ROADBED SOILS -B

Phase Relationship, Shear Strength & Soil Structure (Cont..)

SHEAR STRENGTH

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- Properties which resist stresses generated by gravitational forces:

- SHEAR STRENGTH has three components

  - EFFECTIVE NORMAL STRESS
  - COHESION
  - ANGLE OF INTERNAL FRICTION

- Shear Strength = Cohesion + Normal Stress x TAN (Angle Internal friction)
- Or $S = C + \sigma . (\tan . \theta)$

EFFECTIVE NORMAL STRESS

- There are three conditions for normal stress:
- 1. Dry Soil: $\sigma = \sigma - 0$

- 2. Unsaturated wetted soil when pore water matric suctions (μ) (Soil matric suction is a primary stress state variable used to characterize unsaturated soil behavior) are negative. Effect is to INCREASE normal stress:

$$\sigma = \sigma - (-\mu)$$

- 3. Saturated soil condition where pore water pressure (μ) is positive, acting upwards against gravity. Effect is to DECREASE normal stress:

$$\sigma = \sigma - \mu$$

COHESION

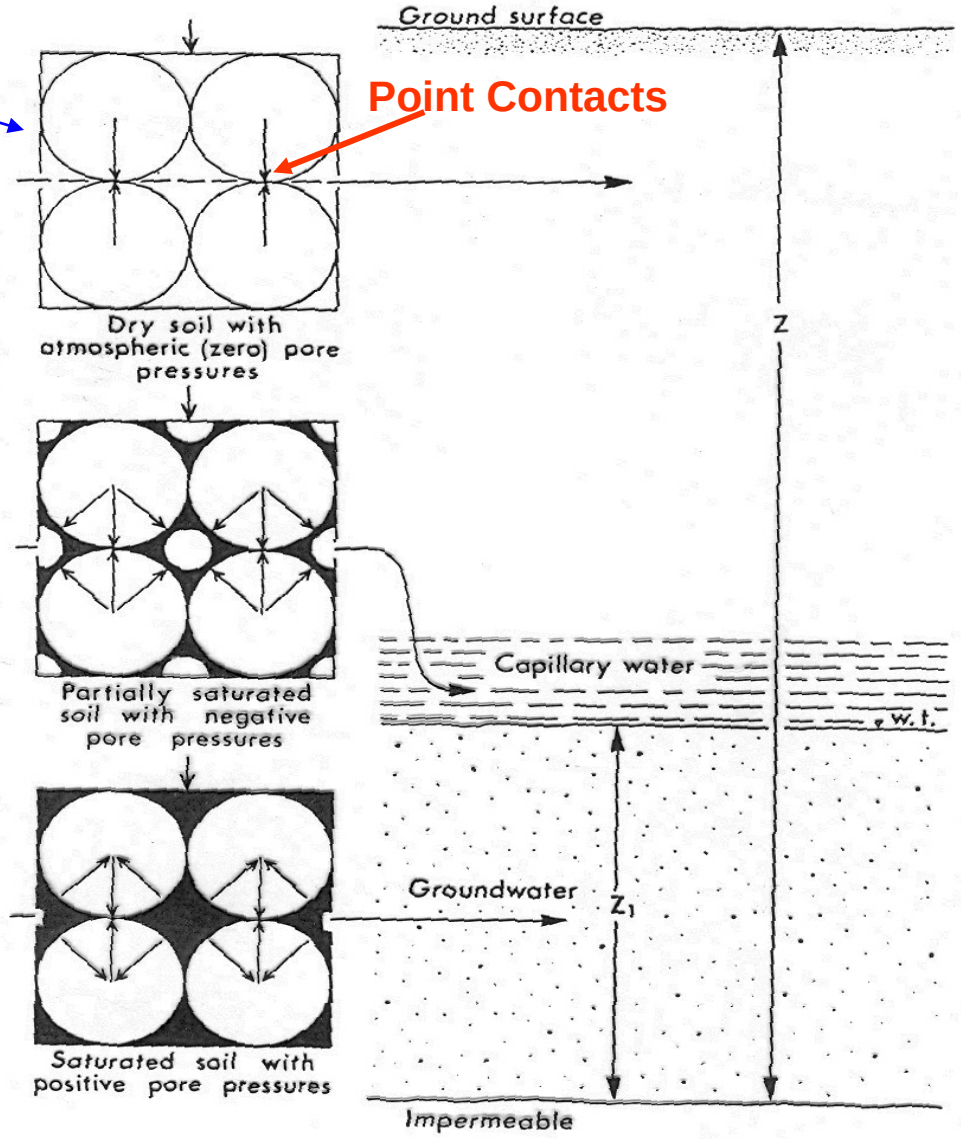
- Cohesion: Bonding
- Rocks:
- Chemical Bonds - Cements….
- Clays:
- Electrostatic forces - Attractive forces between particles and lubrication by water.

- Apparent Cohesion:
- Produced by capillary forces and interlocking friction of particle surfaces.

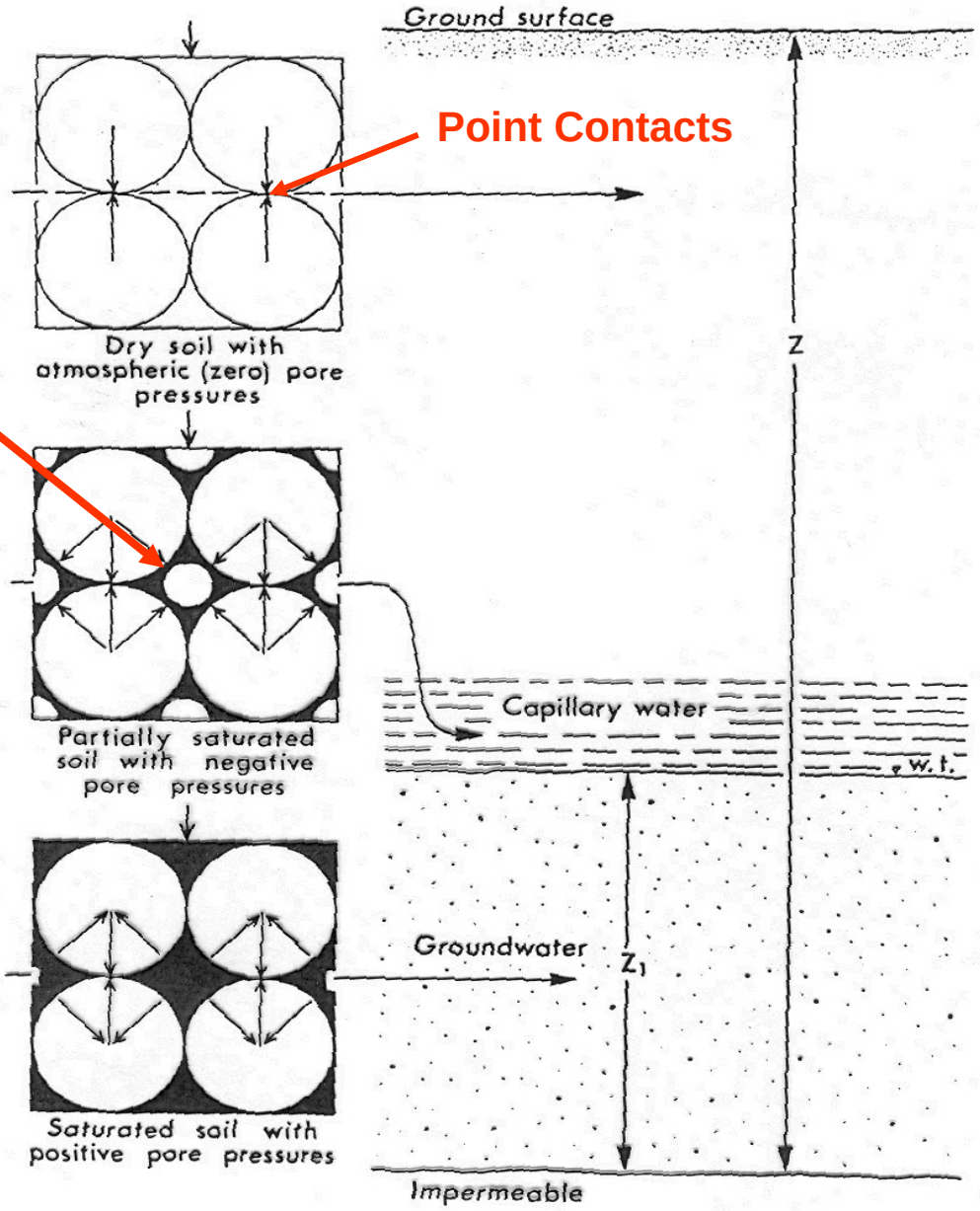
- Affected by SIZE, SHAPE & MINERALOGY of particles.

Normal Stress & Apparent Cohesion: Impact of pore water

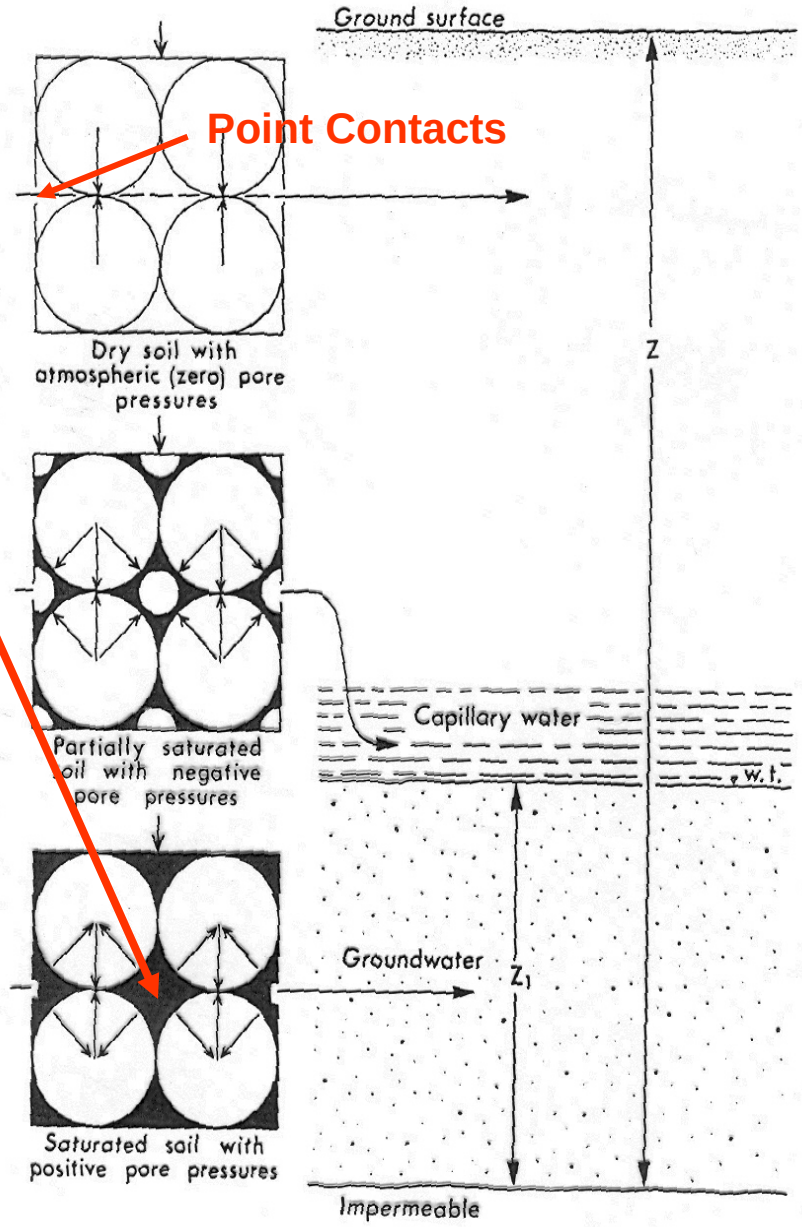
- Dry Soil above water table
- Soil fabric supported by poin contacts .
- Pores air filled and pore water pressure = 0.0.
- No apparent cohesion due to soil moisture tension.



- Moist Soil
- Particles have apparent cohesion due to capillary forces and are under suction due to matric suction effects.

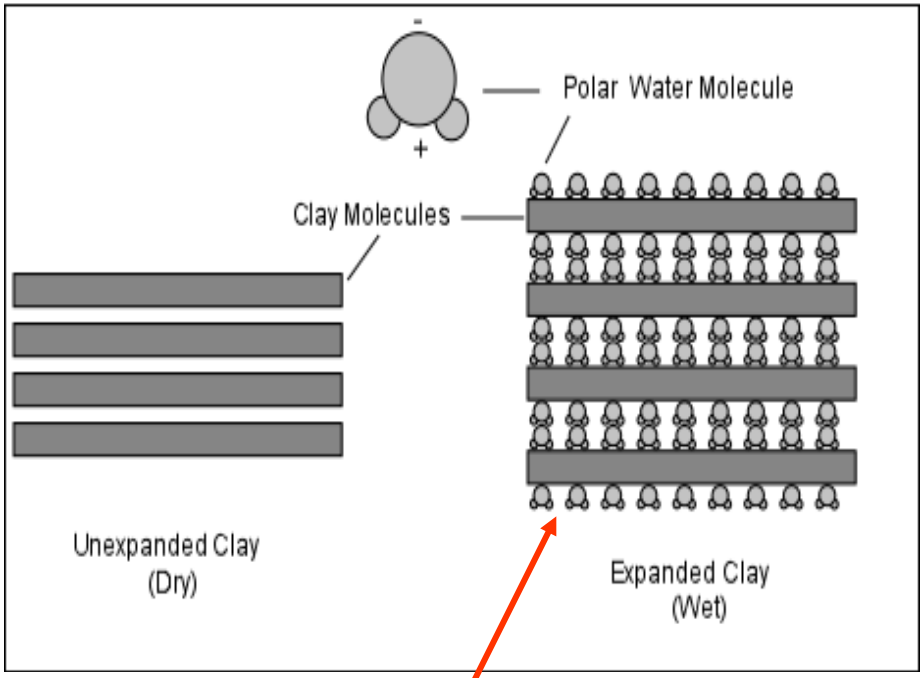


- Saturated soil
- Soil apparent cohesion lost as no capillary forces or matric suction.
- Part of the NORMAL STRESS of overburden taken by the pore water rather than soil fabric.
- (Buoyancy/upthrust) & positive pore water pressures.
- DECREASE IN SOIL STRENGTH



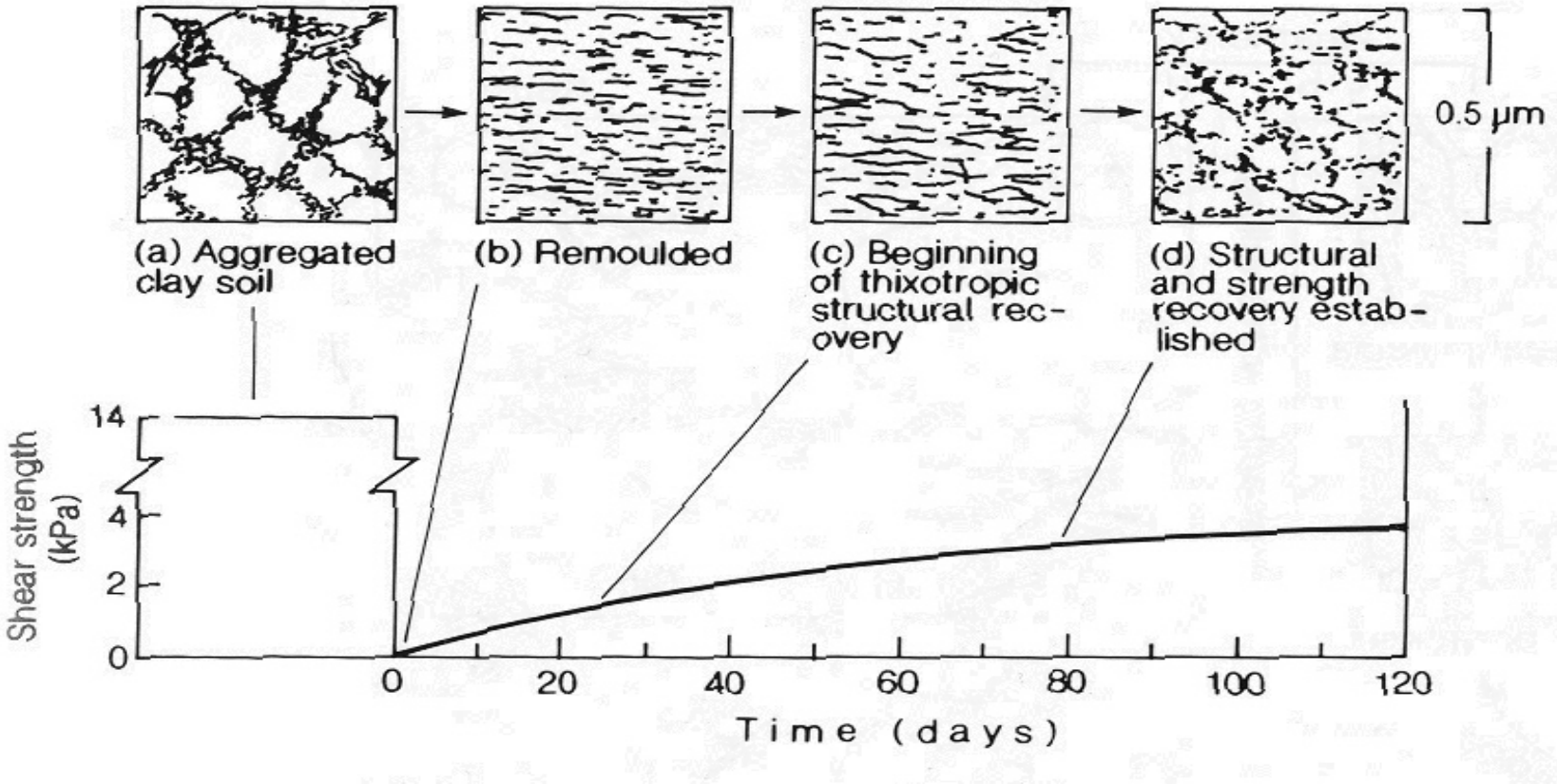
Cohesion effects

- **1. Loss of strength under shear:**
  - **Marine Clays. Highly structured clay fabric.**
  - **Subjected to shear – strength may be reduced to 1/1000th original value. These are QUICK clays.**



Remoulded clay – water between lattices: LOSS OF COHESION

- **2. Thixotropic behaviour: Strength lost on disturbance. Disturbed soils with high water content may rapidly become weak and fail. When they come to rest they REGAIN STRENGTH.**



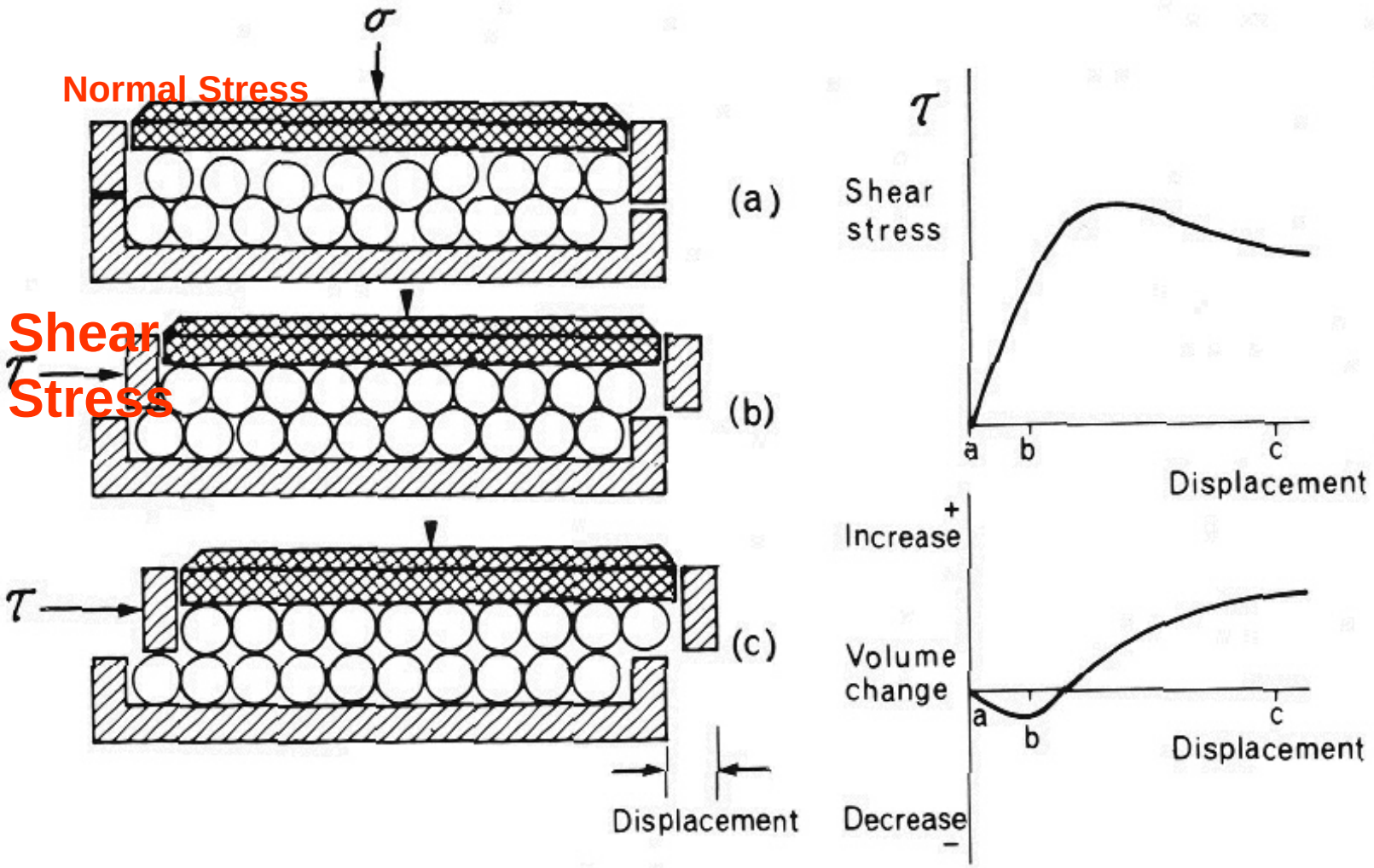
- **3. Addition of water to REMOULDED clay rich soils: reduces strength as electrostatic bonds are weakened by separation of particles.**

- **4. Clays in slurry & mudflow: lose strength due to disruption of aggregate structure & increase water content.**

ANGLE OF INTERNAL FRICTION

FRICTION

- Strength of rocks/soils part controlled by frictional resistance between mineral particles in contact. Interlocking friction and planar friction.
- Friction strength proportional to NORMAL STRESS holding grains in contact.
- Contact points due to size, shape & resistance to crushing of grains.
- Poor sorting increases contacts & interlocking friction.


σ
Normal Stress
(a)
Shear
Stress
τ
(b)
τ
(c)
Displacement
τ
Shear
stress
a
b
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Displacement
+
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Volume
change
a
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Displacement
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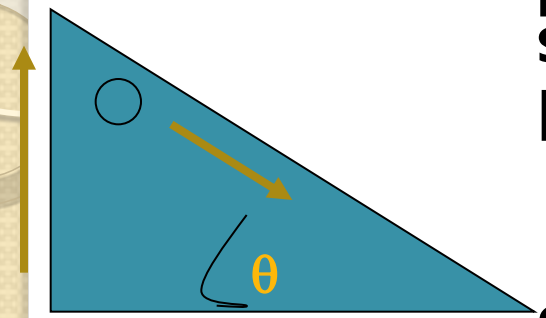


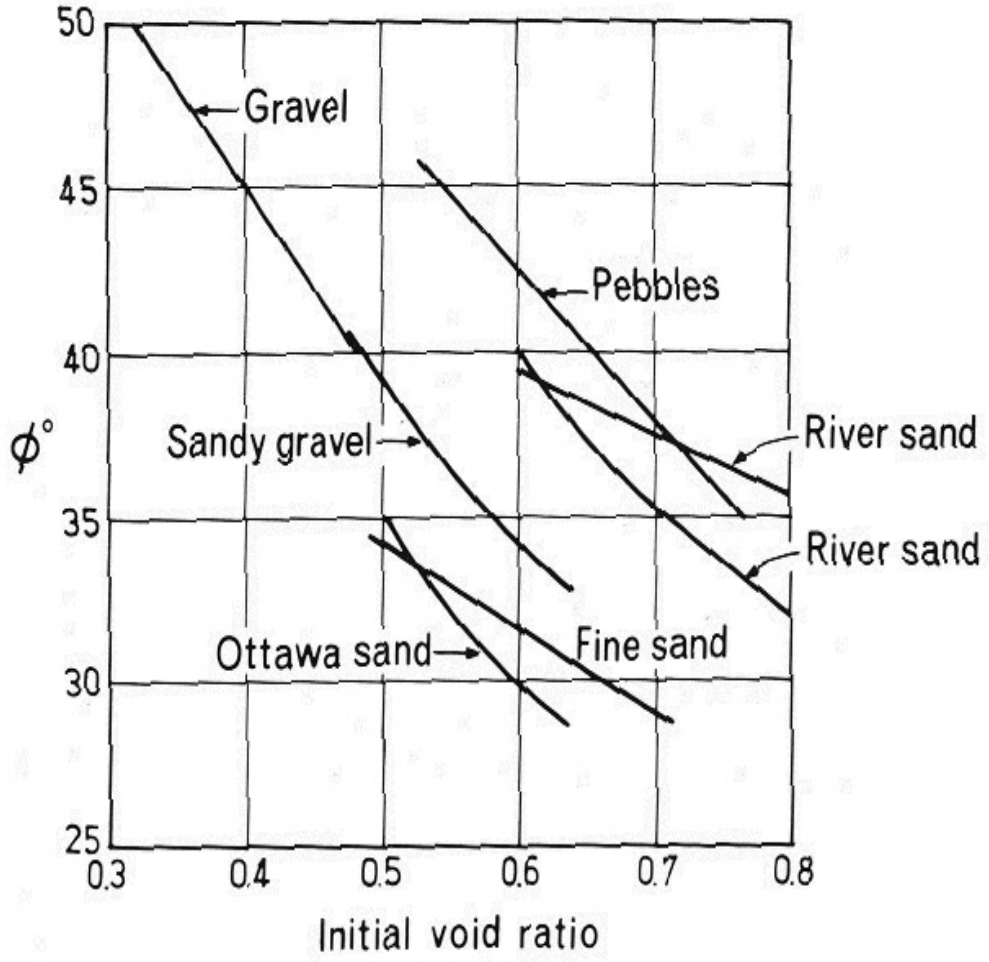
- **Θ: the angle at which the particle begins slide down the surface.**

  Frictional contact is broken.

Soils & rock friction angles controlled by:

1. **volume of voids**
2. **particle size distribution**
3. **particle shape.**

Friction angle decreases with PLASTICITY & WATER CONTENT.



Effect of void ratio on angle of internal friction for non-cohesive materials.

PRIMARY SOIL STRUCTURE

Soil structure is the shape that the soil takes based on its physical and chemical properties; it is the geometric arrangement of soil particles with respect to one another. The process of sedimentation or rock weathering creates the initial soil structure. Among the many factors that effect soil structure is the shape, size, and mineral composition of the soil particles, and the nature and composition of soil water. The basic terminology used to define the soil structure are single-grained, honeycombed, flocculated and dispersed with variations dependent upon the composition of the soil.

- Single Grained. Individual – point to point contact – accidental arrangements – no tendency to form aggregates – high or low ‘e’ – volume increases if deformed – vibrations cause densification – low permeable – loose - sands / gravel

Loose

Dense

- Honey comb. Touching few points – stable because of molecular forces – silt size - water deposited – large ‘e’ – Behaves single grained if critically loaded.

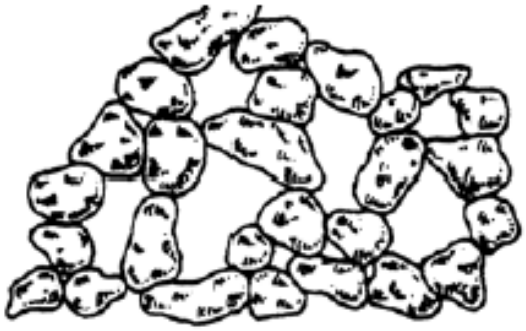


Figure 2-3 Honeycombed Structures

- Flocculent. Clay platelets formed in large bodies of water – may be flocculated or settled form – may form cluster or aggregates – inter cluster bond weaker than within cluster – higher void ratio, reduces under load – considerable reduction when compacted.

Figure 2-10 Flocculent Structure

Thanks