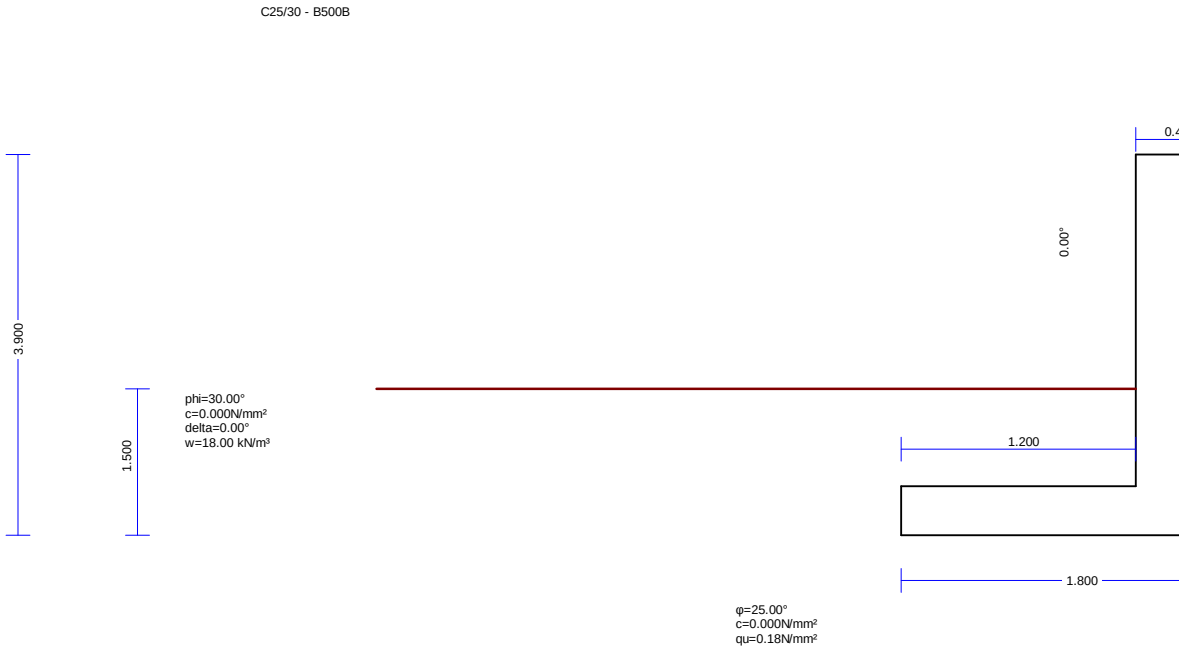
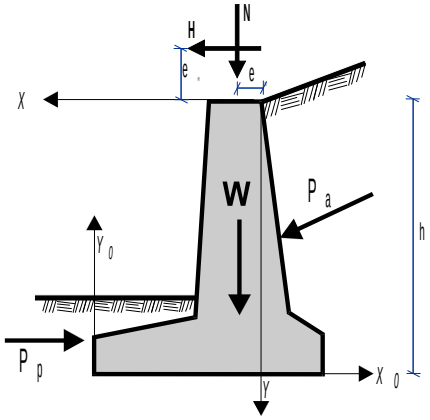
Example

1. ZID_1 PR1

Cantilever concrete wall
(EC2 EN1992-1-1:2004, EC0 EN1990:2002, EC7 EN1997-1-1:2004, EC8 EN1998-5:2004,)



1.1. Wall properties-Parameters-Code requirements



Dimensions

Height of wall	h= 3.900 m
Transverse length of wall	L=10.000 m
Steam thickness at top	B1= 0.400 m
Steam thickness at bottom	B2= 0.400 m
Width of wall base	B= 1.800 m
Width of wall toe	1.200 m
Width of wall heel	0.200 m
Height of wall steam	3.400 m
Thickness of wall footing	0.500 m
Front thickness of wall toe	0.500 m
Back thickness of wall heel	0.500 m
Slope (batter) at frontface	0.000° (0:1)
Slope (batter) at backface	0.000° (0:1)

Weight of wall

Unit weight of wall material	yg=25.000 kN/m³
Cross section area of wall	A= 2.260 m²
Self weight per meter of wall	W= 2.260x25.000= 56.50 kN/m
Center of gravity of wall at	x=0.399 m, y=2.477 m (xo=1.201 m, yo=1.423 m)

Wall materials

Steam : Concrete-Steel class: C25/30-B500B (EN1992-1-1, §3)
: Concrete cover: Cnom=25 mm (EN1992-1-1, §4.4.1)
Footing : Concrete-Steel class: C25/30-B500B
: Concrete cover: Cnom=75 mm

Weight of backfill

Weight of backfill per meter Ws=12.24 kN/m
Center of gravity of backfill x=-0.100 m, y=1.700 m

1.2. Partial factors for actions and soil properties (EC7 Tables A.1-A.4, EC8-5 §3.1)

Equilibrium limit state (EQU), Structural limit state (STR), Geotechnical limit state (GEO)

			(EQU)	(STR)	(GEO)
Actions	Permanent Unfavourable	γGdst:	1.10	1.35	1.00
	Permanent Favourable	γGstb:	0.90	1.00	1.00
	Variable Unfavourable	γQdst:	1.50	1.50	1.30
	Variable Favourable	γQstb:	0.00	0.00	0.00
Soil parameters	Angle of shearing resistance	γφ:	1.25	1.00	1.25
	Effective cohesion	γc:	1.25	1.00	1.25
	Undrained shear strength	γcu:	1.40	1.00	1.40
	Unconfined strength	γqu:	1.40	1.00	1.40
	Weight density	γw:	1.00	1.00	1.00

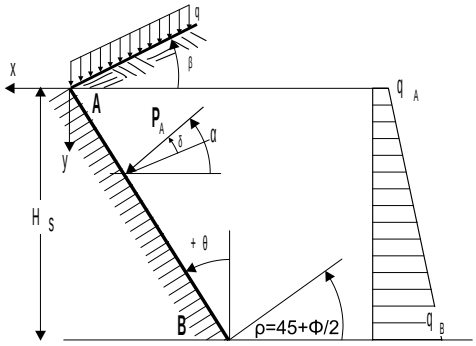
1.3. Properties of foundation soil

Bearing capacity of foundation soil qu=0.18 N/mm²
Friction angle between wall footing and soil φ=25.00°, friction coefficient tan(φ)=0.466
Cohesion between wall footing and soil c=0.000 N/mm²

1.4. Computation of active earth pressure (Coulomb theory)

1.4.1. Wall part from y=0.000 m to y=3.900 m, Hs=3.900 m

Top point A x= 0.000 m y= 0.000 m
Bottom point B x= 0.000 m y= 3.900 m



Soil properties

Soil type : Dense sand
Unit weight of soil γ =18.00 kN/m³
Unit weight of soil (saturated) γs=18.00 kN/m³
Unit weight of water γw=10.00 kN/m³
Angle of shearing resistance of ground φ=30.00°
Cohesion of ground c=0.000 N/mm²
Slope angle of ground surface β= 0.00°
Inclination angle of the wall backface θ= 0.00°
Angle of shear resist. between ground-wall δ=17.50°

Earth pressure according to Coulomb theory

	EQU	STR	GEO
Angle of rupture plane ρ=45°+φ/2 =	57.00	60.00	57.00°
Coefficient of active earth pressure Ka=	0.378	0.299	0.378

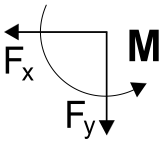
Earth pressure q(y)=qA+γ·y·Ka

$$K_A = \frac{\cos^2(\varphi-\theta)}{\cos^2\theta\cos(\theta+\delta)\left[1+\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi-\beta)}{\cos(\theta+\delta)\cos(\theta-\beta)}}\right]^2}$$

Permanent actions

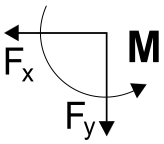
		EQU	STR	GEO	
Earth pressure at the top (y=yA)	qA=	0.00	0.00	0.00	kN/m²
Earth pressure at the bottom (y=yA+ 3.90m)	qB=	26.54	20.99	26.54	kN/m²
Earth force Pa=½(qA+qB)H	Pa=	51.75	40.93	51.75	kN/m
Angle of earth force	α =	14.00	17.50	14.00	°
Earth force in x direction	Pax=	49.35	39.04	49.35	kN/m
Earth force in y direction	Pay=	15.56	12.31	15.56	kN/m
Moment of earth force at top point (x=0,y=0)	M =	-128.31	-101.50	-128.31	kNm/m

Point of application of earth force x= 0.000 m, y= 2.600 m



Total forces and moments

Forces and moments at bottom point B (x=0.000 m, y=3.900 m)



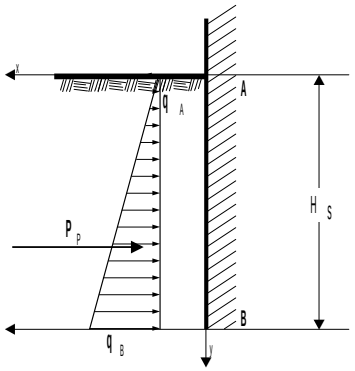
Permanent actions

	EQU	STR	GEO	
Total horizontal earth force Fsx=	49.35	39.04	49.35	kN/m
Total vertical earth force Fsy=	15.56	12.31	15.56	kN/m
Total moment of earth force Ms =	64.16	50.75	64.16	kNm/m

1.5. Computation of passive earth pressure (Rankine theory)

1.5.1. Wall part from y=2.400 m to y=3.900 m, Hs=1.500 m

Top point A x= 1.600 m y= 2.400 m
Bottom point B x= 1.600 m y= 3.900 m



Soil properties

Soil type : Dense sand		
Unit weight of soil	γ =	18.00 kN/m³
Unit weight of soil (saturated)	γs=	20.00 kN/m³
Unit weight of water	γw=	10.00 kN/m³
Angle of shearing resistance of ground	φ=	30.00°
Cohesion of ground	c=	0.000 N/mm²
Slope angle of ground surface	β=	0.00°
Earth pressure on vertical surface	θ=	0.00°
Angle of shear resist. between ground-wall	δ=	0.00°

Earth pressure according to Coulomb theory

	EQU	STR	GEO	
Angle of rupture plane ρ=45°-φ/2 =	33.00	30.00	33.00	°
Coefficient of passive earth pressure Kp=	2.371	3.000	2.371	

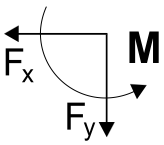
$$K_p = \frac{\cos^2(\varphi+\theta)}{\cos^2\theta\cos(\theta-\delta)\left[1-\sqrt{\frac{\sin(\varphi+\delta)\sin(\varphi+\beta)}{\cos(\theta-\delta)\cos(\theta-\beta)}}\right]^2}$$

Earth pressure q(y)=qA+γ·y·Kp

Permanent actions

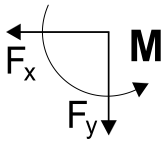
		EQU	STR	GEO	
Earth pressure at the top (y=yA)	qA=	0.00	0.00	0.00	kN/m²
Earth pressure at the bottom (y=yA+ 1.50m)	qB=	-64.02	-81.00	-64.02	kN/m²
Earth force Pa=½(qA+qB)H	Pp=	48.01	60.75	48.01	kN/m
Angle of earth force	α =	0.00	0.00	0.00	°
Earth force in x direction	Ppx=	-48.01	-60.75	-48.01	kN/m
Earth force in y direction	Ppy=	0.00	0.00	0.00	kN/m
Moment of earth force at top point (x=0,y=0)	M =	163.23	206.55	163.23	kNm/m

Point of application of earth force x= 1.600 m, y= 3.400 m



Total forces and moments

Forces and moments at bottom point B (x=1.600 m, y=3.900 m)



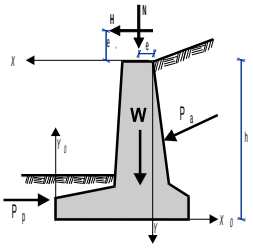
Permanent actions

		EQU	STR	GEO	
Total horizontal earth force	Fsx=	-48.01	-60.75	-48.01	kN/m
Total vertical earth force	Fsy=	0.00	0.00	0.00	kN/m
Total moment of earth force	Ms =	-24.00	-30.38	-24.00	kNm/m

1.6. Checks of wall stability (EQU)

1.6.1. Forces (driving and resisting) on the wall (EQU)

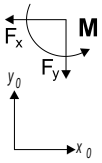
Action		y1 - y2	Fx [kN/m]	Fy [kN/m]	x [m]	y [m]
Active earth pressure	Pa	0.00- 3.90	49.35	15.56	0.000	2.600
Passive earth pressure	Pp	2.40- 3.90	-48.01	0.00	1.600	3.400
Wall weight	W		0.00	56.50	0.399	2.477
Backfill weight	Ws		0.00	12.24	-0.100	1.700



1.6.2. Check of soil bearing capacity (EQU)

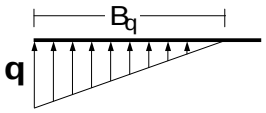
(EC7 EN1997-1-1:2004, §6.5.2)

Check for 0.90x(self weight+top vertical dead load)+0.00x(top vertical live load)



Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.10	0.00- 3.90	54.29	17.12	1.600	1.300	43.18
Wall weight	W x0.90		0.00	50.85	1.201	1.423	-61.07
Backfill weight	Wsx0.90		0.00	11.02	1.700	2.200	-18.73
			Sum=	78.99			-36.62

Sum of vertical forces = 78.99 kN/m
Sum of moments at front toe = -36.62 kNm/m
Sum of moments at middle of base = 34.47 kNm/m
Eccentricity ec=34.47/78.99=0.436m, ec>1.800/6=0.300m
Soil pressure q=0.114 N/mm² Bq=1.391 m

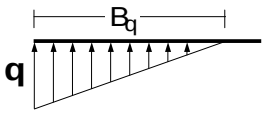


Effective footing L=1.800-2x0.436= 0.927 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=0.927x(1000x0.18)/1.40= 119.19 kN/m
Bearing resistance check Vd=78.99 < Rd=119.19 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

Check for 1.10x(self weight+top vertical dead load)+1.50x(top vertical live load)

Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.10	0.00- 3.90	54.29	17.12	1.600	1.300	43.18
Wall weight	W x1.10		0.00	62.15	1.201	1.423	-74.65
Backfill weight	Wsx1.10		0.00	13.46	1.700	2.200	-22.89
			Sum=	92.73			-54.36

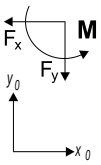
Sum of vertical forces = 92.73 kN/m
Sum of moments at front toe = -54.36 kNm/m
Sum of moments at middle of base = 29.10 kNm/m
Eccentricity ec=29.10/92.73=0.314m, ec>1.800/6=0.300m
Soil pressure q=0.105 N/mm² Bq=1.759 m



Effective footing L=1.800-2x0.314= 1.172 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=1.172x(1000x0.18)/1.40= 150.69 kN/m
Bearing resistance check Vd=92.73 < Rd=150.69 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

1.6.3. Failure check due to overturning (EQU) (EC7 EN1997-1-1:2004, §9.7.4)

Overturning with respect to the toe (xo=0,yo=0) (x=1.600,y=3.900 m)

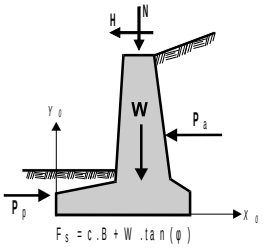


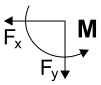
Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	Mo+ [kNm/m]	Mo- [kNm/m]
Active earth pressure	Pax1.10	0.00- 3.90	54.29	17.12	1.600	1.300	70.57	27.39
Wall weight	W x0.90		0.00	50.85	1.201	1.423	0.00	61.07
Backfill weight	Wsx0.90		0.00	11.02	1.700	2.200	0.00	18.73
					Sum=		70.57	107.19

Sum of overturning moments = 70.57 kNm/m
Sum of moments resisting overturning = 107.19 kNm/m
Overturning check Med=70.57 < Mrd=107.19 kNm/m, Check is verified

1.6.4. Failure check against sliding (EQU) (EC7 EN1997-1-1:2004, §9.7.3, §6.5.3)

Action	(γ)	y1 - y2	Fx+ [kN/m]	Fx- [kN/m]	Fy [kN/m]
Active earth pressure	Pax1.10	0.00- 3.90	54.29	0.00	17.12
Passive earth pressure	Ppx0.90	2.40- 3.90	0.00	43.21	0.00
Wall weight	W x0.90		0.00	0.00	50.85
Backfill weight	Wsx0.90		0.00	0.00	11.02
		Sum=	54.29	43.21	78.99



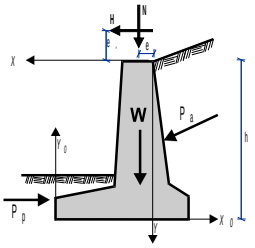


Soil friction Rd=Vd·tanφ/γM= 78.99xtan(25.00°)/1.25= 29.47 kN/m
(resisting forces from effective cohesion are neglected) (EC7 §6.5.3. 10)
Sum of driving forces = 54.29 kN/m
Sum of resisting forces (43.21+29.47) = 72.68 kN/m
Sliding resistance check Hd=54.29 < Rd=72.68 kN/m, Check is verified

1.7. Checks of wall stability (STR)

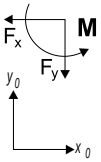
1.7.1. Forces (driving and resisting) on the wall (STR)

Action		y1 - y2	Fx [kN/m]	Fy [kN/m]	x [m]	y [m]
Active earth pressure	Pa	0.00- 3.90	39.04	12.31	0.000	2.600
Passive earth pressure	Pp	2.40- 3.90	-60.75	0.00	1.600	3.400
Wall weight	W		0.00	56.50	0.399	2.477
Backfill weight	Ws		0.00	12.24	-0.100	1.700



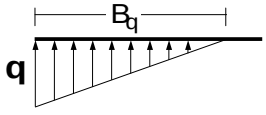
1.7.2. Check of soil bearing capacity (STR) (EC7 EN1997-1-1:2004, §6.5.2)

Check for 1.00x(self weight+top vertical dead load)+0.00x(top vertical live load)



Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.35	0.00- 3.90	52.70	16.62	1.600	1.300	41.92
Wall weight	W x1.00		0.00	56.50	1.201	1.423	-67.86
Backfill weight	Wsx1.00		0.00	12.24	1.700	2.200	-20.81
			Sum=	85.36			-46.75

Sum of vertical forces = 85.36 kN/m
Sum of moments at front toe = -46.75 kNm/m
Sum of moments at middle of base = 30.07 kNm/m
Eccentricity ec=30.07/85.36=0.352m, ec>1.800/6=0.300m
Soil pressure q=0.104 N/mm² Bq=1.643 m

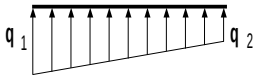


Effective footing L=1.800-2x0.352= 1.095 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=1.095x(1000x0.18)/1.00= 197.10 kN/m
Bearing resistance check Vd=85.36 < Rd=197.10 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

Check for 1.35x(self weight+top vertical dead load)+1.50x(top vertical live load)

Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.35	0.00- 3.90	52.70	16.62	1.600	1.300	41.92
Wall weight	W x1.35		0.00	76.28	1.201	1.423	-91.61
Backfill weight	Wsx1.35		0.00	16.52	1.700	2.200	-28.09
			Sum=	109.42			-77.78

Sum of vertical forces = 109.42 kN/m
Sum of moments at front toe = -77.78 kNm/m
Sum of moments at middle of base = 20.70 kNm/m
Eccentricity ec=20.70/109.42=0.189m, ec<=1.800/6=0.300m



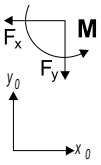
Soil pressure q1=0.099 N/mm² q2=0.022 N/mm²
Effective footing L=1.800-2x0.189= 1.422 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=1.422x(1000x0.18)/1.00= 255.96 kN/m
Bearing resistance check Vd=109.42 < Rd=255.96 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

1.7.3. Failure check due to overturning (STR)

(EC7 EN1997-1-1:2004, §9.7.4)

Overturning with respect to the toe (xo=0,yo=0) (x=1.600,y=3.900 m)

Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	Mo+ [kNm/m]	Mo- [kNm/m]
Active earth pressure	Pax1.35	0.00- 3.90	52.70	16.62	1.600	1.300	68.51	26.60
Wall weight	W x1.00		0.00	56.50	1.201	1.423	0.00	67.86
Backfill weight	Wsx1.00		0.00	12.24	1.700	2.200	0.00	20.81
					Sum=		68.51	115.27

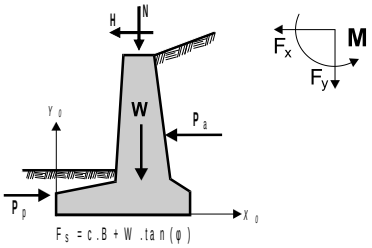


Sum of overturning moments = 68.51 kNm/m
Sum of moments resisting overturning = 115.27 kNm/m
Overturning check Med=68.51 < Mrd=115.27 kNm/m, Check is verified

1.7.4. Failure check against sliding (STR)

(EC7 EN1997-1-1:2004, §9.7.3, §6.5.3)

Action	(γ)	y1 - y2	Fx+ [kN/m]	Fx- [kN/m]	Fy [kN/m]
Active earth pressure	Pax1.35	0.00- 3.90	52.70	0.00	16.62
Passive earth pressure	Ppx1.00	2.40- 3.90	0.00	60.75	0.00
Wall weight	W x1.00		0.00	0.00	56.50
Backfill weight	Wsx1.00		0.00	0.00	12.24
		Sum=	52.70	60.75	85.36

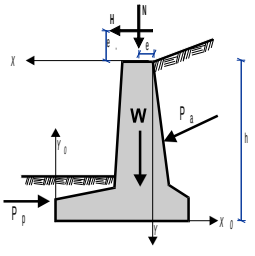


Soil friction Rd=Vd·tanφ/γM= 85.36xtan(25.00°)/1.00= 39.80 kN/m
(resisting forces from effective cohesion are neglected) (EC7 §6.5.3. 10)
Sum of driving forces = 52.70 kN/m
Sum of resisting forces (60.75+39.80) = 100.55 kN/m
Sliding resistance check Hd=52.70 < Rd=100.55 kN/m, Check is verified

1.8. Checks of wall stability (GEO)

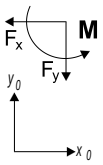
1.8.1. Forces (driving and resisting) on the wall (GEO)

Action		y1 - y2	Fx [kN/m]	Fy [kN/m]	x [m]	y [m]
Active earth pressure	Pa	0.00- 3.90	49.35	15.56	0.000	2.600
Passive earth pressure	Pp	2.40- 3.90	-48.01	0.00	1.600	3.400
Wall weight	W		0.00	56.50	0.399	2.477
Backfill weight	Ws		0.00	12.24	-0.100	1.700



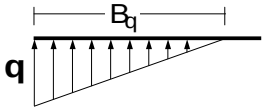
1.8.2. Check of soil bearing capacity (GEO) (EC7 EN1997-1-1:2004, §6.5.2)

Check for 1.00x(self weight+top vertical dead load)+0.00x(top vertical live load)



Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.00	0.00- 3.90	49.35	15.56	1.600	1.300	39.25
Wall weight	W x1.00		0.00	56.50	1.201	1.423	-67.86
Backfill weight	Wsx1.00		0.00	12.24	1.700	2.200	-20.81
			Sum=	84.30			-49.42

Sum of vertical forces = 84.30 kN/m
Sum of moments at front toe = -49.42 kNm/m
Sum of moments at middle of base = 26.45 kNm/m
Eccentricity ec=26.45/84.30=0.314m, ec>1.800/6=0.300m

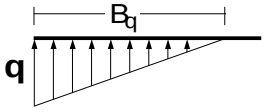


Soil pressure q=0.096 N/mm² Bq=1.759 m
Effective footing L=1.800-2x0.314= 1.172 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=1.172x(1000x0.18)/1.40= 150.69 kN/m
Bearing resistance check Vd=84.30 < Rd=150.69 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

Check for 1.00x(self weight+top vertical dead load)+1.30x(top vertical live load)

Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	M [kNm/m]
Active earth pressure	Pax1.00	0.00- 3.90	49.35	15.56	1.600	1.300	39.25
Wall weight	W x1.00		0.00	56.50	1.201	1.423	-67.86
Backfill weight	Wsx1.00		0.00	12.24	1.700	2.200	-20.81
			Sum=	84.30			-49.42

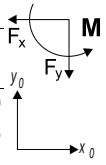
Sum of vertical forces = 84.30 kN/m
Sum of moments at front toe = -49.42 kNm/m
Sum of moments at middle of base = 26.45 kNm/m
Eccentricity ec=26.45/84.30=0.314m, ec>1.800/6=0.300m



Soil pressure q=0.096 N/mm² Bq=1.759 m
Effective footing L=1.800-2x0.314= 1.172 m (EC7 Annex D)
Soil bearing capacity Rd=L·qu/γM=1.172x(1000x0.18)/1.40= 150.69 kN/m
Bearing resistance check Vd=84.30 < Rd=150.69 kN/m, Check is verified (EC7 Eq.2.2, Eq.6.1)

1.8.3. Failure check due to overturning (GEO) (EC7 EN1997-1-1:2004, §9.7.4)

Overturning with respect to the toe (xo=0,yo=0) (x=1.600,y=3.900 m)

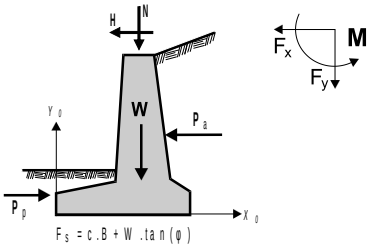


Action	(γ)	y1 - y2	Fx [kN/m]	Fy [kN/m]	xo [m]	yo [m]	Mo+ [kNm/m]	Mo- [kNm/m]
Active earth pressure	Pax1.00	0.00- 3.90	49.35	15.56	1.600	1.300	64.15	24.90
Wall weight	W x1.00		0.00	56.50	1.201	1.423	0.00	67.86
Backfill weight	Wsx1.00		0.00	12.24	1.700	2.200	0.00	20.81
					Sum=		64.15	113.57

Sum of overturning moments = 64.15 kNm/m
Sum of moments resisting overturning = 113.57 kNm/m
Overturning check Med=64.15 < Mrd=113.57 kNm/m, Check is verified

1.8.4. Failure check against sliding (GEO) (EC7 EN1997-1-1:2004, §9.7.3, §6.5.3)

Action	(γ)	y1 - y2	Fx+ [kN/m]	Fx- [kN/m]	Fy [kN/m]
Active earth pressure	Pax1.00	0.00- 3.90	49.35	0.00	15.56
Passive earth pressure	Ppx1.00	2.40- 3.90	0.00	48.01	0.00
Wall weight	W x1.00		0.00	0.00	56.50
Backfill weight	Wsx1.00		0.00	0.00	12.24
		Sum=	49.35	48.01	84.30



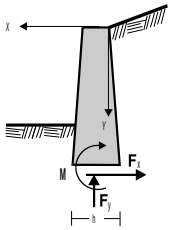
Soil friction Rd=Vd·tanφ/γM= 84.30xtan(25.00°)/1.25= 31.45 kN/m
(resisting forces from effective cohesion are neglected) (EC7 §6.5.3. 10)
Sum of driving forces = 49.35 kN/m
Sum of resisting forces (48.01+31.45) = 79.46 kN/m
Sliding resistance check Hd=49.35 < Rd=79.46 kN/m, Check is verified

1.9. Design of wall steam (EC2 EN1992-1-1:2004)

1.9.1. Loading 1.35x(permanent unfavourable)+1.00x(permanent favourable)+1.50x(variable unfav.)

Forces (at cross section centroid) at wall steam

y [m]	h [m]	Fx [kN/m]	Fy [kN/m]	M [kNm/m]
0.50	0.400	0.86	5.27	0.09
1.00	0.400	3.47	11.09	0.94
1.50	0.400	7.79	17.46	3.40
2.00	0.400	13.85	24.37	8.36
2.50	0.400	21.65	31.83	16.67
3.40	0.400	40.05	46.62	42.86



1.9.2. Design of wall steam in bending (EC2 §9.6, §6.1)

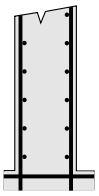
Concrete-Steel class: C25/30-B500B, Concrete cover: Cnom=25 mm (§3, §4.4.1.1)
Vertical reinforcement minimum:0.26(fctm/fyk)d, 0.0013d, 0.0020Ac, maximum: 0.04Ac (EC2 §9.6.2)

y [m]	Med [kN/m]	Ned [kN]	d [mm]	Kd	x/d	εc/εs	Ks	As [cm²/m]	min vyzt. [cm²/m]
0.50	0.09	-5.27	370	37.18	0.01	0.1/20.0	2.30	0.00	(4.00)
1.00	0.94	-11.09	370	22.00	0.01	0.2/20.0	2.31	0.00	(4.00)
1.50	3.40	-17.46	370	14.67	0.02	0.4/20.0	2.31	0.00	(4.00)
2.00	8.36	-24.37	370	10.46	0.03	0.5/20.0	2.32	0.22	(5.00)
2.50	16.67	-31.83	370	7.87	0.04	0.7/20.0	2.33	0.66	(5.00)
3.40	42.86	-46.62	370	5.19	0.06	1.2/20.0	2.35	2.15	(5.00)

1.9.3. Reinforcement of wall steam

Reinforcement at back steam face **Ø10/15.5** (5.06cm²/m)
Secondary transverse reinforcement **Ø 8/40.0** (1.26cm²/m)

Reinforcement at front steam face **Ø10/19.5** (4.03cm²/m)
Secondary transverse reinforcement **Ø 8/40.0** (1.26cm²/m)



1.9.4. Anchorage of wall steam reinforcement (EC2 §8.4)

Basic required anchorage length (EC2 Eq.8.3)
lb,rqd=(Ø/4)(σsd/fbd)=(10/4)x(185/1.61)=287mm
σsd=435.00x215/506=185MPa fbd=2.25x0.70x(fctk0.05/γc)=1.61 MPa (EC2 §8.4.2)
Design anchorage length lbd=1.00x287=287mm, Cnom=25mm<3Ø=30mm (EC2 §8.4.4, T.8.2)
Minimum anchorage length lb,min=max(0.30lbrqd,10Ø,100mm)=100mm
Necessary bend 100mm at lower bar end for anchorage

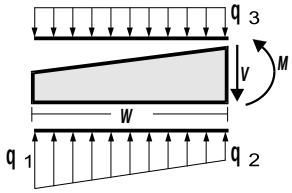
1.9.5. Shear check of wall steam (EC2 EN1992-1-1:2004, §6.2.2)

Concrete-Steel class: C25/30-B500B, Concrete cover: Cnom=25 mm (§3, §4.4.1.1)
The earth pressure load variation is linear, so the variation of shear
force is parabolic. The variation of steam cross section is linear.
The most unfavourable place for shear check is the base of the steam.

Ved=32.49 kN/m, Ned=-40.54 kN/m
Shear capacity without shear reinforcement Vrdc (EC2 §6.2.2)
$Vrdc=[Crdc\cdot k\cdot(100\rho1\cdot fck)^{0.33}+k1\cdot\sigma cp]\cdot bw\cdot d$ (EC2 Eq.6.2.a)
$Vrdc>=(vmin+k1\cdot\sigma cp)\cdot bw\cdot d$ (EC2 Eq.6.2.b)
Crdc=0.18/γc=0.18/1.50=0.120, fck=25.00MPa ,bw=1000mm, d=370mm
$k=1+\sqrt{(200/d)}$ <=2, k=1.74, k1=0.15
$\rho1=As1/(bw\cdot d)=506/(1000x370)=0.0014$
$\sigma cp=Ned/Ac=1000x40.54/400000=0.10N/mm^2$
$vmin=0.035\cdot k^{1.50}\cdot\sqrt{fck}=0.40N/mm^2$ (EC2 Eq.6.3N)
Vrd,c(min)=0.001x(0.40+0.15x0.10)x1000x370=153.55kN/m
$Vrdc=0.001x[0.120x1.74x(0.14x25.00)^{0.33}+0.15x0.10]x1000x370=122.85$, Vrdc=Vrdc(min)=153.55kN/m
Ved=32.49 kN/m <= Vrdc=153.55 kN/m, shear OK

1.10. Design of wall footing and reinforcement (EC2 EN1992-1-1:2004)

1.10.1. Design of front toe x=1.600 m to x=0.400 m

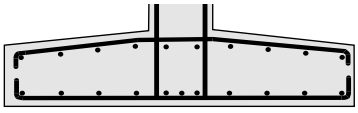


Sum of vertical forces = 109.42 kN/m
Sum of moments at middle of base = 20.70 kNm/m
q1= 0.099 N/mm², q2= 0.048 N/mm², w= 1.200 m
pressure from self weight q3= 0.013 N/mm²
M= 49.74 kNm/m, V= 72.68 kN/m
V at distance d=425mm from the face of the steam = 53.97 kN/m
Med= 49.74k Nm/m, Vsd= 53.97 kN/m

1.10.2. Design of wall footing in bending (EC2 EN1992-1-1:2004, §6.1)

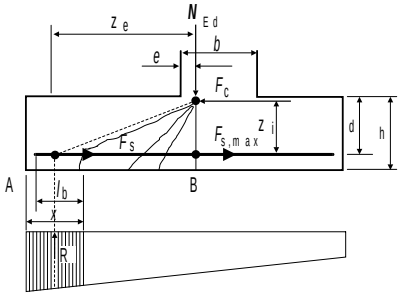
Concrete-Steel class: C25/30-B500B, Concrete cover: Cnom=75 mm (§3, §4.4.1.1)
Med= 49.74kNm/m, d=417mm, Kd= 5.91 x/d=0.05 εc2/εs1=-1.0/20.0 ks=2.34, **As= 2.79cm²/m**
Minimum reinforcement As>=0.26bd·fctm/fyk (As= 5.64cm²/m) (EC2 §9.3.1)
Minimum reinforcement Ø16/35.5(5.66cm²/m)

1.10.3. Reinforcement of wall footing



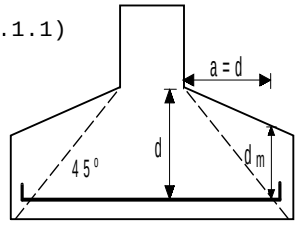
Footing reinforcement at bottom **Ø16/35.5** (5.66cm²/m)
Secondary transverse reinforcement **Ø16/40.0** (5.02cm²/m)

1.10.4. Anchorage of footing reinforcement (EC2 EN1992-1-1:2004, §9.8.2.2, §8.4)



x=h/2=0.250m, R=1000x0.099x0.250=24.75 kN/m
e=0.15b=0.060m ze=1.135 m, zi=0.900d=0.375m
Fs=R·ze/zi=24.75x1.135/0.375=74.85 kN/m
σsd=Fs/As=1000x74.85/566=132 MPa
Basic required anchorage length (EC2 Eq.8.3)
lb,rqd=(Ø/4)(σsd/fbd)=(16/4)x(132/2.30)=230mm
fbd=2.25x1.00x(fctk0.05/γc)=2.30 MPa (EC2 §8.4.2)
Design anchorage length (EC2 §8.4.4, T.8.2)
lbd=0.70x230=161mm, Cnom=75mm>3Ø=48mm
Minimum anchorage length lb,min=max(0.30lbrqd,10Ø,100mm)=160mm
Necessary anchorage length of longitudinal reinforcement Lbd=170mm =0.170m
lbd=170mm<(x-Cnom)=175.00. Sufficient length is available

1.10.5. Design of wall footing for shear and punching shear (EC2 EN1992-1-1:2004, §6.2.2)



Concrete-Steel class: C25/30-B500B, Concrete cover: Cnom=75 mm (§3, §4.4.1.1)
Punching shear capacity without shear reinforcement Vrdc (EC2 §6.4.4)
$Vrdc=[Crdc \cdot k \cdot (100\rho1 \cdot fck)^{0.33} \cdot (2d/a)] \cdot bw \cdot d$ (EC2 Eq.6.50)
$Vrdc>=[vmin \cdot 2d/a] \cdot bw \cdot d$, d=dm=417mm, a=417mm
Crdc=0.18/γc=0.18/1.50=0.120, fck=25.00MPa ,bw=1000mm, d=417mm
$k=1+\sqrt{(200/d)} <=2$, k=1.69
ρ1=As1/(bw·d)=566/(1000x417)=0.0014
$vmin=0.035 \cdot k^{1.50} \cdot \sqrt{fck} = 0.38 N/mm^2$ (EC2 Eq.6.3N)
Vrd,c(min)=0.001x(0.38x2x417/417)x1000x417=316.92kN/m
$Vrdc=0.001x[0.120x1.69x(0.14x25.00)^{0.33}x2x417/417]x1000x417=256.80$, Vrdc=Vrdc(min)=316.92kN/m
Ved=53.97 kN/m <= Vrdc=316.92 kN/m, shear and punching shear OK

1.11. Material estimate

Concrete per meter of wall length		2.260	m³/m
Reinforcing steel per meter of wall		62.604	kg/m
Total concrete of wall	10.000x	2.260=	22.600 m³
Total reinforcing steel of wall	10.000x	62.604=	626.040 kg

1.12. Reinforcing bar schedule

Num	type	reinforcing bar [mm]	items	∅	g/m [kg/m]	length [m]	weight [kg]
1	①	100 — 3770 — 100	65	10	0.617	3.970	159.22
2	④	100 — 3770 — 100	51	10	0.617	3.970	124.92
3	⑨	10000	20	8	0.395	10.000	79.00
4	⑦	1630	28	16	1.580	1.630	72.11
5	⑧	1630	25	16	1.580	1.630	64.39
6	⑩	10000	8	16	1.580	10.000	126.40
		Total weight [kg]					**626.04**