Rekayasa Pondasi II

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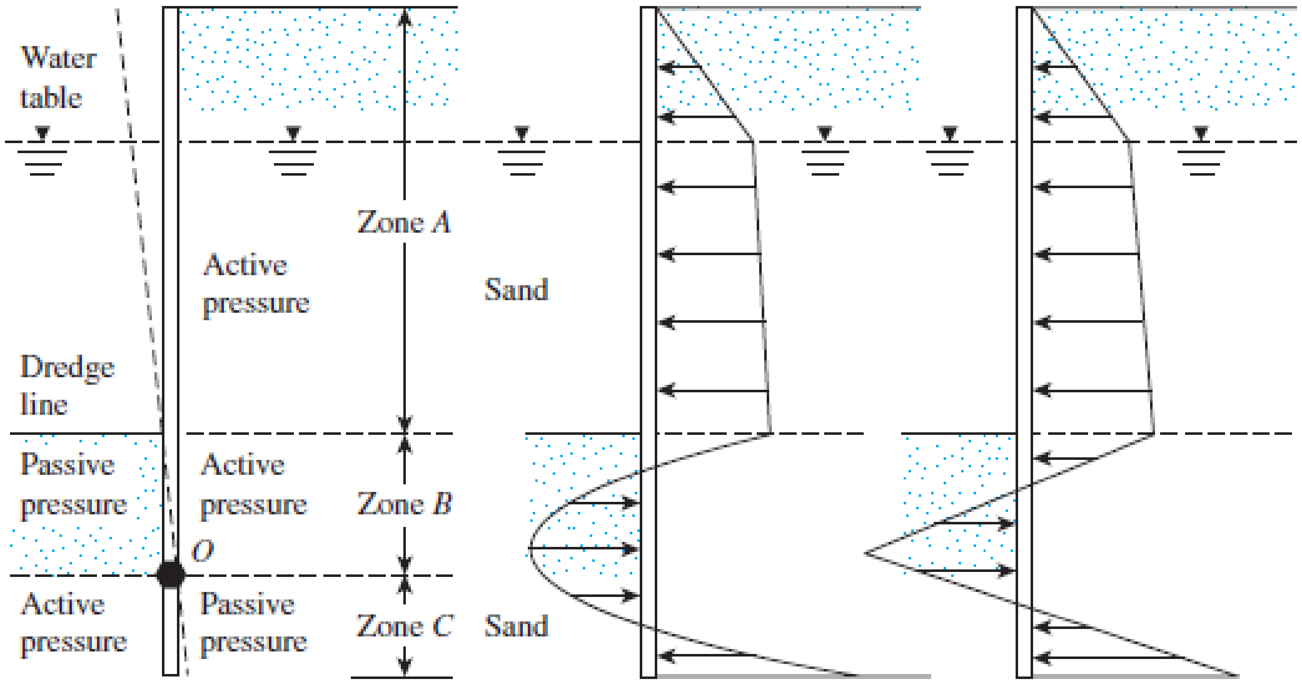
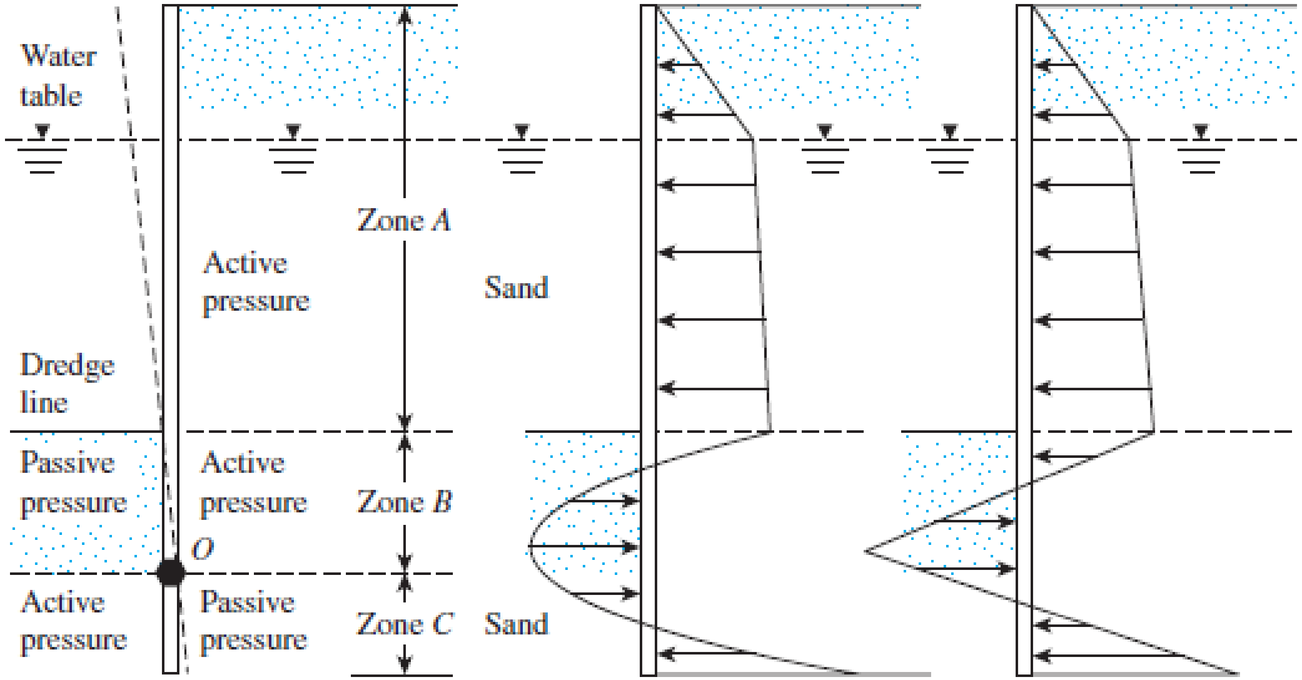
Cantilever Sheet Pile wall



- Moderate height about 6 m or less
- Similar behavior as a wide cantilever beam
- The wall rotate about point **O**
- The hydrostatic pressure at any depth of both sides of the wall will cancel each other
- For calculation, we only consider the effective lateral soil pressure.

Cantilever Sheet Pile wall

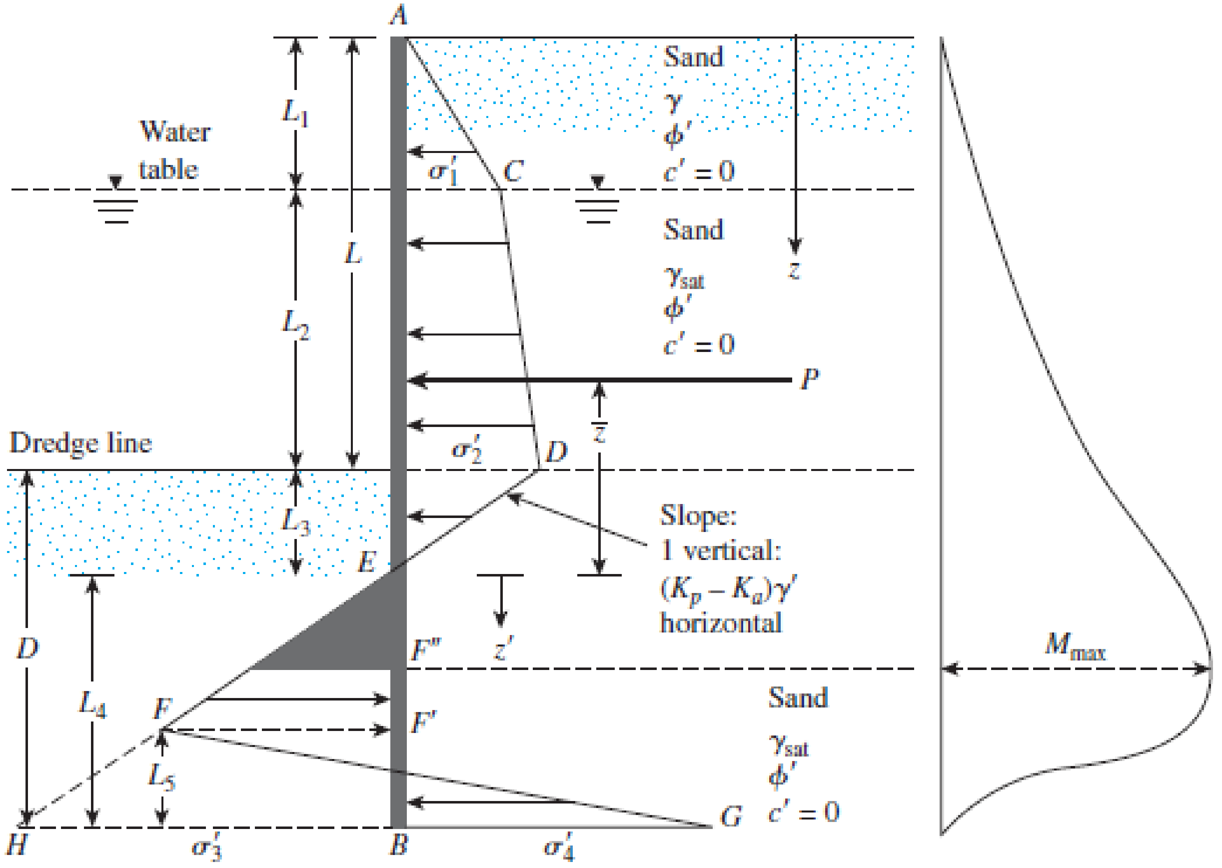


Zone A : the lateral pressure is only the active pressure from the land side.

Zone B : there will be active pressure from the land side and passive pressure from the water side.

Zone C : the condition is reversed in this zone (below the point of rotation O)

Cantilever Sheet Piling Penetrating Sandy Soils



Note that, at the level of the dredge line, the hydrostatic pressures from both sides of the wall are the same magnitude and cancel each other.

The intensity of the active pressure at depth z = L1 :

$$\sigma'_1 = \gamma L_1 K_a$$

The active pressure at a depth of z = L1 + L2 :

$$\sigma'_2 = (\gamma L_1 + \gamma' L_2) K_a$$

The active pressure at a depth of z (below the dredge line) :

$$\sigma'_a = [\gamma L_1 + \gamma' L_2 + \gamma'(z - L_1 - L_2)] K_a$$

The passive pressure at a depth z (below the dredge line) :

$$\sigma'_p = \gamma'(z - L_1 - L_2) K_p$$

Cantilever Sheet Piling Penetrating Sandy Soils

The net lateral pressure :

$$\sigma' = \sigma'_a - \sigma'_p = (\gamma L_1 + \gamma' L_2)K_a - \gamma'(z - L_1 - L_2)(K_p - K_a)$$

$$= \sigma'_2 - \gamma'(z - L)(K_p - K_a)$$

where $L = L_1 + L_2$.

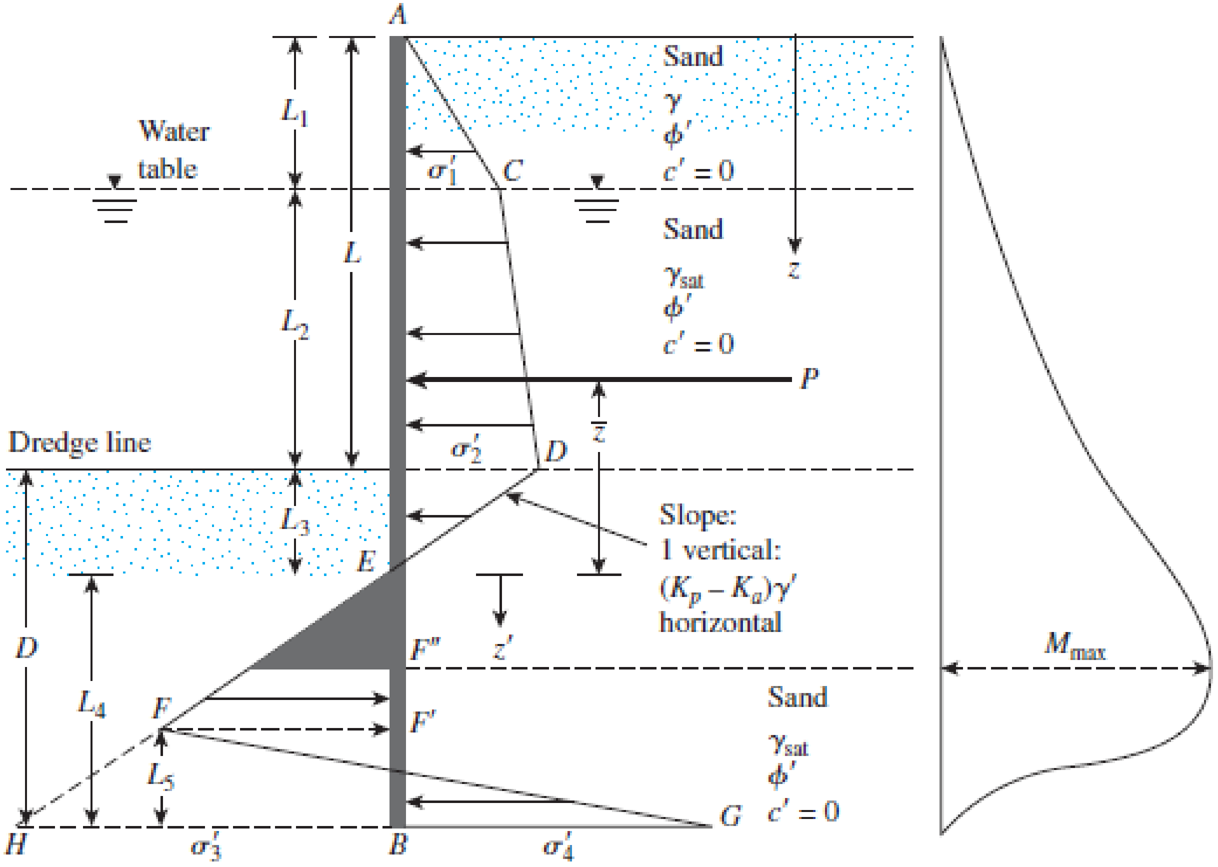
The net lateral pressure σ' becomes equal to zero at a depth L_3 below the dredge line:

$$\sigma'_2 - \gamma'(z - L)(K_p - K_a) = 0$$

$$(z - L) = L_3 = \frac{\sigma'_2}{\gamma'(K_p - K_a)}$$

The slope of the net pressure distribution line DEF is 1 vertical to (K_p -K_a) γ' horizontal :

$$\overline{HB} = \sigma'_3 = L_4(K_p - K_a)\gamma'$$



At the bottom of the sheet pile, passive pressure (σ_p) act from the right toward the left side, and active pressure act from the left toward the right side of the sheet pile. So at z = L+ D : $\sigma'_p = (\gamma L_1 + \gamma' L_2 + \gamma' D)K_p$

Cantilever Sheet Piling Penetrating **Sandy Soils**

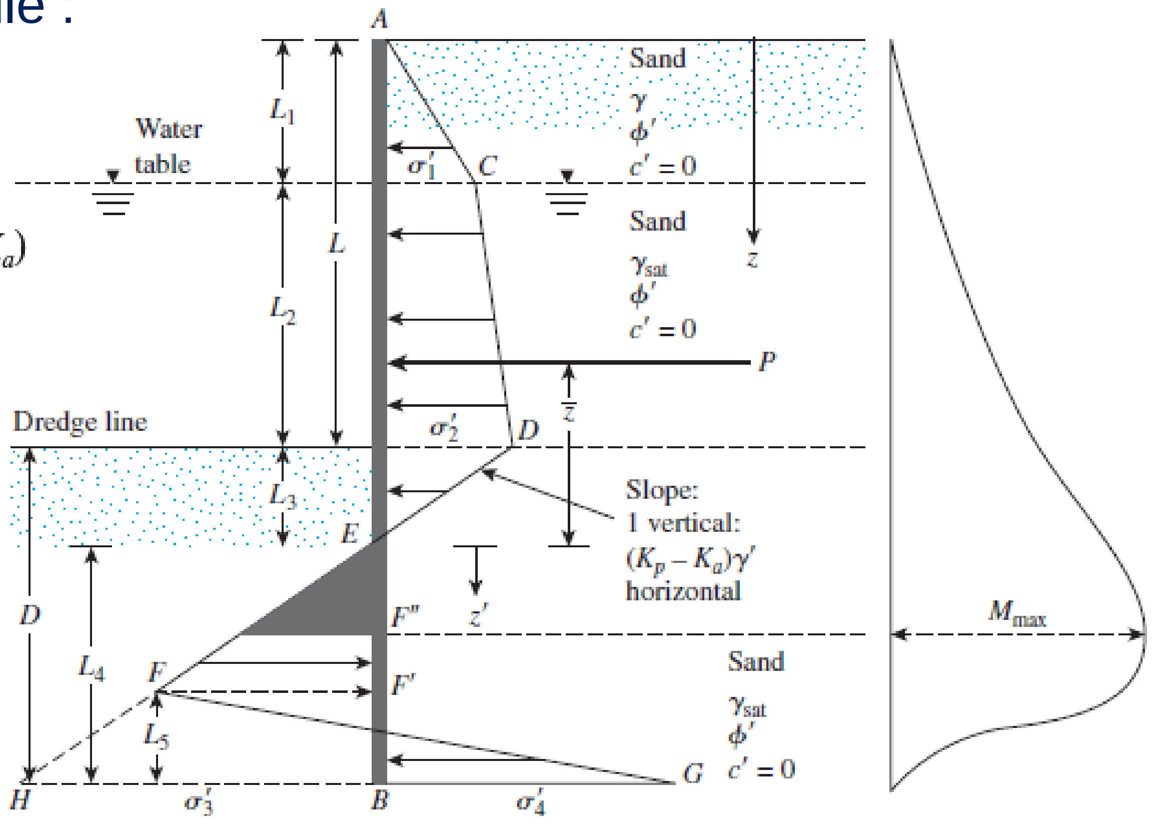
At the same depth : $\sigma'_a = \gamma' D K_a$

The net lateral pressure at the bottom of the sheet pile :

$$\begin{aligned}\sigma'_p - \sigma'_a = \sigma'_4 &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' D(K_p - K_a)\\ &= (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) + \gamma' L_4(K_p - K_a)\\ &= \sigma'_5 + \gamma' L_4(K_p - K_a) \qquad \text{where}\end{aligned}$$

$$\sigma'_5 = (\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a)$$

$$D = L_3 + L_4$$



For the stability of the wall, the principles of the statics can now be applied :

Σ horizontal forces per unit length of wall $= 0$

Σ moment of the forces per unit length of wall about point $B = 0$

For summation of the horizontal force :

Area of the pressure diagram $ACDE$ − area of $EFHB$ + area of $FHBG = 0$

$$P - \tfrac{1}{2}\sigma'_3 L_4 + \tfrac{1}{2} L_5(\sigma'_3 + \sigma'_4) = 0$$

$P =$ area of the pressure diagram $ACDE$.

$$P(L_4 + \bar{z}) - \left(\frac{1}{2}L_4\sigma'_3\right)\left(\frac{L_4}{3}\right) + \frac{1}{2}L_5(\sigma'_3 + \sigma'_4)\left(\frac{L_5}{3}\right) = 0 \qquad L_5 = \frac{\sigma'_3 L_4 - 2P}{\sigma'_3 + \sigma'_4}$$

Cantilever Sheet Piling Penetrating Sandy Soils

Summing the moment of all the force about point B :

$$P(L_4 + \bar{z}) - \left(\frac{1}{2}L_4\sigma_3'\right)\left(\frac{L_4}{3}\right) + \frac{1}{2}L_5(\sigma_3' + \sigma_4')\left(\frac{L_5}{3}\right) = 0$$

$$L_5 = \frac{\sigma_3' L_4 - 2P}{\sigma_3' + \sigma_4'}$$

Combining several equations and simplifying them further, one obtains the following fourth degree equation in terms of L4 :

$$L_4^4 + A_1 L_4^3 - A_2 L_4^2 - A_3 L_4 - A_4 = 0$$

Where

$$A_1 = \frac{\sigma_5'}{\gamma'(K_p - K_a)}$$

$$A_2 = \frac{8P}{\gamma'(K_p - K_a)}$$

$$A_3 = \frac{6P[2\bar{z}\gamma'(K_p - K_a) + \sigma_5']}{\gamma'^2(K_p - K_a)^2}$$

$$A_4 = \frac{P(6\bar{z}\sigma_5' + 4P)}{\gamma'^2(K_p - K_a)^2}$$

No stupid question

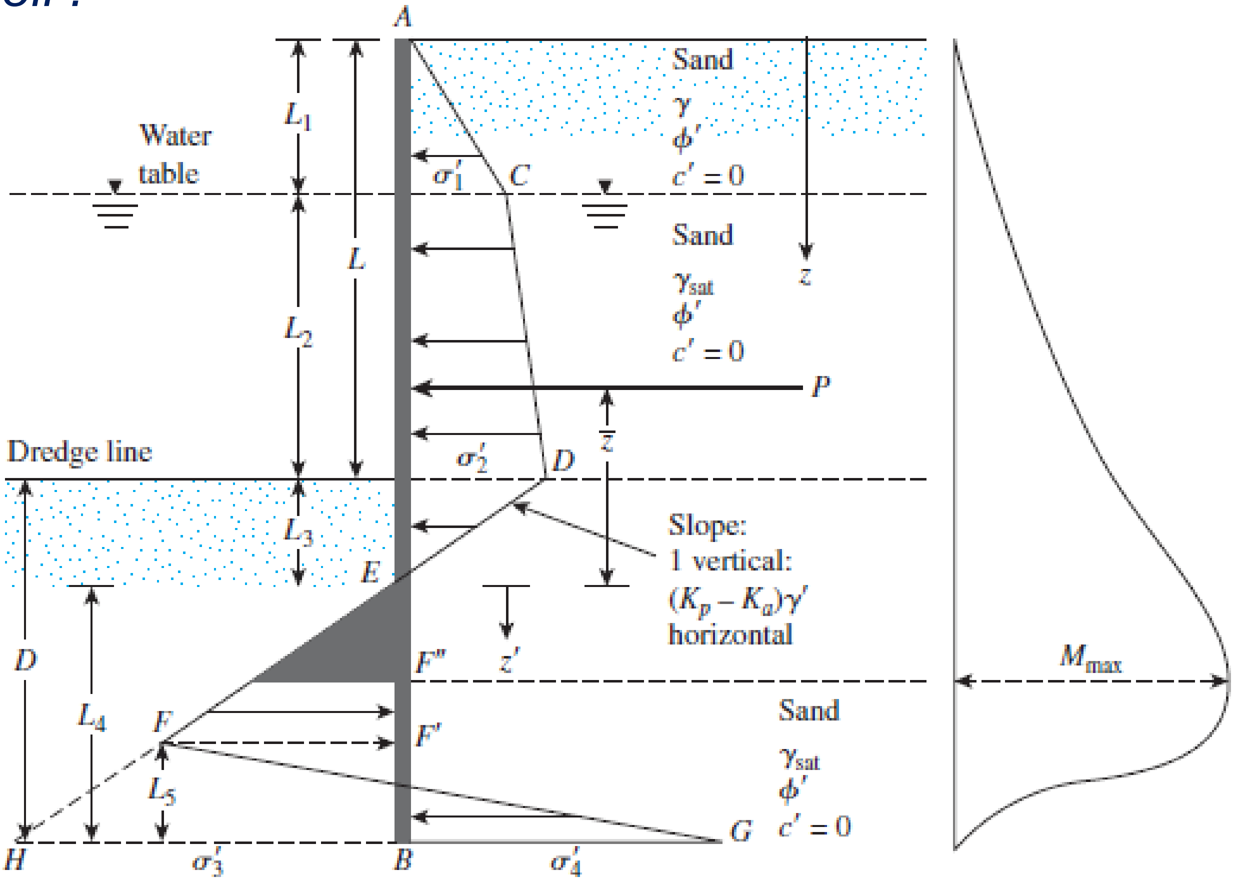
Keep asking questions and find the right answer,
Without knowing you wont be an expert in a lot of things

Hendra Djitno

Cantilever Sheet Piling Penetrating Sandy Soils

Step by step procedure to obtaining the pressure diagram for a cantilever sheet pile wall penetrating a granular soil :

1. Calculate K_a and K_p
2. Calculate σ_1' and σ_2' (L_1 and L_2 will be given)
3. Calculate L_3
4. Calculate P
5. Calculate $\bar{z}$ (the center of pressure for area ACDE, by taking moment about E)
6. Calculate σ_5'
7. Calculate A_1, A_2, A_3, and A_4
8. Solve trial and error to determine L_4
9. Calculate σ_4'
10. Calculate σ_3'
11. Obtain L_5
12. Draw pressure diagram
13. Obtain the theoretical depth of penetration as L_3+L_4



Cantilever Sheet Piling Penetrating Sandy Soils

Calculation of maximum bending moment:

The maximum moment will occur between the points E and F'. Obtaining the maximum moment (Mmax) per unit length of the wall requires determining the point of zero shear. For the new axis z' (with origin at point E) for zero shear:

$$P = \tfrac{1}{2}(z')^2(K_p - K_a)\gamma' \qquad \text{or} \qquad z' = \sqrt{\frac{2P}{(K_p - K_a)\gamma'}}$$

The magnitude of the maximum moment can be obtained as:

$$M_{max} = P(\bar{z} + z') - [\tfrac{1}{2}\gamma' z'^2(K_p - K_a)](\tfrac{1}{3})z'$$

The necessary profile of the sheet piling is then sized according to the allowable flexural stress of the sheet pile material :

$$S = \frac{M_{max}}{\sigma_{all}}$$

where

S = section modulus of the sheet pile required per unit length of the structure

σ_{all} = allowable flexural stress of the sheet pile

Cantilever Sheet Piling Penetrating Sandy Soils

Example 1 :

Figure 14.10 shows a cantilever sheet-pile wall penetrating a granular soil. Here, $L_1 = 2$ m, $L_2 = 3$ m, $\gamma = 15.9$ kN/m^3, $\gamma_{sat} = 19.33$ kN/m^3, and $\phi' = 32°$.

a. What is the theoretical depth of embedment, D?
b. For a 30% increase in D, what should be the total length of the sheet piles?
c. What should be the minimum section modulus of the sheet piles? Use $\sigma_{all} = 172$ MN/m^2.

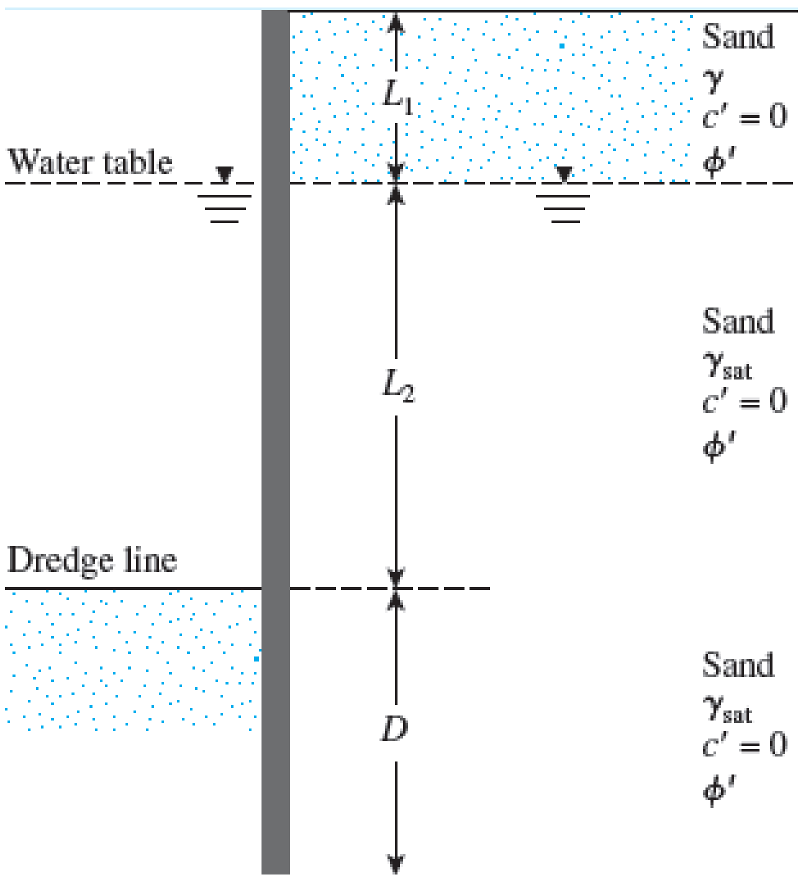


Figure 14.10

Cantilever Sheet Piling Penetrating Sandy Soils

Solution

Part a

Using Figure 14.9a for the pressure distribution diagram, one can now prepare the following table for a step-by-step calculation.

Quantity required	Equation and calculation
K_a	$\tan^2\left(45 - \frac{\phi'}{2}\right) = \tan^2\left(45 - \frac{32}{2}\right) = 0.307$
K_p	$\tan^2\left(45 + \frac{\phi'}{2}\right) = \tan^2\left(45 + \frac{32}{2}\right) = 3.25$
σ_1'	$\gamma L_1 K_a = (15.9)(2)(0.307) = 9.763\ \text{kN/m}^2$
σ_2'	$(\gamma L_1 + \gamma' L_2)K_a = [(15.9)(2) + (19.33 - 9.81)(3)](0.307) = 18.53\ \text{kN/m}^2$
L_3	$\frac{\sigma_2'}{\gamma'(K_p - K_a)} = \frac{18.53}{(19.33 - 9.81)(3.25 - 0.307)} = 0.66\ \text{m}$
P	$\frac{1}{2}\sigma_1' L_1 + \sigma_1' L_2 + \frac{1}{2}(\sigma_2' - \sigma_1')L_2 + \frac{1}{2}\sigma_2' L_3$ $= \left(\frac{1}{2}\right)(9.763)(2) + (9.763)(3) + \left(\frac{1}{2}\right)(18.53 - 9.763)(3) + \left(\frac{1}{2}\right)(18.53)(0.66)$ $= 9.763 + 29.289 + 13.151 + 6.115 = 58.32\ \text{kN/m}$
$\bar{z}$	$\frac{\Sigma M_E}{P} = \frac{1}{58.32}\left[\begin{array}{l} 9.763(0.66 + 3 + \frac{2}{3}) + 29.289(0.66 + \frac{3}{2}) \\ + 13.151(0.66 + \frac{3}{3}) + 6.115(0.66 \times \frac{2}{3}) \end{array}\right] = 2.23\ \text{m}$

Cantilever Sheet Piling Penetrating Sandy Soils

σ'_5	$(\gamma L_1 + \gamma' L_2)K_p + \gamma' L_3(K_p - K_a) = [(15.9)(2) + (19.33 - 9.81)(3)](3.25) + (19.33 - 9.81)(0.66)(3.25 - 0.307) = 214.66\ \text{kN/m}^2$
A_1	$\dfrac{\sigma'_5}{\gamma'(K_p - K_a)} = \dfrac{214.66}{(19.33 - 9.81)(3.25 - 0.307)} = 7.66$
A_2	$\dfrac{8P}{\gamma'(K_p - K_a)} = \dfrac{(8)(58.32)}{(19.33 - 9.81)(3.25 - 0.307)} = 16.65$
A_3	$\dfrac{6P[2\bar{z}\gamma'(K_p - K_a) + \sigma'_5]}{\gamma'^2(K_p - K_a)^2}$ $= \dfrac{(6)(58.32)[(2)(2.23)(19.33 - 9.81)(3.25 - 0.307) + 214.66]}{(19.33 - 9.81)^2(3.25 - 0.307)^2}$ $= 151.93$
A_4	$\dfrac{P(6\bar{z}\sigma'_5 + 4P)}{\gamma'^2(K_p - K_a)^2} = \dfrac{58.32[(6)(2.23)(214.66) + (4)(58.32)]}{(19.33 - 9.81)^2(3.25 - 0.307)^2}$ $= 230.72$
L_4	$L_4^4 + A_1L_4^3 - A_2L_4^2 - A_3L_4 - A_4 = 0$ $L_4^4 + 7.66L_4^3 - 16.65L_4^2 - 151.93L_4 - 230.72 = 0;\ L_4 \approx 4.8\ \text{m}$

Thus, $D_{\text{theory}} = L_3 + L_4 = 0.66 + 4.8 = \mathbf{5.46\ m}$

Cantilever Sheet Piling Penetrating Sandy Soils

Part b

The total length of the sheet piles is

$$L_1 + L_2 + 1.3(L_3 + L_4) = 2 + 3 + 1.3(5.46) = \mathbf{12.1\ m}$$

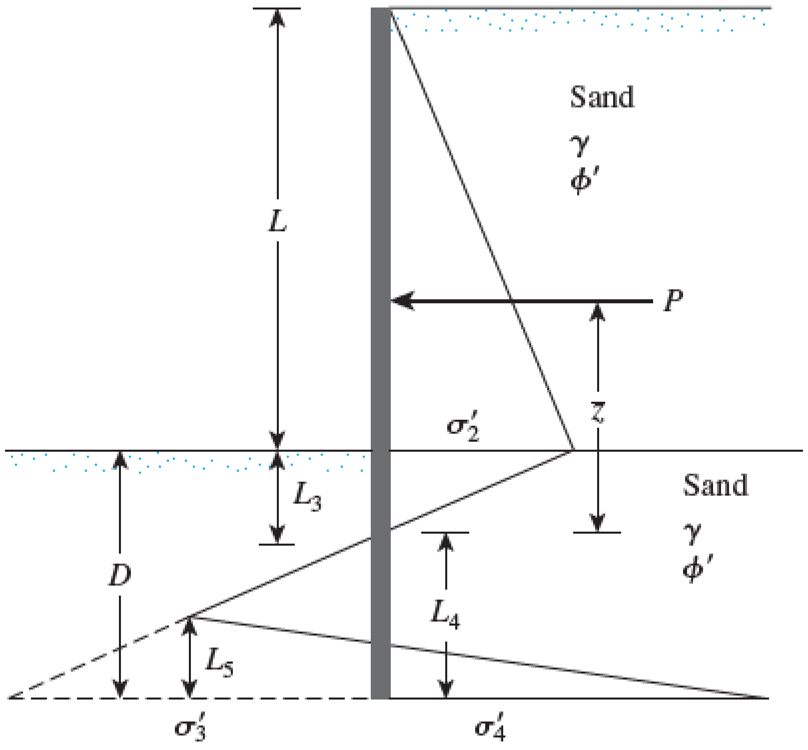
Part c

Finally, we have the following table.

Quantity required	Eq. no.	Equation and calculation
z'	14.21	$\sqrt{\dfrac{2P}{(K_p - K_a)\gamma'}} = \sqrt{\dfrac{(2)(58.32)}{(3.25 - 0.307)(19.33 - 9.81)}} = 2.04\ \text{m}$
M_{max}	14.22	$P(\bar{z} + z') - \left[\dfrac{1}{2}\gamma' z'^2 (K_p - K_a)\right]\dfrac{z'}{3} = (58.32)(2.23 + 2.04)$ $-\left[\left(\dfrac{1}{2}\right)(19.33 - 9.81)(2.04)^2(3.25 - 0.307)\right]\dfrac{2.04}{3}$ $= 209.39\ \text{kN} \cdot \text{m/m}$
S	14.29	$\dfrac{M_{max}}{\sigma_{all}} = \dfrac{209.39\ \text{kN} \cdot \text{m}}{172 \times 10^3\ \text{kN/m}^2} = \mathbf{1.217 \times 10^{-3}\ m^3/m\ of\ wall}$

Special Cases for Cantilever Sheet Piling Penetrating Sandy Soils

Case 1 : Sheet Pile wall the absence of Water Table



$$\sigma_2' = \gamma L K_a$$

$$\sigma_3' = L_4(K_p - K_a)\gamma$$

$$\sigma_4' = \sigma_5' + \gamma L_4(K_p - K_a)$$

$$\sigma_5' = \gamma L K_p + \gamma L_3(K_p - K_a)$$

$$L_3 = \frac{\sigma_2'}{\gamma(K_p - K_a)} = \frac{L K_a}{(K_p - K_a)}$$

$$P = \tfrac{1}{2}\sigma_2' L + \tfrac{1}{2}\sigma_2' L_3$$

$$\bar{z} = L_3 + \frac{L}{3} = \frac{L K_a}{K_p - K_a} + \frac{L}{3} = \frac{L(2K_a + K_p)}{3(K_p - K_a)}$$

$$L_4^4 + A_1' L_4^3 - A_2' L_4^2 - A_3' L_4 - A_4' = 0$$

Where

$$A_1' = \frac{\sigma_5'}{\gamma(K_p - K_a)}$$

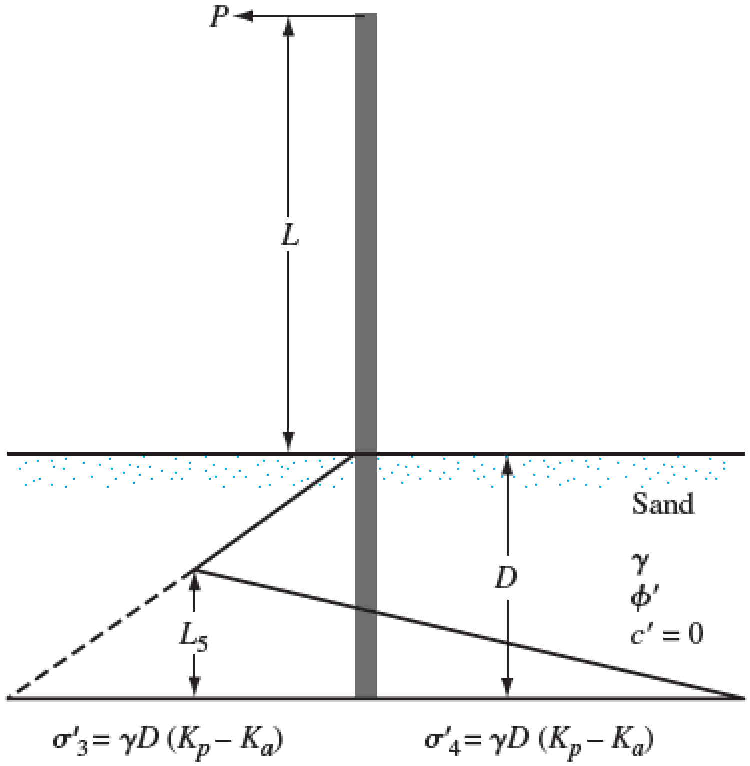
$$A_2' = \frac{8P}{\gamma(K_p - K_a)}$$

$$A_3' = \frac{6P[2\bar{z}\gamma(K_p - K_a) + \sigma_5']}{\gamma^2(K_p - K_a)^2}$$

$$A_4' = \frac{P(6\bar{z}\sigma_5' + 4P)}{\gamma^2(K_p - K_a)^2}$$

Special Cases for Cantilever Sheet Piling Penetrating Sandy Soils

Case 2 : Free Cantilever Sheet Piling



$$D^4 - \left[\frac{8P}{\gamma(K_p - K_a)}\right]D^2 - \left[\frac{12PL}{\gamma(K_p - K_a)}\right]D - \left[\frac{2P}{\gamma(K_p - K_a)}\right]^2 = 0$$

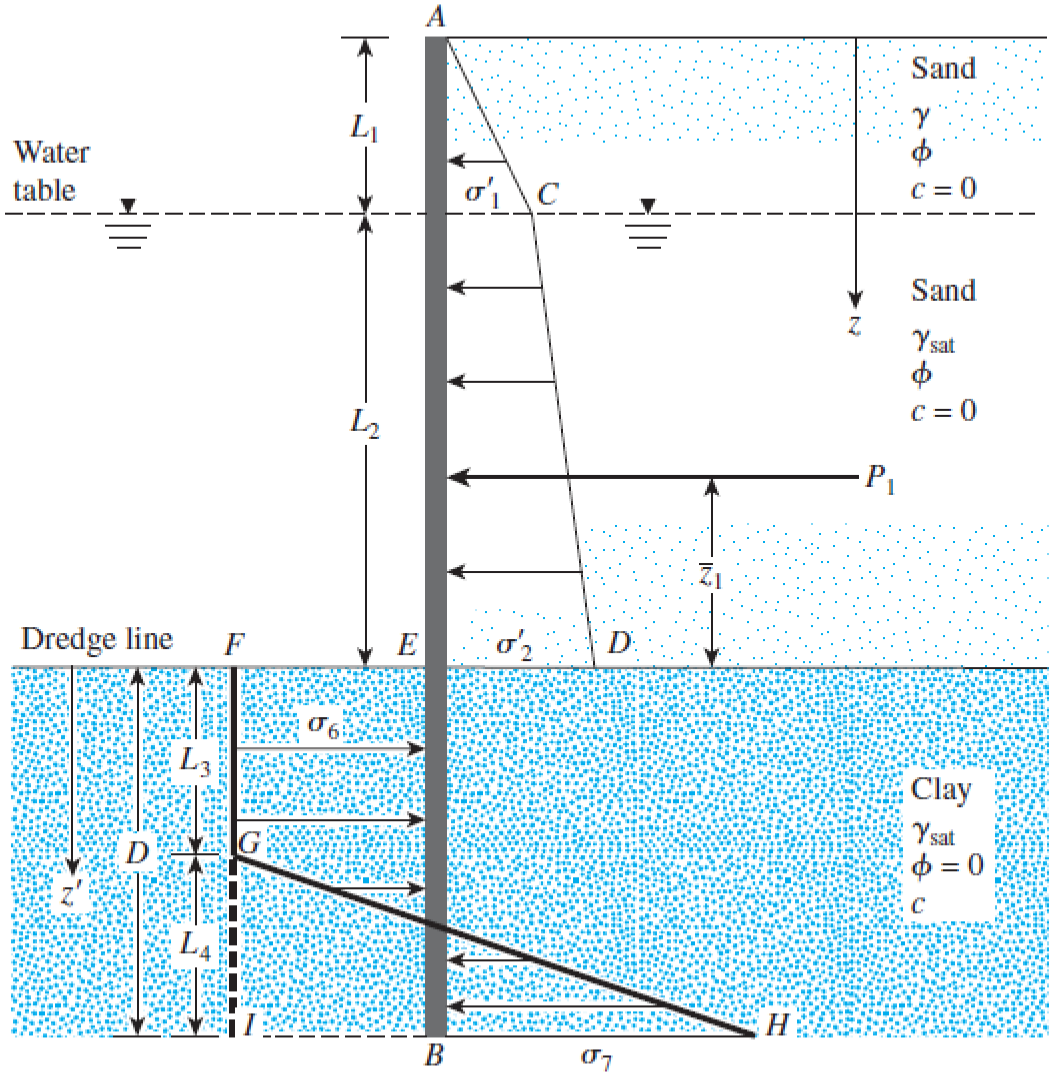
$$L_5 = \frac{\gamma(K_p - K_a)D^2 - 2P}{2D(K_p - K_a)\gamma}$$

$$M_{max} = P(L + z') - \frac{\gamma z'^3(K_p - K_a)}{6}$$

And

$$z' = \sqrt{\frac{2P}{\gamma'(K_p - K_a)}}$$

Cantilever Sheet Piling Penetrating Clay Soils



Where the intensity of the active pressure at a depth z = L1:

$$\sigma'_1 = \gamma L_1 K_a$$

The active pressure at a depth of z = L1+L2 :

$$\sigma'_2 = (\gamma L_1 + \gamma' L_2) K_a$$

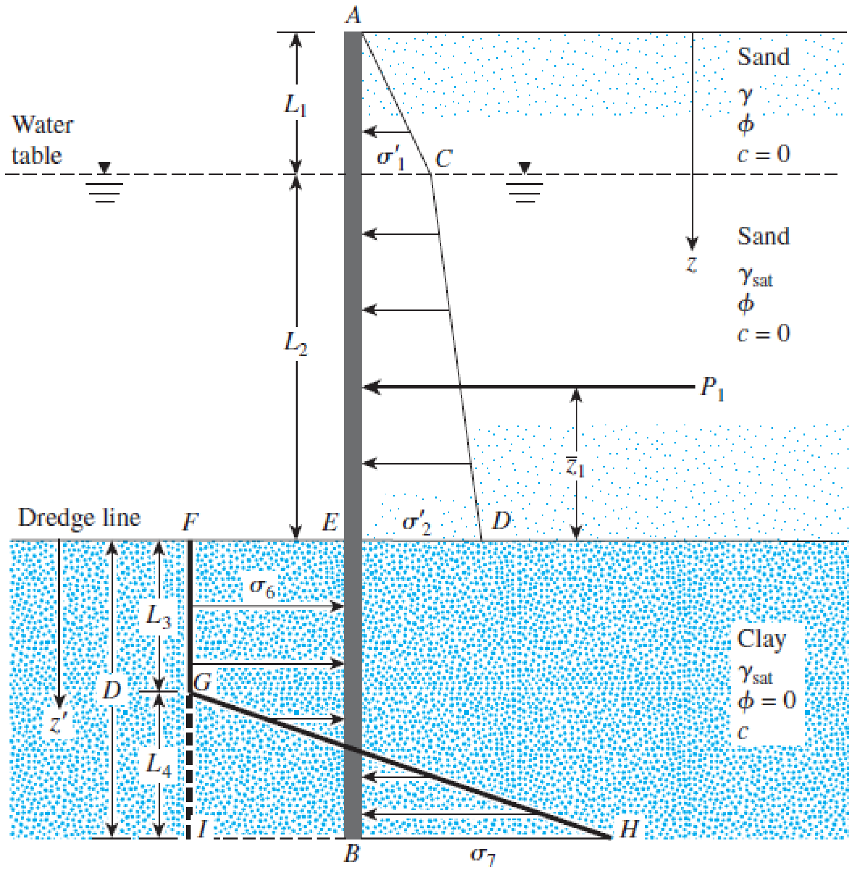
At any depth greater than L1+L2 for =0, Ka=1 and Kp=1. The active pressure at a depth z (below the dredge line) :

$$\sigma_a = [\gamma L_1 + \gamma' L_2 + \gamma_{sat}(z - L_1 - L_2)] - 2c$$

The passive pressure at a depth z (below the dredge line):

$$\sigma_p = \gamma_{sat}(z - L_1 - L_2) + 2c$$

Cantilever Sheet Piling Penetrating Clay Soils



The net lateral pressure :

$$\sigma_6 = \sigma_p - \sigma_a = [\gamma_{sat}(z - L_1 - L_2) + 2c]$$
$$- [\gamma L_1 + \gamma' L_2 + \gamma_{sat}(z - L_1 - L_2)] + 2c$$
$$= 4c - (\gamma L_1 + \gamma' L_2)$$

At the bottom of the sheet pile, the passive pressure from right to left is:

$$\sigma_p = (\gamma L_1 + \gamma' L_2 + \gamma_{sat} D) + 2c$$

The active pressure from left to right is:

$$\sigma_a = \gamma_{sat} D - 2c$$

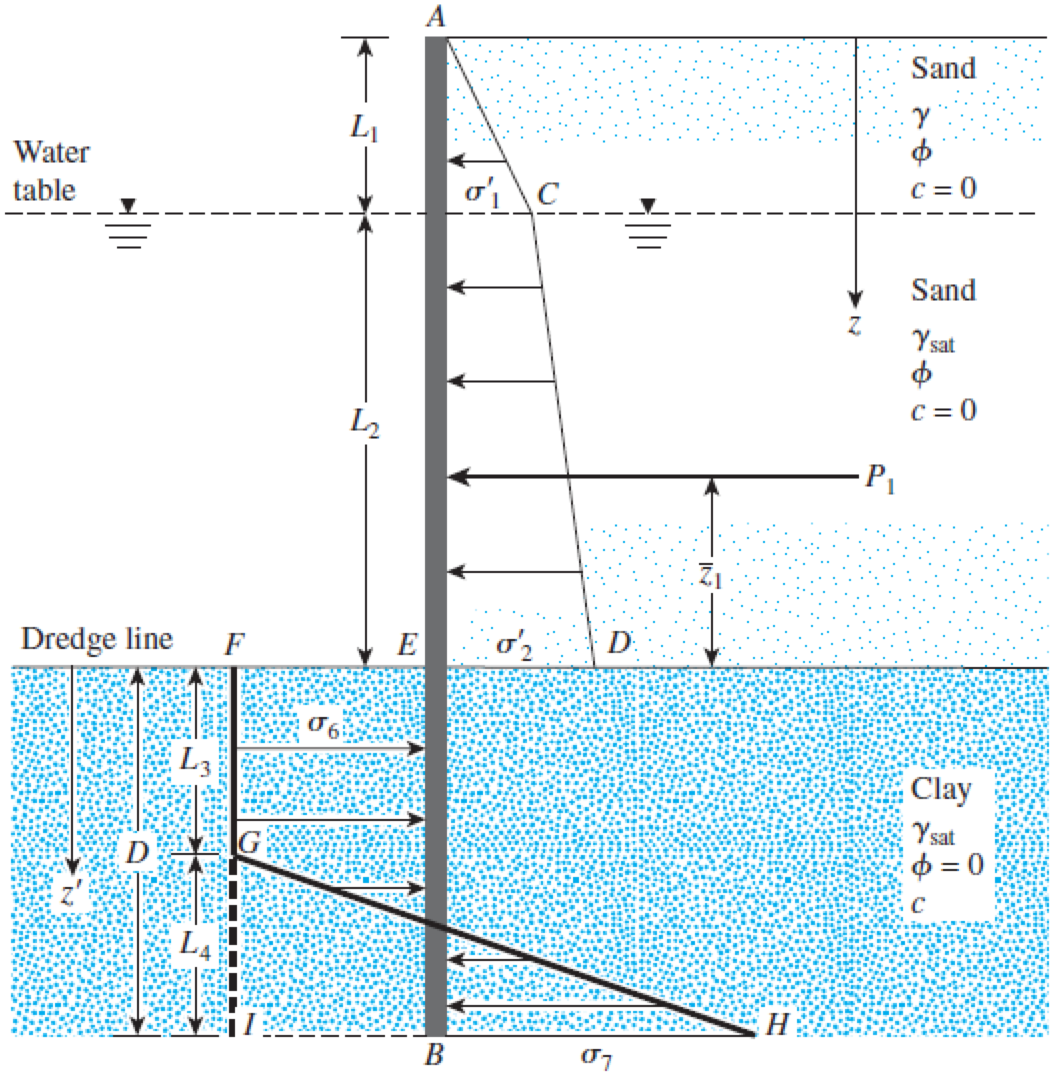
The net pressure is:

$$\sigma_7 = \sigma_p - \sigma_a = 4c + (\gamma L_1 + \gamma' L_2)$$

For equilibrium analysis, FH = 0, that is the area of the pressure diagram ACDE – the area of EFIB + the area of GIH = 0

$$P_1 - [4c - (\gamma L_1 + \gamma' L_2)]D + \tfrac{1}{2} L_4 [4c - (\gamma L_1 + \gamma' L_2) + 4c + (\gamma L_1 + \gamma' L_2)] = 0$$

Cantilever Sheet Piling Penetrating Clay Soils



Simplifying the preceding equation produces:

$$L_4 = \frac{D[4c - (\gamma L_1 + \gamma' L_2)] - P_1}{4c}$$

Taking the moment about point B (MB = 0) yields:

$$P_1(D + \bar{z}_1) - [4c - (\gamma L_1 + \gamma' L_2)]\frac{D^2}{2} + \frac{1}{2}L_4(8c)\left(\frac{L_4}{3}\right) = 0$$

Combine equations above:

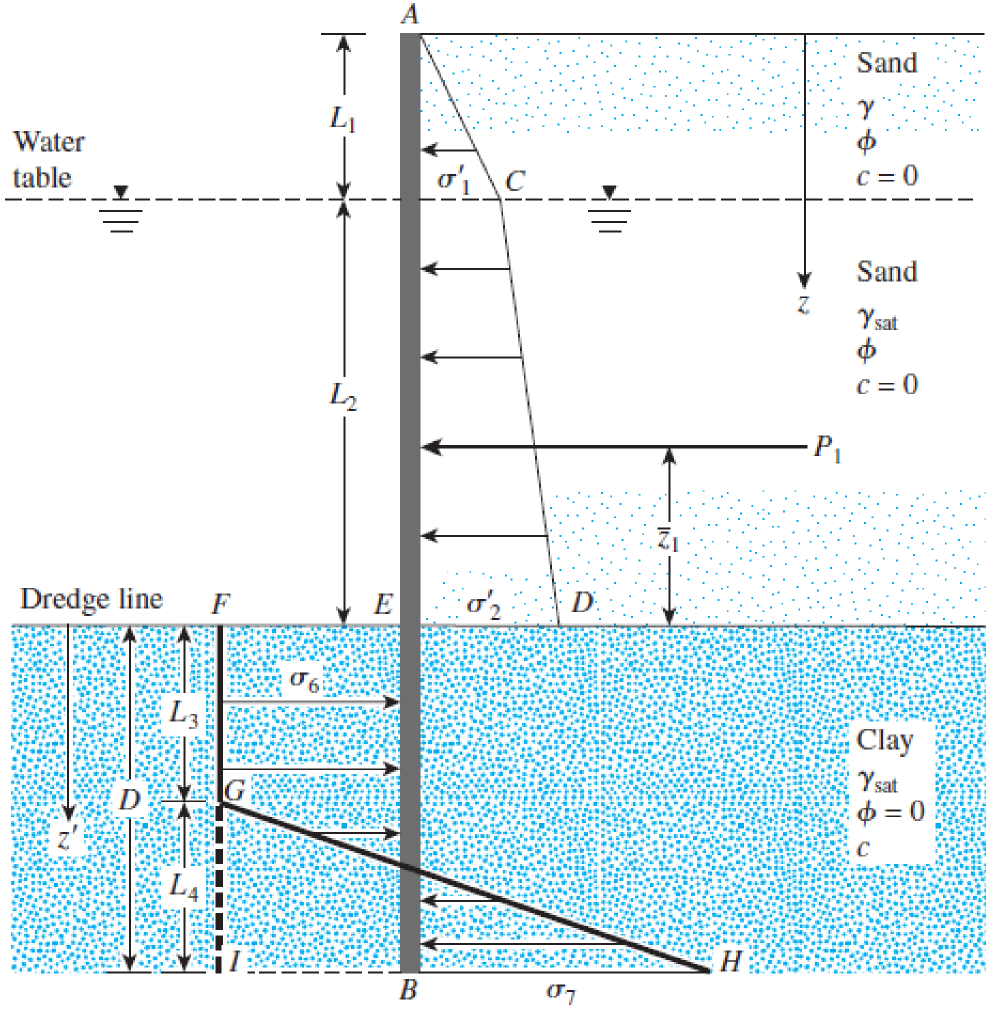
$$D^2[4c - (\gamma L_1 + \gamma' L_2)] - 2DP_1 - \frac{P_1(P_1 + 12c\bar{z}_1)}{(\gamma L_1 + \gamma' L_2) + 2c} = 0$$

Cantilever Sheet Piling Penetrating Clay Soils

Step by step procedure to obtaining the pressure diagram for a cantilever sheet pile wall penetrating a granular soil :

1. Calculate $K_a = \tan^2(45 - \phi'/2)$
2. Calculate σ_1' and σ_2' (L_1 and L_2 will be given)
3. Calculate P_1 and $\bar{z}_1$
4. Solve trial and error to determine D
5. Calculate L_4
6. Calculate σ_6' and σ_7'
7. Draw pressure Distribution diagram
8. The actual depth of penetration is :

$$D_{actual} = 1.4 \text{ to } 1.6(D_{theoretical})$$



Cantilever Sheet Piling Penetrating Clay Soils

Calculation of maximum bending moment:

The maximum moment (zero shear) will be between L1+L2<z<L1+L2+L3. Using a new coordinate system z' (with z' = 0 at the dredge line) for zero shear gives:

$$P_1 - \sigma_6 z' = 0 \qquad \text{or} \qquad z' = \frac{P_1}{\sigma_6}$$

The magnitude of the maximum moment can be obtained as:

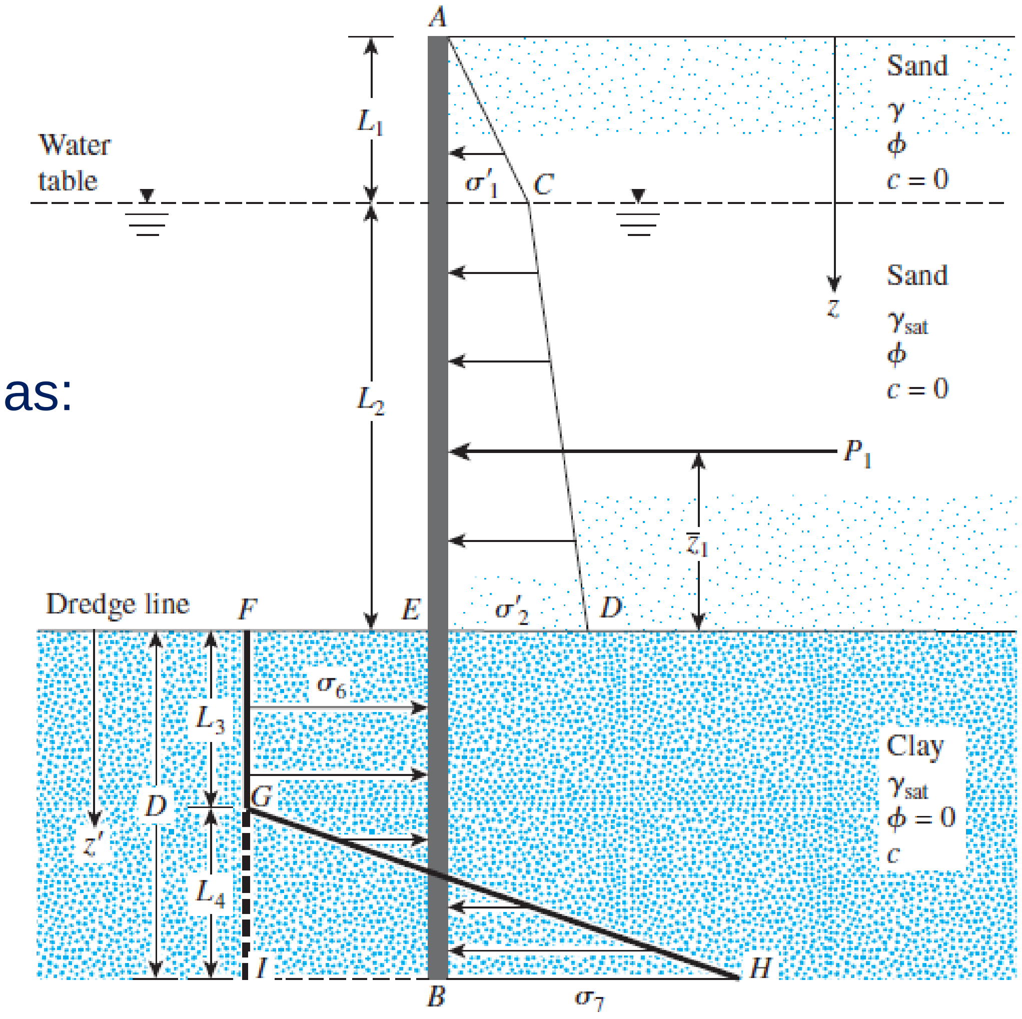
$$M_{max} = P_1(z' + \bar{z}_1) - \frac{\sigma_6 z'^2}{2}$$

The necessary profile of the sheet piling is then sized according to the allowable flexural stress of the sheet pile material:

$$S = \frac{M_{max}}{\sigma_{all}}$$

where

S = section modulus of the sheet pile required per unit length of the structure
σ_{all} = allowable flexural stress of the sheet pile



Cantilever Sheet Piling Penetrating Clay Soils

Example 2 :

In Figure 14.14, for the sheet-pile wall, determine

a. The theoretical and actual depth of penetration. Use $D_{actual} = 1.5D_{theory}$.
b. The minimum size of sheet-pile section necessary. Use $\sigma_{all} = 172.5\ MN/m^2$.

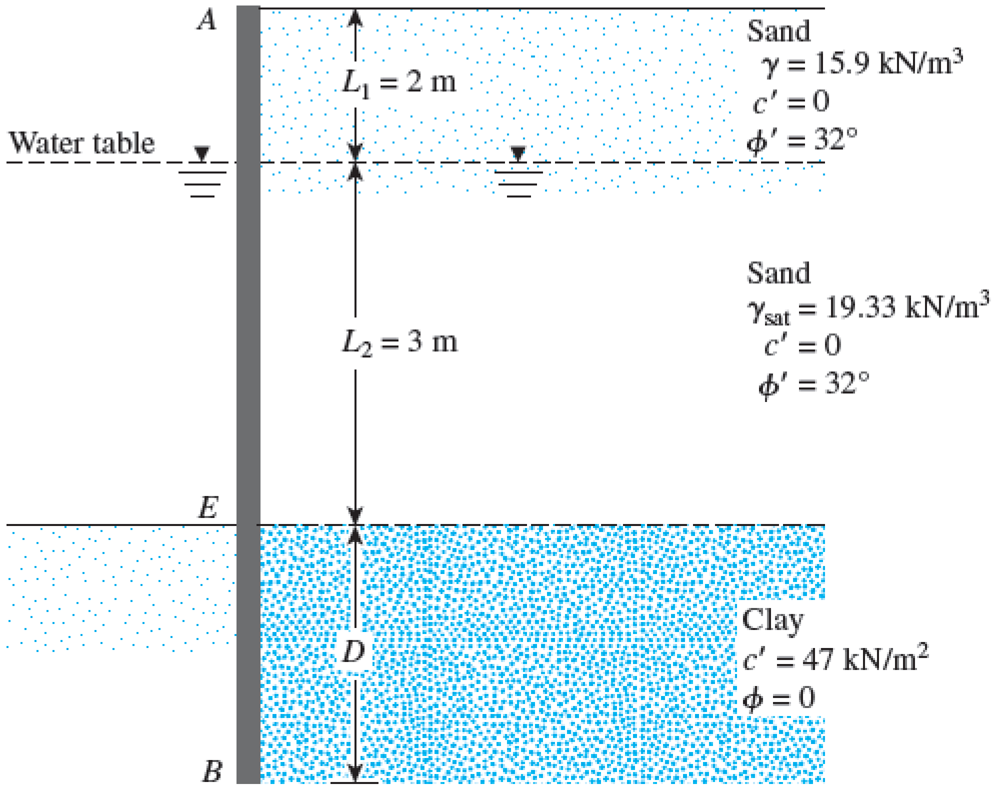


Figure 14.14 Cantilever sheet pile penetrating into saturated clay

Cantilever Sheet Piling Penetrating Clay Soils

Solution

We will follow the step-by-step procedure

Step 1.

$$K_a = \tan^2\left(45 - \frac{\phi'}{2}\right) = \tan^2\left(45 - \frac{32}{2}\right) = 0.307$$

Step 2.

$$\sigma'_1 = \gamma L_1 K_a = (15.9)(2)(0.307) = 9.763 \text{ kN/m}^2$$

$$\sigma'_2 = (\gamma L_1 + \gamma' L_2)K_a = [(15.9)(2) + (19.33 - 9.81)3]0.307$$
$$= 18.53 \text{ kN/m}^2$$

Step 3. From the net pressure distribution diagram

$$P_1 = \frac{1}{2}\sigma'_1 L_1 + \sigma'_1 L_2 + \frac{1}{2}(\sigma'_2 - \sigma'_1)L_2$$
$$= 9.763 + 29.289 + 13.151 = 52.2 \text{ kN/m}$$

and

$$\bar{z}_1 = \frac{1}{52.2}\left[9.763\left(3 + \frac{2}{3}\right) + 29.289\left(\frac{3}{2}\right) + 13.151\left(\frac{3}{3}\right)\right]$$
$$= 1.78 \text{ m}$$

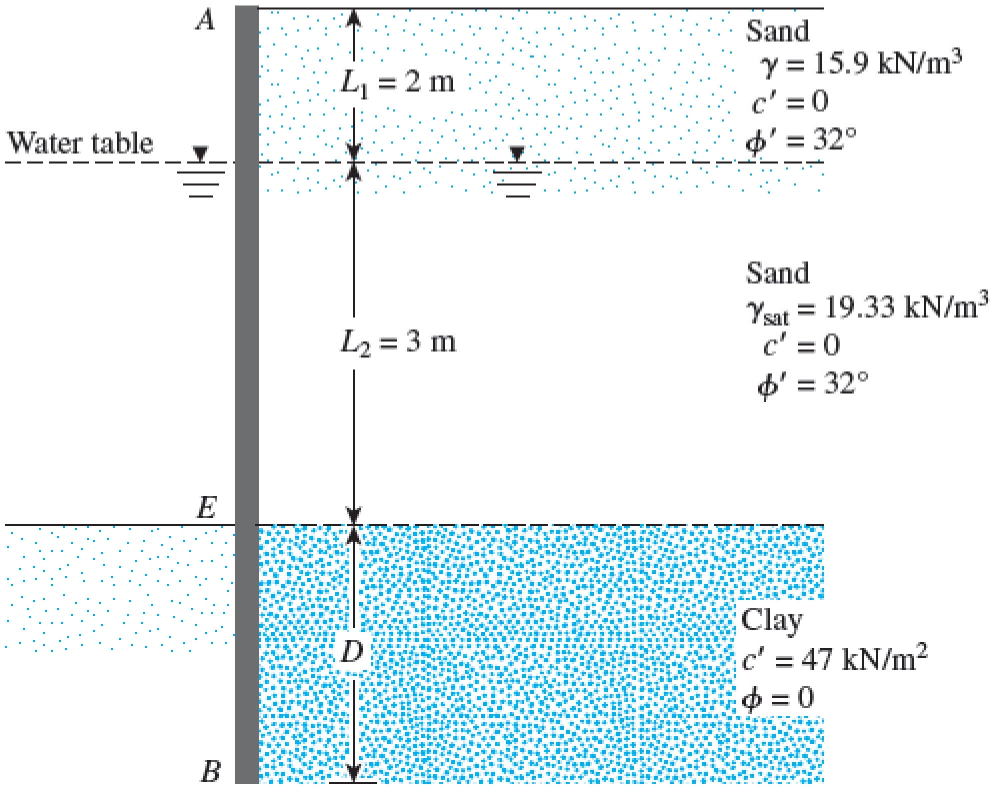


Figure 14.14 Cantilever sheet pile penetrating into saturated clay

Cantilever Sheet Piling Penetrating Clay Soils

Step 4.

$$D^2[4c - (\gamma L_1 + \gamma' L_2)] - 2DP_1 - \frac{P_1(P_1 + 12c\bar{z}_1)}{(\gamma L_1 + \gamma' L_2) + 2c} = 0$$

Substituting proper values yields

$$D^2\{(4)(47) - [(2)(15.9) + (19.33 - 9.81)3]\} - 2D(52.2) - \frac{52.2[52.2 + (12)(47)(1.78)]}{[(15.9)(2) + (19.33 - 9.81)3] + (2)(47)} = 0$$

or

$$127.64D^2 - 104.4D - 357.15 = 0$$

Solving the preceding equation, we obtain $D = 2.13$ m.

Step 5.

$$L_4 = \frac{D[4c - (\gamma L_1 + \gamma' L_2)] - P_1}{4c}$$

and

$$4c - (\gamma L_1 + \gamma' L_2) = (4)(47) - [(15.9)(2) + (19.33 - 9.81)3] = 127.64 \text{ kN/m}^2$$

So,

$$L_4 = \frac{2.13(127.64) - 52.2}{(4)(47)} = 1.17 \text{ m}$$

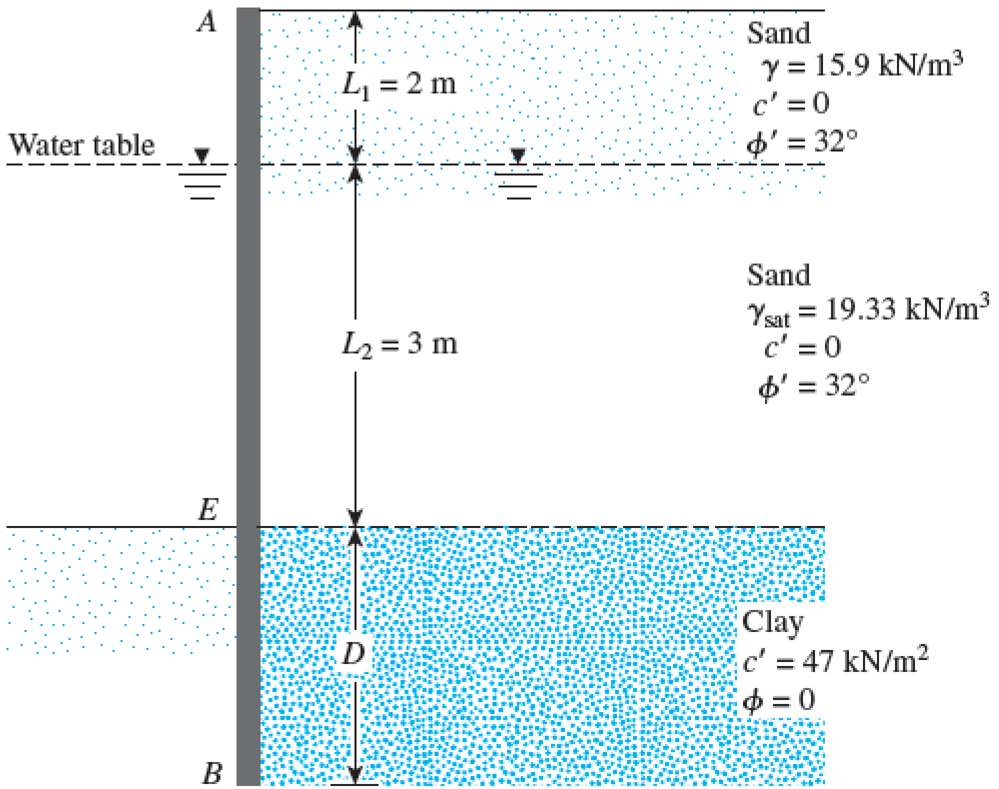


Figure 14.14 Cantilever sheet pile penetrating into saturated clay

Cantilever Sheet Piling Penetrating Clay Soils

Step 6.

$$\sigma_6 = 4c - (\gamma L_1 + \gamma' L_2) = 127.64 \text{ kN/m}^2$$

$$\sigma_7 = 4c + (\gamma L_1 + \gamma' L_2) = 248.36 \text{ kN/m}^2$$

Step 7. The net pressure distribution diagram can now be drawn,

Step 8. $D_{actual} \approx 1.5\, D_{theoretical} = 1.5(2.13) \approx \mathbf{3.2\ m}$

Maximum-Moment Calculation

From Eq. (14.49),

$$z' = \frac{P_1}{\sigma_6} = \frac{52.2}{127.64} \approx 0.41 \text{ m}$$

Again, from Eq. (14.49),

$$M_{max} = P_1(z' + \bar{z}_1) - \frac{\sigma_6 z'^2}{2}$$

So

$$M_{max} = 52.2(0.41 + 1.78) - \frac{127.64(0.41)^2}{2}$$

$$= 114.32 - 10.73 = 103.59 \text{ kN-m/m}$$

The minimum required section modulus (assuming that $\sigma_{all} = 172.5 \text{ MN/m}^2$) is

$$S = \frac{103.59 \text{ kN-m/m}}{172.5 \times 10^3 \text{ kN/m}^2} = \mathbf{0.6 \times 10^{-3}\ m^3/m\ of\ the\ wall}$$

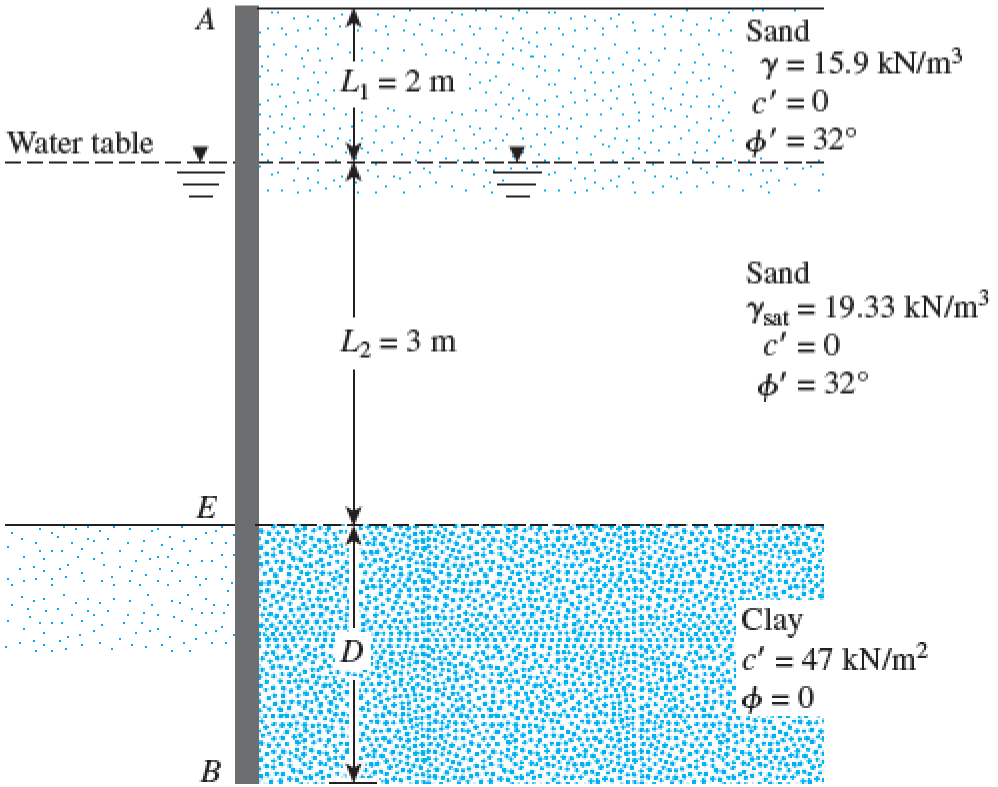


Figure 14.14 Cantilever sheet pile penetrating into saturated clay

Special Cases for Cantilever Sheet Piling Penetrating Clay Soils

Case 1 : Sheet Pile wall the absence of Water Table

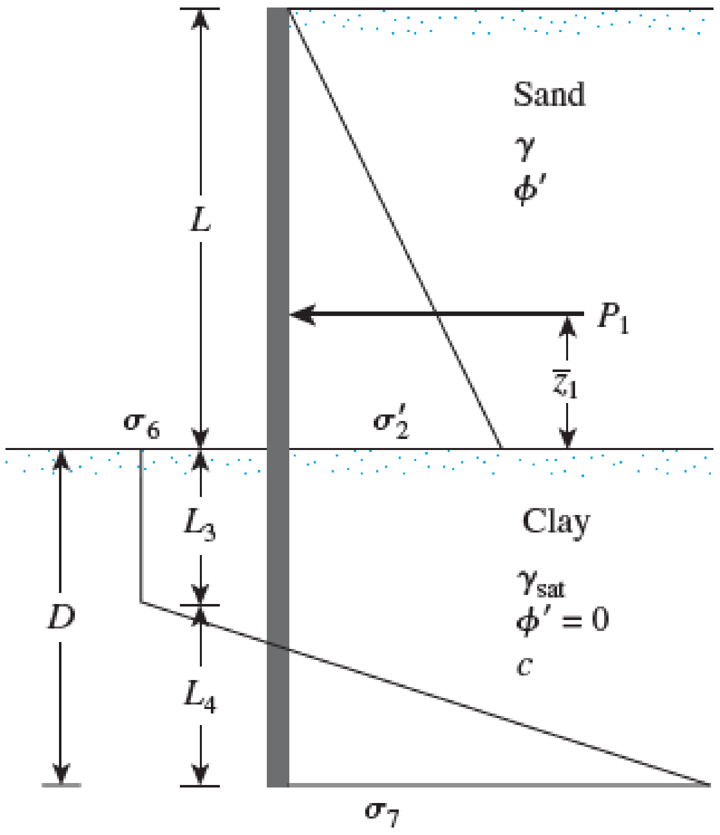


Figure 14.15 Sheet-pile wall penetrating clay

$$\sigma_2' = \gamma L K_a$$

$$\sigma_6 = 4c - \gamma L$$

$$\sigma_7 = 4c + \gamma L$$

$$P_1 = \tfrac{1}{2} L \sigma_2' = \tfrac{1}{2}\gamma L^2 K_a$$

$$L_4 = \frac{D(4c - \gamma L) - \frac{1}{2}\gamma L^2 K_a}{4c}$$

$$D^2(4c - \gamma L) - 2DP_1 - \frac{P_1(P_1 + 12c\bar{z}_1)}{\gamma L + 2c} = 0$$

where $\bar{z}_1 = \frac{L}{3}$.

The magnitude of the maximum moment in the wall is

$$M_{max} = P_1(z' + \bar{z}_1) - \frac{\sigma_6 z'^2}{2}$$

where $z' = \frac{P_1}{\sigma_6} = \frac{\frac{1}{2}\gamma L^2 K_a}{4c - \gamma L}$.

Special Cases for Cantilever Sheet Piling Penetrating Clay Soils

Case 1 : Free Cantilever Sheet Piling Penetrating Clay

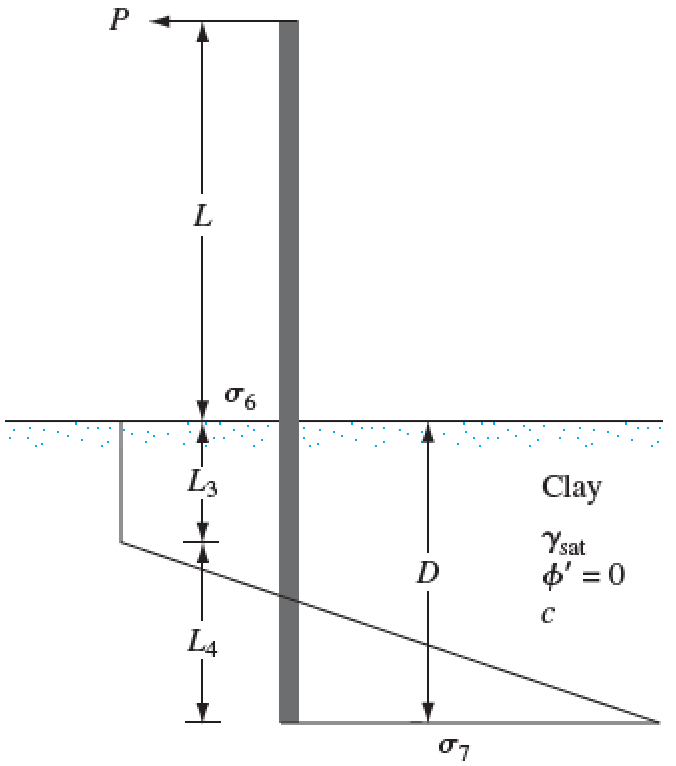


Figure 14.16 Free cantilever sheet piling penetrating clay

$$\sigma_6 = \sigma_7 = 4c$$

The depth of penetration, D, may be obtained from the relation

$$4D^2c - 2PD - \frac{P(P + 12cL)}{2c} = 0$$

Also, note that, for a construction of the pressure diagram,

$$L_4 = \frac{4cD - P}{4c}$$

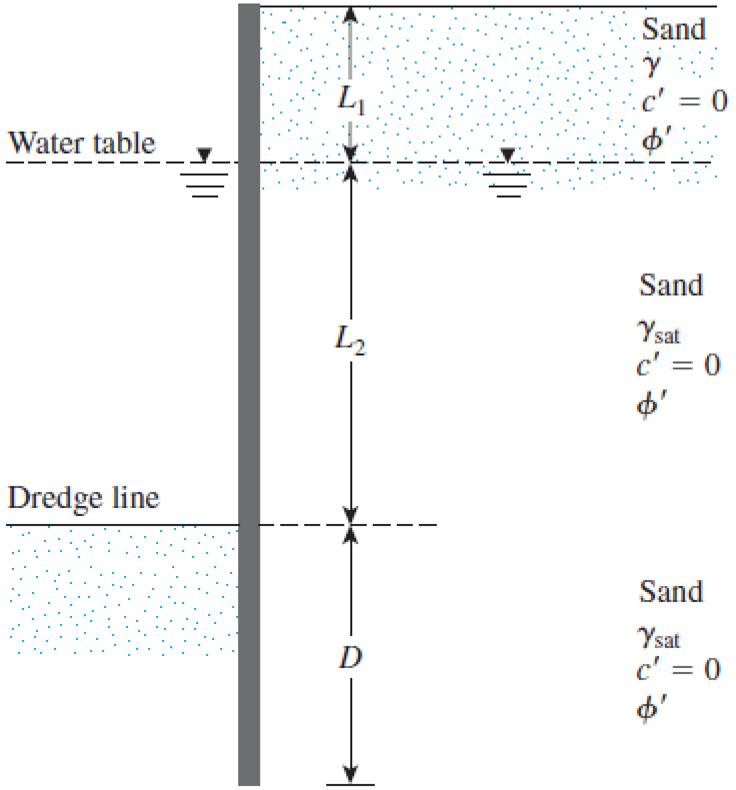
The maximum moment in the wall is

$$M_{max} = P(L + z') - \frac{4cz'^2}{2}$$

Where $z' = \frac{P}{4c}$

PROBLEM #1

Sheet Piling Penetrating Sand Soils

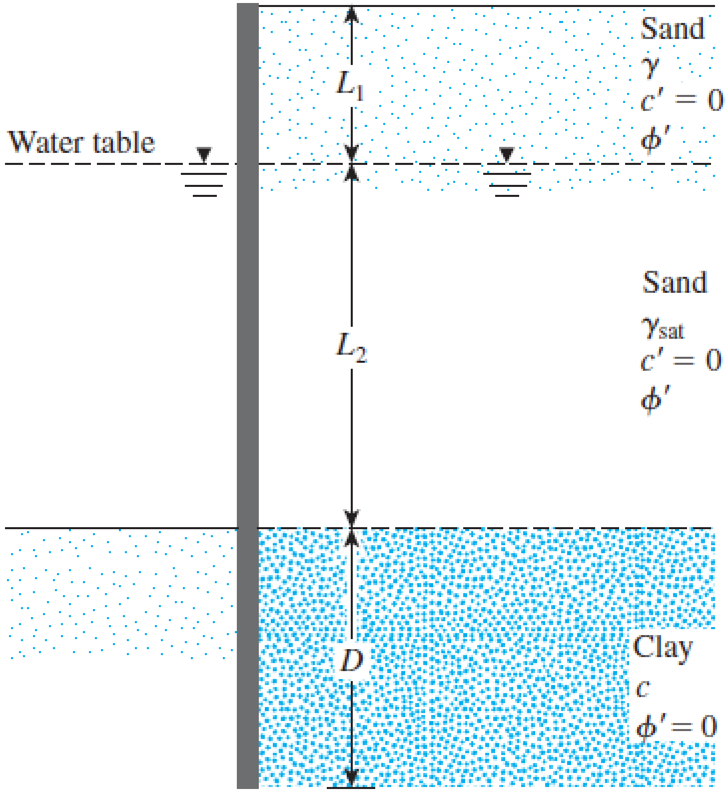


This Figure shows a cantilever sheet-pile wall penetrating a granular soil. Here, $L1$ = 4 m, $L2$ = 8 m, γ' = 16.1 kN/m^3, γ_{sat} = kN/m^3, and ϕ' =32.8^o.

a. What is the theoretical depth of embedment, *D*?
b. For a 30% increase in *D*, what should be the total length of the sheet piles?
c. Determine the theoretical maximum moment of the sheet pile.

PROBLEM #2

Sheet Piling Penetrating Clay Soils



For which $L1$ = 2.4 m, $L2$ = 4.6 m, γ= 15.7 kN/m^3, γ_{sat} =17.3 kN/m^3, and ϕ' =30.8^o and c' = 29 kN/m^2

a. What is the theoretical depth of embedment, *D*?
b. For a 30% increase in *D*, what should be the total length of the sheet piles?
c. Determine the theoretical maximum moment of the sheet pile.