1.4 Special Soils

(1) Compacted clays (sandy clays or silty clays)

- **Unique characteristics**

i. Partially saturated

ii. Dilatant at low pressures

iii. Contractive at moderate pressures

(ii–iii) boundary pressures : 15 – 20 psi

iv. Highly anisotropic due to construction procedure

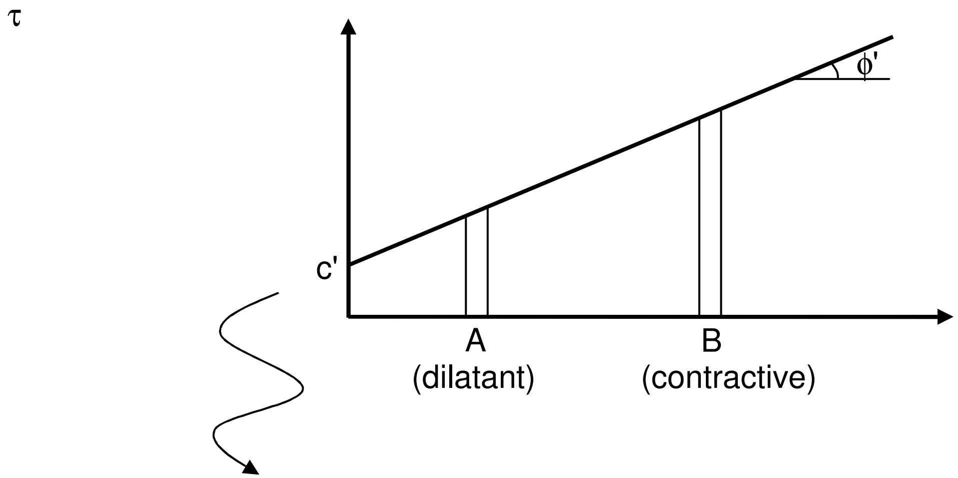
→ strength

→ permeability ($k_h = (9 - 100)k_v$)

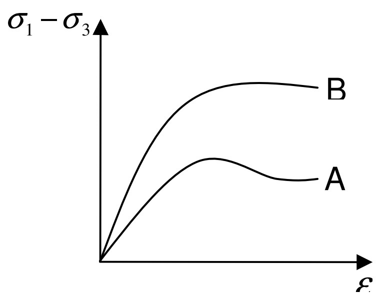
● Applications of shear strength characteristics on embankments

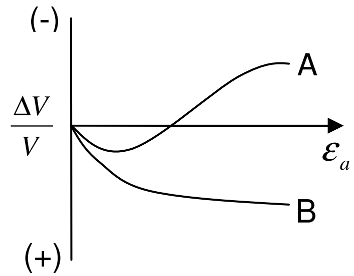
i. Drained shear behavior (CD)

→ Design case : long-term loading of embankment (steady state of seepage)



has a large impact on stability analysis.⇒ In design, it is common to assume c’=0.

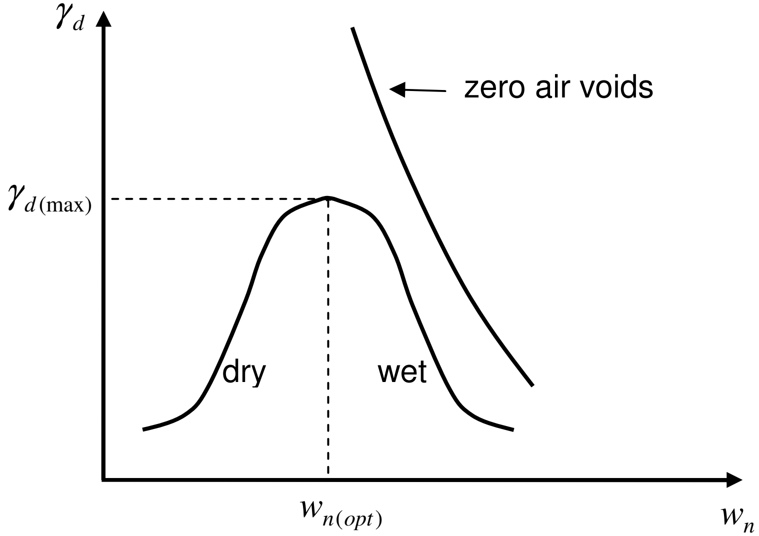


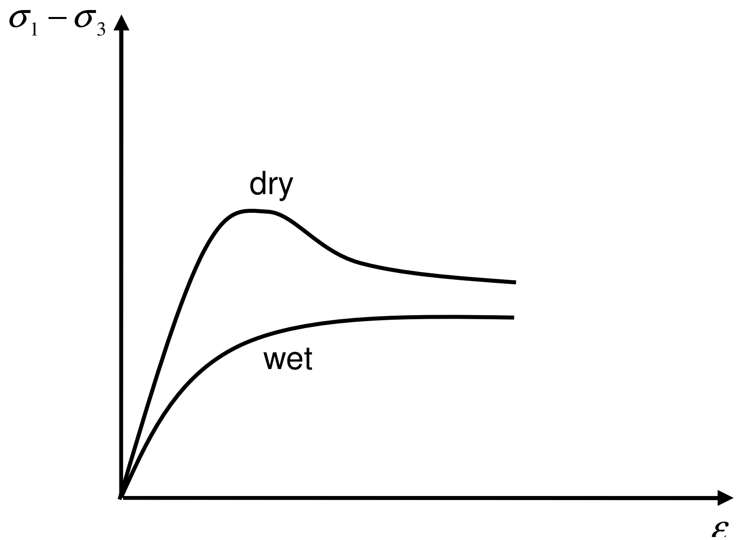


ii. Undrained shear behavior (uu behavior) on partially saturated soil

- Design case : End of construction in dam

→ Excess pore pressures in dam have not significantly dissipated by the time construction is complete.





- How to get s_u value for design to maintain stability;

  Run uu tests on samples prepared at various water content and γ_d. Select s_u values on the specific range of w_n and γ_d based on these results.

- Complicating factors

  1) Different compaction techniques (in field and lab) give different values of w_{opt} and $\gamma_{d(max)}$.

  2) Partial saturation makes strength data interpretation a little more complicated.

  3) Field control is difficult.

- Comment

1) If sample is “too dry”,

① Strong, but hard to mix in field.

② Brittle behavior and can lose its strength when soil becomes saturated.

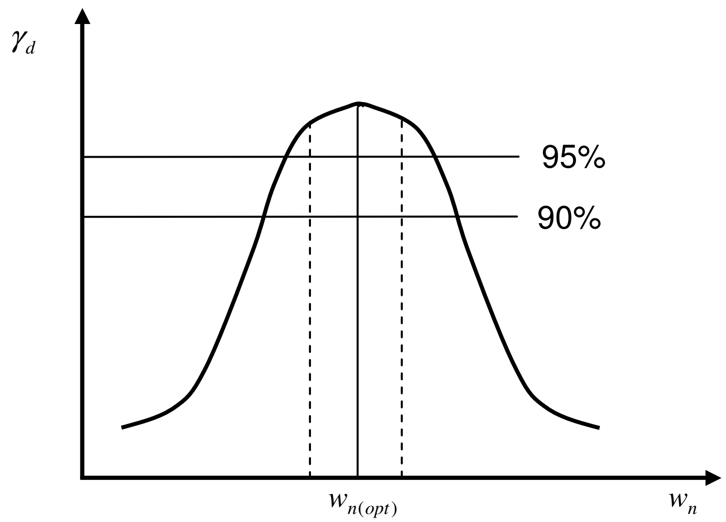
2) If sample is “too wet”

① Ductile behavior

② Weak, but no loss of strength upon saturation.

Ex) $w_{n(placement)} = w_{n(opt)} \pm 2$ %.

$\gamma_d \geq 95$ % of $\gamma_{d(max)}$ based on certain compaction method (i.e. Modified Proctor method)

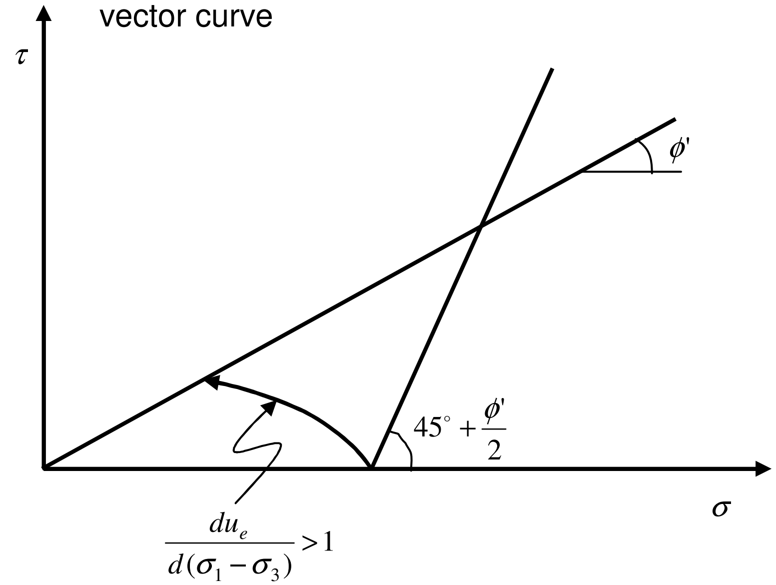


(2) Sensitive Clays

- **Characteristics** :

  i. Large strength loss upon remolding

  ii. $u_e(+)$ is very large at failure ($A_f > 1$).

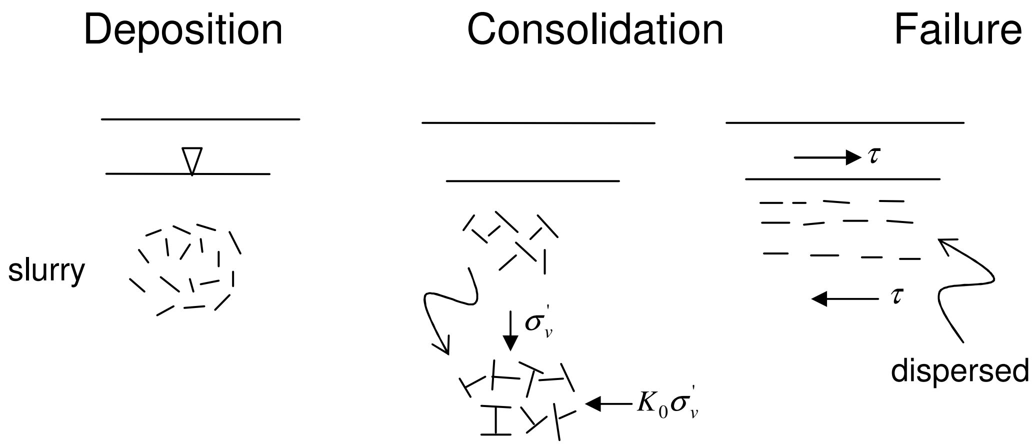


S_t = Sensitivity = $\frac{s_u}{s_{u(remolded)}}$	Name
1	Insensitive (compacted clay when $w_n > w_{opt}$)
1 ~ 2	Slightly sensitive
2 ~ 4	Medium sensitive
4 ~ 8	Very sensitive
8 ~ 16	Slightly quick
16 ~ 32	Medium quick
32 ~ 64	Very quick
> 64	Extra quick

Factors causing sensitivity

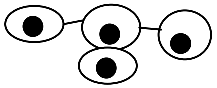
	S_t
• Metastable particle arrangement	8 ~ 16
• Silt skeleton with clay bonds	4 ~ 8
• Leaching of salts	> 64
• Rupture cementing bonds between grains	8 ~ 16
• Ion exchange	8 ~ 16
• Weathering	1 ~ 4
• Add dispersing agent	> 64

Metastable particle arrangements (most lacustrine clays)



Silt skeleton covered with clay bonds (representative of some alluvial clays)

"lean" clays or low plastic clays.

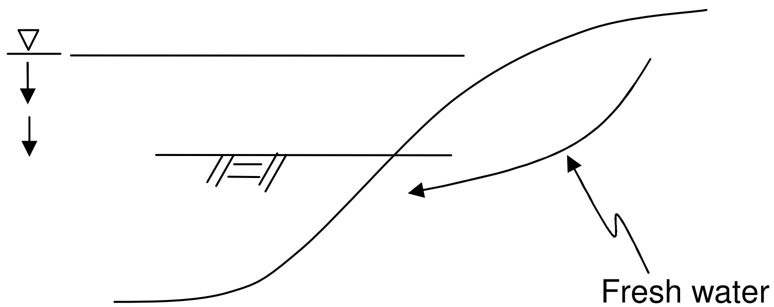


semi-flocculated state

Leaching of salt

$S_t > 64$ (Marine clays)

1) Deposited in salt water environments. ⇒ Highly flocculated state.
2) Clay is lifted above sea level or sea level drops.
3) Change in local ground water regime such that fresh water starts flowing through the clay.
4) Fresh water leaches (removes) the salts (Na^+).

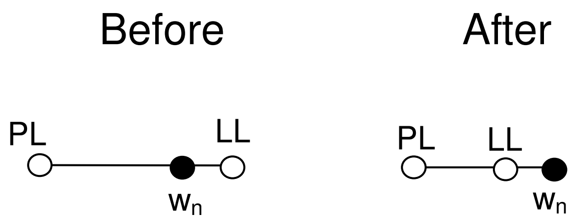


Leaching

① → reduces the attractive forces between clay particles.

② → lowers liquid limit because of ①, but w_n remains the same.

⇒ free water within the clay matrix.



(3) Varved Clays

- Characteristics

  → Sharply layered with alternating layers of clay (winter) and silt (summer).

  → Usually associated with glacial lakes.

  → Soft-NC-to lightly OC.

  → Highly anisotropic.

(4) Residual Soils

1. Soils that have been weathered in place.
2. Soils take an characteristics of parent material (rock) – bedding planes and joint – remnants.
3. Contain some light cementation.

   (but sampling typically destroys this cementation).

   ⇒ Hard to characterize strength and stiffness parameters in laboratory.