ATT-29/22, SOILS IDENTIFICATION, Hand Method

1.0 SCOPE

This method describes the procedures for determining the classification and properties of fine-grained soils using ten simple hand tests and the bottle test.

2.0 EQUIPMENT

Medicine Bottle

wash bottle – a squeeze bottle with a nozzle

0.5 litre Medicine Bottle (with smooth straight sides)

Representative soil sample (0.5 kg)
- Field sample condition for Hand Tests
- Dried and crushed for bottle test

Data Sheet: Field Identification of Soils, such as MAT 6-20

3.0 PROCEDURE

This procedure is used on grading and subgrade preparation projects. The hand method of soils identification (Section 4.0) and the bottle test (Section 5.0) are used to determine to which standard moisture-density relation curve, the in-place density test should be compared to, to calculate the percent compaction.

The hand tests are also used on preliminary soil surveys to identify similar soils and similar moisture conditions. If similar soils are identified, the number of samples tested for soil classifications can be reduced.

4.0 HAND TESTS

1. Obtain approximately 0.5 kg of representative fine grained soil.

2. Enter the project identification on the heading portion of the data sheet, as shown in Figure 1.

3. Record the sample identification data on the column corresponding to the sample being tested.

4.1 Dry Strength

1. Crumble the dry soil with your fingers.

2. Distinguish between:

   a) **slight** dry strength - friable, sample crumbles into powder with some finger pressure.

   b) **medium** dry strength - considerable pressure required to powder the sample; and

   c) **high** dry strength - the dried sample cannot be powdered with finger pressure.

3. Record the estimated dry strength in Line No. 1 of the data sheet, as shown in Figure 1.

   Usually the soil is tested in the field sample condition. If the sample is wet, "dry strength" cannot be performed. The results of the "toughness at the plastic limit" can be used as an indication of the "dry strength". The "dry strength" of a soil may be obtained if a sample is air or oven dried.

4.2 Amount of Water to Wet

1. Use the wash bottle to add water, a few drops at a time, to a small amount of the soil held in the palm of your hand.

2. With each application of water, work the soil so that the moisture will be distributed uniformly throughout the sample.

3. Continue to add water to the sample until it has a thick soupy consistency.

4. Enter on Line No. 2 of the data sheet, an estimation of the amount of water used to wet the sample, e.g. **low**, **medium**, or **high**.

4.3 Percentage of Sand

1. Rub your thumb repeatedly through the soupy soil. If no sand can be felt, there is probably less than 20% sand in the sample. If it feels gritty, estimate the percentage of sand, and record the value in Line No. 3.

   NOTE: Coarse-grained sand leads to over estimation, while fine-grained sand leads to under estimation.

MAT 6 - 20/13

FIELD IDENTIFICATION OF SOILS

PROJECT:	**HWY X:XX**	CONTACT NO.:	**12345**	CONTRACTOR:	**R. Roads**
DATE:	**1-Jan-2013**	TECHNOLOGIST:	**LL**	FROM:	
LOT NO.	**1**	PROJECT MANAGER:	**LL**	TO:	

STATION	*10+241*					
LOCATION	*18 m Rt*					
DEPTH	*2.5 m*					
BORROW PIT NO.	*3*					
CONTAINER NO.	*AD*					

HAND TEST

1.	DRY STRENGTH	*HIGH*					
2.	AMOUNT OF WATER TO WET SOIL	*HIGH*					
3.	PERCENTAGE OF SAND	*-20%*					
4.	DRYING TIME OF FILM ON HAND	*LONG*					
5.	EASE OF REMOVING FILM	*HARD*					
6.	WORK AND TIME TO DRY FROM LL TO PL	*HIGH*					
7.	TOUGHNESS AT PLASTIC LIMIT	*TOUGH*					
8.	ODOR TEST	*NIL*					
9.	SHAKE TEST (Rapid, Medium, None)	*NONE*					
10.	SHINE TEST	*SHINY*					

BOTTLE TEST

1.	COLOR OF SAND	*NIL*					
2.	GRADING OF SAND	*NIL*					
3.	GRAIN SHAPE OF SAND	*NIL*					
4.	ESTIMATED PERCENTAGE OF SAND	*NIL*					

ESTIMATED UNIFIED SOIL CLASSIFICATION

ESTIMATED LIQUID LIMIT	*65*					
ESTIMATED PLASTIC LIMIT	*25*					
ESTIMATED PLASTICITY INDEX	*40*					
UNIFIED SOIL CLASSIFICATION	*CH*					

REMARKS

High plastic fat clay

enter data into shaded areas

FIGURE 1

4.4 Odor Test

1. Smell the sample in the soupy condition. A distinctive odor is characteristic of organic soil.

2. Report the odor as **slight**, **medium**, or **strong** on Line No. 8.

4.5 Drying Time of Film on Hand

1. Place your other thumb in the middle of the soupy soil in the palm of your hand.

2. Exerting some pressure, draw your thumb through the crease in your hand, up and onto your wrist so that a thin film of soil is deposited.

3. While waiting for the thin film of soil to dry, manipulate the soupy soil to reduce its moisture content.

4. When the film is dry, enter on Line No. 4 of the data sheet, using estimated drying times of either **long**, **medium**, or **short**.

4.6 Ease of Removing Film

1. Try to rub the dry film off your wrist (your hand must be dry). Enter on Line No. 5 of the data sheet, an estimation of the ease of removing the film, as **hard**, **medium**, or **easy**.

4.7 Work & Time to Dry from the Liquid Limit (LL) to the Plastic Limit (PL)

1. Manipulate the soupy soil from 3.1.6 until a ball can be formed.

2. Roll the ball into a thread 3 mm in diameter.

3. Repeat steps 1 and 2 until the thread will just hold together. The soil is now at approximately the plastic limit.

   During this manipulation, the moisture content is gradually reduced and the specimen stiffens, finally losing its plasticity and crumbles when the plastic limit is reached.

4. Enter on Line No. 6 of the data sheet, an estimation of the work and time required to change the soil from the soupy consistency to the plastic limit. Record as **short**, **medium** or **long**.

The following criteria can be used to "confirm" the plasticity of the soil at the plastic limit.

Criteria for Describing Plasticity

Description	Criteria
Non-Plastic	A 3 mm (1/8 in.) thread cannot be rolled at any water content.
Low	When drier than the plastic limit, the thread cannot be rolled and the ball can barely be formed.
Medium	▪ The thread is easy to roll and a short time is required to reach the plastic limit. ▪ With increased pressure, the thread can be re-rolled once, after reaching the plastic limit. ▪ The ball crumbles when drier than the plastic limit.
High	▪ Considerable time is required for rolling and kneading to reach the plastic limit. ▪ With increased pressure, the thread can be re-rolled several times after reaching the plastic limit. ▪ The ball can be formed without crumbling when slightly drier than the plastic limit

4.8 Toughness at the Plastic Limit

1. Remold a ball of the soil at the plastic limit with your fingers. If too dry water must be added, and if too wet the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3 mm in diameter. The thread is then folded and re-rolled repeatedly.

2. Estimate the toughness (the resistance to deformation), and enter the result on Line No. 7 of the data sheet, using the following criteria:

Criteria for Describing Toughness

Description	Criteria
Low	▪ Only slight pressure is required to roll the thread near the plastic limit. ▪ The thread and the ball are weak and soft.
Medium	▪ Medium pressure is required to roll the thread to near the plastic limit. ▪ The thread and the ball have medium stiffness.
High	▪ Considerable pressure is required to roll the thread to near the plastic limit. ▪ The thread and the ball have very high stiffness.

4.9 Shine Test

1. Continue to manipulate the soil until it is close to the plastic limit.

2. Use a pencil, knife, fingernail, or some other smooth object, to rub the soil.

3. Observe the rubbed surface, and enter on Line No. 10 of the data sheet, its appearance, e.g. **shiny**, **medium**, or **dull**.

4.10 Shake Test

The shake test is only performed when the soil is granular in texture.

1. Prepare a pat of moist soil, above the plastic limit, and shake it horizontally in the palm of your hand.

2. A positive reaction consists of the appearance of water on the surface of the soil pat which changes to a soft consistency and becomes glossy.

3. If no water is observed, report a negative reaction to the test; if water does appear, continue with steps 4, 5 and 6.

4. Squeeze the sample between your fingers. This causes the moisture and gloss disappear from the surface and changes from shiny to dull. At the same time, the sample stiffens and finally crumbles under increased finger pressure.

5. Shake the broken pieces until they flow together.

6. Distinguish between slow, medium, and rapid reaction to the shake test, and record the result in line "9" of the data sheet, using the following criteria:

Shake Test — Criteria for Describing Dilatancy

Description	Criteria
None	No water is observed (no visible change in the specimen).
Slow	Water appears slowly on the surface of the specimen during shaking, but does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking, and dissappears quickly upon squeezing.

5.0 BOTTLE TEST

In the field lab, this test is used to compare soils and identify similar soils.

1. Place the dried soil in a medicine bottle up to the 50 cm^3 mark.

2. Add water up to the 150 cm^3 mark, and screw the cap on the bottle.

3. Shake the bottle until no soil remains on the walls or bottom.

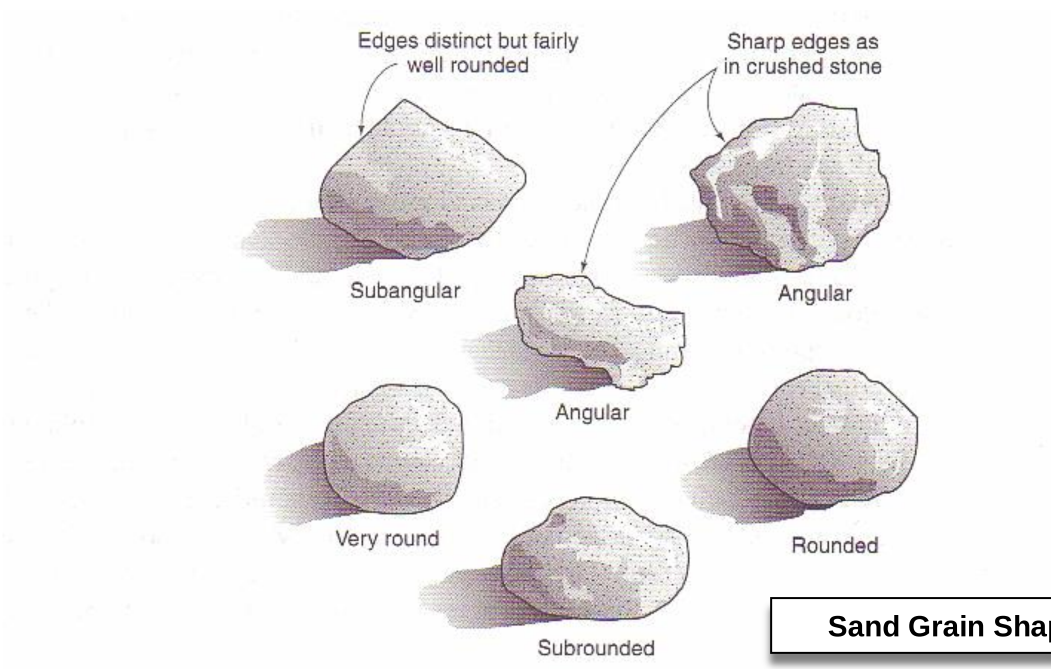
4. Set the sedimentation bottle down on a level surface. Pick a place you can leave the bottle undisturbed for 2 days.

5. Measure the sedimentation results according the following timetable.

6. Wait 1-2 minutes for the sand-sized particles to settle out. Sand particles are the largest of the soil particles and settle out of the mixture the fastest. Measure the thickness of the sand layer, and put a mark on the side of the medicine bottle.

   Observe and record:
   a) Color of the sand (e.g. light brown, dark brown, medium grey, etc.)
   b) Grading of the sand (e.g. well-graded, poorly-graded, uniformly-graded)
   c) Grain shape of the sand (e.g., sharp, sharp to round, round)

   A magnifying glass will help to distinguish the grain shapes.



Sand Grain Shapes

7. Wait 1-2 hours. Silt-sized particles will have settled out. Mark the top of the silt layer and measure the thickness down to the sand layer. This silt layer is often a different color than the sand layer. Silt particles are larger than clay particles but smaller than sand particles.

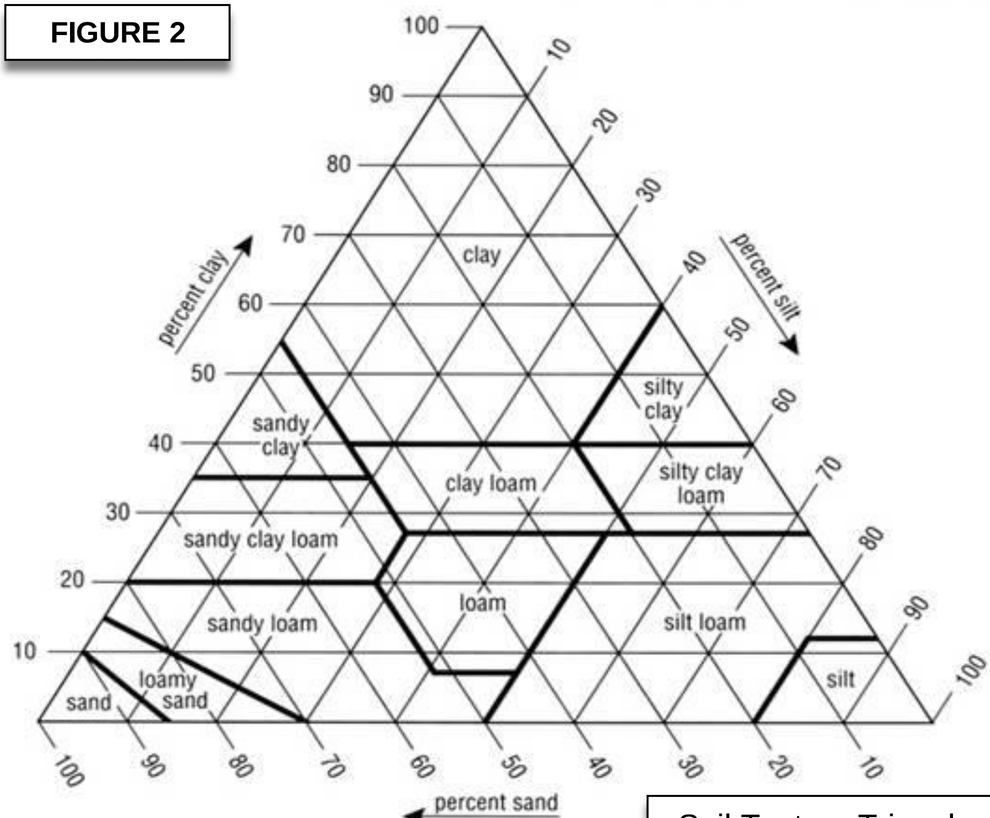
8. Wait 1-2 days. Clay-sized particles will have settled out. Mark the top of the clay layer and measure the thickness of the clay layer. Clay particles are very fine and can remain suspended in the water for a long time.

9. Calculate the proportions for each soil type by adding the thickness of the three layers to get the total height of the sediments. Divide the thickness of each layer by the total height to get the % sand, silt, and clay of the sample.

10. Use the Soil Texture Triangle (Figure 2) to estimate the soil texture classification. Sand, silt and clay are each assigned one side of the triangle. Find the % for each separate on its appropriate scale. Follow the guidelines (see the arrows in the soil texture triangle) into the chart. (Note for example, the guidelines for sand are diagonal and parallel to the right edge of the triangle. The guidelines for silt are diagonal and parallel to the left edge of the triangle. The guidelines for clay are horizontal, and parallel to the base of the triangle.)

    Example: A sample test result shows 10% sand, 30% silt, and 60% clay. Following the appropriate guidelines to the point all three converge in the chart. This sample would be a Clay soil.

FIGURE 2



Soil Texture Triangle

6.0 REMARKS SECTION

For fine-grained soils use the following table to describe the soil.

REMARKS - Soil Description Information

Item	Description
Color	▪ Color is useful in identifying organic soils and materials of similar origin and/or stratum.
Consistency	▪ For intact fine-grained and plastic soils, describe the consistency as very soft, soft, stiff, medium stiff, very stiff, or hard. ▪ Pocket Penetrometer (PP) reading in kPa may be used to aid in estimating consistency.
Density	For intact fine-grained soil, predominantly sand, describe the density as very loose, loose, medium dense, dense, or very dense.
Moisture	Describe the moisture condition as dry, moist, or wet.
Structure	For intact fine-grained soil, predominantly sand, describe the density as very loose, loose, medium dense, dense, or very dense.
Foreign Materials	The observation of materials such as glass, roots, bricks, etc. that are foreign to the natural soil is a strong indication of fill material.
HCL Reaction	The reaction of the soil with diluted HCl indicates the relative amount of calcium carbonate (calcareous materials) in the soil.

REMARKS - Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

7.0 INTERPRETATION OF RESULTS

7.1 Dry Strength

The dry "strength" is a measure of plasticity or cohesiveness of a soil. The dry strength increases with increasing plasticity. High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty, whereas a typical silt has the smooth feel of flour.

Medium dry strength indicates a low to medium plastic inorganic clay.

High dry strength indicates a highly plastic inorganic clay.

7.2 Amount of Water to Wet

The "amount of water to wet" is a measure of the water holding capacity of a soil. The smaller the soil particles, the higher the water holding capacity.

7.3 Percentage of Sand

The higher the percentage of sand, the lower the soil water holding capability.

7.4 Drying Time of Film on Hand

This test confirms the Work and Time from LL to PL test. It indicates the amount of clay present.

The longer the drying period, the greater the capacity of the soil to hold water.

High drying time indicates a soil of medium to high plasticity.

Low drying time indicates a soil of low plasticity, such as clayey sand or clayey silt.

7.5 Ease of Removing Film

This test indicates the type of clay (cohesiveness) and the quantity of clay present.

If the soil dries fast and can be easily powdered clean from the hand but does not exhibit grittiness, the soil is predominantly silt.

If the soil dries fast, is gritty, but will not clean from the hand when dry, even though the sand will brush off readily, the soil is predominantly clayey sand.

If the soil dries slowly and chips from the hand, or will not rub off but has to be washed off, the soil is predominantly clay.

7.6 Work and Time from the LL to the PL

This test indicates the amount of clay present.

Clay gives plasticity (cohesiveness) to a soil.. Without clay, the liquid limit and plastic limit would be approximately at the same moisture content. Thus, the soil would not have a plastic state.

The estimated amount of water removed from the LL to the PL is a direct estimation of the plasticity index. The longer the drying time and the more work required, the greater the clay content, and the higher the plasticity index.

NOTE: Since it is very difficult to recognize the liquid limit condition in a soil, the soupy condition is used. The quantity of water removed in progressing from the LL to the PL is comparable to the quantity of water removed from the soupy consistency to the PL. Therefore, low, medium, or high will apply in either relationship.

7.7 Toughness at the Plastic Limit

This test is an indicator of the amount and type of clay particles (cohesiveness) in a soil.

Slight toughness at the plastic limit indicates a clayey silt or clayey silty sand.

Medium toughness at the plastic limit, indicates a low to medium plastic soil.

High toughness at the plastic limit, indicates a highly plastic soil.

7.8 Odor Test

Organic soil has a distinctive odor. The technologist must determine the difference in odor between a normal soil and an organic soil, by obtaining a sample of known organic material and comparing its odor to that of a normal inorganic soil.

A strong organic odor indicates a highly organic material, such as decomposed peat.

A medium organic odor indicates organic and inorganic soil mixtures, such as topsoil.

A slight or no organic odor probably means no organic material present.

7.9 Shake Test

The shake test indicates the permeability of granular materials.

Very fine clean sands give the quickest and most distinct reaction due to a lack of plasticity, whereas plastic clays have no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Slow reaction indicates a slightly plastic silt or clay.

No reaction indicates a clay sample, or an organic material.

7.10 Shine Test

This test indicates the relationship of the quantity of clay to the granular materials.

A shiny surface indicates a highly plastic clay.

A dull surface indicates a silty or sandy clay.

AVERAGE SOIL

LIQUID LIMIT of 39%
Normal LL range from 30% to 60%

PLASTIC LIMIT of 18%
Normal LL range from 12% to 25%

PLASTICITY INDEX of 21%

High Plasticity	PI	above 27%
Medium Plastici	PI	27% - 15%
Low Plasticity	PI	below 15%

Average soil composed of :
- 25% Sand
- 50% Silt
- 25% Clay

Addition of the following to the above soil
will affect the Plastic Limit as follows :

CLAY	- the PL will increase
SILT	- the PL will remain the same (or increase)
SAND	- the PL will decrease
ORGANICS	- the PL will increase the most

The better the grading of the sand,
the lower will be the soil plastic limit

7.11 Bottle Test

This test is of value in comparing soil samples. It is usually used to correlate in-place filed density tests to the appropriate Moisture-Density Relation tests.

8.0 ESTIMATING THE ATTERGERG LIMITS

With the help of the chart shown in Figure 3 (developed by the Alberta Transportation) and the test data sheet shown in Figure 1, an estimation of the Atterberg Limits can be made based on the following:

a) *Liquid limit*

The liquid limit of a soil is that moisture content at which the bottom of a groove in a pat of soil in the liquid limit machine will close for a distance of 12.5 mm when given 25 blows.

Estimate the liquid limit by summarizing the results recorded in the data sheet.

b) *Plastic Limit*

The plastic limit of a soil is the lowest moisture content at which the soil can be rolled into a thread of 3 mm in diameter without breaking into pieces.

Estimate the plastic limit by summarizing the results on the data sheet.

c) *Plasticity Index*

Plasticity index is the numerical difference between the liquid limit and the plastic limit. This represents the moisture range of the plastic state.

The plasticity index is determined by subtracting the estimated plastic limit from the estimated liquid limit.
The following table shows the range of values for liquid limit, plastic limit, and plasticity index based on the estimated percent clay and water holding capacity of the soil.

Estimated Percent Clay, Water Holding Capacity, and Plasticity	**Atterberg Limits**	
low	Liquid Limit	Lower than 30%
low	Plastic Limit	Lower than 12%
low	Plasticity Index	Lower than 15%
high	Liquid Limit	Higher than 60%
high	Plastic Limit	Higher than 25%
high	Plasticity Index	Higher than 27%

Assess the different tests, and assign moisture contents for the LL and PL in relation to those shown for an average soil in Figure 3. Check if all the tests gave corresponding results. If not, determine which estimations were wrong.

For example, clay has a high surface area, silt has a medium surface area and sand has a low surface area. If a soil has a high dry strength, it must have a large amount of clay, thus will have a large surface area, a high liquid limit, take a long time and a lot of work to bring from the LL to the PL, etc.

Similar evaluations should be made for each of the hand tests.

When an estimation of the LL and PL has been made, determine the Plasticity Index. Plot the LL and PI on the plasticity chart as shown in Figure 2, and determine the material classification. Check the determined classification and its known characteristics against the results of the hand tests to be sure that corresponding results have been obtained for each test.

The hand method of soils classification is a learning tool. It should be performed in its entirety until the technologist has a thorough understanding and is proficient with the process. When the technologist has mastered this method, he/she will gradually perform less steps, until the classification of the soil is performed by texture alone, returning to the individual tests only when in doubt as to a soil characteristic.

PLASTICITY CHART

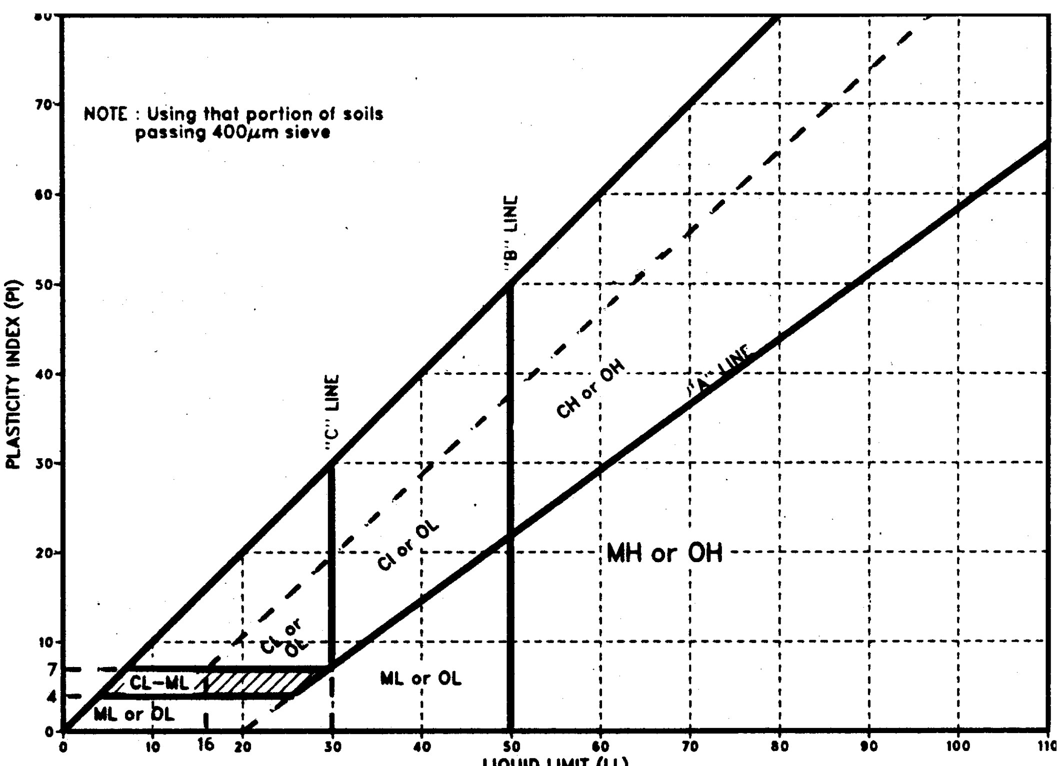
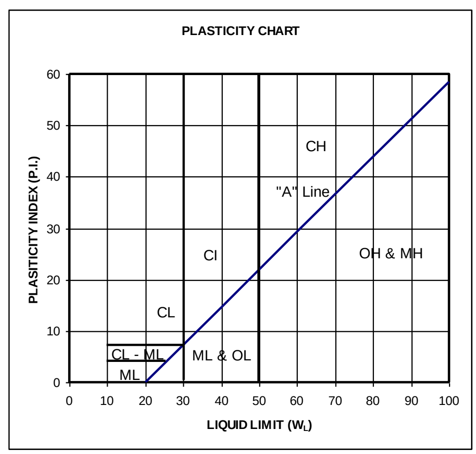


FIGURE 3

Modified Unified Soil Classification System

UNIFIED CLASSIFICATION SYSTEM (MODIFIED BY PFRA)

MAJOR DIVISIONS			GROUP SYMBOL	LOG SYMBOL	TYPICAL NAMES	LABORATORY CLASSIFICATION CRITERIA		
COARSE GRAINED SOILS (More than half of material is larger than 80 µm sieve size)	GRAVELS (More than half of coarse fraction is larger than 5 mm sieve size)	CLEAN GRAVELS (little or no fines)	GW		Well-graded gravels, gravel-sand mixtures, little or no fines	Determine amount of sand and gravel from grain size curve Depending on percent fines (fraction smaller than 80 µm sieve size), coarse-grained soils are classified as follows: Less than 5 % fines: GW, GP, SW, SP More than 12 % fines: GM, GC, SM, SC 5 to 12 % fines: Borderline cases requiring dual symbols(see Note 2)	$C_u = \frac{D_{60}}{D_{10}}$ is greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ is between 1 and 3	
			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 (see Note 1) d / u		Silty gravels, gravel-sand silt mixtures		Atterberg Limits below "A" Line or P.I. is less than 4	Above "A" Line with P.I. 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 P.I. greater than 7	
	SANDS (More than half of coarse fraction is smaller than 5 mm sieve size)	CLEAN SANDS (little or no fines)	SW		Well-graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ is greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ is between 1 and 3	
			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 (see Note 1) d / u		Silty sands, sand-silt mixtures		Atterberg Limits below "A" Line or P.I. is less than 4	Limits plotting in hatched zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
			SC		Clayey sands, sand-clay mixtures		Atterberg Limits above "A" Line with P.I. greater than 7	
FINE GRAINED SOILS (More than half of material is smaller than 80 µm sieve size)	CLAYS (above "A" Line on plasticity chart; negligible organic content)	$w_L < 30\%$	CL		Inorganic clays of low plasticity, gravelly clays, sandy clays, silty clays, lean clays			
		$30\% < w_L < 50\%$	CI		Inorganic clays of medium plasticity, gravelly clays, sandy clays, silty clays			
		$w_L > 50\%$	CH		Inorganic clays of high plasticity, fat clays			
	SILTS (below "A" Line on plasticity chart; negligible organic content)	$w_L < 50\%$	ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands of clayey silts with slight plasticity			
		$w_L > 50\%$	MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic soils			
	ORGANIC SILTS AND CLAYS (below "A" Line)	$w_L < 50\%$	OL		Organic silts and organic silty clays of low plasticity			
		$w_L > 50\%$	OH		Organic clays of medium to high plasticity, organic silts			
	HIGHLY ORGANIC SOILS		Pt		Peat and other highly organic soils	Strong colour or odour and fibrous texture		

Remarks - Soil Description Information

Item	Description
Color	▪ Color is useful in identifying organic soils and materials of similar origin and/or stratum.
Consistency	▪ For intact fine-grained and plastic soils, describe the consistency as very soft, soft, stiff, medium stiff, very stiff, or hard. ▪ Pocket Penetrometer (PP) reading in kPa may be used to aid in estimating consistency.
Density	For intact fine-grained soil, predominantly sand, describe the density as very loose, loose, medium dense, dense, or very dense.
Moisture	Describe the moisture condition as dry, moist, or wet.
Structure	For intact fine-grained soil, predominantly sand, describe the density as very loose, loose, medium dense, dense, or very dense.
Foreign Materials	The observation of materials such as glass, roots, bricks, etc. that are foreign to the natural soil is a strong indication of fill material.
HCL Reaction	The reaction of the soil with diluted HCl indicates the relative amount of calcium carbonate (calcareous materials) in the soil.

Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately