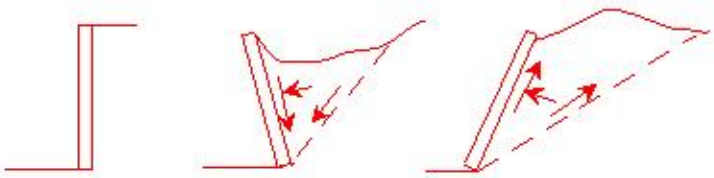
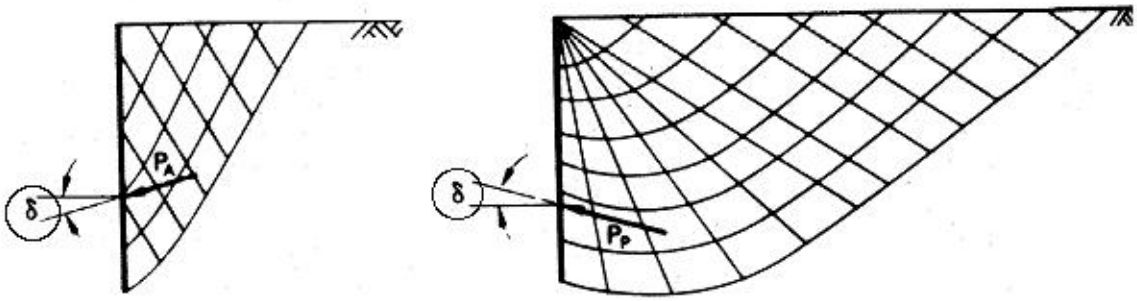
6.4 Lateral Earth Pressures on Frictional Walls

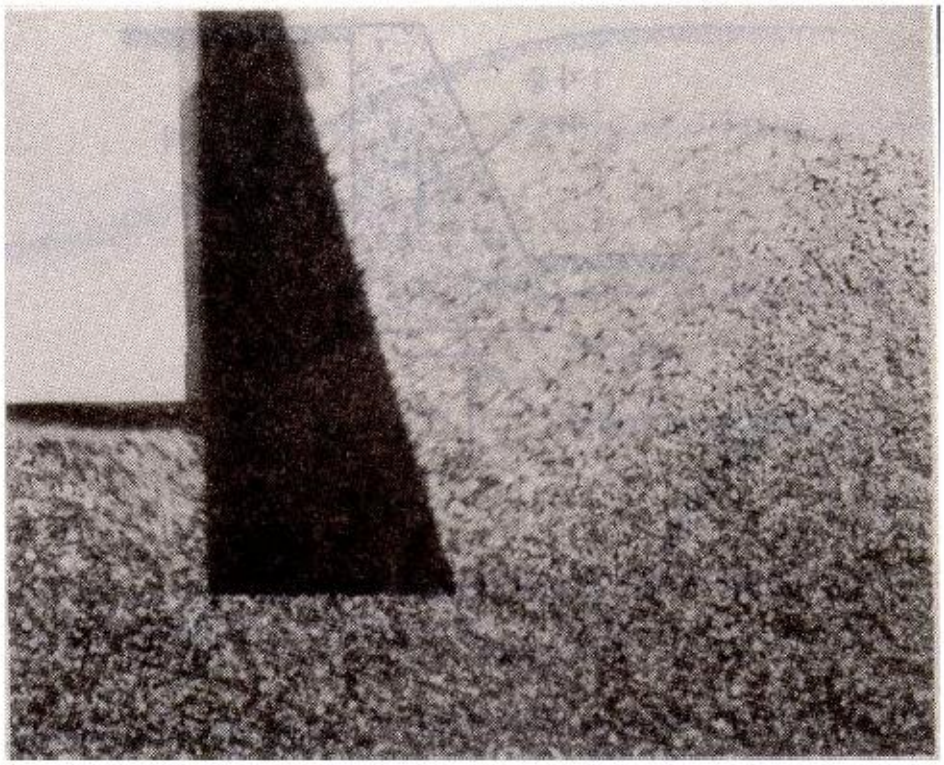
1) Effect of wall frictions

- Shape of failure zone





(a) active case (b) passive case



Double exposure showing movements of "soil" surrounding model retaining wall

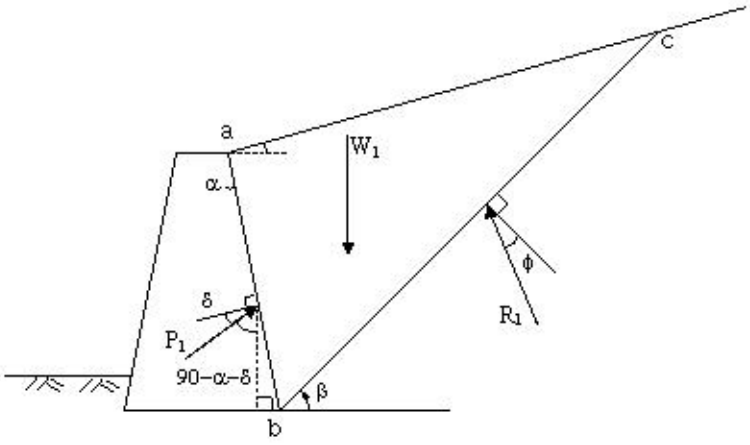
- Typical friction angles between the wall and soil.

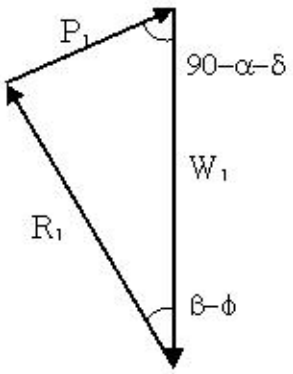
Interface Materials	δ (degree)
Mass concrete on the following foundation materials :	
Clean sound rock	35
Clean gravel, gravel-sand mixtures, coarse sand	29~31
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	24~29
Clean fin sand, silty or clayey fine to medium sand	19~24
Fine sandy silt, nonplastic silt	17~19
Very stiff and hard residual or preconsolidated clay	22~26
Medium stiff and stiff clay and silty clay	17~19

Steel sheet piles against the following soils :	
Clean gravel, gravel-sand mixture, well-graded rock fill with spalls	22
Clean sand, silty sand-gravel mixture, single size hard rock fill	17
Silty sand, gravel or sand mixed with silt or clay	14
Fine sandy silt, nonplastic silt	11

Formed concrete or concrete sheet piling against the following soils :	
Clean gravel, gravel-sand mixture, well-graded rock fill with spalls	22~26
Clean sand, silty sand-gravel mixture, single size hard rock fill	17~22
Silty sand, gravel or sand mixed with silt or clay	17
Fine sandy silt, nonplastic silt	14

2) Coulomb's active pressure





Force Polygon

- Find max. P by (Trial & Error)

- Analytically, $P_a = \frac{1}{2}\gamma H^2 K_a$

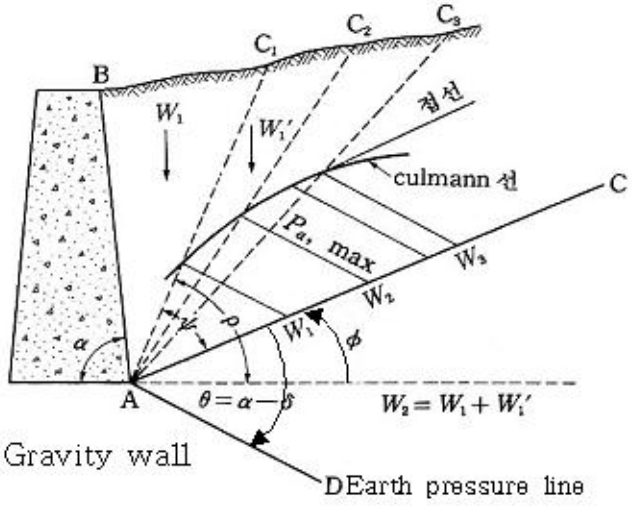
where, $$K_a = \frac{\cos^2(\phi-\alpha)}{\cos^2\alpha\cdot\cos(\delta+\alpha)\left[1+\sqrt{\frac{\sin(\delta+\phi)\sin(\phi-i)}{\cos(\delta+\alpha)\cos(\alpha-i)}}\right]^2}$$ $(\neq \frac{\sigma_h}{\sigma_v})$

∵ backfill not horizontal nor $\delta \neq 0$

in fact, $K_a = \frac{p_a}{\sigma_v} (\neq \frac{\sigma_h}{\sigma_v})$

$$P_a = \int_o^H p_a = \int_0^H K_a \sigma_v = K_a \int_0^H \gamma z$$

- Culmann's graphical construction (p. 166 ~ 168)



i) Draw a dimensional sketch

ii) Draw a line $\overline{AC}$ and $\overline{AD}$ (Earth pressure line)

iii) Draw several failure surfaces (AC_1, AC_2, AC_3 ....)

iv) Intercept AW_1, equal of the wt. of wedge ABC_1, to a convenient scale along $\overline{AC}$

v) Draw a line starting from W_i parallel to $\overline{AD}$

vi) Trace a Culmann's line connecting the intersecting points of the lines in step v) with possible failure surface

vii) Draw a line parallel to $\overline{AC}$ and tangential to the Culmann's line

viii) Find max. P_a

3) Passive resistance

$$K_p = \left[\frac{\sin(\alpha+\phi)/\sin\alpha}{\sqrt{\sin(\alpha-\delta)} - \sqrt{\frac{\sin(\phi+\delta)\sin(\phi+\beta)}{\sin(\alpha-\beta)}}} \right]^2 \rightarrow P_p = \frac{1}{2}\gamma H^2 K_p$$

- If $\delta \leq \phi/3$, O.K.

  If $\delta > \phi/3$, error on the unsafe side.

- Use [ϕ - circle method]

  or [log - spiral method] to obtain exact solution

- Remarks

Assuming $\delta=0$, obtains conservative solution in either case.

In active case, the effect of wall friction is small, and may be neglected.
In passive case, it is large.

6.5 Effect of ground water in the backfill

1) Fully saturated w/ no drainage

▶ Example 23.5 Example of Perched Water Table in Backfill

Given: Retaining wall in Fig. E23.5-1

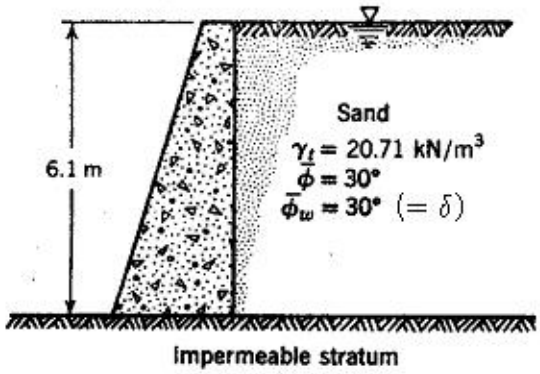


Fig. E23.5-1

Find: Horizontal thrust against wall.
Solution:

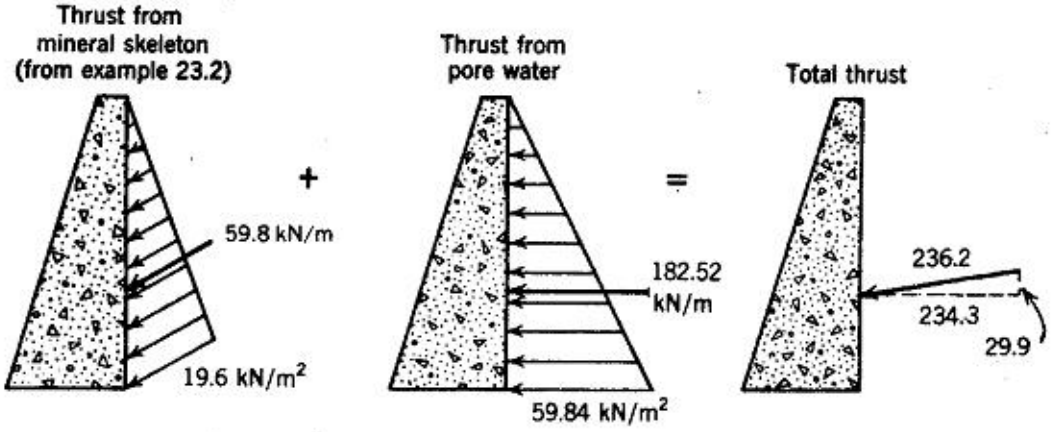
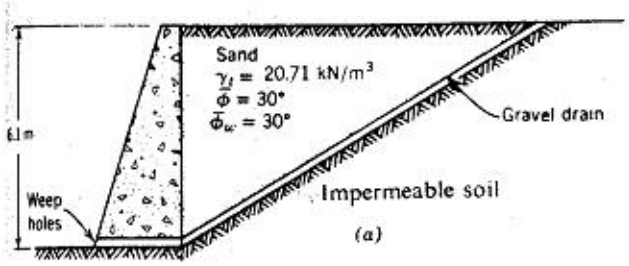
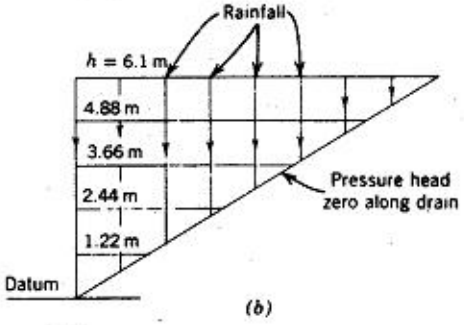


Fig. E23.5-2

2) Fully saturated w/ inclined drainage

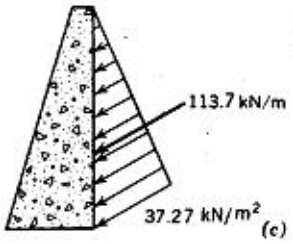




$J = i\gamma_w V$

$i = \frac{dh}{dl} = \frac{6.1}{6.1} = 1$

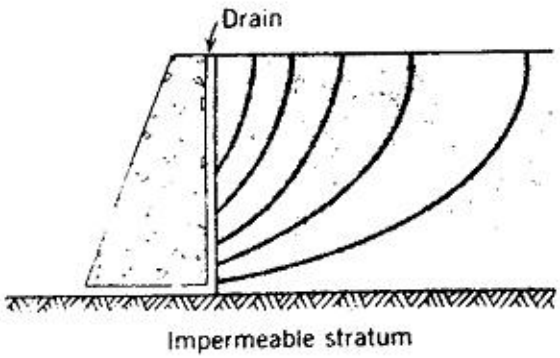
$\therefore J = \gamma_w V$



$\bar{P} = \frac{1}{2}\gamma_t H^2 K_a$
$= \frac{1}{2}(20.71)(6.1)^2 \times (0.295)$
$= 113.7$ k/Nm

Analysis of backfill with sloping underdrain.
(a) Arrangement of drain, (b) Flow net for rainfall on surface of backfill
(c) Stresses on wall from mineral skeleton.

3) Fully saturated w/ vertical drainage



Backfill with vertical drain.

4) Comparison of draining methods

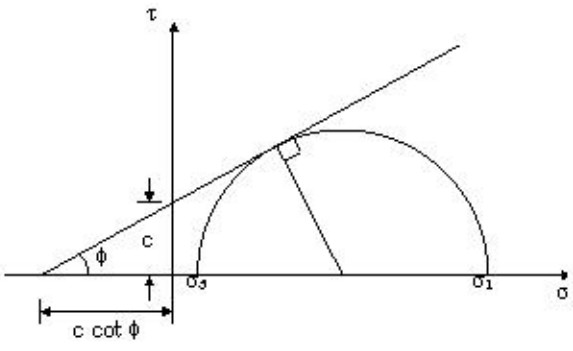
[Table] Active Thrusts for Various Conditions ($\delta = \phi$ assumed)

Condition	Horizontal Component (kN/m)	Vertical Component (kN/m)
Dry	82.8	47.8
Saturated with Sloping drain	98.5	56.9
Saturated with vertical drain	128.9	74.4
Saturated without drain	234.3	29.9

6.6 Lateral earth pressures of cohesive soils

1) Passive resistance ($\sigma_h = \sigma_1$)

- $P_p = \int_0^H \sigma_1 \, dz$



i) $\sin\Phi = \dfrac{\sigma_1 - \sigma_3}{\sigma_1 + \sigma_3 + 2c\cot\Phi}$

ii) $N_\Phi = \dfrac{1+\sin\Phi}{1-\sin\Phi} = \dfrac{\sigma_1 + c\cot\Phi}{\sigma_3 + c\cot\Phi}$

iii) $\cot\Phi\,(N_\Phi - 1) = 2\sqrt{N_\Phi}$

$$\sigma_1 = \sigma_3 N_\Phi + c\cot\Phi\,(N_\Phi - 1)$$
$$= \sigma_3 N_\Phi + 2c\sqrt{N_\Phi}$$

$$- P_p = \frac{1}{2}\gamma H^2 N_\Phi + 2cH\sqrt{N_\Phi}\;(+ q_s H N_\Phi)$$

2) Active pressure

- $P_a = \int_0^H \sigma_3 dz$

- $\sigma_3 = \frac{\sigma_1}{N_\phi} - \frac{1}{N_\phi}\{c\cot\Phi(N_\phi - 1)\}$

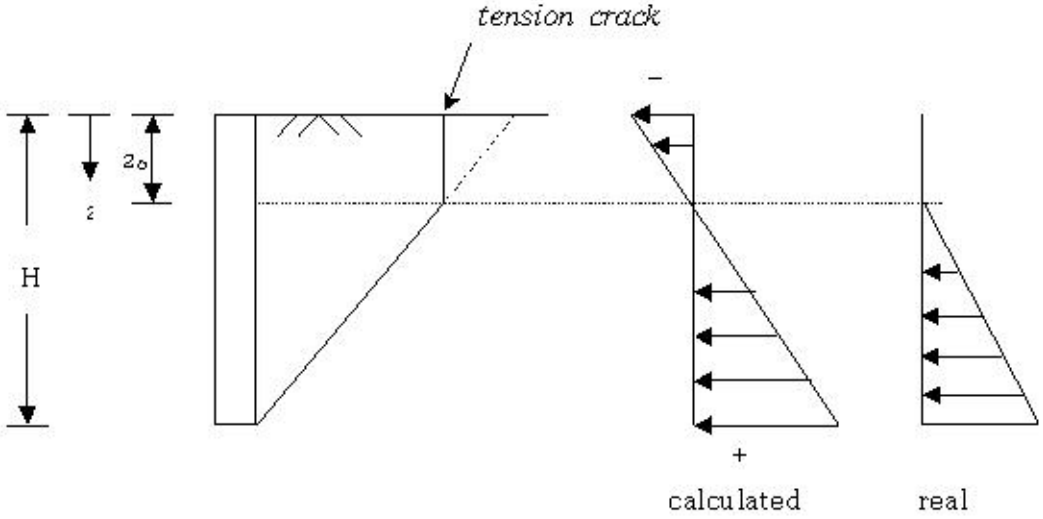
$= \frac{\gamma \cdot z}{N_\phi} - 2c\frac{1}{\sqrt{N_\phi}}$

3) Tension crack (when there is no surcharge)

- note that σ_3 has negative value if,

$$\frac{\gamma \cdot z}{N_\phi} - 2c\frac{1}{\sqrt{N_\phi}} < 0 \rightarrow z < \frac{2c}{\gamma}\tan(45° + \frac{\Phi}{2})$$

$$\rightarrow z_0 = \frac{2c}{\gamma}tan(45° + \frac{\phi}{2})\text{:tension crack depth}$$



$$P_a = \int_{z_0}^{H} \sigma_3\, dz = \int_{z_0}^{H} (\frac{\gamma \cdot z}{N_\phi} - 2c\frac{1}{\sqrt{N_\phi}})dz$$

-HomeWork : obtain the P_a with uniform surcharge of q_s on the backfill