Geotechnical Engineering I

Dr. Naser A. Al-Shayea
Professor, CE, KFUPM

Assemblage of Particles

- Assemblage of mineral particles + water + air
  (solid) (liquid) (Air)
  - mineral particles (diff. sizes)
  - vs. organic matters

- Fig. 1.4 Three phases of an element of natural soil
  - Voids are continuous → water movement
  - Water dissolved salts and carry solutions
  - Dry → No water → No pore fluid
  - Saturated → No air
  - **Compaction**: reduces air by packing soil particles

- Porosity
- Void ratio
- Density
- Phase relationships
- Rock fragments > 1 mm
- Mineral grains (2 mm – 1 μm)
- Ex. Sand - quartz mineral

- Organic matters
  - plant / animal remains
  - microbial activity
  - humus : mixture of organic compounds
  - peat: organic soil, prolonged periods of match development.

Clay Minerals

- Thickness of single water layer = 2.9 A^o
- Kaolinite 7.2 A^o
- head
- Halloysite 10.1 A^o $\rightarrow$ 7.2 A^o
- Montmorillonite 9.6 A^o $\rightarrow$ ∞
- Illite 10 A^o
- Vermiculite 10 to 14 A^o

Clay Minerals

- Weathering of feldspar + mica
- Small particle size $\rightarrow$ large surface area per unit mass
- Have residual (-ve) charge
- Plastic behavior

- Groups
  - kaolinite
  - montmorillonite
  - illite
  - palygorskite
  - chlorite
  - vermiculite
  - Halloysite

- Clay layer-lattice structure (layer silicates)
  - understand properties

Clay Minerals- structure

- Tetrahedral **unit**
- Octahedral **unit**

- **T.** 4 oxygen (or hydroxyls) enclosing a silicon atom
  - Combine into a **sheet** structure
  - Each oxygen in the base is shared by two tetrahedral
  - Tips are hydroxyls in a silica **sheet**

- **O.** Aluminum iron, or magnesium atom enclosed by 6 hydroxyls
  - Combined into **sheets**

- Spacing between T & O sheets
  - Small
  - Link via mutual oxygen or hydroxyl ions
  - Alternate

Clay Minerals - Two-layer lattice

1. **Kaolinite**:
   - alternate T & O
   - a series of units linked together to form stacks
   - L & t

   Table 1.3
   - hydrogen bonds between layers → strong
   - stable → water can't enter between sheets to expand

   unit cells
   - @ water, some hydroxyls dissociate & lose hydrogen atoms → (-ve)
   - low -ve charge

2. **Halloysite**:
   - similar to Kao
   - more randomly packed
   - may be separated by a single molecular layer of water
   - with water → Tube / rod
   - no water → plate

Clay Minerals - Three-layer lattice

- :**Montmorillonite** O ١ +T ٢
- :O - .al, Fe, Mg, or comb
- :T may be replaced by Al (%١٥ <(Si some
- substitution isomorphous
- charge)ve-)
- Na(in the water Cations+Ca ،++K ،+ attracted to satisfy :(
- the charge
- :particle stack of units
- :bond forces Waals vander
- mutual attraction for the exchangeable
- cations
- weak water can enter between sheets
- expansion
- * swelling & shrinkage
- (wetting) (drying) seasonal ---
- rainfall
- Engineering properties charge ve- ,size, shape, surface area
-)face-to-edge(Flocculated Natural
- Particle orientation
-)face-to-face(Dispersed
- F D hexametaphosphate by sodium.
- * water mixture-plasticity of clay clay type ---
- * : cohesion at low)attractive forces interparticle(internal tension

Clay Minerals

- * Plasticity Index (PI)
- * Ac =Activity = colloidal behavior
- of clay > %))
- size , surface forces (specific) surface area
- * specific surface = (SS)
- .Mont SS
- m 2g/

- شرائح

شرائح

- γ_w = ٩,٨١ kN/m3
- ٦٢,٤ = Lb/ft3 (pcf)
- g = ٩,٨١ m/sec2 gravitational acceleration
- ٣٢,٢ = ft/sec2

Deposition