UNIT V-th

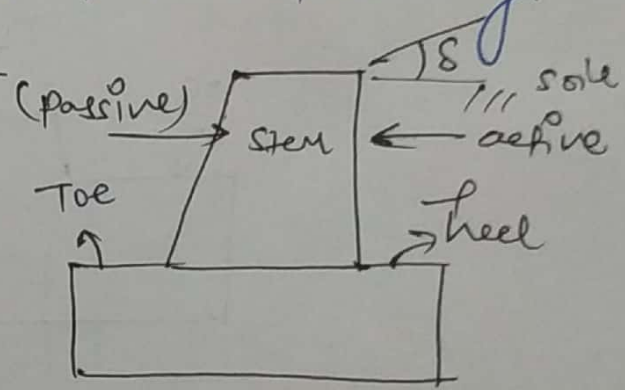
Retaining wall

Retaining walls are used to Retain earth or other loosen material. These walls are used for the following purposes:-

a) In the construction of building basement
b) As wing walls or abutments in the construction of bridges
c) In the construction of embankments.

The material which is retained by retaining wall is called backfill. The sloping backfill is called inclined surcharge. The backfill exerts a push or lateral press which tries to overturn, bend and slide the retaining wall.

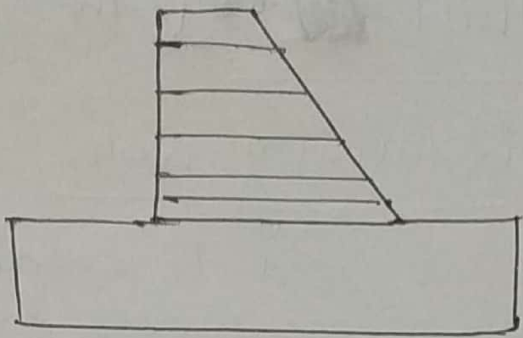
Types of Retaining wall:-



I) Gravity Retaining wall
II) Cantilever " "
III) Counterfort " "
IV) Buttress " "

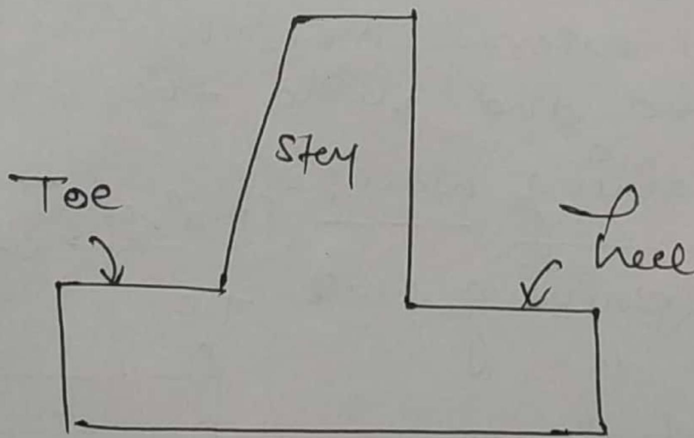
① **Gravity Retaining wall:** A gravity retaining wall is that retaining wall in which the weight of retaining wall provides stability against the pressure exerted by backfill.

Gravity retaining walls are made up of Massive stone or plane concrete. The wall is designed on the basis of the middle third rule

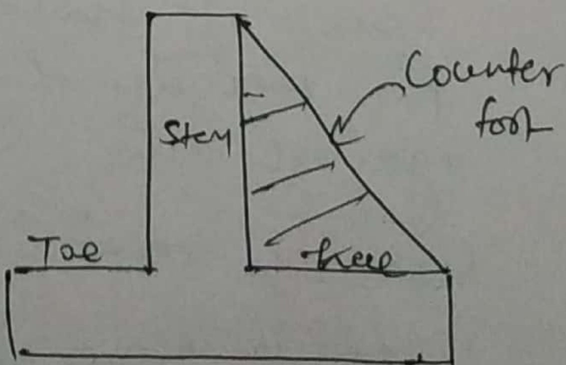


② **Cantilever Retaining walls:** It is most common type of retaining wall which consists of a vertical wall called as a stem, heel slab and toe slab all the components of the wall act as cantilever.

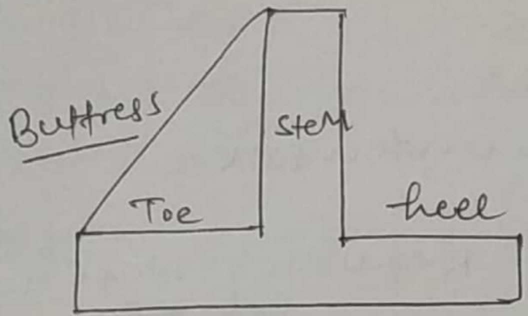
It is used to upto a height of 6M.



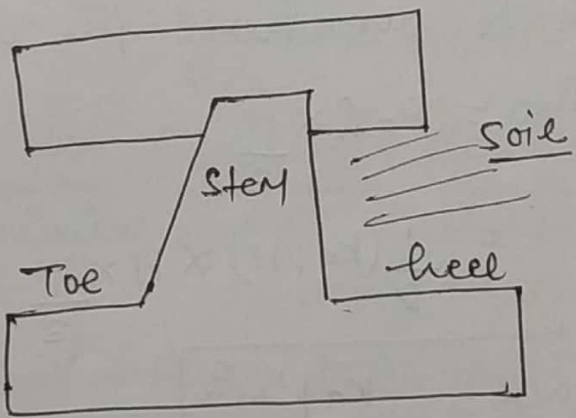
③ **Counter fort Retaining wall:** – when a back fill of greater height is to be retained and the required height of cantilever retaining wall exceeds 6M. Then it is very uneconomical to provide cantilever wall in such case counter fort Retaining wall is provided.



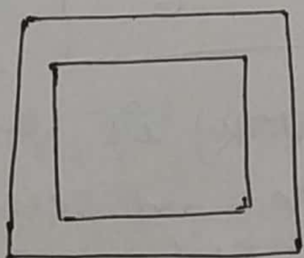
Buttress Retaining wall:. A Buttress Retaining wall is similar to Counterfort retaining wall but with the difference that in the buttress retaining wall. the buttress tie the stem and the toe slab together. ③



⑤ Brick deck Cantilever wall:-



⑥ Box culvert-:



Earth pressure on Retaining wall:- the main force that act on the Retaining is the active/passive earth pressure. this force tends to destabilize the retaining wall in overturning, bending & sliding the wall.

$$K_a / K_p = \frac{\cos\theta \mp \sqrt{\cos^2\theta - \cos^2\phi}}{\cos\theta \pm \sqrt{\cos^2\theta - \cos^2\phi}} \times \cos\theta$$

$$P_a = K_a \gamma H$$

$$K_a / K_p = \frac{1 \mp \sin\phi}{1 \pm \sin\phi}$$

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Stability of a Cantilever retaining wall:-

A cantilever retaining wall may fail in following conditions.

1) overturning
11) sliding
111) Failure of the under soil

① **overturning**:- A Retaining wall is subjected to overturning moments under the action lateral force developed due to lateral earth pressure which tries to overturn the wall about the toe.

$$M_o = P_{ah} \times \frac{H}{3}$$

$$= \frac{1}{2}(K_a \gamma H) \times H \times \frac{H}{3}$$

$$\boxed{M_o = \frac{K_a \gamma H^3}{6}}$$

The Resisting force (MR) is provided by the wt. of backfill. Surcharge and self weight of the retaining wall if (EW) is the res. total vertical load of self wt. of retaining wall and the wt. of backfill on the base slab.

$$MR = \Sigma W \times \bar{x}$$

$fs_1 > 1.4$

IS 456: 2000 clause no.1

$$fs_1 = \frac{0.9 MR}{M_o} \quad \left\{ \frac{0.9(\Sigma W . \bar{x})}{\frac{K_a \gamma H^3}{6}} \geq 1.4 \right\}$$

$$P_{max} = \frac{\Sigma W}{b}\left[1 + \frac{6e}{b}\right] \qquad P_{min} = \frac{\Sigma W}{b}\left[1 - \frac{6e}{b}\right]$$

NOTE-: The max^m pressure at the base should not exceeds the safe bearing capacity of soil and min^m pressure should not negative.

e = eccentricity of the resultant load that can be

Total moment $= M_R - M_O$

Total vertical load $= \Sigma W$

$$\bar{x} = \frac{M_R - M_O}{\Sigma W}$$

Then eccentricity $\left(e = b/2 - \bar{x}\right)$

Proportioning of the Cantilever Retaining wall:-

Designing of Retaining walls involves the determination of its dimension and the amount of steel required.

① depth of foundation – The min^m depth of the foundation is determined on the basis of rankines formula

$$h_{min} = \left(\frac{1 - \sin\phi}{1 + \sin\phi}\right)^2 \frac{q_o}{\gamma}$$

q_o = Safe bearing capacity of soil

γ = unit wt. of soil.

② Height of Retaining wall (H)-: The height of the material to be retained is given. The depth of foundation is added to the height of material (H)

② **Sliding**:- The lateral earth pressure tries to slide the retaining wall away from the backfill that is opposed by the frictional force developed b/w the base slab and soil. If μ is the coeff. of friction b/w the concrete and soil then

$$F_R = \mu \Sigma W$$

$$f_{s_2} = \frac{F_R}{F_S}$$

where $F_S = \frac{1}{2} k_a \gamma H^2 = P_{ah}$

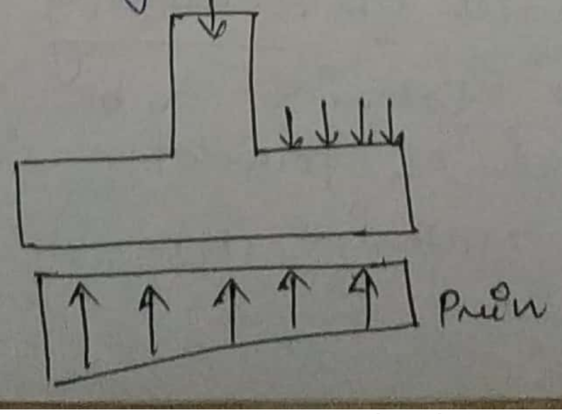
Acc. to code IS-456:2000 and min^m. F.O.S of 1.4

$$f_{s_2} \geq 1.4$$

$$\frac{F_R}{F_S} \geq 1.4$$

$$\left\{ \frac{0.9 \mu \Sigma W}{\frac{1}{2} k_a \gamma H^2} \geq 1.4 \right\}$$

3) **Failure of under soil**:- The base width of the retaining wall is designed in such a way that the max^m pressure on the under soil caused due to load distribution must not exceed the soil bearing capacity (SBC) in addition to that we have to design for no tension through out the section.



Base width (b) :- the width of the base slab can be determined by considering the various forces it varies from 0.4H to 0.6H.

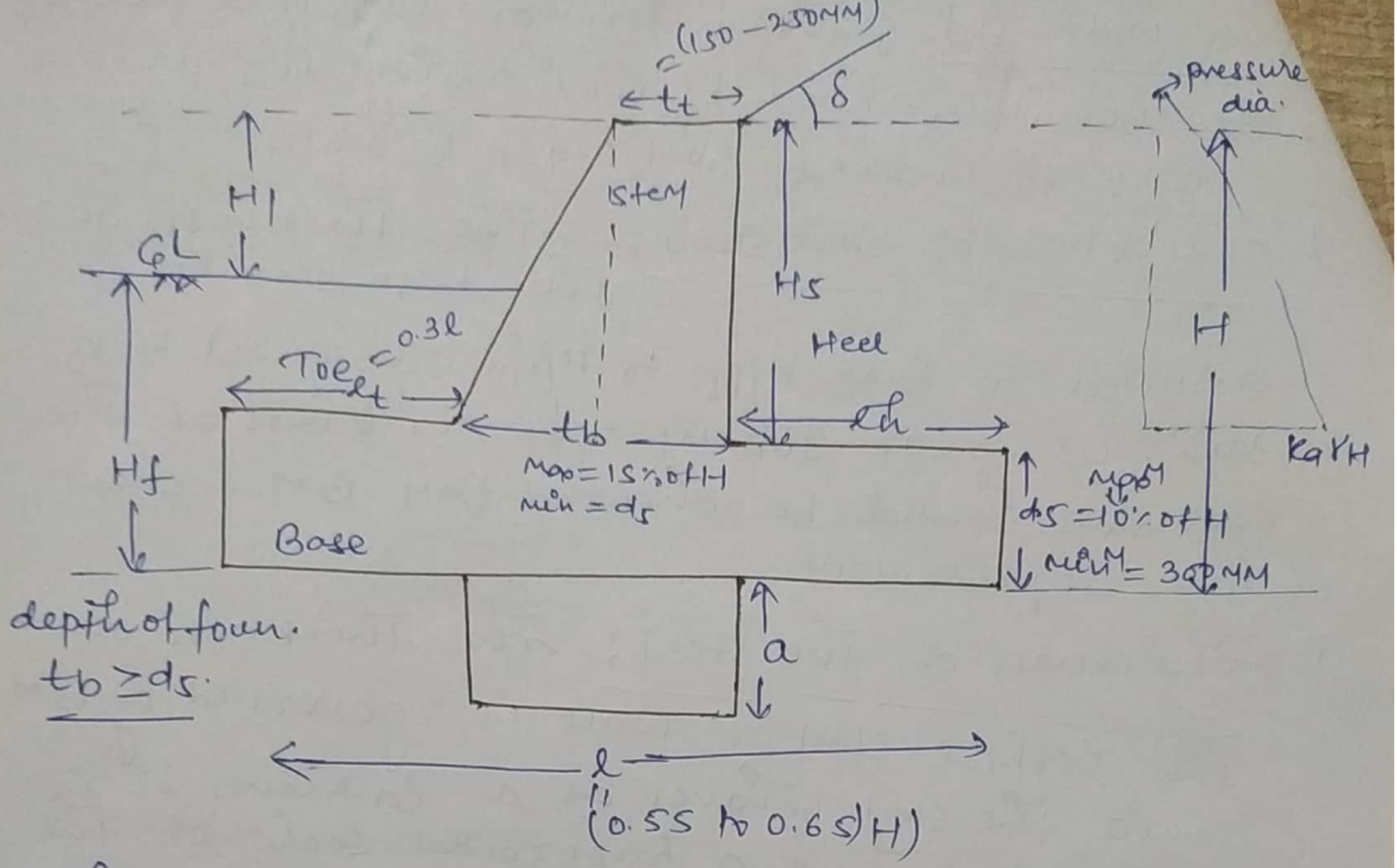
iv) **Thickness of base slab** :- The thickness of the base slab is assumed to from H/15 to H/10 subjected to a min^m. value of 300 mm. The thickness of the base slab should be checked from B.M. & shear force requirements.

v) **Thickness of the stem** :- The thickness of the vertical stem or wall is governed by B.M. criteria the stem behaves as a cantilever it is economical to have a trapezoidal section of the stem.

Trapezoidal section of the stem with min^m thickness 150 mm at the top the thickness at the base of the stem should not be less than 300 mm.

Que :- Design a Reinforced concrete cantilever type retaining wall having a 5m tall stem the wall have soil levelled at its top the soil weights 1800 N/m³ and as an angle of repose 30° the safe bearing capacity of the soil 200 kN/m² use M20 & Fe415 steel.

Solution :-
1. Given values
2. Assumptions of dimensions
3. Stability check
4. Design
   - Stem
   - Heel
   - Toe
5. Detailing



where $\delta \neq 0$ $\quad K_a = \cos\delta \left[\dfrac{\cos\delta - \sqrt{\cos^2\delta - \cos^2\phi}}{\cos\delta + \sqrt{\cos^2\delta - \cos^2\phi}} \right]$

If $\delta = 0$ then $K_a = \dfrac{1 - \sin\phi}{1 + \sin\phi}$

$$P_H = \frac{1}{2} K_a \gamma H \times H = \frac{K_a \gamma H^2}{2}$$

$$\left\{ B.M. = P_H \cdot \frac{H}{3} \right\}$$

$$M_0 = P_H \cdot \frac{H}{3} = \frac{K_a \gamma H^3}{6}$$

Assumption: $t_t = 150 - 200$ MM

$l_t = 0.3l$

t_b = 15% H max^m value

t_b = d_s (min^m value) } take min^m

$l = (0.55$ to $0.65)H)$ & $t_b \geq d_s$

d_s = 10% H max, 300 MM min } take max^m.

ei:- Solution:- M 20 & Fe415 & $\delta = 0$

$H_s = 5M$ (given) $\gamma = 18000 \, N/M^3$.

$SBC = 200 \, KN/M^2$

$M_o = \frac{K_a \gamma H^3}{6}$ $\quad K_a = \frac{1 - \sin 30^\circ}{1 + \sin 30^\circ} = \underline{0.333}$

$M_o = \frac{1}{3} \times 18000 \times \frac{H_s^3}{6}$

$M_o = 1000 \, H_s^3 = 12500 \, NM = 125 \, KNM$

taken $b = 1M$

$M_o = 0.36 \, f_{ck} \, b d^2$

$125000 \times 1000 = 0.36 \times 1000 \times 20 \times d^2$

$\underline{d = 131.76 \, MM}$

$d' = d + \text{clear cover} = 131.76 + 40$
$= \underline{171.76 \, MM}$

$H = H_s + d' = 5 + 0.17176$
$= \underline{5.17 \, M}$

$d_s = 10\% H = 517 \, MM \simeq 520 \, MM$
$\simeq 300 \, MM$ } Max.M

$d_s = 520 \, MM$ then also can take
$H = H_s + .520$
then $H = 5.520 \, M$
corrected value

$l = 0.6H$
$l = 3.312 \, M$
$l_t = 0.3l = 0.9936 \simeq 1M$

assume $t_t = 200MM$

$t_b = 15\%H = 228MM$ or d_s (min)

$t_b \geq d_s$

$t_b = 225$, d_s] min = 520MM

$t_b = 520MM$

$lh = 3.312 - 1 - 0.52 = 1.792M$

iii) stability check → sliding, → overturning