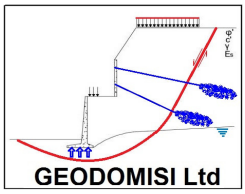


GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

GEOMETRY

Conc. Stem Height	5.18	m	
Stem Thickness Top	30.5	cm	
Stem Thickness Bot	50.8	cm	
Footing Thickness	50.8	cm	
Toe Length	1.22	m	
Heel Length	1.52	m	
Soil Cover @ Toe	0.61	m	
Backfill Height	4.57	m	OK
Backfill Slope Angle	10.0	deg	

APPLIED LOADS

Uniform Surcharge	0.0	KPa
Strip Pressure	0.0	KPa
Strip 0.6 m deep, 1.2 m wide @ 0.9 m from Stem		
Stem Vertical (Dead)	0.0	KN/m
Stem Vertical (Live)	0.0	KN/m
Vertical Load Eccentricity	15.2	cm
Wind Load on Stem	0.0	KPa
Wind Height from Top	1.52	m

BACKFILL PROPERTIES

Wall taper $\alpha = aTan(taper / H) =$ aTan ((50.8 - 30.5) / 100 / 5.18) = 0.039 rad

Backfill slope $\beta = slope * \pi / 180 =$ 10.0 * 3.14 / 180 = 0.175 rad

Internal friction $\phi = Int.\ friction * \pi / 180 =$ 28.0 * 3.14 / 180 = 0.489 rad

Wall-soil friction $\delta = \phi / 2 =$ 0.489 / 2 = 0.244 rad

Seismic angle $\theta = aTan(kh / (1 - kv)) =$ aTan (0.00 / (1 - 0.00)) = 0.000 rad

Footing length $ftg = toe + stem + heel =$ 1.22 + 50.8 / 100 + 1.52 = 3.25 m

Height for Stability $Hs = wedge + backfill + footing =$ 0.30 + 4.57 + 50.8 / 100 = 5.38 m

Earth pressure theory = Coulomb Active Moist density = 19 KN/m³ Saturated density = 20 KN/m³

Active coefficient $ka = \dfrac{Cos^2(\phi + \alpha)}{Cos^2\alpha * Cos(\delta + \alpha) * [1 + \left(\dfrac{Sin(\phi + \delta) * Sin(\phi - \beta)}{Cos(\delta + \alpha) * Cos(\beta - \alpha)}\right)^{1/2}]^2} = 0.39$

Active pressure $pa = ka * \gamma =$ 0.39 * 18.8 = 7.4 KPa/m of height

- For stability analysis (non-seismic)

Active force $Pa = ka * \gamma * Hs^2 / 2 =$ 0.39 * 18.8 * 5.38² / 2 = 107.0 KN/m

$Pah = Pa * Cos(\delta + \alpha) =$ 107.0 * Cos(0.244 + 0.039) = 102.7 KN/m

$Pav = Pa * Sin(\delta + \alpha) =$ 107.0 * Sin(0.244 + 0.039) = 29.9 KN/m

Water force $Pw = (ka * (\gamma s - \gamma w - \gamma) + \gamma w) * (Water\ table)^2 / 2$

Pw = (0.39 * (20.4 - 9.8 - 18.8) + 9.8) * 1.52² / 2 = 7.6 KN/m

- For stem design (non-seismic)

Active force $Pa = ka * \gamma * H^2 / 2 =$ 0.39 * 18.8 * 4.57² / 2 = 77.3 KN/m

$Pah = Pa * Cos(\delta + \alpha) =$ 77.3 * Cos (0.244 + 0.039) = 74.2 KN/m

$Pav = Pa * Sin(\delta + \alpha) =$ 77.3 * Sin (0.244 + 0.039) = 21.6 KN/m

Water force $Pw = (ka * (\gamma s - \gamma w - \gamma) + \gamma w) * (Water\ table - Ftg)^2 / 2$

Pw = (0.39 * (20.4 - 9.8 - 18.8) + 9.8) * (1.52 - 50.8 / 100)² / 2 = 3.4 KN/m

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

Hor. seismic coeff. kh = 0.00 Ver. seismic coeff. kv = 0.00

Active seismic coeff. $kae = \dfrac{Cos^2(\phi - \alpha - \theta)}{Cos\theta * Cos^2\alpha * Cos(\delta + \alpha + \theta) * [1 + (\dfrac{Sin(\phi + \delta) * Sin(\phi - \beta - \theta)}{Cos(\delta + \alpha + \theta) * Cos(\beta - \alpha)})^{1/2}]^2} = 0.39$

- For stability analysis (seismic)

Seismic force $Pae = kae * \gamma * Hs^2 / 2 * (1 - kv) =$ 0.39 * 18.8 * 5.38² / 2 * (1 - 0.0) = 107.0 KN/m

$Paeh = Pae * Cos(\delta + \alpha) =$ 107.0 * Cos (0.244 + 0.039) = 102.7 KN/m

$Paev = Pae * Sin(\delta + \alpha) =$ 107.0 * Sin (0.244 + 0.039) = 29.9 KN/m

Water force $Pwe = kh * (\gamma s - \gamma) * (water)^2 / 2$

Pwe = 0.00 * (20.4 - 18.8) * (1.52)² / 2 = 0.0 KN/m

- For stem design (seismic)

Seismic force $Pae = kae * \gamma * H^2 / 2 =$ 0.39 * 18.8 * 4.57² / 2 = 77.3 KN/m

$Paeh = Pae * Cos(\delta + \alpha) =$ 77.3 * Cos (0.244 + 0.039) = 74.2 KN/m

$Paev = Pae * Sin(\delta + \alpha) =$ 77.3 * Sin (0.244 + 0.039) = 21.6 KN/m

Water force $Pwe = kh * (\gamma s - \gamma) * (water\ table - ftg)^2 / 2$

Pwe = 0.00 * (20.4 - 18.8) * (1.52 - 50.8 / 100)² / 2 = 0.0 KN/m

OVERTURNING CALCULATIONS (Comb. D+H+W)

- Overturning Forces

Backfill = $Lat\ factor * Pah =$ 1.0 * 102.7 = 102.7 KN/m

Arm = $Hs / 3 =$ 5.38 / 3 = 1.79 m Moment = 102.7 * 1.79 = 184.1 KN-m/m

Water table = $Lat\ factor * Pw =$ 1.0 * 7.6 = 7.6 KN/m

Arm = $Water\ table / 3 =$ 1.52 / 3 = 0.51 m Moment = 7.6 * 0.51 = 3.9 KN-m/m

Surcharge = $Lat\ factor * ka * Surcharge * Hs =$ 1.0 * 0.38 * 0.0 * 5.38 = 0.0 KN/m

Arm = $Hs / 2 =$ 5.38 / 2 = 2.69 m Moment = 0.0 * 2.69 = 0.0 KN-m/m

Strip load = $\Sigma\ Lat\ factor * 2 * Q / \pi * [\beta - Sin\beta * Cos(2\alpha)] =$ 0.0 KN/m

Arm = 2.29 m Moment = 0.0 * 2.29 = 0.0 KN-m/m

Wind load = $WL\ factor * Pressure * Wind\ height =$ 1.0 * 0.0 * 1.52 = 0.0 KN/m

Arm = $Ftg + Stem - Wind\ height / 2 =$ 50.8 / 100 + 5.18 - 1.52 / 2 = 4.93 m

Moment = 0.0 * 4.93 = 0.0 KN-m/m

Backfill seismic = $EQ\ factor * (Paeh - Pah) =$ 0.0 * (102.7 - 102.7) = 0.0 KN/m

Arm = $0.6 * Hs =$ 0.6 * 5.38 = 3.23 m Moment = 0.0 * 3.23 = 0.0 KN-m/m

Water seismic = $EQ\ factor * Pwe =$ 0.0 * 0.0 = 0.0 KN/m

Arm = $Water\ table / 3 =$ 1.52 / 3 = 0.51 m Moment = 0.0 * 0.51 = 0.0 KN-m/m

Wall selfweight seismic effect not considered in calculations

Wall seismic = 0 KN

Moment = 0 KN-m/m

Hor. resultant Rh = 102.7 + 7.6 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 110.3 KN/m

Overturning moment OTM = 184.1 + 3.9 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 188.0 KN-m/m

Arm of hor. resultant = $OTM / Rh =$ 188.0 / 110.3 = 1.70 m

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

- Resisting Forces

Stem weight *WStem = DL factor * Thickness * Height * γc* = 1.0 * 30.5 / 100 * 5.18 * 24.00 = 37.9 KN/m

Arm = *Toe + Thickness / 2* = 1.22 + 30.5 / 100 / 2 = 1.37 m Moment = 37.9 * 1.37 = 52.0 KN-m/m

Stem taper *WTaper = DL factor * ΔThick * Height / 2 * γc* = 1.0 * (50.8 - 30.5) / 100 * 5.18 / 2 * 24.00 = 12.6 KN/m

Arm = *Toe + Thick + ΔThick * 2 / 3* = 1.22 + 30.5 / 100 - (50.8 - 30.5) / 100 * 2 / 3 = 1.59 m

Moment = 12.6 * 1.59 = 20.1 KN-m/m

CMU stem at top = 0.0 KN/m

Arm = *Toe + Thickness / 2* = 1.22 + 0.0 / 100 / 2 = 0.00 m

Moment = 0.0 * 0.00 = 0.0 KN-m/m

Ftg. weight *WFtg = DL factor * Length * Thickness * γc* = 1.0 * 3.25 * 50.8 / 100 * 24.00 = 39.6 KN/m

Arm = *Length / 2* = 3.25 / 2 = 1.62 m Moment = 39.6 * 1.62 = 64.3 KN-m/m

Key weight *WKey = DL factor * Depth * Thickness * γc* = 1.0 * 30.50 / 100 * 30.5 / 100 * 24.00 = 2.2 KN/m

Arm = *Toe + Thickness / 2* = 1.22 + 30.5 / 100 / 2 = 1.37 m Moment = 2.2 * 1.37 = 3.1 KN-m/m

Soil cover = *DL factor * Toe * Soil cover * γ* = 1.0 * 1.22 * 0.61 * 18.8 = 14.0 KN/m

Arm = *Toe / 2* = 1.22 / 2 = 0.61 m Moment = 14.0 * 0.61 = 8.5 KN-m/m

Stem wedge = *DL factor * ΔThick * Height / 2 * γ* = 1.0 * (50.8 - 30.5) / 100 * 4.57 / 2 * 18.8 = 8.7 KN/m

Arm = *Toe + Thick - ΔThick / 3* = 1.22 + 50.8 / 100 - (50.8 - 30.5) / 100 / 3 = 1.66 m

Moment = 8.7 * 1.66 = 14.5 KN-m/m

Backfill weight = *DL factor * Heel * Height * γ* = 1.0 * 1.52 * 4.57 * 18.8 = 130.6 KN/m

Arm = *Ftg - Heel / 2* = 3.25 - 1.52 / 2 = 2.49 m Moment = 130.6 * 2.49 = 324.9 KN-m/m

Backfill slope = *DL factor * (Heel + ΔThick) * Wedge / 2 * γ* =

= 1.0 * (1.5 + (50.8 - 30.5) / 100) * 0.30 / 2 * 18.8 = 4.9 KN/m

Arm = *ftg - (Heel + ΔThick) / 3* = 3.25 - (1.52 + (50.8 - 30.5) / 100) / 3 = 2.67 m

Moment = 4.9 * 2.67 = 13.0 KN-m/m

Water = *DL factor * Heel * (Water - Ftg) * (γs - γ)* = 1.0 * 1.52 * (1.52 - 50.8 / 100) * (20.4 - 18.8) = 2.5 KN/m

Arm = *Ftg - Heel / 2* = 3.25 - 1.52 / 2 = 2.49 m Moment = 2.5 * 2.49 = 6.1 KN-m/m

Seismic Pae-Pa = *EQ factor * (Paev - Pav)* = 0.0 * (29.9 - 29.9) = 0.0 KN/m

Arm = *Footing length* = 3.25 m Moment = 0.0 * 3.25 = 0.0 KN-m/m

Backfill Pav = *Lat factor * Pav* = 1.0 * 29.9 = 29.9 KN/m

Arm = *Footing length* = 3.25 m Moment = 29.9 * 3.25 = 97.2 KN-m/m

Concentrated = *DL factor * Ver load + LL factor * Ver load* = 1.0 * 0.0 + 0.0 * 0.0 = 0.0 KN/m

Arm = *Toe + Stem - Ecc* = 1.22 + (30.5 - 15.2) / 100 = 1.37 m

Moment = 0.0 * 1.37 = 0.0 KN-m/m

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

Surcharge = *Srch factor * (Heel + ΔThick) * Surcharge =* 1.0 * (1.5 + (50.8 - 30.5) / 100) * 0.0 = 0.0 KN/m

Arm = *ftg - (Heel + ΔThick) / 2 =* 3.25 - (1.52 + (50.8 - 30.5) / 100) / 2 = 2.39 m

Moment = 0.0 * 2.39 = 0.0 KN-m/m

Strip = *Strip factor * Surcharge * Heel =* 1.0 * 0.0 * 1.52 = 0.0 KN/m

Arm = *Footing - Heel / 2 =* 3.25 - 1.52 / 2 = 2.49 m Moment = 0.0 * 2.49 = 0.0 KN-m/m

Buoyancy = *DL factor * γw * Water table * Ftg =* 1.0 * 9.8 * 1.52 * 3.25 = -48.4 KN/m

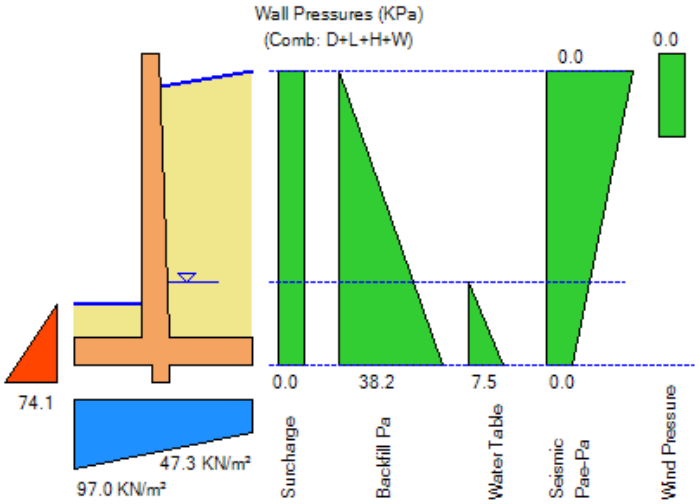
Arm = *Footing / 2 =* 3.25 / 2 = 1.62 m Moment = -48.4 * 1.62 = -78.7 KN-m/m

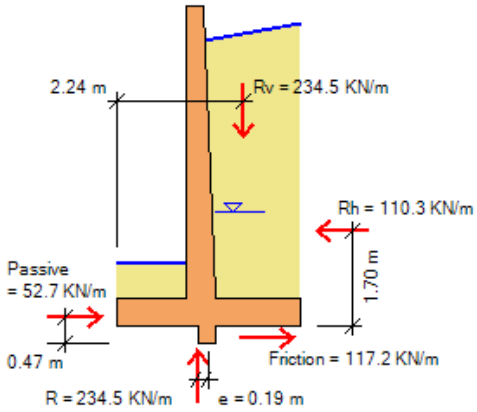
Ver. resultant Rv = *Σ Vertical forces =* 234.5 KN/m

Resisting moment RM = *Σ Moments =* 525.1 KN-m/m

Arm of ver. resultant = *RM / Rv =* 525.1 / 234.5 = 2.24 m

Overturning ratio = *RM / OTM =* 525.1 / 188.0 = 2.79 > 1.50 OK





SOIL BEARING PRESSURES (Comb. D+H+W)

Eccentricity = $\frac{Ftg}{2} - \frac{RM - OTM}{Rv} = \frac{3.25}{2} - \frac{525.1 - 188.0}{234.5}$ = 0.19 m

Bearing length = *Min (Ftg , 3 * (Ftg / 2 - Ecc))* = Min (3.25, 3 * (3.25 / 2 - 0.19)) = 3.25 m

Toe bearing = $\frac{Rv}{Ftg} + \frac{6 * Rv * Ecc}{Ftg^2} = \frac{234.5}{3.25} + \frac{6 * 234.5 * 0.19}{3.25^2}$ = 97.0 KN/m² < 191.6 KN/m² OK

Heel bearing = $\frac{Rv}{Ftg} - \frac{6 * Rv * Ecc}{Ftg^2} = \frac{234.5}{3.25} - \frac{6 * 234.5 * 0.19}{3.25^2}$ = 47.3 KN/m²

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

SLIDING CALCULATIONS (Comb. D+H+W)

Passive coefficient $kp = 1 / ka$ = 1 / 0.36 = 2.77 KN/m²

Passive depth $Dp = Soil\ cover + Ftg + Key - Neglect\ depth$ = 0.61 + (50.8 + 30.5) / 100 - 0.00 = 1.42 m

Passive pressure top = $kp * \gamma * Neglect\ depth$ = 2.77 * 18.8 * 0.00 = 0.00 KN/m²

Passive pressure bot = $kp * \gamma * (Dp + Neglect\ depth)$ = 2.77 * 18.8 * (1.42 + 0.00) = 74.10 KN/m²

Passive force = $(Pressure\ top + Pressure\ bot) / 2 * Dp$ = (0.00 + 74.10) / 2 * 1.42 = 52.7 KN/m

Friction force = $Max\ (0, Rv * Friction\ coeff.)$ = Max (0, 234.5 * 0.50) = 117.2 KN/m

Sliding ratio = $(Passive + Friction) / Rh$ = (52.7 + 117.2) / 110.3 = 1.54 > 1.50 OK

STEM DESIGN (Comb. 0.9D+1.6H+E)

Backfill = $Lat\ factor * Pah$ = 1.6 * 73.7 = 118.7 KN/m

Arm = $Hb / 3$ = 4.57 / 3 = 1.52 m Moment = 118.7 * 1.52 = 180.8 KN-m/m

Water table = $Lat\ factor * Pw$ = 1.6 * 3.3 = 5.4 KN/m

Arm = $(Water\ table - Ftg) / 3$ = (1.52 - 50.8 / 100) / 3 = 0.34 m Moment = 5.4 * 0.34 = 2.7 KN-m/m

Surcharge = $Lat\ factor * ka * Surcharge * Hb$ = 1.6 * 0.38 * 0.0 * 4.57 = 0.0 KN/m

Arm = $Hb / 2$ = 4.57 / 2 = 2.29 m Moment = 0.0 * 2.29 = 0.0 KN-m/m

Strip load = $\Sigma\ Lat\ factor * 2 * Q / \pi * [\beta - Sin\ \beta * Cos\ (2\alpha)]$ = 0.0 KN/m

Arm = 2.29 m Moment = 0.0 * 2.29 = 0.0 KN-m/m

Wind load = $WL\ factor * Pressure * Wind\ height$ = 0.0 * 0.0 * 1.52 = 0.0 KN/m

Arm = $Stem - Wind\ height / 2$ = 5.18 - 1.52 / 2 = 4.42 m Moment = 0.0 * 4.42 = 0.0 KN-m/m

Backfill seismic = $EQ\ factor * (Paeh - Pah)$ = 1.0 * (74.2 - 74.2) = 0.0 KN/m

Arm = $0.6 * Hb$ = 0.6 * 4.57 = 2.74 m Moment = 0.0 * 2.74 = 0.0 KN-m/m

Water seismic = $EQ\ factor * Pwe$ = 1.0 * 0.0 = 0.0 KN/m

Arm = $(Water\ table - Ftg) / 3$ = (1.52 - 50.8 / 100) / 3 = 0.34 m Moment = 0.0 * 0.34 = 0.0 KN-m/m

Max. shear = 118.7 + 5.4 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 124.1 KN/m

Shear at critical section = $Max\ shear - Max\ shear / Hb * d$ = 124.1 - 124.1 / 4.57 * 42.9 / 100 = 112.4 KN/m

Max. moment = 180.8 + 2.7 + 0.0 + 0.0 + 0.0 + 0.0 + 0.0 = 183.6 KN-m/m

Shear strength $\varphi Vn = \varphi * 0.17 * (f'c)^{1/2} * 10 * d$ ACI Eq. (11-3)

φ Vn = 0.75 * 0.17 * (28)½ * 10 * 42.9 = 280.9 KN/m > 112.4 KN/m OK

Use D20 @ 20.0 cm As = 15.71 cm²/m $\rho = As / b\ d$ = 15.71 / (100 * 44.7) = 0.0035

Bending strength $\varphi Mn = \varphi * d^2 * f'c * q * (1 - 0.59 * q)$ ACI 10.2.7

φ Mn = 0.90 * 44.7² * 27.6 * 0.053 * (1 - 0.59 * 0.053) = 253.3 KN-m/m > 183.6 KN-m/m OK

Hooked $Ldh = 0.24 * fy / (f'c)^{1/2} * db * 0.7$ = 0.24 * 413.7 / (27.6)½ * 2.00 * 0.7 * 0.72 = 19.2 cm ACI 12.5

Dev. length at footing = $Ftg - Cover$ = 50.8 - 7.6 = 43.2 cm > 19.2 cm OK

$As\ min = Min\ (Max\ ((1.4 / fy, 0.25 * \sqrt{f'c} / fy) * b * d), 1.33 * As\ req)$ ACI 10.5

= Min (Max ((1.4 / 414, 0.25 * (27.6)½ / 414) * 100 * 44.7, 1.33 * 11.3) = 15.0 cm²/m

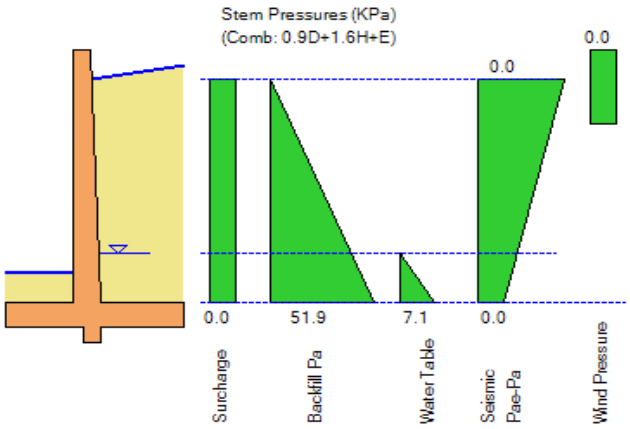
Min. steel area ratio = $As\ min / As$ = 15.04 / 15.71 = 0.96 < 1.0 OK

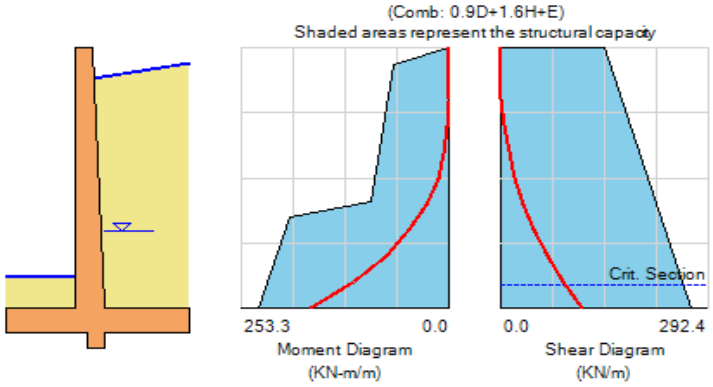
GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN





HEEL DESIGN (Comb. 1.4D)

Bearing force = 0.0 KN/m (Neglect bearing pressure for heel design)

Arm = *(Bearing1 * Heel² / 2 + (Bearing2 - Bearing1) * Heel² / 6) / Force*

= (164.4 * 1.52² / 2 + (93.0 - 164.4) * 1.52² / 6) / 0.0 = 0.83 m

Moment = 0.0 * 0.83 = 0.0 KN-m/m

Concrete weight = *DL factor * Thick * Heel * γc* = 1.4 * 50.8 / 100 * 1.52 * 24.00 = 25.9 KN/m

Arm = *Heel / 2* = 1.52 / 2 = 0.76 m Moment = 25.9 * 0.76 = 19.7 KN-m/m

Backfill weight = *DL factor * Heel * Height * γ* = 1.4 * 1.52 * 4.57 * 18.8 = 182.8 KN/m

Arm = *Heel / 2* = 1.52 / 2 = 0.76 m Moment = 182.8 * 0.76 = 139.0 KN-m/m

Backfill slope = *DL factor * (Heel + ΔThick) * Wedge / 2 * γ* =

= 1.4 * (1.5 + (50.8 - 30.5) / 100) * 0.30 / 2 * 18.8 = 6.8 KN/m

Arm = *Heel * 2 / 3* = 1.52 * 2 / 3 = 1.01 m Moment = 6.8 * 1.01 = 6.9 KN-m/m

Water = *DL factor * Heel * Water table * (γs - γ)* = 1.4 * 1.52 * 1.52 * (20.4 - 18.8) = 3.4 KN/m

Arm = *Heel / 2* = 1.52 / 2 = 0.76 m Moment = 3.4 * 0.76 = 2.6 KN-m/m

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

Surcharge = *Srch factor * (Heel + ΔThick) * Surcharge* = 1.4 * (1.5 + (50.8 - 30.5) / 100) * 0.0 = 0.0 KN/m

Arm = *Heel / 2* = 1.52 / 2 = 0.76 m Moment = 0.0 * 0.76 = 0.0 KN-m/m

Strip = *Strip factor * Surcharge * Width* = 1.4 * 0.0 * 1.22 = 0.0 KN/m

Arm = *Distance - ΔStem + Width / 2* = 0.91 - (50.8 - 30.5) / 100 + 1.22 / 2 = 0.76 m

Moment = 0.0 * 0.76 = 0.0 KN-m/m

Max. Shear Vu = -0.0 + 25.9 + 182.8 + 6.8 + 3.4 + 0.0 + 0.0 = 219.0 KN/m

Max. Moment Mu = -0.0 + 19.7 + 139.0 + 6.9 + 2.6 + 0.0 + 0.0 = 168.2 KN/m

Shear strength $\varphi Vn = \varphi * 0.17 * (f'c)^{½} * 10 * d$ ACI Eq. (11-3)

φ Vn = 0.75 * 0.17 * (28)½ * 10 * 44.7 = 292.4 KN/m > Vu = 219.0 KN/m OK

Use D20 @ 20.0 cm As = 15.71 cm²/m $\rho = As / b\,d$ = 15.71 / (100 * 44.7) = 0.0035

Bending strength $\varphi Mn = \varphi * d^2 * f'c * q * (1 - 0.59 * q)$ ACI 10.2.7

φ Mn = 0.90 * 44.7² * 27.6 * 0.053 * (1 - 0.59 * 0.053) = 253.3 KN-m/m > Mu = 168.2 KN-m/m OK

Cover factor = *Min (2.5, (Cover + db /2, Spacing / 2) / db)* = Min (2.5, (5.1 + 2.00 / 2, 20.0 / 2) / 2.00) = 2.5

Straight *Ld = fy / 1.1 / (f'c)½ * Size * Location / Cover * db* ACI Eq. (12-1)

= 413.7 / 1.1 / (28)½ * 0.8 * 1.3 / 2.5 * 2.00 * 0.66 = 59.5 cm

Hooked *Ldh = 0.24 * fy / (f'c)½ * db * 0.7* = 0.24 * 413.7 / (27.6)½ * 2.00 * 0.7 * 0.66 = 26.4 cm ACI 12.5

Dev. length at toe side = *Ftg - Heel - Cover* = (3.25 - 1.52) * 100 - 5.1 = 167.7 cm > 59.5 cm OK

Dev. length at heel side = *Heel - Cover* = 1.52 * 100 - 5.1 = 146.9 cm > 59.5 cm OK

*As min = Min (Max ((1.4 / fy, 0.25 * √f'c / fy) * b * d), 1.33 * As req)* ACI 10.5

= Min (Max ((1.4 / 414, 0.25 * (27.6)½ / 414) * 100 * 44.7, 1.33 * 6.6) = 13.8 cm²/m

Min. steel area ratio = *As min / As* = 13.75 / 15.71 = 0.88 < 1.0 OK

TOE DESIGN (Comb. 1.2D+1.6(L+H))

Bearing force = *(Bearing1 + Bearing2) / 2 * Toe* = (151.9 + 105.6) / 2 * 1.22 = 157.1 KN/m

Arm = *(Bearing1 * Toe² / 2 + (Bearing2 - Bearing1) * Toe² / 3) / Force*

= (105.6 * 1.22² / 2 + (151.9 - 105.6) * 1.22² / 3) / 157.1 = 0.65 m

Moment = 157.1 * 0.65 = 101.5 KN-m/m

Water Buoyancy = *DL factor * γw * Water table * Toe* = 1.2 * 9.8 * 1.52 * 1.22 = 21.8 KN/m

Arm = *Toe / 2* = 1.22 / 2 = 0.61 m Moment = 21.8 * 0.61 = 13.3 KN-m/m

Concrete weight = *DL factor * Thick * Toe * γc* = 1.2 * 50.8 / 100 * 1.22 * 24.00 = 17.8 KN/m

Arm = *Toe / 2* = 1.22 / 2 = 0.61 m Moment = 17.8 * 0.61 = 10.9 KN-m/m

Soil cover = *DL factor * Toe * Height * γ* = 1.2 * 1.22 * 12.59 * 18.8 = 16.8 KN/m

Arm = *Toe / 2* = 1.22 / 2 = 0.61 m Moment = 16.8 * 0.61 = 10.2 KN-m/m

Max. Shear Vu = 157.1 + 21.8 - 17.8 - 16.8 = 144.3 KN/m

Shear at crit. section Vu = *Max shear * (Toe - d) / Toe* = 144.3 * (1.22 - 42.4 / 100) / 1.22 = 94.1 KN/m

Max. Moment Mu = 101.5 + 13.3 - 10.9 - 10.2 = 93.7 KN/m

Shear strength $\varphi Vn = \varphi * 0.17 * (f'c)^{½} * 10 * d$ ACI Eq. (11-3)

φ Vn = 0.75 * 0.17 * (28)½ * 10 * 42.4 = 277.3 KN/m > Vu = 94.1 KN/m OK

Use D16 @ 20.0 cm As = 10.06 cm²/m $\rho = As / b\,d$ = 10.06 / (100 * 42.4) = 0.0024

Bending strength $\varphi Mn = \varphi * d^2 * f'c * q * (1 - 0.59 * q)$ ACI 10.2.7

φ Mn = 0.90 * 42.4² * 27.6 * 0.036 * (1 - 0.59 * 0.036) = 155.6 KN-m/m > Mu = 93.7 KN-m/m OK

GEODOMISI Ltd

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

Cover factor = *Min (2.5, (Cover + db /2, Spacing / 2) / db)* = Min (2.5, (7.6 + 1.60 / 2, 20.0 / 2) / 1.60) = 2.5

Straight *Ld = fy / 1.1 / (f'c)½ * Size * Location / Cover * db* ACI Eq. (12-1)

= 413.7 / 1.1 / (28)½ * 0.8 * 1.0 / 2.5 * 1.60 * 0.60 = 36.7 cm

Hooked *Ldh = 0.24 * fy / (f'c)½ * db * 0.7* = 0.24 * 413.7 / (27.6)½ * 1.60 * 0.7 * 0.60 = 21.2 cm ACI 12.5

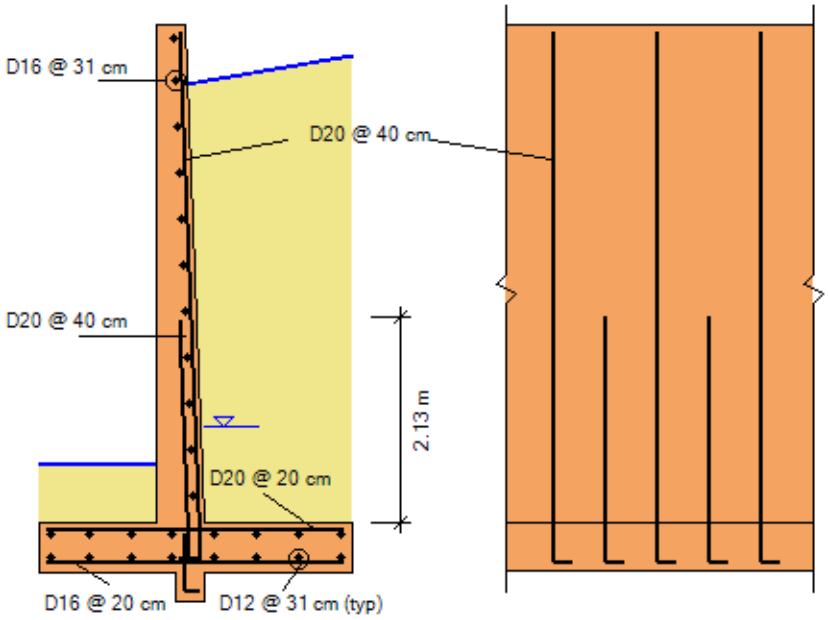
Dev. length at heel side = *Ftg - Toe - Cover* = (3.25 - 1.22) * 100 - 7.6 = 195.2 cm > 36.7 cm OK

Dev. length at toe side = *Toe - Cover* = 1.22 * 100 - 7.6 = 114.4 cm > 36.7 cm OK

*As min = Min (Max ((1.4 / fy, 0.25 * √f'c / fy) * b * d), 1.33 * As req)* ACI 10.5

= Min (Max ((1.4 / 414, 0.25 * (27.6)½ / 414) * 100 * 42.4, 1.33 * 5.8) = 8.0 cm²/m

Min. steel



SHEAR KEY DESIGN (Comb. 0.9D+1.6H+E)

Shear key depth = 30.5 cm Shear key thickness = 30.5 cm

Passive force = *Lat factor * (Passive1 + Passive2) / 2 * Key* = 1.6 * (74.1 + 58.2) / 2 * 30.5 / 100 = 32.3 KN/m

Shear at crit. section Vu = *Max shear * (Key - d) / Key* = 32.3 * (30.5 - 22.1) / 30.5 = 8.9 KN/m

Arm = *(Passive1 * Key² / 2 + (Passive2 - Passive1) * Key² / 3) / Force*

= (58.2 * 30.50² / 2 + (74.1 - 58.2) * 30.50² / 3) / 32.3 = 0.10 m

Max. moment Mu = 32.3 * 0.10 = 3.2 KN-m/m

Shear strength *φ Vn = φ * 0.17 * (f'c)½ * 10 * d* ACI Eq. (11-3)

φ Vn = 0.75 * 0.17 * (28)½ * 10 * 22.1 = 144.4 KN/m > Vu = 8.9 KN/m OK

Use D16 @ 30.5 cm As = 6.60 cm²/m *ρ = As / b d* = 6.60 / (100 * 22.1) = 0.0030

Bending strength *φ Mn = φ * d² * f'c * q * (1 - 0.59 * q)* ACI 10.2.7

φ Mn = 0.90 * 22.1² * 27.6 * 0.045 * (1 - 0.59 * 0.045) = 52.8 KN-m/m > Mu = 3.2 KN-m/m OK

GEODOMISI Ltd. - Dr. Costas Sachpazis

Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 -
Mobile: (+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info

CANTILEVER RETAINING WALL DESIGN

DESIGN CODES

General Analysis	IBC-12
Concrete Design	ACI 318-11
Masonry Design	MSJC-11
Load Combinations	ASCE 7-05

MATERIALS

	Stem	Footing	
Concrete f'c	27.6	27.6	MPa
Rebars fy	413.7	413.7	MPa
Masonry f'm	10.3		MPa

LOAD COMBINATIONS (ASCE 7)

STABILITY	STRENGTH
① D+H+W	① 1.4D
② D+L+H+W	② 1.2D+1.6(L+H)
③ D+H+0.7E	③ 1.2D+0.8W
④ D+L+H+0.7E	④ 1.2D+L+1.6W
	⑤ 1.2D+L+E
	⑥ 0.9D+1.6H+1.6W
	⑦ 0.9D+1.6H+E

GEODOMISI Ltd. - Dr. Costas Sachpazis
Civil & Geotechnical Engineering Consulting Company for
Structural Engineering, Soil Mechanics, Rock Mechanics,
Foundation Engineering & Retaining Structures.
Tel.: (+30) 210 5238127, 210 5711263 - Fax.:+30 210 5711461 - Mobile:
(+30) 6936425722 & (+44) 7585939944,
www.geodomisi.com - costas@sachpazis.info