Note : Unit weight of water γ_w = 10 KN/m3 = 1000 N/m3 = 1 gm/ml =

1 gm/ cm3 = 1 kg/lit = 1 gm/cc

Problem 1) The following are results of compaction test .

Bulk density Kn/M3	Water content in %
16.5	10
17.8	13
19.90	16.5
10.8	20
18.50	24.5
18	29

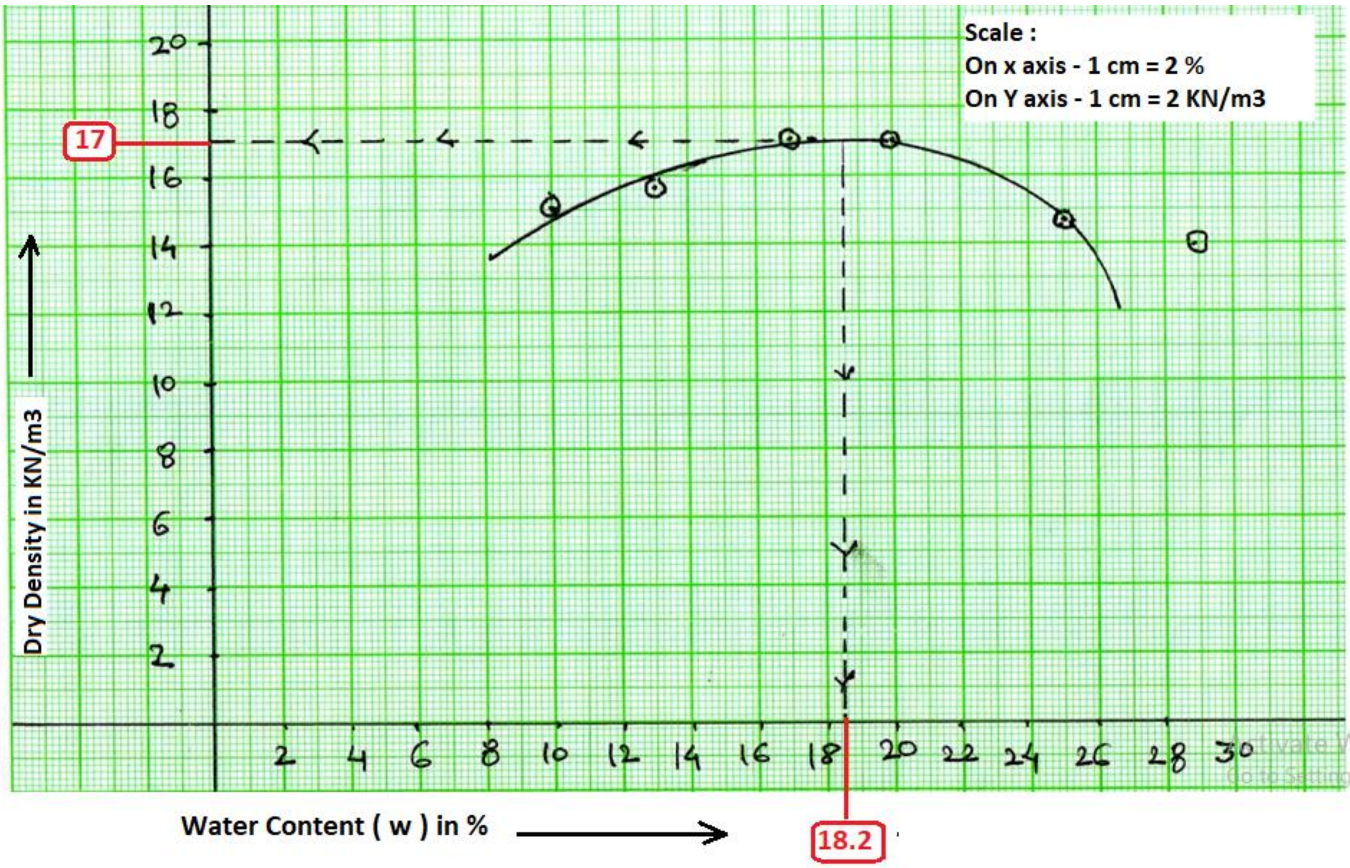
Determine maximum dry density (MDD) and Optimum moisture content (OMC) **?**

Answer :

Bulk density Kn/M3 γ	Water content in fraction w	Dry density $\gamma_d = \frac{\gamma}{1+w}$
16.5	$10/100 = 0.10$	15
17.8	0.13	15.75
19.90	0.165	17.08
10.8	0.20	16.5
18.50	0.24	14.85
18	0.29	13.95

From graph ; MDD i.e. maximum dry density $\gamma_{d\ max} = 17$ KN/m3

Optimum moisture content (OMC) = 18.2 %



Problem 2) Following are results of compaction test :

Mass of mould + wt. of soil (gm)	2925	3095	3150	3125	3070
Water content in %	10	12	14.3	16.1	18.2

Volume of mould = 1000 ml

Mass of mould = 1000 gm ; specific gravity of soil solids = 2.7

Determine :

a) Draw the compaction curve showing the maximum dry density (MDD) and optimum moisture content (OMC).

b) Plot zero air void line

c) Determine the degree of saturation at maximum dry density.

Mass of empty mould (w1)	Mass of mould + compacted soil (gm) W2	Water content in fraction	Volume ml (V)	Bulk density in gm/ml $\gamma = {w2 - w1}/{V}$	Dry Density $\gamma_d = \frac{\gamma}{1+w}$	Zero air void or at 100 % saturation . $= \frac{G\ \gamma_{w}(1-\eta_a)}{1+w\,G}$
1000	2925	10/100=0.1	1000	1.925	1.75	2.125
1000	3025	0.12	1000	2.025	1.87	2.039
1000	3150	0.143	1000	2.150	1.88	1.947
1000	3125	0.161	1000	2.125	1.83	1.885
1000	3025	0.182	1000	2.07	1.751	1.810

From graph, we get.

M.D.D. $(\gamma_{d\,max}) = 1.91$ gm/ml.

O.M.C. $= w = 12.8\% = \frac{12.8}{100} = 0.128$

$G = 2.7$; $S = ?$

Now

$$\gamma_{d\,max} = \frac{G \cdot \gamma_w}{1+e}$$

$$1.91 = \frac{2.7 \times 1}{1+e} \quad \text{------------} \quad \gamma_w = 1 \text{ gm/ml}$$

$$\therefore e = 0.413$$

Now, $S = \frac{wG}{e} = \frac{0.128 \times 2.7}{0.436} = 0.80 \Rightarrow 80.2\%$

$$\gamma_{d\,max\,(theor)} = \frac{G \cdot \gamma_w}{1 + \frac{wG}{S}} = \frac{2.7 \times 1}{1 + \left(\frac{0.128 \times 2.7}{0.80}\right)} = 1.87 \text{ gm/ml}$$

For Zero air void line ; we know

$$\gamma_d = \frac{G\,\gamma_w(1-n_a)}{1+w\cdot G}$$; we know, for zero air void line, $n_a = 0$

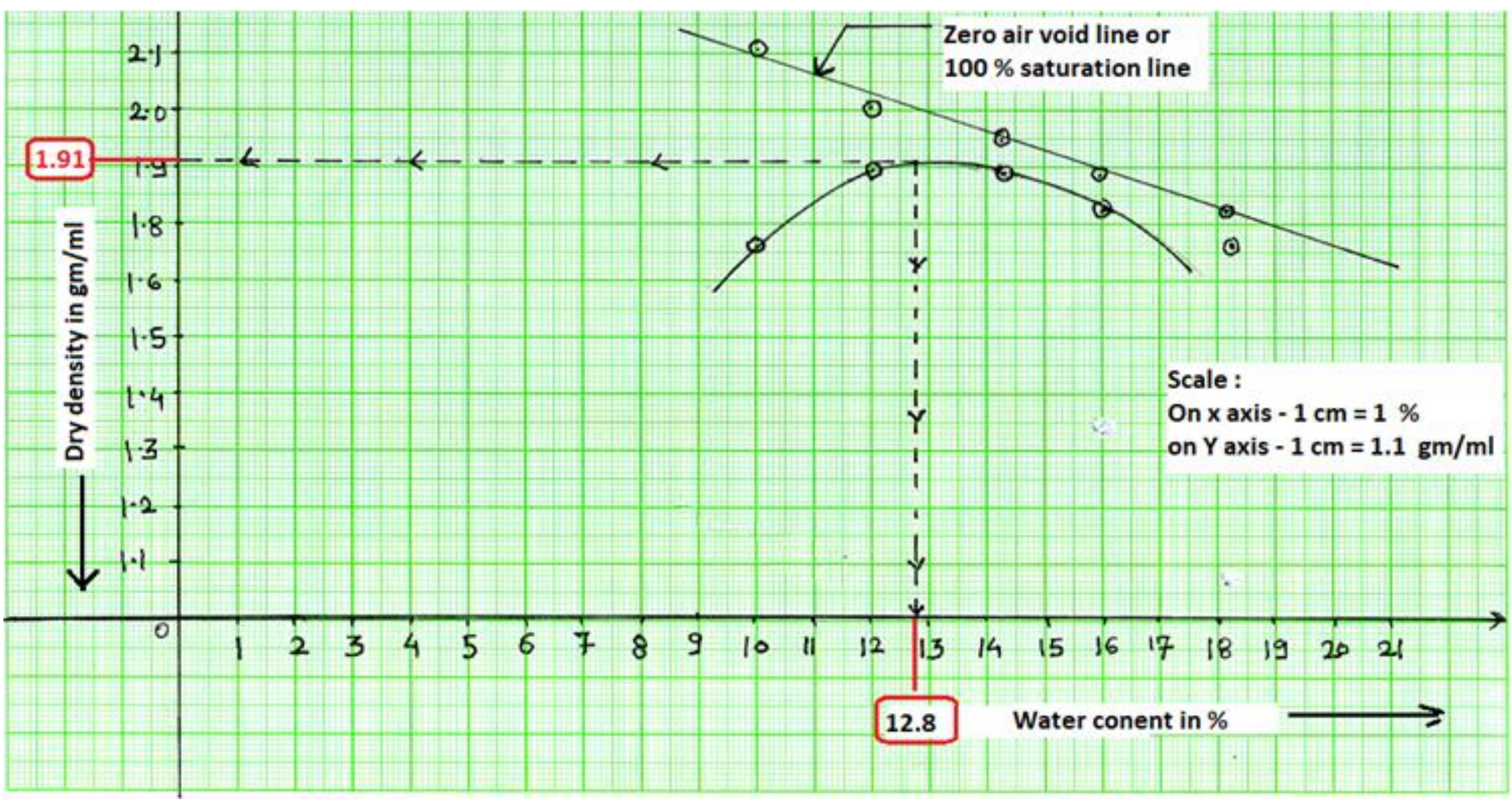
$$\therefore\ \gamma_{d_1} = \frac{2.7\times1\times(1-0)}{1+(0.1\times2.7)} = 2.125$$

$$\gamma_{d_2} = \frac{2.7\times1\times(1-0)}{1+(0.12\times2.7)} = 2.039$$

$$\gamma_{d_3} = \frac{2.7\times1\times(1-0)}{1+(0.143\times2.7)} = 1.947$$

$$\gamma_{d_4} = \frac{2.7\times1\times(1-0)}{1+(0.161\times2.7)} = 1.885$$

$$\gamma_{d_5} = 0.810$$



Problem 3) The optimum moisture content of soil is 16.5 % and maximum dry density is 15.7 KN/m3. Specific gravity of soil solids is 2.65 . determine

a) The degree of saturation and % air voids of the soil at OMC

b) The theoretical dry density at OMC corresponding to zero air voids .

Answer :

Given; water content $w = 16.5\% = \frac{16.5}{100} = 0.165$

$$\gamma_d = \frac{(1-\eta_a) \cdot G \cdot \gamma_w}{1 + wG}$$

$$15.7 = \frac{(1-\eta_a) \times 2.65 \times 9.81}{1 + (0.165 \times 2.65)}$$

$\therefore \eta_a = 0.132$

$\therefore$ % of air voids of the soil $\eta_a = 0.132 = 13.2\%$.

Given, M.D.D. $(\gamma_{d\,max}) = 15.7$ KN/m3

we've

$$\gamma_{d\,max} = \frac{G \cdot \gamma_w}{1+e}$$

$$15.7 = \frac{2.65 \times 9.81}{1+e}$$

$$e = 0.655$$

Degree of Saturation

$$S = \frac{wG}{e} = \frac{0.165 \times 2.65}{0.655} = 66.7\%$$

Again

$$(\gamma_{d\,max})_{theor} = \frac{G \gamma_w}{1 + \frac{G \cdot w}{S}}$$

$$= \frac{2.65 \times 9.81}{1 + \left(\frac{2.65 \times 0.165}{0.667}\right)}$$

$$= 15.70 \text{ KN/m3}$$

Problem 4) following observations are taken in the standard compaction test.

Mass of wet soil in gm	Water content
1.7	8
1.9	11.5
2	14.5
1.98	17.5
1.95	19.5
1.92	21.5

The volume of the mould is 950 cc and specific gravity is 2.65. find

a) Optimum moisture corresponding dry density.

b) 100 % saturation line

Answer :

Mass of wet soil In gm	Water content (%)	Dry density $\gamma_d = \frac{\gamma}{1+w} = \frac{W}{V}\left(\frac{1}{1+w}\right)$	Zero air void or at 100 % saturation . $= \frac{G\ \gamma_{w}(1-\eta_a)}{1+w\ G}$
1.7	0.08	1.65 x 10^{-3}	2.186
1.9	0.115	1.79 x 10^{-3}	2.03
2	0.145	1.83 x 10^{-3}	1.91
1.98	0.175	1.77 x 10^{-3}	1.81
1.95	0.195	1.71 x 10^{-3}	1.747
1.92	0.215	1.66 x 10^{-3}	0.688

Answer :

From Graph;

MDD = $\gamma_{d max} = 1.84 \times 10^{-3}$ gm/cm³

OMC = 14.6 % = 0.146.

Now,

$$\gamma_{d\,max} = \frac{G \cdot \gamma_w}{1+e}$$

$$\therefore 1+e = \frac{2.65 \times 1}{1.84 \times 10^{-3}} \quad \text{------ } \gamma_w = 1 \text{ gm/cm}^3.$$

$$e = 1439.21$$

degree of Saturation;

$$S = \frac{wG}{e} = \frac{0.146 \times 2.65}{1439.21}$$

$$= 2.68 \times 10^{-4}$$

$$S = 0.00026$$

For zero air void line we've

$$(\gamma_d)_1 = \frac{G\gamma_w(1-\eta_a)}{1+w \cdot G} = \frac{2.65 \times 1\,(1-0)}{1+(0.08 \times 2.65)} = 2.186$$

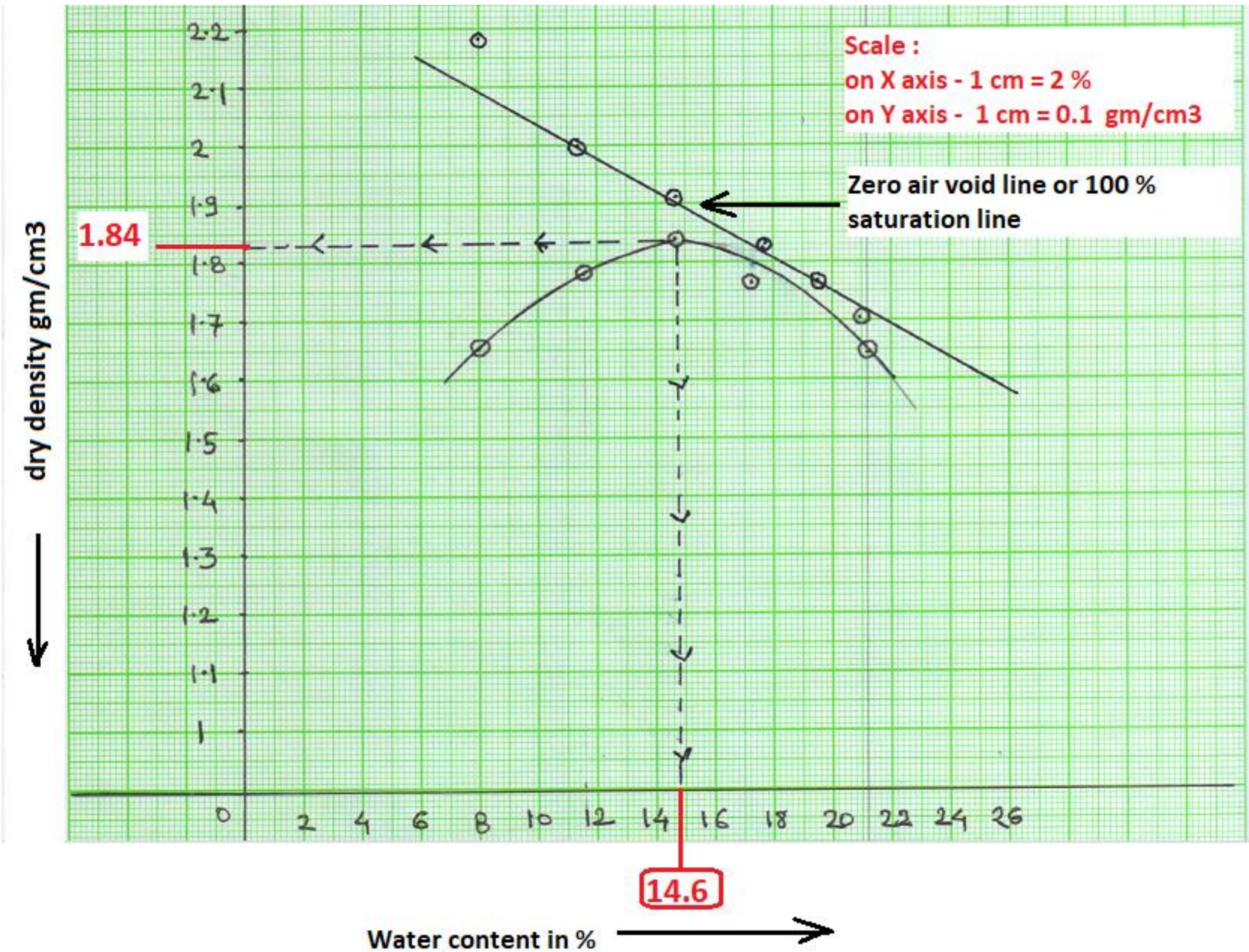
$$\gamma_{d_2} = \frac{2.65 \times 1\,(1-0)}{1+(0.115 \times 2.65)} = 2.03$$

$$\gamma_{d_3} = \frac{2.65 \times 1\,(1-0)}{1+(0.145 \times 2.65)} = 1.91$$

$$\gamma_{d_4} = \frac{2.65 \times 1 \times (1-0)}{1+(0.175 \times 2.65)} = 1.81$$

$$\gamma_{d_5} = \frac{2.65 \times 1 \times (1-0)}{1+(0.195 \times 2.65)} = 1.747$$

$$\gamma_{d_6} = \frac{2.65 \times 1 \times (1-0)}{1+(0.215 \times 2.65)} = 1.688$$


Scale :
on X axis - 1 cm = 2 %
on Y axis - 1 cm = 0.1 gm/cm3
Zero air void line or 100 % saturation line
1.84
dry density gm/cm3
14.6
Water content in %