HOMEWORK 1 Solution

1) V=22.3 cm^3 M_T=39.7 g M_{dry}= M_s= 33 g Gs =2.65

For unit V_S ;

	V	M
Air	(1-S).e	0
Water	e.S	e.S.ρ_w
Solids	1	Gs. ρ_w

Note that all soil parameters in this topic are ratios. Therefore they can be calculated using either the actual volumes and masses, or those in the phase diagram given in terms of V_S. However the numerator and the denominator of these ratios must both come from the same place (both real quantities or both for unit V_S).

a) $\rho_{dry} = \frac{33}{22.3} = 1.48 gr/cm^3$

$\rho_{dry} = \frac{M_S}{V_T} = \frac{G_S \cdot \rho_w}{1+e} = \frac{2.65 \times 1}{1+e} = 1.48 gr/cm^3 \Rightarrow$ e = 0.79

b) $w = \frac{M_W}{M_S} = \frac{39.7 - 33}{33} = 0.203 = 20.3\%$

c) $n = \frac{V_V}{V_T} = \frac{e}{1+e} = \frac{0.79}{1+0.79} = 0.441$

d) $w = \frac{M_W}{M_S} = \frac{e \cdot S \cdot \rho_w}{G_S \cdot \rho_w} = \frac{e \cdot S}{G_S} = \frac{0.79 \cdot S}{2.65} = 0.203 \Rightarrow$ S = 0.681 = 68.1%

OR

$V_V = n \cdot V_T = 0.441 \times 22.3 = 9.83 cm^3$

$M_W = 39.7 - 33 = 6.7 g \quad \Rightarrow \quad V_W = M_W / \rho_w = 6.7 cm^3$

$S = \frac{V_W}{V_V} = \frac{6.7}{9.83} = 68.1\%$

e) All voids are filled with water $\Rightarrow$ $V_W = V_V = e$ and $M_W = e.\rho_w$

$\gamma_{sat} = \frac{W_T}{V_T} = \frac{G_s \cdot \gamma_w + e \cdot \gamma_w}{1+e} = \frac{(2.65 + 0.79) \times 10}{1 + 0.79} = 19.2 kN/m^3$

$G_S.w = S.e \quad \Rightarrow \quad w = \frac{S.e}{G_s} = \frac{1 \times 0.79}{2.65} = 0.298 = 29.8\%$

OR

$M_W = V_V \times \rho_w = 9.83 g$

$w = \frac{M_W}{M_S} = \frac{9.83}{33} = 0.298 = 29.8\%$

2) e_{max}=0.81 e_{min}=0.48 D_R=65 %

Before compaction: $D_R = \frac{e_{max} - e}{e_{max} - e_{min}} = \frac{0.81 - e}{0.81 - 0.48} = 0.65 \Rightarrow$ e = 0.5955

$\frac{\Delta H}{H} = \frac{\Delta e}{1+e}$ $\frac{0.12}{2} = \frac{\Delta e}{1+0.595} \Rightarrow$ Δe = 0.0957 $\Rightarrow$ e_{final} = 0.5955 – 0.0957 = 0.4998

$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} = \frac{0.81 - 0.4998}{0.81 - 0.48} = 0.94 = \mathbf{94\%}$

	V	M
Air	(1- S).e	0
Water		
Solids		

See comment in question 1.

$e.S = G_S \cdot w \Leftarrow G_S \cdot \rho_w \cdot w$

$\Uparrow \qquad \Uparrow$

$1 \Rightarrow G_S \cdot \rho_w$

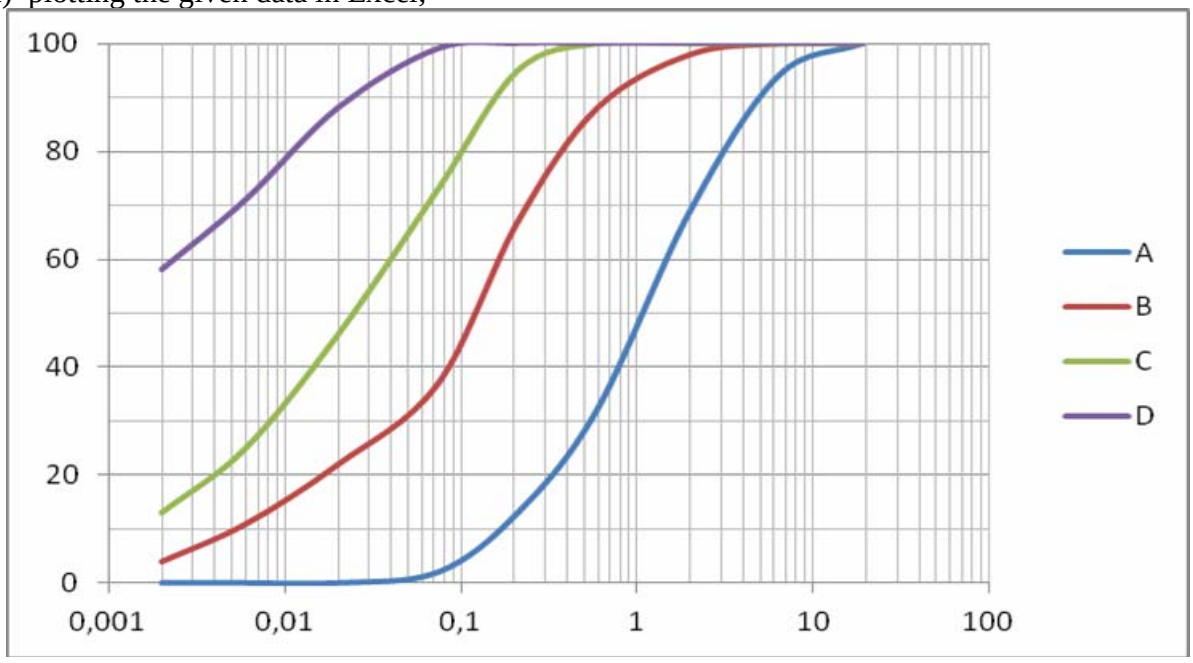
$\rho_{bulk} = \frac{(1+w)\cdot G_S \cdot \rho_w}{1+e} = \frac{(1+0.12)\times 2.6 \times 1}{1+0.4998} =$ **1.942 g/cc or tons/m^3**

$\rho_{dry} = \frac{G_s \rho_w}{1+e} = \frac{2.6}{1+0.4998} =$ **1.734 g/cc or tons/m^3**

$e.S = G_S \cdot w \Rightarrow 0.4998\ S = 2.6 \times 0.12 \Rightarrow S = 0.6247 = 62.47\ \%$

$A = \frac{V_A}{V_S} = \frac{(1-S)\cdot e}{1+e} = \frac{(1-0.6247)\cdot 0.4998}{1+0.4998} = 0.125 =$ **12.5 %**

3) a) plotting the given data in Excel;



b) For soil A:

Gravel percentage (>4.75mm): 100 – 88 = 12%

Sand percentage (<4.75mm, >0.075mm) = 88 – 2 = 86%

Fines (<0.075mm) = 2%

For soil B:

Gravel percentage (>4.75mm): 0%

Sand percentage (<4.75mm, >0.075mm) = 100 – 37 = 63%

Fines=(<0.075mm) = 37%

c) For soil A:

D_{10}=0.17 mm

D_{30}=0.55 mm

D_{60}=1.5 mm

$$C_U = \frac{D_{60}}{D_{10}} = \frac{1.5}{0.17} = 8.8 > 6$$

$$C_Z = \frac{(D_{30})^2}{D_{10} x D_{60}} = \frac{(0.55)^2}{0.17 x 1.5} = 1.2$$

$C_U > 6$ and $1 < C_Z < 3$

$\Rightarrow$ Well Graded

For soil B:

D_{10}=0.005 mm

D_{30}=0.045 mm

D_{60}=0.17 mm

$$C_U = \frac{D_{60}}{D_{10}} = \frac{0.17}{0.005} = 34$$

$$C_Z = \frac{(D_{30})^2}{D_{10} x D_{60}} = \frac{(0.045)^2}{0.005 x 0.17} = 2.38$$

$C_U > 6$ and $1 < C_Z < 3$

$\Rightarrow$ Well Graded

d) **Soil A:** More than 50 % is coarse (98%)

More than 50 % of coarse fraction is sand.

Small amount of fines

Well graded. $\Rightarrow$ SW (well-graded sand)

Soil B: More than 50 % is coarse (63%)

More than 50 % of coarse fraction is sand.

Fines (37%) > 12 %

Non-plastic $\Rightarrow$ SM (sand with non-plastic fines ~ silty sand)

Soil C: More than 50 % is fine (73%)

LL=32% and PI=32-24=8 %

Below A-line $\Rightarrow$ ML (silt with low plasticity)

Soil D: More than 50 % is fine (99%)

LL=78 > 50 %

PI=78-31=47 %

Above A-line $\Rightarrow$ CH (clay with high plasticity)

e) Since natural water content, w (55%) is between PL (31%) and LL (78%), soil D is in plastic consistency.

$$I_P = LL - PL = 78 - 31 = 47\%$$

$$I_L = \frac{w - PL}{I_P} = \frac{55 - 31}{47} = 0.51 = 51\%$$