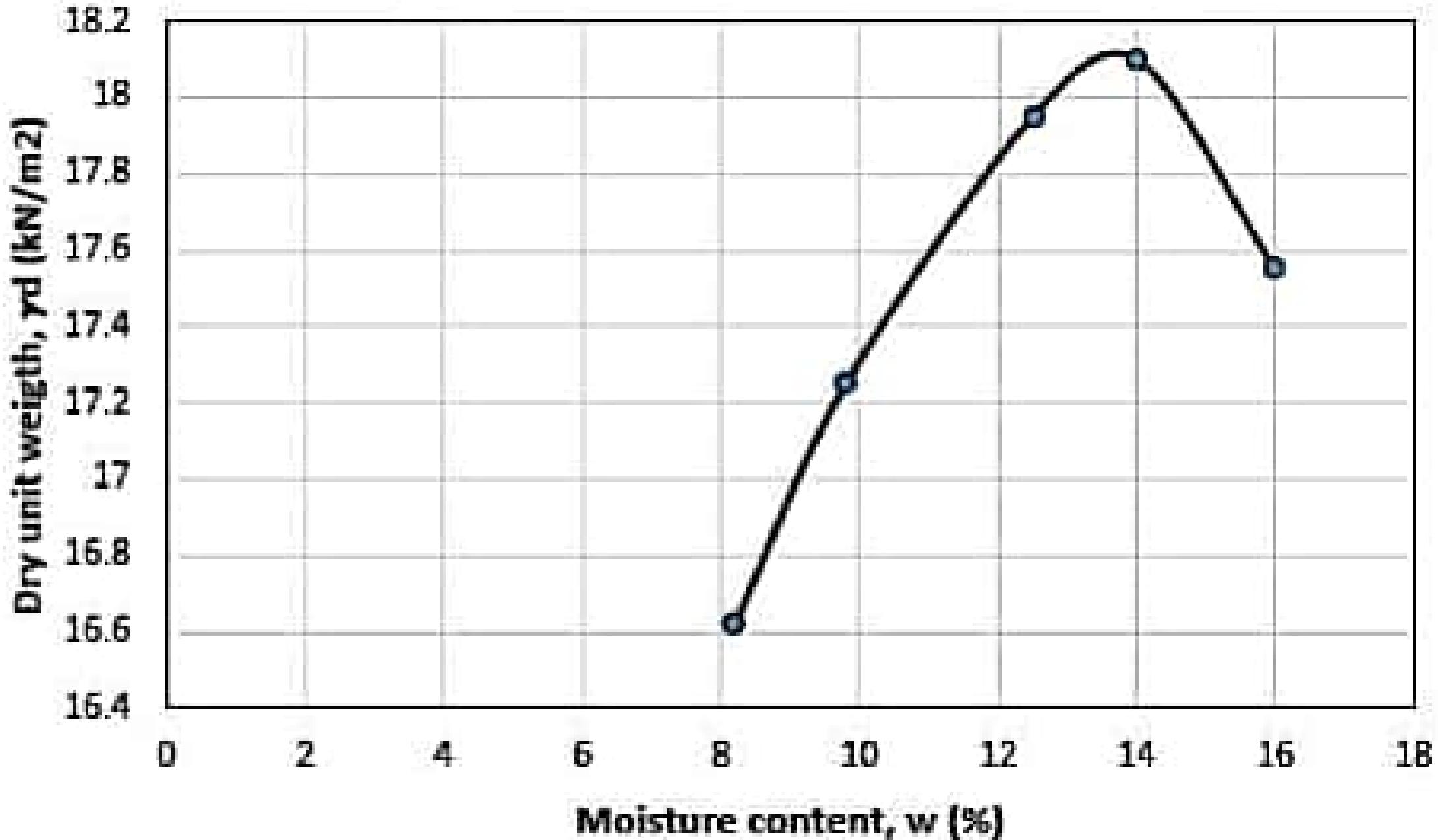


Question 1 Compaction

An earthfill will be constructed on the field. Specific weight and void ratio of the borrow area are 21.70 and 0.95 respectively. A laboratory compaction test was conducted on the soil sample (soil sample was recovered from borrow area) and results presented in the table given below.

γ_d (kN/m ³)	16.62	17.25	17.95	18.10	17.55
w (%)	8.20	9.80	12.50	14.0	16.0

- a) Draw compaction curve and determine w_{opt} .
- b) Calculate degree of saturation of the compacted soil at w_{opt} .
- c) A soil sample was recovered from compacted fill in the field and water content and natural unit weight were found 12% and 19.6 kN/m³ respectively. Determine whether the relative compaction meets the requirements or not ($RC = 95\%$).
- d) If the volume of the excavated soil is to be 30,000 m³, how many m³ compacted fill can be produced from excavated soil?



Solution +

b) $s \cdot e = G_s \cdot w \Rightarrow e = \frac{G_s \cdot w}{s} \quad ①$

② $\gamma_d = \frac{\gamma_w \cdot G_s}{1+e} \Rightarrow$ dry unit weight of soil at wopt is 18.1 kN/m^3
 $\gamma_d = \frac{\gamma_w \cdot G_s}{1+e}$ (dry unit weight of soil at wopt)

$$18.1 = \frac{9.81 \cdot 2.7}{1+e} \Rightarrow e = 0.463$$

$$s = \frac{2.7 \cdot 1.4}{0.463} \Rightarrow s = 0/0.8157$$

c) Relative compaction (R) = $\frac{\gamma_d(\text{field})}{\gamma_d(\text{max-lab})} \times 100$

$$\gamma_d(\text{field}) = \frac{\gamma_n}{1+w} = \frac{19.6}{1+0.12} = 17.5 \text{ kN/m}^3$$

$$R = \frac{17.5}{18.1} \times 100 = 0/0.967 > 0/0.95$$

d) $V = 30000 \text{ m}^3$

$$e = 0/0.95 \quad w = 0/0.12$$

$$G_s = 2.70 \quad \gamma_n = 19.6 \text{ kN/m}^3$$

$$G_s = \frac{\gamma_s}{\gamma_w} \Rightarrow 2.70 \rightarrow \gamma_s = 27 \text{ kN/m}^3 \Rightarrow \gamma_s = \frac{M_s}{V_s}$$

$$e = \frac{V_w}{V_s} \Rightarrow 0.95 = \frac{V_b}{V_s} \Rightarrow V = V_b + V_s = 1.95 V_s$$

$$1.95 V_s = 30000$$

$$V_s = 15385 \text{ m}^3 \star$$

$$V_b = 14615 \text{ m}^3$$

$$M_s = 27 \times 15385 \quad , \quad w = \frac{M_w}{M_s} \rightarrow M_w = 415395 \cdot \underline{0.12} \\ = 49847.4 \text{ kN} \quad \quad \quad = 49847.4 \text{ kN}$$

$$\gamma_n = \frac{M_s + M_w}{V_b + V_s} \Rightarrow 19.6 = \frac{49847.4 + 415395}{V_b + 15385} \Rightarrow$$

$$V_b = 8351.85 \text{ m}^3$$

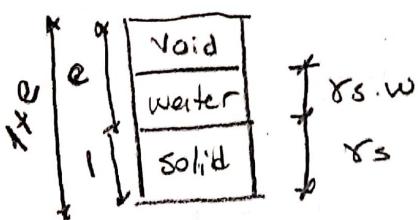
$$V_s = \frac{15385}{23736 \text{ m}^3}$$

Question 2

The in situ void ratio of a soil is 0.9 and the specific gravity of soil solids is 2.7. This soil is to be excavated and transported to a construction site for use in a compacted fill. How many cubic meters compacted soil are produced with $w = 12\%$ and $\gamma_n = 19.4 \text{ kN/m}^3$ using 25000 m^3 of excavated soil?

Solution 2

$$e = \frac{V_v}{V_s}, V_T = 1+e \Rightarrow \left\{ \begin{array}{l} V_I = \frac{1+e_{fill}}{1} \\ V_s \end{array} \right\}$$



$$\gamma_n = \frac{\gamma_s \cdot (1+w)}{1+e} \Rightarrow 1+e_{fill} = \frac{(2.7 \cdot 9.81) (1+0.12)}{19.4}$$

$$1.529 = 1+e_{fill}$$

→ The void ratio of excavated soil is $e = 0.9$

$$\rightarrow \text{The volume of solid in excavated soil: } V_s = \frac{V_{Total}}{1+e}$$

$$= \frac{25000}{1+0.9} \cong 13160 \text{ m}^3$$

→ The volume of solid in fill will be same with excavated one.

$$V_{fill} = V_s \cdot (1+e_{fill}) = 13160 \times (1.529)$$

$$= 20120 \text{ m}^3$$

Question 3

A field unit-weight determination test performed on a clayey silt. The moist density and moisture content of compacted soil were determined as 2.1 kg/m^3 and 10%, respectively. Laboratory test results have shown that $\gamma_{d,max} = 19 \text{ kN/m}^3$. Determine:

- Dry unit weight of compaction in the field.
- Relative compaction in the field.

Solution 3

a) Moist unit weight of compacted soil = $\frac{(2100) \times (9.81)}{1000}$
 $= 20.60 \text{ kN/m}^3$

$$\gamma_d = \frac{\gamma}{1 + \frac{w(\%)}{100}} = \frac{20.60}{1 + \frac{10}{100}} = 18.73 \text{ kN/m}^3$$

b) $R = \frac{\gamma_d(\text{field})}{\gamma_d(\text{max})} = \frac{18.73}{19} = 93\% > 95\% \quad \checkmark$

Question 4

Following are the results of a soil planned to use for an earthfill construction.

$$w = 10\%, e = 1.2, \text{ and } G_s = 2.72$$

For a given soil, following are the results of compaction tests conducted in the laboratory.

$$\delta_d(\text{max}) = 18.50 \text{ kN/m}^3$$

$$w_{opt} = 14\% \text{ kN/m}^3$$

After the compaction of the soil in the field, a hole with a volume of 900 cm^3 was hollowed and moist mass and dry mass were determined as 1935g and 1698g, respectively. The specification require that:

δ_d must be at least 0.95 $\delta_d(\text{max})$, and moisture content (W) should be within $\pm 2\%$ of w_{opt} .

- Calculate the dry unit weight and moisture content of the fill. Determine whether compaction meets the requirements or not.
- Calculate the how many m^3 of soil excavated from borrow area if the volume of the fill is to be 2000 m^3
- If 25% water loss occurs during transportation, determine whether water was added to fill or not.

Solution 4

$$e_{\text{excavated}} = 1.2$$

$$w_{\text{excavated}} = 10\%$$

$$\gamma_d(\text{max}), \text{Lab} = 18.5 \text{ kN/m}^3$$

$$w_{\text{opt}} = 14\% \quad \rightarrow M_s$$

a) $\gamma_d(\text{fill}) = \left(\frac{1698}{900} \right) (9.81) = 18.5 \text{ kN/m}^3$
 $\hookrightarrow V$

$$\gamma_n(\text{fill}) = \left(\frac{1935}{900} \right) (9.81) = 21.09 \text{ kN/m}^3$$

$$R = \frac{\gamma_d(\text{fill})}{\gamma_d(\text{max}), \text{Lab}} = \frac{18.5}{18.5} = 100\% > 95\% \rightarrow \text{It satisfies the requirement.}$$

$$\gamma_k = \frac{\gamma_n}{1+w} \Rightarrow \frac{21.09}{1+w} = 18.5 \Rightarrow w = 14\% \\ = 12 < 14 < 16 \quad \checkmark$$

b)

$$\gamma_d(\text{excavated}) = \frac{G_1 \cdot \gamma_w}{1+e} = \frac{(2.7) \cdot (9.81)}{1+1.2} = 12.04 \text{ kN/m}^3$$

$$\Rightarrow W_d(\text{excavated}) = W_d(\text{fill})$$

$$\Rightarrow \gamma_d(\text{excavated}) \times V_{\text{excavated}} = \gamma_d(\text{fill}) \times V_{\text{fill}}$$

$$\Rightarrow (12.04) \cdot (V_{\text{ex.}}) = \underbrace{(18.5) (20000)}_{370000} \Rightarrow V_{\text{ex.}} \approx 30731 \text{ m}^3 \checkmark$$

c)

$$W_d = 370000 \text{ kN}$$

$$W_w(\text{ex.}) = 370000 \cdot (0.1) = 37000 \text{ kN}$$

Water loss in transportation

$$37000 - 37000 \cdot (0.25) = 27750 \text{ kN}$$

$$W_w(\text{fill}) = 370000 \cdot (0.14) = 51800 \text{ kN}$$

Added water in fill soil

$$W_w(\text{added}) = 51800 - 27750 = 24050 \text{ kN} \quad \frac{24050}{9.81} \approx 2452 \text{ m}^3 \checkmark$$