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

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)
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

C  (heterogeneous zone of weathered rock; saprolite; difficult to drill)

K  (Carbonate horizon; not present everywhere)

R  (bedrock)
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)

IV Properties of engineering soils

<table>
<thead>
<tr>
<th>Particle</th>
<th>Grain size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>&gt; 2 mm</td>
<td>Used for concrete.</td>
</tr>
<tr>
<td>Sand</td>
<td>1/16 mm – 2 mm</td>
<td>Visible to unaided eye</td>
</tr>
</tbody>
</table>
| 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) |
Qualitative Behavior of Soil Types

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


V. Effective stress, pore pressure, and total stress

1. **Effective stress**: normal stress load born by the solid skeleton
2. **Pore pressure**: normal stress load born by the pore fluid \((P)\)
3. **Total stress**: effective stress + normal stress

\[
\sigma_{\text{Effective}} = \sigma_{\text{Total}} - P \quad \text{(compression positive)}
\]
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

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
VI Consolidation (in Geotechnical Engineering)

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

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)

$$\sigma_{\text{Effective}} = \sigma_{\text{Total}} - P \ (\text{compression positive})$$
VI Consolidation (in Geotechnical Engineering)

1. Underconsolidated soil: consolidated by a previous load less than or equal to 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.

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