NATIONAL EXAMS – DECEMBER 2008
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. **ANSWER ANY 5 OUT OF THE 6 QUESTIONS. Only the first 5 answers presented in the booklet will be marked.**

4. Questions have the values shown. The total value is 75.

5. 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. a) Classify the following soil according to the Unified Soil Classification System. The soil has a liquid limit of 20% and a plastic limit of 7%.

(value 7)

Metric Sieve Size	US Sieve Size	Percent finer
25 mm	1 in	100
19 mm	0.75 in	95
9.5 mm	0.375 in	80
4.76 mm	No. 4	50
2.38 mm	No. 8	43
0.84 mm	No. 20	38
420 μm	No. 40	30
250 μm	No. 60	21
150 μm	No. 100	16
75 μm	No. 200	10

b) A sample of fully saturated clay has a moisture content of 30% and the average Specific Gravity of the solids in the sample is 2.5. Calculate the void ratio of the clay.

(Value 8)

2. Fig. Q.2 below illustrates a weir under which seepage flow occurs. A flownet is drawn on the figure.

a) Identify one equipotential line and one flow line.

(Value 5)

b) Calculate the water pressure at point A along the base of the weir.

(Value 10)

3. A 4m high rigid retaining wall illustrated on figure Q.3 supports a silty sand backfill. There is no water table.

a) Using Rankine's earth pressure theory, calculate the force exerted on the wall by the soil assuming that outward rotation of the wall is allowed.

(Value 10)

b) If wall rotation was to be completely prevented, what would be the force on the wall?

(Value 5)

4. Identify and discuss any 3 factors other than geometry, which can affect the stability of a slope.

(Value 15)

5. A 5 m thick clay layer rests on impervious bedrock and is overlain by 5m of sandy soil. The water table is at a depth of 2m below the surface of the sand. A 3m thick layer of fill ($\gamma = 20$ kN/m^3) will be placed on the surface of the sand. The soils properties are:

Sandy soil: $\gamma_t = 21$ kN/m^3, $\gamma_{sat} = 23$ kN/m^3,
Friction angle, $\phi' = 33°$

Clay: $\gamma_{sat} = 19$ kN/m^3, $\phi' = 28°$, $c' = 5$ kPa,
Undrained shear strength, $C_u = 100$ kPa
Initial void ratio, $e_o = 2.055$
Compression Index, $C_c = 0.8$
Recompression or Swelling Index $C_{(r\ or\ s)} = 0.03$
Preconsolidation pressure, $\sigma'_p = 110$ kPa
Coefficient of Consolidation, $c_v = 7.5\text{x}10^{-8}$ m^2/sec

Calculate the consolidation settlement that will occur 3 years after the placement of the fill.

(Value 15)

6. Answer any three of the following questions. Only the first three answers presented in the booklet will be marked.

a) How are clay minerals created?

(Value 5)

b) Explain how particle size contributes to the plasticity of clays.

(Value 5)

c) Explain how isomorphic substitutions (one cation is replaced by another of the same size within a mineral structure) contribute to the plasticity of clays.

(Value 5)

d) What happens to the void ratio of a sand subjected to shear strain?

(Value 5)

e) Define the "at-rest earth pressure coefficient".

(Value 5)

f) Describe with the help of a sketch, the distribution and evolution of pore water pressure throughout the thickness of a layer of Normally Consolidated clay undergoing one-dimensional consolidation.

(Value 5)

g) Is the effective stress a true intergranular stress? Explain your answer.

(Value 5)

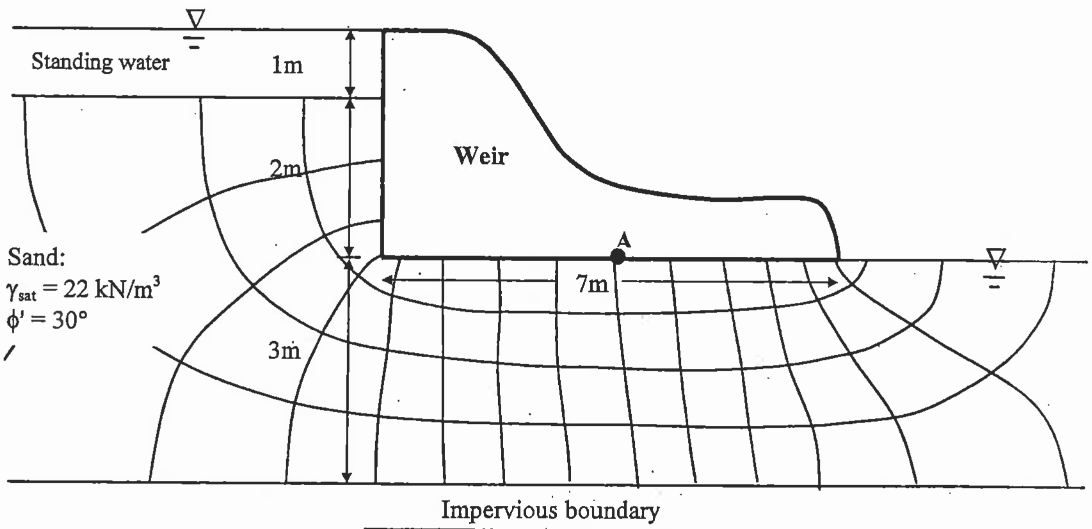


Figure Q.2

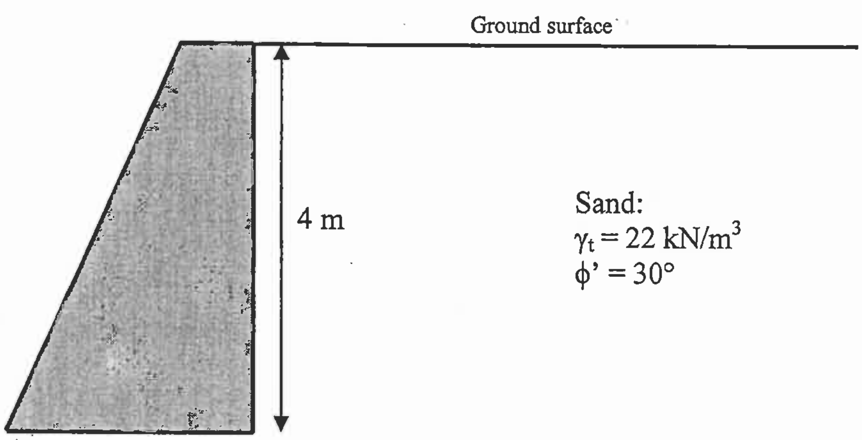
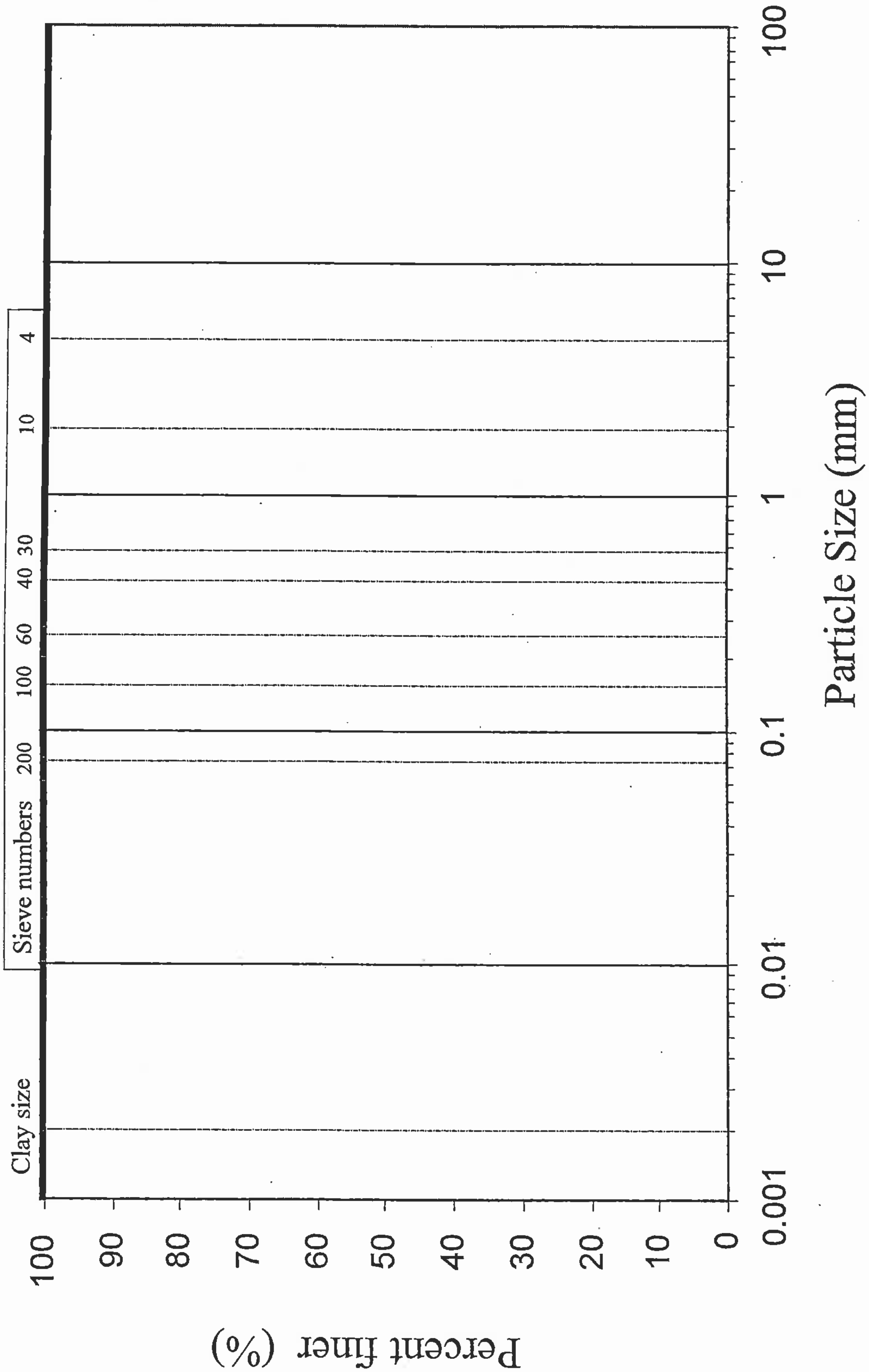
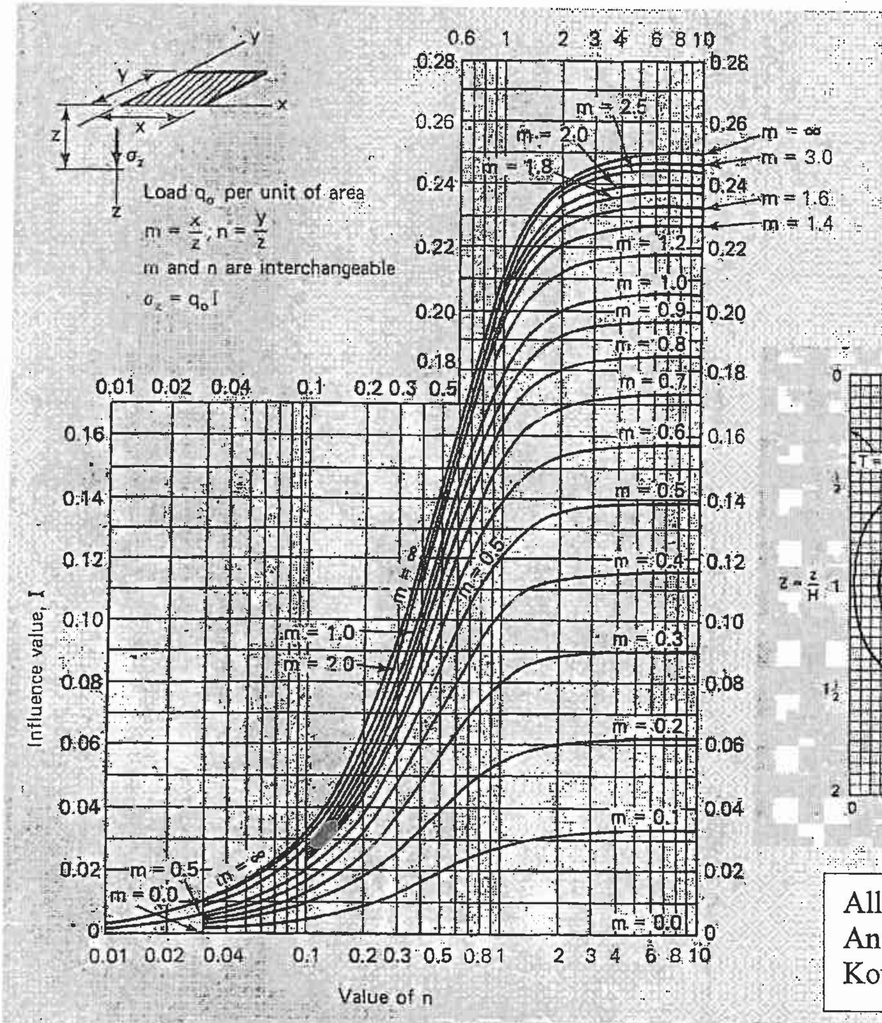
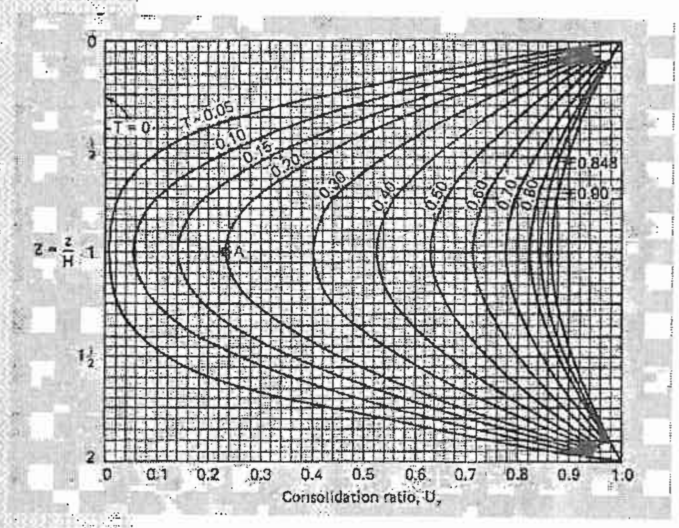


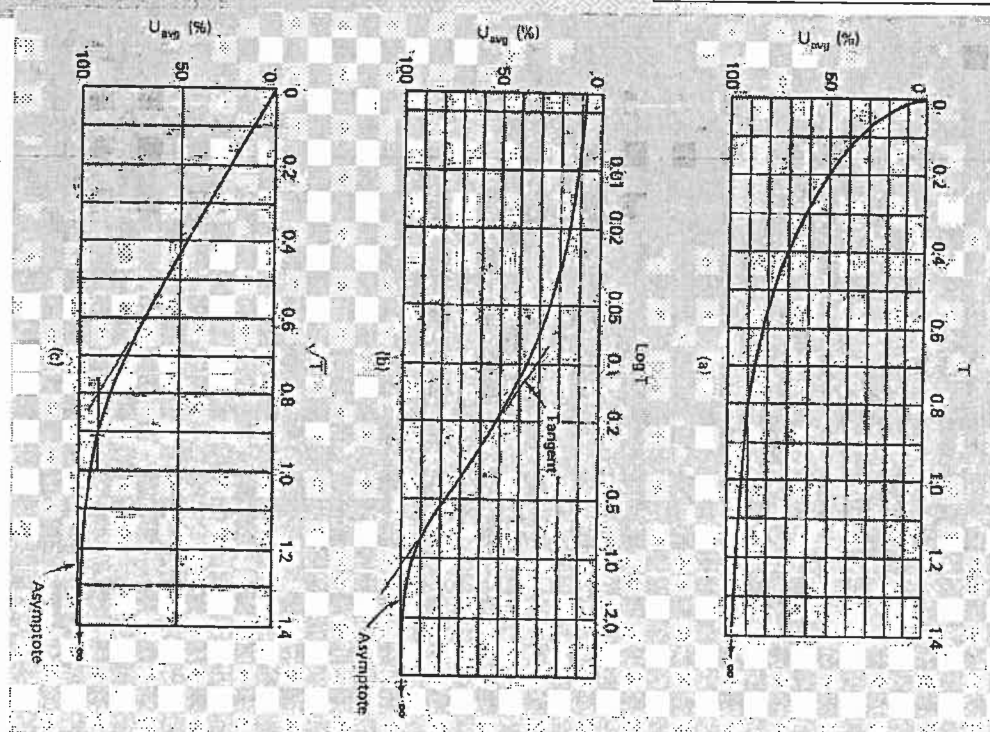
Figure Q.3


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 finer (%)





All charts presented here were extracted form: An Introduction to Soil Mechanics, Holtz and Kovacs



NATIONAL EXAMS – DEC 2008
04-GEOL-A6 SOIL MECHANICS
Formulas and Charts

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

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

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

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

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

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

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

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

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

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

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

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

$e = V_v / V_s$ (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)

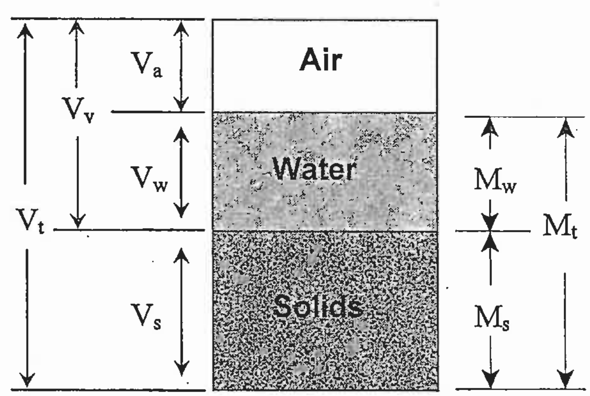
$\rho' = \rho_{sat} - \rho_w$ $\qquad \rho_w = 1000\ kg/m^3$
$\gamma_w = 9.81\ kN/m^3$

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

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

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

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



Major Divisions			Group Symbols (†)	Typical Names	Laboratory Classification Criteria
1	2		3	4	6
Coarse-grained Soils. More than half of material is larger than No. 200 (‡) (75 μm) sieve size.	Gravels. 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. 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	

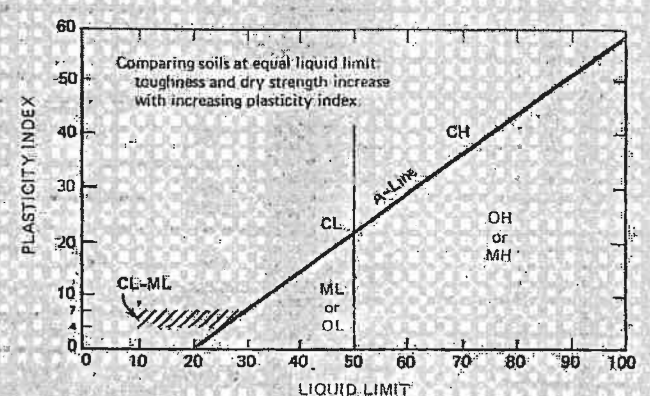
(For visual classification, 5 mm may be used as equivalent to the No. 4 sieve size)

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

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.