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HIGHWAY MATERIALS

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Highway Materials

Materials generally used in construction

- Materials for Foundation/Embankment/Sub grade: **Soil**
- Materials for base/ sub-base: Fine **aggregate** (sand), Coarse aggregates (Stone chips, gravel, brick chips).
- Binding Materials : Ordinary Portland cement, **Bitumen.**
- Reinforcing materials: MS Bar

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Basic Soil Properties

[affecting highway subgrades and structure foundations]

1. **Moisture Content.**

- is defined as the weight of water contained in a given soil mass compared with the oven-dry weight of the soil and is usually expressed as %.

2. **Specific Gravity.**

- The ratio of unit weight of soil particles to the unit weight of water.

3. **Unit Weight.**

- Is the weight of the soil mass per unit volume.

4. **Shearing Resistance.**

- Is attributed to the existence of 'internal friction' and 'cohesion'.

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Basic Soil Properties

[affecting highway subgrades and structure foundations]

5. Other Soil Properties:
   - Permeability
   - Capillarity
   - Shrinkage
   - Swelling
   - Compressibility
   - Elasticity

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Soil Gradation

Well-Graded Soils. A well-graded soil is defined as having a good representation of all particle sizes from the largest to the smallest and the shape of the grain-size distribution curve is considered "smooth."



Figure 4-6. Well-graded soil.

Poorly Graded Soils. The two types of poorly graded soils are-Uniformly graded and Gap-graded.

A *uniformly graded soil* consists primarily of particles of nearly the same size .

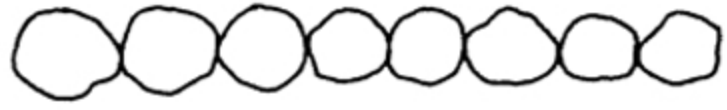


Figure 4-7. Uniformly graded soil.

A gap-graded soil contains both large and small particles, but the gradation continuity is broken by the absence of some particle sizes .



Figure 4-8. Gap-graded soil.

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Grain Size Distribution Curve

- The following figure shows typical examples of well-graded and poorly graded sands and gravels.
- Well-graded soils ((GW) and (SW) curves) would be represented by a long curve spanning a wide range of sizes with a constant or gently varying slope.
- Uniformly graded soils ((SP) curve) would be represented by a steeply sloping curve spanning a narrow range of sizes;
- the curve for a gap-graded soil ((GP) curve) flattens out in the area of the grain-size deficiency.

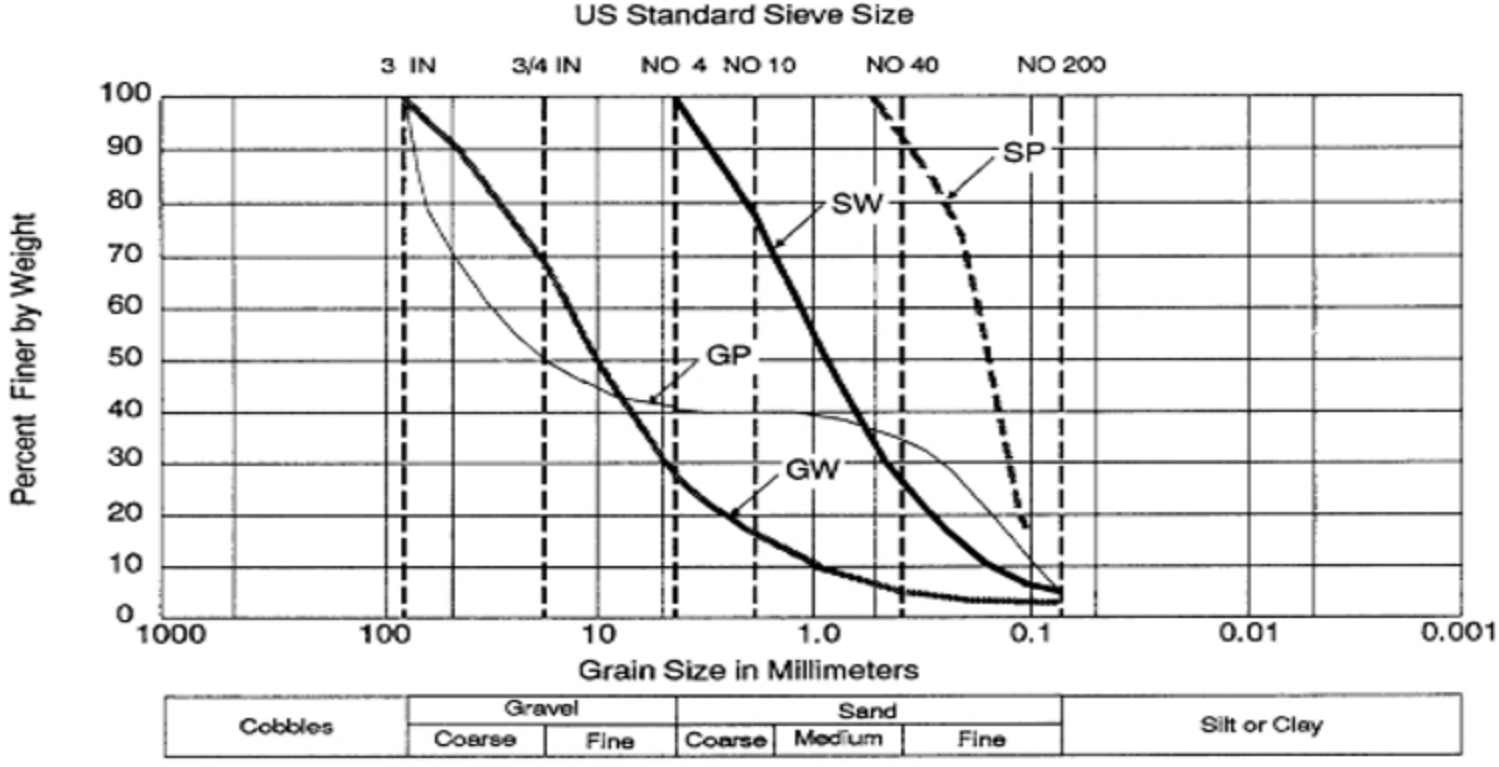


Figure 4-9. Typical grain-size distribution curves for well-graded and poorly graded soils.

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Soil Classification for Highway Purposes

Objective:

- To be able to predict sub grade performance of a given soil on the basis of a few simple tests performed on the soil in a disturbed condition.
- On the basis of these test results and their correlation with field experience, the soil may be correctly identified and placed into a group of soils, all of which have similar characteristics and properties.

Soil Classification for Highway Purposes

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Principal tests are:

- **Mechanical analysis:** This is performed on the entire sample and objective is to determine the proportion of particles of various sizes in the given soil.
- **Routine laboratory tests:** These are performed on the 'soil binder' or fraction passing a No. 40 sieve. Important routine tests are the Atterberg limits, i.e. liquid limit, plastic limit, shrinkage limit, plasticity index etc.

The **Hydrometer Analysis** determines particle size and distribution by measuring the change in fluid density with time of a soil/water suspension in a column. It is used mainly for fine-grained soil and is a convenient way to determine the percent of clay in a sample.

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Soil Classification for Highway Purposes

Mechanical Analysis

- Sieve analysis is done to separate ***soil*** (soils that contain little or no fines, such as clean sand or a soil that may readily be separated from the coarser particles) into its fractions .
- If fine material adheres to the coarser particles and is not removed by drying sieving action, the sample is pre-washed and fine material removed.
- Material that is retained on the no. 200 sieve during the washing process is then dried and subjected to sieving as before. This is called ‘ wet sieve analysis’.
- The practical lower limit for the use of sieves is the No. 200 sieve, which has openings 0.074 mm square.

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Atterberg Limit

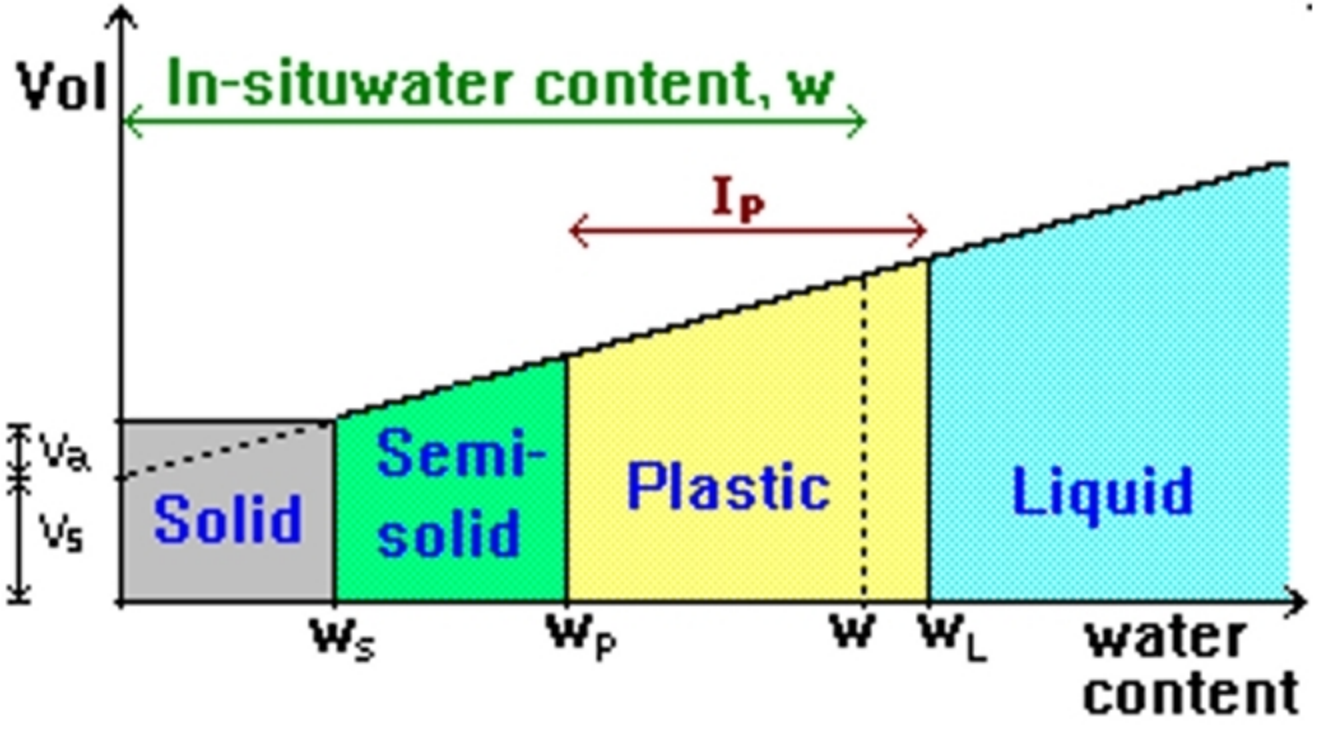
Consistency [stability/regularity] varies with the water content of the soil. The consistency of a soil can range from (dry) *solid* to *semi-solid* to *plastic* to *liquid* (wet). The water contents at which the Consistency changes from one state to the next are called **consistency limits** (or **Atterberg limits**).

Liquid Limit: It is the minimum moisture content at which the soil will flow under the application of a very small shear force. At this , the soil is assumed to behave practically as liquid

Plasticity Limit: It is the minimum moisture content at which the soil remains in a plastic condition.

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Atterberg Limit

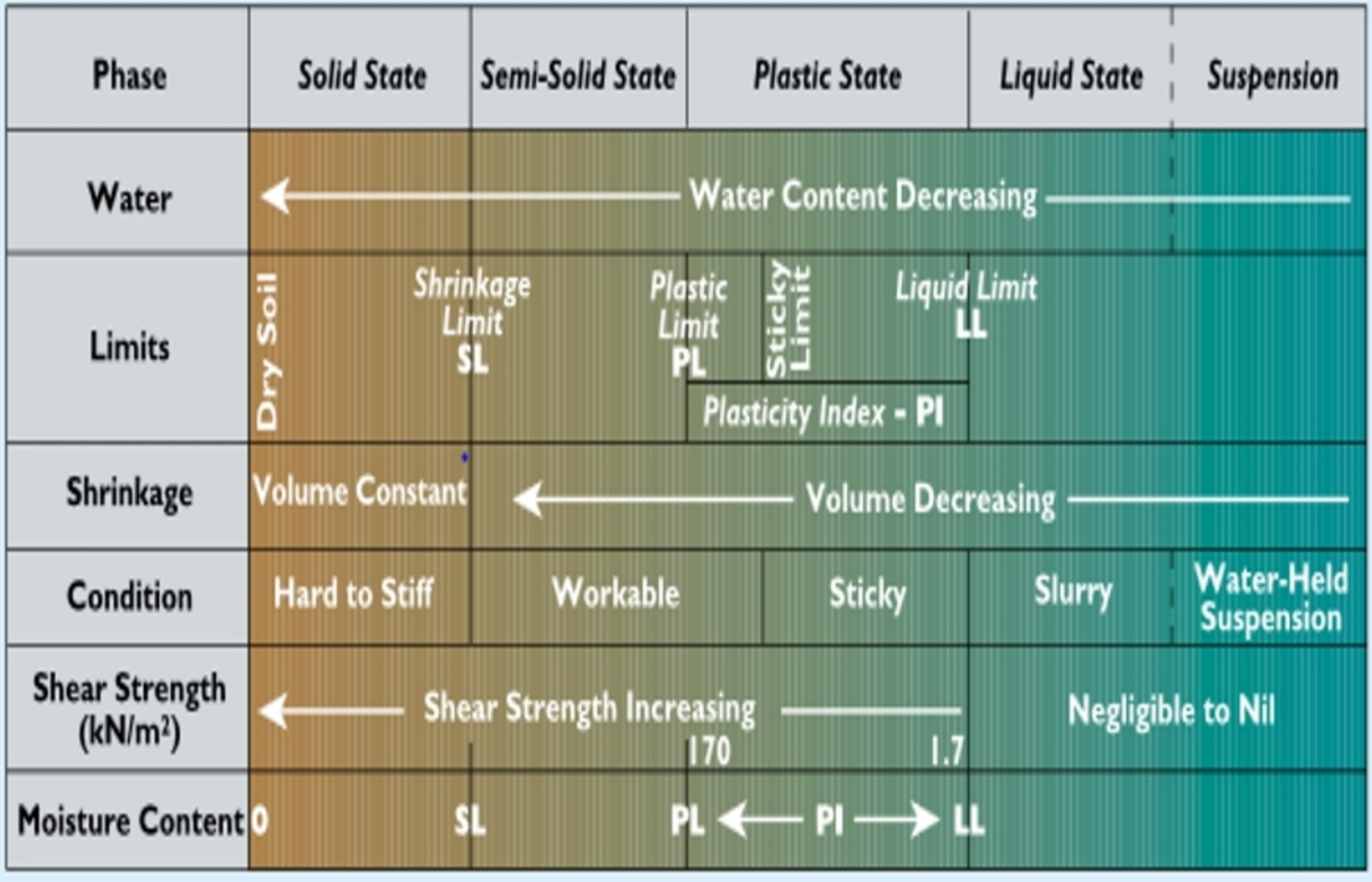


Plasticity Index: It is the numerical difference between the liquid and plastic limit. It indicates the range of moisture content over which the soil is in a plastic condition.

$$I_P = \text{liquid limit} - \text{plastic limit} = w_L - w_P$$

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Phases of Soil and the Atterberg Limits



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Soil Classification for Highway Purposes

1. AASHTO Classification System.

2. Unified Soil Classification System.

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MOISTURE DENSITY RELATIONSHIPS

Introduction:

In the construction of highway embankments, earth dams, and many other engineering projects, loose soils must be compacted to increase their unit weight.

Compaction improves characteristics of soils:

1- Increases Strength
2- Decreases permeability
3- Reduces settlement of foundation
4- Increases slope stability of embankments

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MOISTURE DENSITY RELATIONSHIPS

General Principles:

** The degree of compaction of soil is measured by its unit weight, , and optimum moisture content, w_c.*

** The process of soil compaction is simply expelling the air from the voids or reducing air voids*

** Reducing the water from the voids means consolidation.*