GATE – CIVIL ENGINEERING

GEOTECHNICAL ENGINEERING

8.1 Origin of soils Previous GATE Questions

01. Soil transported by wind are known as………… soils.

GATE CE 1995

Ans. Aeolian

Aeolian soil is formed due to soil transportation by **wind.**

2. Match List-I (Type of soil) with List-II (Mode of transportation and deposition) and select the correct answer using the codes given below the lists:

List-I	List-II
A. Lacustrine soils	1. Transportation by wind
B. Alluvial soil	2. Transportation by running water
C. Aeolian soils	3. Deposited at the bottom of lakes
D. Marine soils	4. Deposited in sea water

a. A1 B2 C3 D4 **b.** A3 B2 C1 D4 c. A3 B2 C4 D1 d. A1 B3 C2 D4

Ans. b

S.No	Type of soil	Mode of transportation and deposition
1.	Lacustrine soils	Deposited at the bottom of lakes
2.	Alluvial soil	Transportation by running water
3.	Aeolian soils	Transportation by wind
4.	Marine soils	Deposited in sea water

3. Lacustrine soils are soils

a. transported by rivers and streams

b. transported by glaciers

c. deposited in sea beds

d. deposited in lake beds

Ans. d

Locus trine soils are silt and clay soils deposited in lake beds.

04. Match list I with list II and select the correct answer

List I	List II
A. Loess	1. Deposited from suspension in running water
B. Peat	2. Deposits of marine origin
C. Alluvial soil	3. Deposits by wind
D. Marl	4. Organic soil

a. A3 B4 C2 D1 b. A4 B3 C1 D2 c. A4 B3 C2 D1 **d**. A3 B4 C1 D2

Ans. d

S.No	Type of soil	Mode of deposition
1.	Loess	Deposits by wind
2.	Peat	Organic soil
3.	Alluvial soil	Deposited from suspension in running water
4.	Marl	Deposits of marine origin

05. The collapsible soil is associated with

a. Dune sands   b. Laterite soils   **c.** Loess   d. Black cotton soils

Ans. c

Collapsible soils –Loess.

6. Soil deposit formed due to transportation by wind is termed as GATE CE 2020

a. Aeolian deposit b. alluvial deposit c. estuarine deposit d. lacustrine deposit

Ans. a

Explanation:

Source of Transportation	Type of soil
Wind	Aeolian soil
Rivers and streams	Alluvial soil
Rivers near Oceans	Esturine Soils
Lakes	Lacustrine soil

8.2 Basic definitions and Relations Numerical

Questions

01. A soil sample has volume of 100 cm^3 and weight of 196 g got reduced to 164 g after oven drying. If the specific gravity of soil is 2.70, the void ratio is

a. 0.20 b. 0.32 **c.** 0.65 d. 0.84

01. c

Volume of soil sample, V = 100 cm Weight of soil sample, W = 196 g Weight of dry soil, W_d =164 g

Specific gravity of soil, G = 2.70

Dry density, $\gamma_d = \frac{W_d}{V} = \frac{W_s}{V} = \frac{164}{100} = 1.64\,g/cm^3$

Void ratio is given by

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow e = \frac{G\gamma w}{\gamma d} - 1$$

$$e = \frac{2.7 \times 1}{1.64} - 1 = 0.65$$

02. A soil sample of weight 156 g and 80 cm^3 volume is reduced to 130 g on oven drying. If the specific gravity of soil sample is 2.64, the degree of saturation is

a. 18.2% b. 24% c. 60% d. 80%

02. d

Weight of soil sample, $W = 156$ g

Volume of soil sample, $V = 80\ cm^3$.

Weight of dry soil, $W_d = W_s = 132$ g

Specific gravity of soil, $G = 2.64$

Degree of saturation, $S = \dfrac{wG}{e}$

Water content, $w = \dfrac{W_w}{W_s} = \dfrac{156-132}{132} = 0.182 = 18.2\%$

Dry density, $\gamma_d = \dfrac{W_s}{V} = \dfrac{132}{80} = 1.65 g/cm^3$

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow e = \frac{G\gamma_w}{\gamma_d} - 1$$

$$e = \frac{2.64 \times 1}{1.65} - 1 = 0.6$$

$$S = \frac{wG}{e} = \frac{0.182 \times 2.64}{0.6} = 0.8 = 80\%$$

03. A soil sample has a water content of 18%. The specific gravity of soil mass is 1.8 and the specific gravity of soil particles is 2.70. The void ratio of the soil is .

a. 0.50 **b.** 0.77 c. 0.84 d. 1.0

03. b

Water content, w = 12% = 0.12

Mass specific gravity of soil, G_m = 1.8

Specific gravity of soil, $G = 2.70$

$$G_m = \frac{\gamma}{\gamma_w} \Rightarrow \gamma = G_m . \gamma_w$$

$$= 1.8 \times 10 = 18\,\text{kN/m}^3$$

$$\gamma_d = \frac{\gamma}{1+w} = \frac{18}{1+0.18} = 15.25\,\text{kN/m}^3$$

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow e = \frac{G\gamma_w}{\gamma_d} - 1 \Rightarrow e = \frac{2.7\times 10}{15.25} - 1 = 0.77$$

04. If the mass specific gravity of dry soil sample is 1.8 and the specific gravity of soil particles is 2.7 , then the void ratio is

a. 0.50 b. 0.64 c. 0.77 d. 1.0

Mass specific gravity of soil sample, $G_m = 1.8$

Specific gravity of soil particles, $G = 2.70$

For dry soil sample, $\gamma = \gamma_d$

$$G_m = \frac{\gamma}{\gamma_w} = \frac{\gamma_d}{\gamma_w} \Rightarrow \gamma_d = G_m.\gamma_w$$

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow e = \frac{G\gamma_w}{\gamma_d} - 1 = \frac{G\gamma_w}{G_m.\gamma_w} - 1$$

$$e = \frac{G}{G_m} - 1 \Rightarrow e = \frac{2.7}{1.8} - 1 = 0.5 \textbf{ Ans- a}$$

05. A fully saturated soil sample with void ratio of 0.6 composed of the following

S.No	Mineral	Percentage of particles by weight	Specific gravity
1.	Quartz	60	2.50
2.	Mica	24	3.00
3.	Iron Oxide	16	4.00

The specific gravity and bulk unit weight of soil respectively are

a. 2.78, 21.63 kN/m^3

b. 2.78, 21.12 kN/m^3

c. 2.86, 21.63 kN/m^3.

d. 2.86, 21.12 kN/m^3.

000

Ans 05. B

For the soil sample, $G = \frac{\gamma_s}{\gamma_w} = \frac{W_s}{V_s . \gamma_w}$

Weight of quartz particles, $W_q = 0.60 W_s$

Weight of mica particles, $W_m = 0.24 W_s$

Weight of iron oxide particles, $W_i = 0.16 W_s$

Volume of quartz particles, $V_q = \dfrac{W_q}{G_q.\gamma_w} = \dfrac{0.60W_s}{2.50\gamma_w} = 0.24\dfrac{W_s}{\gamma_w}$

Volume of mica particles, $V_m = \dfrac{W_m}{G_m.\gamma_w} = \dfrac{0.24W_s}{3.00\gamma_w} = 0.08\dfrac{w_s}{\gamma_w}$

Volume of iron oxide particles, $V_i = \dfrac{W_i}{G_i.\gamma_w} = \dfrac{0.16W_s}{4.00\gamma_w} = 0.04\dfrac{W_s}{\gamma_w}$

V_S : Volume of solids $= V_q + V_m + V_i = (0.24 + 0.08 + 0.04)\dfrac{W_s}{\gamma_w} = 0.36\dfrac{W_s}{r_w}$

$$G = \frac{W_s}{V_s.\gamma_w} = \frac{W_s}{0.36\dfrac{W_s}{\gamma_w}.\gamma_w} = 2.78$$

γ :bulk unit weight of soil $= \left(\dfrac{G + S.e}{1 + e}\right)\gamma_w = \dfrac{2.78 + 1 \times 0.6}{1 + 0.6}$ = 21.12 kN/m^3.

06. A soil sample consists of spherical grains of same diameter arranged in a cubical array. The maximum void ratio is

a. 0.33 b. 0.50 **c.** 0.91 d. 1.0

06. c

Let d be the diameter of the spherical grains arranged in a unit cube.

Number of spherical grains in container $= \frac{1}{d} \cdot \frac{1}{d} \cdot \frac{1}{d} = \frac{1}{d^3}$

Volume of each spherical grain $= \frac{\pi d^3}{6}$

Volume of soil solids, $V_s = \frac{1}{d^3} \cdot \frac{\pi d^3}{6} = \frac{\pi}{6}$

Volume of cube, $V = 1 \times 1 \times 1 = 1\ m^3$.

Volume of voids, $V_v = V - V_s = 1 - \frac{\pi}{6} = 0.91$

07. A soil sample consists of spherical grains of same diameter arranged in a cubical array so that the void ratio will be maximum. If the unit weight of grains is 20 kN/m³, the dry unit weight is

a. 20 kN/m³ b. 18.2kN/m³ c. 13.33 kN/m³ **d.** 10.47 kN/m³.

07. d

Let d be the diameter of the spherical grains arranged in a unit cube.

Number of spherical grains in container. $= \frac{1}{d}.\frac{1}{d}.\frac{1}{d} = \frac{1}{d^3}$

Volume of each spherical grain $= \frac{\pi d^3}{6}$

Volume of soil solids, $V_s = \frac{1}{d^3}.\frac{\pi d^3}{6} = \frac{\pi}{6}$

V_s : Unit weight of grains = 20 kN/m³.

γ_d: Dry unit weight of soil $= \frac{W_s}{V} = \frac{V_s.\gamma_s}{V} = \frac{\pi}{6} \times 20 = 10.47\ \text{kN/m}^3$

08. An embankment of 1000 m^3 of earth fill with void ratio of 0.60 is to be constructed using the excavated soil from borrow pit having the void ratio 0.84. The quantity of soil to be excavated from borrow pit is .

a. 1400 m^3 b. 1183 m^3 c. 1150 m^3 d. 1000 m^3

08. c

Volume of earth fill, $V_1 = 1000\ m^3$.

Void ratio of earth fill, $e_1 = 0.6$

Void ratio of borrow pit soil, $e_2 = 0.84$

Volume of soil to be excavated from borrow pit $V_2 = ?$

Void ratio, $e = \frac{V_v}{V_s}$

$$1 + e = \frac{V_v}{V_s} + 1 = \frac{V_v + V_s}{V_s} = \frac{V}{V_s}$$

For soil in earthfill, $1+e_1 = \dfrac{V_1}{V_s}$

For soil to be excavated from borrow pit. $1+e_2 = \dfrac{V_2}{V_s}$

V_S is same for earthfill and soil excavated from borrow pit.

$$\frac{V_2}{V_1} = \frac{1+e_2}{1+e_1}$$

$$V_2 = \left(\frac{1+0.84}{1+0.60}\right) \times 1000 = 1150\text{m}^3$$

10. A fully saturated soil sample has water content of 24% and bulk unit weight of 19.6 kN/m³. If the degree of saturation is reduced to 80% without change in the void ratio, the bulk unit weight of soil sample is .

a. 20.39 kN/m³ b. 19.6 kN/m³ **c.** 18.84 kN/m³ d. 15.68 kN/m³

10. c

Degree of saturation, $S_1 = 100\%$

Water content, $W_1 = 24\%$

Bulk unit weight, $\gamma_1 = 19.6$ kN/m³.

Degree of saturation, $S_2 = 80\%$

Bulk unit weight, $\gamma_2 = ?$

Dry unit weight $\gamma_d = \frac{\gamma_1}{1+w_1} = \frac{19.6}{1+0.24}$ = 15.81 kN/m³.

$$S_1 = \frac{W_1 G}{1+e} \Rightarrow 15.81 = \frac{G \times 10}{1+0.24G}$$

$$G = 2.55 \qquad e = 0.24 \times 2.55 = 0.612$$

$$\gamma = \left(\frac{G + S.e}{1+e}\right)\gamma_w$$

$$\frac{\gamma_2}{\gamma_1} = \frac{G + S_2 e}{G + S_1 e}$$

$$\gamma_2 = \frac{2.55 + 0.8 \times 0.612}{2.55 + 1 \times 0.612} \times 19.6 = 18.84 \text{ kN/m}^3.$$

11. A fully saturated soil sample has a water content of 27% and bulk unit weight of 19.2 kN/m^3. The specific gravity of soil solids is

a. 2.56 b. 2.60 c. 2.70 d. 2.72

11. a

Degree of saturation, $S = 100\%$

Water content, $W = 27\%$

Bulk unit weight, $\gamma = 19.2$ kN/m^3.

Dry unit weight, $\gamma_d = \frac{\gamma}{1+w} = \frac{19.2}{1+0.27} = 15.12\,\text{kN/m}^3$

$$s = \frac{wG}{e}\quad e = 0.27G$$

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow 15.12 = \frac{G \times 10}{1+0.27G}$$

$G = 2.56$

12. An embankment of earthfill is to be constructed at a void ratio of 0.68 from 1000 m^3 of borrow pit soil having void ratio 1.1. The quantity of earthfill is

a. 618 m^3 **b.** 800 m^3 c. 1250 m^3 d. 1618 m^3

12. b

Volume of earthfill, V_1 = ?

Void ratio of earthfill, $e_1 = 0.68$

Volume of soil excavated from borrow pit, $V_2 = 1000\ m^3$.

Void ratio of borrow pit soil, $e_2 = 1.1$

$$\frac{V_1}{V_2} = \frac{1+e_1}{1+e_2}$$

$$V_1 = \frac{1+0.68}{1+1.1} \times 1000 = 800\ m^3$$

14. A soil sample with porosity of 36% has degree of saturation of 50%. If the specific gravity of soil solid is 2.70, then dry unit weight, bulk unit weight, saturated unit weight and submerged unit weight respectively are (kN/m^3)

a. 19.85; 21.17; 22.5; 12.5 b. 19.85, 22.5, 21.17, 12.5

c. 17.31; 19.11; 20.9; 10.9 d. 17.31; 20.9; 19.11; 10.9

14. c

Porosity, n = 36%

Degree to saturation, S = 50%

Specific gravity of soil solids, G = 2.7

Void ratio, $e = \dfrac{n}{1-n} = \dfrac{0.36}{1-0.36} = 0.56$

Dry unit weight, $\gamma_d = \dfrac{G\gamma_w}{1+e} = \dfrac{2.7 \times 10}{1+0.56} = 17.31$ kN/m^3

$$S = \frac{wG}{e}$$

Water content, $w = \frac{S.e}{G} = \frac{0.5 \times 0.56}{2.7} = 0.104 = 10.4\%$

Bulk unit weight, $\gamma = \gamma_d (1 + w)$

$$= 17.31(1 + 0.104)$$

$$= 19.11\,\text{kN/m}^3$$

Saturated unit weight, $\gamma_{sat} = \left(\frac{G + e}{}\right)\gamma_w = \left(\frac{2.7 + 0.56}{1 + 0.56}\right) \times 10 = 20.9\,\text{kN/m}^3$

Submerged unit weight, $\gamma' = \gamma_{sat} - \gamma_w = 10.9\,\text{kNm}^3$

8.2 Basic definitions and Relations Pervious

GATE Questions

1. A sample of 500 g dry sand, when poured into a 2 litre capacity cylinder which is partially filled with water, displaces 188 cm^3 of water. The density of water is 1 g/cm^3. The specific gravity of the sand is GATE CE 2020

   a. 2.72 **b**. 2.66 c. 2.55 d. 2.52

Ans. b

Solution:

Weight of sample , (Ws) = 500 g

Volume of sand (Vs) = 188 cm^3

Density of water = $\gamma_w = 1 g/cm^3$

Density of sand $= \gamma_s = \frac{W_s}{V_s} = \frac{500}{188} = 2.66\ g/cm^3$

Specific gravity G = $\frac{\gamma_s}{\gamma_w} = \frac{2.66}{1} = 2.66$

2. A soil has dry unit weight of 15.5 kN/m^3, specific gravity of 2.65 and degree of saturation of 72%. Considering the unit weight of water as 10 kN/m^3, the water content of the soil (in %, round off to two decimal places) is….. GATE CE 2020

Ans. 19.28

Dry unit weight of soil , $\gamma_m = 15.5 kN/m^3$

Specific gravity G = 2.65

Degree of saturation S = 72%

Unit weight of water , $\gamma_w = 10 kN/m^3$

Water content (w) = ?

$$\gamma_d = \frac{G\gamma_w}{1+e} \Rightarrow 15.5 = \frac{2.65 \times 10}{1+e} \Rightarrow e = 0.7097$$

$$S = \frac{wG}{e} \Rightarrow 0.72 = \frac{w \times 2.65}{0.7097} \Rightarrow w = 0.1928 = 19.28\%$$

3. A soil has specific gravity of its solids equal to 2.65. The mass density of water is 1000 kg/m^3. Considering zero air voids and 10% moisture content of the soil sample, the dry density (in kg/m^3, round off to 1 decimal place) would be…. GATE CE1 2019

Ans. 2094.8

Solution:

Specific gravity of soil solids, $G = 2.65$

Mass density of water, $\rho = 1000 kg/m^3$

Soil contains zero air voids, $n_a = 0$ and $S_e = 1$

Moisture content, $w = 10\%$

Dry density of soil, $\gamma_d = ?$

$$S = \frac{wG}{e} \Rightarrow 1 = \frac{0.1 \times 2.65}{e} \Rightarrow e = 0.265$$

$$\gamma_d = \frac{G\gamma_w}{1+e} = \frac{2.65 \times 1000}{1+0.265} = 2094.8 kg/m^3$$

4. The porosity (η) and the degree of saturation (S) of a soil sample are 0.7 and 40% respectively. In a 100 m^3 volume of the soil, the volume (expressed in m^3) of air is….. GATE CE1 2016

Ans. 42

Solution:

Porosity, $\eta = 0.7$

Degree of saturation, $S = 40\%$

Volume of soil, $V = 100\ m^3$

Volume of air, $V_a = ?$

$$n = \frac{V_v}{V} \Rightarrow V_v n.V = 0.7 \times 100 = 70m^3$$

$$S = \frac{V_w}{V_v} \Rightarrow V_w = S.V_v = 0.4 \times 70 = 28m^3$$

$$V_a = V_v - V_w = 70 - 28 = 42m^3$$

5. A 588 cm^3 volume of moist sand weights 1010 gm. It dry weight is 918 gm and specific gravity of solids, G is 2.67. Assuming density of water as 1 gm/cm^3, the void ratio is …. GATE CE2 2015

Ans. 0.71

Solution:

Volume of moist sand, $V = 588m^3$

Weight of moist sand, $W = 1010gm$

Dry weight of sand, $W_d = 918gm$

Specific gravity of solids, $G = 2.67$

Density of water, $\gamma_w = 1gm/cc$

Void ratio, $e = ?$

Dry unit weight of sand, $\gamma_d = \frac{W_d}{V} = \frac{918}{588} = 1.561gm/cc$

$$r_d = \frac{G\gamma_w}{1+e} \Rightarrow 1.561 = \frac{2.67 \times 1}{1+e} \Rightarrow \boxed{e = 0.71}$$

6. If the water content of a fully saturated soil mass is 100% the void ratio of the sample is … GATE CE2 2015

a. less than specific gravity of soil
b. equal to specific gravity of soil
c. greater than specific gravity of soil
d. independent of specific gravity of soil

Ans. B

Explanation:

Degree of saturation, $S = 100$

Water content, $w = 100\%$

$$S = \frac{wG}{e} \Rightarrow 1 = \frac{1 \times G}{e} \Rightarrow \boxed{e = G}$$

7. A certain soil has the following properties: $G_s = 2.71$ $n = 40\%$ and $w = 20\%$. The degree of saturation of the soil (rounded off to the nearest percent) is _______

Ans. 81.3 GATE CE2 2014

Solution:

Specific gravity of soil solids, $G_s = 2.71$

Porosity, $n = 40\%$

Water content, $w = 20\%$

Degree of saturation, $S = ?$

Void ratio, $e = \frac{n}{1-n} = \frac{0.4}{1-0.4} = 0.667$

$$S = \frac{wG}{e} = \frac{0.2 \times 2.71}{0.667} = 0.813 = 81.3\%$$

8. In its natural condition, a soil sample has a mass of 1.980 kg and a volume of 0.001 m^3. After being completely dried in an oven, the mass of the sample is 1.800 kg. Specific gravity G is 2.7. Unit weight of water is 10 kN/m^3. The degree of saturation of the soil is : GATE CE 2013

a. 0.65 b. 0.70 **c.** 0.54 d. 0.61

Ans. C

Solution:

Mass of soil sample, $W = 1.980 \text{ kg}$

Volume of soil sample, $V = 0.001 \text{m}^3$

Density of soil sample, $\gamma = 1980 \text{kg/m}^3$

Dry mass of the sample, $W_d = 1.800 \text{kg}$

Specific gravity, $G = 2.7$

Unit weight of water, $\gamma_w = 10 \text{kN/m}^3$

Degree of saturation, $S = ?$

Water content, $w = \frac{1.980 - 1.800}{1.800} \times 100 \quad = 10\%$

$$\gamma_d = \frac{W_d}{V} = \frac{1.980}{0.001} = 1980 \text{ kg/m}^3 = 19.8 \text{ kN/m}^3$$

$$\gamma_d = \frac{G\gamma_w}{1+e} \qquad 18 = \frac{2.7 \times 10}{1+e} \qquad \boxed{e = 0.5}$$

$$S = \frac{wG}{e} \qquad S = \frac{0.1 \times 2.7}{0.5} \qquad \boxed{S = 0.54}$$

9. The water content of a saturated soil and the specific gravity of soil solids were found to be 30% and 2.70, respectively. Assuming the unit weight of water to be 10 kN/m³, the saturated unit weight (kN/m³), and the void ratio of the soil are GATE CE 2007

a. 19.4, 0.81 b. 18.5, 0.30 c. 19.4, 0.45 d. 18.5, 0.452007

Ans. A

Solution:

Water content, $w = 30\%$

Specific gravity, $G = 2.70$

Unit weight of water, $\gamma_w = 10$ kN/m³

Saturated unit weight, $\gamma_{sat} = \left(\frac{G+e}{1+e}\right)$

Void ratio, $e = \frac{w.G}{S}$

Degree of saturation, $S = 1$

Void ratio, $e = \frac{wG}{S} = 0.3 \times 2.7 = 0.81$

$$\gamma_{sat} = \left(\frac{2.7+0.81}{1+0.81}\right)10 = 19.4\,\mathrm{kN/m^3}$$

10. A saturated soil mass has a total density 22 KN/m^3 and a water content of 10%. The bulk density and dry density of this soil are GATE CE 2005

a. 12 KN/m^3 and 20 KN/m^3 respectively.

b. 22 KN/m^3 and 20 KN/m^3 respectively.

c. 19.8 KN/m^3 and 19.8 KN/m^3 respectively.

d. 23.2 KN/m^3 and 19.8 KN/m^3 respectively.

Ans. B

Solution :

Total density or bulk density, $\gamma = 22 \text{KN/m}^3$

Water content, $w = 10\%$

Dry density, $\gamma_d = \dfrac{\gamma}{1+w} = \dfrac{22}{1+0.1} = 20 \text{KN/m}^3$

11. The ratio of saturated unit weight to dry unit weight of soil is 1.25. If the specific gravity of solids (G_s) is 2.56, the void ratio of the soil is GATE CE 2004

a. 0.625 **b.** 0.663 c. 0.944 d. 1.325

Ans. B

Solution:

$$\frac{\text{Saturated unit weight of soil}(\gamma_{sat})}{\text{Dry unit weight of soil}(\gamma_d)} = 1.25$$

Specific gravity of solids, $G_s = 2.56$

Void ratio, e = ?

$$\gamma_{sat} = \frac{G+e}{1+e}.\gamma_w \; ; \quad \gamma_d = \frac{G\gamma_w}{1+e}$$

$$\frac{\gamma_{sat}}{\gamma_d} = \frac{G+e}{G} \; ; \; 1.25 = \frac{2.56+e}{2.56}$$

$$e = 0.663$$

12. The void ratio and specific gravity of a soil are 0.65 and 2.72 respectively. The degree of saturation (in percent) corresponding to water content of 20% is

GATE CE 2001

a. 65.3 b. 20.9 c. 83.7 d. 54.4

Ans. C

Solution:

Void ratio, $e = 0.65$

Specific gravity, $G = 2.72$

Degree of saturation, $S = ?$

Water content, $w = 20\%$

$$S = \frac{wG}{e} = \frac{0.2 \times 2.72}{0.65} = 83.7\%$$

13. A borrow pit soil has a dry density of 17 kN/m³. How many cubic meters of this soil will be required to construct an embankment of 100 m³ volume with a dry density of 16 kN/m³. GATE CE 2000

a. 94 m³ b. 106 m³ c. 100 m³ d. 90 m³

Ans. a

Given data

Property of soil	Borrow pit soil	Embankment
Dry density of soil	$\gamma_{d1} = 17\,KN/m^3$	$\gamma_{d2} = 16\,KN/m^3$
Volume of soil	$V_1 = ?$	$V_2 = 100\,m^3$

Density of soil solids, $\gamma_s = \frac{W_s}{V_s}$, $\gamma_d = \frac{W_s}{V}$, $\gamma_s = \frac{\gamma_d . V}{V_s}$

Since is constant for a given soil, γ_d = constant

$$\gamma_{d1} . V_1 = \gamma_{d2} . V_2 \qquad \frac{V_1}{V_2} = \frac{\gamma_{d2}}{\gamma_{d1}} \qquad V_1 = \frac{16}{17} \times 100 = 94.11\,m^3$$

14. A soil sample has a void ratio of 0.5 and its porosity will be close to

GATE CE 2000

a. 50%   b. 66%   c. 100%   **d.**33%

Ans. D

Solution:

Void ratio, $e = 0.5$

Porosity, $n = \dfrac{e}{1+e} = \dfrac{0.5}{1+0.5} = 0.333 \approx 33.3\%$

15. A soil sample in its natural state has mass of 2.290 kg and a volume of $1.15x10^{-3}$. After being oven dried, the mass of the sample is 2.035 kg. G for soil is 2.68. The void ratio of the natural soil is GATE CE 1999

a. 0.40 b. 0.45 c. 0.55 **d.** 0.53

Ans. D

Method – 1

Specific gravity $G = \frac{\gamma_s}{\gamma_w}$, $\gamma_s = \frac{W_s}{V_s}$

Unit weight of soil solids, $\gamma_s = G.\gamma_w = 2.68 \times 9.81 = 26.291$ kN/m³

Volume of soil solids, $V_s = \frac{W_s}{\gamma_s} = \frac{2.035 \times 9.81}{26.291 \times 10^3} = 0.75 \times 10^{-3}$ m³

Volume of voids, $V_v = V - V_s = 1.15 \times 10^{-3} - 0.75 \times 10^{-3}$

Void ratio, $e = \frac{V_v}{V_s} = \frac{0.4 \times 10^{-3}}{0.75 \times 10^{-3}} = 0.53$

$e = 0.53$

Method - 2

Mass of soil sample , M = 2.290 kg

Volume of soil sample, V $= 1.15 \times 10^{-3} m^3$

Dry mass of the sample, $W_d = 2.035 kg$

Specific gravity of soil, = 2.68

Water content, $w = \frac{W - W_d}{W_d} \times 100 = \frac{2.290 - 2.035}{2.035} \times 100 = 12.53\%$

Dry unit weight of soil, $\gamma_d = \frac{W_d}{V} = \frac{2.035}{1.15 \times 10^{-3}}$ = 1769.3 kg/m³

$$\gamma_d = \frac{G.\gamma_w}{1+e} \qquad 1769.3 = \frac{2.68 \times 981}{1+e}$$

$$e = 0.53$$

16. Principle involved in the relationship between submerged unit weight and saturated weight of a soil is based on GATE CE 1999

a. Equilibrium of floating bodies **b.** Archimedes's principle

c. Stokes' law d. Darcy's law

Ans. b

- **Equilibrium of floating bodies:** If a body is floating over fluid which is in equilibrium, the weight of the fluid displaced by a floating body is equal to the weight of the body.

- **Archimedes's Principle:** If a body is immersed in a fluid, wholly or partially, which is in equilibrium, the upward buoyant force exerted on a body is equal to the weight of the fluid displaced by the body.

- **Stoke's law:** The sedimentation analysis is based on stoke's law, in which terminal velocity of a sphere falling through an infinite liquid medium.

- **Darcy's Law:** The rate of flow or discharge is proportional to the hydraulic gradient. i.e. $q \propto i$

17. If the porosity of a soil sample is 20%, the void ratio is GATE CE 1997

a. 0.20 b. 0.80 c. 1.00 **d.** 0.25

Ans. d

Explanation:

Porosity, n = 20%

Void ratio, $e = \frac{n}{1-n} = \frac{0.2}{1-0.2} = 0.25$

18. Which one of the following relations is not correct?

GATE CE 1996

a. $e = \frac{n}{1-n}$ b. $\gamma_{sat} = \frac{G+e}{1+e}.\gamma_w$ c. $n = \frac{e}{1-e}$ d. $e = \frac{wG}{S}$

where e = void ratio, n = porosity, w = water content, S = degree of saturation, γ_{sat} = saturated unit weight of soil, γ_w = unit weight of water

Ans. A

Explanation:

The correct relations are

$$e = \frac{n}{1-n} \qquad n = \frac{e}{1+e} \qquad S = \frac{wG}{e} \qquad \gamma_{sat} = \frac{G+e}{1+e}\gamma_w$$

e: Void ratio

n : Porosity

w: Water content

S: Degree of saturation

γ_{sat}: Saturated unit weight of soil

γ_w: Unit weight of soil.

19. The void ratio of soil can exceed unity. True / False GATE CE 1995

Ans. True

Void ratio, $e = \frac{V_v}{V_s}$

Void ratio can be more than **unity**.

20. The void ratio of a soil sample is 1, the corresponding porosity of the sample is….

GATE CE 1994

Ans. 0.5

Explanation:

Void ratio of a soil sample, $e = 1$

Porosity, $n = \frac{e}{1+e} = \frac{1}{1+1} = 0.5$

21. A saturated sand sample has dry unit weight of 18 kN/m³, the water content of the soil is……… GATE CE 1991

Ans. 17.8%

Explanation:

Dry unit weight of saturated soil, $\gamma_d = 18\,\text{KN/m}^3$

Specific gravity, $G = 2.65$

Unit weight of water, $\gamma_w = 10\,\text{KN/m}^3$

Water content of soil, $w = ?$

$$\gamma_d = \frac{G.\gamma_w}{1+e} \qquad 18 = \frac{2.65\times 10}{1+e} \qquad e = 0.472$$

$$S = \frac{w.G}{e} \qquad 1 = \frac{w\times 2.65}{0.472} \qquad w = 0.178 \approx 17.8\%$$

22. For sand of uniform spherical particles, the void ratios in the loosest and the densest states are……..and…….respectively. GATE CE 1991

Ans. 0.91; 0.35

Explanation:

For uniform spherical sand particles,

Void ratio in the looset state

Void ratio in the densest state