Worked example – anchored sheet pile wall

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Chairman TC250/SC7

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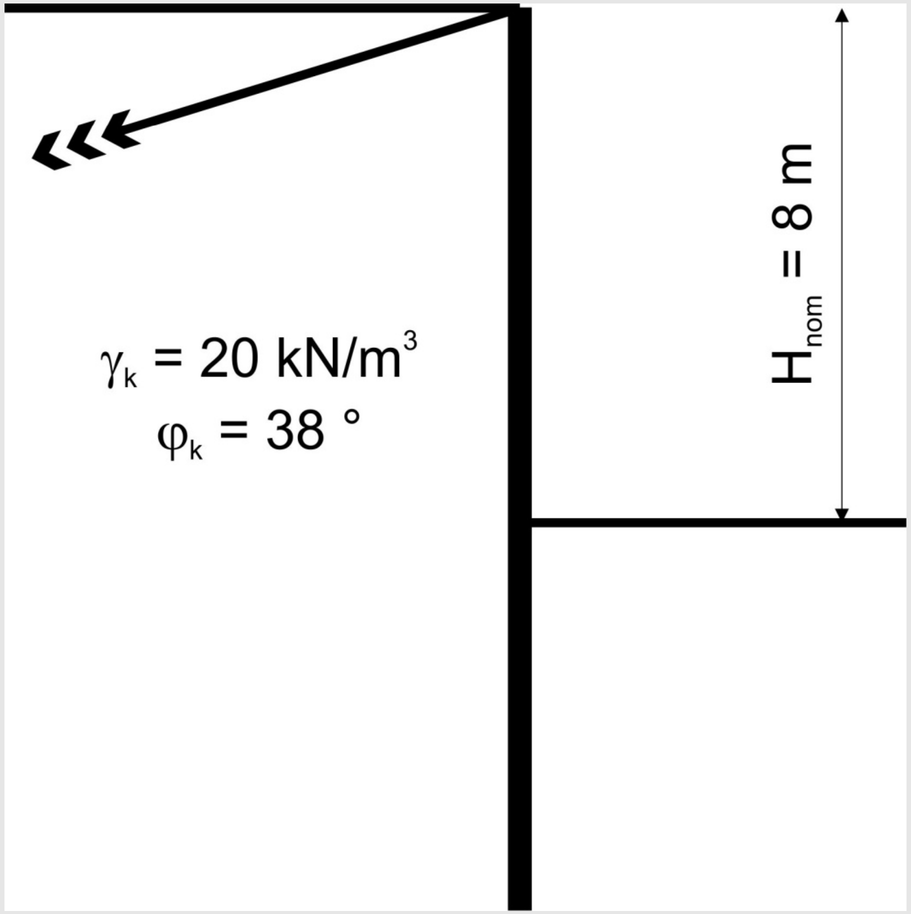
DESIGN SITUATION

Design situation for anchored sheet pile wall



Earth pressure theory

Use Brinch Hansen's equation for $K_{a,h}$ (for a vertical wall):

$$K_{a,\beta} = \left(\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\varphi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\varphi}} \right) \cos\beta$$

Horizontal and vertical component of K_a are:

$$K_{a,h} = K_{a,\beta} \times \cos\beta$$

$$K_{a,v} = K_{a,\beta} \times \sin\beta \left(= K_{a,h} \times \tan\beta \right)$$

Some numbers to save you time...

Self-weight of wall stem

$$W_{stem,k} = \gamma_{c,k} \times t_s \times H$$
$$= 25 \times 0.7 \times 6 = 105 kN/m$$

Self-weight of wall base

$$W_{base,k} = \gamma_{c,k} \times t_b \times B$$
$$= 25 \times 0.8 \times 3.9 = 78 kN/m$$

Self-weight of backfill

$$W_{fill,k} = \gamma_k \times b_{heel} \times \left(\frac{H + h_f}{2} \right)$$
$$= 19 \times 2.25 \times \left(\frac{6 + 6.82}{2} \right) = 274 kN/m$$

Earth pressure coefficients

φ	N_q	φ	N_q
20	6.4	30	18.4
21	7.1	31	20.6
22	7.8	32	23.2
23	8.7	33	26.1
24	9.6	34	29.4
25	10.7	35	33.3
26	11.9	36	37.8
27	13.2	37	42.9
28	14.7	38	48.9
29	16.4	39	56.0

Worksheet DA1 / DA2* – anchored sheet pile

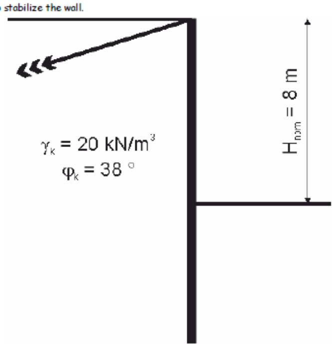
Example JRC-07
Anchored sheet pile wall
Verification of drained strength (limit state GEO)
Design Approach 1

Design situation

Consider a sheet pile wall that retains $H_{nom} = 8.0m$ of dense sand with characteristic weight density $\gamma_k = 20\frac{kN}{m^3}$ and drained angle of shearing resistance $\varphi_k = 38°$. The ground behind the wall is horizontal and subject to a blanket surcharge (representing traffic loading) - but, for simplificty, we will assume $q_k = 0kPa$. The ground is dry.

The sheet pile is a Z section with flange thickness $t_f = 8.5mm$, web thickness $t_w = 8.5mm$, web height $h = 302mm$, clutch-to-clutch breadth $b = 670mm$, elastic section modulus $W_{el} = 1400\frac{cm^3}{m}$, and characteristic yield strength $f_{yk} = 355MPa$.

An anchor with ultimate design resistance of $R_{a,d} = 130\frac{kN}{m}$ will be installed at an angle $\theta = 30°$ to the horizontal to stabilize the wall.



Geometry

Allowing for an unplanned excavation in ULS verifications, the design retained height of the wall is:

$$H_d = H_{nom} + \min(10\% \times H_{nom}, 0.5m) = ▪$$

Material properties

Partial factors from Set $\begin{pmatrix} M1 \\ M2 \end{pmatrix}$: $\gamma_\varphi = ▪$

Calculate:

1. Earth pressure coefficients K_a and K_p
2. Overturning and restoring moments about anchor
3. Depth of embedment needed to ensure equilibrium
4. Maximum bending moment and shear force along the wall
5. Required anchor resistance
6. Bending and shear resistance of sheet pile section

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SOLUTION

Solutions DA1 / DA2* – anchored sheet pile

Verification	DA1		DA2*
	DA1-1	DA1-2	
Depth of embedment	1.38 m	2.01 m	2.05 m
Bending moment	296 kNm/m	303 kNm/m	331 kNm/m
Shear force	81.9 kN/m	81.7 kN/m	88.2 kN/m
Anchor resistance needed	81.9 kN/m	81.7 kN/m	88.2 kN/m

Summary of key points

DAs 1 and 2* produce very similar depths of embedment, maximum bending moment and shear force along the wall, and required anchor resistance.

A subtlety of DA1 is that Combination 1 can quite often produce a larger anchor force (and shear force and bending moment) that Combination 2 – because the depth of embedment for equilibrium is so much shorter

In standard DEU practice, rectangular earth pressure distributions are favoured over triangular – these result in larger anchor forces but smaller bending moments blog.eurocode7.com

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