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2.2.1 NASLOVNA STRAN Z OSNOVNIMI PODATKI O NAČRTU

ŠTEVILČNA OZNAKA NAČRTA IN VRSTA NAČRTA

2 – NAČRT S PODROČJA GRADBENIŠTVA

(načrt arhitekture; načrt krajinske arhitekture; načrt gradbenih konstrukcij in drugi gradbeni načrti; načrt električnih inštalacij in električne opreme; načrt strojnih inštalacij in strojne opreme; načrt telekomunikacij; tehnološki načrt; načrti izkopov in osnovne podgradnje)

INVESTITOR

Direkcija Republike Slovenije za infrastrukturo
Tržaška cesta 19, 1000 Ljubljana

(ime, priimek in naslov investitorja oziroma njegov naziv in sedež)

OBJEKT

Gradnja nadomestnega zidu na državni cesti R2-404/1379
od km 2,550 do km 2,610 Podgrad – Ilirska Bistrica

(poimenovanje objekta, na katerega se gradnja nanaša)

VRSTA PROJEKTNE DOKUMENTACIJE

PZI - Projekt za izvedbo

(idejna zasnova, idejni projekt, projekt za pridobitev gradbenega dovoljenja, projekt za izvedbo, projekt izvedenih del)

ZA GRADNJO

REKONSTRUKCIJA

(nova gradnja, dozidava, nadzidava, rekonstrukcija, odstranitev objekta, sprememba namembnosti)

IZDELOVALEC NAČRTA

Gradbeni biro Mele, Janko Mele s.p.,
Cesta gradenj 6, 1360 Vrhnika

direktor: **Janko Mele, univ.dipl.inž.gradb.,**

(naziv projektanta, sedež, ime in podpis odgovorne osebe projektanta, žig)

POOBLAŠČENI INŽENIR GRADBENIŠTVA

Janko Mele, univ.dipl.inž.gradb.,

id.št. PI G-0292

(ime in priimek, strokovna izobrazba, osebni žig, podpis)

ŠTEVILKA NAČRTA, KRAJ IN DATUM IZDELAVE NAČRTA

številka: **CS 1405-G/21-PZI** številka izvoda: **1 2 3 4 5**

Vrhnika, marec 2021

(številka načrta, evidentirana pri projektantu, kraj in datum izdelave načrta)

VODJA PROJEKTA

Igor Stavrević, univ.dipl.inž.gradb.,

id.št. PI G-3876

(ime in priimek, strokovna izobrazba, osebni žig, podpis)

1379		004.2162	S.1	

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2.2.2 KAZALO VSEBINE NAČRTA S PODROČJA GRADBENIŠTVA št.: CS 1405-G/21-PZI

2.2.1	Naslovna stran načrta
2.2.2	Kazalo vsebine načrta
2.2.3	Tehnično poročilo 1. PRILOGA: Poročilo o sondažnem razkopu za oporni zid na cesti R2-404/1379 od km 2,550 do km 2,610; mag. Simona Golčman Ribič, u.d.i.geol. 2. Statični izračun
2.2.4	Risbe Armaturni načrt opornega zidu

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2.2.3 TEHNIČNO POROČILO

Tehnično poročilo se nanaša na izdelavo PZI dokumentacije za gradnjo *Rekonstrukcija opornega zidu na cesti R2-404/1379 od km 2,550 do km 2,610*.

V okviru projekta je predvidena sanacija obstoječega opornega zidu dolžine cca. L = 60 m, ki varuje brežino nad cesto. Obstoječi zid je na več mestih počen in mestoma premaknjen.

Sanacija je načrtovana na podlagi poročila pregleda (*Poročilo o sondažnem razkopu za oporni zid na cesti R2-404/1379 od km 2,550 do km 2,610*), ki ga je v januarju 2021 izdelala mag. Simona Golčman Ribič, u.d.i.geol. in je priloženo v nadaljevanju.

Obstoječi zid se odstrani in nadomesti z novim zidom dolžine 50 m. Novi zid je prečnega prereza v obliki črke »T«, kjer je manjši del pete (30 cm) obrnjen v zaledje, večji del pa proti cesti. Glede na spreminjajočo se višino stene opornega zidu (od 1,5 m do 3,75 m) sta projektirani dve širini temeljnih pet in sicer L^{P}_{Z1} = 2,50 (med profili Z2-Z8) in L^{P}_{Z2} = 1,90 (med profili Z1-Z2 in Z8-Z11). Debelina AB stene in temeljne pete znaša d = 30 cm.

Spodnji rob temeljne pete se nahaja na koti vsaj -1,0 m pod nivojem urejenega terena pred zidom. AB zid se izvede po odsekih z dilatacijami dolžine L = 10 m. .

V času izdelave dokumentacije smo razpolagali s poročilom o sondažnem razkopu iz katerega smo povzeli osnovne podatke za projektiranje.

Glede nivoja temeljenja je izbrana predlagana različica z zamenjavo slabo nosilnih temeljnih tal s kvalitetnim kamnitim materialom in izvedba temelja na utrjeni kamniti blazini. Potrebno debelino zamenjave temeljnih tal in postopke vgradnje predpiše geomehanik.

Pri izračunu in dimenzioniranju opornih zidov so bile upoštevane predpostavljene lastnosti izboljšanih temeljnih tal: strižni kot $\varphi = 33^{\circ}$, kohezija c = 0 kPa, $\gamma = 19$ kN/m^3 in lastnosti zaledne zemljine $\varphi = 34^{\circ}$, kohezija c = 0, kPa, $\gamma = 18$ kN/m^3 (zasip za zidom).

Odkop za izvedbo temeljev mora pregledati geomehanik in podati svoje mnenje, ter podati navodila za pripravo temeljnih tal. Potrditi mora tudi ostale predpostavke upoštevane ob izračunu, za katere ni bilo podanih natančnih računskih vrednosti.

V zaledju oporne konstrukcije se izvede drenažni sistem za odvodnjavanje zaledne vode.

Izvajanje izkopov in temeljenje zidov naj poteka v kampadah in pod stalnim strokovnim geomehanskim nadzorom!

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Statični izračun je bil izveden s programsko opremo Frilo WSM (oporni zidovi). Račun je bil izveden ob upoštevanju predpisov EUROCODE, navedene geometrije, predpostavljenih lastnosti temeljnih tal in materiala kvalitete:

Beton	C 30/37, D32, S4, XD3, XF4; PV-III	
Armatura	B 500.	
Zaščitna plast betona	a = 4,0 cm	v zemlji;
	a = 4,0 cm	v steni proti cesti;

Janko Mele, u.d.i.g.

Simon Kogoj, u.d.i.g..

Vrhnika, marec 2021.

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2.2.3.1 PRILOGA

Poročilo o sondažnem razkopu
za oporni zid na cesti R2-404/1379 od km 2,550 do km 2,610

Datum izvedbe: 25. 1. 2021
Prisotni: Urška Oset, Tomi Pavlič, Simona Golčman Ribič
Lokacija izvedbe: Oporni zid na cesti R2-404/1379 od km 2,550 do km 2,610 Podgrad – Ilirska Bistrica

1. Uvod

Za potrebe sanacije oz. novogradnje opornega zidu na cesti R2-404/1379 od km 2,550 do km 2,610 je bil 25.1.2021 izveden sondažni razkop. Zaporo ceste in strojni razkop je izvedlo podjetje CPK, d.d.. Razkop je bil izveden ob geološki spremljavi s strani DRI, izvedena je bila meritev z dinamično krožno ploščo, razkop je bil geološko-geotehnično popisan ter fotografiran. Pregledano je bilo tudi ožje območje opornega zidu in brežine nad zidom.

2. Sondažni razkop

Razkop je bil izveden v drenažnem jarku na koncu zidu v km 2,608, na razdalji 1,8 m od roba asfalta. V spodnji preglednici podajamo popis razkopa. Globine so merjene od nivelete vozišča. Fotografije razkopa so podane na *Sliki 1*.

Preglednica 1: Geološki popis razkopa

Globina (m)*	**Material**	**Opomba**
0 – 0,9	Jarek	V jarku zastaja voda
0,9 - 2,0	Rjava do okrasta glina z gruščem (CL/GC), vlažna, srednje do težko gnetna (z globino konsistenčno stanje prehaja iz srednje v težko gnetno), vsebnost grušča se z globino spreminja, glina mestoma prehaja v glinast grušč. Na dnu razkopa se nabira voda, ki priteka iz jarka.	
2,0 – 3,0	Siv glinast grušč oz. preperina fliša – kosi peščenjaka in laporovca v glinasti osnovi. Vlažno.	Meritev z dinamično ploščo na globini 3 m: E_{vd}=35,8 MN/m^2. Z razkopom nismo dosegli kompaktne hribinske podlage.

*merjeno od nivelete

Slika 1: Fotografije razkopa

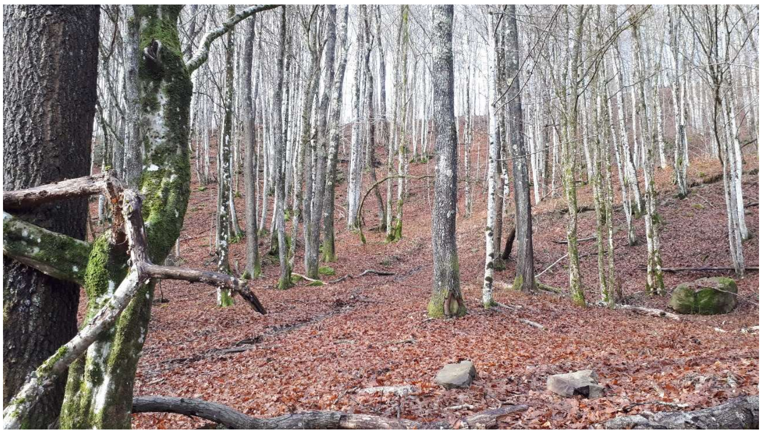
3. Opis stanja opornega zidu in brežine nad njim

Oporni zid dolžine ca. 60 m in višine 1 m varuje brežino nad cesto. V večjem delu med zidom in cestiščem poteka drenažni jarek, v katerem zastaja voda. Zid je dotrajan, na več mestih je počen, mestoma tudi premaknjen. Ni opaziti armature. Na začetku zidu je v drenažnem jarku vidno, da temelj zidu sega ca. 0,5 m po niveleto. Barbakane so suhe (zamašene). Spodaj (*Slika 2*) so podane fotografije obravnavanega zidu.

Slika 2: Fotografije razkopa

V pobočju nad zidom (v km 2,560, 20 m od roba ceste) je manjši izvir. Voda teče proti zidu, vendar se ne steka v drenažni kanal, niti ne teče skozi barbakane, ampak namaka zaledje zidu. Pobočje nad zidom je poraščeno z drevesi, prekrito je z deluvialnimi glinami in grušči, mestoma so opazni izdanki peščenjaka. Neposredno nad zidom ni opaziti znamenj plazenja, vidni pa so sledovi površinskega toka vode, ki se ob večjih deževjih pretaka po slabo prepustnih sedimentih. Na spodnjih fotografijah (*Slika 3*) podajamo fotografije brežine.

Slika 3: Brežina nad opornim zidom



4. Zaključek

Obstoječi oporni zid je dotrajan in neustrezno temeljen. Odvodnjavanje ni ustrezno urejeno. Hribinsko podlago obravnavanega območja gradi fliš (menjavanje laporovca in peščenjaka), ki prepereva v glinaste grušče in glino. Le ti so slabo prepustni, zato se poleg zaledne vode na stiku med hribino in preperino, ob močnejših oz. dolgotrajnih padavinah pojavljajo tudi dotoki površinskih vod. Z razkopom nismo dosegli kompaktne hribinske podlage.

Predlagamo izgradnjo novega opornega zidu, ki naj bo temeljen minimalno 4 m pod niveleto ceste. Kot alternativa je mogoča tudi zamenjava slabo nosilnih tal s kvalitetnim kamnitim materialom in izvedba temelja na utrjeni kamniti blazini. Izbrani način temeljenja in izvedbe opornega je potrebno preveriti s računskimi analizami.

Primernost temeljnih tal med gradnjo mora potrditi geomehanski nadzor. Urediti je potrebno odvodnjavanje zalednih in površinskih vod.

Pripravila:

mag. Simona Golčman Ribič, u.d.i.geol.

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2.2.3.2 STATIČNI IZRAČUN

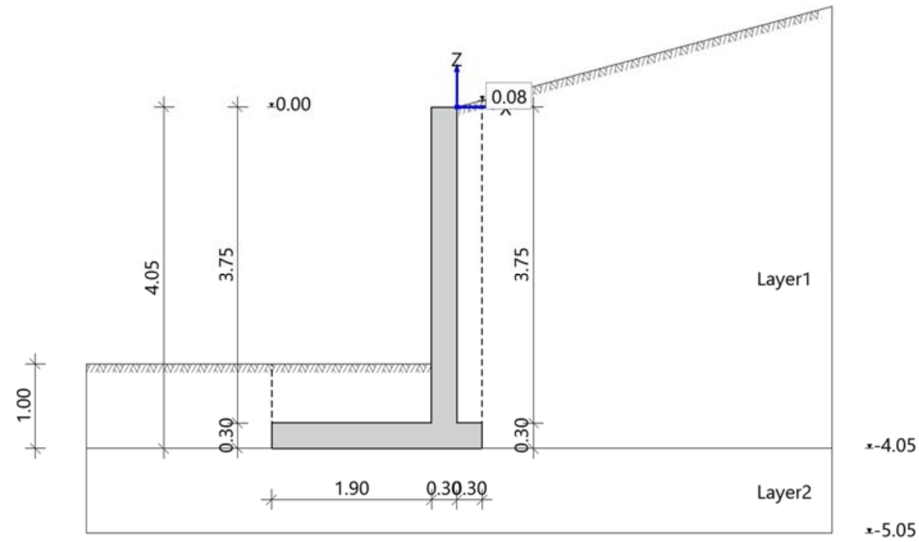
- OPORNA zidova: OZ1
  OZ2

Item: OZ1 Ilirska - Podgrad

Cantilevered Retaining Wall WSM+ 01/21C (FRILO R-2021-1/P07)

System

Graphics



Properties

Design Codes

Design byDIN EN 1992-1-1/NA/A1:2015-12 and DIN EN 1997-1/NA:2010-12

Cantilever wall

	Total height	=	4.05	m	Soil inclination	=	0.0	°	Soil depths difference	=	0.00 m
Wall:	Width top	=	0.30	m	Haunch uphill	=	0.00	m	Haunch downhill side	=	0.00 m
Toe:	Length	=	1.90	m	Height	=	0.30	m			
Heel uphill:	Length	=	0.30	m	Height rear	=	0.30	m	Haunch uphill side	=	0.00 m

Properties

Concrete density	γb	=	25.00	kN/m^3
Soil friction angle	δS,k	=	33.0	°
Active angle of wall friction	δ	=	2/3ϕ'	
Passive wall friction angle	δp	=	0ϕ'	

Soil

Soil layers uphill

Nr.	γ [kN/m^3]	γ' [kN/m^3]	ϕ' [°]	c' [kN/m^2]	d [m]	E* [kN/m^2]	Description
1	18.00	8.00	34.0	0.00	4.05	20000.00	
2	19.00	9.00	33.0	0.00	1.00	20000.00	

Soil layer before downhill heel

γ [kN/m^3]	γ' [kN/m^3]	ϕ' [°]	c' [kN/m^2]	d [m]
18.00	8.00	30.0	0.00	1.00

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Terrain

continuous
Inclination β = 15.0 °

Design

Earth Resistance

Earth resistance not applied.

Earth pressure

Inner stability (reinforced concrete design)

Earth pressure type	=	Active earth pressure
Any tensile forces from cohesion are not applied.		
Increased active earth pressure		
Proportion of active earth pressure	=	0.50
Proportion of earth pressure at rest	=	0.50

Outer stability (geotechnical verifications)

Earth pressure is applied to the vertical sliding surface

Earth pressure type = Active earth pressure
Any tensile forces from cohesion are not applied.

Geotechnical design

The detailed proof of base failure including sliding is maintained

Reinforced concrete analysis

Settings of wall design

Concrete strength class		=	C30/37					
Steel		=	B500A					
Steel diameter inside	ØS,1	=	12 mm		Steel diameter outside	ØS,2	=	12 mm
Diameter stirrup	ØB	=	-					
Measurement inside	cv,l1	=	30	mm	Measurement outside	cv,l2	=	30 mm
Distance reinforcement layer inside	d1	=	41	mm				
Distance reinforcement layer outside	d2	=	41	mm				

Foundation dimension settings

Concrete strength class		=	C30/37					
Steel		=	B500A					
Steel diameter top	ØS,1	=	12 mm		Steel diameter bottom	ØS,2	=	12 mm
Diameter stirrup	ØB	=	-					
Measurement top	cv,l1	=	30	mm	Measurement bottom	cv,l2	=	30 mm
Distance reinforcement layer top	d1	=	41	mm				
Distance reinforcement layer bottom	d2	=	41	mm				

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Reduction of the transverse force with a variable cross-section height is carried out

Results

Result overview

Geotechnical verifications

Proof	Superposition	Utilization ratio μ
Toppling proof	1	0.24
Bearing Resistance Failure	2	0.31
Sliding proof	2	**1.00**
Slope stability	3	0.70
Gapping joint 1st core width	4	0.21
Gaping joint 2nd core width	4	0.10

average settlement s_m = 4 mm Decisive combination : 4
Tilt α = 0.017 ° Decisive combination : 4

Required reinforcement

Location	Flexural reinforcement				Shear reinforcement	
	$a_{sl,req\ top/outer}$ [cm²/m]	LCc. [-]	$a_{sl,req,\ bottom/inner}$ [cm²/m]	LCc. [-]	$a_{sw,req}$ [cm²/m]	LCc. [-]
Constrained wall	0.00	5	6.96	6	0.00	6
Cut part heel	3.97	2	0.00	5	0.00	2
Cut part toe	0.00	5	4.27	2	0.00	2

Overview of superposition and load cases

Actions

Name	ψ_0	ψ_1	ψ_2
Permanent loads	1.00	1.00	1.00

Load cases

No.	Name	Action
1	Soil and wall weight	Permanent loads
2	Earth pressure from dead load	Permanent loads

Decisive combinations (permanent design situation)

No.	Limit state	decisive combination
1	EQU	0.90×(1) + 1.10×(2)
2	STR/GEO-2	1.35×(1) + 1.35×(2)
3	GEO-3	1.00×(1)
4	SLS	1.00×(1) + 1.00×(2)
5	STR/GEO-2	1.00×(1) + 1.00×(2)
6	STR/GEO-2	1.00×(1) + 1.35×(2)
The load numbers are in brackets		

Reinforced Concrete Design

Earth pressure

Active earth pressure factors

from z = [m]	to z = [m]	α [°]	ϕ' [°]	δ [°]	k_{agh} [-]	k_{ach} [-]	k_{aph} [-]
0.00	-3.75	0.0	34.0	22.7	0.285[1]	0.888[1]	0.285[1]
1 : β= 15 °							

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Earth rest coefficients

from z = [m]	to z = [m]	α [°]	φ' [°]	δ [°]	k_{0gh} [-]	k_{0ch} [-]	k_{0ph} [-]
0.00	-3.75	0.0	34.0	NaN	0.550[1]	0.000[1]	0.550[1]

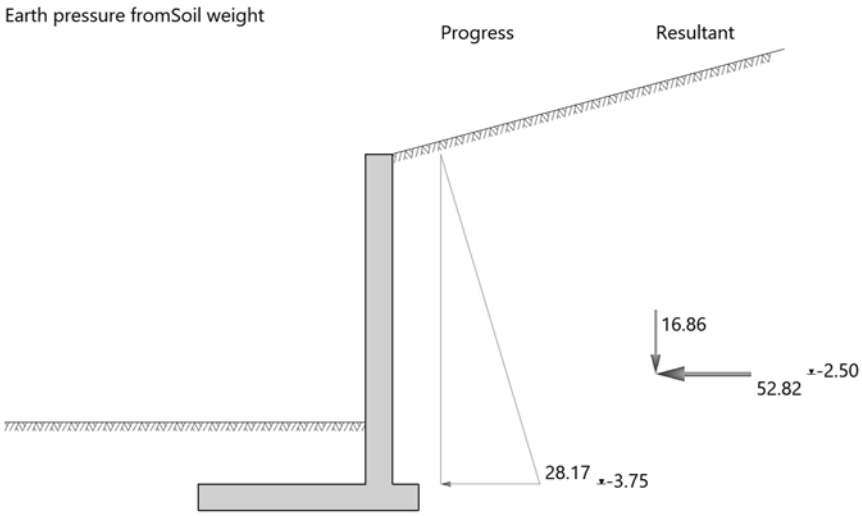
1 : β= 15 °

Earth pressure curve from dead load

z [m]	e_{ah} [kN/m²]
0.00	0.00
-3.75	28.17

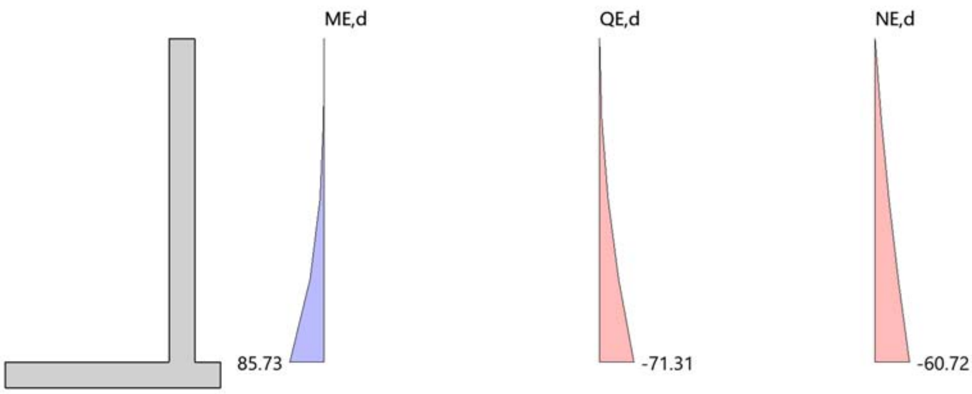
Resultant

Horizontal resultant E_{ah} = 52.82 kN/m Action point from the top of the wall z_a = -2.50 m
Vertical resultant E_{av} = 16.86 kN/m



Wall design

Design values of inner forces



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Bending design in point z = -3.75 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ inner}$ [cm²/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ outer}$ [cm²/m]
85.73	-50.88	300	259	6.96	63.50	-44.98	300	259	0.00
Min. ductility reinforcement is considered Min. compressive reinforcement is considered									

Shear design in point z = -3.75 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz,\ exist}$ [cm²/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm²/m]	$a_{sw,\ min}$ [cm²/m]
-71.31	-50.88	300	259	6.96	199	102.82	133.13	146.62	3.00	761.18	0.00	0.00
Consider min. lateral reinforcement												

Foundation design

Characteristic internal forces for the base pressure calculation in the center of the foundation with reference to the base surface

Action from:	t [kN/m]	n [kN/m]	m [kNm/m]
Soil and wall weight	0.00	91.28	-37.84
Earth pressure from dead load	-45.77	13.18	46.93

Heel uphill

Bearing pressure calculation bending

The design effect of the tangential of soil area :

$t_{Ed} = (-45.77 \cdot 1.35) = -61.78$ kN/m

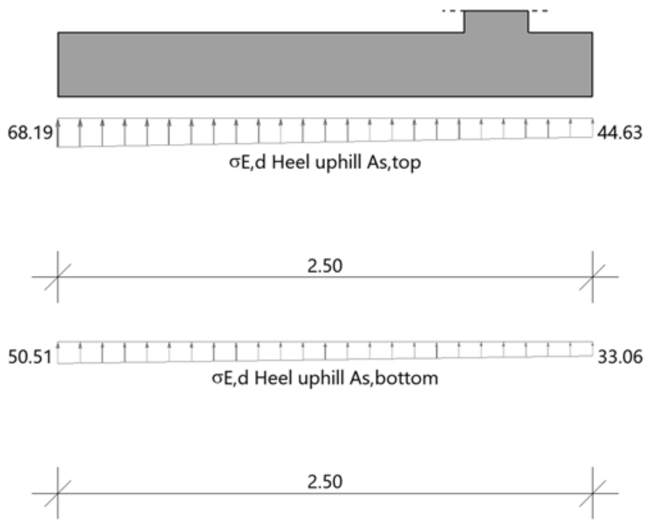
The design effect of the normal of soil area :

$n_{Ed} = (91.28 \cdot 1.35) + (13.18 \cdot 1.35) = 141.02$ kN/m

Moment design effects:

$m_{Ed} = (-37.84 \cdot 1.35) + (46.93 \cdot 1.35) = 12.27$ kNm/m

Eccentricity in	e	=	0.09	m
Sole pressure	σ_{1d}	=	68.19	kN/m²
Bearing	σ_{2d}	=	44.63	kN/m²
Overpressed	l_p	=	2.50	m



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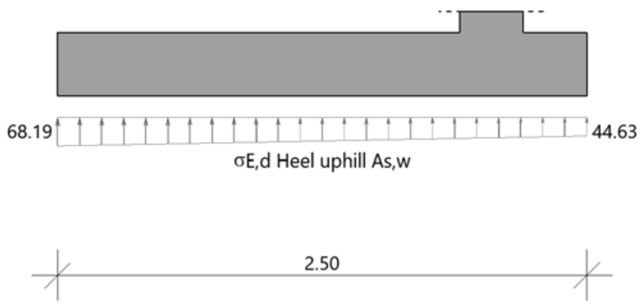
Design internal forces from soil pressure of the the superposition of bending relative to the coordinate system

n,As,top [kN/m]	v,As,top [kN/m]	m,As,top [kNm/m]	n,As,bottom [kN/m]	v,As,bottom [kN/m]	m,As,bottom [kNm/m]
6.05	-13.81	2.96	4.48	-10.23	2.19

Bearing pressure calculation shearing
The design effect of the tangential of soil area :
$t_{Ed} = (-45.77 \cdot 1.35) = -61.78$ kN/m
The design effect of the normal of soil area :
$n_{Ed} = (91.28 \cdot 1.35) + (13.18 \cdot 1.35) = 141.02$ kN/m
Moment design effects:
$m_{Ed} = (-37.84 \cdot 1.35) + (46.93 \cdot 1.35) = 12.27$ kNm/m

Eccentricity in	e	=	0.09	m
Sole pressure	σ_{1d}	=	68.19	kN/m²
Bearing	σ_{2d}	=	44.63	kN/m²
Overpressed	l_p	=	2.50	m



Design internal forces from soil pressure of the the superposition of lateral force bending relative to the coordinate system

n [kN/m]	v [kN/m]	m [kNm/m]
6.05	-13.81	2.96

Bending design in point x = 0.00 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req.\ btm}$ [cm²/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ top}$ [cm²/m]
-22.59	11.54	300	259	0.00	-30.50	15.58	300	259	3.97[1]

Min. ductility reinforcement is considered
Min. compressive reinforcement is considered

1 : Minimum ductility reinforcement decisive

Shear design in point x = 0.00 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz,\ exist}$ [cm²/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm²/m]	$a_{sw,\ min}$ [cm²/m]
11.89	15.58	300	259	3.97	199	79.32	126.25	148.95	1.00	1268.63	0.00	0.00

Consider min. lateral reinforcement

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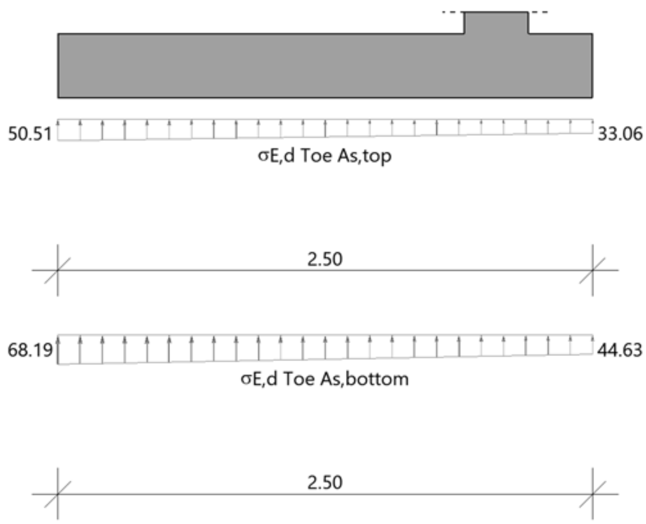
Toe
Bearing pressure calculation bending
The design effect of the tangential of soil area :
t_{Ed} = (-45.77 · 1.35) = -45.77 kN/m
The design effect of the normal of soil area :
n_{Ed} = (91.28 · 1.00) + (13.18 · 1.00) = 104.46 kN/m
Moment design effects:
m_{Ed} = (-37.84 · 1.00) + (46.93 · 1.00) = 9.09 kNm/m

Eccentricity in	e	=	0.09	m
Sole pressure	σ_{1d}	=	50.51	kN/m²
Bearing	σ_{2d}	=	33.06	kN/m²
Overpressed	l_p	=	2.50	m



Design internal forces from soil pressure of the the superposition of bending relative to the coordinate system

n,As,top [kN/m]	v,As,top [kN/m]	m,As,top [kNm/m]	n,As,bottom [kN/m]	v,As,bottom [kN/m]	m,As,bottom [kNm/m]
-36.53	83.37	77.71	-49.31	112.55	104.91

Bearing pressure calculation shearing
The design effect of the tangential of soil area :
t_{Ed} = (-45.77 · 1.35) = -61.78 kN/m
The design effect of the normal of soil area :
n_{Ed} = (91.28 · 1.35) + (13.18 · 1.35) = 141.02 kN/m
Moment design effects:
m_{Ed} = (-37.84 · 1.35) + (46.93 · 1.35) = 12.27 kNm/m

Eccentricity in	e	=	0.09	m
Sole pressure	σ_{1d}	=	68.19	kN/m²
Bearing	σ_{2d}	=	44.63	kN/m²
Overpressed	l_p	=	2.50	m

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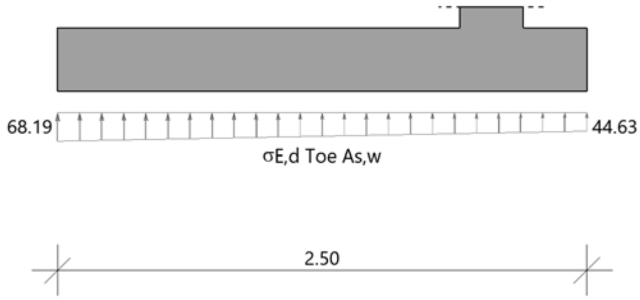

Design internal forces from soil pressure of the the superposition of lateral force bending relative to the coordinate system

n [kN/m]	v [kN/m]	m [kNm/m]
-49.31	112.55	104.91

Bending design in point x = -0.30 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req.\ btm}$ [cm^2/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ top}$ [cm^2/m]
55.93	-49.31	300	259	4.27	41.43	-36.53	300	259	0.00
Min. ductility reinforcement is considered Min. compressive reinforcement is considered									

Shear design in point x = -0.30 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz,\ exist}$ [cm^2/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm^2/m]	$a_{sw,\ min}$ [cm^2/m]
60.99	-49.31	300	259	4.27	199	88.00	132.97	146.68	3.00	761.18	0.00	0.00
Consider min. lateral reinforcement												

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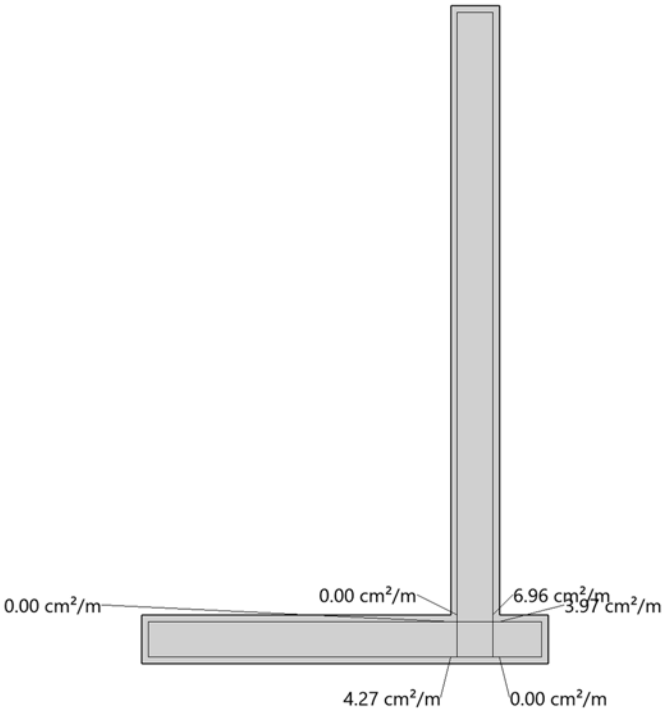
Schematic reinforcement graphic



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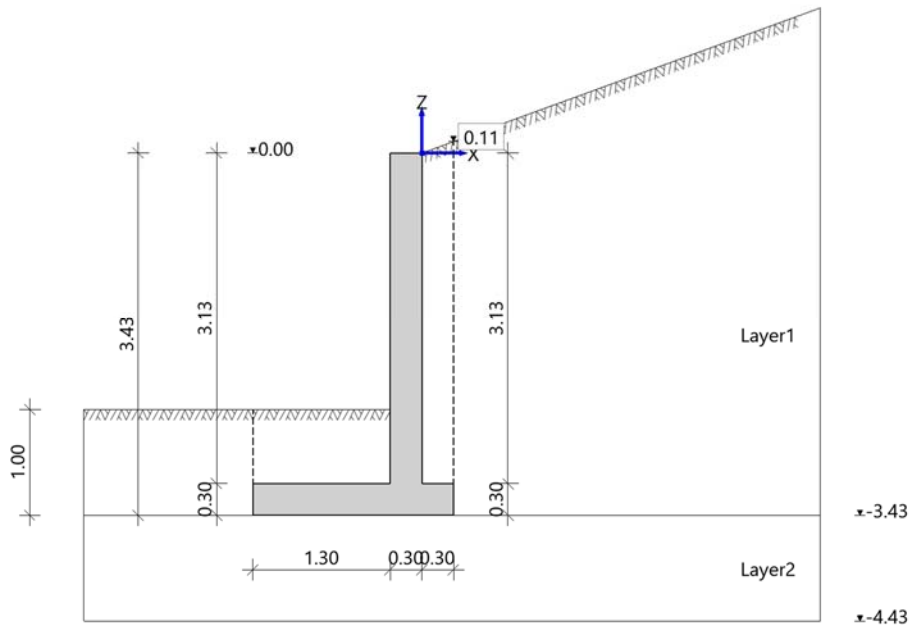
Item: OZ2 Ilirska - Podgrad

Cantilevered Retaining Wall WSM+ 01/21C (FRILO R-2021-1/P07)

System

Graphics



Properties

Design Codes

Design byDIN EN 1992-1-1/NA/A1:2015-12 and DIN EN 1997-1/NA:2010-12

Cantilever wall

	Total height	=	3.43 m	Soil inclination	=	0.0 °	Soil depths difference	=	0.00 m
Wall:	Width top	=	0.30 m	Haunch uphill	=	0.00 m	Haunch downhill side	=	0.00 m
Toe:	Length	=	1.30 m	Height	=	0.30 m			
Heel uphill:	Length	=	0.30 m	Height rear	=	0.30 m	Haunch uphill side	=	0.00 m

Properties

Concrete density	γb	=	25.00	kN/m^3
Soil friction angle	δS,k	=	33.0	°
Active angle of wall friction	δ	=	2/3ϕ'	
Passive wall friction angle	δp	=	0ϕ'	

Soil

Soil layers uphill

Nr.	γ [kN/m^3]	γ' [kN/m^3]	ϕ' [°]	c' [kN/m^2]	d [m]	E* [kN/m^2]	Description
1	18.00	8.00	34.0	0.00	3.43	20000.00	
2	19.00	9.00	33.0	0.00	1.00	20000.00	

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Soil layer before downhill heel

γ [kN/m³]	γ' [kN/m³]	φ' [°]	c' [kN/m²]	d [m]
18.00	8.00	30.0	0.00	1.00

Terrain

continuous
Inclination β = 20.0 °

Design

Earth Resistance

Earth resistance not applied.

Earth pressure

Inner stability (reinforced concrete design)

Earth pressure type = Active earth pressure
Any tensile forces from cohesion are not applied.
Increased active earth pressure
Proportion of active earth pressure = 0.50
Proportion of earth pressure at rest = 0.50

Outer stability (geotechnical verifications)

Earth pressure is applied to the vertical sliding surface

Earth pressure type = Active earth pressure
Any tensile forces from cohesion are not applied.

Geotechnical design

The detailed proof of base failure including sliding is maintained

Reinforced concrete analysis

Settings of wall design

Concrete strength class		=	C30/37						
Steel		=	B500A						
Steel diameter inside	ØS,1	=	12 mm		Steel diameter outside	ØS,2	=	12 mm	
Diameter stirrup	ØB	=	-						
Measurement inside	cv,l1	=	30	mm	Measurement outside	cv,l2	=	30	mm
Distance reinforcement layer inside	d1	=	41	mm					
Distance reinforcement layer outside	d2	=	41	mm					

Foundation dimension settings

Concrete strength class		=	C30/37						
Steel		=	B500A						
Steel diameter top	ØS,1	=	12 mm		Steel diameter bottom	ØS,2	=	12 mm	
Diameter stirrup	ØB	=	-						
Measurement top	cv,l1	=	30	mm	Measurement bottom	cv,l2	=	30	mm
Distance reinforcement layer top	d1	=	41	mm					
Distance reinforcement layer bottom	d2	=	41	mm					

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Reduction of the transverse force with a variable cross-section height is carried out

Results

Result overview

Geotechnical verifications

Proof	Superposition	Utilization ratio μ
Toppling proof	1	0.23
Bearing Resistance Failure	2	0.37
Sliding proof	2	0.97
Slope stability	3	0.69
Gapping joint 1st core width	4	0.34
Gaping joint 2nd core width	4	0.17

average settlement s_m = 4 mm Decisive combination : 4
Tilt α = 0.031 ° Decisive combination : 4

Required reinforcement

Location	Flexural reinforcement				Shear reinforcement	
	$a_{sl,req\ top/outer}$ [cm²/m]	LCc. [-]	$a_{sl,req,\ bottom/inner}$ [cm²/m]	LCc. [-]	$a_{sw,req}$ [cm²/m]	LCc. [-]
Constrained wall	0.00	5	4.05	6	0.00	6
Cut part heel	3.86	6	0.00	5	0.00	6
Cut part toe	2.25	5	3.73	2	0.00	2

Overview of superposition and load cases

Actions

Name	ψ_0	ψ_1	ψ_2
Permanent loads	1.00	1.00	1.00

Load cases

No.	Name	Action
1	Soil and wall weight	Permanent loads
2	Earth pressure from dead load	Permanent loads

Decisive combinations (permanent design situation)

No.	Limit state	decisive combination
1	EQU	0.90×(1) + 1.10×(2)
2	STR/GEO-2	1.35×(1) + 1.35×(2)
3	GEO-3	1.00×(1)
4	SLS	1.00×(1) + 1.00×(2)
5	STR/GEO-2	1.00×(1) + 1.00×(2)
6	STR/GEO-2	1.00×(1) + 1.35×(2)
The load numbers are in brackets		

Reinforced Concrete Design

Earth pressure

Active earth pressure factors

from z = [m]	to z = [m]	α [°]	ϕ' [°]	δ [°]	k_{agh} [-]	k_{ach} [-]	k_{aph} [-]
0.00	-3.13	0.0	34.0	22.7	0.313[1]	0.900[1]	0.313[1]
1 : β= 20 °							

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Earth rest coefficients

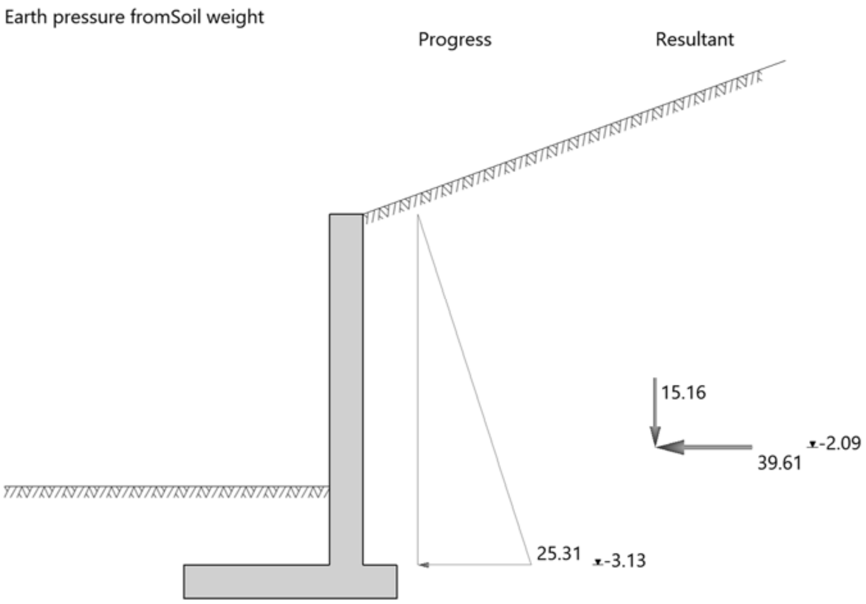
from z = [m]	to z = [m]	α [°]	ϕ' [°]	δ [°]	k_{0gh} [-]	k_{0ch} [-]	k_{0ph} [-]
0.00	-3.13	0.0	34.0	NaN	0.586[1]	0.000[1]	0.586[1]
1 : β= 20 °							

Earth pressure curve from dead load

z [m]	e_{ah} [kN/m^2]
0.00 -3.13	0.00 25.31

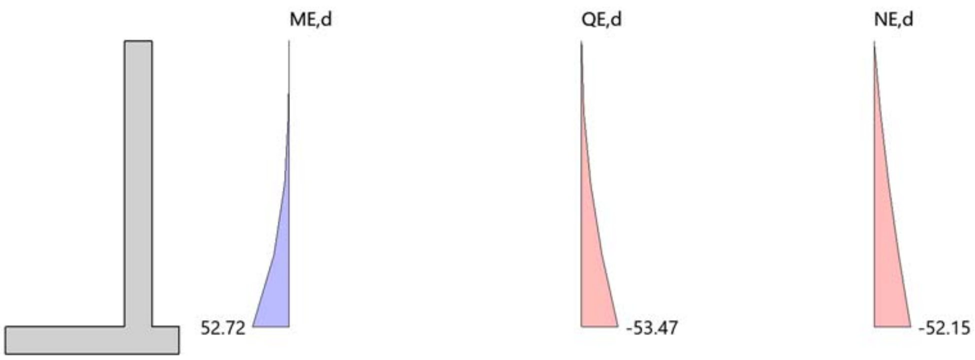
Resultant

Horizontal resultant E_{ah} = 39.61 kN/m Action point from the top of the wall z_a = -2.09 m
Vertical resultant E_{av} = 15.16 kN/m



Wall design

Design values of inner forces



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Bending design in point z = -3.13 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ inner}$ [cm²/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ outer}$ [cm²/m]
52.72	-43.93	300	259	4.05	39.05	-38.63	300	259	0.00
Min. ductility reinforcement is considered Min. compressive reinforcement is considered									

Shear design in point z = -3.13 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz,\ exist}$ [cm²/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm²/m]	$a_{sw,\ min}$ [cm²/m]
-53.47	-43.93	300	259	4.05	199	85.98	132.41	146.87	3.00	761.18	0.00	0.00
Consider min. lateral reinforcement												

Foundation design

Characteristic internal forces for the base pressure calculation in the center of the foundation with reference to the base surface

Action from:	t [kN/m]	n [kN/m]	m [kNm/m]
Soil and wall weight	0.00	71.30	-20.60
Earth pressure from dead load	-35.72	13.31	29.60

Heel uphill

Bearing pressure calculation bending

The design effect of the tangential of soil area :

t_{Ed} = (-35.72 · 1.35) = -48.23 kN/m

The design effect of the normal of soil area :

n_{Ed} = (71.30 · 1.00) + (13.31 · 1.35) = 89.27 kN/m

Moment design effects:

m_{Ed} = (-20.60 · 1.00) + (29.60 · 1.35) = 19.36 kNm/m

Eccentricity in	e	=	0.22	m
Sole pressure	σ_{1d}	=	79.16	kN/m²
Bearing	σ_{2d}	=	14.81	kN/m²
Overpressed	l_p	=	1.90	m

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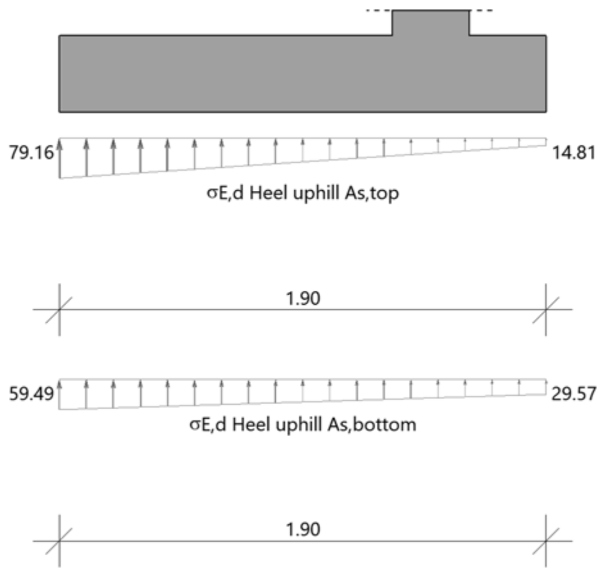
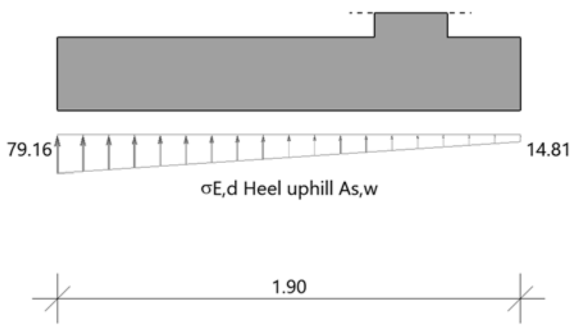


Design internal forces from soil pressure of the the superposition of bending relative to the coordinate system

n,As,top [kN/m]	v,As,top [kN/m]	m,As,top [kNm/m]	n,As,bottom [kN/m]	v,As,bottom [kN/m]	m,As,bottom [kNm/m]
3.22	-5.97	1.30	4.04	-9.58	2.01

Bearing pressure calculation shearing
The design effect of the tangential of soil area :
t_{Ed} = (-35.72 · 1.35) = -48.23 kN/m
The design effect of the normal of soil area :
n_{Ed} = (71.30 · 1.00) + (13.31 · 1.35) = 89.27 kN/m
Moment design effects:
m_{Ed} = (-20.60 · 1.00) + (29.60 · 1.35) = 19.36 kNm/m

Eccentricity in	e	=	0.22	m
Sole pressure	σ_{1d}	=	79.16	kN/m²
Bearing	σ_{2d}	=	14.81	kN/m²
Overpressed	l_p	=	1.90	m



Design internal forces from soil pressure of the the superposition of lateral force bending relative to the coordinate system

n [kN/m]	v [kN/m]	m [kNm/m]
3.22	-5.97	1.30

Bending design in point x = 0.00 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req. btm}$ [cm²/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req top}$ [cm²/m]
-15.30	7.93	300	259	0.00	-21.04	8.47	300	259	3.86[1]
Min. ductility reinforcement is considered Min. compressive reinforcement is considered 1 : Minimum ductility reinforcement decisive									

Shear design in point x = 0.00 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz, exist}$ [cm²/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm²/m]	$a_{sw, min}$ [cm²/m]
10.99	8.47	300	259	3.86	199	79.29	126.98	148.70	1.00	1268.63	0.00	0.00
Consider min. lateral reinforcement												

Toe

Bearing pressure calculation bending

The design effect of the tangential of soil area :

t_{Ed} = (-35.72 · 1.35) = -35.72 kN/m

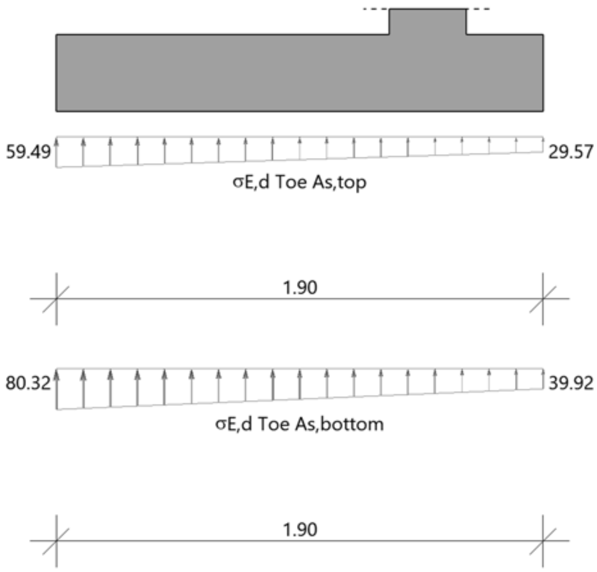
The design effect of the normal of soil area :

n_{Ed} = (71.30 · 1.00) + (13.31 · 1.00) = 84.61 kN/m

Moment design effects:

m_{Ed} = (-20.60 · 1.00) + (29.60 · 1.00) = 9.00 kNm/m

Eccentricity in	e	=	0.11	m
Sole pressure	σ_{1d}	=	59.49	kN/m²
Bearing	σ_{2d}	=	29.57	kN/m²
Overpressed	l_p	=	1.90	m



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Design internal forces from soil pressure of the the superposition of bending relative to the coordinate system

n,As,top [kN/m]	v,As,top [kN/m]	m,As,top [kNm/m]	n,As,bottom [kN/m]	v,As,bottom [kN/m]	m,As,bottom [kNm/m]
-27.04	64.03	40.45	-36.50	86.45	54.61

Bearing pressure calculation shearing

The design effect of the tangential of soil area :

t_{Ed} = (-35.72 · 1.35) = -48.23 kN/m

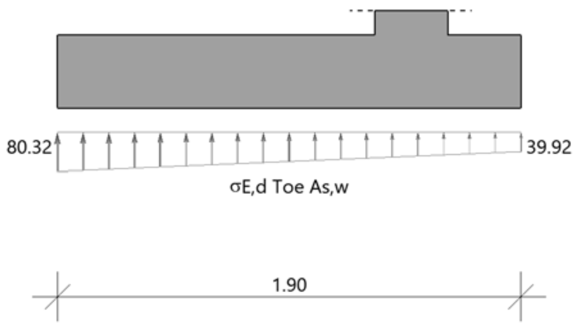
The design effect of the normal of soil area :

n_{Ed} = (71.30 · 1.35) + (13.31 · 1.35) = 114.23 kN/m

Moment design effects:

m_{Ed} = (-20.60 · 1.35) + (29.60 · 1.35) = 12.15 kNm/m

Eccentricity in e = 0.11 m
Sole pressure σ_{1d} = 80.32 kN/m^2
Bearing σ_{2d} = 39.92 kN/m^2
Overpressed l_p = 1.90 m



Design internal forces from soil pressure of the the superposition of lateral force bending relative to the coordinate system

n [kN/m]	v [kN/m]	m [kNm/m]
-36.50	86.45	54.61

Bending design in point x = -0.30 m

m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req.\ btm}$ [cm^2/m]	m_{Ed} [kNm/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sl,req\ top}$ [cm^2/m]
31.68	-36.50	300	259	3.73[1]	23.47	-27.04	300	259	2.25[1]

Min. ductility reinforcement is considered
Min. compressive reinforcement is considered

1 : Minimum ductility reinforcement decisive

Shear design in point x = -0.30 m

v_{Ed} [kN/m]	n_{Ed} [kN/m]	h [mm]	d [mm]	$a_{sz,\ exist}$ [cm^2/m]	z [mm]	$v_{rd,c}$ [kN/m]	$v_{rdc,min}$ [kN/m]	v_{rdcc} [kN/m]	cotθ [-]	v_{rdMax} [kN/m]	$a_{sw,req}$ [cm^2/m]	$a_{sw,\ min}$ [cm^2/m]
51.17	-36.50	300	259	3.73	145	83.02	131.64	107.56	3.00	556.49	0.00	0.00

Consider min. lateral reinforcement

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Fax.: 01/750-25-19
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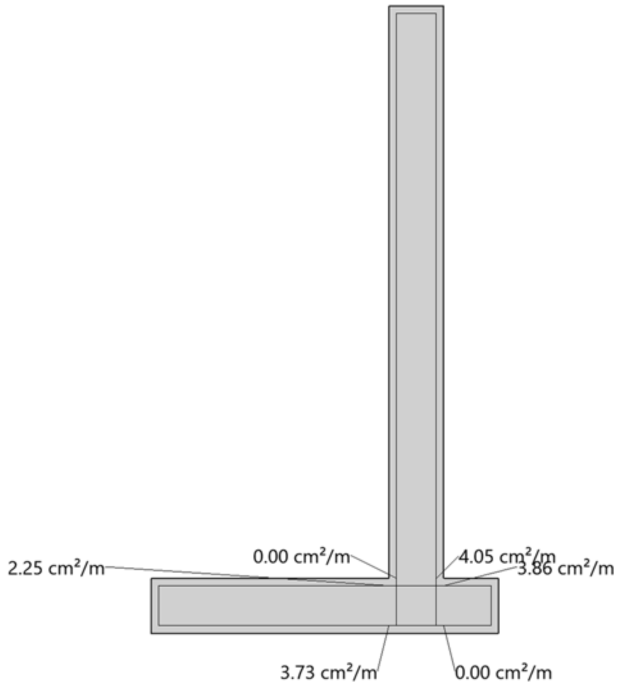
Schematic reinforcement graphic



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2.2.4 RISBE

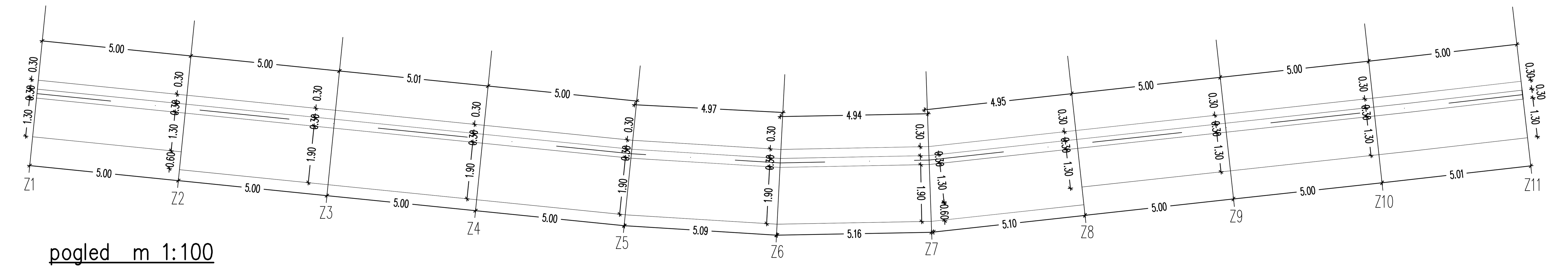
SEZNAM NAČRTOV

list št.

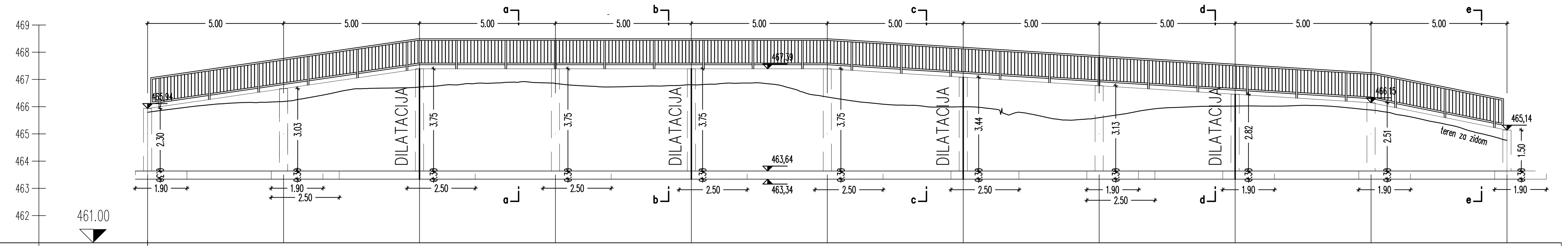
- AB oporni zid – armaturni načrt 1

AB OPORNI ZID C 30/37, XF4, XD3

tloris m 1:100



pogled m 1:100



OZNAKE PROFILOV	Z1	5.000	Z2	5.000	Z3	5.000	Z4	5.000	Z5	5.000	Z6	5.000	Z7	5.000	Z8	5.000	Z9	5.000	Z10	5.000	Z11
STACIONAŽE	-0.00		5.00		10.00		15.00		20.00		25.00		30.00		35.00		40.00		45.00		50.00
KOTE TERENA	465.795		466.191		466.722		466.855		466.804		466.355		465.997		465.598		466.023		465.877		464.765

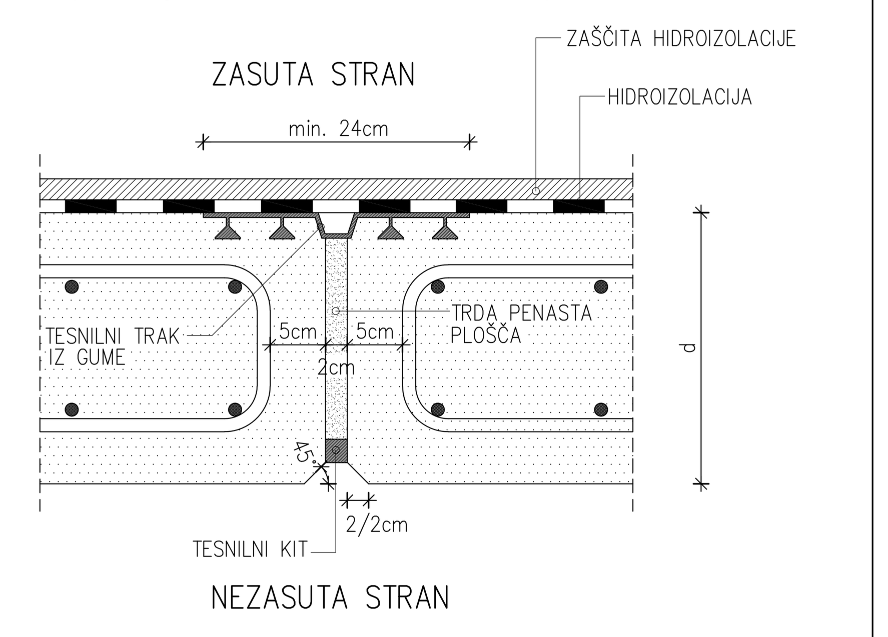
PRI IZVEDBI JE MOŽNO REBRASTE ARMATURNE PALICE ZAMENJATI Z MREŽNO ARMATURO:
ø 12/15 cm = R785
ø 8/15 cm = Q335

B 500

ozn.	ø	l	kom.	ø 8	ø 10	ø 12	ø 14	
1	10	110,00	–		110,00			
2	8	4000,00	–	4000,00				
3	12	2,25	270			607,50		
4	12	2,30	135			310,50		
5	8	1,20	337	404,40				
6	8	~2,63	34	89,42				
7	12	~2,63	34			89,42		
8	12	2,85	202			575,70		
9	14	2,85	303				863,55	
10	10	1,10	202		222,20			
11	8	~3,35	34	113,90				
12	14	1,45	303				439,35	
13	14	~3,35	51				170,85	
14	8	3,70	101	373,70				
15	14	3,70	151				558,70	
16	8	~3,40	67	227,80				
17	14	~3,40	101				343,40	
18	8	~2,28	101	230,28				
19	12	~2,28	101			230,28		
			Σl	5439,50	332,20	1813,40	2375,85	
			kg	2203,00	210,50	1652,00	2951,00	
			Σkg	7.016,50				

detajl dilatacije m 1:5

(dilatacije izvesti na vsakih 10 m zidu)



OBVEZNO GLEJ ŠE NAČRT ARHITEKTURE.

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Investitor: DIREKCIJA RS ZA INFRASTRUKTURO, TRŽAŠKA CESTA 19, 1000 LJUBLJANA

Odg.vodja projekta: Igor Stavrević u.d.i.g. G-3876

Odgovorni projektant: Janko Mele u.d.i.g. G-0292

Sodelavec: Mateja Resnik

Št. projekta: CS1405-21

Datum: marec 2021

Objekt: GRADNJA NADOMESTNEGA ZIDU NA DRŽAVNI CESTI PODGRAD–ILIRSKA BISTRICA

Predmet: oporni zid, ARMATURNI NAČRT

Faza: PZI

Merilo: 1:100, 1:25

Št. lista: 1

Št. odseka:	Arhivska št.:	Faza/objekt:	Šifra risbe:	Črtna koda arhiva:
1379		004.2162	G.1	