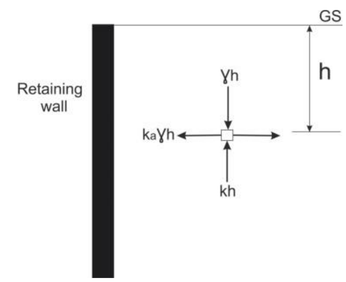
Lateral pressure

Lateral earth pressure is a significant design element in a number of foundation engineering problems. Retaining and sheet-pile walls, both braced and unbraced excavations, grain in silo walls and bins, and earth or rock contacting tunnel walls and other underground structures require a quantitative estimate of the lateral pressure on a structural member for either a design or stability analysis.

Rankine Factor

If we take a point at a depth h below the surface of the soil, the soil column exert a vertical pressure γh, and at instantaneously it will deform the soil and the retaining structures toward the horizontal causing a an active pressure $k_a k\gamma h$ that leads to the collapse of the vertical sides of the soil, as happens in the tunnels, so the retaining walls are used to stop the soil and prevent it from collapsing, as in the following figure :To find the horizontal force acting on, the Rankine factor ka coefficient must be known.



The values range from 0 < ka < 1

Rankin Factor for active pressure

$$\sin\emptyset = \frac{\frac{\gamma h - k_a\gamma h}{2}}{\frac{\gamma h + k_a\gamma h}{2}}$$

$$\sin\emptyset = \frac{\gamma h - k_a\gamma h}{\gamma h + k_a\gamma h} = \frac{\gamma h(1-k_a)}{\gamma h(1+k_a)}$$

$$\sin\emptyset = \frac{1-k_a}{1+k_a}$$

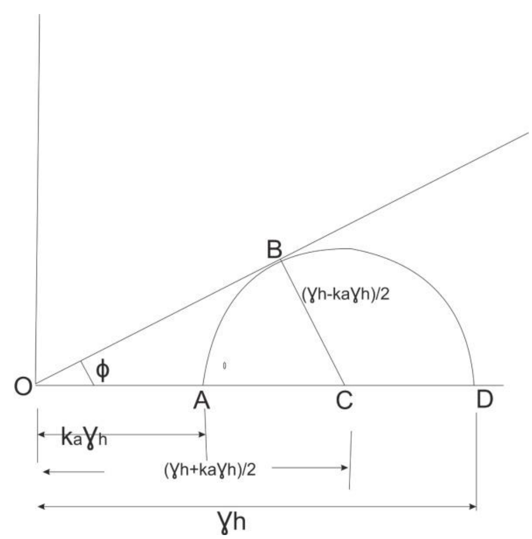
$$1 - k_a = \sin\emptyset\,(1 + k_a)$$

$$1 - k_a = \sin\emptyset + \sin\emptyset\, k_a$$

$$1 - \sin\emptyset = k_a + \sin\emptyset\, k_a$$

$$1 - \sin\emptyset = k_a(1 + \sin\emptyset)$$

$$k_a = \frac{1-\sin\emptyset}{1+\sin\emptyset}$$



Example: if the angle of internal friction $\varphi = 35^{\circ}$, calculate k_a

Ans: $k_a = \frac{1-\sin\emptyset}{1+\sin\emptyset}$, $k_a = \frac{1-\sin 35}{1+\sin 35} = \frac{1-0.573}{1+o.573}$ =0.271 <1 always

Rankin factor for active pressure on slopes may be taken as:-

$$K_a = \frac{\sin^2(\alpha + \phi)}{\sin^2\alpha \sin(\alpha - \delta)\left[1 + \sqrt{\frac{\sin(\phi + \delta)\sin(\phi - \beta)}{\sin(\alpha - \delta)\sin(\alpha + \beta)}}\right]^2}$$

Example 11-1. What is the total active force per meter of wall for the soil-wall system, shown in Fig. E11-1, using the Coulomb equations? Where does P_a act?

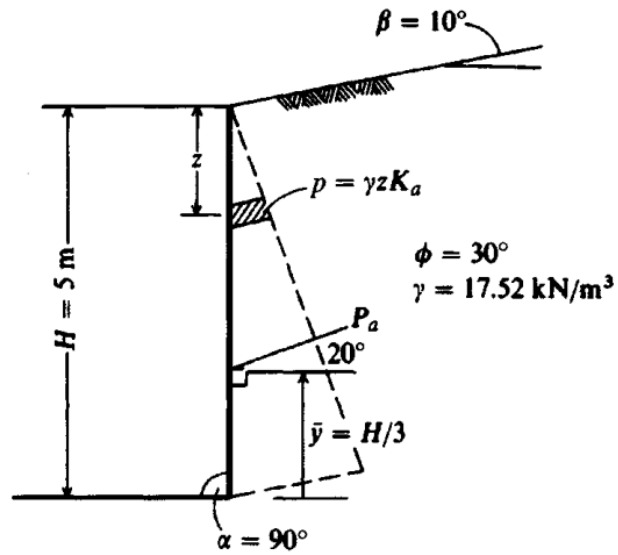
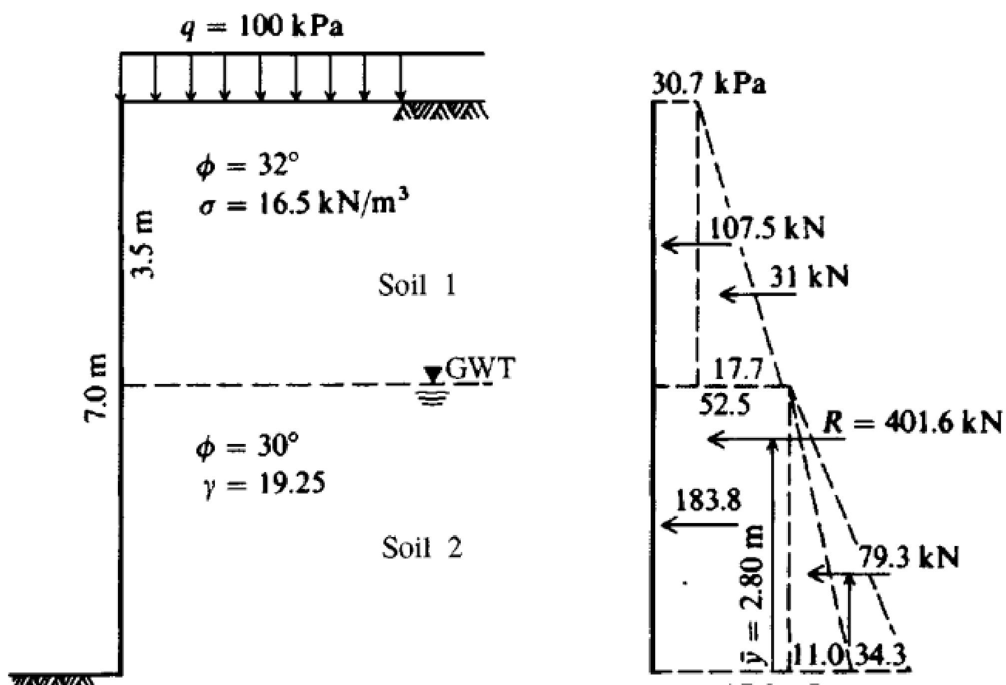
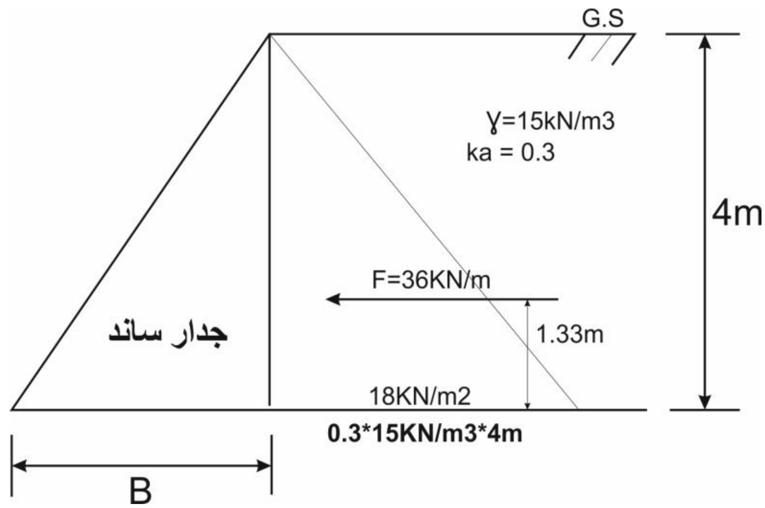


Figure E11-1

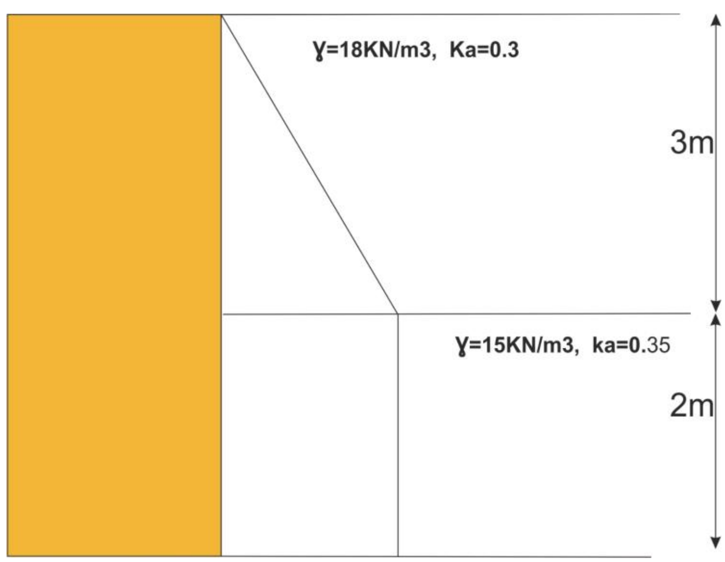
Example 11-2. What is the total active force/unit width of wall and what is the location of the resultant for the system shown in Fig. E11-2*a*? Use the Coulomb equations and take a smooth wall so $\delta = 0°$.

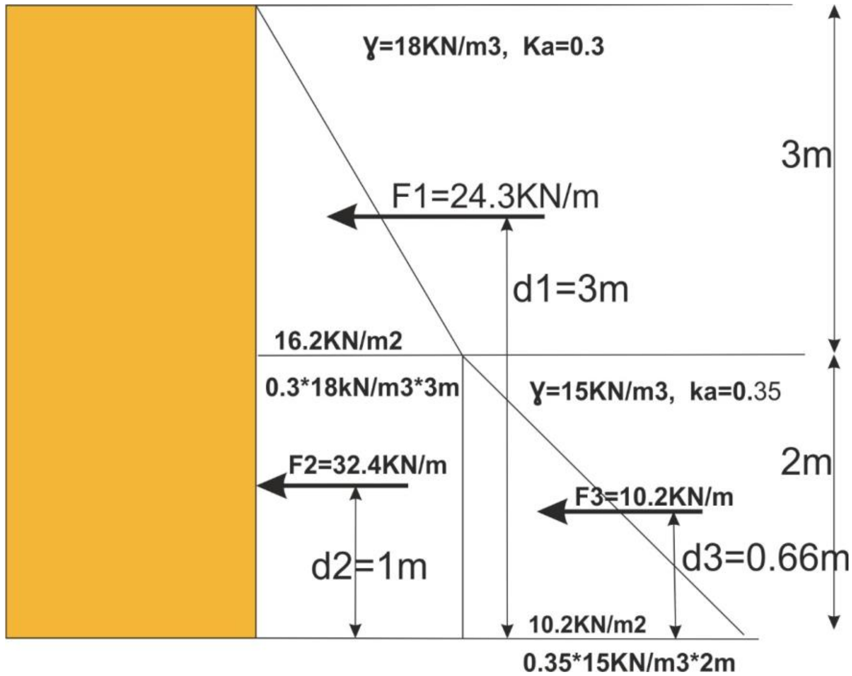


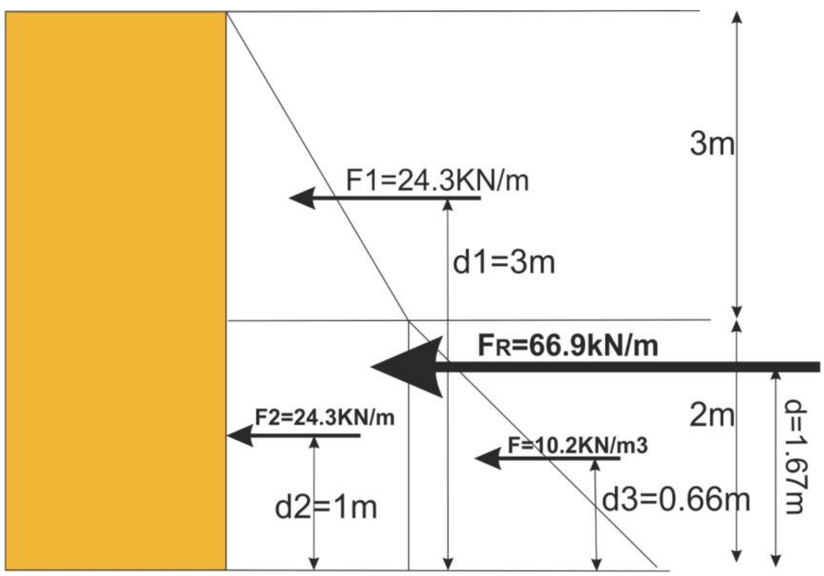
Example: estimate the force acting on the retaining wall and it distance from the base.



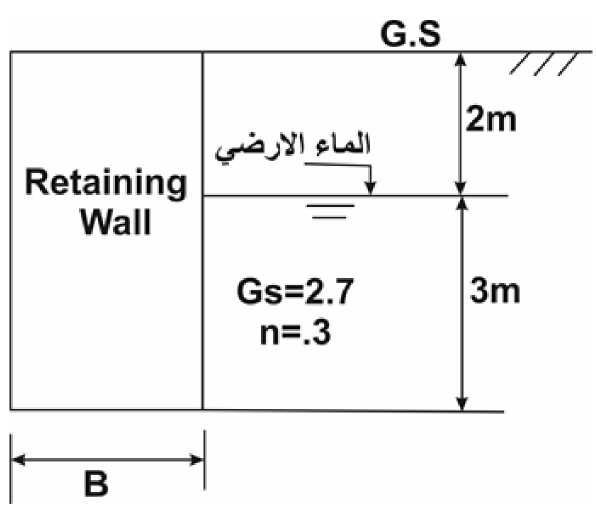
Example: calculate the lateral pressure excreted on the retaining wall shown in the figure. Also calculate the resultant and its distance from the wall basement.

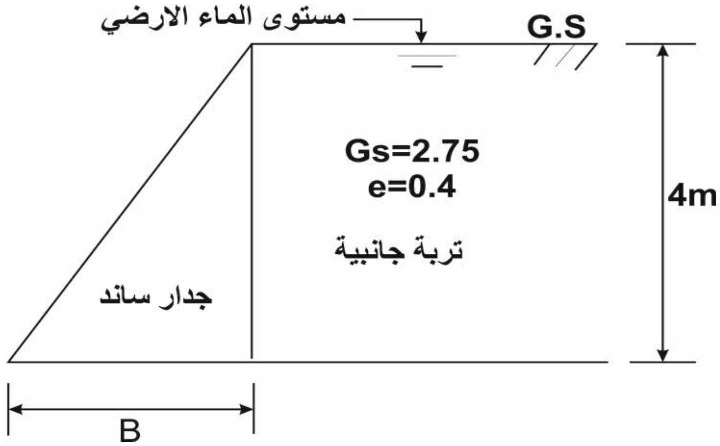






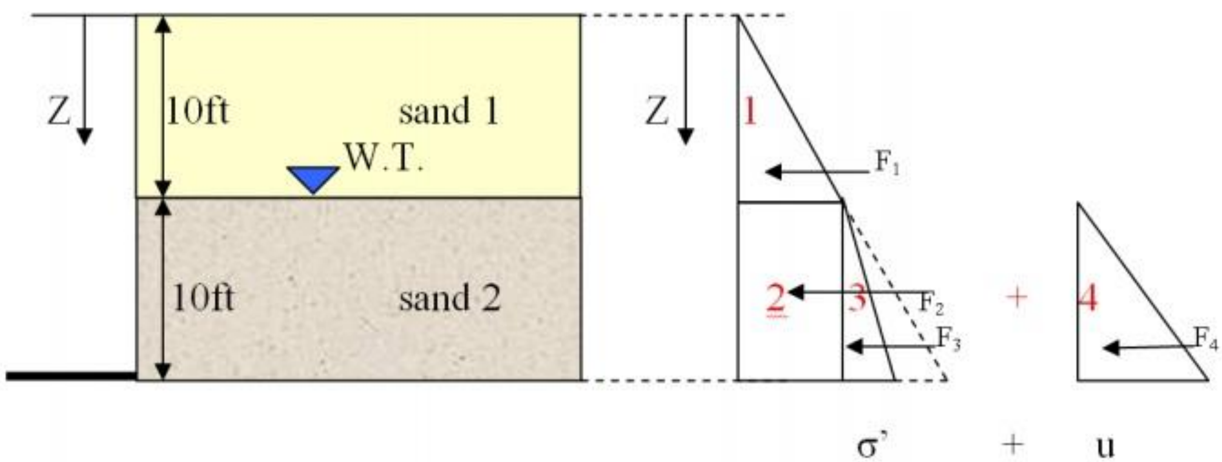
Problem1: **Find the resultant of earth pressure and its location from the base,** $K_a = 0.34$





Pore water pressure

- $u = \gamma_w h$
- **Where u is the pore water pressure in KN/m2. This pressure should be added to the lateral earth pressure by using the submerged density.**



Ans: ***Let us assume*** $v_t = 1m^3$

$e = \frac{v_v}{v_s}$=0.4, $v_v = 0.4v_s$,

*1m3=0.4*$v_s + v_s$, $v_s = 0.714m^3$, v_v =*0.286*m^3

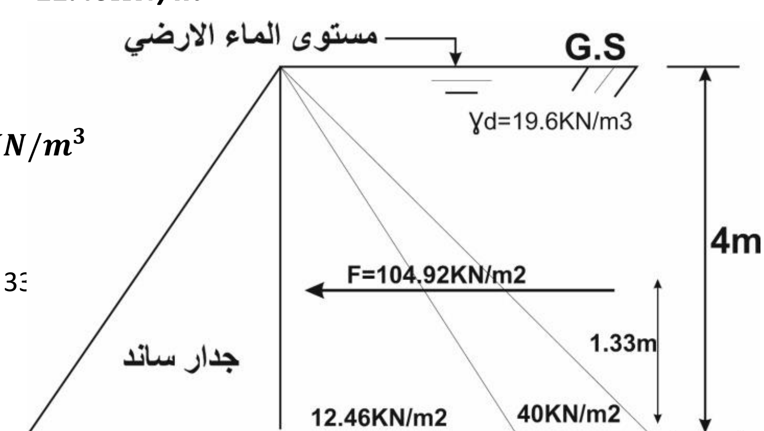
$G_s = \frac{W_s}{v_s\gamma_w}$, $2.75 = \frac{W_s}{0714m^3 * 10KN/m^3}$, $w_s = 19.6KN$

$\gamma_{sat} = \frac{w_s+w_w}{v_t} = \frac{w_s+v_v\gamma_w}{v_t} = \frac{19.6KN*0.286m^3*10KN/m^3}{1m^3}$=*22.46*$KN/m^3$

$\gamma_{sub} = \gamma_{sat} - \gamma_w$

$\gamma_{sub} = 22.46KN/m^3 - 10KN/m^3$=$12.46KN/m^3$

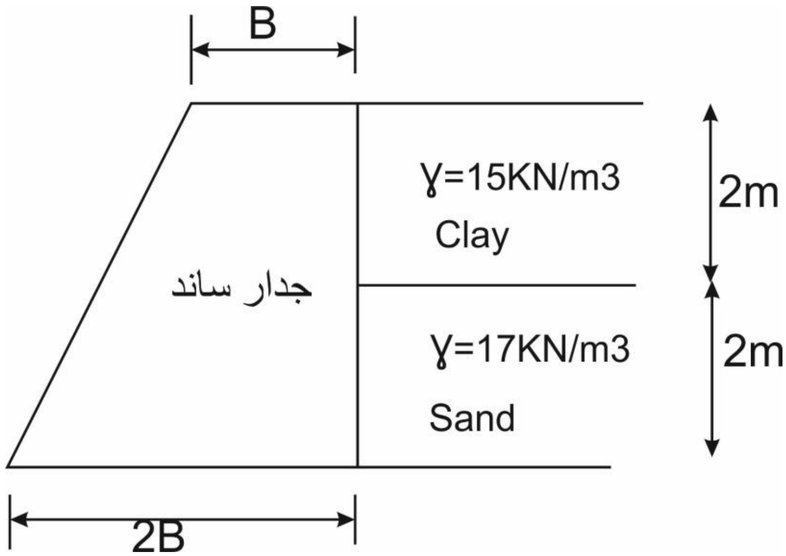
$u = \gamma_w h$ *(pore water pressure)*



$$u = \frac{10KN}{m3} * 4m = 40KN/m^2$$

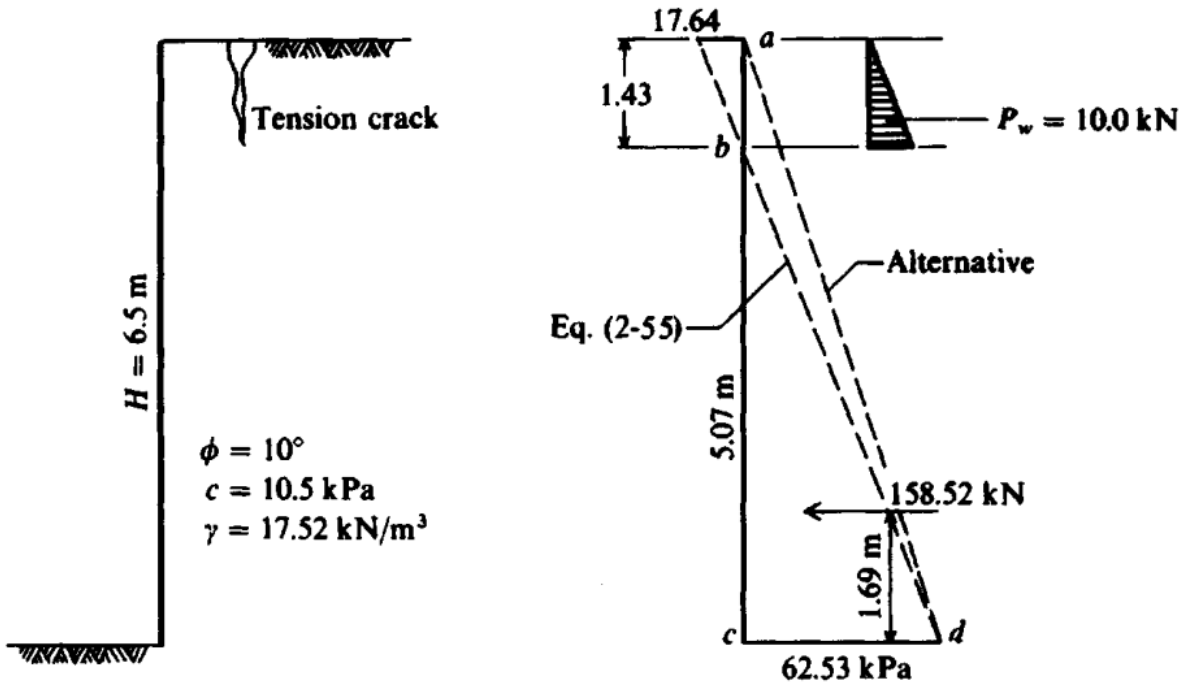
Problem:

A retaining wall in the shape of a trapezoid supporting a column of soil 4 m deep consisting of a clay layer with a Rankine coefficient ka = 0.33, followed by a sand layer with a Rankine coefficient ka = 0.28. Calculate the following: - All lateral forces acting on the wall. Locations of the forces acting on the base of the retaining wall, the resultant forces, and their distance from the base of the wall.



Lateral pressure in Non-cohesion soils

Example 11-4. Draw the active earth pressure diagram for a unit width of wall for the conditions shown in Fig. E11-4*a*. Compare the several possible alternatives that are produced from this problem (tension crack, how the diagram might be modified, and water in tension crack).



(*a*) Given. (*b*) Computed.

At top: $z = 0$

$$p_a = \gamma z K_a - 2c\sqrt{K_a} = -2(10.5)(0.84) = \mathbf{-17.64}\text{ kPa}$$

At $p = 0$:

$$\gamma z K_a - 2c\sqrt{K_a} = 0 \qquad \text{[Set Eq. (2-55) = 0]}$$

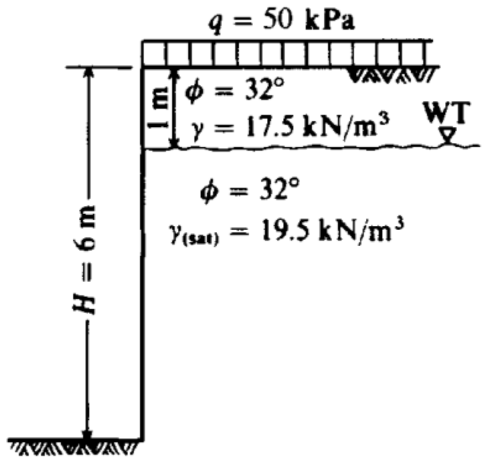
and

$$z = \frac{2c\sqrt{K_a}}{\gamma K_a} = \frac{2c}{\gamma\sqrt{K_a}} = \frac{2(10.5)}{17.52(0.84)} = \mathbf{1.43}\text{ m}$$

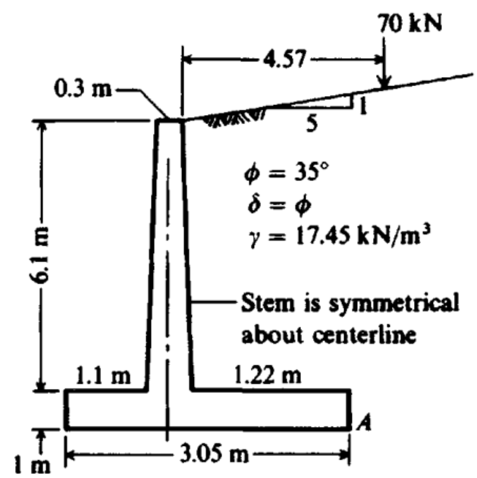
$$p_a = 17.52(6.5)(0.704) - 2(10.5)(0.84) = \mathbf{62.53}\text{ kPa}$$

The resultant force is found as $\sum F_h = R$. The location of the resultant may be found by summing moments at the base or by inspection, depending on the complexity of the pressure diagram. The tension zone $\overline{ab}$ is usually neglected for finding the magnitude and location of the resultant.

Compute the lateral force and show the location of the resultant using the Rankine equations for the wall-soil system of Fig. P11-8.



For the conditions given in Fig. P11-10 find the active
application.



For the conditions given in Fig. P11-11, find the active pressure and estimate its point of application.