

# example\_07

December 24, 2022

$$z_w = 0 \text{ (depth to groundwater)} \quad \gamma_w = 62.400$$

$$h_1 = 5 \text{ (Layer 1 properties)} \quad \gamma_1 = 100 \quad \gamma_{sat1} = 110$$

$$\phi_1 = 26 \quad c_1 = 50$$

$$h_2 = 10 \text{ (layer 2 properties)} \quad \gamma_2 = 110 \quad \gamma_{sat2} = 120$$

$$\phi_2 = 30 \quad c_2 = 0$$

$$h_3 = 7 \text{ (layer 3 properties)} \quad \gamma_3 = 120 \quad \gamma_{sat3} = 130$$

$$\phi_3 = 34 \quad c_3 = 0$$

$$z_0 = 0 \text{ (at the ground surface)}$$

$$\sigma_0 = 0.000$$

$$u_0 = 0.000$$

$$\sigma'_{v_0} = \sigma_0 - u_0 = 0.000 - 0.000 = 0.000$$

$$z_1 = 5 \text{ (at the first layer boundary)}$$

$$\sigma_1 = \sigma_0 + h_1 \cdot \gamma_{sat1} = 0.000 + 5 \cdot 110 = 550.000$$

$$u_1 = (z_1 - z_w) \cdot \gamma_w = (5 - 0) \cdot 62.400 = 312.000$$

$$\sigma'_{v_1} = \sigma_1 - u_1 = 550.000 - 312.000 = 238.000$$

$$\phi_{1_r} = \text{radians}(\phi_1) = \text{radians}(26) = 0.454$$

$$ka_1 = \left( \tan \left( \frac{\pi}{4} - \frac{\phi_{1_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} - \frac{0.454}{2} \right) \right)^2 = 0.390$$

$$kp_1 = \left( \tan \left( \frac{\pi}{4} + \frac{\phi_{1_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} + \frac{0.454}{2} \right) \right)^2 = 2.561$$

$z_2 = 15$  (at the second layer boundary)

$$\sigma_2 = \sigma_1 + h_2 \cdot \gamma_{sat2} = 550.000 + 10 \cdot 120 = 1750.000$$

$$u_2 = (z_2 - z_w) \cdot \gamma_w = (15 - 0) \cdot 62.400 = 936.000$$

$$\sigma'_{v_2} = \sigma_2 - u_2 = 1750.000 - 936.000 = 814.000$$

$$\phi_{2_r} = \text{radians}(\phi_2) = \text{radians}(30) = 0.524$$

$$ka_2 = \left( \tan \left( \frac{\pi}{4} - \frac{\phi_{2_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} - \frac{0.524}{2} \right) \right)^2 = 0.333$$

$$kp_2 = \left( \tan \left( \frac{\pi}{4} + \frac{\phi_{2_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} + \frac{0.524}{2} \right) \right)^2 = 3.000$$

$z_3 = 22$  (at the bottom of the soil profile)

$$\sigma_3 = \sigma_2 + h_3 \cdot \gamma_{sat3} = 1750.000 + 7 \cdot 130 = 2660.000$$

$$u_3 = (z_3 - z_w) \cdot \gamma_w = (22 - 0) \cdot 62.400 = 1372.800$$

$$\sigma'_{v_3} = \sigma_3 - u_3 = 2660.000 - 1372.800 = 1287.200$$

$$\phi_{3_r} = \text{radians}(\phi_3) = \text{radians}(34) = 0.593$$

$$ka_3 = \left( \tan \left( \frac{\pi}{4} - \frac{\phi_{3_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} - \frac{0.593}{2} \right) \right)^2 = 0.283$$

$$kp_3 = \left( \tan \left( \frac{\pi}{4} + \frac{\phi_{3_r}}{2} \right) \right)^2 = \left( \tan \left( \frac{3.142}{4} + \frac{0.593}{2} \right) \right)^2 = 3.537$$

$z_0 = 0$  (at the ground surface)

$$\sigma'_{ha_0} = ka_1 \cdot \sigma'_{v_0} - 2 \cdot c_1 \cdot \sqrt{ka_1} = 0.390 \cdot 0.000 - 2 \cdot 50 \cdot \sqrt{0.390} = -62.487$$

$$\sigma'_{hp_0} = kp_1 \cdot \sigma'_{v_0} + 2 \cdot c_1 \cdot \sqrt{kp_1} = 2.561 \cdot 0.000 + 2 \cdot 50 \cdot \sqrt{2.561} = 160.033$$

$z_1 = 5$  (at the first layer boundary)

$$\sigma'_{ha_{1t}} = ka_1 \cdot \sigma'_{v_1} - 2 \cdot c_1 \cdot \sqrt{ka_1} = 0.390 \cdot 238.000 - 2 \cdot 50 \cdot \sqrt{0.390} = 30.443$$

$$\sigma'_{hp_{1t}} = kp_1 \cdot \sigma'_{v_1} + 2 \cdot c_1 \cdot \sqrt{kp_1} = 2.561 \cdot 238.000 + 2 \cdot 50 \cdot \sqrt{2.561} = 769.568$$

$$\sigma'_{ha_{1b}} = ka_2 \cdot \sigma'_{v_1} - 2 \cdot c_2 \cdot \sqrt{ka_2} = 0.333 \cdot 238.000 - 2 \cdot 0 \cdot \sqrt{0.333} = 79.333$$

$$\sigma'_{hp_{1b}} = kp_2 \cdot \sigma'_{v_1} + 2 \cdot c_2 \cdot \sqrt{kp_2} = 3.000 \cdot 238.000 + 2 \cdot 0 \cdot \sqrt{3.000} = 714.000$$

$z_2 = 15$  (at the second layer boundary)

$$\sigma'_{ha_{2t}} = ka_2 \cdot \sigma'_{v_2} - 2 \cdot c_2 \cdot \sqrt{ka_2} = 0.333 \cdot 814.000 - 2 \cdot 0 \cdot \sqrt{0.333} = 271.333$$

$$\sigma'_{hp_{2t}} = kp_2 \cdot \sigma'_{v_2} + 2 \cdot c_2 \cdot \sqrt{kp_2} = 3.000 \cdot 814.000 + 2 \cdot 0 \cdot \sqrt{3.000} = 2442.000$$

$$\sigma'_{ha_{2b}} = ka_3 \cdot \sigma'_{v_2} - 2 \cdot c_3 \cdot \sqrt{ka_3} = 0.283 \cdot 814.000 - 2 \cdot 0 \cdot \sqrt{0.283} = 230.130$$

$$\sigma'_{hp_{2b}} = kp_3 \cdot \sigma'_{v_2} + 2 \cdot c_3 \cdot \sqrt{kp_3} = 3.537 \cdot 814.000 + 2 \cdot 0 \cdot \sqrt{3.537} = 2879.225$$

$z_3 = 22$  (at the bottom of the soil profile)

$$\sigma'_{ha_3} = ka_3 \cdot \sigma'_{v_3} - 2 \cdot c_3 \cdot \sqrt{ka_3} = 0.283 \cdot 1287.200 - 2 \cdot 0 \cdot \sqrt{0.283} = 363.911$$

$$\sigma'_{hp_3} = kp_3 \cdot \sigma'_{v_3} + 2 \cdot c_3 \cdot \sqrt{kp_3} = 3.537 \cdot 1287.200 + 2 \cdot 0 \cdot \sqrt{3.537} = 4552.996$$