NATIONAL EXAMINATION – MAY 2012
04-GEOL-A6 SOIL MECHANICS

3 HOURS DURATION

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 100.

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 compacted soil sample fills a 944 cm^3 mould. The dry density of the sample is 2065 kg/m^3, the moisture content is 5% and the Specific Gravity of the solids is 2.6. Calculate the total mass of the sample in the mould, the void ratio, and the saturation.

   (Value 10)

   b. The hydraulic conductivity of a soil depends on what?

   (value 5)

2. **Soil Classification.**

   Classify the soils of figure Q.2 (Page 4) according to the Unified Soil Classification System. The fines of soil A have a liquid limit of 60% and a plastic limit of 20%, while those of soil B have a liquid limit of 30% and a plastic limit of 20%.

   (value 10)

3. **In situ Stresses / Consolidation and settlement.**
   A 4m thick sand fill is placed on a layer of Normally-Consolidated clay to pre-consolidate it, as shown on figure Q.3. The free surface (water table) is located at the top of the clay layer and is expected to stay there.

   a. Calculate the time it will take for the 4m fill to settle as much as the full consolidation settlement of a 1m fill. Or in other words, when can we remove 3m of the fill and be left with 1m of fill that will not settle anymore?

   (value 15)

   b. Clays are very frequently observed to be over-consolidated in the field. What causes the over-consolidation of clays?

   (value 10)

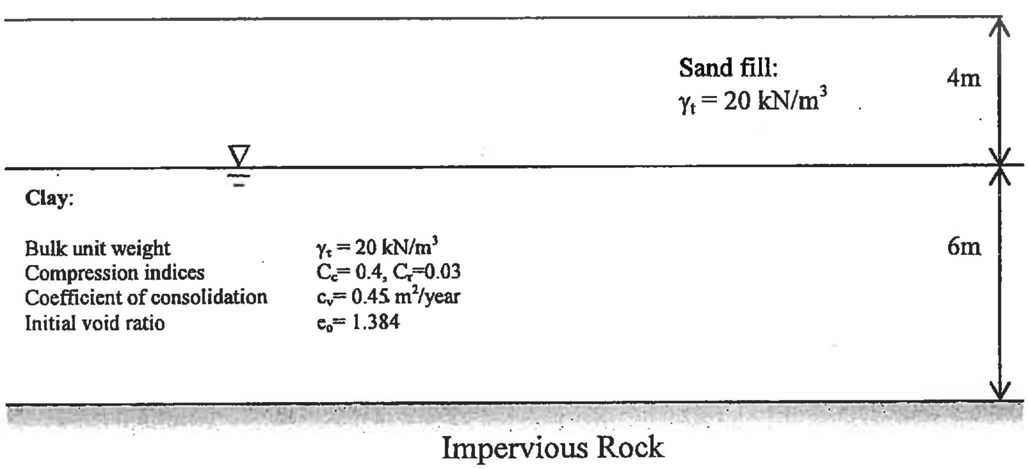


Figure Q.3

4. **Lateral earth Pressures / Slope Stability**
Figure Q.4. shows a Segmental Retaining Wall with geosynthetic reinforcement, installed to stabilize a slope.

a. Sketch and explain conceptual diagrams of the distribution of forces (no numerical values required) acting on the back of the wall facing and the distribution of forces on the reinforced soil mass. What two theories are most commonly used to calculate the forces on retaining walls?

(value 20)

b. Sketch and explain two unlikely slope failure surfaces and two more likely ones.

(value 10)

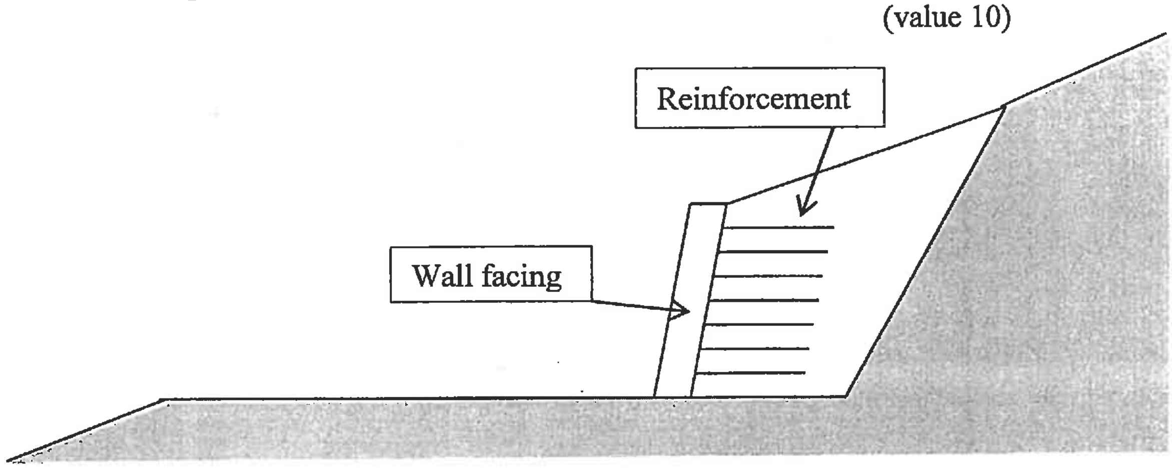


Figure Q.4.

5. **Seepage / Groundwater**

a. Describe and explain any one potential benefit and any one potential detriment of lowering the water table.

(Value 10)

b. At the foot of an earth dam, two piezometers were installed one above the other, to record the pore pressure to monitor for potential instabilities. The lower piezometer has an intake at an elevation of 200m above sea level and the upper piezometer has an intake at 205m. The pore water pressure measured at the lower piezometer is 350kPa and the pressure at the upper one is 280kPa. With supporting calculations and assumptions, evaluate the risk of boiling at that location.

(Value 10)

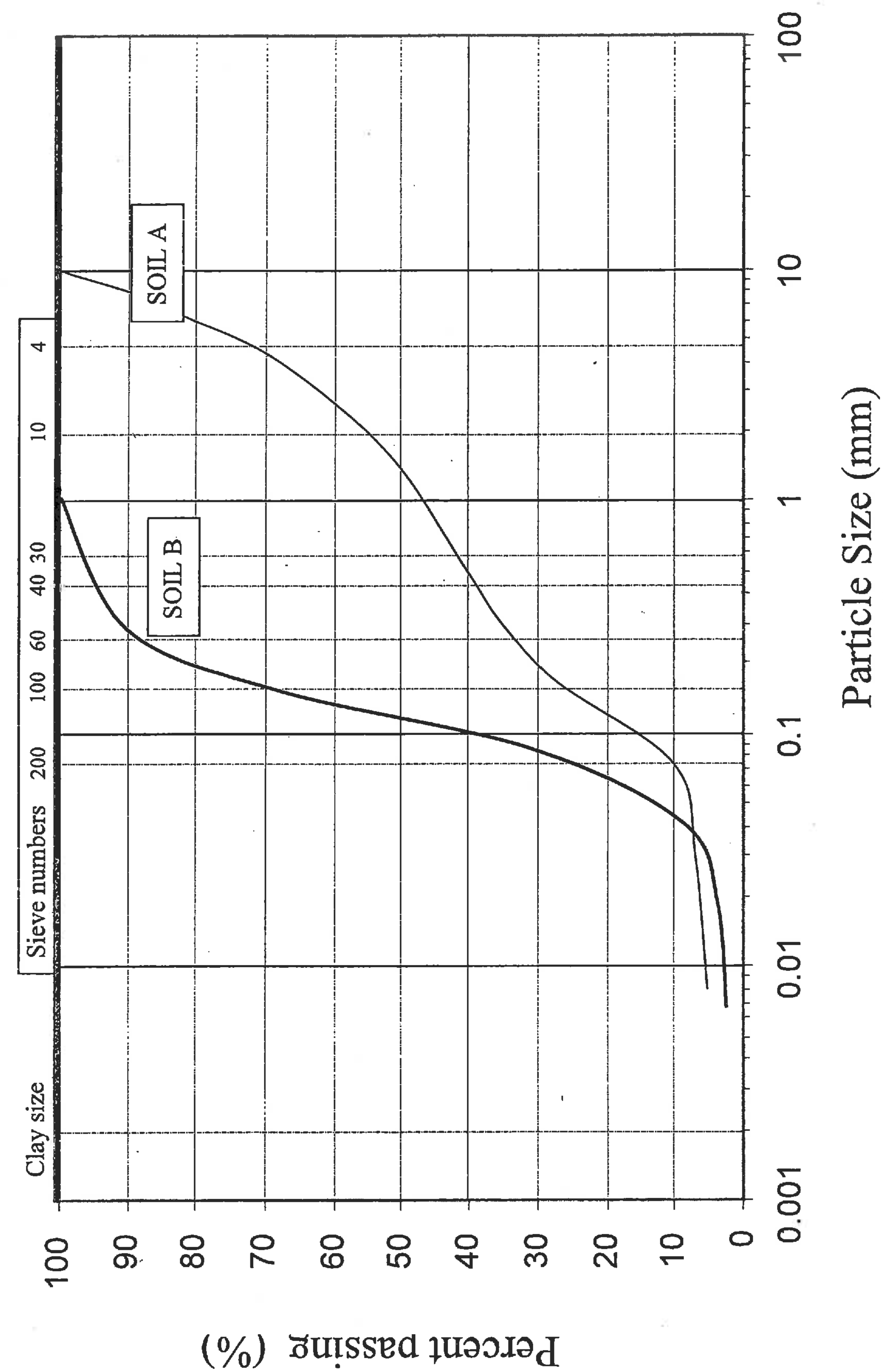
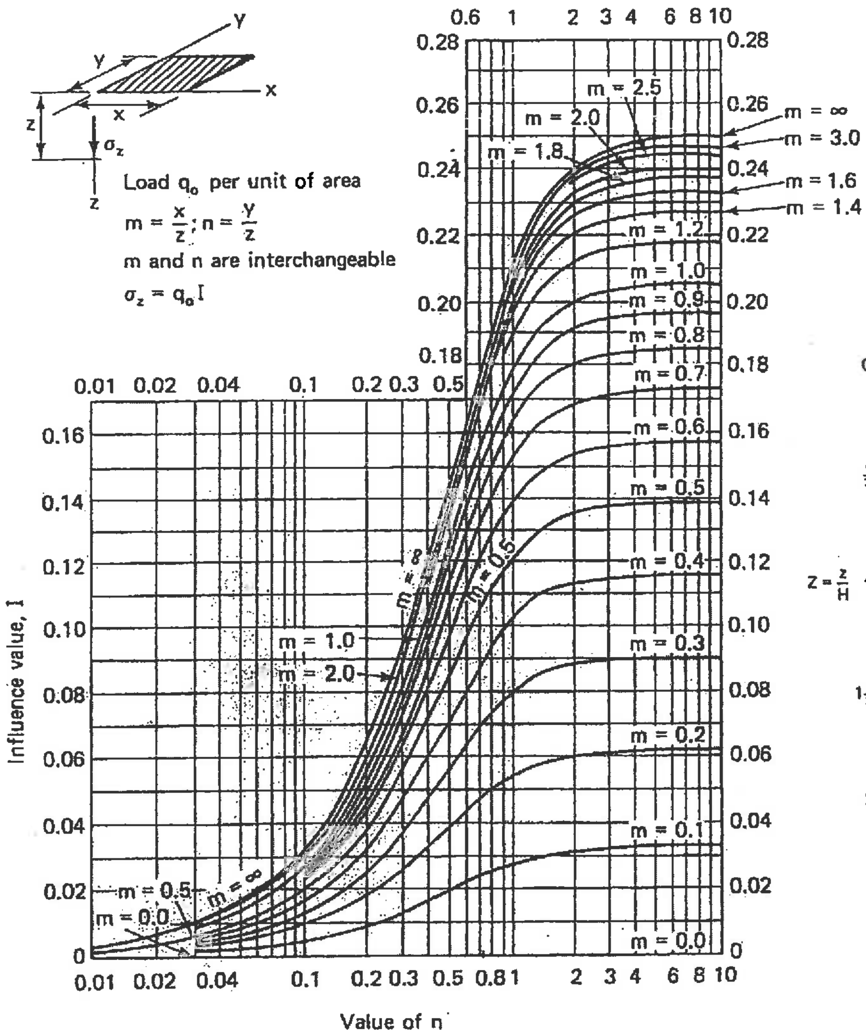
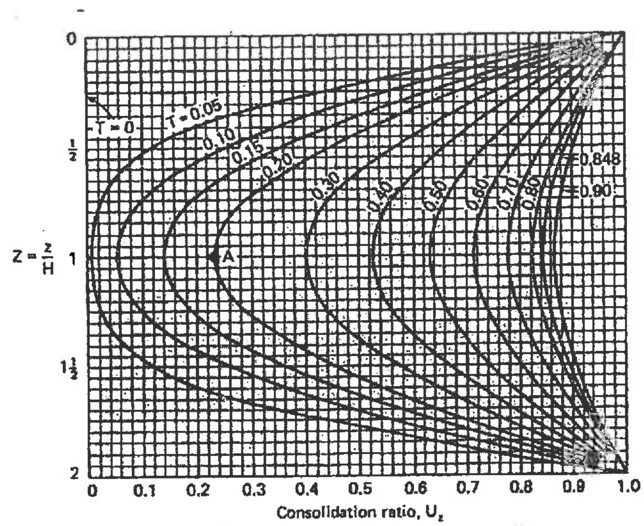

SOIL A
SOIL B
Sieve numbers
4
10
40 30
60
100
200
Clay size
100
10
1
0.1
0.01
0.001
100
90
80
70
60
50
40
30
20
10
0
Particle Size (mm)
Percent passing (%)

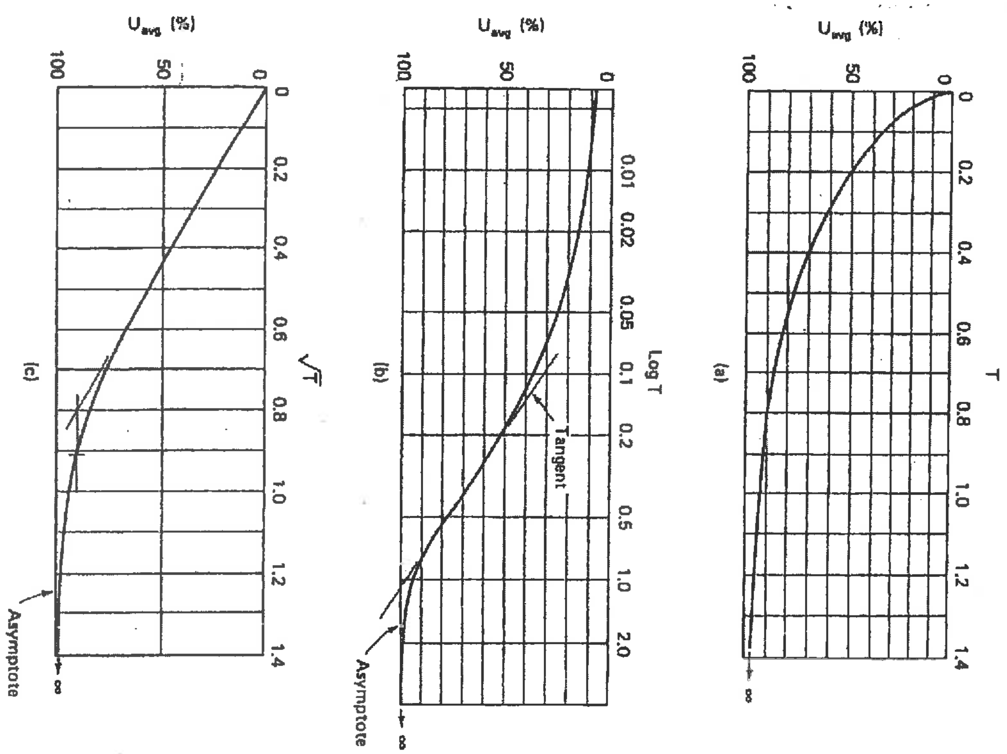
Figure Q.2



Load q_o per unit of area
$m = \frac{x}{z}$; $n = \frac{y}{z}$
m and n are interchangeable
$\sigma_z = q_o I$
Influence value, I
Value of n
m = ∞
m = 3.0
m = 2.5
m = 2.0
m = 1.8
m = 1.6
m = 1.4
m = 1.2
m = 1.0
m = 0.9
m = 0.8
m = 0.7
m = 0.6
m = 0.5
m = 0.4
m = 0.3
m = 0.2
m = 0.1
m = 0.0



$Z = \frac{z}{H}$
Consolidation ratio, U_z
T = 0
T = 0.05
0.10
0.15
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.848
0.90
A



U_{avg} (%)
(c)
$\sqrt{T}$
Asymptote
(b)
Log T
Tangent
Asymptote
(a)
T

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

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

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

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

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

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

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

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

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

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

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

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

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

$$p = \frac{\sigma_1 + \sigma_3}{2} \qquad q = \frac{\sigma_1 - \sigma_3}{2}$$

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

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

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

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

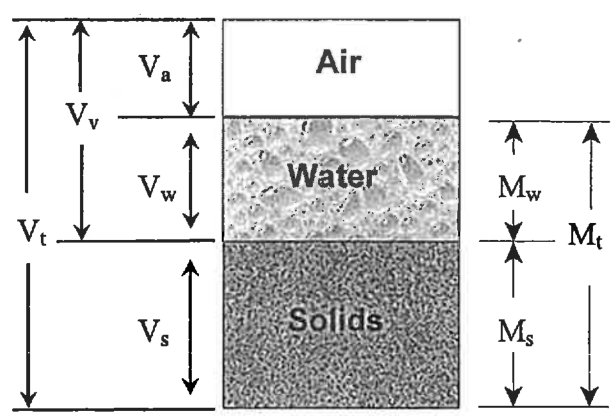
Force → Newton (N) → 1 N = 1 kg m/s^2
Pressure → Pascal (Pa) → 1 Pa = 1N/m^2
→ 1 kPa = 1 kN/m^2

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

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

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

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

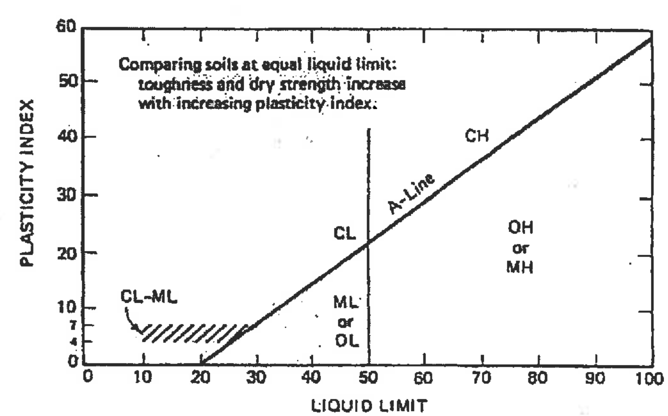


Major Divisions (1)	Major Divisions (2)		Group Symbols (†) (3)	Typical Names (4)	Laboratory Classification Criteria (6)
Coarse-grained Soils: More than half of material is larger than No. 200 (‡) (75 μm) sieve size. The No. 200 sieve size is about the smallest particle visible to the naked eye.	Gravels: More than half of coarse fraction is larger than No. 4 sieve size. (4.75 mm) (For visual classification, 5 mm may be used as equivalent to the No. 4 sieve size)	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: 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: 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.	

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.