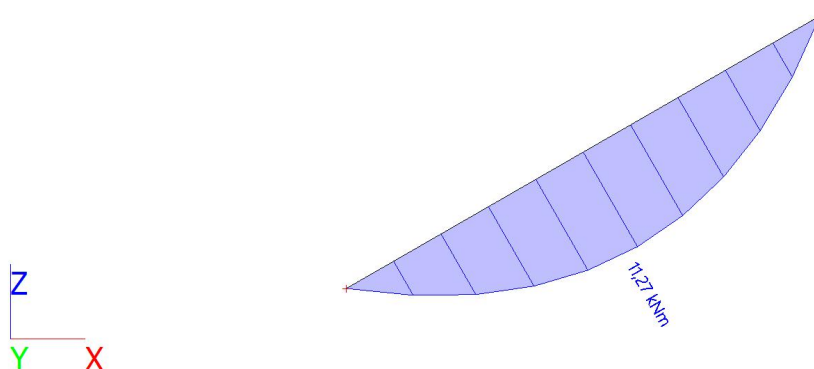
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 9.2.2. Unutarnje sile - LC2

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC2	Snijeg	Variable	LG2	None
	Snow	Static		

#### 9.2.2.1. 1D internal forces; $M_y$

Values:  $M_y$

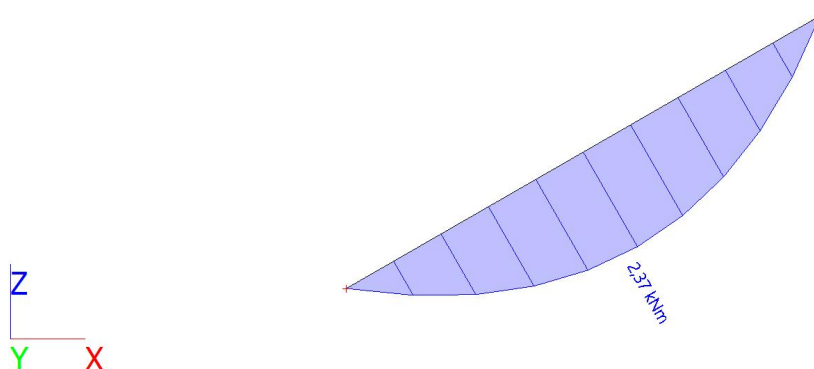
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 9.3. Reakcije

### 9.3.1. Reakcije - LC1

Name	Description	Action type	Load group
	Spec	Load type	
LC1	Stalno opterećenje	Permanent	LG1
		Standard	

#### 9.3.1.

##### 9.3.1.1. Reactions; $R_z$

Values:  $R_z$

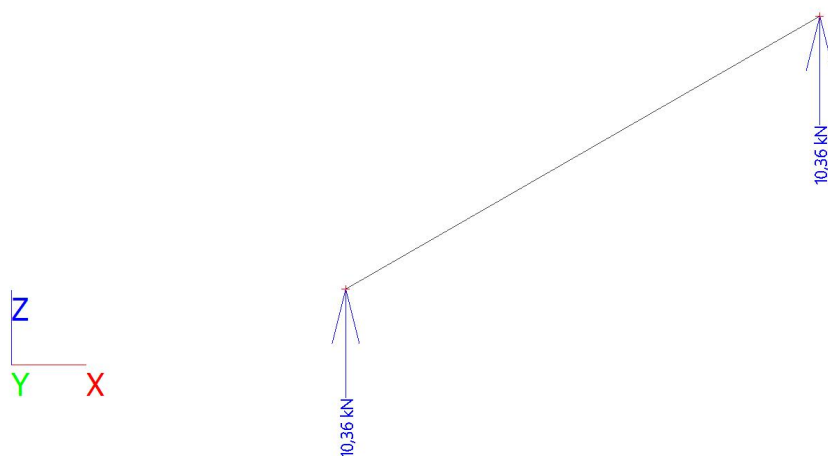
Linear calculation

Load case: LC1

System: Global

Extreme: Global

Selection: All



### 9.3.2. Reakcije - LC2

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC2	Snijeg	Variable	LG2	None
	Snow	Static		

#### 9.3.2.1. Reactions; $R_z$

Values:  $R_z$

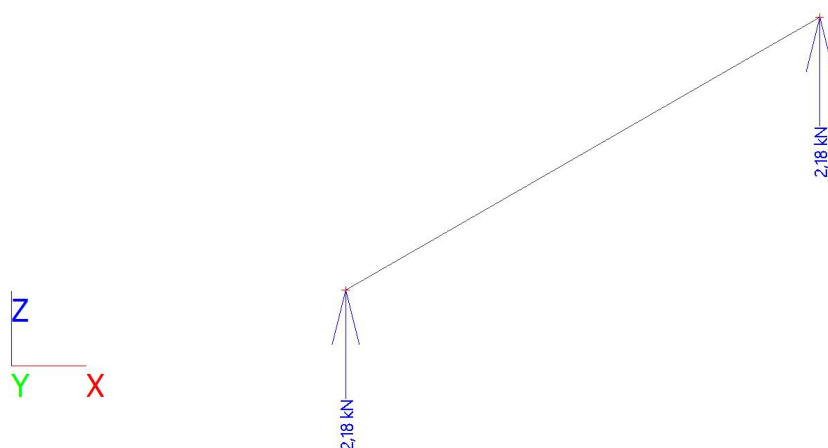
Linear calculation

Load case: LC2

System: Global

Extreme: Global

Selection: All



## 9.4. Proračun

Računske čvrstoće materijala:

Beton C 25/30

Čelik B500B

$$f_{cd} = f_{ck} / \gamma_m = 2.5 / 1.5 = 16.67 \text{ N/mm}^2$$

$$f_{yd} = f_{ck} / \gamma_m = 500 / 1.15 = 434.78 \text{ N/mm}^2$$

Visina presjeka:

$$h = 16 + 5 = 20 \text{ cm}$$

Statička visina presjeka:

$$d = h - c - o/2 = 21 - 2 - 1/2 = 18.5 \text{ cm}$$

$$M_g = 11.27 \text{ kNm}$$

$$M_q = 2.37 \text{ kNm}$$

$$M_{sd} = 1.35 \times M_g + 1.5 \times M_q = 1.35 \times 11.27 + 1.5 \times 2.37 = 18.76 \text{ kNm}$$

$$\mu_{sd} = M_{sd} / (b \times d^2 \times f_{cd}) = 1876 / (100 \times 18.5^2 \times 16.67) = 0.033$$

$$A_{s1} = M_{sd} / (\xi \times d \times f_{yd}) = 1876 / (0.977 \times 18.5 \times 43.48) = 2.39 \text{ cm}^2/\text{m}$$

$$A_{s1,min} = 0.0015 \times b_t \times d = 0.0015 \times 100 \times 18.5 = 2.77 \text{ cm}^2/\text{m}$$

Usvojena armatura u gredicama:

$$\begin{aligned} 2 \text{ o } 8 & \text{ -----> } A_{s1} = 1.01 \text{ cm}^2 / \text{m}' \text{ za } \mathbf{\text{armatura jedne grede}} \\ 2 \text{ o } 10 & \text{ -----> } A_{s1} = 1.57 \text{ cm}^2 / \text{m}' \text{ za } \mathbf{\text{dodatna armatura jedne grede}} \end{aligned}$$

$$2.58 \times 2 > 2.77 \text{ } \mathbf{\text{Zadovoljava}}$$

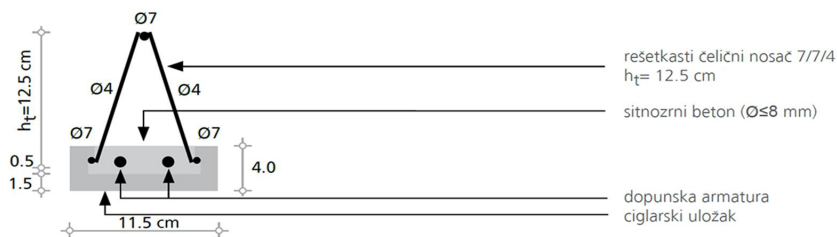
Konstruktivna armatura:

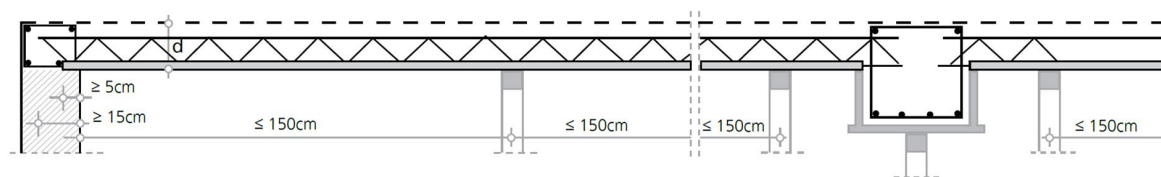
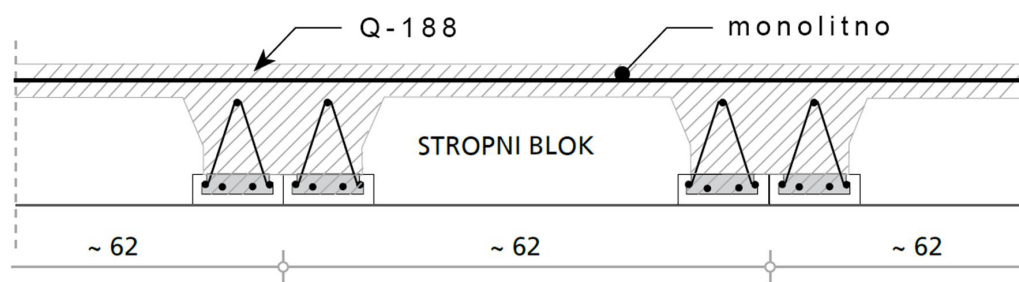
Tlačna ploča debljine 5 cm armira se konstruktivno mrežastom armaturom **Q-188**

Kod izrade fert stropnog sustava fert gredice postavljaju se oslanjanjem na nosive zidove ili grede, tako da međusobni osni razmak gredica bude kao na slici. Fert gredice treba postavljati tako da je minimalno nalijeganje opečne pločice na zid 5 cm. Prilikom postave gredica potrebno izvršiti dodatno podupiranje gredica preko podvlaka na maksimalnom razmaku od 150 cm. Armaturna mreža mora biti sidrena u horizontalni serklaž po čitavom obodu stropa.

Kod raspona fert stropa od 4,0 do 6,0 m izvodi se jedno rebro za ukrućenje u sredini raspona i armira se uzdužnom armaturom 4 o 12 i poprečnom u obliku spona o 8/25 cm.

Na nosivim zidovima izvode se horizontalni serklaži, koji se betoniraju istovremeno s monolitnom pločom kako bi se postigla monolitnost cijelokupnog stropnog sustava.



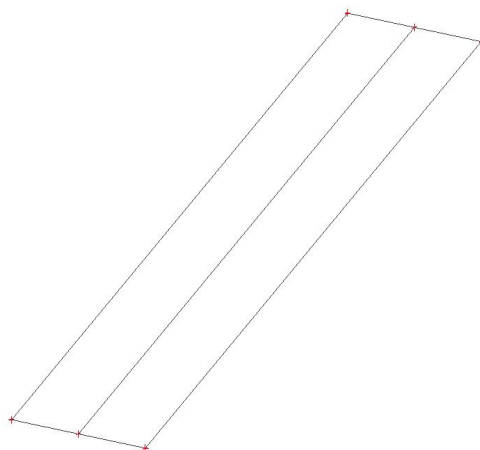


## 10. Opterećenje

### 10.1. Load cases - LC1

Name	Description Spec	Action type Load type	Load group	Direction
LC1	Self weight	Permanent Self weight	LG1	-Z

#### 10.1.1. LC3 / Tot. value

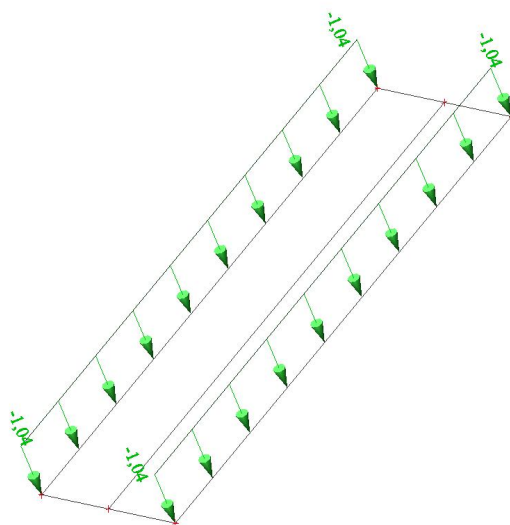
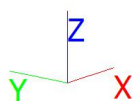


### 10.2. Load cases - LC2

Name	Description Spec	Action type Load type	Load group
LC2	Dodatno stalno	Permanent Standard	LG1

#### 10.2.

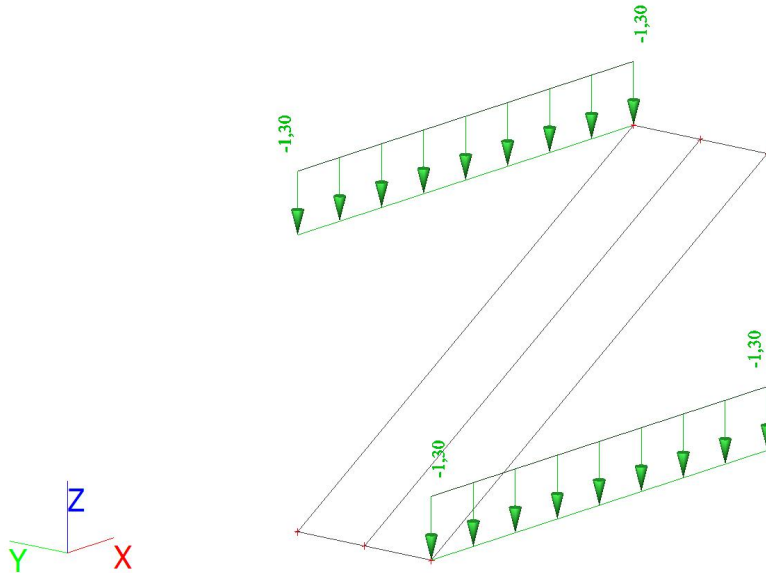
#### 10.2.1. LC3 / Tot. value



### 10.3. Load cases - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Snijeg Standard	Variable Static	LG2	Short	None

#### 10.3.1. LC3 / Tot. value



## 11. Load cases

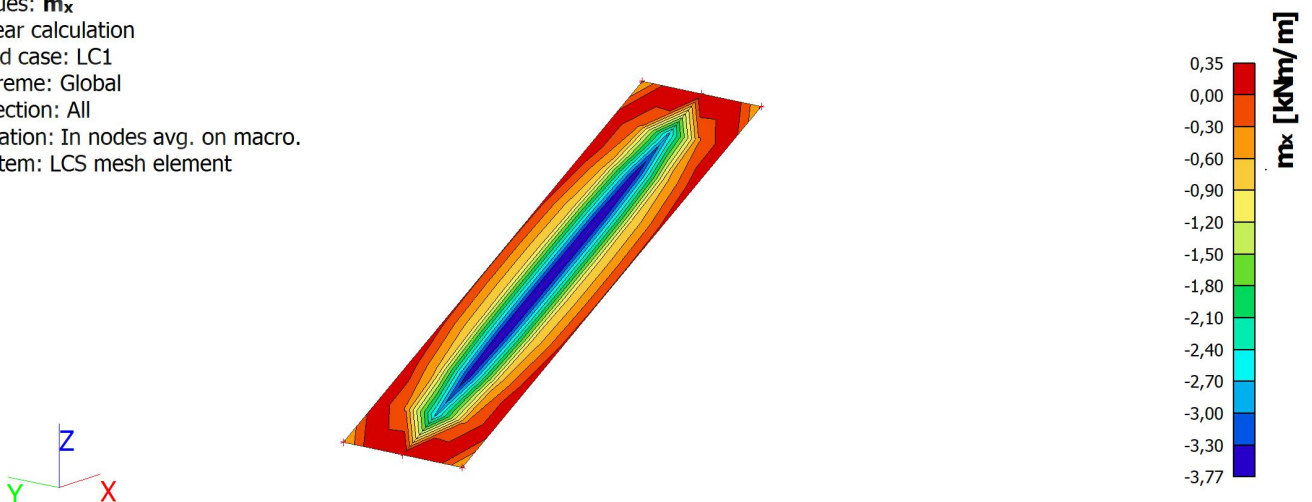
### 11.1. Load cases - LC1

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent Self weight	LG1	-Z

#### 11.1.

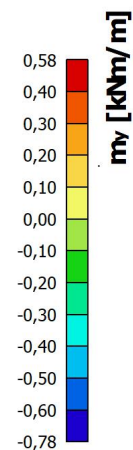
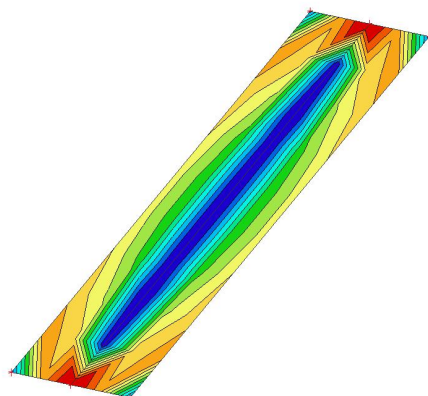
##### 11.1.1. 2D internal forces; $m_x$

Values:  $m_x$   
 Linear calculation  
 Load case: LC1  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



### 11.1.2. 2D internal forces; $m_y$

Values:  $m_y$   
 Linear calculation  
 Load case: LC1  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



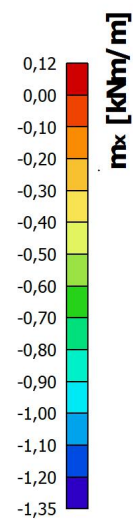
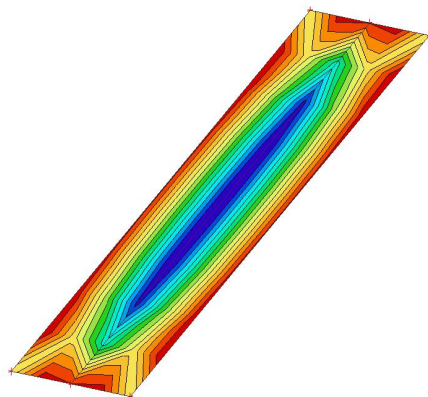
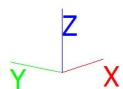
### 11.2. Load cases - LC2

Name	Description	Action type	Load group
	Spec	Load type	
LC2	Dodatno stalno	Permanent	LG1
		Standard	

### 11.2.

#### 11.2.1. 2D internal forces; $m_x$

Values:  $m_x$   
 Linear calculation  
 Load case: LC2  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



### 11.2.2. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

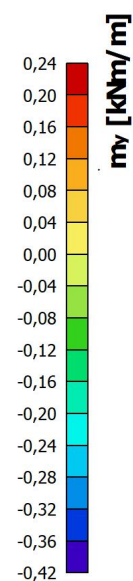
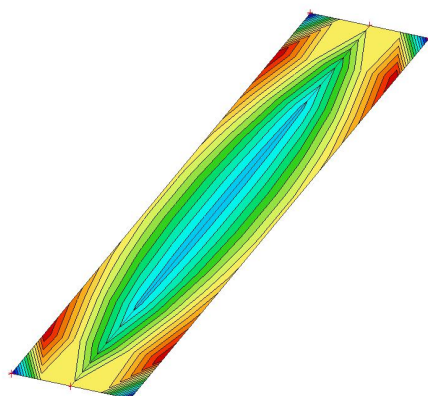
Load case: LC2

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 11.3. Load cases - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Snijeg	Variable	LG2	Short	None
	Standard	Static			

### 11.3.

#### 11.3.1. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

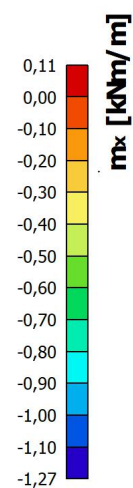
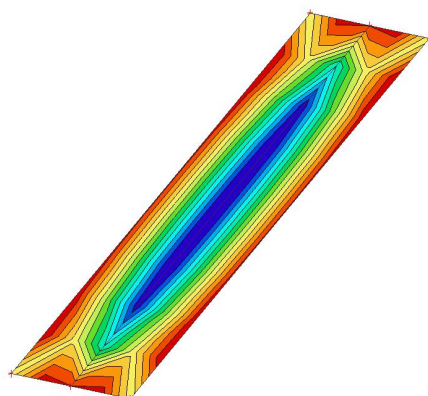
Load case: LC3

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

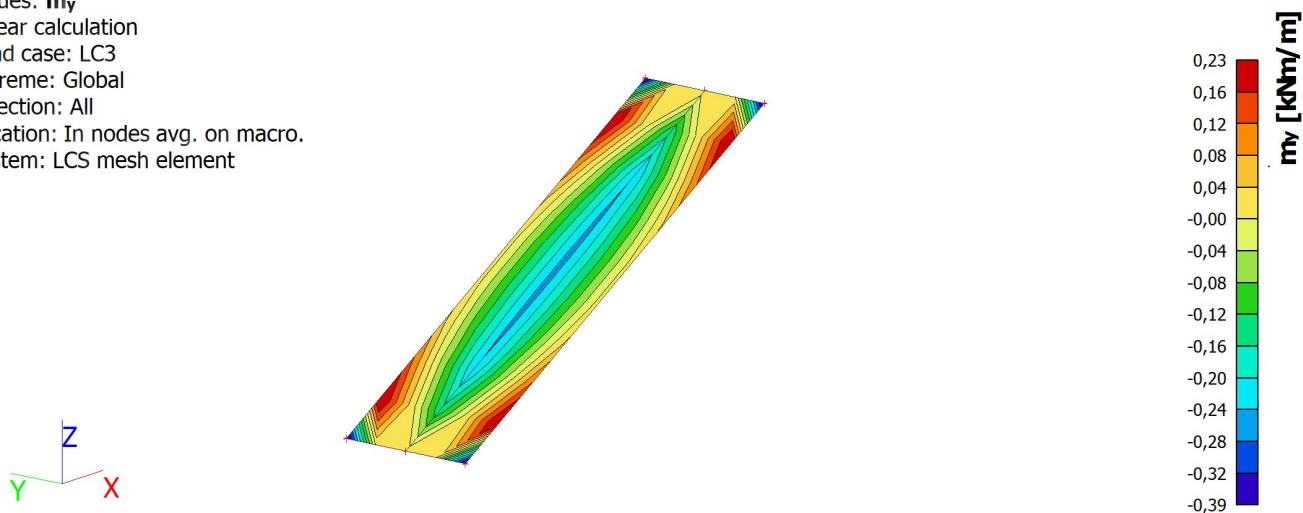
System: LCS mesh element





### 11.3.2. 2D internal forces; $m_y$

Values:  $m_y$   
 Linear calculation  
 Load case: LC3  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



## 12. Dimenzioniranje ploče

Linear calculation  
 Combination: ULS-Set B (auto)  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro. System: LCS mesh element

<b>Plate S1</b>	<b>RECT (1000,0; 210,0)</b>
EC EN 1992-1-1:2004/AC:2008	Node 26/54 [X=4.5m, Y=1.3m, Z=2.58m]

## Design assumptions

### Reinforcement

Longitudinal: **B 500B**

#### Upper surface

- [1+] First layer (0°)
- [2+] Second layer (90°)

Cover:

#### Lower surface

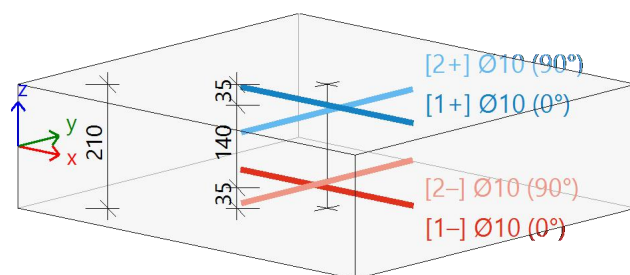
- [1-] First layer (0°)
- [2-] Second layer (90°)

Cover:

Shear: **B 500B**

Ø10,0 mm / Principal  
 Ø10,0 mm / Principal  
 $c_{nom} = 30$  mm

Ø10,0 mm / Principal  
 Ø10,0 mm / Principal  
 $c_{nom} = 30$  mm  
 Ø8 mm



## Concrete:

Material: **C25/30**

Structural class: S3 (design working life of 50 years, no special quality control)

(Table 4.3N)

Environmental conditions: XC3 (in situ)

(Table 4.1N)

Minimum cover

(§4.4.1.2)

$$c_{\min} = \max(c_{\min,bi}; c_{\min,dur} + \Delta c_{dur,y} - \Delta c_{dur,st} - \Delta c_{dur,add}; 10)$$

$$= \max(10; 20 + 0 - 0 - 0; 10) = 20 \text{ mm}$$

(4.2)

Nominal cover

(§4.4.1.1)

$$c_{\text{nom}} = c_{\min} + \Delta c_{\text{dev}} = 20 + 10 = 30 \text{ mm}$$

(4.1)

## Internal forces

### Original FEM-based, critical

Involving the shifting of moment curve: YES

(§9.2.1.3(2))

$$a_l = h \cdot \text{Coeff}_d = 210 \cdot 0.9 = 189 \text{ mm}$$

(§6.2.2(5))

Table of internal forces

Case	$m_x$ [kNm/m]	$m_y$ [kNm/m]	$m_{xy}$ [kNm/m]	$n_x$ [kN/m]	$n_y$ [kN/m]	$n_{xy}$ [kN/m]	$v_x$ [kN/m]	$v_y$ [kN/m]
ULS-Set B (auto)/1	-5,1	-1,0	0,0	0,0	0,0	-3,2	-6,9	0,0
ULS-Set B (auto)/2	-8,8	-1,8	0,0	0,1	0,0	-5,1	-10,8	0,0
ULS-Set B (auto)/3	-6,9	-1,4	0,0	0,0	0,0	-4,3	-9,3	0,0
ULS-Set B (auto)/4	-7,0	-1,4	0,0	0,0	0,0	-4,0	-8,4	0,0

Table of combinations

Case	Combination key
ULS-Set B (auto)/1	LC1+LC2
ULS-Set B (auto)/2	1.35*LC1+1.35*LC2+1.50*LC3
ULS-Set B (auto)/3	1.35*LC1+1.35*LC2
ULS-Set B (auto)/4	LC1+LC2+1.50*LC3

## Design of longitudinal reinforcement

### Statically required reinforcement

Design direction [ $\alpha=0^\circ$ ]

**[1+]: upper surface**

$$m_{Ed} = -8.74 \text{ kNm/m} \quad | \quad n_{Ed} = 5.15 \text{ kN/m} \quad [\text{ULS-Set B (auto)/2}]$$

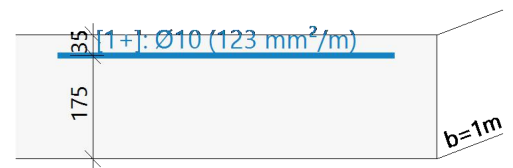
$$f_{cd} = 16.7 \text{ [MPa]} \quad (\gamma_c = 1.5, \alpha_{cc} = 1)$$

$$f_{yd} = 435 \text{ [MPa]} \quad (\gamma_s = 1.15)$$

$$\varnothing 10 \text{ mm} : d_1 = 35 \text{ mm} \rightarrow d = 175 \text{ mm}$$

$$A_{s,req} = 123 \text{ mm}^2/\text{m} \text{ (tensile)}$$

$$\rho = 0.070\%$$



### Design direction [ $\alpha=90^\circ$ ]

#### [2+]: upper surface

$$m_{Ed} = -1.68 \text{ kNm/m} \mid n_{Ed} = 5.1 \text{ kN/m} \text{ [ULS-Set B (auto)/2]}$$

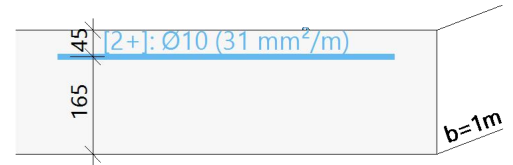
$$f_{cd} = 16.7 \text{ [MPa]} \quad (\gamma_c = 1.5, \alpha_{cc} = 1)$$

$$f_{yd} = 435 \text{ [MPa]} \quad (\gamma_s = 1.15)$$

$$\varnothing 10 \text{ mm} : d_1 = 45 \text{ mm} \rightarrow d = 165 \text{ mm}$$

$$A_{s,req} = 31 \text{ mm}^2/\text{m} \text{ (tensile)}$$

$$\rho = 0.019\%$$



### Check of concrete diagonal strut

#### Check direction (extreme) [ $\alpha=45^\circ$ ]

Design normal force in direction of concrete strut

$$n_{Ed,sc} = -4.84 \text{ kN} \text{ [ULS-Set B (auto)/2]}$$

with full cross-section height:

$$h = 210 \text{ mm} \rightarrow A_{cc} = h \cdot b = 0.21 \cdot 1000 = 210000 \text{ mm}^2$$

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 17 \text{ MPa}$$

Design resistance of concrete strut (in compression)

$$n_{Rd,sc} = A_{cc} \cdot \text{Red}_{fcd} \cdot f_{cd} = 210000 \cdot 0.85 \cdot 17 = 2975 \text{ kN}$$

Unity check

$$UC_{sc} = \frac{\text{abs}(n_{Ed,sc})}{n_{Rd,sc}} = \frac{\text{abs}(-4.84)}{2975} = 0.0016$$

### Detailing of longitudinal reinforcement

#### Minimum reinforcement area

##### Principal [1-] (compression)

Minimum area from maximum spacing of reinforcement bars

$$s_{\max,slab} = \min(\text{Coeff}_{s\max,slab,A} \cdot h; \text{Coeff}_{s\max,slab,B}) = \min(3 \cdot 210; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{\max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 196 \text{ mm}^2/\text{m}$$

##### Principal [2-] (compression)

Minimum area from maximum spacing of reinforcement bars

$$s_{\max,slab} = \min(\text{Coeff}_{s\max,slab,A} \cdot h; \text{Coeff}_{s\max,slab,B}) = \min(3 \cdot 210; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{\max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 196 \text{ mm}^2/\text{m}$$

##### Principal [1+] (tension)

Minimum area from reinforcement ratio

(§9.2.1.1(1))

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \text{Coeff}_{Asmin,2} \cdot \frac{f_{ctm} \cdot b_t \cdot d}{f_{yk}} \\ \text{Coeff}_{Asmin,1} \cdot b_t \cdot d \end{array} \right\} = \text{Max} \left\{ \begin{array}{l} 0.26 \cdot \frac{2.6 \cdot 1000 \cdot 175}{500} \\ 1.3 \cdot 10^{-3} \cdot 1000 \cdot 175 \end{array} \right\} = 237 \text{ mm}^2/\text{m} \quad (9.1N)$$

Minimum area from maximum spacing of reinforcement bars

$$s_{\max,slab} = \min(\text{Coeff}_{s\max,slab,A} \cdot h; \text{Coeff}_{s\max,slab,B}) = \min(3 \cdot 210; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{\max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 196 \text{ mm}^2/\text{m}$$

### Principal [2+] (tension)

Minimum area from reinforcement ratio

(§9.2.1.1(1))

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \text{Coeff}_{Asmin,2} \cdot \frac{f_{ctm} \cdot b_t \cdot d}{f_{yk}} \\ \text{Coeff}_{Asmin,1} \cdot b_t \cdot d \end{array} \right\} = \text{Max} \left\{ \begin{array}{l} 0.26 \cdot \frac{2.6 \cdot 1000 \cdot 165}{500} \\ 1.3 \cdot 10^{-3} \cdot 1000 \cdot 165 \end{array} \right\} = 223 \text{ mm}^2/\text{m} \quad (9.1N)$$

Minimum area from maximum spacing of reinforcement bars

$$s_{max,slab} = \min(\text{Coeff}_{smax,slab,A} \cdot h; \text{Coeff}_{smax,slab,B}) = \min(3 \cdot 210; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 196 \text{ mm}^2/\text{m}$$

## Maximum reinforcement area

### Principal [1-] (compression)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 210000 = 8400 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 10; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{10 + 37} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 1671 \text{ mm}^2/\text{m}$$

### Principal [2-] (compression)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 210000 = 8400 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 10; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{10 + 37} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 1671 \text{ mm}^2/\text{m}$$

### Principal [1+] (tension)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 210000 = 8400 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 10; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{10 + 37} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 1671 \text{ mm}^2/\text{m}$$

### Principal [2+] (tension)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 210000 = 8400 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 10; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

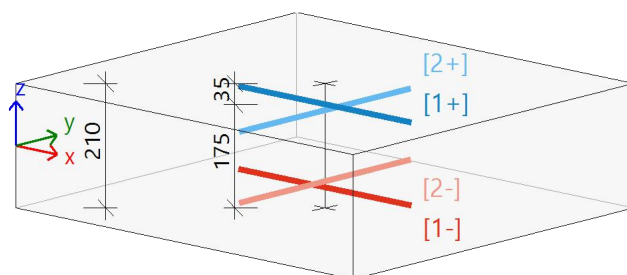
$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{10 + 37} \cdot 0.25 \cdot 3.14 \cdot 10^2 = 1671 \text{ mm}^2/\text{m}$$

## Longitudinal reinforcement - Summary

### Provided reinforcement

	Basic	Additional		$A_{s,prov}$ [mm <sup>2</sup> /m]	$A_{s,req}$ [mm <sup>2</sup> /m]	$A_{s,add,req}$ [mm <sup>2</sup> /m]	$A_{s,min}$ [mm <sup>2</sup> /m]	$A_{s,max}$ [mm <sup>2</sup> /m]	Status
		User input	Designed						
[1+]	φ10,0/150 (524)	no reinf.	no reinf.	524	237 (123)	0	237	1671	OK
[2+]	φ10,0/150 (524)	no reinf.	no reinf.	524	223 (31)	0	223	1671	OK
[1-]	φ10,0/150 (524)	no reinf.	no reinf.	524	0	0	196	1671	OK
[2-]	φ10,0/150 (524)	no reinf.	no reinf.	524	0	0	196	1671	OK

$A_{s,req}$  - required reinforcement including detailings,  $A_{s,prov}$  - provided reinforcement - basic (across whole surface) and additional (local) reinforcement including user input (modelled) 2D reinforcement,  $A_{s,min/max}$  - minimum / maximum reinforcement areas given by detailings, Status - check of  $A_{s,req} \leq A_{s,prov} \leq A_{s,max}$



[1+] φ10,0/150  
[2+] φ10,0/150  
[1-] φ10,0/150  
[2-] φ10,0/150

## Design of shear reinforcement

Design shear force

$$v_{Ed} = \sqrt{v_x^2 + v_y^2} = \sqrt{-10.8^2 + 0.0^2} = 10.8 \text{ kN/m [ULS-Set B (auto)/2]}$$

Principal forces and plane of deformation

$$m_z = -8.8 \text{ kNm} \mid n_z = 0.35 \text{ kN}$$

$$d = 170 \text{ mm} \mid z = 168 \text{ mm}$$

Longitudinal reinforcement ratio

$$\rho_{lx} = \frac{A_{sl,x}}{b \cdot d} = \frac{524}{1000 \cdot 170} = 0.308 \% \quad \rho_{ly} = \frac{A_{sl,y}}{b \cdot d} = \frac{524}{1000 \cdot 170} = 0.308 \%$$

$$\rho_l = \min\left(\sqrt{\rho_{lx} \cdot \rho_{ly}}; 0.02\right) = \min\left(\sqrt{3.08 \cdot 10^{-3} \cdot 3.08 \cdot 10^{-3}}; 0.02\right) = 0.308 \%$$

(§6.4.4(1))

## Shear resistance without shear reinforcement

Normal concrete stresses (positive if compression)

Normal forces (from FEM):  $n_x = 0.1 \text{ kN/m}$   $n_y = 0.0 \text{ kN/m}$  [ULS-Set B (auto)/2]

$$\sigma_{cp,1} = \min\left(\frac{-n_x}{A_c}, 0.2 \cdot f_{cd}\right) = \min\left(\frac{-0.1}{0.21}, 0.2 \cdot 16.7 \cdot 10^6\right) = 0.00 \text{ MPa} \quad (\$6.2.2(1))$$

$$\sigma_{cp,2} = \min\left(\frac{-n_y}{A_c}, 0.2 \cdot f_{cd}\right) = \min\left(\frac{-0.0}{0.21}, 0.2 \cdot 16.7 \cdot 10^6\right) = 0.00 \text{ MPa} \quad (\$6.2.2(1))$$

$$\sigma_{cp} = \frac{\sigma_{cp,1} + \sigma_{cp,2}}{2} = \frac{0.00 + 0.00}{2} = 0.00 \text{ MPa}$$

Design shear resistance without shear reinforcement

(\\$6.4.4(1))

$$k = \min\left(1 + \left(\frac{200}{d}\right)^{\frac{1}{2}}; 2\right) = \min\left(1 + \left(\frac{200}{170}\right)^{\frac{1}{2}}; 2\right) = 2$$

$$C_{Rdc} = 0.12 \quad v_{min} = 0.495 \text{ MPa} \quad k_1 = 0.15$$

$$v_{Rdc} = \max\left(10^6 \cdot \left(C_{Rdc} \cdot k \cdot \left(100 \cdot \rho_l \cdot f_{ck}\right)^{\frac{1}{3}} + k_1 \cdot \sigma_{cp}\right) \cdot d; 0\right) \quad (6.47)$$

$$= \max\left(10^6 \cdot \left(0.12 \cdot 2 \cdot \left(100 \cdot 3.08 \cdot 10^{-3} \cdot 25\right)^{\frac{1}{3}} + 0.15 \cdot -159 \cdot 10^{-6}\right) \cdot 0.17; 0\right) = 80.6 \text{ kN/m}$$

$$v_{Rdcmin} = \max\left(10^6 \cdot (v_{min} + k_1 \cdot \sigma_{cp}) \cdot d; 0\right) = \max\left(10^6 \cdot (0.495 + 0.15 \cdot -159 \cdot 10^{-6}) \cdot 0.17; 0\right) = 84.1 \text{ kN/m}$$

$$v_{Rdc} = \max(v_{Rdc}, v_{Rdcmin}) = \max(80.6 \text{ kN/m}; 84.1 \text{ kN/m}) = 84.1 \text{ kN/m}$$

## Maximal concrete shear resistance

Strength reduction factor for concrete cracked in shear

$$v = 0.6 \cdot \left(1 - \frac{f_{ck}}{250}\right) = 0.6 \cdot \left(1 - \frac{25}{250}\right) = 0.54 \quad (6.6N)$$

Angle of compression concrete strut

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.192$$

Design value of the max shear force which can be sustained by the member

$$v_{Rd,max} = \frac{\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd}}{(\cotg(\theta) + \tg(\theta))} = \frac{1 \cdot 1 \cdot 0.168 \cdot 0.54 \cdot 16.7}{(\cotg(40) + \tg(40))} = 746 \text{ kN/m} \quad (6.9)$$

## Check shear capacity (without shear reinforcement)

Check  $v_{Rd,max}$

$$v_{Ed} = 10.8 \text{ kN/m} \leq v_{Rd,max} = 746 \text{ kN/m} \quad (\text{OK})$$

Check  $v_{Rdc}$

$$v_{Ed} = 10.8 \text{ kN/m} \leq v_{Rdc} = 84.1 \text{ kN/m} \quad (\text{OK, no shear reinforcement is required})$$

## Shear reinforcement - Summary

Design forces  $v_{Ed} = 10,8 \text{ kN}$  [ULS-Set B (auto)/2]

[ULS-Set B (auto)/2] :  $1.35 \cdot \text{LC1} + 1.35 \cdot \text{LC2} + 1.50 \cdot \text{LC3}$

Angle $\theta$ [°]	$A_{sl,x}$ [mm <sup>2</sup> /m]	$A_{sl,y}$ [mm <sup>2</sup> /m]	$\rho_l$ [%]	$v_{Ed}$ [kN/m]	$v_{Rdc}$ [kN/m]	$v_{Rd,max}$ [kN/m]	$A_{sw,req}$ [mm <sup>2</sup> /m <sup>2</sup> ]	Status
User (40°)	524	524	0,308	10,8	84,1	746,2	0 (no reinf.)	OK

$\theta$  - angle of compression strut,  $A_{sl,x/y}$  - tensile longitudinal reinforcement,  $\rho_l$  - mean value of longitudinal reinforcement ratio,  $v_{Rdc}$  - shear resistance without shear reinforcement,  $v_{Rd,max}$  - maximal concrete shear resistance,  $A_{sw,req}$  - required shear reinforcement

## 13. Količina armature

### 13.1. Load cases - LC1

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent	LG1	-Z
		Self weight		

### 13.1.

#### 13.1.1. 2D Reinforcement Design (ULS); $A_{s,req,1+}$

Values:  $A_{s,req,1+}$

Linear calculation

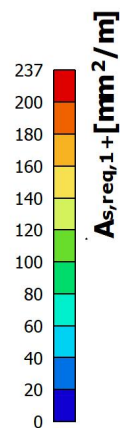
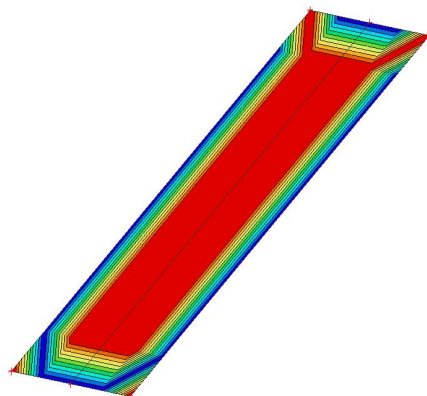
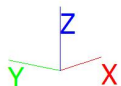
Load case: LC1

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 13.2. Load cases - LC2

Name	Description	Action type	Load group
	Spec	Load type	
LC2	Dodatno stalno	Permanent	LG1
		Standard	

### 13.2.

#### 13.2.1. 2D Reinforcement Design (ULS); $A_{s,req,1+}$

Values:  $A_{s,req,1+}$

Linear calculation

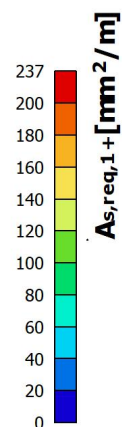
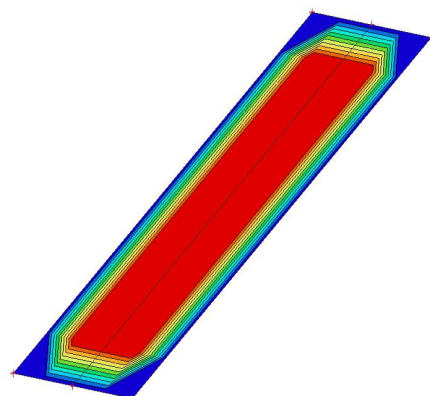
Load case: LC2

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 13.3. Load cases - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Snijeg	Variable	LG2	Short	None
	Standard	Static			

### 13.3.

#### 13.3.1. 2D Reinforcement Design (ULS); $A_{s,req,1+}$

Values:  $A_{s,req,1+}$

Linear calculation

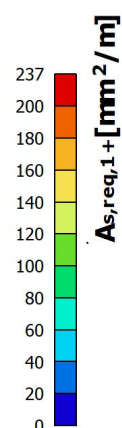
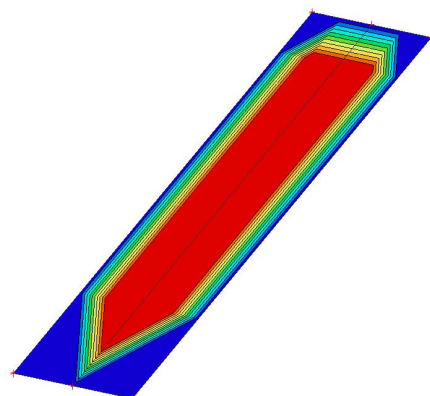
Load case: LC3

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element





## 14. Dimenzioniranje greda

### 14.1. Opterećenje grede

#### 14.1.1. Opterećenje grede - LC1

Name	Description Spec	Action type Load type	Load group	Direction
LC1	Self weight	Permanent Self weight	LG1	-Z

##### 14.1.1.1.

##### 14.1.1.1. LC2 / Tot. value

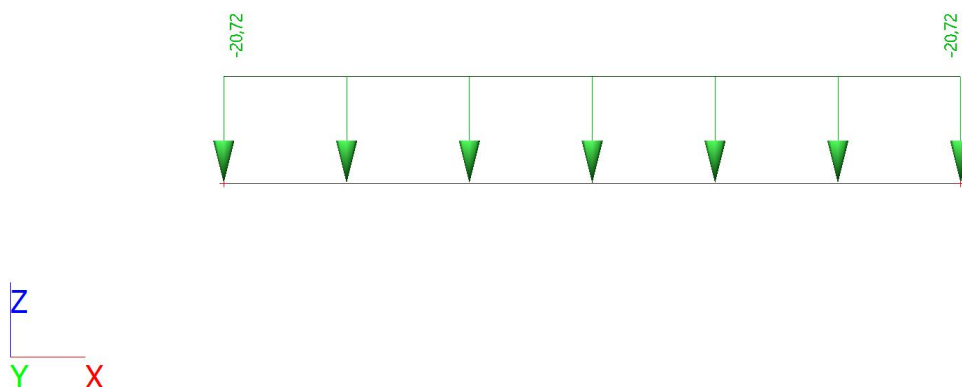


#### 14.1.2. Opterećenje grede - LC2

Name	Description Spec	Action type Load type	Load group
LC2	Dodatno stalno opterećenje	Permanent	LG1
		Standard	

##### 14.1.2.1.

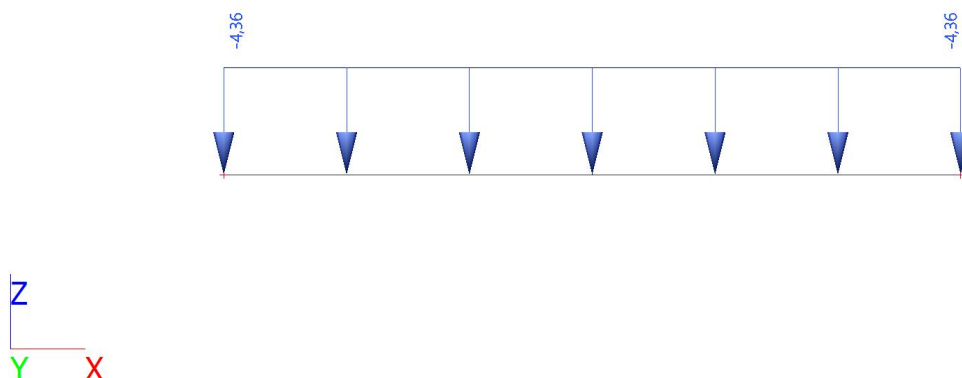
##### 14.1.2.1. LC2 / Tot. value



### 14.1.3. Opterećenje grede - LC3

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC3	Snijeg	Variable	LG2	None
	Snow	Static		

#### 14.1.3.1. LC2 / Tot. value



## 14.2. Unutarnje sile

### 14.2.1. Unutarnje sile - LC1

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent	LG1	-Z
		Self weight		

#### 14.2.1.

##### 14.2.1.1. 1D internal forces; $M_y$

Values:  $M_y$

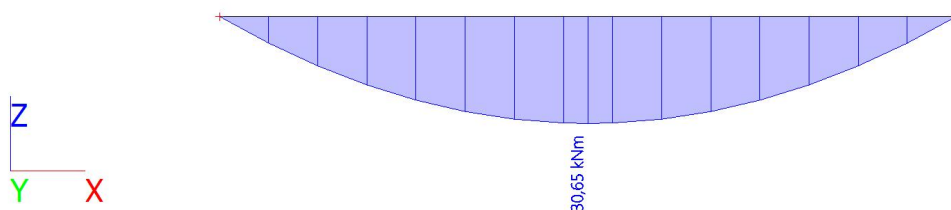
Linear calculation

Load case: LC1

Coordinate system: Principal

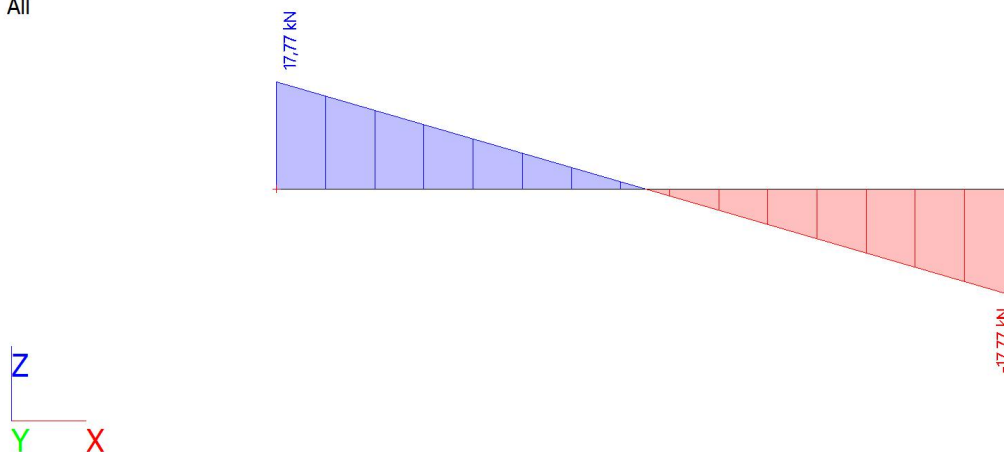
Extreme 1D: Global

Selection: All



#### 14.2.1.2. 1D internal forces; $V_z$

Values:  $V_z$   
 Linear calculation  
 Load case: LC1  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All



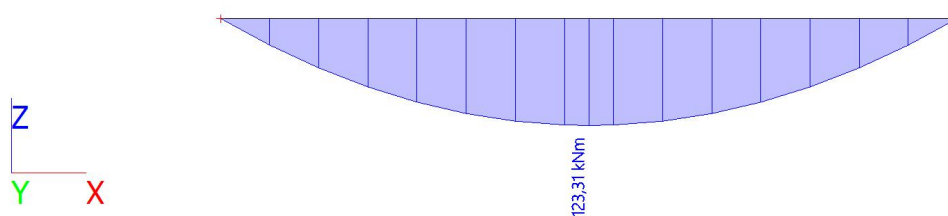
#### 14.2.2. Unutarnje sile - LC2

Name	Description Spec	Action type Load type	Load group
LC2	Dodatno stalno opterećenje	Permanent	LG1
		Standard	

#### 14.2.2.

##### 14.2.2.1. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Load case: LC2  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All



#### 14.2.2.2. 1D internal forces; $V_z$

Values:  $V_z$

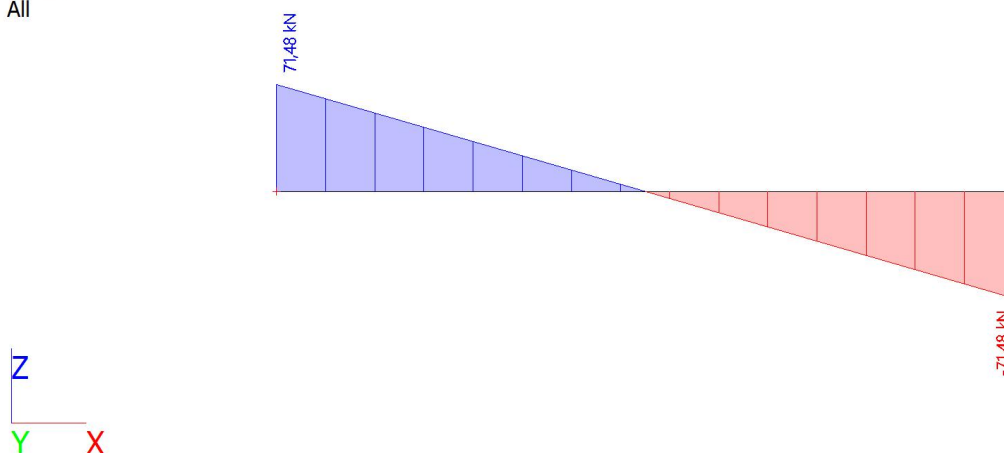
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 14.2.3. Unutarnje sile - LC3

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC3	Snijeg	Variable	LG2	None
	Snow	Static		

#### 14.2.3.

##### 14.2.3.1. 1D internal forces; $M_y$

Values:  $M_y$

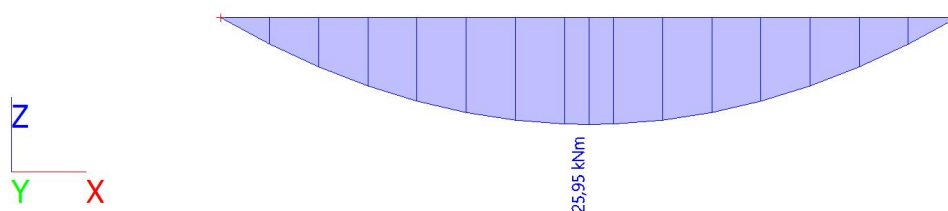
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 14.2.3.2. 1D internal forces; $V_z$

Values:  $V_z$

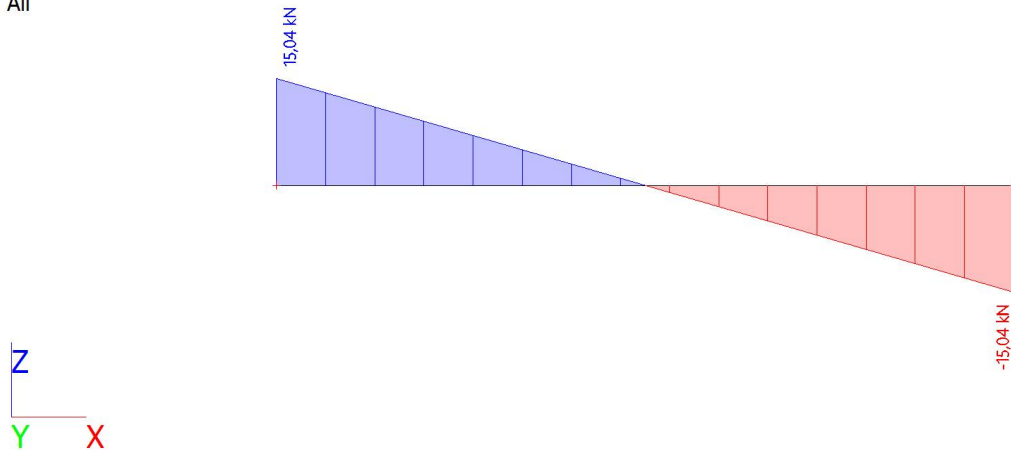
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 14.3. Load cases

#### 14.3.1. Load cases - LC1

Name	Description Spec	Action type Load type	Load group	Direction
LC1	Self weight	Permanent Self weight	LG1	-Z

#### 14.3.1.

##### 14.3.1.1. Reactions; $R_z$

Values:  $R_z$

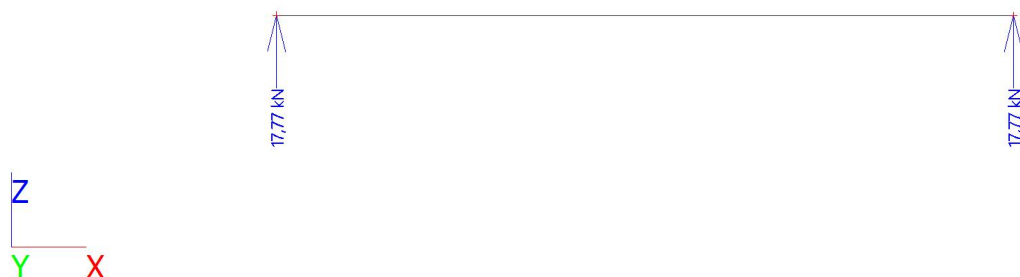
Linear calculation

Load case: LC1

System: Global

Extreme: Member

Selection: All



### 14.3.2. Load cases - LC2

Name	Description	Action type	Load group
	Spec	Load type	
LC2	Dodatno stalno opterećenje	Permanent	LG1
		Standard	

#### 14.3.2.

##### 14.3.2.1. Reactions; $R_z$

Values:  $R_z$

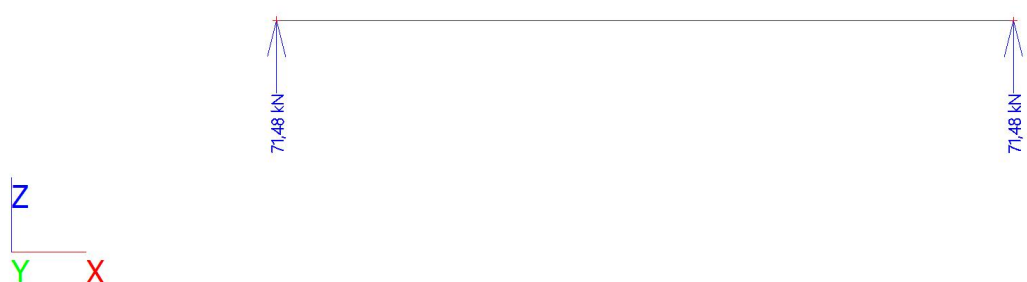
Linear calculation

Load case: LC2

System: Global

Extreme: Member

Selection: All



### 14.3.3. Load cases - LC3

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC3	Snijeg	Variable	LG2	None
	Snow	Static		

#### 14.3.3.

##### 14.3.3.1. Reactions; $R_z$

Values:  $R_z$

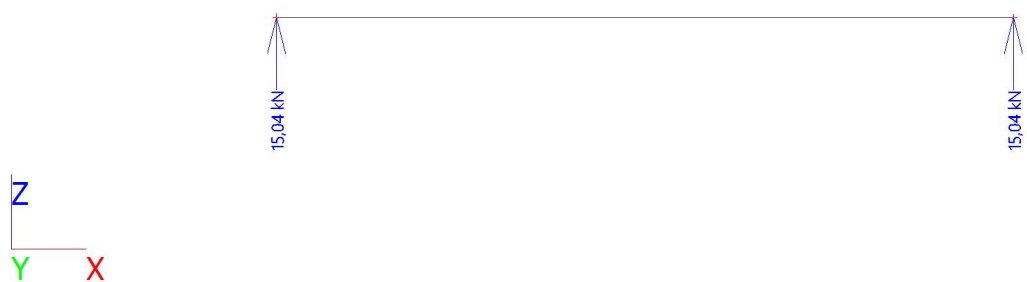
Linear calculation

Load case: LC3

System: Global

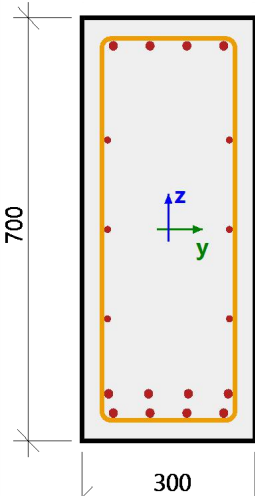
Extreme: Member

Selection: All



#### 14.4. Check capacity-interaction diagram

Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: All

Beam G201		Rectangle (700; 300)
EC EN 1992-1-1:2004/AC:2008		Section 7 [dx = 3.22 m]
<b>Member length:</b>	L = 6.9 m	<b>Concrete: C30/37</b>
Buckling y-y	L <sub>y</sub> = 6.9 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 6.9 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		6φ12 mm + 12φ16 mm (A <sub>s</sub> = 3091 mm <sup>2</sup> )
		ρ <sub>l</sub> = 1,472 % (24.3 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/241 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,199 % (3.27 kg/m) (A <sub>swm</sub> = 417 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

#### Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 30}{1.5} = 20 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 0 \text{ kN} \quad M_y = 246 \text{ kNm} \quad M_z = 0 \text{ kNm}$$

Content of combination:

$$1.35 \cdot LC1 + 1.35 \cdot LC2 + 1.50 \cdot LC3$$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (20 \cdot 10^6 \cdot 0.21) = -420 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -420 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$$N_{Ed} = 0 \text{ kN} \quad M_{Edy} = 247 \text{ kNm} \quad M_{Edz} = 0 \text{ kNm}$$

## Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{res} = 247 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{MyMz} = 180^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{res}$	$\alpha_{NM} = 0^\circ$

## Calculation of resistances

$$\text{Resistances in positive direction} \quad N_{Rd+} = 0 \text{ kN} \quad M_{Rdy+} = 502 \text{ kNm} \quad M_{Rdz+} = 0 \text{ kNm}$$

$$\text{Resistances in negative direction} \quad N_{Rd-} = 0 \text{ kN} \quad M_{Rdy-} = -316 \text{ kNm} \quad M_{Rdz-} = 0 \text{ kNm}$$



## Summary of check

Forces:  $N_{Ed} = 0 \text{ kN}$   $M_{Edy} = 247 \text{ kNm}$   $M_{Edz} = 0 \text{ kNm}$

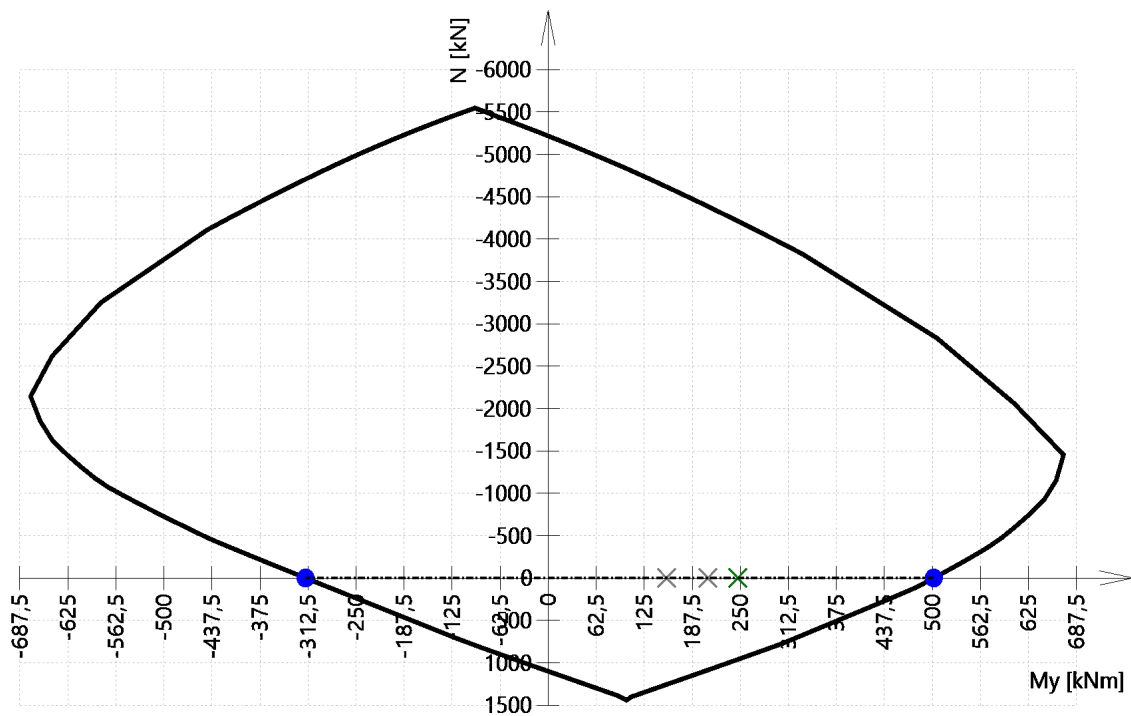
Resistance:  $N_{Rd} = 0 \text{ kN}$   $M_{Rdy} = 502 \text{ kNm}$   $M_{Rdz} = 0 \text{ kNm}$

Calculation of unity check:

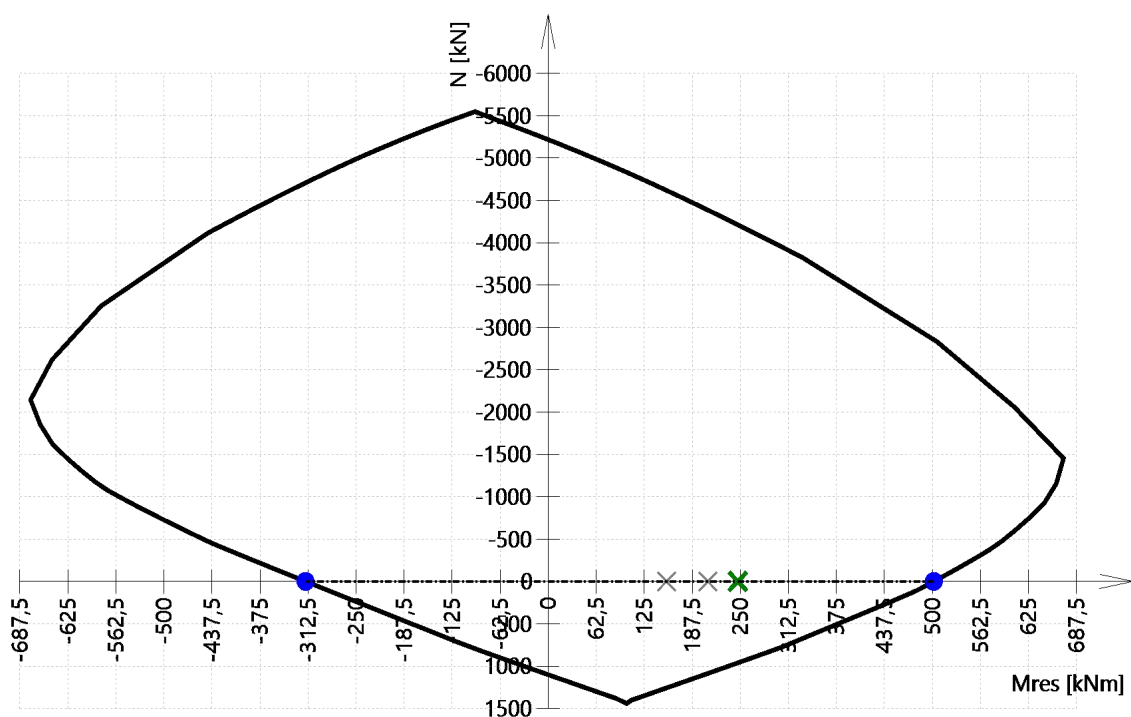
$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{0^2 + 247^2 + 0^2}}{\sqrt{0^2 + 502^2 + 0^2}} = 0.492 \leq 1 \quad \text{OK}$$

List of errors/warnings/notes: N2/1.

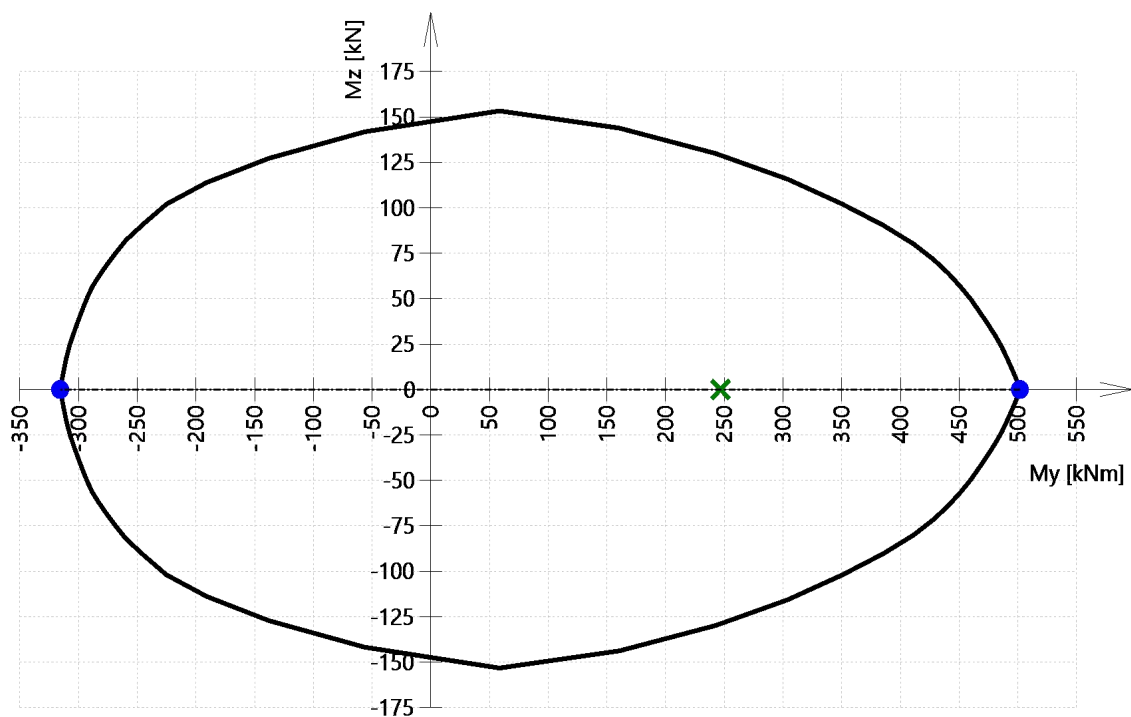
## 3D interaction diagram - Vertical section N-M<sub>y</sub>



### 3D interaction diagram - Vertical section $N-M_{res}$



### 3D interaction diagram - Horizontal section $M_y-M_z$

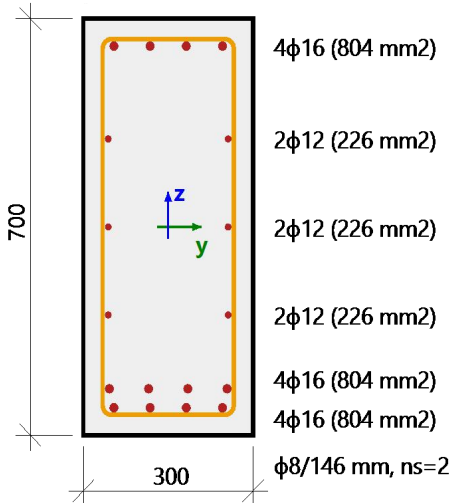


### Explanation of errors, warnings and notes

Index	Type	Description	Solution
N2/1	Note	The member is not considered as a compression member (normal force is relatively small or zero).	

## 14.5. Check shear+torsion (ULS)

Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: All

Beam G201		Rectangle (700; 300)
EC EN 1992-1-1:2004/AC:2008		Section 0 [dx = 0 m]
<b>Member length:</b>	L = 6.9 m	<b>Concrete: C30/37</b>
Buckling y-y	L <sub>y</sub> = 6.9 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 6.9 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		6φ12 mm + 12φ16 mm (A <sub>s</sub> = 3091 mm <sup>2</sup> )
		ρ <sub>l</sub> = 1,472 % (24.3 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/146 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,339 % (5.58 kg/m) (A <sub>swm</sub> = 711 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Settings

Method for calculation shear resistances:

Standard

Limit value of angle between bending moments and shear forces resultant for using standard method: : α<sub>VM,lim</sub> = 15 °

Equivalent thin walled cross-section:

Automatic

The angle between the concrete compression strut and axis member: User input: θ<sub>inp</sub> = 40 ° => cot(θ<sub>inp</sub>) = 1.19

## Forces

Content of combination: 1.35\*LC1+1.35\*LC2+1.50\*LC3

N<sub>Ed</sub> = 0 kN M<sub>E<sub>dy</sub></sub> = 45.1 kNm M<sub>E<sub>dz</sub></sub> = 0 kNm V<sub>E<sub>dy</sub></sub> = 0 kN V<sub>E<sub>dz</sub></sub> = 143 kN T<sub>Ed</sub> = 0 kNm

Angle of gradient of strain plane

$$\alpha_M = 90^\circ$$

Angle of shear resultant

$$\alpha_V = 90^\circ$$

Resultant of shear force

$$V_{Ed} = \sqrt{V_{E_{dy}}^2 + V_{E_{dz}}^2} = \sqrt{0^2 + 143^2} = 143 \text{ kN}$$

Difference between angles α<sub>M</sub> and α<sub>V</sub>

$$\alpha_{MV} = \text{abs}(\alpha_M - \alpha_V) = \text{abs}(90 - 90) = 0^\circ$$

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 30}{1.5} = 20 \text{ MPa}$$

Design tensile strength of concrete

$$f_{ctd} = \frac{\alpha_{ct} \cdot f_{ctk005}}{\gamma_c} = \frac{1 \cdot 2}{1.5} = 1.33 \text{ MPa} \quad (3.15, 3.16)$$

## Check shear and calculation shear resistances

### Cross section parameters

Minimum width of the cross-section in tensile area

$$y_{bw} = 0 \text{ mm}$$

$$z_{bw} = 101 \text{ mm}$$

$$b_w = 300 \text{ mm}$$

Note: Value  $b_w$  is calculated as the smallest width of cross-section in tensile area perpendicular to resultant of shear force.

Minimum width of cross-section between tension and compression chord

$$y_{bw1} = 0 \text{ mm}$$

$$z_{bw1} = 0 \text{ mm}$$

$$b_{w1} = 300 \text{ mm}$$

Note: Value  $b_{w1}$  is calculated as the smallest width of cross-section between tension and compression chord perpendicular to resultant of shear force.

Height of cross-section recalculated to direction of shear force resultant

$$h = 700 \text{ mm}$$

Note: Value  $h$  is calculated as width of cross-section in center of gravity in direction shear force resultant.

Concrete cross-section area

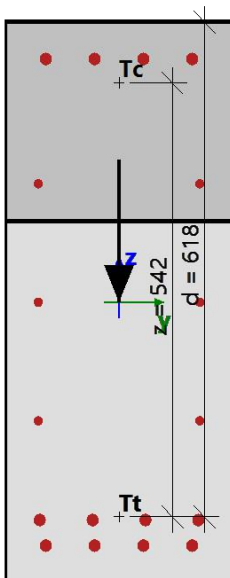
$$A_c = 0.21 \text{ m}^2$$

Effective depth recalculated to direction of shear force resultant

$$d = 618 \text{ mm}$$

Lever arm of internal forces recalculated to direction of shear force resultant

$$z = 542 \text{ mm}$$



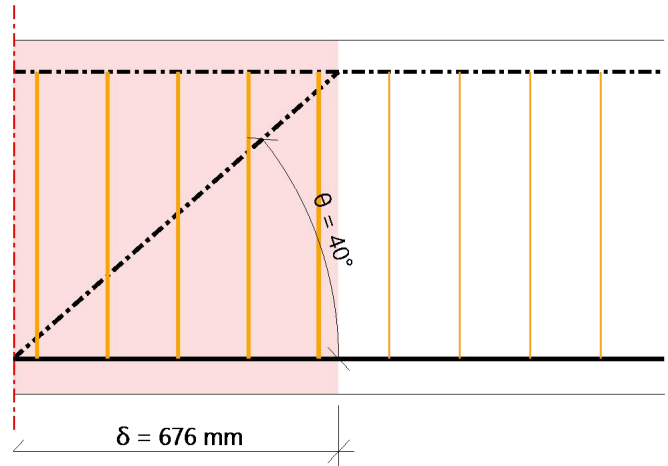
## Parameters of shear reinforcement

### Input parameters

Stirrups on the length of shear crack projection  $\delta = z \cdot \cot(\theta) = 676 \text{ mm}$ , interval (0; 676)

$$z = \text{Coeff}_d \cdot \text{Coeff}_z \cdot h = 0.9 \cdot 0.9 \cdot 0.7 = 567 \text{ mm} \quad \delta = z \cdot \cotg(\theta) = 0.567 \cdot \cotg(40) = 676 \text{ mm}$$

ID	Zone	$x_s$ [mm]	$\phi_s$ [mm]	$s_s$ [mm]	$n_s$ []	$\alpha_s$ [°]	$f_{ywk}$ [MPa]
1	1	50	8	123	2	90	500
2	1	196	8	146	2	90	500
3	1	342	8	146	2	90	500
4	1	488	8	146	2	90	500
5	1	635	8	146	2	90	500
Avg.	-	-	8	141	2	90	500



Number of stirrup links

$$n_s = 2$$

Diameter of reinforcement

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

Centre - to - centre distance of stirrup in longitudinal direction

$$s_{inp} = 0.141 \text{ m}$$

Angle of stirrups from axis of member

$$\alpha_s = 90^\circ$$

Characteristic yield strength

$$f_{ywk} = 500 \text{ MPa}$$

Cross - sectional area of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

Maximum longitudinal spacing of shear links

$$s_l = s_{inp} = 141 \text{ mm}$$

Cross - sectional area per meter

$$A_{swm} = \frac{A_{sw}}{s_l} = \frac{101 \cdot 10^{-6}}{0.141} = 711 \text{ mm}^2/\text{m}$$

## Parameters of longitudinal reinforcement

The area of tensile reinforcement

$$A_{sl} = 2061 \text{ mm}^2$$

## Calculation of shear resistances

### Design shear resistance of the member without shear reinforcement

$$\sigma_{ct,max} = 1.84 \text{ MPa} \geq f_{ctd} = 1.33 \text{ MPa} \Rightarrow \text{section cracked in flexure}$$

Calculation design shear resistance of the member without shear reinf. according to chapter 6.2.2(1).

Coefficient for cross - section height

$$k = \min \left( 1 + \left( \frac{200}{d} \right)^{\frac{1}{2}}; 2 \right) = \min \left( 1 + \left( \frac{200}{618} \right)^{\frac{1}{2}}; 2 \right) = 1.57 \quad (\$6.2.2(1))$$

Geometrical reinforcement ratio

$$\rho_1 = \min \left( \frac{A_{sl}}{b_w \cdot d}; 0.02 \right) = \min \left( \frac{2.06 \cdot 10^{-3}}{0.3 \cdot 0.618}; 0.02 \right) = 0.0111 \quad (\$6.2.2(1))$$

Cross-section axial stress

$$\sigma_{cp} = \min \left( \frac{-N_{Ed}}{A_c}; 0.2 \cdot f_{cd} \right) = \min \left( \frac{-0}{0.21}; 0.2 \cdot 20 \right) = 0 \text{ MPa} \quad (\$6.2.2(1))$$

Other coefficients

$$C_{Rdc} = 0.12 \quad v_{min} = 0.377 \text{ MPa} \quad k_1 = 0.15$$

Calculation design shear resistance

$$\begin{aligned} V_{Rdc} &= 10^6 \cdot \left( C_{Rdc} \cdot k \cdot \left( 100 \cdot \rho_1 \cdot f_{ck} \right)^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right) \cdot b_w \cdot d \\ &= 10^6 \cdot \left( 0.12 \cdot 1.57 \cdot \left( 100 \cdot 0.0111 \cdot 30 \right)^{\frac{1}{3}} + 0.15 \cdot 0 \right) \cdot 0.3 \cdot 0.618 = 112 \text{ kN} \end{aligned} \quad (6.2.a)$$

$$\begin{aligned} V_{Rdcmin} &= 10^6 \cdot \left( v_{min} + k_1 \cdot \sigma_{cp} \right) \cdot b_w \cdot d \\ &= 10^6 \cdot \left( 0.377 + 0.15 \cdot 0 \right) \cdot 0.3 \cdot 0.618 = 70 \text{ kN} \end{aligned} \quad (6.2.b)$$

$$V_{Rdc} = \max(V_{Rdc}; V_{Rdcmin}; 0) = \max(112354; 69848; 0) = 112 \text{ kN}$$

Note: Design shear resistance of the member without shear reinforcement is calculated according to clause 6.2.2(1), because section is cracked in flexure in ULS or section is not loaded by normal force and bending moments.

### Calculation of angle between concrete compression strut and member axis

Limit value of angle

- minimum value:

$$\theta_{min} = 21.8^\circ \Rightarrow \cot(\theta_{min}) = 2.5 \quad (\$6.2.3(2))$$

- maximum value:

$$\theta_{max} = 45^\circ \Rightarrow \cot(\theta_{max}) = 1 \quad (\$6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Design shear resistance of the member with shear reinforcement

Design stress of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

$$\sigma_{swd} = \frac{\frac{\text{abs}(V_{Ed})}{z} \cdot s_l}{A_{sw} \cdot (\cotg(\theta) + \cotg(\alpha_s) \cdot \sin(\alpha_s))} = \frac{\frac{\text{abs}(143054)}{0.542} \cdot 0.14}{101 \cdot 10^{-6} \cdot (\cotg(40) + \cotg(90) \cdot \sin(90))} = 311 \text{ MPa}$$

Design yield strength of shear reinforcement

$$f_{ywd} = 0.8 \cdot f_{ywk} = 0.8 \cdot 500 = 400 \text{ MPa} \quad , (\text{because } \sigma_{swd} < 0.8 \cdot f_{ywk})$$

Note: Design yield strength of shear reinforcement was reduced to 0.8 x  $f_{ywk}$  (EN 1992-1-1, clause 6.2.3(3)), because design stress of the shear reinforcement is below 80% of the characteristic yield stress  $f_{yk}$ .

Design shear resistance of the member with shear reinforcement

$$V_{Rds} = \frac{A_{sw}}{s_l} \cdot z \cdot f_{ywd} \cdot \cotg(\theta) = \frac{101 \cdot 10^{-6}}{0.14} \cdot 0.542 \cdot 400 \cdot 10^6 \cdot \cotg(40) = 184 \text{ kN} \quad (6.8)$$

## Design value of the max shear force which can be sustained by the member

Strength reduction factor for concrete cracked in shear - value  $v$

$$v = 0.6 \cdot \left( 1 - \frac{f_{ck}}{250} \right) = 0.6 \cdot \left( 1 - \frac{30}{250} \right) = 0.528 \quad (6.6N)$$

## Strength reduction factor for concrete cracked in shear - value $v_1$

$$\sigma_{cp} = \min \left( \frac{-N_{Ed}}{A_c}; 0.2 \cdot f_{cd} \right) = \min \left( \frac{-0}{0.21}; 0.2 \cdot 20 \right) = 0 \text{ MPa}$$

$$v_1 = 0.6 \quad (6.10.aN)$$

Coefficient taking into account state of the stress in the compression chord

$$\alpha_{cw} = 1 \quad (\text{for non-prestressed member}) \quad (§6.2.3(3)N3)$$

Design value of the max shear force which can be sustained by the member

$$V_{Rdmax} = \frac{\alpha_{cw} \cdot b_{w1} \cdot z \cdot v_1 \cdot f_{cd}}{(\cotg(\theta) + \tg(\theta))} = \frac{1 \cdot 0.3 \cdot 0.542 \cdot 0.6 \cdot 20 \cdot 10^6}{(\cotg(40) + \tg(40))} = 961 \text{ kN} \quad (6.9)$$

## Maximum shear force near the support (without using factor $\beta$ )

$$V_{Edmax} = 0.5 \cdot b_{w1} \cdot d \cdot v \cdot f_{cd} = 0.5 \cdot 0.3 \cdot 0.618 \cdot 0.528 \cdot 20 \cdot 10^6 = 979 \text{ kN} \quad (6.5)$$

## Shear resistance of the member

$$V_{Rd} = \min(V_{Rds} + V_{ccd} + V_{tdr}; V_{Rdmax} + V_{ccd} + V_{tdr}; V_{Edmax} + V_{ccd} + V_{td}) = \min(184 + 0 + 0; 961 + 0 + 0; 979 + 0 + 0) = 184 \text{ kN}$$

## Shear check

Check  $V_{Rdmax}$

$$V_{Ed} = 143 \text{ kN} \leq V_{Rdmax} + V_{ccd} + V_{td} = 961 \text{ kN}$$

Note: The check satisfies for crushing of the compression strut ( $V_{Ed} \leq V_{Rd,max} + V_{td} + V_{ccd}$ ).

Check  $V_{Edmax}$

$$V_{Ed} = 143 \text{ kN} \leq V_{Edmax} + V_{ccd} + V_{td} = 979 \text{ kN}$$

Note: The check satisfies for shear force near the support ( $V_{Ed} \leq V_{Ed,max} + V_{td} + V_{ccd}$ ).

Check  $V_{Rdc}$  and  $V_{Rds}$

$$V_{Ed} = 143 \text{ kN} > V_{Rdc} = 112 \text{ kN} \text{ and } V_{Ed} = 143 \text{ kN} < V_{Rds} + V_{ccd} + V_{td} = 184 \text{ kN}$$

Note: The check satisfies for shear reinforcement ( $V_{Ed} < V_{Rds} + V_{ccd} + V_{td}$ ).

## Unity check

$$UC = \frac{\text{abs}(V_{Ed})}{V_{Rd}} = \frac{\text{abs}(143 \text{ kN})}{184 \text{ kN}} = 0.779$$

## Check torsion and calculation torsional resistances

Note: Check torsion is not done, because torsional moment ( $T_{Ed}$ ) is zero.

## Interaction check $V_y + V_z + T$

Note: Check interaction  $V_y + V_z + T$  is not done, because torsional moment ( $T_{Ed}$ ) or resultant of shear force ( $V_{Ed}$ ) are zero.

## Total value of unity check

$$UC = \max(UC_{shear}, UC_{tor}, UC_{int.conv}, UC_{int.shear}) = \max(0.779; 0; 0; 0) = 0.779$$



## 14.6. Check deflection

Linear calculation  
Combination: SLS-Char (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: All

<b>Beam G201</b>	<b>Rectangle (700; 300)</b>
EC EN 1992-1-1:2004/AC:2008	Section 8 [dx = 3.45 m]

## Short-term stiffnesses and curvatures under total load

### Settings

Long-term part of applied load = 0%

### Material characteristics

Characteristic concrete compressive strength

$$f_{ck} = 30 \text{ MPa}$$

Characteristic yield strength of longitudinal reinforcement

$$f_{yk} = 500 \text{ MPa}$$

Modulus of elasticity of concrete:

$$E_c = 33 \text{ GPa}$$

### Forces

Content of combination:

LC1+LC2+LC3

From FEM analysis

Characteristic values:  $N = 0 \text{ kN}$   $M_y = 180 \text{ kNm}$   $M_z = 0 \text{ kNm}$

Quasi-permanent values:  $N_{qp} = 0 \text{ kN}$   $M_{y,qp} = 180 \text{ kNm}$   $M_{z,qp} = 0 \text{ kNm}$

Angle of bending moment resultant:  $\alpha_M = 90^\circ$

### Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (20 \cdot 10^6 \cdot 0.21) = -420 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -420 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Characteristic values:  $N_{char,r} = 0 \text{ kN}$   $M_{y,char,r} = 180 \text{ kNm}$   $M_{z,char,r} = 0 \text{ kNm}$

Quasi-permanent values:  $N_{qp,r} = 0 \text{ kN}$   $M_{y,qp,r} = 180 \text{ kNm}$   $M_{z,qp,r} = 0 \text{ kNm}$

Angle of bending moment resultant:  $\alpha_{M,r} = 90^\circ$

## Calculation of $f_{ct,eff}$

Mean tensile concrete strength

$$f_{ctm} = 2.9 \text{ MPa}$$

$$\alpha_M = 90^\circ$$

$$h = 0.7 \text{ m}$$

$$f_{ct,eff} = f_{ctm} = 2.9 \text{ MPa}$$

Strength in concrete, when crack is appeared

$$f_{ct,eff} = 2.9 \text{ MPa}$$

## Cross-section characteristics

Type of component	$t_y$ [m]	$t_z$ [m]	A [m <sup>2</sup> ]	$I_y$ [m <sup>4</sup> ]	$I_z$ [m <sup>4</sup> ]	$x_i$ [m]	$A_{st}$ [m <sup>2</sup> ]	$A_{sc}$ [m <sup>2</sup> ]	$A_s$ [m <sup>2</sup> ]
Linear	0	0	0.21	$8.58 \cdot 10^{-3}$	$1.58 \cdot 10^{-3}$	0.35	-	-	-
Uncracked	0	$-6 \cdot 10^{-3}$	0.229	$9.9 \cdot 10^{-3}$	$1.7 \cdot 10^{-3}$	0.36	$1.84 \cdot 10^{-3}$	$1.26 \cdot 10^{-3}$	$3.09 \cdot 10^{-3}$
Cracked	0	0.174	0.0715	$2.91 \cdot 10^{-3}$	$521 \cdot 10^{-6}$	0.176	$2.29 \cdot 10^{-3}$	$804 \cdot 10^{-6}$	$3.09 \cdot 10^{-3}$

## Check of concrete stresses and calculation of cracking forces

Maximal tensile stress in concrete fibre

$$\sigma_{ct} = 6.26 \text{ MPa}$$

Cracking status

$$\sigma_{ct} > f_{ct,eff} = 6.26 \text{ MPa} > 2.9 \text{ MPa} \Rightarrow \text{Cracks appear.}$$

Stress in reinforcement for cracking load

$$\sigma_{sr} = 83.7 \text{ MPa}$$

Stress in reinforcement for acting load

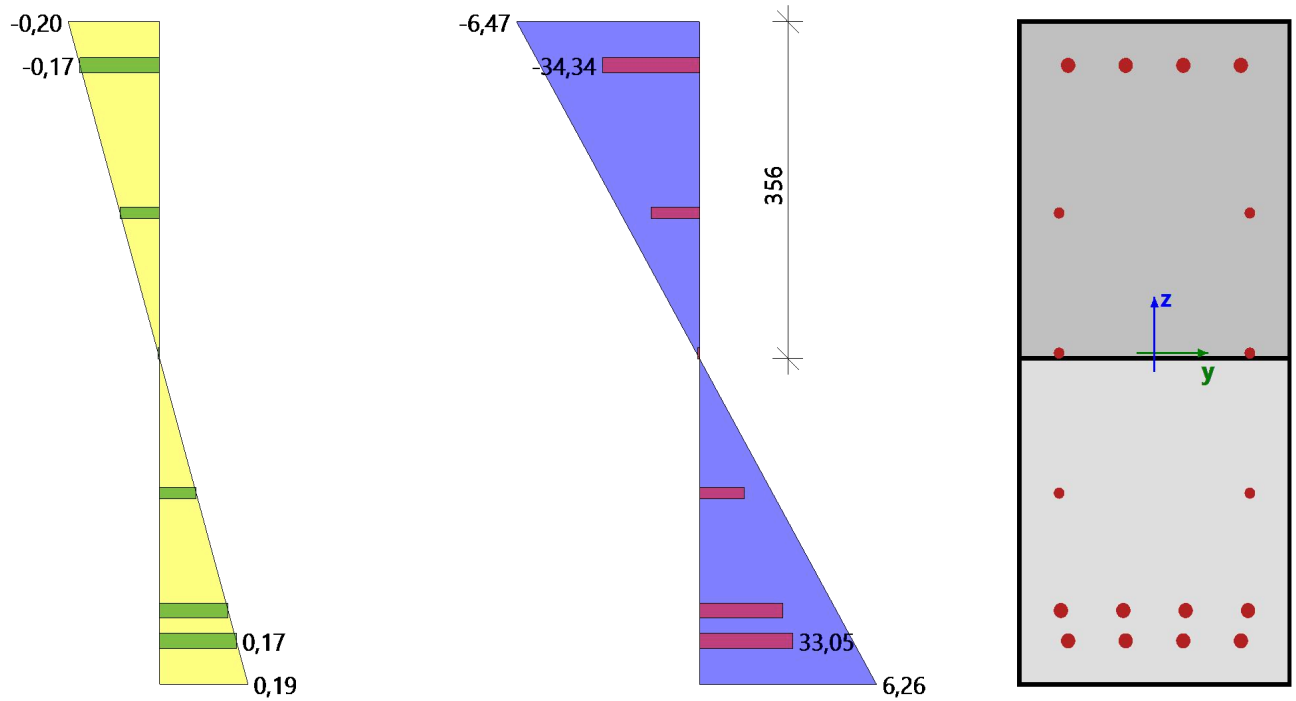
$$\sigma_s = 180 \text{ MPa}$$

Distribution coefficient

$$\zeta = \max \left( 0; 1 - \beta \cdot \left( \frac{\sigma_{sr}}{\sigma_s} \right)^2 \right) = \max \left( 0; 1 - 1 \cdot \left( \frac{83.7}{180} \right)^2 \right) = 0.785 \quad (7.19)$$

$N_{cr}$ [kN]	$M_{y,cr}$ [kNm]	$M_{z,cr}$ [kNm]	$\sigma_{ct}$ [MPa]	$f_{ct,eff}$ [MPa]	Cracked section	$\sigma_{sr}$ [MPa]	$\sigma_s$ [MPa]	$\beta$ [-]	$\zeta$ [-]	$E_c$ [GPa]
0	83.5	0	6.26	2.9	<b>YES</b>	83.7	180	1	0.785	32.8

## Stress and strain distribution for verification of crack appearance for short-term load



## Stiffnesses

### Axial stiffness EA

$$EA_{lin} = E_c \cdot A_c = 32.8 \cdot 0.21 = 6888 \text{ MN}$$

$$EA_I = E_c \cdot A_{c,I} = 32.8 \cdot 0.229 = 7506 \text{ MN}$$

$$EA_{II} = E_c \cdot A_{c,II} = 32.8 \cdot 0.0715 = 2346 \text{ MN}$$

$$EA = \frac{1}{\frac{\zeta}{EA_{II}} + \frac{1-\zeta}{EA_I}} = \frac{1}{\frac{0.785}{2346} + \frac{1-0.785}{7506}} = 2753 \text{ MN} \quad (7.18)$$

$$\text{RatioEA} = \frac{EA}{EA_{lin}} = \frac{2753}{6888} = 0.4$$

### Bending stiffness Ely

$$E_{y,lin} = E_c \cdot I_y = 32.8 \cdot 8.58 \cdot 10^9 = 281 \text{ MNm}^2$$

$$E_{y,I} = E_c \cdot I_{y,I} = 32.8 \cdot 9.9 \cdot 10^9 = 325 \text{ MNm}^2$$

$$E_{y,II} = E_c \cdot I_{y,II} = 32.8 \cdot 2.91 \cdot 10^9 = 95.4 \text{ MNm}^2$$

$$E_y = \frac{1}{\frac{\zeta}{E_{y,II}} + \frac{1-\zeta}{E_{y,I}}} = \frac{1}{\frac{0.785}{95.4} + \frac{1-0.785}{325}} = 113 \text{ MN} \cdot \text{m}^2 \quad (7.18)$$

$$\text{RatioEly} = \frac{E_y}{E_{y,lin}} = \frac{113}{281} = 0.4$$

## Bending stiffness Elz

$$El_{z,lin} = E_c \cdot I_z = 32.8 \cdot 1.58 \cdot 10^9 = 51.7 \text{ MNm}^2$$

$$El_{z,l} = E_c \cdot I_{z,l} = 32.8 \cdot 1.7 \cdot 10^9 = 55.8 \text{ MNm}^2$$

$$El_{z,ll} = E_c \cdot I_{z,ll} = 32.8 \cdot 521 \cdot 10^6 = 17.1 \text{ MNm}^2$$

$$El_z = \frac{1}{\frac{\zeta}{El_{z,ll}} + \frac{1-\zeta}{El_{z,l}}} = \frac{1}{\frac{0.785}{17.1} + \frac{1-0.785}{55.8}} = 20.1 \text{ MN}\cdot\text{m}^2 \quad (7.18)$$

$$\text{RatioElz} = \frac{El_z}{El_{z,lin}} = \frac{20.1}{51.7} = 0.389$$

## Curvatures

### Concrete cross-section

$$\frac{1}{r_{y,lin}} = \frac{-M_{y,qp}}{E_c \cdot I_y} = \frac{-180}{33 \cdot 8.58 \cdot 10^9} = -640 \cdot 10^{-6} \text{ m}^{-1}$$

### Un-cracked cross-section

$$\frac{1}{r_{y,l}} = \frac{-M_{y,qp}}{E_c \cdot I_{y,l}} = \frac{-180}{33 \cdot 9.9 \cdot 10^9} = -554 \cdot 10^{-6} \text{ m}^{-1}$$

### Fully-cracked cross-section

$$\frac{1}{r_{y,ll}} = \frac{-M_{y,qp}}{E_c \cdot I_{y,ll}} = \frac{-180}{33 \cdot 2.91 \cdot 10^9} = -1.89 \cdot 10^{-3} \text{ m}^{-1}$$

## Resultant curvatures

$$\frac{1}{r_y} = \zeta \cdot \frac{1}{r_{y,ll}} + (1 - \zeta) \cdot \frac{1}{r_{y,l}} = 0.785 \cdot -1.89 \cdot 10^{-3} + (1 - 0.785) \cdot -554 \cdot 10^{-6} = -1.6 \cdot 10^{-3} \text{ m}^{-1}$$

## Stiffness ratio

$$\text{ratio}_{ux} = \frac{1}{\text{RatioEA}} = \frac{1}{0.4} = 2.5$$

$$\text{ratio}_{uy} = \frac{1}{\text{RatioElz}} = \frac{1}{0.389} = 2.57$$

$$\text{ratio}_{uz} = \frac{1}{\text{RatioEly}} = \frac{1}{0.4} = 2.5$$

# Long-term stiffnesses and curvatures under total load

## Settings

Long-term part of applied load = 70%

Creep coefficient  $\varphi = 2.328$

## Material characteristics

Characteristic concrete compressive strength

$$f_{ck} = 30 \text{ MPa}$$

Modulus of elasticity of concrete:

$$E_c = \frac{E_{cm}}{1 + \varphi_{ef}} = \frac{32.8 \cdot 10^9}{1 + 2.33} = 9.9 \text{ GPa} \quad (7.20)$$

Characteristic yield strength of longitudinal reinforcement

$$f_{yk} = 500 \text{ MPa}$$

## Forces

Content of combination:

LC1+LC2+LC3

From FEM analysis

Characteristic values:  $N = 0 \text{ kN}$   $M_y = 180 \text{ kNm}$   $M_z = 0 \text{ kNm}$

Quasi-permanent values:  $N_{qp} = 0 \text{ kN}$   $M_{y,qp} = 180 \text{ kNm}$   $M_{z,qp} = 0 \text{ kNm}$

Angle of bending moment resultant:  $\alpha_M = 90^\circ$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (20 \cdot 10^6 \cdot 0.21) = -420 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -420 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Characteristic values:  $N_{char,r} = 0 \text{ kN}$   $M_{y,char,r} = 126 \text{ kNm}$   $M_{z,char,r} = 0 \text{ kNm}$

Quasi-permanent values:  $N_{qp,r} = 0 \text{ kN}$   $M_{y,qp,r} = 126 \text{ kNm}$   $M_{z,qp,r} = 0 \text{ kNm}$

Angle of bending moment resultant:  $\alpha_{M,r} = 90^\circ$

## Calculation of $f_{ct,eff}$

Mean tensile concrete strength

$$f_{ctm} = 2.9 \text{ MPa}$$

$$\alpha_M = 90^\circ$$

$$h = 0.7 \text{ m}$$

$$f_{ct,eff} = f_{ctm} = 2.9 \text{ MPa}$$

Strength in concrete, when crack is appeared

$$f_{ct,eff} = 2.9 \text{ MPa}$$

## Cross-section characteristics

Type of component	$t_y$ [m]	$t_z$ [m]	$A$ [m <sup>2</sup> ]	$I_y$ [m <sup>4</sup> ]	$I_z$ [m <sup>4</sup> ]	$x_i$ [m]	$A_{st}$ [m <sup>2</sup> ]	$A_{sc}$ [m <sup>2</sup> ]	$A_s$ [m <sup>2</sup> ]
Linear	0	0	0.21	$8.58 \cdot 10^{-3}$	$1.58 \cdot 10^{-3}$	0.35	-	-	-
Uncracked	0	-0.016	0.273	0.0129	$1.99 \cdot 10^{-3}$	0.37	$1.84 \cdot 10^{-3}$	$1.26 \cdot 10^{-3}$	$3.09 \cdot 10^{-3}$
Cracked	0	0.09	0.141	$7.49 \cdot 10^{-3}$	$1 \cdot 10^{-3}$	0.26	$2.06 \cdot 10^{-3}$	$1.03 \cdot 10^{-3}$	$3.09 \cdot 10^{-3}$

## Check of concrete stresses and calculation of cracking forces

Maximal tensile stress in concrete fibre

$$\sigma_{ct} = 3.25 \text{ MPa}$$

Cracking status

$$\sigma_{ct} > f_{ct,eff} = 3.25 \text{ MPa} > 2.9 \text{ MPa} \Rightarrow \text{Cracks appear.}$$

Stress in reinforcement for cracking load

$$\sigma_{sr} = 121 \text{ MPa}$$

Stress in reinforcement for acting load

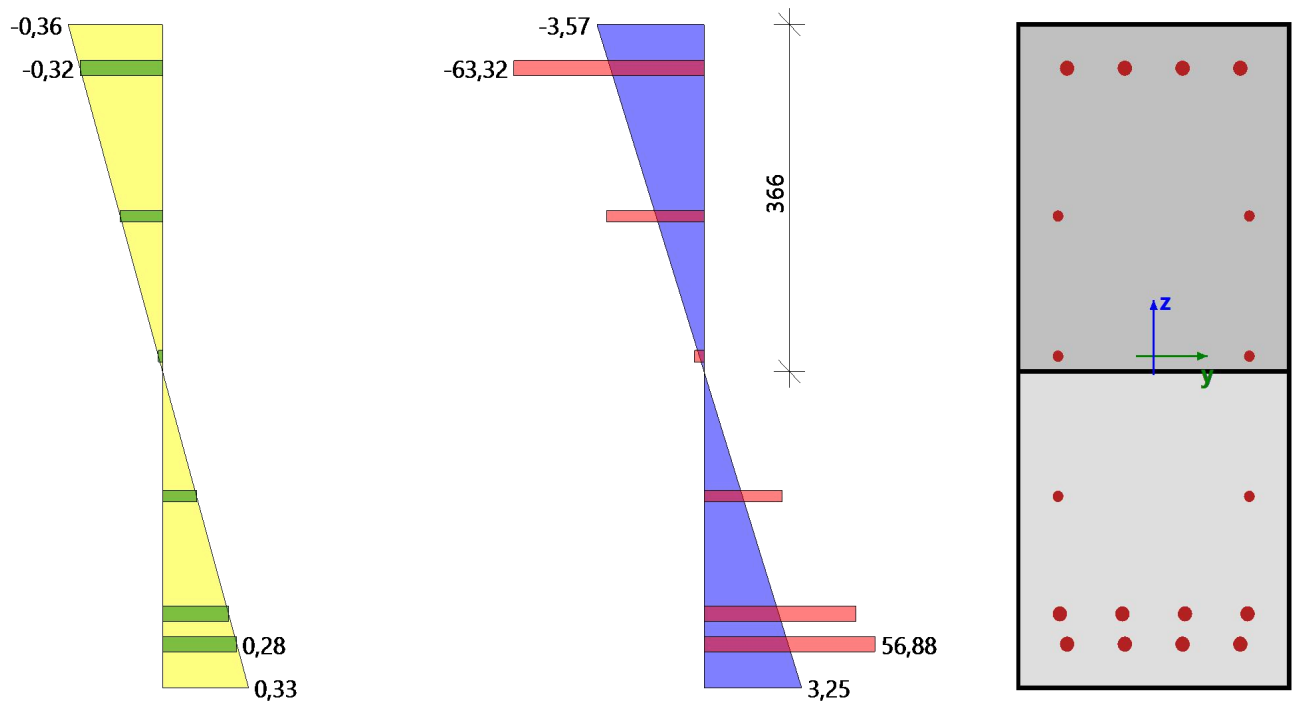
$$\sigma_s = 135 \text{ MPa}$$

Distribution coefficient

$$\zeta = \max \left( 0; 1 - \beta \cdot \left( \frac{\sigma_{sr}}{\sigma_s} \right)^2 \right) = \max \left( 0; 1 - 0.5 \cdot \left( \frac{121}{135} \right)^2 \right) = 0.598 \quad (7.19)$$

$N_{cr}$ [kN]	$M_{y,cr}$ [kNm]	$M_{z,cr}$ [kNm]	$\sigma_{ct}$ [MPa]	$f_{ct,eff}$ [MPa]	Cracked section	$\sigma_{sr}$ [MPa]	$\sigma_s$ [MPa]	$\beta$ [-]	$\zeta$ [-]	$E_c$ [GPa]
0	113	0	3.25	2.9	<b>YES</b>	121	135	0.5	0.598	9.9

## Stress and strain distribution for verification of crack appearance for long-term load



## Stiffnesses

### Axial stiffness EA

$$EA_{lin} = E_c \cdot A_c = 32.8 \cdot 0.21 = 6888 \text{ MN}$$

$$EA_I = E_{c,eff} \cdot A_{c,I} = 9.85 \cdot 0.273 = 2688 \text{ MN}$$

$$EA_{II} = E_{c,eff} \cdot A_{c,II} = 9.85 \cdot 0.141 = 1386 \text{ MN}$$

$$EA = \frac{1}{\frac{\zeta}{EA_{II}} + \frac{1 - \zeta}{EA_I}} = \frac{1}{\frac{0.598}{1386} + \frac{1 - 0.598}{2688}} = 1721 \text{ MN} \quad (7.18)$$

$$\text{RatioEA} = \frac{EA}{EA_{lin}} = \frac{1721}{6888} = 0.25$$

### Bending stiffness Ely

$$Ely_{lin} = E_c \cdot I_y = 32.8 \cdot 8.58 \cdot 10^9 = 281 \text{ MNm}^2$$

$$Ely_I = E_{c,eff} \cdot I_{y,I} = 9.85 \cdot 12.9 \cdot 10^9 = 127 \text{ MNm}^2$$

$$Ely_{II} = E_{c,eff} \cdot I_{y,II} = 9.85 \cdot 7.49 \cdot 10^9 = 73.8 \text{ MNm}^2$$

$$Ely = \frac{1}{\frac{\zeta}{Ely_{II}} + \frac{1 - \zeta}{Ely_I}} = \frac{1}{\frac{0.598}{73.8} + \frac{1 - 0.598}{127}} = 88.9 \text{ MN} \cdot \text{m}^2 \quad (7.18)$$

$$\text{RatioEly} = \frac{Ely}{Ely_{lin}} = \frac{88.9}{281} = 0.316$$

## Bending stiffness $El_z$

$$El_{z,lin} = E_c \cdot I_z = 32.8 \cdot 1.58 \cdot 10^9 = 51.7 \text{ MNm}^2$$

$$El_{z,I} = E_{c,eff} \cdot I_{z,I} = 9.85 \cdot 1.99 \cdot 10^9 = 19.7 \text{ MNm}^2$$

$$El_{z,II} = E_{c,eff} \cdot I_{z,II} = 9.85 \cdot 1 \cdot 10^9 = 9.9 \text{ MNm}^2$$

$$El_z = \frac{1}{\frac{\zeta}{El_{z,II}} + \frac{1-\zeta}{El_{z,I}}} = \frac{1}{\frac{0.598}{9.9} + \frac{1-0.598}{19.7}} = 12.4 \text{ MN}\cdot\text{m}^2 \quad (7.18)$$

$$\text{RatioElz} = \frac{El_z}{El_{z,lin}} = \frac{12.4}{51.7} = 0.239$$

## Curvatures

### Concrete cross-section

$$\frac{1}{r_{y,lin}} = \frac{-M_{y,qp}}{E_{c,eff} \cdot I_y} = \frac{-180}{10 \cdot 8.58 \cdot 10^9} = -2.13 \cdot 10^{-3} \text{ m}^{-1}$$

### Un-cracked cross-section

$$\frac{1}{r_{y,I}} = \frac{-M_{y,qp}}{E_{c,eff} \cdot I_{y,I}} = \frac{-180}{10 \cdot 12.9 \cdot 10^9} = -1.41 \cdot 10^{-3} \text{ m}^{-1}$$

### Fully-cracked cross-section

$$\frac{1}{r_{y,II}} = \frac{-M_{y,qp}}{E_{c,eff} \cdot I_{y,II}} = \frac{-180}{10 \cdot 7.49 \cdot 10^9} = -2.44 \cdot 10^{-3} \text{ m}^{-1}$$

## Resultant curvatures

$$\frac{1}{r_y} = \zeta \cdot \frac{1}{r_{y,II}} + (1 - \zeta) \cdot \frac{1}{r_{y,I}} = 0.598 \cdot -2.44 \cdot 10^{-3} + (1 - 0.598) \cdot -1.41 \cdot 10^{-3} = -2.02 \cdot 10^{-3} \text{ m}^{-1}$$

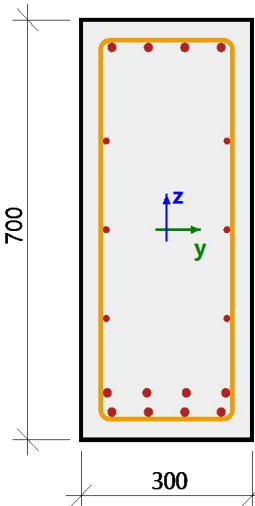
## Stiffness ratio

$$\text{ratio}_{ux} = \frac{1}{\text{RatioEA}} = \frac{1}{0.25} = 4$$

$$\text{ratio}_{uy} = \frac{1}{\text{RatioElz}} = \frac{1}{0.239} = 4.18$$

$$\text{ratio}_{uz} = \frac{1}{\text{RatioEly}} = \frac{1}{0.316} = 3.17$$



<b>Member length:</b>	L = 6.9 m	<b>Concrete: C30/37</b>
Buckling y-y	L <sub>y</sub> = 6.9 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 6.9 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		6φ12 mm + 12φ16 mm (A <sub>s</sub> = 3091 mm <sup>2</sup> )
		ρ <sub>l</sub> = 1,472 % (24.3 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/241 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,199 % (3.27 kg/m) (A <sub>swm</sub> = 417 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Ratios

### Short-term ratios

#### Bending stiffness Ely

$$\text{RatioElys} = \frac{E_{ly,s}}{E_{ly,\text{lin}}} = \frac{113 \cdot 10^6}{281 \cdot 10^6} = 0.4$$

#### Bending stiffness Elz

$$\text{RatioElzs} = \frac{E_{lz,s}}{E_{lz,\text{lin}}} = \frac{20.1 \cdot 10^6}{51.7 \cdot 10^6} = 0.389$$

## Ratios

$$\text{ratio}_{\text{uys}} = \frac{1}{\text{RatioElzs}} = \frac{1}{0.389} = 2.57$$

$$\text{ratio}_{\text{uzs}} = \frac{1}{\text{RatioElys}} = \frac{1}{0.4} = 2.5$$

## Long-term ratios

### Bending stiffness $EI_y$

$$\text{RatioElyl} = \frac{EI_{y,l}}{EI_{y,\text{lin}}} = \frac{88.9 \cdot 10^6}{281 \cdot 10^6} = 0.316$$

### Bending stiffness $EI_z$

$$\text{RatioElzl} = \frac{EI_{z,l}}{EI_{z,\text{lin}}} = \frac{12.4 \cdot 10^6}{51.7 \cdot 10^6} = 0.239$$

## Ratios

$$\text{ratio}_{uyl} = \frac{1}{\text{RatioElzl}} = \frac{1}{0.239} = 4.18$$

$$\text{ratio}_{uzl} = \frac{1}{\text{RatioElyl}} = \frac{1}{0.316} = 3.17$$

## Deflections

### Linear deflection

$$\delta_{\text{lin},y} = u_{ys} + u_{yl} = 0 + 0 = 0 \text{ mm}$$

$$\delta_{\text{lin},z} = u_{zs} + u_{zl} = -0.974 + -2.27 = -3.25 \text{ mm}$$

### Immediate deflection

$$\delta_{\text{imm},y} = u_{yl} \cdot \text{ratio}_{uys} = 0 \cdot 2.57 = 0 \text{ mm}$$

$$\delta_{\text{imm},z} = u_{zl} \cdot \text{ratio}_{uzs} = -2.27 \cdot 2.5 = -5.68 \text{ mm}$$

### Short-term deflection

$$\delta_{\text{short},y} = u_{ys} \cdot \text{ratio}_{uys} = 0 \cdot 2.57 = 0 \text{ mm}$$

$$\delta_{\text{short},z} = u_{zs} \cdot \text{ratio}_{uzs} = -0.974 \cdot 2.5 = -2.43 \text{ mm}$$

### Long-term + creep deflection

$$\delta_{\text{long,creep},y} = u_{yl} \cdot \text{ratio}_{uyl} = 0 \cdot 4.18 = 0 \text{ mm}$$

$$\delta_{\text{long,creep},z} = u_{zl} \cdot \text{ratio}_{uzl} = -2.27 \cdot 3.17 = -7.2 \text{ mm}$$

### Creep deflection

$$\delta_{\text{creep},y} = u_{yl} \cdot (\text{ratio}_{uyl} - \text{ratio}_{uys}) = 0 \cdot (4.18 - 2.57) = 0 \text{ mm}$$

$$\delta_{\text{creep},z} = u_{zl} \cdot (\text{ratio}_{uzl} - \text{ratio}_{uzs}) = -2.27 \cdot (3.17 - 2.5) = -1.51 \text{ mm}$$

### Long-term deflection

$$\delta_{\text{long},y} = \delta_{\text{long,creep},y} - \delta_{\text{creep},y} = 0 - 0 = 0 \text{ mm}$$

$$\delta_{\text{long},z} = \delta_{\text{long,creep},z} - \delta_{\text{creep},z} = -7.2 - -1.51 = -5.68 \text{ mm}$$

## Additional deflection

$$\delta_{\text{add},y} = \delta_{\text{short},y} + \delta_{\text{long,creep},y} - \delta_{\text{imm},y} = 0 + 0 - 0 = 0 \text{ mm}$$

$$\delta_{\text{add},z} = \delta_{\text{short},z} + \delta_{\text{long,creep},z} - \delta_{\text{imm},z} = -2.43 + -7.2 - -5.68 = -3.95 \text{ mm}$$

## Limit additional deflection

$$\delta_{\text{add,lim},y} = 0 \text{ mm}$$

$$\delta_{\text{add,lim},z} = \frac{-l_{0z}}{\text{Lim}_{\text{add}}} = \frac{-6.9}{500} = -13.8 \text{ mm}$$

## Total deflection

$$\delta_{\text{tot},y} = \delta_{\text{short},y} + \delta_{\text{long,creep},y} = 0 + 0 = 0 \text{ mm}$$

$$\delta_{\text{tot},z} = \delta_{\text{short},z} + \delta_{\text{long,creep},z} = -2.43 + -7.2 = -9.63 \text{ mm}$$

## Limit total deflection

$$\delta_{\text{tot,lim},y} = 0 \text{ mm}$$

$$\delta_{\text{tot,lim},z} = \frac{-l_{0z}}{\text{Lim}_{\text{tot}}} = \frac{-6.9}{250} = -27.6 \text{ mm}$$

## Basic values of deflections

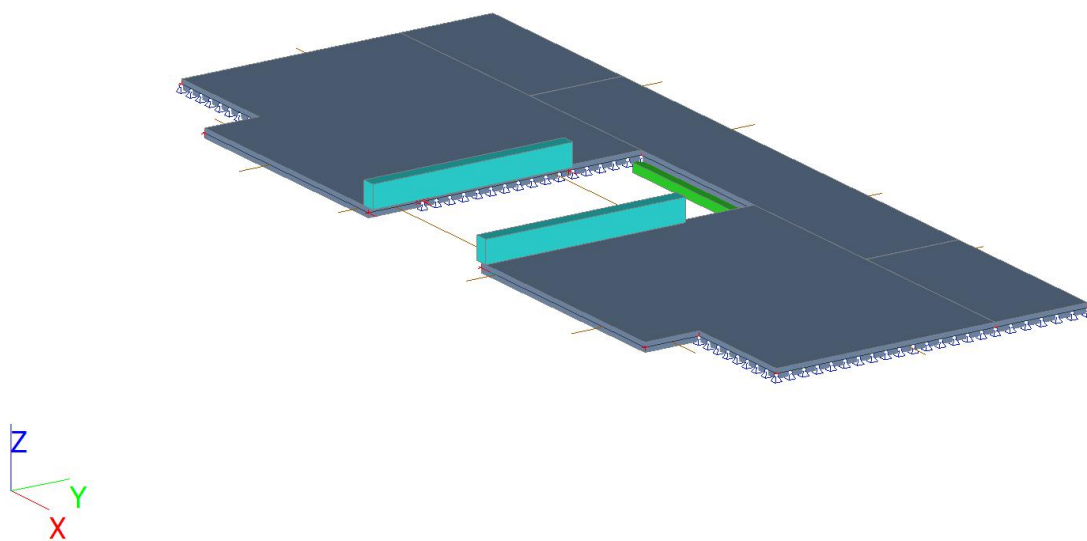
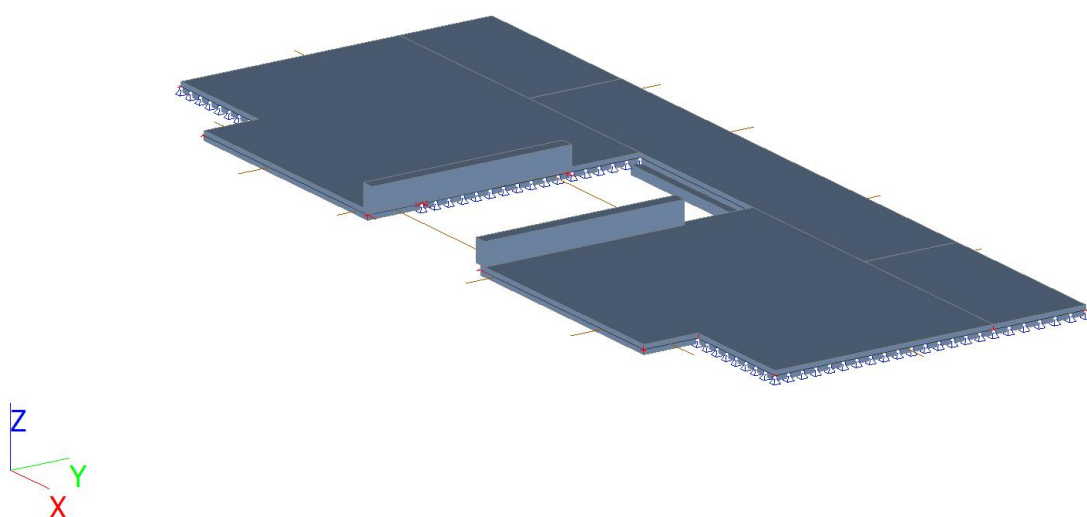
Type of deflection	Ratio short [-]	Ratio long [-]	$\delta_{\text{lin}}$ [mm]	$\delta_{\text{imm}}$ [mm]	$\delta_{\text{add}}$ [mm]	$\delta_{\text{short}}$ [mm]	$\delta_{\text{long}}$ [mm]	$\delta_{\text{long+creep}}$ [mm]	$\delta_{\text{creep}}$ [mm]
$u_y$	2.57	4.18	0	0	0	0	0	0	0
$u_z$	2.5	3.17	-3.25	-5.68	-3.95	-2.43	-5.68	-7.2	-1.51

## Check of additional and total deflections


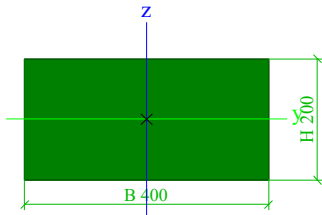

Type of deflection	L [m]	$\delta_{\text{add}}$ [mm]	$\delta_{\text{add,lim}}$ [mm]	$\text{UC}_{\text{add}}$ [-]	$\delta_{\text{tot}}$ [mm]	$\delta_{\text{tot,lim}}$ [mm]	$\text{UC}_{\text{tot}}$ [-]	UC [-]	Limit [-]	Status
$u_y$	6.9	0	0	0	0	0	0	0	1	OK
$u_z$	6.9	-3.95	-13.8	0.29	-9.63	-27.6	0.35	0.35	1	OK

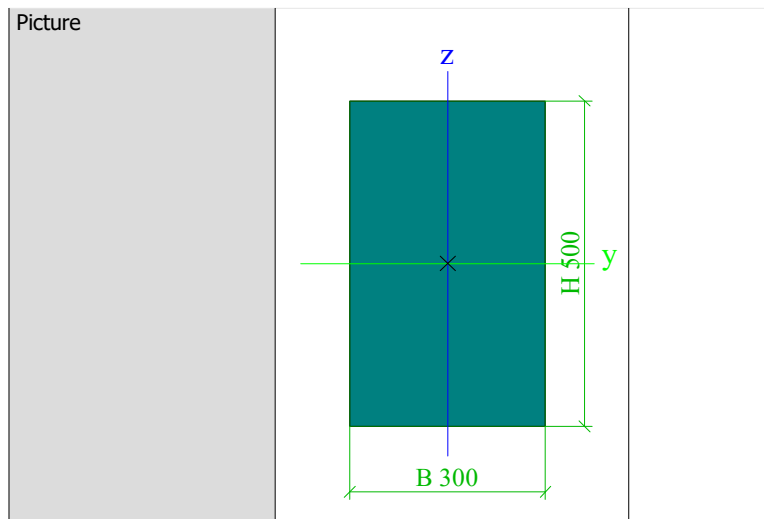
List of errors/warnings/notes: NO

## 15. Model ploče



## 16. Cross-sections


CS1			
Type	Rectangle		
Detailed	200; 400		
Shape type	Thick-walled		
Item material	C25/30		
Fabrication	concrete		
Colour			
A [m²]	8,0000e-02		
A <sub>y</sub> [m²], A <sub>z</sub> [m²]	6,6667e-02	6,6667e-02	
A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]	1,2000e+00	1,2000e+00	
C <sub>y,UCS</sub> [mm], C <sub>z,UCS</sub> [mm]	200	100	
α [deg]	0,00		
I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]	2,6667e-04	1,0667e-03	
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	58	115	
W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]	2,6667e-03	5,3333e-03	
W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]	0,0000e+00	0,0000e+00	
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	0,00e+00	0,00e+00	
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	0,00e+00	0,00e+00	
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0	
I <sub>t</sub> [m⁴], I <sub>w</sub> [m⁶]	7,3192e-04	0,0000e+00	
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0	
Picture			
CS2			
Type	Rectangle		
Detailed	500; 300		
Shape type	Thick-walled		
Item material	C25/30		
Fabrication	concrete		
Colour			
A [m²]	1,5000e-01		
A <sub>y</sub> [m²], A <sub>z</sub> [m²]	1,2500e-01	1,2500e-01	
A <sub>L</sub> [m²/m], A <sub>D</sub> [m²/m]	1,6000e+00	1,6000e+00	
C <sub>y,UCS</sub> [mm], C <sub>z,UCS</sub> [mm]	150	250	
α [deg]	0,00		
I <sub>y</sub> [m⁴], I <sub>z</sub> [m⁴]	3,1250e-03	1,1250e-03	
i <sub>y</sub> [mm], i <sub>z</sub> [mm]	144	87	
W <sub>el,y</sub> [m³], W <sub>el,z</sub> [m³]	1,2500e-02	7,5000e-03	
W <sub>pl,y</sub> [m³], W <sub>pl,z</sub> [m³]	0,0000e+00	0,0000e+00	
M <sub>pl,y,+</sub> [Nm], M <sub>pl,y,-</sub> [Nm]	0,00e+00	0,00e+00	
M <sub>pl,z,+</sub> [Nm], M <sub>pl,z,-</sub> [Nm]	0,00e+00	0,00e+00	
d <sub>y</sub> [mm], d <sub>z</sub> [mm]	0	0	
I <sub>t</sub> [m⁴], I <sub>w</sub> [m⁶]	2,8170e-03	0,0000e+00	
β <sub>y</sub> [mm], β <sub>z</sub> [mm]	0	0	



Explanations of symbols	
$A$	Area
$A_y$	Shear Area in principal y-direction
$A_z$	Shear Area in principal z-direction
$A_L$	Circumference per unit length
$A_D$	Drying surface per unit length
$C_{Y,UCS}$	Centroid coordinate in Y-direction of Input axis system
$C_{Z,UCS}$	Centroid coordinate in Z-direction of Input axis system
$I_{Y,LCS}$	Second moment of area about the YLCS axis
$I_{Z,LCS}$	Second moment of area about the ZLCS axis
$I_{YZ,LCS}$	Product moment of area in the LCS system
$\alpha$	Rotation angle of the principal axis system
$I_y$	Second moment of area about the principal y-axis
$I_z$	Second moment of area about the principal z-axis
$i_y$	Radius of gyration about the principal y-axis
$i_z$	Radius of gyration about the principal z-axis
$W_{el,y}$	Elastic section modulus about the principal y-axis
$W_{el,z}$	Elastic section modulus about the principal z-axis
$W_{pl,y}$	Plastic section modulus about the principal y-axis
$W_{pl,z}$	Plastic section modulus about the principal z-axis
$M_{pl,y,+}$	Plastic moment about the principal y-axis for a positive $M_y$ moment
$M_{pl,y,-}$	Plastic moment about the principal y-axis for a negative $M_y$ moment
$M_{pl,z,+}$	Plastic moment about the principal z-axis for a positive $M_z$ moment
$M_{pl,z,-}$	Plastic moment about the principal z-axis for a negative $M_z$ moment
$d_y$	Shear center coordinate in principal y-direction measured from the centroid - Not calculated or simplified
$d_z$	Shear center coordinate in principal z-direction measured from the centroid - Not calculated or simplified
$I_t$	Torsional constant - Not calculated or simplified

Explanations of symbols	
$I_w$	Warping constant - Not calculated or simplified
$\beta_y$	Mono-symmetry constant about the principal y-axis
$\beta_z$	Mono-symmetry constant about the principal z-axis

## 17. Materials

Name	Type	$\rho$ [kg/m <sup>3</sup> ]	Density in fresh state [kg/m <sup>3</sup> ]	$E_{mod}$ [MPa]	$\mu$	$\alpha$ [m/mK]	$f_{c,k,28}$ [MPa]	Colour
C25/30	Concrete	2500,0	2600,0	3,1500e+04	0,2	0,00	25,00	

Explanations of symbols	
Density in fresh state	The value in the density in fresh state property is used only in case a composite deck is input and its self-weight load is taken into account.

Reinforcement EC2

Name	Type	$\rho$ [kg/m <sup>3</sup> ]	$E_{mod}$ [MPa]	$G_{mod}$ [MPa]	$\alpha$ [m/mK]	$f_{y,k}$ [MPa]
B 500B	Reinforcement steel	7850,0	2,0000e+05	8,3333e+04	0,00	500,0

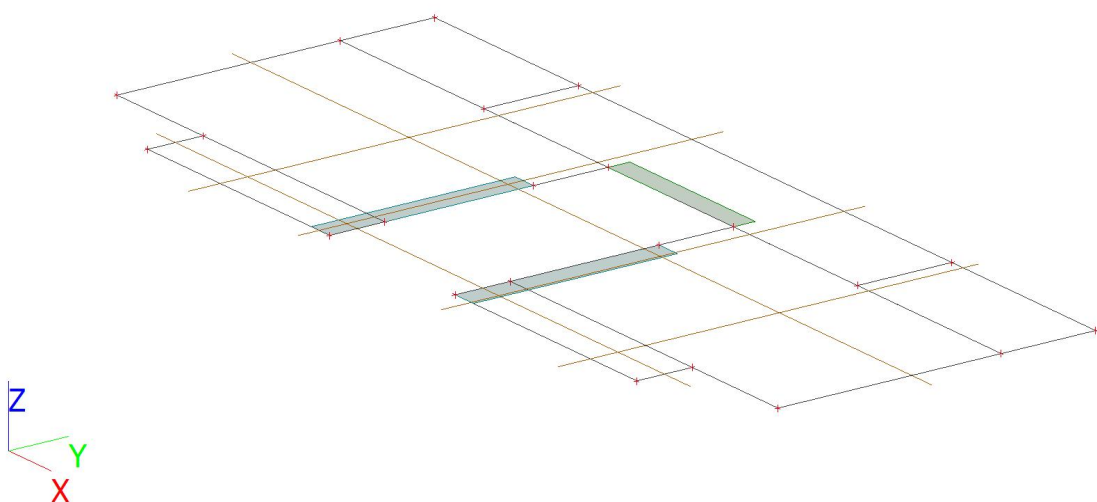
## 18. Opterećenje ploče

### 18.1. Load cases - LC1

Name	Description Spec	Action type Load type	Load group	Direction
LC1	Self weight	Permanent Self weight	LG1	-Z

### 18.1.

#### 18.1.1. LC2 / Tot. value

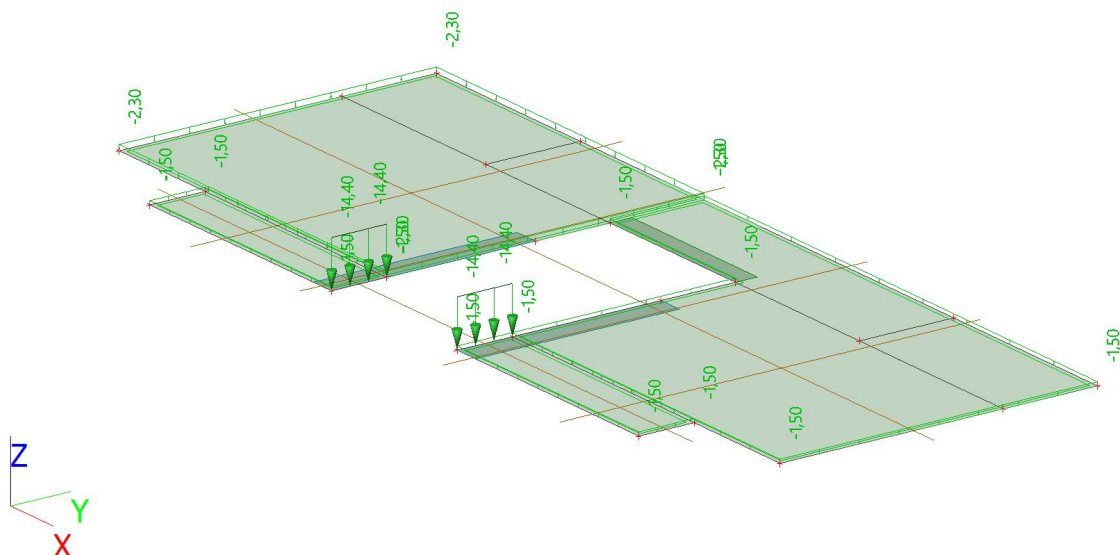


## 18.2. Load cases - LC2

Name	Description	Action type	Load group
	Spec	Load type	
LC2	Dodatno stalno	Permanent	LG1
		Standard	

### 18.2.

#### 18.2.1. LC2 / Tot. value

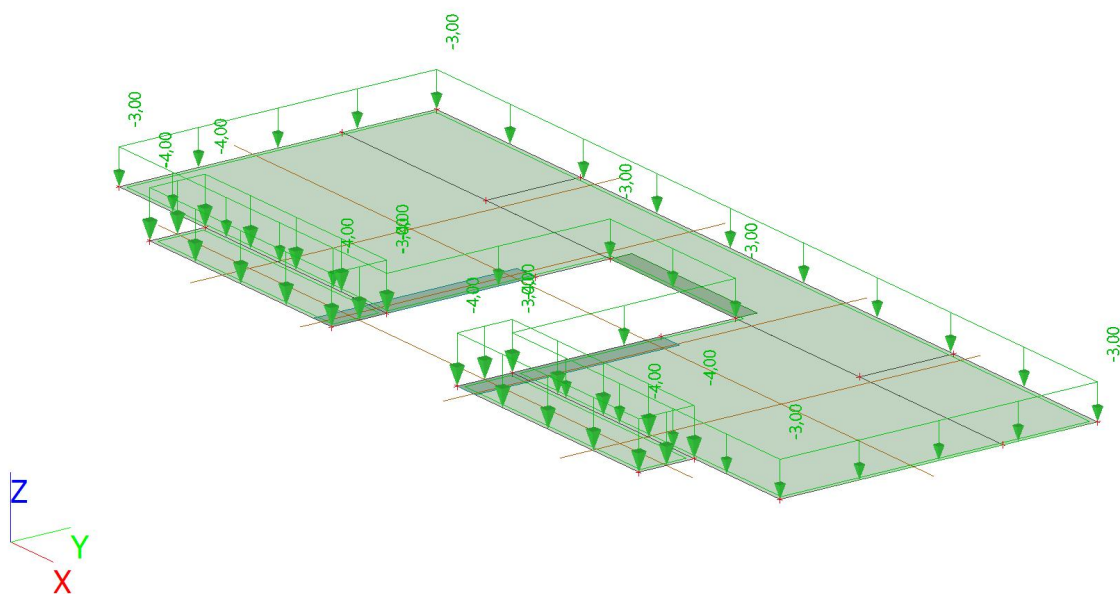


## 18.3. Load cases - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Uporabno 1	Variable	LG2	Short	None
	Standard	Static			

### 18.3.

#### 18.3.1. LC2 / Tot. value



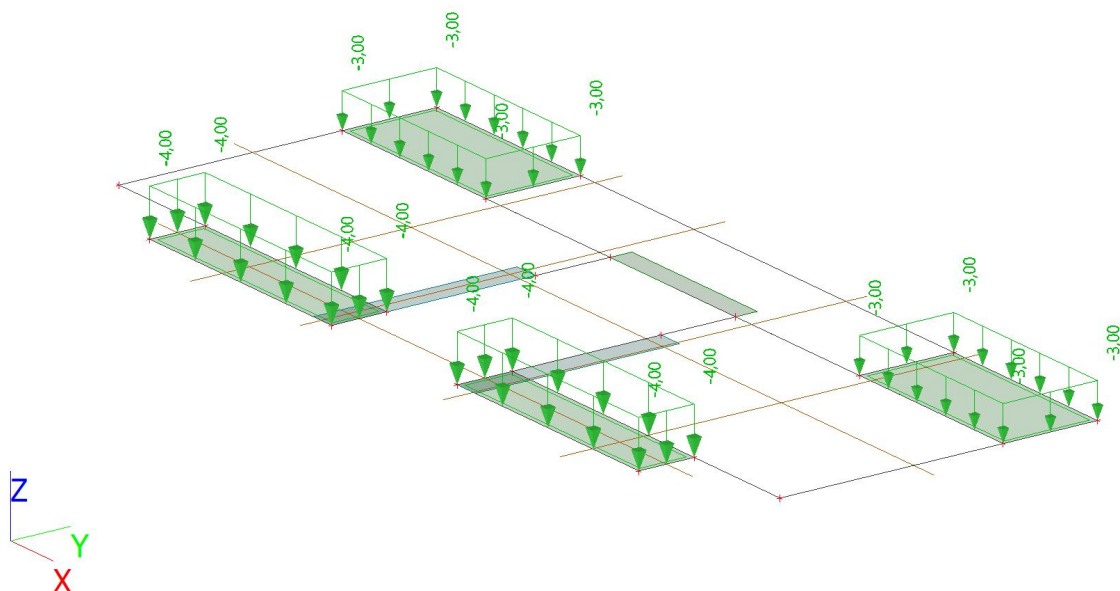


## 18.4. Load cases - LC4

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC4	Uporabno 2	Variable	LG2	Short	None
	Standard	Static			

### 18.4.

#### 18.4.1. LC2 / Tot. value

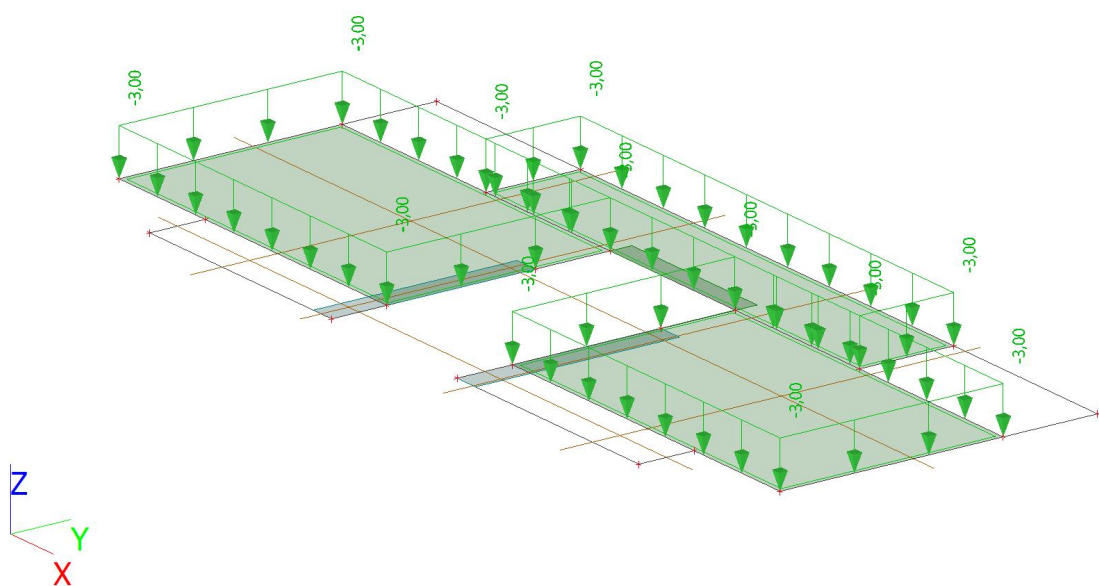


## 18.5. Load cases - LC5

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC5	Uporabno 3	Variable	LG2	Short	None
	Standard	Static			

### 18.5.

#### 18.5.1. LC2 / Tot. value

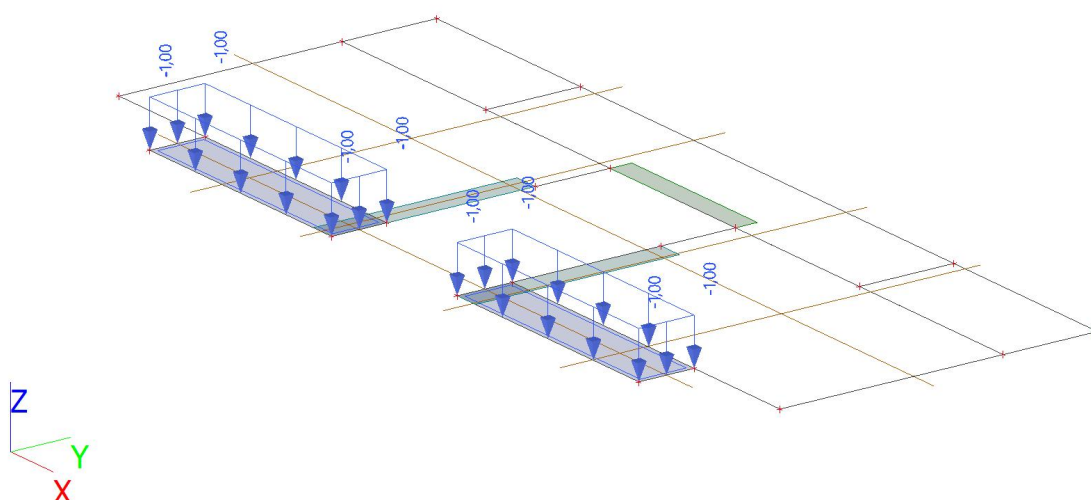


## 18.6. Load cases - LC6

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC6	Snijeg	Variable	LG3	None
	Snow	Static		

## 18.6.

### 18.6.1. LC2 / Tot. value



## 19. Unutarnje sile u gredama

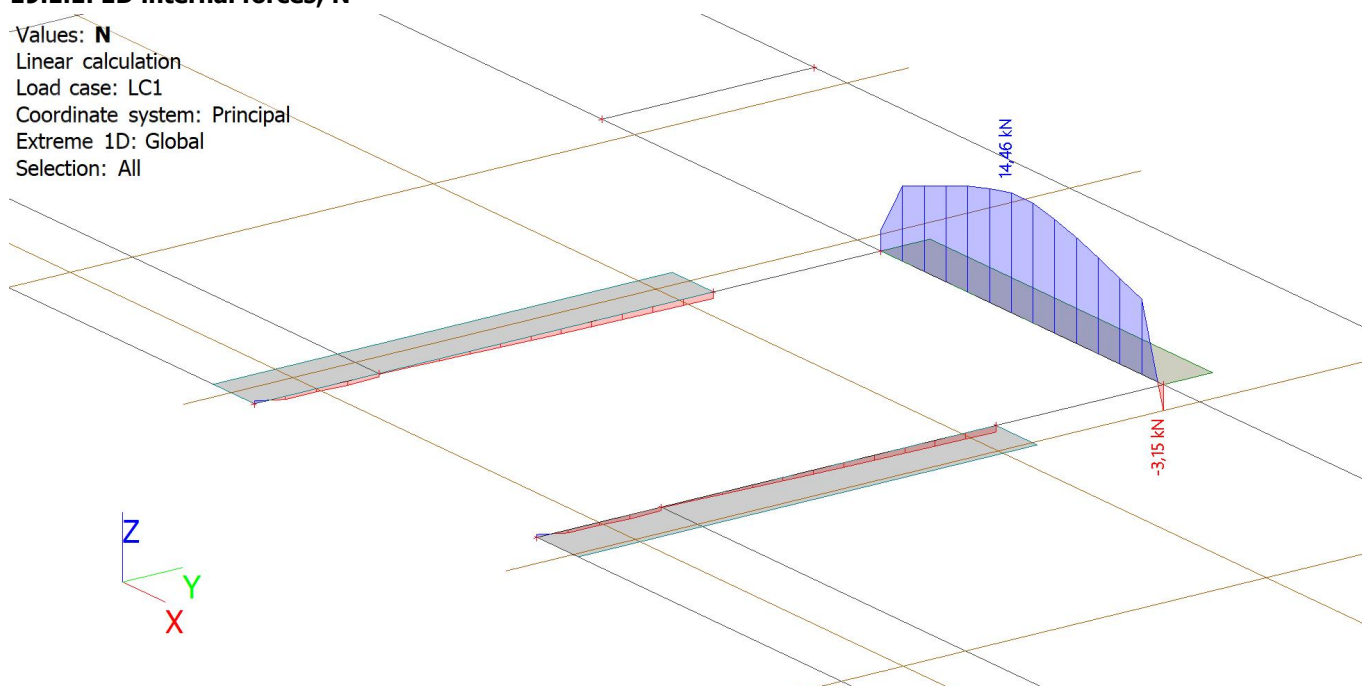
### 19.1. Unutarnje sile u gredama - LC1

Name	Description	Action type	Load group	Direction
	Spec	Load type		
LC1	Self weight	Permanent	LG1	-Z
		Self weight		

## 19.1.

### 19.1.1. 1D internal forces; N

Values: **N**  
 Linear calculation  
 Load case: LC1  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All



### 19.1.2. 1D internal forces; $V_z$

Values:  $V_z$

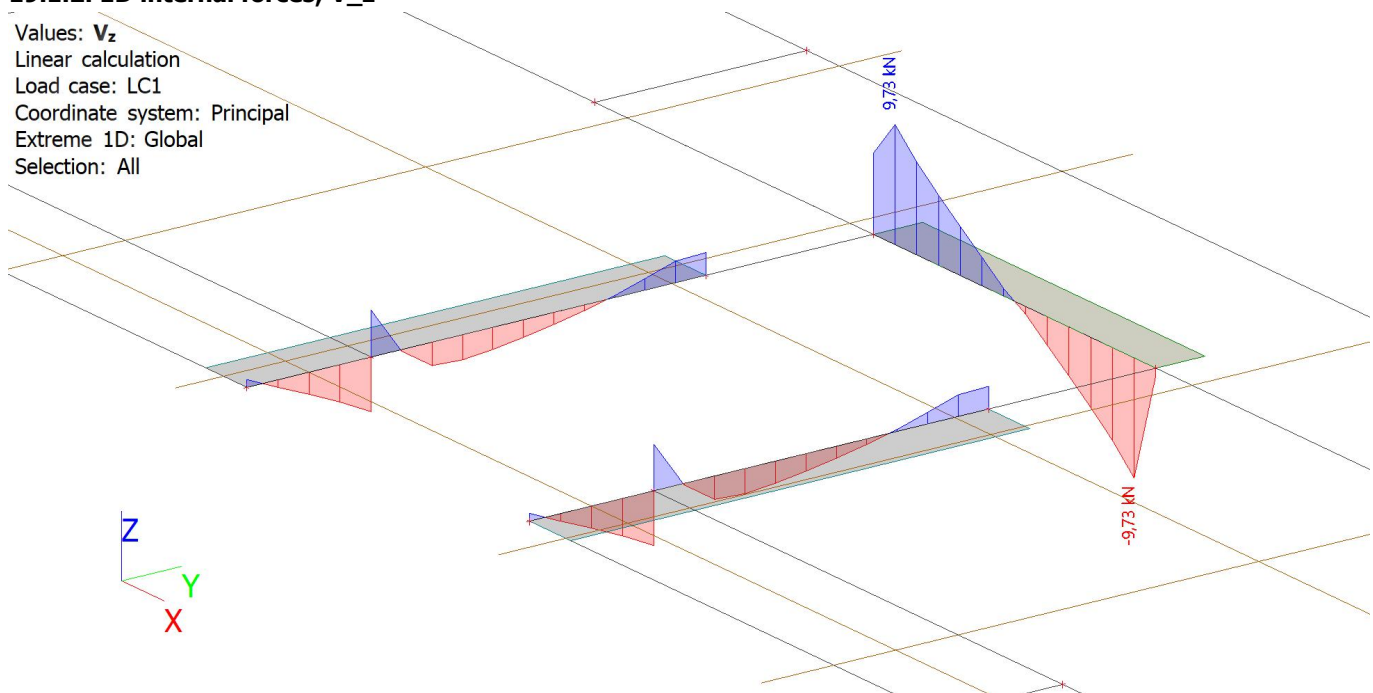
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 19.1.3. 1D internal forces; $M_y$

Values:  $M_y$

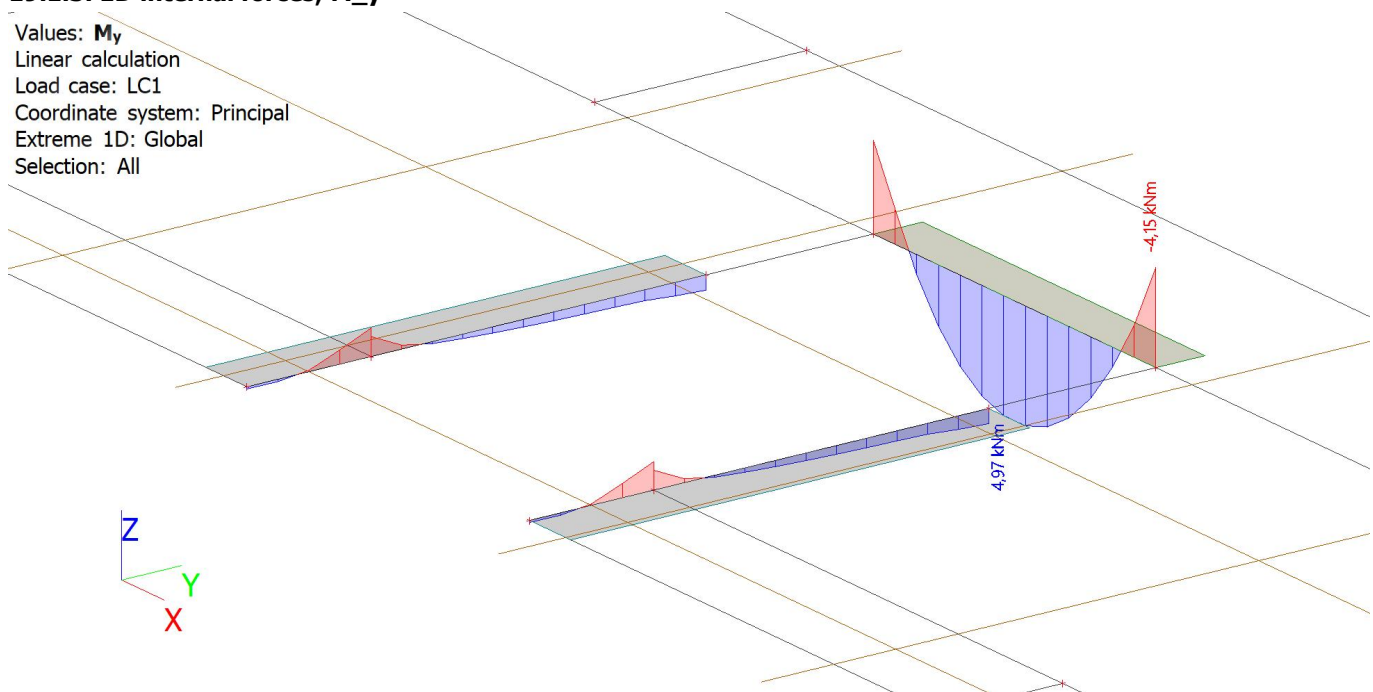
Linear calculation

Load case: LC1

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 19.2. Unutarnje sile u gredama - LC2

Name	Description Spec	Action type Load type	Load group
LC2	Dodatno stalno	Permanent Standard	LG1

### 19.2.

#### 19.2.1. 1D internal forces; N

Values: **N**

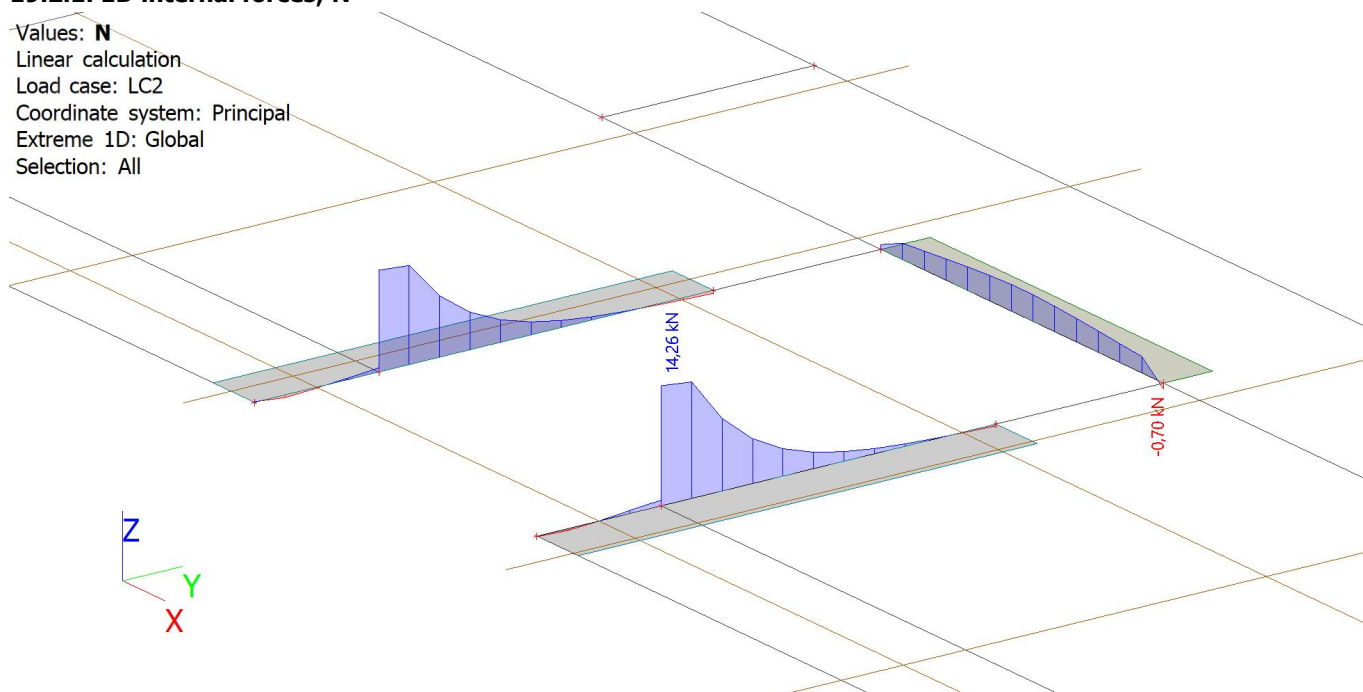
Linear calculation

Load case: LC2

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 19.2.2. 1D internal forces; V<sub>z</sub>

Values: **V<sub>z</sub>**

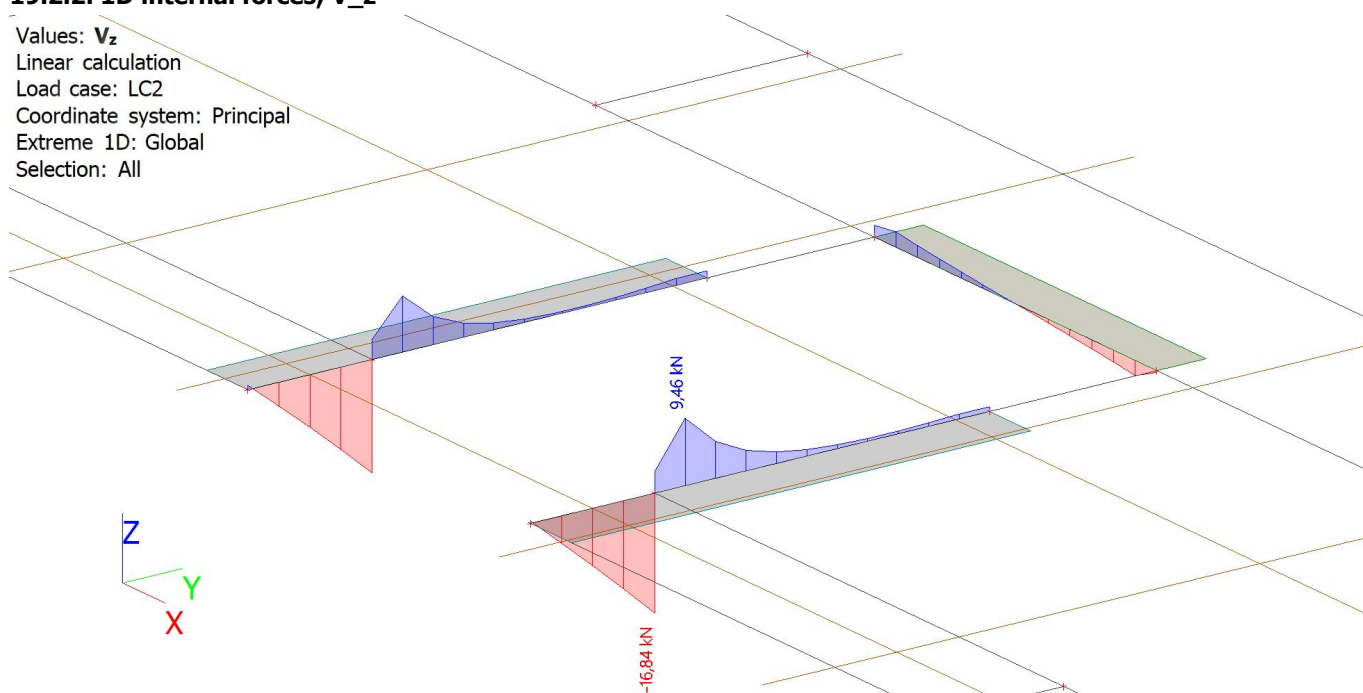
Linear calculation

Load case: LC2

Coordinate system: Principal

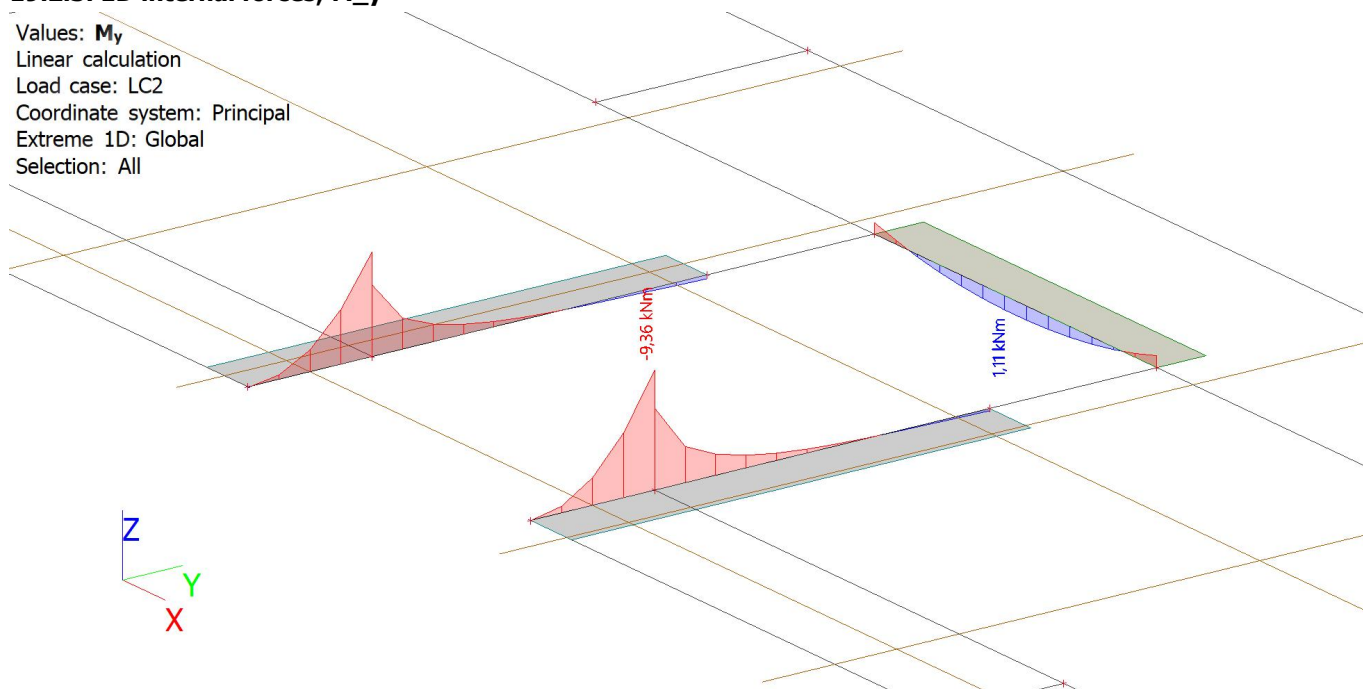
Extreme 1D: Global

Selection: All



### 19.2.3. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Load case: LC2  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All



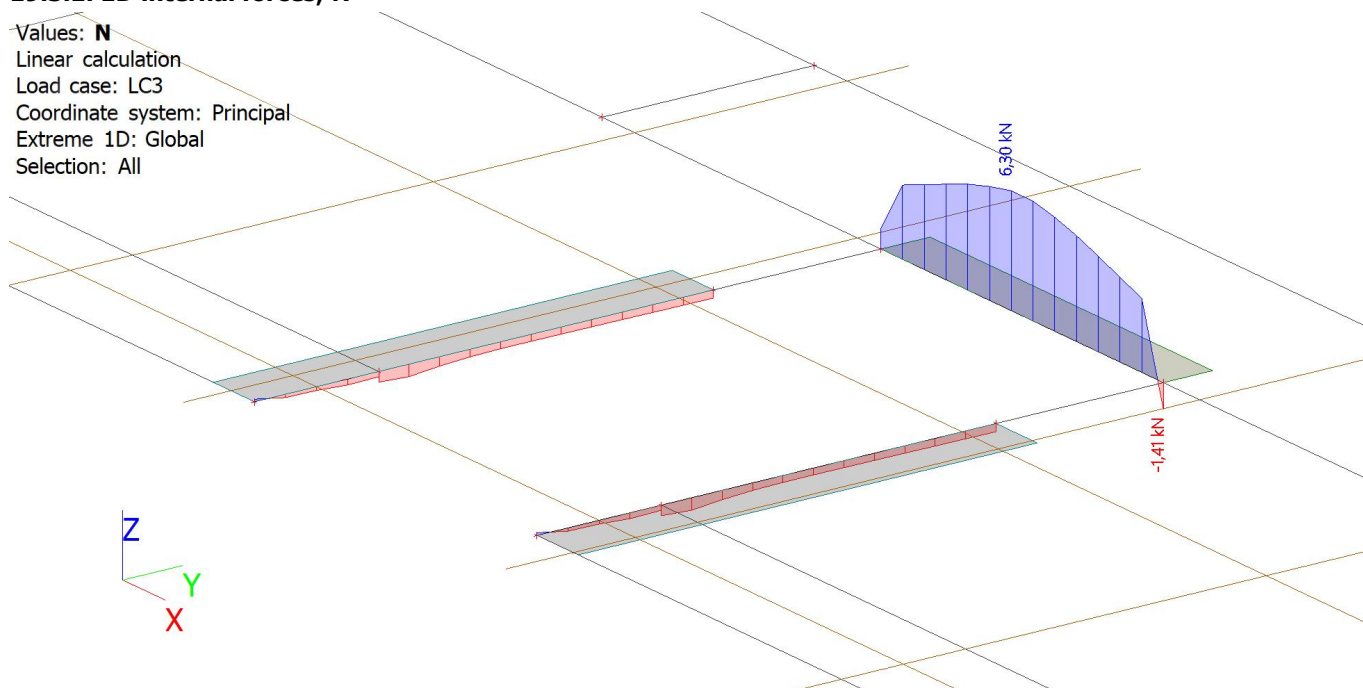
### 19.3. Unutarnje sile u gredama - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Uporabno 1	Variable	LG2	Short	None
	Standard	Static			

### 19.3.

#### 19.3.1. 1D internal forces; $N$

Values:  $N$   
 Linear calculation  
 Load case: LC3  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All





### 19.3.2. 1D internal forces; $V_z$

Values:  $V_z$

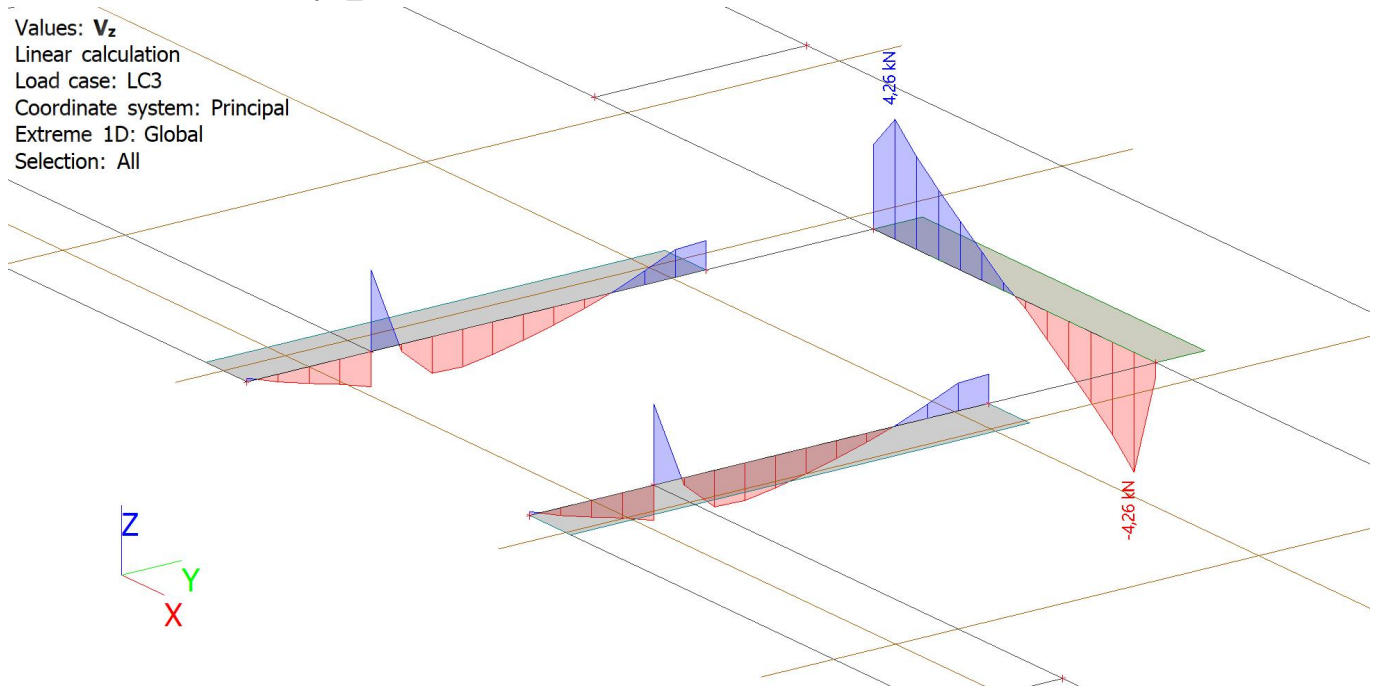
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 19.3.3. 1D internal forces; $M_y$

Values:  $M_y$

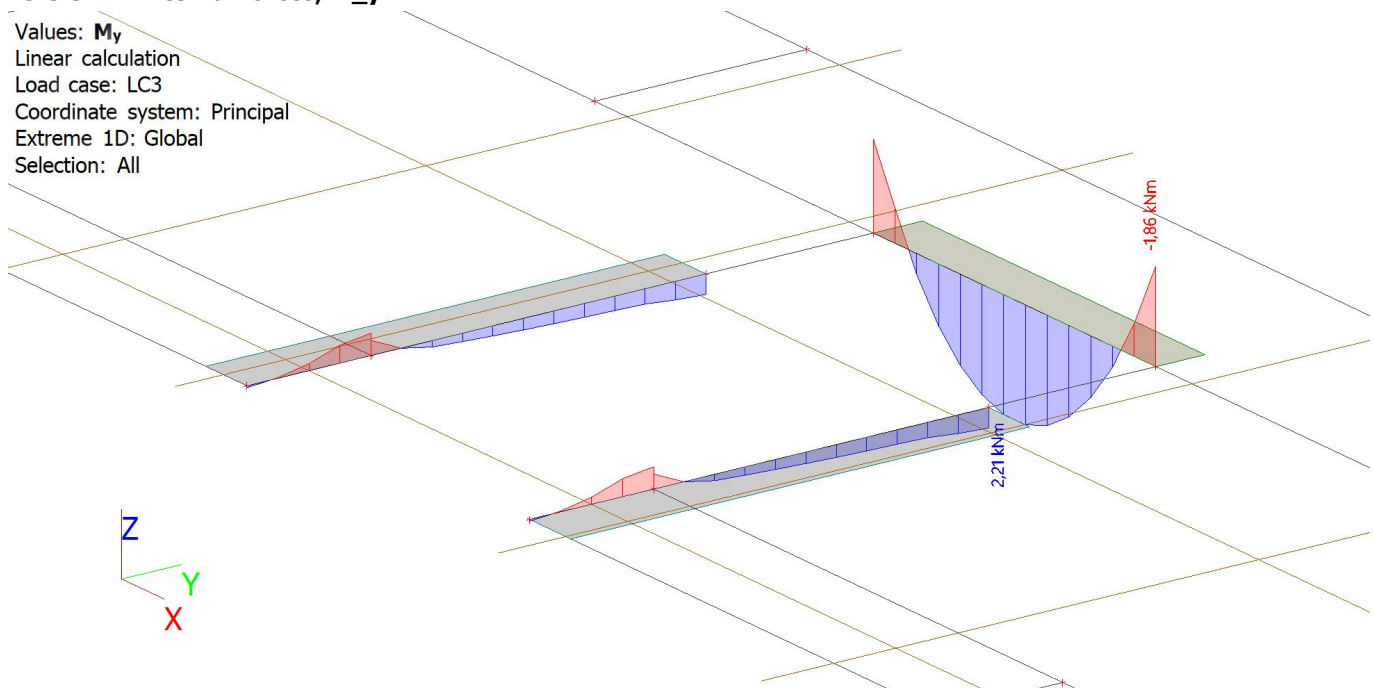
Linear calculation

Load case: LC3

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 19.4. Unutarnje sile u gredama - LC4

Name	Description	Action type	Load group	Duration	Master load case
	<b>Spec</b>	<b>Load type</b>			
LC4	Uporabno 2 Standard	Variable Static	LG2	Short	None

### 19.4.

#### 19.4.1. 1D internal forces; N

Values: **N**

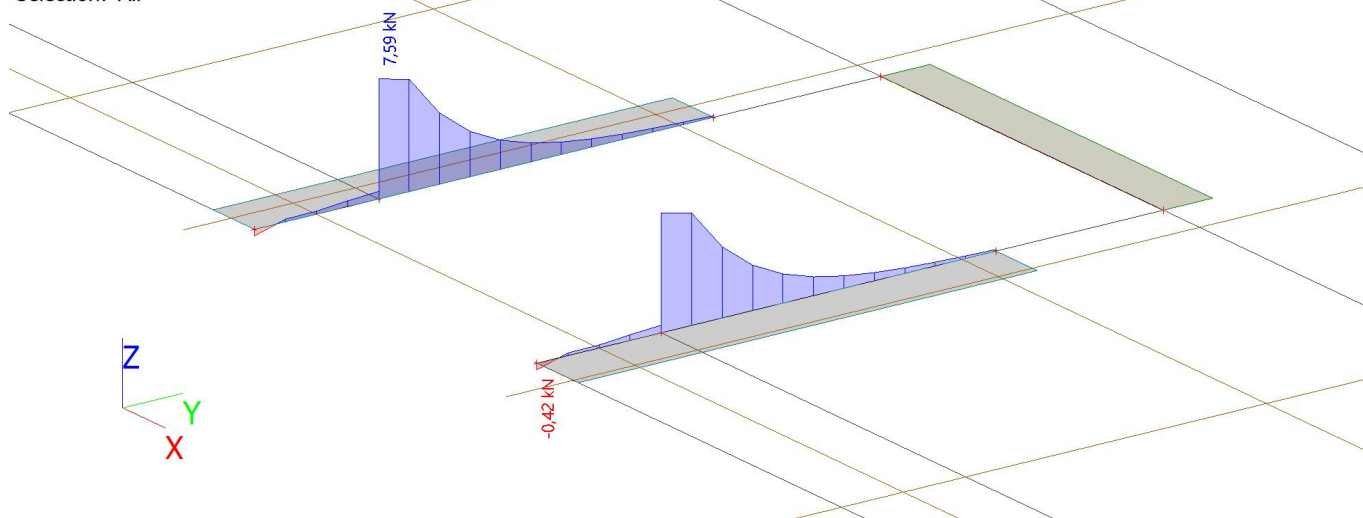
Linear calculation

Load case: LC4

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 19.4.2. 1D internal forces; V<sub>z</sub>

Values: **V<sub>z</sub>**

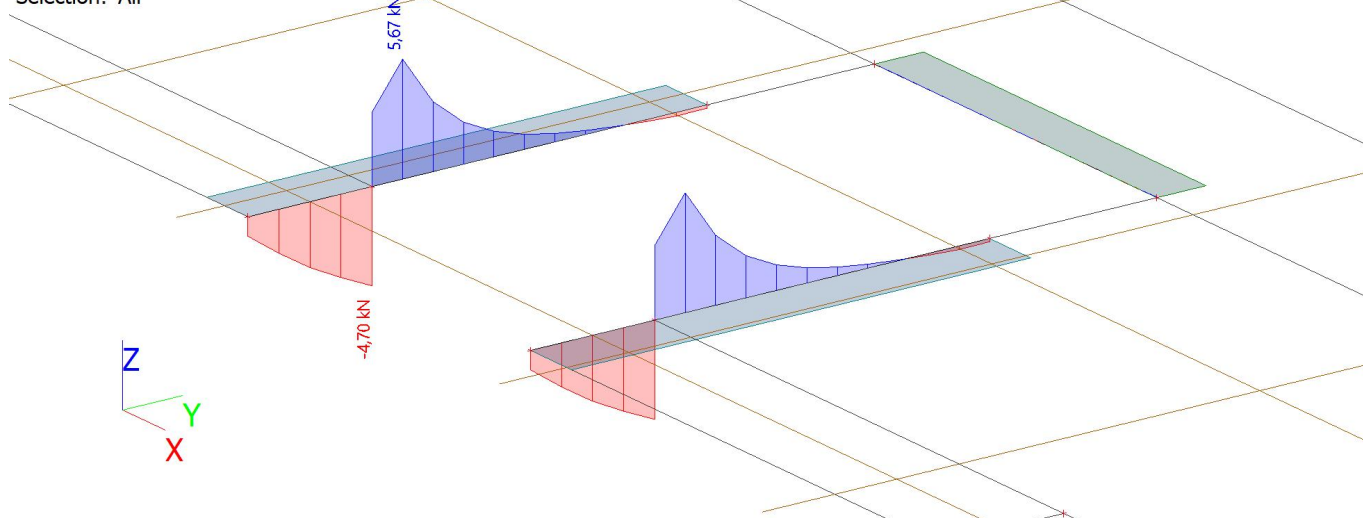
Linear calculation

Load case: LC4

Coordinate system: Principal

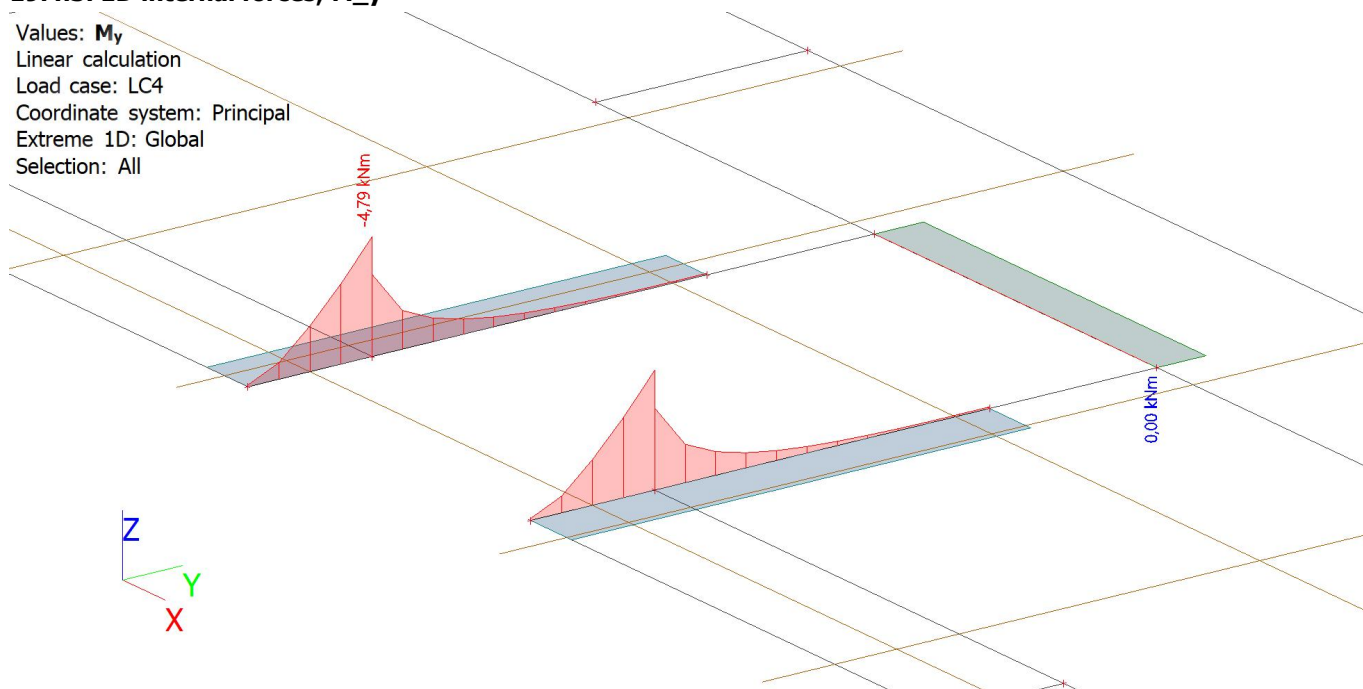
Extreme 1D: Global

Selection: All



### 19.4.3. 1D internal forces; $M_y$

Values:  $M_y$   
 Linear calculation  
 Load case: LC4  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All



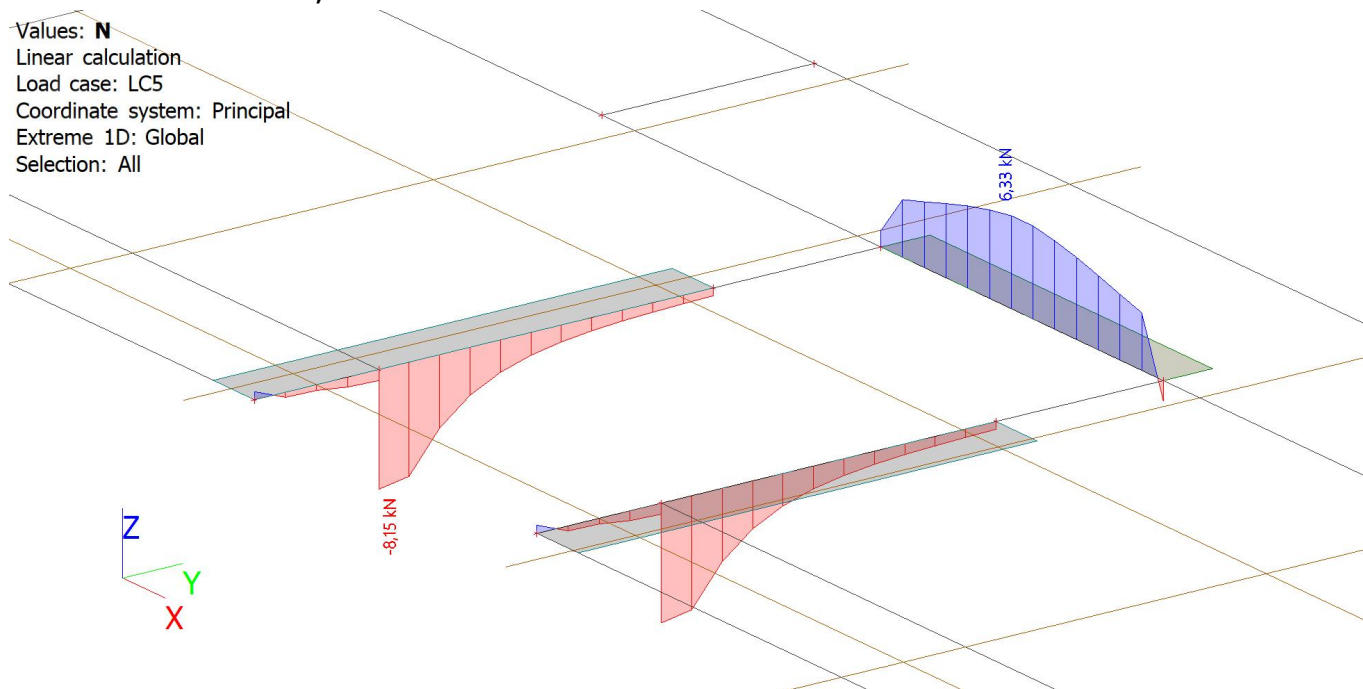
### 19.5. Unutarnje sile u gredama - LC5

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC5	Uporabno 3	Variable	LG2	Short	None
	Standard	Static			

### 19.5.

#### 19.5.1. 1D internal forces; $N$

Values:  $N$   
 Linear calculation  
 Load case: LC5  
 Coordinate system: Principal  
 Extreme 1D: Global  
 Selection: All





### 19.5.2. 1D internal forces; $V_z$

Values:  $V_z$

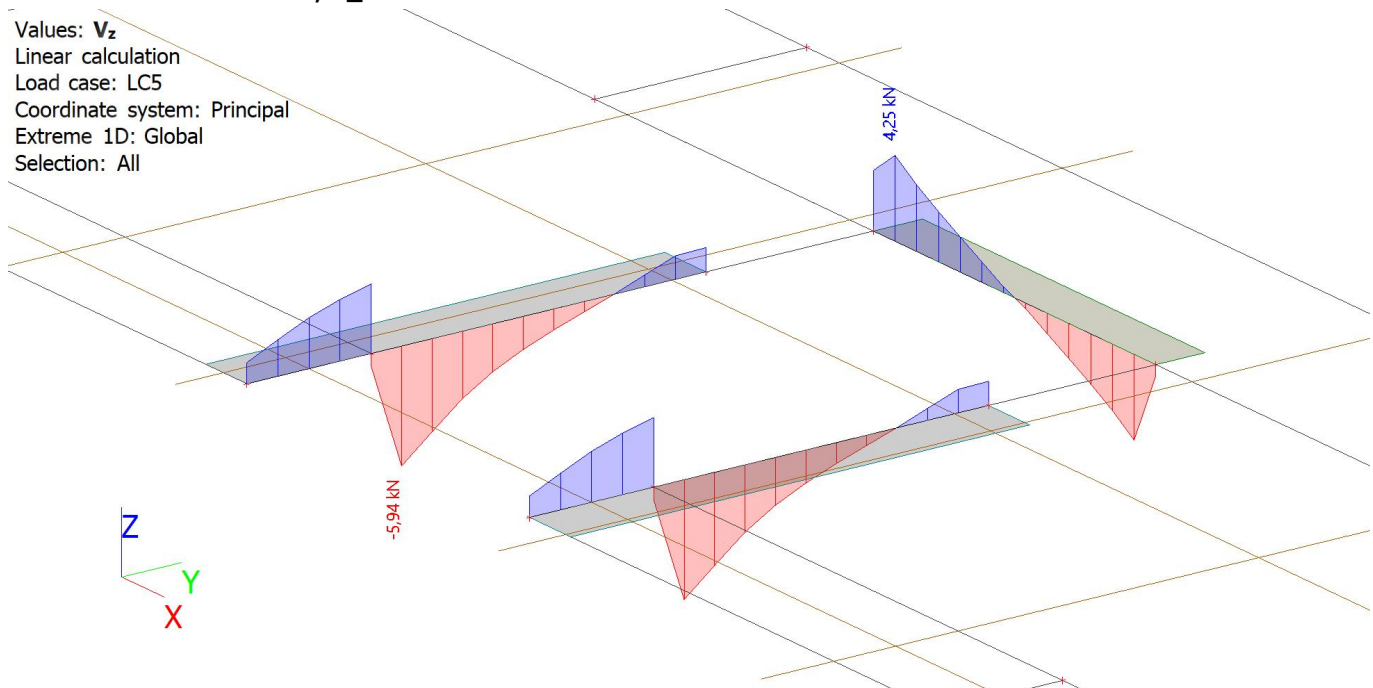
Linear calculation

Load case: LC5

Coordinate system: Principal

Extreme 1D: Global

Selection: All



### 19.5.3. 1D internal forces; $M_y$

Values:  $M_y$

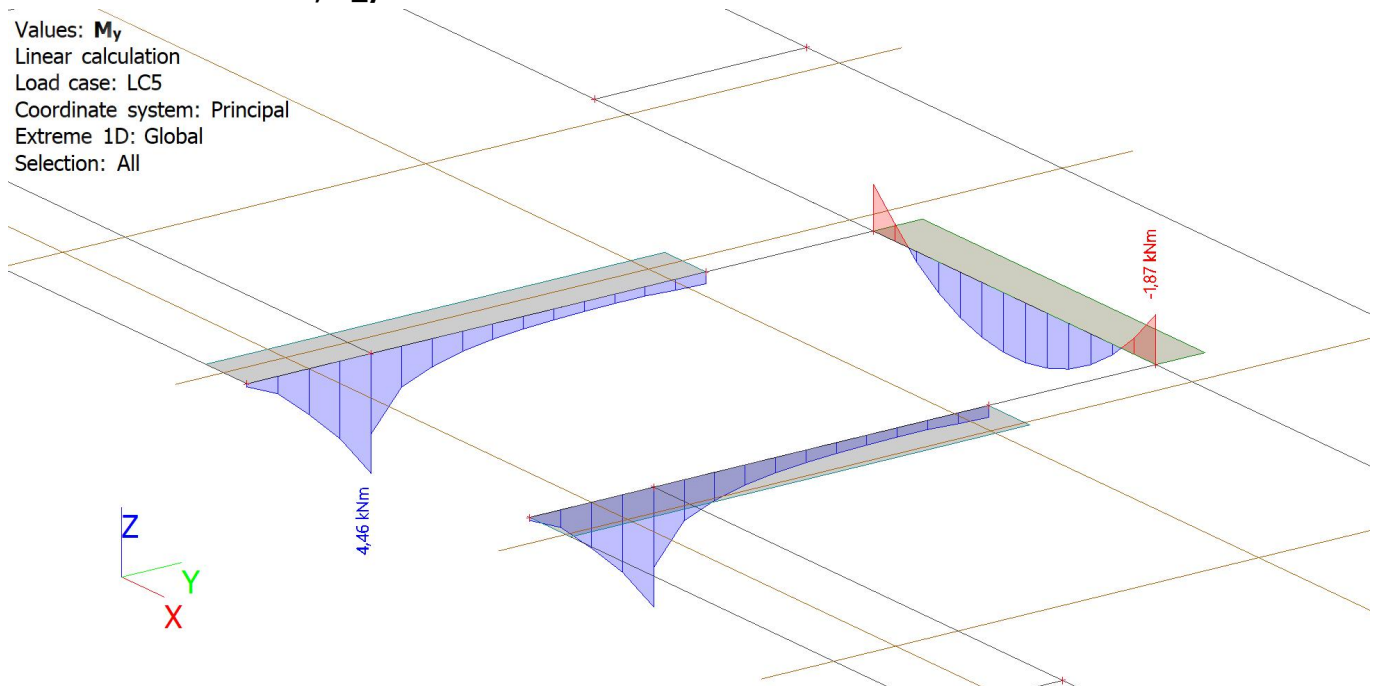
Linear calculation

Load case: LC5

Coordinate system: Principal

Extreme 1D: Global

Selection: All



## 19.6. Unutarnje sile u gredama - LC6

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC6	Snijeg	Variable	LG3	None
	Snow	Static		

### 19.6.

#### 19.6.1. 1D internal forces; N

Values: **N**

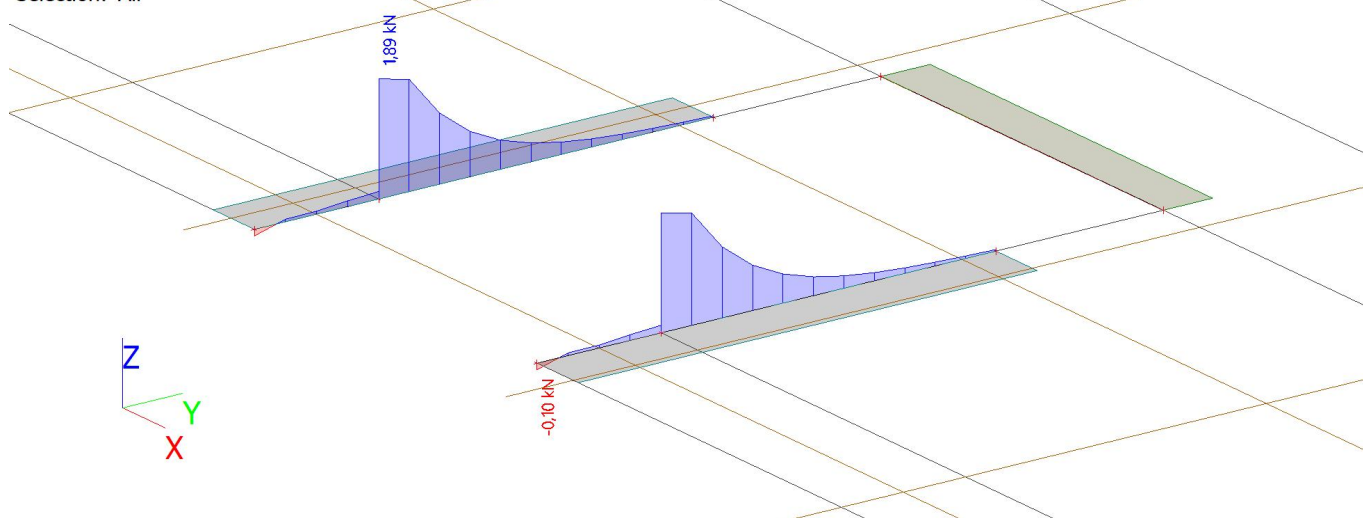
Linear calculation

Load case: LC6

Coordinate system: Principal

Extreme 1D: Global

Selection: All



#### 19.6.2. 1D internal forces; V<sub>z</sub>

Values: **V<sub>z</sub>**

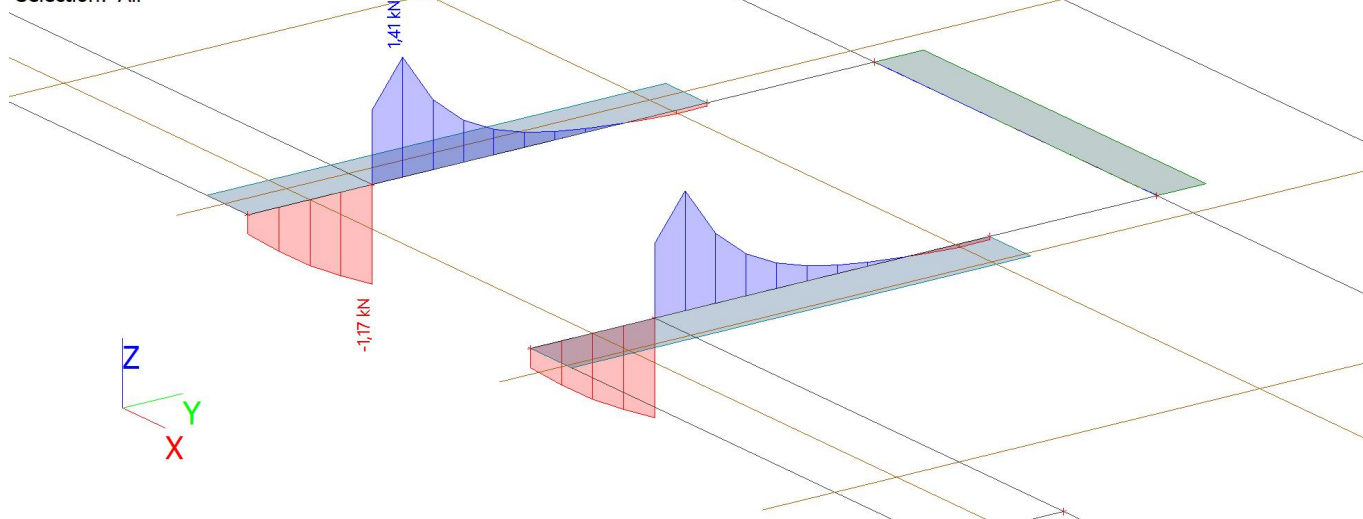
Linear calculation

Load case: LC6

Coordinate system: Principal

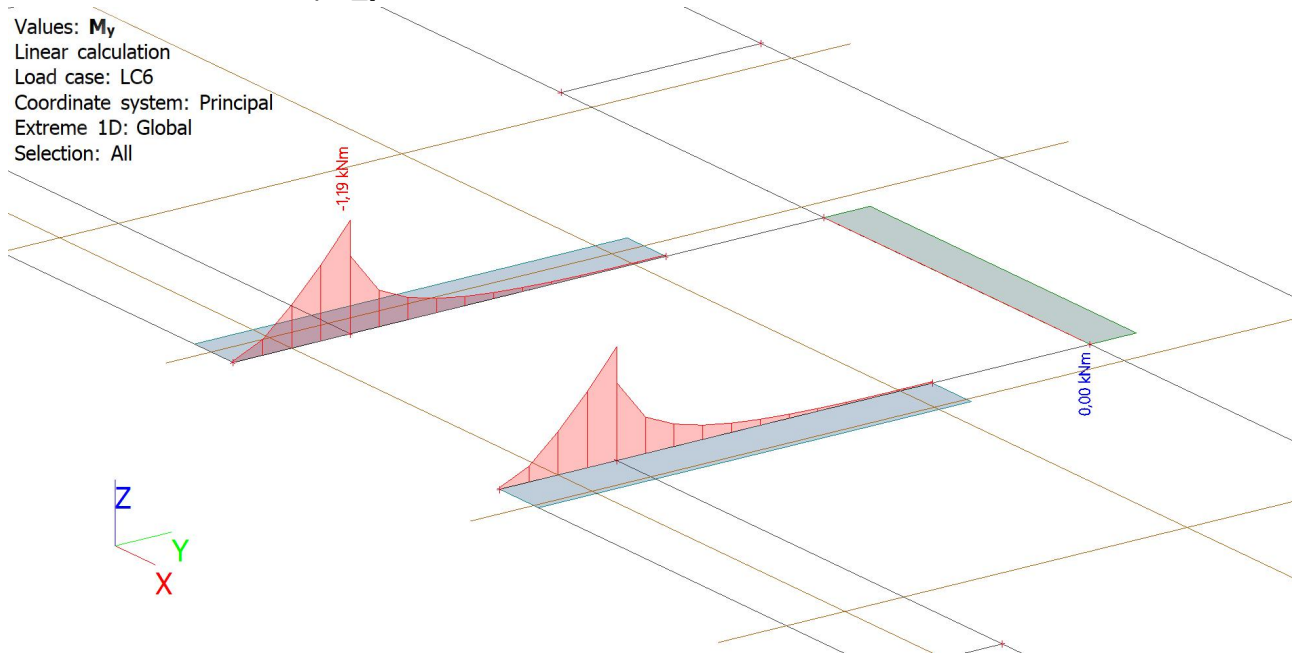
Extreme 1D: Global

Selection: All



### 19.6.3. 1D internal forces; $M_y$

Values:  $M_y$   
Linear calculation  
Load case: LC6  
Coordinate system: Principal  
Extreme 1D: Global  
Selection: All



## 20. Unutarnje sile ploče

### 20.1. Unutarnje sile ploče - LC1

Name	Description Spec	Action type Load type	Load group	Direction
LC1	Self weight	Permanent Self weight	LG1	-Z

#### 20.1.

##### 20.1.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

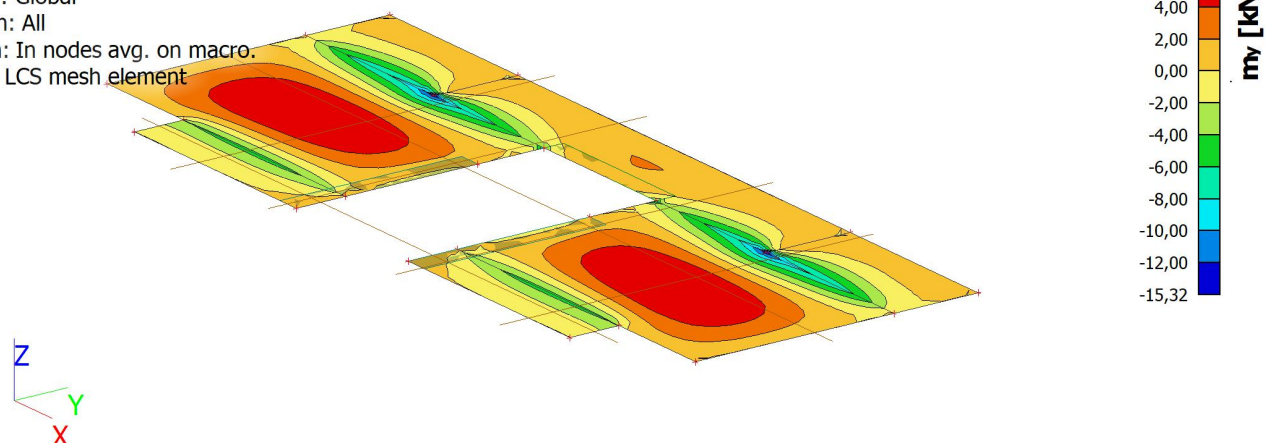
Load case: LC1

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



##### 20.1.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

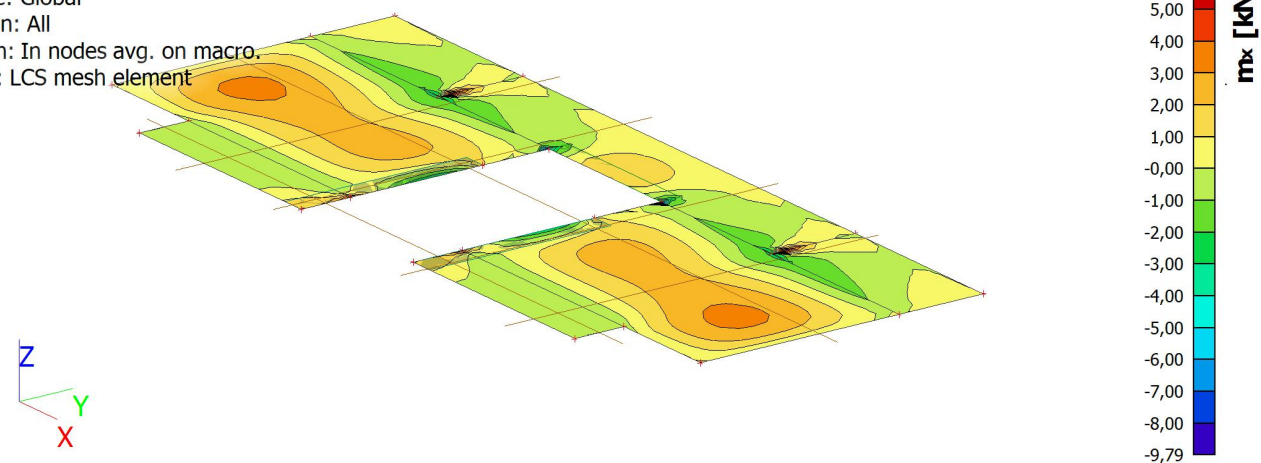
Load case: LC1

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 20.2. Unutarnje sile ploče - LC2

Name	Description Spec	Action type Load type	Load group
LC2	Dodatno stalno	Permanent	LG1
		Standard	

### 20.2.

#### 20.2.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

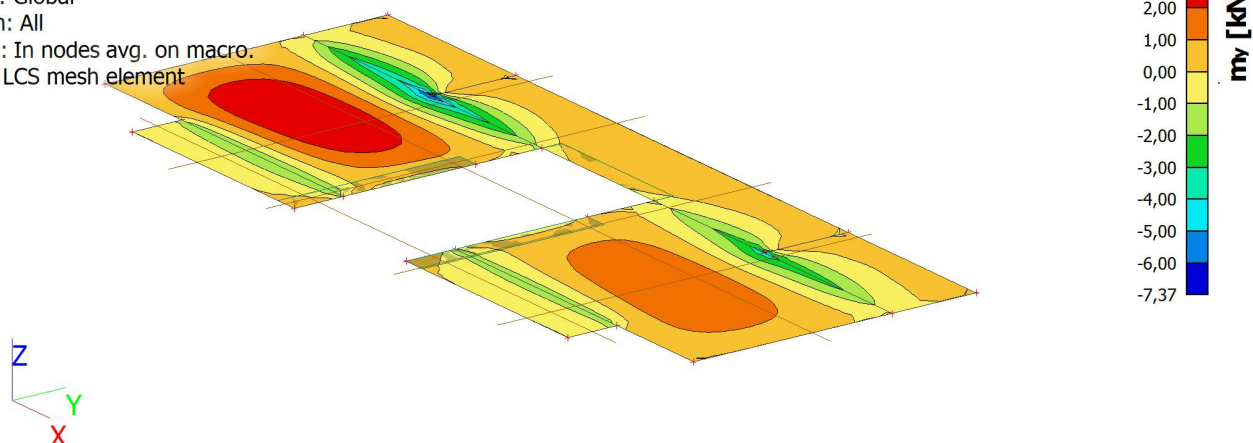
Load case: LC2

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 20.2.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

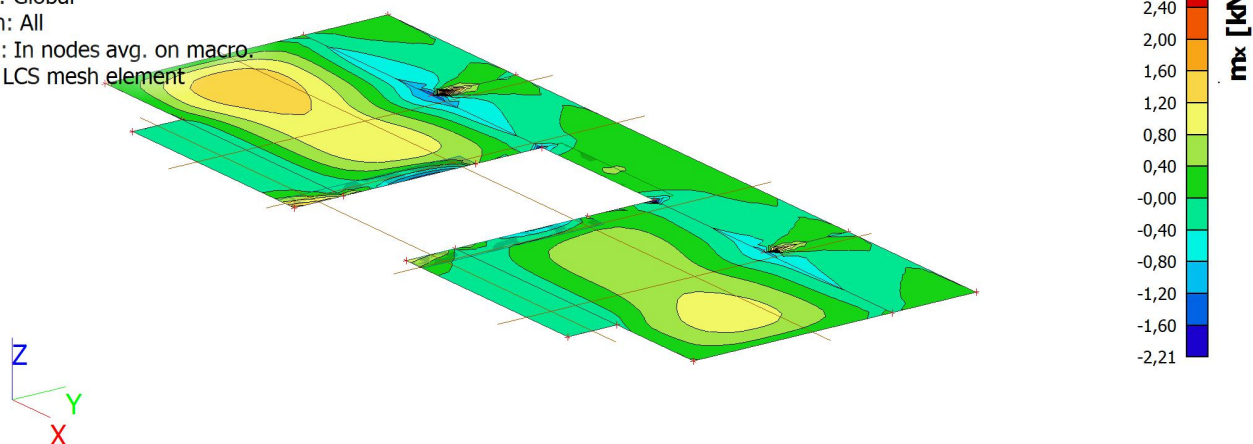
Load case: LC2

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element





## 20.3. Unutarnje sile ploče - LC3

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC3	Uporabno 1	Variable	LG2	Short	None
	Standard	Static			

### 20.3.

#### 20.3.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

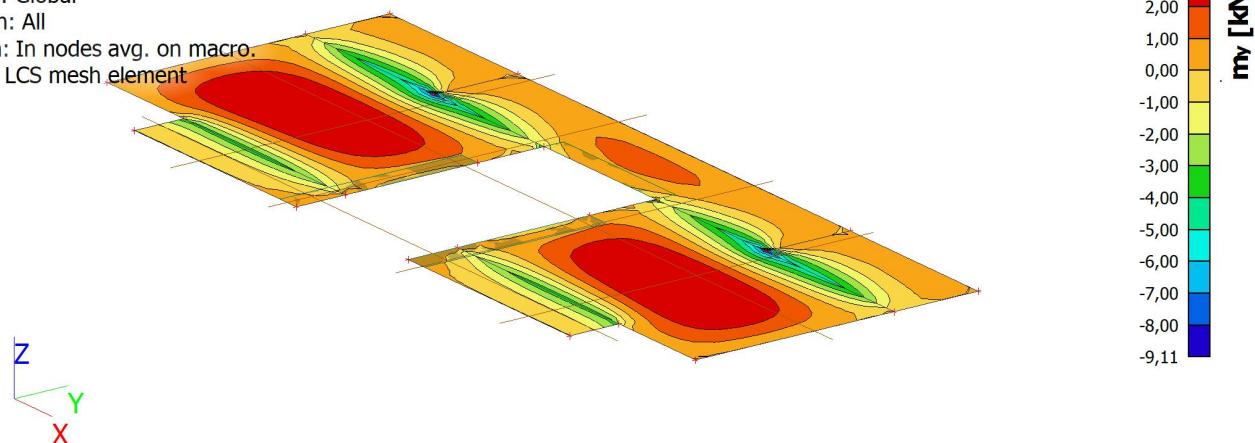
Load case: LC3

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 20.3.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

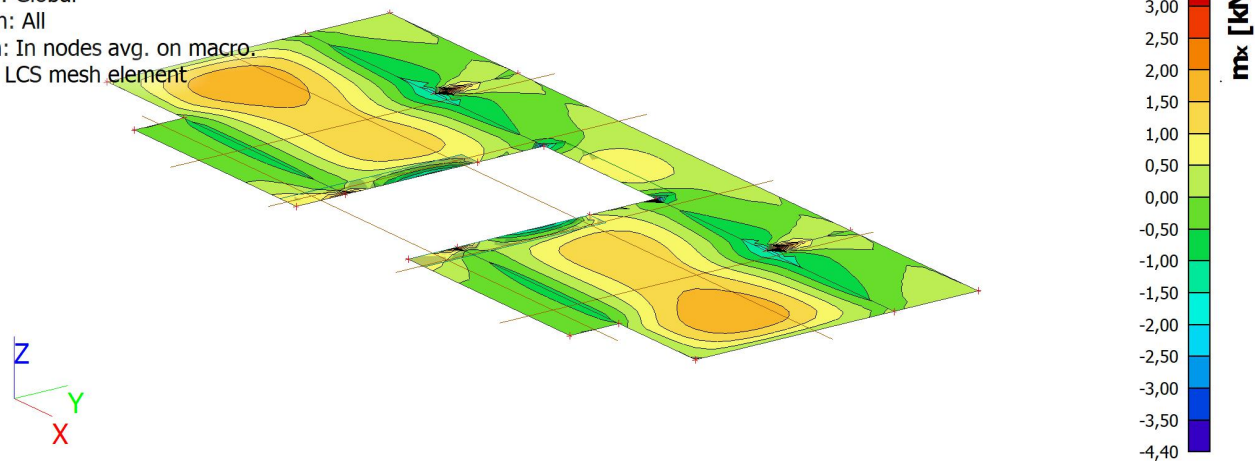
Load case: LC3

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 20.4. Unutarnje sile ploče - LC4

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC4	Uporabno 2	Variable	LG2	Short	None
	Standard	Static			

### 20.4.

#### 20.4.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

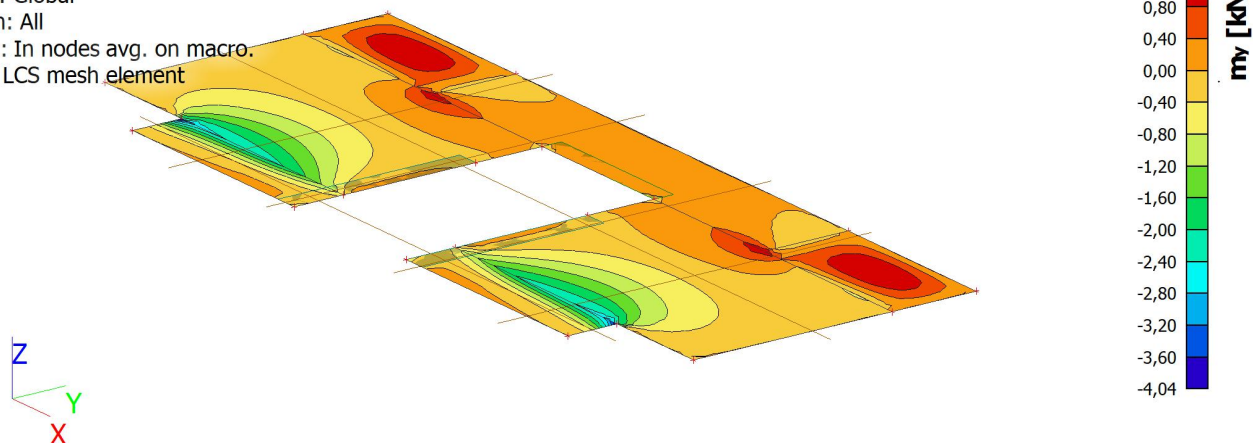
Load case: LC4

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 20.4.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

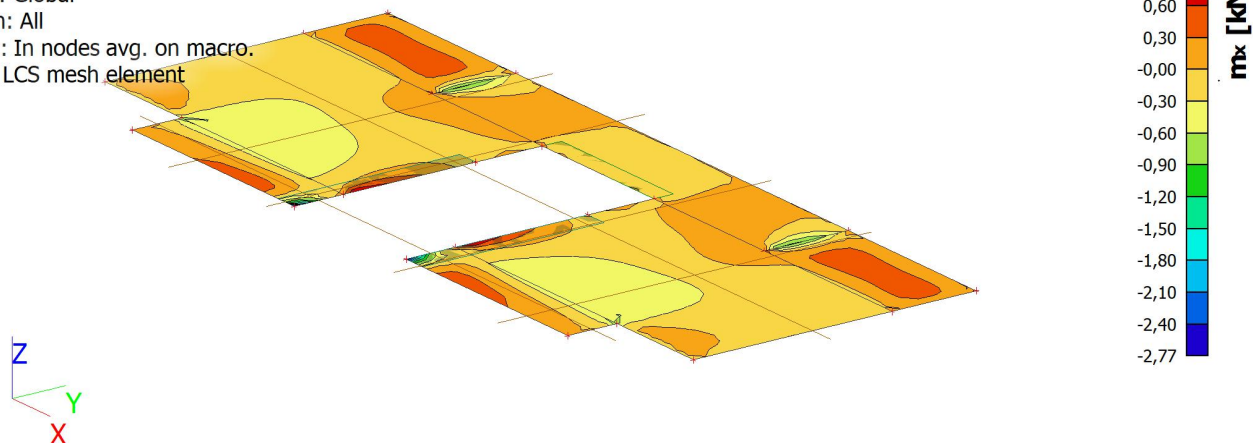
Load case: LC4

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 20.5. Unutarnje sile ploče - LC5

Name	Description	Action type	Load group	Duration	Master load case
	Spec	Load type			
LC5	Uporabno 3	Variable	LG2	Short	None
	Standard	Static			

### 20.5.

#### 20.5.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

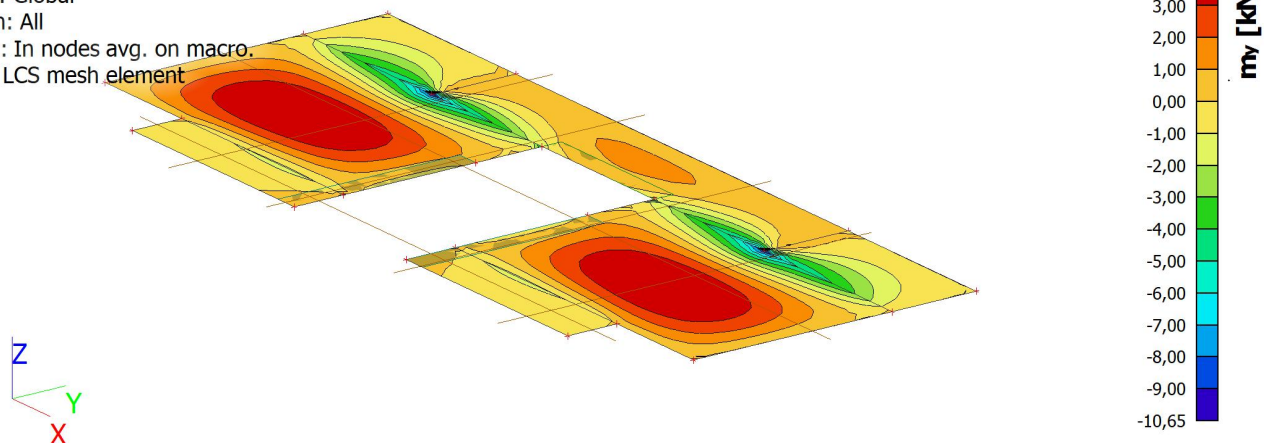
Load case: LC5

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 20.5.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

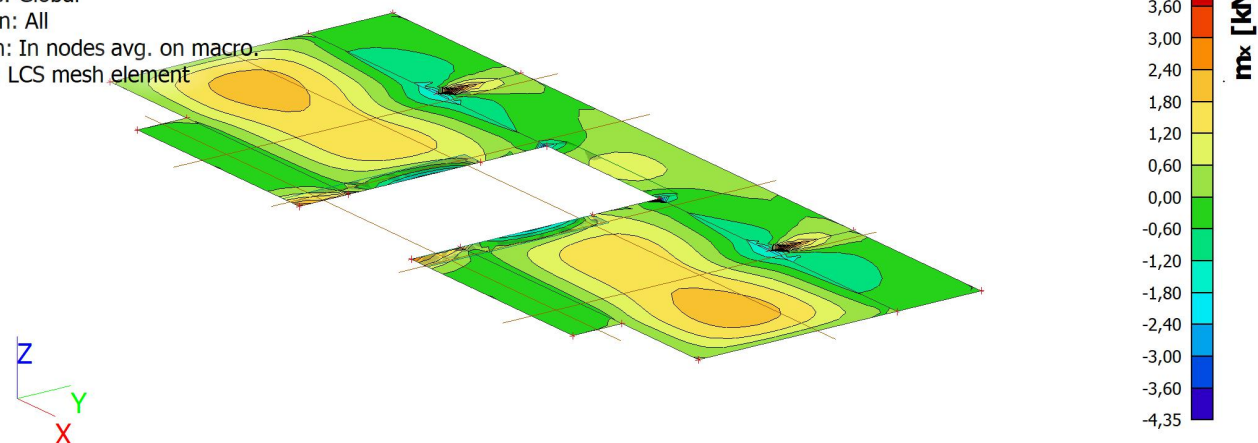
Load case: LC5

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element





## 20.6. Unutarnje sile ploče - LC6

Name	Description	Action type	Load group	Master load case
	Spec	Load type		
LC6	Snijeg	Variable	LG3	None
	Snow	Static		

### 20.6.

#### 20.6.1. 2D internal forces; $m_y$

Values:  $m_y$

Linear calculation

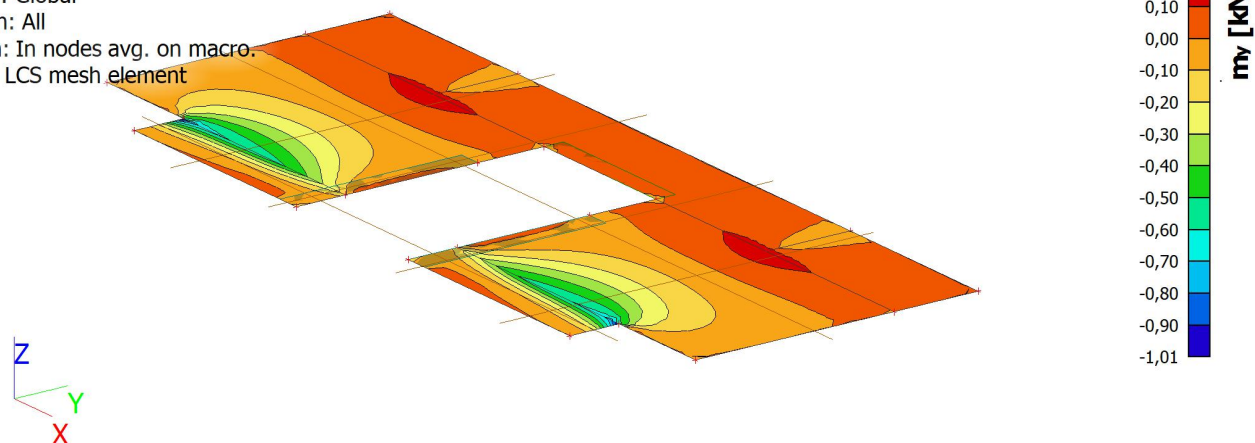
Load case: LC6

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



#### 20.6.2. 2D internal forces; $m_x$

Values:  $m_x$

Linear calculation

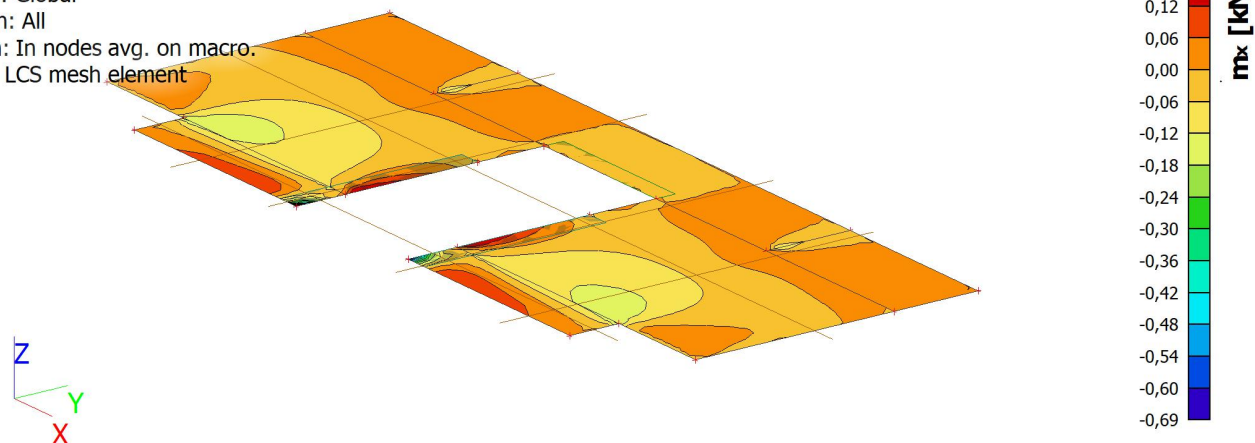
Load case: LC6

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 21. Potrebna armatura ploče

### 21.1. 2D Reinforcement Design (ULS); $A_{s,req,1+}$

Values:  $A_{s,req,1+}$

Linear calculation

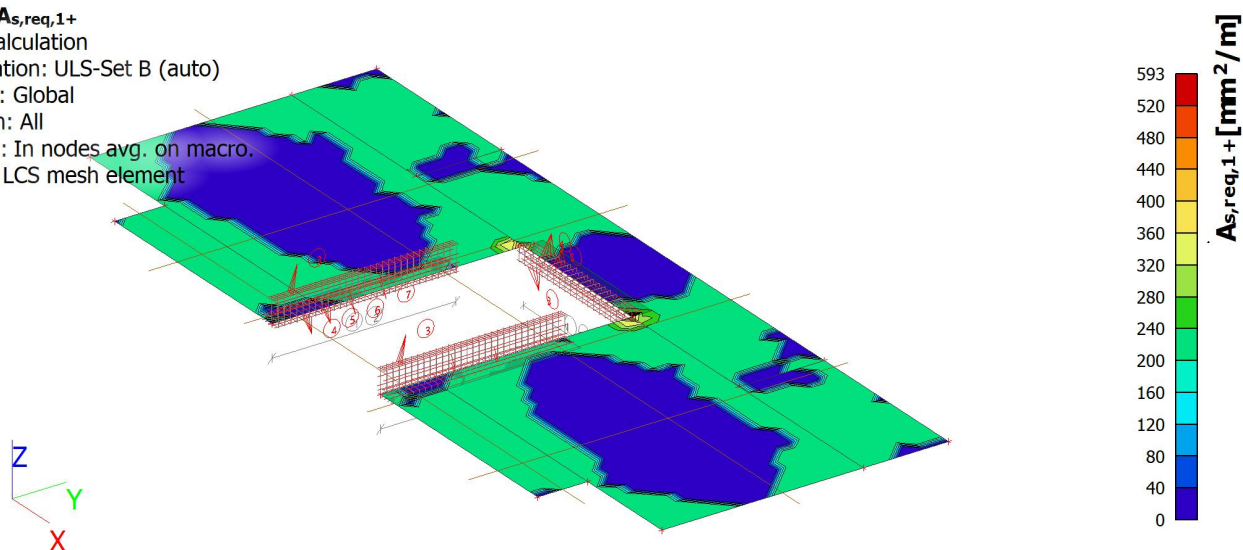
Combination: ULS-Set B (auto)

Extreme: Global

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 21.2. 2D Reinforcement Design (ULS); $A_{s,req,2+}$

Values:  $A_{s,req,2+}$

Linear calculation

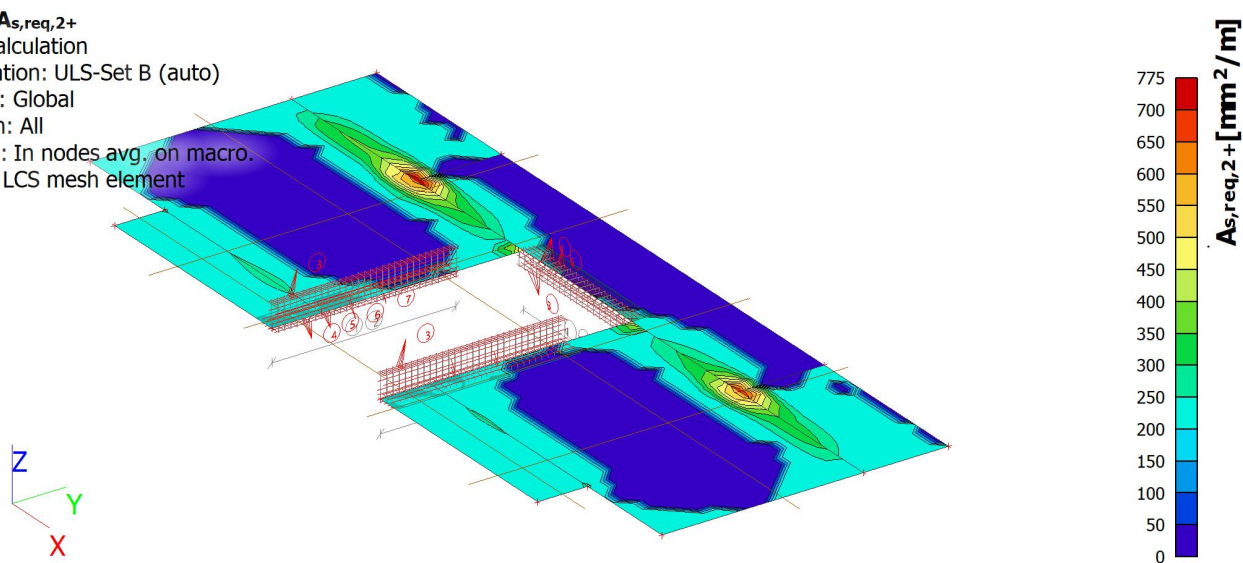
Combination: ULS-Set B (auto)

Extreme: Global

Selection: All

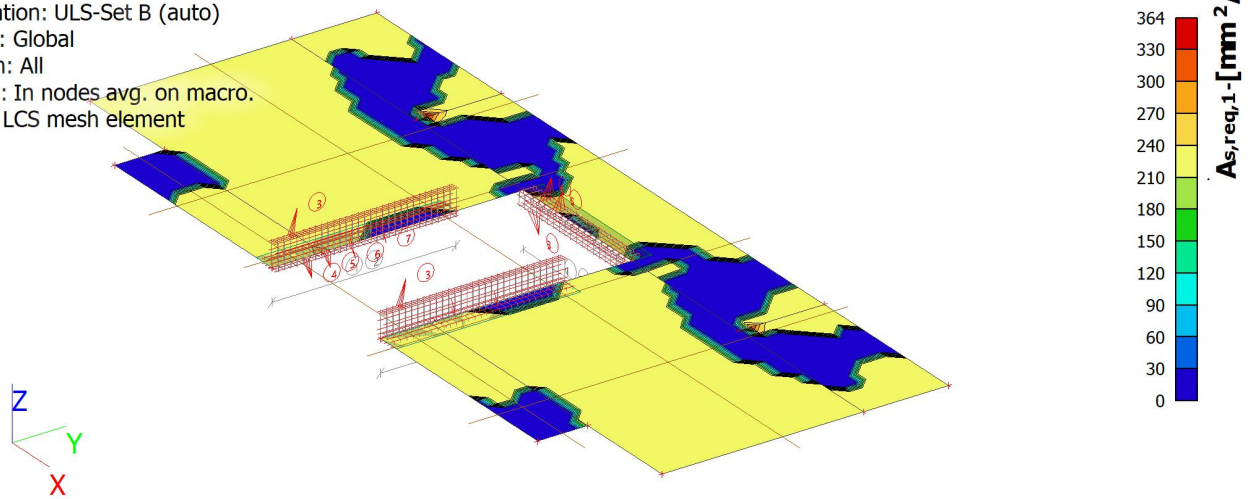
Location: In nodes avg. on macro.

System: LCS mesh element



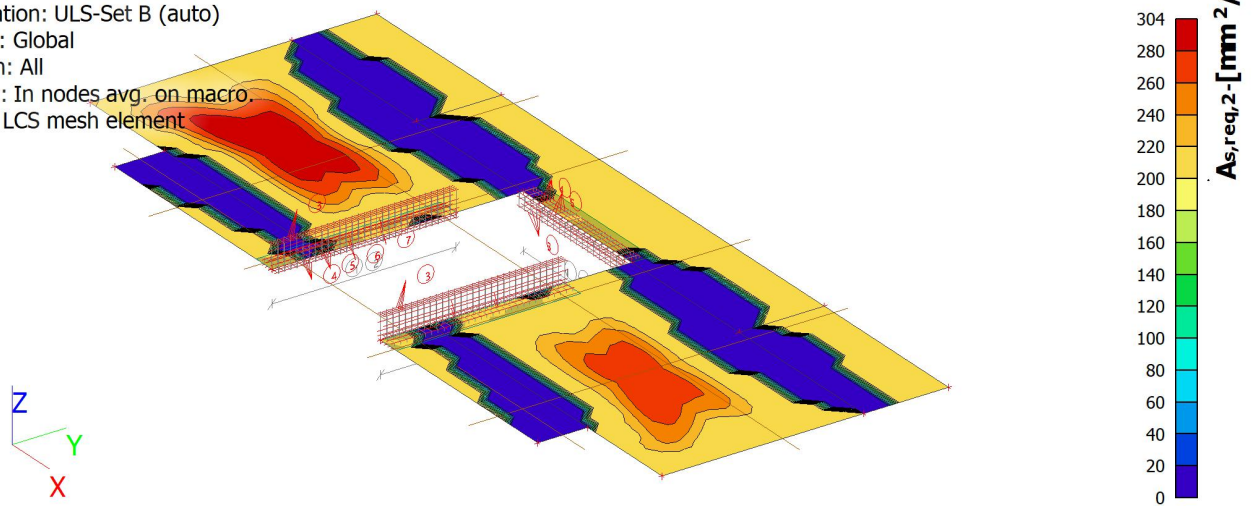
### 21.3. 2D Reinforcement Design (ULS); $A_{s,req,1}$ -

Values:  $A_{s,req,1}$ -  
 Linear calculation  
 Combination: ULS-Set B (auto)  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



### 21.4. 2D Reinforcement Design (ULS); $A_{s,req,2}$ -

Values:  $A_{s,req,2}$ -  
 Linear calculation  
 Combination: ULS-Set B (auto)  
 Extreme: Global  
 Selection: All  
 Location: In nodes avg. on macro.  
 System: LCS mesh element



## 21.5. 2D Reinforcement Design (ULS); $A_{s,req,1+}$

Values:  $A_{s,req,1+}$

Linear calculation

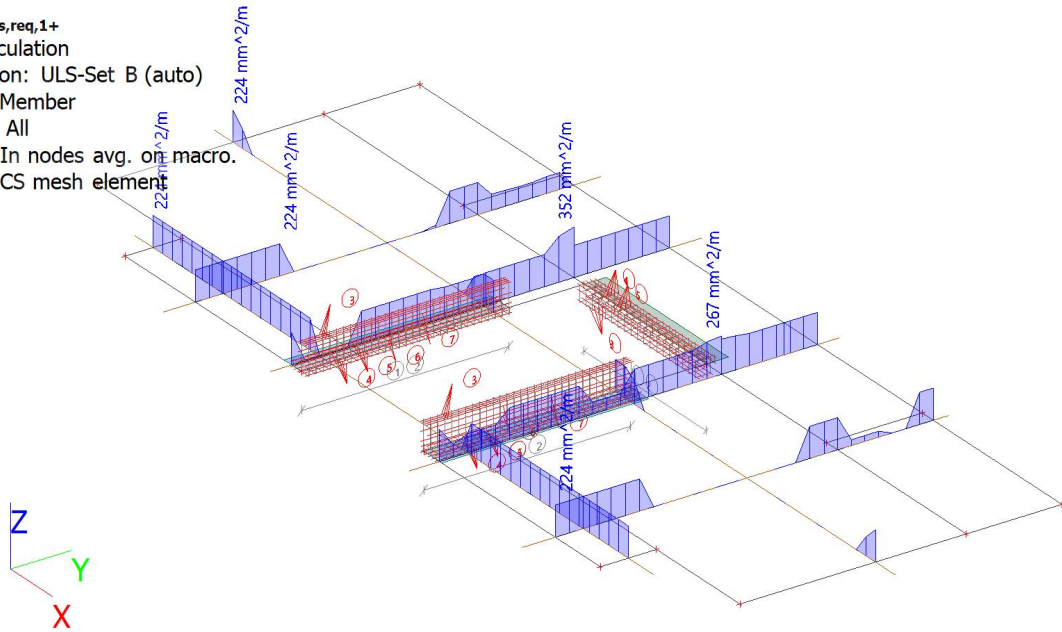
Combination: ULS-Set B (auto)

Extreme: Member

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 21.6. 2D Reinforcement Design (ULS); $A_{s,req,2+}$

Values:  $A_{s,req,2+}$

Linear calculation

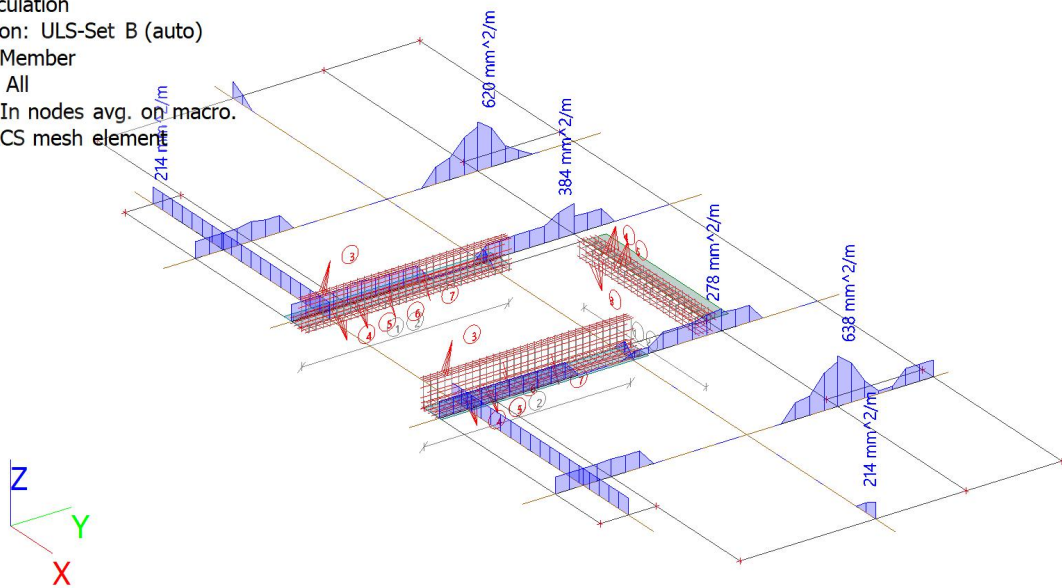
Combination: ULS-Set B (auto)

Extreme: Member

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element





### 21.7. 2D Reinforcement Design (ULS); $A_{s,req,1}$ -

Values:  $A_{s,req,1}$ -

Linear calculation

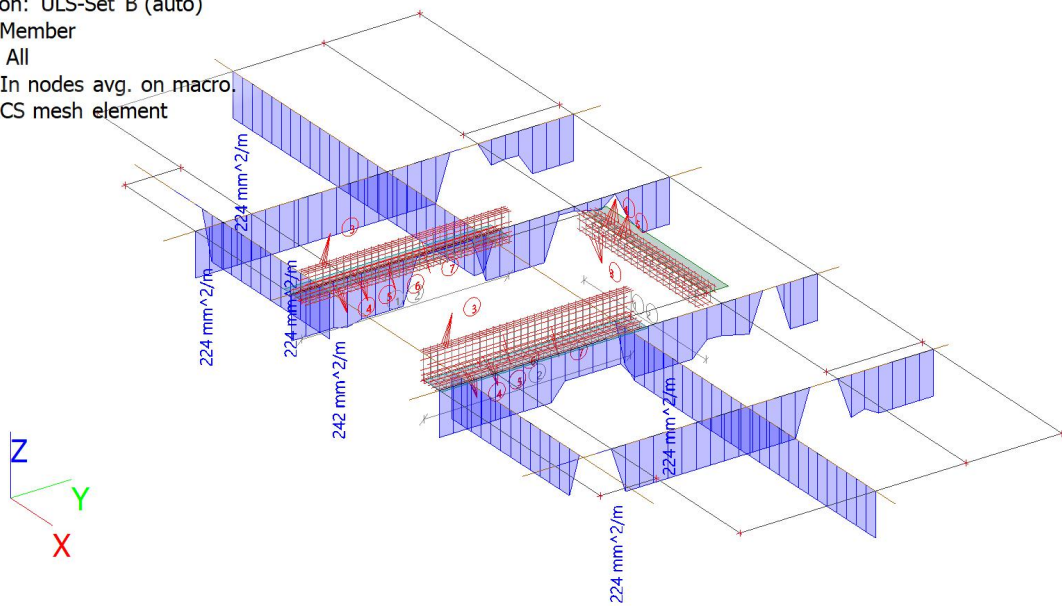
Combination: ULS-Set B (auto)

Extreme: Member

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



### 21.8. 2D Reinforcement Design (ULS); $A_{s,req,2}$ -

Values:  $A_{s,req,2}$ -

Linear calculation

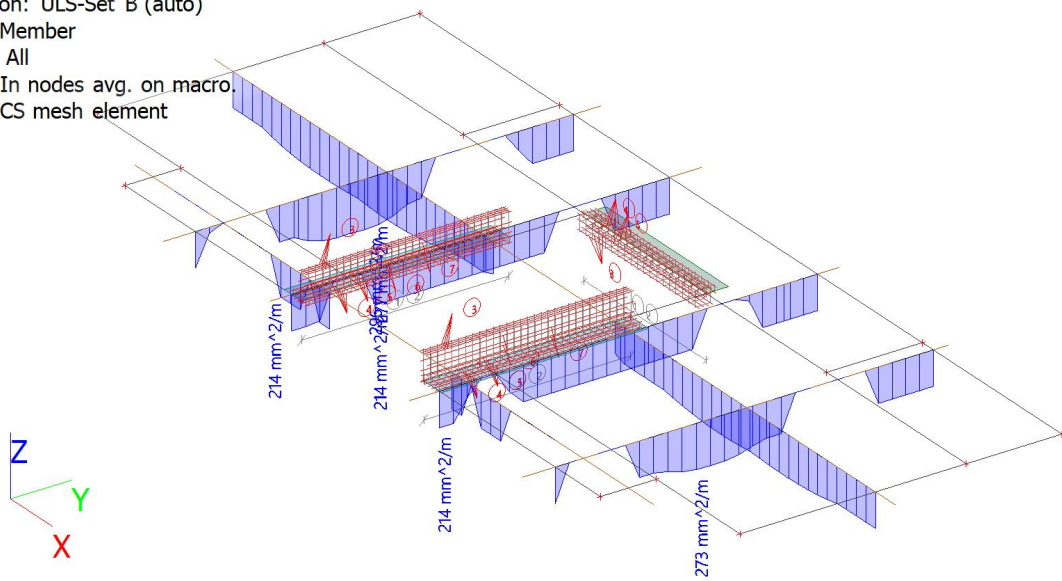
Combination: ULS-Set B (auto)

Extreme: Member

Selection: All

Location: In nodes avg. on macro.

System: LCS mesh element



## 21.9. 2D Reinforcement Design (ULS)

Linear calculation

Combination: ULS-Set B (auto)

Extreme: Global

Selection: All

Location: In nodes avg. on macro. System: LCS mesh element

<b>Plate S4</b>	<b>RECT (1000,0; 200,0)</b>
EC EN 1992-1-1:2004/AC:2008	Node 8/78 [X=11.9m, Y=6.05m, Z=0m]

## Design assumptions

### Reinforcement

Longitudinal: **B 500B**

#### Upper surface

[1+] First layer (0°)

Ø8,0 mm / Principal

[2+] Second layer (90°)

Ø8,0 mm / Principal

Cover:

$c_{nom} = 30 \text{ mm}$

#### Lower surface

[1-] First layer (0°)

Ø8,0 mm / Principal

[2-] Second layer (90°)

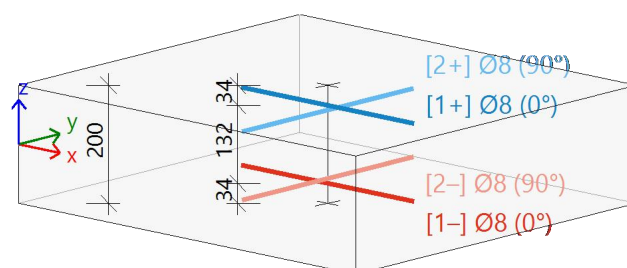
Ø8,0 mm / Principal

Cover:

$c_{nom} = 30 \text{ mm}$

Shear: **B 500B**

Ø8 mm



### Concrete:

Material: **C25/30**

Structural class: S3 (design working life of 50 years, no special quality control)

(Table 4.3N)

Environmental conditions: XC3 (in situ)

(Table 4.1N)

Minimum cover

(§4.4.1.2)

$$c_{min} = \max(c_{min,b}; c_{min,dur} + \Delta c_{dur,y} - \Delta c_{dur,st} - \Delta c_{dur,add}; 10)$$

(4.2)

$$= \max(8; 20 + 0 - 0 - 0; 10) = 20 \text{ mm}$$

Nominal cover

(§4.4.1.1)

$$c_{nom} = c_{min} + \Delta c_{dev} = 20 + 10 = 30 \text{ mm}$$

(4.1)

## Internal forces

### Original FEM-based, critical

Involving the shifting of moment curve : YES

(§9.2.1.3(2))

$$a_l = h \cdot \text{Coeff}_d = 200 \cdot 0.9 = 180 \text{ mm}$$

(§6.2.2(5))

Table of internal forces

Case	$m_x$ [kNm/m]	$m_y$ [kNm/m]	$m_{xy}$ [kNm/m]	$n_x$ [kN/m]	$n_y$ [kN/m]	$n_{xy}$ [kN/m]	$v_x$ [kN/m]	$v_y$ [kN/m]
ULS-Set B (auto)/1	-10,9	-7,1	1,3	107,5	12,1	-15,2	-31,4	19,9
ULS-Set B (auto)/2	-20,9	-13,3	2,6	203,5	23,1	-29,9	-58,9	38,1
ULS-Set B (auto)/3	-17,1	-10,7	2,3	166,0	18,9	-24,9	-47,6	30,5
ULS-Set B (auto)/4	-14,7	-9,6	-1,8	145,0	16,2	-20,3	-42,7	27,4
ULS-Set B (auto)/5	-20,9	-13,1	2,7	203,6	23,2	-30,2	-58,6	37,5
ULS-Set B (auto)/6	-10,9	-7,2	-1,4	107,4	12,0	-15,0	-31,8	20,5
ULS-Set B (auto)/7	-20,9	-13,2	2,7	203,6	23,2	-30,2	-58,6	37,6

Table of combinations

Case	Combination key
ULS-Set B (auto)/1	LC1+LC2
ULS-Set B (auto)/2	1.35*LC1+1.35*LC2+1.50*LC3+0.75*LC6
ULS-Set B (auto)/3	LC1+LC2+1.50*LC5
ULS-Set B (auto)/4	1.35*LC1+1.35*LC2+1.50*LC4+0.75*LC6
ULS-Set B (auto)/5	1.35*LC1+1.35*LC2+1.50*LC5
ULS-Set B (auto)/6	LC1+LC2+1.50*LC4+0.75*LC6
ULS-Set B (auto)/7	1.35*LC1+1.35*LC2+1.50*LC5+0.75*LC6

## Design of longitudinal reinforcement

### Statically required reinforcement

Design direction [ $\alpha=0^\circ$ ]

#### [1+]: upper surface

$$m_{Ed} = -19 \text{ kNm/m} \mid n_{Ed} = 238 \text{ kN/m} \quad [\text{ULS-Set B (auto)/5}]$$

$$f_{cd} = 16.7 \text{ [MPa]} \quad (\gamma_c = 1.5, \alpha_{cc} = 1)$$

$$f_{yd} = 435 \text{ [MPa]} \quad (\gamma_s = 1.15)$$

$$\varnothing 8 \text{ mm} : d_1=34 \text{ mm} \rightarrow d=166 \text{ mm}$$

$$A_{s,req}=593 \text{ mm}^2/\text{m} \text{ (tensile)}$$

$$\rho=0,357\%$$

#### [1-]: lower surface

$$m_{Ed} = -9.99 \text{ kNm/m} \mid n_{Ed} = 168 \text{ kN/m} \quad [\text{ULS-Set B (auto)/4}]$$

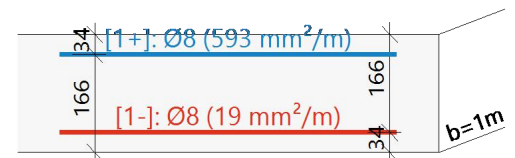
$$f_{cd} = 16.7 \text{ [MPa]} \quad (\gamma_c = 1.5, \alpha_{cc} = 1)$$

$$f_{yd} = 435 \text{ [MPa]} \quad (\gamma_s = 1.15)$$

$$\varnothing 8 \text{ mm} : d_1=34 \text{ mm} \rightarrow d=166 \text{ mm}$$

$$A_{s,req}=19 \text{ mm}^2/\text{m} \text{ (tensile)}$$

$$\rho=0,011\%$$



### Design direction [ $\alpha=90^\circ$ ]

#### [2+]: upper surface

$$m_{Ed} = -14.6 \text{ kNm/m} \mid n_{Ed} = 56 \text{ kN/m} \text{ [ULS-Set B (auto)/2]}$$

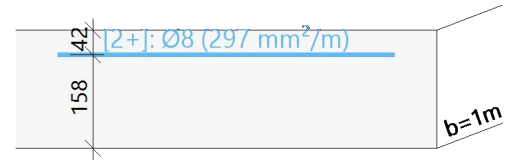
$$f_{cd} = 16.7 \text{ [MPa]} \quad (\gamma_c = 1.5, \alpha_{cc} = 1)$$

$$f_{yd} = 435 \text{ [MPa]} \quad (\gamma_s = 1.15)$$

$$\varnothing 8 \text{ mm} : d_1=42 \text{ mm} \rightarrow d=158 \text{ mm}$$

$$A_{s,req}=297 \text{ mm}^2/\text{m} \text{ (tensile)}$$

$$\rho=0,188\%$$



### Check of concrete diagonal strut

#### Check direction (extreme) [ $\alpha=45^\circ$ ]

Design normal force in direction of concrete strut

$$n_{Ed,sc} = -64.1 \text{ kN} \text{ [ULS-Set B (auto)/5]}$$

with full cross-section height:

$$h=200 \text{ mm} \rightarrow A_{cc} = h \cdot b = 0.2 \cdot 1000 = 200000 \text{ mm}^2$$

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 17 \text{ MPa}$$

Design resistance of concrete strut (in compression)

$$n_{Rd,sc} = A_{cc} \cdot \text{Red}_{fcd} \cdot f_{cd} = 200000 \cdot 0.85 \cdot 17 = 2833 \text{ kN}$$

Unity check

$$UC_{sc} = \frac{\text{abs}(n_{Ed,sc})}{n_{Rd,sc}} = \frac{\text{abs}(-64.1)}{2833} = 0.023$$

### Detailing of longitudinal reinforcement

#### Minimum reinforcement area

##### Principal [1-] (tension)

Minimum area from reinforcement ratio

(§9.2.1.1(1))

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \text{Coeff}_{Asmin,2} \cdot \frac{f_{ctm} \cdot b_t \cdot d}{f_{yk}} \\ \text{Coeff}_{Asmin,1} \cdot b_t \cdot d \end{array} \right\} = \text{Max} \left\{ \begin{array}{l} 0.26 \cdot \frac{2.6 \cdot 1000 \cdot 166}{500} \\ 1.3 \cdot 10^{-3} \cdot 1000 \cdot 166 \end{array} \right\} = 224 \text{ mm}^2/\text{m} \quad (9.1N)$$

Minimum area from maximum spacing of reinforcement bars

$$s_{max,slab} = \min(\text{Coeff}_{smax,slab,A} \cdot h; \text{Coeff}_{smax,slab,B}) = \min(3 \cdot 200; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 126 \text{ mm}^2/\text{m}$$

##### Principal [2-] (compression)

Minimum area from maximum spacing of reinforcement bars

$$s_{max,slab} = \min(\text{Coeff}_{smax,slab,A} \cdot h; \text{Coeff}_{smax,slab,B}) = \min(3 \cdot 200; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 126 \text{ mm}^2/\text{m}$$



#### Principal [1+] (tension)

Minimum area from reinforcement ratio

(§9.2.1.1(1))

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \text{Coeff}_{Asmin,2} \cdot \frac{f_{ctm} \cdot b_t \cdot d}{f_{yk}} \\ \text{Coeff}_{Asmin,1} \cdot b_t \cdot d \end{array} \right\} = \text{Max} \left\{ \begin{array}{l} 0.26 \cdot \frac{2.6 \cdot 1000 \cdot 166}{500} \\ 1.3 \cdot 10^{-3} \cdot 1000 \cdot 166 \end{array} \right\} = 224 \text{ mm}^2/\text{m} \quad (9.1N)$$

Minimum area from maximum spacing of reinforcement bars

$$s_{max,slab} = \min(\text{Coeff}_{smax,slab,A} \cdot h; \text{Coeff}_{smax,slab,B}) = \min(3 \cdot 200; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 126 \text{ mm}^2/\text{m}$$

#### Principal [2+] (tension)

Minimum area from reinforcement ratio

(§9.2.1.1(1))

$$A_{s,min} = \text{Max} \left\{ \begin{array}{l} \text{Coeff}_{Asmin,2} \cdot \frac{f_{ctm} \cdot b_t \cdot d}{f_{yk}} \\ \text{Coeff}_{Asmin,1} \cdot b_t \cdot d \end{array} \right\} = \text{Max} \left\{ \begin{array}{l} 0.26 \cdot \frac{2.6 \cdot 1000 \cdot 158}{500} \\ 1.3 \cdot 10^{-3} \cdot 1000 \cdot 158 \end{array} \right\} = 214 \text{ mm}^2/\text{m} \quad (9.1N)$$

Minimum area from maximum spacing of reinforcement bars

$$s_{max,slab} = \min(\text{Coeff}_{smax,slab,A} \cdot h; \text{Coeff}_{smax,slab,B}) = \min(3 \cdot 200; 400) = 400 \text{ mm} \quad (§9.3.1.1(3))$$

$$A_{s,min} = \frac{b}{s_{max,slab}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{400} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 126 \text{ mm}^2/\text{m}$$

### Maximum reinforcement area

#### Principal [1-] (tension)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 200000 = 8000 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 8; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{8 + 37} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 1117 \text{ mm}^2/\text{m}$$

#### Principal [2-] (compression)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 200000 = 8000 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 8; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{8 + 37} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 1117 \text{ mm}^2/\text{m}$$

#### Principal [1+] (tension)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{Asmax} \cdot A_c = 0.04 \cdot 200000 = 8000 \text{ mm}^2/\text{m} \quad (§9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 8; 32 + 5; 20) = 37 \text{ mm} \quad (§8.2(2))$$

$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{8 + 37} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 1117 \text{ mm}^2/\text{m}$$

### Principal [2+] (tension)

Maximum area from reinforcement ratio

$$A_{s,max} = \text{Coeff}_{A_{s,max}} \cdot A_c = 0.04 \cdot 200000 = 8000 \text{ mm}^2/\text{m} \quad (\$9.2.1.1(3))$$

Maximum area from minimum clear spacing of reinforcement bars

$$s_{min,lim} = \max(k_1 \cdot \phi; d_g + k_2 \cdot s_{lb,min}) = \max(1 \cdot 8; 32 + 5; 20) = 37 \text{ mm} \quad (\$8.2(2))$$

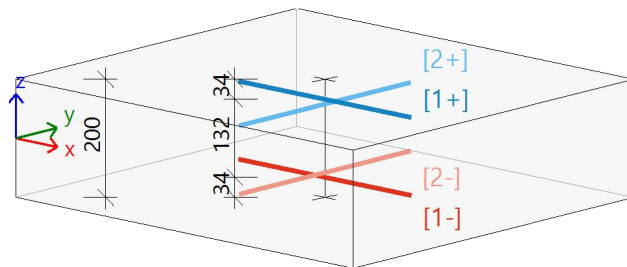
$$A_{s,max} = \frac{b}{\phi + s_{min,lim}} \cdot 0.25 \cdot \pi \cdot \phi^2 = \frac{1000}{8 + 37} \cdot 0.25 \cdot 3.14 \cdot 8^2 = 1117 \text{ mm}^2/\text{m}$$

## Longitudinal reinforcement - Summary

### Provided reinforcement

	Basic	Additional		$A_{s,prov}$ [mm <sup>2</sup> /m]	$A_{s,req}$ [mm <sup>2</sup> /m]	$A_{s,add,req}$ [mm <sup>2</sup> /m]	$A_{s,min}$ [mm <sup>2</sup> /m]	$A_{s,max}$ [mm <sup>2</sup> /m]	Status
		User input	Designed						
[1+]	$\phi 8,0/150$ (335)	no reinf.	$\phi 8,0/150$ (335)	670	593	0	224	1117	OK
[2+]	$\phi 8,0/150$ (335)	no reinf.	no reinf.	335	297	0	214	1117	OK
[1-]	$\phi 8,0/150$ (335)	no reinf.	no reinf.	335	224 (19)	0	224	1117	OK
[2-]	$\phi 8,0/150$ (335)	no reinf.	no reinf.	335	0	0	126	1117	OK

$A_{s,req}$  - required reinforcement including detailings,  $A_{s,prov}$  - provided reinforcement - basic (across whole surface) and additional (local) reinforcement including user input (modelled) 2D reinforcement,  $A_{s,min/max}$  - minimum / maximum reinforcement areas given by detailings, Status - check of  $A_{s,req} \leq A_{s,prov} \leq A_{s,max}$



[1+]  $\phi 8,0/150$  +  $\phi 8,0/150$   
 [2+]  $\phi 8,0/150$   
 [1-]  $\phi 8,0/150$   
 [2-]  $\phi 8,0/150$

## Design of shear reinforcement

Design shear force

$$v_{Ed} = \sqrt{v_x^2 + v_y^2} = \sqrt{-58.9^2 + 38.1^2} = 70.1 \text{ kN/m [ULS-Set B (auto)/2]}$$

Principal forces and plane of deformation

$$m_z = -22 \text{ kNm} \mid n_z = 207 \text{ kN}$$

$$d = 162 \text{ mm} \mid z = 160 \text{ mm}$$

Longitudinal reinforcement ratio

$$\rho_{lx} = \frac{A_{sl,x}}{b \cdot d} = \frac{670}{1000 \cdot 162} = 0.414 \% \quad \rho_{ly} = \frac{A_{sl,y}}{b \cdot d} = \frac{335}{1000 \cdot 162} = 0.207 \%$$

$$\rho_I = \min\left(\sqrt{\rho_{lx} \cdot \rho_{ly}}, 0.02\right) = \min\left(\sqrt{4.14 \cdot 10^{-3} \cdot 2.07 \cdot 10^{-3}}, 0.02\right) = 0.292 \%$$

(\\$6.4.4(1))

## Shear resistance without shear reinforcement

Normal concrete stresses (positive if compression)

Normal forces (from FEM):  $n_x = 203.5 \text{ kN/m}$   $n_y = 23.1 \text{ kN/m}$  [ULS-Set B (auto)/2]

$$\sigma_{cp,1} = \min\left(\frac{-n_x}{A_c}; 0.2 \cdot f_{cd}\right) = \min\left(\frac{-203.5}{0.2}; 0.2 \cdot 16.7 \cdot 10^6\right) = -1.02 \text{ MPa} \quad (\$6.2.2(1))$$

$$\sigma_{cp,2} = \min\left(\frac{-n_y}{A_c}; 0.2 \cdot f_{cd}\right) = \min\left(\frac{-23.1}{0.2}; 0.2 \cdot 16.7 \cdot 10^6\right) = -0.12 \text{ MPa} \quad (\$6.2.2(1))$$

$$\sigma_{cp} = \frac{\sigma_{cp,1} + \sigma_{cp,2}}{2} = \frac{-1.02 + -0.12}{2} = -0.57 \text{ MPa}$$

Design shear resistance without shear reinforcement

(\\$6.4.4(1))

$$k = \min\left(1 + \left(\frac{200}{d}\right)^{\frac{1}{2}}; 2\right) = \min\left(1 + \left(\frac{200}{162}\right)^{\frac{1}{2}}; 2\right) = 2$$

$$C_{Rdc} = 0.12 \quad v_{min} = 0.495 \text{ MPa} \quad k_1 = 0.15$$

$$v_{Rdc} = \max\left(10^6 \cdot \left(C_{Rdc} \cdot k \cdot \left(100 \cdot \rho_l \cdot f_{ck}\right)^{\frac{1}{3}} + k_1 \cdot \sigma_{cp}\right) \cdot d; 0\right) \quad (6.47)$$

$$= \max\left(10^6 \cdot \left(0.12 \cdot 2 \cdot \left(100 \cdot 2.92 \cdot 10^{-3} \cdot 25\right)^{\frac{1}{3}} + 0.15 \cdot -0.567\right) \cdot 0.162; 0\right) = 61.7 \text{ kN/m}$$

$$v_{Rdcmin} = \max\left(10^6 \cdot (v_{min} + k_1 \cdot \sigma_{cp}) \cdot d; 0\right) = \max\left(10^6 \cdot (0.495 + 0.15 \cdot -0.567) \cdot 0.162; 0\right) = 66.4 \text{ kN/m}$$

$$v_{Rdc} = \max(v_{Rdc}, v_{Rdcmin}) = \max(61.7 \text{ kN/m}; 66.4 \text{ kN/m}) = 66.4 \text{ kN/m}$$

## Maximal concrete shear resistance

Strength reduction factor for concrete cracked in shear

$$v = 0.6 \cdot \left(1 - \frac{f_{ck}}{250}\right) = 0.6 \cdot \left(1 - \frac{25}{250}\right) = 0.54 \quad (6.6N)$$

Angle of compression concrete strut

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.192$$

Design value of the max shear force which can be sustained by the member

$$v_{Rd,max} = \frac{\alpha_{cw} \cdot b_w \cdot z \cdot v_1 \cdot f_{cd}}{\left(\cotg(\theta) + \tg(\theta)\right)} = \frac{1 \cdot 1 \cdot 0.16 \cdot 0.54 \cdot 16.7}{\left(\cotg(40) + \tg(40)\right)} = 710 \text{ kN/m} \quad (6.9)$$

## Check shear capacity (without shear reinforcement)

Check  $v_{Rd,max}$

$$v_{Ed} = 70.1 \text{ kN/m} \leq v_{Rd,max} = 710 \text{ kN/m} \quad (\text{OK})$$

Check  $v_{Rdc}$

$$v_{Ed} = 70.1 \text{ kN/m} > v_{Rdc} = 66.4 \text{ kN/m} \quad (\text{NOT OK, shear reinforcement is required})$$

## Statically required shear reinforcement

$$f_{ywd,req} = \frac{f_{ywk,req}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa}$$
$$A_{sw,req} = \frac{V_{Ed}}{z \cdot f_{ywd,req} \cdot \cotg(\theta)} = \frac{70.1}{0.16 \cdot 435 \cdot \cotg(40)} = 845 \text{ mm}^2/\text{m} \quad (6.8)$$

Required shear reinforcement

$$17\phi 8/\text{m}^2 \Rightarrow A_{sw,req} = 845 \text{ mm}^2/\text{m}^2$$

## Detailing of shear reinforcement

### Minimal depth of slab with shear reinforcement 9.3.2(1)

Depth of slab

$$h = 200 \text{ mm}$$

Minimal depth of slab with shear reinforcement

$$h_{\min} = 200 \text{ mm} \quad (\$9.3.2(1))$$

$$h \geq h_{\min}$$

$$200 \text{ mm} \geq 200 \text{ mm}$$

Note: Shear reinforcement according detailing provisions can be designed.

### Minimal area of shear reinforcement from minimal ratio 9.3.2(2)

Characteristic cylinder concrete strength

$$f_{ck} = 25 \text{ MPa}$$

Characteristic yield strength of reinforcement

$$f_{ywk} = 500 \text{ MPa}$$

Minimal allowed reinforcement percentage of stirrups

$$\rho_{w,min} = \frac{\text{Coeff}_{pw,min} \cdot \sqrt{f_{ck}}}{f_{ywk}} = \frac{0.08 \cdot \sqrt{25}}{500} = 800 \cdot 10^{-6} \quad (9.5N)$$

Minimum width of the cross-section in tensile area

$$b_w = 1000 \text{ mm}$$

Angle between shear reinforcement and the longitudinal axis

$$\alpha = 90^\circ$$

Minimal area of shear reinforcement

$$A_{sws,p,min} = \rho_{w,min} \cdot b_w \cdot \sin(\alpha) = 800 \cdot 10^{-6} \cdot 1000 \cdot \sin(90) = 800 \text{ mm}^2/\text{m}$$

## Minimal area of shear reinforcement from max. spacing of shear links 9.3.2(4)

Effective height of beam

$$d = 162 \text{ mm}$$

Angle between shear reinforcement and the longitudinal axis

$$\alpha = 90^\circ$$

Maximal spacing of shear links

$$s_{\max, \text{long}} = \text{Coeff}_{s_{\max}} \cdot d \cdot (1 + \cotg(\alpha)) = 0.75 \cdot 0.162 \cdot (1 + \cotg(90)) = 0.122 \text{ m} \quad (9.9)$$

Minimal area of shear reinforcement

$$A_{\text{sws,sp,min}} = \frac{1}{s_{\max, \text{long}}} \cdot \pi \cdot \frac{\phi^2}{4} = \frac{1}{0.122} \cdot 3.14 \cdot \frac{8^2}{4} = 414 \text{ mm}^2/\text{m}$$

## Shear reinforcement - Summary

Design forces  $v_{\text{Ed}} = 70,1 \text{ kN}$  [ULS-Set B (auto)/2]

[ULS-Set B (auto)/2] :  $1.35 \cdot \text{LC1} + 1.35 \cdot \text{LC2} + 1.50 \cdot \text{LC3} + 0.75 \cdot \text{LC6}$

Angle $\theta$ [°]	$A_{\text{sl,x}}$ [mm <sup>2</sup> /m]	$A_{\text{sl,y}}$ [mm <sup>2</sup> /m]	$\rho_l$ [%]	$v_{\text{Ed}}$ [kN/m]	$v_{\text{Rdc}}$ [kN/m]	$v_{\text{Rd,max}}$ [kN/m]	$A_{\text{sw,req}}$ [mm <sup>2</sup> /m <sup>2</sup> ]	Status
User (40°)	670	335	0,292	70,1	66,4	710,3	845 (17φ8)	OK

$\theta$  - angle of compression strut,  $A_{\text{sl,x/y}}$  - tensile longitudinal reinforcement,  $\rho_l$  - mean value of longitudinal reinforcement ratio,  $v_{\text{Rdc}}$  - shear resistance without shear reinforcement,  $v_{\text{Rd,max}}$  - maximal concrete shear resistance,  $A_{\text{sw,req}}$  - required shear reinforcement

## 22. Potrebna armatura grede

### 22.1. Check capacity-interaction diagram

Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: B1

Rib B1		L g (700; 554; 200; 300)
EC EN 1992-1-1:2004/AC:2008		Section 8 [dx = 1.2 m]
<b>Member length:</b>	L = 4.43 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 7.01 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 6.77 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		8φ12 mm + 9φ14 mm (A <sub>s</sub> = 2290 mm <sup>2</sup> )
		ρ <sub>l</sub> = 0,878 % (18 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/147 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,260 % (5.32 kg/m) (A <sub>swm</sub> = 677 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 29 \text{ kN} \quad M_y = -14.2 \text{ kNm} \quad M_z = 5.08 \text{ kNm}$$

Content of combination:

$$1.35 \cdot \text{LC1} + 1.35 \cdot \text{LC2} + 1.50 \cdot \text{LC4} + 0.75 \cdot \text{LC6}$$

## Compression member

Limit axial force to consider member as compression:

$$N_{\text{com}} = -\text{Coeff}_{\text{com}} \cdot (f_{\text{cd}} \cdot A_c) = -0.1 \cdot (16.7 \cdot 10^6 \cdot 0.261) = -435 \text{ kN}$$

Check condition:

$$N_{\text{Ed}} \geq N_{\text{com}} = 29 \text{ kN} \geq -435 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$$N_{\text{Ed}} = 29 \text{ kN} \quad M_{\text{Edy}} = -20.7 \text{ kNm} \quad M_{\text{Edz}} = 6.82 \text{ kNm}$$

## Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{\text{res}} = 21.8 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{M_y M_z} = 18.2^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{\text{res}}$	$\alpha_{NM} = 53.1^\circ$

## Calculation of resistances

Resistances in positive direction  $N_{\text{Rd}+} = 270 \text{ kN} \quad M_{\text{Rdy}+} = 458 \text{ kNm} \quad M_{\text{Rdz}+} = 64 \text{ kNm}$

Resistances in negative direction  $N_{\text{Rd}-} = -642 \text{ kN} \quad M_{\text{Rdy}-} = -193 \text{ kNm} \quad M_{\text{Rdz}-} = -151 \text{ kNm}$

## Summary of check

Forces:  $N_{Ed} = 29 \text{ kN}$   $M_{Edy} = -20.7 \text{ kNm}$   $M_{Edz} = 6.82 \text{ kNm}$

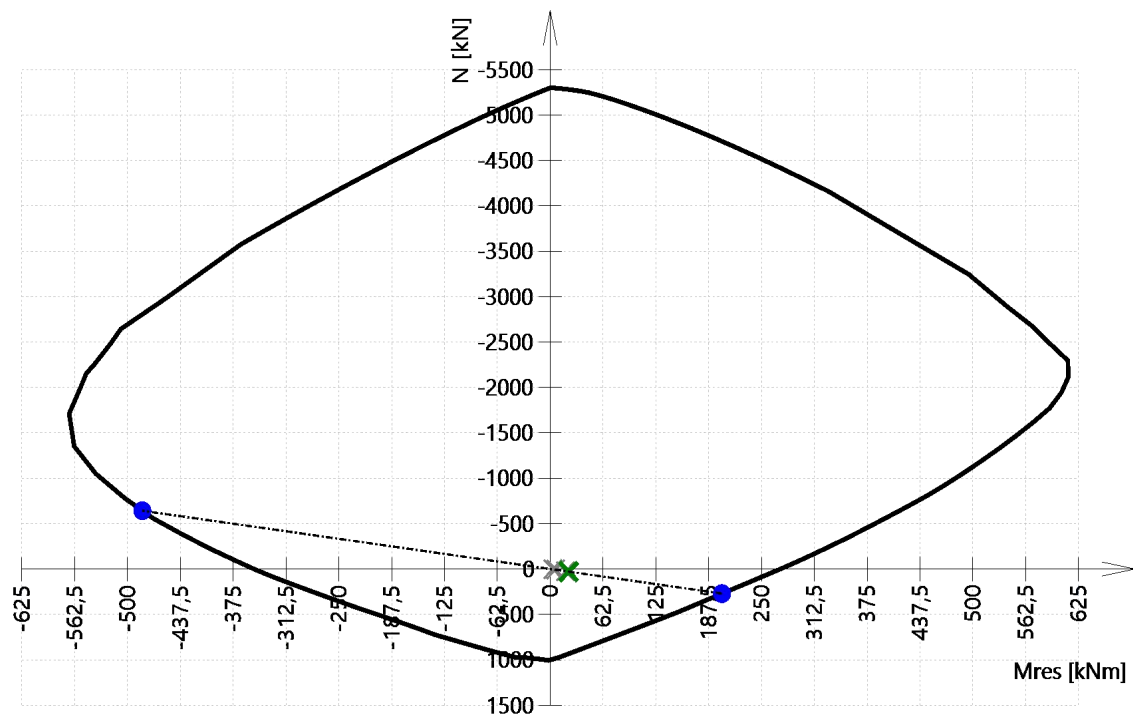
Resistance:  $N_{Rd} = 270 \text{ kN}$   $M_{Rdy} = -193 \text{ kNm}$   $M_{Rdz} = 64 \text{ kNm}$

Calculation of unity check:

$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{29^2 + -20.7^2 + 6.82^2}}{\sqrt{270^2 + -193^2 + 63.6^2}} = 0.107 \leq 1 \quad \text{OK}$$

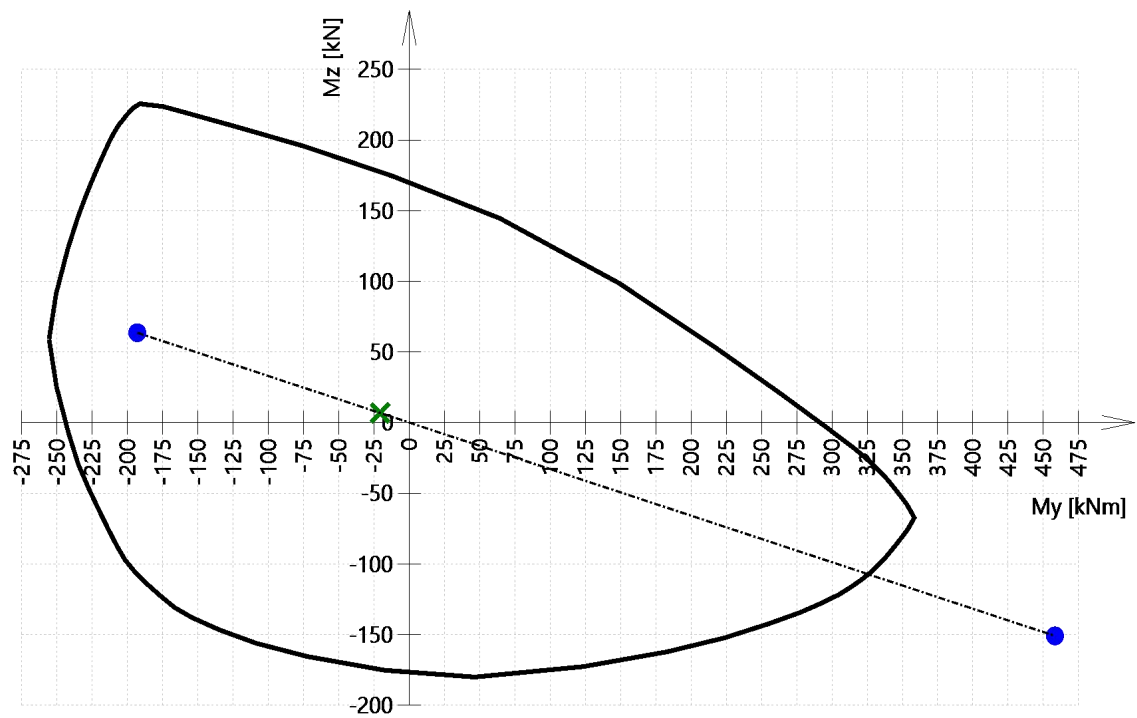
List of errors/warnings/notes: N2/1.

## 3D interaction diagram - Vertical section N-M<sub>res</sub>





### 3D interaction diagram - Horizontal section $M_y$ - $M_z$



### Explanation of errors, warnings and notes

Index	Type	Description	Solution
N2/1	Note	The member is not considered as a compression member (normal force is relatively small or zero).	

## 22.2. Check shear+torsion (ULS)

Rib B1		L g (700; 554; 200; 300)
EC EN 1992-1-1:2004/AC:2008		Section 8 [dx = 1.2 m]
<b>Member length:</b>	L = 4.43 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 7.01 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 6.77 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		8φ12 mm + 9φ14 mm (A <sub>s</sub> = 2290 mm <sup>2</sup> )
		ρ <sub>l</sub> = 0,878 % (18 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/147 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,260 % (5.32 kg/m) (A <sub>swm</sub> = 677 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

### Settings

Method for calculation shear resistances:

Standard

Limit value of angle between bending moments and shear forces resultant for using standard method: : α<sub>VM,lim</sub> = 15 °

Equivalent thin walled cross-section:

Automatic

The angle between the concrete compression strut and axis member: User input: θ<sub>inp</sub> = 40 ° => cot(θ<sub>inp</sub>) = 1.19

### Forces

Content of combination: 1.35\*LC1+1.35\*LC2+1.50\*LC5

N<sub>Ed</sub> = 3.98 kN M<sub>Edy</sub> = -5.94 kNm M<sub>Edz</sub> = 3.06 kNm V<sub>Edy</sub> = -0.491 kN V<sub>Edz</sub> = 8.02 kN T<sub>Ed</sub> = 14.9 kNm

Angle of gradient of strain plane

Angle of shear resultant

$$\alpha_M = 117^\circ$$

$$\alpha_V = 93.5^\circ$$

Resultant of shear force

Difference between angles α<sub>M</sub> and α<sub>V</sub>

$$V_{Ed} = \sqrt{V_{Edy}^2 + V_{Edz}^2} = \sqrt{(-0.491)^2 + 8.02^2} = 8.04 \text{ kN}$$

$$\alpha_{MV} = \text{abs}(\alpha_M - \alpha_V) = \text{abs}(117 - 93.5) = 23.8^\circ$$

Note: The angle between gradient of the strain plane and the resultant of shear forces is greater, than limit angle  
The method based on interaction formula (biaxial shear calculation) should be used, because for greater angle than limit angle, the value d and z recalculated to direction of shear force rapidly decreased

### Material characteristics

Design concrete compressive strength

Design tensile strength of concrete

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

$$f_{ctd} = \frac{\alpha_{ct} \cdot f_{ctk005}}{\gamma_c} = \frac{1 \cdot 1.8}{1.5} = 1.2 \text{ MPa} \quad (3.15, 3.16)$$

### Calculation of angle between concrete compression strut and member axis

- minimum value:

$$\theta_{\min} = 21.8^\circ \Rightarrow \cot(\theta_{\min}) = 2.5 \quad (\$6.2.3(2))$$

- maximum value:

$$\theta_{\max} = 45^\circ \Rightarrow \cot(\theta_{\max}) = 1 \quad (\$6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{\text{inp}} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Check shear and calculation shear resistances

### Cross section parameters

Minimum width of the cross-section in tensile area

$$y_{bw} = 6.53 \text{ mm}$$

$$z_{bw} = -107 \text{ mm}$$

$$b_w = 301 \text{ mm}$$

Note: Value  $b_w$  is calculated as the smallest width of cross-section in tensile area perpendicular to resultant of shear force.

Warning: Calculated width  $b_{w,\text{orig}} = 36.3 \text{ mm}$  is lesser than 10 % of average of cutoff lengths in direction perpendicular on shear forces resultant in each point of cross-section  $b_{w,\text{lim}} = 27.2 \text{ mm}$ . Therefore  $b_w$  is increased to next cutoff length 301 mm. Pay attention to  $b_w$  it can be higher than expected. To decrease effective width of rib or to increase width of web of rib.

Minimum width of cross-section between tension and compression chord

$$y_{bw1} = -13 \text{ mm}$$

$$z_{bw1} = 213 \text{ mm}$$

$$b_{w1} = 301 \text{ mm}$$

Note: Value  $b_{w1}$  is calculated as the smallest width of cross-section between tension and compression chord perpendicular to resultant of shear force.

Height of cross-section recalculated to direction of shear force resultant

$$h = 733 \text{ mm}$$

Note: Value  $h$  is calculated as width of cross-section in center of gravity in direction shear force resultant.

Concrete cross-section area

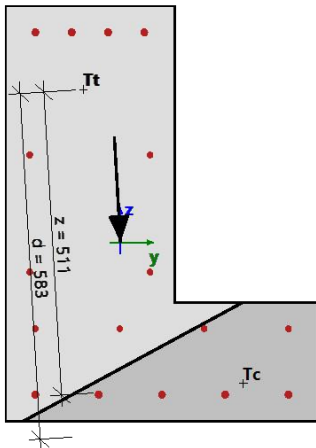
$$A_c = 0.261 \text{ m}^2$$

Effective depth recalculated to direction of shear force resultant

$$d = 583 \text{ mm}$$

Lever arm of internal forces recalculated to direction of shear force resultant

$$z = 511 \text{ mm}$$



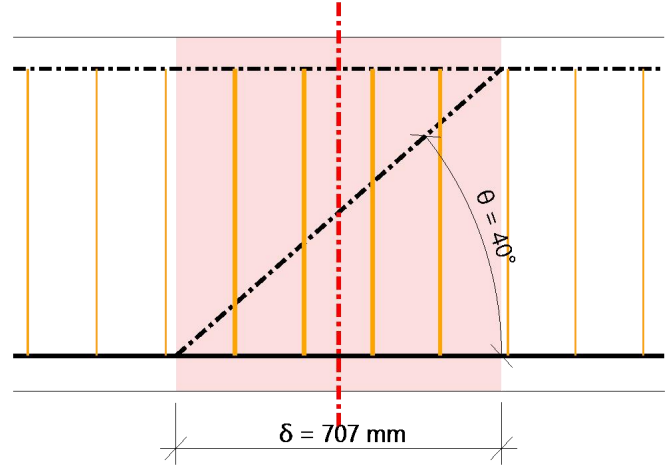
## Parameters of shear reinforcement

### Input parameters

Stirrups on the length of shear crack projection  $\delta = z \cdot \cot(\theta) = 707 \text{ mm}$ , interval (-354; 354)

$$z = \text{Coeff}_d \cdot \text{Coeff}_z \cdot h = 0.9 \cdot 0.9 \cdot 0.73 = 593 \text{ mm} \quad \delta = z \cdot \cot(\theta) = 0.593 \cdot \cot(40) = 707 \text{ mm}$$

ID	Zone	$x_s$ [mm]	$\phi_s$ [mm]	$s_s$ [mm]	$n_s$ []	$\alpha_s$ [°]	$f_{ywk}$ [MPa]
1	1	-225	8	150	2	90	500
2	1	-75	8	149	2	90	500
3	1	73.5	8	148	2	90	500
4	1	220	8	147	2	90	500
Avg.	-	-	8	148	2	90	500



Number of stirrup links

$$n_s = 2$$

Diameter of reinforcement

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

Centre - to - centre distance of stirrup in longitudinal direction

$$s_{inp} = 0.148 \text{ m}$$

Angle of stirrups from axis of member

$$\alpha_s = 90^\circ$$

Characteristic yield strength

$$f_{ywk} = 500 \text{ MPa}$$

Cross - sectional area of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

Maximum longitudinal spacing of shear links

$$s_l = s_{inp} = 148 \text{ mm}$$

Cross - sectional area per meter

$$A_{swm} = \frac{A_{sw}}{s_l} = \frac{101 \cdot 10^{-6}}{0.148} = 677 \text{ mm}^2/\text{m}$$

## Parameters of longitudinal reinforcement

The area of tensile reinforcement

$$A_{sl} = 1448 \text{ mm}^2$$

## Calculation of shear resistances

### Design shear resistance of the member without shear reinforcement

$$\sigma_{ct,max} = 0.263 \text{ MPa} < f_{ctd} = 1.2 \text{ MPa} \Rightarrow \text{Section uncracked in flexure}$$

Calculation design shear resistance of the member without shear reinf. according to chapter 12.6.3

Compressed concrete area for uncracked cross-section under ULS loading

$$A_{cc} = 116938 \text{ mm}^2$$

Normal stress of uncracked cross-section under ULS loading

$$\sigma_{cp} = \frac{-N_{Ed}}{A_{cc}} = \frac{-3975}{0.117} = -0.034 \text{ MPa} \quad (12.3)$$

Limit value of stress caused by axial force

$$\sigma_{clim} = f_{cd} - 2 \cdot \sqrt{f_{ctd} \cdot (f_{ctd} + f_{cd})} = 16.7 - 2 \cdot \sqrt{1.2 \cdot (1.2 + 16.7)} = 7.41 \text{ MPa} \quad (12.7)$$

Concrete design strength in shear and compression

$$f_{cvd} = \sqrt{f_{ctd}^2 + \sigma_{cp} \cdot f_{ctd}} = \sqrt{1.2^2 + -0.034 \cdot 1.2} = 1.18 \text{ MPa} \quad (\text{because } \sigma_{cp} < \sigma_{clim}) \quad (12.5)$$

Coefficient for shear stress

$$k = 1.5 \quad (\$12.6.3(2)N)$$

Shear stress of uncracked cross-section under ULS loading

$$\tau_{cp} = \frac{k \cdot V_{Ed}}{A_{cc}} = \frac{1.5 \cdot 8035}{0.117} = 0.103 \text{ MPa} \quad (12.4)$$

Calculation design shear resistance of the member without shear reinforcement

$V_{Rdc}$  is calculated from equation 12.4, when  $\tau_{cp} = f_{cvd}$

$$V_{Rdc} = \frac{f_{cvd} \cdot A_{cc}}{k} = \frac{1.18 \cdot 10^6 \cdot 0.117}{1.5} = 92 \text{ kN}$$

Note: Design shear resistance of the member without shear reinforcement is calculated according to clause 12.6.3 because section is uncracked in flexure in ULS.

### Calculation of angle between concrete compression strut and member axis

Limit value of angle

- minimum value:

$$\theta_{min} = 21.8^\circ \Rightarrow \cot(\theta_{min}) = 2.5 \quad (\$6.2.3(2))$$

- maximum value:

$$\theta_{max} = 45^\circ \Rightarrow \cot(\theta_{max}) = 1 \quad (\$6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Design shear resistance of the member with shear reinforcement

Design stress of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

$$\sigma_{swd} = \frac{\frac{\text{abs}(V_{Ed})}{z} \cdot s_l}{A_{sw} \cdot (\cotg(\theta) + \cotg(\alpha_s) \cdot \sin(\alpha_s))} = \frac{\frac{\text{abs}(8035)}{0.511} \cdot 0.15}{101 \cdot 10^{-6} \cdot (\cotg(40) + \cotg(90) \cdot \sin(90))} = 19.5 \text{ MPa}$$

Design yield strength of shear reinforcement

$$f_{ywd} = 0.8 \cdot f_{ywk} = 0.8 \cdot 500 = 400 \text{ MPa} \quad , (\text{because } \sigma_{swd} < 0.8 \cdot f_{ywk})$$

Note: Design yield strength of shear reinforcement was reduced to  $0.8 \times f_{ywk}$  (EN 1992-1-1, clause 6.2.3(3)), because design stress of the shear reinforcement is below 80% of the characteristic yield stress  $f_{yk}$ .

Design shear resistance of the member with shear reinforcement

$$V_{Rds} = \frac{A_{sw}}{s_l} \cdot z \cdot f_{ywd} \cdot \cotg(\theta) = \frac{101 \cdot 10^{-6}}{0.15} \cdot 0.511 \cdot 400 \cdot 10^6 \cdot \cotg(40) = 165 \text{ kN} \quad (6.8)$$

## Design value of the max shear force which can be sustained by the member

Strength reduction factor for concrete cracked in shear - value  $v$

$$v = 0.6 \cdot \left( 1 - \frac{f_{ck}}{250} \right) = 0.6 \cdot \left( 1 - \frac{25}{250} \right) = 0.54 \quad (6.6N)$$

## Strength reduction factor for concrete cracked in shear - value $v_1$

$$\sigma_{cp} = \min \left( \frac{-N_{Ed}}{A_c}; 0.2 \cdot f_{cd} \right) = \min \left( \frac{-3.98}{0.261}; 0.2 \cdot 16.7 \right) = -0.0152 \text{ MPa}$$

$$v_1 = 0.6 \quad (6.10.aN)$$

Coefficient taking into account state of the stress in the compression chord

$$\alpha_{cw} = 1 \quad (\text{for non-prestressed member}) \quad (\$6.2.3(3)N3)$$

Design value of the max shear force which can be sustained by the member

$$V_{Rdmax} = \frac{\alpha_{cw} \cdot b_{w1} \cdot z \cdot v_1 \cdot f_{cd}}{(\cotg(\theta) + \tg(\theta))} = \frac{1 \cdot 0.301 \cdot 0.511 \cdot 0.6 \cdot 16.7 \cdot 10^6}{(\cotg(40) + \tg(40))} = 757 \text{ kN} \quad (6.9)$$

## Maximum shear force near the support (without using factor $\beta$ )

$$V_{Edmax} = 0.5 \cdot b_{w1} \cdot d \cdot v \cdot f_{cd} = 0.5 \cdot 0.301 \cdot 0.583 \cdot 0.54 \cdot 16.7 \cdot 10^6 = 789 \text{ kN} \quad (6.5)$$

## Shear resistance of the member

$$V_{Rd} = \min(V_{Rds} + V_{ccd} + V_{tdr}; V_{Rdmax} + V_{ccd} + V_{tdr}; V_{Edmax} + V_{ccd} + V_{td}) = \min(165 + 0 + 0; 757 + 0 + 0; 789 + 0 + 0) = 165 \text{ kN}$$

## Shear check

Check  $V_{Rdmax}$

$$V_{Ed} = 8.04 \text{ kN} \leq V_{Rdmax} + V_{ccd} + V_{td} = 757 \text{ kN}$$

Note: The check satisfies for crushing of the compression strut ( $V_{Ed} \leq V_{Rd,max} + V_{td} + V_{ccd}$ ).

Check  $V_{Edmax}$

$$V_{Ed} = 8.04 \text{ kN} \leq V_{Edmax} + V_{ccd} + V_{td} = 789 \text{ kN}$$

Note: The check satisfies for shear force near the support ( $V_{Ed} \leq V_{Ed,max} + V_{td} + V_{ccd}$ ).

Check  $V_{Rdc}$  and  $V_{Rds}$

$$V_{Ed} = 8.04 \text{ kN} < V_{Rdc} = 92.2 \text{ kN} \text{ and } V_{Ed} = 8.04 \text{ kN} < V_{Rds} + V_{ccd} + V_{td} = 165 \text{ kN}$$

Note: The check satisfies, shear force carried by concrete ( $V_{Ed} \leq V_{Rdc}$ ) and  $V_{Ed} \leq V_{Rds}$ , no shear reinforcement is required. Only minimum shear reinforcement according to detailing provisions has to be inputted.

## Unity check

$$UC = \frac{\text{abs}(V_{Ed})}{V_{Rd}} = \frac{\text{abs}(8.04 \text{ kN})}{165 \text{ kN}} = 0.0487$$

## Check torsion and calculation torsional resistances

### Cross section parameters

Total area of cross-section

$$A_c = 260833 \text{ mm}^2$$

Total area of cross-section

$$u_c = 2508 \text{ mm}$$

The area of longitudinal reinforcement for torsion

$$A_{sl} = 1489 \text{ mm}^2$$

The minimum distance between reinf. bars inside stirrup for torsion and edge of cross-section

$$a_{sl} = 44 \text{ mm}$$

Effective wall thickness

$$t_{ef} = \max\left(\frac{A_c}{u_c}, 2 \cdot a_{sl}\right) = \max\left(\frac{0.261}{2.51}, 2 \cdot 0.044\right) = 104 \text{ mm} \quad (\$6.3.2(1))$$

Perimeter of area and area enclosed by the centre line of effective cross-section

$$u_k = 1584 \text{ mm}$$

$$A_k = 116827 \text{ mm}^2$$

Note: Parameters for torsion [value  $A_k$  and  $u_k$ ] are calculated by automatic method [Method = From torsional stirrup].

## Parameters of shear/torsion reinforcement

Stirrups on the length of shear crack projection  $\delta = z \cdot \cot(\theta) = 707 \text{ mm}$ , interval (-354; 354)

$$z = \text{Coeff\_d} \cdot \text{Coeff\_z} \cdot h = 0.9 \cdot 0.9 \cdot 0.73 = 593 \text{ mm} \quad \delta = z \cdot \cot(\theta) = 0.593 \cdot \cot(40) = 707 \text{ mm}$$

ID	Zone	$x_s$ [mm]	$\phi_s$ [mm]	$s_s$ [mm]	$n_s$ []	$\alpha_s$ [°]	$f_{ywk}$ [MPa]
1	1	-225	8	150	2	90	500
2	1	-75	8	149	2	90	500
3	1	73.5	8	148	2	90	500
4	1	220	8	147	2	90	500
Avg.	-	-	8	148	2	90	500

## Input parameters

Diameter  $\phi_{st} = 8 \text{ mm}$

Centre - to - centre distance in longitudinal direction  $s_{tinp} = 0.148 \text{ m}$

Angle of stirrups from axis of member  $\alpha_{st} = 90^\circ$

Characteristic yield strength  $f_{ywk} = 500 \text{ MPa}$

Cross - sectional area of shear reinforcement

$$A_{swt} = \pi \cdot \left( \frac{\phi_{st}}{2} \right)^2 = 3.14 \cdot \left( \frac{8}{2} \right)^2 = 50.3 \text{ mm}^2$$

Maximum longitudinal spacing of shear links

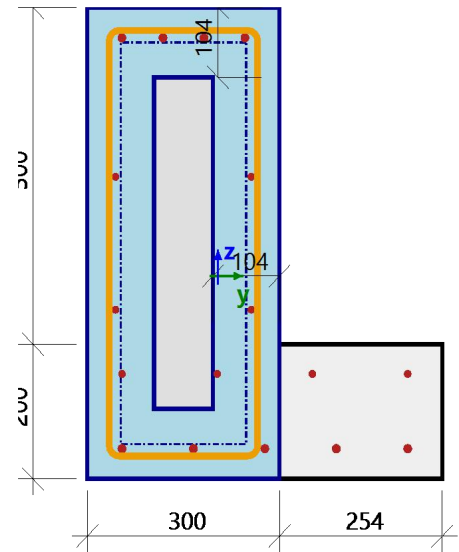
$$s_{lt} = s_{tinp} = 148 \text{ mm}$$

Cross - sectional area of shear reinforcement per meter

$$A_{swtm} = \frac{A_{swt}}{s_{lt}} = \frac{50.3 \cdot 10^{-6}}{0.148} = 339 \text{ mm}^2/\text{m}$$

Design yield strength of shear reinforcement

$$f_{ywd} = \frac{f_{ywk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa}$$



## Calculation of angle between concrete compression strut and member axis

- minimum value:

$$\theta_{\min} = 21.8^\circ \Rightarrow \cot(\theta_{\min}) = 2.5 \quad (\S 6.2.3(2))$$

- maximum value:

$$\theta_{\max} = 45^\circ \Rightarrow \cot(\theta_{\max}) = 1 \quad (\S 6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.



## Calculation of torsional resistances

### Design torsional cracking moment

$$T_{Rdc} = 2 \cdot f_{ctd} \cdot t_{ef} \cdot A_k = 2 \cdot 1.2 \cdot 10^6 \cdot 0.104 \cdot 0.117 = 29.2 \text{ kNm}$$

### Design torsional resistance moment of torsional reinforcement

$$T_{Rds} = 2 \cdot A_k \cdot \frac{A_{swt}}{S_{lt}} \cdot f_{ywd} \cdot \cotg(\theta) = 2 \cdot 0.117 \cdot \frac{50.3 \cdot 10^{-6}}{0.148} \cdot 435 \cdot 10^6 \cdot \cotg(40) = 41 \text{ kNm}$$

### Maximal design torsional resistance moment

Strength reduction factor for concrete cracked in shear - value  $v$

$$v = 0.6 \cdot \left( 1 - \frac{f_{ck}}{250} \right) = 0.6 \cdot \left( 1 - \frac{25}{250} \right) = 0.54 \quad (6.6N)$$

$$v_1 = 0.6 \quad (6.10.aN)$$

Coefficient taking into account state of the stress in the compression chord

$$\alpha_{cw} = 1 \quad (\text{for non-prestressed member}) \quad (\$6.2.3(3)N3)$$

Maximal design torsional resistance moment

$$\begin{aligned} T_{Rdmax} &= 2 \cdot v \cdot \alpha_{cw} \cdot f_{cd} \cdot A_k \cdot t_{ef} \cdot \cos(\theta) \cdot \sin(\theta) \\ &= 2 \cdot 0.54 \cdot 1 \cdot 16.7 \cdot 10^6 \cdot 0.117 \cdot 0.104 \cdot \cos(40) \cdot \sin(40) = 108 \text{ kNm} \end{aligned}$$

### Torsional resistance moment of the member

$$T_{Rd} = \min(T_{Rds}; T_{Rdmax}) = \min(41; 108) = 41 \text{ kNm}$$

### Additional torsion force

Design additional stress

$$\sigma_{sd} = \frac{\text{abs}(T_{Ed}) \cdot u_k \cdot \cotg(\theta)}{2 \cdot A_k \cdot A_{sl}} = \frac{\text{abs}(14.9) \cdot 1584 \cdot \cotg(40)}{2 \cdot 116827 \cdot 1489} = 80.8 \text{ MPa} \quad (6.28)$$

Design yield strength

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa}$$

Design additional tensile force

$$F_{sd} = \sigma_{sd} \cdot A_{sl} = 80.8 \cdot 1489 = 120 \text{ kN}$$

Maximum design force

$$F_{sdmax} = f_{yd} \cdot A_{sl} = 435 \cdot 1489 = 647 \text{ kN}$$

## Torsional check

### Check $T_{Rdmax}$

$$T_{Ed} = 14.9 \text{ kNm} \leq T_{Rdmax} = 108 \text{ kNm}$$

Note: The check satisfies for crushing of the compression strut ( $T_{Ed} < T_{Rd,max}$ ).

### Check $T_{Rdc}$ and $T_{Rds}$

$$T_{Ed} = 14.9 \text{ kNm} < T_{Rdc} = 29.2 \text{ kNm} \text{ and } T_{Ed} = 14.9 \text{ kNm} < T_{Rds} = 41 \text{ kNm}$$

Note: The check satisfies, torsional moment can be carried by concrete, no shear reinforcement is required. Only minimum shear reinforcement according to detailing provision has to be inputted.

### Check $F_{sdmax}$

$$F_{sd} = 120 \text{ kN} \leq F_{sdmax} = 647 \text{ kN}$$

Note: The check for additional tensile force in longitudinal reinforcement satisfies.

### Unity check

$$UC = \max\left(\frac{\text{abs}(T_{Ed})}{T_{Rd}}, \frac{F_{sd}}{F_{sdmax}}\right) = \max\left(\frac{\text{abs}(14.9 \text{ kNm})}{41 \text{ kNm}}, \frac{120 \text{ kN}}{647 \text{ kN}}\right) = 0.363$$

## Interaction check $V_y + V_z + T$

### Interaction check $V_y + V_z + T$ (concrete)

Check equation  $(T_{Ed}/T_{Rdmax}) + (V_{Ed}/V_{Rdmax})$

$$\left(\frac{\text{abs}(T_{Ed})}{T_{Rdmax}}\right) + \left(\frac{\text{abs}(V_{Ed})}{V_{Rdmax}}\right) = \left(\frac{\text{abs}(14.9)}{108}\right) + \left(\frac{\text{abs}(8.04)}{757}\right) = 0.149 \leq 1 \quad (6.29)$$

Note: Interaction check  $V_y + V_z + T$  for crushing of the compression strut satisfies.

Check equation  $(T_{Ed}/T_{Rdc}) + (V_{Ed}/V_{Rdc})$

$$\left(\frac{\text{abs}(T_{Ed})}{T_{Rdc}}\right) + \left(\frac{\text{abs}(V_{Ed})}{V_{Rdc}}\right) = \left(\frac{\text{abs}(14.9)}{29.2}\right) + \left(\frac{\text{abs}(8.04)}{92.2}\right) = 0.598 \leq 1 \quad (6.31)$$

Note: Interaction check  $V_y + V_z + T$  for concrete satisfies, shear forces and torsional moment carried by concrete, no shear reinforcement is required. Only minimum shear reinforcement according to detailing provisions has to be inputted.

Unity check

$$UC_{int.con} = 0.149$$

## Interaction check $V_y + V_z + T$ (shear reinforcement)

Design stress

$$\sigma_{swd} = \left( \frac{\text{abs}(T_{Ed})}{2 \cdot A_k} + \frac{V_{Ed}}{n_s \cdot z} \right) \cdot \left( \frac{s_{lt}}{A_{swt} \cdot \cotg(\theta)} \right) = \left( \frac{\text{abs}(14.9)}{2 \cdot 116827} + \frac{8.04}{2 \cdot 511} \right) \cdot \left( \frac{148}{50.3 \cdot \cotg(40)} \right) = 177 \text{ MPa}$$

Design yield strength

$$f_{ywd} = 0.8 \cdot f_{ywk} = 0.8 \cdot 500 = 400 \text{ MPa} \quad , \text{ (because } \sigma_{swd} < 0.8 \cdot f_{ywk} \text{)}$$

Note: Design yield strength of shear reinforcement was reduced to  $0.8 \times f_{ywk}$  (EN 1992-1-1, clause 6.2.3(3)) because design stress of the shear reinforcement is below 80% of the characteristic yield stress  $f_{yk}$ .

Design force

$$F_{swd} = \sigma_{swd} \cdot A_{swt} = 177 \cdot 50.3 = 8.92 \text{ kN}$$

Maximum design force

$$F_{swdmax} = f_{ywd} \cdot A_{swt} = 400 \cdot 50.3 = 20.1 \text{ kN}$$

Check

$$F_{swd} = 8.92 \text{ kN} < F_{swdmax} = 20.1 \text{ kN}$$

Note: Interaction check  $V_y + V_z + T$  for shear reinforcement satisfies.

Unity check

$$UC_{int.shear} = \frac{F_{swd}}{F_{swdmax}} = \frac{8.92}{20.1} = 0.443$$

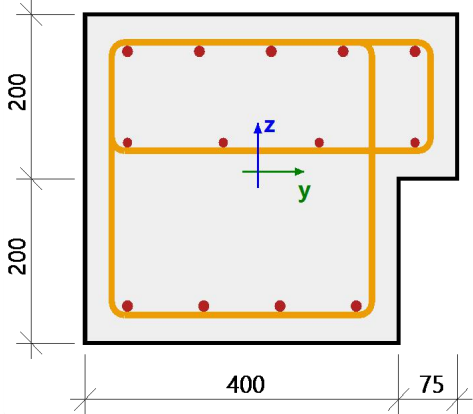
## Total unity check of interaction

$$UC_{int} = \max(UC_{int.con}, UC_{int.shear}) = \max(0.149; 0.443) = 0.443$$

## Total value of unity check

$$UC = \max(UC_{shear}, UC_{tor}, UC_{int.con}, UC_{int.shear}) = \max(0.0487; 0.363; 0.149; 0.443) = 0.443$$

## 22.3. Check capacity-interaction diagram

Rib B3		L g (400; 475; 200; 400)
EC EN 1992-1-1:2004/AC:2008		Section 11 [dx = 1.75 m]
<b>Member length:</b>	L = 3.8 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 4.81 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 4.96 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		4φ12 mm + 9φ14 mm (A <sub>s</sub> = 1838 mm <sup>2</sup> )
		ρ <sub>l</sub> = 1,050 % (14.4 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/200 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,287 % (3.95 kg/m) (A <sub>swm</sub> = 503 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 33.3 \text{ kN} \quad M_y = 11.5 \text{ kNm} \quad M_z = 8.34 \text{ kNm}$$

Content of combination:

$$1.35 \cdot LC1 + 1.35 \cdot LC2 + 1.50 \cdot LC5$$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (16.7 \cdot 10^6 \cdot 0.175) = -292 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 33 \text{ kN} \geq -292 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$N_{Ed} = 33.3 \text{ kN}$   $M_{Edy} = 11.5 \text{ kNm}$   $M_{Edz} = 8.34 \text{ kNm}$

### Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{res} = 14.2 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{MyMz} = 144^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{res}$	$\alpha_{NM} = 66.9^\circ$

### Calculation of resistances

Resistances in positive direction  $N_{Rd+} = 222 \text{ kN}$   $M_{Rdy+} = 77 \text{ kNm}$   $M_{Rdz+} = 55 \text{ kNm}$

Resistances in negative direction  $N_{Rd-} = -436 \text{ kN}$   $M_{Rdy-} = -151 \text{ kNm}$   $M_{Rdz-} = -109 \text{ kNm}$

## Summary of check

Forces:  $N_{Ed} = 33.3 \text{ kN}$   $M_{Edy} = 11.5 \text{ kNm}$   $M_{Edz} = 8.34 \text{ kNm}$

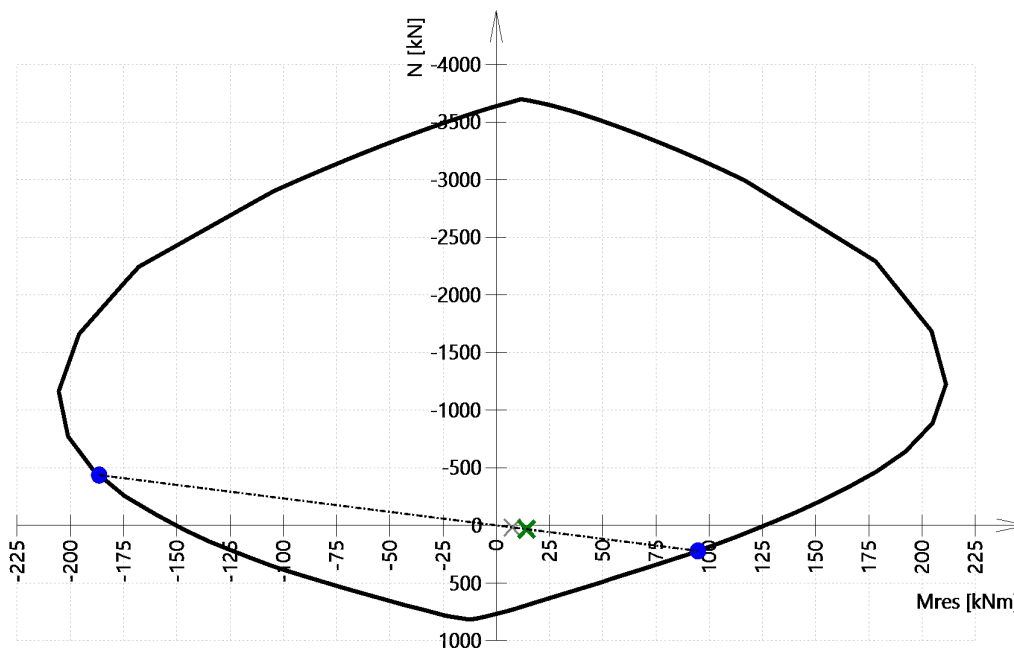
Resistance:  $N_{Rd} = 222 \text{ kN}$   $M_{Rdy} = 77 \text{ kNm}$   $M_{Rdz} = 55 \text{ kNm}$

Calculation of unity check:

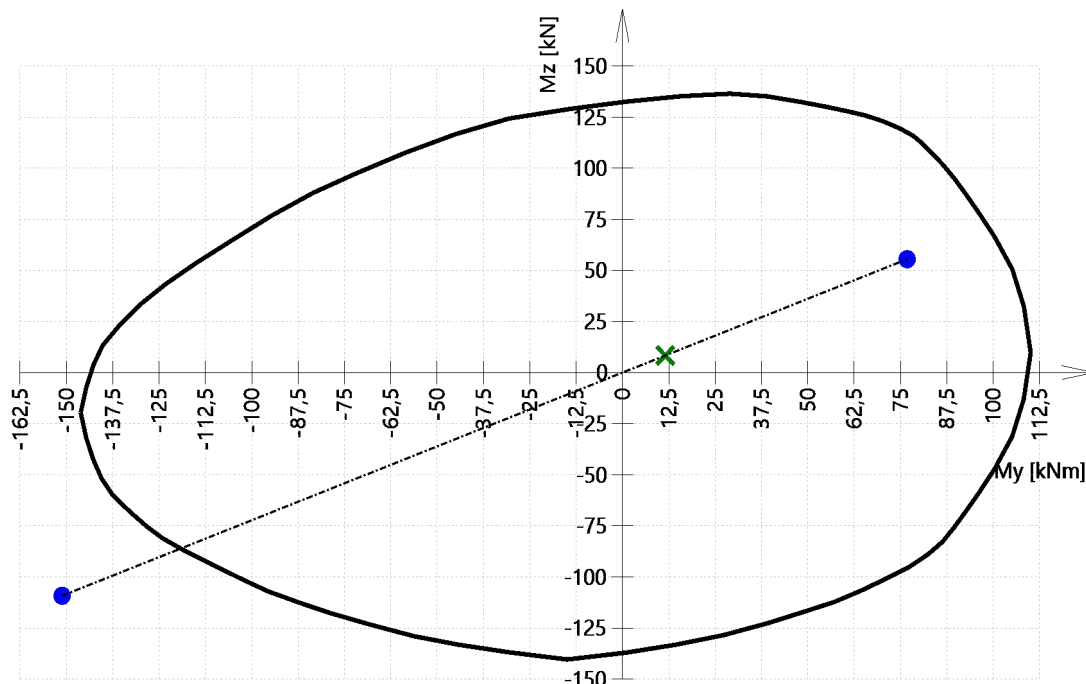
$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{33.3^2 + 11.5^2 + 8.34^2}}{\sqrt{222^2 + 76.8^2 + 55.5^2}} = 0.15 \leq 1 \quad \text{OK}$$

List of errors/warnings/notes: N2/1.

## 3D interaction diagram - Vertical section N-M<sub>res</sub>



## 3D interaction diagram - Horizontal section M<sub>y</sub>-M<sub>z</sub>



## 22.4. Check shear+torsion (ULS)

Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: B3

Rib B3		L g (400; 475; 200; 400)
EC EN 1992-1-1:2004/AC:2008		Section 0 [dx = 0 m]
<b>Member length:</b>	L = 3.8 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 4.81 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 4.96 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch 4φ12 mm + 9φ14 mm (A <sub>s</sub> = 1838 mm <sup>2</sup> ) ρ <sub>l</sub> = 1,050 % (14.4 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch φ8/200 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> ) ρ <sub>w</sub> = 0,287 % (3.95 kg/m) (A <sub>swm</sub> = 503 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Settings

Method for calculation shear resistances:

Standard

Limit value of angle between bending moments and shear forces resultant for using standard method: : α<sub>VM,lim</sub> = 15 °

Equivalent thin walled cross-section:

Automatic

The angle between the concrete compression strut and axis member: User input: θ<sub>inp</sub> = 40 ° => cot(θ<sub>inp</sub>) = 1.19

## Forces

Content of combination: 1.35\*LC1+1.35\*LC2+1.50\*LC5

N<sub>Ed</sub> = 5.92 kN M<sub>Edy</sub> = -9.09 kNm M<sub>Edz</sub> = -2.44 kNm V<sub>Edy</sub> = 0.156 kN V<sub>Edz</sub> = 15.6 kN T<sub>Ed</sub> = 3.33 kNm

Angle of gradient of strain plane

$$\alpha_M = 82.1^\circ$$

Angle of shear resultant

$$\alpha_V = 89.4^\circ$$

Resultant of shear force

$$V_{Ed} = \sqrt{V_{Edy}^2 + V_{Edz}^2} = \sqrt{0.156^2 + 15.6^2} = 15.6 \text{ kN}$$

Difference between angles α<sub>M</sub> and α<sub>V</sub>

$$\alpha_{MV} = \text{abs}(\alpha_M - \alpha_V) = \text{abs}(82.1 - 89.4) = 7.29^\circ$$

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design tensile strength of concrete

$$f_{ctd} = \frac{\alpha_{ct} \cdot f_{ctk005}}{\gamma_c} = \frac{1 \cdot 1.8}{1.5} = 1.2 \text{ MPa} \quad (3.15, 3.16)$$

## Calculation of angle between concrete compression strut and member axis

- minimum value:

$$\theta_{\min} = 21.8^\circ \Rightarrow \cot(\theta_{\min}) = 2.5 \quad (\$6.2.3(2))$$

- maximum value:

$$\theta_{\max} = 45^\circ \Rightarrow \cot(\theta_{\max}) = 1 \quad (\$6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{\text{inp}} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Check shear and calculation shear resistances

### Cross section parameters

Minimum width of the cross-section in tensile area

$$y_{bw} = -0.591 \text{ mm}$$

$$z_{bw} = -58.9 \text{ mm}$$

$$b_w = 400 \text{ mm}$$

Note: Value  $b_w$  is calculated as the smallest width of cross-section in tensile area perpendicular to resultant of shear force.

Minimum width of cross-section between tension and compression chord

$$y_{bw1} = -1.66 \text{ mm}$$

$$z_{bw1} = -166 \text{ mm}$$

$$b_{w1} = 400 \text{ mm}$$

Note: Value  $b_{w1}$  is calculated as the smallest width of cross-section between tension and compression chord perpendicular to resultant of shear force.

Height of cross-section recalculated to direction of shear force resultant

$$h = 405 \text{ mm}$$

Note: Value  $h$  is calculated as width of cross-section in center of gravity in direction shear force resultant.

Concrete cross-section area

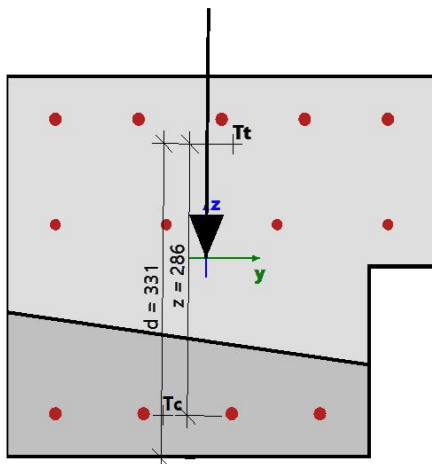
$$A_c = 0.175 \text{ m}^2$$

Effective depth recalculated to direction of shear force resultant

$$d = 331 \text{ mm}$$

Lever arm of internal forces recalculated to direction of shear force resultant

$$z = 286 \text{ mm}$$





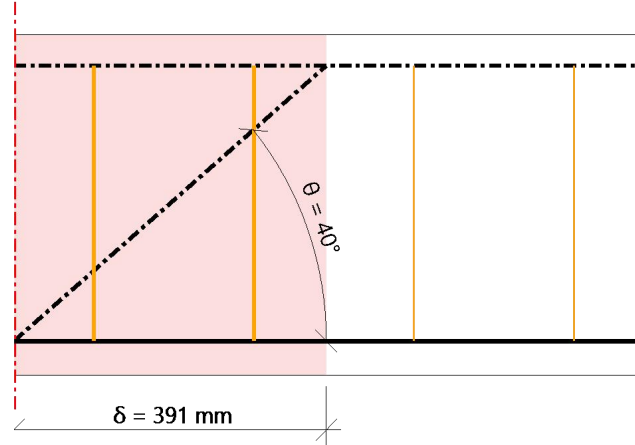
## Parameters of shear reinforcement

### Input parameters

Stirrups on the length of shear crack projection  $\delta = z \cdot \cot(\theta) = 391 \text{ mm}$ , interval (0; 391)

$$z = \text{Coeff}_d \cdot \text{Coeff}_z \cdot h = 0.9 \cdot 0.9 \cdot 0.4 = 328 \text{ mm} \quad \delta = z \cdot \cotg(\theta) = 0.328 \cdot \cotg(40) = 391 \text{ mm}$$

ID	Zone	$x_s$ [mm]	$\phi_s$ [mm]	$s_s$ [mm]	$n_s$ []	$\alpha_s$ [°]	$f_{ywk}$ [MPa]
1	1	100	8	200	2	90	500
2	1	300	8	200	2	90	500
Avg.	-	-	8	200	2	90	500



Number of stirrup links

$$n_s = 2$$

Diameter of reinforcement

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

Centre - to - centre distance of stirrup in longitudinal direction

$$s_{inp} = 0.2 \text{ m}$$

Angle of stirrups from axis of member

$$\alpha_s = 90^\circ$$

Characteristic yield strength

$$f_{ywk} = 500 \text{ MPa}$$

Cross - sectional area of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

Maximum longitudinal spacing of shear links

$$s_l = s_{inp} = 200 \text{ mm}$$

Cross - sectional area per meter

$$A_{swm} = \frac{A_{sw}}{s_l} = \frac{101 \cdot 10^{-6}}{0.2} = 503 \text{ mm}^2/\text{m}$$

## Parameters of longitudinal reinforcement

The area of tensile reinforcement

$$A_{sl} = 1222 \text{ mm}^2$$

## Calculation of shear resistances

### Design shear resistance of the member without shear reinforcement

$$\sigma_{ct,max} = 0.876 \text{ MPa} < f_{ctd} = 1.2 \text{ MPa} \Rightarrow \text{Section uncracked in flexure}$$

Calculation design shear resistance of the member without shear reinf. according to chapter 12.6.3

Compressed concrete area for uncracked cross-section under ULS loading

$$A_{cc} = 80778 \text{ mm}^2$$

Normal stress of uncracked cross-section under ULS loading

$$\sigma_{cp} = \frac{-N_{Ed}}{A_{cc}} = \frac{-5917}{0.0808} = -0.0733 \text{ MPa} \quad (12.3)$$

Limit value of stress caused by axial force

$$\sigma_{dim} = f_{cd} - 2 \cdot \sqrt{f_{ctd} \cdot (f_{ctd} + f_{cd})} = 16.7 - 2 \cdot \sqrt{1.2 \cdot (1.2 + 16.7)} = 7.41 \text{ MPa} \quad (12.7)$$

Concrete design strength in shear and compression

$$f_{c,d} = \sqrt{f_{ctd}^2 + \sigma_{cp} \cdot f_{ctd}} = \sqrt{1.2^2 + -0.0733 \cdot 1.2} = 1.16 \text{ MPa} \quad (\text{because } \sigma_{cp} < \sigma_{dim}) \quad (12.5)$$

Coefficient for shear stress

$$k = 1.5 \quad (\S 12.6.3(2)N)$$

Shear stress of uncracked cross-section under ULS loading

$$\tau_{cp} = \frac{k \cdot V_{Ed}}{A_{cc}} = \frac{1.5 \cdot 15579}{0.0808} = 0.289 \text{ MPa} \quad (12.4)$$

Calculation design shear resistance of the member without shear reinforcement

$V_{Rdc}$  is calculated from equation 12.4, when  $\tau_{cp} = f_{c,d}$

$$V_{Rdc} = \frac{f_{c,d} \cdot A_{cc}}{k} = \frac{1.16 \cdot 10^6 \cdot 0.0808}{1.5} = 63 \text{ kN}$$

Note: Design shear resistance of the member without shear reinforcement is calculated according to clause 12.6.3 because section is uncracked in flexure in ULS.

### Calculation of angle between concrete compression strut and member axis

Limit value of angle

- minimum value:

$$\theta_{min} = 21.8^\circ \Rightarrow \cot(\theta_{min}) = 2.5 \quad (\S 6.2.3(2))$$

- maximum value:

$$\theta_{max} = 45^\circ \Rightarrow \cot(\theta_{max}) = 1 \quad (\S 6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Design shear resistance of the member with shear reinforcement

Design stress of shear reinforcement

$$A_{sw} = n_s \cdot \pi \cdot \left( \frac{\phi_s}{2} \right)^2 = 2 \cdot 3.14 \cdot \left( \frac{8}{2} \right)^2 = 101 \text{ mm}^2$$

$$\sigma_{swd} = \frac{\frac{\text{abs}(V_{Ed})}{z} \cdot s_l}{A_{sw} \cdot (\cotg(\theta) + \cotg(\alpha_s) \cdot \sin(\alpha_s))} = \frac{\frac{\text{abs}(15579)}{0.286} \cdot 0.2}{101 \cdot 10^{-6} \cdot (\cotg(40) + \cotg(90) \cdot \sin(90))} = 90.9 \text{ MPa}$$

Design yield strength of shear reinforcement

$$f_{ywd} = 0.8 \cdot f_{ywk} = 0.8 \cdot 500 = 400 \text{ MPa} \quad (\text{because } \sigma_{swd} < 0.8 \cdot f_{ywk})$$

Note: Design yield strength of shear reinforcement was reduced to  $0.8 \times f_{ywk}$  (EN 1992-1-1, clause 6.2.3(3)), because design stress of the shear reinforcement is below 80% of the characteristic yield stress  $f_{yk}$ .

Design shear resistance of the member with shear reinforcement

$$V_{Rds} = \frac{A_{sw}}{s_l} \cdot z \cdot f_{ywd} \cdot \cotg(\theta) = \frac{101 \cdot 10^{-6}}{0.2} \cdot 0.286 \cdot 400 \cdot 10^6 \cdot \cotg(40) = 69 \text{ kN} \quad (6.8)$$

## Design value of the max shear force which can be sustained by the member

Strength reduction factor for concrete cracked in shear - value  $v$

$$v = 0.6 \cdot \left( 1 - \frac{f_{ck}}{250} \right) = 0.6 \cdot \left( 1 - \frac{25}{250} \right) = 0.54 \quad (6.6N)$$

## Strength reduction factor for concrete cracked in shear - value $v_1$

$$\sigma_{cp} = \min \left( \frac{-N_{Ed}}{A_c}; 0.2 \cdot f_{cd} \right) = \min \left( \frac{-5.92}{0.175}; 0.2 \cdot 16.7 \right) = -0.0338 \text{ MPa}$$

$$v_1 = 0.6 \quad (6.10.aN)$$

Coefficient taking into account state of the stress in the compression chord

$$\alpha_{cw} = 1 \quad (\text{for non-prestressed member}) \quad (6.2.3(3)N3)$$

Design value of the max shear force which can be sustained by the member

$$V_{Rdmax} = \frac{\alpha_{cw} \cdot b_{w1} \cdot z \cdot v_1 \cdot f_{cd}}{(\cotg(\theta) + \tg(\theta))} = \frac{1 \cdot 0.4 \cdot 0.286 \cdot 0.6 \cdot 16.7 \cdot 10^6}{(\cotg(40) + \tg(40))} = 564 \text{ kN} \quad (6.9)$$

## Maximum shear force near the support (without using factor $\beta$ )

$$V_{Edmax} = 0.5 \cdot b_{w1} \cdot d \cdot v \cdot f_{cd} = 0.5 \cdot 0.4 \cdot 0.331 \cdot 0.54 \cdot 16.7 \cdot 10^6 = 596 \text{ kN} \quad (6.5)$$

## Shear resistance of the member

$$V_{Rd} = \min(V_{Rds} + V_{ccd} + V_{td}; V_{Rdmax} + V_{ccd} + V_{td}; V_{Edmax} + V_{ccd} + V_{td}) = \min(68.6 + 0 + 0; 564 + 0 + 0; 596 + 0 + 0) = 68.6 \text{ kN}$$

## Shear check

### Check $V_{Rdmax}$

$$V_{Ed} = 15.6 \text{ kN} \leq V_{Rdmax} + V_{ccd} + V_{td} = 564 \text{ kN}$$

Note: The check satisfies for crushing of the compression strut ( $V_{Ed} \leq V_{Rd,max} + V_{td} + V_{ccd}$ ).

### Check $V_{Edmax}$

$$V_{Ed} = 15.6 \text{ kN} \leq V_{Edmax} + V_{ccd} + V_{td} = 596 \text{ kN}$$

Note: The check satisfies for shear force near the support ( $V_{Ed} \leq V_{Ed,max} + V_{td} + V_{ccd}$ ).

### Check $V_{Rdc}$ and $V_{Rds}$

$$V_{Ed} = 15.6 \text{ kN} < V_{Rdc} = 62.6 \text{ kN} \text{ and } V_{Ed} = 15.6 \text{ kN} < V_{Rds} + V_{ccd} + V_{td} = 68.6 \text{ kN}$$

Note: The check satisfies, shear force carried by concrete ( $V_{Ed} \leq V_{Rdc}$ ) and  $V_{Ed} \leq V_{Rds}$ , no shear reinforcement is required. Only minimum shear reinforcement according to detailing provisions has to be inputted.

## Unity check

$$UC = \frac{\text{abs}(V_{Ed})}{V_{Rd}} = \frac{\text{abs}(15.6 \text{ kN})}{68.6 \text{ kN}} = 0.227$$

## Check torsion and calculation torsional resistances

### Cross section parameters

Total area of cross-section

$$A_c = 175000 \text{ mm}^2$$

Total area of cross-section

$$u_c = 1750 \text{ mm}$$

The area of longitudinal reinforcement for torsion

$$A_{sl} = 1345 \text{ mm}^2$$

The minimum distance between reinf. bars inside stirrup for torsion and edge of cross-section

$$a_{sl} = 45 \text{ mm}$$

Effective wall thickness

$$t_{ef} = \max\left(\frac{A_c}{u_c}; 2 \cdot a_{sl}\right) = \max\left(\frac{0.175}{1.75}; 2 \cdot 0.045\right) = 100 \text{ mm} \quad (\$6.3.2(1))$$

Perimeter of area and area enclosed by the centre line of effective cross-section

$$u_k = 1200 \text{ mm}$$

$$A_k = 90000 \text{ mm}^2$$

Note: Parameters for torsion [value  $A_k$  and  $u_k$ ] are calculated by automatic method [Method = From torsional stirrup].

## Parameters of shear/torsion reinforcement

Stirrups on the length of shear crack projection  $\delta = z \cdot \cot(\Theta) = 391 \text{ mm}$ , interval (0; 391)

$$z = \text{Coeff}_d \cdot \text{Coeff}_z \cdot h = 0.9 \cdot 0.9 \cdot 0.4 = 328 \text{ mm} \quad \delta = z \cdot \cot(\theta) = 0.328 \cdot \cot(40) = 391 \text{ mm}$$

ID	Zone	$x_s$ [mm]	$\phi_s$ [mm]	$s_s$ [mm]	$n_s$ []	$\alpha_s$ [°]	$f_{ywk}$ [MPa]
1	1	100	8	200	2	90	500
2	1	300	8	200	2	90	500
Avg.	-	-	8	200	2	90	500

## Input parameters

Diameter  $\phi_{st} = 8 \text{ mm}$

Centre - to - centre distance in longitudinal direction  $s_{linp} = 0.2 \text{ m}$

Angle of stirrups from axis of member  $\alpha_{st} = 90^\circ$

Characteristic yield strength  $f_{ywk} = 500 \text{ MPa}$

Cross - sectional area of shear reinforcement

$$A_{swt} = \pi \cdot \left( \frac{\phi_{st}}{2} \right)^2 = 3.14 \cdot \left( \frac{8}{2} \right)^2 = 50.3 \text{ mm}^2$$

Maximum longitudinal spacing of shear links

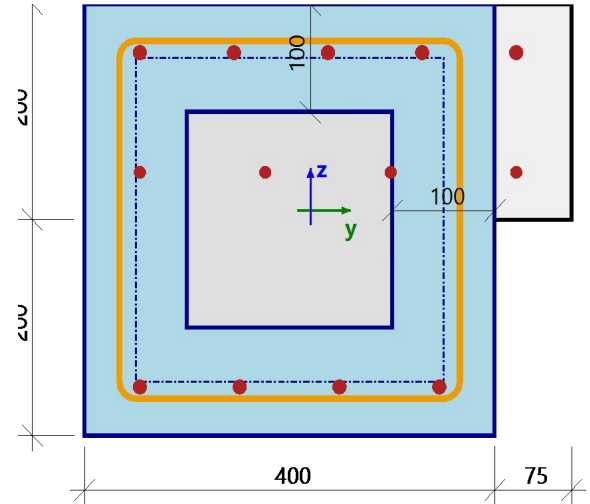
$$s_{lt} = s_{linp} = 200 \text{ mm}$$

Cross - sectional area of shear reinforcement per meter

$$A_{swtm} = \frac{A_{swt}}{s_{lt}} = \frac{50.3 \cdot 10^{-6}}{0.2} = 251 \text{ mm}^2/\text{m}$$

Design yield strength of shear reinforcement

$$f_{ywd} = \frac{f_{ywk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa}$$



## Calculation of angle between concrete compression strut and member axis

- minimum value:

$$\theta_{\min} = 21.8^\circ \Rightarrow \cot(\theta_{\min}) = 2.5 \quad (\$6.2.3(2))$$

- maximum value:

$$\theta_{\max} = 45^\circ \Rightarrow \cot(\theta_{\max}) = 1 \quad (\$6.2.3(2))$$

- input/calculated value:

$$\theta = \theta_{inp} = 40^\circ, \cot(\theta) = 1.19$$

Note: Automatic calculation of angle is switched off, user value is taken into account.

## Calculation of torsional resistances

Design torsional cracking moment

$$T_{Rdc} = 2 \cdot f_{ctd} \cdot t_{ef} \cdot A_k = 2 \cdot 1.2 \cdot 10^6 \cdot 0.1 \cdot 0.09 = 21.6 \text{ kNm}$$

### Design torsional resistance moment of torsional reinforcement

$$T_{Rds} = 2 \cdot A_k \cdot \frac{A_{swt}}{s_{lt}} \cdot f_{ywd} \cdot \cotg(\theta) = 2 \cdot 0.09 \cdot \frac{50.3 \cdot 10^{-6}}{0.2} \cdot 435 \cdot 10^6 \cdot \cotg(40) = 23.4 \text{ kNm}$$

### Maximal design torsional resistance moment

Strength reduction factor for concrete cracked in shear - value  $v$

$$v = 0.6 \cdot \left( 1 - \frac{f_{ck}}{250} \right) = 0.6 \cdot \left( 1 - \frac{25}{250} \right) = 0.54 \quad (6.6N)$$

$$v_1 = 0.6 \quad (6.10.aN)$$

Coefficient taking into account state of the stress in the compression chord

$$\alpha_{cw} = 1 \quad (\text{for non-prestressed member}) \quad (§6.2.3(3)N3)$$

Maximal design torsional resistance moment

$$\begin{aligned} T_{Rdmax} &= 2 \cdot v \cdot \alpha_{cw} \cdot f_{cd} \cdot A_k \cdot t_{ef} \cdot \cos(\theta) \cdot \sin(\theta) \\ &= 2 \cdot 0.54 \cdot 1 \cdot 16.7 \cdot 10^6 \cdot 0.09 \cdot 0.1 \cdot \cos(40) \cdot \sin(40) = 79.8 \text{ kNm} \end{aligned}$$

### Torsional resistance moment of the member

$$T_{Rd} = \min(T_{Rds}, T_{Rdmax}) = \min(23.4; 79.8) = 23.4 \text{ kNm}$$

### Additional torsion force

Design additional stress

$$\sigma_{sd} = \frac{\text{abs}(T_{Ed}) \cdot u_k \cdot \cotg(\theta)}{2 \cdot A_k \cdot A_{sl}} = \frac{\text{abs}(3.33) \cdot 1200 \cdot \cotg(40)}{2 \cdot 90000 \cdot 1345} = 19.7 \text{ MPa} \quad (6.28)$$

Design yield strength

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa}$$

Design additional tensile force

$$F_{sd} = \sigma_{sd} \cdot A_{sl} = 19.7 \cdot 1345 = 26.5 \text{ kN}$$

Maximum design force

$$F_{sdmax} = f_{yd} \cdot A_{sl} = 435 \cdot 1345 = 585 \text{ kN}$$

### Torsional check

Check  $T_{Rdmax}$

$$T_{Ed} = 3.33 \text{ kNm} \leq T_{Rdmax} = 79.8 \text{ kNm}$$

Note: The check satisfies for crushing of the compression strut ( $T_{Ed} < T_{Rd,max}$ ).

Check  $T_{Rdc}$  and  $T_{Rds}$

$$T_{Ed} = 3.33 \text{ kNm} < T_{Rdc} = 21.6 \text{ kNm} \text{ and } T_{Ed} = 3.33 \text{ kNm} < T_{Rds} = 23.4 \text{ kNm}$$

Note: The check satisfies, torsional moment can be carried by concrete, no shear reinforcement is required. Only minimum shear reinforcement according to detailing provision has to be inputted.

Check  $F_{sdmax}$

$$F_{sd} = 26.5 \text{ kN} \leq F_{sdmax} = 585 \text{ kN}$$

Note: The check for additional tensile force in longitudinal reinforcement satisfies.

**Unity check**

$$UC = \max \left( \frac{\text{abs}(T_{Ed})}{T_{Rd}}, \frac{F_{sd}}{F_{sdmax}} \right) = \max \left( \frac{\text{abs}(3.33 \text{ kNm})}{23.4 \text{ kNm}}, \frac{26.5 \text{ kN}}{585 \text{ kN}} \right) = 0.142$$

**Interaction check  $V_y + V_z + T$**

**Interaction check  $V_y + V_z + T$  (concrete)**

Check equation  $(T_{Ed}/T_{Rdmax}) + (V_{Ed}/V_{Rdmax})$

$$\left( \frac{\text{abs}(T_{Ed})}{T_{Rdmax}} \right) + \left( \frac{\text{abs}(V_{Ed})}{V_{Rdmax}} \right) = \left( \frac{\text{abs}(3.33)}{79.8} \right) + \left( \frac{\text{abs}(15.6)}{564} \right) = 0.0694 \leq 1 \quad (6.29)$$

Note: Interaction check  $V_y + V_z + T$  for crushing of the compression strut satisfies.

Check equation  $(T_{Ed}/T_{Rdc}) + (V_{Ed}/V_{Rdc})$

$$\left( \frac{\text{abs}(T_{Ed})}{T_{Rdc}} \right) + \left( \frac{\text{abs}(V_{Ed})}{V_{Rdc}} \right) = \left( \frac{\text{abs}(3.33)}{21.6} \right) + \left( \frac{\text{abs}(15.6)}{62.6} \right) = 0.403 \leq 1 \quad (6.31)$$

Note: Interaction check  $V_y + V_z + T$  for concrete satisfies, shear forces and torsional moment carried by concrete, no shear reinforcement is required. Only minimum shear reinforcement according to detailing provisions has to be inputted.

Unity check

$$UC_{int.con} = 0.0694$$

## Interaction check Vy+Vz+T (shear reinforcement)

Design stress

$$\sigma_{swd} = \left( \frac{\text{abs}(T_{Ed})}{2 \cdot A_k} + \frac{V_{Ed}}{n_s \cdot z} \right) \cdot \left( \frac{s_{lt}}{A_{swt} \cdot \cotg(\theta)} \right) = \left( \frac{\text{abs}(3.33)}{2 \cdot 90000} + \frac{15.6}{2 \cdot 286} \right) \cdot \left( \frac{200}{50.3 \cdot \cotg(40)} \right) = 153 \text{ MPa}$$

Design yield strength

$$f_{ywd} = 0.8 \cdot f_{ywk} = 0.8 \cdot 500 = 400 \text{ MPa} \quad , \text{ (because } \sigma_{swd} < 0.8 \cdot f_{ywk} \text{)}$$

Note: Design yield strength of shear reinforcement was reduced to  $0.8 \times f_{ywk}$  (EN 1992-1-1, clause 6.2.3(3)) because design stress of the shear reinforcement is below 80% of the characteristic yield stress  $f_{yk}$ .

Design force

$$F_{swd} = \sigma_{swd} \cdot A_{swt} = 153 \cdot 50.3 = 7.68 \text{ kN}$$

Maximum design force

$$F_{swdmax} = f_{ywd} \cdot A_{swt} = 400 \cdot 50.3 = 20.1 \text{ kN}$$

Check

$$F_{swd} = 7.68 \text{ kN} < F_{swdmax} = 20.1 \text{ kN}$$

Note: Interaction check  $V_y + V_z + T$  for shear reinforcement satisfies.

Unity check

$$UC_{int.shear} = \frac{F_{swd}}{F_{swdmax}} = \frac{7.68}{20.1} = 0.382$$

## Total unity check of interaction

$$UC_{int} = \max(UC_{int.con}, UC_{int.shear}) = \max(0.0694; 0.382) = 0.382$$

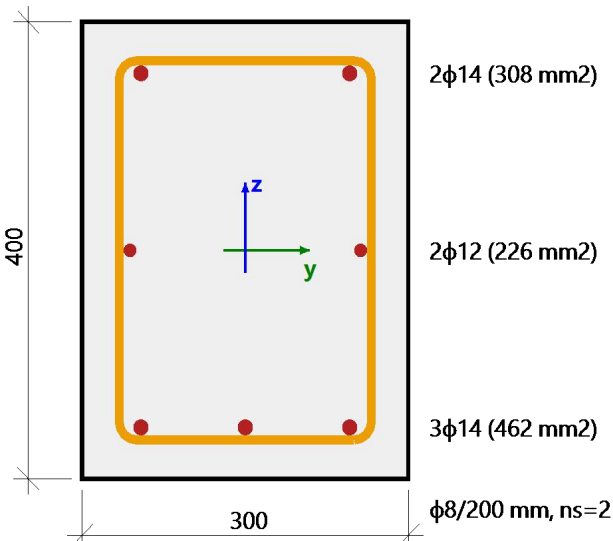
## Total value of unity check

$$UC = \max(UC_{shear}, UC_{tor}, UC_{int.con}, UC_{int.shear}) = \max(0.227; 0.142; 0.0694; 0.382) = 0.382$$



## 23. Nadvoji

Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: N101

Beam N101		Rectangle (400; 300)
EC EN 1992-1-1:2004/AC:2008		Section 4 [dx = 1.47 m]
<b>Member length:</b>	L = 3.3 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 3.3 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 3.3 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		2φ12 mm + 5φ14 mm (A <sub>s</sub> = 996 mm <sup>2</sup> )
		ρ <sub>l</sub> = 0,830 % (7.82 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/200 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,419 % (3.95 kg/m) (A <sub>swm</sub> = 503 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 0 \text{ kN} \quad M_y = 43.5 \text{ kNm} \quad M_z = 0 \text{ kNm}$$

Content of combination:

$$1.35 \cdot LC1 + 1.35 \cdot LC2$$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (16.7 \cdot 10^6 \cdot 0.12) = -200 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -200 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$$N_{Ed} = 0 \text{ kN} \quad M_{Edy} = 44 \text{ kNm} \quad M_{Edz} = 0 \text{ kNm}$$

## Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{res} = 44 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{MyMz} = 180^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{res}$	$\alpha_{NM} = 0^\circ$

## Calculation of resistances

Resistances in positive direction  $N_{Rd+} = 0 \text{ kN} \quad M_{Rdy+} = 84 \text{ kNm} \quad M_{Rdz+} = 0 \text{ kNm}$

Resistances in negative direction  $N_{Rd-} = 0 \text{ kN} \quad M_{Rdy-} = -63 \text{ kNm} \quad M_{Rdz-} = 0 \text{ kNm}$

## Summary of check

Forces:  $N_{Ed} = 0 \text{ kN}$   $M_{Edy} = 44 \text{ kNm}$   $M_{Edz} = 0 \text{ kNm}$

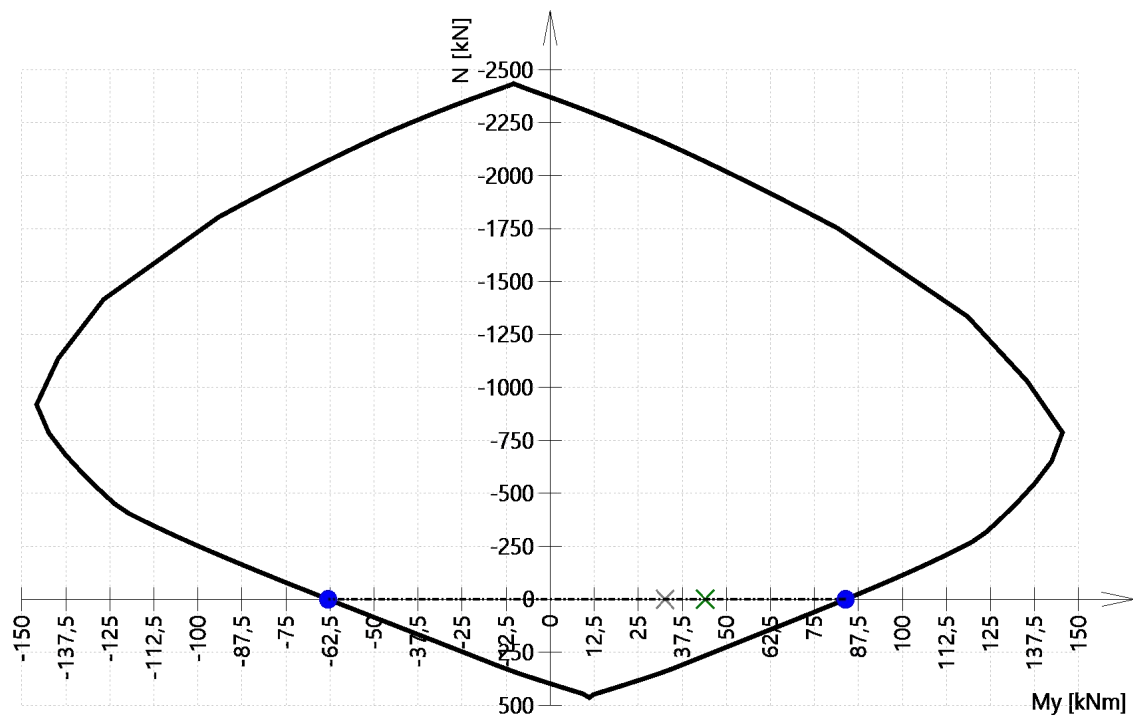
Resistance:  $N_{Rd} = 0 \text{ kN}$   $M_{Rdy} = 84 \text{ kNm}$   $M_{Rdz} = 0 \text{ kNm}$

Calculation of unity check:

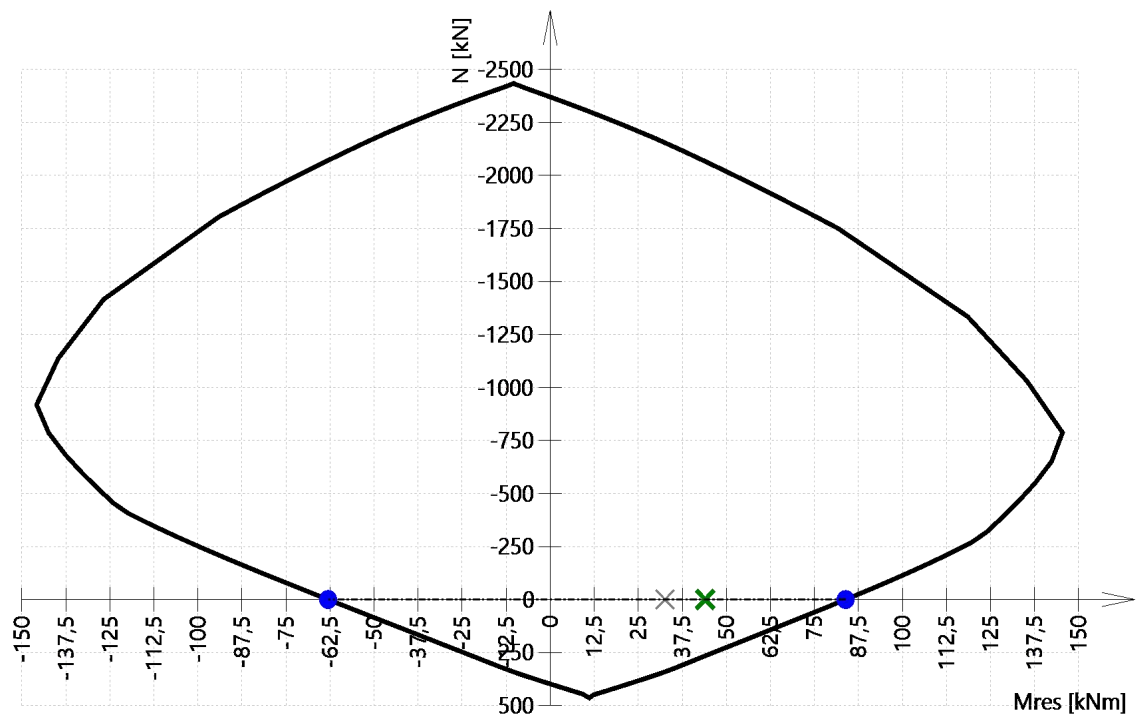
$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{0^2 + 44^2 + 0^2}}{\sqrt{0^2 + 83.9^2 + 0^2}} = 0.525 \leq 1 \quad \text{OK}$$

List of errors/warnings/notes: N2/1.

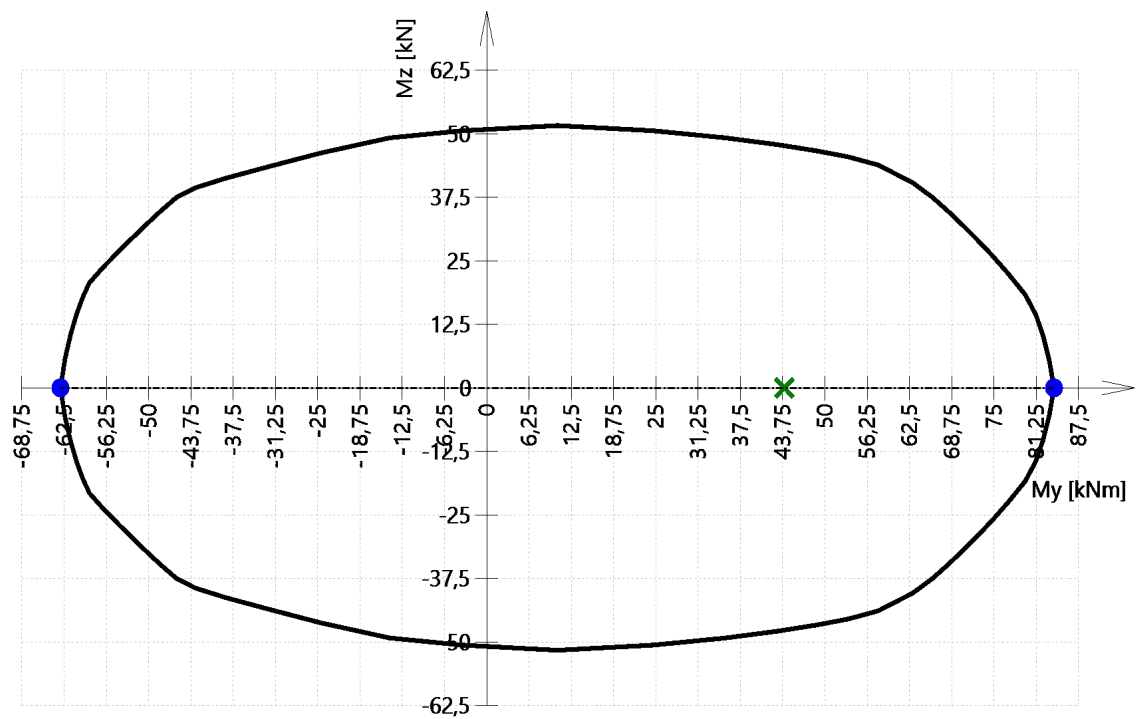
## 3D interaction diagram - Vertical section N-M<sub>y</sub>



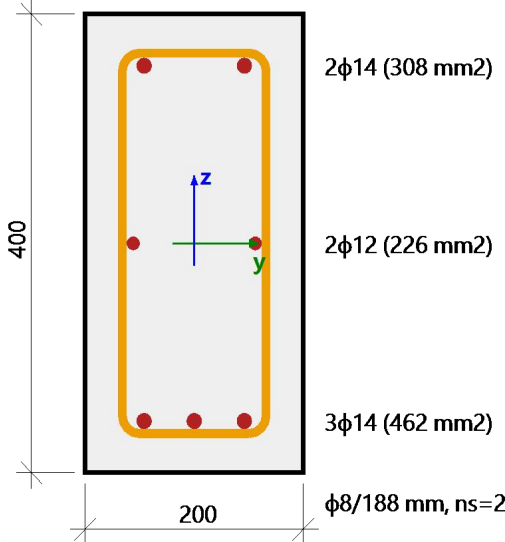
### 3D interaction diagram - Vertical section N-M<sub>res</sub>



### 3D interaction diagram - Horizontal section M<sub>y</sub>-M<sub>z</sub>



Linear calculation  
Combination: ULS-Set B (auto)  
Coordinate system: Member  
Extreme 1D: Global  
Selection: N102

Beam N102		Rectangle (400; 200)
EC EN 1992-1-1:2004/AC:2008		Section 4 [dx = 1.47 m]
<b>Member length:</b>	L = 3.3 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 3.3 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 3.3 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch 2φ12 mm + 5φ14 mm (A <sub>s</sub> = 996 mm <sup>2</sup> ) ρ <sub>l</sub> = 1,245 % (7.82 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch φ8/188 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> ) ρ <sub>w</sub> = 0,668 % (4.19 kg/m) (A <sub>swm</sub> = 534 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 0 \text{ kN} \quad M_y = 41.7 \text{ kNm} \quad M_z = 0 \text{ kNm}$$

Content of combination:

$$1.35 \cdot LC1 + 1.35 \cdot LC2$$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = -\text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (16.7 \cdot 10^6 \cdot 0.08) = -133 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -133 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$$N_{Ed} = 0 \text{ kN} \quad M_{Edy} = 42.2 \text{ kNm} \quad M_{Edz} = 0 \text{ kNm}$$

## Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{res} = 42.2 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{MyMz} = 180^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{res}$	$\alpha_{NM} = 0^\circ$

## Calculation of resistances

$$\text{Resistances in positive direction} \quad N_{Rd+} = 0 \text{ kN} \quad M_{Rdy+} = 81 \text{ kNm} \quad M_{Rdz+} = 0 \text{ kNm}$$

$$\text{Resistances in negative direction} \quad N_{Rd-} = 0 \text{ kN} \quad M_{Rdy-} = -61 \text{ kNm} \quad M_{Rdz-} = 0 \text{ kNm}$$

## Summary of check

Forces:  $N_{Ed} = 0 \text{ kN}$   $M_{Edy} = 42.2 \text{ kNm}$   $M_{Edz} = 0 \text{ kNm}$

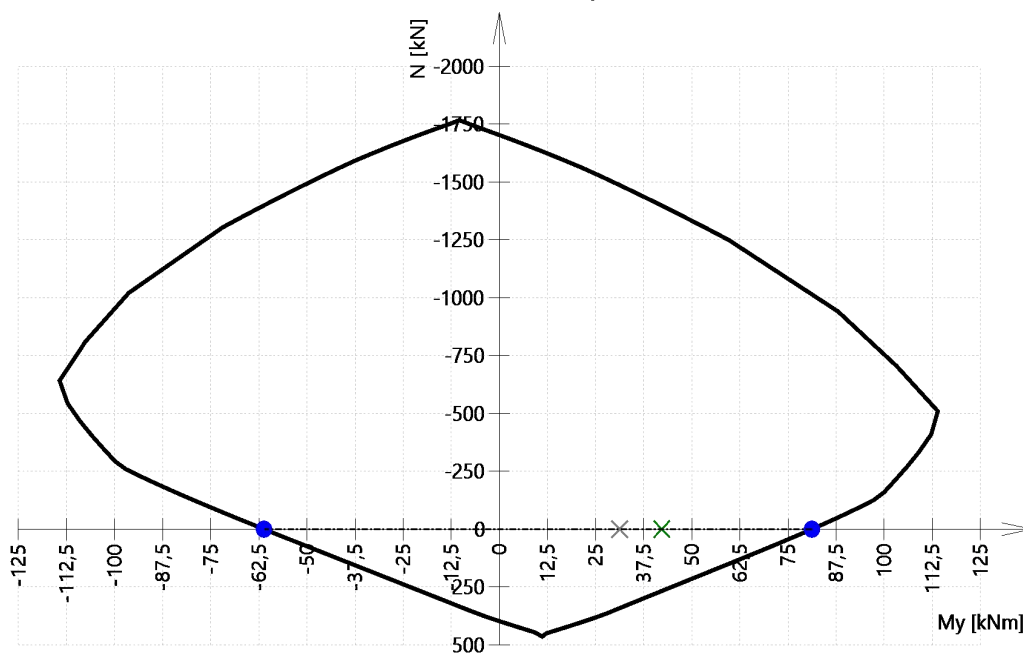
Resistance:  $N_{Rd} = 0 \text{ kN}$   $M_{Rdy} = 81 \text{ kNm}$   $M_{Rdz} = 0 \text{ kNm}$

Calculation of unity check:

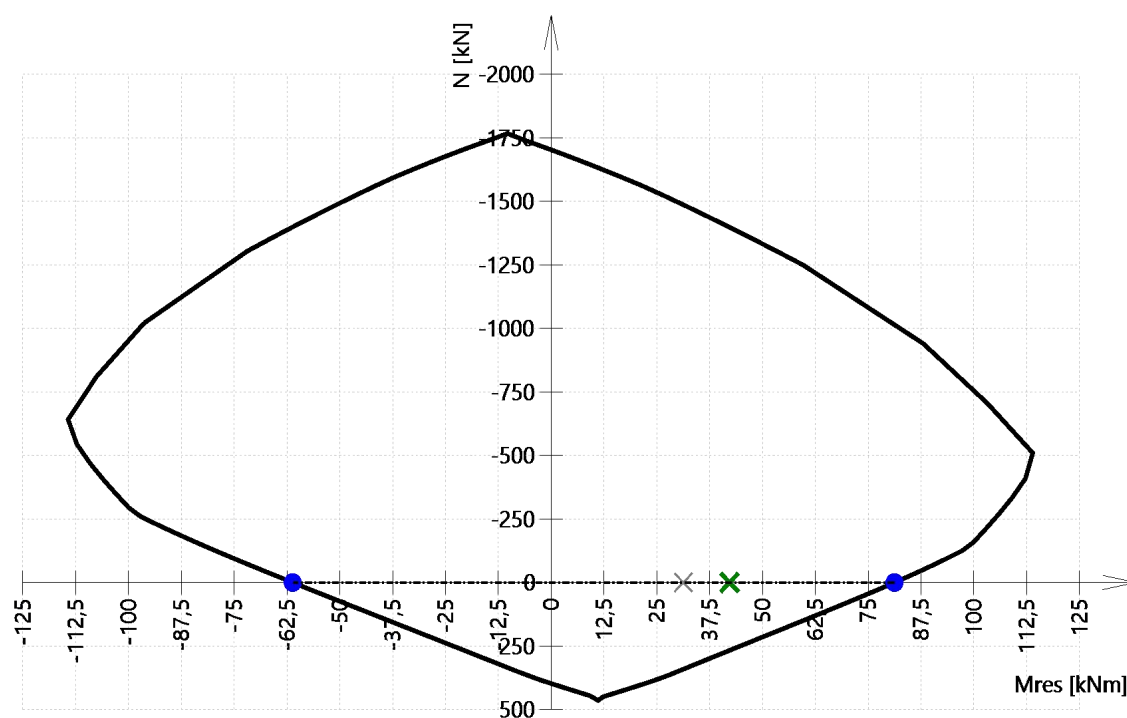
$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{0^2 + 42.2^2 + 0^2}}{\sqrt{0^2 + 81.2^2 + 0^2}} = 0.519 \leq 1 \quad \text{OK}$$

List of errors/warnings/notes: N2/1.

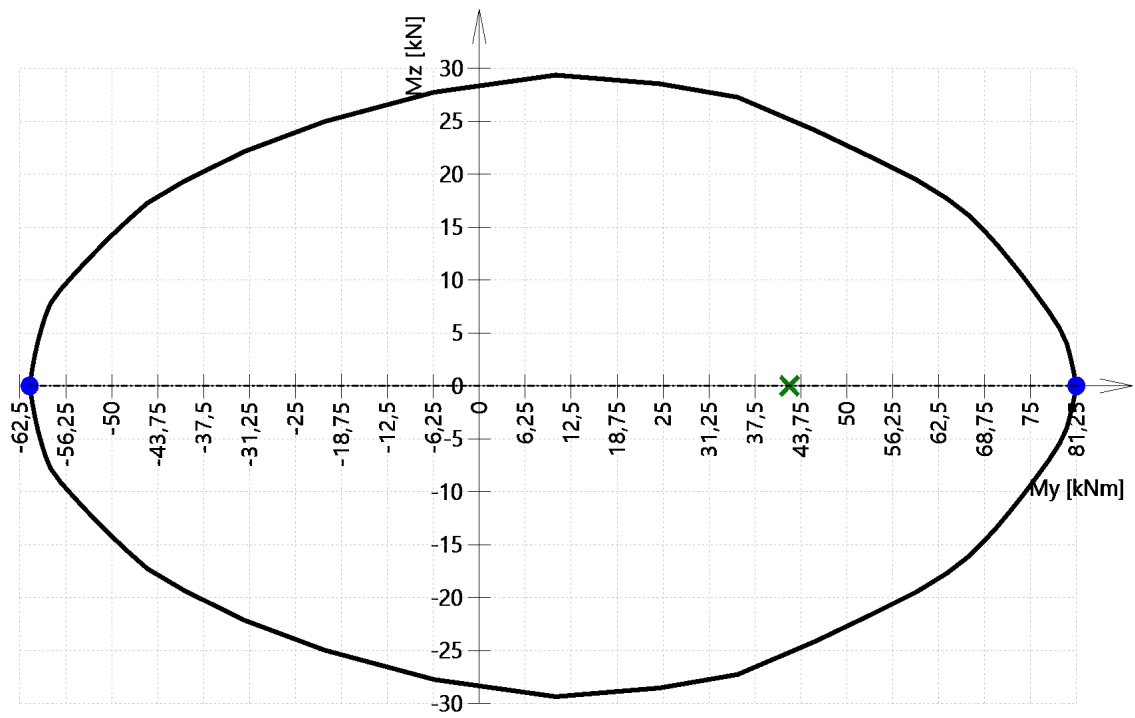
## 3D interaction diagram - Vertical section N-M<sub>y</sub>



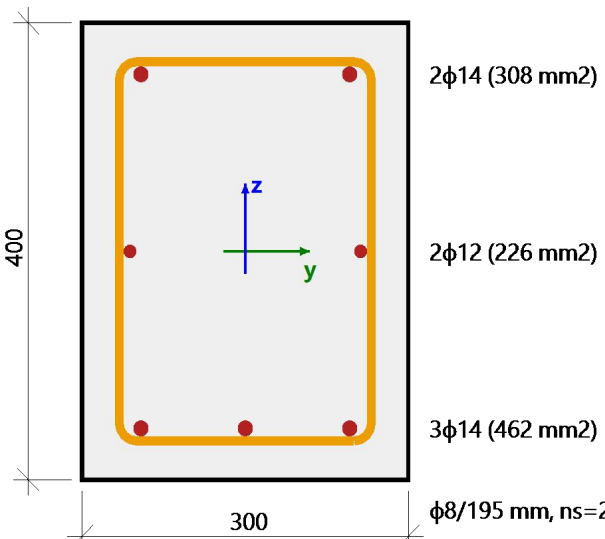
## 3D interaction diagram - Vertical section N-M<sub>res</sub>



### 3D interaction diagram - Horizontal section $M_y$ - $M_z$





Beam N201		Rectangle (400; 300)
EC EN 1992-1-1:2004/AC:2008		Section 5 [dx = 1.9 m]
<b>Member length:</b>	L = 3.8 m	<b>Concrete: C25/30</b>
Buckling y-y	L <sub>y</sub> = 3.8 m (sway)	Bi-linear stress-strain diagram
Buckling z-z	L <sub>z</sub> = 3.8 m (sway)	Exposure class: XC3
		<b>Longitudinal reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		2φ12 mm + 5φ14 mm (A <sub>s</sub> = 996 mm <sup>2</sup> )
		ρ <sub>l</sub> = 0,830 % (7.82 kg/m)
		<b>Shear reinforcement: B 500B</b>
		Bi-linear with an inclined top branch
		φ8/195 mm (n <sub>s</sub> = 2) (A <sub>sw</sub> = 101 mm <sup>2</sup> )
		ρ <sub>w</sub> = 0,430 % (4.05 kg/m) (A <sub>swm</sub> = 516 mm <sup>2</sup> /m)
		<b>Cover (stirrup)</b>
		Top: 30 mm
		Bottom: 30 mm
		Left: 30 mm
		Right: 30 mm

## Material characteristics

Design concrete compressive strength

$$f_{cd} = \frac{\alpha_{cc} \cdot f_{ck}}{\gamma_c} = \frac{1 \cdot 25}{1.5} = 16.7 \text{ MPa}$$

Design yield strength of longitudinal reinforcement

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1.15} = 435 \text{ MPa} \quad (3.15)$$

## Forces

From FEM analysis

$$N = 0 \text{ kN} \quad M_y = 58.3 \text{ kNm} \quad M_z = 0 \text{ kNm}$$

Content of combination:

$$1.35 \cdot \text{LC1} + 1.35 \cdot \text{LC2}$$

## Compression member

Limit axial force to consider member as compression:

$$N_{com} = - \text{Coeff}_{com} \cdot (f_{cd} \cdot A_c) = -0.1 \cdot (16.7 \cdot 10^6 \cdot 0.12) = -200 \text{ kN}$$

Check condition:

$$N_{Ed} \geq N_{com} = 0 \text{ kN} \geq -200 \text{ kN} \dots \text{ not compression member}$$

Note: The member is not considered as a compression member (normal force is relatively small or zero).

Recalculation bending moments:

Moment reduction above support: No

Shear forces reduction above support: No

Use Shift rule: Yes

$N_{Ed} = 0 \text{ kN}$   $M_{Edy} = 58.3 \text{ kNm}$   $M_{Edz} = 0 \text{ kNm}$

### Input data for generation of interaction diagrams

Method of interaction diagram check	$N_u M_u$
Division of vertical strains	250
Number of vertical cuts	36
Resultant value of bending moment	$M_{res} = 58.3 \text{ kNm}$
Angle of resultant bending moment related to $M_y$ direction in horizontal plane $M_y$ - $M_z$	$\alpha_{MyMz} = 180^\circ$
Angle of resultant bending moment related to N direction in vertical plane N- $M_{res}$	$\alpha_{NM} = 0^\circ$

### Calculation of resistances

Resistances in positive direction  $N_{Rd+} = 0 \text{ kN}$   $M_{Rdy+} = 84 \text{ kNm}$   $M_{Rdz+} = 0 \text{ kNm}$

Resistances in negative direction  $N_{Rd-} = 0 \text{ kN}$   $M_{Rdy-} = -63 \text{ kNm}$   $M_{Rdz-} = 0 \text{ kNm}$

### Summary of check

Forces:  $N_{Ed} = 0 \text{ kN}$   $M_{Edy} = 58.3 \text{ kNm}$   $M_{Edz} = 0 \text{ kNm}$

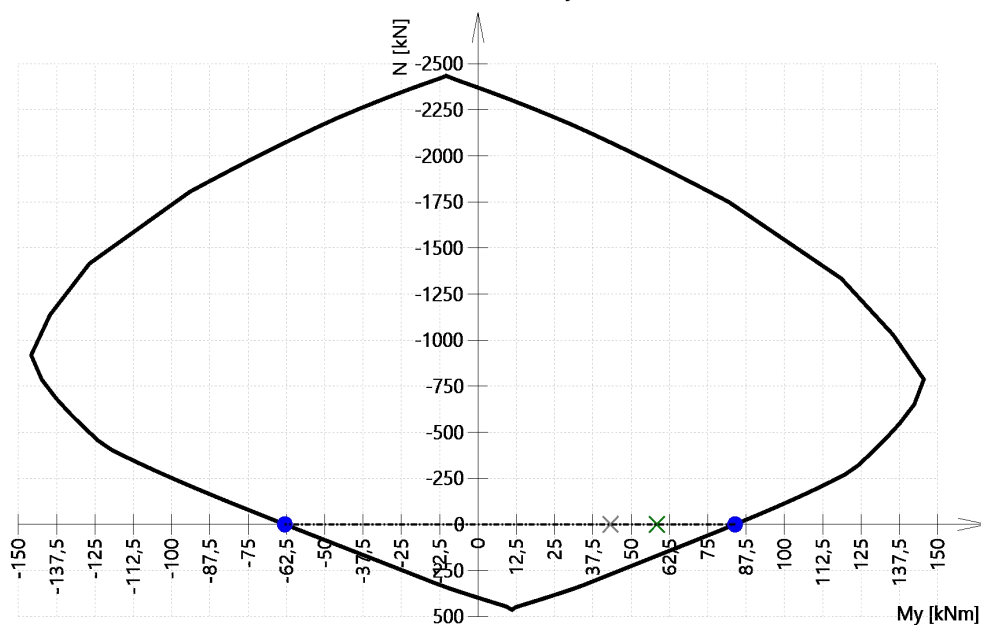
Resistance:  $N_{Rd} = 0 \text{ kN}$   $M_{Rdy} = 84 \text{ kNm}$   $M_{Rdz} = 0 \text{ kNm}$

Calculation of unity check:

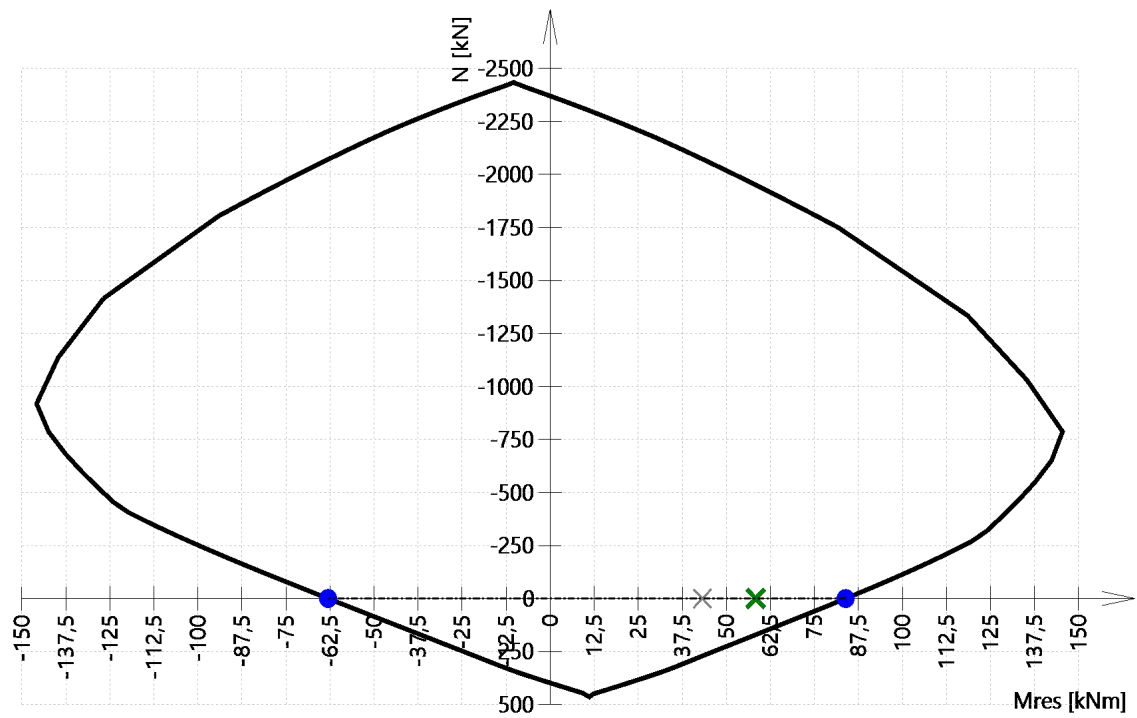
$$UC = \frac{\sqrt{N_{Ed}^2 + M_{Edy}^2 + M_{Edz}^2}}{\sqrt{N_{Rd}^2 + M_{Rdy}^2 + M_{Rdz}^2}} = \frac{\sqrt{0^2 + 58.3^2 + 0^2}}{\sqrt{0^2 + 83.9^2 + 0^2}} = 0.696 \leq 1 \quad \text{OK}$$

List of errors/warnings/notes: N2/1.

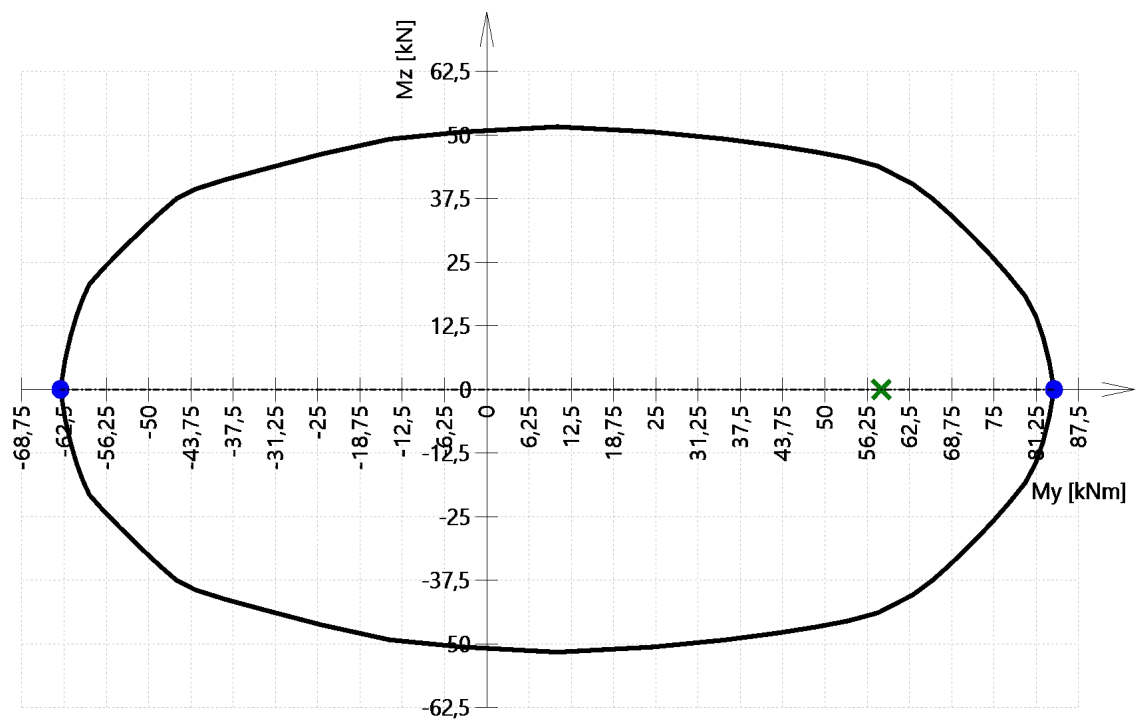
### 3D interaction diagram - Vertical section N- $M_y$



### 3D interaction diagram - Vertical section N-M<sub>res</sub>



### 3D interaction diagram - Horizontal section M<sub>y</sub>-M<sub>z</sub>



## 24. Temelji

### Proračun temeljne trake TT1

XC2 (c=5,0 cm)

Dimenzije trake

$$B = 0.6 \text{ m}$$

$$H = 0.8 \text{ m}$$

Maksimalne vrijednosti reakcije

$$F_z = 57 \text{ kN}$$

Težina trake

$$1.0 \times 0.6 \times 0.8 \times 25 = 12 \text{ kN}$$

$$N_{ed,uk} = 57 + 12 = 69 \text{ kN}$$

Naprezanja ispod TT

$$A_t = 1.0 \times 0.6 = 0.6 \text{ m}^2$$

$$\sigma_1 = \sigma_2 = N_{ed,uk}/A = 69/0.6 = 115 \text{ kN/m}^2$$

Maksimalni moment savijanja stope

$$M_{max} = 1/48 (5\sigma_1 + \sigma_2)B^3$$

$$M_{max} = 1/48 (5 \times 115 + 115) \times 1.0^3 = 14.38 \text{ kNm}$$

Bezdimenzijski moment savijanja

$$\mu_{sd} = (M_{ed}) / (b \times d^2 \times f_{cd}) = (14.38 \times 100) / (100 \times 73.5^2 \times 1.667) = 0.0016 < \mu_{sd,max} = 0.252$$

Minimalna armatura

$$A_{s,min} = 0.0015 \times b \times d = 0.0015 \times 60 \times 73.5 = 6.62 \text{ cm}^2/\text{m}'$$

$$A_{s,min} = 0.6 \times b \times d / f_{yk} = 0.6 \times 60 \times 73.5 / 500 = 5.29 \text{ cm}^2/\text{m}'$$

Potrebna površina armature

$$A_{s,prov} = 6.62 \text{ cm}^2$$

**ODABRANO** (o12/15)

$$A_{s,prov.} = 7.53 \text{ cm}^2 > 6.62 \text{ cm}^2$$

### Proračun temeljne trake TT2

XC2 (c=5,0 cm)

Dimenzije trake

$$B = 0.7 \text{ m}$$

$$H = 0.8 \text{ m}$$

Maksimalne vrijednosti reakcije

$$F_z = 92 \text{ kN}$$

Težina trake

$$1.0 \times 0.7 \times 0.8 \times 25 = 14 \text{ kN}$$

$$N_{ed,uk} = 92 + 14 = 106 \text{ kN}$$

Naprezanja ispod TT

$$A_t = 1.0 \times 0.7 = 0.7 \text{ m}^2$$

$$\sigma_1 = \sigma_2 = N_{ed,uk}/A = 106/0.7 = 151.43 \text{ kN/m}^2$$

Maksimalni moment savijanja stope

$$M_{max} = 1/48 (5\sigma_1 + \sigma_2)B^3$$

$$M_{max} = 1/48 (5 \times 151.43 + 151.43) \times 1.0^3 = 18.93 \text{ kNm}$$

Bezdimenzijski moment savijanja

$$\mu_{sd} = (M_{ed}) / (b \times d^2 \times f_{cd}) = (18.93 \times 100) / (100 \times 73.5^2 \times 1.667) = 0.0021 < \mu_{sd,max} = 0.252$$

Minimalna armatura

$$A_{s,min} = 0.0015 \times b \times d = 0.0015 \times 70 \times 73.5 = 7.41 \text{ cm}^2/\text{m}'$$

$$A_{s,min} = 0.6 \times b \times d / f_{yk} = 0.6 \times 70 \times 73.5 / 500 = 6.17 \text{ cm}^2/\text{m}'$$

Potrebna površina armature

$$A_{s,prov} = 7.41 \text{ cm}^2$$

**ODABRANO** (o12/15)

$$A_{s,prov.} = 7.53 \text{ cm}^2 > 7.41 \text{ cm}^2$$

### Proračun temeljne trake TT3

XC2 (c=5,0 cm)

Dimenzije trake

$$B = 0.4 \text{ m}$$

$$H = 0.8 \text{ m}$$

Maksimalne vrijednosti reakcije

$$F_z = 25 \text{ kN}$$

Težina trake

$$1.0 \times 0.4 \times 0.8 \times 25 = 8 \text{ kN}$$

$$N_{ed,uk} = 25 + 8 = 33 \text{ kN}$$

Naprezanja ispod TT

$$A_t = 1.0 \times 0.4 = 0.4 \text{ m}^2$$

$$\sigma_1 = \sigma_2 = N_{ed,uk}/A = 33/0.4 = 82.5 \text{ kN/m}^2$$

Maksimalni moment savijanja stope

$$M_{max} = 1/48 (5\sigma_1 + \sigma_2)B^3$$

$$M_{max} = 1/48 (5 \times 82.5 + 82.5) \times 1.0^3 = 10.31 \text{ kNm}$$

Bezdimenzijski moment savijanja

$$\mu_{sd} = (M_{ed}) / (b \times d^2 \times f_{cd}) = (10.31 \times 100) / (100 \times 73.5^2 \times 1.667) = 0.0011 < \mu_{sd,max} = 0.252$$

Minimalna armatura

$$A_{s,min} = 0.0015 \times b \times d = 0.0015 \times 40 \times 73.5 = 4.41 \text{ cm}^2/\text{m}'$$

$$A_{s,min} = 0.6 \times b \times d / f_{yk} = 0.6 \times 40 \times 73.5 / 500 = 3.53 \text{ cm}^2/\text{m}'$$

Potrebna površina armature

$$A_{s,prov} = 4.41 \text{ cm}^2$$

**ODABRANO** (o12/20)

$$A_{s,prov.} = 4.52 \text{ cm}^2 > 4.41 \text{ cm}^2$$

U kuteve poprečnog presjeka i po potrebi u sredine postaviti armaturne šipke O12 koje čine konstruktivnu armaturu za vezne grede.

Na polovici visine poprečnog presjeka trakastih temelja postaviti O10, dakle ukupno 2O10. Odabrana armatura odnosi se na obje zone trakastog temelja.

Veznu gredu **VG1** armirati s četiri šipke u uglovima poprečnog presjeka koje čine glavnu armaturu i vilicama O8 na razmacima od 30 cm koje čine poprečnu armaturu.

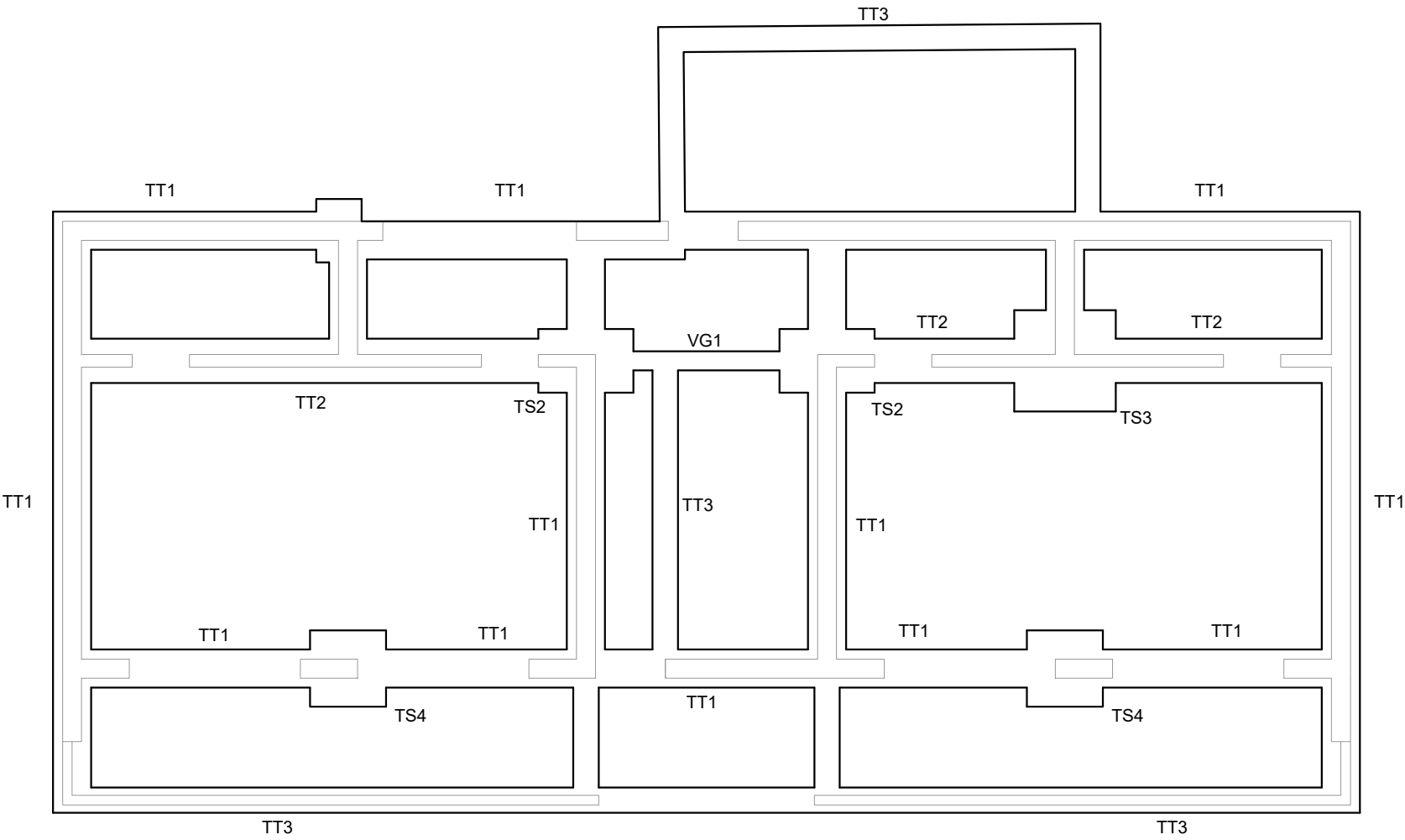
### ***Napomena***

Podna ploča – h = 15.0 cm , armiranje Q283, obje zone.

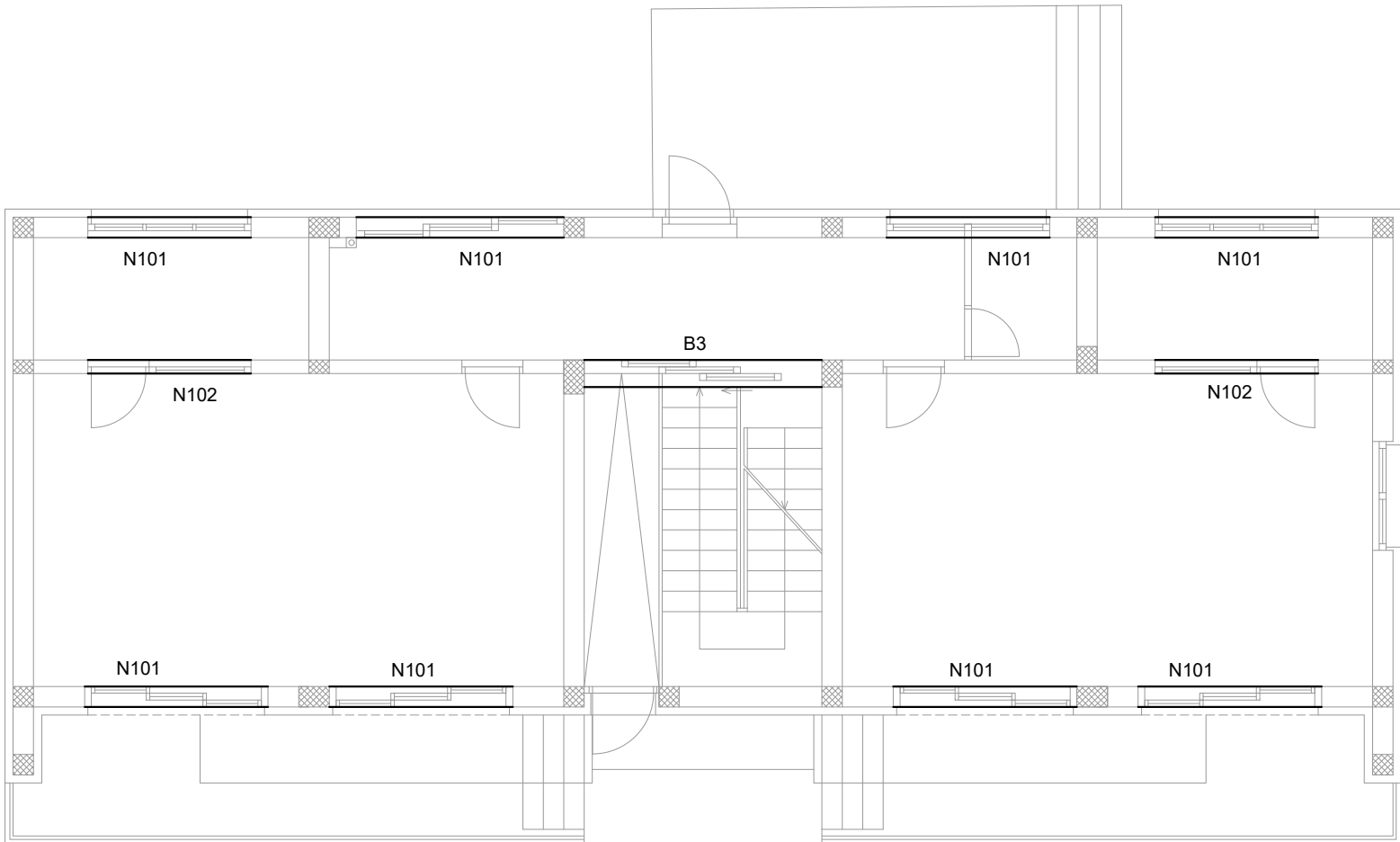
Ispod AB podne ploče osigurati tamponski sloj (min. 30cm) zbijenosti najmanje 60MPa.

Geotehnički elaborat ne postoji. Temelji građevine projektirani su na temeljnim trakama. Minimalna dubina temeljenja iznosi 80cm ispod razine tla.

Zbog složenosti konstrukcije i njenih dijelova potrebna je izrada izvedbenog projekta, te prilikom izvođenja osigurati projektantski nadzor.

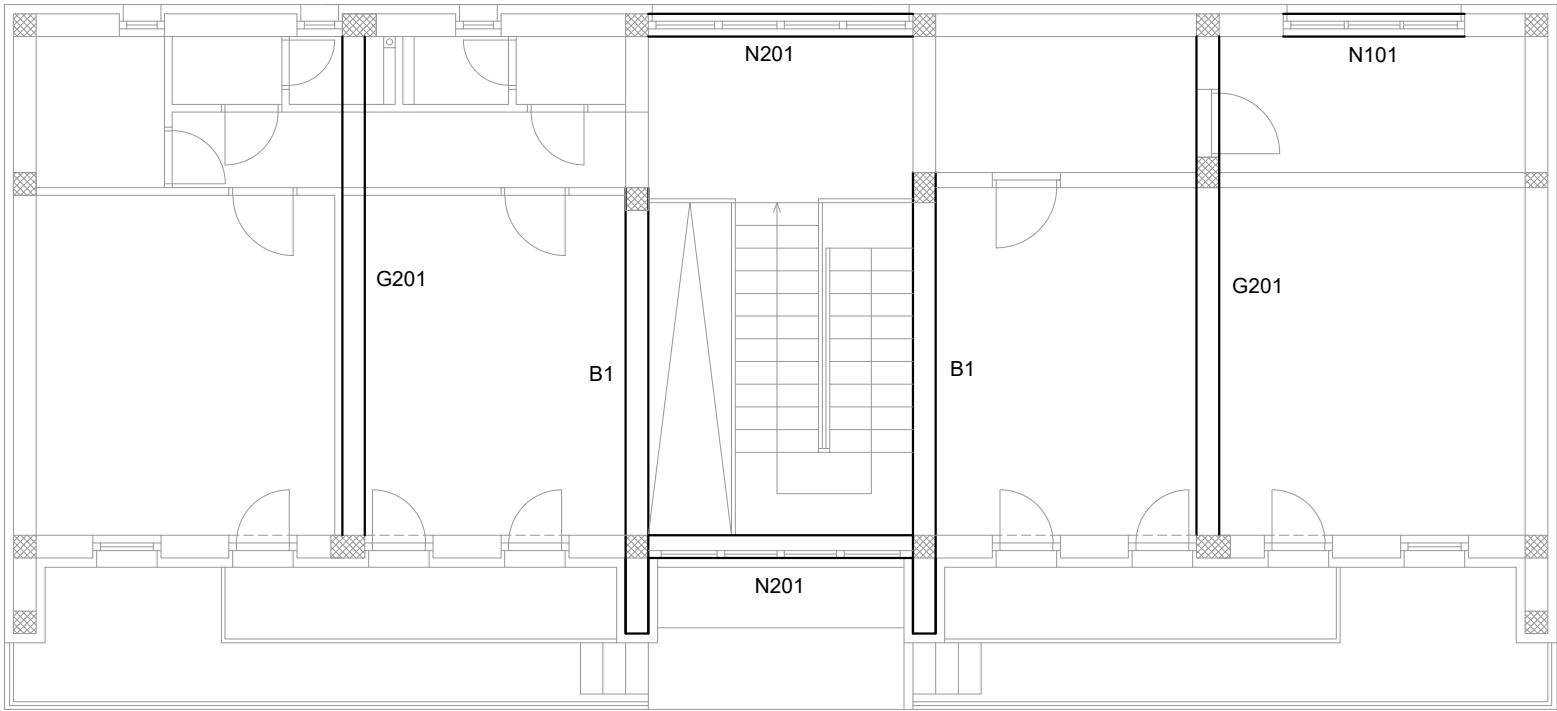


URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Plan pozicija temelja	60/19-GP	17/19	lipanj 2019.g.	1:100	1.



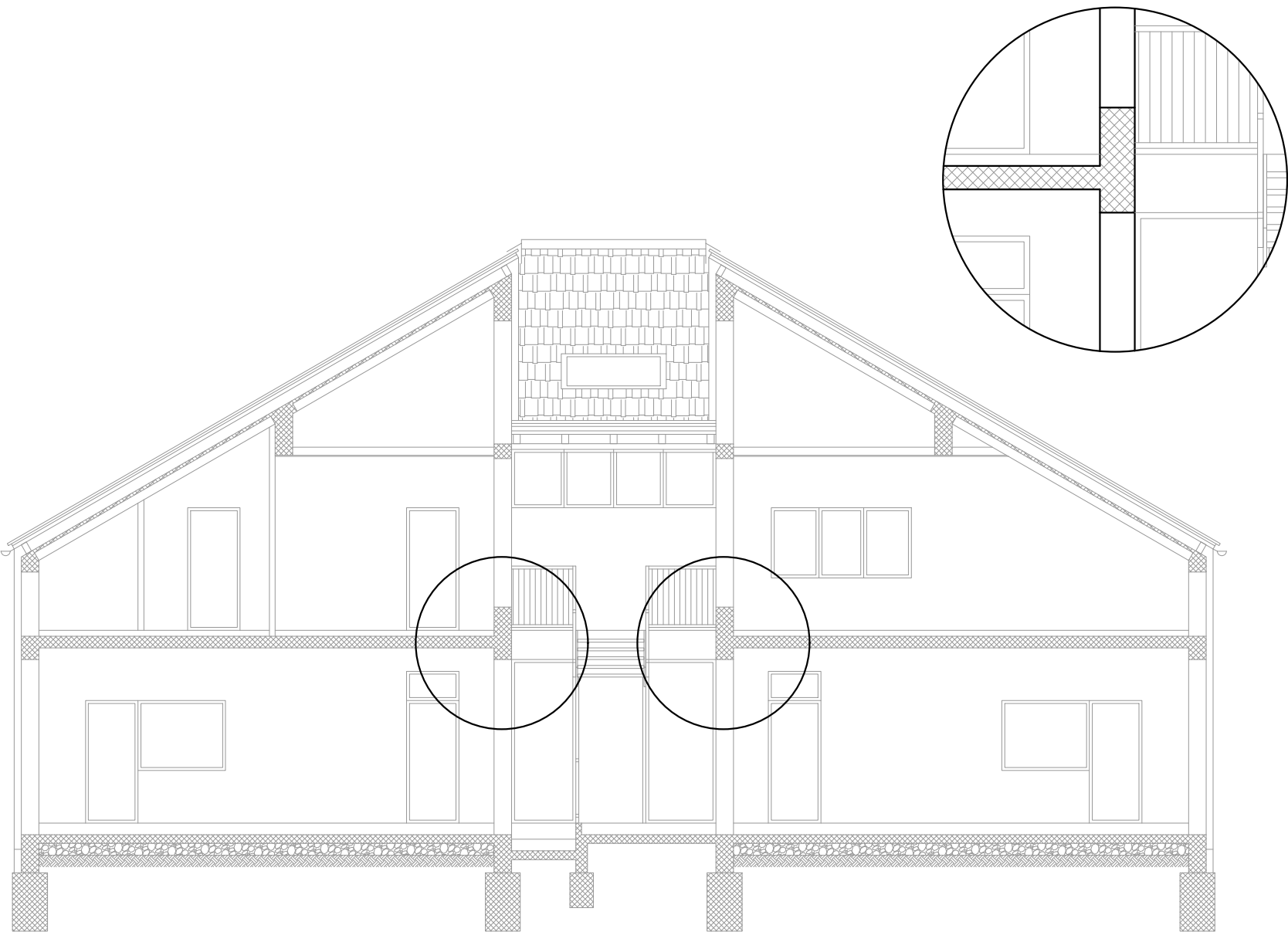
URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
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Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Plan pozicija grede - prizemlje	60/19-GP	17/19	lipanj 2019.g.	1:100	2.



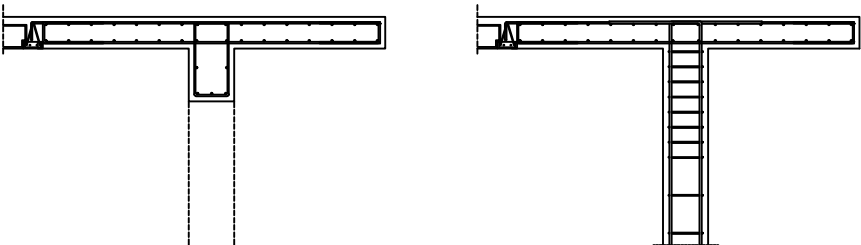


URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
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Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Plan pozicija grede - potkrovlje	60/19-GP	17/19	lipanj 2019.g.	1:100	3.

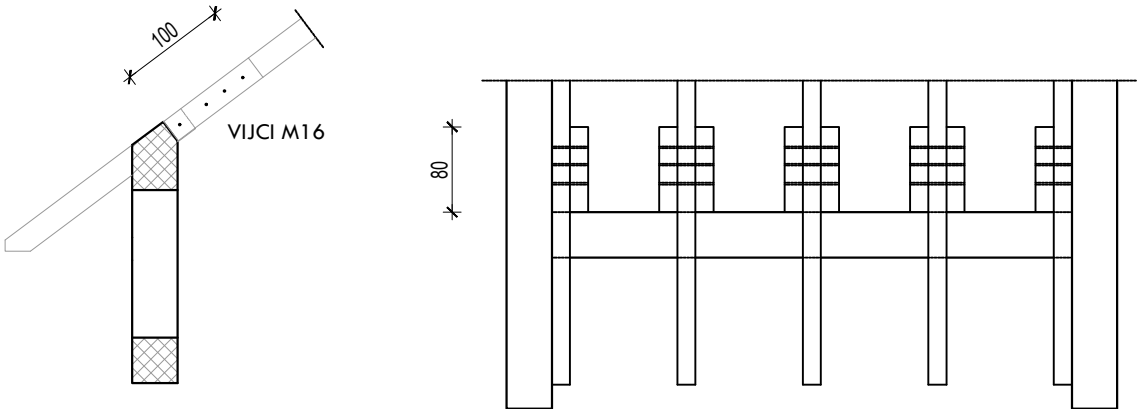
DETALJ UPUŠTENE GREDE



GREDE BALKONA



DETALJ SPOJA ROGOVA



URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslica "Dječji vrtić Zeko" Slatina					
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina	Projektant: Željko Šaponja d.i.g.				
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Detalj upuštene grede	60/19-GP	17/19	lipanj 2019.g.	1:100	4.



INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
FAZA PROJEKTA:	Glavni projekt – građevinski projekt
BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

## VODOVOD I KANALIZACIJA

- a) Tekstualni dio
  - Posebni uvjeti
  - Tehnički opis vodoopskrba i odvodnja

**URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO**, Slatina, M. Gupca 159

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INVESTITOR:	Grad Slatina, Trg Svetog Josipa 10, Slatina
GRAĐEVINA:	Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina
LOKACIJA:	Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616
FAZA PROJEKTA:	Glavni projekt – građevinski projekt
BROJ PROJEKTA:	60/19-GP
GLAVNI PROJEKTANT:	Željko Šaponja dipl.ing.građ.

## a) Tekstualni dio

## Obavijest o utvrđenim uvjetima priključenja

REPUBLIKA HRVATSKA  
Virovitičko-podravska županija, Upravni odjel za  
prostorno uređenje, graditeljstvo, komunalne poslove i  
zaštitu okoliša, Izdvojeno mjesto rada Slatina

Primijeno:	01.10.2019	
Klasif. oznaka:	350-05/19-28/000069	
Unudžbeni broj:	KOMRAD-19-0007	
Org.jed.:	Broj priloga:	Vrij.:

### Podaci o javnopravnom tijelu

Naziv	KOMRAD d.o.o.
Adresa	HR-33520 Slatina, Braće Radića 2
OIB	96537643037

### Podaci o pismenu

Vrsta akta	Uvjeti priključenja
Naziv akta	
Klasa	
Uredžbeni broj	URBROJ: 1-1531/19
Datum nastanka	01.10.2019. godine
Zakonska osnova	temeljem članka 136. stavka 3. Zakona o prostornom uređenju ("Narodne novine" broj 153/13., 65/17., 114/18. i 39/19.) odnosno članka 82. stavka 3. Zakona o gradnji ("Narodne novine" broj 153/13., 20/17. i 39/19.)

### Podaci o podnositelju

Podnositelj zahtjeva	▪ SAMANTA REŠETAR, HR-33520 SLATINA, ANE KATARINE ZRINSKE 26
Nadležno tijelo	Virovitičko-podravska županija, Upravni odjel za prostorno uređenje, graditeljstvo, komunalne poslove i zaštitu okoliša, Izdvojeno mjesto rada Slatina

### Podaci o građevini / zahvatu

Opis	▪ rekonstrukciju građevine (dogradnja) javne i društvene namjene (predškolska ustanova), 2.b skupine - -----
Lokacija - na katastarskoj(im) čestici(ama)	▪ k.č. br. 3616, k.o. Podravska Slatina (Slatina, Bana Jelačića 25)

DOKUMENT: UVJETI PRIKLJUČENJA

INVESTITOR: SAMANTA REŠETAR, HR-33520 SLATINA, ANE KATARINE ZRINSKE 26, OIB 05634556341

KLASA: , URBROJ: 1-1531/19

ID: P20190920-411906-Z05

STRANICA 1/5



Uvid u podatke i dokumentaciju iz spisa omogućen je putem elektroničkog sustava eKonferencija u trajanju od 26.09.2019. godine do zaključno sa 10.10.2019. godine sukladno članku 136. stavka 3. Zakona o prostornom uređenju ("Narodne novine" broj 153/13., 65/17., 114/18. i 39/19.) odnosno članku 82. stavka 3. Zakona o gradnji ("Narodne novine" broj 153/13., 20/17. i 39/19.).

Za predmetni zahvat utvrđuju se uvjeti priključenja .

Predmet izdavanja ovih uvjeta nije usklađenost dostavljene dokumentacije s prostorno-planskom dokumentacijom.

Temeljem Vašeg zahtjeva za uvjetima priključenja, izdaju se slijedeći uvjeti:

#### A)– VODOVOD

-Potrebno je utvrditi dimenzije priključka prema normativima i proračunu i ovisno o predviđenoj potrošnji i prema projektnoj dokumentaciji.

Vodoopskrbi priključak ne može biti manji od 20 mm unutarnjeg presjeka,

-Vodoopskrbni priključak izvesti u skladu s Komradovim Općim i Tehničkim uvjetima isporuke vodnih usluga (<http://www.komrad.hr/vodovod>).

-Priključak se izvodi podzemno na dubini koja sigurno osigurava zaštitu od smrzavanja, u pravilu okomito na vodovodnu mrežu.

-vodomjerno okno ( min. svijetlog otvora 1,0 x 1,0 x 1,0m, poklopac min. 0,6 x 0,6m) za smještaj vodomjera mora biti izgrađeno na lako dostupnom mjestu, u pravilu 1m. iza regulacione linije građevinske čestice, te u dogovoru sa predstavnikom Komrada.

U vodomjerno okno postaviti vodomjer ne manjih dimenzija od dimenzije vodovodnog priključka. Za iskope na javnim površinama potrebno je dobiti suglasnost vlasnika.

#### B) KANALIZACIJA

- Kontrolno okno postavlja se u pravilu neposredno uz regulacionu liniju

- sanitarne otpadne vode dozvoljeno je ispuštati u javni kanalizacijski sustav.

-Priključak na javni kanalizacijski sustav treba izvesti u najbližem oknu na kanalizacijskom kolektoru.

- Priključak se izvodi podzemno na dubini koja sigurno osigurava zaštitu od smrzavanja, u pravilu okomito na kanalizacijsku mrežu

Kišne oluke i ne zagađene slivne vode nije dozvoljeno odvoditi zajedno sa otpadnim sanitarnim vodama.

- Sva vertikalna i horizontalna kanalizacija mora biti vodonepropusna

- Prije početka izvođenja radova obavijestiti Komrad d.o.o. i tražiti lociranje i obilježavanje izgrađene trase kanalizacijskog sustava, te vodoopskrbnog sustava.

Na mjestima mogućeg dodira sa opremom izgrađenog vodoopskrbnog i kanalizacijskog sustava , iskop zemlje izvoditi isključivo ručno

-Kanalizacijski priključak izvesti u skladu sa Komradovim Općim i Tehničkim uvjetima isporuke vodnih usluga, <http://www.komrad.hr/vodovod/> .

Kod izvođenja radova u slučaju oštećenja vodnih objekata, potrebno je sanirati oštećene objekte , te ih dovesti u prvobitno stanje i snositi troškove zbog gubitaka vode nastalih uslijed oštećenja vodne infrastrukture.

Investitor mora dobiti suglasnost vlasnika javne površine preko koje se izvodi priključenje na javne vodne sustave..

INVESTITOR: Grad Slatina, Trg Svetog Josipa 10, Slatina  
GRAĐEVINA: Dogradnja zgrade jaslica „Dječji vrtić Zeko“, Slatina  
LOKACIJA: Slatina, Bana Jelačića 25, k.o. Podravska Slatina, k.č.br. 3616  
FAZA PROJEKTA: Glavni projekt – građevinski projekt  
BROJ PROJEKTA: 60/19-GP  
GLAVNI PROJEKTANT: Željko Šaponja dipl.ing.građ.

## TEHNIČKI OPIS VODOOPSKRBA I ODVODNJA

Primjenjeni propisi i zakoni:

- Zakon o zaštiti pučanstva od zaraznih bolesti (NN 79/07, 113/08, 43/09 i 130/17)
- Zakon o hrani (NN 81/13)
- Zakon o higijeni hrane i mikrobiološkim kriterijima za hranu (NN 81/13), a u svezi s Uredbom (EZ) br. 852/2004 Europskog parlamenta i Vijeća od 29. travnja 2004.g. o higijeni hrane (SL L 139, 30, 4.2004)
- Zakona o predmetima opće uporabe (NN 39/13, 47/14)
- Odredba Državnog predškolskog standarda predškolskog odgoja i naobrazbe (NN 63/08, 90/10)
- Zakon o materijalima i predmetima koji dolaze u neposredni dodir s hranom (NN 25/13), u svezi s Uredbom (EZ) br. 1935/2004 Europskog parlamenta i Vijeća od 27. listopada 2004.g. o materijalima i predmetima namijenjenim neposrednom dodiru s hranom (SL.L338, 13.11.2004.)
- Tehnički propis o sustavu ventilacije, djelomične klimatizacije i klimatizacije zgrada (NN 03/07)
- Pravilnik o zdravstvenoj ispravnosti materijala i predmeta koji dolaze u neposredan dodir s hranom (NN 25/2013 i 41/2014).
- Zakona o vodi za ljudsku potrošnju (NN 56/13, 64/15)
- Pravilnik o parametrima sukladnosti i metodama analize vode za ljudsku potrošnju (NN 125/13, 141/13 i 128/15).

### A. VODOVOD

#### A1. PRIKLJUČAK VODOVODNE INSTALACIJE

Vodovodna instalacija će se priključiti na sustav javne vodoopskrbe na već postojeći priključak na parceli.

Sanitarno opterećenje:

SANITARIJE	KOM	I.J.	Σ I.J.
UMIVAONIK	8	0,50	4,00
ZAHODSKA ŠKOLJKA	6	0,25	1,50
VODOKOTLIČEM	2	1,50	3,00
TUŠ			
<b>UKUPNO:</b>			8,50

-potrebna količina vode:

$$Q_s = 0,25 \cdot \sqrt{J \cdot 0} = 0,25 \cdot 8 = 0,729$$



$$d = \sqrt{\frac{4 \cdot Q}{w \cdot \pi}} = \sqrt{\frac{4 \cdot 0,729}{2 \cdot \pi \cdot 1000}} = 0,0215m = 22mm$$

Priključak vodovodne instalacije izvesti će se unutar parcele, a s obzirom na zahtjevanu količinu vode, vodovodni priključak izvesti **PEHD cijevima profila DN25** - unutarnji promjer.

## A2. UNUTARNJA INSTALACIJA VODOVODA

Za potrebe opskrbe objekta vodom izvesti će se priključak na javnu vodovodnu mrežu kako je to prikazano na shemi vodovodne instalacije.

Za pripremu tople vode predviđeno je koristiti plinski bojler koji će se smjestiti na katu građevine u strojarnici.

Kompletna vodovodna instalacija za sanitarne potrebe se predviđa od PEHD cijevi. Svaki sanitarni predmet ima svoje ventile.

PEHD cijevi i drugi sastavni dijelovi cjevovoda moraju biti prije montaže pregledani i sa unutrašnje strane očišćeni.

### SPAJANJE CIJEVI

Na predmetnom cjevovodu predviđa se zavarivanje pomoću elektrootpornih spojnica. Iako je ovaj postupak zavarivanja praktički automatski, ipak se mora paziti na pripreme i rad opreme zavarivanja. Za dobar uspjeh zavarivanja potrebno je da površine elektrospojnice i cijevi (koje se zavarivaju), budu suhe i čiste. Dijelovi cijevi koji ulaze u elektrospojnicu moraju se prije ulaska ostrugati, da bi se skinuo površinski spoj. Zavarivanje mogu obavljati samo, za te radove, atestirani zavarivači.

### ISPITIVANJE CIJEVOVODA NA TLAK

Nakon montaže instalacije, a prije zatvaranja kanala, žljebova i dr. izvršit će se tlačna proba cijele instalacije. Tlak ispitivanja bit će 10 bara. Vrijeme ispitivanja bit će najmanje 60 minuta. O izvršenoj tlačnoj probi sastavit će se zapisnik. Ispitivanje cjevovoda na tlak provodi se prema uputama nadzornog inženjera u dogovoru s predstavnikom lokalnog distributera.

### PRANJE I DEZINFEKCIJA CJEVOVODA

Pranje cjevovoda moguće je izvesti kroz ispuste, a odvodnja se predviđa u kanalizaciju. Ispiranje i dezinfekcija cjevovoda provodi se prema uputama ovlaštene osobe. Prije puštanja u rad vodoopskrbnog cjevovoda, izvoditelj je dužan ishoditi atest o sanitarnoj ispravnosti položenog cjevovoda kod nadležne zdravstvene ustanove.

## B. KANALIZACIJA

### B1. VANJSKA KANALIZACIJA

Odvodnja sanitarnih otpadnih voda riješena je odvođenjem na javnu kanalizacijsku mrežu, sve kako je prikazano u grafičkom dijelu građevinskog projekta vodovoda i odvodnje.

Odvodnju oborinske krovne vode sa građevine riješit će se upuštanjem u teren tako da ne ugrožava susjedno zemljište i objekte.

Vanjska kanalizacija će se postaviti u iskopane rovove. Prilikom iskopa treba voditi računa o padu dna te ga odmah isplanirati u odgovarajućem nagibu. Cijevi se postavljaju na posteljicu od pijeska debljine 10 cm te se po izvršenom polaganju zatrpavaju pijeskom u debljini sloja 30 cm. Ostali dio rova se može zatrpati preostalim materijalom od iskopa. Spoj vanjske i unutarnje kanalizacije izvesti u revizionom oknu, koje će se za tu svrhu izvesti na svakom mjestu spajanja te mjestu promjene smjera.

Reviziona okna će biti izvedena od vodonepropusnog betona C16/20. U dnu okna izvesti kinetu polukružnog oblika i obraditi ju sa cementnim mortom.

## **B2. UNUTARNJA INSTALACIJA KANALIZACIJE**

Odvodnja sanitarnih otpadnih voda se predviđa od PE cijevi, koji se spajaju elektrozavarivanjem. Cijevi se vode u zidovima i podu do priključka na fekalnu glavnu temeljnu kanalizaciju.

Kanalizacija će biti izvedena od plastičnih kanalizacionih cijevi dimenzija po projektu.

Padovi unutarnje kanalizacije trebaju biti 2 - 2,5 % ,a vanjske 1 - 0,5 %.

## **C. SANITARNI PREDMETI**

Izbor sanitarnih predmeta, armature i sanitarne galanterije odabrat će investitor u dogovoru s projektantom interijera, a troškovnikom će biti odabrane vrhunske sanitarije i sanitarne armature.

### ***Napomena:***

Izvođač radova po izvršenom ispitivanju vodovoda na tlak, treba izvršiti ispiranje i dezinfekciju cjevovoda te pribaviti atest kvalitete vode od ustanove koja je registrirana za tu vrstu poslova.

Za unutarnju kanalizaciju treba izvršiti ispitivanje na vodonepropusnost uz tlak od min. 0,1 bar. Na tehničkom pregledu izvođač radova mora dostaviti snimku izvedenog stanja vodovoda i kanalizacije, ateste o kvaliteti ugrađenog materijala te ateste o svim izvršenim ispitivanjima.

## **D. UNUTARNJA HIDRANTSKA MREŽA:**

Hidrantska mreža za gašenje požara biti će izgrađena kao mokra hydrantska mreža. Prostor oko hidranta mora biti slobodan i očišćen, kako bi hidrant bio stalno dostupan. U građevini koja se štiti unutarnjom hydrantskom mrežom za gašenje požara postavljaju se na cjevovod zidni hidranti. U građevini se postavljaju zidni hidranti, izvedeni tako da omoguće sigurno i efikasno rukovanje i uporaba, odnosno sukladni normi HRN EN 671-1. zidni hidranti smješteni su u hydrantske ormariće zajedno s pripadajućom opremom. Unutarnja hydrantska mreža, protočne količine vode od 40 l/min. (0,42 l/s), min. tlakom na mlaznici od 2,5 bara, u trajanju 60 min. Zidni hidranti obojeni su crvenom bojom te se na njima nalazi oznaka prema normi HRN ISO 6309. Unutarnjom hydrantskom mrežom za gašenje požara ostvaruje se potpuno prekrivanje prostora koji se štiti. Zidni hidranti moraju biti sukladni normi HRN EN 671-1, dužina cijevi iznosi maksimalno 30 m. Hidranti na kolutu se postavljaju u ormariće pričvršćene na nosivi dio građevine, izveden na način da se osigura pravilna upotreba, odnosno da ne predstavlja opasnost za osobe koje borave u prostoru ili se koriste hydrantom. Pozicije unutarnjih hidranata prikazane su u grafičkom djelu dokumentacije. Sve horizontalne vodove potrebno je polagati u padu prema vertikalama, a prije zatvaranja vertikalnih, horizontalnih zidnih i podnih usjeka potrebno je izvršiti tlačnu probu te otkloniti eventualne nedostatke. Poslije uspješne tlačne probe potrebno je isprati cjevovod i izvršiti dezinfekciju istog. U slučaju da se potrebna protočna količina vode u požarnom sektoru koji se štiti ostvaruje s dva ili više hidranata potrebno je da se cjelokupna štićena površina prekrije s onoliko hidranata koliko je potrebno da se ostvari potrebna protočna količina vode.

Kontrola tlaka na najvišem hydrantu

Potrebni tlak istjecanja 2,50 bar

Glavni vodomjer 0,10 bar

Geodetska visina 0,6 bar

Gubici u cjevovodu 0,18 bar

UKUPNO: 3,38 bar

hidraulički proračun |

- A. vodovod
- B. kanalizacija

## A. VODOVOD

### PRORAČUN SANITARNE MREŽE

Sanitarno opterećenje:

SANITARIJE				KOM	I.J.	Σ I.J.
UMIVAONIK				8	0,50	4,00
ZAHODSKA	ŠKOLJKA	S		6	0,25	1,50
VODOKOTLIČEM				2	1,50	3,00
TUŠ						
UKUPNO:						8,50

-potrebna količina vode:

$$Q_s = 0,25 \cdot \sqrt{J \cdot O} = 0,25 \cdot 8 = 0,729$$

$$d = \sqrt{\frac{4 \cdot Q}{w \cdot \pi}} = \sqrt{\frac{4 \cdot 0,729}{2 \cdot \pi \cdot 1000}} = 0,0215m = 22mm$$

Priključak vodovodne instalacije izvesti će se unutar parcele, a s obzirom na zahtjevanu količinu vode, vodovodni priključak izvesti **PEHD cijevima profila DN25** - unutarnji promjer.

## B. KANALIZACIJA

### B1. SANITARNA KANALIZACIJA

Dimenzioniranje kanalizacije izvršeno prema njemačkim propisima (DIN 1986).

#### 5.2. Dimenzioniranje sanitarne kanalizacije prema DIN 1986.

Ovaj se propis zasniva na količini otpadne vode koja otječe iz sanitarnih i uređajnih predmeta, a prema priključnim vrijednostima

$AW_s$  u l/s, prikazanih u tablici 5.4

Njemački standard pri određivanju dimenzija pojedinih dijelova kućne kanalizacije uvodi priključne vrijednosti  $AW_s$  s pripadajućim količinama otpadne vode u l/s iz pojedinog sanitarnog predmeta. Zbroj priključnih vrijednosti ( $AW_s$ ) daje protok prema kojem se određuju dimenzije vodova, a pri tome se vodi računa i o istovremenosti upotrebe sanitarnih predmeta.

Postupak dimenzioniranja prikazan je u nastavku.

Zbrojem vrijednosti  $AW_s$  iz tablice 5.4. dobit će se količina otjecanja  $q_s$ , a iz te se vrijednosti određuju poprečni presjeci cijevi. Tako se prema vrsti objekta razlikuje odtok iz:

stambenih i sličnih zgrada s kratkim vršnim opterećenjem:

$$1. \quad q_s = 0,5 \sqrt{\sum AW_s} \quad (l/s) \quad (5.1)$$

hotela i velikih restorana:

$$2. \quad q_s = 0,7 \sqrt{\sum AW_s} \quad (l/s) \quad (5.2)$$

industrijskih objekata, koji je dugotrajan i ravnomjeran, a iznosi:

$$3. \quad q_s = 1,2 \sqrt{\sum AW_s} \quad (l/s) \quad (5.3)$$

U navedenim jednadžbama drugi korijen izražava istovremenost upotrebe sanitarnih predmeta.

Iz tablice 5.5. moguće je pročitati odtok sanitarne otpadne vode  $q_s$  prema zbiru priključenih vrijednosti  $AW_s$ , a prema jednadžbi 1. za stambene zgrade.

Tablica 5.4. Priključne vrijednosti sanitarnih predmeta i promjeri priključnih cijevi [1]

Sanitarni predmeti		Promjer ogranka $\phi$ [mm]	Priključna vrijednost $AW_s$ [l/s]
1.	Bide (sa $\leq 2$ pregiba cijevi) (sa $> 2$ pregiba cijevi)	40 50	0,5 0,5
2.	Tuš	50	1
3.	Tuš serijski bez čepa	prema protoku u l/s	
4.	Izljev kuhinjski	50	1
5.	Izljev fekalni	100	2,5
6.	Kada, direktno spojena	50	1
7.	Kada, grana nad podom, duž $\leq 1m$	40	1
8.	Kada sa slivnikom	50	1
9.	Pisoar pojedinačni	50	1
10.	Pisoar serijski do 2 mjesta do 4 mjesta do 6 mjesta $> 6$ mjesta	70 - - -	0,5 1 1,5 2
11.	Odjeljivači masti, benzina, ulja	Prema kapacitetu	
12.	Sudoper kuhinjski	50	1
13.	Sudoper veliki ( $> 30 l$ )	70	1,5
14.	Perilica posuda, kućanska	50	1
15.	Perilica posuda, privredna	100	2
16.	Perilica rublja $< 6 kg$ 6...12 kg	50 70	1 1,5
17.	Slivnik $\phi 50$ $\phi 70$ $\phi 100$	50 70 100	1 1,5 2
18.	Umivaonik (sa $\leq 2$ pregiba cijevi) (sa $> 2$ pregiba cijevi)	40 50	0,5 0,5
19.	Umivaonici serijski, bez čepa	prema dotoku l/s	
20.	Zahod	100	2,5
21.	Pumpa za dizanje otp. vode	prema maks. kapacitetu	
22.	Svi san. predmeti stana (kup.+z.+kuh.) na 1 vertikalni	-	5,5
23.	San. predmeti u stanu bez kuhinjskog sudopera	-	4,5

#### PRIKLJUČNE VRIJEDNOSTI SANITARNIH PREDMETA

SANITARIJE	KOM	$AW_s$	$\sum AW_s$
UMIVAONIK	8	1,00	8,00
ZAHODSKA ŠKOLJKA S VODOKOTLIČEM	6	4,00	24,00
TUŠ	2	2,00	4,00
UKUPNO:			36,00

Istovremenost upotrebe sanitarnih predmeta:  $0,5 * \sqrt{\sum AW_s}$

**Qsanitar. ukupno = 3 l/s**

$$(q_s = 0.5 \cdot \sqrt{\sum AW_s}) [1].$$

AW <sub>s</sub>	q <sub>s</sub> [l/s]	AW <sub>s</sub>	q <sub>s</sub> [l/s]	AW <sub>s</sub>	q <sub>s</sub> [l/s]	AW <sub>s</sub>	q <sub>s</sub> [l/s]	AW <sub>s</sub>	q <sub>s</sub> [l/s]	AW <sub>s</sub>	q <sub>s</sub> [l/s]
26	2,55	56	3,74	86	4,64	140	5,92	280	8,37	650	12,75
28	2,65	58	3,81	88	4,69	145	6,02	290	8,51	700	12,94
30	2,74	60	3,87	90	4,74	150	6,12	300	8,66	750	13,69
32	2,83	62	3,94	92	4,8	160	6,33	320	8,94	800	14,14
34	2,92	64	4	94	4,85	170	6,52	340	9,22	850	14,53
36	3	66	4,06	96	4,9	180	6,71	360	9,49	900	15
38	3,08	68	4,12	98	4,95	190	6,89	380	9,75	950	15,41
40	3,16	70	4,18	100	5	200	7,07	400	10	1000	15,8
42	3,24	72	4,24	105	5,12	210	7,25	420	10,25	1500	19,5
44	3,32	74	4,3	110	5,24	220	7,42	440	10,49	2000	22,5
46	3,39	76	4,36	115	5,36	230	7,58	460	10,72	3000	27,5
48	3,46	78	4,42	120	5,48	240	7,75	480	10,25	4000	31,5
50	3,54	80	4,47	125	5,59	250	7,91	500	11,18	5000	35,5
52	3,61	82	4,5	130	5,7	260	8,06	550	11,73		
54	3,67	84	4,58	135	5,81	270	8,22	600	12,25		

Tablica 5.6.: Dimenzioniranje horizontalne katne mreže (grane) [1]

Promjer grane $\phi$ [mm]		50	70	100
$\Sigma AW_s$ dozv.	bez ventilacije	1	3	15
	s ventilacijom	15	45	-

Tablica 5.7. Dimenzije sanitarnih vertikalâ s primarnom ventilacijom [1]

Promjer $\phi$ [mm]	Dopušteni prikljucci		Protok u l/s $q_{s, \text{dozv.}}$	
	AW <sub>s</sub> [l/s]	broj zahoda	stanovi	labor. i dr.
70	9	-	1,5	1,5
100	64	13	4	3,2
125	154	31	6,2	4,6
150	408	82	10,1	7,5

**Tablica 5.8.** Sanitarne vertikale s pomoćnom ventilacijom [1]

Promjer $\phi$ [mm]	Dopušteni priključci		$q_s$ [l/s] dopušt.
	$AW_s$	broj zahoda	
70	18	-	2,1
100	125	25	5,6
125	300	60	8,7
150	795	159	14,1

**Tablica 5.9.** Sanitarne vertikale sa sekundarnom ventilacijom [1]

Promjer $\phi$ [mm]	Dopušteni priključci		$q_s$ [l/s] dopušt.
	$AW_s$	broj zahoda	
70	27	-	2,6
100	185	37	6,8
125	441	88	10,5
150	1183	236	17,2

Horizontalni dijelovi sanitarne kanalizacije dimenzioniraju se prema tablici 5.10.

**Tablica 5.10.** Sanitarni horizontalni vodovi [1]

Promjer $\phi$ [mm]	NAGIB KANALA							
	2%		1,5%		1%		1:0,5	1: $\phi$
	$q_s$ [l/s]	$AW_s$	$q_s$ [l/s]	$AW_s$	$q_s$ [l/s]	$AW_s$	$q_s$ [l/s]	$q_s$ [l/s]
70	1,5	9	-	-	-	-	-	-
100	4	64	3,4	46	2,8	31	-	-
125	7,2	207	6,1	149	5	100	-	4,5
150	11,7	548	10,1	408	8,2	269	-	6,7
200	25	2500	21,7	1884	17,7	1253	-	12,45
250	45,4	-	39,3	-	32	-	28,6	20,15
300	73,5	-	63,7	-	52	-	42,3	29,8
400	157	-	136,3	-	111	-	78,5	55,0
500	283	-	245,3	-	200	-	126,0	89,0

Za vanjski razvod kanalizacije odabrana cijev DN150.

program kontrole i osiguranja  
kvalitete

- A. vodovod
- B. vodovodna instalacija
- C. kanalizacija
- D. sanitarni uređaji



## A. VODOVOD

Za predmetnu građevinu potrebno je izvršiti slijedeću kontrolu:

- visina nadsloja iznad cijevi iznosi 0.80 - 1.40 m
- širina rova na mjestima gdje se vrši samo polaganje cijevi iznosi minimalno širina cijevi +20 cm
- širina rova na mjestima gdje je potrebno izvoditi radove u rovu iznosi minimalno širina cijevi +60 cm
- debljina sloja pijeska na pripremljenom dnu rova iznosi 10 cm
- Preporučljiva temperatura prilikom polaganja cjevovoda je veća od 0 C°, a u suprotnom obavezno je vršiti predgrijavanje
- cijevi i svi elementi prije polaganja moraju biti očišćeni i pregledani obzirom na moguća vanjska oštećenja
- prilikom transporta, skladištenja i ugradnje cijevi pridržavati se uputstva proizvođača cijevi
- provjeriti točnost utvrđenog položaja postojećih podzemnih instalacija
- provjeriti da li je izvoditelj zemljanih radova izveo iskop na za to predviđenim mjestima
- izvršiti ispitivanje mreže na pritisak prije zatrpavanja spojnih mjesta i o izvršenom ispitivanju sastaviti zapisnik
- po završetku montaže kompletnog cjevovoda i postave hidranata i ormarića izvršiti ispitivanje instalacije na protočnost i pritisak na mlaznici u skladu sa pravilnikom
- radove može izvoditi pravna ili fizička osoba registrirana za obavljanje tih poslova
- u toku izvođenja radova osigurati stalni stručni nadzor
- po završetku polaganja cijevi ,a prije zatrpavanja napraviti geodetski snimak instalacija

## B. VODOVODNA INSTALACIJA

Pri projektiranju, izboru i nabavi materijala kao i same izgradnje-instaliranja vodovodnih instalacija te uređaja koji dolaze u neposredni dodir sa vodom za ljudsku potrošnju, bez obzira radi li se o metalnim ili polimernim materijalima moraju posjedovati uredan dokaz o zdravstvenoj ispravnosti predmeta koji dolaze u neposredan dodir s hranom.

Nakon dovršenja montažnih radova ,a prije zatvaranja cjevovoda u rovove i zidne žljebove obavezno se izvodi tlačna proba pod tlakom od 1,5 puta većim od radnog tlaka a najmanje 10 bara u trajanju od 24 sata. Nakon uspješno izvedene tlačne probe potrebno je konstatirati zapisnički uz potpis odgovornih osoba. Tek tada se može pristupiti zatvaranju i zatrpavanju vodovodne instalacije.

Vodovodna instalacija se nakon izvedene uspješne tlačne probe ispire protokom vode i dezinficira rastvorom klora ili nekim drugim sredstvima. Nakon toga uzima se uzorak vode iz cijevne mreže i šalje na ispitivanje u za to registriranu ustanovu. Tek po dobivanju povoljnog nalaza ispitivanja može se vodovodna mreža pustiti u pogon.

Vodovodne cijevi hladne i tople vode obavezno se štite od korozije i orošavanja ,a cjevovod tople vode od gubitka topline. Prolaz cijevi kroz temelje, zidove i stropove mora biti od jednog komada radi eventualnih pomaka građevine. Ugrađeni elementi i materijali moraju odgovarati kvaliteti prema važećim propisima i standardima ,a rad se izvodi prema pravilima zanata i struke.

### Spisak propisa za vodovod:

1. Zakon o zaštiti na radu NN br. 71/14
2. Polaganje cijevi za plinske i vodovodne mreže DIN 19630
3. Pravilnik o uvjetima za utvrđivanje zona sanitarne zaštite izvorišta (NN 066/2011, 047/13)
4. Pravilnik o načinu obavljanja zdravstvenih pregleda osoba pod zdravstvenim nadzorom (NN 023/94)
5. Zakon o vodama NN 153/09

Spisak standarda za vodovod:

HRN G.C6.501 PVC vodovodne cijevi  
HRN G.C6.505 način polaganja  
HRN M.B6.031 EV zasuni  
HRN M.C5.010 način ispitivanja zasuna  
DIN 3222 nadzemni hidrant  
DIN 3340 kompenzacije  
HRN C.J1.021 tehnički uvjeti isporuke fazonskih komada  
HRN C.J1.506 E-ks spojni komad s kolčakom i prirubnicom  
HRN C.J1.503 MMA-ks spojni komad s kolčacima i prirubnicom  
HRN C.J1.071 T otcjepni komad s prirubnicama  
HRN C.J1.051 FFR reducirani element s prirubnicama  
HRN C.J1.064 N90 lučni komad sa stopalom  
HRN C.B5.225 čelične pocinčane tlačne cijevi  
HRN G.C5.601 Polietilenske cijevi PE tip 1 i PE tip 2  
HRN PVC cijevi i fazonski komadi B.C6.505  
HRN M.C5.262 Slobodno protočni ventili  
HRN M.C5.261 Slobodno protočni ventili sa ispustom  
HRN M.C5.280 Ispusni ventili

## **C. KANALIZACIJA**

Kanalizacijski sistem mora biti vodonepropustan. Kontrola vodonepropusnosti izvodi se putem dima ili vodenom probom. Proba vodonepropusnosti koja to dokazuje konstatira se zapisnički uz potpis odgovornih osoba. Nakon toga se kanalizacijske cijevi mogu zatvoriti u žljebove i zatrpati u rovove. Svaka vertikalna mora završiti ventilacionim kanalom radi dobre funkcionalnosti sistema kanalizacije.

Prilikom zatrapavanja rova za vanjsku kanalizaciju mora se voditi briga o eventualnim zarušavanjima zemlje i osiguranju iskopa razupiranjem. Prilikom polaganja horizontalnih dijelova cjevovoda voditi računa o padu cijevi da ne dođe do taloženja i začepljenja cijevi.

Kanalizacijske cijevi moraju biti udaljene od kablova elektrike i PTT-a kao i plina prema posebnim uvjetima distributera. Svi izvedeni radovi moraju biti izvedeni u skladu s važećim standardima, propisima, pravilima struke i uputama proizvođača.

Spisak propisa za kanalizaciju:

1. Zakon o vodama NN 153/09
2. Pravilnik o izdavanju vodopravnih akata NN 078/10

Spisak standarda za kanalizaciju:

Kanalski poklopci M.J6.210  
Cijevi od PVC-a i fazonski komadi G.C6.501, G.C6.502, G.C6.503  
PVC sifoni G.C6.520  
PVC ventilacione glave ( kape) G.C6.521  
Stupaljke M.J6.285

#### **D. SANITARNI UREĐAJI**

Sanitarni uređaji moraju biti spojeni na vodovod i kanalizaciju vodonepropusno prema pravilima struke i uputstava proizvođača. Kvaliteta uređaja mora odgovarati važećim standardima.

##### Spisak standarda za sanitarije:

Umivaonik od keramike U.N5.110

WC školjka od keramike U.N5.121

Tuš kada ljevano-željezna U.N5.230

Podni top sifon C.J1.480

Sifon za umivaonik M.C5.810

Vodovodne i sanitarne armature M.C5.011

Mješalica za umivaonik M.C5.803

Mješalica za tuš M.C5.802

Ispusni ventil M.C5.290

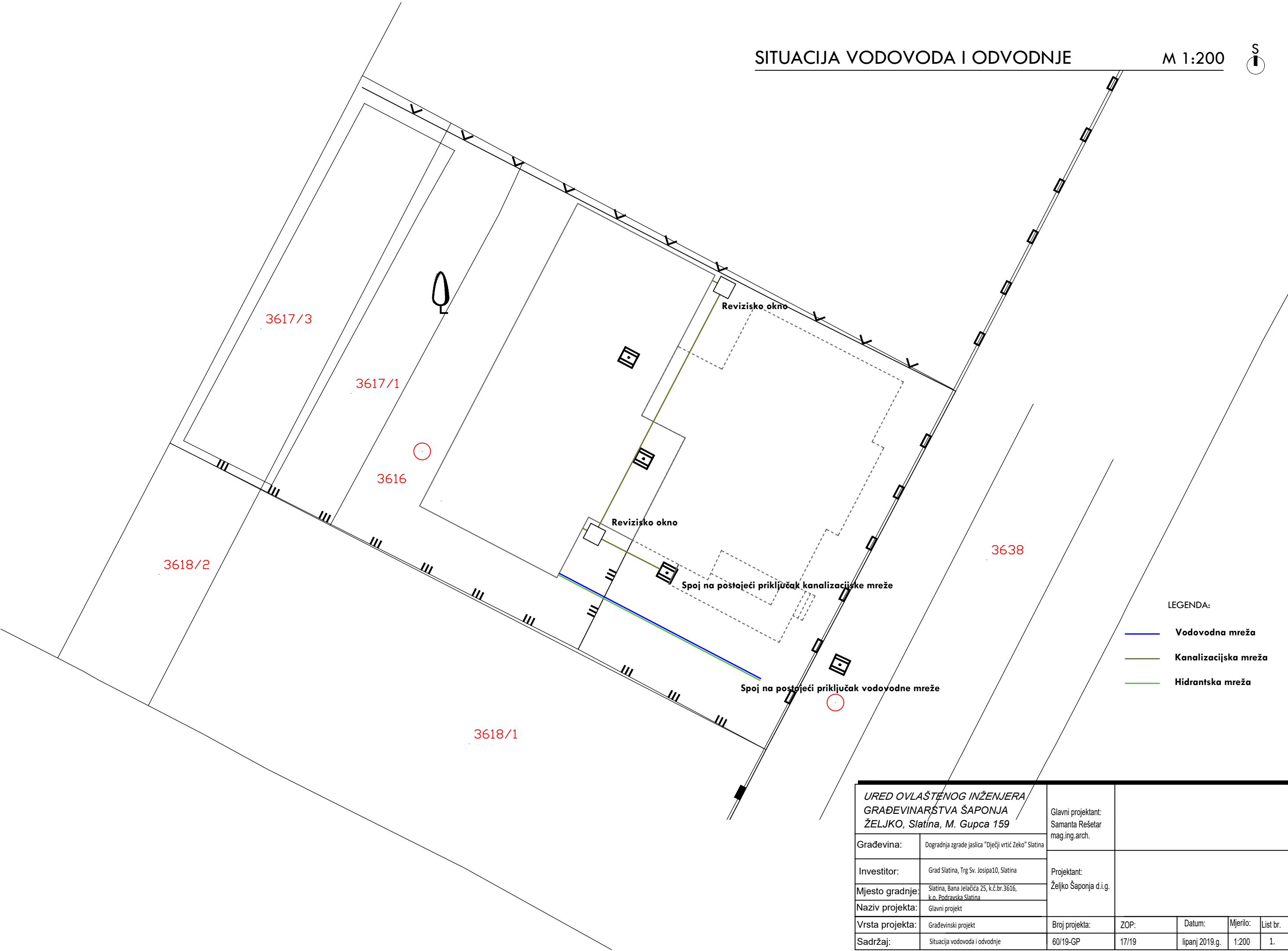
Slatina, rujan 2019.g.

Projektant:

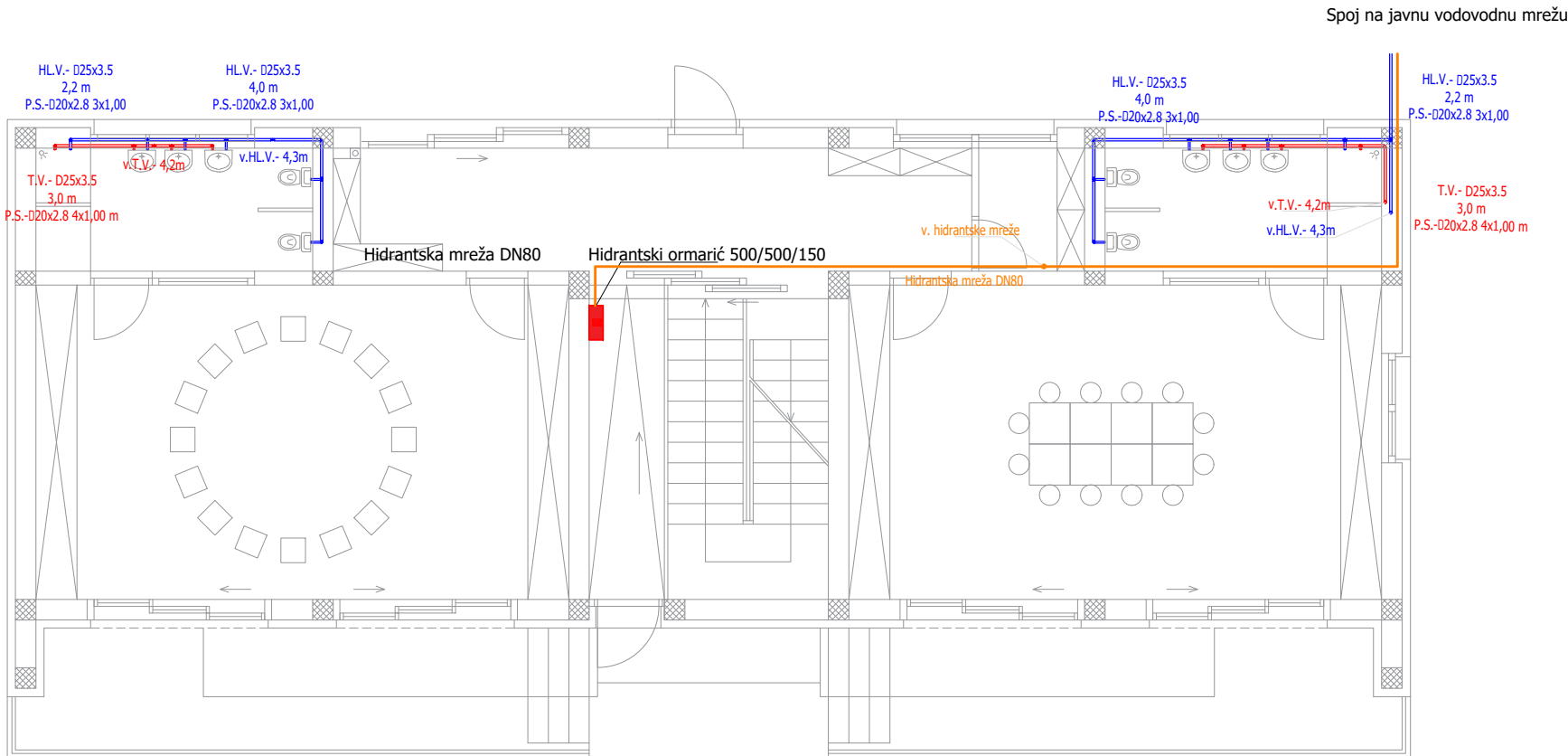
Željko Šaponja dipl.ing.građ.

grafički prilozi |

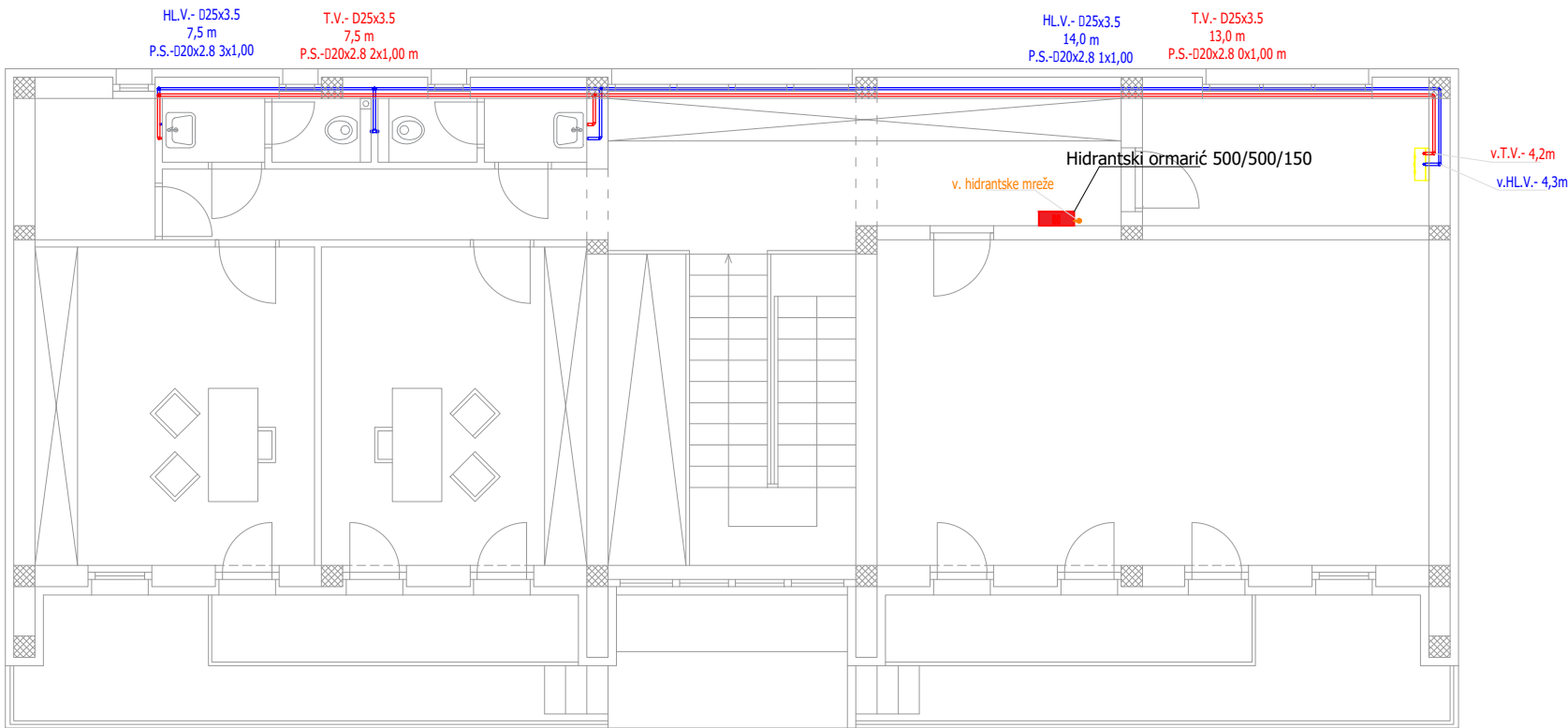
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2. tlocrt prizemlja/vodovod
3. tlocrt prizemlja/kanalizacija
4. prostorna shema vodovoda
5. detalj revizionog okna
6. vodomjerno okno



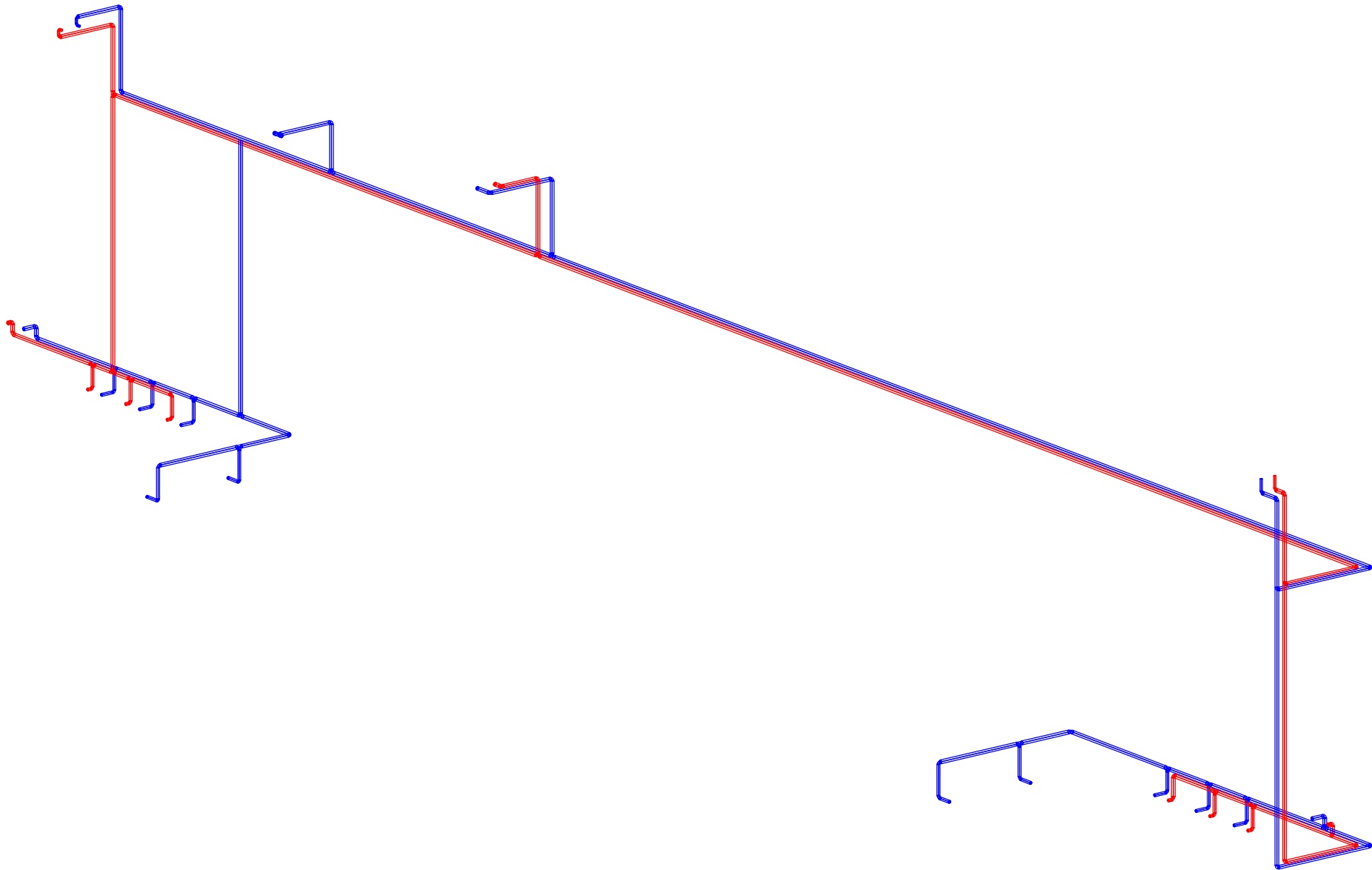
URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Situacija vodo voda i odvodnje	60/19-GP	17/19	lipanj 2019.g.	1:200	1.



URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt	Broj projekta:		ZOP:	Datum:	Mjerilo:
Vrsta projekta:	Građevinski projekt	60/19-GP		17/19	lipanj 2019.g.	1:100
Sadržaj:	Tlocrt prizemlja - vodovod					2.

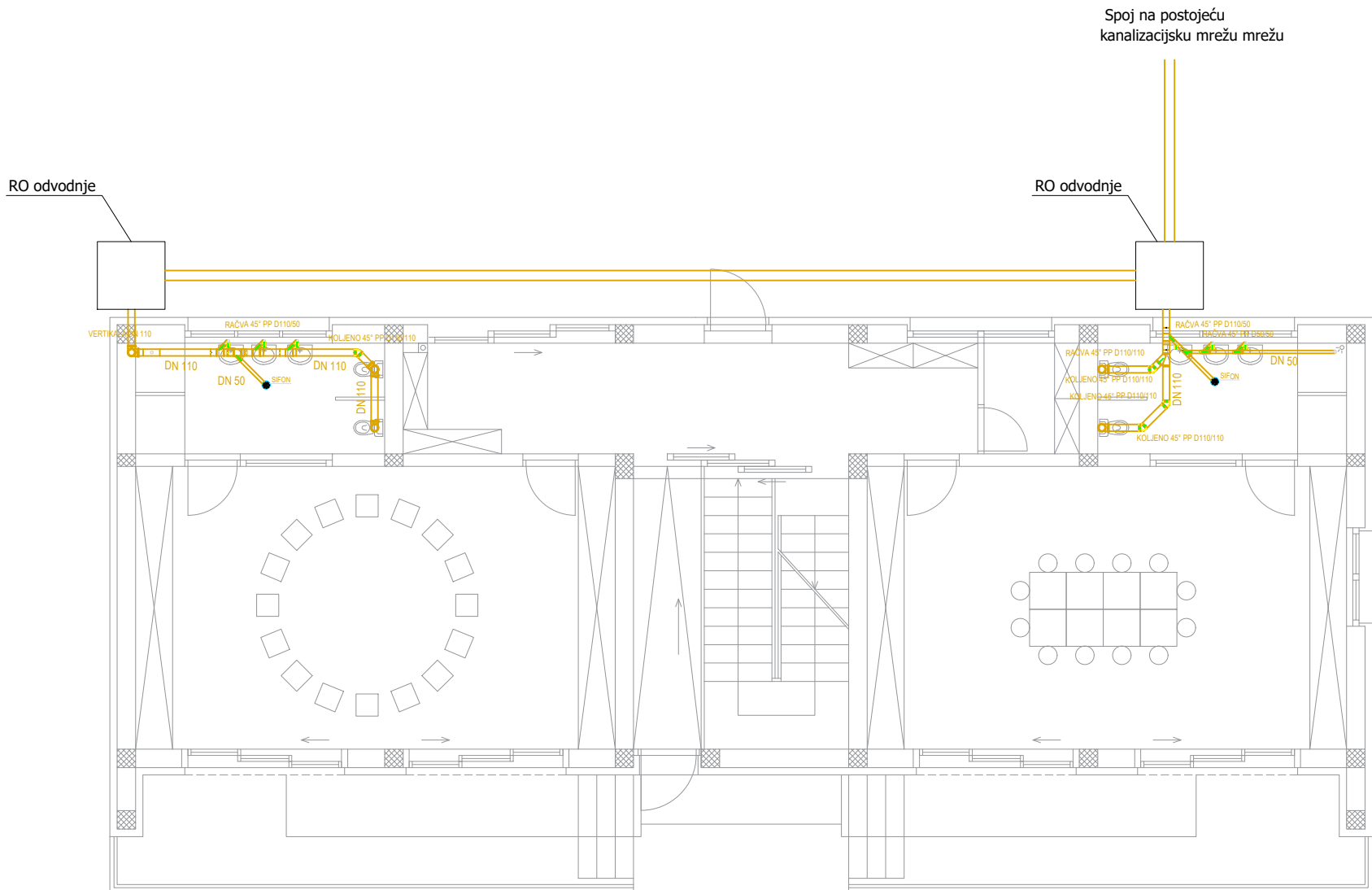


URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Tlocrt potkrovlja - vodovod	60/19-GP	17/19	lipanj 2019.g.	1:100	3.

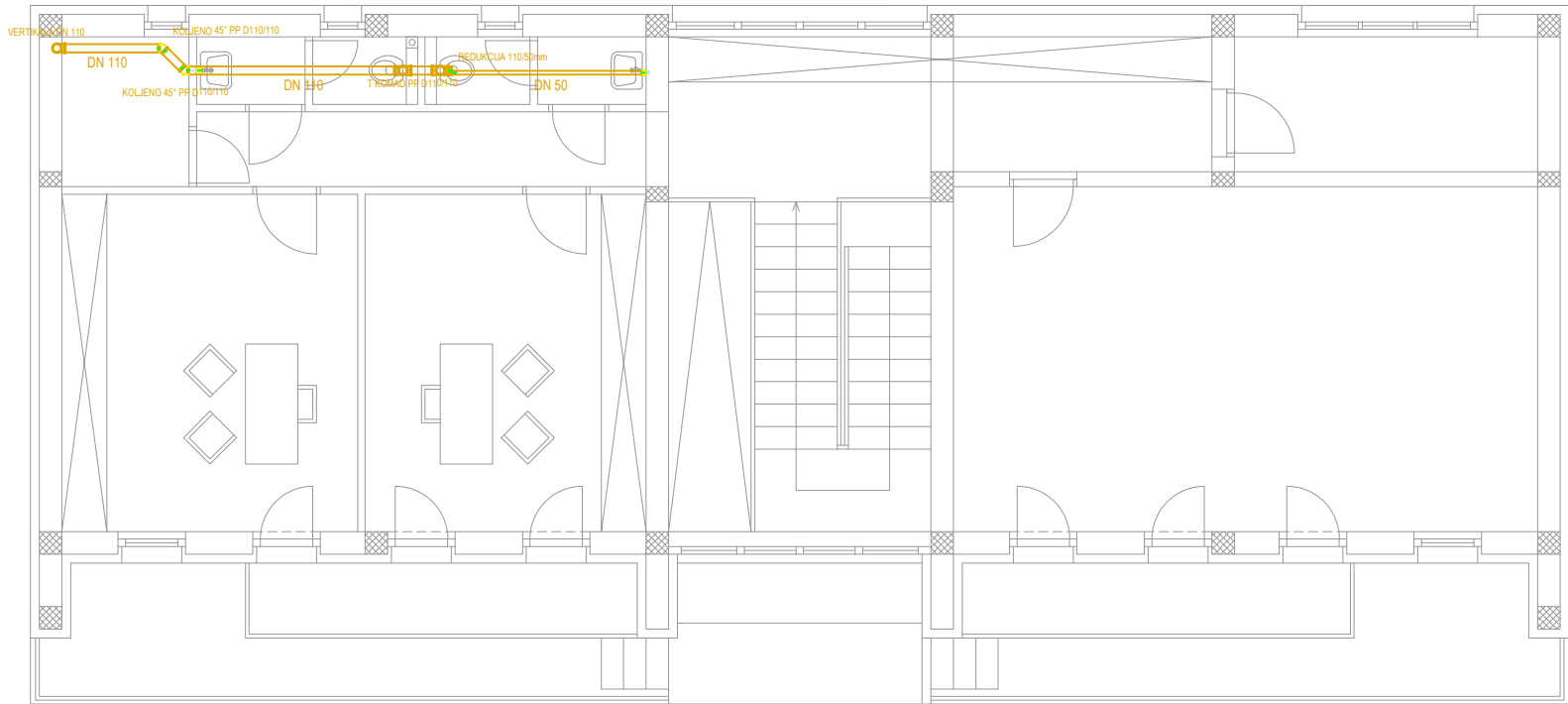


URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslica "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Prostorna shema vodovoda	60/19-GP	17/19	lipanj 2019.g.	1:100	4.





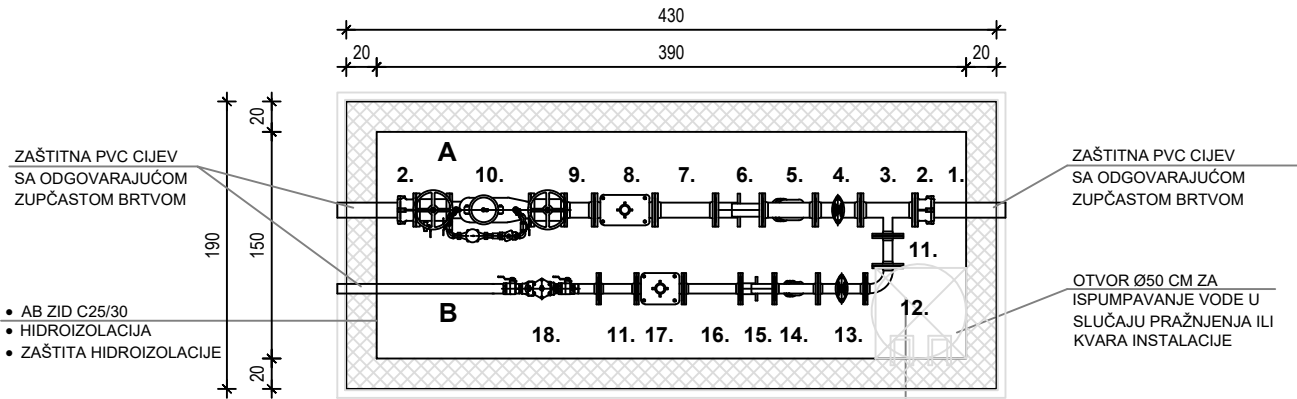
URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Tlocrt prizemlja - odvodnja	60/19-GP	17/19	lipanj 2019.g.	1:100	5.



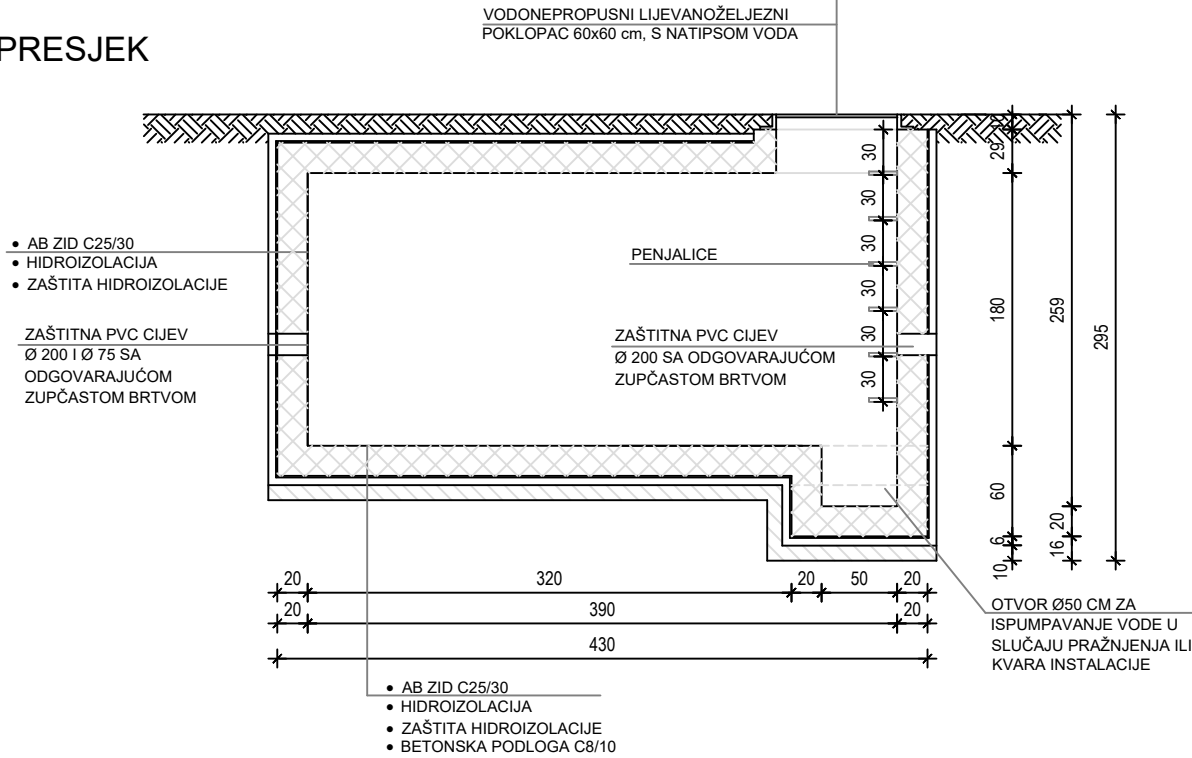
URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dogradnja zgrade jaslca "Dječji vrtić Zeko" Slatina					
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina	Projektant: Željko Šaponja d.i.g.				
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt					
Vrsta projekta:	Građevinski projekt	Broj projekta:	ZOP:	Datum:	Mjerilo:	List br.
Sadržaj:	Tlocrt potkrovlja - odvodnja	60/19-GP	17/19	lipanj 2019.g.	1:100	6.

VODOMJERNO OKNO 150x390/180 cm

TLOCRT



PRESJEK



LEGENDA:

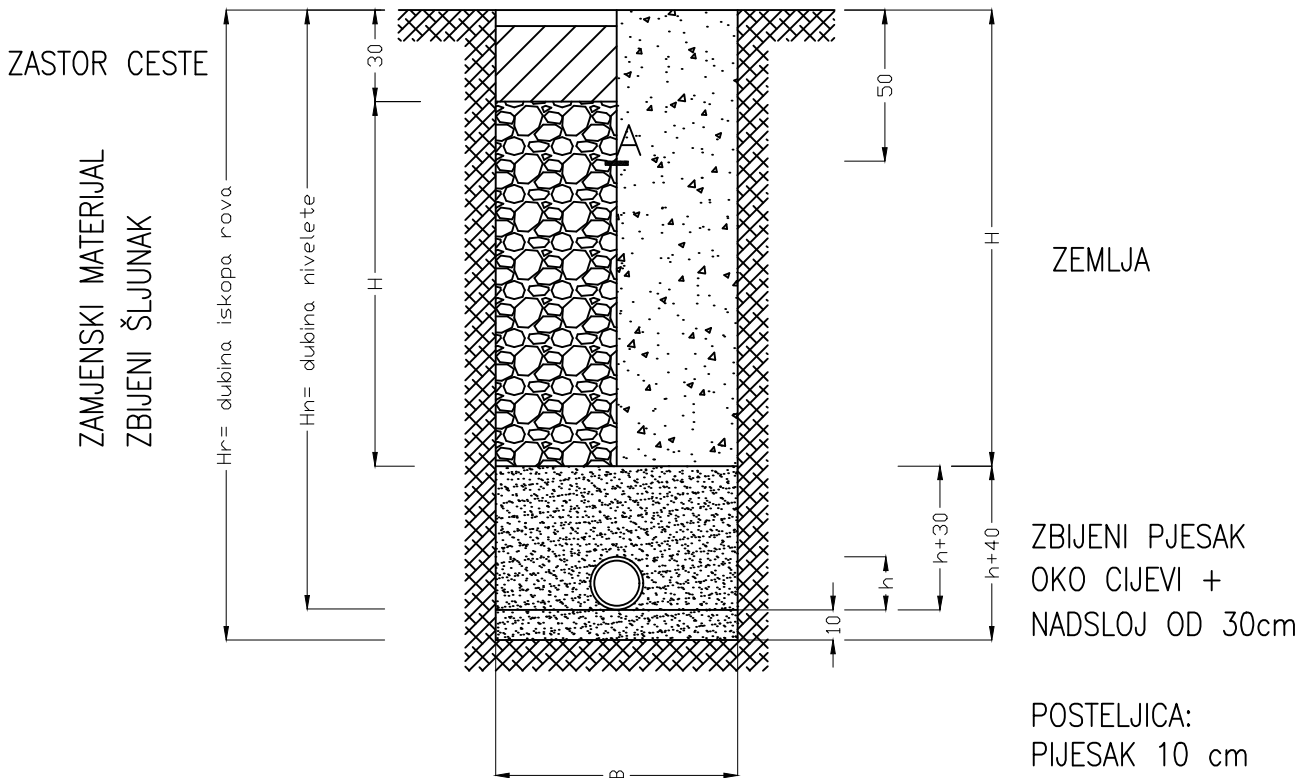
- A. LINIJA PROTUPOŽARNE VODE  
B. LINIJA SANITARNE VODE
1. SPOJNI VOD Ø100 mm
  2. PRIRUBNICA Ø100 mm
  3. T-KOMAD Ø100/50 mm
  4. ZASUN Ø100 mm
  5. HVATAČ NEČISTOĆA Ø100 mm
  6. MONTAŽNO DEMONTAŽNI KOMAD Ø100 mm
  7. FF KOMAD L=600mm Ø100 mm
  8. KOMBINIRANI VODOMJER WS Ø100 mm
  9. FF KOMAD L=200mm Ø100 mm
  10. ZOPT tip EC Ø100 mm
  11. FF KOMAD l=200mm Ø50 mm
  12. Q KOMAD Ø50 mm
  13. ZASUN Ø50 mm
  14. HVATAČ NEČISTOĆE Ø50 mm
  15. MONTAŽNO DEMONTAŽNI KOMAD Ø50 mm
  16. FF KOMAD l=300mm Ø50 mm
  17. VODOMJER WPV Ø50 mm
  18. ZOPT tip EC Ø65 mm

NAPOMENA:  
TOČAN POLOŽAJ I VELIČINU VODOMJERNOG OKNA ODREDIT ĆE PREDSTAVNIK NADLEŽNOG KOMUNALNOG PODUZEĆA UVIĐAJEM NA LICU MJESTA. U VODOMJERNO OKNO UGRADIT ĆE SE DVA GLAVNA VODOMJERA. GLAVNI VODOMJER SANITARNE VODE TIP WPV DN 50 mm I GLAVNI KOMBINIRANI VODOMJER PROTUPOŽARNE VODE TIP WS DN 100 mm. NA SVIM LINIJAMA IZA GLAVNIH VODOMJERA UGRADIT ĆE SE ZASUNI, HVATAČI NEČISTOĆA, MDK, TE JE OBAVEZNA UGRADNJA ZOPT-a. NA VODU SANITARNE VODE (POSLIJE VODOMJERA) POTREBNO JE UGRADITI ZAŠTITU OD KAMENCA, PROIZVOD KAO WELLAN.

URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159		Glavni projektant: Samanta Rešetar mag.ing.arch.				
Građevina:	Dograđnja zgrade jasilica "Dječji vrtić Zeko" Slatina	Projektant: Željko Šaponja d.i.g.				
Investitor:	Grad Slatina, Trg Sv. Josipa10, Slatina					
Mjesto gradnje:	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
Naziv projekta:	Glavni projekt	Broj projekta:		ZOP:	Datum:	Mjerilo:
Vrsta projekta:	Građevinski projekt	60/19-GP		17/19	lipanj 2019.g.	1:100
Sadržaj:	Detalj vodomjernog okna					7.

## KARAKTERISTIČNI PRESJEK ROVA ZA POLAGANJE VODOVODNIH CIJEVI

KOLNA POVRŠINA | ZELENA POVRŠINA



A – traka upozorenja s oznakom "vodovod"

D- profil cijevi (mm)	do 200	200 do 400	450 do 800	850 do 1500	od 1500
B- širina rova (m)	0,80	0,80	D + 0,80	D + 1,00	D + 1,20

<b>URED OVLAŠTENOG INŽENJERA GRAĐEVINARSTVA ŠAPONJA ŽELJKO, Slatina, M. Gupca 159</b>		Glavni projektant: Samanta Rešetar mag.ing.arch.				
<b>Građevina:</b>	Dogradnja zgrade jaslica "Dječji vrtić Zeko" Slatina					
<b>Investitor:</b>	Grad Slatina, Trg Sv. Josipa10, Slatina	Projektant: Željko Šaponja d.i.g.				
<b>Mjesto gradnje:</b>	Slatina, Bana Jelačića 25, k.č.br.3616, k.o. Podravska Slatina					
<b>Naziv projekta:</b>	Glavni projekt					
<b>Vrsta projekta:</b>	Građevinski projekt	<b>Broj projekta:</b>	ZOP:	Datum:	Mjerilo:	List br.
<b>Sadržaj:</b>	Detalji polaganja cijevi	60/19-GP	17/19	lipanj 2019.g.	1:100	8.

