Hydraulics Structures

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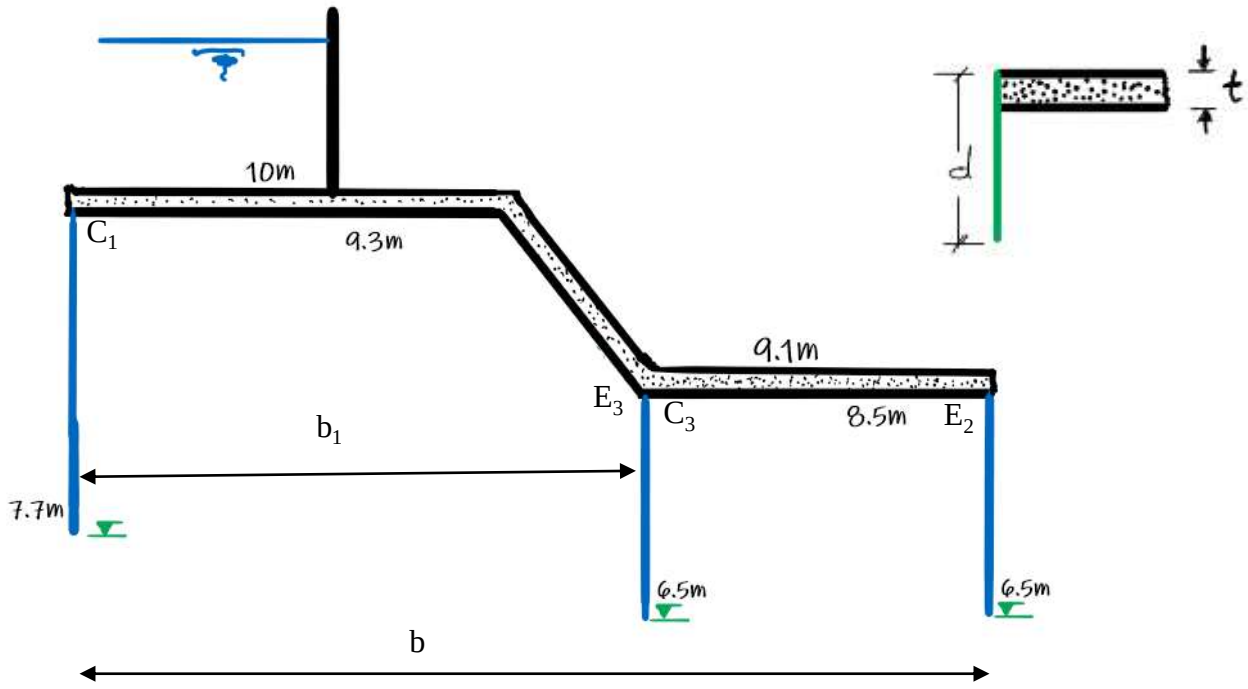
Correction of Pressure

- *Correction of mutual interference of pile:*

$$C1 = 19\sqrt{\frac{D}{b_1}}\left(\frac{d+D}{b}\right)$$



b_1 = Distance between two piles

b = Length of the floor

d = depth of pile (d-t)

D = depth of pile whose effect required to be determined

$DC_1 = 9.3 - 6.5$
$DC_3 = 8.5 - 6.5$
$DE_3 = 8.5 - 7.7$
$DE_2 = 8.5 - 6.5$

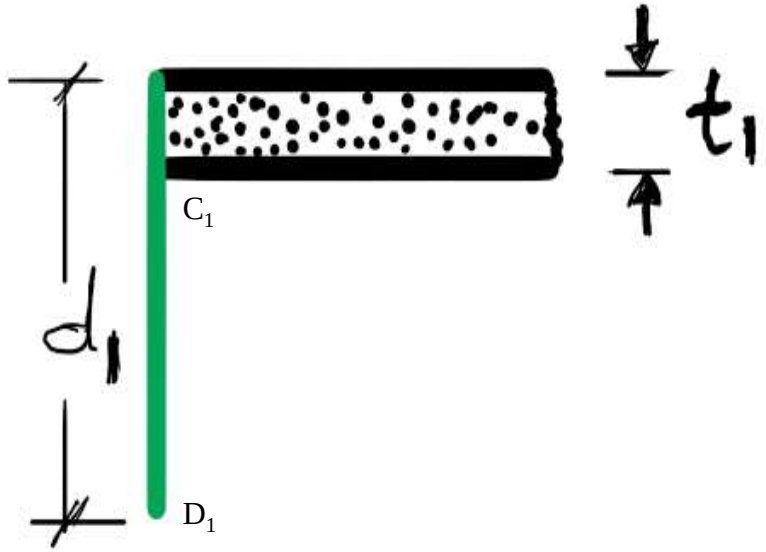
Note: The correction value (C) is +ve in the rear or back of water and the correction value (C1) is -ve in the front of the flow.

Correction of Pressure

- *Correction of floor thickness*

Khosle's graphs give the percentage of pressure at the top level of the floor.
While the actual junction at the bottom

$$C_{2\emptyset_{C_1}} = \left(\frac{\emptyset_{D1} - \emptyset_{C1}}{d_1}\right)(t_1)$$

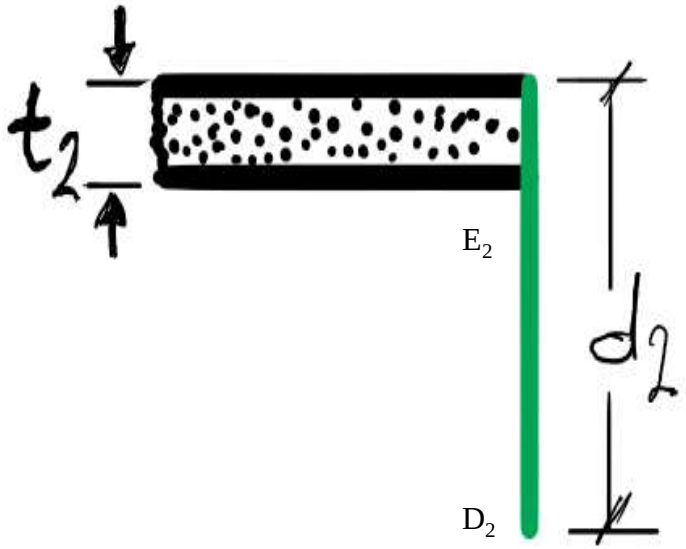


Correction of Pressure

- *Correction of floor thickness*

Khosle's graphs give the percentage of pressure at the top level of the floor.
While the actual junction at the bottom

$$C_{2\emptyset_{E_2}} = \left(\frac{\emptyset_{E2} - \emptyset_{D2}}{d_2}\right)(t_2)$$



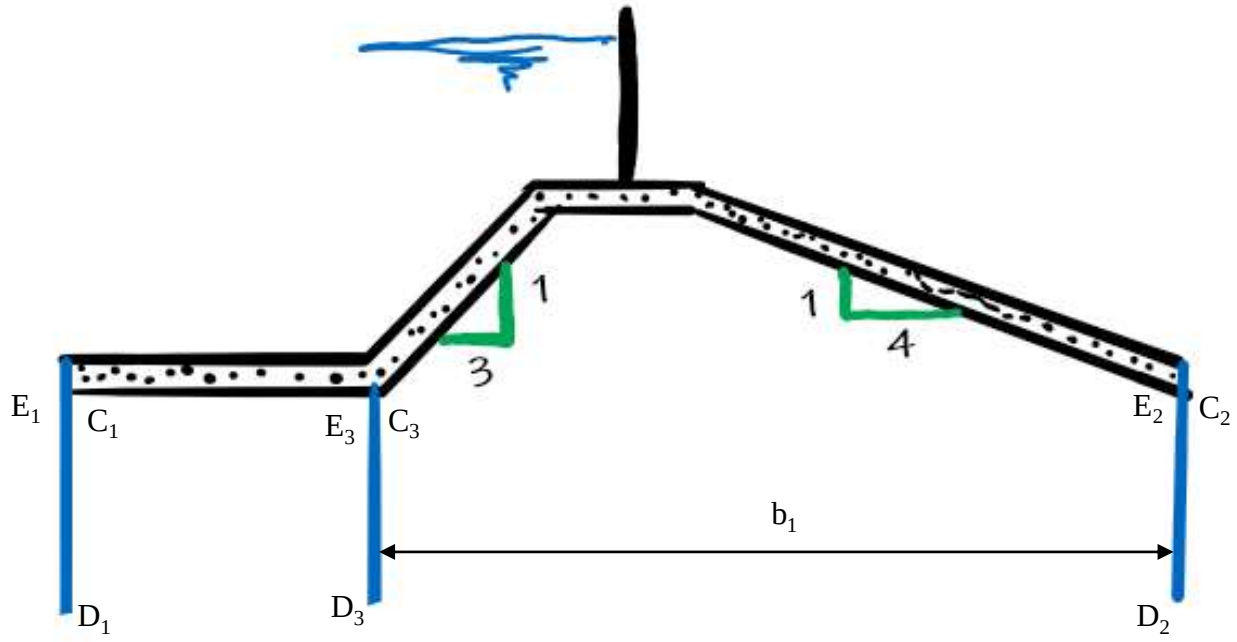
Note: The correction of thickness is $_+$ve for the key point lie on the D/S side of pile, and this correction is –ve for the key point on the U/S side of the pile.

Correction of Pressure

- *Correction of slope:*

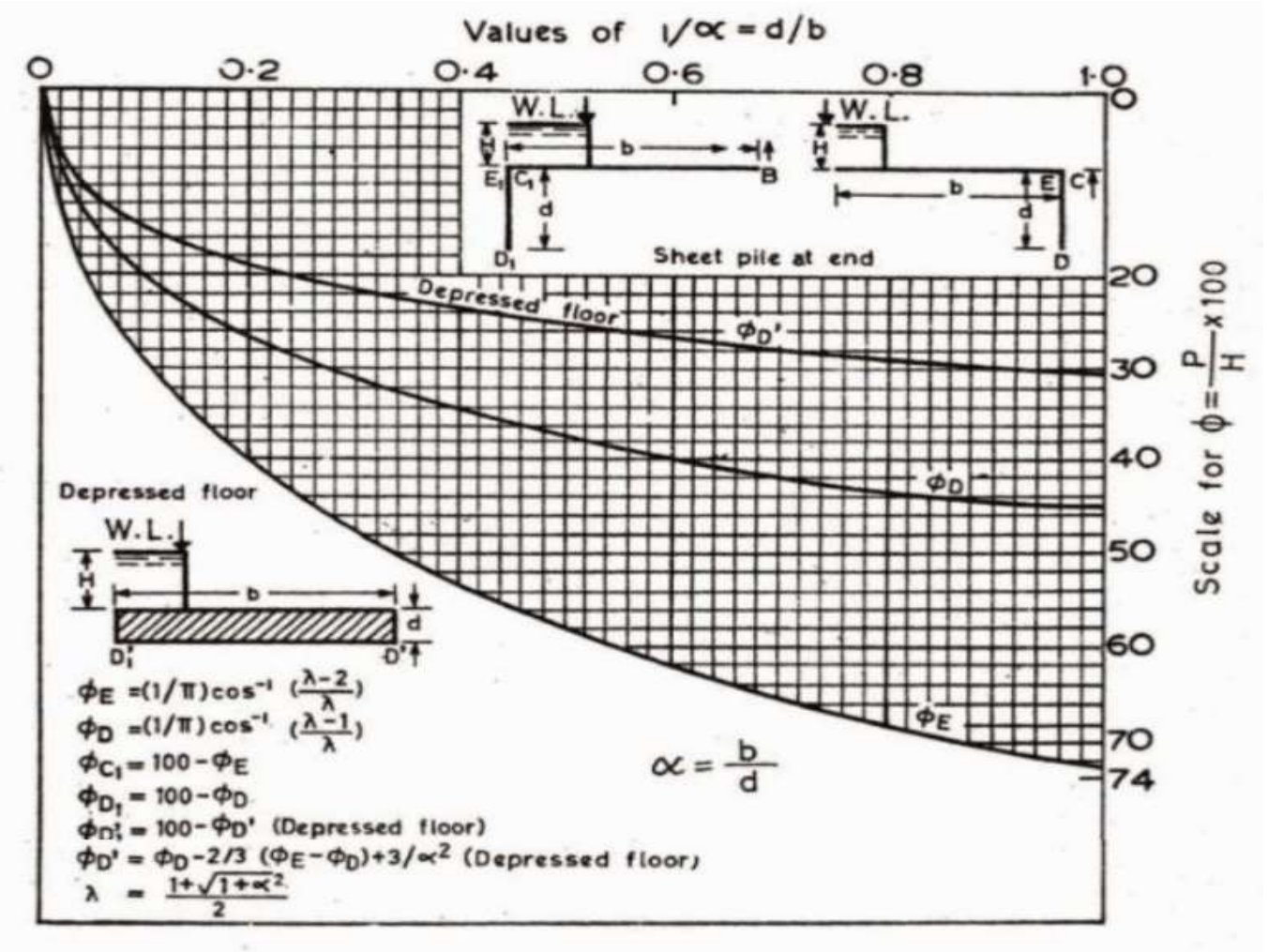
Correction is applied for sloping floor and take $_{+}$ve for the down and –ve for up slopes following the direction of flow.

The correction given in the table is to be multiplied by horizontal distance of slope and divided by the distance between two piles.



Slope H:V	1:1	2:1	3:1	4:1	5:1	6:1	7:1	8:1
Correction	11.2	6.5	4.5	3.3	2.8	2.5	2.3	2.0

Example: Determine the percentage pressure at key points and then find the thickness of floor at point A by using Khosle's Theory.



Solution:

1. **The Percentage Pressure at Key Points**

- **For the U/S pile**

$$\frac{1}{\alpha} = \frac{d_1}{b}$$

$$d_1 = 23.9 - 18.1 = 5.8\,m$$

$$\frac{1}{\alpha} = \frac{5.8}{25} = 0.23$$

$\emptyset E_1 = 100\%$

$\emptyset D_1 = 100\% - \emptyset D$ (from curve) $\quad \emptyset D = 28\%$

$\emptyset D_1 = 100\% - 28\% = 72\%$

$\emptyset C_1 = 100\% - \emptyset E$ (from curve) $\quad \emptyset E = 42\%$

$\emptyset C_1 = 100\% - 42\% = 58\%$ (This value must be corrected)

➢ *The correction of interference of ØC$_1$*

$$C_1 = 19\sqrt{\frac{D}{b_1}}\left(\frac{d+D}{b}\right)$$

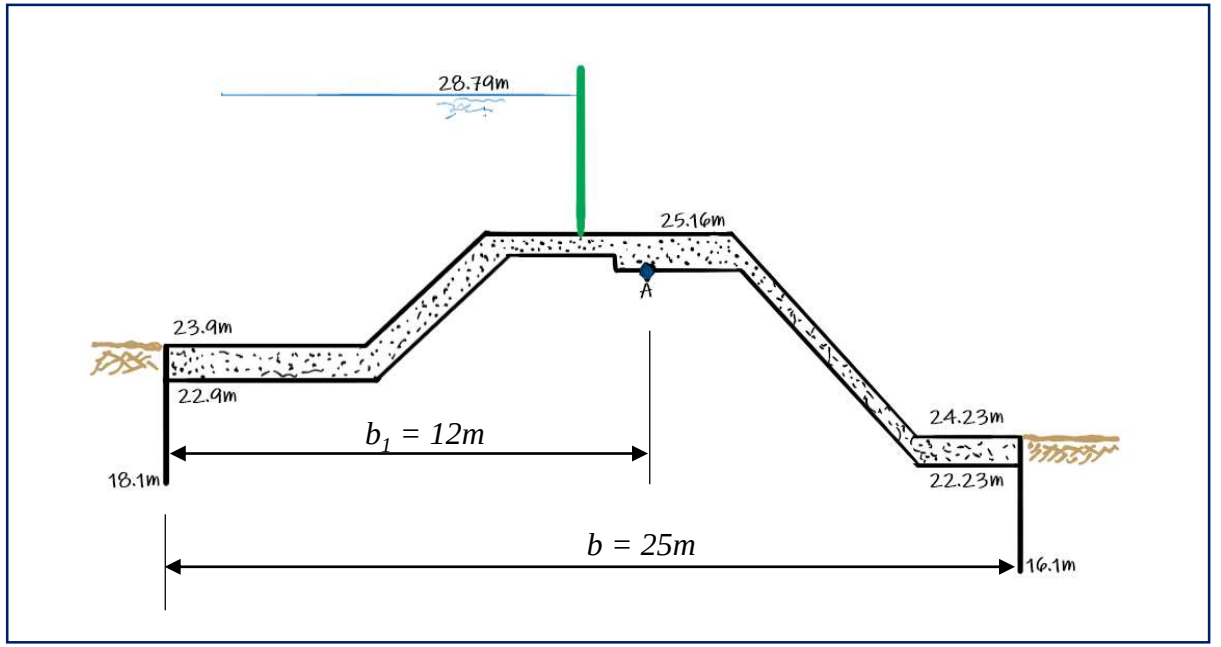
$b_1 = b = 25$ m

d =22.9- 18.1 = 4.8m

D = 22.9- 16.1 = 6.8m

$$C_{\emptyset c1} = 19\sqrt{\frac{6.8}{25}}\left(\frac{4.8+6.8}{25}\right)$$

$$C_{\emptyset c1} = 4.61\ \%\ (+ve)$$

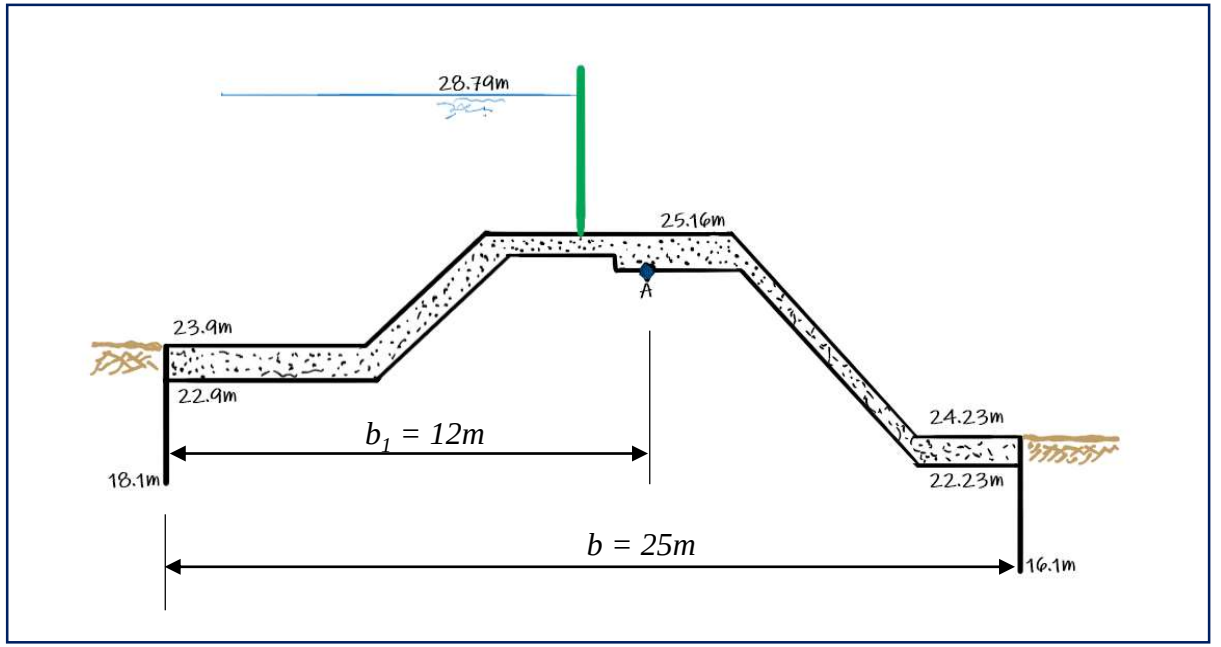


➢ *The correction for thickness of* $\emptyset_{C1}$

$$C_{2\emptyset_{c1}} = \left(\frac{\emptyset_{D1} - \emptyset_{C1}}{d_1}\right)(t_1)$$

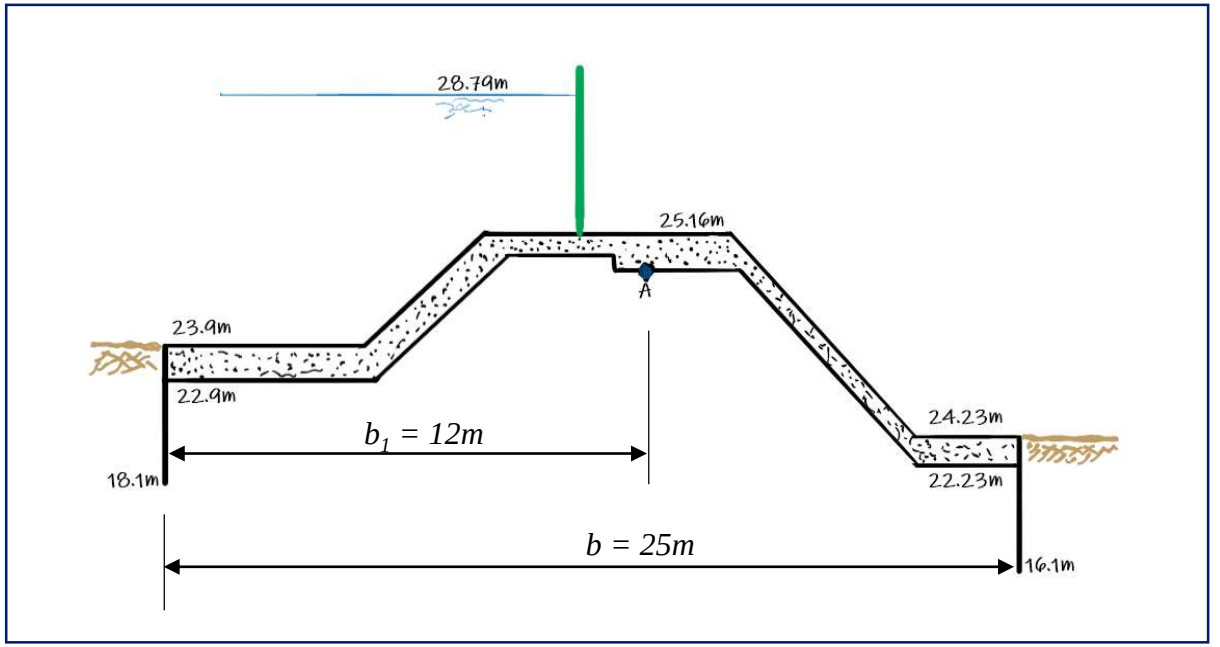
$$C_{2\emptyset_{c1}} = \left(\frac{72-58}{5.8}\right)(1)$$

= 2.41 % (+ve)



➢ *The correction for sloping*

There is no need for correction for sloping because the pile is sitting on horizontal surface.



Corrected $\emptyset_{C1}$= 58+ 4.61+ 2.41

=65.02%

Example: Determine the percentage pressure at key points and then find the thickness of floor at point A by using Khosle's Theory.

Solution:

1. **The Percentage Pressure at Key Points**

- **For the D/S pile**

$$\frac{1}{\propto} = \frac{d_2}{b}$$

$$d_2 = 24.23 - 16.1 = 8.13\ m$$

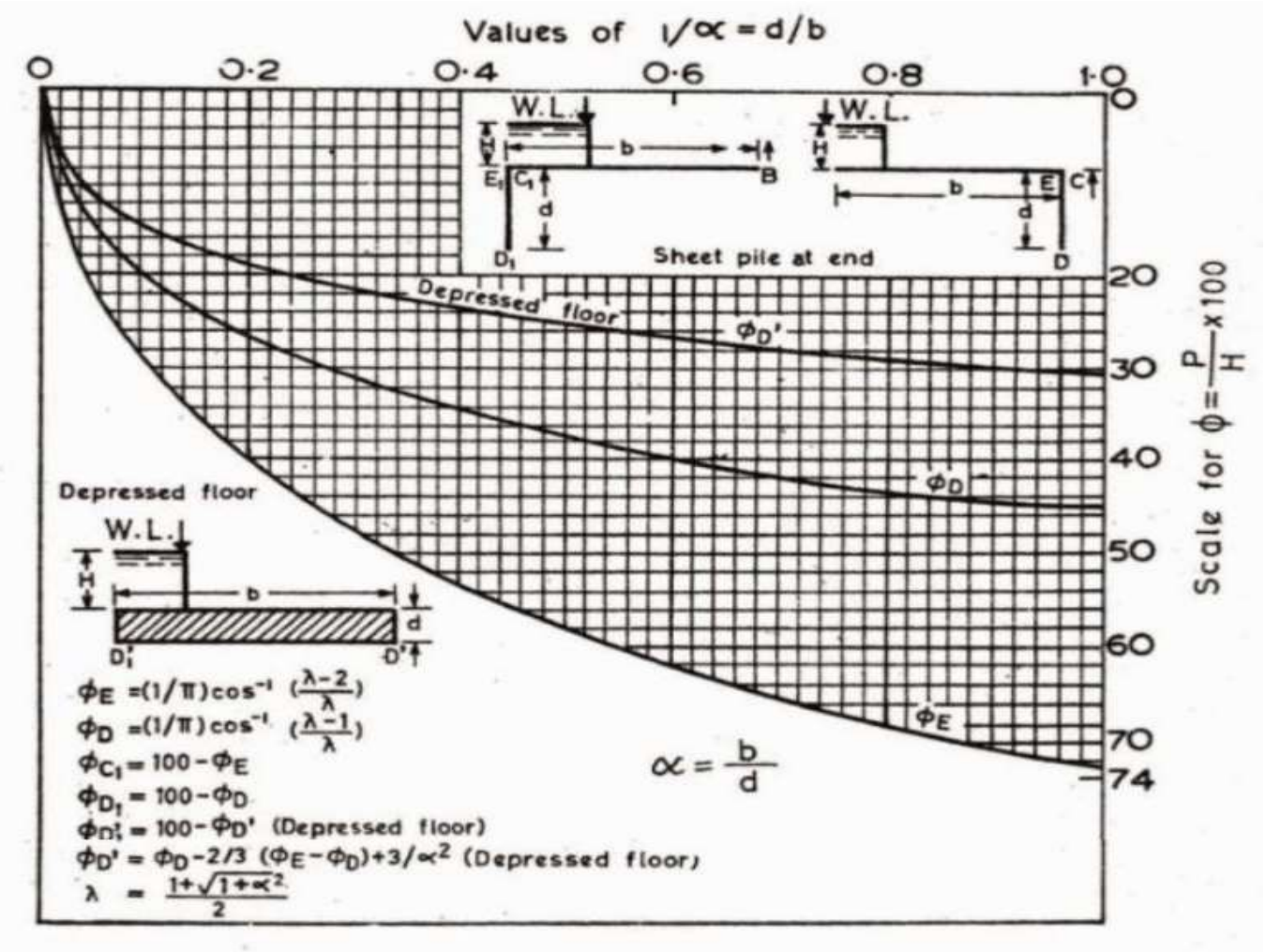
$$\frac{1}{\propto} = \frac{8.13}{25} = 0.325$$

$\emptyset E_2 = \emptyset E$ (from curve) $\emptyset E = 48\%$

$\emptyset E_2 = 48\%$ (must be corrected)

$\emptyset D_2 = \emptyset D$ (from curve) $\emptyset D = 32\%$ $\emptyset D_2 = 32\%$

$\emptyset C_2$ = Zero



➢ *The correction of interference of ØE$_2$*

$$C_1 = 19\sqrt{\frac{D}{b_1}}\left(\frac{d+D}{b}\right)$$

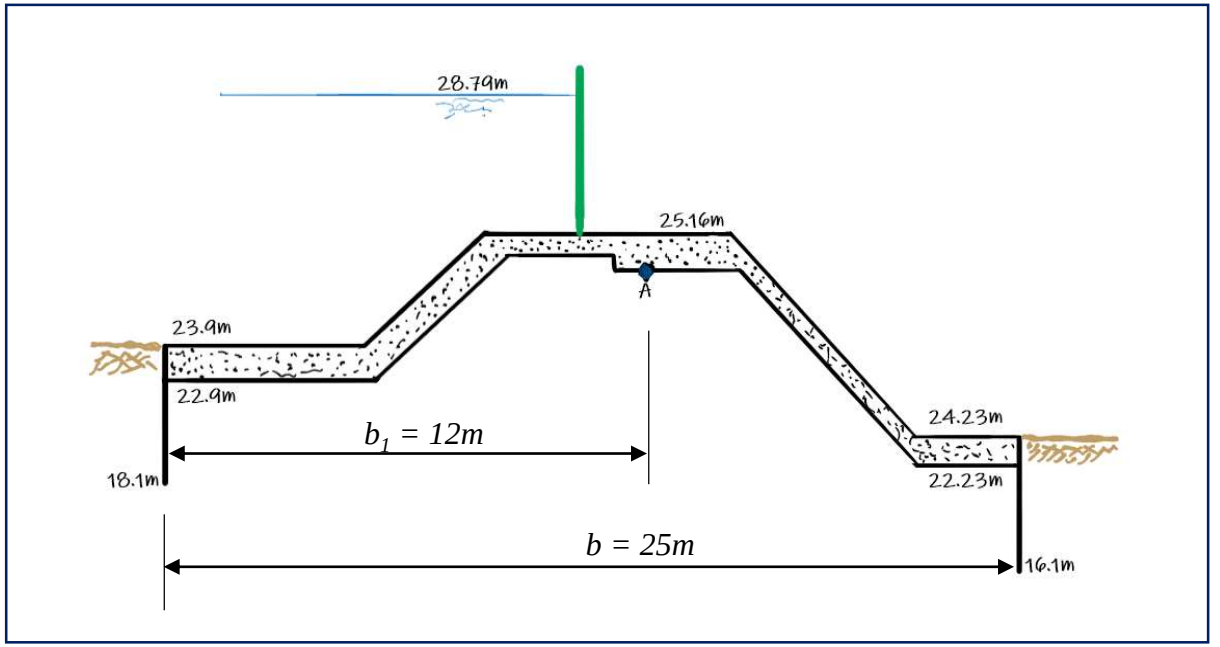
$b_1 = b = 25$ m

d =22.23 - 16.1 = 6.13m

D = 22.23 - 18.1 = 4.13m

$$C_{\emptyset_{E2}} = 19\sqrt{\frac{4.13}{25}}\left(\frac{6.13+4.13}{25}\right)$$

$$C_{\emptyset_{E2}} = 3.17\ \%\ (-ve)$$

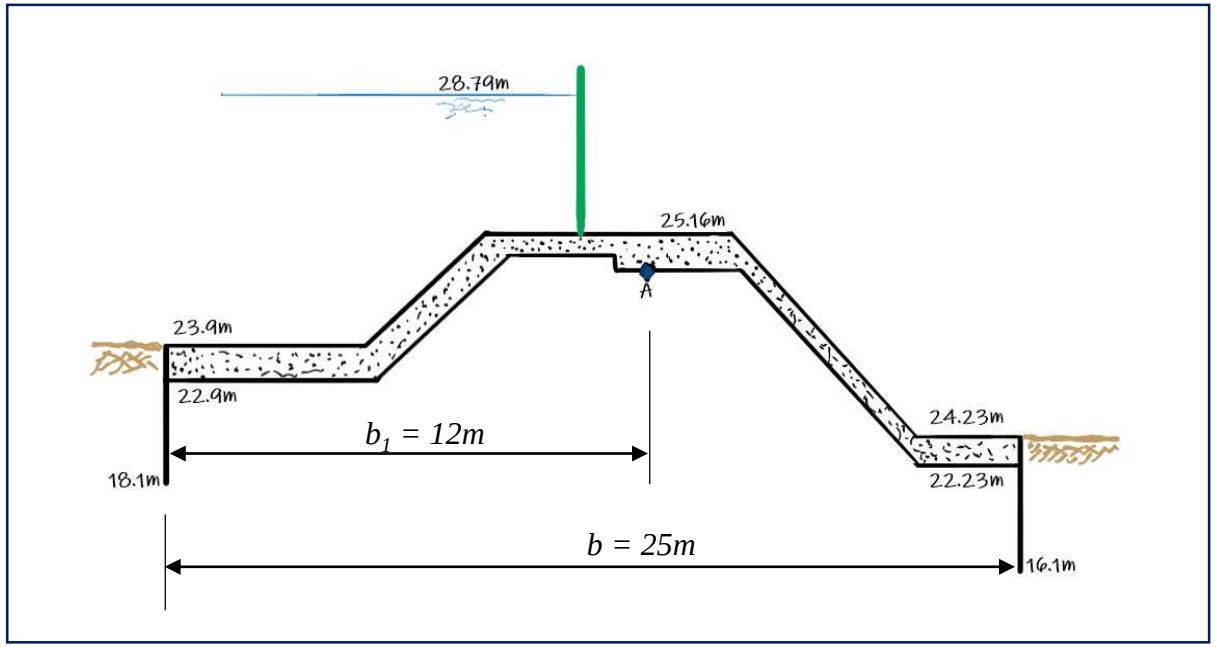


➢ *The correction for thickness of* $\emptyset_{E2}$

$$C_{2\emptyset_{E2}} = \left(\frac{\emptyset_{E2} - \emptyset_{D2}}{d_2}\right)(t_2)$$

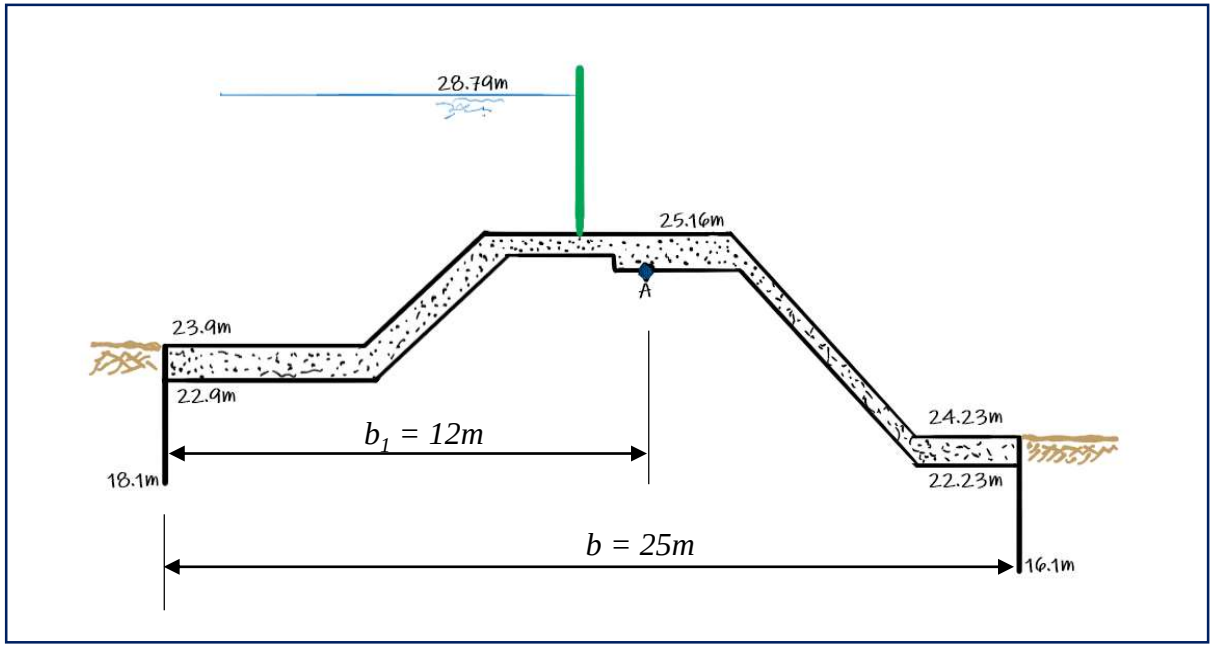
$$C_{2\emptyset_{E2}} = \left(\frac{48-32}{8.13}\right)(24.23-22.23)$$

= 3.94 % (-ve)



➢ *The correction for sloping*

There is no need for correction for sloping because the pile is sitting on horizontal surface.



Corrected $\emptyset E_2 = 48 - 3.17 - 3.94$

$= 40.89\%$

Example: Determine the percentage pressure at key points and then find the thickness of floor at point A by using Khosle's Theory.

Solution:

1. **The Thickness of Floor at Point A**

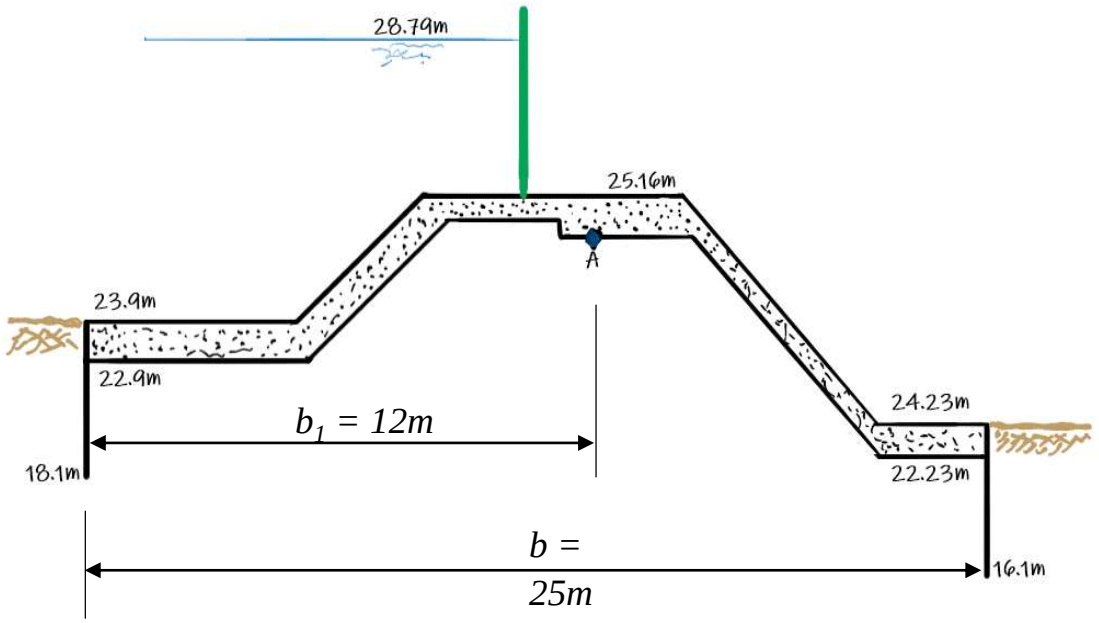
The percentage head at point A = $\emptyset_{C1} - \frac{(\emptyset_{C1} - \emptyset_{E2})}{b} (b_1)$

$$\text{OR} = \emptyset_{E2} + \left(\frac{\emptyset_{C1} - \emptyset_{E2}}{b}\right)(b_2)$$

$$= 65.02 - \left(\frac{65.02 - 40.89}{25}\right) * (12)$$

$$\text{OR} = 40.89 + \left(\frac{65.02 - 40.89}{25}\right) * (13)$$

$$= 53.43\%$$



Example: Determine the percentage pressure at key points and then find the thickness of floor at point A by using Khosle's Theory.

Solution:

1. **The Thickness of Floor at Point A**

h_A= 0.5343 H

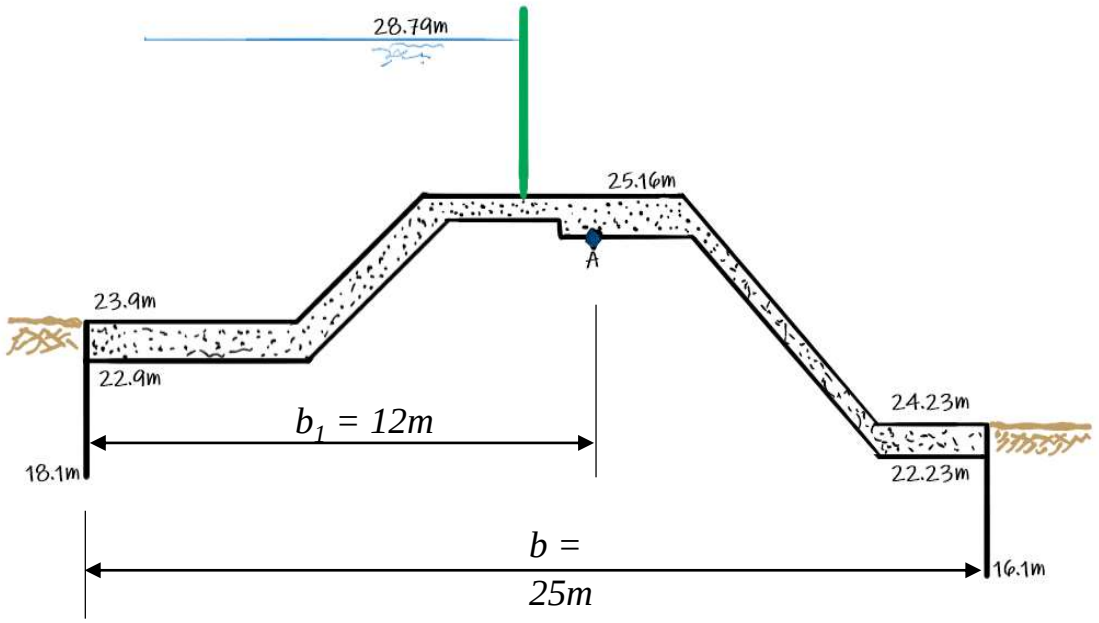
= 0.5343 (28.79 – 24.23)

= 2.439 m

$$t_A = \frac{h_A}{G-1}\left(\frac{4}{3}\right)$$

$t_A = \frac{2.439}{2.4-1}\left(\frac{4}{3}\right)$

t_A= 2.32 m



Exit Gradient (G.e)

$$F.S = \frac{1}{G.e}$$

$$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$$

$$\lambda = \frac{1 + \sqrt{1+\propto^2}}{2}$$

$$\propto = \frac{b}{d}$$

No.	Soil Type	G.e
1	Shingle	$\frac{1}{4}\ to\ \frac{1}{5}$
2	Coarse sand	$\frac{1}{5}\ to\ \frac{1}{6}$
3	Fine sand	$\frac{1}{6}\ to\ \frac{1}{7}$

Where:

$G.e$ = Exit gradient

H= total head

= U/S water level – D/S water level (closed gate)

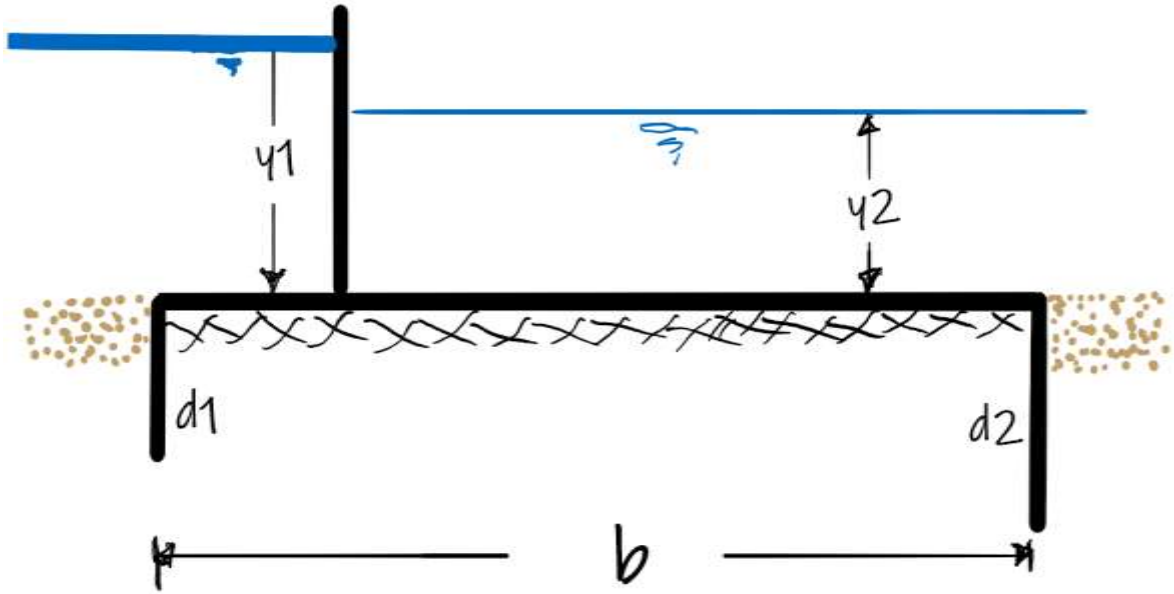
d = depth of D/S pile

b = length of floor

Depth of pile

$$R_s = 1.35 \left(\frac{q^2}{f}\right)^{1/3}$$

$$q = \frac{Q}{S_w}$$



Where:

f = Silt Factor (0.65 - 1)

$f = 1.76\sqrt{D}$

R_s = The distance from water surface to the lower point of excavation

D = diameter of particles

$d_1 = (1 – 1.25)\ R_s - y_1$

$d_2 = (1.25 – 1.5)\ R_s - y_2$

Example: For the hydraulic structure in the figure below, Does the structure safe against piping when $G.e = \frac{1}{6}$?

Solution:

$$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$$

H = 28.79 – 24.23 = 4.56 m

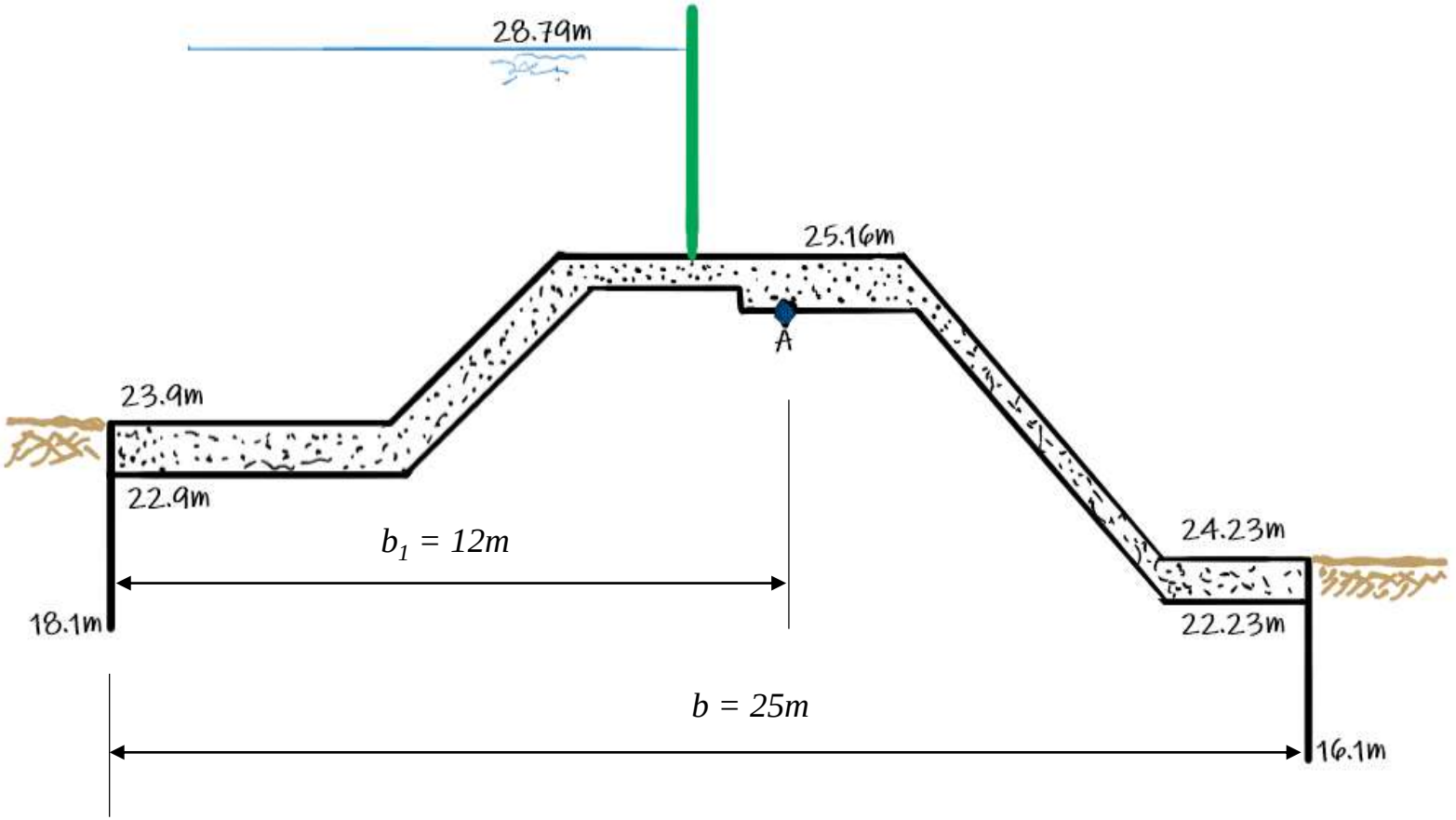
d = d_2 = 24.23 – 16.1 = 8.13 m

b = 25 m

$$\lambda = \frac{1 + \sqrt{1+\propto^2}}{2}$$

$$\propto = \frac{b}{d} = \frac{25}{8.13} = 3.075$$

$$\lambda = \frac{1 + \sqrt{1 + 3.075^2}}{2} = 2.116$$



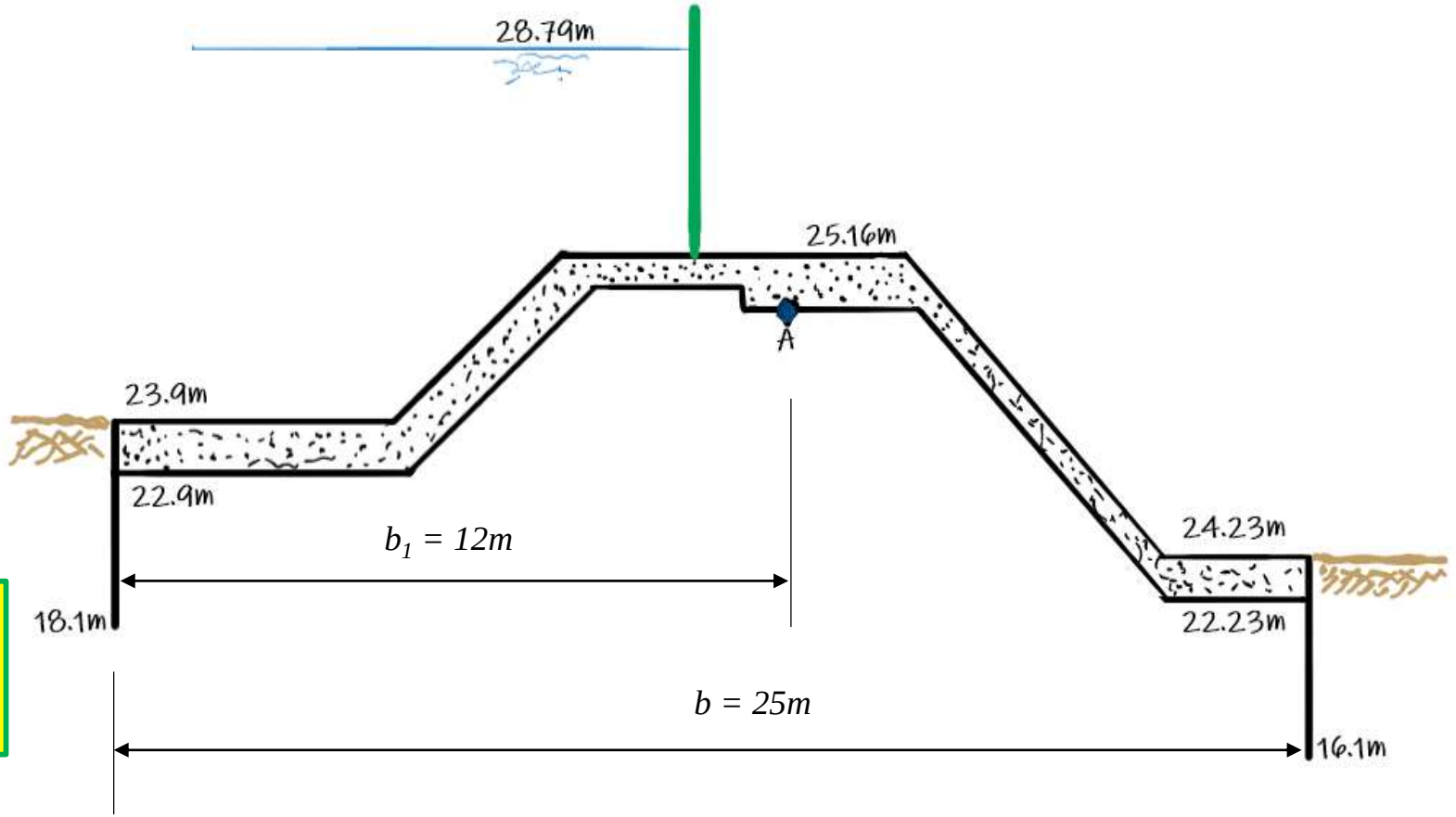
Example: For the hydraulic structure in the figure below, Does the structure safe against piping? Use $G.e = \frac{1}{6}$

$$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$$

$$G.e = \frac{4.56}{8.13} * \frac{1}{\pi\sqrt{2.116}} = 0.122$$

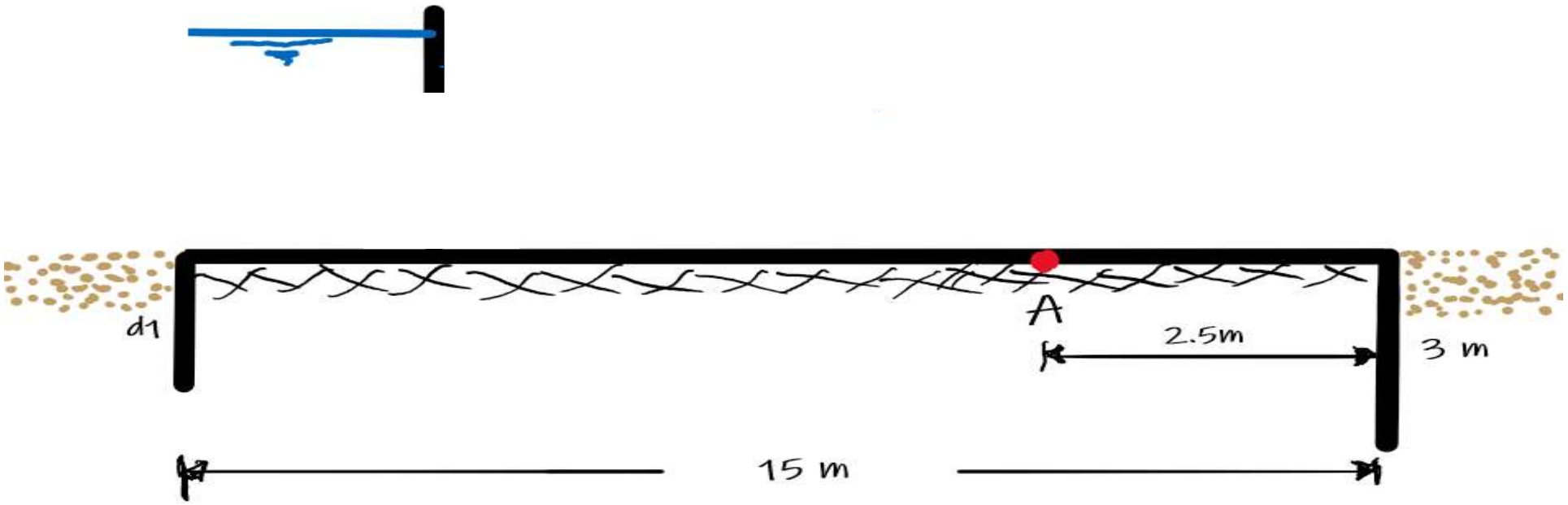
$$\frac{1}{8.2} < \frac{1}{6}$$

The structure is safe against piping



Example: A regulator was constructed to pass a discharge of canal with allowable head loss (ΔH) equal to (0.145 m). The following data are available: - Depth of D/S pile d_2= 3m, length of horizontal floor b= 15 m, width of regulator gate S_w = 6m, $G.e = \frac{1}{7}$, f = 0.712, C= 0.92, $G_{con.} = 2.4\ ton/m^3$, Neglect h_v

a. Find the approximate design discharge (Q) of this regulator
b. Find thickness of floor at point (A) using Bligh's theory
c. Is this structure being safe against piping by using Bligh's theory use i =$\frac{1}{12}$



➢ *Find the approximate design discharge (Q) of this regulator*

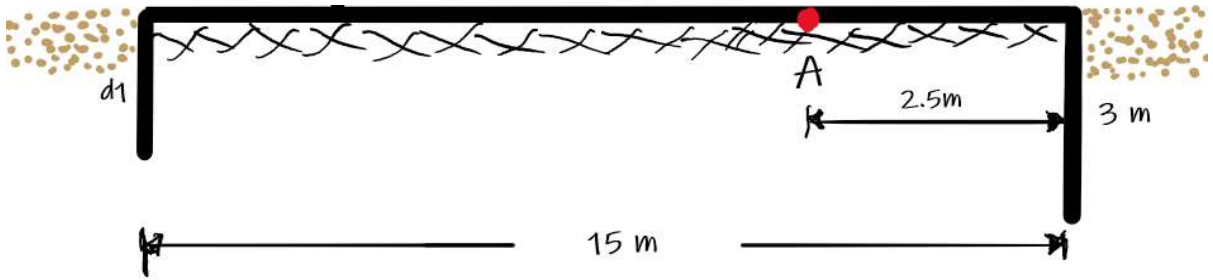
$Q = C * S_w * y_t * \sqrt{2gH_1}$

$H_1 = \Delta H + h_v$ → $H_1 = 0.145\ m$

S_w = 6 m,

C= 0.92 ,

y_t=?



$G.e = \frac{H}{d} * \frac{1}{\pi\sqrt{\lambda}}$, $\propto = \frac{b}{d} = \frac{15}{3} = 5$

$\lambda = \frac{1+\sqrt{1+\propto^2}}{2} = \frac{1+\sqrt{1+5^2}}{2} = 3.049$

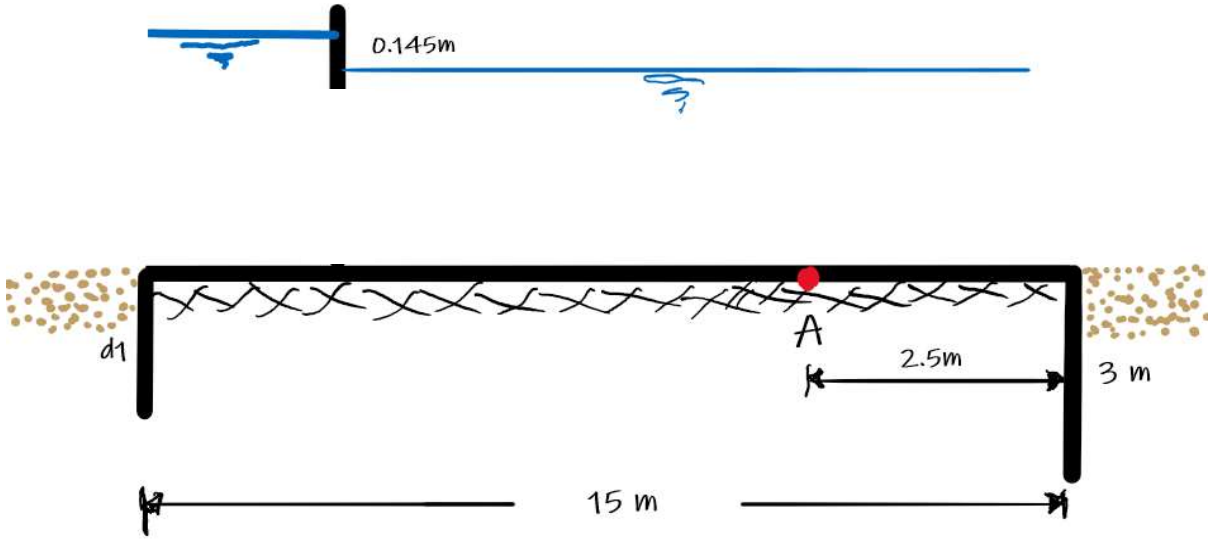
$\frac{1}{7} = \frac{H}{3} * \frac{1}{\pi\sqrt{3.049}}$ → $H = 2.351\ m$ → $H = y_1$

y_t = H - ΔH = 2.351 – 0.145 y_t = 2.206 m

$Q = 0.92 * 6 * 2.206 * \sqrt{2(9.81)(0.145)}$

$Q = 20.5\ m^3/sec$

➢ *Find thickness of floor at point (A) using Bligh's theory*



$d_1 = (1 - 1.25)\, R_s - y_1$

$R_s = 1.35\, (\frac{q^2}{f})^{1/3}$

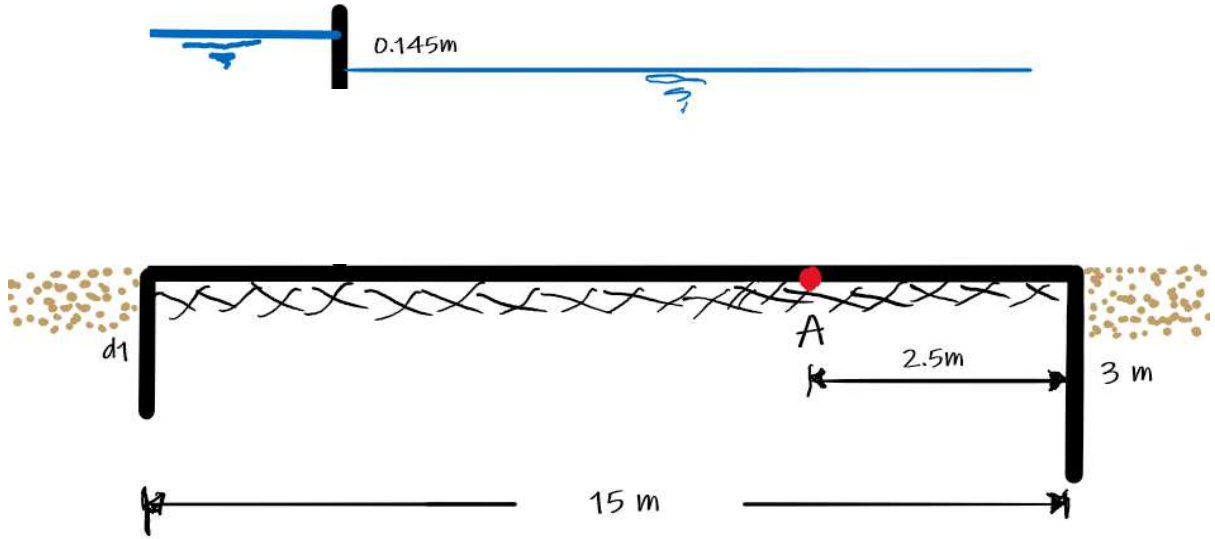
$q = \frac{20.5}{6} = 3.416\, m^3/sec/\text{m}$

$R_s = 1.35\, (\frac{(3.416)^2}{0.712})^{1/3} = 3.429$ m

$d_1 = 1.25\, (3.429) - 2.351$

$= 1.935$ m ≈ 2 m

➢ *Find thickness of floor at point (A) using Bligh's theory*



L.W= $2(d_1+ d_2) +b$ = 2(2+3) +15

L.W = 25 m

$L.W_A= 2d_1 + (b -2.5)$ = 2(2) + (15-2.5)

$L.W_A$ = 16.5 m

$h_A= H\left(1- \frac{L.W_A}{L.W}\right)$ = 2.351 $\left(1- \frac{16.5}{25}\right)$

h_A = 0.799 m

$$t_A = \frac{4}{3} * \frac{h_A}{G-1} = \frac{4}{3} * \frac{0.799}{2.4-1}$$

$t_A = 0.76\ m$

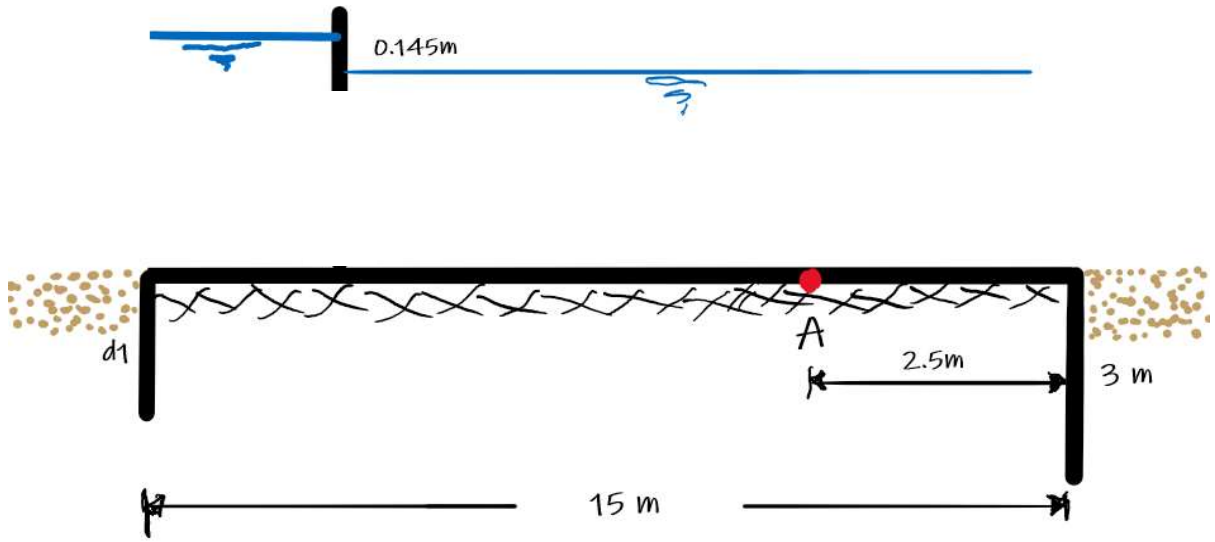
What would be the thickness of floor at point (A) without using the sheet pile at U/S?

➢ *Is this structure being safe against piping ?*

L.W= 25 m

H= 2.351 m

$$i = \frac{H}{L.W} = \frac{2.351}{25}$$



$$\frac{1}{10.6} > \frac{1}{12}$$

The structure is not safe against piping

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