Flocculation occurs when the net force between particles at the time of deposition is attraction. Net repulsion creates dispersion. The conditions of soil water greatly affects the structure. If there is a concentration of disolved minerals in the water (e.g. marine water), the tendency of flocculation is increased and the settling particles join to form aggregates or *flocs*. The structures of salt water and fresh water deposits, typically represented by Lambe* are shown in Fig. 2.5.

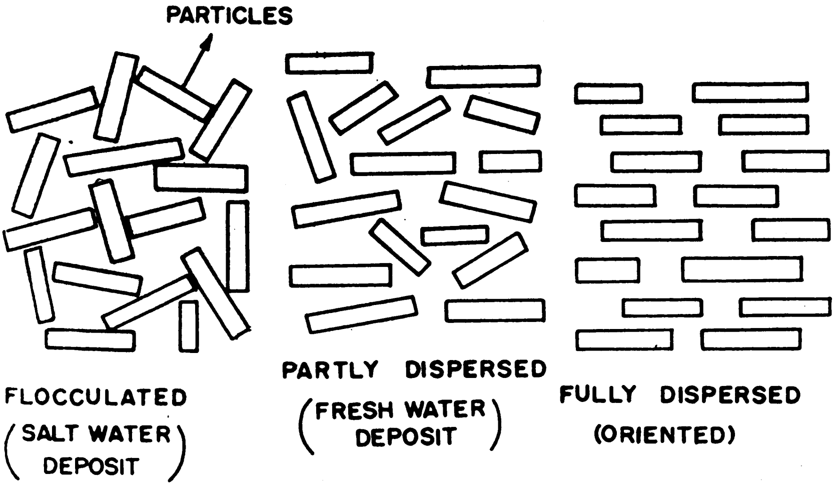

Fig. 2.5 **Basic clay structures. Structures of salt water and fresh water clay deposits**

Since some amounts of dissolved salts are normally found in all waters, majority of the sedimentary clays will initially have a flocculated structure. It is only the subsequent physical changes which result towards dispersed arrangement. Some of these changes are: consolidation, compaction, shear deformation and remoulding.

Flocculated clays are characterized by high voids ratio, high water content, greater permeability, greater compressibility and low density. Any disturbance to the original structure (or remoulding) may lead to a considerable decrease in strength.

2.6 Composite Soil Structure

The structure of composite soils depends on the relative proportions of bulky particles and clay particles. Two boundary types of structure may be termed as the *cohesive matrix* structure and the *bulky-grain skeleton* (or framed) structure. A predominance of the amount of

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*Lambe, T.W. 1953. The structure or inorganic soil. Proc ASCE, 79, Separate No. 315, Oct.

$$e = \frac{G\,\rho_w}{\rho_d} - 1 = 0.895$$

$$S_r = \frac{wG}{e} = 51.3\%$$

Prob. 3.8 Given: undisturbed soil $V = 1.96 \times 10^3$ cm^3, $M_s = 3.6$ kg, $G = 2.7$, $e_{min} = 0.36$ and $e_{max} = 0.90$. Find I_D.

$$\rho_d = \frac{3.6 \times 10^3}{1.96 \times 10^3} = 1.837 \text{ g/cm}^3$$

$$e = \frac{G\rho_w}{\rho_d} - 1 = 0.47 \text{ (insitu value)}$$

$$I_D = \frac{e_{max} - e}{e_{max} - e_{min}} = 79.6\%$$

Prob. 3.9 Given: insitu $n = 40\%$, max $\rho_d = 2.2$ g/cm^2 min. $\rho_d = 1.45$ g/cm^3, and $G = 2.65$. Find I_D.

$$e = \frac{n}{1-n} = 0.667$$

$$e_{min} = \frac{G\,\rho_w}{\max \rho_d} - 1 = 0.205$$

$$e_{max} = \frac{G\,\rho_w}{\min \rho_d} - 1 = 0.83$$

$$I_D = 0.261 = 26.1\%$$

Prob. 3.10 Given: On borrowpit site A, $\rho = 1.78$ g/cm^3 and $w = 5\%$; on borrowpit site B, $\rho = 1.6$ g/cm^3 and $w = 20\%$, G on both sites $= 2.7$.

Find insitu ρ_d on sites A and B. If the hauling charges for building an embankment from sites A and B are respectively Rs. 100-/m^3 and Rs. 80-/m^3, which site is economical.

Site A; $\rho_d = \dfrac{\rho}{(1 + w)} = 1.695$ g/cm^3

Site B; $\rho_d = 1.568$ g/cm^3

To build one unit of embankment equal volume of solids must be transported from the two sites;

$$V_s = \frac{V_a}{1 + e_a} = \frac{V_b}{1 + e_b} \quad (a \text{ and } b \text{ refer to sites})$$

Consider 1.0 m^3 of earth at site A (cost Rs 100/-)

$$e_a = \frac{G\rho_w}{\rho_d} - 1 = \frac{2.7 \times 1}{1.695} - 1 = 0.593$$

(b) *Hydrometer corrections* A few corrections are applied to the actual hydrometer reading R_h' taken at the top of the meniscus, (the suspension being opaque, only the *top* of meniscus formed along the stem can be read). The difference between the top of the meniscus and the level of liquid is called *meniscus correction* $(+ C_m)$. This can be known by floating the hydrometer in distilled water alone filled in the cylinder. The hydrometer is calibrated to read the density of distilled water as 1.000 g/cm^3 at a standard temperature (27 °C). A difference in test temperature needs correction, *temperature correction* $(\pm C_t)$, which is added (+ve) for higher test termperatures and subtracted (−ve) for lower test temperatures. (The correction is usually given by the manufacturers). Addition of dispersing agent also increases liquid density, hence an equivalent *dispersing agent* correction $(-C_d)$ is applied. This can be known by measuring the density of distilled water containing the dispersing agent at a concentration used actually in the test. The corrected hydrometer reading R can, therefore, be written as,

$$R = R_h' + C_m \pm G_t - C_d = R_h' \pm C \qquad (3.62)$$

or

$$R = R_h \pm C_t - C_d \qquad (3.63)$$

where, R_h' is the top of meniscus reading and $R_h = (R_h' + C_m)$ is the corrected liquid level reading which is used in the calibration curve. 'C' is called the *composite correction*. The composite correction can be known by taking the meniscus top and liquid-level readings of distilled water containing the dispersing agent as used in the test and keeping the temperature of distilled water as will prevail during the test.

(c) *Sedimentation test and calculations* About 30 g of sample passing the 75 micron sieve is turned into 1000 ml suspension with distilled water filled in a 1000 ml measuring cylinder to which a suitable dispersing agent is also added. The test is started with an initial uniform supension (obtained by shaking the cylinder end-over-end), the hydrometer is inserted and the top of meniscus is read at 0.5, 1, 2 and 4 minutes. The hydrometer is then taken out and allowed to float in a second cylinder containing distilled water and an equal amount of dispersing agent. This cylinder is used to read the meniscus correction $(+ C_m)$ and the composite correction $(\pm C)$. Further readings are taken at 8, 15 and 30 minutes and 1, 2, 4, 8, 16 and 24 hours, after the start of the test. The overall corrected reading R and the meniscus corrected reading R_h are obtained from Eqs. 3.62 and 3.63.

The hydrometer gives density of suspension at various time intervals. It is usual to record the hydrometer reading after substracting

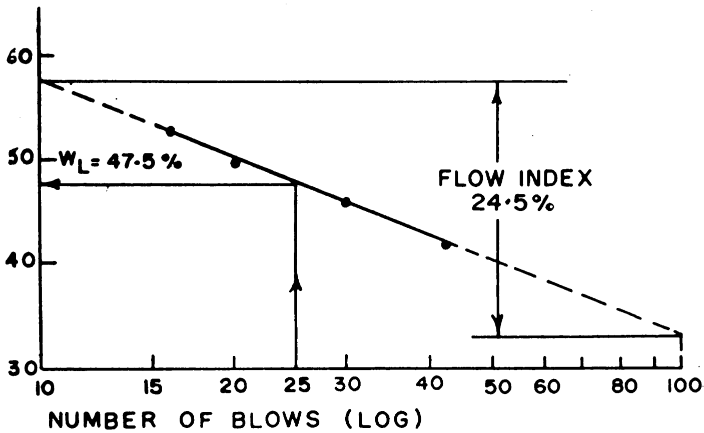

Fig. 4.3 Flow curve for liquid limit determination

index varying from 0.068 to 0.121. If e is assumed as 0.1 and the number of blows n is recorded within the range of 15 to 35 blows, Eq. 4.1 can be used to determine the liquid limit fairly accurately. This is knows as the *one point method.* An alternative expression for determining w_L by one observation only is,

$$w_L = \frac{w}{1.3215 - 0.23 \log n} \tag{4.2}$$

(2) *Cone pentreometer method for w_L* The penetrometer fitted with

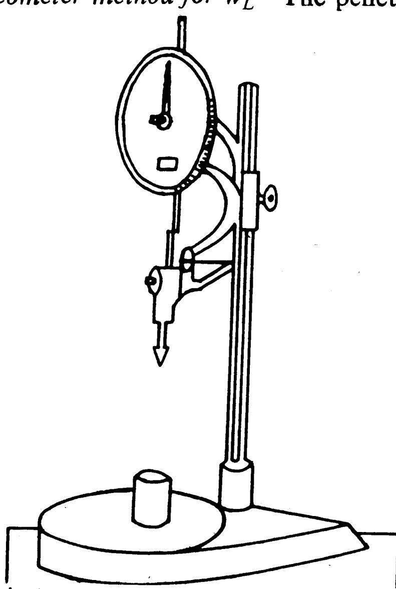

Fig. 4.4 Cone pepetrometer for limit determination