### **Geotechnical Engineering I**

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## **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  $\rightarrow$  water movement
  - Water dissolved salts and carry solutions
  - Dry  $\rightarrow$  No water  $\rightarrow$  No pore fluid
  - $\quad \text{Saturated} \ \rightarrow \ \text{No} \ \text{air}$
  - **Compaction**: reduces air by packing soil particles
- Porosity
- Void ratio
- Density
- Phase relationships
- Rock fragments > 1 mm
- Mineral grains  $(2 \text{ mm} 1 \mu \text{m})$
- <u>Ex.</u> 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°
- Kaolinite 7.2 A°
- head
- Halloysite  $10.1 \text{ A}^{\circ} \rightarrow 7.2 \text{ A}^{\circ}$
- Montmorillonite 9.6 A°  $\rightarrow \infty$
- Illite 10 A°
- Vermiculite 10 to 14 A°

# **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 <u>unit</u>
- Octahedral unit
- <u>T.</u> 4 oxygen (or hydroxyls) enclosing a <u>silicon</u> atom
  - Combine into a **<u>sheet</u>** structure
  - Each oxygen in the base is <u>shared</u> by two tetrahedral
  - Tips are hydroxyls in a silica sheet
- <u>O.</u> 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. <u>Kaolinite:</u>

- alternate T & O
- a series of units linked together to form stacks
- L&t

#### Table 1.3

- hydrogen bonds between layers  $\rightarrow$  strong
- stable  $\rightarrow$  water can't enter between sheets to expand

- unit cells
- • @ water, some hydroxyls dissociate & lose hydrogen
- atoms  $\rightarrow$  (-ve)
- • low -ve charge
- 2. <u>Halloysite</u>:
- similar to Kao
- • more randomly packed
- • may be separated by a single molecular layer of water
- • with water  $\rightarrow$  Tube / rod
- • no water  $\rightarrow$  plate

## Clay Minerals - Three-layer lattice

• • •	: <b>Montmorillonite</b> :Oal, Fe, Mg, or comb :T may be replaced by Al (% <sup>1</sup> ° <( <u>Si</u> some substitution isomorphous charge )ve-)	0 ۲ ۲ ۲ ۱					
•			Na(in the wate	r Cations+Ca .++	K ،+ attract	ted to satisfy :(	
•	the charge		,				
•	5			:particle sta	ick of units		
•				;bond forces		der	
•					mutual att	raction for the exchangeable	
•	cations					<b>3</b>	
•			weak	water can enter	<sup>.</sup> between sh	neets	
•					expansion		
•			* swelling & shrinkage				
•				(wetting)	(drying)	seasonal	
•				rainfall	(		
•	Engineering properties charge ve- ,size,	shape, surface	area				
•		1 /	)face-to-edge(	Flocculated	Natural		
•	Particle orientation		,				
•	)face-to-face(Dispersed						
•		<u>taphosphate</u> by	sodium.				
•	* water mixture-plasticity of clay clay type -						

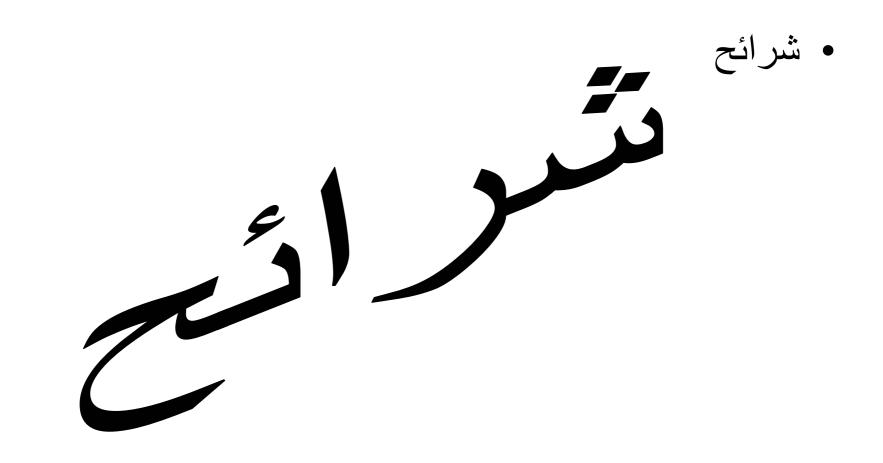
• \* : cohesion at low )attractive forces interparticle( internal tension

# **Clay Minerals**

- \* Plasticity Index (PI)
- \* Ac = Activity = colloidal behavior

(specific)

- size , surface forces surface area
- \* specific surface = (SS)
- .Mont SS



- 3m/kN  $9, \Lambda ) = w$  •
- (pcf)3 ft/Lb  $\forall \forall, \xi = \bullet$
- gravitational  $2\sec/m$   $9,\Lambda$  = g acceleration
  - 2sec/ft  $\forall \forall, \forall = \bullet$

#### Deposition