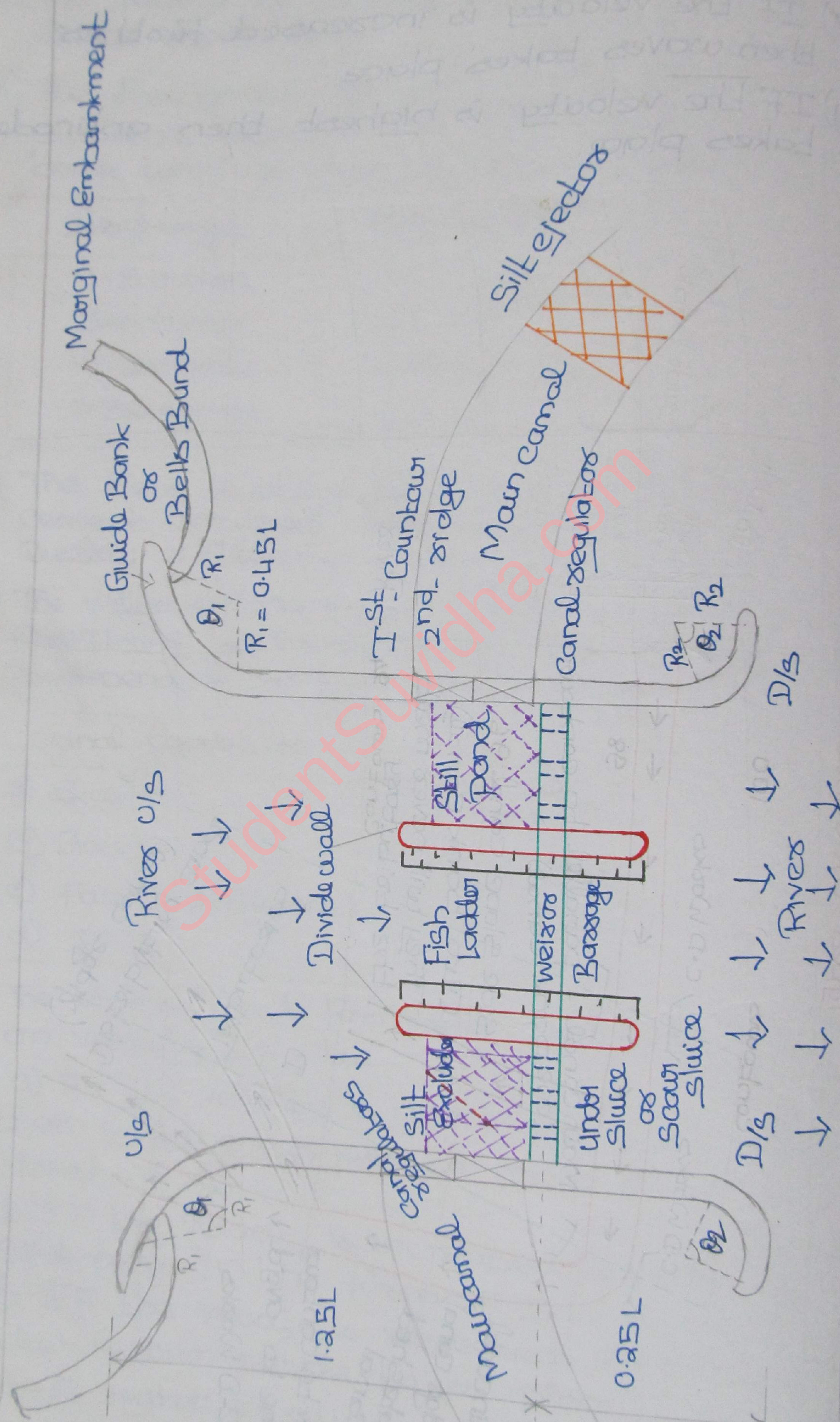
25/11/2010
to
26/11/2010

Diversion Head Work

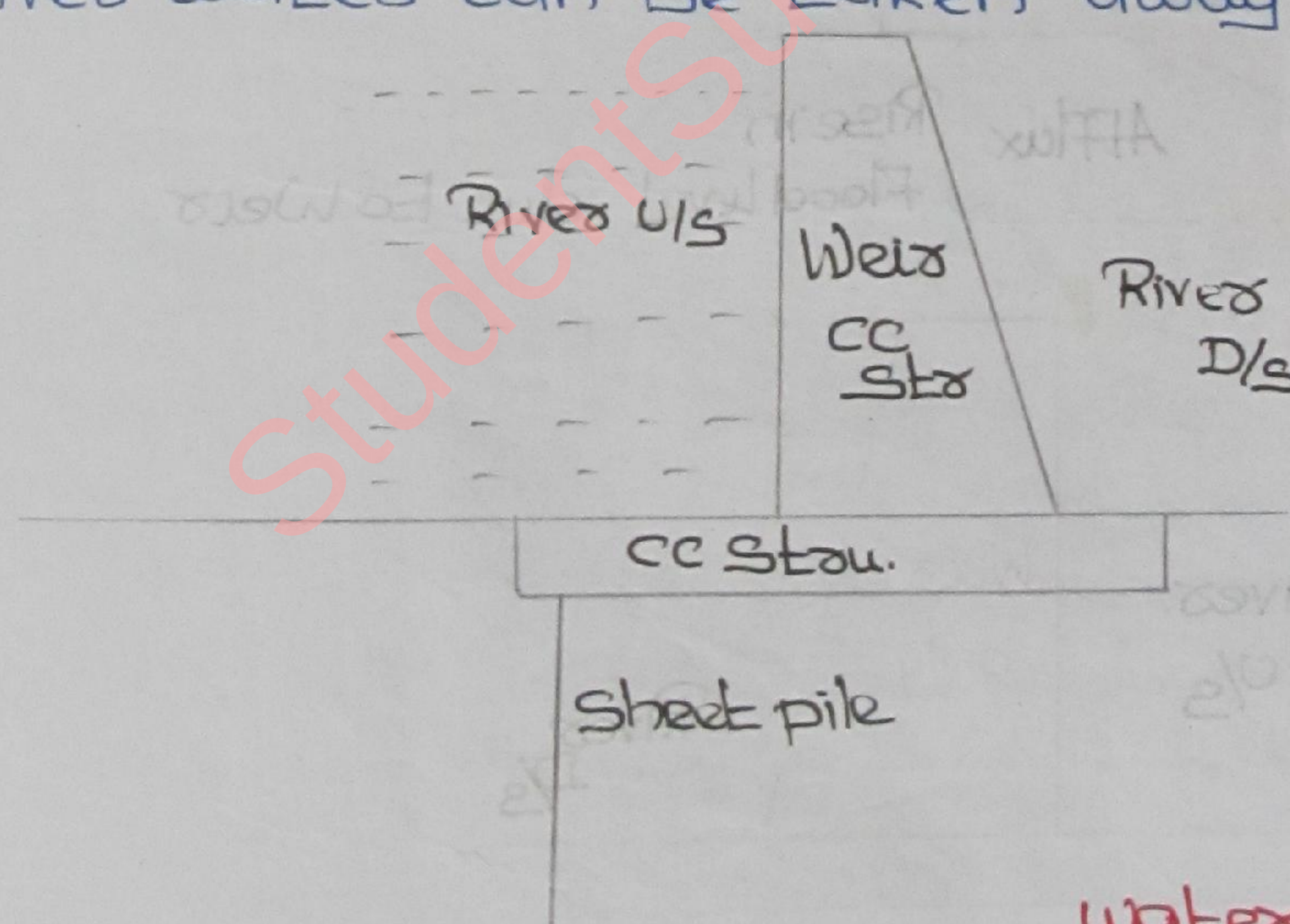


Layout of DHW

1. $R_1 (U/S) = 0.45L$, $L = 4.75\sqrt{Q}$
2. $\theta_1 (U/S) = 120^\circ$ to 135°
3. $R_2 (D/S) = R_1/2$
4. $\theta_2 (D/S) = 45$ to 60°

5) parts of DHW
   a) Marginal Embankment
   b) Guide Bank or Bells bund
   c) Weir or Barrage
   d) Divide wall
   e) Fish ladder
   f) Scour sluice (under sluice)
   g) Canal regulator

6) Weir:-
   - permanent barrier across the river just to raise the water level so that the river water can be taken away by the canal

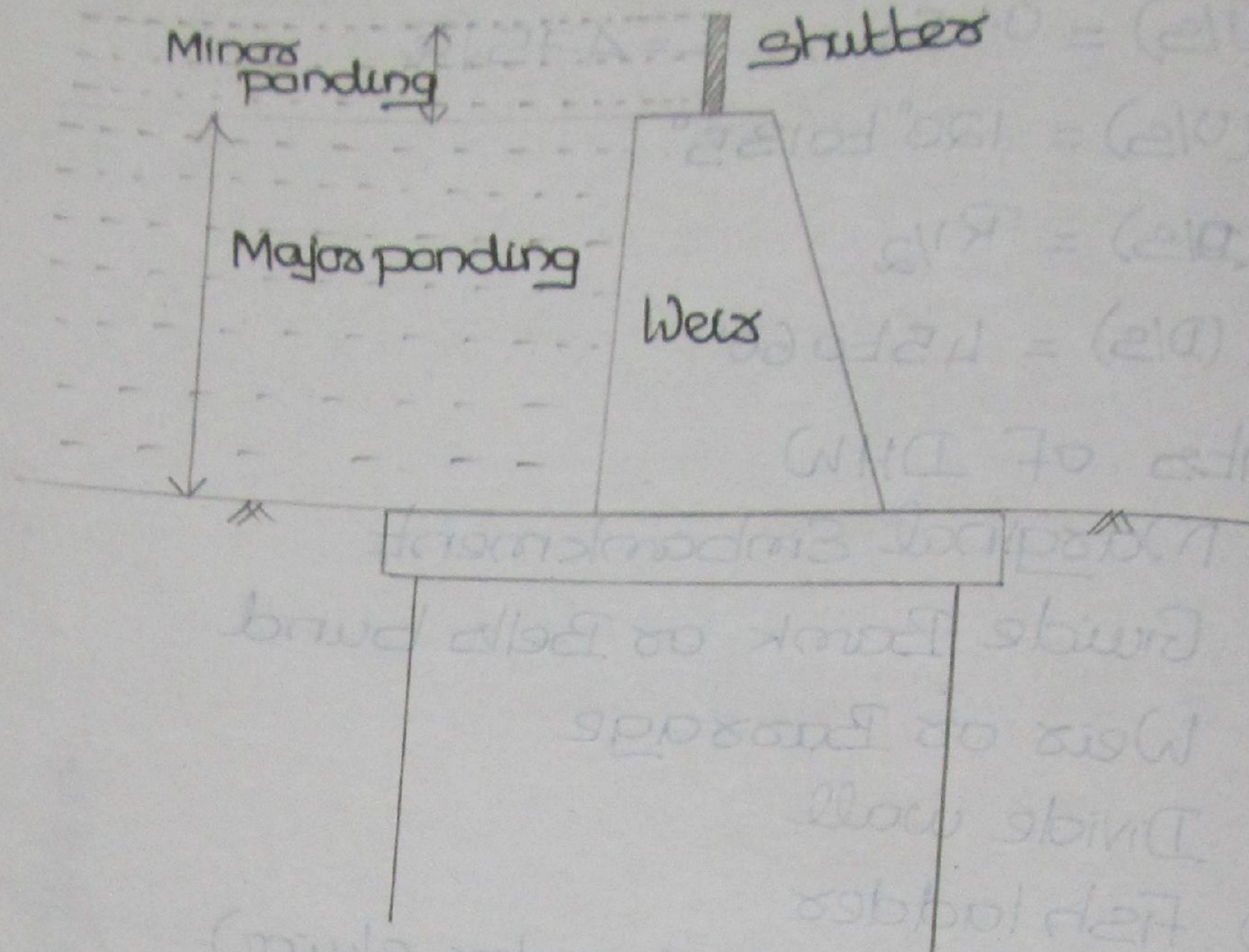


Length of Weir is Linear water way.

$L_{WW} = 4.75\sqrt{Q}$

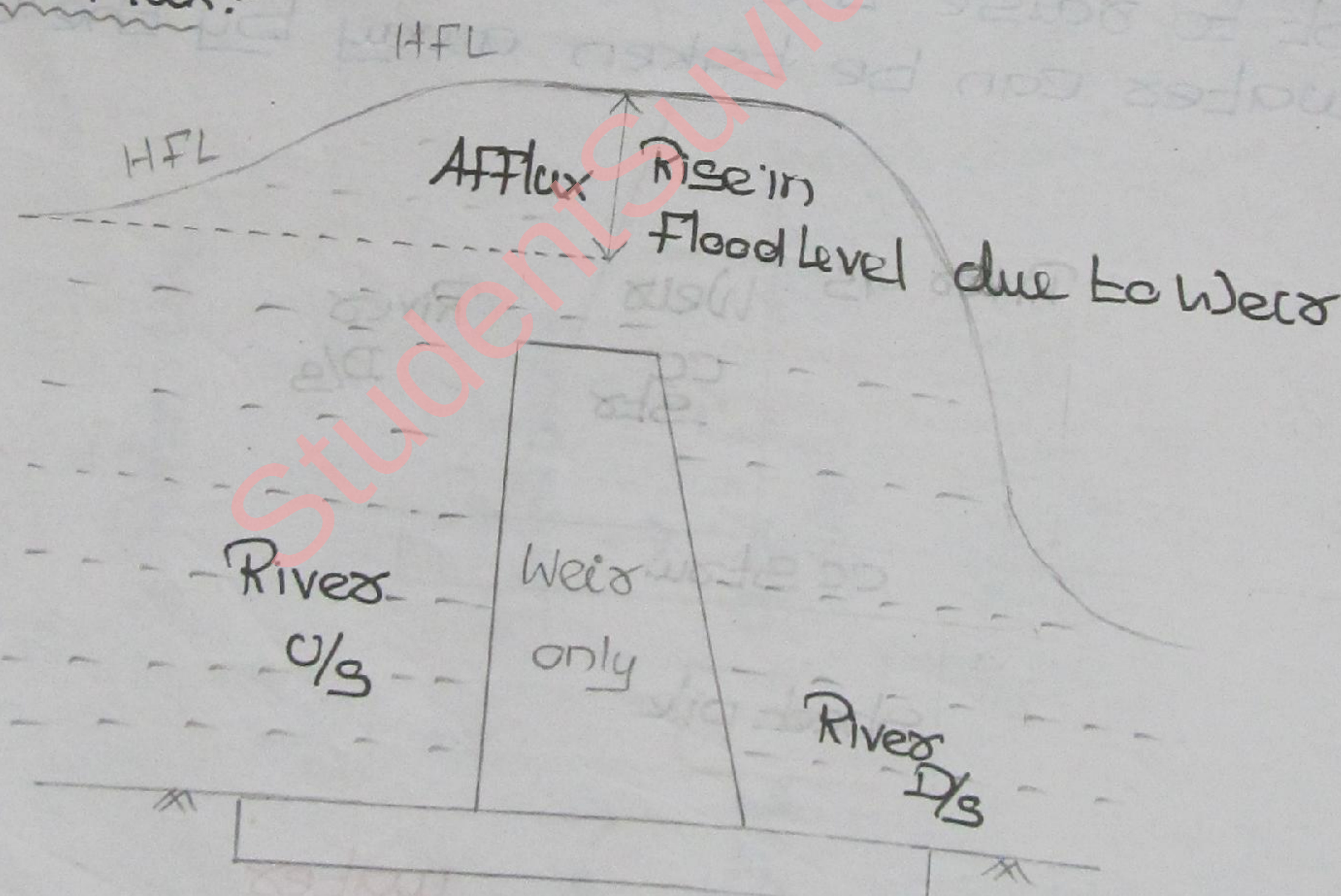
Weir is a cement concrete structure

7)

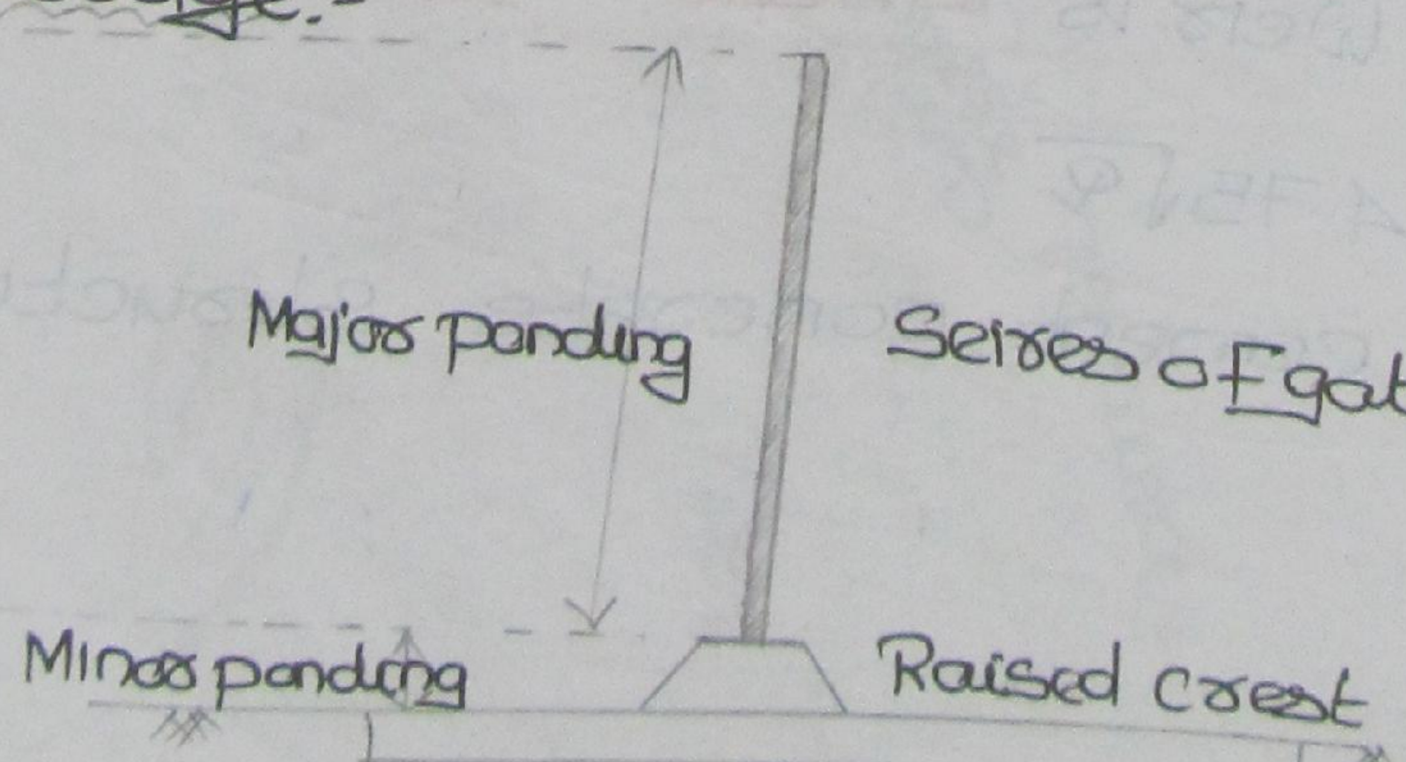


If the major ponding is done by the raised Crest (structure) and minor ponding is achieved by the shutter, then the barrier across the river is called Weir

8) Afflux:-



9) Barrage:-

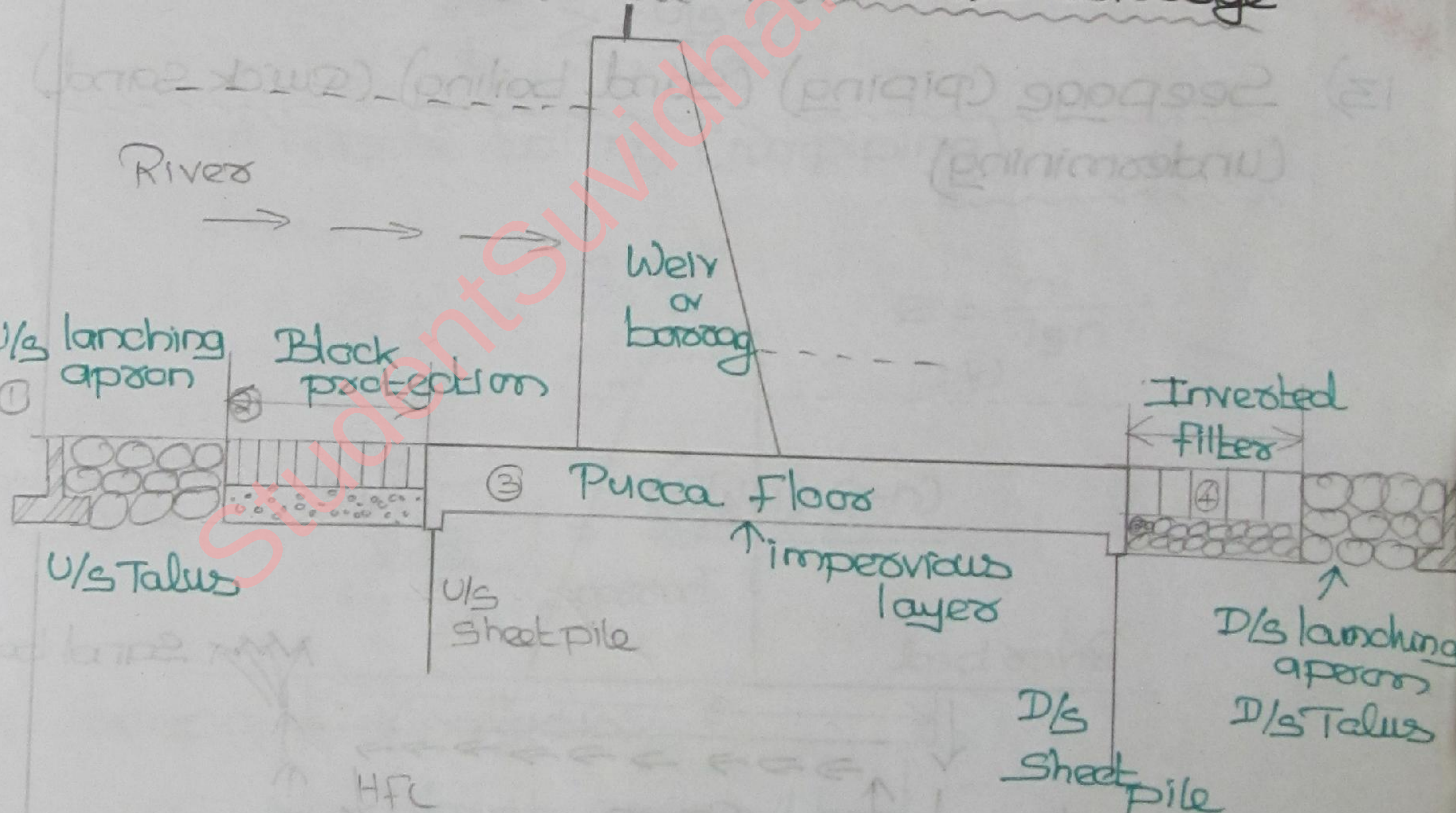


If major ponding is achieved by shutters and minor ponding by the raised crest then the barrier across the river is called Barrage.

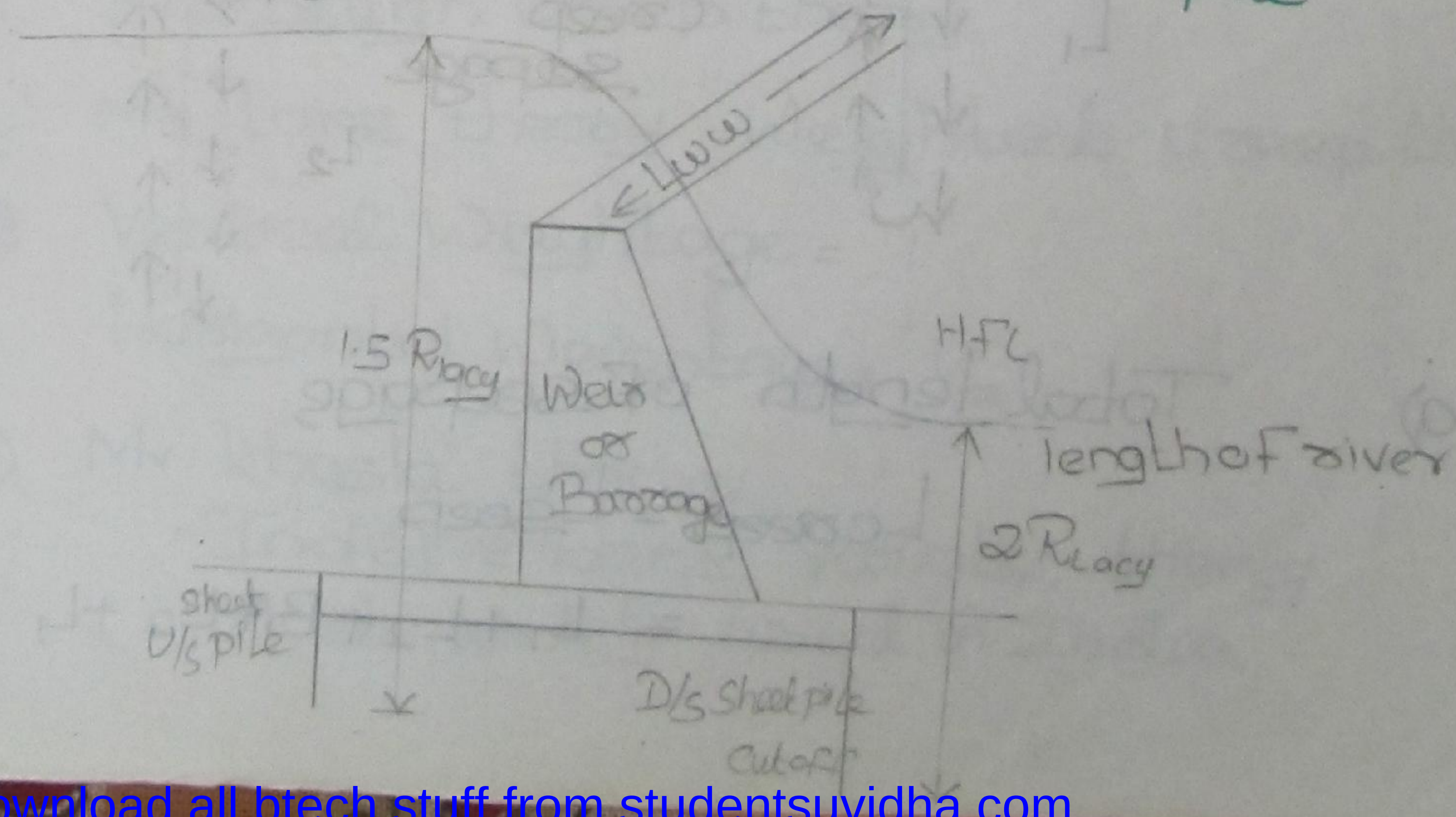
During Flood the shutters of the barrage are lifted up due to which there is no chance of developing Afflux. hence better Control over the river can be obtained by the barrage as well as bridge can be Constructed easily.

10) Barrage is Costlier than the Weir (No maintenance in the Weir but maintenance is mandatary in the case of barrage), even though barriage is preferred.

11) parts of foundation of Weir & barrage



12)



Depth of sheet pile (U/S) = 1.5 R_{lacy} - HFL

$$R_{lacy} = 1.35\left[\frac{q^2}{F}\right]^{1/3} \text{ or}$$

Depth of sheet pile (D/S) = 2 R_{lacy} - HFL

$$q = \frac{Q}{L_{WW}} = \frac{Q}{L} = \frac{Q}{4.75\sqrt{Q}}$$

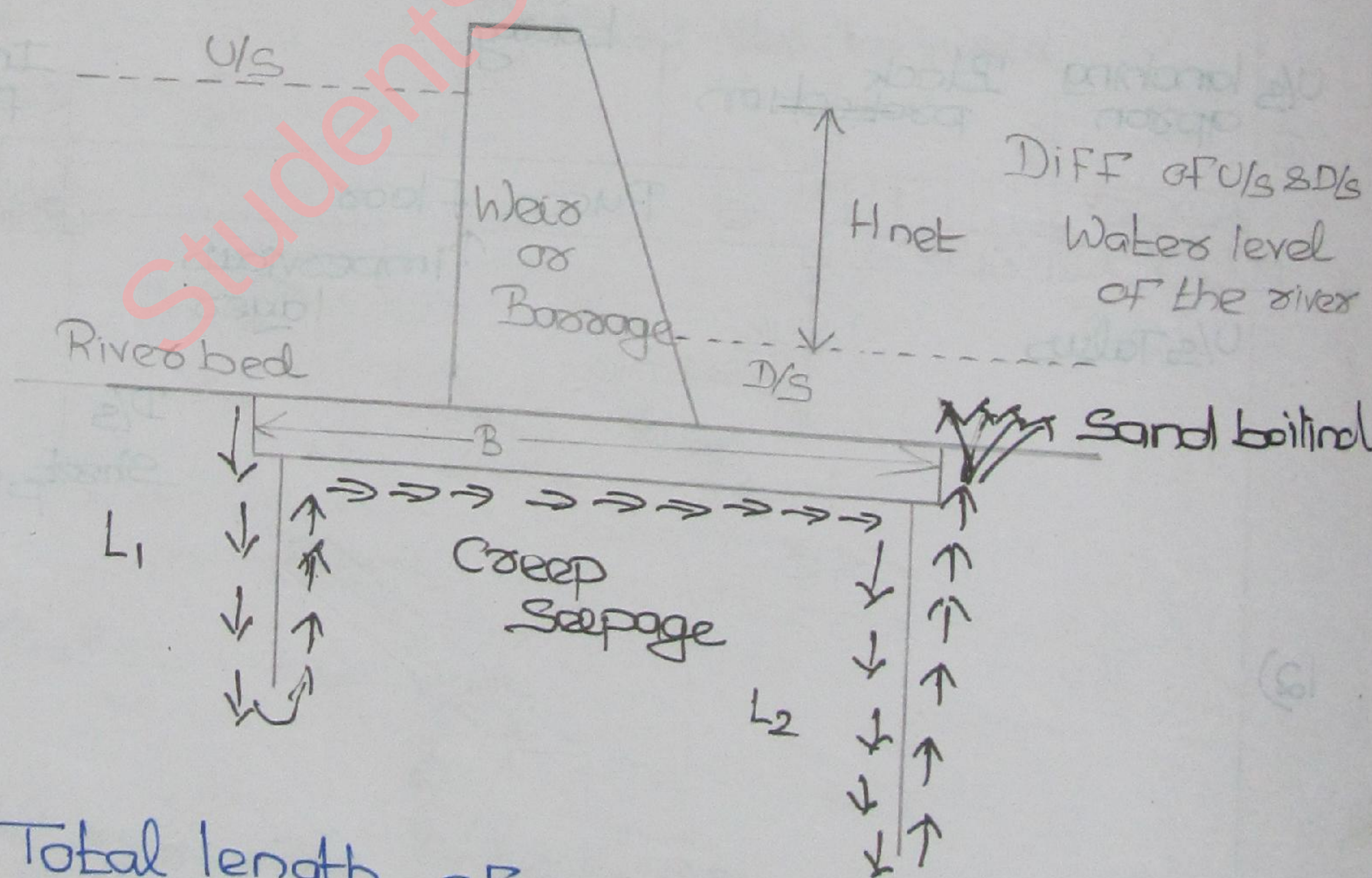
$$R_{lacy} = 1.35\left[\frac{q^2}{F}\right]^{1/3} \text{ or}$$

$$0.47\left[\frac{Q}{F}\right]^{1/3}$$

F - Silt factor = $1.76\sqrt{d}$

d - Silt size in 'mm'

*** 13) Seepage (piping) (Sand boiling) (Quick sand) (undermining)



a) Total length of seepage

$$L_{creep} = L_{seep}$$

$$= L_1 + L_2 + B + L_2 + L_1$$

$= 2L_1 + B + 2L_2$

b) Actual hydraulic gradient

$$i = \frac{H_{net}}{L_{creep}} = \frac{\Delta H}{L}$$

Independant of soil property

c) Critical hydraulic gradient

$$i_c = \frac{G_s - 1}{1+e} = \frac{\gamma_{sub}}{\gamma_w} \quad [\sigma' = 0]$$

Dependent on soil property only

and it is independent of

i) head of water and

ii) seepage length.

d) For sand boiling $i \geq i_c$

$$\Rightarrow \frac{\Delta H}{L} \geq \frac{G_s - 1}{1+e}$$

e) for no sand boiling (No piping)

$i < i_c$

$$i = \frac{i_c}{F.O.S} = \frac{\frac{G_s - 1}{1+e}}{F} \qquad e = \frac{n}{1-n}$$

$$i = \frac{\frac{G_s - 1}{1 + \frac{n}{(1-n)}}}{F} = \frac{(G_s - 1)(1-n)}{F}$$

14) Seepage Analysis:-

a) Mr. Blaigh creep theory

b) Mr. Lane theory Weighted creep theory

- Vertical Weightage = 1

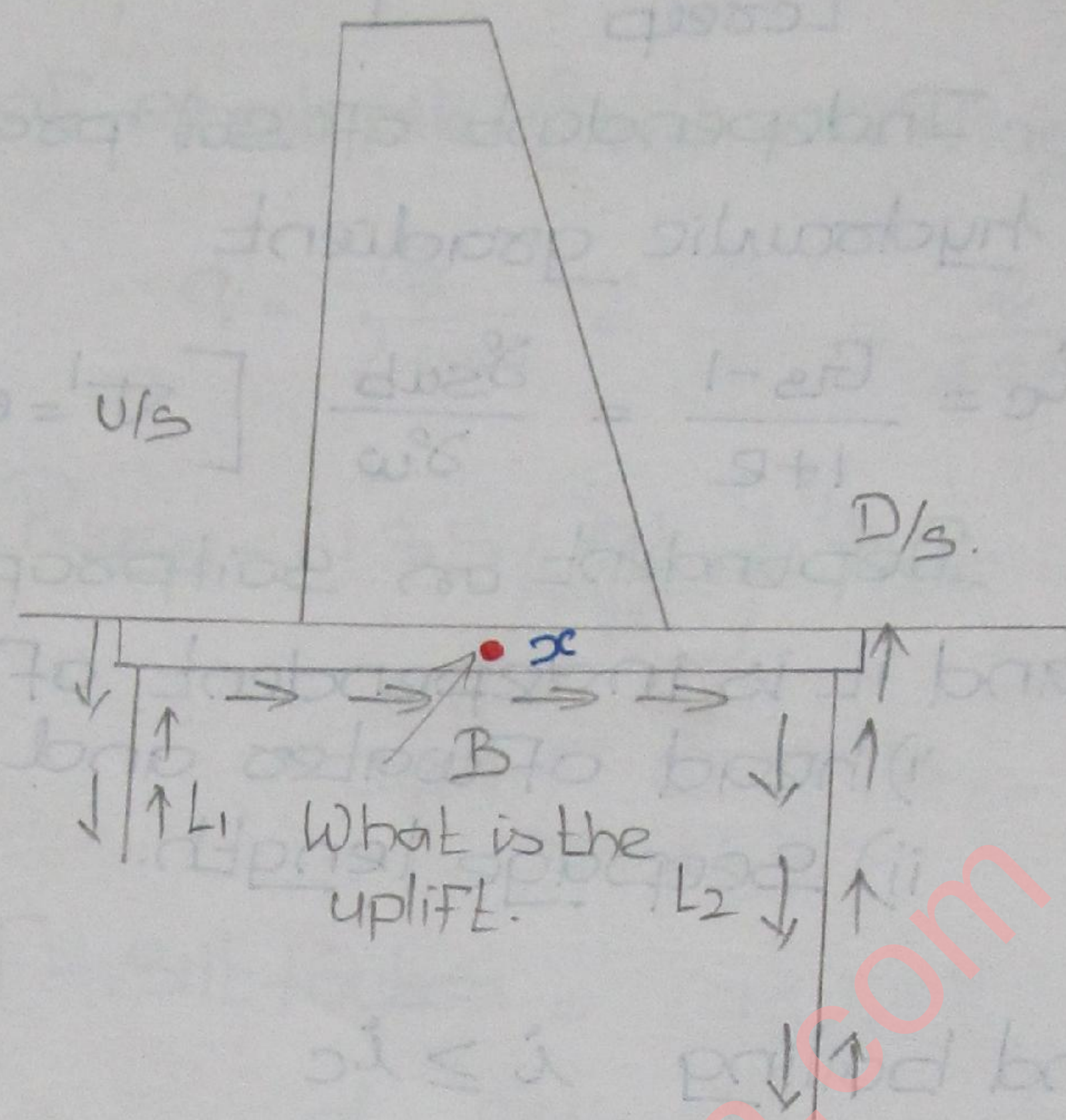
  Horizontal Weightage = 1/3

c) Mr. khosla theory

- Independent variable theory

  Most Widely used in India

15) According to Mr. Blaigh, horizontal and vertical weightage are of Equal weightage



Seepage length $= 2L_1 + B + 2L_2$

Seepage length at Middle of Floor

$$L_c' = L_1 + L_1 + B/2$$

$$= 2L + B/2$$

∵ For $L_c = (2L_1 + 2L_2 + B)$ head lost $= H_{net}$

∴ For 1 head lost $= \frac{H_{net}}{L_c}$

∴ For L_c' head lost $= \frac{H_{net}}{L_c} \times L_c'$

Head available at pt x $H_x = H_{net} - \frac{H_{net}}{L_c} L_c'$

$$H_x = H_{net}\left(1 - \frac{L_c'}{L_c}\right)$$

$$H_x = \frac{p}{\gamma} + \frac{V^2}{2g} + Z$$

16)

17)

$$H_x = H_{net}\left[1 - \frac{(2L_1 + B/2)}{(2L_1 + 2L_2 + B)}\right]$$

16) According to Mr. Lane

$V = 3$, $H = 1$ (Theory purp) or $V = 1$, $H = 1/3$ (practical Numerical)

Total creep length = $\left(L_c = L_1 + L_1 + \frac{B}{3} + L_2 + L_2\right)$

$$L_c = 2L_1 + \frac{B}{3} + 2L_2$$

$$= 2(L_1 + L_2) + \frac{B}{3}$$

Creep length upto x

$$L_c' = L_1 + L_1 + \left(\frac{B}{2}\right)\frac{1}{3}$$

$$= 2L_1 + \frac{B}{6}$$

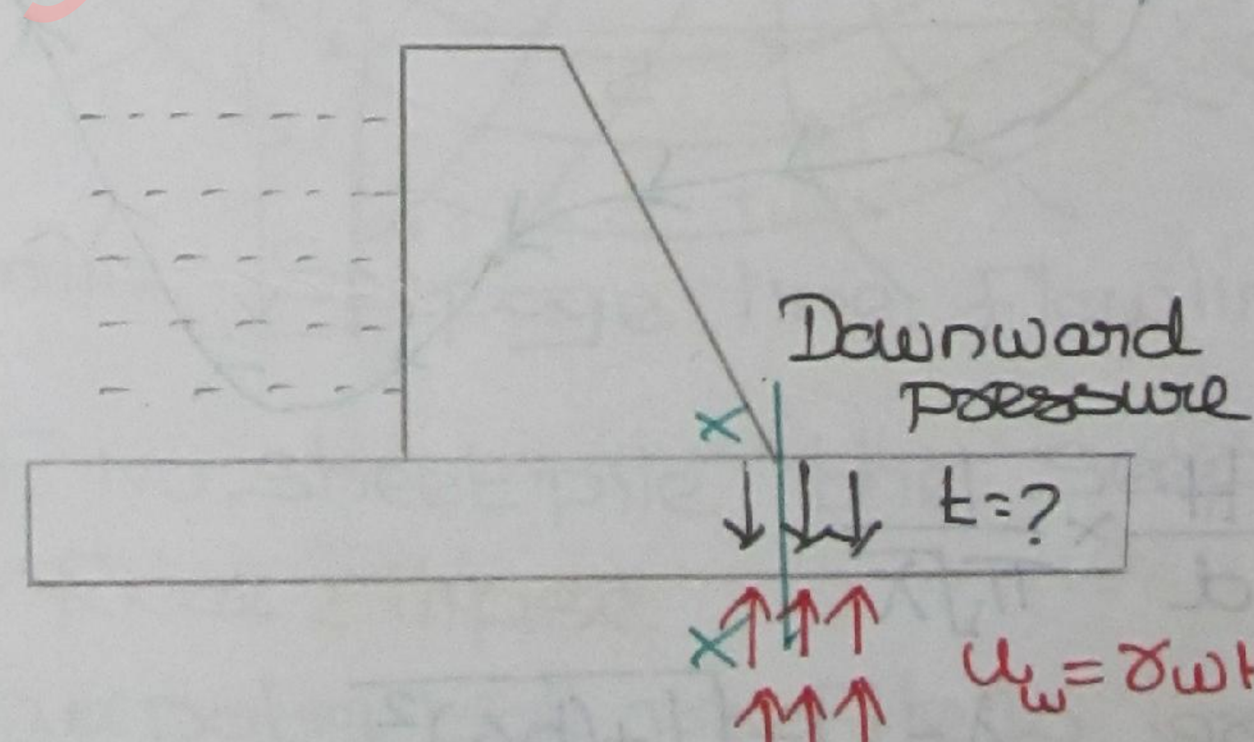
uplift @ x

$$H_x = H_{net}\left[1 - \frac{L_c'}{L_c}\right]$$

$$= H_{net}\left[1 - \frac{2L_1 + B/6}{2(L_1 + L_2) + B/3}\right]$$

***

17) Thickness of Floor:-



uplift pressure due to seepage at xx

= Downward pressure due to submerged self weight of floor.

$\gamma_w \times H_x = (\gamma_{Floor} - \gamma_w)\, t$ $\qquad G_s = \frac{\gamma_s}{\gamma_w}$

$\gamma_s = G_s \gamma_w$

$$t_{floor} = \frac{\gamma_w \times H_{net}\left(1 - \frac{L_c'}{L_c}\right)}{(G_s\gamma_w - \gamma_w)}$$

$$= \frac{H_{net}\left(1 - \frac{L_c'}{L_c}\right)}{G_s - 1}$$

** $$t_{Floor} = \frac{H_x}{G_s - 1}$$ **

H_x - uplift head at x'

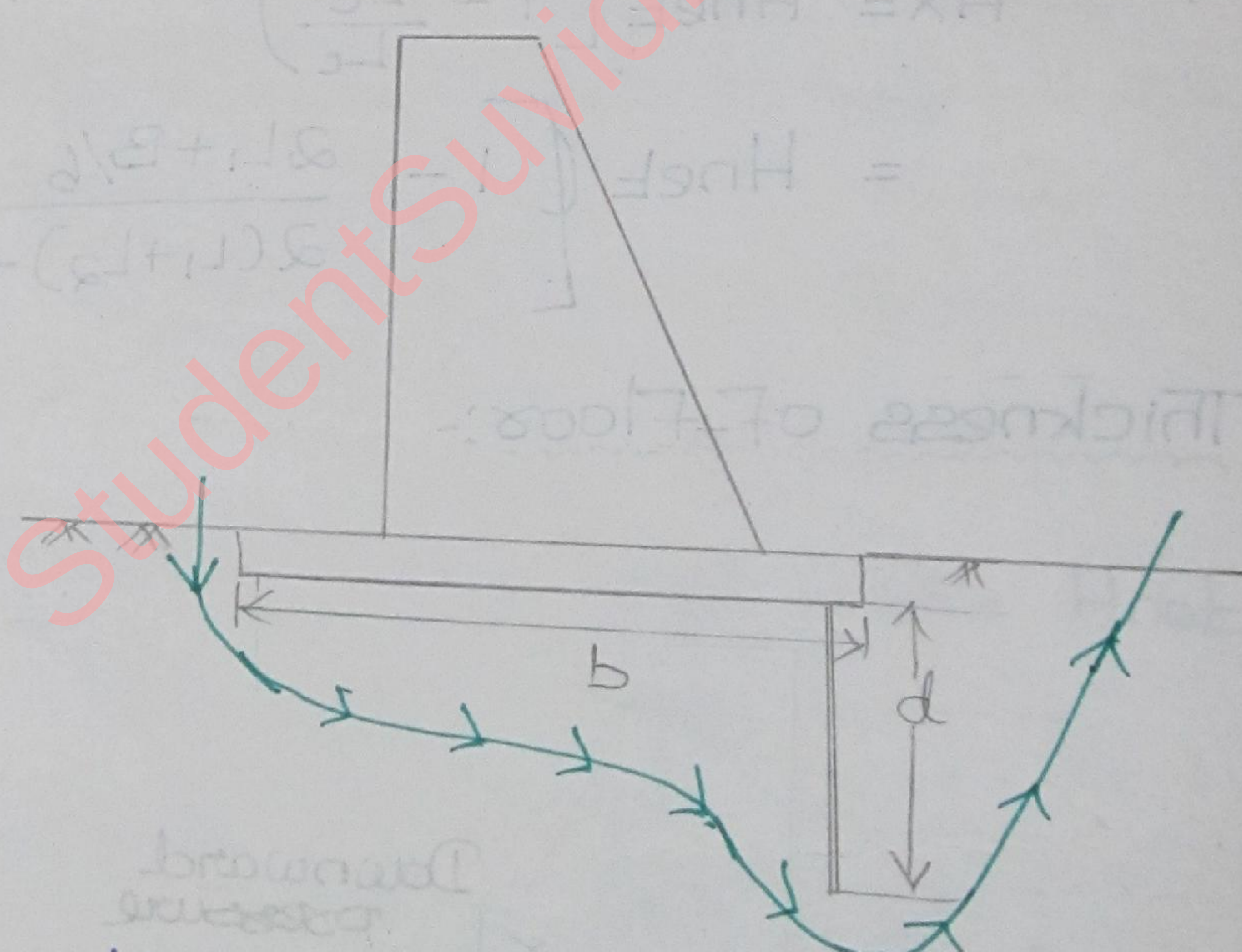
$$= H_{net}\left(1 - \frac{L_c'}{L}\right)$$

F.O.S of thickness of Floor = $\frac{4}{3}$

$$t_F = \frac{4}{3}\frac{H_x}{G_s - 1}$$

****

18) Khosla theory:-



$$i = \frac{H}{d} \times \frac{1}{\pi\sqrt{\lambda}}$$

where $\lambda = \frac{1 + \sqrt{1 + (b/d)^2}}{2}$

Note:-

1) If no sheet pile $d = 0$ and hence

$$i = \frac{H}{d}\frac{1}{\pi\sqrt{\lambda}} = \frac{H}{0} \times \frac{1}{\pi\sqrt{\lambda}} = \infty$$

19)

Stre

$$i_c = \frac{G_s - 1}{1+e} = (1-n)(G_s - 1)$$

$i < i_c$ For No sand boiling

$$i = \frac{i_c}{F.O.S}$$

F.O.S = 4-5 → shingle (large size gravel)
= 5-6 → ~~Medium~~ Coarse grained
= 6-7 → Fine grained.

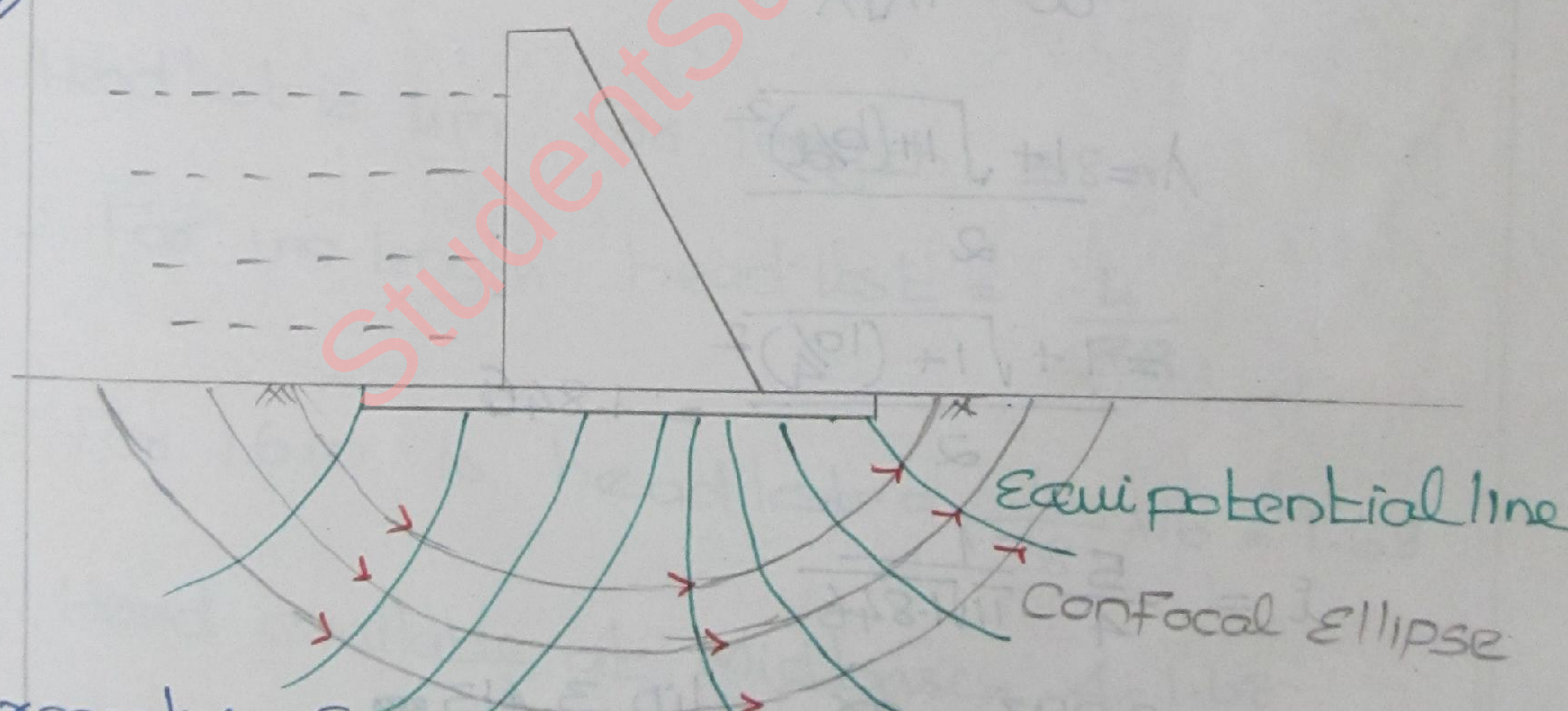
$$i = \left(\frac{1}{4} \text{ to } \frac{1}{5}\right) i_c \text{ - shingle}$$

$$= \left(\frac{1}{5} \text{ to } \frac{1}{6}\right) i_c \text{ - Medium grained}$$

$$= \left(\frac{1}{6} \text{ to } \frac{1}{7}\right) i_c \text{ - Coarse grained}$$

$$i_c = \frac{2.65 - 1}{1 + 0.65} = 1 \text{ (Generally)}$$

19)



Streamline, Seepage line, Flowline, phreatic line

IF No sheet pile the seepage profile is Confocal Ellipse

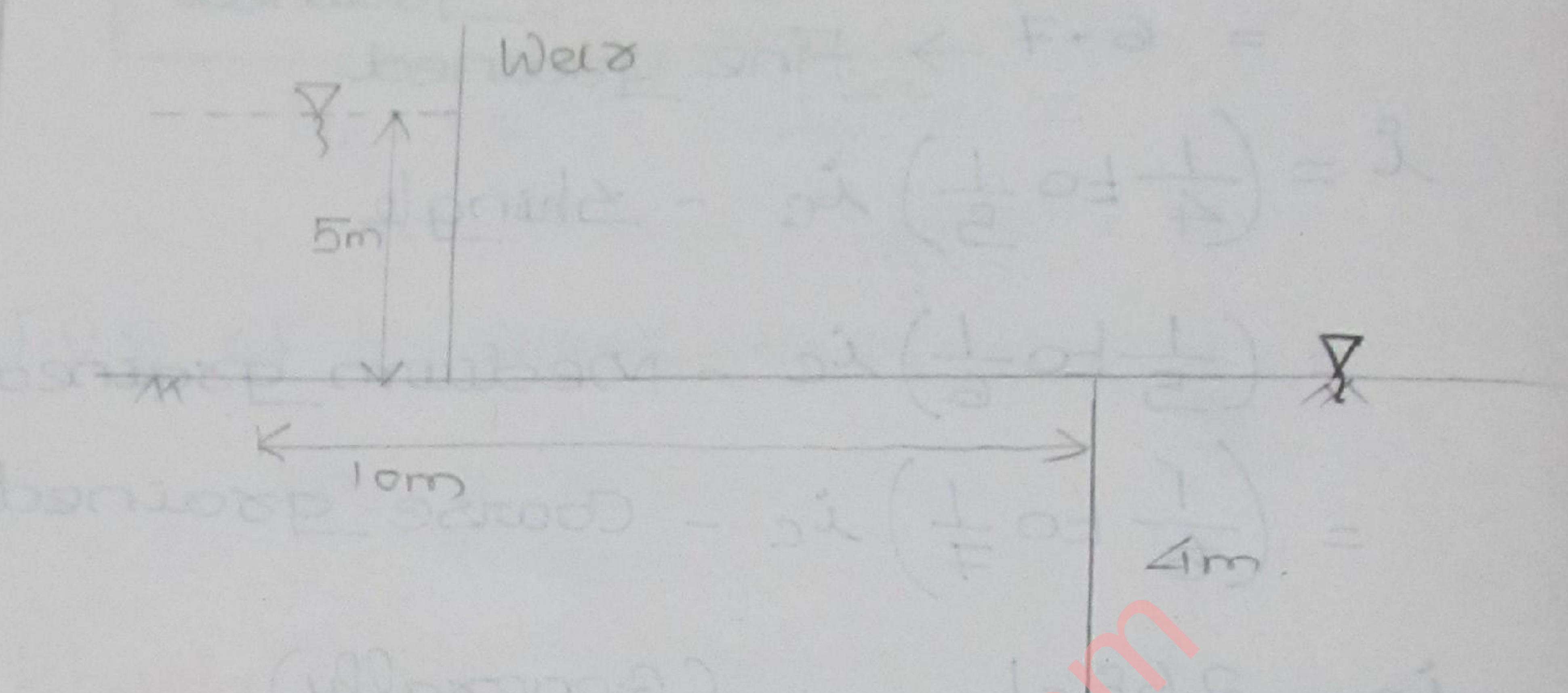
Equipotential profile is Confocal hyperbola

A curve perpendicular to ellipse is hyperbola.

9/12/2010

Numericals:-

1) A Weir on a permeable foundation with downstream sheet pile is shown in the Fig below. Determine the exit gradient as per khosla theory.



A $i = \frac{H}{d}\frac{1}{\pi\sqrt{\lambda}}$

$$\lambda = \frac{1+\sqrt{1+(b/d)^2}}{2}$$

$$= \frac{1+\sqrt{1+(10/4)^2}}{2} = 1.846$$

$$i = \frac{5}{4}\frac{1}{\pi\sqrt{1.846}}$$

$= 0.293$ or 1in 3.413

2) A Weir is constructed across a river where the depth of water on U/s is 5m and on D/s is 1m. Total base of impervious floor is 20m. There are two sheet piles having depth 3m and 6m. on U/s & D/s. Determine

i) uplift pressure @ Mid of base

ii) Thickness of floor @ Mid Section,

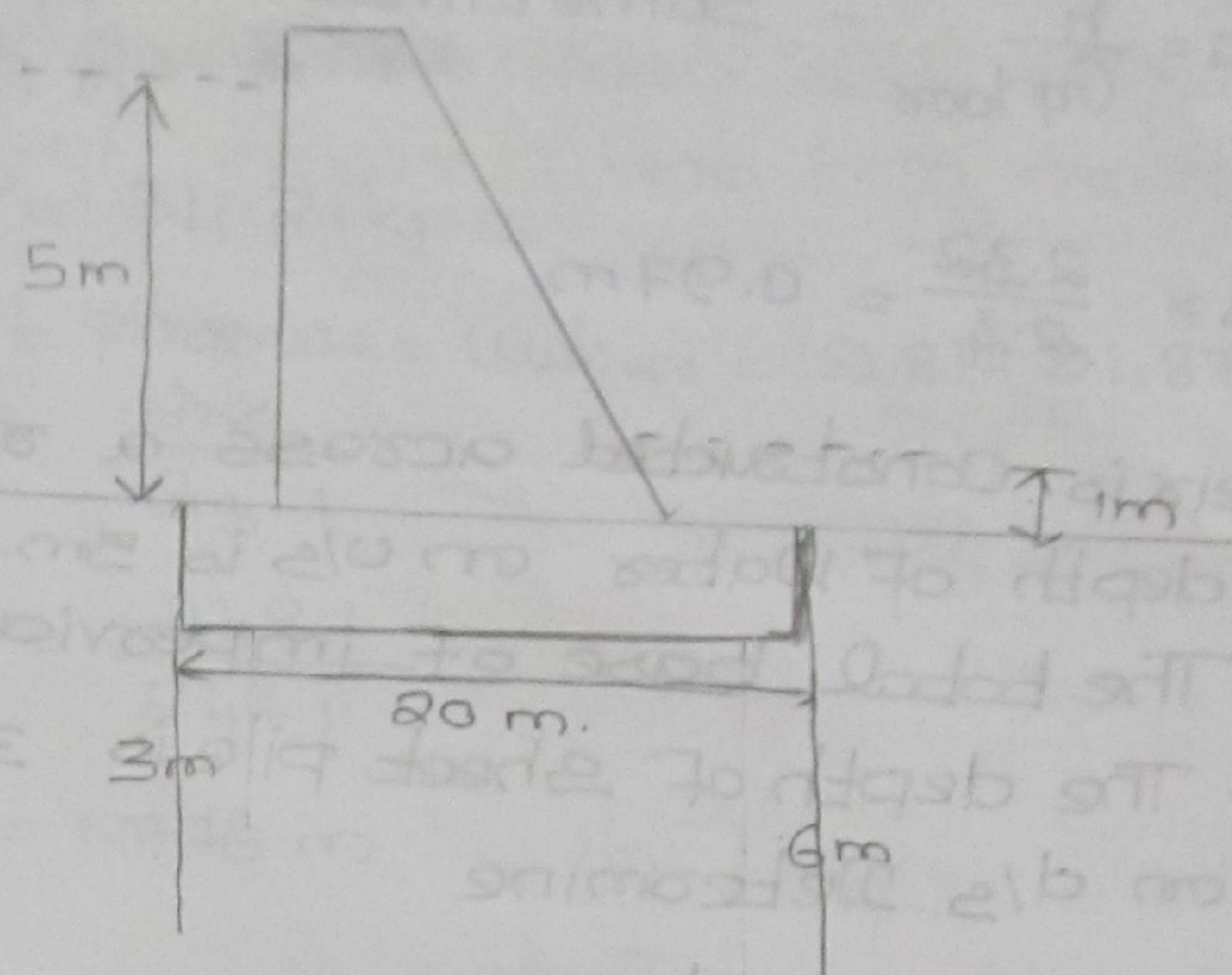
Use Bligh theory. Take $G_s = 2.65$ (soil)

oundation with
shown in the
exit gradient

4m

river where
and on
vious Floor
iles having
D/s. Determine
e
tion,
.5 (soil)

$G_{(Floor)} = 2.4$



Creep length = $2\times3+20+2\times6$

$= 38m.$

Creep length till Mid length = $2\times3+10$

$= 16m.$

Head lost is 4m for length 38 m

$\therefore$ For 1m length head lost = $\frac{4}{38}$

$\therefore$ For 16m head lost = $\frac{4}{38}\times16 = 1.68$

Head available at Mid base = $4-1.68$

$= 2.32m$

~~$\frac{P}{\gamma}+\frac{V^2}{2g}+z$ = Head available~~

~~$\frac{P}{\gamma}+0+0 = 2.32$~~

$U_3 = P = \gamma_w h_{avail}$

$\frac{P}{\gamma} = 2.32$

$P = 2.32\times9.81$

$= 22.76$ kpa

$t_{Floor} = \frac{H_x}{G_s-1} = \frac{2.32}{2.4-1} = 1.66$ m

Note:-

$$t = \frac{h}{G_{Floor}} \quad \text{- Sometimes}$$

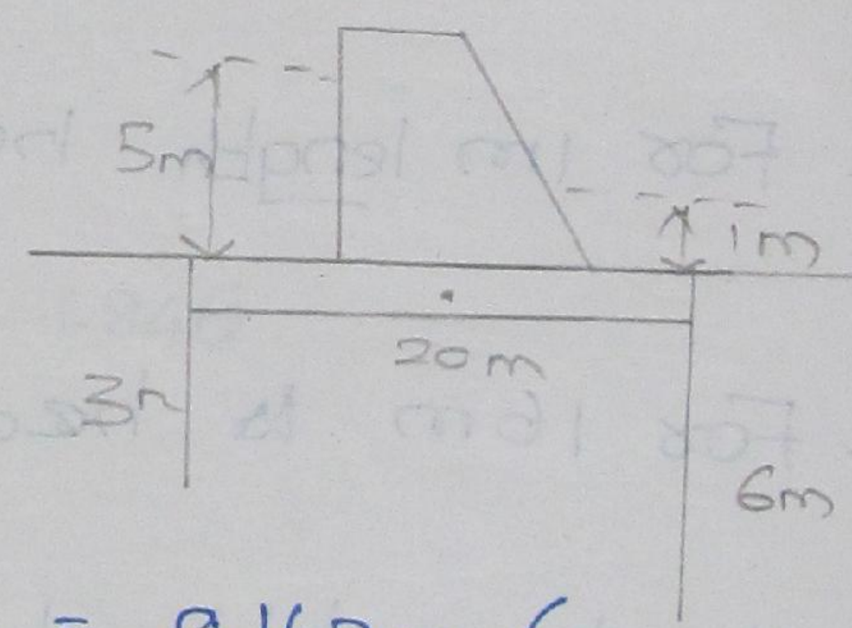
$$t = \frac{2.32}{2.4} = 0.97m.$$

3) A Weir is constructed across a river where the depth of water on U/s is 5m. and on d/s is 1m. The total base of impervious floor is 20m. The depth of sheet pile is 3m on U/s and 6m on d/s Determine

i) Exit gradient
ii) Seepage pressure @ Mid of base
iii) Thickness of Floor. @ Mid of base
iv) Critical exit gradient
v) Safe exit gradient if F.O.S is 5

Use lane theory. Take $G_{soil} = 2.65$ $G_{Floor} = 2.4$
$n = 0.4$.

i)
$$L_c = 3^{\times 2} + \frac{1}{3} \times 20 + 6 \times 2$$
$$= 24.67$$



$H_{net} = (5-1) = 4m$

$$i_a = \frac{\Delta H}{L} = \frac{4m}{24.67m} = 0.162m. \ (1 \text{ in } 6.17)$$

ii)
$$L_c' = 3 \times 2 + \left(\frac{1}{3} \times 20\right)\frac{1}{2} = 9.33m.$$

For 24.67 m Head lost is 4 m

∴ For 9.33m Head lost is $\frac{4}{24.67} \times 9.33 = 1.513$

$H_{available} = 4m - 1.513m = 2.487m.$ > Bligh residual head

$$\frac{P}{\gamma} + \frac{V^2}{2g} + Z = H_{available}$$

$\frac{P}{9.81} + 0 - 0 = 2.487$

$\frac{P}{9.81} = 2.487$

(Seepage) $P = 34.21$ kpa

uplift pressure $= u_w h_{av} = 9.81 \times 2.487 = 24.4$ m

iii) $t_{floor} = \frac{H_{xt}}{G_s - 1}$

$= \frac{2.487}{2.4 - 1}$

$= 1.776$ m.

iv) $i_c = \frac{G_s - 1}{1 + e}$

$e = \frac{n}{1-n} = \frac{0.4}{1-0.4} = 0.67$

$i_c = \frac{2.65 - 1}{1 + 0.67} = 0.988$ (1 in 1.012)

iv) Safe exit gradient $= \frac{i_c}{F.O.S}$

$= \frac{0.988}{5} = 0.198$ (1 in 5.051)

4) Determine the safe exit gradient if $G_s = 2.65$ and void ratio 0.65 use coarse sand khosla theory

$i_c = \frac{G_s - 1}{1 + e} = \frac{2.65 - 1}{1 + 0.65} = 1$

$i_{safe} = \frac{i_c}{F.O.S}$

Coarse graind $= \frac{1}{5}$ to $\frac{1}{6}$

$i_{safe} = \frac{1}{5}$ to $\frac{1}{6} = 0.2$ to ~~0.33~~ 0.167

5) A river carries total discharge 10 cumec/m width. The mean size of the silt 0.03cm. Determine the depth of sheet pile on upstream and downstream below water level

$f = 1.76\sqrt{d}$

$= 1.76\sqrt{0.03 \times 10}$

$= 0.964$

$R_{lacy} = 1.35\left[\frac{q^2}{f}\right]^{1/3}$

$q = \frac{Q}{Lww} = 10 cumec/m$

$R_{lacy} = 1.35\left[\frac{10^2}{0.964}\right]^{1/3}$

$= 6.34m$

Depth of U/s pile $= 1.5 R_{lacy}$ from HFL

$= 9.5m$ from HFL

Depth of D/s pile $= 2 R_{lacy}$ from HFL

$= 2 \times 6.34$

$= 12.68\ m$ from HFL.

Important Notes:-

** 1) Width of water way during design of a barrage is determined by Lacy formula for wetted perimeter. and discharge capacity of barrage as computed by weir equations.

2) Barrage floor thickness is determined by khosla uplift pressure variation.

silt 0.03cm
dle on
w water.

3) Depth of sheet pile and the total length of the barrage floor depends upon the Lacy scour depth and khosla exit gradient

4) The level and the length of the down stream floor is determined by hydraulic jump consideration.

5) If there is no sheet pile, then exit gradient became infinity (only for khosla theory)

6) If there is no sheet pile then
   Stream line - Confocal ellipse
   Equipotential line - confocal hyperbola

7) Construction of barrage is costlier than weir.

8) Barrage consist of a series of gates which are operated mechanically to lift up during high flood to control Afflux

9) The characteristic of barrage is not to for reservoir to store

10) The barrage provides better control over the river than that of the weir

FL

FL.

a barrage
etted
barrage.

ed by

**

11) The design capacity of under sluice or scour sluice shall be based on
   a) Twice the discharge of the canal
   b) About 15% flood discharge (10-15%) of river
   c) Winter flow of the river

Note:-

It is not based on 50% 100 year Flood frequency discharge of the river