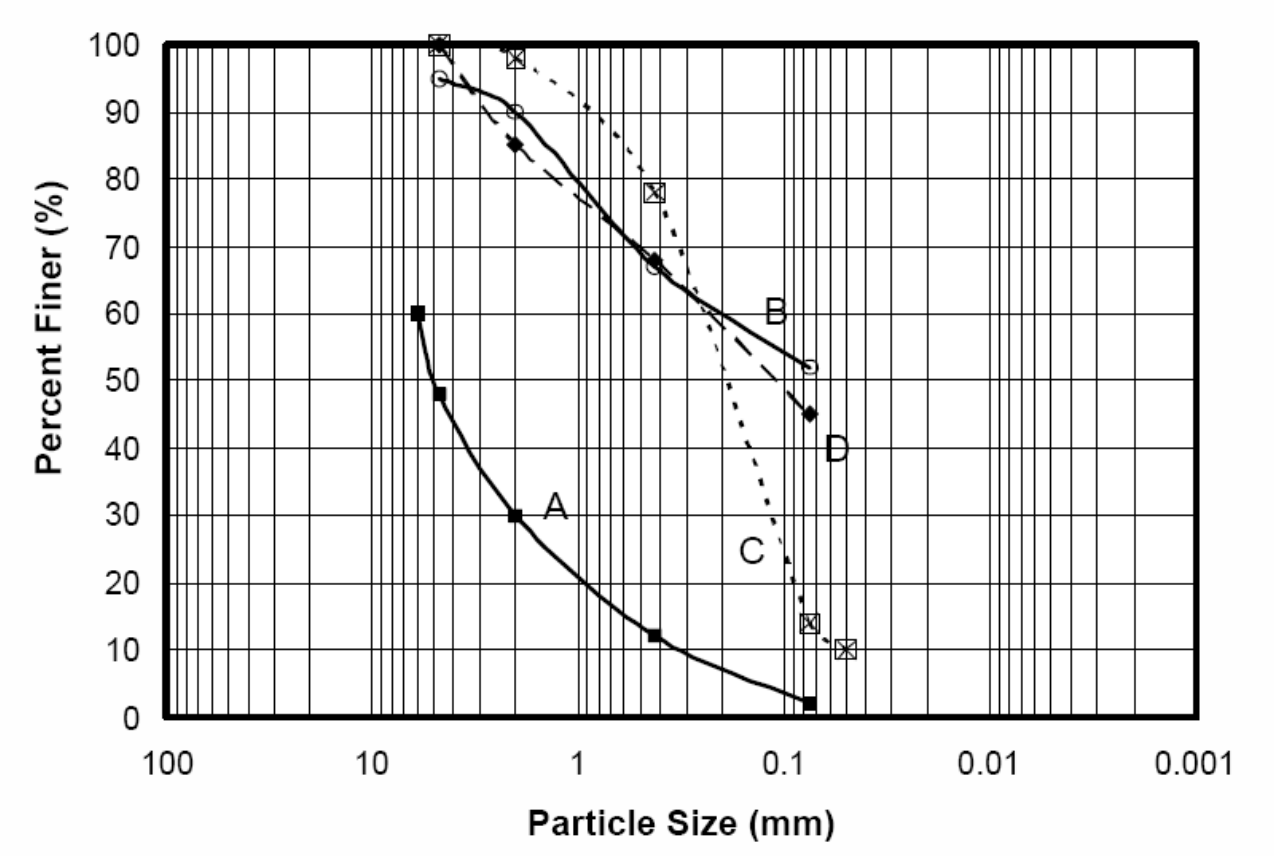
BACKGROUND AND REVIEW

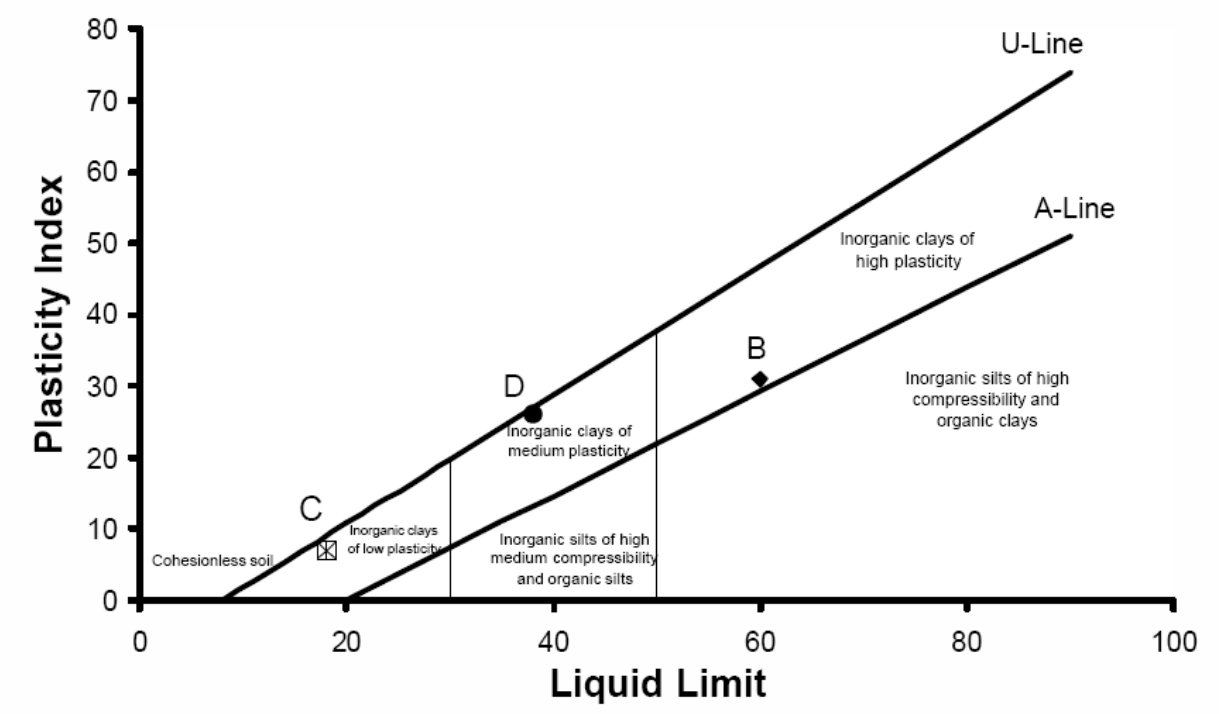
Solution:

Q1.

Soil	Sieve analysis, % finer				Liquid Limit	Plastic Limit
	No. 4	No. 10	No. 40	No. 200		
A	48	30	12	2	-	NP
B	95	90	67	52	60	29
C	100	100	78	14	25	17
D	100	85	68	45	38	12



TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)



Soil	D_{10}	D_{60}	D_{30}	C_u	C_c	Group Symbols
A	0.32	6.0	2.0	19.0	2.1	GW
B	-		-	-	-	CH
C	0.05	0.25	0.12	5.0	1.2	SC
D	-		-	-	-	SC

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)

Q2.

a. Bulk density (M*g/m³*)

$$\rho = \frac{W}{V} = \frac{(10.2)(1000)}{5600} = 1.82 g/cm^3 = 1.82 Mg/m^3$$

b. Dry density (M*g/m³*)

$$\rho_d = \frac{\rho}{1+w} = \frac{1.82}{1+0.1} = 1.66 Mg/m^3$$

c. Void ratio

$$e = \frac{G_s \rho_w}{\rho_d} - 1 = \frac{(2.7)(1.0)}{1.66} - 1 = 0.63$$

d. Porosity

$$n = \frac{e}{1+e} = \frac{0.63}{1+0.63} = 0.39$$

e. Degree of Saturation (%)

$$S_r = \frac{wG_s}{e} = \frac{(0.1)(2.7)}{0.63} = 0.43 = 43\%$$

f. Volume occupied by water (c*m³*)

Since, $S_r = \frac{V_w}{V_v}$

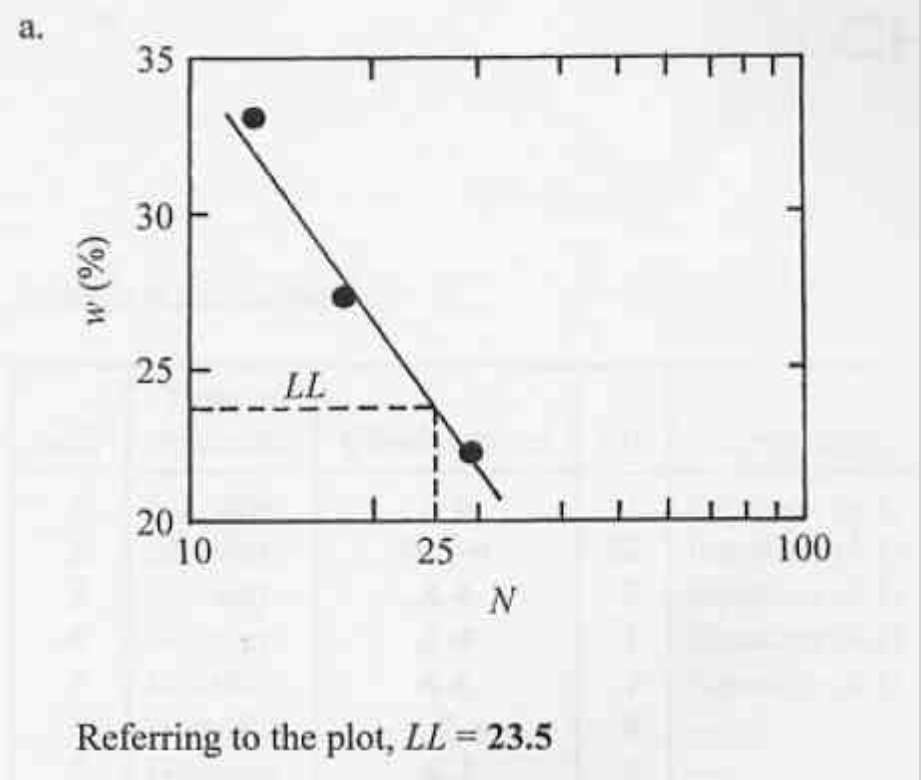
And $n = \frac{V_v}{V}$

So, $V_w = S_r V_v = S_r n V = (43\%)(0.39)(5600) = 927 cm^3$

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)

Q3.

a. Flow curve



(Note: the above figure is referred to as flow curve in the literature)

Liquid limit: 23.5

b. Plasticity index:

$$I_p = w_L - w_p = 23.5 - 11 = 12.5$$

c. Liquidity index:

$$I_L = \frac{w - w_p}{I_p} = \frac{15 - 11}{12.5} = 0.32$$

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)

d. Understanding liquidity index: $I_L = \frac{w - w_p}{I_p}$

If I_L<0, Soil is in hard brittle state; if 0<= I_L<1, soil is in plastic state; if I_L >=1, soil is in liquid state.

e. Flow curve cannot be measured for a sandy soil because it is NP. However, for fine-grained soils, the flow curve is flatter as the plasticity is higher. In other words, a clayey soil will have a flatter slope compared to silty soil. The w_L value will be higher for a clay in comparison to silt.

Q4.

$$\frac{e_{max} - e}{e_{max} - e_{min}} = \frac{\gamma_{d\,max}}{\gamma_d} * \frac{\gamma_d - \gamma_{d\,min}}{\gamma_{d\,max} - \gamma_{d\,min}}$$

Use the right side of the equation:

$$\frac{\gamma_{d\,max}}{\gamma_d} * \frac{\gamma_d - \gamma_{d\,min}}{\gamma_{d\,max} - \gamma_{d\,min}} = \frac{\frac{G_s}{1 + e_{min}}}{\frac{G_s}{1 + e}} * \frac{\frac{G_s}{1 + e} - \frac{G_s}{1 + e_{max}}}{\frac{G_s}{1 + e_{min}} - \frac{G_s}{1 + e_{max}}}$$

$$\frac{\frac{1}{1 + e_{min}}}{\frac{1}{1 + e}} * \frac{\frac{1}{1 + e} - \frac{1}{1 + e_{max}}}{\frac{1}{1 + e_{min}} - \frac{1}{1 + e_{max}}} = \frac{1 + e}{1 + e_{min}} * \frac{\frac{1}{1 + e} - \frac{1}{1 + e_{max}}}{\frac{1}{1 + e_{min}} - \frac{1}{1 + e_{max}}} =$$

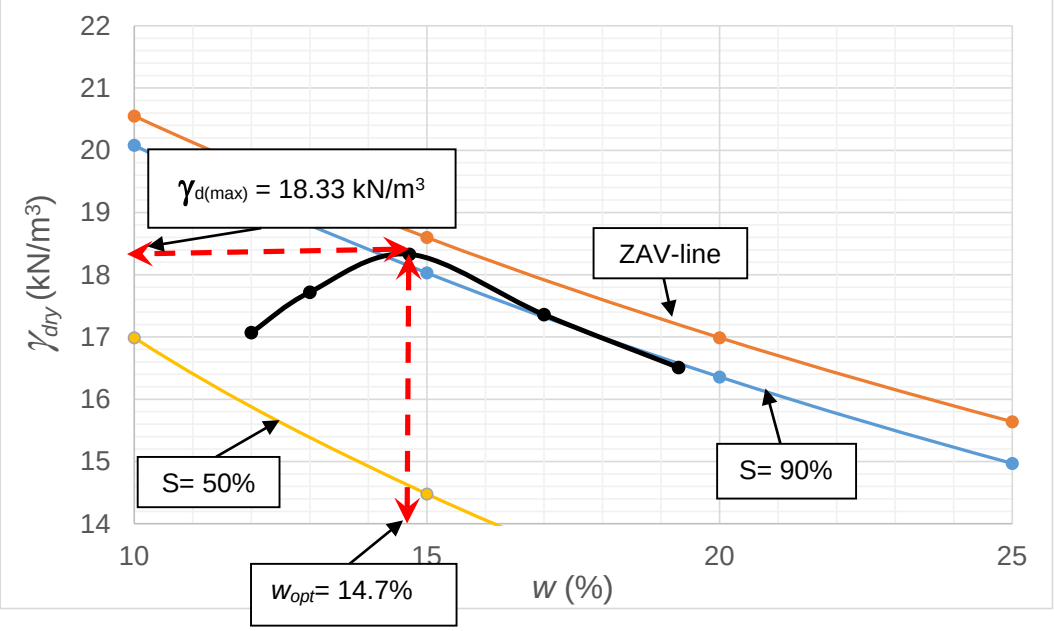
$$\frac{1 - \frac{1 + e}{1 + e_{max}}}{1 - \frac{1 + e_{min}}{1 + e_{max}}} = \frac{\frac{1 + e_{max} - (1 + e)}{1 + e_{max}}}{\frac{1 + e_{max} - (1 + e_{min})}{1 + e_{max}}} = \frac{e_{max} - e}{e_{max} - e_{min}}$$

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)

Q5.

Volume of the mold is 944 cm³

Mass of soil (g)	1805	1890	1985	1917	1860
Bulk unit weight (kN/m³)	19.12	20.02	21.03	20.31	19.7
Water content (%)	12	13	14.7	17	19.3
Dry unit weight (kN/m³)	17.07	17.72	18.33	17.36	16.55



$\gamma_{d(max)}$ = 18.33 kN/m³

Optimum water content, w_{opt}= 14.7%

(The above values can be slightly different depending on the compaction curves)

(Sample calculations: see next page for more details)

$$\gamma_{zav} = \frac{G_s \gamma_w}{1+wG_s} = \frac{2.65\times9.81}{1+(0.05\times2.65)} = 22.95 \text{ (kN/m}^3\text{)}$$

$$\gamma_{90\%} = \frac{G_s \gamma_w}{1+\frac{wG_s}{S}} = \frac{2.65\times9.81}{1+\frac{0.05\times2.65}{0.9}} = 22.66 \text{ (kN/m}^3\text{)}$$

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)

G_s	w (%)	γ_{ZAV} (kN/m^3)	$\gamma_{90\%}$ (kN/m^3)	$\gamma_{50\%}$ (kN/m^3)
2.65	5	22.95	22.66	20.55
2.65	10	20.55	20.08	16.99
2.65	15	18.6	18.03	14.48
2.65	20	16.99	16.36	12.62
2.65	25	15.64	14.97	11.18
2.65	30	14.48	13.8	10.04

TA: Mohammed Al-Khazaali (malkh018@uottawa.ca)