THEORETICAL QUESTIONS

(1) $\gamma' = \frac{W_{sat} - \gamma_w \cdot V}{V}$; $\gamma_d = \frac{W_s}{V}$; $\gamma_w = \frac{W_w}{V_w}$; $e = \frac{V_v}{V_s}$

$$\gamma' = \gamma_d - \gamma_w \cdot \frac{1}{1+e} = \frac{W_s}{V} - \gamma_w \cdot \frac{1}{1+\frac{V_v}{V_s}} = \frac{W_s}{V} - \gamma_w \cdot \frac{V_s}{V} = \frac{1}{V}\left[W_s - \gamma_w \cdot V_s\right] =$$

$$\frac{V_s + V_v}{V_s} = \frac{V}{V_s}$$

$$= \frac{1}{V}\left[W_s - \gamma_w (V - V_v)\right] = \frac{1}{V}\left[(W_s + \gamma_w \cdot V_v) - \gamma_w \cdot V\right] = \frac{W_{sat} - \gamma_w \cdot V}{V}$$

As soil is submerged (and saturated) $\Rightarrow V_v \equiv V_w$

$\Rightarrow W_s + \gamma_w \cdot V_w = W_{sat}$

(2) Lesson 2. Slide 14. See next page.

(3) • A soil is named GRAVEL when

% coarse particles > % fine particles

AND

% gravel particles > % sand particles

• In order to distinguish clayey soils from silty soils, the Casagrande's Plasticity chart should be used. (M) Silty soils → below "the A" ; (C) Clayey soils → above "the A"

• SP-SM → with silt / poorly-graded / Sand } ⇒ Poorly-graded sand with silt

(4) Lesson 3. Slide 13. See next page.

2. BASIC CHARACTERISTICS OF SOILS AND ROCKS.

PHYSICAL PROPERTIES OF INTACT ROCKS (II). Unit weight and porosity.

Unit weight (γ) $\gamma = \frac{W}{V}$

Porosity (n) $n = \frac{V_v}{V}$

It is a very important property, because if voids exist, there will be weakness areas.

Effective porosity (n_e)

$$n_e = \frac{(W_{sat} - W_s)}{\gamma_w \cdot V}$$

The interconnected void spaces in a rock that contribute to fluid flow.

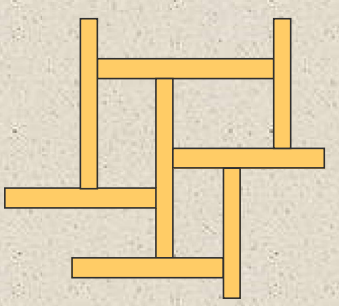
Rock	Mass density (g/cm^3)	Porosity (%)
Basalt	2.7 - 2.9	0.1 - 2
Chalk	1.7 - 2.3	30
Gneiss	2.7 - 3.0	0.5 - 1,5
Granite	2.6 - 2.7	0.5 - 1,5
Limestone	2.3 - 2.6	5 - 20
Quartzite	2.6 - 2.7	0.1 - 0.5
Schist	2.5 - 2.8	3
Sandstone	2.3 - 2.6	5 - 25
Slate	2.5 - 2.7	0.1 - 1
Tufa	1.9 - 2.3	14 - 40

These properties are determined by the test method defined in UNE-EN 1936:2007 standard.

3. SOIL AND ROCK CLASSIFICATION.

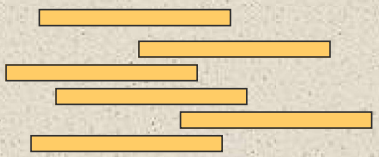
PROPERTIES OF CLAYS (III). Particle arrangements.

➔ Flocculated structure, edge-to-face arrangement. ⇒ High void ratios, low density, high water content, strong and resistant to external forces because of the attraction between particles.



COHESION

➔Dispersed structure, face-to-face arrangement. It occurs after reworking or remoulding.



NO COHESION

EXERCISE 1

$\gamma = 19\ kN/m^3 = \gamma_{sat}$

$G = 2.7 \rightarrow \gamma_s = G \cdot \gamma_w = 2.7 \cdot 9.8 = 26.46\ kN/m^3$

$S_r = 100\% = 1$

$$\gamma_{sat} = \gamma_d + n \cdot \gamma_w = \gamma_s (1-n) + n \cdot \gamma_w$$

$$19 = 26.46 (1-n) + n \cdot 9.8 = 26.46 - 26.46 \cdot n + 9.8\, n = 26.46 - 16.66 \cdot n \Rightarrow$$

$$\Rightarrow n = 0.448$$

$$e = \frac{n}{1-n} = \frac{0.448}{1-0.448} = 0.812$$

$$S_r = \frac{w}{e} \cdot \frac{\gamma_s}{\gamma_w} = \frac{w}{e} \cdot G \Rightarrow w = \frac{S_r \cdot e}{G} = \frac{100 \cdot 0.812}{2.7} = 30.1\%$$

EXERCISE 2

$M = 245.18\ g$, $M_S = 210.59\ g$

Passes #200 = 157.85 g (PAN) (≈ 0.08 mm) ⇒ Fines = $\frac{157.85}{210.59} = 0.7495 = 75\%$

Coarse particles = 100 − 75 = 25% ⇒ Equal

Passes No 4 = 210.59 g (≈ 5 mm) ⇒ Sand (%) = #4 − #200 = 100 − 75 = 25%

Gravel (%) = 0%

$w_p = \frac{6.56 - 5.34}{5.34} = 22.8\%$

(w_L^+) $w_{25} = \frac{20.66 - 15.09}{15.09} = 36.9\%$

$w_{18} = \frac{25.21 - 17.94}{17.94} = 40.5\%$

} Chart → $w_L^+ = 38\%$

(w_L^-) $w_{26} = \frac{18.03 - 11.56}{11.56} = 56.0\%$

$w_{18} = \frac{41.03 - 25.55}{25.55} = 60.6\%$

} Chart → $w_L^- = 57\%$

USCS SHEET 1 Fine-grained soil (> 50% passes #200 sieve)

$\frac{w_L^+}{w_L^-} = \frac{38}{57} = 0.6\overline{6} < 0.75$ ⇒ Organic fines (O)

$w_L = w_L^- = 57\%$ → SHEET 6

SHEET 6 $w_L > 50$ ⇒ SHEET 7

$I_p = w_L - w_p = 57 - 22.8 = 34.2$

$w_L = 57\%$

} ⇒ Above A-line and $I_p > 7$ ⇒

⇒ OH, Organic clay

SHEET 8 29% > Coarse particles > 15%

Sand (%) = 25% > Gravel (%) = 0%

} ⇒ with sand

OH, ORGANIC CLAY WITH SAND

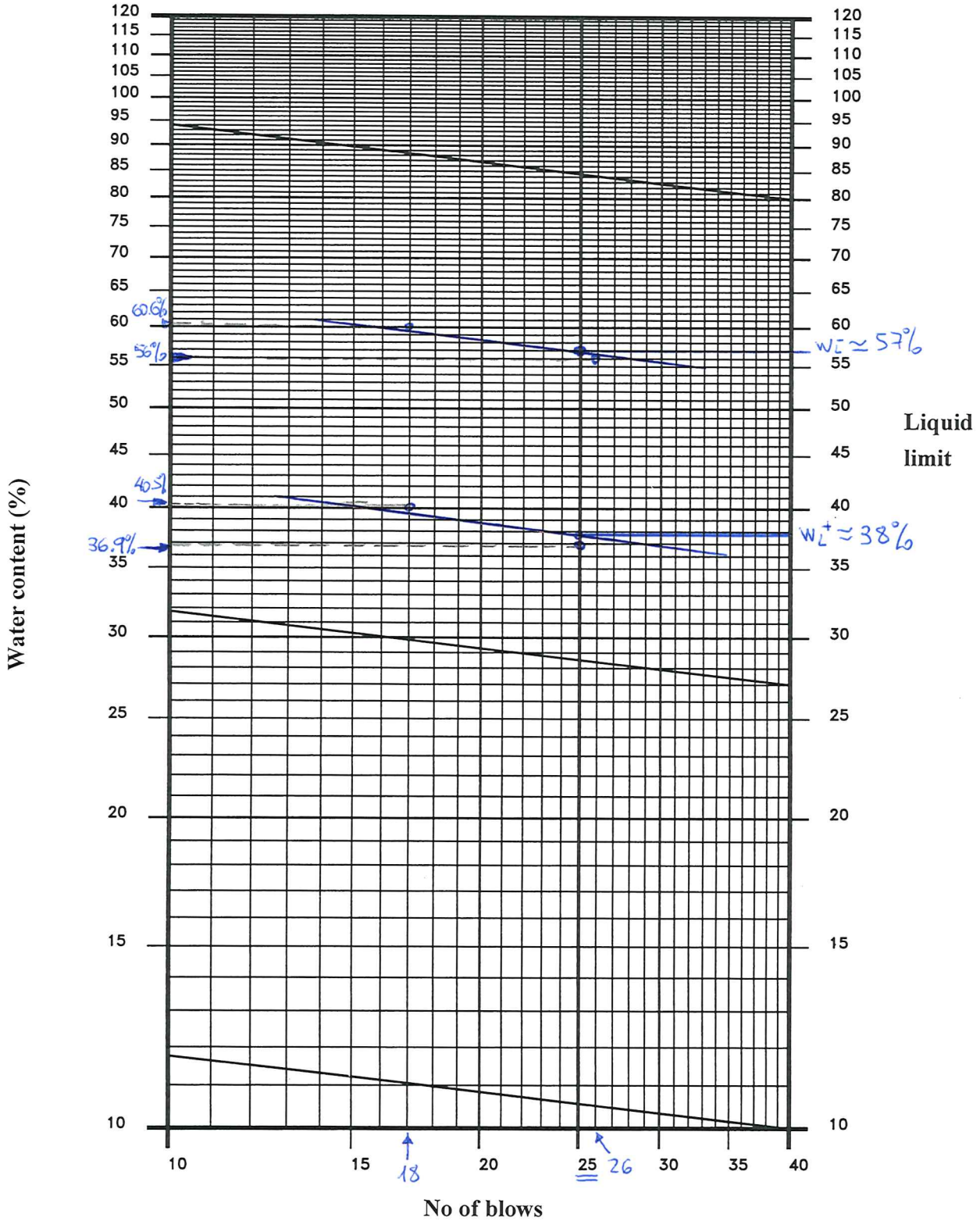


FIGURE TO DETERMINE LIQUID LIMIT