Engineering properties of soil comprises of physical properties

Soil engineers' calculations are necessary both for designing a foundation for a structure and for designing the structure itself. Soil engineers take borings and soil samples and investigate soil composition and grade, among other factors. This analysis is needed not only for buildings but also for bridges, levees, roads, and reservoirs.

A soil engineer's consultation may be sought when retrofitting an existing structure.

Engineering properties of soil comprises of physical properties, index properties, strength parameters (shear strength parameters), permeability characteristics, consolidation properties, modulus parameters, dynamic behavior etc.

Cohesion:

It is the internal molecular attraction which resists the rupture or shear of a material. Cohesion is derived in the fine grained soils from the water films which bind together the individual particles in the soil mass.

Cohesion is the property of the fine grained soil with particle size below 0.002 mm. cohesion of a soil decreases as the moisture content increases. Cohesion is greater in well compacted clays and it is independent of the external load applied.

Capillarity:

It is the ability of soil to transmit moisture in all directions regardless of any gravitational force. Water rises up through soil pores due to capillary attraction. The maximum theoretical height of capillary rise depends upon the pressure which tends to force the water into the soil, and this force increases as the size of the soil particles decreases.

Permeability:

Permeability of a soil is the rate at which water flows through it under action of hydraulic gradient. The passage of moisture through the inter-spaces or pores of the soil is called ‘percolation’. Soils having porous enough for percolation to occur are termed ‘pervious’ or ‘permeable’, while those which do not permit the passage of water are termed ‘impervious’ or ‘impermeable’. The rate of flow is directly proportional to the head of water.

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Permeability is a property of soil mass and not of individual particles. The permeability of cohesive soil is, in general, very small. Knowledge of permeability is required not only for seepage, drainage and ground water problems but also for the rate of settlement of structures on saturated soils

Soil permeability is a measure of how quickly water passes through a soil. This is important information for any engineering structure located on, in, or under the soil. The presence of water affects soil properties. Water passing into or through a soil will impact upon the soil strength and stresses.

Factors Affecting Permeability of Soil

There are several factors that affect the permeability of the soil including,

The permeability of soil is affected by several factors, including:

1. Soil particle size
2. Soil compaction
3. Soil structure
4. Soil moisture content
5. Soil type
6. Presence of organic matter
7. Degree of saturation
8. Depth of soil layer
9. Temperature
10. Type and amount of contaminants in soil.

The table below lists soils in order of reducing permeability (k, measured in m/sec)

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Soil type	Permeability k (m/sec)	Reducing permeability
Gravel	>0.1	↓
Sand	0.1 – 10^{-4}	
Silt	10^{-4} – 10^{-8}	
Clay	<10^{-8}	

Soil Consistency (Atterberg Limits):

When a clayey soil is mixed with an excessive amount of water, it may flow like a semiliquid. If the soil is gradually dried, it will behave like a plastic, semisolid, or solid material depending on its moisture content. The moisture content, in percent, at which the soil changes from a liquid to a plastic state, is defined as the liquid limit (LL).

Similarly, the moisture contents, in percent, at which the soil change from a plastic to a semisolid state and from a semisolid to a solid state are define as the plastic limit (PL) and the shrinkage limit (SL), respectively. Hence on an arbitrary basis, depending on the moisture content, the behavior of soil can be divided into the four basic states shown in Figure 1: solid, semisolid, plastic, and liquid.

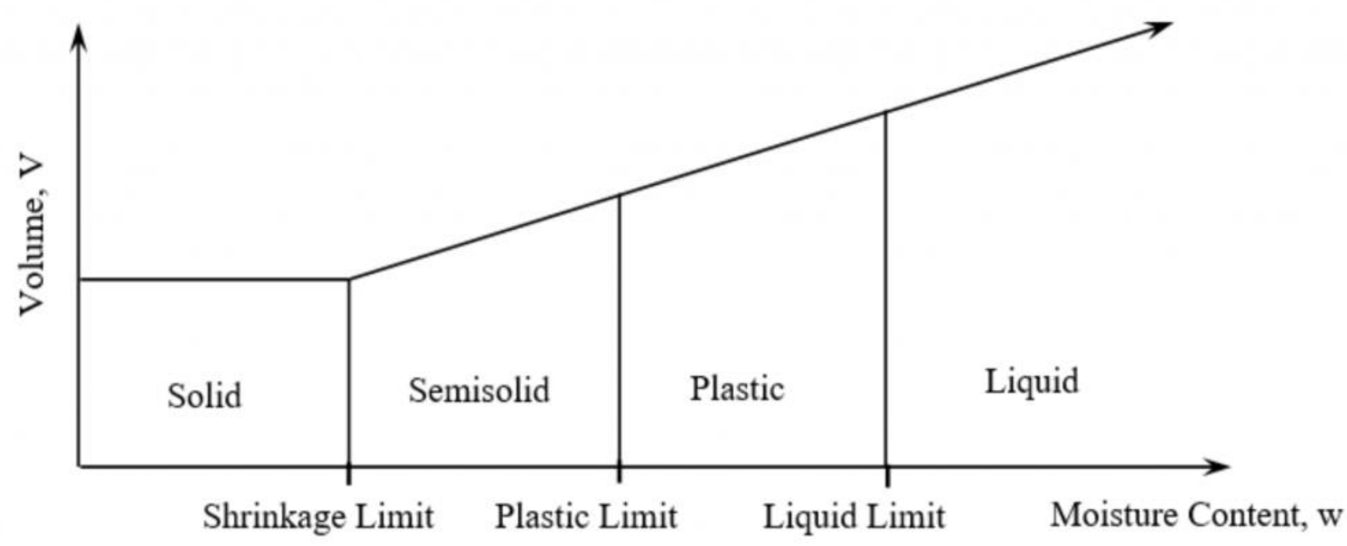


Figure 1 : Qualitative positions of Atterberg limits on a moisture content scale

The percent of moisture content at which the transition from solid to semi-solid state takes place is defined as the shrinkage limit (SL). The moisture content at the point of transition from semi-solid to plastic state is the plastic limit (PL), and from plastic to liquid state is the liquid limit (LL). These parameters are also known as Atterberg limits.

A. Plastic Limit(PL):

The plastic limit (PL) is the moisture content at which a soil transitions from being in a semisolid state to a plastic state.

B. Liquid Limit (LL) :

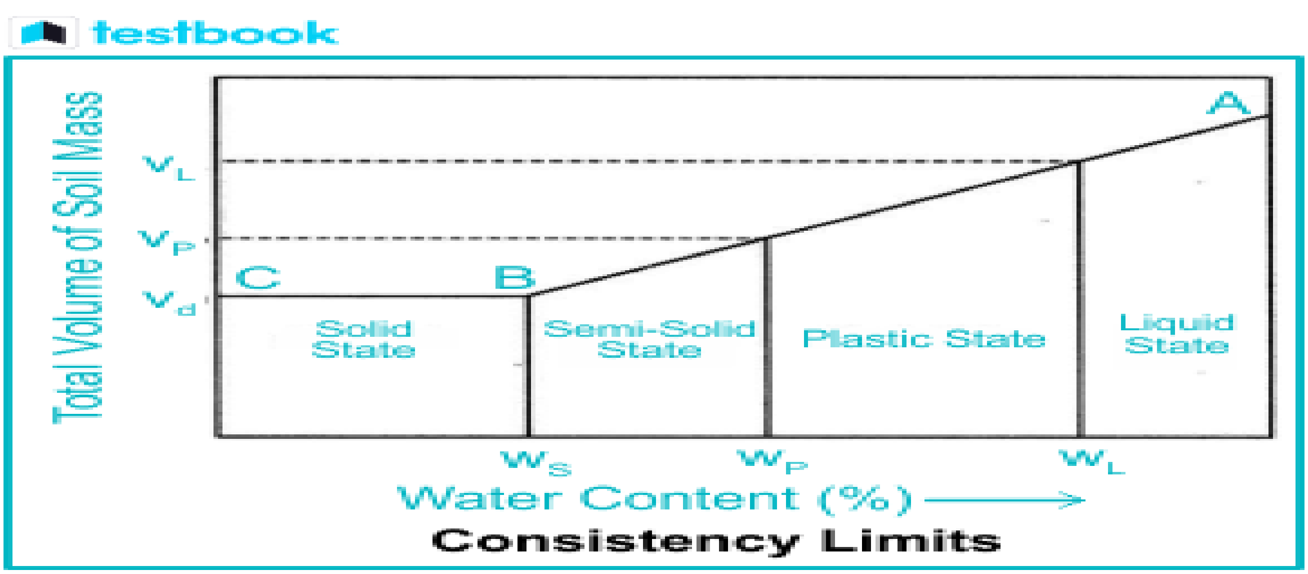
The liquid limit (LL) is defined as the moisture content at which a soil transitions from a plastic state to a liquid state.

C. Plasticity Index:

The plasticity index (PI) is defined as the difference between the liquid limit and the plastic limit of a soil

PI = LL − PL.

The PI represents the range of moisture contents within which the soil behaves as a plastic solid.



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PI Range	Description
0	Non plastic
1 – 5	Slightly Plastic
5 – 10	Low Plasticity
10 – 20	Medium Plasticity
20 – 40	High Plasticity
> 40	Very High Plasticity

The liquid limit, plastic limit, and shrinkage limit are extremely useful in correlating anticipated soil behavior with previous experience on soils in similar consistency states. Each limit represents a water content at which the soil changes from one state to another.

To solve for the plasticity index, use the following formula below:

$$PI = LL - PL$$

where: LL = Liquid limit = $39.5 PL$ = plastic limit = 19.2
Substitute the values in the given formula

$$PI = 39.5 - 19.2$$

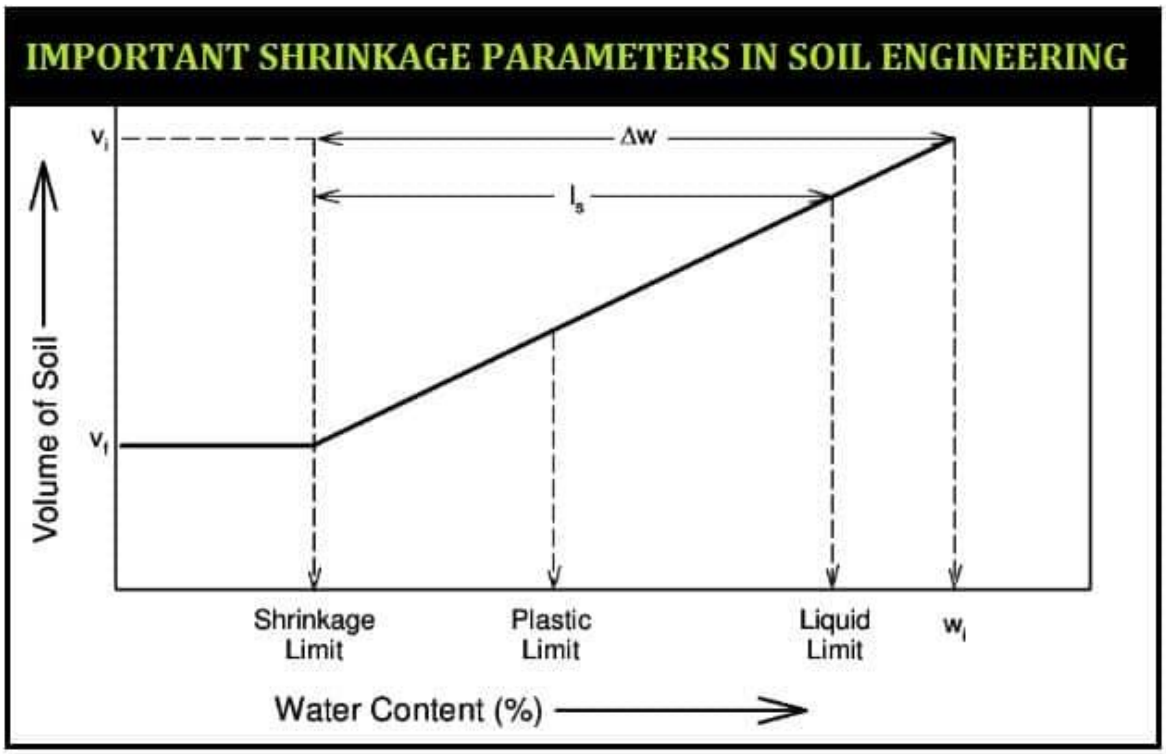
$$\boxed{PI = 20.3\%}$$

Shrinkage and Swell:

Certain soil types (highly plastic) have a large potential for volumetric change depending on the moisture content of the soil. These soils can shrink with decreasing moisture or swell with increasing moisture.

Shrinkage can cause soil to pull away from structure thus reducing the bearing area or causing settlement of the structure beyond that predicted by settlement analysis.

Swelling of the soil can cause an extra load to be applied to the structure that was not accounted for in design. Therefore, the potential for shrinkage and swelling should be determined for soils that have high plasticity.



Shrink–swell is the volume change that occurs as a result of changes in the moisture content of clay-rich soils. Swelling pressures can cause heave, or lifting of structures, whilst shrinkage can cause settlement or subsidence, which may be differential.

The shrinkage factor helps in the design problems of structure made up of this soil or resting on such soil. It helps in assessing the suitability of soil as a construction material in foundations, roads, embankments, and dams.