Geotechnical Engineering–I

BSc Civil Engineering – 4th Semester

Lecture # 7

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by

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Lecture Handouts: https://groups.google.com/d/forum/geotec-1

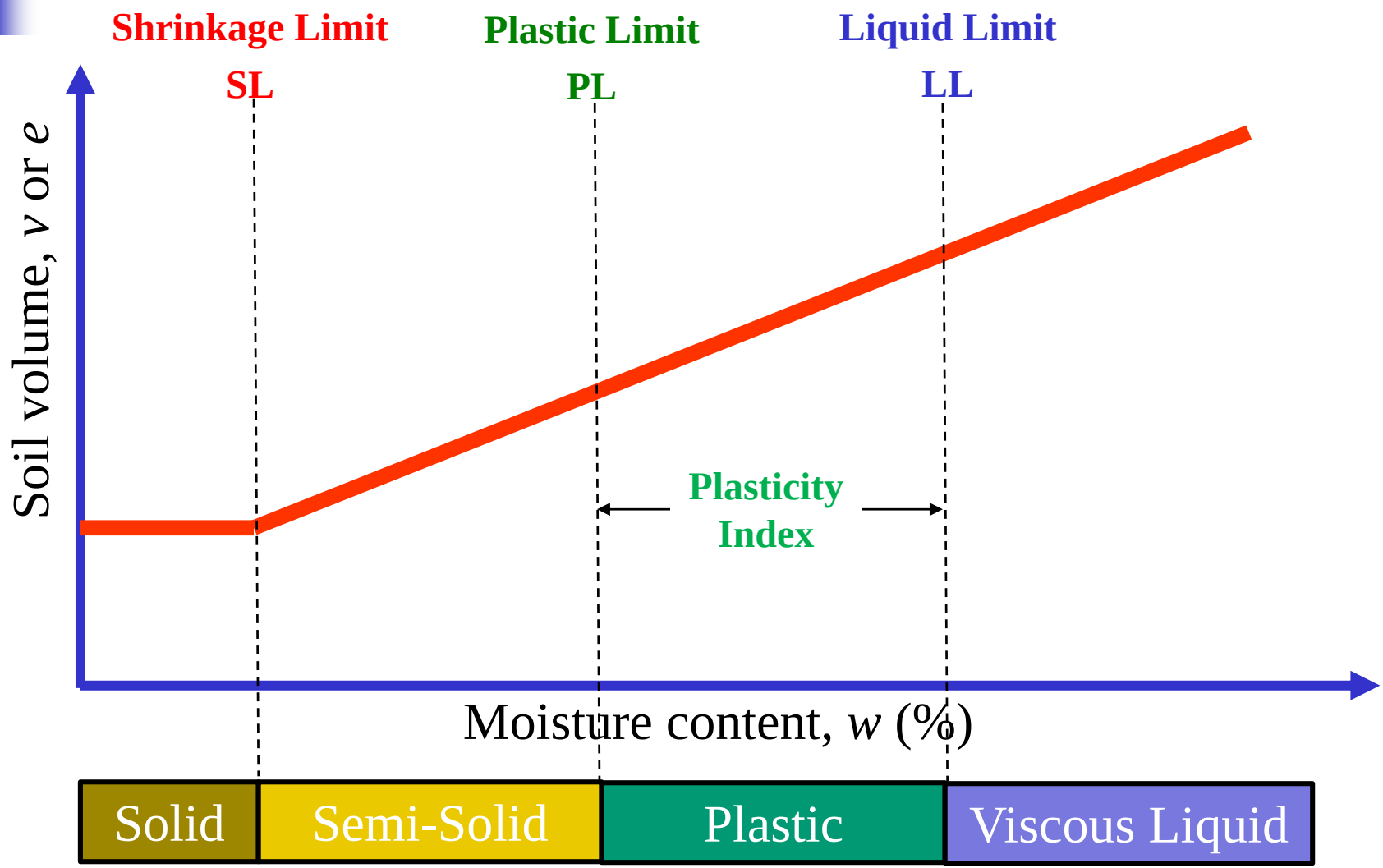
SOIL CONSISTENCY

- Indicates the *degree of firmness* of *fine-grained soil*.
- Generally expressed in terms of *very soft*, *soft*, *stiff*, *very stiff*, and *hard*.

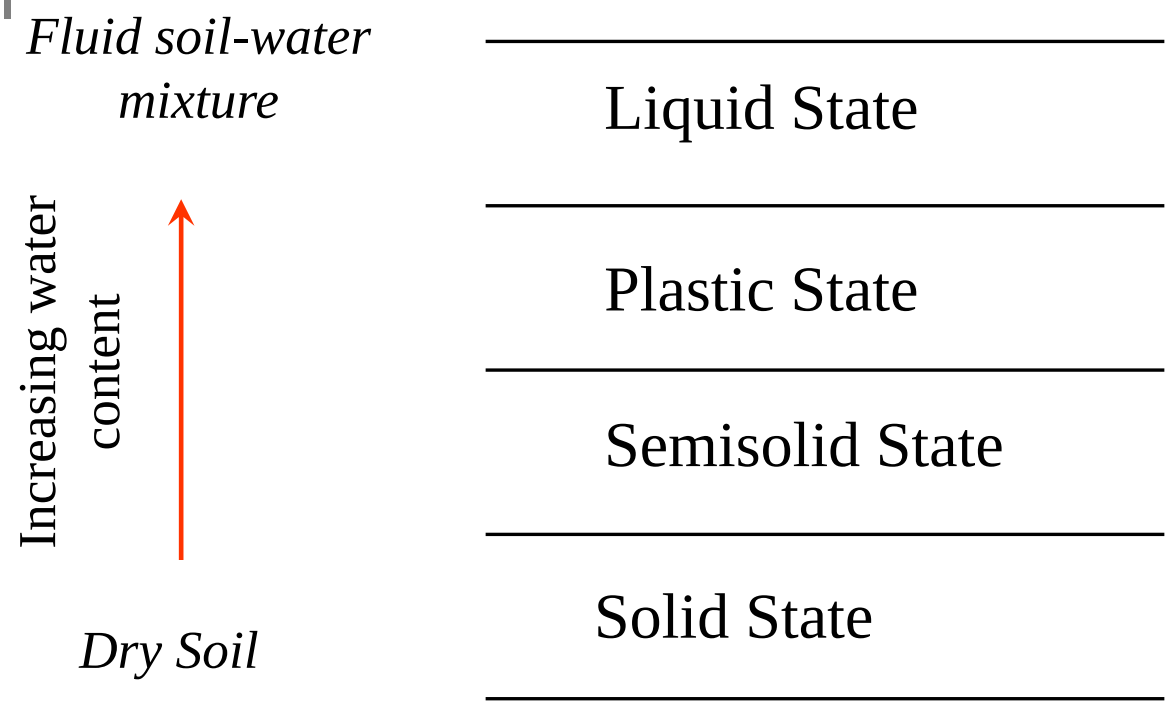
Soil behave like:

- SOILD at very low moisture content
- LIQUID at very high moisture content

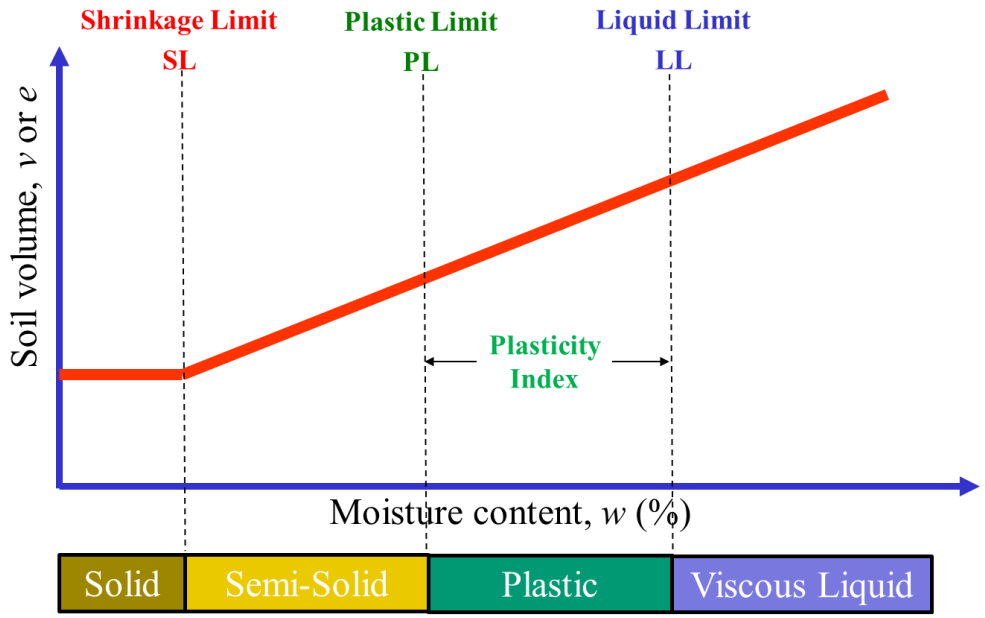
ATTERBERG/CONSISTENCY LIMITS



ATTERBERG LIMITS



LIQUID LIMIT (*LL* or w_{LL})



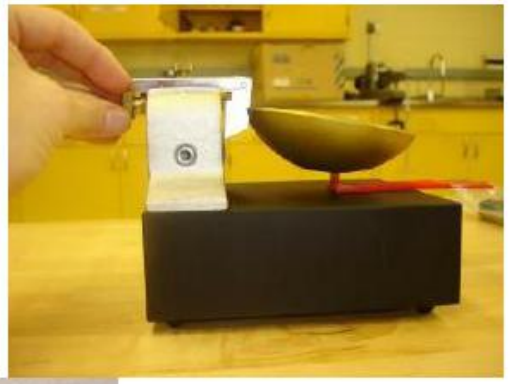
Liquid Limit (LL) is defined as the *moisture content* at which soil begins to behave as a liquid material and begins to flow.

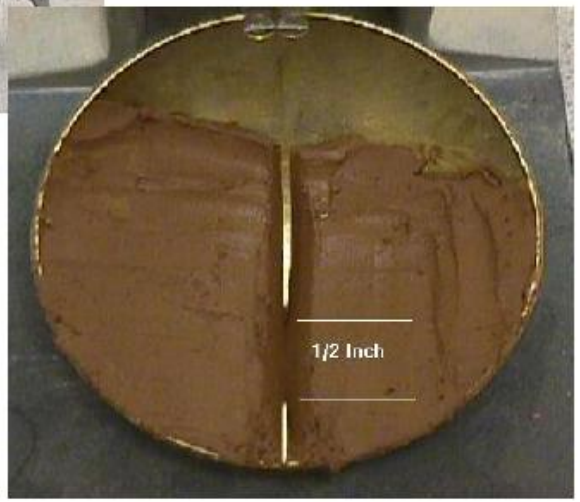
(LL of a fine-grained soil gives the moisture content at which the shear strength of the soil is approximately 2.5kN/m^2)

LIQUID LIMIT DETERMINATION

Casagrande Apparatus

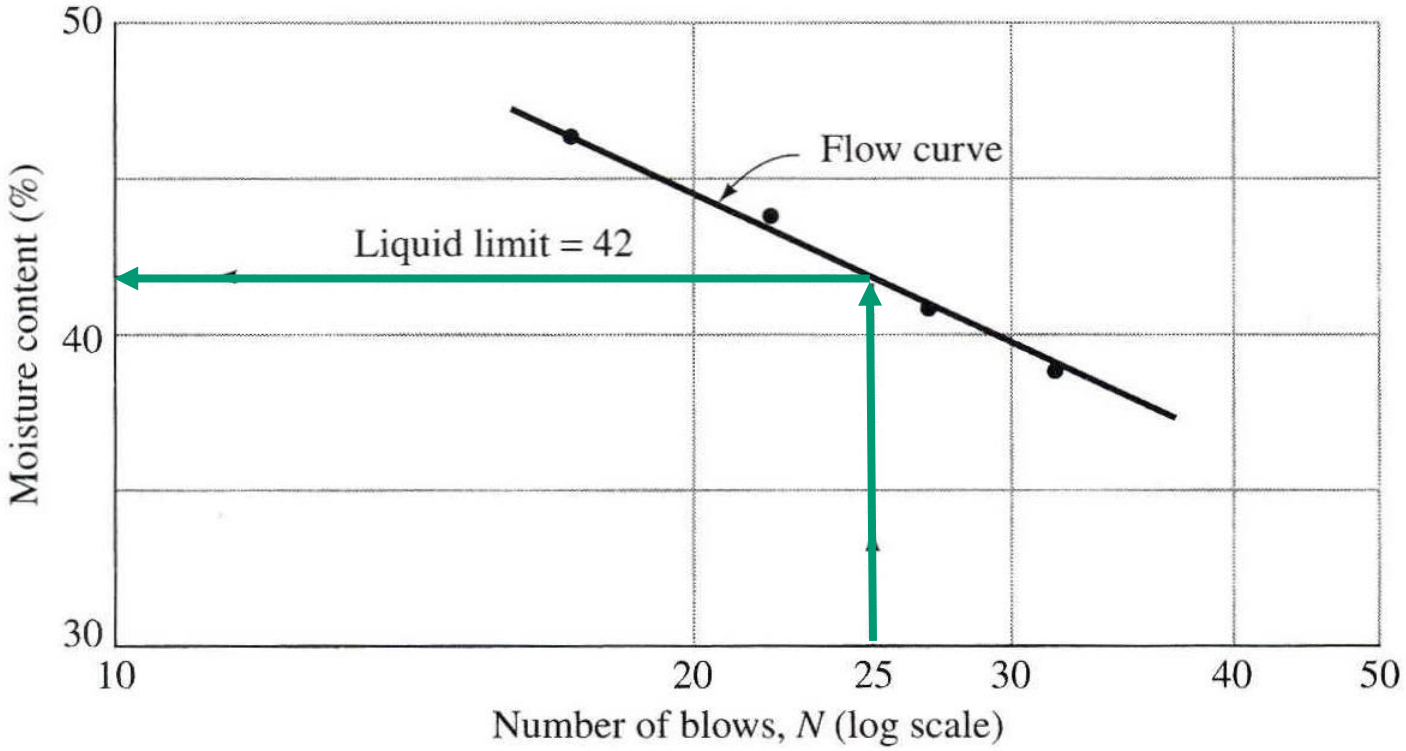
ASTM D-4318





LIQUID LIMIT DETERMINATION

A) Three-Point Method



LL is the *moisture content* required to close a 2-mm wide groove in a soil pat a distance of 12.7 mm (1/2”) along the bottom of the groove after 25 blows.

LIQUID LIMIT DETERMINATION

B) One-Point Method

$$LL = w_n \left(\frac{N}{25} \right)^{\tan\beta}$$

$$N = number\ of\ blows$$

$$w_n = corresponding\ \ moisture\ content$$

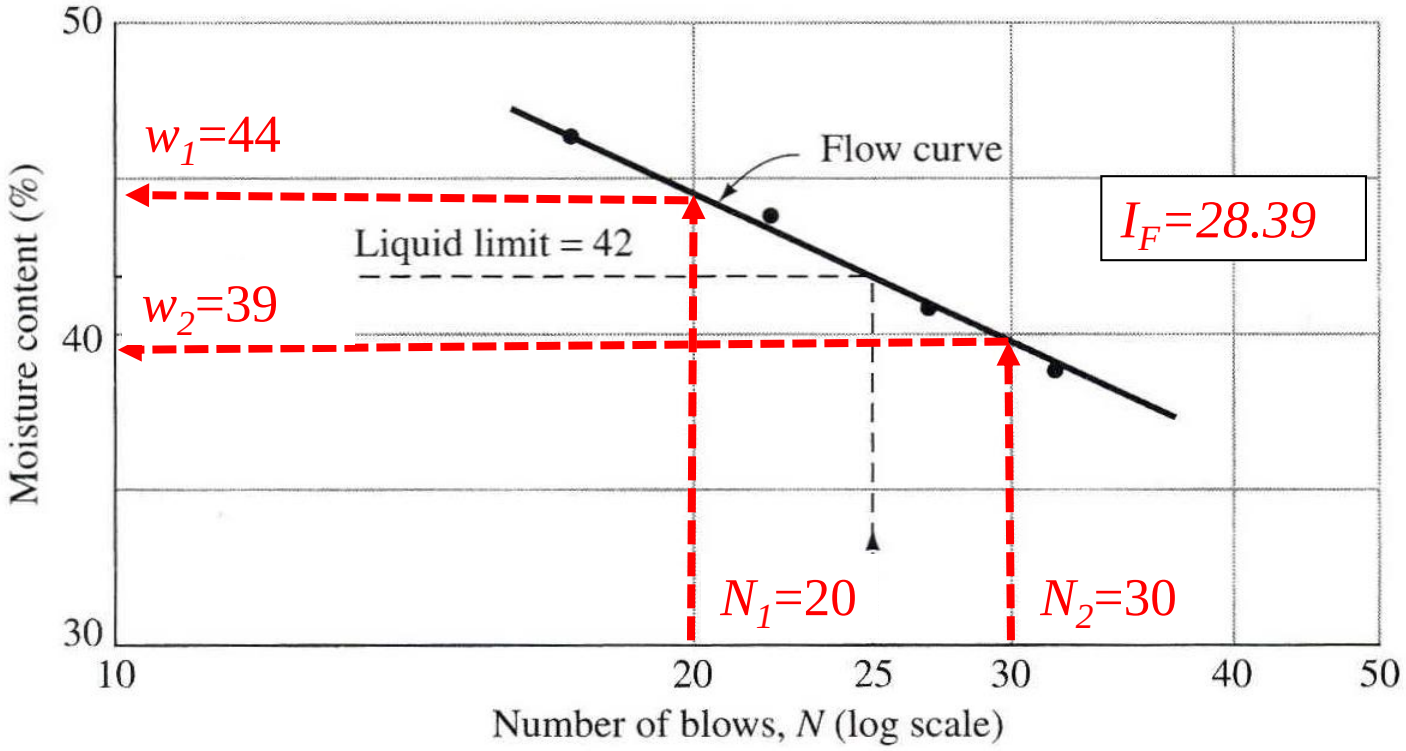
$$\tan\beta = 0.121$$

- Assumes a constant slope of the flow curve.
- The slope is a statistical result of 767 liquid limit tests.

Limitations:

- tan β is an empirical coefficient, so it is not always 0.121.
- Good results can be obtained only for the blow number between 20 to 30.

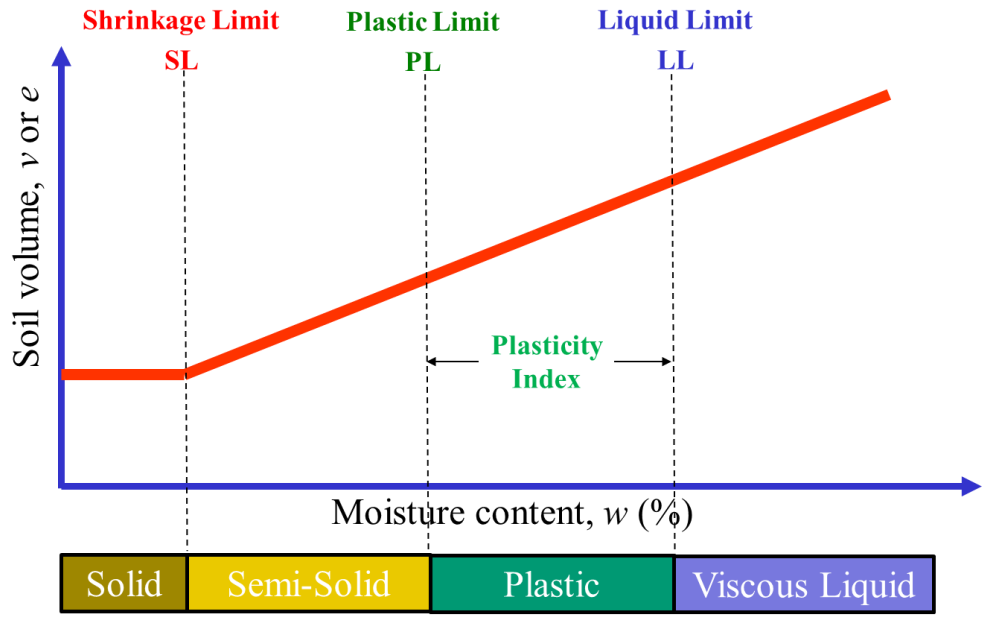
FLOW INDEX (I_F)



Flow Index $$I_F = \frac{w_1 - w_2}{\log\left(\frac{N_2}{N_1}\right)}$$

- Larger the I_F, smaller will be shear strength of soil.

PLASTIC LIMIT (PL or w_{PL})



Plastic Limit (PL) is defined as the *moisture content* at which soil begins to behave as a plastic material.

Plasticity Index (PI or I_P) = LL - PL

PLASTIC LIMIT DETERMINATION

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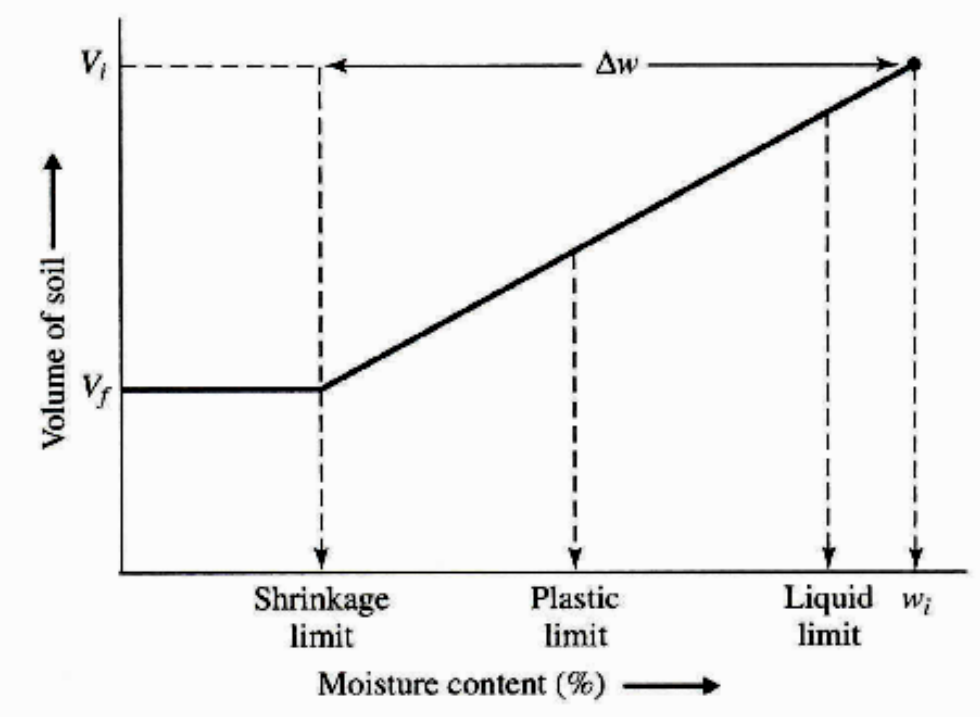
Moisture content at which the soil when rolled into threads of 3.2mm (1/8 in) in diameter, will crumble.

PL = w% at 3.2 mm (1/8 in) dia.

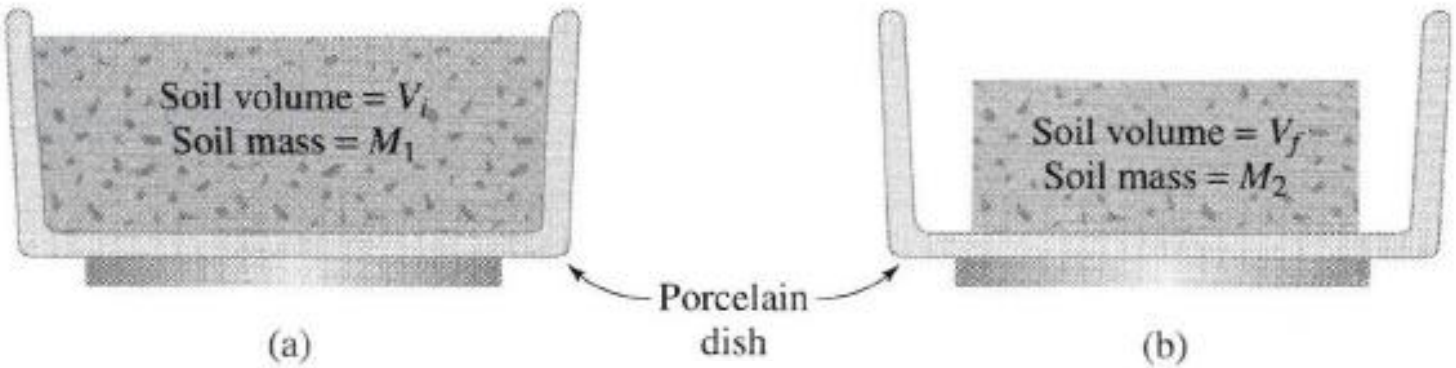
SHRINKAGE LIMIT

Shrinkage Limit (SL) is defined as the *moisture content* at which no further volume change occurs with further reduction in moisture content.



$$SL = w_i(\%) - \Delta w(\%)$$

SHRINKAGE LIMIT



$$SL = w_i(\%) - \Delta w(\%)$$

$$w_i(\%) = \frac{M_1 - M_2}{M_2} \times 100$$

$$\Delta w(\%) = \frac{(V_i - V_f)\rho_w}{M_2} \times 100$$

Assignment: Prove this relationship

PLASTICITY/A-LINE CHART

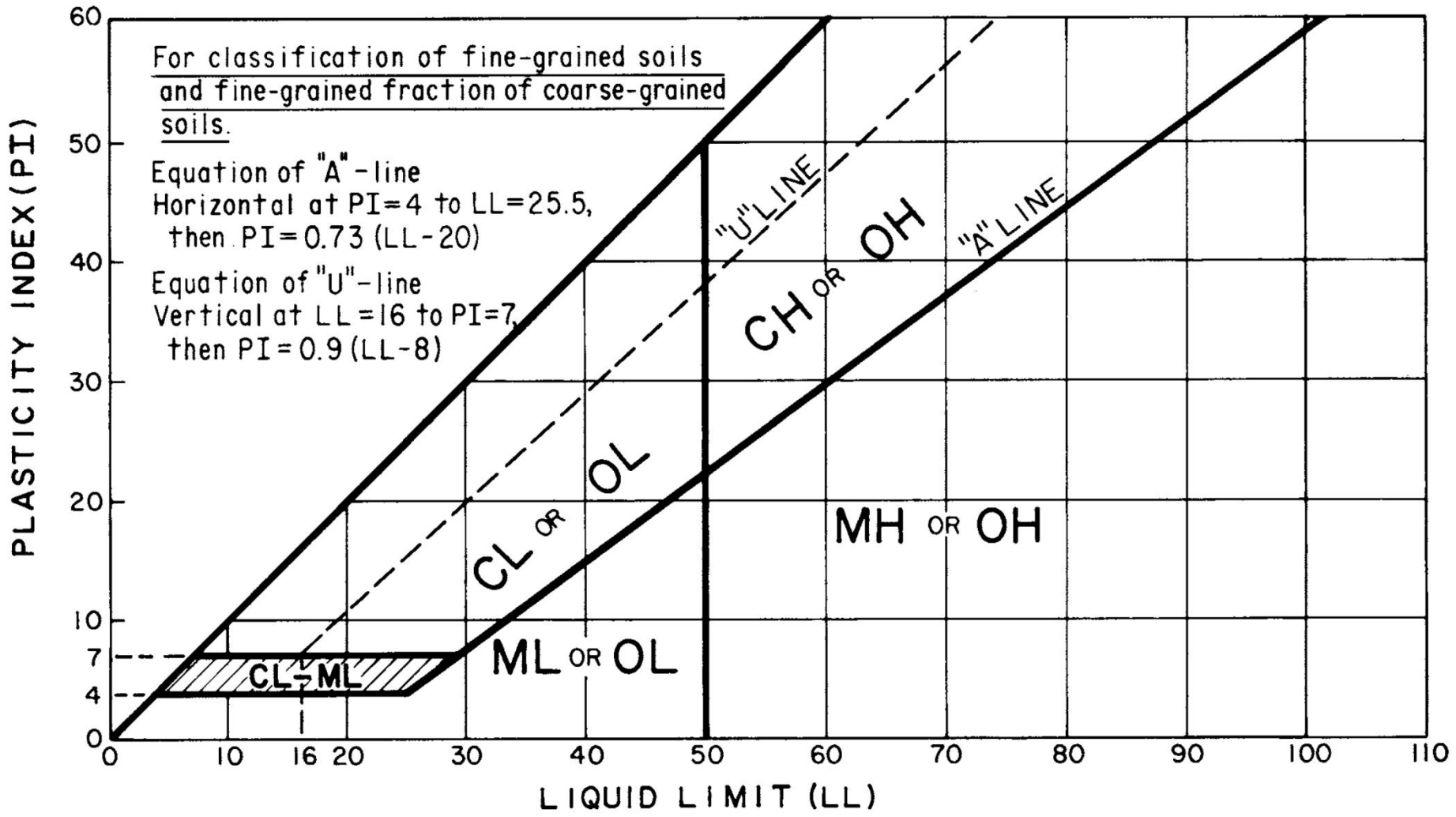


FIG. 4 Plasticity Chart

PLASTICITY/A-LINE CHART

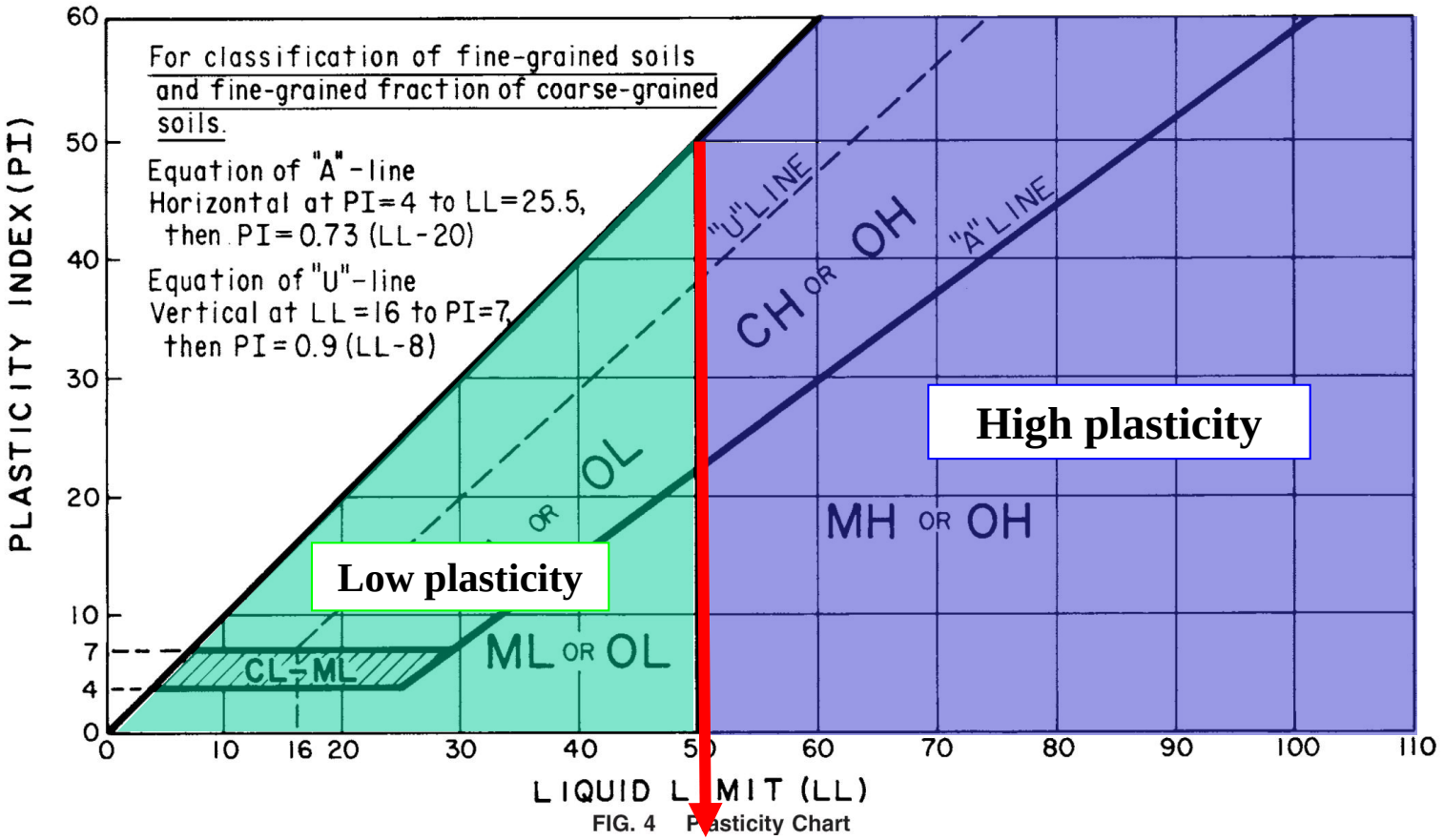


FIG. 4 Plasticity Chart

LL=50%

PLASTICITY/A-LINE CHART

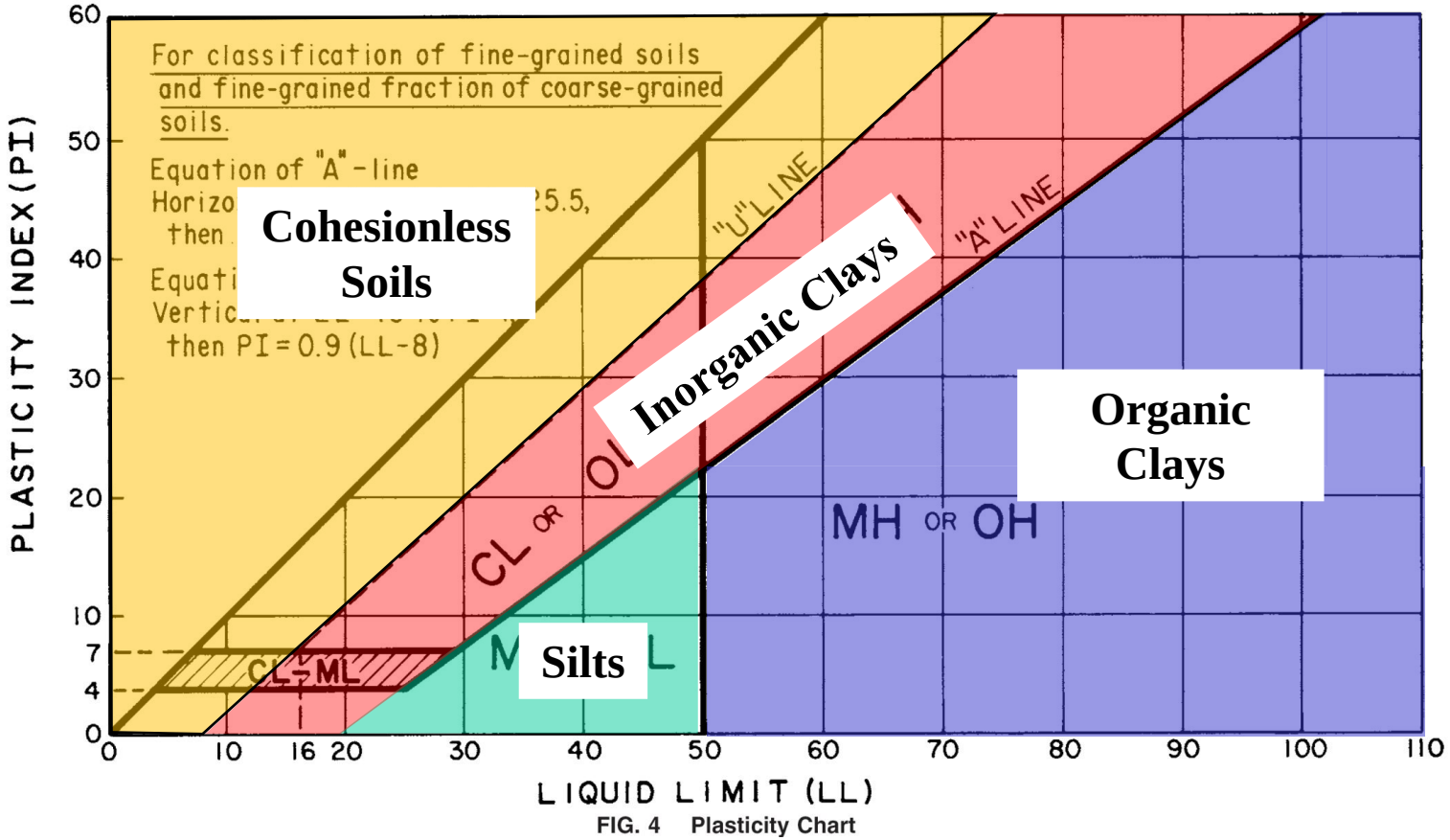


FIG. 4 Plasticity Chart

LIQUIDITY INDEX (I_L)

$$I_L = \frac{w_n - PL}{LL - PL}$$

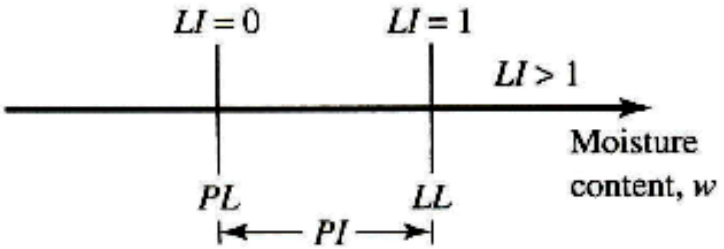
where,

I_L= Liquidity index

w_n= Natural moisture content

PL= Plastic limit moisture content

LL= Liquid limit moisture content



$0<I_L<1$ → Soil is in plastic state

$I_L < 0$ → Soil is in semi-plastic or solid state

$I_L > 1$ → Soil is in liquid state (quick clays or ultra sensitive clays)

TOUGHNESS INDEX (I_t)

$$I_t = \frac{Plasticity\ Index}{Flow\ Index} = \frac{PI}{I_F}$$

Soil Type	I_t
Clayey soils	0-3
Soils which are friable at plastic limit (e.g. Silts)	<1

Toughness index (I_t) is useful to distinguish between soils of different physical properties.

ACTIVITY, *A*

$$A = \frac{PI}{\%\,clay\ fraction\ smaller\ than < 0.002mm}$$

- Helpful to predict the *dominant clay type/mineral* in soil sample.

- *High activity* signifies *large volume change* when wetted and *large shrinkage* when dried.

Clay Type	Activity
Inactive Clays	< 0.75
Normal Clays	0.75 < A < 1.25
Active Clays	> 1.25

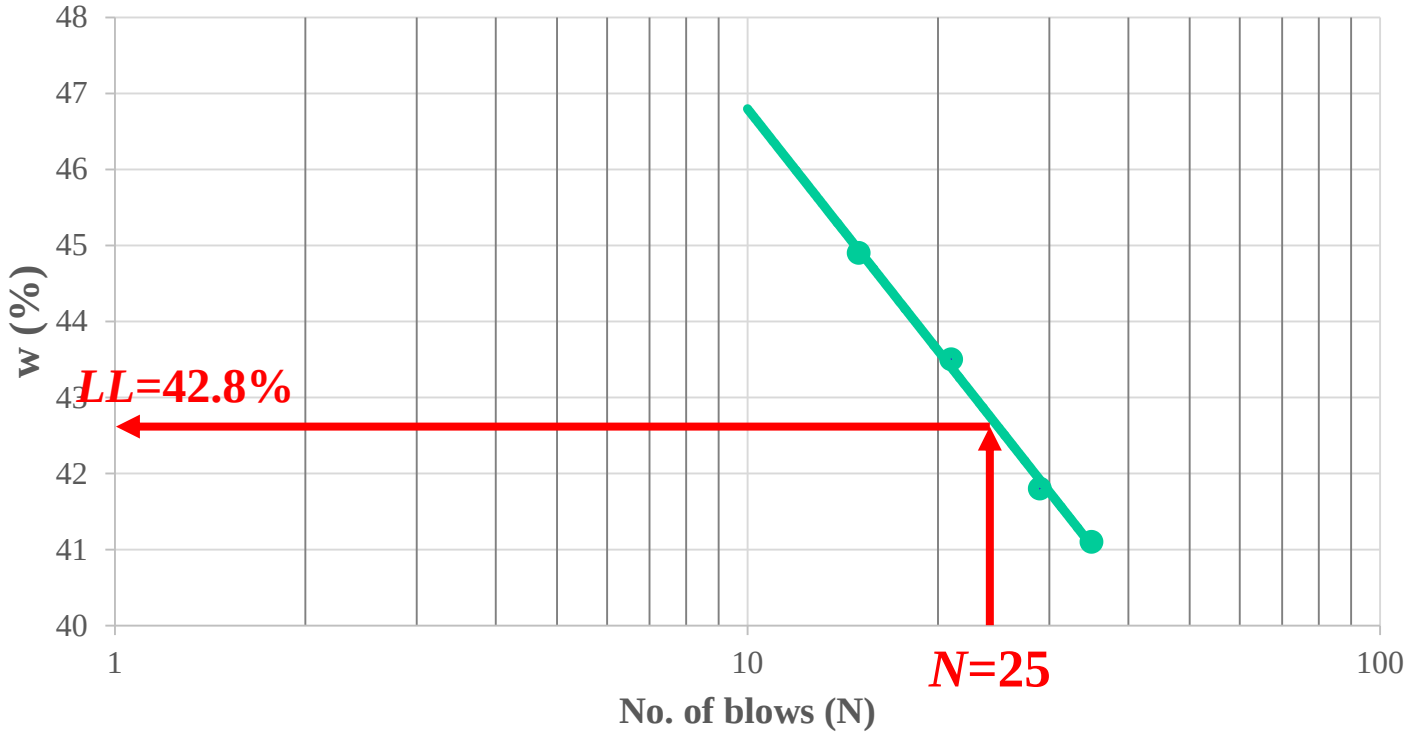
Practice Problem#1

The following data were recorded from a *LL* test on a silty clay;

No. of blows	Water content (%)
35	41.1
29	41.8
21	43.5
15	44.9

If *PL*=23.4%, determine *LL*, *flow index*, and the *toughness index*.

Practice Problem#1



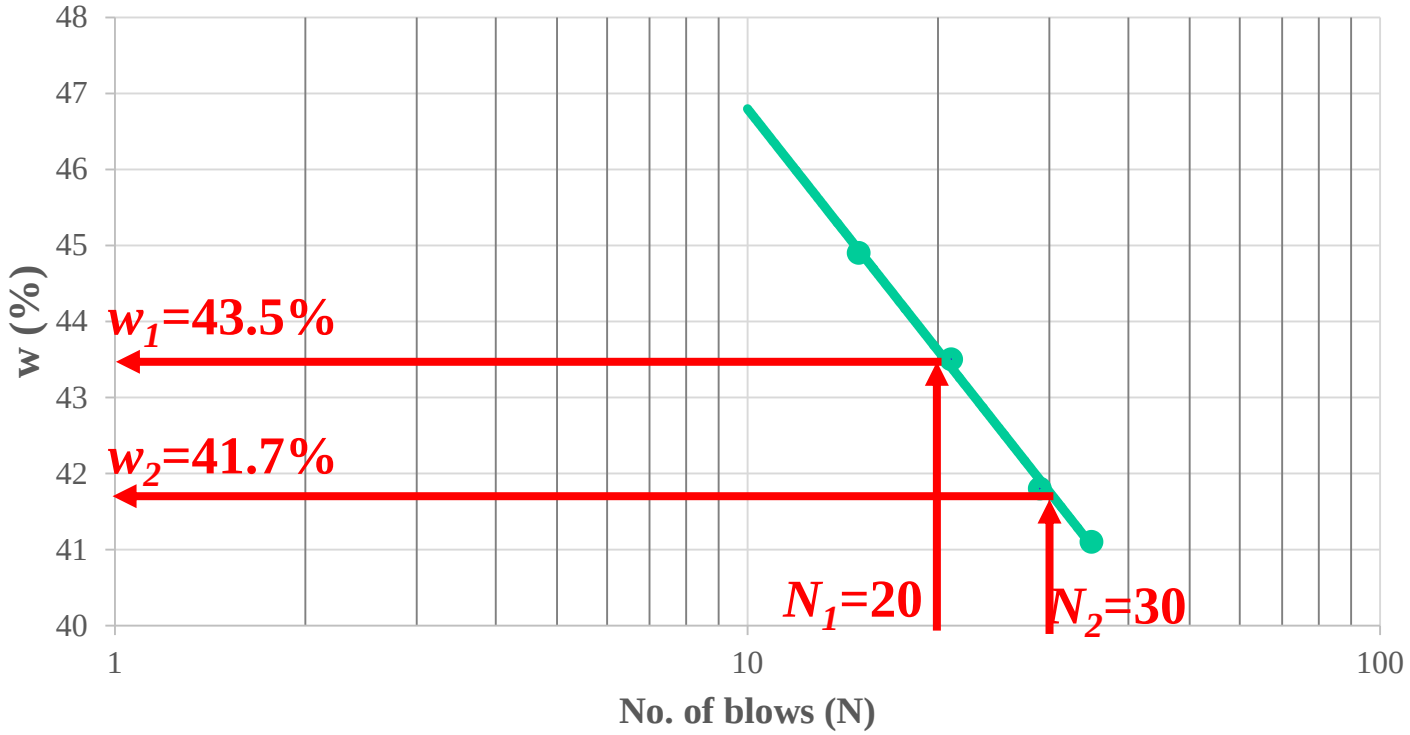
LL = 42.8%

PL = 23.4%

PI = 42.8-23.4

PI = 19.4%

Practice Problem#1



$$I_F = \frac{w_1 - w_2}{\log\left(\frac{N_2}{N_1}\right)} = \frac{43.5 - 41.7}{\log\left(\frac{30}{20}\right)}$$

I_F= 10.22

I_t= I_P/I_F

I_t=19.4/10.22

I_t=1.898

Practice Problem#2

Four different types of soil were encountered in a big project. Their LL, PL, and natural moisture content (NMC) are given below;

Type of Soil	Liquid Limit (%)	Plastic Limit (%)	NMC (%)
1	120	40	150
2	64	32	34
3	60	30	30
4	65	32	25

Determine liquidity index and comment on the state of soil in the field.

$$I_L = \frac{w_n - PL}{LL - PL}$$

Practice Problem#3

A soil specimen has liquidity index of 0.2, liquid limit of 56% and plasticity index of 20%. Determine the natural moisture content of this soil specimen.

Practice Problem#4

Liquid limit test carried out on two samples of clay resulted in the following information.

	Test #	1	2	3	4
Sample #1	w (%)	120	114	98	96
	No. of blows	7	10	30	40
Sample #2	w (%)	96	74	45	30
	No. of blows	9	15	32	46

PL for sample #1 is 40% and PL for sample is 32%. Determine the flow index and toughness index for two samples.

CONCLUDED