Question 3.4

The moist unit weight is the moist weight (W) divided by the volume (V).

$$\rho = \frac{W}{V} = \frac{23 \text{ lb}}{0.2 \text{ ft}^3} = \boxed{115 \ \frac{\text{lb}}{\text{ft}^3}}$$

The dry unit weight is the dry weight (W_d) divided by the volume (W).

$$\rho_d = \frac{W_d}{V} = \frac{(100\% - 11\%) \times 23 \text{ lb}}{0.2 \text{ ft}^3} = \boxed{102.35 \ \frac{\text{lb}}{\text{ft}^3}}$$

The void ratio is calculated using the following equation, with ρ_w being the density of water (62.4 $\frac{\text{lb}}{\text{ft}^3}$), and G_s being the specific gravity of 2.7:

$$e = \frac{G_s \times \rho_w}{\rho_d} - 1 = \boxed{0.65}$$

The porosity is calculated using the following equation:

$$n = \frac{e}{1+e} = \boxed{0.39}$$

The degree of saturation is calculated using the following equation, with w being the moisture content of 11%:

$$S = \frac{w \times G_s}{e} = \boxed{45.97\%}$$

Lastly, the volume occupied by water is calculated using the following equation:

$$V_w = \frac{W - \frac{W}{1+w}}{\rho_w} = \boxed{0.04 \text{ ft}^3}$$

Question 3.16

The equation for bulk density (γ_m) at a 50% saturation is as follows, with G_s being the specific gravity, e being the void ratio, and ρ_w being the density of water (62.4 $\frac{\text{lb}}{\text{ft}^3}$).

$$\gamma_{m50} = \frac{(G_s + 50\% \times e) \times \rho_w}{1+e} = 105.73 \ \frac{\text{lb}}{\text{ft}^3}$$

The equation for bulk density (γ_m) at a 75% saturation is as follows, with G_s being the specific gravity, e being the void ratio, and ρ_w being the density of water (62.4 $\frac{\text{lb}}{\text{ft}^3}$).

$$\gamma_{m75} = \frac{(G_s + 75\% \times e) \times \rho_w}{1+e} = 112.67 \ \frac{\text{lb}}{\text{ft}^3}$$

Solving the 75% saturation equation for G_s, the following equation is obtained:

$$G_s = 1.81 + 1.06 \times e$$

Solving the 50% saturation equation for G_s, the following equation is obtained:

$$G_s = 1.69 + 1.19 \times e$$

Setting both equations equal yields the following:

$$1.69 + 1.19 \times e = 1.81 + 1.06 \times e$$

$$e = \boxed{0.92}$$

Plugging e into the G_s equation yields the following:

$$G_s = \boxed{2.79}$$

Question 3.18

First, utilize the void ratio from the borrow pit (e_1) to determine the required volume of solids (V_s):

$$e_1 = \frac{V_v}{V_s} = \frac{V_1 - V_s}{V_s}$$

Since the required volume (V_1) is 1 cubic foot, we get the following equation:

$$e_1 = \frac{1 \text{ ft}^3 - V_s}{V_s}$$

$$(1 + e_1) \times V_s = 1 \text{ ft}^3$$

Substituting 1.1 for e_1 and solving for V_s gives the following:

$$V_s = 0.47 \text{ ft}^3$$

Using the required V_s yields the following required volume, using the equation for the final void ratio.

$$e_2 = \frac{V_v}{V_s} = \frac{V_2 - V_s}{V_s} = 0.8$$

$$\frac{V_2 - 0.47 \text{ ft}^3}{0.47 \text{ ft}^3} = 0.8$$

$$V_2 = \boxed{0.86 \text{ ft}^3}$$

Question 3.24

Below is the equation for relative density:

$$D_r = \frac{e_{\text{max}} - e}{e_{\text{max}} - e_{\text{min}}}$$

Solving the equation for e yields the following:

$$e = e_{\text{max}} - D_r \times (e_{\text{max}} - e_{\text{min}}) = 0.9 - 40\% \times (0.9 - 0.46) = 0.724$$

The equation for dry unit weight is:

$$\gamma_d = \frac{G_s \times \gamma_w}{1 + e} = \frac{2.65 \times 62.4 \ \frac{\text{lb}}{\text{ft}^3}}{1 + 0.724} = \boxed{95.92 \ \frac{\text{lb}}{\text{ft}^3}}$$

Determining the void ratio at a relative density of 75% yields the following:

$$e_{75} = e_{\text{max}} - D_r \times (e_{\text{max}} - e_{\text{min}}) = 0.9 - 75\% \times (0.9 - 0.46) = 0.57$$

The following equation is used to determine the change in thickness:

$$\frac{\Delta H}{H} = \frac{\Delta e}{1 + e} = \frac{e - e_{75}}{1 + e} = \frac{0.724 - 0.57}{1 + 0.724} = 0.089$$

$$\Delta H = 0.89 \times H = 0.089 \times 6 \text{ ft} = \boxed{0.54 \text{ ft}}$$