

SOILS (06)

I Main Topics

- A Pedologic classification schemes
- B Engineering classification schemes
- C Properties of engineering soils
- D Effective stress, pore pressure, and total stress
- E Consolidation

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II Pedologic classification schemes

- A Soils: the part of the regolith that can support rooted plants
 - 1 Soils contain organic material
 - 2 Factors influencing soil development (Hans Jenny)
 - a Climate
 - b Organic factors
 - c Topography
 - d Parent material
 - e Time (soils in many ways are non-renewable)

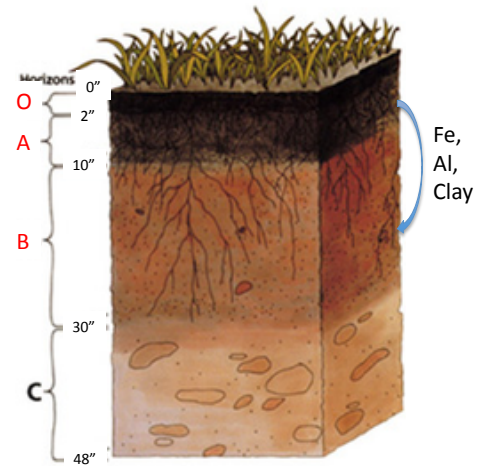
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II Pedologic classification schemes

- B Master soil horizons
- 1 O horizon (surface accumulation of organic material)
 - 2 A horizon (mixture of organic material and mineral soil)
 - a Zone of clay loss and leaching of iron and aluminum
 - b Moderately dark color
 - 3 E horizon (not present in many places)
 - a Less organic material than A (so lighter color)
 - b Less iron, aluminum, and clay than B
 - 4 B horizon
 - a Zone of clay accumulation, ped development
 - b Clay can develop in place or be transported in
 - c Red color (iron and aluminum accumulation)
 - d Concentration of insoluble elements



<http://en.wikipedia.org/wiki/Soil>

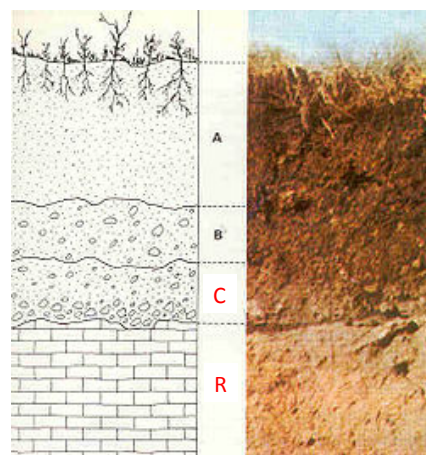
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II Pedologic classification schemes

- 5 C horizon
(heterogeneous zone of weathered rock; saprolite; difficult to drill)
- 6 K horizon (Carbonate horizon; not present everywhere)
- 7 R horizon (bedrock)



<http://en.wikipedia.org/wiki/Soil>

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III Engineering classification schemes

- A Rock: requires blasting or heavy earth-moving equipment
- B Soils: can excavate by hand or with light earth-moving equipment
- C Soils as solid particles and fluid-filled voids (multiphase system)

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IV Properties of engineering soils

Particle	Grain size	Comments
Gravel	> 2 mm	Used for concrete.
Sand	1/16 mm – 2 mm	Visible to unaided eye
Silt	1/256 mm – 1/16 mm	Not visible to unaided eye Gritty Washes off fingers easily Can fracture and collapse Consists mostly of quartz and feldspar
Clay	< 1/256 mm	Not visible to unaided eye Gives soil cohesion Sticks to fingers when wet Beware quick clays and expansive clays (montmorillonite or sodium bentonite; from weathered volcanic ash)

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Qualitative Behavior of Soil Types

Property/behavior	Sand	Silt	Clay
Water-holding capacity	Low	Medium to high	High
Aeration	Good	Medium	Poor
Drainage rate	High	Slow to medium	Very slow
Soil organic matter level	Low	Medium to high	High to medium
Decomposition of organic matter	Rapid	Medium	Slow
Warm-up in spring	Rapid	Moderate	Slow
Compactability	Low	Medium	High
Susceptibility to wind erosion	Moderate (high if fine sand)	High	Low
Susceptibility to water erosion		High	Low
Shrink/swell potential	Very low	Low	Moderate to very high
Sealing of ponds, dams, and landfills (i.e., permeability)	Poor	Poor	Good
Suitability for tillage after rain	Good	Medium	Poor
Pollutant leaching potential	High	Medium	Low (unless cracked)
Ability to store plant nutrients	Poor	Medium to high	High
Resistance to pH change	Low	Medium	High

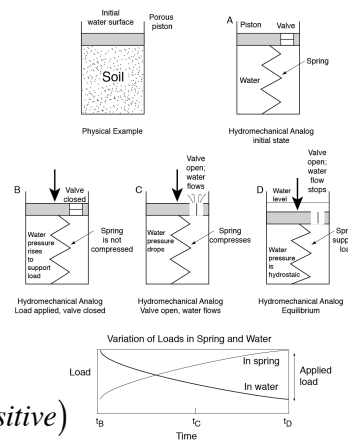
<http://en.wikipedia.org/wiki/Soil>

V Effective stress, pore pressure, and total stress

- Effective stress:** normal stress load born by the solid skeleton
- Pore pressure:** normal stress load born by the pore fluid (P)
- Total stress:** effective stress + normal stress

$$\sigma_{Effective} = \sigma_{Total} - P \text{ (compression positive)}$$

Hydromechanical Analog for Consolidation (from Lambe and Whitman, 1969)



VI Consolidation (in Geotechnical Engineering)

- A Consolidation: volume loss due to loss of fluid volume
- B Compaction: volume loss due to loss of gas (air) volume using mechanical devices
- C In soil science, compaction means engineering consolidation and compaction together

Sheepsfoot Roller



Vibratory Rammer



http://en.wikipedia.org/wiki/Soil_compaction

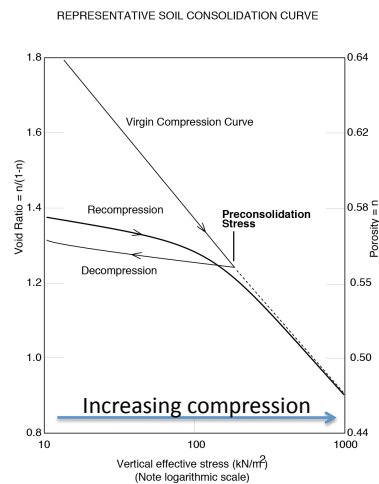
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VI Consolidation (in Geotechnical Engineering)

- D During consolidation porosity (void ratio) and water content decrease and strength increases
- E Usually soil strength increases with consolidation and depth
- F Time for consolidation primarily controlled by the time it takes water to flow from material
 - 1 Soil memory and pre-consolidation stress (maximum vertical compressive stress experienced in the past)
 - 2 Mechanical behavior of an unconsolidated material depends on its loading history



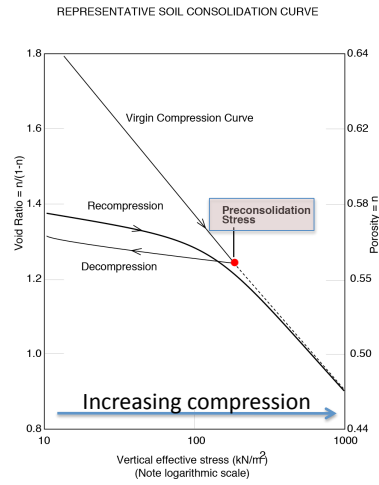
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VI Consolidation (in Geotechnical Engineering)

G Normally consolidated soil: soil consolidated by a load equivalent to that of the existing overburden



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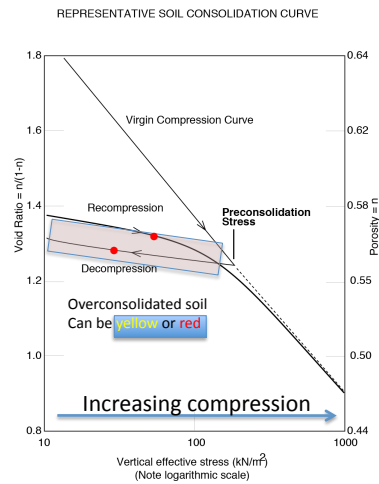
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VI Consolidation (in Geotechnical Engineering)

H Overconsolidated soil

- 1 Definition: soil that has experienced a larger vertical effective compressive stress in the past that it does now
- 2 Possible causes
 - a Extensive erosion or excavation that lowers the ground surface
 - b Past loading from a glacier or former structure (e.g., a storage tank)
 - c Recent elevation of ground water table, increasing pore pressure and decreasing effective stress
 - d Past desiccation, past absorption of water by plant roots, or past chemistry changes that produced negative pore pressure in the soil
- 3 Generally good (soil is relatively strong)

$$\sigma_{\text{Effective}} = \sigma_{\text{Total}} - P \text{ (compression positive)}$$



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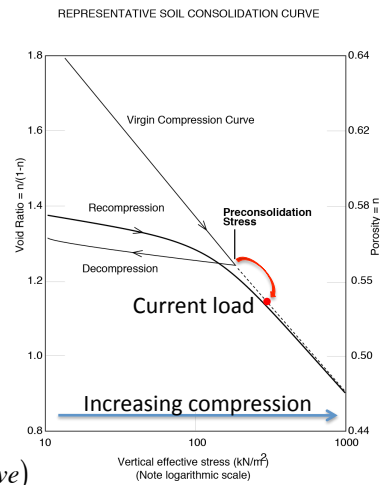
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VI Consolidation (in Geotechnical Engineering)

- 1 Underconsolidated soil: consolidated by a previous load less than of the existing overburden
- 2 Soil is still consolidating
- 3 Possible cause:
Very recent loading
- 4 Soil is susceptible to relatively large deformation and can distress structures built on it

$$\sigma_{Effective} = \sigma_{Total} - P \text{ (compression positive)}$$



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