

Soil Mechanics Fundamentals

Soil Mechanics Fundamentals – Study Notes

1. Introduction to Soil Mechanics

Concept	Description
Soil	A natural, unconsolidated material composed of mineral particles, organic matter, water, and air.
Soil Mechanics	Branch of civil engineering that studies the behavior of soil under various loading conditions and its interaction with structures.
Why It Matters	Determines bearing capacity, settlement, stability of foundations, slopes, and earth-retaining structures.

2. Soil Classification

Classification System	Main Criteria	Typical Uses
Unified Soil Classification System (USCS)	Grain size, plasticity, and behavior	Geotechnical reports, design of foundations, embankments
AASHTO Soil Classification	Grain size & plasticity (for highways)	Road and pavement design
ASTM Soil Classification	Similar to USCS, with additional specifications	Laboratory testing standards

2.1 Grain Size Distribution

- **Sieve analysis** – for particles $> 0.075\text{ mm}$ (coarse fraction).
- **Hydrometer or pipette analysis** – for particles $\leq 0.075\text{ mm}$ (fine fraction).

Key parameters

- D_{10} , D_{30} , D_{60} – particle diameters at 10%, 30%, 60% passing.
- **Coefficient of Uniformity (C_u)** = D_{60} / D_{10} .
- **Coefficient of Curvature (C_c)** = $(D_{30})^2 / (D_{10} \cdot D_{60})$.

Soil Mechanics Fundamentals

Soil type	Cu	Cc
Well-graded sand/gravel	>4 (sand) / >6 (gravel)	1–3
Poorly graded (uniform)	<4 (sand) / <6 (gravel)	–
Silts & clays	–	–

2.2 Atterberg Limits (Fine-grained soils)

Limit	Definition	Typical Range
Liquid Limit (LL)	Moisture content at which soil changes from plastic to liquid behavior.	20–80%
Plastic Limit (PL)	Moisture content at which soil changes from semi-solid to plastic.	5–30%
Plasticity Index (PI)	$PI = LL - PL$; measures plasticity.	0–50%
Shrinkage Limit (SL)	Moisture content below which volume no longer changes on drying.	0–15%

Interpretation

- $PI < 7$? non-plastic (silt).
- $PI > 7$? plastic (clay).
- High LL & PI ? highly compressible, low shear strength.

3. Soil Properties

Property	Symbol	Units	Typical Test
Unit Weight (γ)	$\gamma = w / V$	kN/m ³	Moisture-density (Proctor) test
Specific Gravity (G_s)	–	–	Pycnometer test
Porosity (n)	$n = V_v / V_t$	%	Derived from γ and G_s
Void Ratio (e)	$e = V_v / V_s$	–	$e = n / (1 - n)$

**Water Content (w)