STATIČNI RAČUN

Pripravila:

dr. Klemen Sinkovič, univ. dipl. inž. grad. (PNZ d.o.o.)

Janez Maurer, univ. dipl. inž. grad. (Elea IC d.o.o.)

VSEBINA:

1 UVOD

Analizirane protihrupne ograje (PHO) se nahajajo na zahodni ljubljanski obvoznici na odseku Koseze - Kozarje. Statično poročilo zajema naslednje absorpcijske (APO) in transparentne (TPO) protihrupne ograje:

- OAPO 02a (H=400cm; L=523m, obojestranska)
- OAPO 02b (H=350cm; L=120m, obojestranska)
- TPO 03 (H=400cm; L=72m)
- APO 04 (H=400cm; L=168m)
- APO 05 (H=250cm; L=172m)
- OAPO 06 (H=350cm; L=640m, obojestranska)
- APO 07 (H=250cm; L=120m)
- APO 08a (H=450+70cm; L=206m)
- APO 08b (H=300cm; L=290m)
- APO 08c (H=450+70cm; L=388m)
- APO 09a (H=350cm; L=210m)
- APO 09a+TPO (H=350cm; L=298m)
- APO 09b (H=550cm; L=140m)
- APO 09c (H=500cm; L=206m)
- APO 09d (H=500cm; L=84m)

Višine sten protihrupnih ograj so med *H* = 250 - 550 cm in so vertikalne. Izjemoma so stene ograj pri APO 08a in APO 08c vertikalne do višine *H* = 450cm, pri vrhu pa imajo lomljeno os dolžine cca. 95cm. Naklon lomljene osi je 45º. Najvišji stebriček je v tem primeru visok *H* = 450 cm + 70 cm = 520 cm. Glavni nosilni sistem predstavljajo stebri HEA 200, ki so na določenih odsekih PHO ojačeni, in sicer s pločevino 180/10mm na obeh pasnicah HEA profila. Vsi jekleni stebri so iz konstrukcijskega jekla kvalitete S 235 in so postavljeni v rastru 4,00 m. Jekleni stebri so temeljeni na vtisnjenih jeklenih pilotih okroglega prečnega prereza *D* / *t* = 620 / 8 mm, do globine vsaj 3.00 m in so, prav tako kot stebri, iz konstrukcijskega jekla S 235.

Analiza PHO je narejena za tiste primere ograj, v katerih se pričakujejo največje obremenitve. Ti primeri so naslednji:

- TPO 03 (H=400cm; L=72m) oz. APO 04 (H=400cm; L=168m),
- APO 09a (H=350cm; L=210m) in APO 09b (H=550cm; L=140m),
- APO 08a (H=450+70cm; L=206m) oz. APO 08c (H=450+70cm; L=388m)

Omenjene PHO so merodajne tudi za dimenzioniranje preostalih protihrupnih ograj. V primeru PH ograje APO 09a in APO 09b je preverjen prehod oz. stopničenje PHO.

Pri preračunu vseh konstrukcij so bili uporabljeni naslednji računalniški programi:

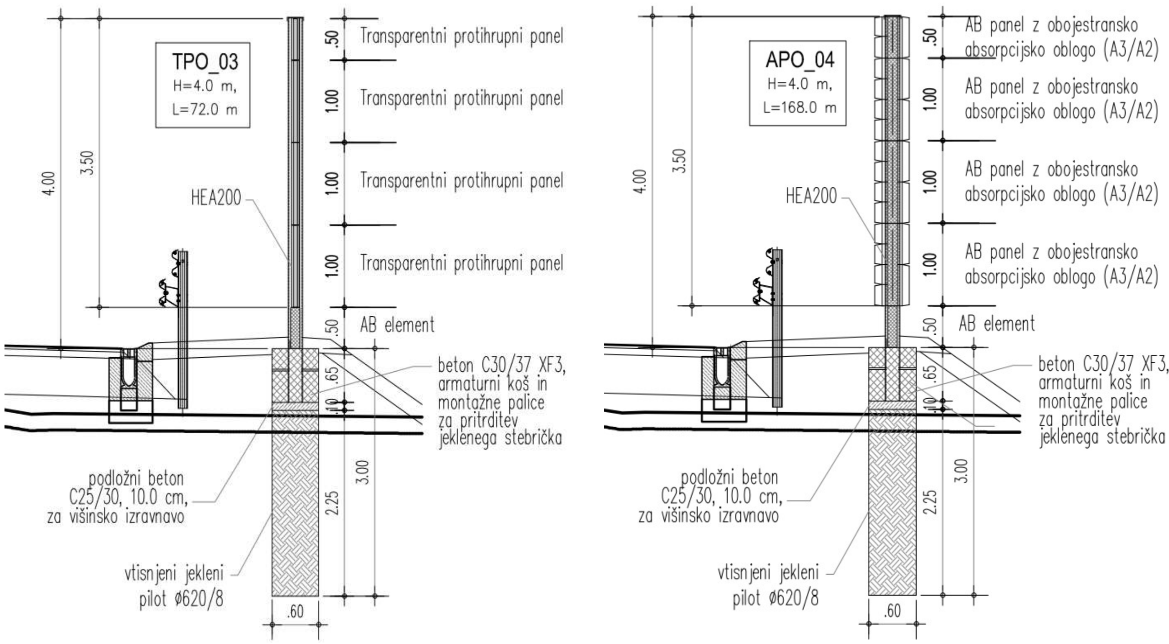
– Statična analiza MKE na linijskih modelih: SCIA ENGINEER
– Obdelava in prebiranje grafičnih podlog: AUTOCAD

Uporabljeni standardi:

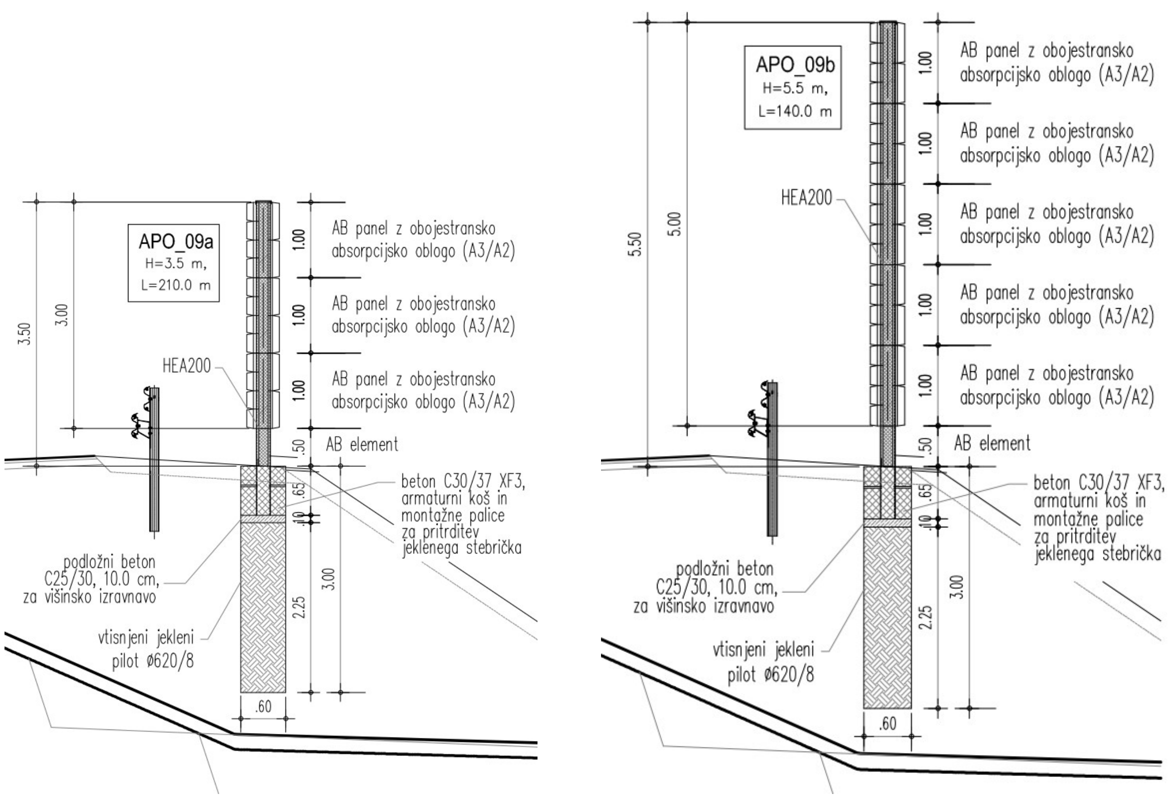
– Uporabljeni so standardi, predpisi in pravilniki, ki so veljavni na ozemlju Republike Slovenije.
– Prav tako so upoštevane smernice za projektiranje, ki jih je izdalo Ministrstvo za promet.

2 GEOMETRIJSKI PODATKI

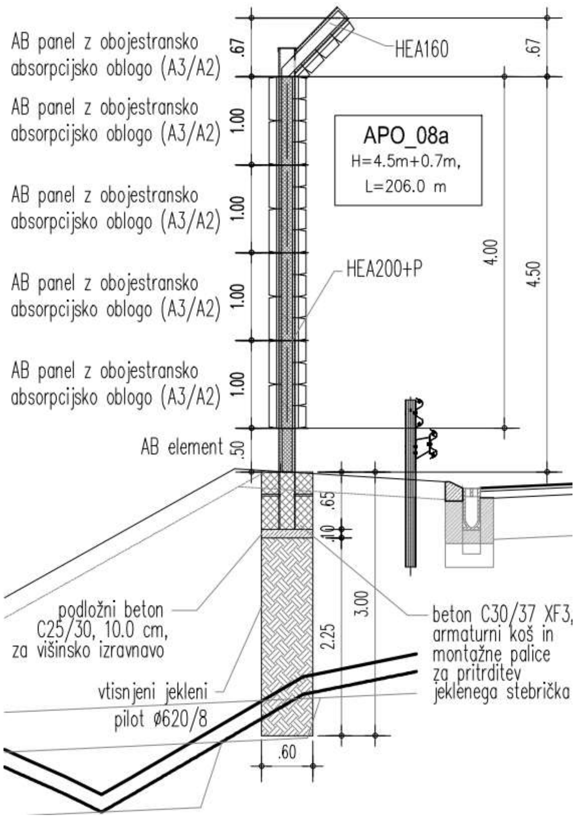
V nadaljevanju so prikazani karakteristični prečni prerezi obravnavanih protihrupnih ograj (PHO):

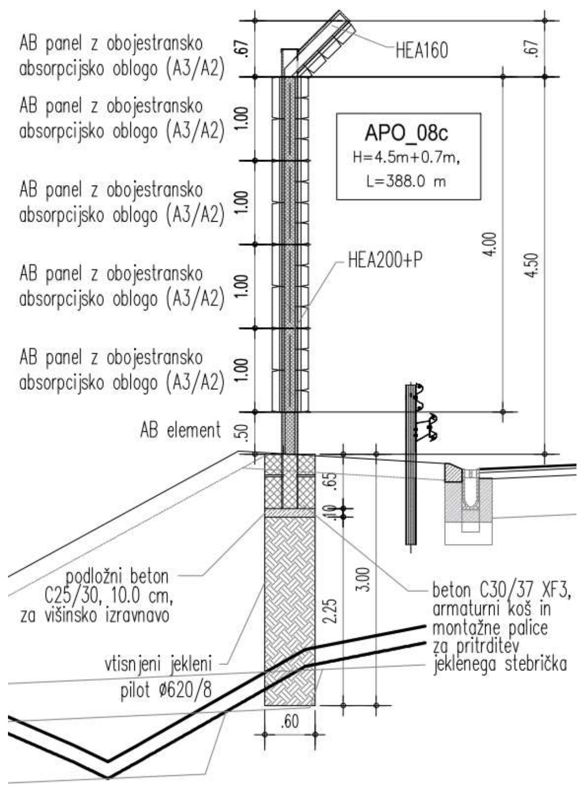


Slika 2-1: Karakteristični prečni prerez protihrupne ograje TPO03 (levo) in APO04 (desno).



Slika 2-2: Karakteristični prečni prerez protihrupne ograje APO09a (levo) in APO09b (desno).



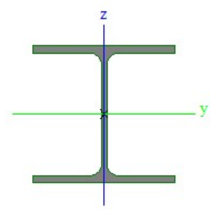


Slika 2-3: Karakteristični prečni prerez protihrupne APO08a (levo) on AP08c (desno).

3 UPORABLJENI PREREZI IN LASTNOSTI MATERIALOV

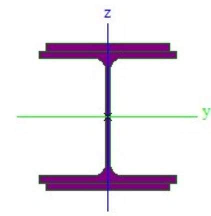
Prečni prerezi konstrukcijskih elementov:

Name	CS8
Type	HEA200
Source description	Profil Arbed / Structural shapes / Edition Octobre 1995
Item material	S 235
Fabrication	rolled
Flexural buckling y-y	b
Flexural buckling z-z	c
Lateral torsional buckling	Default
Use 2D FEM analysis	×



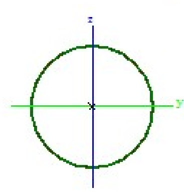
A [m²]	5.3800e-03	
A y, z [m²]	3.8781e-03	1.3287e-03
I y, z [m⁴]	3.6900e-05	1.3400e-05
I w [m⁶], t [m⁴]	1.0800e-07	2.1000e-07
Wel y, z [m³]	3.8900e-04	1.3400e-04
Wpl y, z [m³]	4.2917e-04	2.0375e-04
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	100	95
α [deg]	0.00	
A L, D [m²/m]	1.1400e+00	1.1360e+00
Mply +, - [Nm]	1.01e+05	1.01e+05
Mplz +, - [Nm]	4.79e+04	4.79e+04

Name	HEA200+t180/10
Type	General cross-section
Item material	S 235
Fabrication	general
Flexural buckling y-y	d
Flexural buckling z-z	d
Lateral torsional buckling	Default
Use 2D FEM analysis	✓



A [m²]	9.4383e-03	
A y, z [m²]	7.6202e-03	1.5052e-03
I y, z [m⁴]	7.8004e-05	2.4291e-05
I w [m⁶], t [m⁴]	2.2051e-07	1.2438e-06
Wel y, z [m³]	7.3416e-04	2.4291e-04
Wpl y, z [m³]	8.3742e-04	3.8612e-04
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	0	0
α [deg]	0.00	
A L, D [m²/m]	1.1810e+00	1.1810e+00
Mply +, - [Nm]	1.97e+05	1.97e+05
Mplz +, - [Nm]	9.07e+04	9.07e+04

Name	CS7
Type	CFCHS610X8
Source description	Rautaruukki Oyj / Structural Hollow Sections EN10219 / Ed.2007
Item material	S 235
Fabrication	cold formed
Flexural buckling y-y	c
Flexural buckling z-z	c
Lateral torsional buckling	Default
Use 2D FEM analysis	×



A [m²]	1,5130e-02	
A y, z [m²]	9,6320e-03	9,6320e-03
I y, z [m⁴]	6,8551e-04	6,8551e-04
I w [m⁶], t [m⁴]	1,1220e-37	1,3710e-03
Wel y, z [m³]	2,2476e-03	2,2476e-03
Wpl y, z [m³]	2,8994e-03	2,8994e-03
d y, z [mm]	0	0
c YUCS, ZUCS [mm]	305	305
α [deg]	0,00	
A L, D [m²/m]	1,9160e+00	3,7823e+00
Mply +, - [Nm]	6,81e+05	6,81e+05
Mplz +, - [Nm]	6,81e+05	6,81e+05

Konstrukcijsko jeklo:	f_{yk} (MPa)	f_{yd} (MPa)	γ_S	ρ [kg/m³]	μ	E_s (GPa)	G_{mod} (Gpa)
S235 J0	235	235	1,00	7850,0	0.3	210	83,3

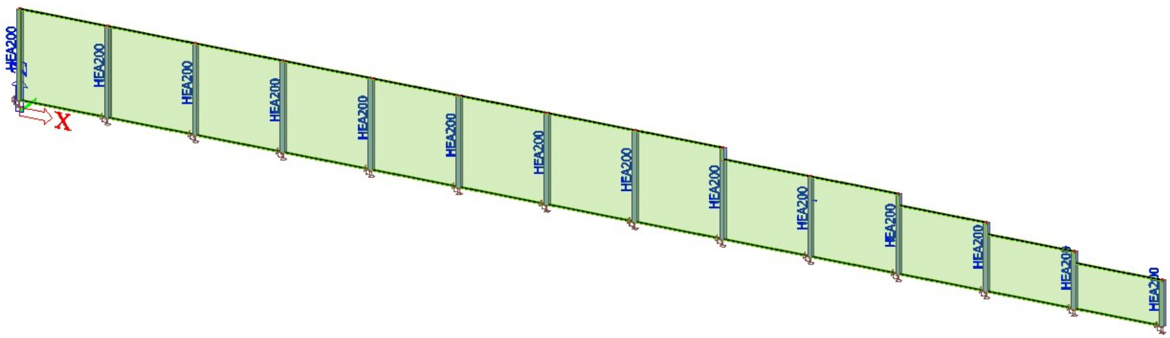
4 MODELIRANJE

Analiza obsega statično analizo jeklenih stebričkov PHO ter vse potrebne preverbe in izračune nosilnosti in stabilnosti v mejnem stanju nosilnosti (MSN) in kontrolo pomikov v mejnem stanju uporabnosti (MSU).

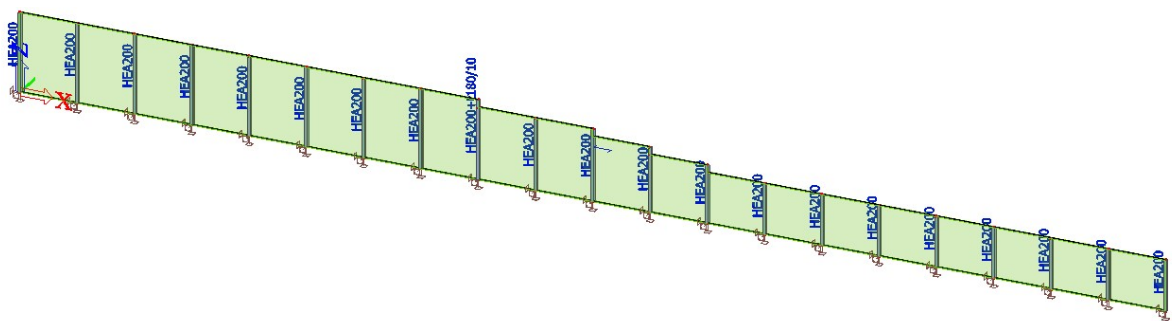
Statični model PH ograje je jeklena konzola, ki je togo vpeta v temelj – zabit jeklen pilot okroglega prečnega prereza *D* / *t* = 620 / 8 mm dolžine 3,0 m. Prečno togost PHO zagotavljajo jeklene konzole, vzdolžno togost pa jeklene konzole skupaj z vmesnimi paneli. Paneli nimajo neposrednega vpliva na jeklene konzole, saj so gravitacijsko položeni na tla. Izjemo predstavljajo paneli na PH ograje APO 08a in APO 08c, ki so položeni pri vrhu ograje pod kotom 45º. Paneli prenašajo prečno obremenitev vplivov vetra in pluženja snega.

Pri PH ograjah APO 08a in APO 08c so konzolni stebri višine 4,50m + 0,70m iz jeklenega profila HEA 200 + t180/10. Tak prečni prerez je modeliran do višine konzolnega stebra 2.00m, nato pa se isti prečni prerez pojavi brez pločevine za ojačitev t180/10. Pri preostalih stebrih so konzole modelirane iz jeklenega profila HEA 200.

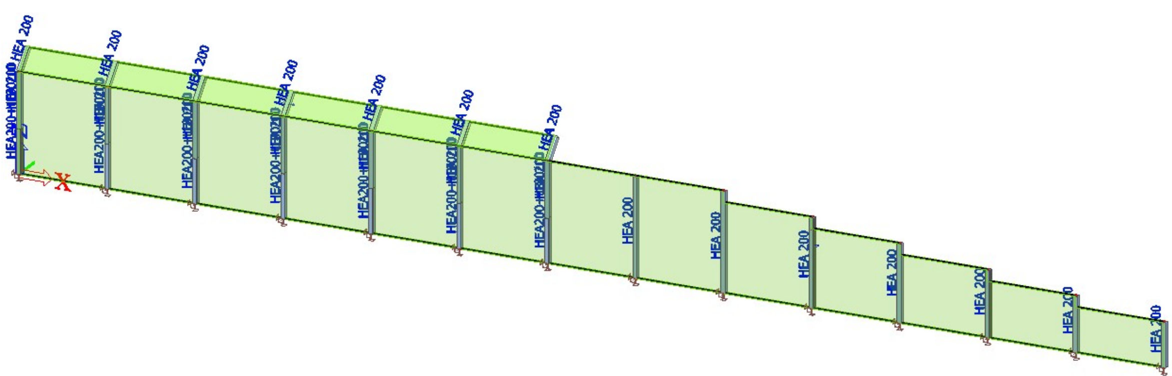
Matematični modeli obravnavnih PHO so prikazani v nadaljevanju.



Slika 4-1: Matematični model PH ograje TPO 03 oz. APO 04, višine *H* = 400 cm, skupaj s stopničenjem (Δ*h* = 50 cm) na koncu PHO.



Slika 4-2: Matematični model PH ograje APO 09a (*H* = 350 cm) in APO 09b (*H* = 550 cm), skupaj prehodnim stopničenjem.



Slika 4-3: Matematični model protihrupne ograje APO 08a, višine *H* = 530 cm (Δ*h* = 70 cm), skupaj s stopničenjem na koncu PHO.

5 VPLIVI NA KONSTRUKCIJE

Pri analizi PHO so upoštevani stalni vplivi (lastna teža konstrukcije in teža nekonstrukcijskih elementov, t.j. protihrupnih panelov) ter spremenljivi vplivi vetra v obeh smereh, spremenljiva obtežba snega ter pluženje snega.

5.1 Lastna teža

Teža konstrukcijskih elementov	γ (kN/m^3)
Beton konstrukcije	25,0
Jekleni profil HEA 200	7850
Jekleni profil HEA 200 + pločevina180/10	7850

5.2 Stalna obtežba

Teža nekonstrukcijskih elementov	γ (kN/m^2)
Protihrupni paneli	6,73

Teža nekonstrukcijskih elementov se prenaša direktno v tla, z izjemo teže panelov na protihrupnih ograjah APO 08a in APO 08c, ki so položeni pri vrhu ograje pod kotom 45º.

5.3 Spremenljiva obtežba

5.3.1 Vplivi vetra

a) Protihrupna ograja TPO 03 (H=400cm; L=72m) oz. APO 04 (H=400cm; L=168m):

Dolžina: $l_{PHO} := 168 \cdot m$

Višina: $h_{PHO} := 4.0\ m$

Naklon PHO: $\alpha_{PHO} := 0\ deg$

Dolžina stebrickov: $l_{profil} := \dfrac{h_{PHO}}{\cos(\alpha_{PHO})}$ ..... $l_{profil} = 4.00\ \mathrm{m}$

Raster stebrickov: $r_{PHO} := 4.00\ m$

Referencna hitrost vetra: $v_{ref.0} := 20\ \dfrac{m}{s}$ $v_b := v_{ref.0}$

Višina objekta nad tlemi: $z_e := h_{PHO}$

Lokalni parametri razgibanosti okoliškega terena: $teren := 1$
(SIST EN 1991-1-4, Preglednica 4.1)

Tlak pri najvecji hitrosti vetra: $q_p = 0.56 \cdot \dfrac{kN}{m^2}$

Koeficienti tlaka na površine

Velja za polnozapolnjene prostostojece stene brez vogalnega zidu:

$H_{PHO} := h_{PHO}$ .... $H_{PHO} = 4.00\ \mathrm{m}$

$c_{p.net.A} = 3.4$ na obmocju med 0 m in $l_A := 0.3 \cdot H_{PHO}$

$c_{p.net.B} = 2.8$ na obmocju med $l_A = 1.2\ m$ in $l_B := 2 \cdot H_{PHO}$

$c_{p.net.C} = 1.7$ na obmocju med $l_B = 8\ m$ in $l_C := 4 \cdot H_{PHO}$

$c_{p.net.D} = 1.2$ od $l_C = 16\ m$ *dalje*

$w_A := q_p \cdot c_{p.net.A}$ $\quad w_A = 1.91 \cdot \frac{kN}{m^2}$

$w_B := q_p \cdot c_{p.net.B}$ $\quad w_B = 1.57 \cdot \frac{kN}{m^2}$

$w_C := q_p \cdot c_{p.net.C}$ $\quad w_C = 0.95 \cdot \frac{kN}{m^2}$

$w_D := q_p \cdot c_{p.net.D}$ $\quad w_D = 0.67 \cdot \frac{kN}{m^2}$

b) Protihrupna ograja APO 09a (H=350cm; L=210m) in APO 09b (H=550cm; L=140m):

Dolžina: $l_{PHO} := 140 \cdot m$

Višina: $h_{PHO} := 5.50\ m$

Naklon PHO: $\alpha_{PHO} := 0\ deg$

Dolžina stebrickov: $l_{profil} := \frac{h_{PHO}}{\cos(\alpha_{PHO})}$ ..... $l_{profil} = 5.50\ m$

Raster stebrickov: $r_{PHO} := 4.00\ m$

Referencna hitrost vetra: $v_{ref.0} := 20\ \frac{m}{s}$ $\quad v_b := v_{ref.0}$

Višina objekta nad tlemi: $z_e := h_{PHO}$

Lokalni parametri razgibanosti okoliškega terena: $teren := 2$
(SIST EN 1991-1-4, Preglednica 4.1)

Tlak pri najvecji hitrosti vetra: $q_p = 0.50 \cdot \frac{kN}{m^2}$

Koeficienti tlaka na površine

Velja za polnozapolnjene prostostojece stene brez vogalnega zidu:

$H_{PHO} := h_{PHO}$ .... $H_{PHO} = 5.50\ m$

$c_{p.net.A} = 3.4$ na obmocju med 0 m in $l_A := 0.3 \cdot H_{PHO}$

$c_{p.net.B} = 2.8$ na obmocju med $l_A = 1.5\ \mathrm{m}$ in $l_B := 2 \cdot H_{PHO}$

$c_{p.net.C} = 1.7$ na obmocju med $l_B = 10\ \mathrm{m}$ in $l_C := 4 \cdot H_{PHO}$

$c_{p.net.D} = 1.2$ od $l_C = 20\ \mathrm{m}$ dalje

$w_A := q_p \cdot c_{p.net.A}$ $\quad w_A = 1.69 \cdot \frac{kN}{m^2}$

$w_B := q_p \cdot c_{p.net.B}$ $\quad w_B = 1.39 \cdot \frac{kN}{m^2}$

$w_C := q_p \cdot c_{p.net.C}$ $\quad w_C = 0.84 \cdot \frac{kN}{m^2}$

$w_D := q_p \cdot c_{p.net.D}$ $\quad w_D = 0.60 \cdot \frac{kN}{m^2}$

c) <u>Protihrupna ograja APO 08a (H=450+70cm; L=206m) oz. APO 08c (H=450+70cm; L=388m):</u>

Dolžina: $l_{PHO} := 206 \cdot m$

Višina: $h_{PHO} := 4.50\ m + 0.70\ m$

Naklon PHO: $\alpha_{PHO} := 0\ deg$

Dolžina stebrickov: $l_{profil} := \frac{h_{PHO}}{\cos(\alpha_{PHO})}$ ..... $l_{profil} = 5.20\ \mathrm{m}$

Raster stebrickov: $r_{PHO} := 4.00\ m$

Referencna hitrost vetra: $v_{ref.0} := 20\ \frac{m}{s}$ $\quad v_b := v_{ref.0}$

Višina objekta nad tlemi: $z_e := h_{PHO}$

Lokalni parametri razgibanosti okoliškega terena: $teren := 2$
(SIST EN 1991-1-4, Preglednica 4.1)

Tlak pri najvecji hitrosti vetra: $q_p = 0.49 \cdot \frac{kN}{m^2}$

Koeficienti tlaka na površine

Velja za polnozapolnjene prostostojece stene brez vogalnega zidu:

$H_{PHO} := h_{PHO}$ .... $H_{PHO} = 5.20\ \mathrm{m}$

$c_{p.net.A} = 3.4$ na obmocju med 0 m in $l_A := 0.3 \cdot H_{PHO}$

$c_{p.net.B} = 2.8$ na obmocju med $l_A = 1.59\ \mathrm{m}$ in $l_B := 2 \cdot H_{PHO}$

$c_{p.net.C} = 1.7$ na obmocju med $l_B = 10.6\ \mathrm{m}$ in $l_C := 4 \cdot H_{PHO}$

$c_{p.net.D} = 1.2$ od $l_C = 21.2\ \mathrm{m}$ dalje

$w_A := q_p \cdot c_{p.net.A}$ $\quad w_A = 1.66 \cdot \frac{kN}{m^2}$

$w_B := q_p \cdot c_{p.net.B}$ $\quad w_B = 1.37 \cdot \frac{kN}{m^2}$

$w_C := q_p \cdot c_{p.net.C}$ $\quad w_C = 0.83 \cdot \frac{kN}{m^2}$

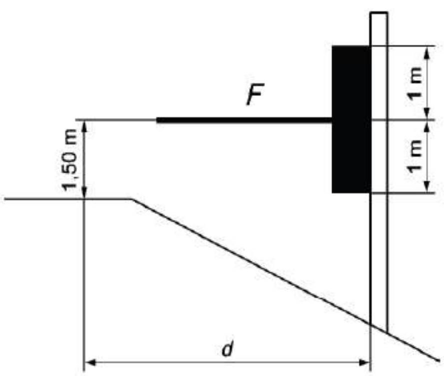
$w_D := q_p \cdot c_{p.net.D}$ $\quad w_D = 0.59 \cdot \frac{kN}{m^2}$

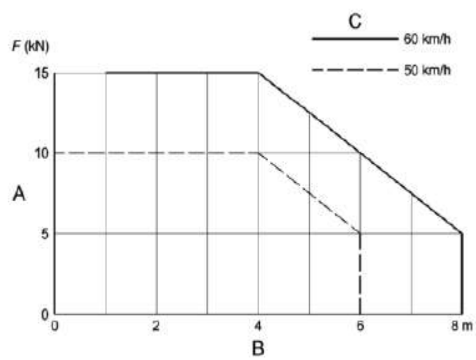
5.3.2 Obtežba pluženja

$d_{plug} := 2.50\ m$

$h_{niv} := 0.50\ m$ .... Višinska razlika med niveleto in vrhom temelja:

$h_{plug} := 0.67\ m + h_{niv}$ $\quad h_{plug} = 1.17\ \mathrm{m}$





Obtežba pluženja F_{plug} = 15 kN deluje na višini 1.50 m nad nivojem roba ceste vzdolž celotne dolžine PHO. Obtežba je enaka za vse primere protihrupnih ograj.

5.3.3 Obtežba snega

Obtežba snega je določena v skladu s SIST EN 1991-1-3. Lokacija odseka Koseze – Kozarje na zahodni ljubljanski obvoznici se nahaja v snežni coni A2 na 302 m.n.v.. Obtežba snega na tleh je tu enaka s_k = 1.52 kN/m^2.

Pri določitvi obtežbe snega za začasna in trajna projektna stanja je za vsa PHO upoštevan koeficienta izpostavljenosti C_e = 1.0, toplotni koeficient C_t = 1.0 ter oblikovni koeficient μ = 0.4 za površine pod kotom 45º.

Obtežba snega je na vertikalnih elementih jeklenih konzol zanemarjena. Na lomljenih delih jeklenih konzol deluje obtežba snega $s = \mu \cdot c_e \cdot c_t \cdot s_k$ = 0.61 kN/m^2.

5.4 Kombinacije vplivov

Za kontrolo nosilnosti prečnih prerezov nosilne konstrukcije je v skladu s SIST EN 1990 in pripadajočimi nacionalnimi dodatki upoštevana obtežna kombinacija za mejno stanje nosilnosti (MSN) v naslednji kombinaciji vplivov:

$$\sum_{j\geq 1} \gamma_{G.j} \cdot G_{k.j} \text{"+"} \gamma_p \cdot P \text{"+"} \gamma_{Q.1} \cdot Q_{k,1} \text{" + "} \sum_{i>1} \gamma_{Q.i} \cdot \Psi_{0.i} \cdot Q_{k,i}$$

Vrednosti faktorjev γ in Ψ so določene v SIST EN 1991 in v dodatku A standarda SIST EN 1990.

Tvorjeni sta dve kombinaciji obtežb, ki sta predstavljeni v nadaljevanju.

1)

Name	MSN_(stalna+veter+sneg)
Description	
Type	EN-ULS (STR/GEO) Set B
Structure	Building
Active coefficients	☑
Contents of combination	
LC1a - lastna [-]	1.35
LC1b - stalna [-]	1.35
LC2a - veter A [-]	1.50
LC2b - veter B [-]	1.50
LC2c - veter C [-]	1.50
LC2d - veter D [-]	1.50
LC4 - sneg [-]	1.50

2)

Name	MSN_(stalna+plug)
Description	
Type	Envelope - ultimate
Contents of combination	
LC1a - lastna [-]	1.35
LC1b - stalna [-]	1.35
LC3a - pluzenje 1 [-]	1.50

Kontrola uporabnosti konstrukcije se kontrolira s pomiki, ki se jih v skladu z SIST EN 1990 za mejno stanje uporabnosti (MSU) določi s karakteristično kombinacijo (EN - SLS Characteristic) v naslednji kombinaciji vplivov:

$$\sum_{j\geq 1} G_{k.j} \text{"+"} P \text{"+"} Q_{k,1} \text{" + "} \sum_{i>1} \Psi_{0.i} \cdot Q_{k,i}$$

Vrednosti faktorjev Ψ so določene v SIST EN 1991 in v dodatku A standarda SIST EN 1990.

Tvorjeni sta dve kombinaciji obtežb, ki sta predstavljeni v nadaljevanju.

Omejitev pomikov PHO je kontrolirana v skladu z Aneksom A v standardu EN 1794-1.

1)

Name	MSU_(stalna+veter+sneg)
Description	
Type	EN-SLS Characteristic
Structure	Building
Contents of combination	
LC1a - lastna [-]	1.00
LC1b - stalna [-]	1.00
LC2a - veter A [-]	1.00
LC2b - veter B [-]	1.00
LC2c - veter C [-]	1.00
LC2d - veter D [-]	1.00
LC4 - sneg [-]	1.00

2)

Name	MSU_(stalna+plug)
Description	
Type	Envelope - serviceability
Contents of combination	
LC1a - lastna [-]	1.00
LC1b - stalna [-]	1.00
LC3a - pluzenje 1 [-]	1.00

6 REZULTATI

Analizo jeklene konstrukcije PHO (brez temeljenja) je izvedel g. Klemen Sinkovič (PNZ d.o.o.).

Analizo temeljenja PHO je izvedel g. Janez Maurer (Elea IC d.o.o.).

6.1 Protihrupna ograja TPO 03 oz. APO 04

6.1.1 Mejno stanje nosilnosti (MSN)

Za merodajno kombinacijo se izkaže kombinacija lastne teže in obtežbe vetra. Stalna obtežba in obtežba snega v tem primeru nimata neposrednega vpliva na jeklene konzole PHO.

Member B77	0.000 / 4.000 m	HEA200	S 235	All ULS	0.42 -

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

a) Kontrola napetosti:

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-2.52	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	21.93	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-53.14	kNm
$M_{z,Ed}$	0.00	kNm

The cross-section is classified as Class 1

Compression check

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

A	5.3800e-03	m^2
$N_{c,Rd}$	1264.30	kN
Unity check	0.00	-

Bending moment check for M_y

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

$W_{pl,y}$	4.2917e-04	m^3
$M_{pl,y,Rd}$	100.85	kNm
Unity check	0.42	-

Shear check for V_z

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

η	1.20	
A_v	1.8050e-03	m^2
$V_{pl,z,Rd}$	244.90	kN
Unity check	0.09	-

Combined bending, axial force and shear force check

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

$M_{pl,y,Rd}$	100.85	kNm
Unity check	0.42	-

Note: Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.
Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

The member satisfies the section check.

b) Kontrola stabilnosti:

The cross-section is classified as Class 1

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

Buckling parameters	yy	zz	
Sway type	sway	non-sway	
System length L	4.500	4.500	m
Buckling factor k	2.00	0.70	
Buckling length L_{cr}	9.011	3.150	m
Critical Euler load N_{cr}	941.94	2799.00	kN
Slenderness λ	108.80	63.12	
Relative slenderness λ_{rel}	1.16	0.67	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	

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

Torsional(-Flexural) Buckling check
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check
According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Elastic critical moment M_{cr}	744.93	kNm
Relative slenderness $\lambda_{rel,LT}$	0.37	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

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

Mcr parameters		
LTB length L	4.500	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	3.80	
LTB moment factor C_2	0.00	
LTB moment factor C_3	3.39	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Note: C parameters for I-section cantilevers are determined according to ECCS 119 2006.
Warning: For this method k should be inputted as 2 and k_w should be inputted as 1.
Please review the input of the buckling data!

Bending and axial compression check
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	5.3800e-03	m^2
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Design compression force N_{Ed}	2.52	kN
Design bending moment (maximum) $M_{y,Ed}$	-53.14	kNm
Design bending moment (maximum) $M_{z,Ed}$	0.00	kNm
Characteristic compression resistance N_{Rk}	1264.30	kN
Characteristic moment resistance $M_{y,Rk}$	100.85	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.00	
Interaction factor k_{zy}	0.52	

Maximum moment $M_{y,Ed}$ is derived from beam B77 position 0.000 m.
Maximum moment $M_{z,Ed}$ is derived from beam B77 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	1194.99	kN
Critical Euler load $N_{cr,z}$	433.95	kN
Elastic critical load $N_{cr,T}$	2188.27	kN
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Elastic section modulus $W_{el,y}$	3.8900e-04	m^3
Plastic section modulus $W_{pl,z}$	2.0375e-04	m^3
Elastic section modulus $W_{el,z}$	1.3400e-04	m^3
Second moment of area I_y	3.6900e-05	m^4
Second moment of area I_z	1.3400e-05	m^4
Torsional constant I_t	2.1000e-07	m^4
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-42.18	kNm
Maximum relative deflection δ_z	-21.6	mm
Equivalent moment factor $C_{my,0}$	1.00	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor ε_y	260.73	
Factor a_{LT}	0.99	
Critical moment for uniform bending $M_{cr,0}$	47.11	kNm
Relative slenderness $\lambda_{rel,0}$	1.46	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.38	
Equivalent moment factor C_{my}	1.00	
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.00	
Factor d_{LT}	0.00	
Factor w_y	1.10	
Factor w_z	1.50	
Factor n_{pl}	0.00	
Maximum relative slenderness $\lambda_{rel,max}$	1.71	
Factor C_{yy}	1.00	
Factor C_{zy}	1.00	

Unity check (6.61) = 0.00 + 0.42 + 0.00 = 0.42 -
Unity check (6.62) = 0.00 + 0.22 + 0.00 = 0.22 -

Shear Buckling check

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

Shear Buckling parameters		
Buckling field length a	4.500	m
Web	unstiffened	
Web height h_w	170	mm
Web thickness t	7	mm
Material coefficient ε	1.00	
Shear correction factor η	1.20	

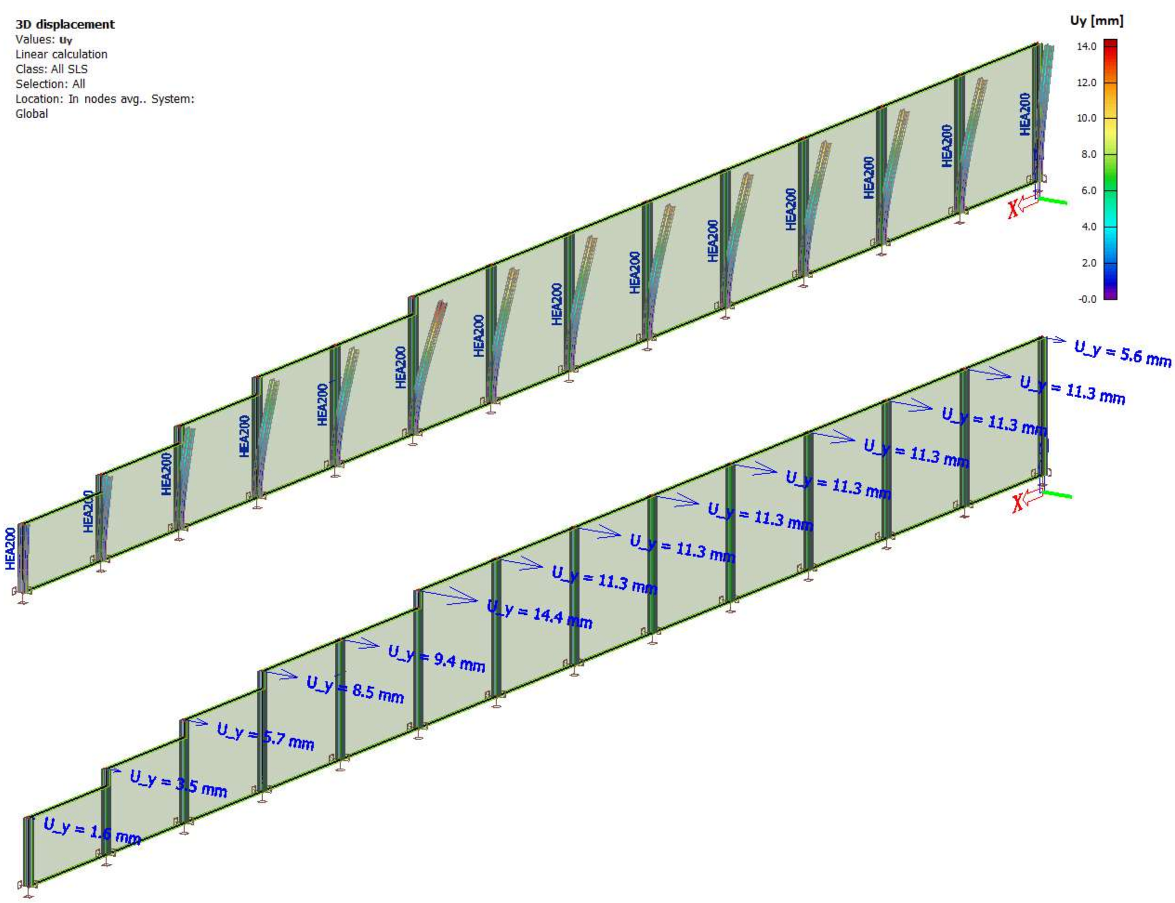
Shear Buckling verification	
Web slenderness h_w/t	26.15
Web slenderness limit	60.00

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

The member satisfies the stability check.

6.1.2 Mejno stanje uporabnosti (MSU)

Pomiki PHO so v skladu z Aneksom A v standardu EN 1794-1 omejeni na vrednost 30 mm. Omejitev velja za PHO višine manjše ali enake 450 cm. Pomiki protihrupne ograje TPO 03 oz. APO 04 so v MSU prikazani na spodnji sliki.



Slika 6-1: Pomiki PH ograje TPO 03 (*H* = 400cm) oz. APO 04 (*H* = 400cm) v MSU.

6.2 Protihrupna ograja APO 09a in APO 09b

6.2.1 Mejno stanje nosilnosti (MSN)

Za merodajno kombinacijo se izkaže kombinacija lastne teže in obtežbe vetra. Stalna obtežba in obtežba snega v tem primeru nimata neposrednega vpliva na jeklene konzole PHO.

Member B76	0.000 / 5.500 m	HEA200	S 235	All ULS	0.52 -

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

Material		
Yield strength f_y	235.0	MPa
Ultimate strength f_u	360.0	MPa
Fabrication	Rolled	

a) Kontrola napetosti:

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-3.08	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	17.28	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-51.87	kNm
$M_{z,Ed}$	0.00	kNm

The cross-section is classified as Class 1

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

A	5.3800e-03	m^2
$N_{c,Rd}$	1264.30	kN
Unity check	0.00	-

Bending moment check for M_y
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	4.2917e-04	m^3
$M_{pl,y,Rd}$	100.85	kNm
Unity check	0.51	-

Shear check for V_z
According to EN 1993-1-1 article 6.2.6 and formula (6.17)

η	1.20	
A_v	1.8050e-03	m^2
$V_{pl,z,Rd}$	244.90	kN
Unity check	0.07	-

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

$M_{pl,y,Rd}$	100.85	kNm
Unity check	0.51	-

Note: Since the shear forces are less than half the plastic shear resistances their effect on the moment resistances is neglected.
Note: Since the axial force satisfies both criteria (6.33) and (6.34) of EN 1993-1-1 article 6.2.9.1(4) its effect on the moment resistance about the y-y axis is neglected.

The member satisfies the section check.

b) Kontrola stabilnosti:

The cross-section is classified as Class 1

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

Buckling parameters	**yy**	**zz**	
Sway type	sway	non-sway	
System length L	5.500	5.500	m
Buckling factor k	2.00	0.70	
Buckling length L_{cr}	11.013	3.850	m
Critical Euler load N_{cr}	630.56	1873.71	kN
Slenderness λ	132.98	77.14	
Relative slenderness λ_{rel}	1.42	0.82	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	

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

Torsional(-Flexural) Buckling check
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)
Note: For this I-section the Torsional(-Flexural) buckling resistance is higher than the resistance for Flexural buckling. Therefore Torsional(-Flexural) buckling is not printed on the output.

Lateral Torsional Buckling check
According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.3 and formula (6.54)

LTB parameters		
Method for LTB curve	Alternative case	
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Elastic critical moment M_{cr}	379.42	kNm
Relative slenderness $\lambda_{rel,LT}$	0.52	
Limit slenderness $\lambda_{rel,LT,0}$	0.40	

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

Mcr parameters		
LTB length L	5.500	m
Influence of load position	no influence	
Correction factor k	1.00	
Correction factor k_w	1.00	
LTB moment factor C_1	2.54	
LTB moment factor C_2	0.20	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

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

Bending and axial compression check
According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	5.3800e-03	m^2
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Design compression force N_{Ed}	3.08	kN
Design bending moment (maximum) $M_{y,Ed}$	-51.87	kNm
Design bending moment (maximum) $M_{z,Ed}$	0.00	kNm
Characteristic compression resistance N_{Rk}	1264.30	kN
Characteristic moment resistance $M_{y,Rk}$	100.85	kNm
Reduction factor χ_y	1.00	
Reduction factor χ_z	1.00	
Modified reduction factor $\chi_{LT,mod}$	1.00	
Interaction factor k_{yy}	1.01	
Interaction factor k_{zy}	0.52	

Maximum moment $M_{y,Ed}$ is derived from beam B76 position 0.000 m.
Maximum moment $M_{z,Ed}$ is derived from beam B76 position 0.000 m.

Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	630.56	kN
Critical Euler load $N_{cr,z}$	1873.71	kN
Elastic critical load $N_{cr,T}$	2605.64	kN
Plastic section modulus $W_{pl,y}$	4.2917e-04	m^3
Elastic section modulus $W_{el,y}$	3.8900e-04	m^3
Plastic section modulus $W_{pl,z}$	2.0375e-04	m^3
Elastic section modulus $W_{el,z}$	1.3400e-04	m^3
Second moment of area I_y	3.6900e-05	m^4
Second moment of area I_z	1.3400e-05	m^4
Torsional constant I_t	2.1000e-07	m^4
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-51.87	kNm
Maximum relative deflection δ_z	7.9	mm
Equivalent moment factor $C_{my,0}$	1.00	
Factor μ_y	1.00	
Factor μ_z	1.00	
Factor ε_y	233.22	
Factor a_{LT}	0.99	
Critical moment for uniform bending $M_{cr,0}$	149.55	kNm
Relative slenderness $\lambda_{rel,0}$	0.82	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.32	
Equivalent moment factor C_{my}	1.00	
Equivalent moment factor C_{mLT}	1.00	
Factor b_{LT}	0.00	
Factor d_{LT}	0.00	
Factor w_y	1.10	
Factor w_z	1.50	
Factor n_{pl}	0.00	
Maximum relative slenderness $\lambda_{rel,max}$	1.42	
Factor C_{yy}	1.00	
Factor C_{zy}	1.00	

Unity check (6.61) = 0.00 + 0.52 + 0.00 = 0.52 -
Unity check (6.62) = 0.00 + 0.27 + 0.00 = 0.27 -

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

Shear Buckling parameters		
Buckling field length a	5.500	m
Web	unstiffened	
Web height h_w	170	mm
Web thickness t	7	mm
Material coefficient ε	1.00	
Shear correction factor η	1.20	

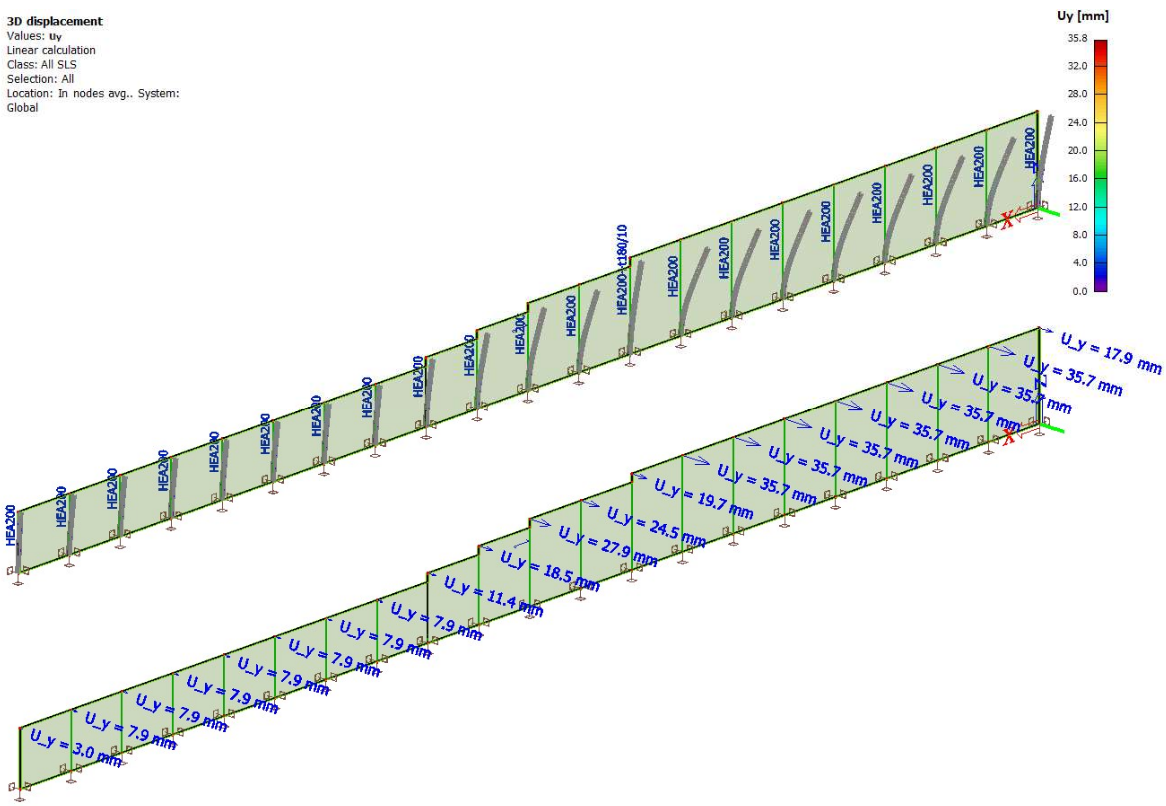
Shear Buckling verification	
Web slenderness h_w/t	26.15
Web slenderness limit	60.00

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

The member satisfies the stability check.

6.2.2 Mejno stanje uporabnosti (MSU)

Pomiki PHO so v skladu z Aneksom A v standardu EN 1794-1 omejeni na vrednost H / 150 = 37 mm za APO 09b, kjer je višina ograje večja od 450 cm. Za PH ograjo APO 09a, kjer je višina ograje manjša ali enaka 450 cm, so pomiki omejeni na vrednost 30 mm. Pomiki obeh PHO so v MSU prikazani na spodnji sliki.



Slika 6-2: Pomiki PH ograje APO 09a (*H* = 350cm) in APO 09b (*H* = 550cm) v MSU.

6.3 Protihrupna ograja APO 08a oz. APO 08c

6.3.1 Mejno stanje nosilnosti (MSN)

Za merodajno kombinacijo se izkaže kombinacija lastne teže, stalne obtežbe, obtežbe vetra in obtežbe snega.

Member B75	**0.000 / 2.000 m**	**General cross-section**	**S 235**	**All ULS**	**0.82 -**

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

Material		
Yield strength f_y	235.0	MPa
Ultimate strength f_u	360.0	MPa
Fabrication	Rolled	

a) Kontrola napetosti:

The critical check is on position 0.000 m

Internal forces	Calculated	Unit
N_{Ed}	-44.44	kN
$V_{y,Ed}$	0.00	kN
$V_{z,Ed}$	21.89	kN
T_{Ed}	0.00	kNm
$M_{y,Ed}$	-72.94	kNm
$M_{z,Ed}$	0.00	kNm

The cross-section is classified as Class 2

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

A	9.4383e-03	m^2
$N_{c,Rd}$	2218.00	kN
Unity check	0.02	-

Bending moment check for M_y
According to EN 1993-1-1 article 6.2.5 and formula (6.12),(6.13)

$W_{pl,y}$	8.3742e-04	m^3
$M_{pl,y,Rd}$	196.79	kNm
Unity check	0.37	-

Shear check for V_z
According to EN 1993-1-1 article 6.2.6 and formula (6.19)

$\tau_{Vz,Ed}$	18.1	MPa
τ_{Rd}	135.7	MPa
Unity check	0.13	-

Combined bending, axial force and shear force check
According to EN 1993-1-1 article 6.2.1(5) and formula (6.1)

Elastic verification		
Fibre	7	
$\sigma_{N,Ed}$	4.7	MPa

Elastic verification		
$\sigma_{My,Ed}$	99.4	MPa
$\sigma_{Mz,Ed}$	0.0	MPa
$\sigma_{tot,Ed}$	104.1	MPa
$\tau_{Vy,Ed}$	0.0	MPa
$\tau_{Vz,Ed}$	0.0	MPa
$\tau_{t,Ed}$	0.0	MPa
$\tau_{tot,Ed}$	0.0	MPa
$\sigma_{von\ Mises,Ed}$	104.1	MPa
Unity check	0.44	-

Note: For this section no plastic shear resistance and corresponding Rho value can be determined. Therefore the elastic yield criterion according to EN 1993-1-1 article 6.2.1(5) is verified.

The member satisfies the section check.

b) Kontrola stabilnosti:

The cross-section is classified as Class 2

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

Buckling parameters	yy	zz	
Sway type	sway	non-sway	
System length L	4.500	4.500	m
Buckling factor k	2.00	2.00	
Buckling length L_{cr}	9.000	9.000	m
Critical Euler load N_{cr}	1995.96	621.55	kN
Slenderness λ	99.00	177.41	
Relative slenderness λ_{rel}	1.05	1.89	
Limit slenderness $\lambda_{rel,0}$	0.20	0.20	
Buckling curve	d	d	
Imperfection α	0.76	0.76	
Reduction factor χ	0.44	0.19	
Buckling resistance $N_{b,Rd}$	976.61	429.79	kN

Flexural Buckling verification		
Cross-section area A	9.4383e-03	m^2
Buckling resistance $N_{b,Rd}$	429.79	kN
Unity check	0.10	-

Torsional(-Flexural) Buckling check
According to EN 1993-1-1 article 6.3.1.1 and formula (6.46)

Torsional buckling length L_{cr}	9.000	m
Elastic critical load $N_{cr,T}$	9789.53	kN
Elastic critical load $N_{cr,TF}$	621.55	kN
Relative slenderness $\lambda_{rel,T}$	1.89	
Limit slenderness $\lambda_{rel,0}$	0.20	
Buckling curve	d	
Imperfection α	0.76	
Reduction factor χ	0.19	
Cross-section area A	9.4383e-03	m^2
Buckling resistance $N_{b,Rd}$	429.79	kN
Unity check	0.10	-

Lateral Torsional Buckling check
According to EN 1993-1-1 article 6.3.2.1 & 6.3.2.2 and formula (6.54)

LTB parameters		
Reduction factor χ_{LT}	0.52	
Design buckling resistance $M_{b,Rd}$	102.08	kNm
Unity check	0.71	-

Mcr parameters		
LTB length L	9.000	m
Influence of load position	no influence	
Correction factor k	2.00	
Correction factor k_w	1.00	
LTB moment factor C_1	1.88	
LTB moment factor C_2	0.11	
LTB moment factor C_3	1.00	
Shear center distance d_z	0	mm
Distance of load application z_g	0	mm
Mono-symmetry constant β_y	0	mm
Mono-symmetry constant z_j	0	mm

Bending and axial compression check

According to EN 1993-1-1 article 6.3.3 and formula (6.61),(6.62)

Bending and axial compression check parameters		
Interaction method	alternative method 1	
Cross-section area A	9.4383e-03	m^2
Plastic section modulus $W_{pl,y}$	8.3742e-04	m^3
Design compression force N_{Ed}	44.44	kN
Design bending moment $M_{y,Ed}$	-72.94	kNm
Design bending moment $M_{z,Ed}$	0.00	kNm
Characteristic compression resistance N_{Rk}	2218.00	kN
Characteristic moment resistance $M_{y,Rk}$	196.79	kNm
Reduction factor χ_y	0.44	
Reduction factor χ_z	0.19	
Reduction factor χ_{LT}	0.52	
Interaction factor k_{yy}	1.09	
Interaction factor k_{zy}	0.57	

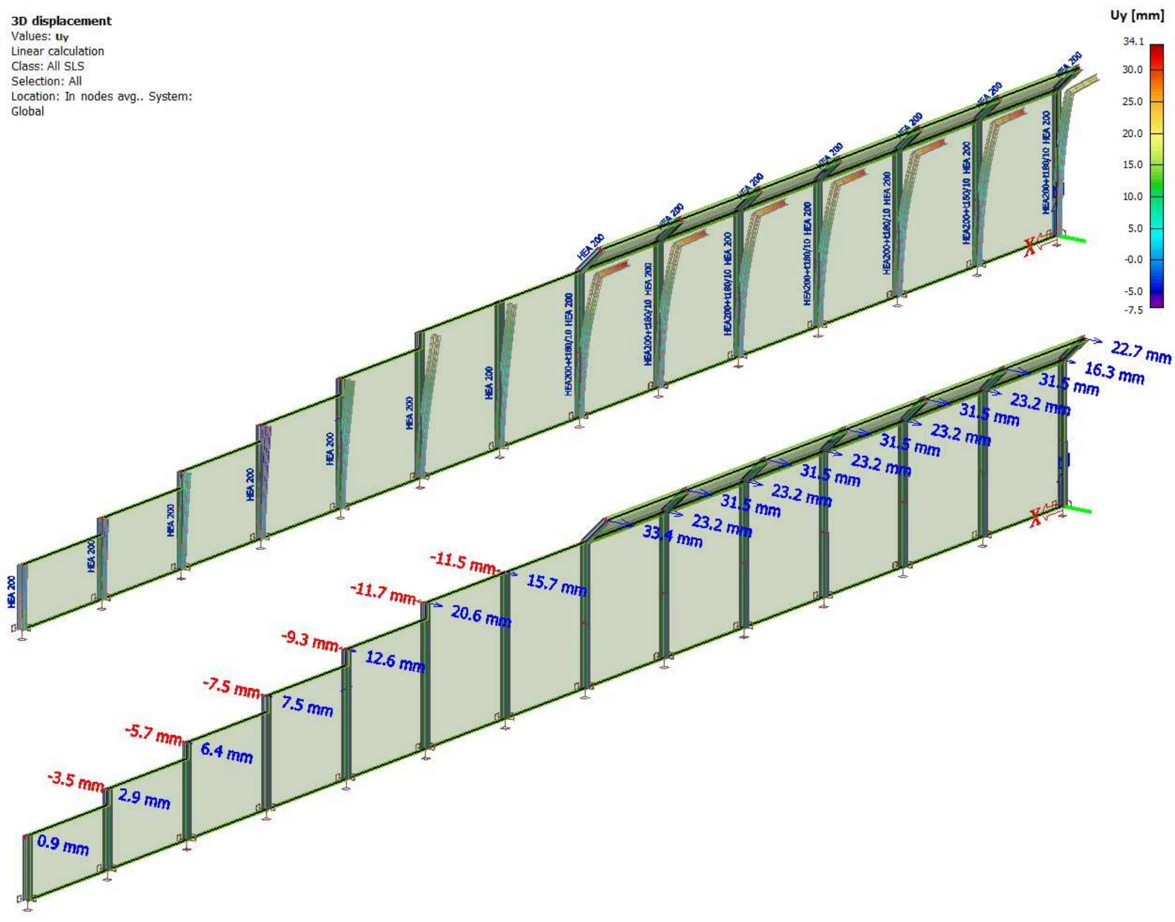
Interaction method 1 parameters		
Critical Euler load $N_{cr,y}$	1995.96	kN
Critical Euler load $N_{cr,z}$	621.55	kN
Elastic critical load $N_{cr,T}$	9789.53	kN
Plastic section modulus $W_{pl,y}$	8.3742e-04	m^3
Elastic section modulus $W_{el,y}$	7.3416e-04	m^3
Plastic section modulus $W_{pl,z}$	3.8612e-04	m^3
Elastic section modulus $W_{el,z}$	2.4291e-04	m^3
Second moment of area I_y	7.8004e-05	m^4
Second moment of area I_z	2.4291e-05	m^4
Torsional constant I_t	1.2438e-06	m^4
Method for equivalent moment factor $C_{my,0}$	Table A.2 Line 2 (General)	
Design bending moment (maximum) $M_{y,Ed}$	-72.94	kNm
Maximum relative deflection δ_z	-35.8	mm
Equivalent moment factor $C_{my,0}$	1.06	
Factor μ_y	0.99	
Factor μ_z	0.94	
Factor ε_y	21.10	
Factor a_{LT}	0.98	
Critical moment for uniform bending $M_{cr,0}$	128.40	kNm
Relative slenderness $\lambda_{rel,0}$	1.24	
Limit relative slenderness $\lambda_{rel,0,lim}$	0.27	
Equivalent moment factor C_{my}	1.01	
Equivalent moment factor C_{mLT}	1.05	
Factor b_{LT}	0.00	
Factor d_{LT}	0.00	
Factor w_y	1.14	
Factor w_z	1.50	
Factor n_{pl}	0.02	
Maximum relative slenderness $\lambda_{rel,max}$	1.89	
Factor C_{yy}	0.98	
Factor C_{zy}	0.93	

Unity check (6.61) = 0.05 + 0.78 + 0.00 = 0.82 -
Unity check (6.62) = 0.10 + 0.41 + 0.00 = 0.51 -

The member satisfies the stability check.

6.3.2 Mejno stanje uporabnosti (MSU)

Pomiki PHO so v skladu z Aneksom A v standardu EN 1794-1 omejeni na vrednost H / 150 = 35 mm. Omejitev velja za PHO višine večje od 450 cm. Pomiki PH ograje APO 08a oz. APO 08c so v MSU prikazani na spodnji sliki.



Slika 6-3: Pomiki protihrupne ograje APO 08a (*H* = 520cm) oz. APO 08c (*H* = 520cm) v MSU.

6.4 Kontrola temeljenja

Analizo temeljenja PHO je izvedel g. Janez Maurer (Elea IC).

V programu ZSoil 2016 v.16.06 smo preverili horizontalne pomike temeljev protihrupnih ograj (PHO). Temeljenje je bilo preverjeno za izvedbo temelja z vtisnjenimi okroglimi cevmi D/t=610/8mm, ki so vtisnjene v temeljna tla v ločilnem pasu, dolžina cevi znaša 3,0 m. Raster izvedenih pilotov znaša 4 m. Za izračun pomikov smo uporabili reakcije pridobljene iz strani projektanta PHO, prikazane v preglednici 1. Za posamezen tip ograje so bile upoštevane maksimalne vrednosti notranjih sil pri MSU.

Preglednica 1: Reakcije na glavo pilota.

		(a) PHO H=400cm TPO 03 in APO 04			(b) PHO H=500cm APO 09a in APO 09b			(c) PHO H=450+50cm APO 08a		
		Nx [kN]	Vz [kN]	My [kNm]	Nx [kN]	Vz [kN]	My [kNm]	Nx [kN]	Vz [kN]	My [kNm]
MSN1	max My	2,6	-22,0	53,2	5,5	-20,5	60,4	46,0	-21,9	83,8
MSN2	max Vz	2,6	-22,0	53,2	3,1	-21,4	36,4	2,0	-24,2	45,6
MSN3	Max Nx	2,6	0,0	0,0	5,5	0,0	0,0	47,5	-11,3	52,4
MSU1	max My	**1,9**	**-14,7**	**35,5**	4,0	-13,7	**40,3**	33,7	-14,6	**56,9**
MSU2	max Vz	1,9	-14,7	35,5	2,3	**-14,3**	24,3	1,5	**-16,1**	30,4
MSU3	Max Nx	1,9	0,0	0,0	**4,0**	0,0	0,0	**34,7**	-7,5	36,0

My … moment na vrhu pilota

Vz … deluje prečno na vrhu pilota

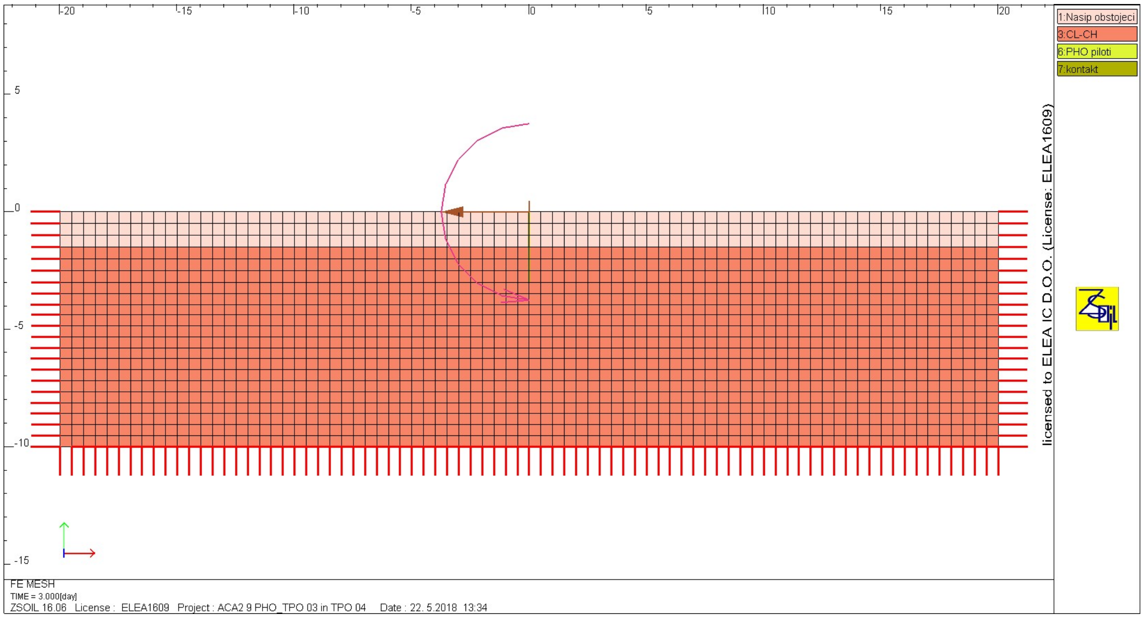
Nx … deluje vzdolžno na smer pilota

Za določitev pomikov z zgoraj navedenimi obremenitvami smo uporabili najneugodnejšo geologijo na območju izvedbe PHO (prečni prerez ACA2 9). V izračunu smo predpostavili, da je plašč pilota izveden v 1,5 m v nasipu in 1,5 m v podlagi grajeni iz gline. Materialne karakteristike slojev so prikazane v preglednici 2.

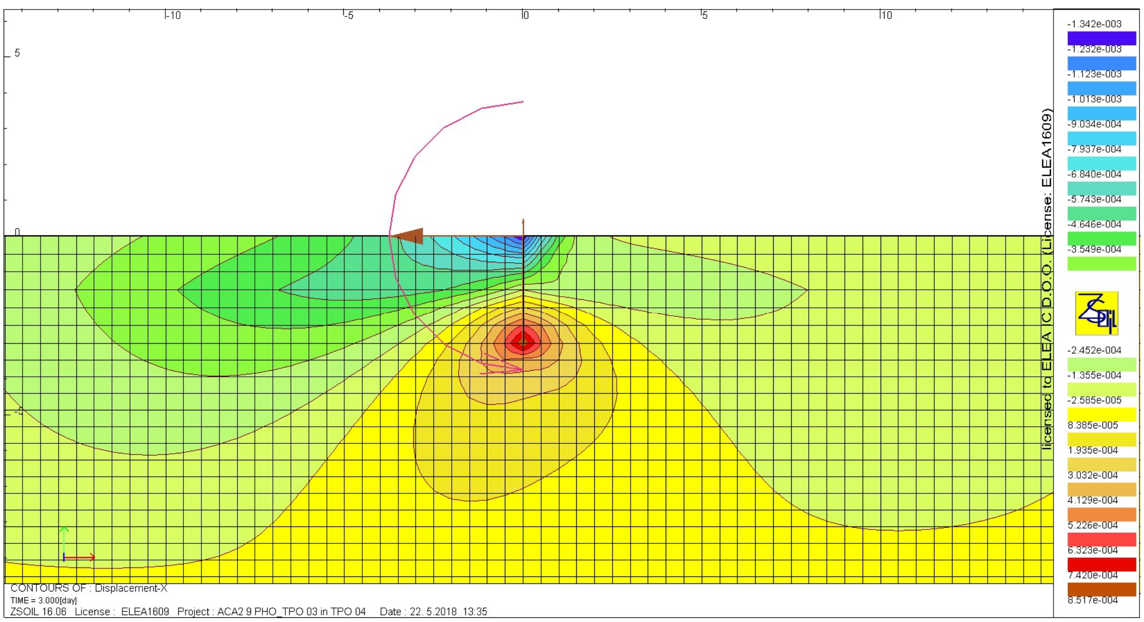
Preglednica 2: Geomehanske karakteristike slojev v katerih bodo izvedeni piloti.

SLOJ	Prostorninska teža	Strižni kot	Kohezija	Elastični modul
Nasip	21	38	0	50000
Glina	17	23	0,1	2200

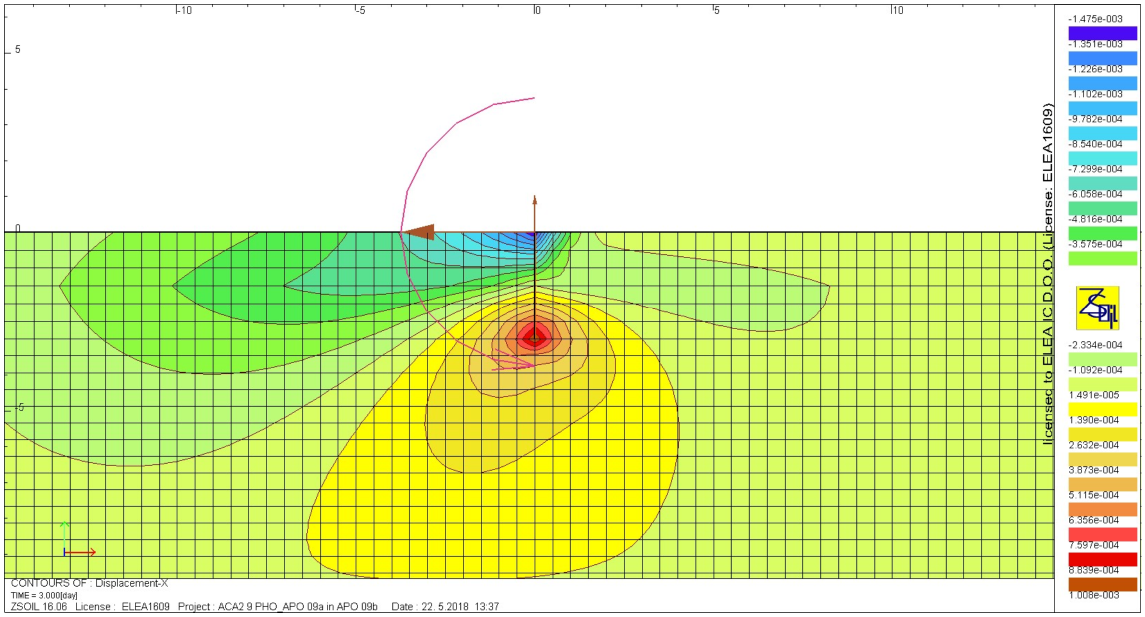
Na podlagi zgornjih podatkov je izveden račun prikazal, da pomiki pilotov ob zgoraj navedenih silah znašajo < 3 mm.



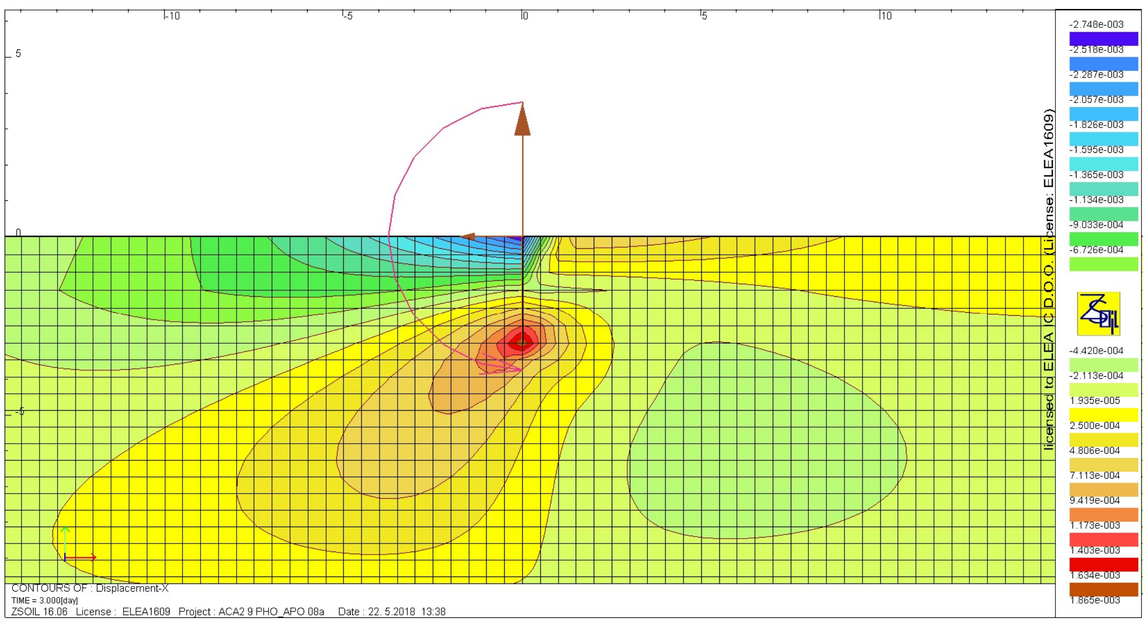
Slika 6-4: Model končnih elementov



Slika 6-5: Horizontalni pomik pilota (TPO 03 in TPO 04)



Slika 6-6: Horizontalni pomik pilota (APO 09a in APO 09b)



Slika 6-7: Horizontalni pomik pilota (APO 08a)

Kontrola nosilnosti pilotov po alternativni metodi (SIST EN 1997-2; PP2)

Za pilote se upošteva vsota nosilnosti pod konico pilota in nosilnosti po plašču pilota.. Nosilnost kolov je izračunana po alternativni metodi po SIST EN 1997-2. Pri izračunu so upoštevani delni faktorji odpornosti po SIST EN 1997-1, projektni pristop 2.

SKUPNA NOSILNOST

ξ = **1,4**

Kol		NOGA	PLAŠČ	**SKUPAJ**	**PROJ. NOS.**
D	R	$Q_{b,d}$	$Q_{s,d}$	**Q**	**Qd**
m	m	kN	kN	**kN**	**kN**
3	0,62	0,2	133,3	**133,6**	**95,4**

7 ZAKLJUČEK

Za dimenzioniranje PHO so najbolj kritični najvišji stebrički na APO 09a in na APO 09b, kjer je narejen prehod med protihrupno ograjo iz 5.50m na 3.50m. V teh primerih je zaradi zagotavljanja kriterija pomikov potrebno privariti dodatne pločevine 180/10mm na pasnice HEA 200 profilov in sicer do višine stebra 2,00m od vpetja v jekleni pilot okroglega prečnega prereza *D* / *t* = 620 / 8 mm. Ostali stebrički, ki so enakih prečnih prerezov in brez ojačitev – profil HEA 200, ustrezajo vsem kriterijem nosilnosti in pomikov. Temeljenje je ustrezno.