



Project PCC Retaining Flood Wall Check				Job no. 279	
Calcs for 2045 Design Check - Cantilever Section				Start page no./Revision 2045 1 1.1	
Calcs by MC	Calcs date 23/07/2025	Checked by NJ	Checked date 23/07/2025	Approved by JP	Approved date 23/07/2025

STEEL SHEET PILING ANALYSIS & DESIGN

In accordance with BS EN1997-1:2004 - Code of Practice for Geotechnical design and the UK National Annex

Tedds calculation version 2.0.07

Design summary

Combination 1

Description	Unit	Provided	Required	Utilisation	Result
Total length required	mm	9480	5404	1.754	PASS
Moment capacity	kNm/m	385.9	71.6	5.390	PASS
Shear capacity	kN/m	779.3	139.2	5.600	PASS

Combination 2

Description	Unit	Provided	Required	Utilisation	Result
Total length required	mm	9480	6330	1.498	PASS
Moment capacity	kNm/m	385.9	81.1	4.761	PASS
Shear capacity	kN/m	779.3	120.5	6.466	PASS

Geometry

Total length of sheet pile provided	$H_{pile} = 9480$ mm
Number of different types of soil	$N_s = 6$
Retained height	$d_{ret} = 1870$ mm
Depth of unplanned excavation	$d_{ex} = 500$ mm
Total retained height	$d_s = 2370$ mm
Angle of retained slope	$\beta = 0.0$ deg
Depth from GL to top of water table retained side	$d_w = 1350$ mm
Depth from GL to top of water table retaining side	$d_{wp} = 2370$ mm

Loading

Permanent surcharge	$p_{o,G} = 5.0$ kN/m ²
Variable surcharge	$p_{o,Q} = 5.0$ kN/m ²

Soil layer 1

Characteristic shearing resistance angle	$\phi'_{k_{s1}} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_{s1}} = 28.0$ deg
Moist density of soil	$\gamma_{m_{s1}} = 17.5$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_{s1}} = 21.0$ kN/m ³
Height of soil 1	$h_1 = 630$ mm

Soil layer 2

Characteristic shearing resistance angle	$\phi'_{k_{s2}} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_{s2}} = 28.0$ deg
Moist density of soil	$\gamma_{m_{s2}} = 17.5$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_{s2}} = 20.0$ kN/m ³
Height of soil 2	$h_2 = 2400$ mm

Soil layer 3

Characteristic shearing resistance angle	$\phi'_{k_{s3}} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_{s3}} = 28.0$ deg
Moist density of soil	$\gamma_{m_{s3}} = 14.0$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_{s3}} = 18.0$ kN/m ³
Height of soil 3	$h_3 = 900$ mm

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Soil layer 4

Characteristic shearing resistance angle	$\phi'_{k_s4} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_s4} = 28.0$ deg
Moist density of soil	$\gamma_{m_s4} = 15.0$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_s4} = 19.0$ kN/m ³
Height of soil 4	$h_4 = 1100$ mm

Soil layer 5

Characteristic shearing resistance angle	$\phi'_{k_s5} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_s5} = 25.0$ deg
Moist density of soil	$\gamma_{m_s5} = 14.0$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_s5} = 19.0$ kN/m ³
Height of soil 5	$h_5 = 1100$ mm

Soil layer 6

Characteristic shearing resistance angle	$\phi'_{k_s6} = 30.0$ deg
Characteristic wall friction angle	$\delta_{k_s6} = 30.0$ deg
Moist density of soil	$\gamma_{m_s6} = 14.0$ kN/m ³
Characteristic saturated density of retained soil	$\gamma_{s_s6} = 19.0$ kN/m ³
Height of soil 6	$h_6 = 5700$ mm

Partial factors on actions - Section A.3.1 - Combination 1

Permanent unfavourable action	$\gamma_G = 1.35$
Permanent favourable action	$\gamma_{G,f} = 1.00$
Variable unfavourable action	$\gamma_Q = 1.50$
Angle of shearing resistance	$\gamma_{\phi'} = 1.00$
Weight density	$\gamma_\gamma = 1.00$

Design soil properties - soil 1

Design effective shearing resistance angle	$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = 30.0$ deg
Design wall friction angle	$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = 28.0$ deg
Design moist density of retained soil	$\gamma_{m,d1} = \gamma_m / \gamma_\gamma = 17.5$ kN/m ³
Design saturated density of retained soil	$\gamma_{s,d1} = \gamma_s / \gamma_\gamma = 21.0$ kN/m ³
Design buoyant density of retained soil	$\gamma_{d,d1} = \gamma_{s,d1} - \gamma_w = 11.2$ kN/m ³
Active pressure using Coulomb theory	$K_{a1} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))))^2) = 0.296$
Passive pressure using Coulomb theory	$K_{p1} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d)))]^2) = 9.012$

Design soil properties - soil 2

Design effective shearing resistance angle	$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = 30.0$ deg
Design wall friction angle	$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = 28.0$ deg
Design moist density of retained soil	$\gamma_{m,d2} = \gamma_m / \gamma_\gamma = 17.5$ kN/m ³
Design saturated density of retained soil	$\gamma_{s,d2} = \gamma_s / \gamma_\gamma = 20.0$ kN/m ³
Design buoyant density of retained soil	$\gamma_{d,d2} = \gamma_{s,d2} - \gamma_w = 10.2$ kN/m ³
Active pressure using Coulomb theory	$K_{a2} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))))^2) = 0.296$

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Passive pressure using Coulomb theory

$$K_{p2} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{9.012}$$

Design soil properties - soil 3

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_\phi) = \mathbf{30.0 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_\phi) = \mathbf{28.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d3} = \gamma_m / \gamma_\gamma = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d3} = \gamma_s / \gamma_\gamma = \mathbf{18.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d3} = \gamma_{s.d3} - \gamma_w = \mathbf{8.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a3} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))})^2) = \mathbf{0.296}$$

Passive pressure using Coulomb theory

$$K_{p3} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{9.012}$$

Design soil properties - soil 4

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_\phi) = \mathbf{30.0 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_\phi) = \mathbf{28.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d4} = \gamma_m / \gamma_\gamma = \mathbf{15.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d4} = \gamma_s / \gamma_\gamma = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d4} = \gamma_{s.d4} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a4} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))})^2) = \mathbf{0.296}$$

Passive pressure using Coulomb theory

$$K_{p4} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{9.012}$$

Design soil properties - soil 5

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_\phi) = \mathbf{30.0 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_\phi) = \mathbf{25.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d5} = \gamma_m / \gamma_\gamma = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d5} = \gamma_s / \gamma_\gamma = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d5} = \gamma_{s.d5} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a5} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))})^2) = \mathbf{0.296}$$

Passive pressure using Coulomb theory

$$K_{p5} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{7.704}$$

Design soil properties - soil 6

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_\phi) = \mathbf{30.0 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_\phi) = \mathbf{30.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d6} = \gamma_m / \gamma_\gamma = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d6} = \gamma_s / \gamma_\gamma = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d6} = \gamma_{s.d6} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

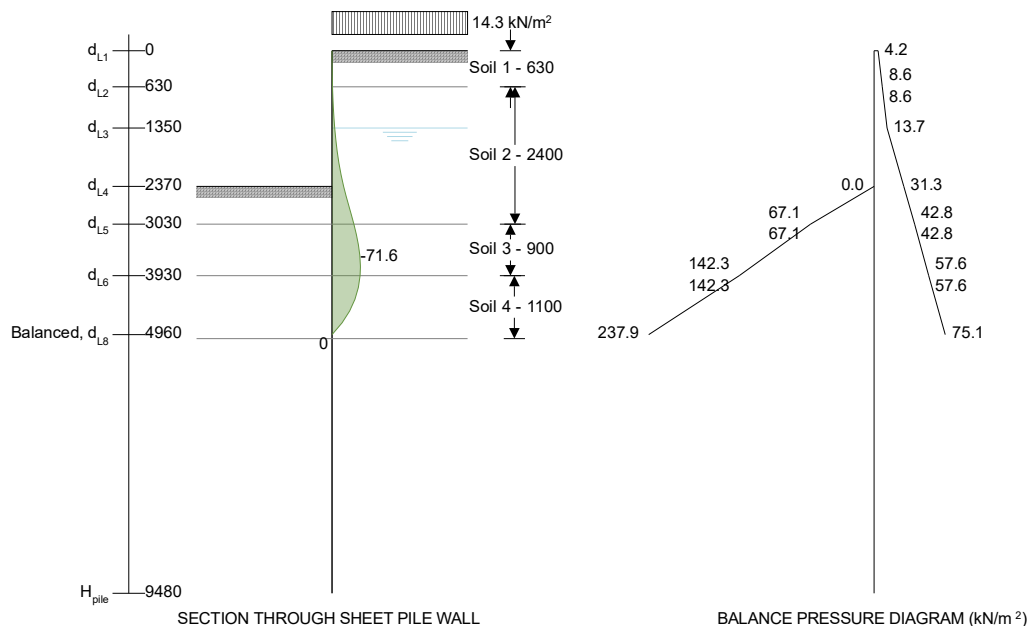
$$K_{a6} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))})^2) = \mathbf{0.297}$$

Passive pressure using Coulomb theory

$$K_{p6} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{10.095}$$



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Overburden on active side

Overburden at 0 mm below GL in soil 1
Overburden at 630 mm below GL in soil 1
Overburden at 630 mm below GL in soil 2
Overburden at 1350 mm below GL in soil 2
Overburden at 2370 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 4
Overburden at 4962 mm below GL in soil 4

$$\begin{aligned}OB'_{a11} &= (p_{o,G} \times \gamma_G + p_{o,Q} \times \gamma_Q) = \mathbf{14.3 \text{ kN/m}^2} \\OB'_{a21} &= \gamma_G \times \gamma_{m,d1} \times h_{a1} + OB'_{a11} = \mathbf{29.1 \text{ kN/m}^2} \\OB'_{a22} &= \gamma_G \times \gamma_{m,d1} \times h_{a1} + OB'_{a11} = \mathbf{29.1 \text{ kN/m}^2} \\OB'_{a31} &= \gamma_G \times \gamma_{m,d2} \times h_{a2} + OB'_{a22} = \mathbf{46.1 \text{ kN/m}^2} \\OB'_{a41} &= \gamma_G \times \gamma_{d,d2} \times h_{a3} + OB'_{a31} = \mathbf{60.2 \text{ kN/m}^2} \\OB'_{a51} &= \gamma_G \times \gamma_{d,d2} \times h_{a4} + OB'_{a41} = \mathbf{69.3 \text{ kN/m}^2} \\OB'_{a52} &= \gamma_G \times \gamma_{d,d2} \times h_{a4} + OB'_{a41} = \mathbf{69.3 \text{ kN/m}^2} \\OB'_{a61} &= \gamma_G \times \gamma_{d,d3} \times h_{a5} + OB'_{a52} = \mathbf{79.2 \text{ kN/m}^2} \\OB'_{a62} &= \gamma_G \times \gamma_{d,d3} \times h_{a5} + OB'_{a52} = \mathbf{79.2 \text{ kN/m}^2} \\OB'_{a71} &= \gamma_G \times \gamma_{d,d4} \times h_{a6} + OB'_{a62} = \mathbf{92.0 \text{ kN/m}^2}\end{aligned}$$

Overburden on passive side

Overburden at 2370 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 4
Overburden at 4962 mm below GL in soil 4

$$\begin{aligned}OB'_{p41} &= 0 \text{ kN/m}^2 = \mathbf{0.0 \text{ kN/m}^2} \\OB'_{p51} &= \gamma_{G,f} \times \gamma_{d,d2} \times h_{p4} + OB'_{p41} = \mathbf{6.7 \text{ kN/m}^2} \\OB'_{p52} &= \gamma_{G,f} \times \gamma_{d,d2} \times h_{p4} + OB'_{p41} = \mathbf{6.7 \text{ kN/m}^2} \\OB'_{p61} &= \gamma_{G,f} \times \gamma_{d,d3} \times h_{p5} + OB'_{p52} = \mathbf{14.1 \text{ kN/m}^2} \\OB'_{p62} &= \gamma_{G,f} \times \gamma_{d,d3} \times h_{p5} + OB'_{p52} = \mathbf{14.1 \text{ kN/m}^2} \\OB'_{p71} &= \gamma_{G,f} \times \gamma_{d,d4} \times h_{p6} + OB'_{p62} = \mathbf{23.6 \text{ kN/m}^2}\end{aligned}$$

Pressure on active side

Active at 0 mm below GL in soil 1
Active at 630 mm below GL in soil 1
Active at 630 mm below GL in soil 2
Active at 1350 mm below GL in soil 2
Active at 2370 mm below GL in soil 2
Active at 3030 mm below GL in soil 2
Active at 3030 mm below GL in soil 3
Active at 3930 mm below GL in soil 3

$$\begin{aligned}p'_{a11} &= K_{a1} \times OB'_{a11} = \mathbf{4.2 \text{ kN/m}^2} \\p'_{a21} &= K_{a1} \times OB'_{a21} = \mathbf{8.6 \text{ kN/m}^2} \\p'_{a22} &= K_{a2} \times OB'_{a22} = \mathbf{8.6 \text{ kN/m}^2} \\p'_{a31} &= K_{a2} \times OB'_{a31} = \mathbf{13.7 \text{ kN/m}^2} \\p'_{a41} &= K_{a2} \times OB'_{a41} + \gamma_G \times \gamma_w \times (d_{L4} - d_w) = \mathbf{31.3 \text{ kN/m}^2} \\p'_{a51} &= K_{a2} \times OB'_{a51} + \gamma_G \times \gamma_w \times (d_{L5} - d_w) = \mathbf{42.8 \text{ kN/m}^2} \\p'_{a52} &= K_{a3} \times OB'_{a52} + \gamma_G \times \gamma_w \times (d_{L5} - d_w) = \mathbf{42.8 \text{ kN/m}^2} \\p'_{a61} &= K_{a3} \times OB'_{a61} + \gamma_G \times \gamma_w \times (d_{L6} - d_w) = \mathbf{57.6 \text{ kN/m}^2}\end{aligned}$$



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Active at 3930 mm below GL in soil 4

$$p'_{a62} = K_{a4} \times OB'_{a62} + \gamma_G \times \gamma_w \times (d_{L6} - d_w) = \mathbf{57.6 \text{ kN/m}^2}$$

Active at 4962 mm below GL in soil 4

$$p'_{a71} = K_{a4} \times OB'_{a71} + \gamma_G \times \gamma_w \times (d_{L7} - d_w) = \mathbf{75.1 \text{ kN/m}^2}$$

Pressure on passive side

Passive at 2370 mm below GL in soil 2

$$p'_{p41} = K_{p2} \times OB'_{p41} + \gamma_{G,f} \times \gamma_w \times (d_{L4} - \max(d_s, d_w)) = \mathbf{0.0 \text{ kN/m}^2}$$

Passive at 3030 mm below GL in soil 2

$$p'_{p51} = K_{p2} \times OB'_{p51} + \gamma_{G,f} \times \gamma_w \times (d_{L5} - \max(d_s, d_w)) = \mathbf{67.1 \text{ kN/m}^2}$$

Passive at 3030 mm below GL in soil 3

$$p'_{p52} = K_{p3} \times OB'_{p52} + \gamma_{G,f} \times \gamma_w \times (d_{L5} - \max(d_s, d_w)) = \mathbf{67.1 \text{ kN/m}^2}$$

Passive at 3930 mm below GL in soil 3

$$p'_{p61} = K_{p3} \times OB'_{p61} + \gamma_{G,f} \times \gamma_w \times (d_{L6} - \max(d_s, d_w)) = \mathbf{142.3 \text{ kN/m}^2}$$

Passive at 3930 mm below GL in soil 4

$$p'_{p62} = K_{p4} \times OB'_{p62} + \gamma_{G,f} \times \gamma_w \times (d_{L6} - \max(d_s, d_w)) = \mathbf{142.3 \text{ kN/m}^2}$$

Passive at 4962 mm below GL in soil 4

$$p'_{p71} = K_{p4} \times OB'_{p71} + \gamma_{G,f} \times \gamma_w \times (d_{L7} - \max(d_s, d_w)) = \mathbf{237.8 \text{ kN/m}^2}$$

By iteration the depth at which the active moments equal the passive moments has been determined as 4960 mm as follows:-

Active moment about 4960 mm

Moment level 1

$$M_{a11} = 0.5 \times p'_{a11} \times h_{a1} \times ((H - d_{L2}) + 2/3 \times h_{a1}) = \mathbf{6.3 \text{ kNm/m}}$$

Moment level 1

$$M_{a12} = 0.5 \times p'_{a21} \times h_{a1} \times ((H - d_{L2}) + 1/3 \times h_{a1}) = \mathbf{12.3 \text{ kNm/m}}$$

Moment level 2

$$M_{a21} = 0.5 \times p'_{a22} \times h_{a2} \times ((H - d_{L3}) + 2/3 \times h_{a2}) = \mathbf{12.7 \text{ kNm/m}}$$

Moment level 2

$$M_{a22} = 0.5 \times p'_{a31} \times h_{a2} \times ((H - d_{L3}) + 1/3 \times h_{a2}) = \mathbf{19.0 \text{ kNm/m}}$$

Moment level 3

$$M_{a31} = 0.5 \times p'_{a31} \times h_{a3} \times ((H - d_{L4}) + 2/3 \times h_{a3}) = \mathbf{22.8 \text{ kNm/m}}$$

Moment level 3

$$M_{a32} = 0.5 \times p'_{a41} \times h_{a3} \times ((H - d_{L4}) + 1/3 \times h_{a3}) = \mathbf{46.8 \text{ kNm/m}}$$

Moment level 4

$$M_{a41} = 0.5 \times p'_{a41} \times h_{a4} \times ((H - d_{L5}) + 2/3 \times h_{a4}) = \mathbf{24.5 \text{ kNm/m}}$$

Moment level 4

$$M_{a42} = 0.5 \times p'_{a51} \times h_{a4} \times ((H - d_{L5}) + 1/3 \times h_{a4}) = \mathbf{30.3 \text{ kNm/m}}$$

Moment level 5

$$M_{a51} = 0.5 \times p'_{a52} \times h_{a5} \times ((H - d_{L6}) + 2/3 \times h_{a5}) = \mathbf{31.4 \text{ kNm/m}}$$

Moment level 5

$$M_{a52} = 0.5 \times p'_{a61} \times h_{a5} \times ((H - d_{L6}) + 1/3 \times h_{a5}) = \mathbf{34.5 \text{ kNm/m}}$$

Moment level 6

$$M_{a61} = 0.5 \times p'_{a62} \times h_{a6} \times ((H - d_{L7}) + 2/3 \times h_{a6}) = \mathbf{20.4 \text{ kNm/m}}$$

Moment level 6

$$M_{a62} = 0.5 \times p'_{a71} \times h_{a6} \times ((H - d_{L7}) + 1/3 \times h_{a6}) = \mathbf{13.3 \text{ kNm/m}}$$

Passive moment about 4960 mm

Moment level 4

$$M_{p41} = 0.5 \times p'_{p41} \times h_{p4} \times ((H - d_{L5}) + 2/3 \times h_{p4}) = \mathbf{0.0 \text{ kNm/m}}$$

Moment level 4

$$M_{p42} = 0.5 \times p'_{p51} \times h_{p4} \times ((H - d_{L5}) + 1/3 \times h_{p4}) = \mathbf{47.6 \text{ kNm/m}}$$

Moment level 5

$$M_{p51} = 0.5 \times p'_{p52} \times h_{p5} \times ((H - d_{L6}) + 2/3 \times h_{p5}) = \mathbf{49.2 \text{ kNm/m}}$$

Moment level 5

$$M_{p52} = 0.5 \times p'_{p61} \times h_{p5} \times ((H - d_{L6}) + 1/3 \times h_{p5}) = \mathbf{85.2 \text{ kNm/m}}$$

Moment level 6

$$M_{p61} = 0.5 \times p'_{p62} \times h_{p6} \times ((H - d_{L7}) + 2/3 \times h_{p6}) = \mathbf{50.3 \text{ kNm/m}}$$

Moment level 6

$$M_{p62} = 0.5 \times p'_{p71} \times h_{p6} \times ((H - d_{L7}) + 1/3 \times h_{p6}) = \mathbf{42.0 \text{ kNm/m}}$$

Total moments about 4960 mm

Total active moment

$$\Sigma M_a = \mathbf{274.6 \text{ kNm/m}}$$

Total passive moment

$$\Sigma M_p = \mathbf{274.9 \text{ kNm/m}}$$

Required pile length

Length of pile required to balance moments

$$H = \mathbf{4960 \text{ mm}}$$

Depth of equal pressure

$$d_{\text{contra}} = \mathbf{2742 \text{ mm}}$$

Add 20% below this point

$$d_{e_add} = 1.2 \times (H - d_{\text{contra}}) = \mathbf{2662 \text{ mm}}$$

Minimum required pile length

$$H_{\text{total}} = d_{\text{contra}} + d_{e_add} = \mathbf{5404 \text{ mm}}$$

Pass - Provided length of sheet pile greater than minimum required length of pile

Pile capacity (EN1993-5)

Maximum moment in pile (from analysis)

$$M_{\text{pile}} = \max(\text{abs}(M_{\text{min}}), \text{abs}(M_{\text{max}})) / 1\text{m} = \mathbf{71.6 \text{ kNm/m}}$$

Maximum shear force in pile (from analysis)

$$V_{\text{pile}} = \mathbf{139.2 \text{ kN/m}}$$

Nominal yield strength of pile

$$f_{y_pile} = \mathbf{240 \text{ N/mm}^2}$$

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User defined section

Plastic modulus of pile	$W_{pl,y} = 2010 \text{ cm}^3/\text{m}$
Thickness of web	$s = 6.1 \text{ mm}$
Thickness of flange	$t = 12.2 \text{ mm}$
Overall height	$h = 381 \text{ mm}$
Section width	$b = 400 \text{ mm}$
Web incline angle	$\alpha_{pile} = 67.0 \text{ deg}$

Shear buckling of web (cl.5.2.2(6))

Width of section	$c = (h - t) / \sin(\alpha_{pile}) = 401 \text{ mm}$
Thickness of web	$t_w = s = 6.1 \text{ mm}$
	$\varepsilon = \sqrt{(235 \text{ N/mm}^2 / f_{y_pile})} = 0.990$
	$c / t_w = 65.7 = 66.4 \times \varepsilon \leq 72 \times \varepsilon$

PASS - Shear buckling of web within limits

Bending

Interlock reduction factor (cl.5.2.2)	$\beta_B = 0.8$
Design bending resistance (eqn.5.2)	$M_{c,Rd} = W_{pl,y} \times f_{y_pile} \times \beta_B / \gamma_{M0} = 385.9 \text{ kNm/m}$

PASS - Moment capacity exceeds moment in pile

Shear

Projected shear area of web (eqn.5.6)	$A_v = s \times (h - t) = 2250 \text{ mm}^2$
Design shear resistance (eqn.5.5)	$V_{pl,Rd} = A_v \times f_{y_pile} / (\sqrt{3}) \times \gamma_{M0} / b = 779.3 \text{ kN/m}$

PASS - Shear capacity exceeds shear in pile

Partial factors on actions - Section A.3.1 - Combination 2

Permanent unfavourable action	$\gamma_G = 1.00$
Permanent favourable action	$\gamma_{G,f} = 1.00$
Variable unfavourable action	$\gamma_Q = 1.30$
Angle of shearing resistance	$\gamma_{\phi'} = 1.25$
Weight density	$\gamma_\gamma = 1.00$

Design soil properties - soil 1

Design effective shearing resistance angle	$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = 24.8 \text{ deg}$
Design wall friction angle	$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = 23.0 \text{ deg}$
Design moist density of retained soil	$\gamma_{m,d1} = \gamma_m / \gamma_\gamma = 17.5 \text{ kN/m}^3$
Design saturated density of retained soil	$\gamma_{s,d1} = \gamma_s / \gamma_\gamma = 21.0 \text{ kN/m}^3$
Design buoyant density of retained soil	$\gamma_{d,d1} = \gamma_{s,d1} - \gamma_w = 11.2 \text{ kN/m}^3$
Active pressure using Coulomb theory	$K_{a1} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta)))})^2) = 0.358$
Passive pressure using Coulomb theory	$K_{p1} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d)))})^2] = 5.106$

Design soil properties - soil 2

Design effective shearing resistance angle	$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = 24.8 \text{ deg}$
Design wall friction angle	$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = 23.0 \text{ deg}$
Design moist density of retained soil	$\gamma_{m,d2} = \gamma_m / \gamma_\gamma = 17.5 \text{ kN/m}^3$
Design saturated density of retained soil	$\gamma_{s,d2} = \gamma_s / \gamma_\gamma = 20.0 \text{ kN/m}^3$
Design buoyant density of retained soil	$\gamma_{d,d2} = \gamma_{s,d2} - \gamma_w = 10.2 \text{ kN/m}^3$

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Active pressure using Coulomb theory

$$K_{a2} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.358}$$

Passive pressure using Coulomb theory

$$K_{p2} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{5.106}$$

Design soil properties - soil 3

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = \mathbf{24.8 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = \mathbf{23.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d3} = \gamma_m / \gamma_r = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d3} = \gamma_s / \gamma_r = \mathbf{18.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d3} = \gamma_{s.d3} - \gamma_w = \mathbf{8.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a3} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.358}$$

Passive pressure using Coulomb theory

$$K_{p3} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{5.106}$$

Design soil properties - soil 4

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = \mathbf{24.8 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = \mathbf{23.0 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d4} = \gamma_m / \gamma_r = \mathbf{15.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d4} = \gamma_s / \gamma_r = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d4} = \gamma_{s.d4} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a4} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.358}$$

Passive pressure using Coulomb theory

$$K_{p4} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{5.106}$$

Design soil properties - soil 5

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = \mathbf{24.8 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = \mathbf{20.5 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d5} = \gamma_m / \gamma_r = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d5} = \gamma_s / \gamma_r = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d5} = \gamma_{s.d5} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

$$K_{a5} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.360}$$

Passive pressure using Coulomb theory

$$K_{p5} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = \mathbf{4.622}$$

Design soil properties - soil 6

Design effective shearing resistance angle

$$\phi'_d = \text{Atan}(\tan(\phi'_k) / \gamma_{\phi'}) = \mathbf{24.8 \text{ deg}}$$

Design wall friction angle

$$\delta_d = \text{atan}(\tan(\delta_k) / \gamma_{\phi'}) = \mathbf{24.8 \text{ deg}}$$

Design moist density of retained soil

$$\gamma_{m.d6} = \gamma_m / \gamma_r = \mathbf{14.0 \text{ kN/m}^3}$$

Design saturated density of retained soil

$$\gamma_{s.d6} = \gamma_s / \gamma_r = \mathbf{19.0 \text{ kN/m}^3}$$

Design buoyant density of retained soil

$$\gamma_{d.d6} = \gamma_{s.d6} - \gamma_w = \mathbf{9.2 \text{ kN/m}^3}$$

Active pressure using Coulomb theory

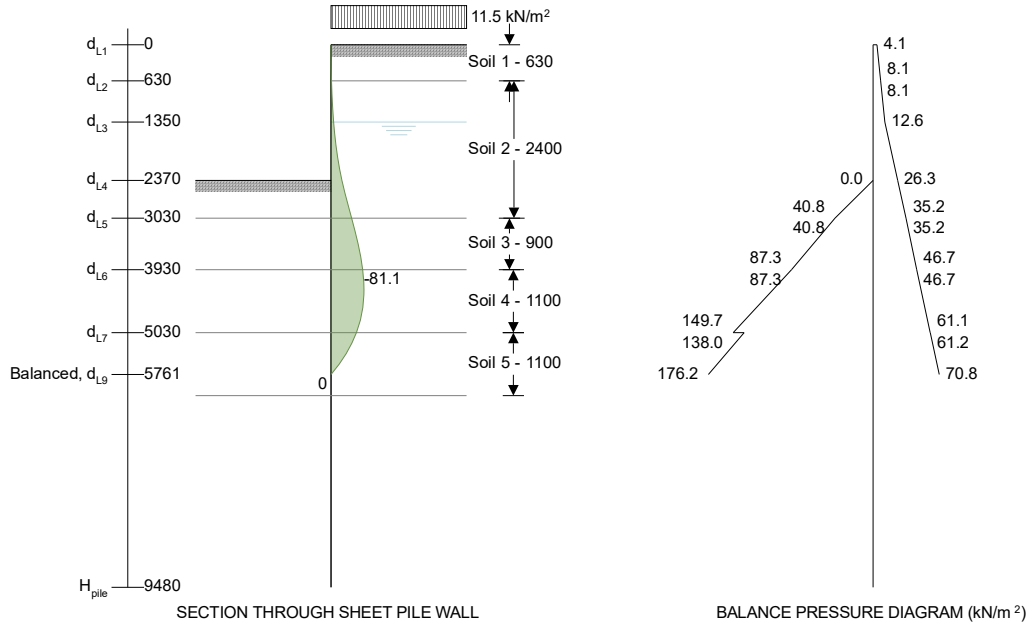
$$K_{a6} = \sin(\alpha + \phi'_d)^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta_d) \times (1 + \sqrt{(\sin(\phi'_d + \delta_d) \times \sin(\phi'_d - \beta) / (\sin(\alpha - \delta_d) \times \sin(\alpha + \beta))}))^2) = \mathbf{0.358}$$



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Passive pressure using Coulomb theory

$$K_{p6} = \sin(90 - \phi'_d)^2 / (\sin(90 + \delta_d) \times [1 - \sqrt{\sin(\phi'_d + \delta_d) \times \sin(\phi'_d) / (\sin(90 + \delta_d))}]^2) = 5.480$$



Overburden on active side

Overburden at 0 mm below GL in soil 1
Overburden at 630 mm below GL in soil 1
Overburden at 630 mm below GL in soil 2
Overburden at 1350 mm below GL in soil 2
Overburden at 2370 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 4
Overburden at 5030 mm below GL in soil 4
Overburden at 5030 mm below GL in soil 5
Overburden at 5761 mm below GL in soil 5

$$\begin{aligned} OB'_{a11} &= (p_{o,G} \times \gamma_G + p_{o,Q} \times \gamma_Q) = 11.5 \text{ kN/m}^2 \\ OB'_{a21} &= \gamma_G \times \gamma_{m,d1} \times h_{a1} + OB'_{a11} = 22.5 \text{ kN/m}^2 \\ OB'_{a22} &= \gamma_G \times \gamma_{m,d1} \times h_{a1} + OB'_{a11} = 22.5 \text{ kN/m}^2 \\ OB'_{a31} &= \gamma_G \times \gamma_{m,d2} \times h_{a2} + OB'_{a22} = 35.1 \text{ kN/m}^2 \\ OB'_{a41} &= \gamma_G \times \gamma_{d,d2} \times h_{a3} + OB'_{a31} = 45.5 \text{ kN/m}^2 \\ OB'_{a51} &= \gamma_G \times \gamma_{d,d2} \times h_{a4} + OB'_{a41} = 52.2 \text{ kN/m}^2 \\ OB'_{a52} &= \gamma_G \times \gamma_{d,d2} \times h_{a4} + OB'_{a41} = 52.2 \text{ kN/m}^2 \\ OB'_{a61} &= \gamma_G \times \gamma_{d,d3} \times h_{a5} + OB'_{a52} = 59.6 \text{ kN/m}^2 \\ OB'_{a62} &= \gamma_G \times \gamma_{d,d3} \times h_{a5} + OB'_{a52} = 59.6 \text{ kN/m}^2 \\ OB'_{a71} &= \gamma_G \times \gamma_{d,d4} \times h_{a6} + OB'_{a62} = 69.7 \text{ kN/m}^2 \\ OB'_{a72} &= \gamma_G \times \gamma_{d,d4} \times h_{a6} + OB'_{a62} = 69.7 \text{ kN/m}^2 \\ OB'_{a81} &= \gamma_G \times \gamma_{d,d5} \times h_{a7} + OB'_{a72} = 76.4 \text{ kN/m}^2 \end{aligned}$$

Overburden on passive side

Overburden at 2370 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 2
Overburden at 3030 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 3
Overburden at 3930 mm below GL in soil 4
Overburden at 5030 mm below GL in soil 4
Overburden at 5030 mm below GL in soil 5
Overburden at 5761 mm below GL in soil 5

$$\begin{aligned} OB'_{p41} &= 0 \text{ kN/m}^2 = 0.0 \text{ kN/m}^2 \\ OB'_{p51} &= \gamma_{G,f} \times \gamma_{d,d2} \times h_{p4} + OB'_{p41} = 6.7 \text{ kN/m}^2 \\ OB'_{p52} &= \gamma_{G,f} \times \gamma_{d,d2} \times h_{p4} + OB'_{p41} = 6.7 \text{ kN/m}^2 \\ OB'_{p61} &= \gamma_{G,f} \times \gamma_{d,d3} \times h_{p5} + OB'_{p52} = 14.1 \text{ kN/m}^2 \\ OB'_{p62} &= \gamma_{G,f} \times \gamma_{d,d3} \times h_{p5} + OB'_{p52} = 14.1 \text{ kN/m}^2 \\ OB'_{p71} &= \gamma_{G,f} \times \gamma_{d,d4} \times h_{p6} + OB'_{p62} = 24.2 \text{ kN/m}^2 \\ OB'_{p72} &= \gamma_{G,f} \times \gamma_{d,d4} \times h_{p6} + OB'_{p62} = 24.2 \text{ kN/m}^2 \\ OB'_{p81} &= \gamma_{G,f} \times \gamma_{d,d5} \times h_{p7} + OB'_{p72} = 30.9 \text{ kN/m}^2 \end{aligned}$$

Pressure on active side

Active at 0 mm below GL in soil 1
Active at 630 mm below GL in soil 1

$$\begin{aligned} p'_{a11} &= K_{a1} \times OB'_{a11} = 4.1 \text{ kN/m}^2 \\ p'_{a21} &= K_{a1} \times OB'_{a21} = 8.1 \text{ kN/m}^2 \end{aligned}$$



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Active at 630 mm below GL in soil 2
Active at 1350 mm below GL in soil 2
Active at 2370 mm below GL in soil 2
Active at 3030 mm below GL in soil 2
Active at 3030 mm below GL in soil 3
Active at 3930 mm below GL in soil 3
Active at 3930 mm below GL in soil 4
Active at 5030 mm below GL in soil 4
Active at 5030 mm below GL in soil 5
Active at 5761 mm below GL in soil 5

$$\begin{aligned}p'_{a22} &= K_{a2} \times OB'_{a22} = \mathbf{8.1 \text{ kN/m}^2} \\p'_{a31} &= K_{a2} \times OB'_{a31} = \mathbf{12.6 \text{ kN/m}^2} \\p'_{a41} &= K_{a2} \times OB'_{a41} + \gamma_G \times \gamma_w \times (d_{L4} - d_w) = \mathbf{26.3 \text{ kN/m}^2} \\p'_{a51} &= K_{a2} \times OB'_{a51} + \gamma_G \times \gamma_w \times (d_{L5} - d_w) = \mathbf{35.2 \text{ kN/m}^2} \\p'_{a52} &= K_{a3} \times OB'_{a52} + \gamma_G \times \gamma_w \times (d_{L5} - d_w) = \mathbf{35.2 \text{ kN/m}^2} \\p'_{a61} &= K_{a3} \times OB'_{a61} + \gamma_G \times \gamma_w \times (d_{L6} - d_w) = \mathbf{46.7 \text{ kN/m}^2} \\p'_{a62} &= K_{a4} \times OB'_{a62} + \gamma_G \times \gamma_w \times (d_{L6} - d_w) = \mathbf{46.7 \text{ kN/m}^2} \\p'_{a71} &= K_{a4} \times OB'_{a71} + \gamma_G \times \gamma_w \times (d_{L7} - d_w) = \mathbf{61.1 \text{ kN/m}^2} \\p'_{a72} &= K_{a5} \times OB'_{a72} + \gamma_G \times \gamma_w \times (d_{L7} - d_w) = \mathbf{61.2 \text{ kN/m}^2} \\p'_{a81} &= K_{a5} \times OB'_{a81} + \gamma_G \times \gamma_w \times (d_{L8} - d_w) = \mathbf{70.8 \text{ kN/m}^2}\end{aligned}$$

Pressure on passive side

Passive at 2370 mm below GL in soil 2
Passive at 3030 mm below GL in soil 2
Passive at 3030 mm below GL in soil 3
Passive at 3930 mm below GL in soil 3
Passive at 3930 mm below GL in soil 4
Passive at 5030 mm below GL in soil 4
Passive at 5030 mm below GL in soil 5
Passive at 5761 mm below GL in soil 5

$$\begin{aligned}p'_{p41} &= K_{p2} \times OB'_{p41} + \gamma_{G,f} \times \gamma_w \times (d_{L4} - \max(d_s, d_w)) = \mathbf{0.0 \text{ kN/m}^2} \\p'_{p51} &= K_{p2} \times OB'_{p51} + \gamma_{G,f} \times \gamma_w \times (d_{L5} - \max(d_s, d_w)) = \mathbf{40.8 \text{ kN/m}^2} \\p'_{p52} &= K_{p3} \times OB'_{p52} + \gamma_{G,f} \times \gamma_w \times (d_{L5} - \max(d_s, d_w)) = \mathbf{40.8 \text{ kN/m}^2} \\p'_{p61} &= K_{p3} \times OB'_{p61} + \gamma_{G,f} \times \gamma_w \times (d_{L6} - \max(d_s, d_w)) = \mathbf{87.3 \text{ kN/m}^2} \\p'_{p62} &= K_{p4} \times OB'_{p62} + \gamma_{G,f} \times \gamma_w \times (d_{L6} - \max(d_s, d_w)) = \mathbf{87.3 \text{ kN/m}^2} \\p'_{p71} &= K_{p4} \times OB'_{p71} + \gamma_{G,f} \times \gamma_w \times (d_{L7} - \max(d_s, d_w)) = \mathbf{149.7 \text{ kN/m}^2} \\p'_{p72} &= K_{p5} \times OB'_{p72} + \gamma_{G,f} \times \gamma_w \times (d_{L7} - \max(d_s, d_w)) = \mathbf{138.0 \text{ kN/m}^2} \\p'_{p81} &= K_{p5} \times OB'_{p81} + \gamma_{G,f} \times \gamma_w \times (d_{L8} - \max(d_s, d_w)) = \mathbf{176.2 \text{ kN/m}^2}\end{aligned}$$

By iteration the depth at which the active moments equal the passive moments has been determined as 5761 mm as follows:-

Active moment about 5761 mm

Moment level 1
Moment level 1
Moment level 2
Moment level 2
Moment level 3
Moment level 3
Moment level 4
Moment level 4
Moment level 5
Moment level 5
Moment level 6
Moment level 6
Moment level 7
Moment level 7

$$\begin{aligned}M_{a11} &= 0.5 \times p'_{a11} \times h_{a1} \times ((H - d_{L2}) + 2/3 \times h_{a1}) = \mathbf{7.2 \text{ kNm/m}} \\M_{a12} &= 0.5 \times p'_{a21} \times h_{a1} \times ((H - d_{L2}) + 1/3 \times h_{a1}) = \mathbf{13.6 \text{ kNm/m}} \\M_{a21} &= 0.5 \times p'_{a22} \times h_{a2} \times ((H - d_{L3}) + 2/3 \times h_{a2}) = \mathbf{14.2 \text{ kNm/m}} \\M_{a22} &= 0.5 \times p'_{a31} \times h_{a2} \times ((H - d_{L3}) + 1/3 \times h_{a2}) = \mathbf{21.1 \text{ kNm/m}} \\M_{a31} &= 0.5 \times p'_{a31} \times h_{a3} \times ((H - d_{L4}) + 2/3 \times h_{a3}) = \mathbf{26.1 \text{ kNm/m}} \\M_{a32} &= 0.5 \times p'_{a41} \times h_{a3} \times ((H - d_{L4}) + 1/3 \times h_{a3}) = \mathbf{50.1 \text{ kNm/m}} \\M_{a41} &= 0.5 \times p'_{a41} \times h_{a4} \times ((H - d_{L5}) + 2/3 \times h_{a4}) = \mathbf{27.5 \text{ kNm/m}} \\M_{a42} &= 0.5 \times p'_{a51} \times h_{a4} \times ((H - d_{L5}) + 1/3 \times h_{a4}) = \mathbf{34.3 \text{ kNm/m}} \\M_{a51} &= 0.5 \times p'_{a52} \times h_{a5} \times ((H - d_{L6}) + 2/3 \times h_{a5}) = \mathbf{38.5 \text{ kNm/m}} \\M_{a52} &= 0.5 \times p'_{a61} \times h_{a5} \times ((H - d_{L6}) + 1/3 \times h_{a5}) = \mathbf{44.8 \text{ kNm/m}} \\M_{a61} &= 0.5 \times p'_{a62} \times h_{a6} \times ((H - d_{L7}) + 2/3 \times h_{a6}) = \mathbf{37.6 \text{ kNm/m}} \\M_{a62} &= 0.5 \times p'_{a71} \times h_{a6} \times ((H - d_{L7}) + 1/3 \times h_{a6}) = \mathbf{36.9 \text{ kNm/m}} \\M_{a71} &= 0.5 \times p'_{a72} \times h_{a7} \times ((H - d_{L8}) + 2/3 \times h_{a7}) = \mathbf{10.9 \text{ kNm/m}} \\M_{a72} &= 0.5 \times p'_{a81} \times h_{a7} \times ((H - d_{L8}) + 1/3 \times h_{a7}) = \mathbf{6.3 \text{ kNm/m}}\end{aligned}$$

Passive moment about 5761 mm

Moment level 4
Moment level 4
Moment level 5
Moment level 5
Moment level 6
Moment level 6

$$\begin{aligned}M_{p41} &= 0.5 \times p'_{p41} \times h_{p4} \times ((H - d_{L5}) + 2/3 \times h_{p4}) = \mathbf{0.0 \text{ kNm/m}} \\M_{p42} &= 0.5 \times p'_{p51} \times h_{p4} \times ((H - d_{L5}) + 1/3 \times h_{p4}) = \mathbf{39.7 \text{ kNm/m}} \\M_{p51} &= 0.5 \times p'_{p52} \times h_{p5} \times ((H - d_{L6}) + 2/3 \times h_{p5}) = \mathbf{44.6 \text{ kNm/m}} \\M_{p52} &= 0.5 \times p'_{p61} \times h_{p5} \times ((H - d_{L6}) + 1/3 \times h_{p5}) = \mathbf{83.7 \text{ kNm/m}} \\M_{p61} &= 0.5 \times p'_{p62} \times h_{p6} \times ((H - d_{L7}) + 2/3 \times h_{p6}) = \mathbf{70.3 \text{ kNm/m}} \\M_{p62} &= 0.5 \times p'_{p71} \times h_{p6} \times ((H - d_{L7}) + 1/3 \times h_{p6}) = \mathbf{90.4 \text{ kNm/m}}\end{aligned}$$



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Moment level 7

$$M_{p71} = 0.5 \times p'_{p72} \times h_{p7} \times ((H - d_{L8}) + 2/3 \times h_{p7}) = \mathbf{24.6 \text{ kNm/m}}$$

Moment level 7

$$M_{p72} = 0.5 \times p'_{p81} \times h_{p7} \times ((H - d_{L8}) + 1/3 \times h_{p7}) = \mathbf{15.7 \text{ kNm/m}}$$

Total moments about 5761 mm

Total active moment

$$\Sigma M_a = \mathbf{369.1 \text{ kNm/m}}$$

Total passive moment

$$\Sigma M_p = \mathbf{369.2 \text{ kNm/m}}$$

Required pile length

Length of pile required to balance moments

$$H = \mathbf{5761 \text{ mm}}$$

Depth of equal pressure

$$d_{\text{contra}} = \mathbf{2914 \text{ mm}}$$

Add 20% below this point

$$d_{e_add} = 1.2 \times (H - d_{\text{contra}}) = \mathbf{3416 \text{ mm}}$$

Minimum required pile length

$$H_{\text{total}} = d_{\text{contra}} + d_{e_add} = \mathbf{6330 \text{ mm}}$$

Pass - Provided length of sheet pile greater than minimum required length of pile

Pile capacity (EN1993-5)

Maximum moment in pile (from analysis)

$$M_{\text{pile}} = \max(\text{abs}(M_{\text{min}}), \text{abs}(M_{\text{max}})) / 1\text{m} = \mathbf{81.1 \text{ kNm/m}}$$

Maximum shear force in pile (from analysis)

$$V_{\text{pile}} = \mathbf{120.5 \text{ kN/m}}$$

Nominal yield strength of pile

$$f_{y_pile} = \mathbf{240 \text{ N/mm}^2}$$

User defined section

Plastic modulus of pile

$$W_{pl,y} = \mathbf{2010 \text{ cm}^3/\text{m}}$$

Thickness of web

$$s = \mathbf{6.1 \text{ mm}}$$

Thickness of flange

$$t = \mathbf{12.2 \text{ mm}}$$

Overall height

$$h = \mathbf{381 \text{ mm}}$$

Section width

$$b = \mathbf{400 \text{ mm}}$$

Web incline angle

$$\alpha_{\text{pile}} = \mathbf{67.0 \text{ deg}}$$

Shear buckling of web (cl.5.2.2(6))

Width of section

$$c = (h - t) / \sin(\alpha_{\text{pile}}) = \mathbf{401 \text{ mm}}$$

Thickness of web

$$t_w = s = \mathbf{6.1 \text{ mm}}$$

$$\varepsilon = \sqrt{(235 \text{ N/mm}^2 / f_{y_pile})} = \mathbf{0.990}$$

$$c / t_w = 65.7 = 66.4 \times \varepsilon \leq 72 \times \varepsilon$$

PASS - Shear buckling of web within limits

Bending

Interlock reduction factor (cl.5.2.2)

$$\beta_B = \mathbf{0.8}$$

Design bending resistance (eqn.5.2)

$$M_{c,Rd} = W_{pl,y} \times f_{y_pile} \times \beta_B / \gamma_{M0} = \mathbf{385.9 \text{ kNm/m}}$$

PASS - Moment capacity exceeds moment in pile

Shear

Projected shear area of web (eqn.5.6)

$$A_v = s \times (h - t) = \mathbf{2250 \text{ mm}^2}$$

Design shear resistance (eqn.5.5)

$$V_{pl,Rd} = A_v \times f_{y_pile} / (\sqrt{3} \times \gamma_{M0}) / b = \mathbf{779.3 \text{ kN/m}}$$

PASS - Shear capacity exceeds shear in pile