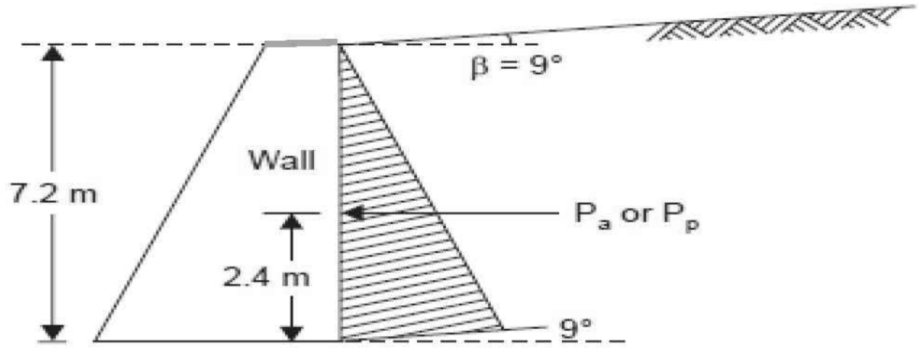
Example 9: A vertical wall with a smooth face is 7.2 m high and retains soil with a uniform surcharge angle of 9°. If the angle of internal friction of soil is 27°, compute the active earth pressure and passive earth resistance assuming $\gamma = 20\ kN/m^3$.

$H = 7.2$ m $\quad \beta = 9°$

$\phi = 27° \quad \gamma = 20$ kN/m³



According to Rankine's theory,

$$K_a = \cos\beta\left(\frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}\right)$$

$$= \cos 9°\left(\frac{\cos 9° - \sqrt{\cos^2 9° - \cos^2 27°}}{\cos 9° + \sqrt{\cos^2 9° - \cos^2 27°}}\right)$$

$$= 0.988 \times 0.397 = 0.392$$

$$K_p = \cos\beta\left(\frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}\right) = 0.988 \times \frac{1}{0.397} = 2.488$$

Total active thrust per metre run of the wall

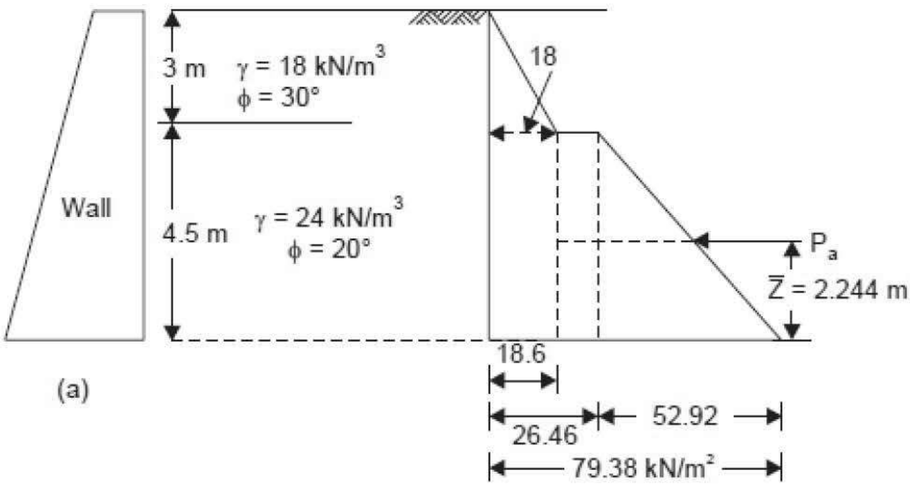
$$P_a = \frac{1}{2}\gamma H^2.K_a = \frac{1}{2} \times 20 \times (7.2)^2 \times 0.392 = \mathbf{203.2\ kN}$$

Total passive resistance per metre run of the wall

$$P_p = \frac{1}{2}\gamma H^2.K_p = \frac{1}{2} \times 20 \times (7.2)^2 \times 2.488 = \mathbf{1289.8\ kN}$$

Example 10: A retaining wall, 7.5 m high, retains a cohsionless backfill. The top 3 m of the fill has a unit weight of 18 kN/m^3 and φ = 30° and the rest has unit weight of 24 kN/m^3 and φ = 20°. Determine the pressure distribution on the wall.

Solution:



(b)

$$K_a \text{ for top layer} = \frac{1-\sin 30°}{1+\sin 30°} = \frac{1}{3}$$

$$K_a \text{ for bottom layer} = \frac{1-\sin 20°}{1+\sin 20°} = 0.49$$

Active pressure at 3 m depth – considering first layer

$$K_{a_1}.\sigma_v = \frac{1}{3} \times 3 \times 18 = 18 \text{ kN/m}^2$$

Active pressure at 3 m depth – considering second layer

$$K_{a_2}.\sigma_v = 0.49 \times 3 \times 18 = 26.46 \text{ kN/m}^2$$

Active pressure at the base of the wall :

$$K_{a_2} \times 3 \times 18 + K_{a_2} \times 4.5 \times 24 = 26.46 + 0.49 \times 4.5 \times 24 = 79.38 \text{ kN/m}^2$$

The pressure distribution with depth is shown in Fig. 13.57 (*b*).

Total active thrust, P_a, per metre run of the wall

= Area of the pressure distribution diagram

$$= \frac{1}{2} \times 3 \times 18 + 4.5 \times 26.46 + \frac{1}{2} \times 4.5 \times 52.92$$

= 27 + 119.07 + 119.07 = **265.14 kN**

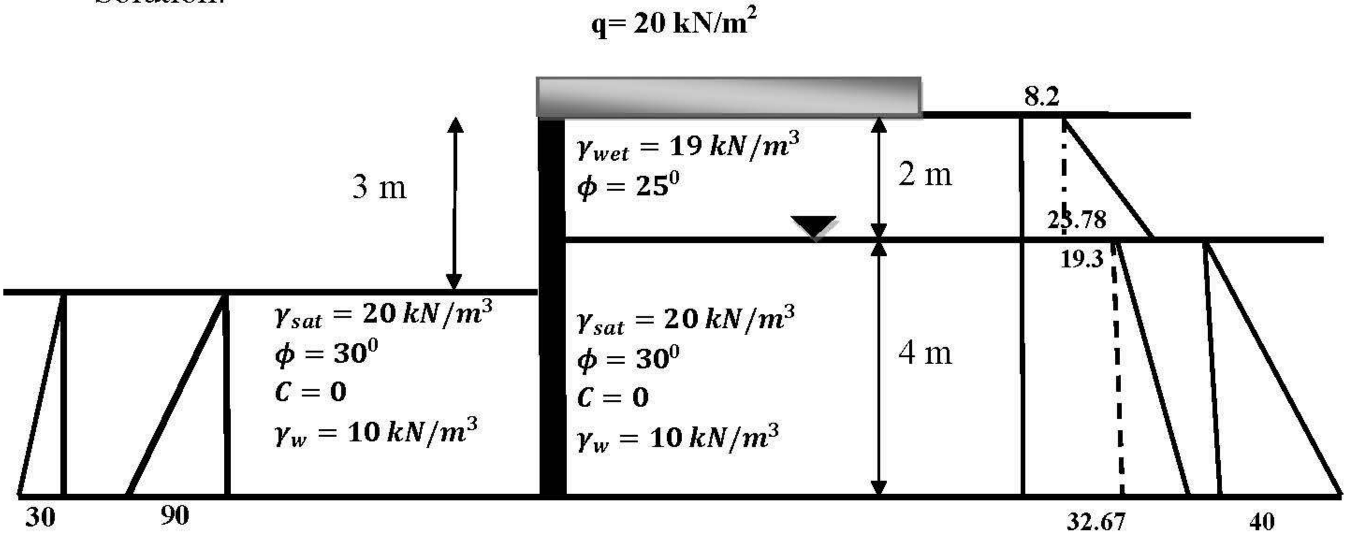
The height of the point of application of this thrust above the base of the wall is obtained by taking moments, as usual.

$$\bar{z} = \frac{(27 \times 5.5 + 119.07 \times 2.25 + 11907 \times 1.5)}{265.14} \text{m} = \mathbf{2.244 \text{ m}}$$

Example 13: For the frictionless sheet pile shown in below Figure, determine the following:

1. The active lateral earth pressure distribution with depth.
2. The passive lateral earth pressure distribution with depth.
3. The magnitudes and location of active and passive forces.

Solution:



1) Active Side:

$$\sigma_a = (q + \gamma . Z).K_a - 2C.\sqrt{K_a} \qquad C = 0$$

$$\sigma_a = (q + \gamma . Z).K_a$$

a) Layer (1)

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 25}{1+\sin 25} = 0.41$$

$$\sigma_{a(1)} = (0 + 20) \times 0.41 = 8.2\ kN/m^2$$

$$\sigma_{a(2)} = (20 + 2 \times 19) \times 0.41 = 23.78\ kN/m^2$$

b) Layer (2)

$$K_a = \frac{1-\sin\phi}{1+\sin\phi} = \frac{1-\sin 30}{1+\sin 30} = 0.334$$

$$\sigma_{a(2)} = (20 + 2 \times 19) \times 0.334 = 19.33\ kN/m^2$$

$$\sigma_{a(3)} = (20 + 2 \times 19 + (20 - 10) \times 4) \times 0.334 = 32.67\ kN/m^2$$

$$\sigma_{water} = \gamma_w \times H_w = 10 \times 4 = 40\ kN/m^2$$

The active lateral force:

$$P_a = [8.2 \times 2] + \left[\frac{1}{2} \times (37.78) \times 2\right] + [19.33 \times 4] + \left[\frac{1}{2} \times (32.67 - 19.33) \times 4\right] + [\left[\frac{1}{2} \times (40) \times 4\right]$$

$$\boldsymbol{P_a = 16.4 + 15.58 + 77.32 + 26.68 + 80 = 215.98\ kN/m}$$

$$y^{`} = \frac{\left[16.4 \times \left(\frac{1}{2}(2) + 4\right)\right] + \left[15.58 \times (2 \times \left(\frac{1}{3}\right) + 4)\right] + [\left[77 \times 4 \times \left(\frac{1}{2}\right)\right] + \left[26.68 \times \frac{4}{3}\right] + [80 \times \frac{4}{3}]}{215.98}$$

$\boldsymbol{y^{`} = 2.53\ m}$ **(Location of active force, from the base of the wall)**

2) Passive Side:

$\sigma_p = (q + \gamma.Z).K_p + 2C.\sqrt{K_a}$ $\qquad C = 0$

$\sigma_p = (\gamma.Z).K_p$

$K_p = \frac{1+\sin\phi}{1-\sin\phi} = \frac{1+\sin 25}{1-\sin 25} = 3$

$\sigma_{p(1)} = (0 \times 20) \times 3 = 0\ kN/m^2$

$\sigma_{p(2)} = (3 \times (20 - 10)) \times 3 = 90\ kN/m^2$

$\sigma_{water} = \gamma_w \times H_w = 10 \times 3 = 30\ kN/m^2$

$$\boldsymbol{P_p = \left[\frac{1}{2} \times 90 \times 3\right] + \left[\frac{1}{2} \times (30) \times 3\right] = 135 + 45 = 180\ kN/m}$$

$\boldsymbol{y^{`} = \frac{\left[135 \times \left(\frac{1}{3}\right) \times 3\right] + \left[45 \times (3 \times \left(\frac{1}{3}\right))\right]}{180} = 1m}$ **(Location of passive force, from the base of the wall)**