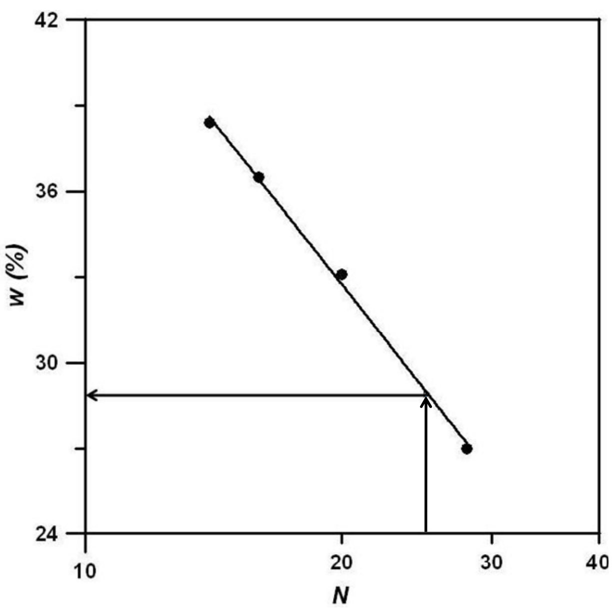
Chapter 4

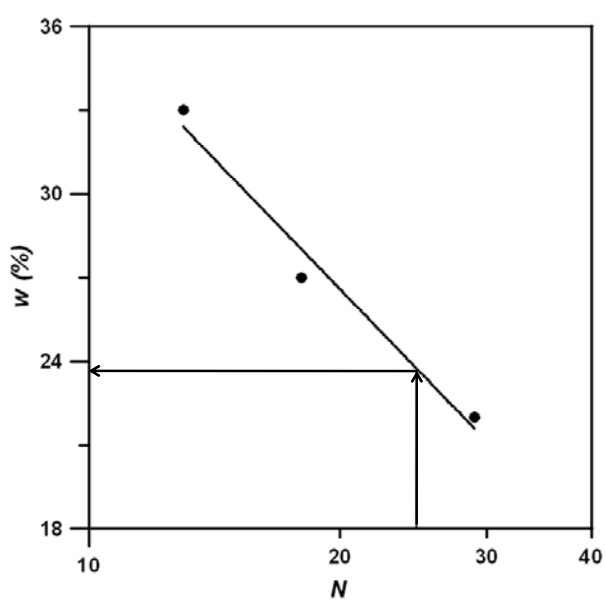
4.1 a. Refer to the plot of w versus N.
LL = **29.0**



b. $PI = LL - PL$
$= 29.0 - 13.4$
$= \mathbf{15.6}$

4.2 $LI = \dfrac{w - PL}{LL - PL} = \dfrac{32 - 13.4}{15.6} = \mathbf{1.19}$

4.3 a. From the plot,
LL = **23.6**.



b. $PI = LL - PL$
$= 23.6 - 19.1$
$= \mathbf{4.5}$

4.4 $$LI = \frac{w - PL}{LL - PL} = \frac{21 - 19.1}{4.5} = \mathbf{0.422}$$

4.5 $$SL = \left(\frac{M_1 - M_2}{M_2}\right)(100) - \left(\frac{V_i - V_f}{M_2}\right)(\rho_w)(100)$$

$$= \left(\frac{34 - 24}{24}\right)(100) - \left(\frac{20.2 - 14.3}{24}\right)(1)(100) = \mathbf{17.08}$$

$$SR = \frac{M_2}{V_f \rho_w} = \frac{24}{(14.3)(1)} = \mathbf{1.68}$$

4.6 $$SL = \left(\frac{M_1 - M_2}{M_2}\right)(100) - \left(\frac{V_i - V_f}{M_2}\right)(\rho_w)(100)$$

$$= \left(\frac{44.6 - 32.8}{32.8}\right)(100) - \left(\frac{16.2 - 10.8}{32.8}\right)(1)(100) = \mathbf{19.51}$$

$$SR = \frac{M_2}{V_f \rho_w} = \frac{32.8}{(10.8)(1)} = \mathbf{3.03}$$

CRITICAL THINKING PROBLEMS

4.C.1 a. From Eq. (4.26): $A = \dfrac{PI}{(\text{\% of clay-size fraction, by weight})}$

The computed *PI* values are provided in the table on the following page.

Soil	% clay (< 0.002 mm in size)	A	$\tau_{f\text{-undisturbed}}$ (kN/m^2)	S_t	PI	$\tau_{f\text{-remolded}}$ (kN/m^2)
Beauharnois	79	0.52	18	14	**41.08**	**1.3**
Detroit I	36	0.36	17	2.5	**12.96**	**6.9**
Horten	40	0.42	41	17	**16.8**	**2.4**
Gosport	55	0.89	29	2.2	**48.95**	**13.0**
Mexico City	90	4.5	46	5.3	**405**	**8.7**
Shellhaven	41	1.33	36	7.6	**54.53**	**4.8**
St. Thuribe	36	0.33	38	150	**11.88**	**0.3**

b. From Table 4.2:

Beauharnois
A = 0.52; PI = 41.08; Mineral: **Illite**

Detroit I
A = 0.36; PI = 12.96; Mineral: **Kaolinite**

Horten
A = 0.42; PI = 16.8; Mineral: **Kaolinite**

Gosport
A = 0.89; PI = 48.95; Mineral: **Illite**

Mexico City
A = 4.5; PI = 405; Mineral: **Montmorillonite**

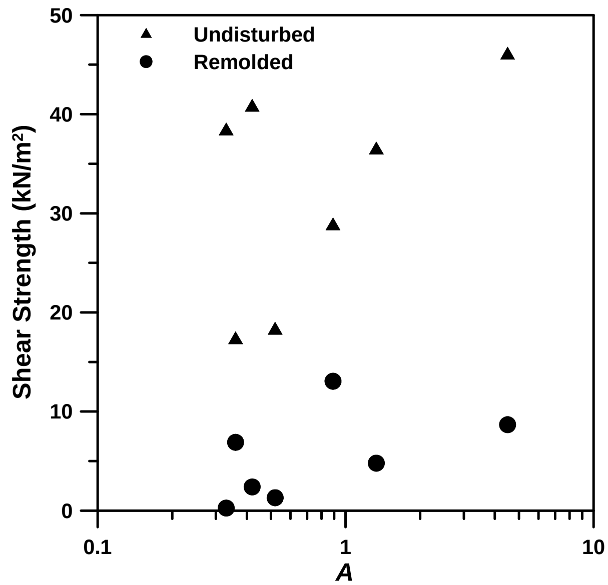
Shellhaven
A = 1.33; PI = 54.53; Mineral: **Illite**

St. Thuribe
A = 0.33; PI = 11.88; Mineral: **Kaolinite**

c. Sensitivity, $S_t = \dfrac{\tau_{f-\text{undisturbed}}}{\tau_{f-\text{remolded}}}$

$\tau_{f\text{-remolded}}$ is calculated using the above equation and listed in the table (Part a).

d. The plots are shown below.



Explanation: The shear strength of clay comes from two components: the cohesion, which is the cementing force between particles, and the frictional resistance, which is mainly due to the movement of one particle over another. The greater the activity of clay, the greater is the contribution of cohesion to shear strength. Although no reliable correlation can be developed from the above plots, both the undisturbed and remolded shear strengths certainly show increasing trends as the activity increases.

4.C.2 a. The liquidity index is given by: $LI = \dfrac{w - PL}{LL - PL}$

The range of liquidity index corresponding to the range in natural water content is calculated and listed in the table.

Soil	% clay (< 0.002 mm in size)	w_n (%)	LL	PL	LI
1	34	59-67	49	26	**1.43-1.78**
2	44	18-36	37	21	**-0.18-0.94**
3	54	51-56	61	26	**0.71-0.86**
4	81	61-70	58	24	**1.08-1.35**
5	28	441-600	511	192	**0.78-1.28**
6	67	98-111	132	49	**0.59-0.75**
7	72	51-65	89	31	**0.34-0.57**

b. **Soils 1 and 4**: Since *LI* range is greater than 1.0, the water content is greater than the liquid limit. From Figure 4.1, the soil behaves like a viscous fluid with practically no shearing resistance.

Soil 2: At a water content of 18%, the $LI < 0$, and the soil behaves like a brittle solid with high shear resistance. At water content of 36%, the soil is in a plastic state ($0 < LI < 1$) showing moderate shearing resistance and a ductile behavior.

Soils 3, 6, and 7: Since $0 < LI < 1$, the water content is less than the liquid limit. From Figure 4.1, the soil is in the plastic state showing moderate shearing resistance and a ductile behavior.

Soil 5: At a water content of 441%, the soil is in the plastic state ($0 < LI < 1$) with moderate shear resistance. At water content of 600%, the $LI > 1$, and the soil becomes a viscous fluid with practically no shearing resistance.