UNIVERSITY OF MUSTANSIRIYAH-COLLEGE OF ENGINEERING –CIVIL ENGINEERING DEPARTMENT

Highway Pavement Lab1

Soil Classification

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Lab of Highway Pavement

Soil Classification

Evaluation of the properties of the subgrade soil

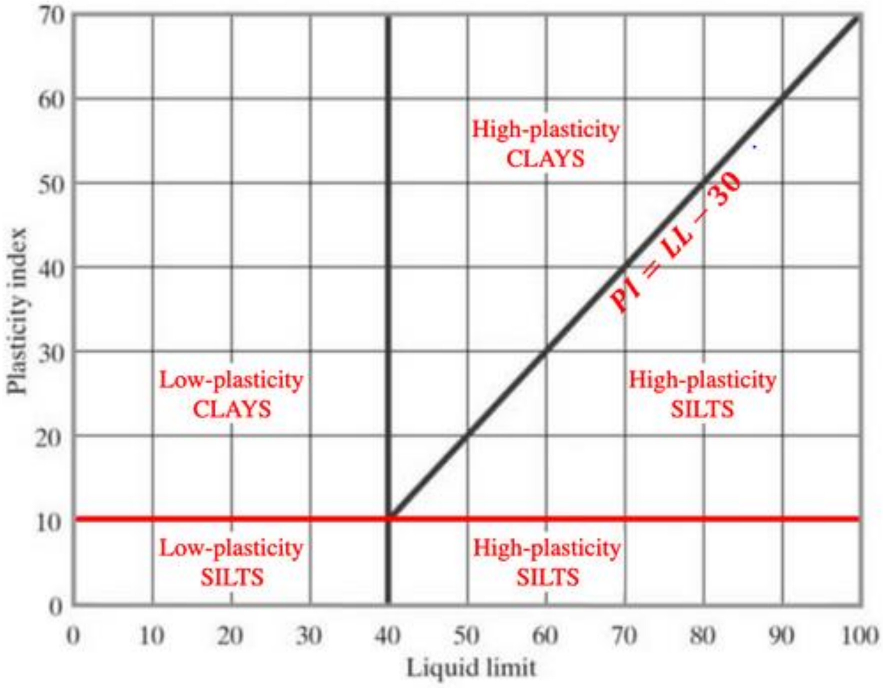
The *sub-grade course* is typically the natural soil as well as chosen particle size aggregate which is compacted to specific levels to relative stress from the weight of the above course. Thus, the indigent soil serves as the foundation that supports the road.

The determination of soil type is essential and considered one of the important inputs of the pavement structural design

AASHTO Classification System

The AASHTO system of soil classification was developed (ASTM designation D -3282 AASHTO method M14.5) to classify soil according o its engineering behavior.

The AASHTO classification classified the soil into seven major groups: A -l through A-7. Soils classified under groups A-1, A-2. and A-3 are granular materials of which 35% or less of the particles pass through the No. 200 sieve. Soils of which more than 35% pass through the No. 200 sieve are classified under groups A-4, A-5, 4-6 and A-7. These soils are mostly silt and clay-type materials.



AASHTO Liquid Limit Vs Plasticity Index

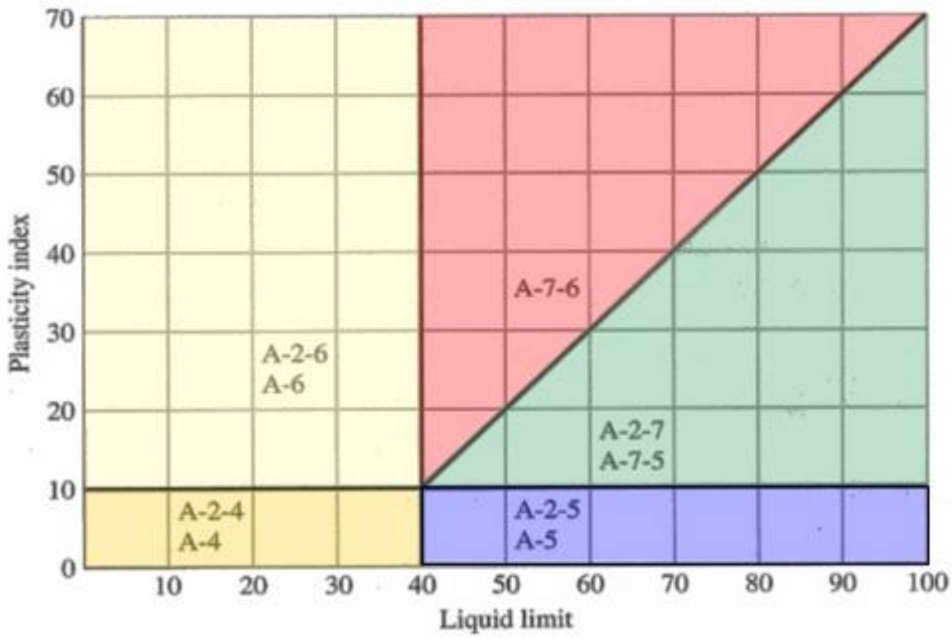
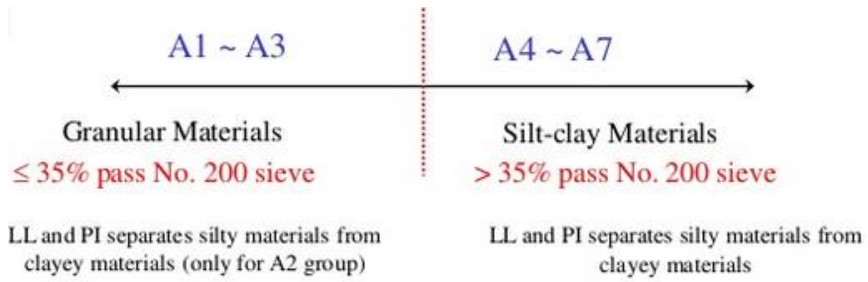


Figure 1 .1 Range of liquid limit and plasticity index for soils in groups A -2, A-4, A-5.4 -6, and A-7



To evaluate the quality of a soil as a highway sub-grade material, one must also incorporate a number called the group index (GI) with groups and sub groups of the soil. The index is written in parentheses after the group or subgroup designation. The group index is given by the equation.

$$GI = (F_{200} - 35)\,[0.2 + 0.005\,(LL - 40)] + 0.01\,(F_{200} - 15)(PI - 10) \quad \text{...... Eq 1}$$

Where:

$F_{200} = percentage\ of\ passing\ through\ the\ No. 200\ seive$

$LL = liquid\ limit$

$PI = plasticity\ index$

The aim of this lecture is to find the soil classification type according to AASHTO method through finding LL, PI, and GI

1. Atterberg Limits

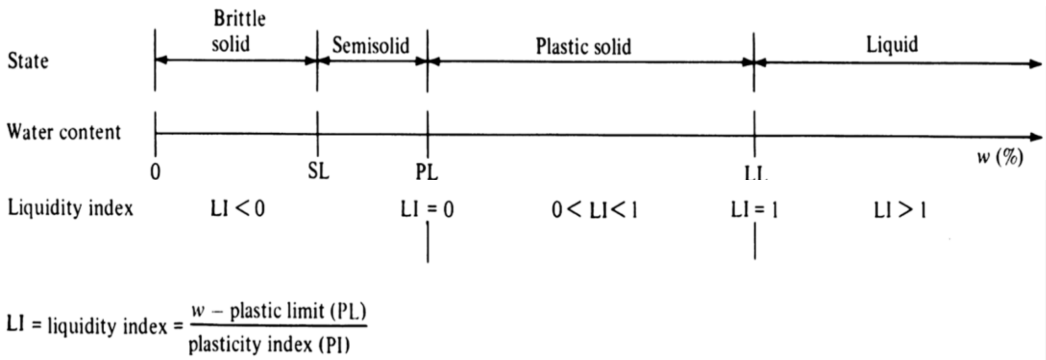
Cohesive soil, e.g. clay soil, with very low moisture content will be in the form of solids As the water content level increase, the solid soil gradually becomes plastic—that is, the soil easily can be molded into different shapes without breaking up.

Continuous increase of the water content will eventually bring the soil to a state where it can flow as a viscous liquid.

The stiffness or consistency of the soil at any time therefore depends on the state at which the soil is, which in turn depends on the amount of water present in the soil.

Atterberg limits are developed to classify the fine grained soil based on the water content level and according to the Unified Soil Classification system or AASHTO system to simulate the engineering behavior of soil.

Three limits are developed, they are the shrinkage limit (SL), plastic limit (PL), and liquid limit (LL), as illustrated in Figure below.



Shrinkage Limit (SL)

When a saturated soil is slowly dried, the volume shrinks, but the soil continues to contain moisture. Continuous drying of the soil, however, will lead to moisture content at which further drying will not result in additional shrinkage. The volume of the soil will stay constant, and further drying will be accompanied by air entering the voids. The moisture content at which this occurs is the shrinkage limit, or SL, of the soil.

Plastic Limit (PL)

The plastic limit, or PL, is defined as the moisture content at which the soil crumbles when it is rolled down to a diameter of one-eighth of an inch (3mm). The moisture content is higher than the PL if the soil can be rolled down to diameters less than one-eighth of an inch, and the moisture content is lower than the PL if the soil crumbles before it can be rolled to one-eighth of an inch diameter.

Liquid Limit (LL)

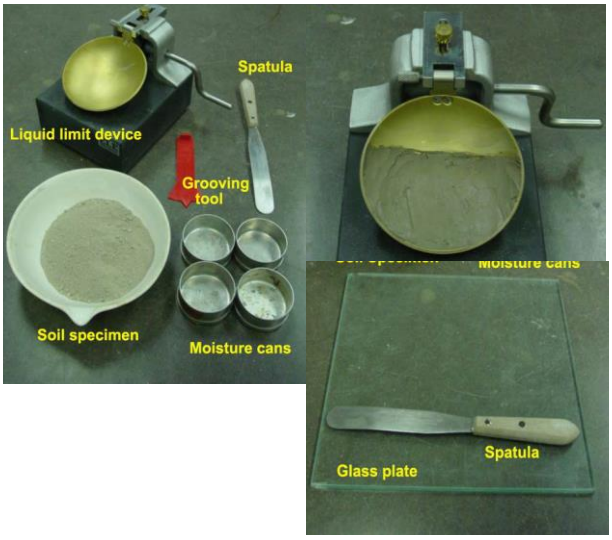
It is determined by measuring the water content and the number of blows requires to close a specific groove for a specific length of one-half inch (13mm). In a standard liquid limit device (w% at 25 blows)

Purposes of this test:

1. Soil classification
2. To estimate the strength of the subgrade soil

Equipment (Apparatus):

1. Liquid limit device (Casagrande):consist of shallow circular bar cup, raising on a headrubber base
2. Grooving tool
3. Soil specimen, Porcelain dish
4. Smooth glass plate
5. containers
6. Spatula
7. Soil sample passing sieve no. 4 (4.75 mm)
8. Wash bottle filled with distilled water,
9. Drying oven set at 105°C.



Procedure in Lab

<u>Determination of LL</u>

1. Record the weight of the empty containers (gm)

2. Take a sample of soil passing sieve no. 4 (4.75 mm)
   With enough weight for LL and PL tests

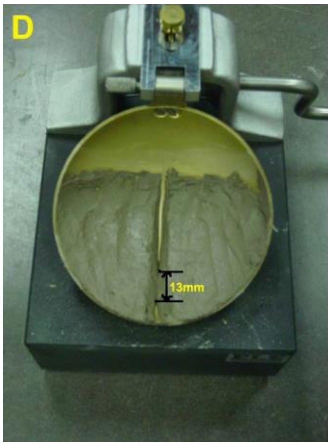
3. Mix the soil sample with an amount of water using the glass plate and the spatula


4. Put the wet soil in the Porcelain (evaporating) dish which will help to rduce the water content of the wet soil during the test time to get three samples with different water contents. The first sample has higher water content and the last sample has less water content.

5. Put a portion of the wet soil in the shallow circular bar cup of the liquid limit device. Be sure that the sample is distributed at the same level at specifies part of the cup.

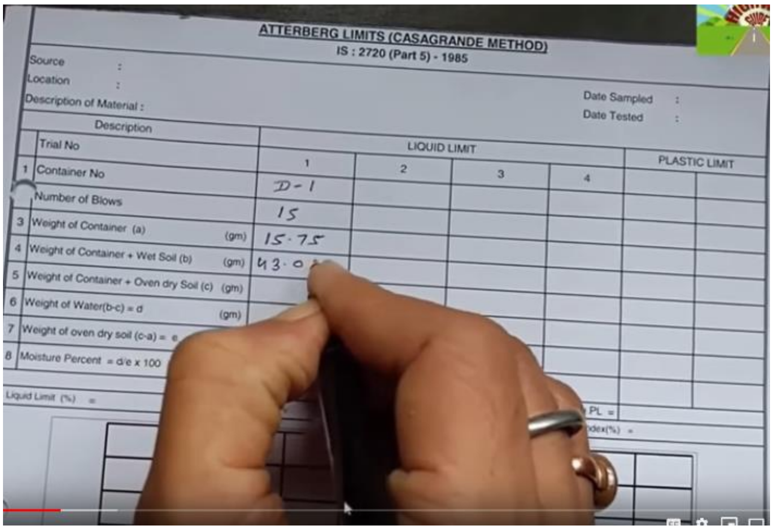

6. Make a groove as shown below using the grooving tool


7. Record the number of blows required to cause the groove close to about 1 cm using the liquid limit device (be sure to have a range of blows between 10 to 40 and the rate of blows is 2 blows per sec)

8. Take a representative portion of the soil sample from the closed point in the cup for water content determination and record the weight of (the container +wet soil)(gm)


9. Repeat the steps (5 to 8) for at least three times to obtain three records which should be recorded in a specific test sheet as below



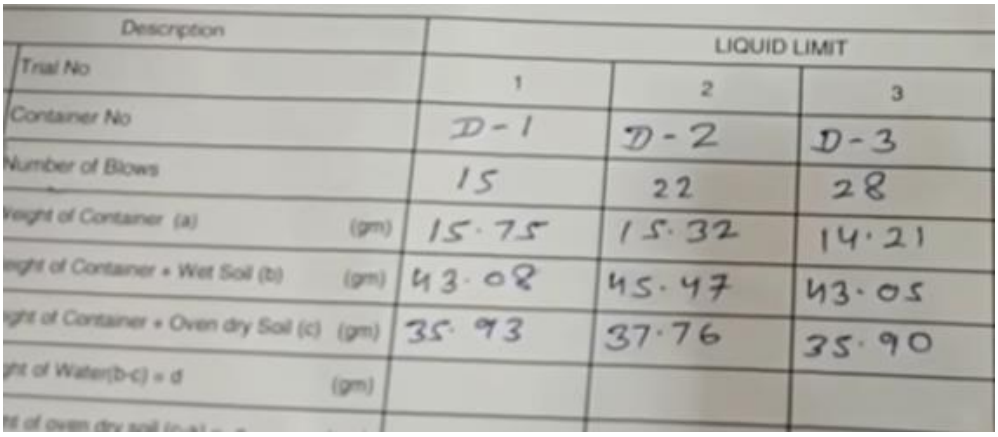
ATTERBERG LIMITS (CASAGRANDE METHOD)
IS : 2720 (Part 5) - 1985

Source :
Location :
Description of Material :
Date Sampled :
Date Tested :

Description		LIQUID LIMIT				PLASTIC LIMIT	
Trial No		1	2	3	4		
1	Container No	D-1					
	Number of Blows	15					
3	Weight of Container (a) (gm)	15.75					
4	Weight of Container + Wet Soil (b) (gm)	43.0					
5	Weight of Container + Oven dry Soil (c) (gm)						
6	Weight of Water(b-c) = d (gm)						
7	Weight of oven dry soil (c-a) = e						
8	Moisture Percent = d/e x 100						

Liquid Limit (%) =

10. Put the all containers containing the wet soil samples in a drying oven set at 60°C for 24 hours. Then record the (weight of containers +dry soil)



Description	LIQUID LIMIT		
Trial No	1	2	3
Container No	D-1	D-2	D-3
Number of Blows	15	22	28
Weight of Container (a) (gm)	15.75	15.32	14.21
Weight of Container + Wet Soil (b) (gm)	43.08	45.47	43.05
Weight of Container + Oven dry Soil (c) (gm)	35.93	37.76	35.90
Weight of Water(b-c) = d (gm)			
Weight of oven dry soil (c-a) = e			

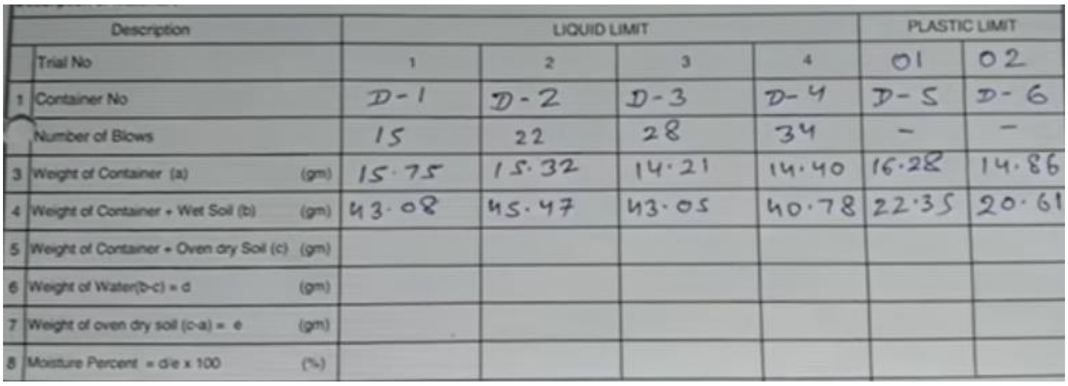
Plastic limit determination

1. Repeat the steps from 1 to 4 of Liquid limit determination

2. Take a portion of the wet sample and roll it into 3mm tread till crumbling. The rate of rolling should be 80 to 90 strokes per minute to form a 3mm diameter.

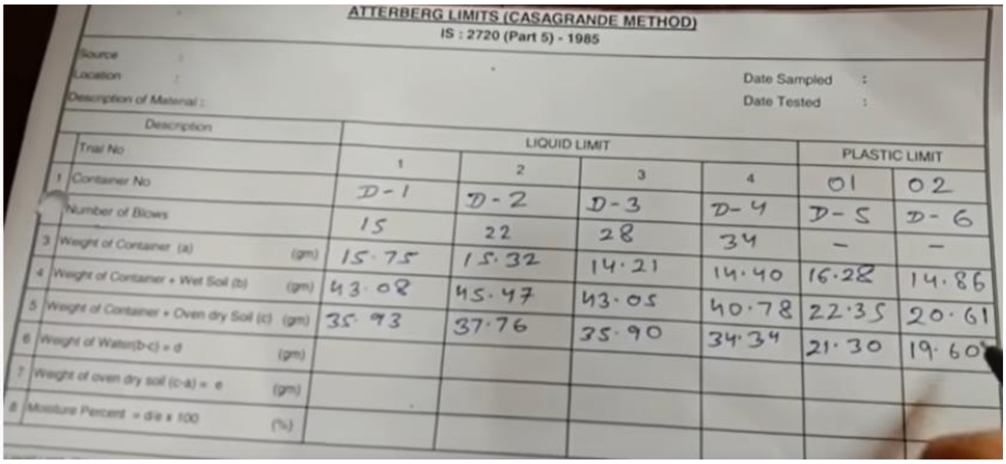

3. Take a portion of the crumpled soil rolls to measure the (weight of container + wet soil)

4. Repeat the steps 2 and 3 for at least 3 times and record the results in the lab sheet



Description	LIQUID LIMIT				PLASTIC LIMIT	
Trial No	1	2	3	4	01	02
1 Container No	D-1	D-2	D-3	D-4	D-5	D-6
2 Number of Blows	15	22	28	34	–	–
3 Weight of Container (a) (gm)	15.75	15.32	14.21	14.40	16.28	14.86
4 Weight of Container + Wet Soil (b) (gm)	43.08	45.47	43.05	40.78	22.35	20.61
5 Weight of Container + Oven dry Soil (c) (gm)						
6 Weight of Water(b-c) = d (gm)						
7 Weight of oven dry soil (c-a) = e (gm)						
8 Moisture Percent = d/e x 100 (%)						

5. Put the containers in the drying oven to measure the weight of the (containers +dry soil)



ATTERBERG LIMITS (CASAGRANDE METHOD)
IS : 2720 (Part 5) - 1985

Source :
Location :
Description of Material :
Date Sampled :
Date Tested :

Description	LIQUID LIMIT				PLASTIC LIMIT	
Trial No	1	2	3	4	01	02
1 Container No	D-1	D-2	D-3	D-4	D-5	D-6
2 Number of Blows	15	22	28	34	–	–
3 Weight of Container (a) (gm)	15.75	15.32	14.21	14.40	16.28	14.86
4 Weight of Container + Wet Soil (b) (gm)	43.08	45.47	43.05	40.78	22.35	20.61
5 Weight of Container + Oven dry Soil (c) (gm)	35.93	37.76	35.90	34.34	21.30	19.60
6 Weight of Water(b-c) = d (gm)						
7 Weight of oven dry soil (c-a) = e (gm)						
8 Moisture Percent = d/e x 100 (%)						

Calculations

<u>Liquid limit determination</u>

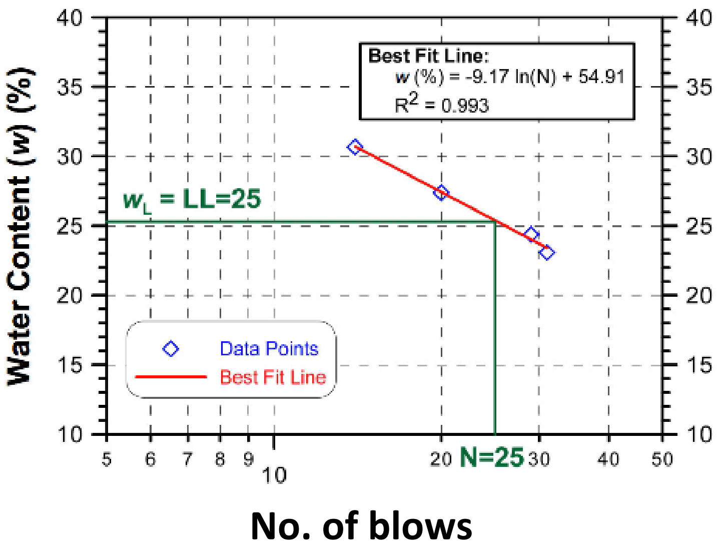
1. Find the weight of the wet soil (gm) of the first sample (wws1)

= weight of the (containers +wet soil) - weight of empty container

2. Find the weight of the dry soil (gm) of the first sample (wds1)

= weight of the (containers +dry soil) - weight of empty container

3. Find the weight of water of the first sample (ww1)
   = weight of the wet soil (gm) - weight of the dry soil (gm)
4. Find the water content of the first sample (%w1)=(ww1/ wds1)*100
5. Repeat steps from 1 to 4 for at least three samples
6. Draw a graphical relationship between the %w and the number of blows
7. Find the %w for number of blows=25 using the graph developed in step 6
8. The LL= %w for number of blows=25



<u>Plastic limit determination</u>

1. Find the weight of the wet soil (gm) of the first sample (wwsp1)

= weight of the (containers +wet soil) - weight of empty container

2. Find the weight of the dry soil (gm) of the first sample (wdsp1)

= weight of the (containers +dry soil) - weight of empty container

3. Find the weight of water of the first sample (wwp1)

   = weight of the wet soil (gm) - weight of the dry soil (gm)
4. Find the water content of the first sample (%wp1)=(wwp1/wdsp1)*100
5. Repeat steps from 1 to 4 for at least three samples
6. The PL= average of %wp

<u>Plasticity Index determination</u>

PI=LL-PL

[a]For A-7-5, $PI \leq LL - 30$
[b]For A-7-6, $PI > LL - 30$

2. Percentage passing sieve No. 200

Purpose: soil classification

Equipment (Apparatus):

1. Sieve No. 200
2. Balance
3. Pan
4. Drying oven
5. 100gm soil sample

Calculation

%passing sieve no. 200=

(Weight of dry soil passing sieve No.200/ soil sample weight (100gm))*100

3. Classify soil

1. Use the figure below to find the soil type based on the %passing no. 200, LL and PI

General Classification	Granular Materials (35% or less passing the 0.075 mm sieve)							Silt-Clay Materials (>35% passing the 0.075 mm sieve)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5 A-7-6
Sieve Analysis, % passing											
2.00 mm (No. 10)	50 max	...	...	...	...	...	...	...	...	...	...
0.425 (No. 40)	30 max	50 max	51 min	...	...	...	...	...	...	...	...
0.075 (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid Limit	...		...	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[1]
Usual types of significant constituent materials	stone fragments, gravel and sand		fine sand	silty or clayey gravel and sand				silty soils		clayey soils	
General rating as a subgrade	excellent to good							fair to poor			

[a]For A-7-5, $PI \leq LL - 30$
[b]For A-7-6, $PI > LL - 30$

2. Find the GI using Eq 1

Example 1

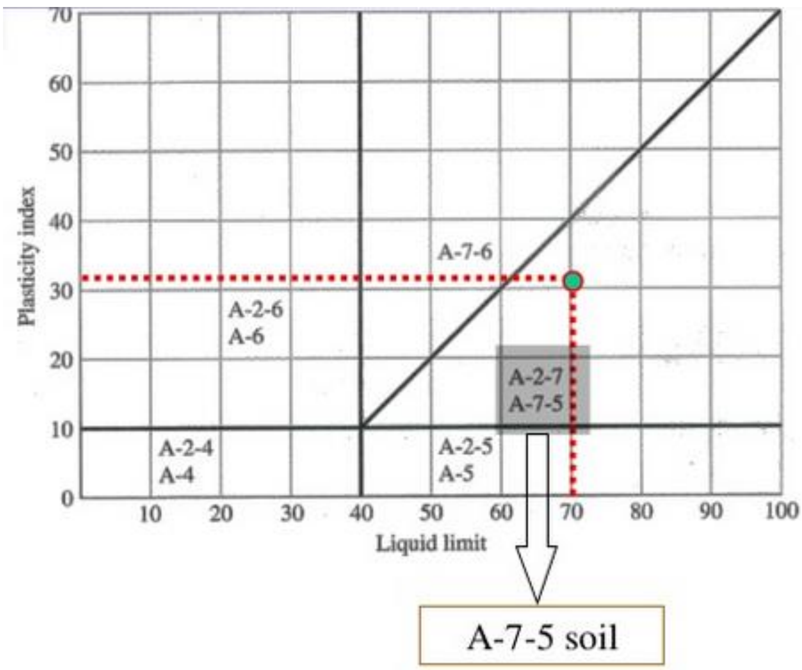
Classify the following soils by the AASHTO classification system.

Description	Soil A	Soil B	Soil C	Soil D	Soil E
Percent finer than No. 10 sieve	83	100	48	90	100
Percent finer than No. 40 sieve	48	92	28	76	82
Percent finer than No. 200 sieve	20	86	6	34	38
Liquid limit[a]	20	70	—	37	42
Plasticity index[a]	5	32	Nonplastic	12	23

Solution

General classification	Silt-clay materials (more than 35% of total sample passing No. 200)			
Group classification	**A-4**	**A-5**	**A-6**	**A-7 A-7-5[a] A-7-6[b]**
Sieve analysis (percentage passing)				
No. 10				
No. 40				
No. 200	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40				
Liquid limit	40 max.	41 min.	40 max.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

[a]For A-7-5, $PI \le LL - 30$
[b]For A-7-6, $PI > LL - 30$



Passing No.200 86%
LL=70, PI=32
LL-30=40 > PI=32

Example 2

Classify the following soil Using AASHTO System. Given:

% passing No. 10 = 100;

% passing No. 40 = 80;

% passing No.200 = 58

LL = 30; PI = 10

Solution

General classification	Silt-clay materials (more than 35% of total sample passing No. 200)			
Group classification	A-4	A-5	A-6	A-7 A-7-5[a] A-7-6[b]
Sieve analysis (percentage passing)				
No. 10				
No. 40				
No. 200	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40				
Liquid limit	40 max.	41 min.	40 max.	41 min.
Plasticity index	10 max.	10 max.	11 min.	11 min.
Usual types of significant constituent materials	Silty soils		Clayey soils	
General subgrade rating	Fair to poor			

[a]For A-7-5, $PI \le LL - 30$
[b]For A-7-6, $PI > LL - 30$

GI=3

A-4(3)

https://www.youtube.com/watch?v=aTXYQXyanfU

https://www.youtube.com/watch?v=OttOSrhRD6s&vl=en