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PROJEKTO PAVADINIMAS:	**Maitinio paskirties pastato, J. Biliūno g. 31, Anykščiai, paskirties keitimo į mokslo paskirties pastatą ir rekonstravimo projektas**
ADRESAS:	**J. Biliūno g. 31, Anykščiai**
SKLYPO KADASTRINIS NR.:	**3403/0014:42**
STATINIO UNIKALUS NR.:	**3495-9000-4040**
UŽSAKOVAS:	**Anykščių Antano Vienuolio progimnazija**
STATINIO KATEGORIJA:	**Neypatingasis statinys**
STATYBOS RŪŠIS:	**Rekonstravimas**
STATINIO NAUDOJIMO PASKIRTIS:	**Maitinimo paskirties**
PROJEKTAVIMO DARBŲ STADIJA:	**Techninis projektas**
PROJEKTO DALIS	**Konstrukcijų. Sprendinių detalieji skaičiavimai**
LAIDA	**0**
BYLA:	**IN2317-01-TP-SK-S**

Direktorius		Marius Matuliukštis
AV.	Parašas	
PV		Jolanta Stefanovič KA Nr. 2232
	Parašas	
PDV.		Mindaugas Zabinas KA Nr. 37460
	Parašas	
Proj.		Margarita Čekalina KA Nr. 40628
	Parašas	

2023 m.

PROJEKTO SUDĖTIES ŽINIARAŠTIS		
Eil. Nr.	Projekto dalies pavadinimas	Raidinis žymėjimas
1.	Bendroji dalis	BD
2.	Sklypo sutvarkymo (sklypo planas)	SP
3.	Architektūrinė (statinio architektūra)	SA
4.	Konstrukcinė (statinio konstrukcijos)	SK
5.	Vandentiekio ir nuotekų šalinimo (laukas)	LVN
	Vandentiekio ir nuotekų šalinimo (vidus)	VN
6.	Šildymo, vėdinimo ir oro kondicionavimo	ŠVOK
7.	Elektrotechnikos (lauko, vidaus, teritorijos žaibosaugos)	E
8.	Elektroninių ryšių (telekomunikacijos) (lauko ir vidaus)	ER
9.	Apsauginės signalizacijos	AS
10.	Gaisro aptikimo ir signalizacijos	GSS
11.	Šilumos gamybos ir tiekimo	ŠGT
12.	Pasirengimo statybai ir statybos darbų organizavimo	SO
13.	Statybos skaičiuojamosios kainos nustatymo	KS

PROJEKTO DALIES BYLŲ (SEGTUVŲ) SUDĖTIES ŽINIARAŠTIS				
Eil. Nr.	Bylos (segtuvo) žymuo	Laida	Pavadinimas	Pastabos
1.	IN2317-01-TP-SK	0	Konstrukcijų (statinio konstrukcijos)	
3.	**IN2317-01-TP-SK-S**	**0**	**Konstrukcijų. Sprendinių detalieji skaičiavimai**	

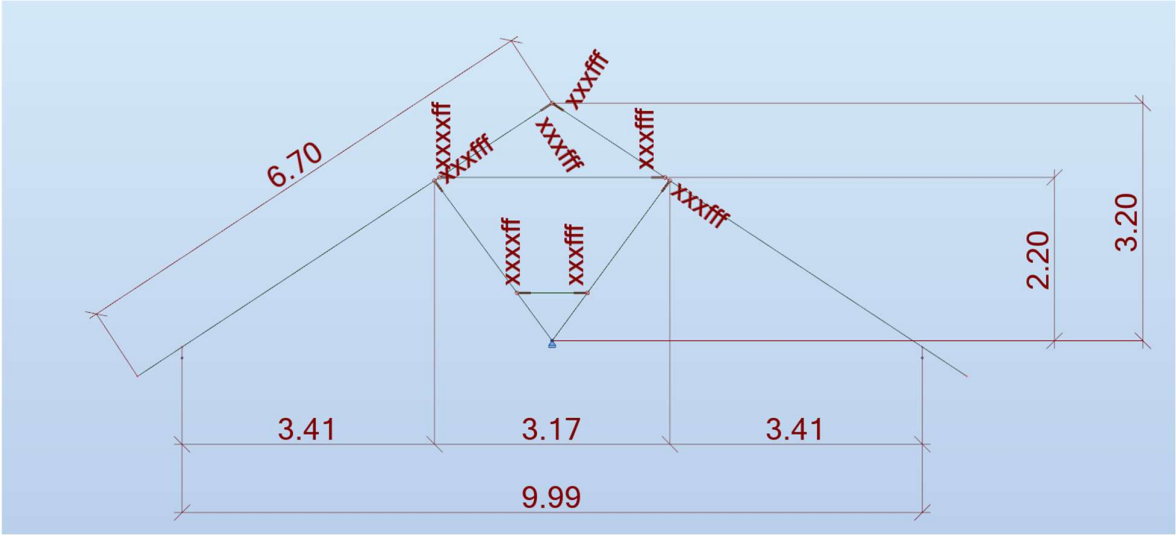
1. KONSTRUKCIJŲ SKAIČIAVIMAS

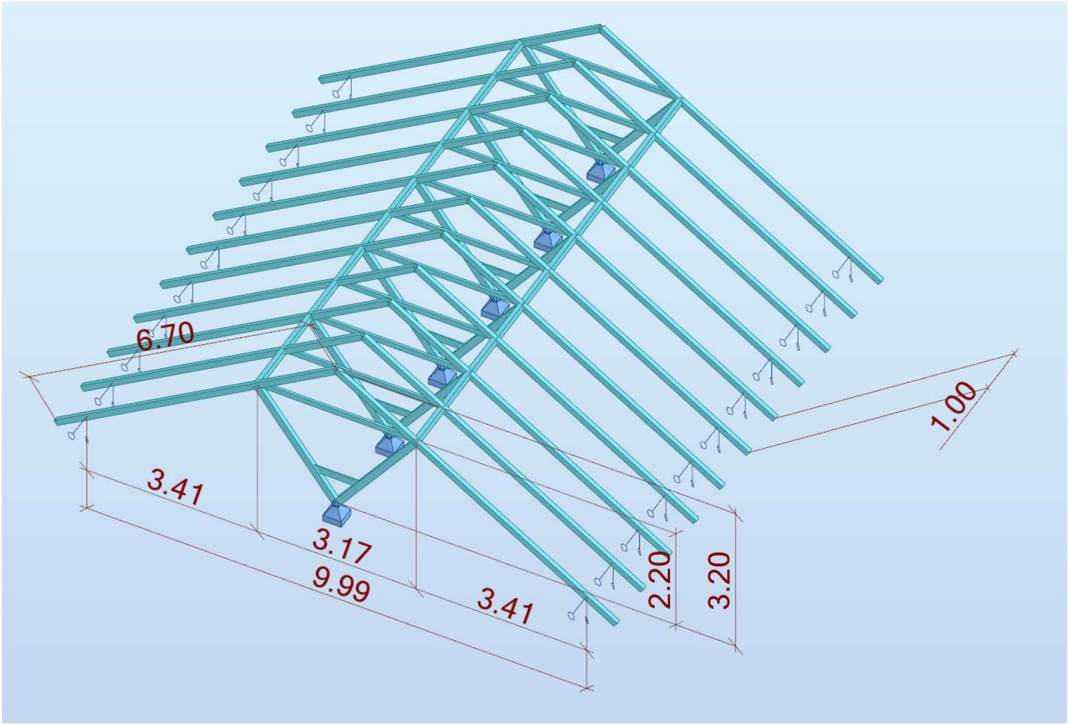
Laikančių konstrukcijų skaičiavimai atlikti baigtinių elementų skaičiavimo programa Autodesk Robot Structural Analysis Professional 2023.

1.1. Esama sena pastato dalis tarp ašių A-C

1.1.1. Esamo medinio stogo tikrinimas

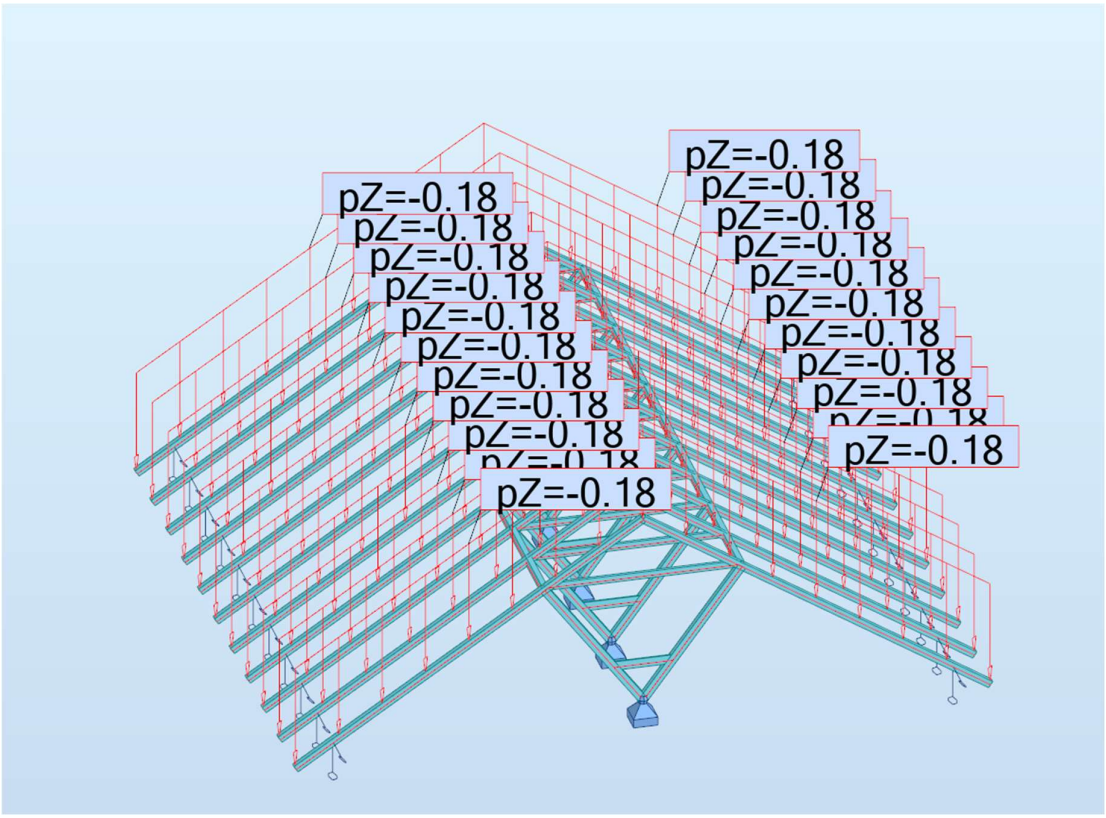
Tikrinamas esamas medinis stogas, gegnių žingsnis 1m., Pamatuotas gegnių skerspjūvis 120x90mm, spyrių pamatuotas skerspjūvis 140x90mm, stygos pamatuotas skerspjūvis 115x50mm, išilginių sijų pamatuotas skerspjūvis 140x90mm. Naudojama mažiausia medienos klasė C18. Gegnės kraige jungiasi lanksčiai, stygos ir spyriai jungiasi lanksčiai, gegnės ant išorinių sienų turi paslankias atramas. Skaičiuojamoji schema:



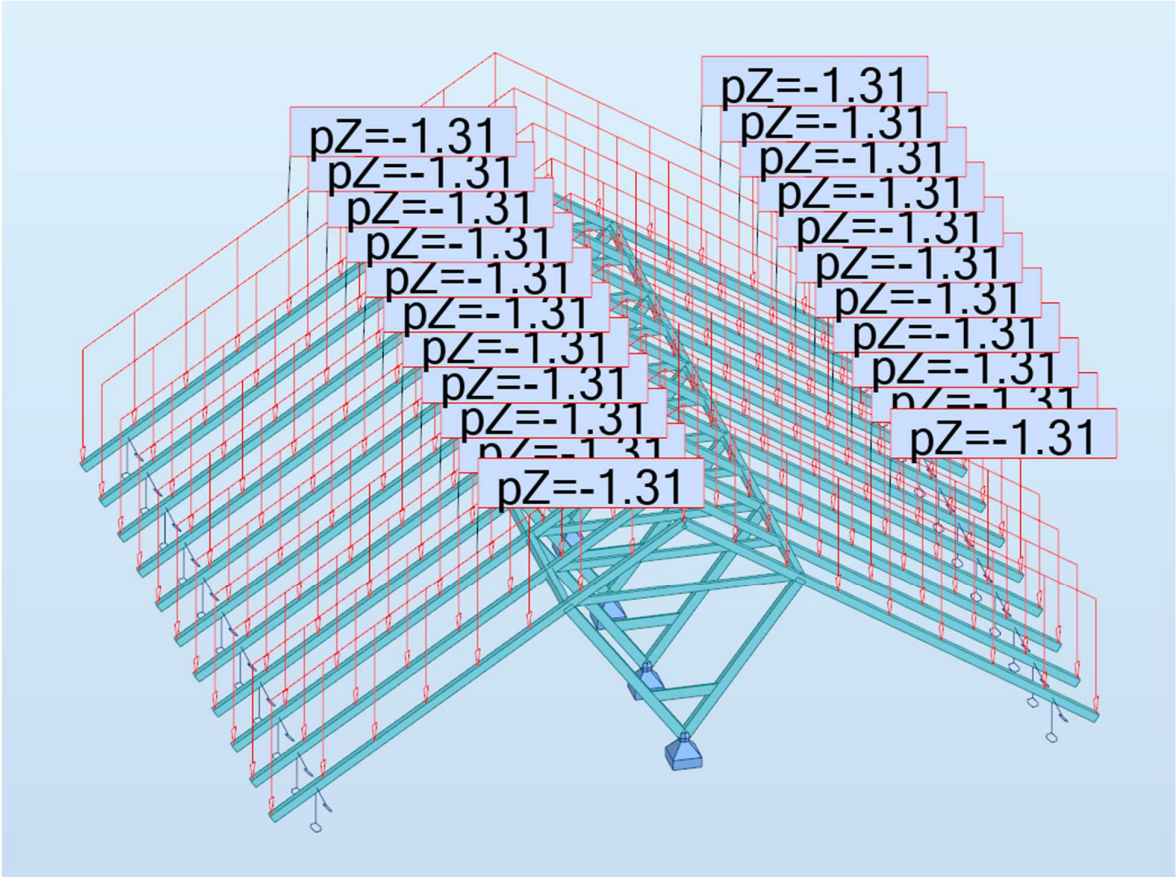


Veikiančios apkrovos (apkrovų skaičiavimas pateiktas AR 1.2 skyriuje):

Nuolatinės apkrovos:



Sniego apkrovos:



Esamų gegnių skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 44 Gegnė_44 **POINT:** 3 **COORDINATE:** x = 0.28 L = 1.90 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_120x90

ht=12.0 cm

bf=9.0 cm	Ay=72.00 cm2	Az=72.00 cm2	Ax=108.00 cm2
tw=4.5 cm	Iy=1296.00 cm4	Iz=729.00 cm4	Ix=1538.2 cm4
tf=4.5 cm	Wy=216.00 cm3	Wz=162.00 cm3	

STRESSES **ALLOWABLE STRESSES**

Sig_t,0,d = N/Ax = -8.87/108.00 = -0.82 MPa
Sig_m,y,d = MY/Wy= -2.66/216.00 = -12.30 MPa

f t,0,d = 7.50 MPa
f m,y,d = 11.58 MPa
f v,d = 2.09 MPa

Tau z,d = 1.5*-10.41/108.00 = -1.45 MPa

Factors and additional parameters

kh = 1.11 kh_y = 1.05 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 5.97 m Lambda_rel m = 0.68
Sig_cr = 38.63 MPa k crit = 1.00

BUCKLING PARAMETERS:

About Y axis: About Z axis:

VERIFICATION FORMULAS:

Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d = 0.82/7.50 + 12.30/11.58 = 1.17 > 1.00 (6.17)
Sig_m,y,d/(kcrit*f m,y,d) = 12.30/(1.00*11.58) = 1.06 > 1.00 (6.33)
(Tau z,d/kcr)/f v,d = (1.45/0.67)/2.09 = 1.03 > 1.00 (6.13)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.2 cm < u fin,max,y = L/150.00 = 4.5 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 3.0 cm < u fin,max,z = L/150.00 = 4.5 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section incorrect !!!

Tarpinė išvada: gegnių laikomoji galia nepakankama. Reikalingas stiprinimas.

Esamų sijų skaičiaivmas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 67 Sija_67 **POINT:** 1 **COORDINATE:** x = 0.50 L = 1.00 m

---

LOADS:

Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30 f m,0,k = 18.00 MPa f t,0,k = 11.00 MPa f c,0,k = 18.00 MPa
f v,k = 3.40 MPa f t,90,k = 0.40 MPa f c,90,k = 2.20 MPa E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa G moyen = 560.00 MPa Service class: 1 Beta c = 0.20

SECTION PARAMETERS: RECT_140x90

ht=14.0 cm
bf=9.0 cm Ay=84.00 cm2 Az=84.00 cm2 Ax=126.00 cm2

tw=4.5 cm Iy=2058.00 cm4 Iz=850.50 cm4 Ix=2024.2 cm4
tf=4.5 cm Wy=294.00 cm3 Wz=189.00 cm3

STRESSES

Sig_c,0,d = N/Ax = 0.03/126.00 = 0.00 MPa
Sig_m,y,d = MY/Wy= 2.89/294.00 = 9.83 MPa
Sig_m,z,d = MZ/Wz= 0.10/189.00 = 0.55 MPa
Tau y,d = 1.5*0.01/126.00 = 0.00 MPa
Tau z,d = 1.5*-2.94/126.00 = -0.35 MPa
Tau tory,d = 0.03 MPa, Tau torz,d = 0.04 MPa

ALLOWABLE STRESSES

f c,0,d = 11.08 MPa
f m,y,d = 11.23 MPa
f m,z,d = 12.27 MPa
f v,d = 2.09 MPa

Factors and additional parameters

km = 0.70 kh = 1.11 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 1.80 m Lambda_rel m = 0.39
Sig_cr = 116.58 MPa k crit = 1.00

BUCKLING PARAMETERS:

About Y axis:

LY = 2.00 m Lambda Y = 49.49
Lambda_rel Y = 0.86 ky = 0.93
LFY = 2.00 m kcy = 0.79

About Z axis:

LZ = 1.00 m Lambda Z = 38.49
Lambda_rel Z = 0.67 kz = 0.76
LFZ = 1.00 m kcz = 0.89

VERIFICATION FORMULAS:

(Sig_c,0,d/kc,y*f c,0,d) + Sig_m,y,d/f m,y,d + km*Sig_m,z,d/f m,z,d = 0.91 < 1.00 (6.23)
Sig_m,y,d/(kcrit*f m,y,d) = 9.83/(1.00*11.23) = 0.87 < 1.00 (6.33)
(Tau y,d/kcr+Tau tory,d/kshape)/f v,d = 0.02 < 1.00 (Tau z,d/kcr+Tau torz,d/kshape)/f v,d = 0.27 < 1.00 (6.13-4)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 1.3 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 0.4 cm < u fin,max,z = L/150.00 = 1.3 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

Tarpinė išvada: esamų sijų laikomoji galia pakankama.

Esamų spyrių skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 17 Styga_17 **POINT:** 3 **COORDINATE:** x = 1.00 L = 2.68 m

---

LOADS:

Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_140x90

ht=14.0 cm

bf=9.0 cm	Ay=84.00 cm2	Az=84.00 cm2	Ax=126.00 cm2
tw=4.5 cm	Iy=2058.00 cm4	Iz=850.50 cm4	Ix=2024.2 cm4
tf=4.5 cm	Wy=294.00 cm3	Wz=189.00 cm3	

STRESSES

Sig_c,0,d = N/Ax = 23.29/126.00 = 1.85 MPa
Sig_m,y,d = MY/Wy= 0.10/294.00 = 0.34 MPa

Tau z,d = 1.5*-0.12/126.00 = -0.01 MPa

ALLOWABLE STRESSES

f c,0,d = 11.08 MPa
f m,y,d = 11.23 MPa
f v,d = 2.09 MPa

Factors and additional parameters

kh = 1.11 kh_y = 1.01 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 2.41 m	Lambda_rel m = 0.45
Sig_cr = 87.09 MPa	k crit = 1.00

BUCKLING PARAMETERS:

About Y axis:

LY = 2.68 m	Lambda Y = 66.25	LZ = 2.68 m	Lambda Z = 103.05
Lambda_rel Y = 1.15	ky = 1.25	Lambda_rel Z = 1.80	kz = 2.26
LFY = 2.68 m	kcy = 0.58	LFZ = 2.68 m	kcz = 0.27

About Z axis:

VERIFICATION FORMULAS:

Sig_c,0,d/(kc,z*f c,0,d) + km*Sig_m,y,d/f m,y,d = 1.85/(0.27*11.08) + 0.70*0.34/11.23 = 0.63 < 1.00 (6.24)
Sig_c,0,d/(kc,z*f c,0,d) + (Sig_m,y,d/(kcrit*f m,y,d))^2 = 1.85/(0.27*11.08) + (0.34/(1.00*11.23))^2= 0.61 < 1.00 (6.35)
(Tau z,d/kcr)/f v,d = (0.01/0.67)/2.09 = 0.01 < 1.00 (6.13)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 1.8 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 0.0 cm < u fin,max,z = L/150.00 = 1.8 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

Tarpinė išvada: esamų spyrių laikomoji galia pakankama.

Esamų stygų skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 70 Styga_70 **POINT:** 2 **COORDINATE:** x = 0.50 L = 1.52 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_115x50

ht=11.5 cm			
bf=5.0 cm	Ay=38.33 cm2	Az=38.33 cm2	Ax=57.50 cm2
tw=2.5 cm	Iy=633.70 cm4	Iz=119.79 cm4	Ix=347.9 cm4
tf=2.5 cm	Wy=110.21 cm3	Wz=47.92 cm3	

STRESSES	**ALLOWABLE STRESSES**
Sig_t,0,d = N/Ax = -14.05/57.50 = -2.44 MPa	f t,0,d = 8.43 MPa
Sig_m,y,d = MY/Wy= -0.03/110.21 = -0.26 MPa	f m,y,d = 11.68 MPa

---

Factors and additional parameters
kh = 1.25 kh_y = 1.05 kmod = 0.80 Ksys = 1.00

LATERAL BUCKLING PARAMETERS:

lef = 2.74 m	Lambda_rel m = 0.75
Sig_cr = 31.82 MPa	k crit = 1.00

BUCKLING PARAMETERS:

 About Y axis:

 About Z axis:

VERIFICATION FORMULAS:
Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d = 2.44/8.43 + 0.26/11.68 = 0.31 < 1.00 (6.17)
Sig_m,y,d/(kcrit*f m,y,d) = 0.26/(1.00*11.68) = 0.02 < 1.00 (6.33)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 2.0 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 0.1 cm < u fin,max,z = L/150.00 = 2.0 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

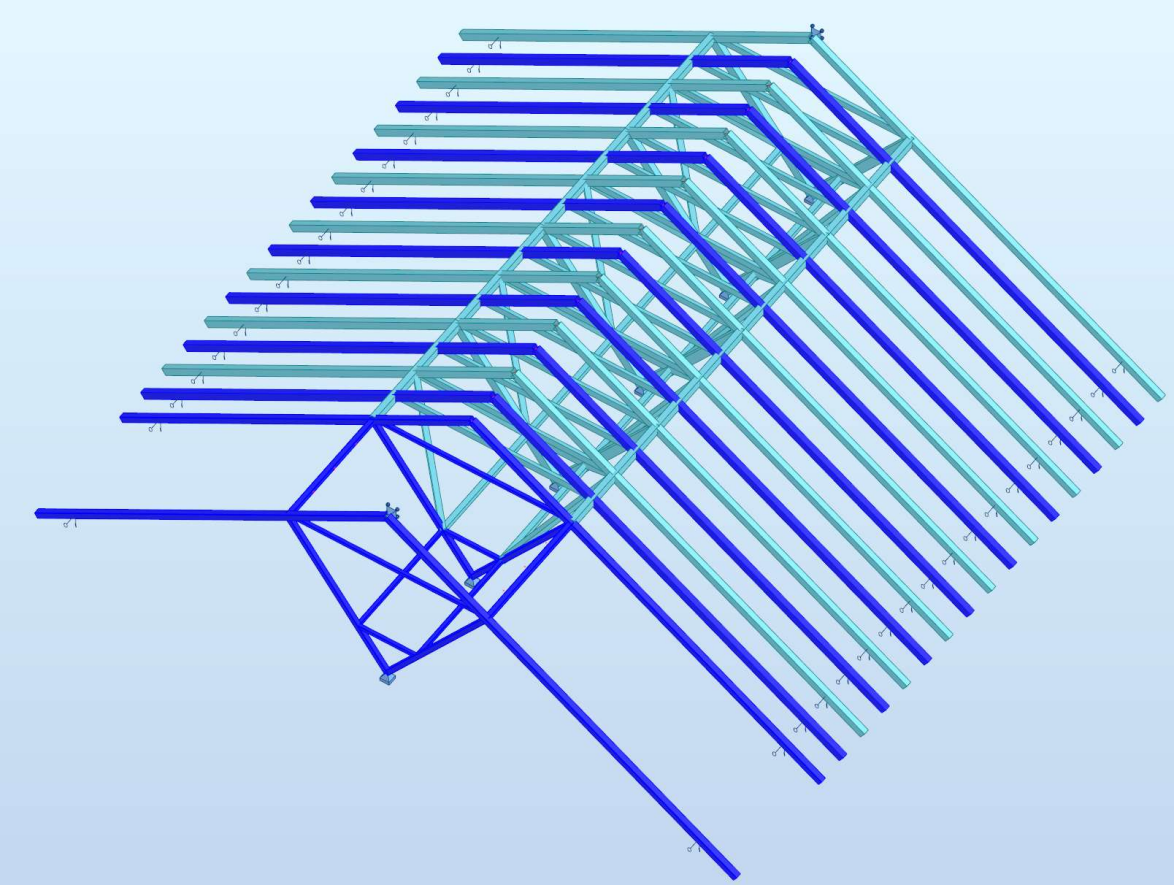
Tarpinė išvada: esamų stygų laikomoji galia pakankama.

BENDRA IŠVADA: esamų stygų, spyrių ir sijų laikomoji galia pakankama, tačiau gegnės 17% viršija saugos ribinį būvį. Reikalingas stogo stiprinimas įvedant papildomas gegnes į tarpus, išlaikant esamą skaičiuojamąją schemą. Dėl padidėjusios apkrovos ant esamų sijų galimas papildomų spyrių įvedimas, kad nukrauti siją.

Į tarpus įdedamos gegnės, išlaikant esamą skaičiuojamąją schemą, naujas gegnių žingsnis 0,5m. Kad nukrauti esamas sijas, ant kuriu remiasi gegnės, įvedami papildomi ryšiai nuo sijos vidurio link vidurinės atramos. Taip pat įvedama kraigo sija.

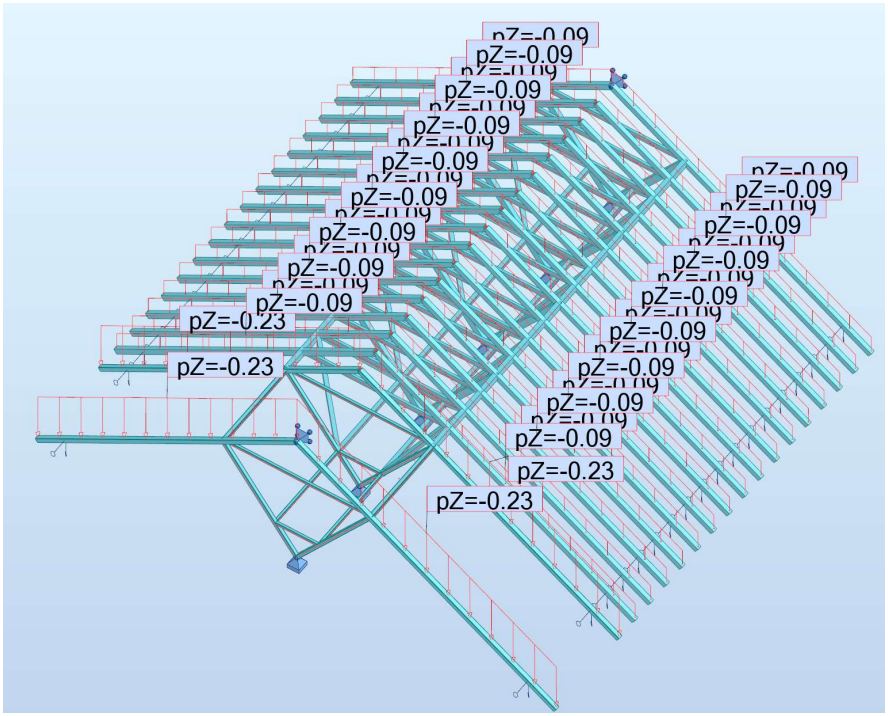
Kad užtikrinti 2m ruože nuo ugniasienės stogo ugniaatsparumą R90 demontuojamos 3 eilės esamų gegnių ir projektuojamos Plieninės gegnės iš dėžinių skerpsjūvių, suvaržytų styga ir apjungtų horizontaliais ryšiais, atkartojama medinių gegnių skaičiuojamoji schema.

Nauja skaičiuojamoji schema su pažymėtais naujais elementais:

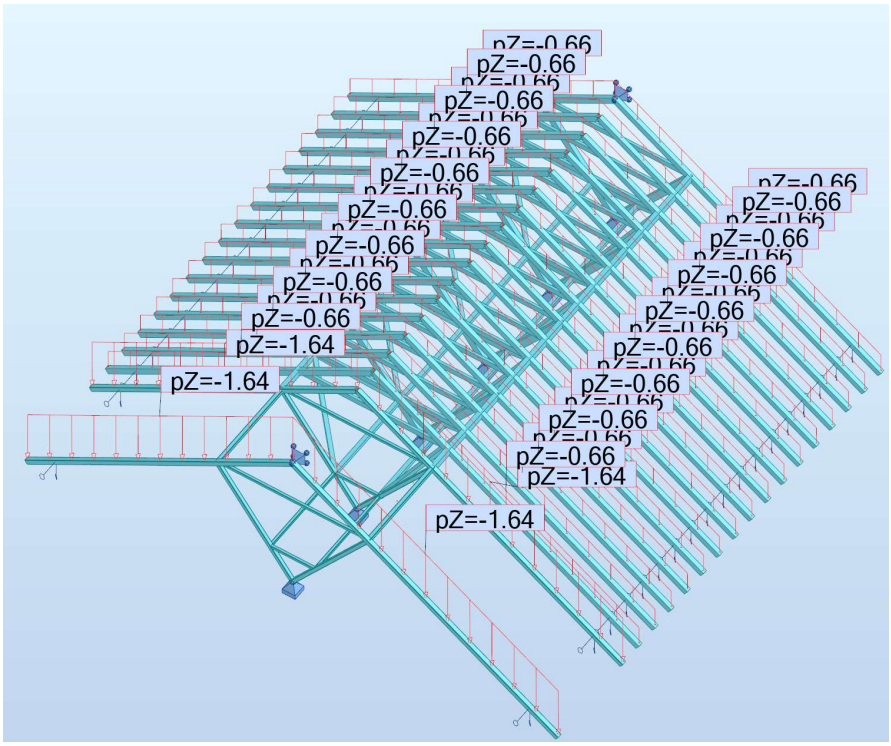


Naujos gegnes veikiančios apkrovos (apkrovų skaičiavimas pateiktas AR 1.2 skyriuje):

Nuolatinės apkrovos:



Sniego apkrovos:



Esamų/naujų gegnių skaičiavimas po stiprinimo

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 9 Gegnė_9 **POINT:** 3 **COORDINATE:** x = 0.28 L = 1.90 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_120x90

ht=12.0 cm

bf=9.0 cm	Ay=72.00 cm2	Az=72.00 cm2	Ax=108.00 cm2
tw=4.5 cm	Iy=1296.00 cm4	Iz=729.00 cm4	Ix=1538.2 cm4
tf=4.5 cm	Wy=216.00 cm3	Wz=162.00 cm3	

STRESSES
Sig_t,0,d = N/Ax = -3.22/108.00 = -0.30 MPa
Sig_m,y,d = MY/Wy= -1.33/216.00 = -6.18 MPa

Tau z,d = 1.5*-4.48/108.00 = -0.62 MPa

ALLOWABLE STRESSES
f t,0,d = 7.50 MPa
f m,y,d = 11.58 MPa
f v,d = 2.09 MPa

Factors and additional parameters
kh = 1.11 kh_y = 1.05 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 5.97 m	Lambda_rel m = 0.68
Sig_cr = 38.63 MPa	k crit = 1.00

BUCKLING PARAMETERS:

 About Y axis:

 About Z axis:

VERIFICATION FORMULAS:
Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d = 0.30/7.50 + 6.18/11.58 = 0.57 < 1.00 (6.17)
Sig_m,y,d/(kcrit*f m,y,d) = 6.18/(1.00*11.58) = 0.53 < 1.00 (6.33)
(Tau z,d/kcr)/f v,d = (0.62/0.67)/2.09 = 0.44 < 1.00 (6.13)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 4.5 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 1.6 cm < u fin,max,z = L/150.00 = 4.5 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

Tarpinė išvada: esamų/naujų gegnių laikomoji galia pakankama.

Esamų sijų skaičiavimas po stiprinimo

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 67 Sija_67 **POINT:** 3 **COORDINATE:** x = 0.75 L = 1.50 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_140x90

ht=14.0 cm

bf=9.0 cm	Ay=84.00 cm2	Az=84.00 cm2	Ax=126.00 cm2
tw=4.5 cm	Iy=2058.00 cm4	Iz=850.50 cm4	Ix=2024.2 cm4
tf=4.5 cm	Wy=294.00 cm3	Wz=189.00 cm3	

STRESSES

Sig_t,0,d = N/Ax = -0.02/126.00 = -0.00 MPa
Sig_m,y,d = MY/Wy= -0.80/294.00 = -2.73 MPa
Sig_m,z,d = MZ/Wz= -0.17/189.00 = -0.92 MPa
Tau y,d = 1.5*0.79/126.00 = 0.09 MPa
Tau z,d = 1.5*2.70/126.00 = 0.32 MPa
Tau tory,d = 0.04 MPa, Tau torz,d = 0.05 MPa

ALLOWABLE STRESSES

f t,0,d = 7.50 MPa
f m,y,d = 11.23 MPa
f m,z,d = 12.27 MPa
f v,d = 2.09 MPa

Factors and additional parameters

km = 0.70 kh = 1.11 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 1.80 m Lambda_rel m = 0.35
Sig_cr = 150.43 MPa k crit = 1.00

BUCKLING PARAMETERS:


About Y axis:


About Z axis:

VERIFICATION FORMULAS:

Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d + km*Sig_m,z,d/f m,z,d = 0.30 < 1.00 (6.17)
Sig_m,y,d/(kcrit*f m,y,d) = 2.73/(1.00*11.23) = 0.24 < 1.00 (6.33)
(Tau y,d/kcr+Tau tory,d/kshape)/f v,d = 0.09 < 1.00 (Tau z,d/kcr+Tau torz,d/kshape)/f v,d = 0.25 < 1.00 (6.13-4)

LIMIT DISPLACEMENTS


Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 1.3 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2
u fin,z = 0.0 cm < u fin,max,z = L/150.00 = 1.3 cm Verified
Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

Tarpinė išvada: esamų sijų laikomoji galia pakankama.

Plieninės gegnės projektavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 13 Metalinė gegnė_13 **POINT:** 3 **COORDINATE:** x = 0.28 L = 1.90 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL:
S 355 (S 355) fy = 355.00 MPa

SECTION PARAMETERS: SQUA 100x100x4

h=10.0 cm	gM0=1.10	gM1=1.10	
b=10.0 cm	Ay=7.47 cm2	Az=7.47 cm2	Ax=14.95 cm2
tw=0.4 cm	Iy=226.35 cm4	Iz=226.35 cm4	Ix=354.71 cm4
tf=0.4 cm	Wply=53.30 cm3	Wplz=53.30 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = -5.12 kN	My,Ed = -3.35 kN*m	
Nt,Rd = 482.41 kN	My,pl,Rd = 17.20 kN*m	
	My,c,Rd = 17.20 kN*m	Vz,Ed = -9.44 kN
	MN,y,Rd = 17.20 kN*m	Vz,c,Rd = 139.26 kN
	Mb,Rd = 17.20 kN*m	
		Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 1874.79 kN*m	Curve,LT - d	XLT = 1.00
Lcr,low=0.60 m	Lam_LT = 0.10	fi,LT = 0.39	XLT,mod = 1.00

BUCKLING PARAMETERS:

About y axis: About z axis:

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nt,Rd = 0.01 < 1.00 (6.2.3.(1))

My,Ed/My,c,Rd = 0.19 < 1.00 (6.2.5.(1))
Vz,Ed/Vz,c,Rd = 0.07 < 1.00 (6.2.6.(1))
Global stability check of member:
My,Ed/Mb,Rd = 0.19 < 1.00 (6.3.2.1.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0.0 cm < uy max = L/150.00 = 4.5 cm Verified
Governing Load Case: 7 SLS:CHR/1=1*1.00 + 2*1.00 (1+2)*1.00
uz = 0.8 cm < uz max = L/150.00 = 4.5 cm Verified
Governing Load Case: 7 SLS:CHR/1=1*1.00 + 2*1.00 (1+2)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

Tarpinė išvada: plieninės gegnės laikomoji galia pakankama

Plieninio spyrio projektavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 17 Metalinė styga_17 **POINT:** 3 **COORDINATE:** x = 1.00 L = 2.68 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL:
S 355 (S 355) fy = 355.00 MPa

SECTION PARAMETERS: SQUA 80x80x4

h=8.0 cm	gM0=1.10	gM1=1.10	
b=8.0 cm	Ay=5.87 cm2	Az=5.87 cm2	Ax=11.75 cm2
tw=0.4 cm	Iy=111.04 cm4	Iz=111.04 cm4	Ix=176.24 cm4
tf=0.4 cm	Wply=33.07 cm3	Wplz=33.07 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 22.47 kN	My,Ed = -0.06 kN*m		Vy,Ed = 0.05 kN
Nc,Rd = 379.14 kN	My,Ed,max = -0.06 kN*m	Mz,Ed,max = 0.04 kN*m	Vy,c,Rd = 109.45 kN
Nb,Rd = 215.80 kN	My,c,Rd = 10.67 kN*m	Mz,c,Rd = 10.67 kN*m	Vz,Ed = -0.09 kN
	MN,y,Rd = 10.67 kN*m		Vz,c,Rd = 109.45 kN
	Mb,Rd = 10.67 kN*m		
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 235.43 kN*m	Curve,LT - d	XLT = 1.00
Lcr,low=2.68 m	Lam_LT = 0.22	fi,LT = 0.45	XLT,mod = 1.00

BUCKLING PARAMETERS:

 About y axis:

Ly = 2.68 m Lam_y = 1.14
Lcr,y = 2.68 m Xy = 0.57
Lamy = 87.08 kyy = 1.06

 About z axis:

Lz = 2.68 m Lam_z = 1.14
Lcr,z = 2.68 m Xz = 0.57
Lamz = 87.08 kzy = 0.67

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.06 < 1.00 (6.2.4.(1))
My,Ed/My,c,Rd = 0.01 < 1.00 (6.2.5.(1))
Vy,Ed/Vy,c,Rd = 0.00 < 1.00 (6.2.6.(1))
Vz,Ed/Vz,c,Rd = 0.00 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 87.08 < Lambda,max = 210.00 Lambda,z = 87.08 < Lambda,max = 210.00 STABLE
My,Ed,max/Mb,Rd = 0.01 < 1.00 (6.3.2.1.(1))
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.11 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.11 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

 ***Deflections (LOCAL SYSTEM):***

uy = 0.0 cm < uy max = L/150.00 = 1.8 cm Verified
Governing Load Case: 7 SLS:CHR/1=1*1.00 + 2*1.00 (1+2)*1.00
uz = 0.0 cm < uz max = L/150.00 = 1.8 cm Verified
Governing Load Case: 7 SLS:CHR/1=1*1.00 + 2*1.00 (1+2)*1.00

 ***Displacements (GLOBAL SYSTEM):*** *Not analyzed*

Section OK !!!

Tarpinė išvada: plieninio spyrio laikomoji galia pakankama

Plieninės stygos projektavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 70 Metalinė styga_70 **POINT:** 2 **COORDINATE:** x = 0.50 L = 1.52 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL:
S 355 (S 355) fy = 355.00 MPa

 **SECTION PARAMETERS: SQUA 60x60x4**

h=6.0 cm gM0=1.10 gM1=1.10
b=6.0 cm Ay=4.27 cm2 Az=4.27 cm2 Ax=8.55 cm2
tw=0.4 cm Iy=43.55 cm4 Iz=43.55 cm4 Ix=70.72 cm4
tf=0.4 cm Wply=17.64 cm3 Wplz=17.64 cm3

INTERNAL FORCES AND CAPACITIES:

N,Ed = -10.47 kN
Nt,Rd = 275.87 kN
My,Ed = 0.10 kN*m
My,pl,Rd = 5.69 kN*m
My,c,Rd = 5.69 kN*m
MN,y,Rd = 5.69 kN*m

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nt,Rd = 0.04 < 1.00 (6.2.3.(1))
My,Ed/My,c,Rd = 0.02 < 1.00 (6.2.5.(1))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0.0 cm < uy max = L/150.00 = 2.0 cm Verified
Governing Load Case: 7 SLS:CHR/1=1*1.00 + 2*1.00 (1+2)*1.00
uz = 0.1 cm < uz max = L/150.00 = 2.0 cm Verified
Governing Load Case: 9 SLS:QPR/3=1*1.00 + 2*0.20 1*1.00+2*0.20

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

Tarpinė išvada: plieninės stygos laikomoji galia pakankama

BENDRA IŠVADA: įvedus naujas gegnes į tarpus ir sumažinus žingsnį iki 500mm, įvedus naujus spyrius paremti sijas, ant kurių remiasi gegnes visi konstrukcijos elementai tenkina tinkamumo ir saugos ribinius būvius. Plieninių gegnių, kurių žingsnis 2m ir plieninių ryšių ir stygų laikomoji galia pakankama. Plieniniai elementai dažomi priešgaisriniais dažas R90.

1.2. Esama naujesnė pastato dalis tarp ašių C-D

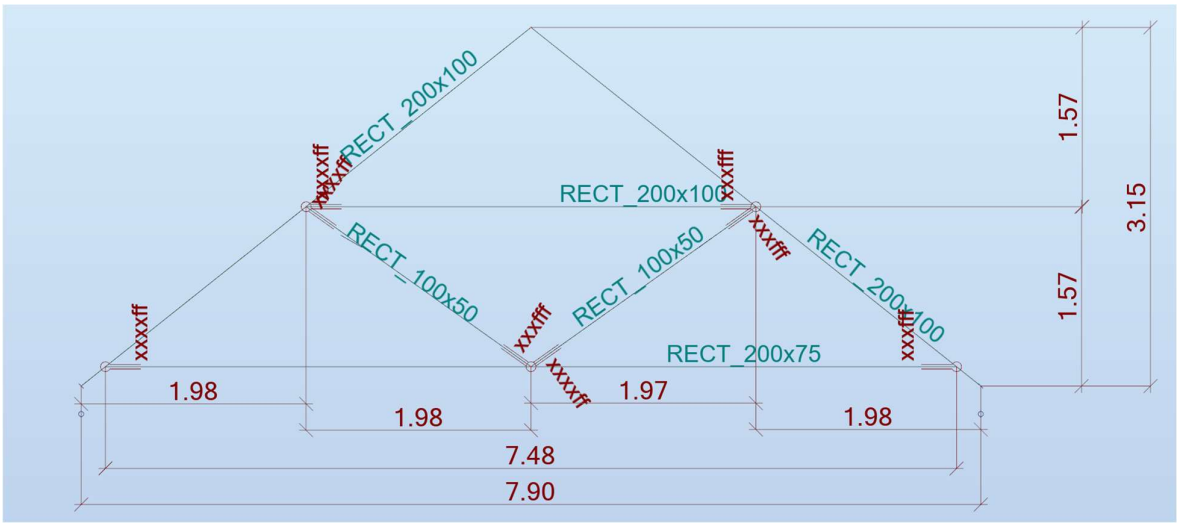
1.2.1. Naujų medinių stogo konstrukcijų projektavimas

Demontuojamas visas esamas medinis stogas ir projektuojama nauja sistema be atramos per vidurį. Naujų gegnių skerspjūvis 200x100mm, naujų įstrižų spyrių skerspjūvis 100x50mm, naujos viršutinės stygos skerspjūvis 200x100mm, naujos apatinės stygos skerspjūvis 200x75mm.

Spyriai ir stygos tvirtinasi laksčiai, gegnės kraige tvirtinasi lanksčiai, gegnių atrama išorinėse sienose paslanki. Naudojama medienos klasė C18. Gegnių tarpatramis 1m.

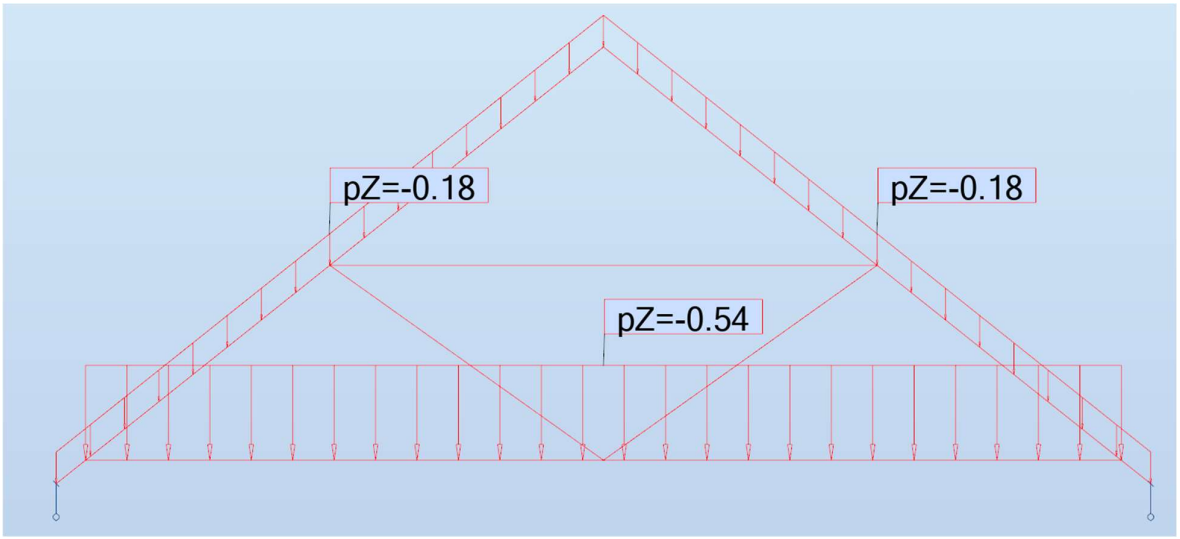
Ant apatinės stygos projektuojama palėpės perdanga su 1kPa naudojimo apkrova.

Skaičiuojamoji schema:

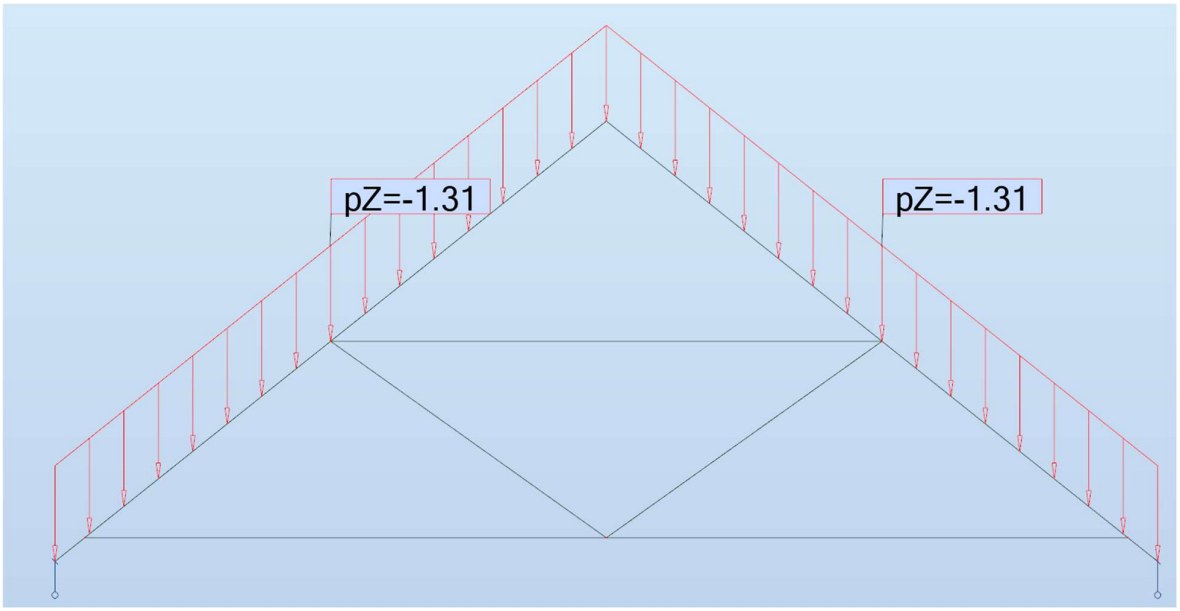


Veikiančios apkrovos (apkrovų skaičiavimas pateiktas AR 1.2 skyriuje):

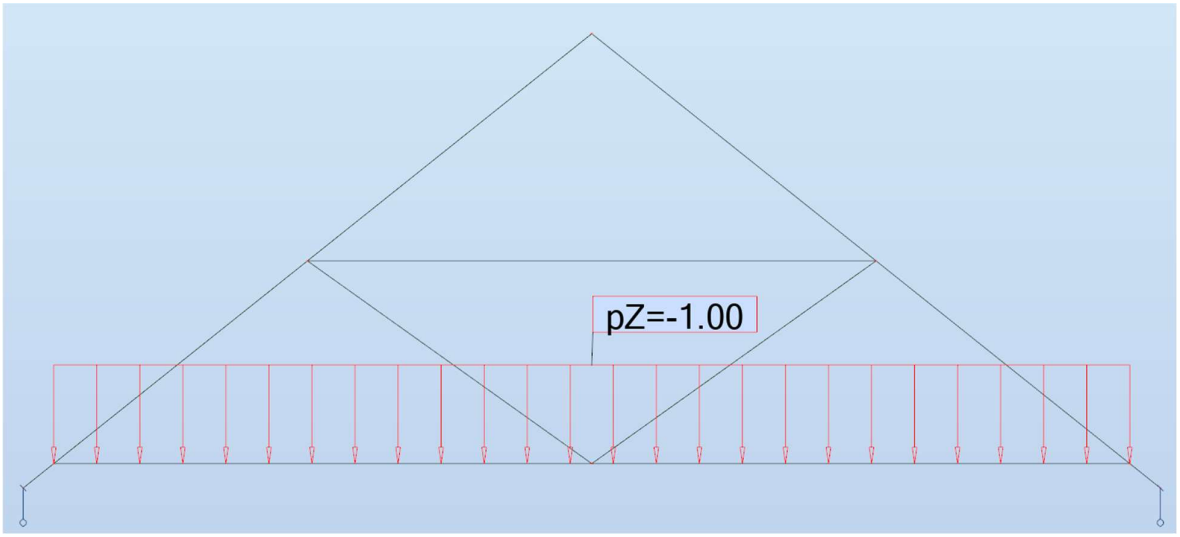
Nuolatinės apkrovos:



Sniego apkrovos:



Naudojimo apkrovos:



Gegnės skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 4 Gegnė_4 **POINT:** 3 **COORDINATE:** x = 1.00 L = 5.05 m

---

LOADS:
Governing Load Case: 10 ULS/7=1*1.35 + 3*0.91 + 2*1.30 1*1.35+3*0.91+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa

E 0,05 = 6000.00 MPa G moyen = 560.00 MPa Service class: 1 Beta c = 0.20

SECTION PARAMETERS: RECT_200x100

ht=20.0 cm

bf=10.0 cm	Ay=133.33 cm2	Az=133.33 cm2	Ax=200.00 cm2
tw=5.0 cm	Iy=6666.67 cm4	Iz=1666.67 cm4	Ix=4573.7 cm4
tf=5.0 cm	Wy=666.67 cm3	Wz=333.33 cm3	

STRESSES

Sig_c,0,d = N/Ax = 10.50/200.00 = 0.53 MPa

Tau z,d = 1.5*-13.17/200.00 = -0.99 MPa

ALLOWABLE STRESSES

f c,0,d = 11.08 MPa

f v,d = 2.09 MPa

Factors and additional parameters

kh = 1.08 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis:

LY = 2.53 m	Lambda Y = 43.75	LZ = 0.30 m	Lambda Z = 10.39
Lambda_rel Y = 0.76	ky = 0.84	Lambda_rel Z = 0.18	kz = 0.50
LFY = 2.53 m	kcy = 0.85	LFZ = 0.30 m	kcz = 1.00

About Z axis:

VERIFICATION FORMULAS:

Sig_c,0,d/f c,0,d = 0.53/11.08 = 0.05 < 1.00 (6.23-4)]

Sig_c,0,d/(kc*f c,0,d) = 0.53/(0.85*11.08) = 0.06 < 1.00 (6.23-4)

(Tau z,d/kcr)/f v,d = (0.99/0.67)/2.09 = 0.70 < 1.00 (6.13)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 3.4 cm Verified

Governing load case: (1+0.6)*1

u fin,z = 0.3 cm < u fin,max,z = L/150.00 = 3.4 cm Verified

Governing load case: (1+0.6)*1 + (1+0.2*0.6)*2 + (0.7+0.3*0.6)*3

Displacements (GLOBAL SYSTEM):

Section OK !!!

Išvada: gegnės laikomoji galia pakankama

Apatinės stygos skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*

ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 5 Styga1_5 **POINT:** 1 **COORDINATE:** x = 0.50 L = 3.74 m

---

LOADS:

Governing Load Case: 5 ULS/2=1*1.35 + 3*1.30 1*1.35+3*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_200x75

ht=20.0 cm

bf=7.5 cm	Ay=100.00 cm2	Az=100.00 cm2	Ax=150.00 cm2
tw=3.8 cm	Iy=5000.00 cm4	Iz=703.12 cm4	Ix=2148.0 cm4
tf=3.8 cm	Wy=500.00 cm3	Wz=187.50 cm3	

STRESSES

Sig_t,0,d = N/Ax = -9.64/150.00 = -0.64 MPa

Sig_m,y,d = MY/Wy= -3.48/500.00 = -6.96 MPa

Tau z,d = 1.5*4.84/150.00 = 0.48 MPa

ALLOWABLE STRESSES

f t,0,d = 6.80 MPa

f m,y,d = 9.69 MPa

f v,d = 1.83 MPa

Factors and additional parameters

kh = 1.15 kh_y = 1.00 kmod = 0.70 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 6.63 m Lambda_rel m = 1.02

Sig_cr = 17.44 MPa k crit = 0.80

BUCKLING PARAMETERS:

 About Y axis:

 About Z axis:

VERIFICATION FORMULAS:

Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d = 0.64/6.80 + 6.96/9.69 = 0.81 < 1.00 (6.17)

Sig_m,y,d/(kcrit*f m,y,d) = 6.96/(0.80*9.69) = 0.90 < 1.00 (6.33)

(Tau z,d/kcr)/f v,d = (0.48/0.67)/1.83 = 0.39 < 1.00 (6.13)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 5.0 cm Verified

Governing load case: (1+0.6)*1

u fin,z = 0.6 cm < u fin,max,z = L/150.00 = 5.0 cm Verified

Governing load case: (1+0.6)*1 + (0.7+0.2*0.6)*2 + (1+0.3*0.6)*3

Displacements (GLOBAL SYSTEM):

Section OK !!!

Išvada: apatinės stygos laikomoji galia pakankama

Viršutinės stygos skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*

ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 6 Styga_6 **POINT:** 2 **COORDINATE:** x = 0.50 L = 1.97 m

---

LOADS:
Governing Load Case: 4 ULS/1=1*1.35 + 3*1.30 + 2*0.91 1*1.35+3*1.30+2*0.91

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_200x100

ht=20.0 cm			
bf=10.0 cm	Ay=133.33 cm2	Az=133.33 cm2	Ax=200.00 cm2
tw=5.0 cm	Iy=6666.67 cm4	Iz=1666.67 cm4	Ix=4566.7 cm4
tf=5.0 cm	Wy=666.67 cm3	Wz=333.33 cm3	

STRESSES
Sig_c,0,d = N/Ax = 21.44/200.00 = 1.07 MPa
Sig_m,y,d = MY/Wy= 0.17/666.67 = 0.25 MPa

ALLOWABLE STRESSES
f c,0,d = 11.08 MPa
f m,y,d = 11.08 MPa

Factors and additional parameters
kh = 1.08 kh_y = 1.00 kmod = 0.80 Ksys = 1.00

LATERAL BUCKLING PARAMETERS:
lef = 3.55 m Lambda_rel m = 0.57
Sig_cr = 54.73 MPa k crit = 1.00

BUCKLING PARAMETERS:

About Y axis:

About Z axis:

LY = 3.95 m	Lambda Y = 68.42	LZ = 3.95 m	Lambda Z = 136.83
Lambda_rel Y = 1.19	ky = 1.30	Lambda_rel Z = 2.39	kz = 3.55
LFY = 3.95 m	kcy = 0.55	LFZ = 3.95 m	kcz = 0.16

VERIFICATION FORMULAS:
Sig_c,0,d/(kc,z*f c,0,d) + km*Sig_m,y,d/f m,y,d = 1.07/(0.16*11.08) + 0.70*0.25/11.08 = 0.61 < 1.00 (6.24)
Sig_c,0,d/(kc,z*f c,0,d) + (Sig_m,y,d/(kcrit*f m,y,d))^2 = 1.07/(0.16*11.08) + (0.25/(1.00*11.08))^2= 0.60 < 1.00 (6.35)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 2.6 cm Verified
Governing load case: (1+0.6)*1
u fin,z = 0.1 cm < u fin,max,z = L/150.00 = 2.6 cm Verified
Governing load case: (1+0.6)*1 + (1+0.3*0.6)*3

Displacements (GLOBAL SYSTEM):

Section OK !!!

Išvada: viršutinės stygos laikomoji galia pakankama

Įstrižo spyrio skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 2 Styga_2 **POINT:** 2 **COORDINATE:** x = 0.50 L = 1.21 m

---

LOADS:
Governing Load Case: 5 ULS/2=1*1.35 + 3*1.30 1*1.35+3*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_100x50

ht=10.0 cm			
bf=5.0 cm	Ay=33.33 cm2	Az=33.33 cm2	Ax=50.00 cm2
tw=2.5 cm	Iy=416.67 cm4	Iz=104.17 cm4	Ix=285.4 cm4
tf=2.5 cm	Wy=83.33 cm3	Wz=41.67 cm3	

STRESSES
Sig_t,0,d = N/Ax = -8.39/50.00 = -1.68 MPa
Sig_m,y,d = MY/Wy= -0.01/83.33 = -0.15 MPa

ALLOWABLE STRESSES
f t,0,d = 7.38 MPa
f m,y,d = 10.51 MPa

Factors and additional parameters
kh = 1.25 kh_y = 1.08 kmod = 0.70 Ksys = 1.00

LATERAL BUCKLING PARAMETERS:
lef = 2.18 m Lambda_rel m = 0.64
Sig_cr = 44.59 MPa k crit = 1.00

BUCKLING PARAMETERS:

About Y axis:

About Z axis:

VERIFICATION FORMULAS:
Sig_t,0,d/f t,0,d + Sig_m,y,d/f m,y,d = 1.68/7.38 + 0.15/10.51 = 0.24 < 1.00 (6.17)
Sig_m,y,d/(kcrit*f m,y,d) = 0.15/(1.00*10.51) = 0.01 < 1.00 (6.33)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
u fin,y = 0.0 cm < u fin,max,y = L/150.00 = 1.6 cm Verified
Governing load case: (1+0.6)*1
u fin,z = 0.0 cm < u fin,max,z = L/150.00 = 1.6 cm Verified
Governing load case: (1+0.6)*1 + (1+0.3*0.6)*3

Displacements (GLOBAL SYSTEM):

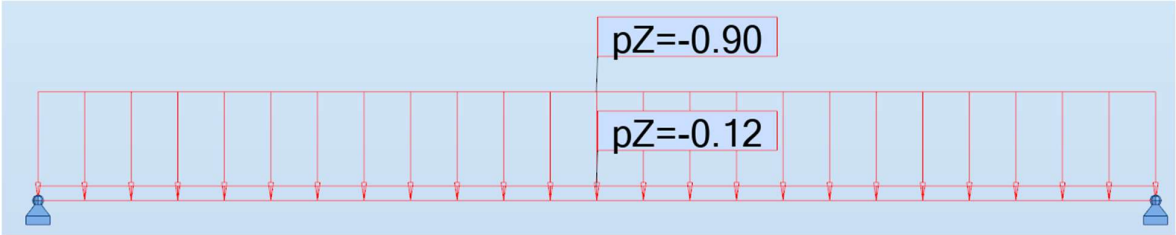
Section OK !!!

Išvada: įstrižo spyrio laikomoji galia pakankama

1.2.2. Medinės perdangos ant apatinės stygos tašo projektavimas

Ant apatinės stygos projektuojama medinė perdanga (PST-1 mazgas). Viršutinio tašo tarpatramis 1m. Tašas projektuojamas kaip laisvai atremta dviatramė sija. Tašo skerpsjūvis 50x50mm. Naudojama medienos klasė C18. Tašo žingsnis 900mm.

Skaičiuojamoji schema su veikiančiomis apkrovomis (apkrovų skaičiavimas pateiktas AR 1.2 skyriuje):



Medinės perdangos tašo skaičiavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 1 Tašas_1 **POINT:** 2 **COORDINATE:** x = 0.50 L = 0.50 m

---

LOADS:
Governing Load Case: 3 ULS/1=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_50x50

ht=5.0 cm			
bf=5.0 cm	Ay=16.67 cm2	Az=16.67 cm2	Ax=25.00 cm2
tw=2.5 cm	Iy=52.08 cm4	Iz=52.08 cm4	Ix=77.1 cm4
tf=2.5 cm	Wy=20.83 cm3	Wz=20.83 cm3	

STRESSES
Sig_m,y,d = MY/Wy= 0.17/20.83 = 8.06 MPa

ALLOWABLE STRESSES
f m,y,d = 12.07 MPa

Factors and additional parameters
kh_y = 1.25 kmod = 0.70 Ksys = 1.00

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About Y axis: About Z axis:

VERIFICATION FORMULAS:

Sig_m,y,d/f m,y,d = 8.06/12.07 = 0.67 < 1.00 (6.11)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.0 cm < u fin,max,y = L/120.00 = 0.8 cm Verified

Governing load case: (1+0.6)*1

u fin,z = 0.4 cm < u fin,max,z = L/120.00 = 0.8 cm Verified

Governing load case: (1+0.6)*1 + (1+0.3*0.6)*2

Displacements (GLOBAL SYSTEM):

Section OK !!!

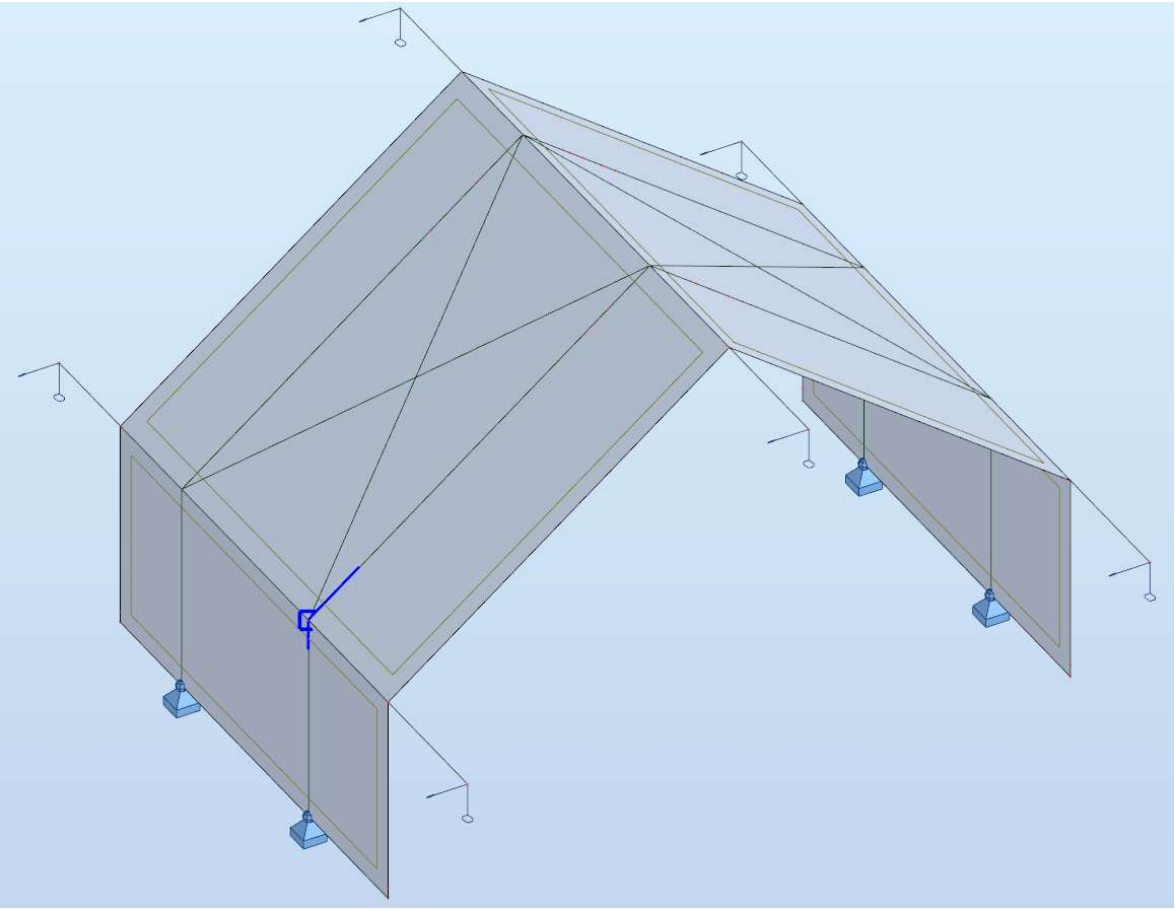
Išvada: tašo laikomoji galia ir poslinkiai neviršija ribinių

1.3. Naujo priestato tarp ašių D-E projektavimas

1.3.1. Plieninių konstrukcijų karkaso projektavimas

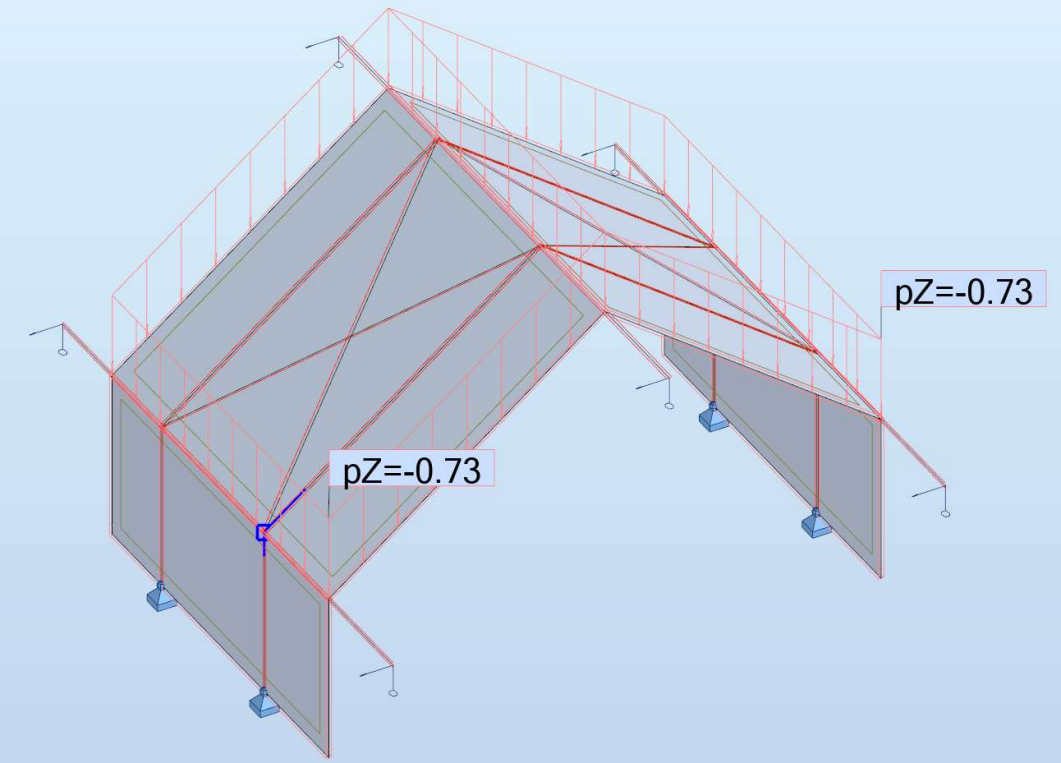
Naujo priestato sistema karkasinė sieninė. Projektuojami du metaliniai rėmai iš dvitėjinių skerspjūvių. Naudojama plieno klasė S355J2. Kolonos bazė lankstinė, sija su kolona jungiama standžiai, sijos tarpusavyje jungiamos standžiai. Rėmai lanksčiai sujungiami horizontaliais ir įstrižais ryšiais tarpusavyje, galuose ryšiai tvirtinami prie mūrinių sienų. Mūrinės sienos veikia kaip standumo diafragmos, kurios užtikrina sistemos stabilumą. Ryšiai iš dėžinių profilių. Naudojama plieno klasė S355J2H.

Skaičiuojamoji schema:

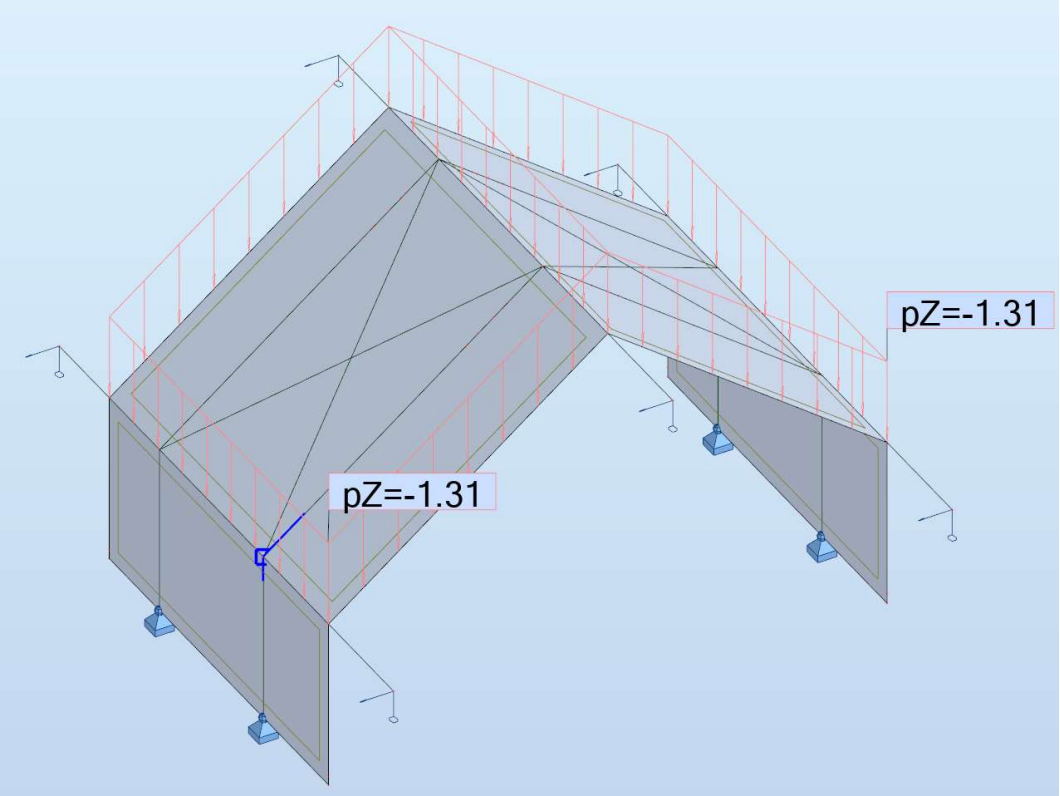


Veikiančios apkrovos (apkrovų skaičiavimas pateiktas AR 1.2 skyriuje):

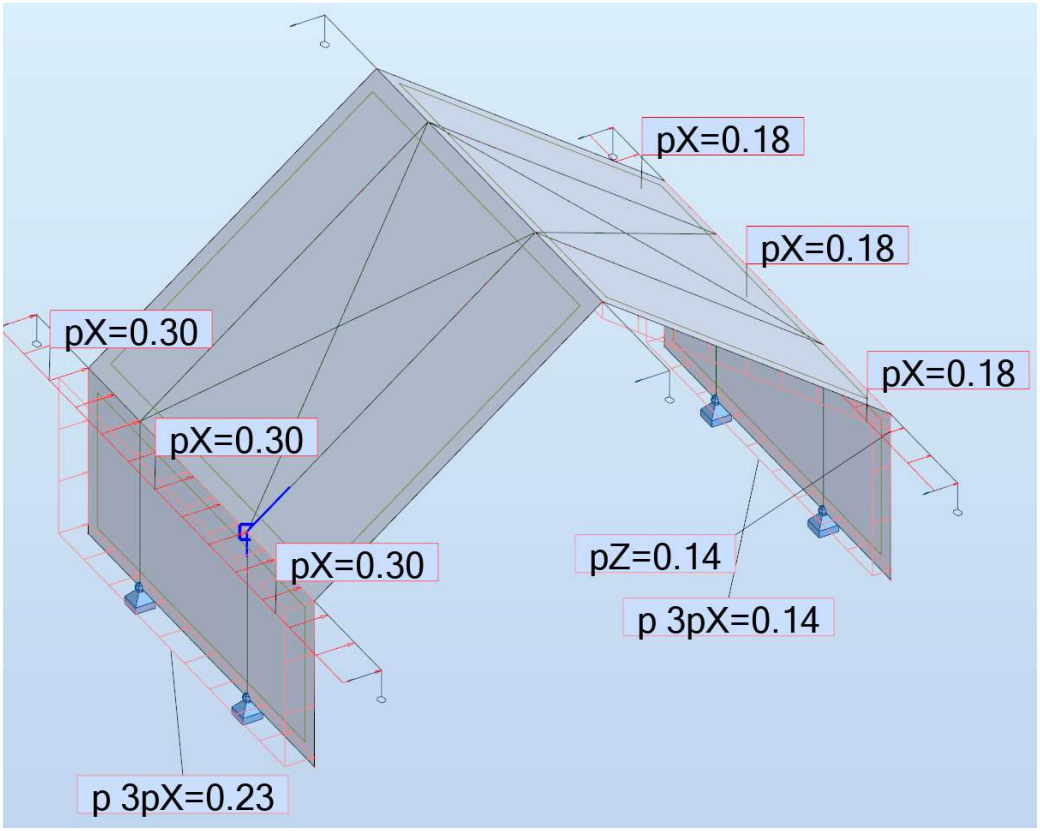
Nuolatinės apkrovos:



Sniego apkrovos:



Vėjo apkrovos:



Kolonos skaičiavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 2 Column_2 **POINT:** 3 **COORDINATE:** x = 1.00 L = 2.55 m

---

LOADS:
Governing Load Case: 10 ULS/7=1*1.35 + 3*0.78 + 2*1.30 1*1.35+3*0.78+2*1.30

MATERIAL:
S 355 (S 355) fy = 355.00 MPa

SECTION PARAMETERS: IPE 300

h=30.0 cm	gM0=1.10	gM1=1.10	
b=15.0 cm	Ay=36.16 cm2	Az=25.68 cm2	Ax=53.81 cm2
tw=0.7 cm	Iy=8356.11 cm4	Iz=603.78 cm4	Ix=19.47 cm4
tf=1.1 cm	Wply=628.40 cm3	Wplz=125.22 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 48.49 kN	My,Ed = 39.45 kN*m	Mz,Ed = 0.00 kN*m	Vy,Ed = -0.00 kN
Nc,Rd = 1736.66 kN	My,Ed,max = 39.45 kN*m	Mz,Ed,max = 0.00 kN*m	Vy,c,Rd = 673.78 kN
Nb,Rd = 1363.57 kN	My,c,Rd = 202.80 kN*m	Mz,c,Rd = 40.41 kN*m	Vz,Ed = 15.05 kN

MN,y,Rd = 202.80 kN*m MN,z,Rd = 40.41 kN*m Vz,c,Rd = 478.52 kN
Mb,Rd = 202.80 kN*m

Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 617.14 kN*m	Curve,LT - b	XLT = 0.92
Lcr,upp=2.55 m	Lam_LT = 0.60	fi,LT = 0.67	XLT,mod = 1.00

BUCKLING PARAMETERS:

About y axis: About z axis:

Ly = 2.55 m	Lam_y = 0.54	Lz = 2.55 m	Lam_z = 0.70
Lcr,y = 5.10 m	Xy = 0.91	Lcr,z = 1.78 m	Xz = 0.79
Lamy = 40.93	kyy = 0.79	Lamz = 53.29	kyz = 0.54

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.03 < 1.00 (6.2.4.(1))
My,Ed/MN,y,Rd = 0.19 < 1.00 (6.2.9.1.(2))
Mz,Ed/MN,z,Rd = 0.00 < 1.00 (6.2.9.1.(2))
(My,Ed/MN,y,Rd)^ 2.00 + (Mz,Ed/MN,z,Rd)^1.00 = 0.04 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,c,Rd = 0.00 < 1.00 (6.2.6.(1))
Vz,Ed/Vz,c,Rd = 0.03 < 1.00 (6.2.6.(1))

Global stability check of member:

Lambda,y = 40.93 < Lambda,max = 120.00 Lambda,z = 53.29 < Lambda,max = 120.00 STABLE
My,Ed,max/Mb,Rd = 0.19 < 1.00 (6.3.2.1.(1))
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.18 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.12 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM): *Not analyzed*

Displacements (GLOBAL SYSTEM):

vx = 0.36 cm < vx max = L/700.00 = 0.36 cm Verified
Governing Load Case: 14 SLS:CHR/1=1*1.00 + 3*1.00 + 2*0.70 (1+3)*1.00+2*0.70
vy = 0.04 cm < vy max = L/700.00 = 0.36 cm Verified
Governing Load Case: 18 SLS:CHR/5=1*1.00 + 2*1.00 (1+2)*1.00

Section OK !!!

Išvada: sąlyga tenkinama

Sijos skaičiavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 8 Sija 1_8 **POINT:** 3 **COORDINATE:** x = 1.00 L = 5.22 m

---

LOADS:
Governing Load Case: 10 ULS/7=1*1.35 + 3*0.78 + 2*1.30 1*1.35+3*0.78+2*1.30

MATERIAL:

S 355 (S 355) fy = 355.00 MPa

SECTION PARAMETERS: IPE 300

h=30.0 cm	gM0=1.10	gM1=1.10	
b=15.0 cm	Ay=36.16 cm2	Az=25.68 cm2	Ax=53.81 cm2
tw=0.7 cm	Iy=8356.11 cm4	Iz=603.78 cm4	Ix=19.47 cm4
tf=1.1 cm	Wply=628.40 cm3	Wplz=125.22 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 36.67 kN	My,Ed = -39.45 kN*m	Mz,Ed = 0.00 kN*m	Vy,Ed = -0.00 kN
Nc,Rd = 1736.66 kN	My,Ed,max = -39.45 kN*m		Mz,Ed,max = 0.00 kN*m
	Vy,T,Rd = 673.74 kN		
Nb,Rd = 1578.03 kN	My,c,Rd = 202.80 kN*m	Mz,c,Rd = 40.41 kN*m	Vz,Ed = -28.37 kN
	MN,y,Rd = 202.80 kN*m	MN,z,Rd = 40.41 kN*m	Vz,T,Rd = 478.50 kN
	Mb,Rd = 202.80 kN*m		Tt,Ed = 0.00 kN*m
			Class of section = 1

LATERAL BUCKLING PARAMETERS:

z = 1.00	Mcr = 1348.95 kN*m	Curve,LT - b	XLT = 1.00
Lcr,low=1.00 m	Lam_LT = 0.41	fi,LT = 0.56	XLT,mod = 1.00

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 5.22 m	Lam_y = 0.55	Lz = 1.00 m	Lam_z = 0.39
Lcr,y = 5.22 m	Xy = 0.91	Lcr,z = 1.00 m	Xz = 0.93
Lamy = 41.88	kyy = 1.00	Lamz = 29.85	kyz = 0.68

VERIFICATION FORMULAS:

Section strength check:

N,Ed/Nc,Rd = 0.02 < 1.00 (6.2.4.(1))
My,Ed/MN,y,Rd = 0.19 < 1.00 (6.2.9.1.(2))
Mz,Ed/MN,z,Rd = 0.00 < 1.00 (6.2.9.1.(2))
(My,Ed/MN,y,Rd)^ 2.00 + (Mz,Ed/MN,z,Rd)^1.00 = 0.04 < 1.00 (6.2.9.1.(6))
Vy,Ed/Vy,T,Rd = 0.00 < 1.00 (6.2.6-7)
Vz,Ed/Vz,T,Rd = 0.06 < 1.00 (6.2.6-7)
Tau,ty,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)
Tau,tz,Ed/(fy/(sqrt(3)*gM0)) = 0.00 < 1.00 (6.2.6)

Global stability check of member:

Lambda,y = 41.88 < Lambda,max = 150.00 Lambda,z = 29.85 < Lambda,max = 150.00 STABLE
My,Ed,max/Mb,Rd = 0.19 < 1.00 (6.3.2.1.(1))
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) + kyz*Mz,Ed,max/(Mz,Rk/gM1) = 0.22 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) + kzz*Mz,Ed,max/(Mz,Rk/gM1) = 0.12 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

uy = 0.00 cm < uy max = L/150.00 = 3.48 cm Verified
Governing Load Case: 14 SLS:CHR/1=1*1.00 + 3*1.00 + 2*0.70 (1+3)*1.00+2*0.70
uz = 0.13 cm < uz max = L/150.00 = 3.48 cm Verified
Governing Load Case: 18 SLS:CHR/5=1*1.00 + 2*1.00 (1+2)*1.00

Displacements (GLOBAL SYSTEM): *Not analyzed*

Section OK !!!

Išvada: sąlyga tenkinama

Įstrižo rysio skaičiavimas

CODE: *EN 1993-1:2005/A1:2014, Eurocode 3: Design of steel structures.*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 13 rysys_13 **POINT:** 2 **COORDINATE:** x = 0.50 L = 2.95 m

---

LOADS:
Governing Load Case: 11 ULS/8=1*1.35 + 2*1.30 1*1.35+2*1.30

MATERIAL:
S 355 (S 355) fy = 355.00 MPa

SECTION PARAMETERS: SQUA 80x80x4

h=8.0 cm	gM0=1.10	gM1=1.10	
b=8.0 cm	Ay=5.87 cm2	Az=5.87 cm2	Ax=11.75 cm2
tw=0.4 cm	Iy=111.04 cm4	Iz=111.04 cm4	Ix=176.24 cm4
tf=0.4 cm	Wply=33.07 cm3	Wplz=33.07 cm3	

INTERNAL FORCES AND CAPACITIES:

N,Ed = 3.90 kN	My,Ed = 0.45 kN*m
Nc,Rd = 379.14 kN	My,Ed,max = 0.45 kN*m
Nb,Rd = 55.17 kN	My,c,Rd = 10.67 kN*m
	MN,y,Rd = 10.67 kN*m

Class of section = 1

LATERAL BUCKLING PARAMETERS:

BUCKLING PARAMETERS:

About y axis:

About z axis:

Ly = 5.90 m	Lam_y = 2.51	Lz = 1.00 m	Lam_z = 0.43
Lcr,y = 5.90 m	Xy = 0.15	Lcr,z = 1.00 m	Xz = 0.95
Lamy = 191.86	kyy = 1.03	Lamz = 32.53	kzy = 0.69

VERIFICATION FORMULAS:
Section strength check:
N,Ed/Nc,Rd = 0.01 < 1.00 (6.2.4.(1))
My,Ed/My,c,Rd = 0.04 < 1.00 (6.2.5.(1))
Global stability check of member:
Lambda,y = 191.86 < Lambda,max = 200.00 Lambda,z = 32.53 < Lambda,max = 200.00 STABLE
N,Ed/(Xy*N,Rk/gM1) + kyy*My,Ed,max/(XLT*My,Rk/gM1) = 0.11 < 1.00 (6.3.3.(4))
N,Ed/(Xz*N,Rk/gM1) + kzy*My,Ed,max/(XLT*My,Rk/gM1) = 0.04 < 1.00 (6.3.3.(4))

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
uy = 0.00 cm < uy max = L/150.00 = 3.93 cm Verified
Governing Load Case: 17 SLS:CHR/4=1*1.00 + 3*0.60 + 2*1.00 (1+2)*1.00+3*0.60

uz = 0.52 cm < uz max = L/150.00 = 3.93 cm Verified
Governing Load Case: 19 SLS:QPR/6=1*1.00 + 2*0.20 1*1.00+2*0.20

Displacements (GLOBAL SYSTEM): *Not analyzed*

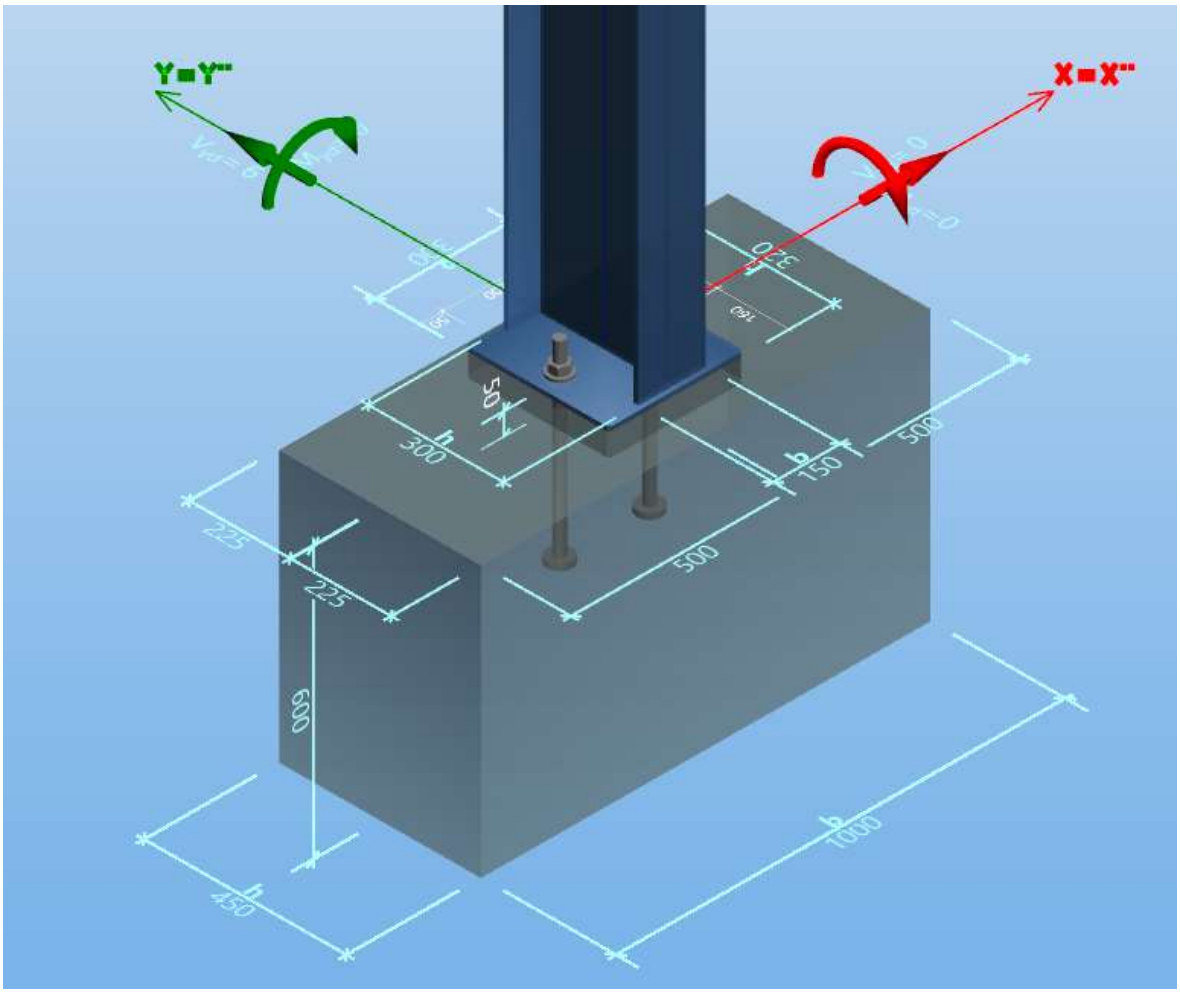
Section OK !!!

Išvada: sąlyga tenkinama

1.3.2. Plieninio karkaso mazgų projektavimas

1.3.2.1. Kolonų inkarinių varžtų projektavimas

Metalinės kolonos bazės inkariniai varžtai pagal atramines reakcijas pamate parenkami „Peikko Designer“ programa.



Summary

Name	Stage	#	Load Case	Page No.	Max Utilization	Status
Column 1	Final	1	Nd=-32.0, Mxd=0.0, Myd=0.0, Vxd=0.0, Vyd=6.0	4	2%	OK

Column 1

Note:

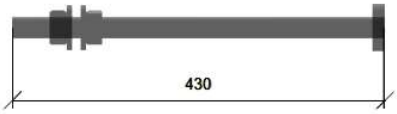
Number of Columns: 1

Peikko Products

Bolts: 2 x HPM24L

Totals

Product	Amount
HPM24L	2



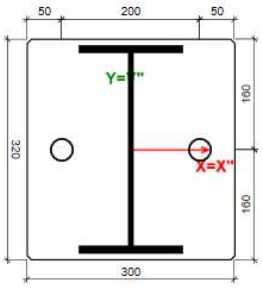
Minimum required torque value of nuts : T_{min} = 200 Nm
Maximum allowed torque value of nuts : T_{max} = 380 Nm
Bolt installation template: PPL24-2 200

Materials and Geometry

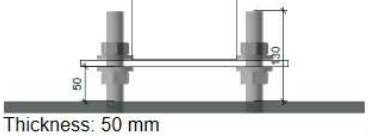
Column: 150x300

f_{cd}= 20 N/mm²

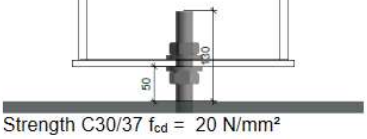
Plane View



X"-axis view



Y"-axis view



Grouting:

Thickness: 50 mm

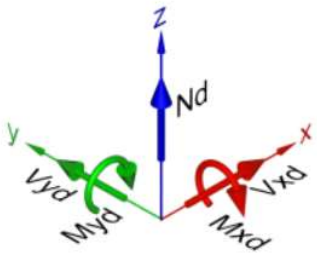
Strength C30/37 f_{cd} = 20 N/mm²

X; Y = local coordinate system of profile
X"; Y" = local coordinate system of anchors

Load Cases

NOTE: Loads are defined in the local coordinate system of the profile.

(Design loads)



Final Stage

#	Name	N_d [kN]	M_{xd} [kNm]	M_{yd} [kNm]	V_{xd} [kN]	V_{yd} [kN]
1		-32.0	0.0	0.0	0.0	6.0

Erection stage

No load case for this stage defined

Išvada: kolonų bazės laikomoji galia užtikrinta.

1.3.2.2. Kolonos-sijos mazgo projektavimas

Projektuojama standi kolonos-sijos jungtis.

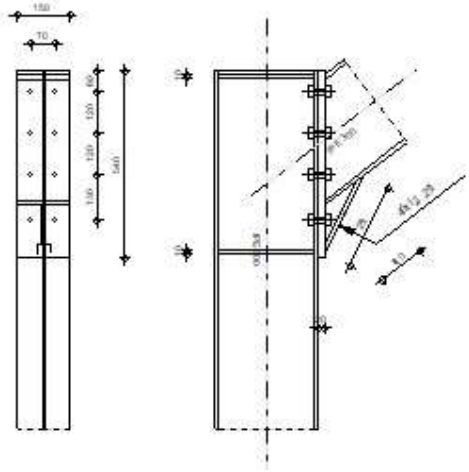
Robot Structural Analysis Professional 2023

Design of fixed beam-to-column connection

EN 1993-1-8:2005/AC:2009

OK

Ratio **0.36**



General

Connection no.: 1

Connection name: Frame knee

Structure node: 2

Structure members: 1, 7

Geometry

Column

Section: IPE 300

Member no.: 1

α =	-90.0	[Deg]	Inclination angle
h_c =	300	[mm]	Height of column section
b_{fc} =	150	[mm]	Width of column section
t_{wc} =	7	[mm]	Thickness of the web of column section
t_{fc} =	11	[mm]	Thickness of the flange of column section
r_c =	15	[mm]	Radius of column section fillet

Section: IPE 300

A_c = 53.81 [cm^2] Cross-sectional area of a column

I_{xc} = 8356.11 [cm^4] Moment of inertia of the column section

Material: S 355

f_{yc} = 355.00 [MPa] Resistance

Beam

Section: IPE 300

Member no.: 7

α = 37.4 [Deg] Inclination angle

h_b = 300 [mm] Height of beam section

b_f = 150 [mm] Width of beam section

t_{wb} = 7 [mm] Thickness of the web of beam section

t_{fb} = 11 [mm] Thickness of the flange of beam section

r_b = 15 [mm] Radius of beam section fillet

r_b = 15 [mm] Radius of beam section fillet

A_b = 53.81 [cm^2] Cross-sectional area of a beam

I_{xb} = 8356.11 [cm^4] Moment of inertia of the beam section

Material: S 355

f_{yb} = 355.00 [MPa] Resistance

Bolts

The shear plane passes through the UNTHREADED portion of the bolt.

d = 16 [mm] Bolt diameter

Class = 8.8 Bolt class

F_{tRd} = 90.43 [kN] Tensile resistance of a bolt

n_h = 2 Number of bolt columns

n_v = 4 Number of bolt rows

h_1 = 60 [mm] Distance between first bolt and upper edge of front plate

Horizontal spacing e_i = 70 [mm]

d = 16 [mm] Bolt diameter

Vertical spacing p_i = 120;120;130 [mm]

Plate

h_p = 540 [mm] Plate height

b_p = 150 [mm] Plate width

t_p = 20 [mm] Plate thickness

Material: S 355

f_{yp} = 355.00 [MPa] Resistance

Lower stiffener

w_d = 40 [mm] Plate width

t_{fd} = 12 [mm] Flange thickness

h_d = 140 [mm] Plate height

t_{wd} = 10 [mm] Web thickness

l_d = 140 [mm] Plate length

α = 63.7 [Deg] Inclination angle

Material: S 355

f_{ybu} = 355.00 [MPa] Resistance

Column stiffener

Upper

h_{su} = 279 [mm] Stiffener height

b_{su} = 71 [mm] Stiffener width

t_{hu} = 10 [mm] Stiffener thickness

Material: S 355

f_{ysu} = 355.00 [MPa] Resistance

Lower

h_{sd} = 279 [mm] Stiffener height

b_{sd} = 71 [mm] Stiffener width

t_{hd} = 10 [mm] Stiffener thickness

h_{sd} = 279 [mm] Stiffener height

Material: S 355

f_{ysu} = 355.00 [MPa] Resistance

Fillet welds

a_w = 5 [mm] Web weld

a_f = 8 [mm] Flange weld

a_s = 5 [mm] Stiffener weld

a_{fd} = 5 [mm] Horizontal weld

Material factors

γ_{M0} = 1.10 Partial safety factor [2.2]

γ_{M1} = 1.10 Partial safety factor [2.2]

γ_{M2} = 1.25 Partial safety factor [2.2]

γ_{M3} = 1.25 Partial safety factor [2.2]

Loads

Ultimate limit state

Case: 11: ULS/8=1*1.35 + 2*1.30 1*1.35+2*1.30

$M_{b1,Ed}$ = 37.47 [kN*m] Bending moment in the right beam

$V_{b1,Ed}$ = 45.43 [kN] Shear force in the right beam

$N_{b1,Ed}$ = -11.96 [kN] Axial force in the right beam

$M_{c1,Ed}$ = 37.47 [kN*m] Bending moment in the lower column

$V_{c1,Ed}$ = 14.69 [kN] Shear force in the lower column

$N_{c1,Ed}$ = -49.11 [kN] Axial force in the lower column

Results

Beam resistances

COMPRESSION

A_b = 53.81 [cm^2] Area EN1993-1-1:[6.2.4]

$N_{cb,Rd} = A_b f_{yb} / \gamma_{M0}$

$N_{cb,Rd}$ = 1736.66 [kN] Design compressive resistance of the section EN1993-1-1:[6.2.4]

SHEAR

A_{vb} = 39.68 [cm^2] Shear area EN1993-1-1:[6.2.6.(3)]

$V_{cb,Rd} = A_{vb} (f_{yb} / \sqrt{3}) / \gamma_{M0}$

$V_{cb,Rd}$ = 739.38 [kN] Design sectional resistance for shear EN1993-1-1:[6.2.6.(2)]

$V_{b1,Ed} / V_{cb,Rd} \leq 1,0$ 0.06 < 1.00 verified (0.06)

BENDING - PLASTIC MOMENT (WITHOUT BRACKETS)

W_{plb} = 628.40 [cm^3] Plastic section modulus EN1993-1-1:[6.2.5.(2)]

$M_{b,pl,Rd} = W_{plb} f_{yb} / \gamma_{M0}$

$M_{b,pl,Rd}$ = 202.80 [kN*m] Plastic resistance of the section for bending (without stiffeners) EN1993-1-1:[6.2.5.(2)]

BENDING ON THE CONTACT SURFACE WITH PLATE OR CONNECTED ELEMENT

W_{pl} = 1141.93 [cm^3] Plastic section modulus EN1993-1-1:[6.2.5]

$M_{cb,Rd} = W_{pl} f_{yb} / \gamma_{M0}$

$M_{cb,Rd}$ = 368.53 [kN*m] Design resistance of the section for bending EN1993-1-1:[6.2.5]

FLANGE AND WEB - COMPRESSION

$M_{cb,Rd}$ = 368.53 [kN*m] Design resistance of the section for bending EN1993-1-1:[6.2.5]

h_f = 497 [mm] Distance between the centroids of flanges [6.2.6.7.(1)]

$F_{c,fb,Rd} = M_{cb,Rd} / h_f$

$F_{c,fb,Rd}$ = 740.92 [kN] Resistance of the compressed flange and web [6.2.6.7.(1)]

WEB OR BRACKET FLANGE - COMPRESSION - LEVEL OF THE BEAM BOTTOM FLANGE

Bearing:

β = 37.4 [Deg] Angle between the front plate and the beam

γ = 63.7 [Deg] Inclination angle of the bracket plate

$b_{eff,c,wb}$ = 178 [mm] Effective width of the web for compression [6.2.6.2.(1)]

A_{vb} = 25.68 [cm^2] Shear area EN1993-1-1:[6.2.6.(3)]

ω = 0.87 Reduction factor for interaction with shear [6.2.6.2.(1)]

$\sigma_{com,Ed}$ = 57.96 [MPa] Maximum compressive stress in web [6.2.6.2.(2)]

k_{wc} = 1.00 Reduction factor conditioned by compressive stresses [6.2.6.2.(2)]

$F_{c,wb,Rd1} = [\omega\ k_{wc}\ b_{eff,c,wb}\ t_{wb}\ f_{yb} / \gamma_{M0}] \cos(\gamma) / \sin(\gamma - \beta)$

$F_{c,wb,Rd1}$ = 356.02 [kN] Beam web resistance [6.2.6.2.(1)]

Buckling:

d_{wb} = 249 [mm] Height of compressed web [6.2.6.2.(1)]

λ_p = 1.14 Plate slenderness of an element [6.2.6.2.(1)]

ρ = 0.73 Reduction factor for element buckling [6.2.6.2.(1)]

$F_{c,wb,Rd2} = [\omega\ k_{wc}\ \rho\ b_{eff,c,wb}\ t_{wb}\ f_{yb} / \gamma_{M1}] \cos(\gamma) / \sin(\gamma - \beta)$

$F_{c,wb,Rd2}$ = 258.22 [kN] Beam web resistance [6.2.6.2.(1)]

Final resistance:

$F_{c,wb,Rd,low} = \text{Min}(F_{c,wb,Rd1}, F_{c,wb,Rd2})$

$F_{c,wb,Rd,low}$ = 258.22 [kN] Beam web resistance [6.2.6.2.(1)]

Column resistances

WEB PANEL - SHEAR

$M_{b1,Ed}$ = 37.47 [kN*m] Bending moment (right beam) [5.3.(3)]

$M_{b2,Ed}$ = 0.00 [kN*m] Bending moment (left beam) [5.3.(3)]

$V_{c1,Ed}$ = 14.69 [kN] Shear force (lower column) [5.3.(3)]

$V_{c2,Ed}$ = 0.00 [kN] Shear force (upper column) [5.3.(3)]

z = 394 [mm] Lever arm [6.2.5]

$V_{wp,Ed} = (M_{b1,Ed} - M_{b2,Ed}) / z - (V_{c1,Ed} - V_{c2,Ed}) / 2$

$V_{wp,Ed}$ = 87.72 [kN] Shear force acting on the web panel [5.3.(3)]

A_{vs} = 25.68 [cm^2] Shear area of the column web EN1993-1-1:[6.2.6.(3)]

A_{vc} = 25.68 [cm^2] Shear area EN1993-1-1:[6.2.6.(3)]

d_s = 510 [mm] Distance between the centroids of stiffeners [6.2.6.1.(4)]

$M_{pl,fc,Rd}$ = 1.52 [kN*m] Plastic resistance of the column flange for bending [6.2.6.1.(4)]

$M_{pl,stu,Rd}$ = 1.33 [kN*m] Plastic resistance of the upper transverse stiffener for bending [6.2.6.1.(4)]

$M_{pl,stl,Rd}$ = 1.33 [kN*m] Plastic resistance of the lower transverse stiffener for bending [6.2.6.1.(4)]

$V_{wp,Rd} = 0.9 (A_{vs} * f_{y,wc}) / (\sqrt{3}\ \gamma_{M0}) + \text{Min}(4\ M_{pl,fc,Rd} / d_s , (2\ M_{pl,fc,Rd} + M_{pl,stu,Rd} + M_{pl,stl,Rd}) / d_s)$

$V_{wp,Rd}$ = 441.86 [kN] Resistance of the column web panel for shear [6.2.6.1]

$V_{wp,Ed} / V_{wp,Rd} \leq 1,0$	0.20 < 1.00	verified	(0.20)

WEB - TRANSVERSE COMPRESSION - LEVEL OF THE BEAM BOTTOM FLANGE

Bearing:

t_{wc} = 7	[mm]	Effective thickness of the column web	[6.2.6.2.(6)]
$b_{eff,c,wc}$ = 218	[mm]	Effective width of the web for compression	[6.2.6.2.(1)]
A_{vc} = 25.68	[cm²]	Shear area	EN1993-1-1:[6.2.6.(3)]
ω = 0.82		Reduction factor for interaction with shear	[6.2.6.2.(1)]
$\sigma_{com,Ed}$ = 64.87	[MPa]	Maximum compressive stress in web	[6.2.6.2.(2)]
k_{wc} = 1.00		Reduction factor conditioned by compressive stresses	[6.2.6.2.(2)]
A_s = 14.29	[cm²]	Area of the web stiffener	EN1993-1-1:[6.2.4]

$F_{c,wc,Rd1} = \omega\ k_{wc}\ b_{eff,c,wc}\ t_{wc}\ f_{yc} / \gamma_{M0} + A_s\ f_{ys} / \gamma_{M0}$

$F_{c,wc,Rd1}$ = 873.14	[kN]	Column web resistance	[6.2.6.2.(1)]

Buckling:

d_{wc} = 249	[mm]	Height of compressed web	[6.2.6.2.(1)]
λ_p = 1.26		Plate slenderness of an element	[6.2.6.2.(1)]
ρ = 0.67		Reduction factor for element buckling	[6.2.6.2.(1)]
λ_s = 5.60		Stiffener slenderness	EN1993-1-1:[6.3.1.2]
χ_s = 1.00		Buckling coefficient of the stiffener	EN1993-1-1:[6.3.1.2]

$F_{c,wc,Rd2} = \omega\ k_{wc}\ \rho\ b_{eff,c,wc}\ t_{wc}\ f_{yc} / \gamma_{M1} + A_s\ \chi_s\ f_{ys} / \gamma_{M1}$

$F_{c,wc,Rd2}$ = 736.76	[kN]	Column web resistance	[6.2.6.2.(1)]

Final resistance:

$F_{c,wc,Rd,low} = \text{Min}\ (F_{c,wc,Rd1}\ ,\ F_{c,wc,Rd2})$

$F_{c,wc,Rd}$ = 736.76	[kN]	Column web resistance	[6.2.6.2.(1)]

WEB - TRANSVERSE COMPRESSION - LEVEL OF THE BEAM TOP FLANGE

Bearing:

t_{wc} = 7	[mm]	Effective thickness of the column web	[6.2.6.2.(6)]
$b_{eff,c,wc}$ = 205	[mm]	Effective width of the web for compression	[6.2.6.2.(1)]
A_{vc} = 25.68	[cm²]	Shear area	EN1993-1-1:[6.2.6.(3)]

t_{wc} = 7 [mm] Effective thickness of the column web [6.2.6.2.(6)]

ω = 0.84 Reduction factor for interaction with shear [6.2.6.2.(1)]

$\sigma_{com,Ed}$ = 64.87 [MPa] Maximum compressive stress in web [6.2.6.2.(2)]

k_{wc} = 1.00 Reduction factor conditioned by compressive stresses [6.2.6.2.(2)]

A_s = 14.29 [cm^2] Area of the web stiffener EN1993-1-1:[6.2.4]

$F_{c,wc,Rd1} = \omega\, k_{wc}\, b_{eff,c,wc}\, t_{wc}\, f_{yc} / \gamma_{M0} + A_s\, f_{ys} / \gamma_{M0}$

$F_{c,wc,Rd1}$ = 855.16 [kN] Column web resistance [6.2.6.2.(1)]

Buckling:

d_{wc} = 249 [mm] Height of compressed web [6.2.6.2.(1)]

λ_p = 1.22 Plate slenderness of an element [6.2.6.2.(1)]

ρ = 0.69 Reduction factor for element buckling [6.2.6.2.(1)]

λ_s = 5.60 Stiffener slenderness EN1993-1-1:[6.3.1.2]

χ_s = 1.00 Buckling coefficient of the stiffener EN1993-1-1:[6.3.1.2]

$F_{c,wc,Rd2} = \omega\, k_{wc}\, \rho\, b_{eff,c,wc}\, t_{wc}\, f_{yc} / \gamma_{M1} + A_s\, \chi_s\, f_{ys} / \gamma_{M1}$

$F_{c,wc,Rd2}$ = 731.67 [kN] Column web resistance [6.2.6.2.(1)]

Final resistance:

$F_{c,wc,Rd,upp} = \text{Min}\,(F_{c,wc,Rd1}\,,\, F_{c,wc,Rd2})$

$F_{c,wc,Rd,upp}$ = 731.67 [kN] Column web resistance [6.2.6.2.(1)]

Geometrical parameters of a connection

EFFECTIVE LENGTHS AND PARAMETERS - COLUMN FLANGE

Nr	m	m_x	e	e_x	p	$l_{eff,cp}$	$l_{eff,nc}$	$l_{eff,1}$	$l_{eff,2}$	$l_{eff,cp,g}$	$l_{eff,nc,g}$	$l_{eff,1,g}$	$l_{eff,2,g}$
1	19	-	40	-	120	122	134	122	134	181	131	131	131
2	19	-	40	-	120	122	128	122	128	240	120	120	120
3	19	-	40	-	125	122	128	122	128	250	125	125	125
4	19	-	40	-	130	122	127	122	127	191	129	129	129

EFFECTIVE LENGTHS AND PARAMETERS - FRONT PLATE

Nr	m	m_x	e	e_x	p	$l_{eff,cp}$	$l_{eff,nc}$	$l_{eff,1}$	$l_{eff,2}$	$l_{eff,cp,g}$	$l_{eff,nc,g}$	$l_{eff,1,g}$	$l_{eff,2,g}$
1	26	-	40	-	120	162	170	162	170	201	154	154	154
2	26	-	40	-	120	162	153	153	153	240	120	120	120
3	26	-	40	-	125	162	153	153	153	250	125	125	125
4	26	-	40	-	130	162	153	153	153	211	142	142	142

m – Bolt distance from the web

m_x – Bolt distance from the beam flange

e – Bolt distance from the outer edge

e_x – Bolt distance from the horizontal outer edge

p – Distance between bolts

$l_{eff,cp}$ – Effective length for a single bolt row in the circular failure mode

$l_{eff,nc}$ – Effective length for a single bolt row in the non-circular failure mode

$l_{eff,1}$ – Effective length for a single bolt row for mode 1

$l_{eff,2}$ – Effective length for a single bolt row for mode 2

$l_{eff,cp,g}$ – Effective length for a group of bolts in the circular failure mode

$l_{eff,nc,g}$ – Effective length for a group of bolts in the non-circular failure mode

$l_{eff,1,g}$ – Effective length for a group of bolts for mode 1

$l_{eff,2,g}$ – Effective length for a group of bolts for mode 2

Connection resistance for compression

$N_{j,Rd}$ = Min ($N_{cb,Rd}$2 $F_{c,wb,Rd,low}$, 2 $F_{c,wc,Rd,low}$, 2 $F_{c,wc,Rd,upp}$)

$N_{j,Rd}$ = 516.45 [kN] Connection resistance for compression [6.2]

$N_{b1,Ed}$ / $N_{j,Rd}$ ≤ 1,0 0.02 < 1.00 verified (0.02)

Connection resistance for bending

$F_{t,Rd}$ = 90.43 [kN] Bolt resistance for tension [Table 3.4]

$B_{p,Rd}$ = 182.01 [kN] Punching shear resistance of a bolt [Table 3.4]

$F_{t,fc,Rd}$ – column flange resistance due to bending

$F_{t,wc,Rd}$ – column web resistance due to tension

$F_{t,ep,Rd}$ – resistance of the front plate due to bending

$F_{t,fc,Rd}$ – column flange resistance due to bending

$F_{t,wb,Rd}$ – resistance of the web in tension

$F_{t,fc,Rd} = Min (F_{T,1,fc,Rd} , F_{T,2,fc,Rd} , F_{T,3,fc,Rd})$ [6.2.6.4] , [Tab.6.2]

$F_{t,wc,Rd} = \omega\ b_{eff,t,wc}\ t_{wc}\ f_{yc} / \gamma_{M0}$ [6.2.6.3.(1)]

$F_{t,ep,Rd} = Min (F_{T,1,ep,Rd} , F_{T,2,ep,Rd} , F_{T,3,ep,Rd})$ [6.2.6.5] , [Tab.6.2]

$F_{t,wb,Rd} = b_{eff,t,wb}\ t_{wb}\ f_{yb} / \gamma_{M0}$ [6.2.6.8.(1)]

RESISTANCE OF THE BOLT ROW NO. 1

$F_{t1,Rd,comp}$ - Formula	**$F_{t1,Rd,comp}$**	**Component**
$F_{t1,Rd} = Min (F_{t1,Rd,comp})$	157.25	Bolt row resistance
$F_{t,fc,Rd(1)} = 157.25$	157.25	Column flange - tension
$F_{t,wc,Rd(1)} = 261.31$	261.31	Column web - tension
$F_{t,ep,Rd(1)} = 180.86$	180.86	Front plate - tension
$F_{t,wb,Rd(1)} = 371.35$	371.35	Beam web - tension
$B_{p,Rd} = 364.01$	364.01	Bolts due to shear punching
$V_{wp,Rd}/\beta = 441.86$	441.86	Web panel - shear
$F_{c,wc,Rd} = 736.76$	736.76	Column web - compression
$F_{c,fb,Rd} = 740.92$	740.92	Beam flange - compression
$F_{c,wb,Rd} = 258.22$	258.22	Beam web - compression

RESISTANCE OF THE BOLT ROW NO. 2

$F_{t2,Rd,comp}$ - Formula	**$F_{t2,Rd,comp}$**	**Component**
$F_{t2,Rd} = Min (F_{t2,Rd,comp})$	100.98	Bolt row resistance
$F_{t,fc,Rd(2)} = 154.43$	154.43	Column flange - tension
$F_{t,wc,Rd(2)} = 261.31$	261.31	Column web - tension
$F_{t,ep,Rd(2)} = 180.86$	180.86	Front plate - tension
$F_{t,wb,Rd(2)} = 350.97$	350.97	Beam web - tension
$B_{p,Rd} = 364.01$	364.01	Bolts due to shear punching
$V_{wp,Rd}/\beta - \sum_1^1 F_{ti,Rd} = 441.86 - 157.25$	284.62	Web panel - shear

$F_{t2,Rd,comp}$ - Formula	**$F_{t2,Rd,comp}$**	**Component**
$F_{c,wc,Rd} - \sum_1^1 F_{tj,Rd} = 736.76 - 157.25$	579.51	Column web - compression
$F_{c,fb,Rd} - \sum_1^1 F_{tj,Rd} = 740.92 - 157.25$	583.68	Beam flange - compression
$F_{c,wb,Rd} - \sum_1^1 F_{tj,Rd} = 258.22 - 157.25$	100.98	Beam web - compression
$F_{t,fc,Rd(2+1)} - \sum_1^1 F_{tj,Rd} = 306.74 - 157.25$	149.49	Column flange - tension - group
$F_{t,wc,Rd(2+1)} - \sum_1^1 F_{tj,Rd} = 450.56 - 157.25$	293.31	Column web - tension - group
$F_{t,ep,Rd(2+1)} - \sum_1^1 F_{tj,Rd} = 361.73 - 157.25$	204.48	Front plate - tension - group
$F_{t,wb,Rd(2+1)} - \sum_1^1 F_{tj,Rd} = 627.04 - 157.25$	469.80	Beam web - tension - group

RESISTANCE OF THE BOLT ROW NO. 3

$F_{t3,Rd,comp}$ - Formula	**$F_{t3,Rd,comp}$**	**Component**
$F_{t3,Rd} = \text{Min}(F_{t3,Rd,comp})$	0.00	Bolt row resistance
$F_{t,fc,Rd(3)} = 154.43$	154.43	Column flange - tension
$F_{t,wc,Rd(3)} = 261.31$	261.31	Column web - tension
$F_{t,ep,Rd(3)} = 180.86$	180.86	Front plate - tension
$F_{t,wb,Rd(3)} = 350.97$	350.97	Beam web - tension
$B_{p,Rd} = 364.01$	364.01	Bolts due to shear punching
$V_{wp,Rd}/\beta - \sum_1^2 F_{ti,Rd} = 441.86 - 258.22$	183.64	Web panel - shear
$F_{c,wc,Rd} - \sum_1^2 F_{tj,Rd} = 736.76 - 258.22$	478.53	Column web - compression
$F_{c,fb,Rd} - \sum_1^2 F_{tj,Rd} = 740.92 - 258.22$	482.70	Beam flange - compression
$F_{c,wb,Rd} - \sum_1^2 F_{tj,Rd} = 258.22 - 258.22$	0.00	Beam web - compression
$F_{t,fc,Rd(3+2)} - \sum_2^2 F_{tj,Rd} = 304.39 - 100.98$	203.41	Column flange - tension - group
$F_{t,wc,Rd(3+2)} - \sum_2^2 F_{tj,Rd} = 444.31 - 100.98$	343.34	Column web - tension - group
$F_{t,fc,Rd(3+2+1)} - \sum_2^1 F_{tj,Rd} = 459.99 - 258.22$	201.77	Column flange - tension - group
$F_{t,wc,Rd(3+2+1)} - \sum_2^1 F_{tj,Rd} = 555.32 - 258.22$	297.10	Column web - tension - group
$F_{t,ep,Rd(3+2)} - \sum_2^2 F_{tj,Rd} = 361.73 - 100.98$	260.75	Front plate - tension - group
$F_{t,wb,Rd(3+2)} - \sum_2^2 F_{tj,Rd} = 561.38 - 100.98$	460.41	Beam web - tension - group
$F_{t,ep,Rd(3+2+1)} - \sum_2^1 F_{tj,Rd} = 542.59 - 258.22$	284.37	Front plate - tension - group

$F_{t3,Rd,comp}$ - Formula	$F_{t3,Rd,comp}$	Component
$F_{t,wb,Rd(3+2+1)} - \sum_2^1 F_{tj,Rd}$ = 913.46 - 258.22	655.24	Beam web - tension - group

The remaining bolts are inactive (they do not carry loads) because resistance of one of the connection components has been used up or these bolts are positioned below the center of rotation.

SUMMARY TABLE OF FORCES

Nr	h_j	$F_{tj,Rd}$	$F_{t,fc,Rd}$	$F_{t,wc,Rd}$	$F_{t,ep,Rd}$	$F_{t,wb,Rd}$	$F_{t,Rd}$	$B_{p,Rd}$
1	454	157.25	157.25	261.31	180.86	371.35	180.86	364.01
2	334	100.98	154.43	261.31	180.86	350.97	180.86	364.01
3	214	-	154.43	261.31	180.86	350.97	180.86	364.01
4	84	-	154.29	261.31	180.86	350.97	180.86	364.01

CONNECTION RESISTANCE FOR BENDING $M_{j,Rd}$

$M_{j,Rd} = \sum h_j F_{tj,Rd}$

$M_{j,Rd}$ = 105.15 [kN*m] Connection resistance for bending [6.2]

$M_{b1,Ed} / M_{j,Rd} \le 1,0$	0.36 < 1.00	verified	(0.36)

Connection resistance for shear

α_v = 0.60 Coefficient for calculation of $F_{v,Rd}$ [Table 3.4]

β_{Lf} = 0.96 Reduction factor for long connections [3.8]

$F_{v,Rd}$ = 74.07 [kN] Shear resistance of a single bolt [Table 3.4]

$F_{t,Rd,max}$ = 90.43 [kN] Tensile resistance of a single bolt [Table 3.4]

$F_{b,Rd,int}$ = 160.93 [kN] Bearing resistance of an intermediate bolt [Table 3.4]

$F_{b,Rd,ext}$ = 160.93 [kN] Bearing resistance of an outermost bolt [Table 3.4]

Nr	$F_{tj,Rd,N}$	$F_{tj,Ed,N}$	$F_{tj,Rd,M}$	$F_{tj,Ed,M}$	$F_{tj,Ed}$	$F_{vj,Rd}$
1	180.86	-2.99	157.25	56.04	53.05	117.11
2	180.86	-2.99	100.98	35.98	32.99	128.84
3	180.86	-2.99	0.00	0.00	-2.99	148.14
4	180.86	-2.99	0.00	0.00	-2.99	148.14

$F_{tj,Rd,N}$ – Bolt row resistance for simple tension

$F_{tj,Ed,N}$ – Force due to axial force in a bolt row

$F_{tj,Rd,N}$ – Bolt row resistance for simple tension

$F_{tj,Rd,M}$ – Bolt row resistance for simple bending

$F_{tj,Ed,M}$ – Force due to moment in a bolt row

$F_{tj,Ed}$ – Maximum tensile force in a bolt row

$F_{vj,Rd}$ – Reduced bolt row resistance

$F_{tj,Ed,N} = N_{j,Ed} F_{tj,Rd,N} / N_{j,Rd}$

$F_{tj,Ed,M} = M_{j,Ed} F_{tj,Rd,M} / M_{j,Rd}$

$F_{tj,Ed} = F_{tj,Ed,N} + F_{tj,Ed,M}$

$F_{vj,Rd} = Min (n_h F_{v,Ed} / (1 - F_{tj,Ed} / (1.4 n_h F_{t,Rd,max})), n_h F_{v,Rd} , n_h F_{b,Rd})$

$V_{j,Rd} = n_h \sum_1^n F_{vj,Rd}$ [Table 3.4]

$V_{j,Rd}$ =	542.23	[kN]	Connection resistance for shear	[Table 3.4]

$V_{b1,Ed} / V_{j,Rd} \leq 1,0$	0.08 < 1.00	verified	(0.08)

Weld resistance

A_w =	87.85	[cm^2]	Area of all welds	[4.5.3.2(2)]
A_{wy} =	45.26	[cm^2]	Area of horizontal welds	[4.5.3.2(2)]
A_{wz} =	42.59	[cm^2]	Area of vertical welds	[4.5.3.2(2)]
I_{wy} =	26245.32	[cm^4]	Moment of inertia of the weld arrangement with respect to the hor. axis	[4.5.3.2(5)]
$\sigma_{\perp max}=\tau_{\perp max}$ =	-30.39	[MPa]	Normal stress in a weld	[4.5.3.2(6)]
$\sigma_{\perp}=\tau_{\perp}$ =	-27.20	[MPa]	Stress in a vertical weld	[4.5.3.2(5)]
τ_{II} =	10.67	[MPa]	Tangent stress	[4.5.3.2(5)]
β_w =	0.90		Correlation coefficient	[4.5.3.2(7)]

$\sqrt{[\sigma_{\perp max}^2 + 3*(\tau_{\perp max}^2)]} \leq f_u/(\beta_w*\gamma_{M2})$	60.77 < 417.78	verified	(0.15)
$\sqrt{[\sigma_{\perp}^2 + 3*(\tau_{\perp}^2+\tau_{II}^2)]} \leq f_u/(\beta_w*\gamma_{M2})$	57.45 < 417.78	verified	(0.14)
$\sigma_{\perp} \leq 0.9*f_u/\gamma_{M2}$	30.39 < 338.40	verified	(0.09)

Connection stiffness

t_{wash} =	4	[mm]	Washer thickness	[6.2.6.3.(2)]
h_{head} =	12	[mm]	Bolt head height	[6.2.6.3.(2)]
h_{nut} =	16	[mm]	Bolt nut height	[6.2.6.3.(2)]

Connection stiffness

t_{wash} = 4 [mm] Washer thickness [6.2.6.3.(2)]

L_b = 53 [mm] Bolt length [6.2.6.3.(2)]

k_{10} = 5 [mm] Stiffness coefficient of bolts [6.3.2.(1)]

STIFFNESSES OF BOLT ROWS

Nr	hj	k_3	k_4	k_5	$k_{eff,j}$	$k_{eff,j}\ h_j$	$k_{eff,j}\ h_j^2$
					Sum	14.61	498.96
1	454	2	18	64	1	6.15	279.22
2	334	2	18	50	1	4.44	148.38
3	214	2	18	52	1	2.89	61.78
4	84	2	18	59	1	1.14	9.57

$k_{eff,j} = 1 / (\sum_3^5 (1 / k_{i,j}))$ [6.3.3.1.(2)]

$z_{eq} = \sum_j k_{eff,j}\ h_j^2 / \sum_j k_{eff,j}\ h_j$

z_{eq} = 341 [mm] Equivalent force arm [6.3.3.1.(3)]

$k_{eq} = \sum_j k_{eff,j}\ h_j / z_{eq}$

k_{eq} = 4 [mm] Equivalent stiffness coefficient of a bolt arrangement [6.3.3.1.(1)]

A_{vc} = 25.68 [cm^2] Shear area EN1993-1-1:[6.2.6.(3)]

β = 1.00 Transformation parameter [5.3.(7)]

z = 341 [mm] Lever arm [6.2.5]

k_1 = 3 [mm] Stiffness coefficient of the column web panel subjected to shear [6.3.2.(1)]

k_2 = ∞ Stiffness coefficient of the compressed column web [6.3.2.(1)]

$S_{j,ini} = E\ z_{eq}^2 / \sum_i (1 / k_1 + 1 / k_2 + 1 / k_{eq})$ [6.3.1.(4)]

$S_{j,ini}$ = 41958.59 [kN*m] Initial rotational stiffness [6.3.1.(4)]

μ = 1.00 Stiffness coefficient of a connection [6.3.1.(6)]

$S_j = S_{j,ini} / \mu$ [6.3.1.(4)]

S_j = 41958.59 [kN*m] Final rotational stiffness [6.3.1.(4)]

Connection classification due to stiffness.

$S_{j,rig}$ = 26902.35 [kN*m] Stiffness of a rigid connection [5.2.2.5]

$S_{j,pin}$ = 1681.40 [kN*m] Stiffness of a pinned connection [5.2.2.5]

$S_{j,ini} \geq S_{j,rig}$ RIGID

Weakest component:
BEAM WEB OR BRACKET FLANGE - COMPRESSION

Remarks

The angle between the bracket flange and the beam flange exceeds 45 degrees 63.7 [Deg] > 45.0 [Deg]

Connection conforms to the code	Ratio	0.36

Išvada sąlyga tenkinama. Mazgas standus, laikomoji galia pakankama

1.3.3. Naujo priestato ilginių projektavimas

Projektuojami ilginiai kaip karpytos dviatramės sijos iš plonasienių Z profilių. Ilginiai paskaičiuoti su RUUKKI skaičiavimo programa. Ilginius perskaičiuoja gamintojas DP metu.

Structural part: Naujas stogas

Updated: 2024-07-01 12:37 (GMT) **Version:** 1.1.36 (2024-06-26)

Created: 2023-12-13 10:47 (GMT)

Reliability class: RC2

Structure type: Roof purlin

Roof slope: 0 °

Deflection limit: L/200 (custom)

SLS combination: Characteristic

Profile type: Z-profile

Purlin direction: Longitudinal

Purlin orientation: Wide flange top

Bottom flange deflection restricted: No

Design according to testing: No

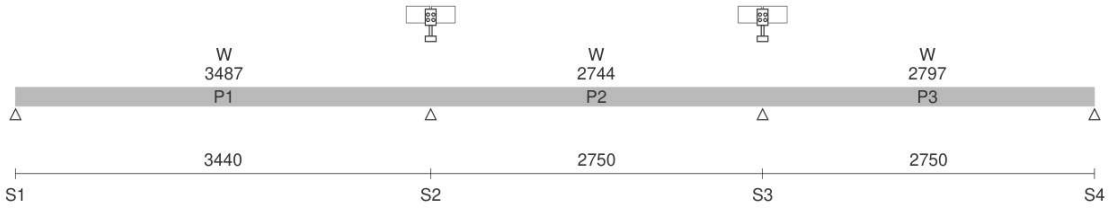
Chosen purlins fulfill design criteria. Maximum utilization rate: 61.9 %

Chosen fasteners fulfill design criteria. Maximum utilization rate: 12.6 %

Structural model

Left end: Distance to end of purlin: 50 mm

Right end: Distance to end of purlin: 50 mm



Selected purlin: LP-Z150

Purlin interval: 1000 mm

Total weight of the purlins: 3.0 kg/m^2

Global warming potential, GWP (A1...A3): 7.9 kg CO_2 eq. / m^2 Zinc-coated

Span	Thickness	Length
	[mm]	[mm]
P1	1.5	3487
P2	1.5	2744
P3	1.5	2797

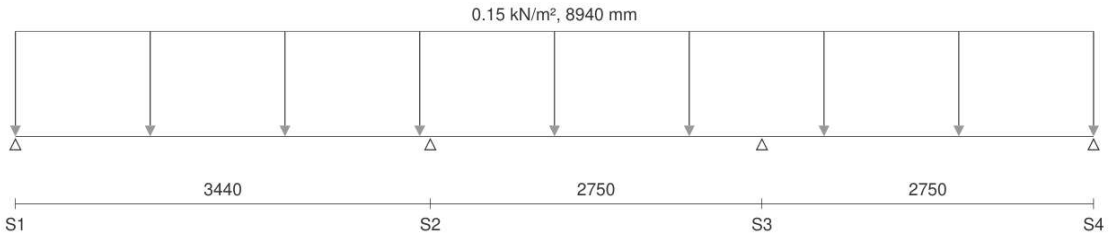
Supports and joints

Support	Axial support	Joint type
S1	Yes	End support
S2	Yes	Discontinuous
S3	Yes	Discontinuous
S4	Yes	End support

Dead load

Structure weight without purlins and sheeting: 0 kN/m^2

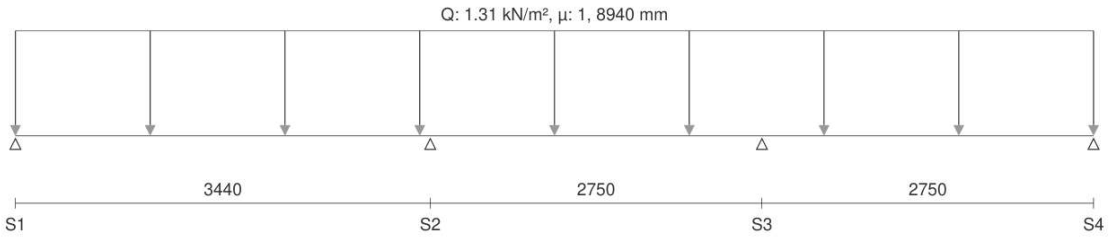
Total weight of the sheeting: 0 kN/m^2



Snow load

Basic snow load: 1.31 kN/m^2

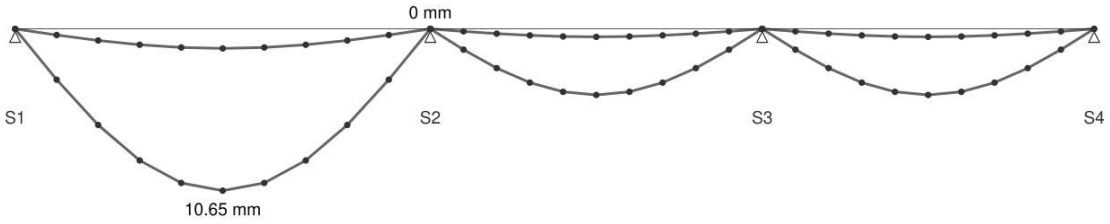
Movement: 0 %



Utilization rates

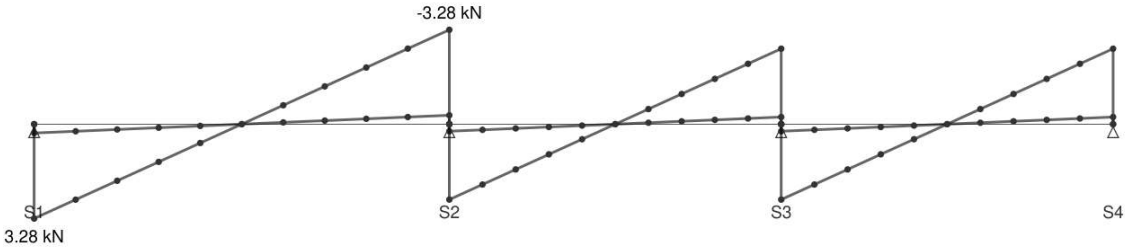
Purlin	M	N	V	N/V/M	σ	D
	[kNm]	[kN]	[kN]		[MPa]	[mm]
P1	2.8 / 5.6 50.6 %	0.0 / 83.4 0.0 %	3.3 / 25.4 13.0 %	50.6 %	176.9 / 350.0 50.6 %	10.6 / 17.2 61.9 %
P2	1.8 / 5.6 32.3 %	0.0 / 83.4 0.0 %	2.6 / 25.4 10.4 %	32.3 %	113.1 / 350.0 32.3 %	4.3 / 13.8 31.6 %
P3	1.8 / 5.6 32.3 %	0.0 / 83.4 0.0 %	-2.6 / 25.4 10.4 %	32.3 %	113.1 / 350.0 32.3 %	4.3 / 13.8 31.6 %

Deflection



Bending moment

Shear force



Support reactions

ULS

	Transverse direction		Axial direction	
Support	**Min**	**Max**	**Min**	**Max**
	[kN/purlin]	[kN/purlin]	[kN]	[kN]
S1	0.31	3.28	0.0	0.0
S2	0.56	5.91	0.0	0.0
S3	0.49	5.25	0.0	0.0
S4	0.25	2.63	0.0	0.0

Fasteners

Cleat wall thickness: 4 mm

Cleat steel grade: S355J2 (355/490)

Web fastener: M12 8.8

Fastener spacing in 4-hole cleat: 70 mm

Edge distance to the fastener at middle support: 32 mm

Gap width at support: 6 mm

Upper flange support from load bearing sheet

Positioning of sheeting: Wide flange of the sheet fixed to purlin

Continuity of the sheet: Single-span structure

Sheet fastener distance in upper flange: 50 %

Fixing interval: Through every through

Load bearing sheet name: T45-30-905

Nominal sheet thickness: 0.6 mm

	Support fasteners		
Support	pcs / support	Utilization rate [%]	Design criterion
S1	2	11.2	Bearing
S2	2 + 2	12.6	Bearing
S3	2 + 2	10.0	Bearing
S4	2	8.9	Bearing

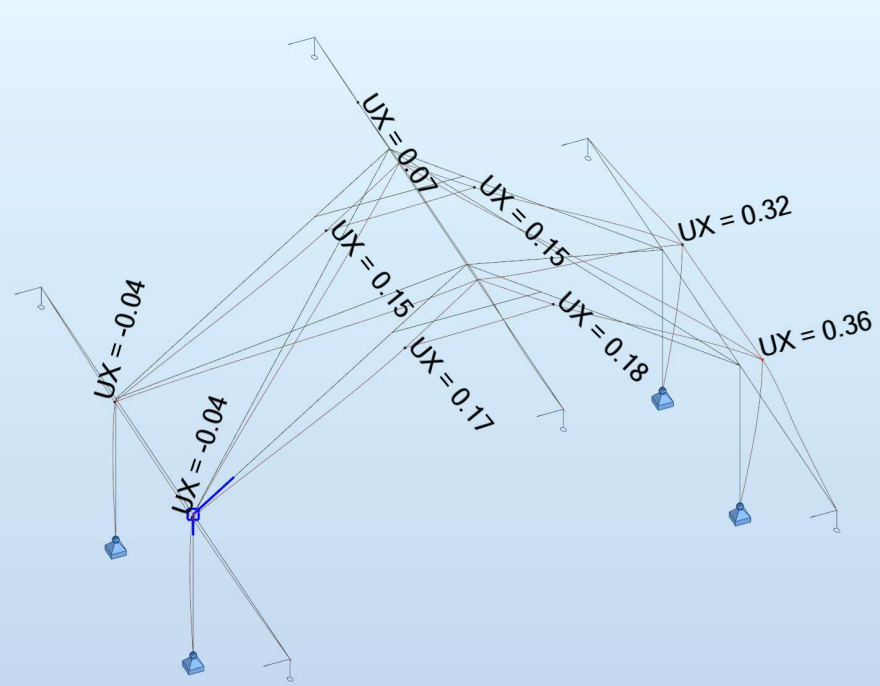
Amount of fasteners

Total amount: 12 pcs / purlin row

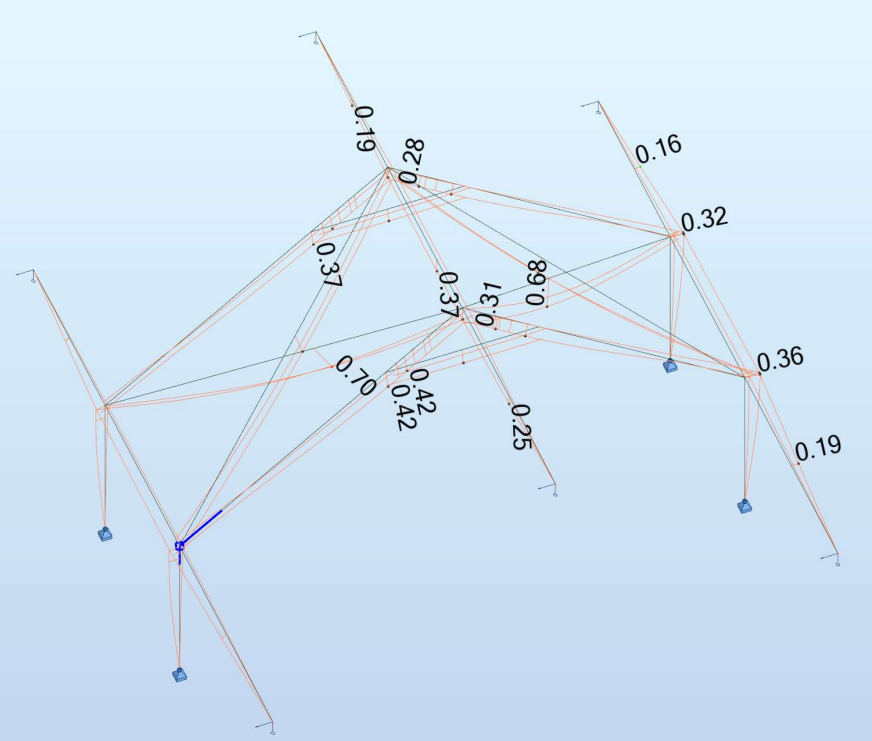
Išvada: ilginių laikomoji galia pakankama

1.3.4. Plieninio karkaso tinkamumo ribinis būvis

Karkaso deformuota schema veikiant tinkamumo ribinio būvio apkrovų deriniui:



Kolonų horizontalus poslinkis U_{max}=3,6 cm≤h_s/700=2,55/700=3,6 cm.



Sijų maksimalus įlinkis: U_{max}=0,42 cm≤L/150=5,22/150=3,4 cm.

IŠVADA: Priestato deformacijos neviršija ribinių.

1.4. Pamatų projektavimas

Pamatų sprendinius tikslinti Darbo projekte. Pamatų betonas ne žemesnės klasės nei C25/30, W6, XC2, F100. Armatūra S500. Pamatų atramines reakcijas žiūrėti kartu su atraminių reakcijų planu.

Pamatų reakcijos

Reakcijas žiūrėti reakcijų plane.

Pagal STR 2.05.04:2003 „Poveikiai ir apkrovos“ STR ir GEO ribiniam būviui apkrovų deriniai sudaromi pagal 6.4 formulę:

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

Čia “+“ reiškia derinimas su; $G_{k,j}$ ir $Q_{k,j}$ yra nuolatinių ir kintamų apkrovų charakteristinės reikšmės, γG ir γQ yra daliniai nuolatinių ir kintamųjų poveikių koeficientai, kurie atsižvelgia į įrąžų skaičiavimo modelių neapibrėžtumus, skaičiuojamosios schemos neapibrėžtumus, galimas perkrovas ir t.t.; $\Psi_{0,i}$ – kintamojo poveikio derintinės reikšmės koeficientas.

Daliniai koeficientai poveikiams (γ_F) ir jų efektams (γ_E):

Poveikis		**Žymuo**	**Apkrovimo grupė**	
			A1	*A2*
Nuolatinis	Nepalankus	γ_G	1,35	1,0
	Palankus		1,0	1,0
Kintamasis	Nepalankus	γ_Q	1,3	1,3
	Palankus		0	0

Pamatų reakcijos po kolonomis A1

	Fx, kN	Fy, kN	Fz, kN	Mx, kN	My, kN
1/ 11 (C)	6.27>>	0	30.41	0	0
1/ 8 (C)	0.81<<	0	12.07	0	0
1/ 11 (C)	6.27	0.00>>	30.41	0	0
1/ 8 (C)	0.81	0.00<<	12.07	0	0
1/ 10 (C)	5.67	0	31.62>>	0	0
1/ 9 (C)	1.82	0	10.06<<	0	0
1/ 9 (C)	1.82	0	10.06	-0.00>>	0
1/ 10 (C)	5.67	0	31.62	-0.00<<	0
1/ 11 (C)	6.27	0	30.41	0	0.00>>

1/ 8 (C)	0.81	0	12.07	0	0.00<<
1/ 11 (C)	6.27	0	30.41	0	0
1/ 5 (C)	1.45	0	15.59	0	0
3/ 9 (C)	-1.82>>	0	10.06	0	0
3/ 10 (C)	-6.37<<	0	28.54	0	0
3/ 10 (C)	-6.37	0.00>>	28.54	0	0
3/ 9 (C)	-1.82	0.00<<	10.06	0	0
3/ 11 (C)	-6.27	0	30.41>>	0	0
3/ 8 (C)	-1.99	0	6.95<<	0	0
3/ 13 (C)	-5.63	0	26.89	0.00>>	0
3/ 5 (C)	-2.63	0	10.47	-0.00<<	0
3/ 12 (C)	-5.73	0	25.02	0	0.00>>
3/ 5 (C)	-2.63	0	10.47	0	-0.00<<
3/ 6 (C)	-2.46	0	13.59	0	0
3/ 12 (C)	-5.73	0	25.02	0	0
5/ 11 (C)	5.43>>	0	25.94	0	0
5/ 8 (C)	0.71<<	0	10.16	0	0
5/ 9 (C)	1.59	-0.00>>	8.41	0	0
5/ 10 (C)	4.9	-0.00<<	26.99	0	0
5/ 10 (C)	4.9	0	26.99>>	0	0
5/ 9 (C)	1.59	0	8.41<<	0	0
5/ 12 (C)	4.34	0	24.04	0.00>>	0
5/ 6 (C)	2.15	0	11.36	-0.00<<	0
5/ 5 (C)	1.27	0	13.1	0	0.00>>
5/ 13 (C)	4.87	0	23	0	0.00<<
5/ 4 (C)	3.56	0	23.31	0	0
5/ 9 (C)	1.59	0	8.41	0	0
7/ 9 (C)	-1.60>>	0	8.42	0	0
7/ 10 (C)	-5.53<<	0	24.34	0	0
7/ 8 (C)	-1.75	-0.00>>	5.71	0	0
7/ 11 (C)	-5.44	-0.00<<	25.97	0	0
7/ 11 (C)	-5.44	0	25.97>>	0	0
7/ 8 (C)	-1.75	0	5.71<<	0	0
7/ 12 (C)	-4.97	0	21.39	0.00>>	0
7/ 6 (C)	-2.15	0	11.37	-0.00<<	0
7/ 7 (C)	-4.05	0	15.93	0	-0.00>>
7/ 6 (C)	-2.15	0	11.37	0	-0.00<<
7/ 6 (C)	-2.15	0	11.37	0	0
7/ 7 (C)	-4.05	0	15.93	0	0

1.4.1. Esamų sekliųjų pamatų ant ašių 1 ir 3 tikrinimas

Tikrinami esami seklieji pamatai. Priimamas pamato plotis esamos sienos pločio 500mm. Skaičiuojamas 1m ruožas. Mažiausias grunto kūginis stipris po pamato padu q_c=21MPa; šoninė trintis po pamato padu f_s=250 kPa. Deformacijų modulis 52,6MPa-93,8MPa pagal sluoksnius.

Reakcijos po sienomis pateiktos reakcijų plane.

Esamų sienų ant ašių 1 ir 3 sekliojo pamato pado pagrindo laikomoji galia:

Veikiančios įrąžos:

Įrąžos atvejui A1:

$N_{Ed.1} := 31$ kN

$V_{Ed.x.1} := 0.1$ kN

$V_{Ed.y.1} := 0.1$ kN

$M_{Ed.x.1} := 0.1$ kNm

$M_{Ed.y.1} := 0.1$ kNm

Daliniai koeficientai:

Daliniai medžiagų patikimumo koef. atvejui M1:

$\gamma_{\varphi.1} := 1$

$\gamma_{c.1} := 1$

$\gamma_{cu.1} := 1$

$\gamma_{qu.1} := 1$

$\gamma_{\gamma} := 1$

Daliniai medžiagų patikimumo koef. atvejui M2:

$\gamma_{\varphi.2} := 1.25$

$\gamma_{c.2} := 1.25$

$\gamma_{cu.2} := 1.4$

$\gamma_{qu.2} := 1.4$

$\gamma_{\alpha} := 1$

Daliniai stiprumo koeficientai:

	Atvejui R1:	Atvejui R2:	Atvejui R3:
Gniuždymui :	$\gamma_{R.v.1} := 1$	$\gamma_{R.v.2} := 1.4$	$\gamma_{R.v.3} := 1$
Kirpimui :	$\gamma_{R.h.1} := 1$	$\gamma_{R.h.2} := 1.1$	$\gamma_{R.h.3} := 1$

Grunto rodikliai:

$\rho := 19.5 \ \frac{kN}{m^3}$

$E := 67.7$ MPa

Sankiba :

$c := 0$ kPa

$q_c := 21$ MPa

$\varphi := 40.8$

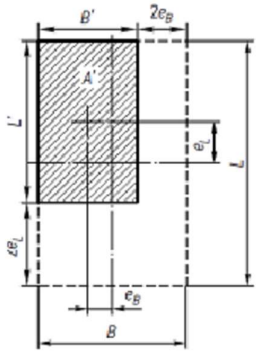
Geometriniai rodikliai:

$h_1 := 1.8$ m

$h := 0.4$ m

$L := 1$ m

$B := 0.5$ m



Posvyrio kampas (radianais):

$\alpha := 0$

Pamato svoris:

$q_p := L \cdot B \cdot h \cdot 2500 = 500$ kg

$q_{pd} := q_p \cdot 10 \cdot 10^{-3} = 5$ kN

Preliminarūs pado matmenys:

$M_1 := V_{Ed.x.1} \cdot h + M_{Ed.y.1} = 0.14$ kNm

$M_2 := V_{Ed.y.1} \cdot h + M_{Ed.x.1} = 0.14$ kNm

$e_1 := \frac{M_1}{N_{Ed.1}} = 4.516 \times m0^{-3}$ $\quad \frac{L}{6} = 0.167$

$e_2 := \frac{M_2}{N_{Ed.1}} = 4.516 \times m0^{-3}$ $\quad \frac{B}{6} = 0.083$

Efektyvusispado plotas:

$L_{ef} := L - 2 \cdot e_1 = 0.991$ m

$B_{ef} := B - 2e_2 = 0.491$ m

$A_{ef} := B_{ef} \cdot L_{ef} = 0.487$ m^2

Laikomoji galia:

$R := 1 \cdot 1.3 \cdot 0.1 \cdot q_c = 2.73$ MPa

Reikalingas plotas:

$A_r := \frac{N_{Ed.1}}{R \cdot 10^3} = 0.011$ m^2 $\quad A_{ef} = 0.487$ Gerai!

Pirmas projektavimo atvejis:
A1+M1+R1

Drenuojančios sąlygos:

Efektyvioji sankiba:

$c_1 := \frac{c}{\gamma_{c.1}} = 0$ kPa

Priekrovos svoris:

$q := h_1 \cdot \rho \cdot 1.35 = 47.385$ kPa

Efektyvusis grunto slėgis:

$q = 47.385$ kPa

Vienetinis svoris:

$$\gamma_1 := \frac{\rho}{\gamma_\gamma} = 19.5$$

Vidinės trinties kampo tangentas:

$$\tan\varphi := \frac{\tan(\varphi \cdot \text{deg})}{\gamma_{\varphi.1}} = 0.863$$

$e = 2.718$

Bedimensiai koeficientai:
Laikomosios galios:

$$N_{q.1} := e^{\pi \cdot \tan\varphi} \cdot \left[\tan\left[\left(45 + \frac{\varphi}{2}\right) \cdot \text{deg}\right]\right]^2 = 71.826$$

$$N_{c.1} := \left(N_{q.1} - 1\right) \cdot \frac{\cos(\varphi \cdot \text{deg})}{\sin(\varphi \cdot \text{deg})} = 82.052$$

$$N_{\gamma.1} := 2 \cdot \left(N_{q.1} - 1\right) \cdot \tan\varphi = 122.27$$

Pamato pado posvyrio:

$$b_{q.1} := (1 - \alpha \cdot \tan\varphi)^2 = 1$$

$$b_{c.1} := b_{q.1} - \frac{\left(1 - b_{q.1}\right)}{N_{c.1} \cdot \tan\varphi} = 1$$

$$b_{\gamma.1} := b_{q.1} = 1$$

Pamato pado formos:

$$s_{q.1} := 1 + \frac{B_{ef}}{L_{ef}} \cdot \sin(\varphi \cdot \text{deg}) = 1.324$$

$$s_{\gamma.1} := 1 - 0.3 \cdot \frac{B_{ef}}{L_{ef}} = 0.851$$

$$s_{c.1} := \frac{s_{q.1} \cdot N_{q.1} - 1}{N_{q.1} - 1} = 1.328$$

Apkrovos posvyrio:

$$m_L := \frac{2 + \frac{L_{ef}}{B_{ef}}}{1 + \frac{L_{ef}}{B_{ef}}} = 1.331$$

$$m_B := \frac{2 + \frac{B_{ef}}{L_{ef}}}{1 + \frac{B_{ef}}{L_{ef}}} = 1.669$$

$$\phi := \operatorname{atan}\left(\frac{V_{Ed.x.1}}{V_{Ed.y.1}}\right) \cdot \frac{180}{\pi} = 45$$

$$m := m_L \cdot \cos(\phi \cdot \mathrm{deg})^2 + m_B \cdot \sin(\phi \cdot \mathrm{deg})^2 = 1.5$$

$$i_{q.1} := \left(1 - \frac{V_{Ed}}{N_{Ed.1} + q_{pd} + A_{ef} \cdot c_1 \cdot \frac{1}{\tan\varphi}}\right)^m = 0.994$$

$$i_{c.1} := i_{q.1} - \frac{1 - i_{q.1}}{N_{c.1} \cdot \tan\varphi} = 0.994$$

$$i_{\gamma.1} := \left(1 - \frac{V_{Ed}}{N_{Ed.1} + q_{pd} + A_{ef} \cdot c_1 \cdot \frac{1}{\tan\varphi}}\right)^{(m+1)} = 0.99$$

$$R_{2.1} := c_1 \cdot N_{c.1} \cdot b_{c.1} \cdot s_{c.1} \cdot i_{c.1} + q \cdot N_{q.1} \cdot b_{q.1} \cdot s_{q.1} \cdot i_{q.1} + 0.5 \cdot \gamma_1 \cdot B \cdot N_{\gamma.1} \cdot b_{\gamma.1} \cdot s_{\gamma.1} \cdot i_{\gamma.1} = 4.981 \times 10^3$$

$$A_{2.1} := \frac{N_{Ed.1}}{R_{2.1}} = 6.223 \times 10^{-3} \qquad A_{ef} = 0.487 \quad \text{Gerai!}$$

$$\frac{A_{2.1}}{A_{ef}} \cdot 100 = 1.279$$

Išvada: reikalingas pamato pado plotas 0,00623 m2<0,487m2. Esamo pamato laikomosios galios išnaudojimas 1%, sąlyga tenkinama. Naujai projektuojamų naujo priestato pamatų ant 1, 3 ir E ašių apkrovos ne didesnės, negu esamų pamatų ant 1 ir 3 ašies, todėl šitas skaičiavimas taikomas ir jiems.

1.4.2. Esamų sekliųjų pamatų ant D ašies tikrinimas

Tikrinami esami seklieji pamatai. Priimamas pamato plotis esamos sienos pločio 500mm. Skaičiuojamas 1m ruožas. Mažiausias grunto kūginis stipris po pamato padu q_c=21MPa; šoninė trintis po pamato padu f_s=250 kPa. Deformacijų modulis 52,6MPa-93,8MPa pagal sluoksnius.

Reakcijos po sienomis pateiktos reakcijų plane.

Esamų sienų ant D ašies sekliojo pamato pado pagrindo laikomoji galia:

Veikiančios įrąžos:

Įrąžos atvejui A1:

$N_{Ed.1} := 91$ kN

$V_{Ed.x.1} := 0.1$ kN

$V_{Ed.y.1} := 0.1$ kN

$M_{Ed.x.1} := 0.1$ kNm

$M_{Ed.y.1} := 0.1$ kNm

Daliniai koeficientai:

Daliniai medžiagų patikimumo koef. atvejui M1:

$\gamma_{\varphi.1} := 1$

$\gamma_{c.1} := 1$

$\gamma_{cu.1} := 1$

$\gamma_{qu.1} := 1$

$\gamma_{\gamma} := 1$

Daliniai medžiagų patikimumo koef. atvejui M2:

$\gamma_{\varphi.2} := 1.25$

$\gamma_{c.2} := 1.25$

$\gamma_{cu.2} := 1.4$

$\gamma_{qu.2} := 1.4$

$\gamma_{\gamma} := 1$

Daliniai stiprumo koeficientai:

	Atvejui R1:	Atvejui R2:	Atvejui R3:
Gniuždymui :	$\gamma_{R.v.1} := 1$	$\gamma_{R.v.2} := 1.4$	$\gamma_{R.v.3} := 1$
Kirpimui :	$\gamma_{R.h.1} := 1$	$\gamma_{R.h.2} := 1.1$	$\gamma_{R.h.3} := 1$

Grunto rodikliai:

$\rho := 19.5 \ \frac{kN}{m^3}$

$E := 67.7$ MPa

Sankiba :

$c := 0$ kPa

$q_c := 21$ MPa

$\varphi := 40.8$

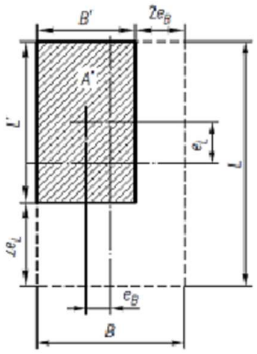
Geometriniai rodikliai:

$h_1 := 1.8$ m

$h := 0.4$ m

$L := 1$ m

$B := 0.5$ m



Posvyrio kampas (radianais):

$\alpha := 0$

Pamato svoris:

$q_p := L \cdot B \cdot h \cdot 2500 = 500$ kg

$q_{pd} := q_p \cdot 10 \cdot 10^{-3} = 5$ kN

Preliminarūs pado matmenys:

$M_1 := V_{Ed.x.1} \cdot h + M_{Ed.y.1} = 0.14$ kNm

$M_2 := V_{Ed.y.1} \cdot h + M_{Ed.x.1} = 0.14$ kNm

$e_1 := \frac{M_1}{N_{Ed.1}} = 1.538 \times m0^{-3}$ $\quad \frac{L}{6} = 0.167$

$e_2 := \frac{M_2}{N_{Ed.1}} = 1.538 \times m0^{-3}$ $\quad \frac{B}{6} = 0.083$

Efektyvusis pado plotas:

$L_{ef} := L - 2 \cdot e_1 = 0.997$ m

$B_{ef} := B - 2e_2 = 0.497$ m

$A_{ef} := B_{ef} \cdot L_{ef} = 0.495$ m^2

Laikomoji galia:

$R := 1 \cdot 1.3 \cdot 0.1 \cdot q_c = 2.73$ MPa

Reikalingas plotas:

$A_r := \frac{N_{Ed.1}}{R \cdot 10^3} = 0.033$ m^2 $\quad A_{ef} = 0.495$ Gerai!

Pirmas projektavimo atvejis: A1+M1+R1

Drenuojančios sąlygos:

Efektyvioji sankiba:

$c_1 := \frac{c}{\gamma_{c.1}} = 0$ kPa

Priekrovos svoris:

$q := h_1 \cdot \rho \cdot 1.35 = 47.385$ kPa

Efektyvusis grunto slėgis:

$q = 47.385$ kPa

Vienetinis svoris:

$\gamma_1 := \frac{\rho}{\gamma_\gamma} = 19.5$

Vidinės trinties kampo tangentas:

$\tan\varphi := \frac{\tan(\varphi \cdot deg)}{\gamma_{\varphi.1}} = 0.863$

$e = 2.718$

Bedimensiai koeficientai:
Laikomosios galios:

$N_{q.1} := e^{\pi \cdot \tan\varphi} \cdot \left[\tan\left[\left(45 + \frac{\varphi}{2}\right) \cdot deg\right]\right]^2 = 71.826$

$N_{c.1} := \left(N_{q.1} - 1\right) \cdot \frac{\cos(\varphi \cdot deg)}{\sin(\varphi \cdot deg)} = 82.052$

$N_{\gamma.1} := 2 \cdot \left(N_{q.1} - 1\right) \cdot \tan\varphi = 122.27$

Pamato pado posvyrio:

$b_{q.1} := (1 - \alpha \cdot \tan\varphi)^2 = 1$

$b_{c.1} := b_{q.1} - \frac{\left(1 - b_{q.1}\right)}{N_{c.1} \cdot \tan\varphi} = 1$

$b_{\gamma.1} := b_{q.1} = 1$

Pamato pado formos:

$s_{q.1} := 1 + \frac{B_{ef}}{L_{ef}} \cdot \sin(\varphi \cdot deg) = 1.326$

$s_{\gamma.1} := 1 - 0.3 \cdot \frac{B_{ef}}{L_{ef}} = 0.85$

$s_{c.1} := \frac{s_{q.1} \cdot N_{q.1} - 1}{N_{q.1} - 1} = 1.33$

Apkrovos posvyrio:

$m_L := \frac{2 + \frac{L_{ef}}{B_{ef}}}{1 + \frac{L_{ef}}{B_{ef}}} = 1.333$

$$m_B := \frac{2 + \frac{B_{ef}}{L_{ef}}}{1 + \frac{B_{ef}}{L_{ef}}} = 1.667$$

$$\phi := \operatorname{atan}\left(\frac{V_{Ed.x.1}}{V_{Ed.y.1}}\right) \cdot \frac{180}{\pi} = 45$$

$$m := m_L \cdot \cos(\phi \cdot \mathrm{deg})^2 + m_B \cdot \sin(\phi \cdot \mathrm{deg})^2 = 1.5$$

$$i_{q.1} := \left(1 - \frac{V_{Ed}}{N_{Ed.1} + q_{pd} + A_{ef} \cdot c_1 \cdot \frac{1}{\tan\varphi}}\right)^m = 0.998$$

$$i_{c.1} := i_{q.1} - \frac{1 - i_{q.1}}{N_{c.1} \cdot \tan\varphi} = 0.998$$

$$i_{\gamma.1} := \left(1 - \frac{V_{Ed}}{N_{Ed.1} + q_{pd} + A_{ef} \cdot c_1 \cdot \frac{1}{\tan\varphi}}\right)^{(m+1)} = 0.996$$

$$R_{2.1} := c_1 \cdot N_{c.1} \cdot b_{c.1} \cdot s_{c.1} \cdot i_{c.1} + q \cdot N_{q.1} \cdot b_{q.1} \cdot s_{q.1} \cdot i_{q.1} + 0.5 \cdot \gamma_1 \cdot B \cdot N_{\gamma.1} \cdot b_{\gamma.1} \cdot s_{\gamma.1} \cdot i_{\gamma.1} = 5.007 \times 10^3$$

$$A_{2.1} := \frac{N_{Ed.1}}{R_{2.1}} = 0.018 \qquad A_{ef} = 0.495 \quad \text{Gerai!}$$

$$\frac{A_{2.1}}{A_{ef}} \cdot 100 = 3.669$$

Išvada: reikalingas pamato pado plotas 0,018 m2<0,495m2. Esamo pamato laikomosios galios išnaudojimas 4%, sąlyga tenkinama.

1.4.3. Esamų sekliųjų pamatų nuosėdžių skaičiavimas

Tikrinami esamų juostinių sekliųjų pamatų nuosėdžiai veikiant didžiausiai apkrovai (D ašis). Nuosėdžiai skaičiuojami sumavimo metodu.

Eil. Nr.	d,m	γ, kN/m^3	σ_{zg}, kPa	$0,2\sigma_{zg}$, kPa	z,m	ξ=2z/b	η=l/b	K	σ_{zp}, kPa	$\sigma_{zp,vid}$, kPa	H_i, m	E, Mpa	S_i, m
1	1.8	18.8	33.84	6.768	0	0	2	1	148.16		0.1		
2	1.9	19.5	35.79	7.158	0.1	0.4	2	0.977	144.75	146.5	0.1	67.7	0.0002
3	2	19.5	37.74	7.548	0.2	0.8	2	0.881	130.53	137.6	0.1	67.7	0.0002
4	2.1	19.5	39.69	7.938	0.3	1.2	2	0.755	111.86	121.2	0.1	67.7	0.0002
5	2.2	19.5	41.64	8.328	0.4	1.6	2	0.642	95.119	103.5	0.1	67.7	0.0002
6	2.3	19.5	43.59	8.718	0.5	2	2	0.55	81.488	88.3	0.1	67.7	0.0001
7	2.4	19.5	45.54	9.108	0.6	2.4	2	0.477	70.672	76.08	0.1	67.7	0.0001
8	2.5	19.5	47.49	9.498	0.7	2.8	2	0.42	62.227	66.45	0.1	67.7	1E-04
8	2.6	19.5	49.44	9.888	0.8	3.2	2	0.374	55.412	58.82	0.1	67.7	9E-05
8	2.7	19.5	51.39	10.28	0.9	3.6	2	0.337	49.93	52.67	0.1	67.7	8E-05
8	2.8	19.5	53.34	10.67	1	4	2	0.306	45.337	47.63	0.1	67.7	7E-05
8	2.9	19.5	55.29	11.06	1.1	4.4	2	0.28	41.485	43.41	0.1	67.7	6E-05
8	3	19.5	57.24	11.45	1.2	4.8	2	0.258	38.225	39.86	0.1	67.7	6E-05
8	3.1	19.5	59.19	11.84	1.3	5.2	2	0.239	35.41	36.82	0.1	67.7	5E-05
8	3.2	19.5	61.14	12.23	1.4	5.6	2	0.223	33.04	34.22	0.1	67.7	5E-05
8	3.3	19.5	63.09	12.62	1.5	6	2	0.208	30.817	31.93	0.1	67.7	5E-05
8	3.4	19.5	65.04	13.01	1.6	6.4	2	0.196	29.039	29.93	0.1	67.7	4E-05
8	3.5	19.5	66.99	13.4	1.7	6.8	2	0.184	27.261	28.15	0.1	67.7	4E-05
8	3.6	19.5	68.94	13.79	1.8	7.2	2	0.175	25.928	26.59	0.1	67.7	4E-05
8	3.7	19.5	70.89	14.18	1.9	7.6	2	0.166	24.595	25.26	0.1	67.7	4E-05
8	3.8	19.5	72.84	14.57	2	8	2	0.158	23.409	24	0.1	67.7	4E-05
8	3.9	19.5	74.79	14.96	2.1	8.4	2	0.15	22.224	22.82	0.1	67.7	3E-05
8	4	19.5	76.74	15.35	2.2	8.8	2	0.144	21.335	21.78	0.1	67.7	3E-05
8	4.1	19.5	78.69	15.74	2.3	9.2	2	0.137	20.298	20.82	0.1	67.7	3E-05
8	4.2	19.5	80.64	16.13	2.4	9.6	2	0.132	19.557	19.93	0.1	67.7	3E-05
8	4.3	19.5	82.59	16.52	2.5	10	2	0.126	18.668	19.11	0.1	67.7	3E-05
8	4.4	19.5	84.54	**16.91**	2.6	10.4	2	0.114	**16.89**	17.78	0.1	67.7	3E-05
												Σs_i=	0.002

Ned	91
B	0.5
L	1
A	0.5

Išvada: esamų pamatų nuosėdis 0,2cm<2,5cm, sąlyga tenkinama.

1.4.4. Polinių pamatų po kolonomis ir sienomis skaičiavimas

Projektuojami nauji poliniai pamatai apjungti rostverku po kolonomis ir sienomis. Poliaus skersmuo 300mm, rostverko matmenys 600x450mm. Mažiausias grunto kūginis stipris po pamato padu q_c=21MPa; šoninė trintis po pamato padu f_s=250 kPa. Deformacijų modulis 52,6MPa-93,8MPa pagal sluoksnius.

Reakcijos po kolonomis pateiktos reakcijų plane ir gaubtinėje.

Gniuždomojo poliaus po kolona laikomoji galia:

Veikiančios įrąžos:

$N_{Ed.1} := 51 \cdot 10^{-3} = 0.051$ MN

$N_{Ed.2} := 45 \cdot 10^{-3} = 0.045$ MN

Daliniai koeficientai:

Daliniai medžiagų patikimumo koef. atvejui M1:

$\gamma_{\varphi.1} := 1$

$\gamma_{c.1} := 1$

$\gamma_{cu.1} := 1$

$\gamma_{qu.1} := 1$

$\gamma_{\gamma 1} := 1$

Daliniai medžiagų patikimumo koef. atvejui M2:

$\gamma_{\varphi.2} := 1.25$

$\gamma_{c.2} := 1.25$

$\gamma_{cu.2} := 1.4$

$\gamma_{qu.2} := 1.4$

$\gamma_{\gamma 2} := 1$

Daliniai koeficientai CFA polių pagrindo atsparumui

	R1	R2	R3	R4
Polio pado laikomoji galia	$\gamma_{b1} := 1.1$	$\gamma_{b2} := 1.1$	$\gamma_{b3} := 1.0$	$\gamma_{b4} := 1.45$
Polio kamieno šoninio paviršiaus alikomoji galia gniuždymui	$\gamma_{s1} := 1.0$	$\gamma_{s2} := 1.1$	$\gamma_{s3} := 1.0$	$\gamma_{s4} := 1.30$
Polio pado suminis atsparumas gniuždymui	$\gamma_{t1} := 1.1$	$\gamma_{t2} := 1.1$	$\gamma_{t3} := 1.0$	$\gamma_{t4} := 1.40$
Polio laikomoji galia tempimui	$\gamma_{st1} := 1.25$	$\gamma_{st2} := 1.15$	$\gamma_{st3} := 1.1$	$\gamma_{st4} := 1.60$

$\alpha_b := 0.5$

$\xi_3 := 1.4$

Grunto rodikliai:

$\rho := 21 \ \frac{kN}{m^3}$

$q_c := 21$ MPa

$f_{s1} := 0.25$ MPa $f_{s2} := 0.0$ MPa $f_{s3} := 0.0$ MPa $f_{s4} := 0.0$ MPa $f_{s5} := 0.0$ MPa $f_{s6} := 0.02$ MPa $f_{s7} := 0.0$ MPa

Geometriniai rodikliai:

$f_{s8} := 0.0$ MPa

$h_1 := 0.5$ m $h_2 := 0.0$ m $h_3 := 0.0$ m $h_4 := 0.0$ m $h_5 := 0.0$ m $h_6 := 0$ m $h_7 := 0.0$ m $h_8 := 0.0$ m

$d := 0.3$ m

$A_p := \frac{\pi \cdot d^2}{4} = 0.071$ m^2

$A_{š1} := \pi \cdot d \cdot h_1 = 0.471$ m^2 $A_{š2} := \pi \cdot d \cdot h_2 = 0$ m^2 $A_{š3} := \pi \cdot d \cdot h_3 = 0$ m^2

$A_{š4} := \pi \cdot d \cdot h_4 = 0$ m^2 $A_{š5} := \pi \cdot d \cdot h_5 = 0$ m^2 $A_{š6} := \pi \cdot d \cdot h_6 = 0$ m^2

$A_{š7} := \pi \cdot d \cdot h_7 = 0$ m^2 $A_{š8} := \pi \cdot d \cdot h_8 = 0$ m^2

Pirmas projektavimo atvejis:
A1+M1+R1

$q_b := \alpha_b \cdot q_c = 10.5$ MPa

$R_b := q_b \cdot A_p = 0.742$ MN

$R_s := f_{s1} \cdot A_{s1} + f_{s2} \cdot A_{s2} + f_{s3} \cdot A_{s3} + f_{s4} \cdot A_{s4} + f_{s5} \cdot A_{s5} + f_{s6} \cdot A_{s6} + f_{s7} \cdot A_{s7} + f_{s8} \cdot A_{s8} = 0.118$

$$R_{c.cal1} := \frac{R_b}{\gamma_{b1}} + \frac{R_s}{\gamma_{s1}} = 0.793 \quad \text{MN}$$

$$R_{c.k1} := \frac{R_{c.cal1}}{\xi_3} = 0.566 \quad \text{MN}$$

$$R_{c.d1} := \frac{R_{c.k1}}{\gamma_{t1}} = 0.515 \quad \text{MN}$$

$$\frac{N_{Ed.1}}{R_{c.d1}} = 0.099$$

Antras projektavimo atvejis:
A2+M1+R4

$$R_{c.cal2} := \frac{R_b}{\gamma_{b4}} + \frac{R_s}{\gamma_{s4}} = 0.602 \quad \text{MN}$$

$$R_{c.k2} := \frac{R_{c.cal2}}{\xi_3} = 0.43 \quad \text{MN}$$

$$R_{c.d2} := \frac{R_{c.k2}}{\gamma_{t4}} = 0.307 \quad \text{MN}$$

$$\frac{N_{Ed.2}}{R_{c.d2}} = 0.146$$

Išvada: Esamo pamato laikomosios galios išnaudojimas A2 projektavimo atveju 15%, sąlyga tenkinama.

Reakcijos po sienomis pateiktos reakcijų plane ir gaubtinėje. Didžiausias atstumas tarp polių 4,22m.

Gniuždomojo poliaus po siena laikomoji galia:

Veikiančios įrąžos:

$N_{Ed.1} := 102 \cdot 10^{-3} = 0.102$ MN

$N_{Ed.2} := 64 \cdot 10^{-3} = 0.064$ MN

Daliniai koeficientai:

Daliniai medžiagų patikimumo koef. atvejui M1:

$\gamma_{\varphi.1} := 1$

$\gamma_{c.1} := 1$

$\gamma_{cu.1} := 1$

$\gamma_{qu.1} := 1$

$\gamma_{\gamma 1} := 1$

Daliniai medžiagų patikimumo koef. atvejui M2:

$\gamma_{\varphi.2} := 1.25$

$\gamma_{c.2} := 1.25$

$\gamma_{cu.2} := 1.4$

$\gamma_{qu.2} := 1.4$

$\gamma_{\gamma 2} := 1$

Daliniai koeficientai CFA polių pagrindo atsparumui

	R1	R2	R3	R4
Polio pado laikomoji galia	$\gamma_{b1} := 1.1$	$\gamma_{b2} := 1.1$	$\gamma_{b3} := 1.0$	$\gamma_{b4} := 1.45$
Polio kamieno šoninio paviršiaus alikomoji galia gniuždymui	$\gamma_{s1} := 1.0$	$\gamma_{s2} := 1.1$	$\gamma_{s3} := 1.0$	$\gamma_{s4} := 1.30$
Polio pado suminis atsparumas gniuždymui	$\gamma_{t1} := 1.1$	$\gamma_{t2} := 1.1$	$\gamma_{t3} := 1.0$	$\gamma_{t4} := 1.40$
Polio laikomoji galia tempimui	$\gamma_{st1} := 1.25$	$\gamma_{st2} := 1.15$	$\gamma_{st3} := 1.1$	$\gamma_{st4} := 1.60$

$\alpha_b := 0.5$

$\xi_3 := 1.4$

Grunto rodikliai:

$\rho := 21 \ \frac{kN}{m^3}$

$q_c := 21$ MPa

$f_{s1} := 0.25$ MPa $f_{s2} := 0.0$ MPa $f_{s3} := 0.0$ MPa $f_{s4} := 0.0$ MPa $f_{s5} := 0.0$ MPa $f_{s6} := 0.02$ MPa $f_{s7} := 0.0$ MPa

Geometriniai rodikliai:

$f_{s8} := 0.0$ MPa

$h_1 := 0.5$ m $h_2 := 0.0$ m $h_3 := 0.0$ m $h_4 := 0.0$ m $h_5 := 0.0$ m $h_6 := 0$ m $h_7 := 0.0$ m $h_8 := 0.0$ m

$d := 0.3$ m

$A_p := \frac{\pi \cdot d^2}{4} = 0.071$ m^2

$A_{š1} := \pi \cdot d \cdot h_1 = 0.471$ m^2 $A_{š2} := \pi \cdot d \cdot h_2 = 0$ m^2 $A_{š3} := \pi \cdot d \cdot h_3 = 0$ m^2

$A_{š4} := \pi \cdot d \cdot h_4 = 0$ m^2 $A_{š5} := \pi \cdot d \cdot h_5 = 0$ m^2 $A_{š6} := \pi \cdot d \cdot h_6 = 0$ m^2

$A_{š7} := \pi \cdot d \cdot h_7 = 0$ m^2 $A_{š8} := \pi \cdot d \cdot h_8 = 0$ m^2

Pirmas projektavimo atvejis:
A1+M1+R1

$q_b := \alpha_b \cdot q_c = 10.5$ MPa

$R_b := q_b \cdot A_p = 0.742$ MN

$R_s := f_{s1} \cdot A_{s1} + f_{s2} \cdot A_{s2} + f_{s3} \cdot A_{s3} + f_{s4} \cdot A_{s4} + f_{s5} \cdot A_{s5} + f_{s6} \cdot A_{s6} + f_{s7} \cdot A_{s7} + f_{s8} \cdot A_{s8} = 0.118$

$$R_{c.cal1} := \frac{R_b}{\gamma_{b1}} + \frac{R_s}{\gamma_{s1}} = 0.793 \quad \text{MN}$$

$$R_{c.k1} := \frac{R_{c.cal1}}{\xi_3} = 0.566 \quad \text{MN}$$

$$R_{c.d1} := \frac{R_{c.k1}}{\gamma_{t1}} = 0.515 \quad \text{MN}$$

$$\frac{N_{Ed.1}}{R_{c.d1}} = 0.198$$

Antras projektavimo atvejis:
A2+M1+R4

$$R_{c.cal2} := \frac{R_b}{\gamma_{b4}} + \frac{R_s}{\gamma_{s4}} = 0.602 \quad \text{MN}$$

$$R_{c.k2} := \frac{R_{c.cal2}}{\xi_3} = 0.43 \quad \text{MN}$$

$$R_{c.d2} := \frac{R_{c.k2}}{\gamma_{t4}} = 0.307 \quad \text{MN}$$

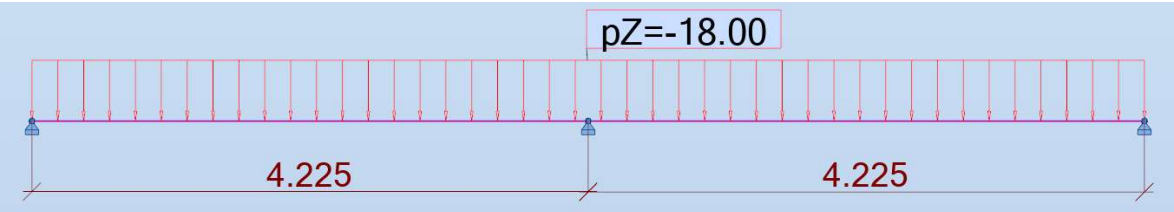
$$\frac{N_{Ed.2}}{R_{c.d2}} = 0.208$$

Išvada: Esamo pamato laikomosios galios išnaudojimas A2 projektavimo atveju 21%, sąlyga tenkinama.

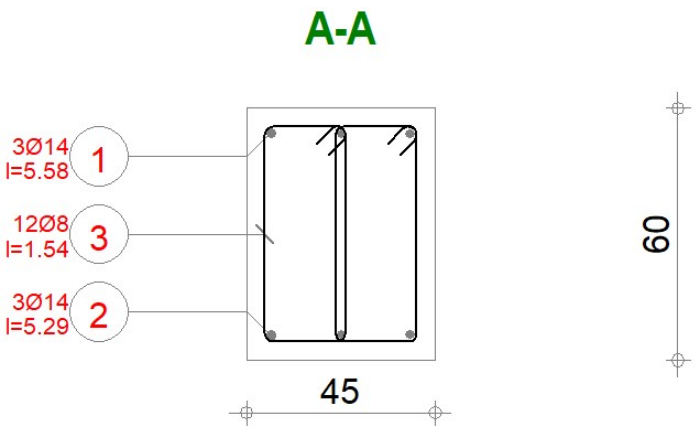
1.4.5. Rostverko virš naujų polių skaičiavimas

Projektuojamas polius apjungiantis monolitinis rostverkas kaip nekarpyta daugiaatramė sija. Skerspjūvis 600x450mm. Betonas C35/30 XC2 W6 F100, armatūra S500.

Skaičiuojamoji schema su veikiančiomis charakteristinėmis apkrovomis:



Reikalingas armavimas:



1 Level:

- Name :
- Reference level : ---
- Maximum cracking : 0.30 (mm)
- Exposure : XC2
- Concrete creep coefficient : φ_{π} = 2.64
- Cement class : N
- Concrete age (loading moment) : 28 (days)
- Concrete age : 50 (years)
- Concrete age after erecting a structure : 365 (years)
- Structure class : S4
- Fire resistance class : no requirements
- FFB Recommendations 7.4.3(7) : 0.00

2 Beam: Beam1 Number of identical elements: 1

2.1 Material properties:

- Concrete : C25/30 f_{ck} = 25.00 (MPa)
  Rectangular stress distribution [3.1.7(3)]
  Density : 2501.36 (kG/m3)
  Aggregate size : 20.0 (mm)
- Longitudinal reinforcement: : B500B f_{yk} = 500.00 (MPa)
  Horizontal branch of the stress-strain diagram
  Ductility class : B
- Transversal reinforcement: : B500B f_{yk} = 500.00 (MPa)
  Horizontal branch of the stress-strain diagram
  Ductility class : B
- Additional reinforcement: : f_{yk} = 0.00 (MPa)
  Horizontal branch of the stress-strain diagram
- Modified partial coefficients:

α_{cc} = 0.9 1992-1-1 3.1.6 (1)P

2.2 Geometry:

2.2.1

Span	Position	L.supp. (m)	L (m)	R.supp. (m)
P1	**Span 0.300**	**3.925**	**0.300**	

Span length: L_o = 4.225 (m)
Section from 0.000 to 3.925 (m)
45.0 x 60.0 (cm)
without left slab
without right slab

2.2.2

Span	Position	L.supp. (m)	L (m)	R.supp. (m)
P2	**Span 0.300**	**3.925**	**0.300**	

Span length: L_o = 4.225 (m)
Section from 0.000 to 3.925 (m)
45.0 x 60.0 (cm)
without left slab
without right slab

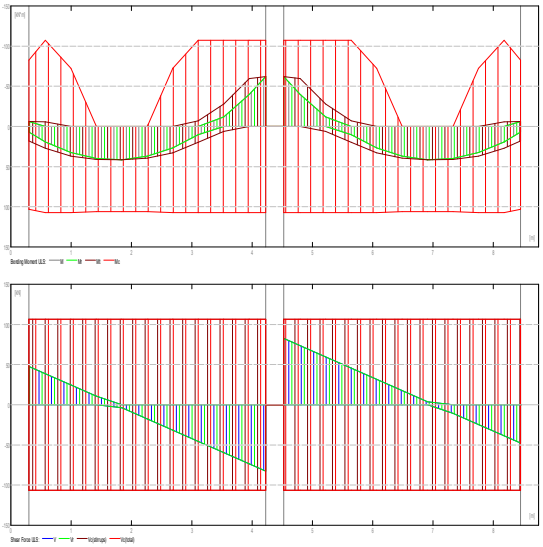
2.3 Calculation options:

- Regulation of combinations : EN 1990:2002
- Calculations according to : EN 1992-1-1:2004/A1:2014
- Seismic dispositions : No requirements
- Precast beam : no
- Cover : bottom c = 4.0 (cm)
  : side c1= 4.0 (cm)
  : top c2= 4.0 (cm)
- Cover deviations : Cdev = 1.0(cm), Cdur = 0.0(cm)
- Coefficient β_2 =0.50 : long-term or cyclic load
- Method of shear calculations : strut inclination

2.4 Calculation results:

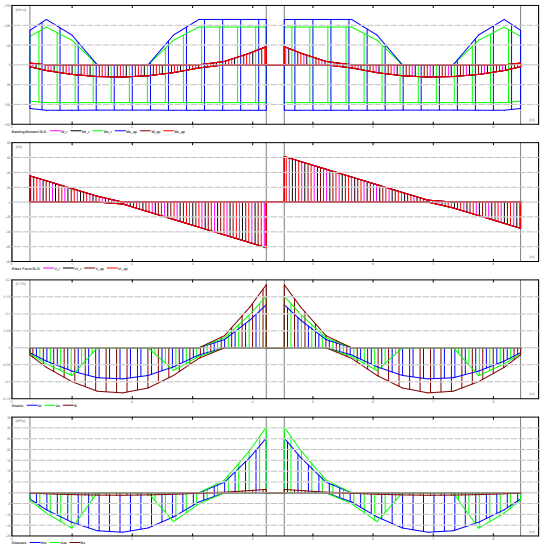
2.4.1 Internal forces in ULS

Span	Mt max. (kN*m)	Mt min. (kN*m)	Ml (kN*m)	Mr (kN*m)	Ql (kN)	Qr (kN)
P1	41.54	-6.83	17.94	-62.06	47.68	-82.79
P2	41.54	-6.83	-62.06	17.94	82.79	-47.68



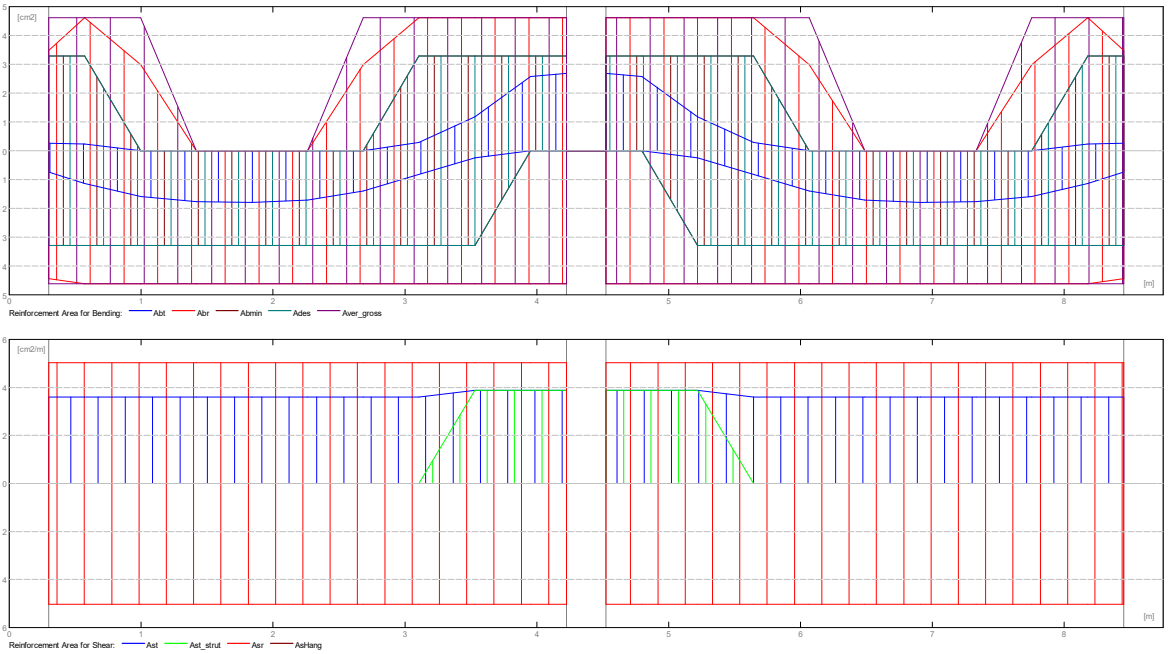
2.4.2 Internal forces in SLS

Span	Mt max. (kN*m)	Mt min. (kN*m)	Ml (kN*m)	Mr (kN*m)	Ql (kN)	Qr (kN)
P1	30.77	0.00	5.07	-45.97	35.32	-61.33
P2	30.77	0.00	-45.97	5.07	61.33	-35.32



2.4.3 Required reinforcement area

Span	Span (cm2)		Left support (cm2)		Right support (cm2)	
	bottom	top	bottom	top	bottom	top
P1	1.79	0.00	0.74	0.26	0.00	2.69
P2	1.79	0.00	0.00	2.69	0.74	0.26



2.4.4 Deflection and cracking

wt(QP) Total due to quasi-permanent combination
wt(QP)dop Allowable due to quasi-permanent combination
Dwt(QP) Deflection increment from the quasi-permanent load combination after erecting a structure.
Dwt(QP)dop Admissible deflection increment from the quasi-permanent load combination after erecting a structure.

wk - width of perpendicular cracks

Span	wt(QP) (cm)	wt(QP)dop (cm)	Dwt(QP) (cm)	Dwt(QP)dop (cm)	wk (mm)
P1	0.06	1.69	0.01	0.85	0.0
P2	0.06	1.69	0.01	0.85	0.0

2.5 Theoretical results - detailed results:

2.5.1 P1 : Span from 0.300 to 4.225 (m)

	ULS		SLS			
Abscissa (m)	M max. (kN*m)	M min. (kN*m)	M max. (kN*m)	M min. (kN*m)	A bottom (cm2)	A top (cm2)
0.300	17.94	-6.23	5.07	-4.62	0.74	0.26
0.573	26.96	-5.56	14.28	0.00	1.13	0.23
0.995	36.90	-0.00	24.17	0.00	1.59	0.00
1.418	40.91	-0.00	29.67	0.00	1.76	0.00
1.840	41.54	-0.00	30.77	0.00	1.79	0.00
2.263	39.65	-0.00	27.47	0.00	1.71	0.00
2.685	32.67	-0.00	19.78	0.00	1.40	0.00
3.108	19.77	-6.83	7.69	0.00	0.82	0.28
3.530	5.97	-28.08	0.00	-8.79	0.25	1.18
3.953	0.00	-59.68	0.00	-29.67	0.00	2.58
4.225	0.00	-62.06	0.00	-45.97	0.00	2.69

Abscissa (m)	ULS V max. (kN)	SLS V max. (kN)	afp (mm)
0.300	47.68	35.32	0.0

0.573	38.62	28.61	0.0
0.995	24.58	18.21	0.0
1.418	10.53	7.80	0.0
1.840	-3.51	-2.60	0.0
2.263	-17.56	-13.00	0.0
2.685	-31.60	-23.41	0.0
3.108	-45.64	-33.81	0.0
3.530	-59.69	-44.21	0.0
3.953	-73.73	-54.62	0.0
4.225	-82.79	-61.33	0.0

2.5.2 P2 : Span from 4.525 to 8.450 (m)

	ULS		SLS			
Abscissa (m)	M max. (kN*m)	M min. (kN*m)	M max. (kN*m)	M min. (kN*m)	A bottom (cm2)	A top (cm2)
4.525	0.00	-62.06	0.00	-45.97	0.00	2.69
4.798	0.00	-59.68	0.00	-29.67	0.00	2.58
5.220	5.97	-28.08	0.00	-8.79	0.25	1.18
5.643	19.77	-6.83	7.69	0.00	0.82	0.28
6.065	32.67	-0.00	19.78	0.00	1.40	0.00
6.488	39.65	-0.00	27.47	0.00	1.71	0.00
6.910	41.54	-0.00	30.77	0.00	1.79	0.00
7.333	40.91	-0.00	29.67	0.00	1.76	0.00
7.755	36.90	-0.00	24.17	0.00	1.59	0.00
8.178	26.96	-5.56	14.28	0.00	1.13	0.23
8.450	17.94	-6.23	5.07	-4.62	0.74	0.26

Abscissa (m)	ULS V max. (kN)	SLS V max. (kN)	afp (mm)
4.525	82.79	61.33	0.0
4.798	73.73	54.62	0.0
5.220	59.69	44.21	0.0
5.643	45.64	33.81	0.0
6.065	31.60	23.41	0.0
6.488	17.56	13.00	0.0
6.910	3.51	2.60	0.0
7.333	-10.53	-7.80	0.0
7.755	-24.58	-18.21	0.0
8.178	-38.62	-28.61	0.0
8.450	-47.68	-35.32	0.0

2.6 Reinforcement:

2.6.1 P1 : Span from 0.300 to 4.225 (m)

Longitudinal reinforcement:

- bottom (B500B)
  3 ϕ14 l = 8.891 from 0.040 to 8.710
- assembling (top) (B500B)
  3 ϕ8 l = 2.610 from 0.535 to 3.145
- support (B500B)
  3 ϕ14 l = 1.574 from 0.040 to 1.360
  3 ϕ14 l = 4.109 from 2.320 to 6.430

Transversal reinforcement:

- main (B500B)
  stirrups 20 ϕ8 l = 1.536
  e = 1*0.163 + 9*0.400 (m)

2.6.2 P2 : Span from 4.525 to 8.450 (m)

Longitudinal reinforcement:

- assembling (top) (B500B)
  3 ϕ8 l = 2.610 from 5.605 to 8.215
- support (B500B)

3 ϕ14 l = 1.574 from 7.390 to 8.710

Transversal reinforcement:

- main (B500B)
  stirrups 20 ϕ8 l = 1.536
  e = 1*0.163 + 9*0.400 (m)

3 Material survey:

- Concrete volume = 2.363 (m3)
- Formwork = 14.573 (m2)

- Steel B500B
  - Total weight = 89.00 (kG)
  - Density = 37.67 (kG/m3)
  - Average diameter = 10.3 (mm)
  - Survey according to diameters:

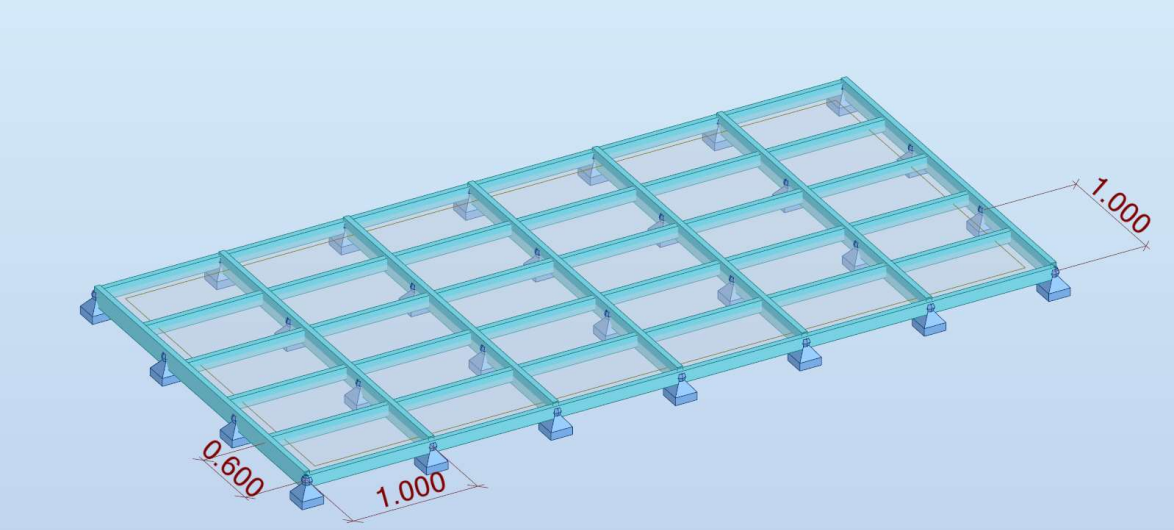
Diameter (mm)	Length (m)	Weight (kG)	Number (No.)	Total weight (kG)
8	1.536	0.61	40	24.26
8	2.610	1.03	6	6.18
14	1.574	1.90	6	11.42
14	4.109	4.97	3	14.90
14	8.891	10.75	3	32.24

Išvada: sąlyga tenkinama

1.5. Terasos ilginių ir sraigtinių polių parinkimas

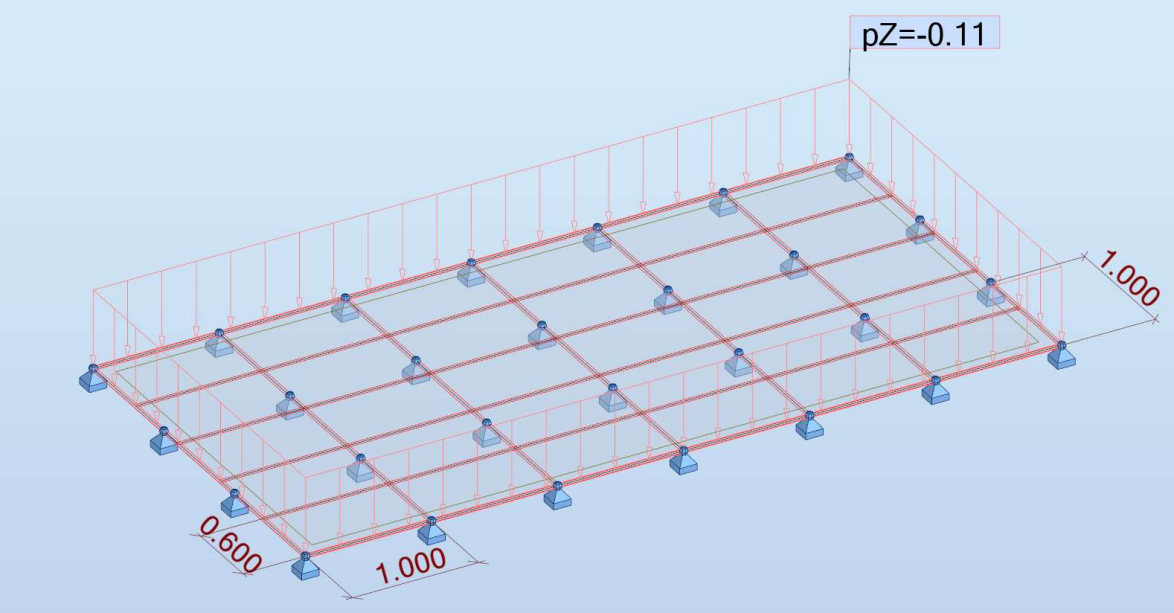
Projektuojama terasa iš pagrindinių medinių ilginių 145x45mm skerspjūvio ir šalutinių medinių ilginių 95x45mm, medienos klasė C18. Pagrindinių ilginių žingsnis 1m, atramos-sraigtiniai poliai išdėstyti kas metrą, šalutinių ilginių žingsnis 600mm (žingsnis tikslinamas DP metu pagal medžio kompozito apdailos lentų gamintoją). Skaičiuojama tik terasos dalis.

Skaičiuojamoji schema:

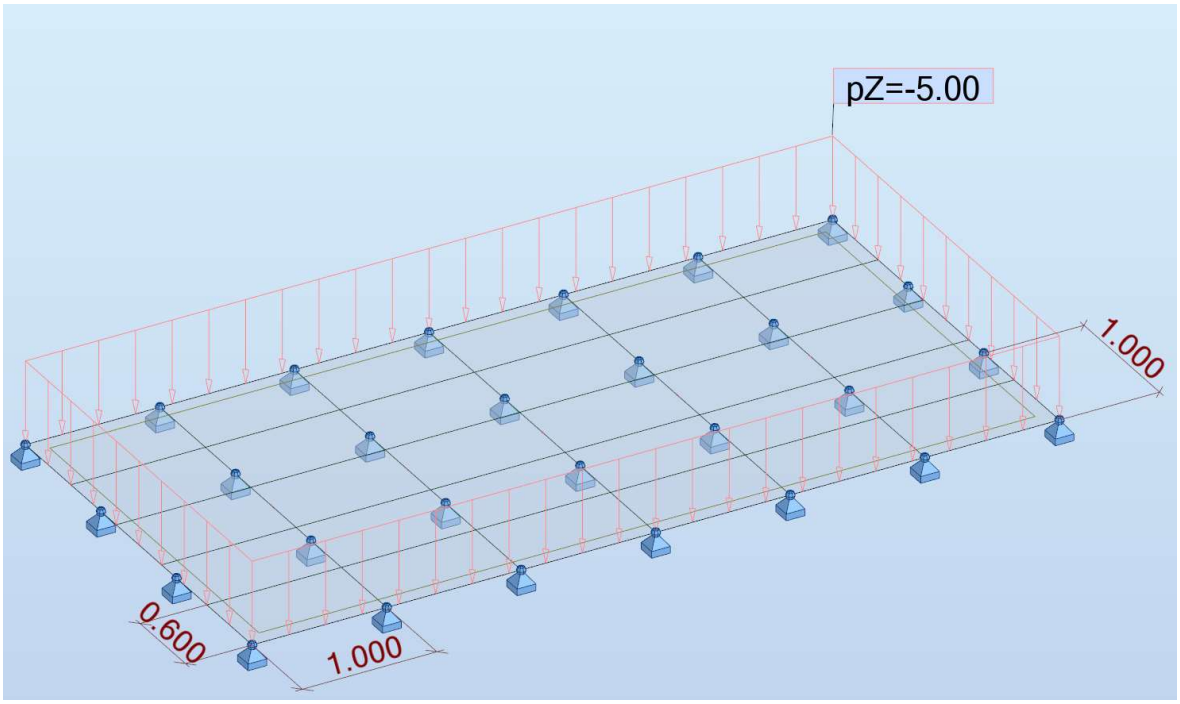


Veikiančios apkrovos.

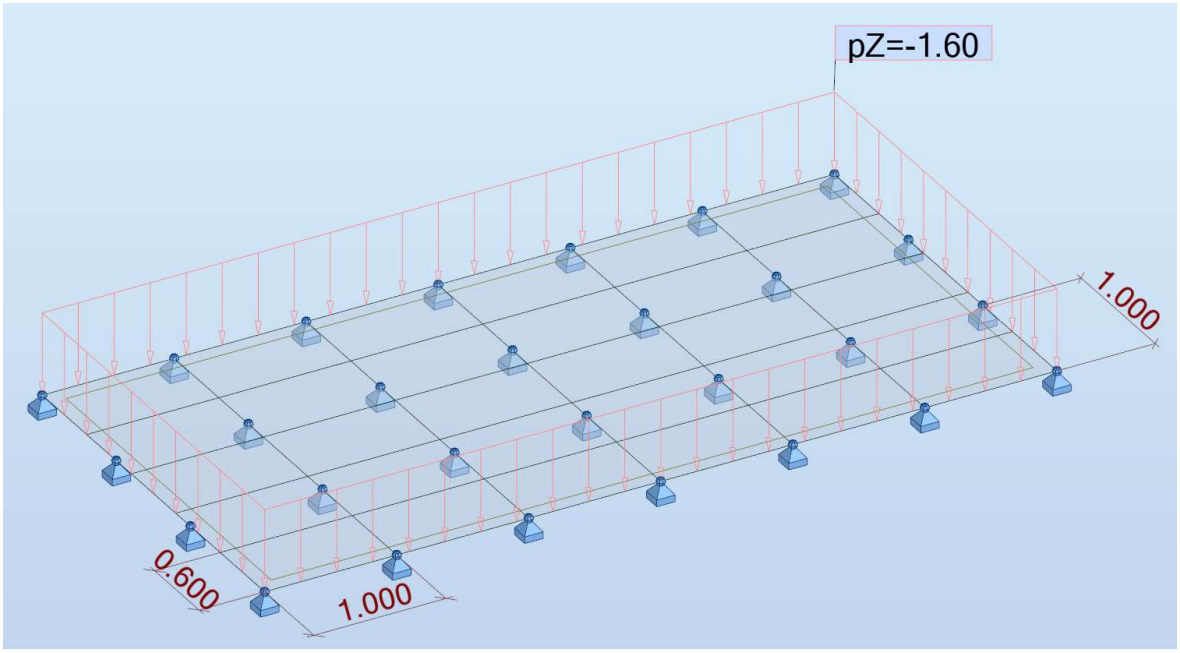
Nuolatinės apkrovos:



Naudojimo apkrovos:



Sniego apkrovos:



Pagrindinių ilginių projektavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:

MEMBER: 11 Pagrindinė sija_11 **POINT:** 3 **COORDINATE:** x = 0.67 L = 2.000 m

---

LOADS:

Governing Load Case: 4 ULS/1=1*1.35 + 2*1.30 + 3*0.91 1*1.35+2*1.30+3*0.91

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_145x45

ht=14.5 cm

bf=4.5 cm	Ay=43.50 cm2	Az=43.50 cm2	Ax=65.25 cm2
tw=2.3 cm	Iy=1143.23 cm4	Iz=110.11 cm4	Ix=354.3 cm4
tf=2.3 cm	Wy=157.69 cm3	Wz=48.94 cm3	

STRESSES

Sig_m,y,d = MY/Wy= -0.95/157.69 = -6.05 MPa

Tau z,d = 1.5*-5.55/65.25 = -1.28 MPa

Tau tory,d = 0.00 MPa, Tau torz,d = 0.00 MPa

ALLOWABLE STRESSES

f m,y,d = 11.15 MPa

f v,d = 2.09 MPa

Factors and additional parameters

kh_y = 1.01 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 2.628 m Lambda_rel m = 0.90

Sig_cr = 22.42 MPa k crit = 0.89

BUCKLING PARAMETERS:

 About Y axis:

 About Z axis:

VERIFICATION FORMULAS:

Sig_m,y,d/f m,y,d = 6.05/11.15 = 0.54 < 1.00 (6.11)

Sig_m,y,d/(kcrit*f m,y,d) = 6.05/(0.89*11.15) = 0.61 < 1.00 (6.33)

(Tau y,d/kcr+Tau tory,d/kshape)/f v,d = 0.00 < 1.00 (Tau z,d/kcr+Tau torz,d/kshape)/f v,d = 0.91 < 1.00 (6.13-4)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):

u fin,y = 0.00 cm < u fin,max,y = L/200.00 = 1.50 cm Verified

Governing load case: (1+0.6)*1

u fin,z = 0.04 cm < u fin,max,z = L/200.00 = 1.50 cm Verified

Governing load case: (1+0.6)*1 + (1+0.6*0.6)*2 + (0.7+0.2*0.6)*3

Displacements (GLOBAL SYSTEM):

Section OK !!!

Išvada: sąlyga tenkinama

Šalutinių ilginių projektavimas

CODE: *EN 1995-1:2004/A2:2014*
ANALYSIS TYPE: Member Verification

CODE GROUP:
MEMBER: 6 šalutinė sija_6 **POINT:** 1 **COORDINATE:** x = 0.83 L = 5.000 m

---

LOADS:
Governing Load Case: 4 ULS/1=1*1.35 + 2*1.30 + 3*0.91 1*1.35+2*1.30+3*0.91

MATERIAL C18

gM = 1.30	f m,0,k = 18.00 MPa	f t,0,k = 11.00 MPa	f c,0,k = 18.00 MPa
f v,k = 3.40 MPa	f t,90,k = 0.40 MPa	f c,90,k = 2.20 MPa	E 0,moyen = 9000.00 MPa
E 0,05 = 6000.00 MPa	G moyen = 560.00 MPa	Service class: 1	Beta c = 0.20

SECTION PARAMETERS: RECT_95x45

ht=9.5 cm

bf=4.5 cm	Ay=28.50 cm2	Az=28.50 cm2	Ax=42.75 cm2
tw=2.3 cm	Iy=321.52 cm4	Iz=72.14 cm4	Ix=202.4 cm4
tf=2.3 cm	Wy=67.69 cm3	Wz=32.06 cm3	

STRESSES
Sig_m,y,d = MY/Wy= -0.51/67.69 = -7.60 MPa

Tau z,d = 1.5*2.96/42.75 = 1.04 MPa
Tau tory,d = 0.01 MPa, Tau torz,d = 0.01 MPa

ALLOWABLE STRESSES
f m,y,d = 12.14 MPa
f v,d = 2.09 MPa

Factors and additional parameters
kh_y = 1.10 kmod = 0.80 Ksys = 1.00 kcr = 0.67

LATERAL BUCKLING PARAMETERS:

lef = 5.353 m	Lambda_rel m = 1.07
Sig_cr = 15.68 MPa	k crit = 0.76

BUCKLING PARAMETERS:

 About Y axis:

 About Z axis:

VERIFICATION FORMULAS:
Sig_m,y,d/f m,y,d = 7.60/12.14 = 0.63 < 1.00 (6.11)
Sig_m,y,d/(kcrit*f m,y,d) = 7.60/(0.76*12.14) = 0.83 < 1.00 (6.33)
(Tau y,d/kcr+Tau tory,d/kshape)/f v,d = 0.00 < 1.00 (Tau z,d/kcr+Tau torz,d/kshape)/f v,d = 0.74 < 1.00 (6.13-4)

LIMIT DISPLACEMENTS

Deflections (LOCAL SYSTEM):
u fin,y = 0.00 cm < u fin,max,y = L/200.00 = 3.00 cm Verified
Governing load case: (1+0.6)*1
u fin,z = 0.10 cm < u fin,max,z = L/200.00 = 3.00 cm Verified
Governing load case: (1+0.6)*1 + (1+0.6*0.6)*2 + (0.7+0.2*0.6)*3

Displacements (GLOBAL SYSTEM):

Section OK !!!

Išvada: sąlyga tenkinama

Sraigtinį polį veikiančios apkrovos:

	FX (kN)	FY (kN)	FZ (kN)	MX (kNm)	MY (kNm)	MZ (kNm)
MAX	0.08	0.03	9.80	0.00	0.00	0.00
Node	41	63	52	40	39	59
Case	20 (C)	22 (C)	6 (C)	7 (C)	6 (C)	22 (C)
MIN	-0.00	-0.01	0.03	-0.00	-0.00	-0.00
Node	5	2	2	5	53	5
Case	22 (C)	20 (C)	19 (C)	7 (C)	6 (C)	22 (C)

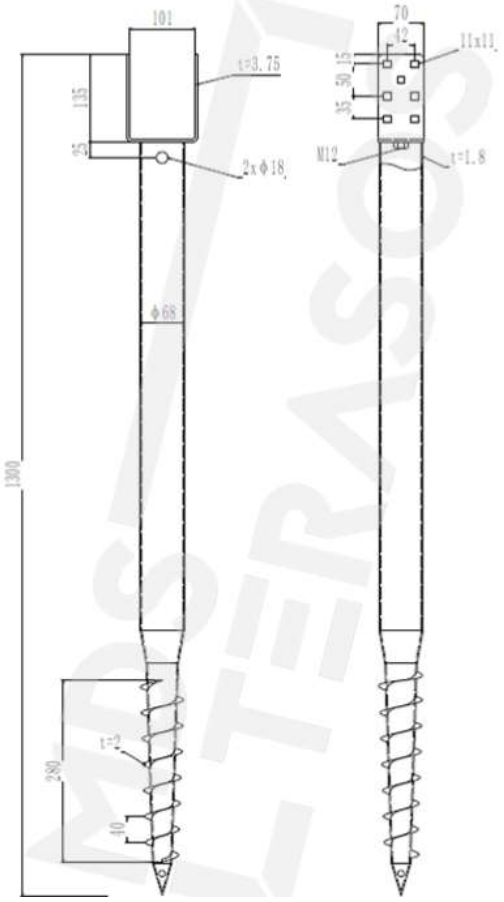
Sraigtinis polis pasirenkamas pagal gamintojo techninių duomenų lapą. Gali būti naudojamas kito gamintojo produktas su charakteristikomis ne blogesnėmis už pasirinktą produktą.

U1300x101 M12

	Išorinis ø *Outer ø*	Ilgis *Lenght*	Storis *Thickness*	Sriegis *Thread*	Galvos plotis *Top width*	Sriegio aukštis *Thread height*	Svoris *Weight*
U 1300x101 M12	68 mm.	1300 mm.	1.8 mm.	M12.	101 mm.	280 mm.	4.30 kg.

Sraigtiniai pamatai pagaminti iš plieno: (S235) kokybė atitinka DIN EN 10025-2:2004-10 standartą. Karštai cinkuotas pagal DIN EN ISO 1461 reikalavimus.
Ground screws are made of S235 steel grade. Quality meets the DIN EN 10025-2:2004-10 standard. Galvanization standard: DIN EN ISO 1461.

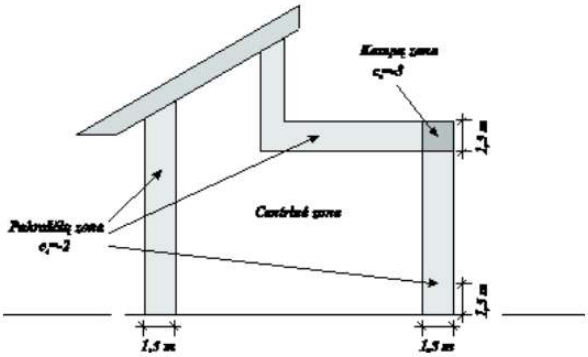
	Maksimali tiesinė apkrova *Max vertical compression force, kN (kg)*	Maksimali rovimo apkrova *Max vertical uplift force, kN (kg)*	Maksimali šoninė apkrova *Max horizontal force, kN (kg)*
U 1300x101 M12	10.0 (1019)	6.2 (632)	3.9 (397)



Išvada: Fz=9,80kN<10kN, Fx=0,08kN<3,9kN. Sąlygos tenkinamos, sraigtinio poliaus U1300x101 M12 laikomoji galia pakankama.

1.6. Nevėdinamos sistemos tvirtinimo elemento prie pagrindo ištraukimo iš pagrindo arba nutraukimo jėgos skaičiavimas

Sienų zonavimo schema pagal STR2.04.01:2018:



1.2 paveikslas. Pastato sienų aerodinaminių koeficientų nustatymo schema. Pagal išorinį sienų kontūrą išilgai paviršiaus 1,5 m plotyje esančiose vietose aerodinaminis koeficientas c_e= -2; 1,5 m nuo pastato kampo aerodinaminis koeficientas c_e= -3.

Mechaniškai tvirtinamos nevėdinamos sistemos projektinis atplėšimo stipris R_{mt}:

$R_{mt} = \frac{N_{rt} \cdot n}{g_{mt}} = \frac{0{,}6 \cdot 4}{2} = 1{,}2\ kPa.$

Čia:

N_{rt} – tvirtinimo prie pagrindo elemento ištraukimo jėga iš pagrindo, kurią pateikia gamintojas (kN), ją privaloma patikrinti bandymu statybos aikštelėje;

n – bendras tvirtinimo elementų kiekis pagal gamintojo tvirtinimo elementų išdėstymo schemą (vnt/m^2);

g_{mt} – atsargos koeficintas mechaniškai tvirtinamai nevėdinamai sistemai. Suminis sistemos svoris be klijų 56 kg/m^2 yra didesnis už 10 kg/m^2, $g_{mt} = 2$.

Kampų zonos:

Aukštis h [m]	Vietovės tipas	Atvira sienos dalis mažesnė nei 5 %	Vėjo stiprumas $v_{ref,0}$ [m/s]	Skaičiuojama vieta
6.93	B	Taip	24	Kampas

c(z)	ci	ce
0.5579	0.2	-3

Vėdinamos sistemos atplėšimo nuo pagrindo stipris R_{vent} (kPa) turi būti ne mažesnis užprojektinę vėjo apkrovą s_{ds} (kPa): $R_{vent} \geq s_{ds}$

kur:

projektinė vėjo apkrova: $s_{ds} = 0{,}001 \cdot |w_{sum}| \cdot \gamma_Q =$ -0.90

suminis vėjo slėgis į atitvaros paviršių: $w_{sum} = w_{me} - w_i =$ -695.15

vėjo slėgis į išorinį (priešvėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_e =$ -651.70

vėjo slėgis į vidinį (pavėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_i =$ 43.45

atskaitinis vėjo slėgis: $q_{ref} = \frac{\rho}{2} \cdot v_{ref}^2 =$ 389.38

atskaitinis vėjo greitis: $v_{ref} = c_{DIR} \cdot c_{TEM} \cdot c_{ALT} \cdot v_{ref,0} \cdot 1{,}04 =$ 24.96

čia: $\rho = 1{,}25 kg/m^3$; $c_{DIR} = 1{,}0$; $c_{TEM} = 1{,}0$; $c_{ALT} = 1{,}0$; $\gamma_Q = 1{,}3$.

Vėdinamos sistemos tvirtinimo elemento prie pagrindo ištraukimo iš pagrindo jėga arba nutraukimo jėga skaičiuojama pagal:

$$s_{ds} = \frac{N_{(Rtv)} \cdot n_{vent}}{\gamma_{vent}} \rightarrow N_{(Rtv)} = \frac{s_{ds} \cdot \gamma_{vent}}{n_{vent}} =$$ -0.452

čia:

vėdinamos sistemos tvirtinimo prie pagrindo elementų kiekis: $n_{vent} =$ 4

atsargos koeficientas vėdinamai sistemai: $\gamma_{vent} =$ 2

Išvada: $R_{mt} = 1,2\ kPa > s_{ds} = 0,90\ kPa.$, smeigių ištaukimo laikomoji galia pakankama. Kadangi suminis sistemos svoris be klijų 56 kg/m^2, turi būti naudojamos smeigės su metlainėmis vinimis.

Pakraščių zonos:

Aukštis h [m]	Vietovės tipas	Atvira sienos dalis mažesnė nei 5 %	Vėjo stiprumas $v_{ref,0}$ [m/s]	Skaičiuojama vieta
6.93	B	Taip	24	Pakraštys

c(z)	ci	ce
0.5579	0.2	-2

Vėdinamos sistemos atplėšimo nuo pagrindo stipris R_{vent} (kPa) turi būti ne mažesnis užprojektinę vėjo apkrovą s_{ds} (kPa): $R_{vent} \geq s_{ds}$

kur:

projektinė vėjo apkrova: $s_{ds} = 0{,}001 \cdot |w_{sum}| \cdot \gamma_Q =$ -0.62

suminis vėjo slėgis į atitvaros paviršių: $w_{sum} = w_{me} - w_i =$ -477.91

vėjo slėgis į išorinį (priešvėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_e =$ -434.47

vėjo slėgis į vidinį (pavėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_i =$ 43.45

atskaitinis vėjo slėgis: $q_{ref} = \frac{\rho}{2} \cdot v_{ref}^2 =$ 389.38

atskaitinis vėjo greitis: $v_{ref} = c_{DIR} \cdot c_{TEM} \cdot c_{ALT} \cdot v_{ref,0} \cdot 1{,}04 =$ 24.96

čia: $\rho = 1{,}25 kg/m^3$; $c_{DIR} = 1{,}0$; $c_{TEM} = 1{,}0$; $c_{ALT} = 1{,}0$; $\gamma_Q = 1{,}3$.

Vėdinamos sistemos tvirtinimo elemento prie pagrindo ištraukimo iš pagrindo jėga arba nutraukimo jėga skaičiuojama pagal:

$$s_{ds} = \frac{N_{(Rtv)} \cdot n_{vent}}{\gamma_{vent}} \rightarrow N_{(Rtv)} = \frac{s_{ds} \cdot \gamma_{vent}}{n_{vent}} =$$ -0.311

čia:

vėdinamos sistemos tvirtinimo prie pagrindo elementų kiekis: $n_{vent} =$ 4

atsargos koeficientas vėdinamai sistemai: $\gamma_{vent} =$ 2

Išvada: $R_{mt} = 1,2\ kPa > s_{ds} = 0,62\ kPa.$, smeigių ištaukimo laikomoji galia pakankama. Kadangi suminis sistemos svoris be klijų 56 kg/m², turi būti naudojamos smeigės su metlainėmis vinimis.

Centrinės zonos:

Aukštis h [m]	Vietovės tipas	Atvira sienos dalis mažesnė nei 5 %	Vėjo stiprumas $v_{ref,0}$ [m/s]	Skaičiuojama vieta
6.93	B	Taip	24	Centras

c(z)	ci	ce
0.5579	0.2	-0.8

Vėdinamos sistemos atplėšimo nuo pagrindo stipris R_{vent} (kPa) turi būti ne mažesnis užprojektinę vėjo apkrovą s_{ds} (kPa): $R_{vent} \geq s_{ds}$

kur:

projektinė vėjo apkrova: $s_{ds} = 0{,}001 \cdot |w_{sum}| \cdot \gamma_Q =$ -0.28

suminis vėjo slėgis į atitvaros paviršių: $w_{sum} = w_{me} - w_i =$ -217.23

vėjo slėgis į išorinį (priešvėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_e =$ -173.79

vėjo slėgis į vidinį (pavėjinį) atitvaros paviršių: $w_{me} = q_{ref} \cdot c(z) \cdot c_i =$ 43.45

atskaitinis vėjo slėgis: $q_{ref} = \frac{\rho}{2} \cdot v_{ref}^2 =$ 389.38

atskaitinis vėjo greitis: $v_{ref} = c_{DIR} \cdot c_{TEM} \cdot c_{ALT} \cdot v_{ref,0} \cdot 1{,}04 =$ 24.96

čia: $\rho = 1{,}25 kg/m^3$; $c_{DIR} = 1{,}0$; $c_{TEM} = 1{,}0$; $c_{ALT} = 1{,}0$; $\gamma_Q = 1{,}3$.

Vėdinamos sistemos tvirtinimo elemento prie pagrindo ištraukimo iš pagrindo jėga arba nutraukimo jėga skaičiuojama pagal:

$$s_{ds} = \frac{N_{(Rtitv)} \cdot n_{vent}}{\gamma_{vent}} \quad \rightarrow \quad N_{(Rtitv)} = \frac{s_{ds} \cdot \gamma_{vent}}{n_{vent}} = \text{-0.141}$$

čia:

vėdinamos sistemos tvirtinimo prie pagrindo elementų kiekis: $n_{vent} =$ 4

atsargos koeficientas vėdinamai sistemai: $\gamma_{vent} =$ 2

Išvada: $R_{mt} = 1{,}2\ kPa > s_{ds} = 0{,}28\ kPa.$, smeigių ištraukimo laikomoji galia pakankama. Kadangi suminis sistemos svoris be klijų 56 kg/m², turi būti naudojamos smeigės su metlainėmis vinimis.

1.7. Laisvai stovinčios mūro sienos projektavimas

Projektuojama nesurišta mūro siena iš akyto betono blokelių. Sienos storis 250mm, sienos aukščiausias aukštis iki monolitinio žiedo 5,3m.

Tikrinami sienos aukščio ir storio leistinieji santykiai, gembinei sienai leistinasis santykis pamažintas 30%:

SIENŲ AUKŠČIO IR STORIO LEISTINIEJI SANTYKIAI

Sienos aukštis:

$l_s := 5.3$ m

Sienos storis:

$h_s := 0.25$ m

Laisvasis sienos ilgis:

$l_{os} := 8.45$ m

$if\left(l_s > l_{os}, if\left(\frac{l_{os}}{h_s} < 1.2 \cdot 25, concat("gerai"), concat("Los per didelis")\right), concat("Los tinka")\right) = "Los tinka"$

Sienos inercijos momentas:

$I_s := \frac{l_{os} \cdot h_s^3}{12} = 0.011$ m4

Sienos skerspjūvio plotas:

$A_s := h_s \cdot l_{os} = 2.112$ m2

Sienos efektyvusis storis:

$h_{eff.s} := 3.5 \cdot \sqrt{\frac{I_s}{A_s}} = 0.253$ m

Sienos aukščio ir storio santykis:

$\beta_s := \frac{l_s}{h_{eff.s}} = 20.983$

Sienoms neapkrautoms denginio ir perdangų apkrova, kai hs>=250, kai gembinė siena

$if(l_{os} < 2.5 \cdot l_s, if(\beta_s < 1.2 \cdot 25 \cdot 0.7, concat("gerai"), concat("blogai")), if(l_{os} > 3.5 \cdot l_s, if(\beta_s < 1.2 \cdot 0.8 \cdot 25 \cdot 0.7, concat("gerai"), concat("blogai")), if(\beta_s < 1.2 \cdot 0.9 \cdot 25 \cdot 0.7, concat("gerai"), concat("blogai")))) = "gerai"$

Išvada: aukščio ir storio leistinieji santykiai tenkinami

Skaičiuojamas 5MPa stiprio akytų blokelių mūro skaičiuojamasis stipris:

NEARMUOTO MŪRO SKAIČIUOJAMASIS STIPRIS

$\gamma_M := 3$

$f_b := 5$ MPa

$f_m := 5$ MPa

$K := 0.45$

$f_k := K \cdot f_b^{0.7} \cdot f_m^{0.3} = 2.25$ MPa

$f_d := \frac{f_k}{\gamma_M} = 0.75$ MPa

Skaičiuojama ekscentriškai gniuždomos sienos laikomoji galia, skaičiuojant nuo apkrovos nuo stogo ilginių, veikiančios su ekscentricitetu:

Sienos aukštis

$l := 5.3$ m

Sienos ilgis (atstumas tarp skersinių sienų)

$l_{0s} := 8.45$ m

Sienos storis

$h := 0.25$ m

$y := \frac{h}{2} = 0.125$ m

Veikianti ašinė jėga

$N_{ed} := 3.28$ kN

Jėgos pridėjimo ekscentricitetas

$e_0 := 0.063$ m

Skaičiuojamasis elemento aukštis

$l_0 := 1 = 5.3$ m

Santykis

$\lambda_h := \frac{l_0}{h} = 21.2$

Mūro tamprumo charakteristika iš 16 lentelės

$\alpha := 500$

Klupumo koeficientas iš 19 lentelės

$\varphi := 0.45$

Gniuždomos zonos aukštis

$h_c := h - 2 \cdot e_0 = 0.124$

Gniuždomos zonos santykis

$\lambda_{hc} := \frac{l}{h_c} = 42.742$

Gniuždomos zonos klupumo koeficientas iš 19 lentelės

$\varphi_c := 0.17$

$$\varphi_1 := \frac{\varphi + \varphi_c}{2} = 0.31$$

Elemento skerspjūvio plotas

$A := h \cdot l_{0s} = 2.112$ m2

$$A_c := A \cdot \left(1 - \frac{2 \cdot e_0}{h}\right) = 1.048$$

$e_{0lt} := e_0 = 0.063$ m

$N_{Edlt} := 3.28$ kN

$\eta := 0.08$ iš 21 lentelės

$$m_{lt} := if\left[h \geq 0.3, 1, 1 - \eta \cdot \frac{N_{Edlt}}{N_{ed}} \cdot \left(1 + \frac{1.2 \cdot e_{0lt}}{h}\right)\right] = 0.896$$

$$\omega := 1 + \frac{e_0}{h} = 1.252$$ iš 20 lentelės

Skaičiuojamasis mūro gniuždomasis stipris

$f_d := 0.75 \cdot 10^3 = 750$ kPa

$N_{Rd} := m_{lt} \cdot \varphi_1 \cdot f_d \cdot A_c \cdot \omega = 273.225$ kN

$$\frac{N_{ed}}{N_{Rd}} = 0.012$$

Išvada: sąlyga tenkinama

Skaičiuojama centriškai gniuždomos sienos laikomoji galia, skaičiuojant sieną apatiniame pjūvyje nuo atraminės reakcijos apkrovos:

Centriškai gniuždoma nearmuota mūrinė siena

Sienos aukštis

$l := 5.3$ m

Sienos storis

$h := 0.25$ m

$y := \frac{h}{2} = 0.125$ m

Veikianti ašinė jėga

$N_{ed} := 24$ kN

Skaičiuojamasis elemento aukštis

$l_0 := 1 = 5.3$ m

Santykis

$\lambda_h := \frac{l_0}{h} = 21.2$

Mūro tamprumo charakteristika iš 16 lentelės

$\alpha := 500$

Klupumo koeficientas iš 19 lentelės

$\varphi := 0.45$

Elemento skerspjūvio plotas

$A := h \cdot 1 = 0.25$ m2

$e_{0lt} := 0$ m

$N_{Edlt} := 24$ kN

$\eta := 0.14$ iš 21 lentelės

$$m_{lt} := \text{if}\left[h \geq 0.3, 1, 1 - \eta \cdot \frac{N_{Edlt}}{N_{ed}} \cdot \left(1 + \frac{1.2 \cdot e_{0lt}}{h}\right)\right] = 0.86$$

Skaičiuojamasis mūro gniuždomasis stipris

$f_d := 0.75 \cdot 10^3 = 750$ kPa

$N_{Rd} := m_{lt} \cdot \varphi \cdot f_d \cdot A = 72.563$ kN

$$\frac{N_{ed}}{N_{Rd}} = 0.331$$

Išvada: sąlyga tenkinama

1.8. Projekte atliktų skaičiavimų atitiktis projekto rengimo dokumentams, normatyvinių statybos techninių dokumentų reikalavimams

Projekte atliktų skaičiavimų rezultatai atitinka projekto rengimo dokumentų reikalavimus, normatyvinių statybos techninių dokumentų reikalavimus, o konstrukcinių elementų ir jungčių laikomosios galios išnaudojimas neviršija ribinių verčių.