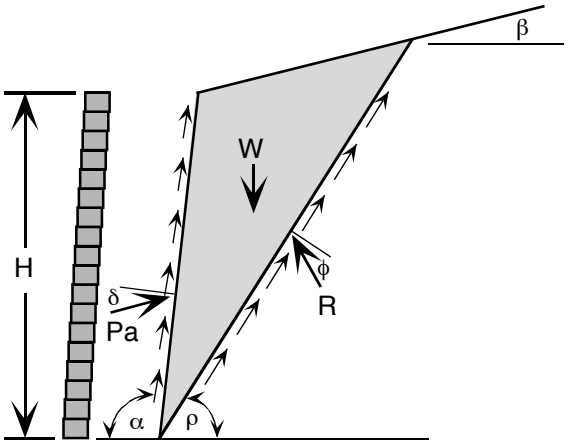
Coulomb/Rankine Earth Pressure

There are two commonly accepted methods for calculating simple earth pressure, Coulomb and Rankine theory. The Coulomb theory was developed in the 1776 and the Rankine theory was developed in the 1857 and both remain the basis for present day earth pressure calculation.

The general equations developed for both theories are based on the fundamental assumptions that the retained soil is **cohesionless** (no clay component), **homogeneous** (not a varying mixture of materials), **isotropic** (similar stress-strain properties in all directions or in practical terms, not reinforced), **semi-infinite** (wall is very long and soil goes back a long distance without bends or other boundary conditions), and **well drained** to avoid consideration of pore pressures.

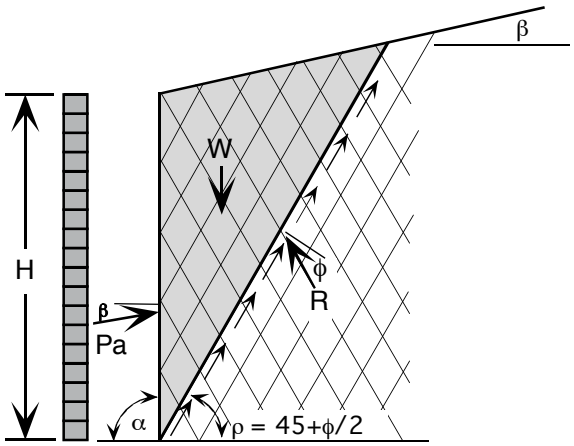
The active earth pressure calculation below requires that the wall structure rotates or yields sufficiently to engage the entire shear strength of the soils involved to create the active earth pressure state. The amount of movement required is highly dependent upon the soils involved.



$$\textbf{Pah} = 1/2\ \gamma\ H^2\ \textbf{Ka}\ \mathrm{Cos}(\delta-(90-\alpha))$$

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

Coulomb Wedge Analysis



$$\textbf{Pah} = 1/2\ \gamma\ H^2\ \textbf{Ka}\ \mathrm{Cos}\ (\beta)$$

$$\textbf{Ka} = \cos\beta\left[\frac{\cos\beta-\sqrt{\cos^2\beta-\cos^2\phi}}{\cos\beta+\sqrt{\cos^2\beta-\cos^2\phi}}\right]$$

Rankine "state of stress" Analysis

Using identical parameters, Coulomb wedge theory calculates less earth pressure than Rankine theory for a level backslope whereas the values converge under backslope conditions when $\delta = \beta$. Coulomb theory calculates a unique failure angle for every design condition whereas application of Rankine theory to reinforced soil structures fixes the internal failure plane at $45 + \phi/2$.

The application of Coulomb active wedge theory and a calculated failure plane is favored by the National Masonry Concrete Association (NCMA) and described in their *Design Manual for Segmental Retaining Walls - Second Edition.*

The application of Rankine "state of stress" earth pressure theory and fixed failure plane is favored by the transportation agencies (AASHTO and FHWA) and is described in recent editions of the AASHTO *Standard Specifications for Highway Bridges.*