**NATIONAL EXAMINATION – DECEMBER 2012**
**04-GEOL-A6 SOIL MECHANICS**

**3 HOURS DURATION**

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NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is a CLOSED-BOOK exam. Only Casio or Sharp approved model calculators are permitted. **A formula sheet and some charts are attached to this exam.**

3. Questions have the values shown. The total value is 70.

4. In the absence of specific parameters required in the formulation and solution of problems, the candidates are expected to exercise sound engineering judgment and to clearly state their assumptions.

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1. **Soil properties**
   - **a.** A soil has a dry density of 2.065 Mg/m$^3$ and a bulk density of 2.093 Mg/m$^3$. The void ratio of the soil is 0.283. Calculate the moisture content and the Specific Gravity of the solids.

     (value 5)
   - **b.** A fully saturated clay soil has a void ratio of 2.134. Knowing that the average Specific Gravity of the clay minerals in the soil is 2.6, calculate the bulk unit weight and the dry unit weight of the clay

     (value 5)
   - **c.** How are the drained and undrained shear strength parameters of a clay soil obtained?

     (value 10)

2. **Soil Classification.**
   Classify the soils of the table below according to the USCS.

   (value 10)

| | Percent retained | |
|---|---|---|
| Sieve | Soil A | Soil B |
| No 4 | 2 | 0 |
| No 10 | 14 | 0 |
| No 20 | 50 | 0 |
| No 40 | 72 | 1 |
| No 60 | 82 | 5 |
| No 100 | 86 | 10 |
| No 200 | 90 | 14 |
| 0.01 mm | 100 | 58 |
| 0.02 mm | 100 | 68 |
| LL | -- | 55 |
| PI | Non-Plastic | 28 |

3. **In situ Stresses / Consolidation and settlement.**
   A 4m by 4m reservoir is to be placed at the surface of a sandy soil as illustrated on Figure Q3. The reservoir when filled, will weigh 1200 kN. The water table is located at a depth of 2m.

   - **a.** Calculate the maximum consolidation settlement that is expected to take place in the clay layer.

     (value 10)
   - **b.** How much settlement is expected after 3 years?

     (value 5)

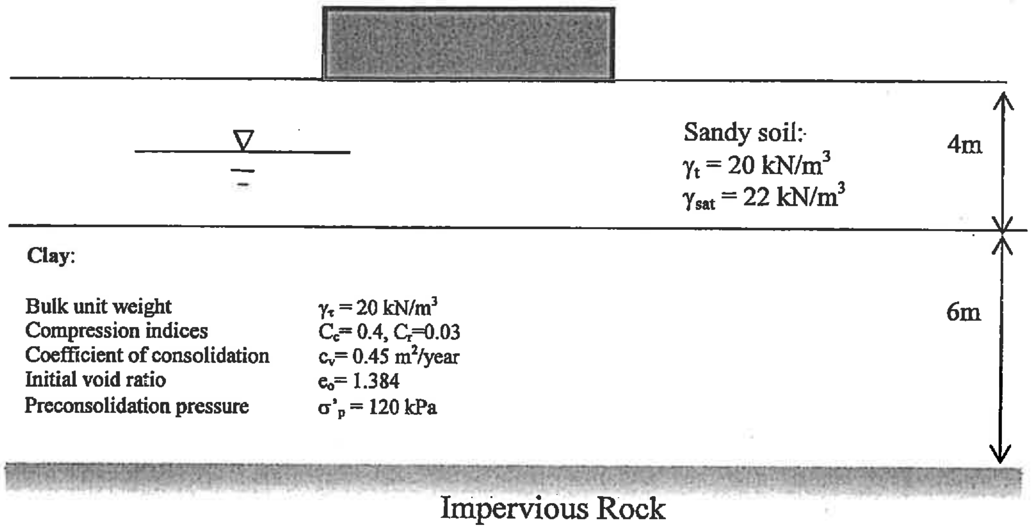



Figure Q.3

## 4. Lateral earth Pressures / Slope Stability

**a.** Explain the "at rest", "active" and "passive" earth pressure coefficients. (value 6)

**b.** Describe the general approach common to all limit equilibrium methods of slope stability analysis. (value 4)

## 5. Seepage / Groundwater

The dam shown in Figure Q6 retains 10 m of water. A sheet pile wall is placed, in the upstream section of the structure, in order to reduce the flow beneath the dam. The sheet pile wall is embedded 3 m in a 20 m thick layer of silty sand. Beneath the silt lays an impermeable clay. The average hydraulic conductivity of the silty sand is 2 x10$^{-4}$ cm/s. We assume that the silty sand is homogeneous and isotropic.

**a.** Complete the flow net in Figure Q5. (value 3)
**b.** Calculate the flow rate below the dam. (value 3)
**c.** Calculate the pore water pressure at corner A on both sides of the sheet pile wall and at corner B beneath the dam. (value 6)
**d.** Estimate the factor of safety against piping. (value 3)

Name: ____________

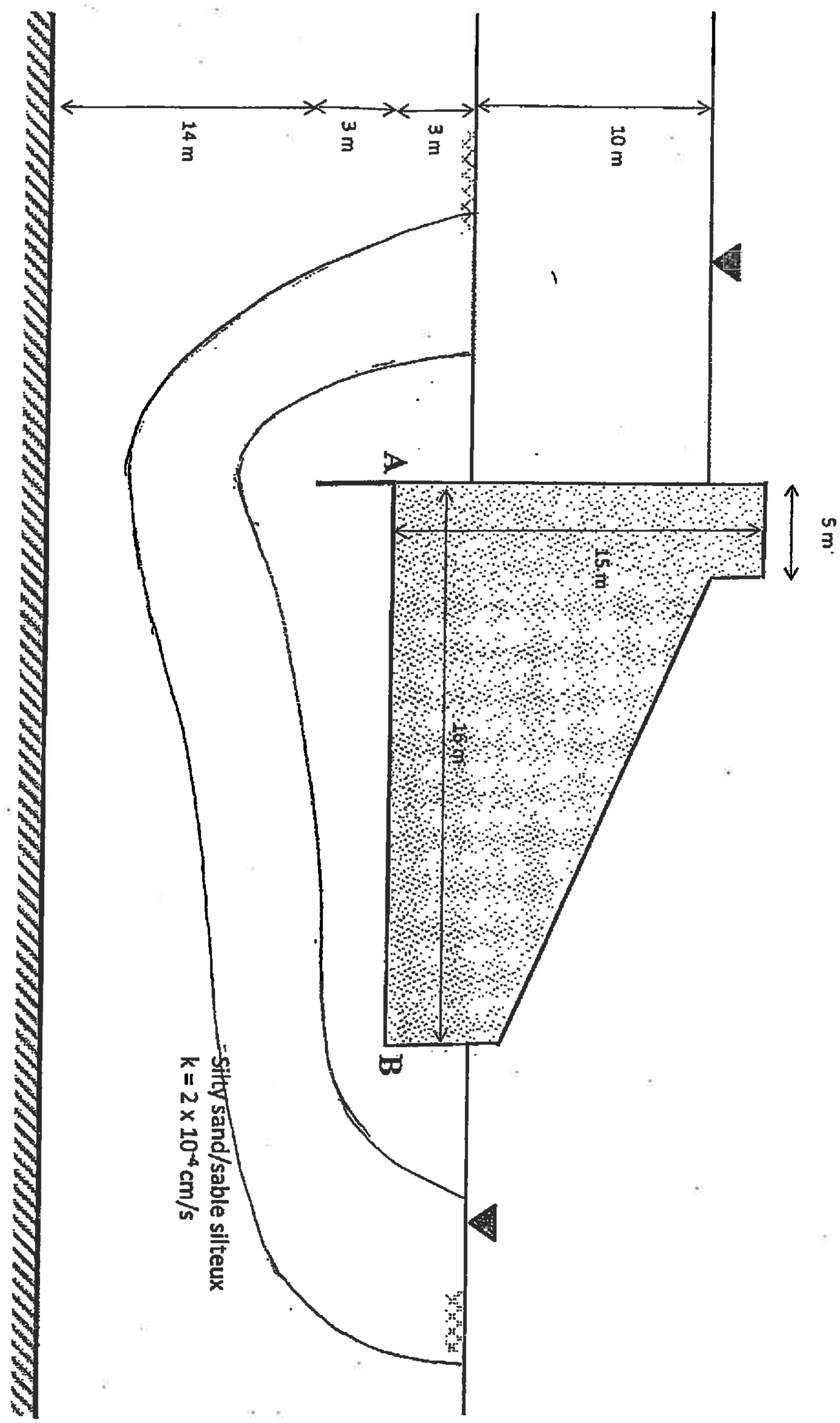
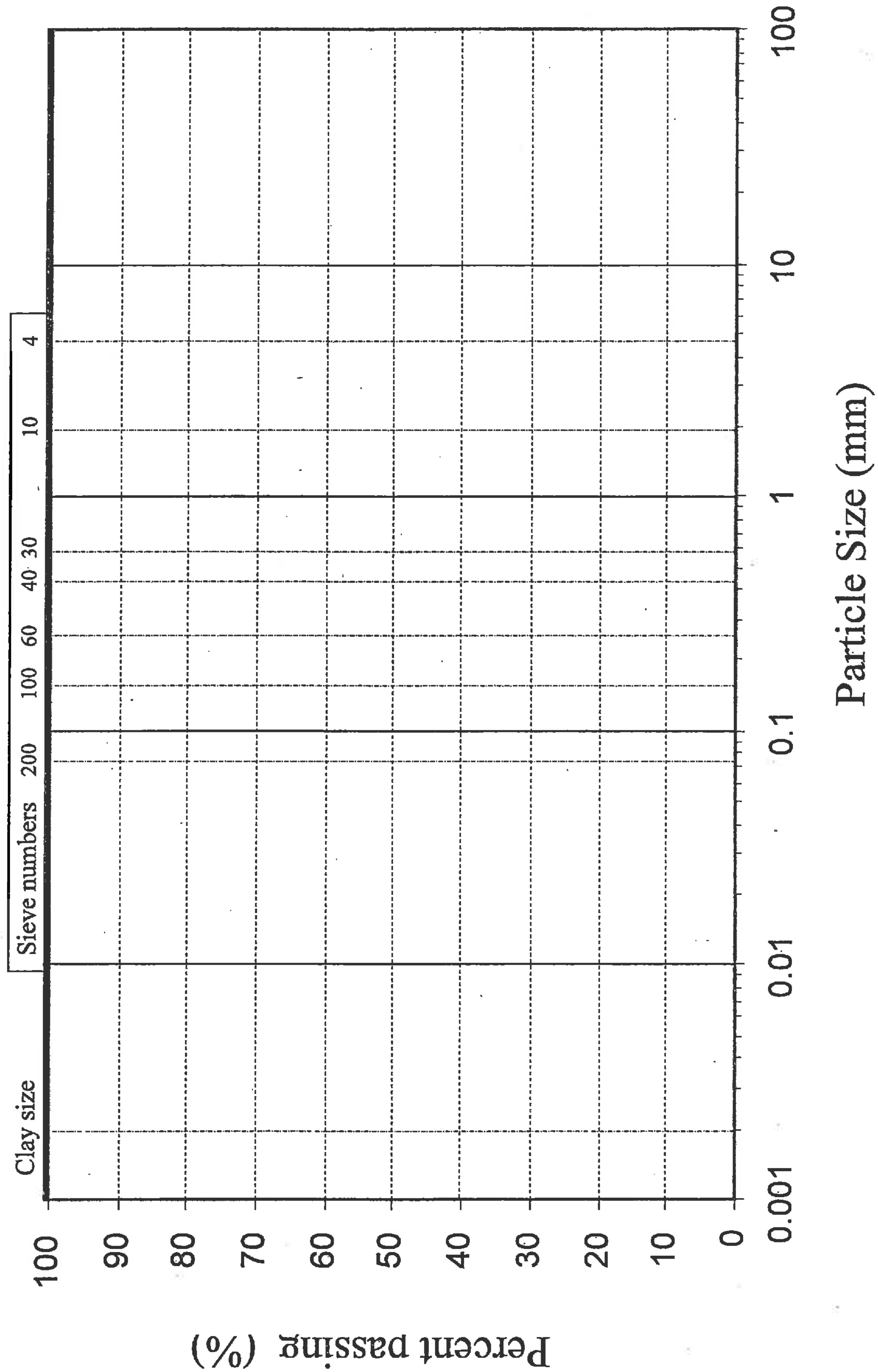
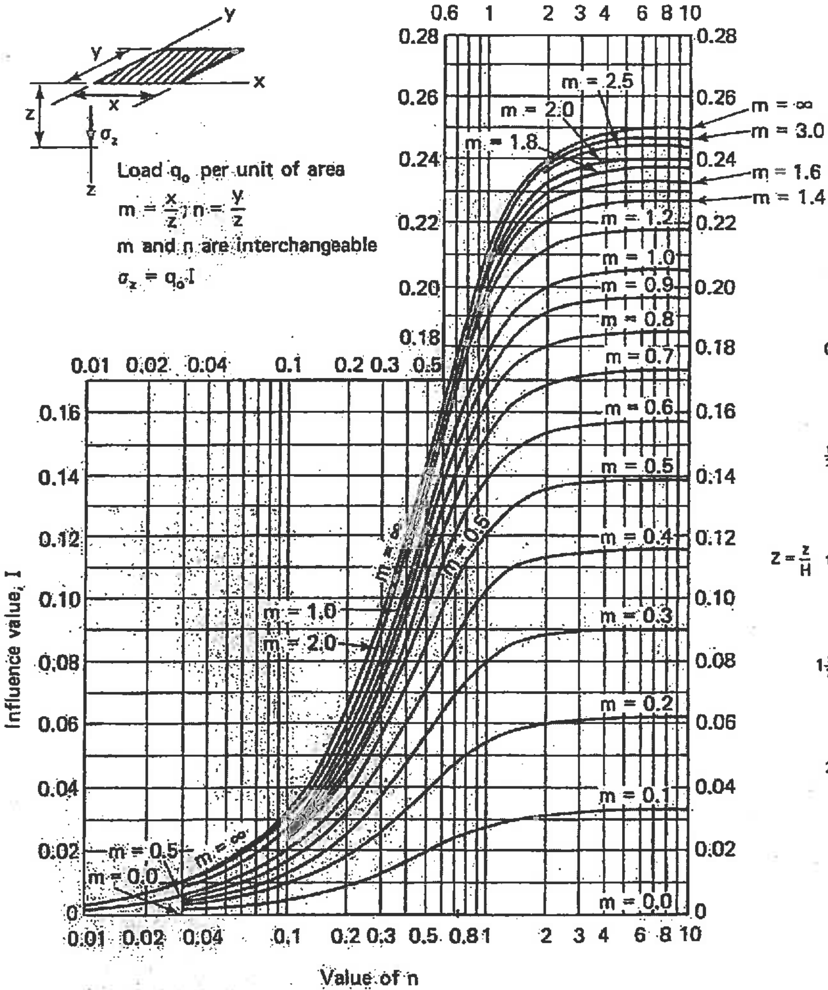


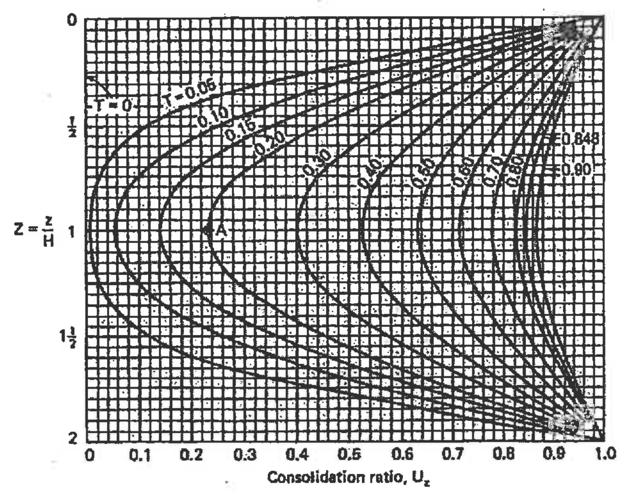

Figure Q5

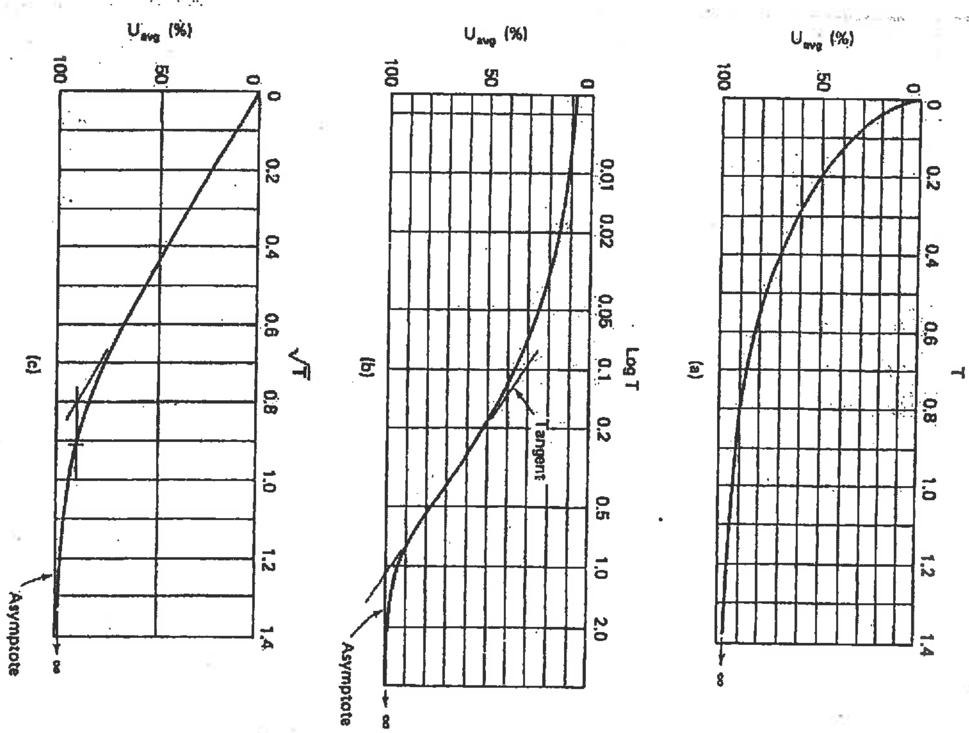

Sieve numbers
4
10
40 30
60
100
200
Clay size
100
10
1
0.1
0.01
0.001
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
Percent passing (%)

# NATIONAL EXAMS – DECEMBER 2012
## 04-GEOL-A6 SOIL MECHANICS
### Formulas and Charts





$$\Delta u = B[\Delta\sigma_3 + A(\Delta\sigma_1 - \Delta\sigma_3)]$$

$$\sigma' = \sigma - u$$

$$\tau_f = c' + \sigma' \tan\phi'$$

$$S_c = C_r\left(\frac{H_o}{1+e_o}\right)\log\frac{\sigma'_p}{\sigma'_{vo}} + C_c\left(\frac{H_o}{1+e_o}\right)\log\frac{\sigma'_{vf}}{\sigma'_p}$$

$$T = \frac{c_v t}{H_{dr}^{\ 2}}$$

$$q = k\Delta h\frac{N_f}{N_d}$$

$$h_t = h_p + z = \frac{u}{\gamma_w} + z$$

$$C_u = \frac{D_{60}}{D_{10}}$$

$$C_c = \frac{(D_{30})^2}{D_{10}D_{60}}$$

$$i = \frac{\Delta h}{l}$$

$$\rho_d = \frac{\rho_t}{(1+w)}$$

$\psi' = \arctan(\sin\phi')$ $\quad a = c'\cos\phi'$

$e = V_v / V_s$ (void ratio)
$n = V_v / V_t$ (porosity)
$w = M_w / M_s$ (moisture content)
$S = V_w / V_v$ (saturation)

$p = \dfrac{\sigma_1 + \sigma_3}{2}$ $\quad q = \dfrac{\sigma_1 - \sigma_3}{2}$

$$k_N = \frac{H}{\left(\frac{H_1}{k_1} + \frac{H_2}{k_2} + \frac{H_3}{k_3}\right)}$$

$$k_p = \frac{k_1H_1 + k_2H_2 + k_3H_3}{H}$$

$k = CD_{10}^2$ (C=100, k = cm/s & $D_{10}$ = cm)

$\rho' = \rho_{sat} - \rho_w$ $\quad \rho_w = 1000\ kg/m^3$
$\gamma_w = 9.81\ kN/m^3$

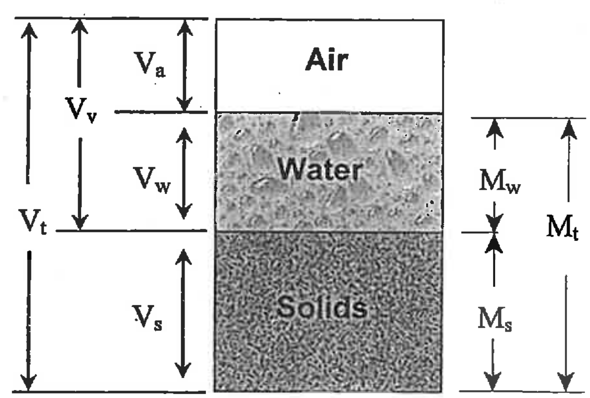
**Force** → Newton (N) → 1 N = 1 kg m/s$^2$
**Pressure** → Pascal (Pa) → 1 Pa = 1N/m$^2$
→ 1 kPa = 1 kN/m$^2$

$N_{corr} = 100 \times (N - N_{fines}) / (100 - N_{fines})$

$$\Delta\sigma_{v(avg)} = \frac{(\Delta\sigma_{v(top)} + 4\Delta\sigma_{v(mid)} + \Delta\sigma_{v(bot)})}{6}$$

$K_a = \dfrac{1 - \sin\phi'}{1 + \sin\phi'}$ $\quad K_p = 1/K_a$ $\quad K_o \approx 1 - \sin\phi'$

$\sigma'_h = \sigma'_v K_a - 2C'\sqrt{K_a}$ $\quad \sigma'_h = \sigma'_v K_p + 2C'\sqrt{K_p}$



| Major Divisions (1) | Major Divisions (2) | | Group Symbols (†) (3) | Typical Names (4) | Laboratory Classification Criteria (6) |
|---|---|---|---|---|---|
| Coarse-grained Soils<br>More than half of material is larger than No. 200 (‡) (75 μm) sieve size. | Gravels<br>More than half of coarse fraction is larger than No. 4 sieve size. (4.75 mm) | Clean Gravels (little or no fines) | GW | Well-graded gravels, gravel-sand mixtures, little or no fines. | $C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 (See Sec. 2-5) |
| | | | GP | Poorly graded gravels, gravel-sand mixtures, little or no fines. | Not meeting all gradation requirements for GW |
| | | Gravels with Fines (appreciable amount of fines) | GM | Silty gravels, gravel-sand-silt mixtures. | Atterberg limits below A-line, or PI less than 4 — Above A-line with PI between 4 and 7 are borderline cases requiring use of dual symbols. |
| | | | GC | Clayey gravels, gravel-sand-clay mixtures. | Atterberg limits above A-line with PI greater than 7 |
| | Sands<br>More than half of coarse fraction is smaller than No. 4 sieve size. (4.75 mm) | Clean Sands (little or no fines) | SW | Well-graded sands, gravelly sands, little or no fines. | $C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3 (See Sec. 2-5) |
| | | | SP | Poorly graded sands, gravelly sands, little or no fines. | Not meeting all gradation requirements for SW |
| | | Sands with Fines (appreciable amount of fines) | SM | Silty sands, sand-silt mixtures. | Atterberg limits below A-line, or PI less than 4 — Limits plotting in hatched zone with PI between 4 and 7 are borderline cases requiring use of dual symbols. |
| | | | SC | Clayey sands, sand-clay mixtures. | Atterberg limits above A-line with PI greater than 7 |
| Fine-grained Soils<br>More than half of material is smaller than No. 200 (75 μm) sieve size. | Silts and Clays | Liquid limit less than 50 | ML | Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity. | Plasticity Chart — For laboratory classification of fine-grained soils |
| | | | CL | Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. | |
| | | | OL | Organic silts and organic silty clays of low plasticity. | |
| | Silts and Clays | Liquid limit greater than 50 | MH | Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts. | |
| | | | CH | Inorganic clays of high plasticity, fat clays. | |
| | | | OH | Organic clays of medium to high plasticity, organic silts. | |
| Highly Organic Soils | | | Pt | Peat and other highly organic soils. | |

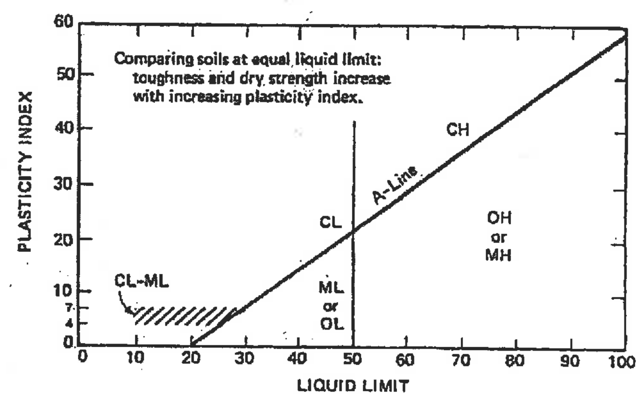
The No. 200 sieve size is about the smallest particle visible to the naked eye.

(For visual classification, 5 mm may be used as equivalent to the No. 4 sieve size)

Use grain size curve in identifying the fractions as given under field identification.

Determine percentages of gravel and sand from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:
Less than 5%: GW, GP, SW, SP
More than 12%: GM, GC, SM, SC
5% to 12%: Borderline cases requiring use of dual symbols.

Plasticity Chart
For laboratory classification of fine-grained soils




† Boundary classifications: soils possessing characteristics of two groups are designated by combinations of group symbols. For example: GW-GC, well-graded gravel sand mixture with clay binder.

‡ All sieve sizes on this chart are U.S. Standard.