Engineering Properties of Soils

Soil and Soil Engineering

*** The term Soil has various meanings depending upon the general field in which it is being considered.**

***To a Pedologist (agricultural soil scientist)... Soil is the substance existing on the earth's surface, which grows and develops crops (plant life).**

***To a Geologist ..... Soil is the material in the thin surface zone within which roots occur, and all the rest of the earth's crust is termed ROCK irrespective of its hardness.**

***To an Engineer .... Soil is the un-cemented deposits of mineral and/or organic particles or fragments covering large portion of the earth's crust.**

Soil Materials

*** Soil material is the product of rock**

*** The geological process that produces soil is called WEATHERING**

*** Variation in Particle size and shape depends on:**

- Weathering & Transportation Process

*** Transportation and Deposition**

Four forces that cause the transportation and deposition of soils :

1- Water ------- Alluvial Soil
2- Ice ---------- Glacial Soils
3- Wind -------- Aeolin Soils
4- Gravity ----- Colluvial Soil

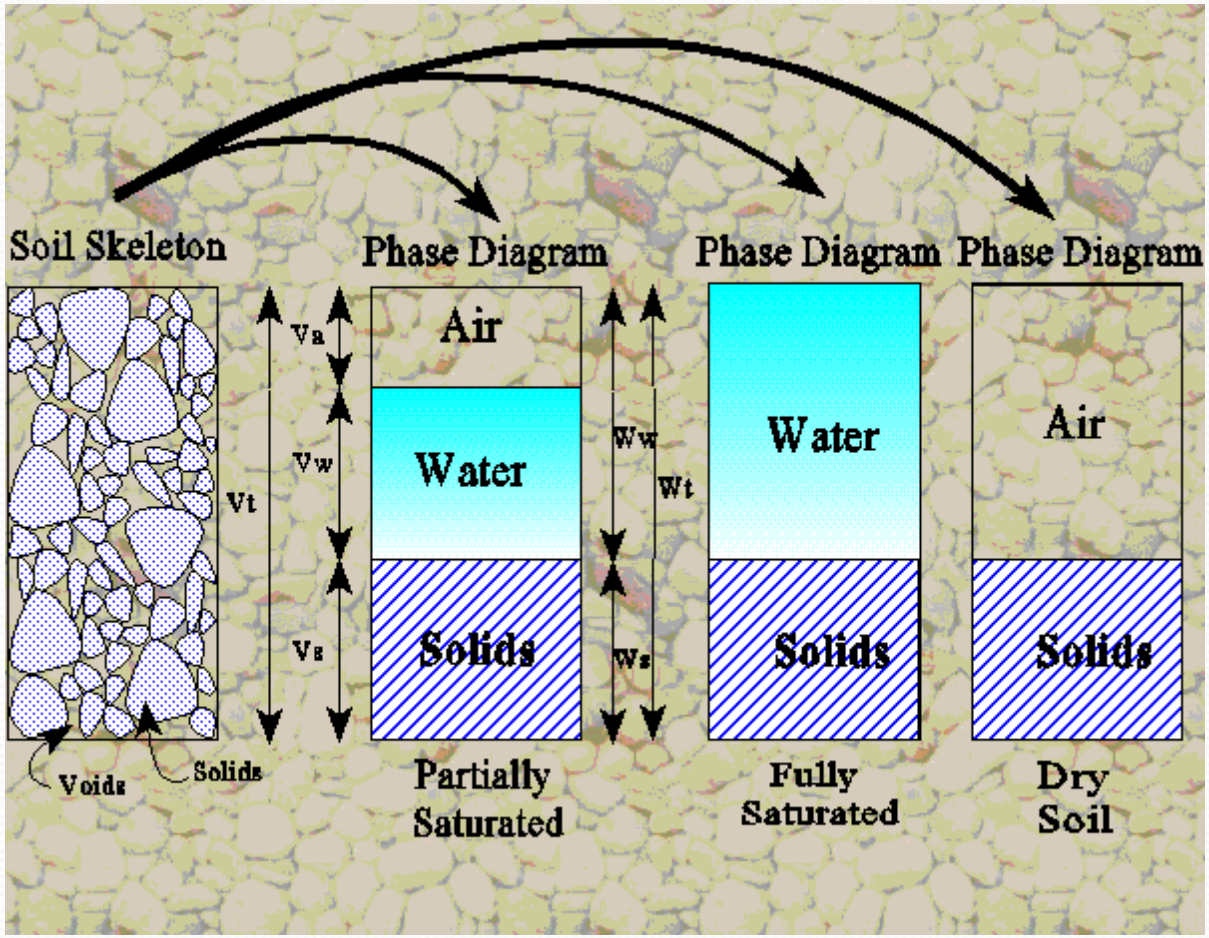
Soil Component Types

- **- Boulders**
- **- Gravel**
- **- Sand**
- **- Silt**
- **- Clay**
- **-Organics**

Soil Phases: Moisture Condition

- Dry
- Saturated
  - Fully Saturated
  - Partially Saturated
- Submerged

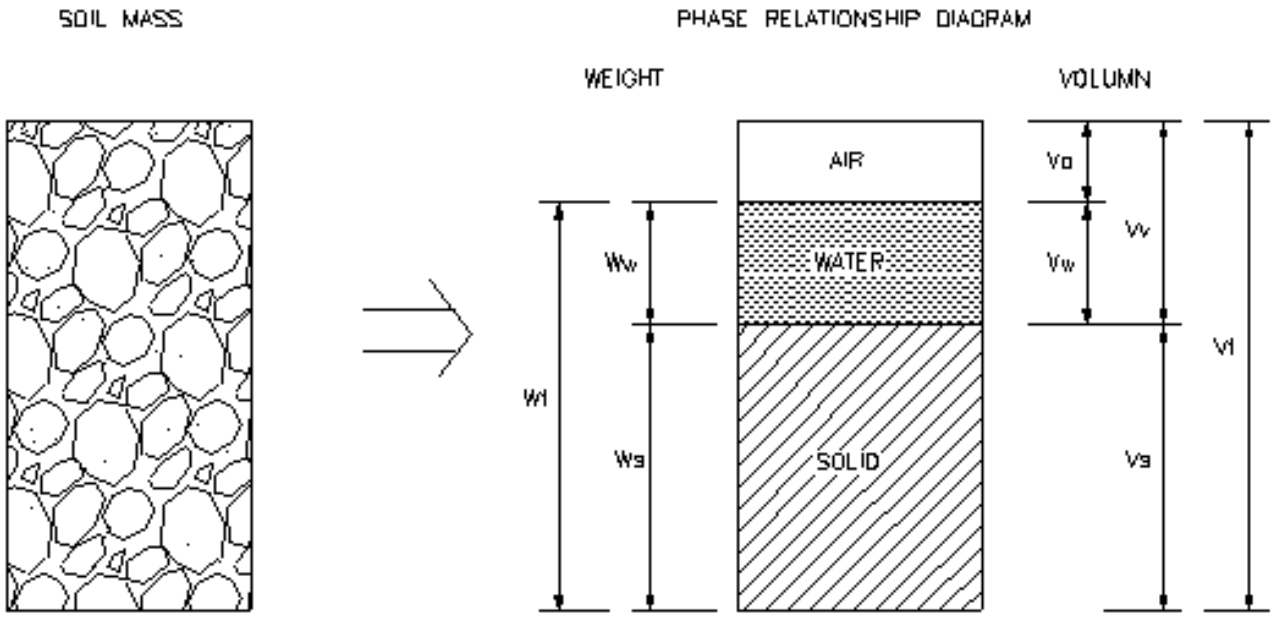
Graphical Representation of Soil Phases:



- Soils are made of a combination of dissimilar materials – solids, liquid, gas
- Strength & behavior is a function of the interaction the components!
- How MUCH of each component matters.

The Phase Diagram

- Solid
- Water
- Air



- If we determine the proportions of the components, we can calculate MANY other properties of the soil!

Basic Relationships for Calculating Phase Diagram Components

- **Weight --Wt = Ww + Ws**
- **Volume --Vt = Vv + Vs = Va + Vw + Vs**
- **Unit Weight (Density)**

$$\gamma_{soil} = \frac{Total\ Weight}{Total\ Volume} = \frac{W_t}{V_t}$$

- **This is also known as (same thing by different names)**
  - **Bulk Density**
  - **Soil Density**
  - **Unit Weight**
  - **Wet Density**

Properties We Can Calculate ONCE WE KNOW Volume & Mass of Components:

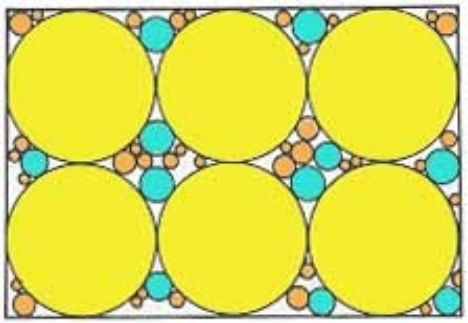
$$\text{Degree of Saturation} = S_r = \frac{\text{Volume of Water}}{\text{Volume of Voids}} = \frac{V_w}{V_v}$$

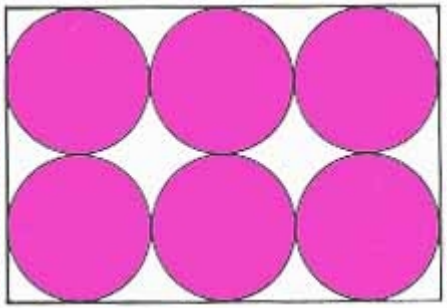
- The degree of saturation can range between zero for a completely dry soil, and 1 for a fully saturated soil.
- Degree of Saturation effects:
  - strength of soil
  - compressibility
  - flow & transport of fluids in soil

Soil Porosity

- Amount of void space between soil particles.
- *Infiltration* (groundwater movement) and water storage occur in these void spaces.
- The porosity of soil is the ratio of the volume of pore space to the total volume of material.

$$Porosity = n = \frac{Volume\ of\ Voids}{Total\ Volume} = \frac{V_v}{V_t}\ x\ 100\%$$





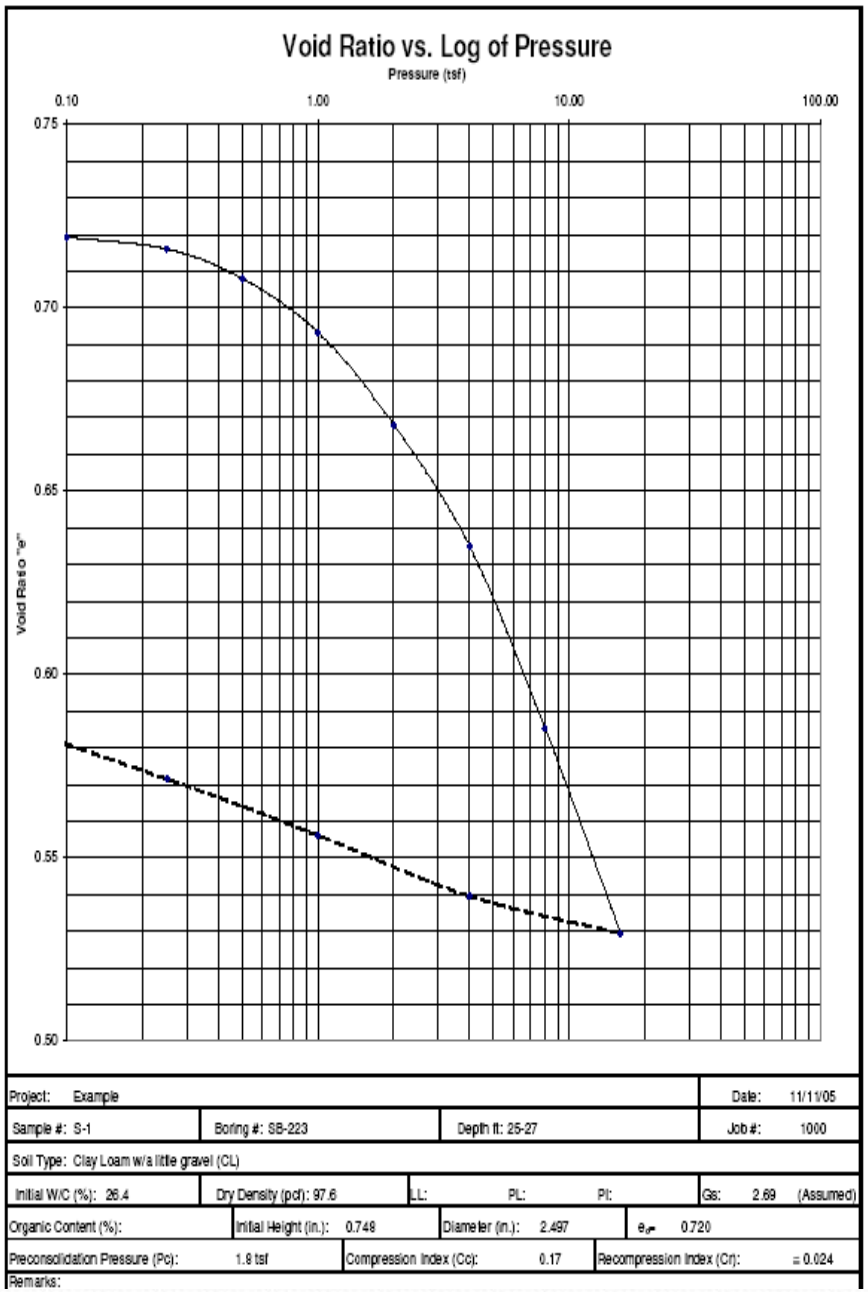
Void Ratio

$$\text{Void Ratio} = e = \frac{\text{Volume of Voids}}{\text{Volume of Solids}} = \frac{V_v}{V_s}$$

- Represents denseness of the soil mass
  (ratio of voids vs. solids)

- Obviously, effects permeability & strength

Void Ratio vs. Bearing Pressure



Other Weight-Volume Relationships For Solving Phase Diagrams

Total (moist) Unit Weight $\gamma_t = \frac{W_{total}}{V_{total}}$

Dry Unit Weight $\gamma_d = \frac{W_{solids}}{V_{total}}$

Solid Unit Weight $\gamma_s = \frac{W_{solids}}{V_{solids}}$

Other Weight-Volume Relationships For Solving Phase Diagrams

Specific Gravity SG = $\gamma_{solids} / \gamma_{water}$

;where water = 62.4 lbs/ft^3

Moisture Content $$w = \frac{W_{water}}{W_{solids}} \times 100\%$$

LET'S WORK AN EXAMPLE OF DEVELOPING A PHASE DIAGRAM!!