

Gravity wall analysis

Input data (Stage of construction 1)

Settings

Slovenia - EN 1997

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)

Coefficients EN 1992-1-1 : standard

Masonry (stone) wall : EN 1996-1-1 (EC6)

Wall analysis

Verification methodology : according to EN 1997

Active earth pressure calculation : Coulomb

Passive earth pressure calculation : Caquot-Kerisel

Earthquake analysis : Mononobe-Okabe

Shape of earth wedge : Calculate as skew

Allowable eccentricity : 0,333

Design approach : 2 - reduction of actions and resistances

Partial factors on actions (A)				
Permanent design situation				
		Unfavourable	Favourable	
Permanent actions :	$\gamma_G =$	1,35 [-]	1,00	[-]
Variable actions :	$\gamma_Q =$	1,50 [-]	0,00	[-]
Water load :	$\gamma_w =$	1,35 [-]		

Partial factors for resistances (R)				
Permanent design situation				
Partial factor on overturning :		$\gamma_{Rv} =$	1,40	[-]
Partial factor on sliding resistance :		$\gamma_{Rh} =$	1,10	[-]
Partial factor on bearing capacity :		$\gamma_{Re} =$	1,40	[-]

Partial factors for variable actions				
Permanent design situation				
Factor for combination value :		$\psi_0 =$	0,70	[-]
Factor for frequent value :		$\psi_1 =$	0,50	[-]
Factor for quasi-permanent value :		$\psi_2 =$	0,30	[-]

Partial factors on actions (A)				
Seismic design situation				
		Unfavourable	Favourable	
Permanent actions :	$\gamma_G =$	1,10 [-]	1,00	[-]
Variable actions :	$\gamma_Q =$	1,10 [-]	0,00	[-]
Water load :	$\gamma_w =$	1,10 [-]		

Partial factors for resistances (R)				
Seismic design situation				
Partial factor on overturning :		$\gamma_{Rv} =$	1,20	[-]
Partial factor on sliding resistance :		$\gamma_{Rh} =$	1,00	[-]
Partial factor on bearing capacity :		$\gamma_{Re} =$	1,20	[-]

Anchors

Verification methodology : Limit states (LSD)

Reduction coefficients			
Reduction. coeff of steel strength :	$\gamma_s =$	1,35	[-]
Reduction coefficient of pull out resistance (soil) :	$\gamma_e =$	1,35	[-]
Reduction coefficient of pull out resistance (grouting) :	$\gamma_c =$	1,35	[-]

Material of structure

Unit weight $\gamma = 25,00 \text{ kN/m}^3$

Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

Concrete: C 25/30

Cylinder compressive strength

$f_{ck} = 25,00 \text{ MPa}$

Tensile strength

$f_{ctm} = 2,60 \text{ MPa}$

Longitudinal reinforcement: B500B

Yield strength

$f_{yk} = 500,00 \text{ MPa}$

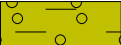
Geometry of structure

No.	Coordinate X [m]	Depth Z [m]
1	0,00	0,00
2	-0,65	6,50
3	-3,65	6,20
4	-1,00	0,00

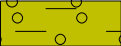
The origin [0,0] is located at the most upper right point of the wall.

Wall section area = $12,95 \text{ m}^2$.

Basic soil parameters

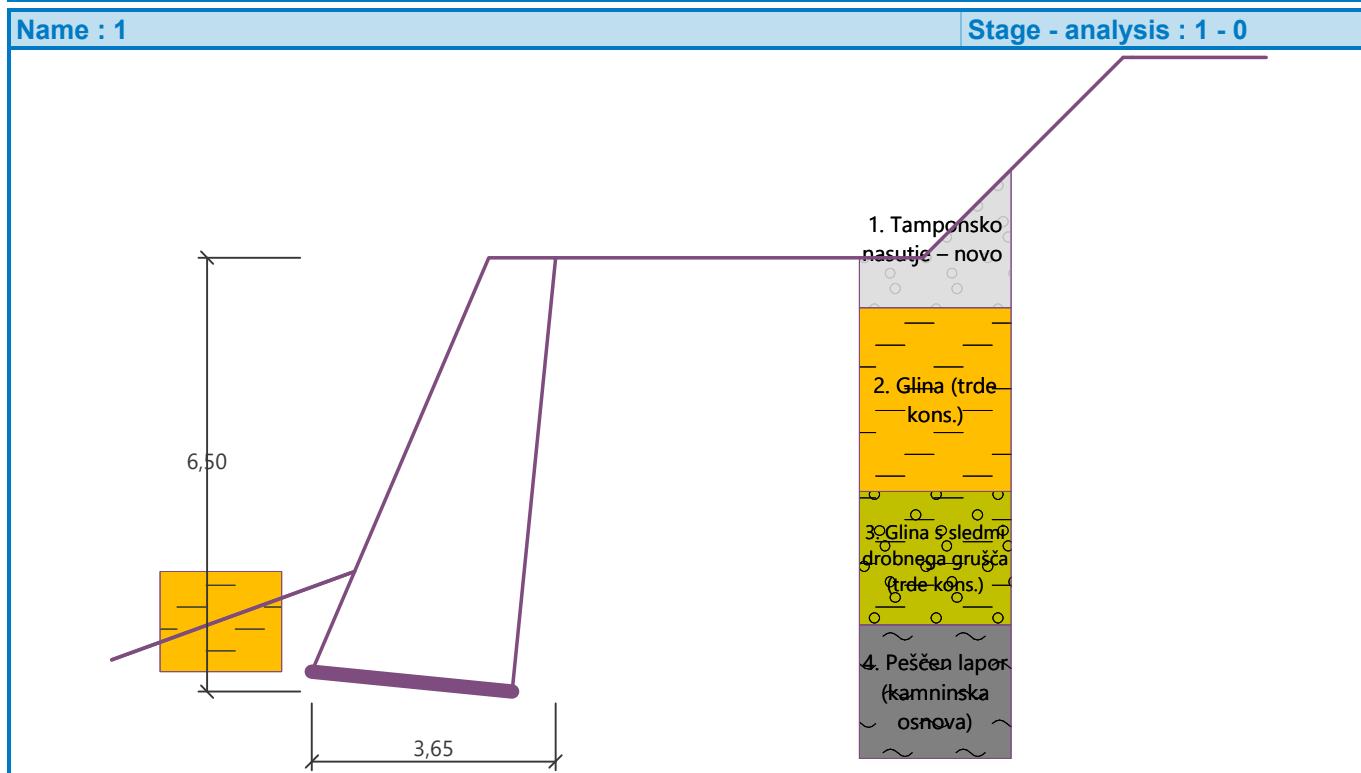
No.	Name	Pattern	Φ_{ef} [°]	C_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Tamponsko nasutje – novo		38,00	0,50	21,00	12,00	33,00
2	Glina (trde kons.)		31,80	2,30	18,80	9,80	26,80
3	Glina s sledmi drobnega grušča (trde kons.)		31,70	1,40	16,60	7,60	26,70
4	Peščen lapor (kamninska osnova)		44,00	100,00	22,00	13,00	39,00

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	Φ_{ef} [°]	ν [-]	OCR [-]	K_r [-]
1	Tamponsko nasutje – novo		cohesionless	38,00	-	-	-
2	Glina (trde kons.)		cohesive	-	0,30	-	-
3	Glina s sledmi drobnega grušča (trde kons.)		cohesive	-	0,30	-	-
4	Peščen lapor (kamninska osnova)		cohesive	-	0,25	-	-

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,75	0,00 .. 0,75	Tamponsko nasutje – novo	
2	2,75	0,75 .. 3,50	Glina (trde kons.)	
3	2,00	3,50 .. 5,50	Glina s sledmi drobnega grušča (trde kons.)	
4	-	5,50 .. ∞	Peščen lapor (kamninska osnova)	



Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	5,50	0,00
3	8,50	-3,00
4	9,50	-3,00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Glina (trde kons.)

Soil thickness in front of structure $h = 1,50 \text{ m}$
Soil slope in front of structure $\beta = -20,00^\circ$

Global settings

Minimum pressure is considered as $\sigma_{a,\min} = 0,20\sigma_z$

Settings of the stage of construction

Design situation : permanent

The wall is free to move. Active earth pressure is therefore assumed.

Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 1)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-2,49	323,69	2,19	1,000	1,000	1,350
Active pressure	81,22	-1,90	21,32	3,27	1,350	1,350	1,350

Verification of complete wall

Check for overturning stability

Resisting moment $M_{\text{res}} = 573,36 \text{ kNm/m}$

Overturning moment $M_{\text{ovr}} = 208,36 \text{ kNm/m}$

Wall for overturning is **SATISFACTORY**

Check for slip

Resisting horizontal force $H_{\text{res}} = 591,57 \text{ kN/m}$

Active horizontal force $H_{\text{act}} = 74,03 \text{ kN/m}$

Wall for slip is **SATISFACTORY**

Overall check - WALL is **SATISFACTORY**

Maximum stress in footing bottom : 157,34 kPa

Bearing capacity of foundation soil (Stage of construction 1)

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [-]	Stress [kPa]
1	-127,22	474,36	61,90	0,000	157,34
2	-49,19	361,63	73,12	0,000	119,95

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-94,23	351,38	45,85

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0,000$

Maximum allowable eccentricity $e_{\text{alw}} = 0,333$

Eccentricity of the normal force is **SATISFACTORY**

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 1000,00 \text{ kPa}$

Partial factor on bearing capacity $\gamma_{Rv} = 1,40$

Max. stress at footing bottom $\sigma = 158,12 \text{ kPa}$
Allowable bearing capacity of foundation soil $R_d = 714,29 \text{ kPa}$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1 (Stage of construction 1)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-2,58	312,14	2,19	1,000	1,000	1,000
Active pressure	74,02	-2,10	21,32	3,27	1,350	1,350	1,350

Wall check at the construction joint 6,20 m from the wall crest

Cross-section depth $h = 3,03 \text{ m}$

Ultimate shear force $V_{Rd} = 2070,75 \text{ kN/m} > 99,93 \text{ kN/m} = V_{Ed}$

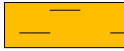
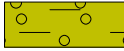
Ultimate compressive force $N_{Rd} = 36220,73 \text{ kN/m} > 340,92 \text{ kN/m} = N_{Ed}$

Ultimate moment $M_{Rd} = -1656,60 \text{ kNm/m} > -53,29 \text{ kNm/m} = M_{Ed}$

Cross-section bearing capacity is SATISFACTORY

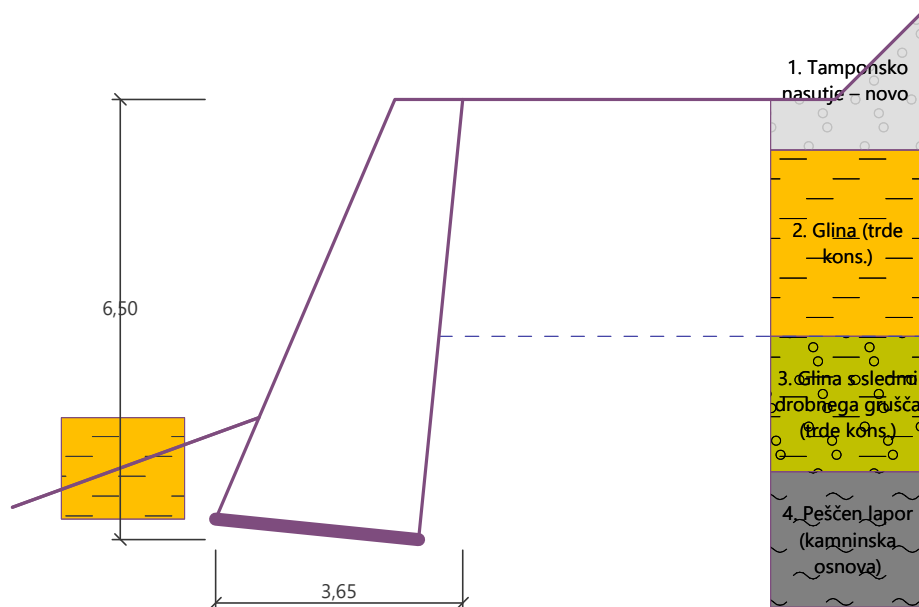
Input data (Stage of construction 2)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,75	0,00 .. 0,75	Tamponsko nasutje – novo	
2	2,75	0,75 .. 3,50	Glina (trde kons.)	
3	2,00	3,50 .. 5,50	Glina s sledmi drobnega grušča (trde kons.)	
4	-	5,50 .. ∞	Peščen lapor (kamninska osnova)	

Name : 2

Stage - analysis : 2 - 0



Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	5,50	0,00
3	8,50	-3,00
4	9,50	-3,00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

GWT behind the structure lies at a depth of 3,50 m

Uplift in foot. bottom due to different pressures is not considered.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Gлина (trde kons.)

Soil thickness in front of structure $h = 1,50$ m

Soil slope in front of structure $\beta = -20,00^\circ$

Settings of the stage of construction

Design situation : permanent

The wall is free to move. Active earth pressure is therefore assumed.

Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 2)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-2,49	323,69	2,19	1,000	1,000	1,350
Active pressure	72,74	-2,04	19,79	3,28	1,350	1,350	1,350
Water pressure	45,00	-0,70	-4,50	3,10	1,350	1,350	1,350
Uplift pressure	0,00	-6,20	0,00	3,65	1,000	1,000	1,350

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 555,23$ kNm/m

Overturning moment $M_{ovr} = 242,49$ kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 585,96$ kN/m

Active horizontal force $H_{act} = 123,90$ kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 156,28 kPa

Bearing capacity of foundation soil (Stage of construction 2)

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [-]	Stress [kPa]
1	-72,52	471,16	111,28	0,000	156,28
2	5,51	358,44	122,50	0,005	120,11

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-53,72	349,01	82,43

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0,005$

Maximum allowable eccentricity $e_{alw} = 0,333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 1000,00$ kPa

Partial factor on bearing capacity $\gamma_{Rv} = 1,40$

Max. stress at footing bottom $\sigma = 157,05$ kPa

Allowable bearing capacity of foundation soil $R_d = 714,29$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1 (Stage of construction 2)

Forces acting on construction

Name	F _{hor} [kN/m]	App.Pt. z [m]	F _{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-2,58	312,14	2,19	1,000	1,000	1,000
Active pressure	67,07	-2,22	19,79	3,28	1,350	1,350	1,350
Water pressure	36,38	-0,90	-3,64	3,12	1,350	1,350	1,350
Uplift pressure	0,00	-6,20	0,00	3,65	1,000	1,000	1,000

Wall check at the construction joint 6,20 m from the wall crest

Cross-section depth $h = 3,03$ m

Ultimate shear force $V_{Rd} = 2068,55$ kN/m $> 139,67$ kN/m $= V_{Ed}$

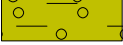
Ultimate compressive force $N_{Rd} = 37696,64$ kN/m $> 333,94$ kN/m $= N_{Ed}$

Ultimate moment $M_{Rd} = -1653,07$ kNm/m $> -33,72$ kNm/m $= M_{Ed}$

Cross-section bearing capacity is **SATISFACTORY**

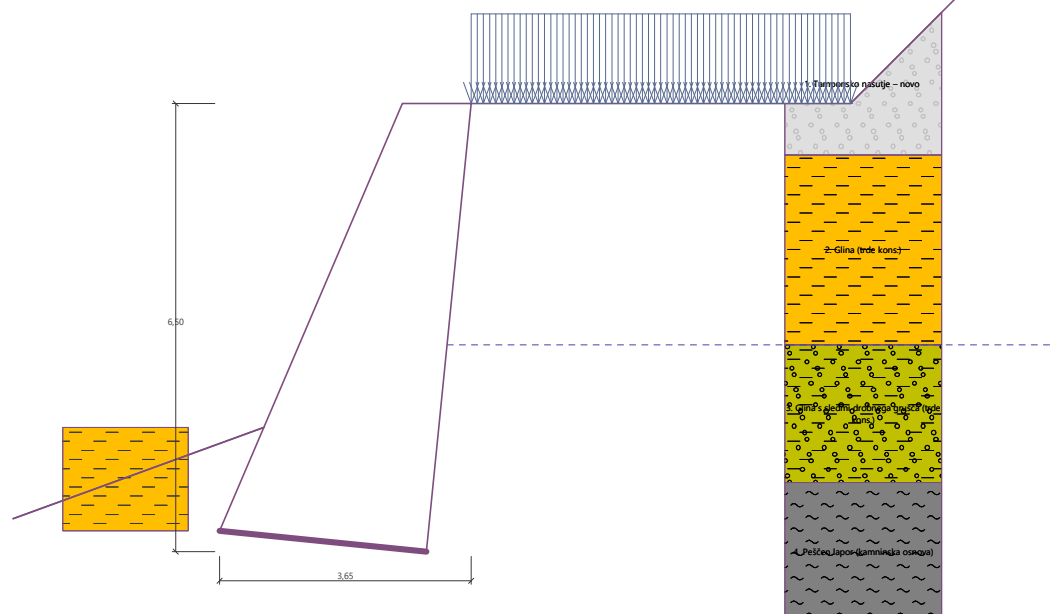
Input data (Stage of construction 3)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,75	0,00 .. 0,75	Tamponsko nasutje – novo	
2	2,75	0,75 .. 3,50	Glina (trde kons.)	
3	2,00	3,50 .. 5,50	Glina s sledmi drobnega grušča (trde kons.)	
4	-	5,50 .. ∞	Peščen lapor (kamninska osnova)	

Name : 3

Stage - analysis : 3 - 0



Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	5,50	0,00
3	8,50	-3,00
4	9,50	-3,00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

GWT behind the structure lies at a depth of 3,50 m

Uplift in foot. bottom due to different pressures is not considered.

Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m ²]	Mag.2 [kN/m ²]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	Yes		variable	16,70		0,00	5,50	on terrain

No.	Name
1	Prometna obtežba

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Glina (trde kons.)

Soil thickness in front of structure $h = 1,50$ m

Soil slope in front of structure $\beta = -20,00^\circ$

Settings of the stage of construction

Design situation : permanent

The wall is free to move. Active earth pressure is therefore assumed.
Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 3)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-2,49	323,69	2,19	1,000	1,000	1,350
Active pressure	72,74	-2,04	19,79	3,28	1,350	1,350	1,350
Water pressure	45,00	-0,70	-4,50	3,10	1,350	1,350	1,350
Uplift pressure	0,00	-6,20	0,00	3,65	1,000	1,000	1,350
Prometna obtežba	24,91	-3,08	10,49	3,33	1,500	1,500	1,500

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 592,64$ kNm/m

Overturning moment $M_{ovr} = 357,57$ kNm/m

Wall for overturning is **SATISFACTORY**

Check for slip

Resisting horizontal force $H_{res} = 558,88$ kN/m

Active horizontal force $H_{act} = 159,52$ kN/m

Wall for slip is **SATISFACTORY**

Overall check - **WALL is SATISFACTORY**

Maximum stress in footing bottom : 167,08 kPa

Bearing capacity of foundation soil (Stage of construction 3)

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [-]	Stress [kPa]
1	19,38	490,53	146,54	0,013	167,08
2	97,41	377,80	157,75	0,086	151,16

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	7,55	361,92	105,93

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0,086$

Maximum allowable eccentricity $e_{alw} = 0,333$

Eccentricity of the normal force is **SATISFACTORY**

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 1000,00$ kPa

Partial factor on bearing capacity $\gamma_{Rv} = 1,40$

Max. stress at footing bottom $\sigma = 190,88$ kPa

Allowable bearing capacity of foundation soil $R_d = 714,29$ kPa

Bearing capacity of foundation soil is **SATISFACTORY**

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1 (Stage of construction 3)

Forces acting on construction

Name	F _{hor} [kN/m]	App.Pt. z [m]	F _{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-2,58	312,14	2,19	1,000	1,000	1,000
Active pressure	67,07	-2,22	19,79	3,28	1,350	1,350	1,350
Water pressure	36,38	-0,90	-3,64	3,12	1,350	1,350	1,350
Uplift pressure	0,00	-6,20	0,00	3,65	1,000	1,000	1,000
Prometna obtežba	24,23	-3,17	10,04	3,34	1,500	1,500	1,500

Wall check at the construction joint 6,20 m from the wall crest

Cross-section depth h = 3,03 m

Ultimate shear force $V_{Rd} = 2073,30 \text{ kN/m} > 176,02 \text{ kN/m} = V_{Ed}$

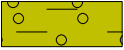
Ultimate compressive force $N_{Rd} = 34193,60 \text{ kN/m} > 349,00 \text{ kN/m} = N_{Ed}$

Ultimate moment $M_{Rd} = 1660,68 \text{ kNm/m} > 81,09 \text{ kNm/m} = M_{Ed}$

Cross-section bearing capacity is SATISFACTORY

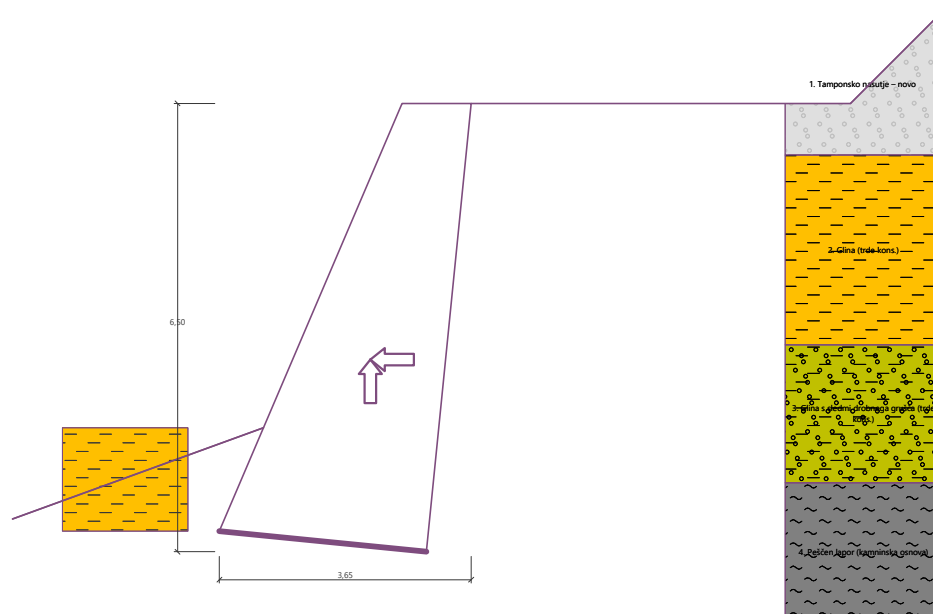
Input data (Stage of construction 4)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,75	0,00 .. 0,75	Tamponsko nasutje – novo	
2	2,75	0,75 .. 3,50	Glina (trde kons.)	
3	2,00	3,50 .. 5,50	Glina s sledmi drobnega grušča (trde kons.)	
4	-	5,50 .. ∞	Peščen lapor (kamninska osnova)	

Name : 4

Stage - analysis : 4 - 0



Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	5,50	0,00
3	8,50	-3,00
4	9,50	-3,00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure: not considered

Soil on front face of the structure - Glina (trde kons.)

Soil thickness in front of structure $h = 1,50 \text{ m}$

Soil slope in front of structure $\beta = -20,00^\circ$

Earthquake

Factor of horizontal acceleration $K_h = 0,1333$

Factor of vertical acceleration $K_v = 0,0660$

Water below the GWT is restricted.

Settings of the stage of construction

Design situation : seismic

The wall is free to move. Active earth pressure is therefore assumed.

Reduction of soil/soil friction angle : do not reduce

Verification No. 1 (Stage of construction 4)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-2,49	323,69	2,19	1,000	1,000	1,100
Earthq.- constr.	43,15	-2,49	-21,36	2,19	1,000	1,000	1,000
Active pressure	81,22	-1,90	21,32	3,27	1,100	1,100	1,100
Earthq.- act.pressure	32,40	-3,96	13,46	3,43	1,000	1,000	1,000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 653,91$ kNm/m

Overturning moment $M_{ovr} = 405,42$ kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 556,12$ kN/m

Active horizontal force $H_{act} = 130,31$ kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 165,65 kPa

Bearing capacity of foundation soil (Stage of construction 4)

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [-]	Stress [kPa]
1	132,02	386,17	125,64	0,114	165,65
2	154,32	353,96	128,85	0,145	165,17

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	141,45	351,03	121,06

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0,145$

Maximum allowable eccentricity $e_{alw} = 0,333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 1000,00$ kPa

Partial factor on bearing capacity $\gamma_{Rv} = 1,20$

Max. stress at footing bottom $\sigma = 220,86$ kPa

Allowable bearing capacity of foundation soil $R_d = 833,33$ kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1 (Stage of construction 4)

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-2,58	312,14	2,19	1,000	1,000	1,000
Earthq.- constr.	41,61	-2,58	-20,60	2,19	1,000	1,000	1,000
Active pressure	74,02	-2,10	21,32	3,27	1,100	1,100	1,100
Earthq.- act.pressure	29,01	-4,06	12,01	3,44	1,000	1,000	1,000

Wall check at the construction joint 6,20 m from the wall crest

Cross-section depth $h = 3,03$ m

Ultimate shear force $V_{Rd} = 2066,35$ kN/m $> 152,04$ kN/m $= V_{Ed}$

Ultimate compressive force $N_{Rd} = 29522,01$ kN/m $> 327,01$ kN/m $= N_{Ed}$

Ultimate moment $M_{Rd} = 1649,57$ kNm/m $> 133,26$ kNm/m $= M_{Ed}$

Cross-section bearing capacity is SATISFACTORY