Example

In its natural condition a soil sample has a mass of 2290 g and a volume of $1.15*10^{-3}$ m^3. After being completely dried in an oven the mass of the sample is 2035 g. The value of G_s for the soil is 2.68. Determine the mass density, unit weight, water content, void ratio, porosity, and degree of saturation.

$$\rho = \frac{M}{V} = \frac{2.290}{1.15 \times 10^{-3}} = 1990\,\text{kg/m}^3$$

$$\gamma = \frac{Mg}{V} = 1990 \times 9.8 = 19\,500\,\text{N/m}^3$$

$$w = \frac{\text{Weight of water}}{\text{Weight of soil solids}} = \frac{W_w}{W_s} \cdot 100\%$$

$$w = \frac{M_w}{M_s} = \frac{2290 - 2035}{2035} = 0.125 \text{ or } 12.5\%$$

$$\gamma = \frac{G_s(1+\omega) * \gamma_w}{1+e}$$

$$19.5 = \frac{2.68(1+.125) * 9.81}{1+e}$$

e =0.52

$$\text{Porosity, } n = \frac{e}{1+e} = \frac{0.52}{1.52} = 0.34 \text{ or } 34\%$$

$$\text{Degree of saturation, } S_r = \frac{wG_s}{e} = \frac{0.125 \times 2.68}{0.52} = 0.645 \text{ or } 64.5\%$$

Example

The mass of a moist soil sample having a volume of 0.0057 m³ is 10.5 kg. The moisture content (w) and the specific gravity of soil solids (G_s) were determined to be 13% and 2.68, respectively. Determine

- **a.** Moist density, ρ (kg/m³)
- **b.** Dry density, ρ_d (kg/m³)
- **c.** Void ratio, e
- **d.** Porosity, n
- **e.** Degree of saturation, S (%)

Solution

$$\rho = \frac{M}{V} = \frac{10.5}{0.0057} = \mathbf{1842\ kg/m^3}$$

$$\rho_d = \frac{\rho}{1 + w} = \frac{1842}{1 + \frac{13}{100}} = \mathbf{1630\ kg/m^3}$$

$$\gamma = \frac{(Se + G_s)}{1 + e}\gamma_w$$

At dry state (S=0)

$$\gamma_d = \frac{W_s}{V} = \frac{G_s\gamma_w}{1 + e}$$

$$\rho_d = \frac{G_s * \rho_w}{1 + e}$$

$$e = \frac{G_s * \rho_w}{\rho_d} - 1$$

$$e = \frac{2.68 * 1000}{1630} - 1 = 0.64$$

$$n = \frac{e}{1 + e} = \frac{0.64}{1 + 0.64} = \mathbf{0.39}$$

$$S(\%) = \frac{wG_s}{e} \times 100 = \frac{(0.13)(2.68)}{0.64} \times 100 = \mathbf{54.4\%}$$

Example

For a saturated soil, given $w = 40\%$ and $G_s = 2.71$, determine the saturated and dry unit weights in lb/ft^3 and kN/m^3.

$$Se = wG_s$$

$$e = wG_s = (0.4)(2.71) = 1.084$$

$$\gamma = \frac{(Se + G_s)}{1+e}\gamma_w$$

$$\gamma_{sat} = \frac{(G_s + e)\gamma_w}{1 + e} = \frac{(2.71 + 1.084)62.4}{1 + 1.084} = \mathbf{113.6\ lb/ft^3}$$

$$\gamma_{sat} = (113.6)\left(\frac{9.81}{62.4}\right) = \mathbf{17.86\ kN/m^3}$$

$$\gamma_d = \frac{W_s}{V} = \frac{G_s\gamma_w}{1 + e}$$

$$\gamma_d = \frac{G_s\gamma_w}{1 + e} = \frac{(2.71)(62.4)}{1 + 1.084} = \mathbf{81.1\ lb/ft^3}$$

$$\gamma_d = (81.1)\left(\frac{9.81}{62.4}\right) = \mathbf{12.75\ kN/m^3}$$

Example

Given: mass of wet sample =254.1gm, void ratio = 0.6133, volume of air = 1.9 cm3, mass of solids = 210 gm. Determine: Degree of saturation, dry unit weight.

Solution:

Mass of water = 254.1 -210= 44.1 gm

$$\text{Volume of water} = \frac{w_w}{\gamma_w} = 44.1\ cm^3$$

$$e = \frac{v_v}{v_s} \rightarrow 0.6133 = \frac{v_v}{v_s} = \frac{v_w + v_a}{v_s} = \frac{44.1+1.9}{v_s}$$

$$0.6133 = \frac{46}{v_s} \rightarrow v_s = 75.cm^3$$

$$S = \frac{v_w}{v_v} = \frac{44.1}{46} = 95.8\%$$

$$G_s = \frac{w_s}{V_s\ \gamma_w}\ or\ \frac{M_s}{V_s\ \rho_w}$$

$$= \frac{210}{75 * 1} = 2.8$$

$$\gamma_{dry} = \frac{G_s}{1+e}\ \gamma_w \rightarrow \gamma_{dry} = \frac{2.8}{1+0.6133} * 10 = 17.355\ kN/m^3$$