4.3.2 Active and/or Passive Earth Pressure

Depending on the shoring system the value of the active and/or passive pressure can be determined using either the Rankine, Coulomb or trial wedge methods.

4.3.2.1 Rankine's Theory

Rankine's theory is the simplest formulation proposed for earth pressure calculations and it is based on the following assumptions:

- The wall is smooth and vertical.
- No friction or adhesion between the wall and the soil.
- The failure wedge is a plane surface and is a function of soil's friction ϕ and the backfill slope β as shown in Eq. 4-14 and Eq. 4-17.
- Lateral earth pressure varies linearly with depth.
- The direction of the lateral earth pressure acts parallel to slope of the backfill as shown in Figure 4-5 and Figure 4-6.
- The resultant earth pressure acts at a distance equal to one-third of the wall height from the base.

Values for the coefficient of active lateral earth pressure using the Rankine Theory may be taken as shown in Eq. 4-14:

$$K_a = \cos\beta \frac{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}} \qquad \text{Eq. 4-14}$$

And the magnitude of active earth pressure can be determined as shown in Figure 4-5 and Eq. 4-15:

$$P_a = \frac{1}{2}(\gamma)(h^2)(K_a) \qquad \text{Eq. 4-15}$$

The failure plane angle α can be determined as shown in Eq. 4-16:

$$\alpha = \left(45 + \frac{\phi}{2}\right) - \frac{1}{2}\left(Arc\sin\left(\frac{\sin\beta}{\sin\phi}\right) - \beta\right) \qquad \text{Eq. 4-16}$$

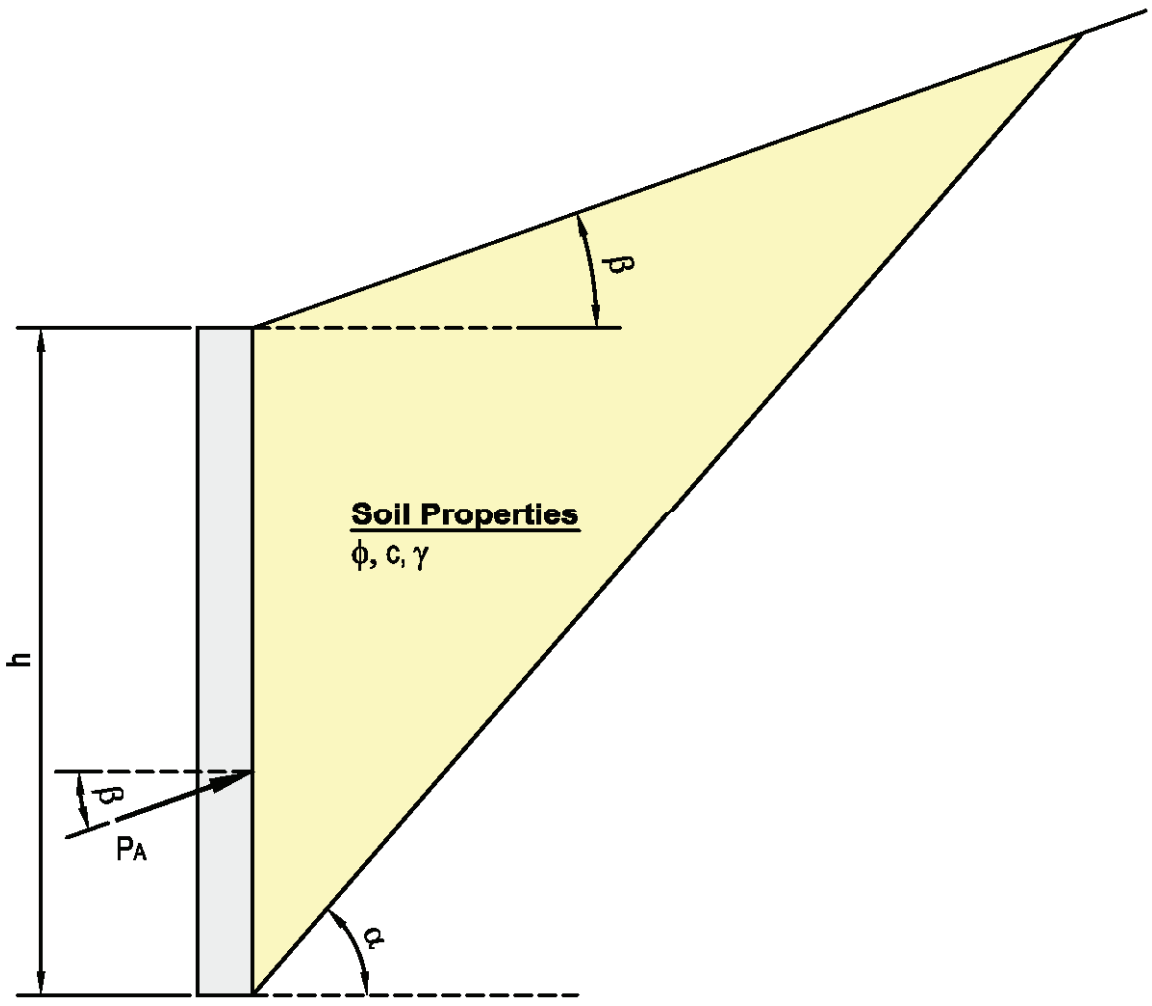

Figure 4-5. Rankine's active wedge

Rankine made similar assumptions to his active earth pressure theory to calculate the passive earth pressure. Values for the coefficient of passive lateral earth pressure may be taken as:

$$K_p = \cos\beta \frac{\cos\beta + \sqrt{\cos^2\beta - \cos^2\phi}}{\cos\beta - \sqrt{\cos^2\beta - \cos^2\phi}} \qquad \text{Eq. 4-17}$$

And the magnitude of passive earth pressure can be determined as shown in Figure 4-6 and Eq. 4-18:

$$P_p = \frac{1}{2}(\gamma)(h^2)(K_p) \qquad \text{Eq. 4-18}$$

The failure plane angle α can be determined as shown in Eq. 4-19:

$$\alpha = \left(45 - \frac{\phi}{2}\right) + \frac{1}{2}\left(Arc\sin\left(\frac{\sin\beta}{\sin\phi}\right) + \beta\right) \qquad \text{Eq. 4-19}$$

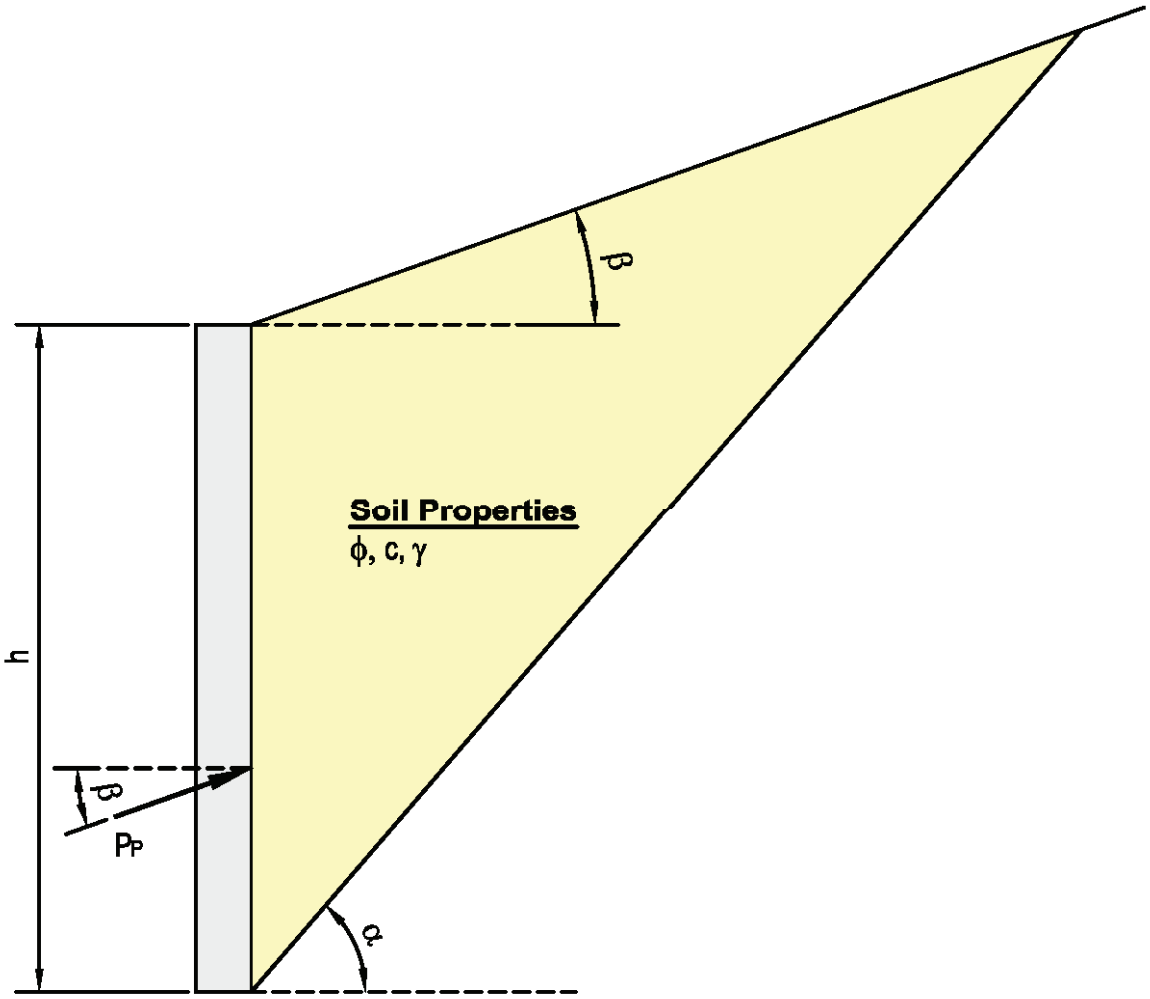

Figure 4-6. Rankine's passive wedge

Where:

h = height of pressure surface on the wall.

P_a = active lateral earth pressure resultant per unit width of wall.

P_p = passive lateral earth pressure resultant per unit width of wall.

β = angle from backfill surface to the horizontal.

α = failure plane angle with respect to horizontal.

ϕ = effective friction angle of soil.

K_a = coefficient of active lateral earth pressure.

K_p = coefficient of passive lateral earth pressure.

γ = unit weight of soil.

Although Rankine's equation for the passive earth pressure is provided above, one should not use the Rankine method to calculate the passive earth pressure when the backfill angle is greater than zero ($\beta>0$). As a matter of fact the K_p value for both positive ($\beta>0$) and negative ($\beta<0$) backfill slope is identical. This is clearly not correct. Therefore, avoid using the Rankine equation to calculate the passive earth pressure coefficient for sloping ground.