REATINING WALLS

CONTENT

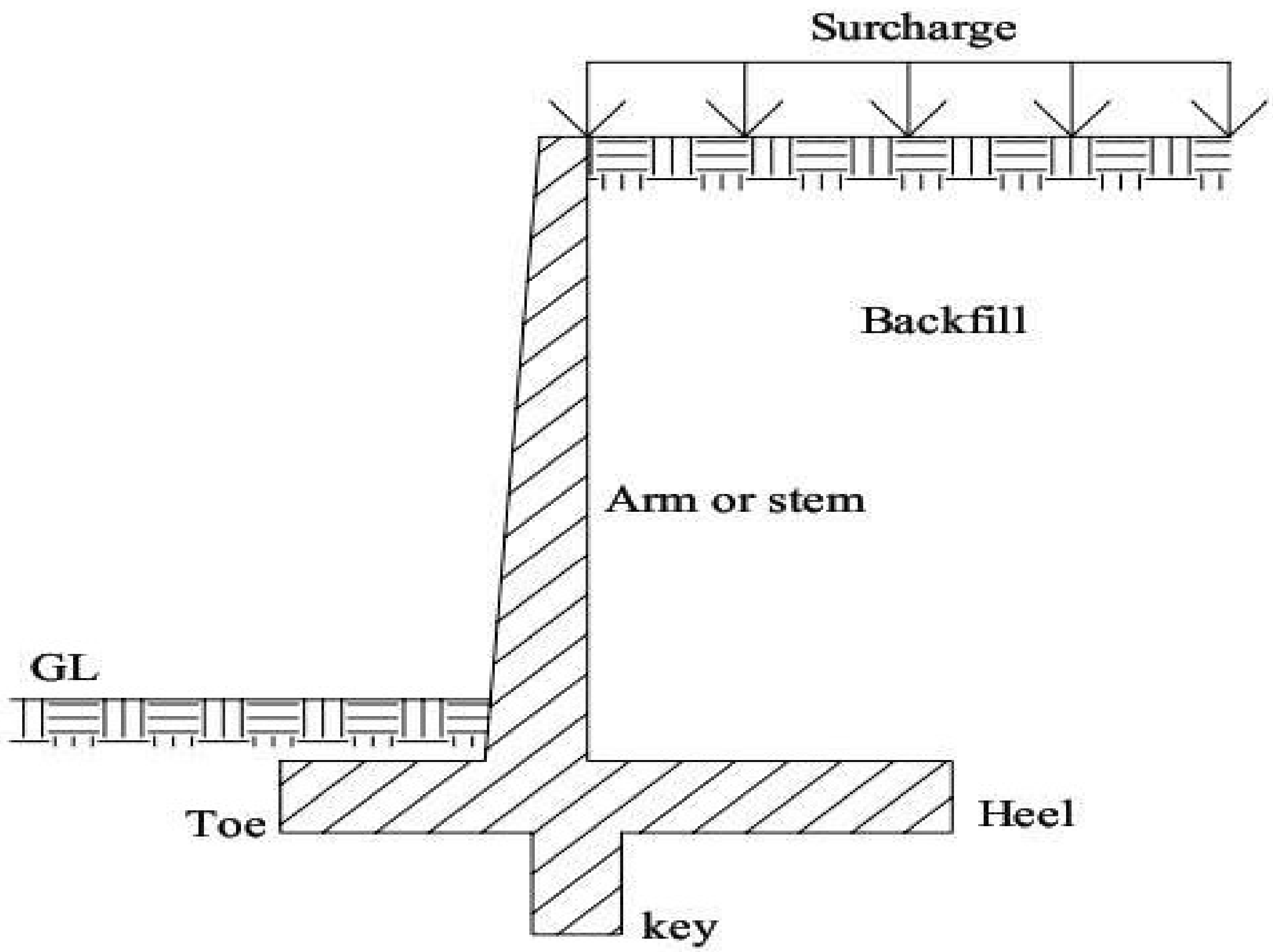
What is Retaining Wall?

- A Retaining wall is a structure used to retain earth or other material and to maintain ground surface at different elevation on either side of it .
- Retaining wall are used to retain earth or other materials which have the tendency to slide and repose at a particular inclination .
- They provide lateral support to the backfill , embankment or in order to hold them in a vertical position.

Retaining Wall

- The main components of retaining wall are :

1. Stem
2. Toe slab
3. Heel slab
4. Counter forts
5. Shear key



Retaining Wall

Application of Retaining wall

1. Construction of basement below ground level in buildings.
2. Wing wall and abutment in bridge work are designed as retaining wall.
3. To retain slopes in hilly terrain roads.
4. As side walls of bridge approach roads.
5. To provide lateral support to embankment.

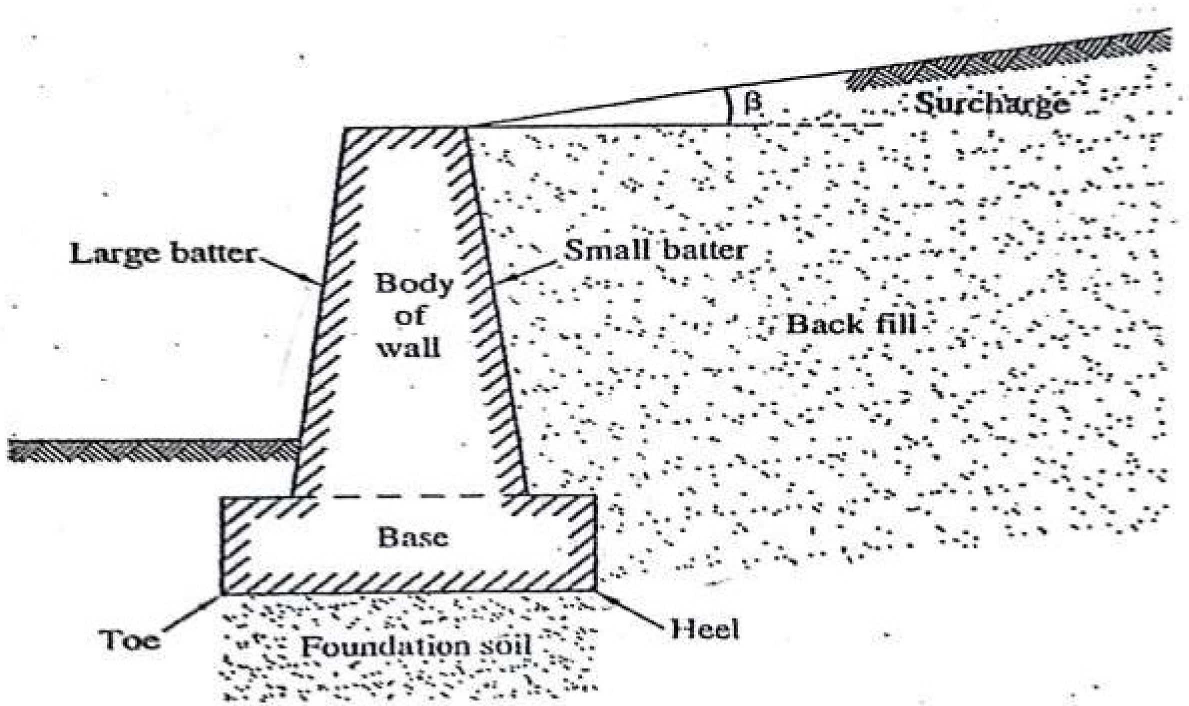
Types of Retaining Wall

The different types of retaining wall are as follows :

1. Gravity retaining wall
2. Cantilever retaining wall
3. Counterfort retaining wall
4. Buttress wall
5. Bridge Abutment
6. Box Culvert

1. Gravity retaining wall :

- The stability of the wall is maintained by its own weight.
- It is generally made up to a height of 3m of wall .

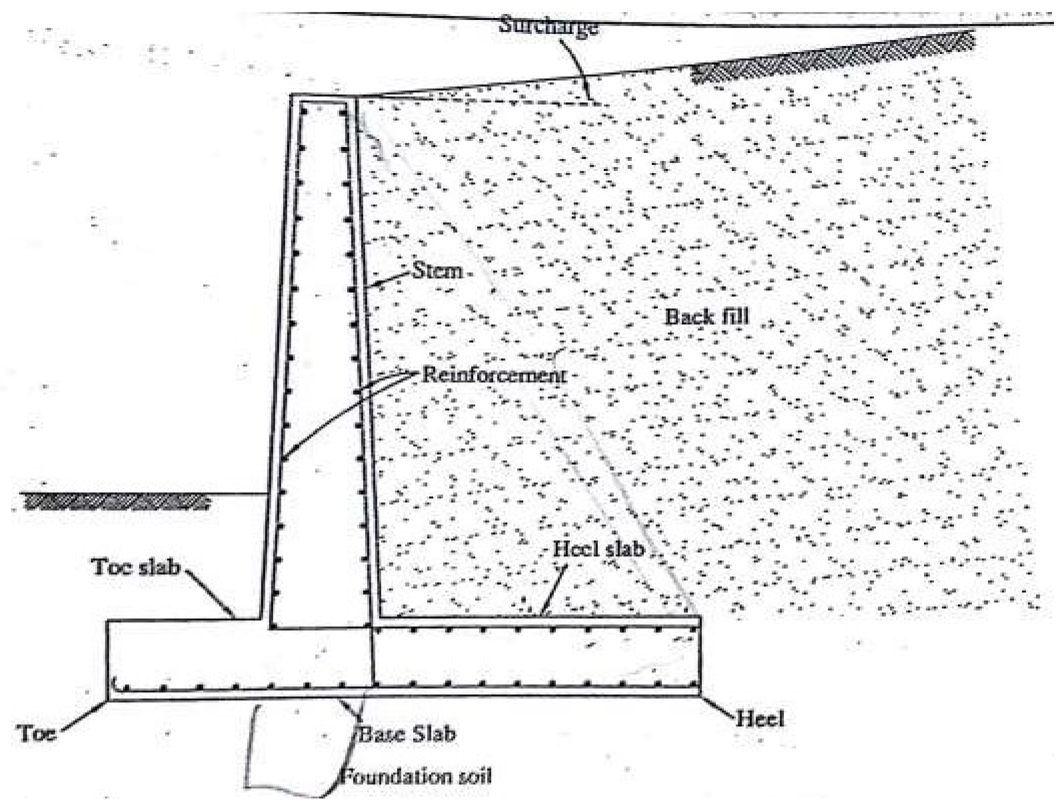


2. Cantilever retaining wall :

- It consists of a vertical wall, heel slab and toe slab which act as cantilever beams .
- It is generally used when the height of wall is up to 6m .

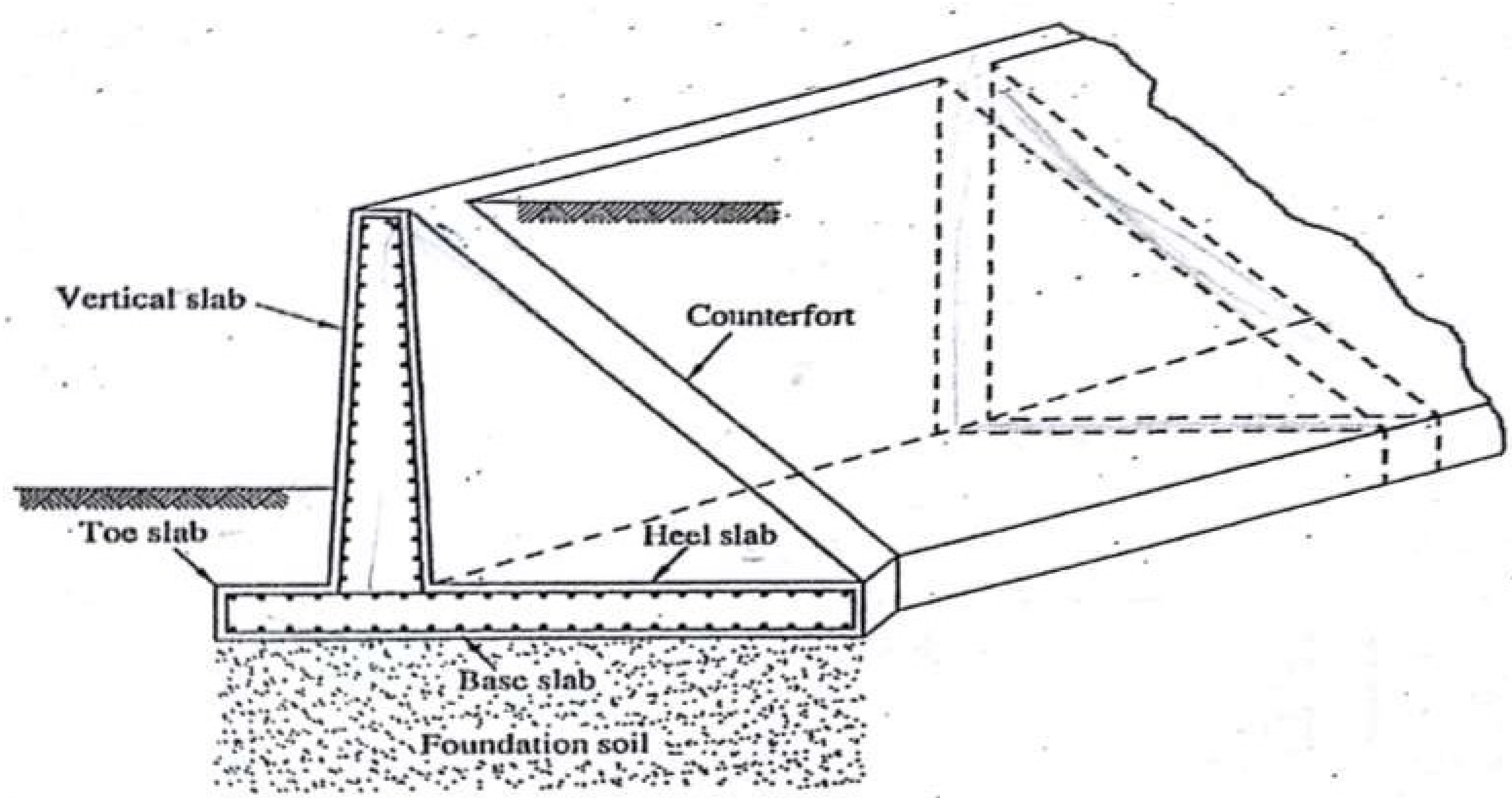
- The cantilever retaining wall are of three types :

1. T-shaped
2. L-shaped
3. T-shaped with shear key



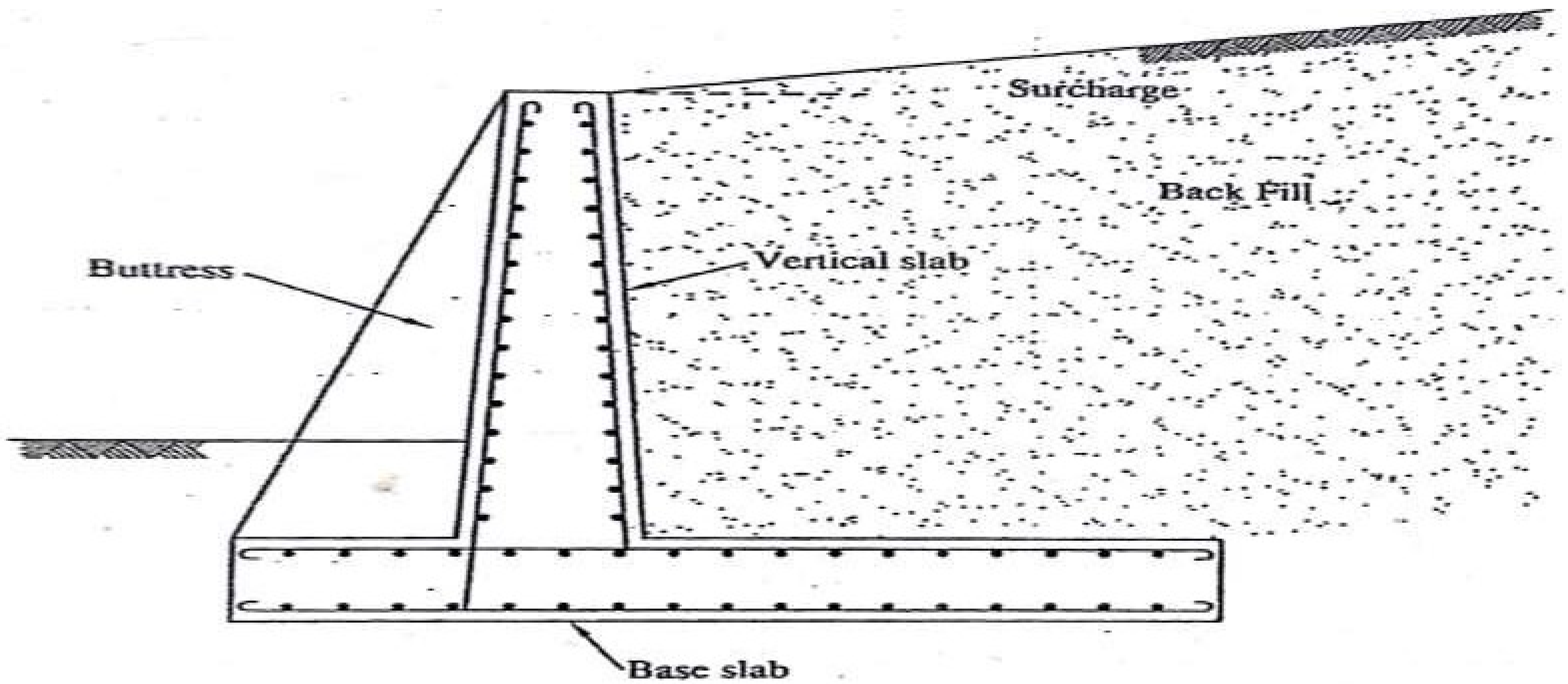
3 . Counterfort retaining wall :

- In this type of retaining wall the stem and base slab are tied together by counter fort at suitable interval.
- Economical for heights over about 6m.

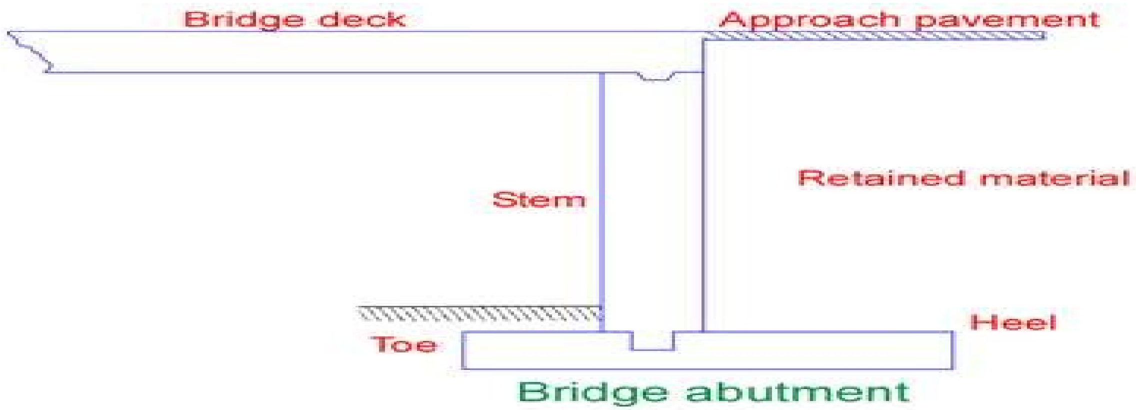


4. Buttress wall :

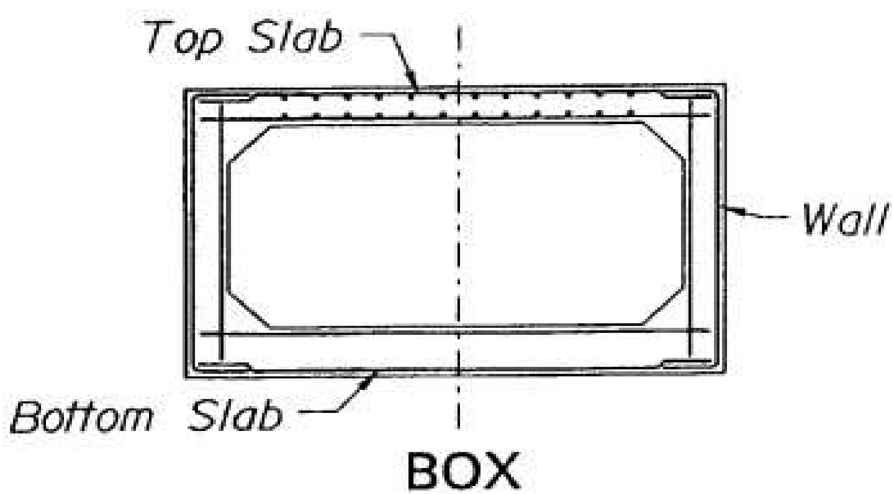
- Modification of counterfort wall with counter forts called buttresses, provided to other side of backfill.



5. Bridge Abutment : similar to the top of stem of retaining wall is braced by the deck slab of bridge.



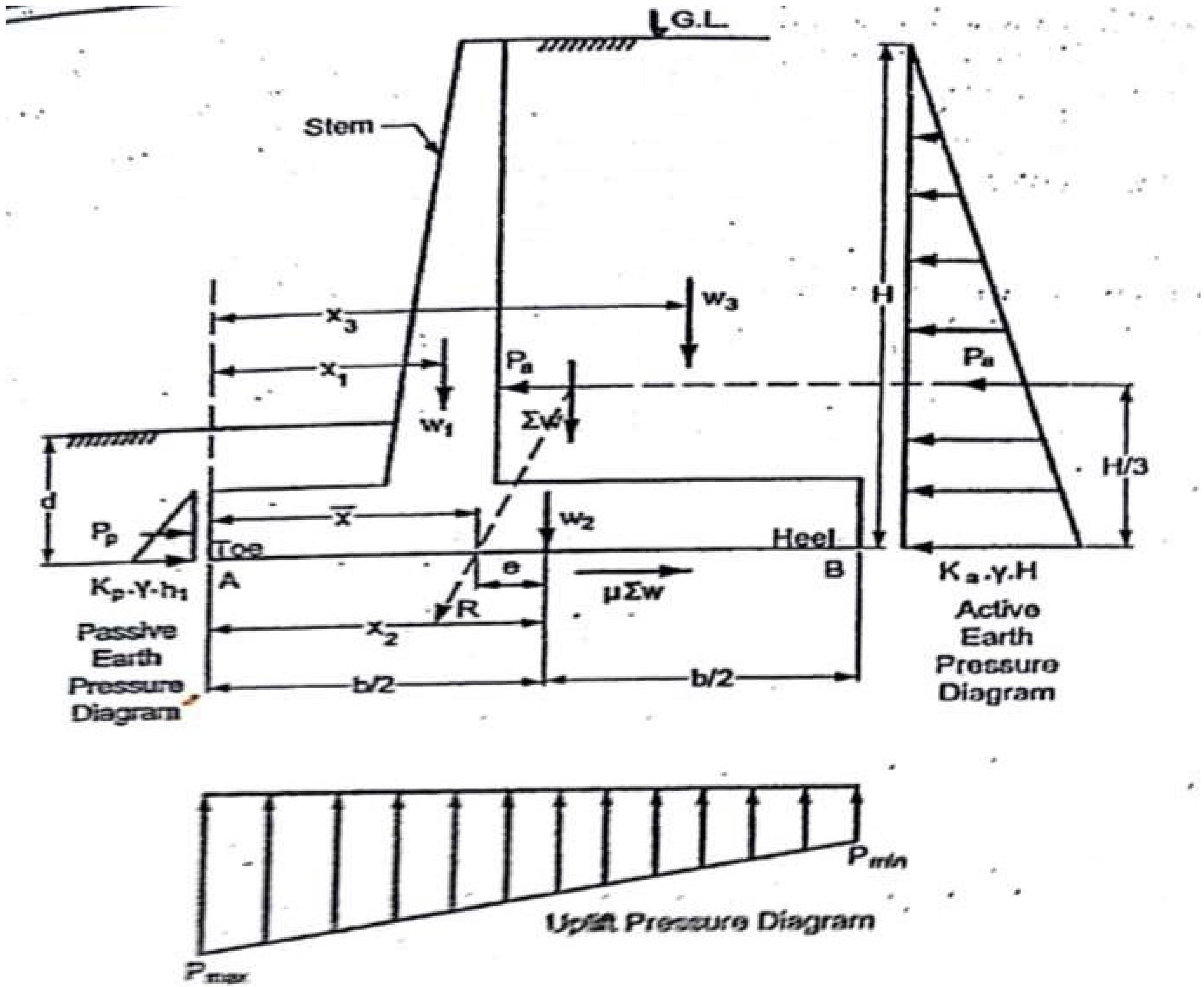
6. Box Culvert : it acts as a close rigid frame, consisting of single or multiple cells.



Forces Acting on Retaining wall

The various forces acting on retaining wall are :

1. Lateral earth pressure
2. Self weight of retaining wall
3. Weight of soil above the base slab
4. Surcharge
5. Soil reactions below base slab
6. Frictional force at the bottom of base slab .



G.L.
Stem
x_3
w_3
H
x_1
P_a
P_a
w_1
Σw
H/3
d
$\bar{x}$
w_2
P_p
Toe
Heel
e
$K_p \cdot \gamma \cdot h_1$
A
B
$K_a \cdot \gamma \cdot H$
$\mu \Sigma w$
R
Passive Earth Pressure Diagram
x_2
Active Earth Pressure Diagram
b/2
b/2
P_{min}
Uplift Pressure Diagram
P_{max}

- Lateral Earth Pressure :

  The lateral Earth pressure due to earth pressure is the major force acting on the retaining wall .

- Active Earth pressure by Rankine Theory : (For Cohesionless soils)

1. Dry or moist backfill with no surcharge
2. Submerged backfill
3. Backfill with uniform surcharge
4. Backfill with sloping surcharge
5. Inclined back and surcharge ,

Dry or moist backfill with no surcharge

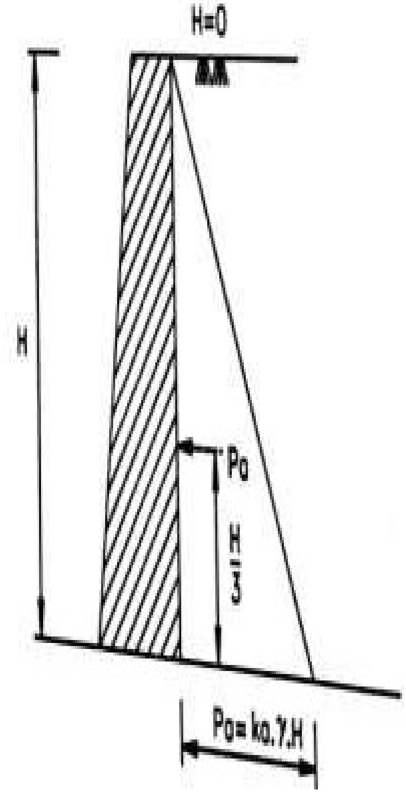
- Pressure at the base of wall,

$p_a = k_a \times \gamma \times H$

Total pressure acting on the wall,

$P_a = 0.5\ k_a \times \gamma \times H^2$

This pressure act at H/3 above the base of wall.



Submerged backfill

- Lateral earth pressure is made up of two component,

1. Due to submerged weight γ' of soil,

   $= k_a \times \gamma' \times H$

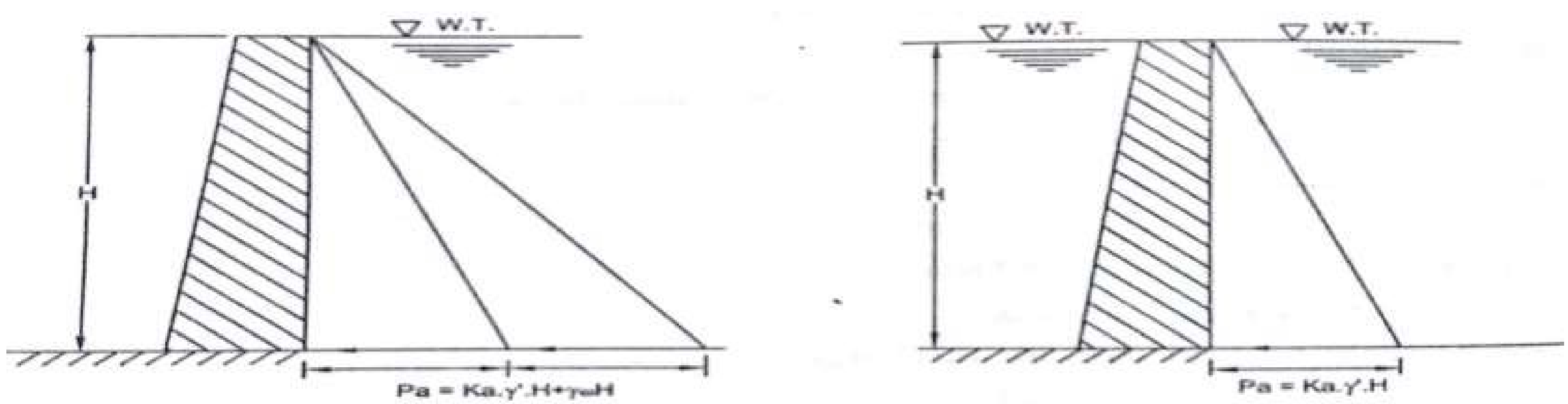
2. Lateral pressure due to water,

   $= \gamma_w \times H$

Total pressure at base, $= k_a \times \gamma' \times H + \gamma_w \times H$

If backfill is partly submerged,

$P_a = k_a \times \gamma \times H_1 + k_a \times \gamma' \times H_2 + \gamma_w \times H_2$



(a) Water on one side

(b) Water on both side

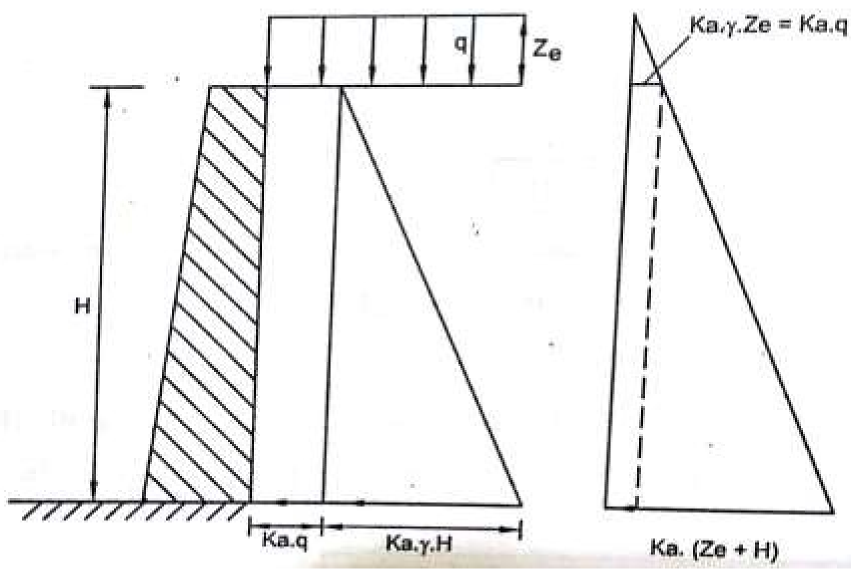
Backfill with uniform surcharge

- If backfill carries surcharge of uniform intensity q per unit area,

Lateral pressure due to surcharge = $k_a . q$

Lateral earth pressure due to backfill = $k_a \times \Upsilon \times H$

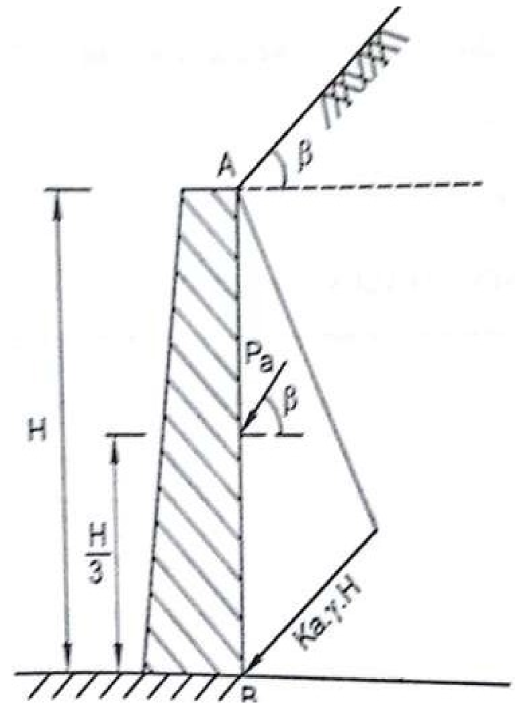
Lateral pressure intensity at base = $k_a . Q + k_a \times \Upsilon \times H$



Backfill with sloping surcharge

- Total earth pressure acting at angle β with horizontal ,

$$K_a = \cos\beta \frac{\cos\beta - \sqrt{\cos 2\beta - \cos 2\varphi}}{\cos\beta + \sqrt{\cos 2\beta - \cos 2\varphi}}$$



If surcharge is horizontal, $\beta = 0$

$$K_a = \frac{1 - \sin\emptyset}{1 + \sin\emptyset}$$

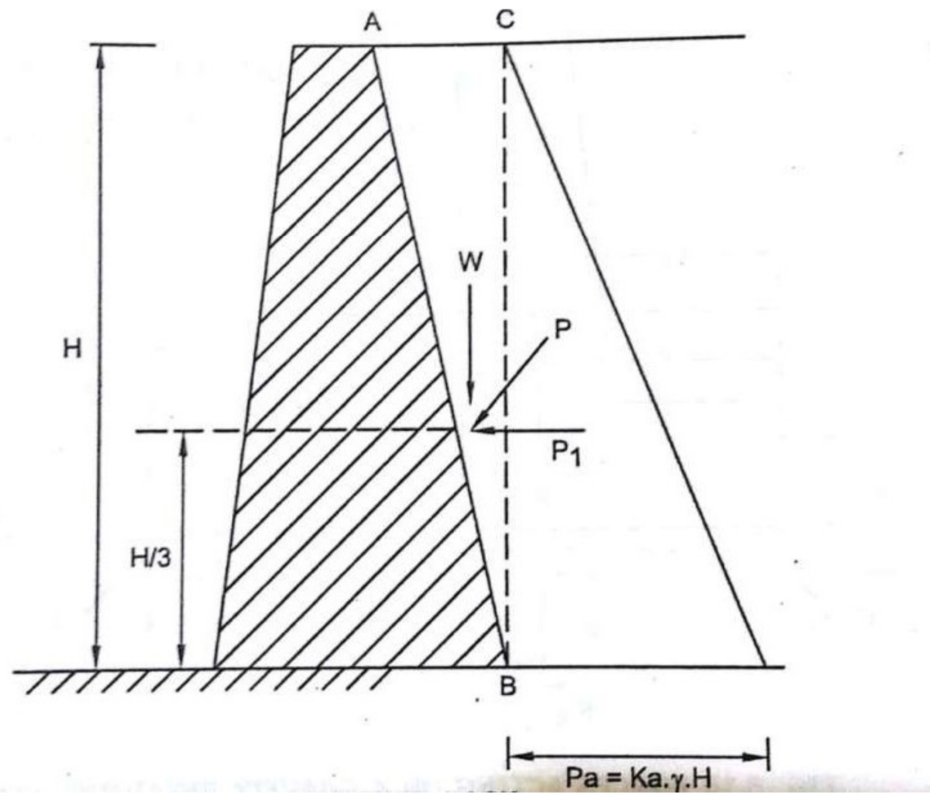
Inclined back

- Resultant of pressure P_1 and weight of soil wedge w is calculated as P.

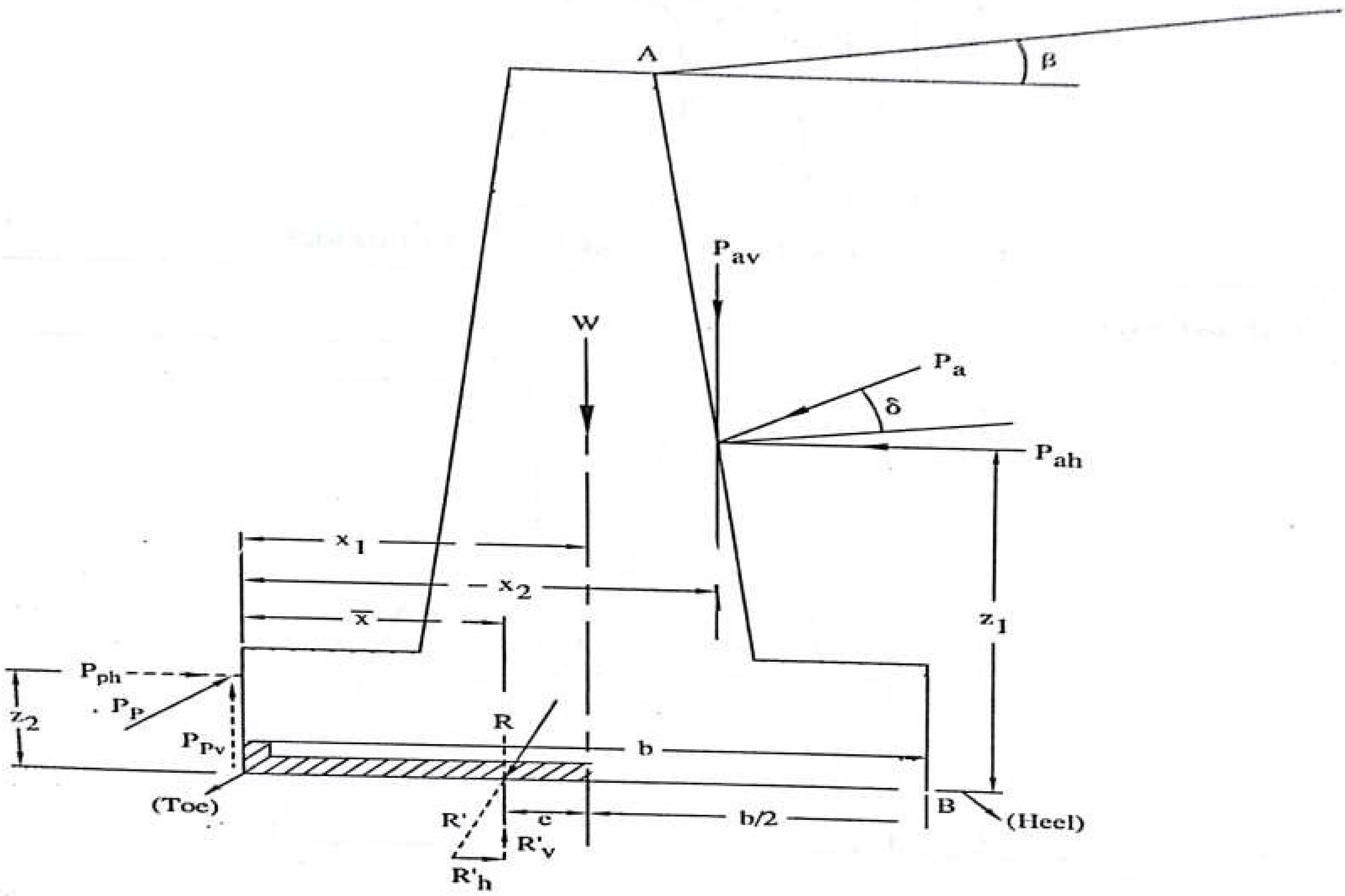
$$P = \sqrt{p_1^2 + W^2}$$

Where ,

$$p_1 = 0.5 k_a x \Upsilon x H^2$$



Forces acting on gravity retaining wall



Design criteria

- The criteria for the design of a gravity retaining wall are:-

- The base width (b) of the wall must be such that the maximum pressure exerted on the foundation soil does not exceed the SBC of the soil.

- No tension should be developed anywhere in the wall.

- The wall must be safe against sliding.

- The wall must be safe against overturning.

- W = weight of wall per unit weight
- P_a = total active earth pressure
- P_p = total passive earth pressure
- R = resultant of all forces

$x = \Sigma M / \Sigma V$

where, x = distance of R from toe

ΣM = sum of moment of all actuating force

ΣV = sum of all vertical forces

Eccentricity ,

$e = b / 2 - x$

b = base width of wall

Stability checks

1. No sliding :-

- Sliding force = $R_h = P_{ah}$

- Resisting force = $\mu \cdot R_v = \mu \cdot \Sigma V$

  μ = coefficient of friction between base of the wall and the foundation soil
  = $\tan\Phi$

- F.S = Restoring force/Sliding force
  = $\mu \cdot R_v / R_h$

2. No overturning:

F.S. = (sum of restoring moments at toe) /

(sum of overturning moments at toe)

$$= \Sigma M_R / \Sigma M_o$$

$$M_R = w \,.\, X_1 + P_{av} \,.\, X_2 + P_{ph} \,.\, Z_2$$

$$M_O = P_{ah} \,.\, Z_1$$

FOS against overturning should be greater than 1.5

3. . NO tension :

For no tension in wall, eccentricity should not exceed b / 6.

$\sigma_{max} = R_v / b (1 + 6. e / b)$…..At toe

$\sigma_{min} = R_v / b (1 - 6. e / b)$…..At heel

- e < b/6 , the stress anywhere on the base of the wall is Compressive

e = b/6 , the stress anywhere on the base of the wall is Compressive with its value at the heel equal to zero.

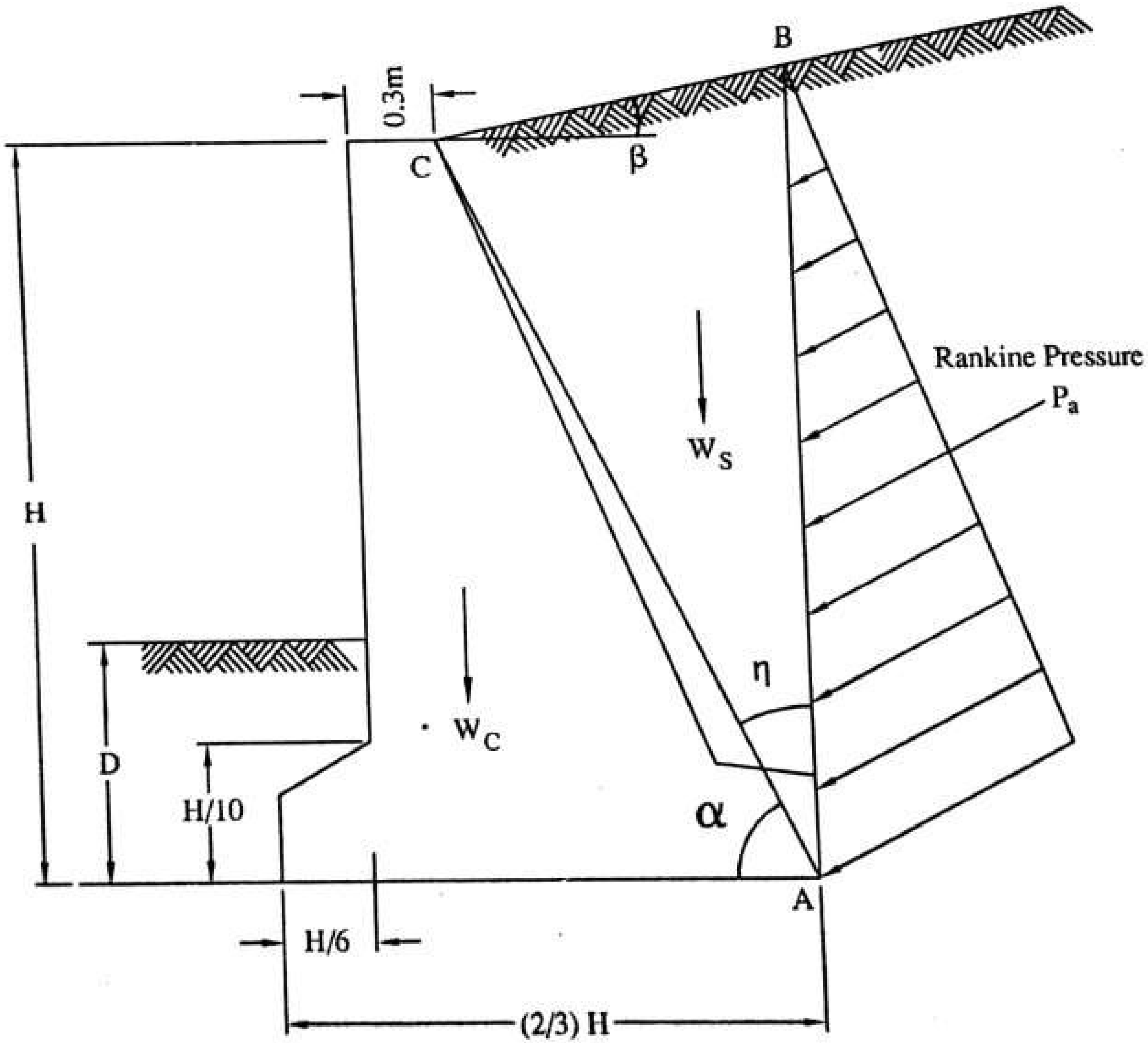
e > b/6 . Tensile stress is developed at the heel and compressive stress is developed at toe.

4. No bearing capacity failure :-

- The max. pressure at the base of the wall should not exceed allowable bearing capacity.

$$F.S = \frac{q_{ua}}{P_{max}}$$

Rankine's theory



- For using Rankine's theory a vertical line AB is drawn through the heel of wall. It is assumed that the Rankine acive condition exist along the vertical line.

- $\acute{\eta} = (45 + \beta/2) - (\Phi / 2) - \sin^{-1}(\sin\beta / \sin\Phi)$

where , β = angle of surcharge

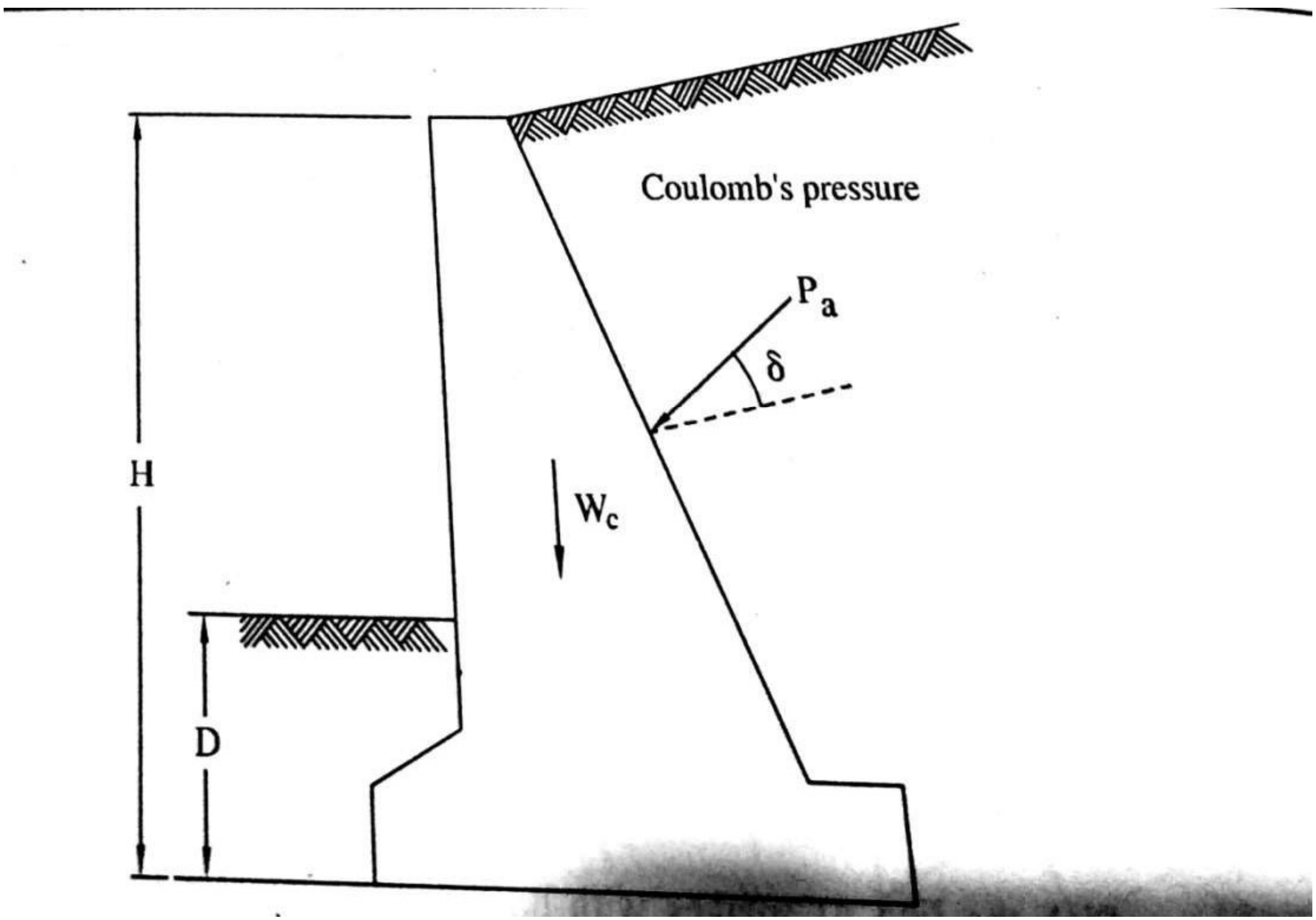
The angle α which the line AC makes with horizontal is given by

$$\alpha = 90 - \acute{\eta} = 90 - (45 + \beta/2) - (\Phi / 2) - \sin^{-1}(\sin\beta / \sin\Phi)$$

$$= (45 + \Phi / 2) - \beta/2 + \sin^{-1}(\sin\beta / \sin\Phi)$$

When $\beta = 0$ …….. $\acute{\eta} = 45 - \Phi / 2$ & $\alpha = 45 + \Phi / 2$

Coulomb's theory

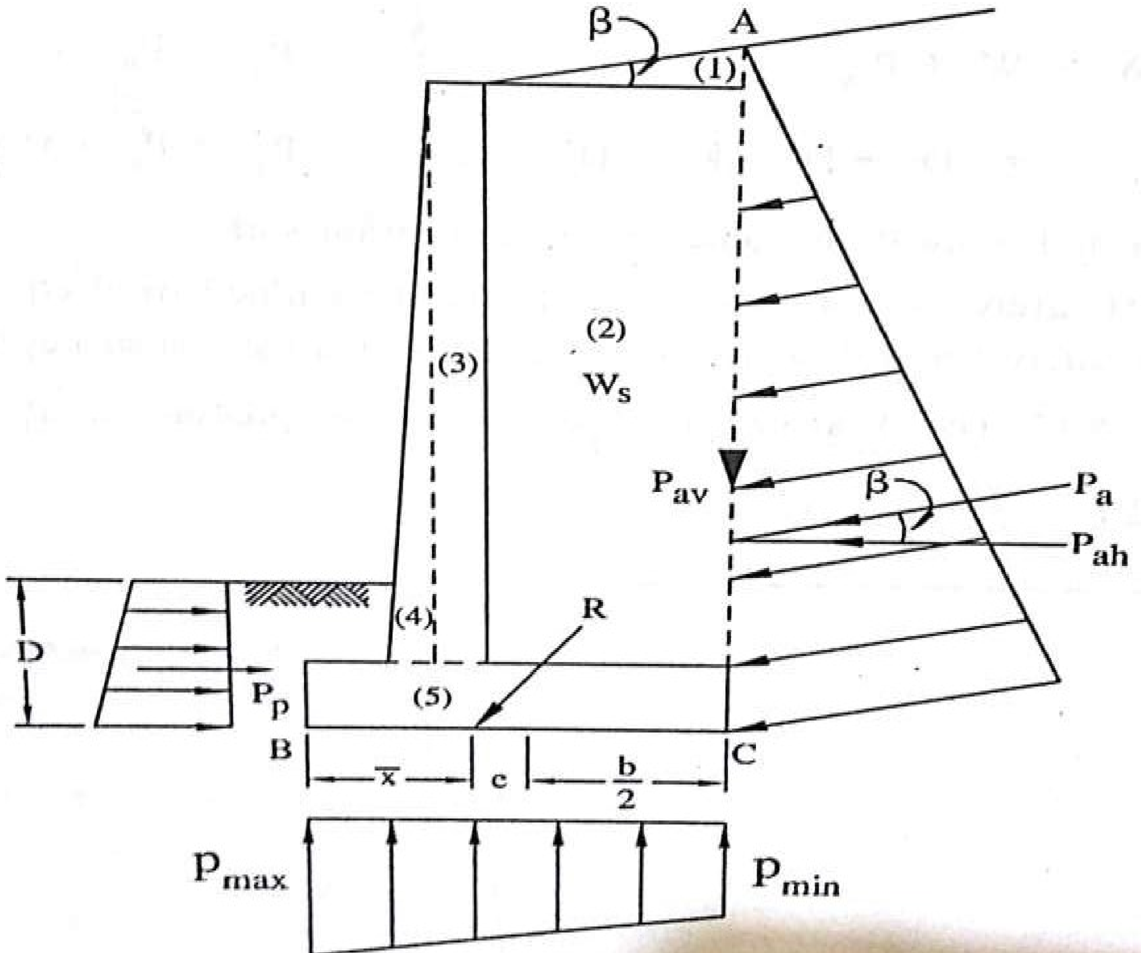


- Coulomb’s theory can also be used for determination of earth pressure.

- As it gives directly lateral pressure on back face, hence in this case the weight of soil W_s is not considered separately.

- Thus for checking the stability the forces to be considered are only the lateral earth pressure P_a given by Coloumb’s theory and the weight of the wall $W_{c.}$

Forces Acting on cantilever retaining wall



Stability checks

1. No sliding :

F.S. = (resisting force) / (sliding force)

$= \Sigma F_R / \Sigma F_D$

where, ΣF_D = sum of driving force

ΣF_R = sum of resisting force

2. No overturning :

F.S. = $\Sigma M_R / \Sigma M_O$

The force causing overturning is P_{ah} acting at H/3 frombase.

$\Sigma M_O = P_{ah} * H/3$

ΣM_R is due to weight of structure.

3. No tension :

For no tension in wall eccentricity e should not exceed b / 6.

$R = \sqrt{(\Sigma V)^2 + P_{ah}^2}$

The resultant cut the base at distance x from toe,

$x = \Sigma M / \Sigma V$

Eccentricity = $b / 2 - x$

For no tension $e < b/6$

4. No bearing capacity failures :

P_{max} at base should not exceed allowable bearing capacity.

F.S. = q_{na} / p_{max}

$P_{max} = \Sigma V (1 + 6. e / b)$

Drainage of backfill

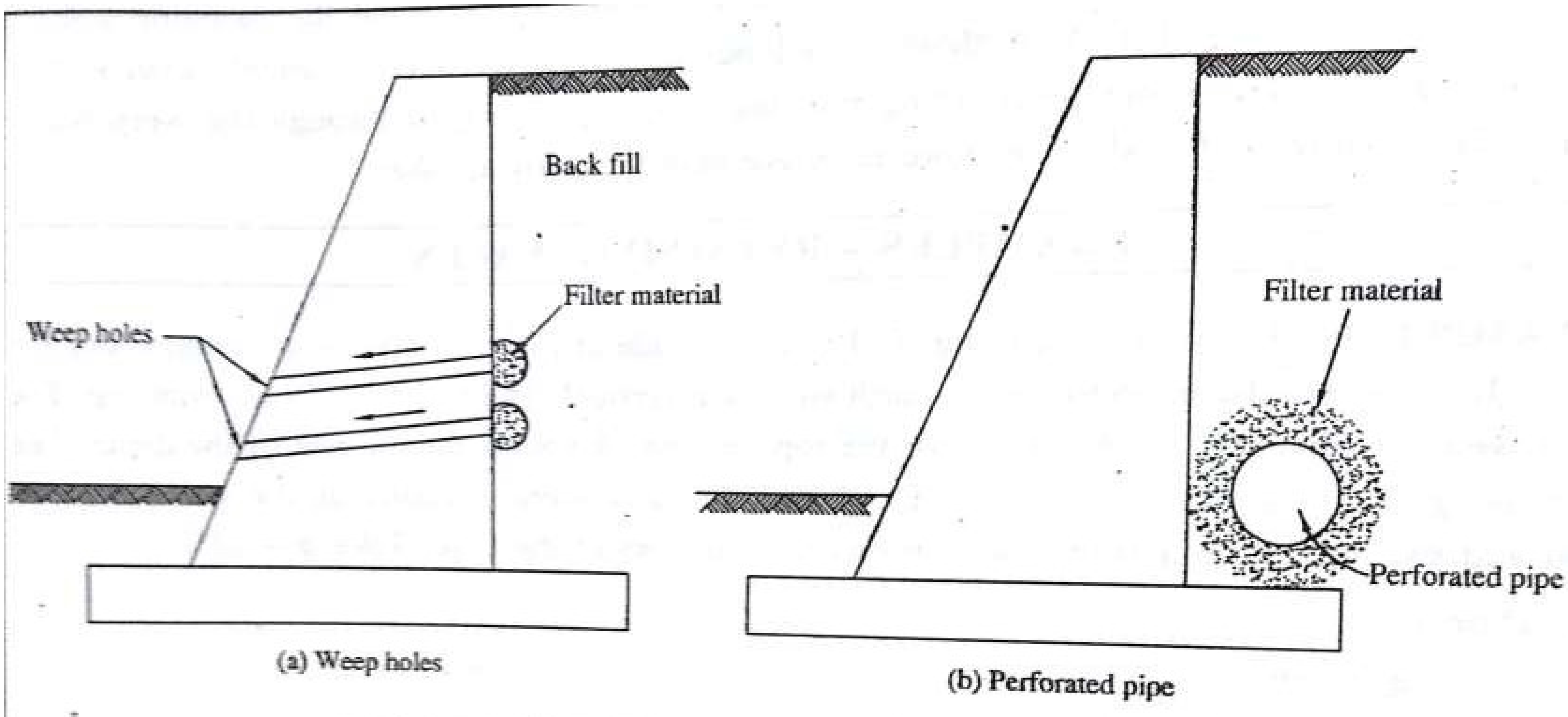


FIG. 5.18 (A) WEEP HOLES (B) PERFORATED

- When the backfill becomes wet due to rainfall or any other reason , its unit weight increases. It increase the pressure on retaining wall and create unstable conditions.

- If the water table rises the pore water pressure develops and it cause excessive hydrostatic pressure on retaining wall.

- To reduce the excessive lateral pressure on retaining wall, adequate drainage must be provided.

- For the drainage of backfill weep holes are generally provided. The weep holes are of 0.1 m dia. And their spacing varies from 1.5 m to 3.0 m. in horizontal direction.

- Perforated pipes may also be used as drainage of backfill. They are placed at the base of the wall. The filler materials is placed around the pipes to avoid washing of backfill material in perforated pipe.

Sheet Pile Walls

- Sheet pile walls are a type of earth retaining structures in which a continuous wall is constructed by joining sheet piles.

- They are made of timber, steel or reinforced concrete and consists of special shapes which have interlocking arrangements.

- They are embedded in ground to develop passive resistance in front to keep wall in equilibrium.

- A bulkhead is a sheet pile retaining wall of water front, backed up by ground.

Uses of Sheet Pile Walls

- Waterfront structures
- Canal locks
- Cofferdams
- River protection , etc.