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2nd Internal Test – May 2017

Sub:	Hydraulic Structures and Irrigation Design – Drawing							Code:	10CV65
Date:	10/ 05 / 2017	Duration:	3hrs	Max Marks:	70	Sem:	6	Branch:	CIVIL

Note: Answer any one question. Draw neat sketches. Assume necessary data

	Marks	OBE CO	OBE RBT
1. Design a canal drop (Notch type) for the following data	[25]	CIV605.5	L4
Draw to a suitable scale: 1) Half plan at top and half plan at foundation [20] 2) Longitudinal section [15] 3) Half cross section along the drop and half elevation [10]		CIV605.6	L4

1. Design a canal drop (Notch type) for the following data

Particulars	**U/s canal**	**D/s canal**
Full supply discharge	$10m^3/s$	$10m^3/s$
Bed level	+20.00m	+18.00m
Full supply level	+21.50m	+19.50m
Bed width	8.0m	8.0m
Top level of embarkment	+22.50m	+20.50m
Top width of embarkment	2.0m	2.0m
Side slopes	1:1(cut)	1.5:1(fill)
Average ground level	+20.50m	+20.50m
Hard soil available@	+18.50m	+18.50m

Draw to a suitable scale

1) Half plan at top and half plan at foundation [20]
2) Longitudinal section [15]
3) Half cross section along the drop and half elevation [10]

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Marks OBE CO RBT

1. Design a canal drop (Notch type) for the following data [25] CIV605.5 L4

Particulars | U/s canal | D/s canal
Full supply discharge | 10m3/s | 10m3/s
Bed level | +20.00m | +18.00m
Full supply level | +21.50m | +19.50m
Bed width | 8.0m | 8.0m
Top level of embarkment | +22.50m | +20.50m
Top width of embarkment | 2.0m | 2.0m
Side slopes | 1:1(cut) | 1.5:1(fill)
Average ground level | +20.50m | +20.50m
Hard soil available@ | +18.50m | +18.50m

Draw to a suitable scale
1) Half plan at top and half plan at foundation [20]
2) Longitudinal section [15]
3) Half cross section along the drop and half elevation [10]
CIV605.6 L4

2. Design a surplus weir with stepped apron of a tank forming a part of a chain of tanks with the following details. [25]

a) Combined catchment area – 24.5 km^2
b) Intercepted catchment area – 20.4 km^2
c) Maximum water level - +103.25m
d) Full tank level – +102.5m
e) Ground level at proposed site – +101.5m
f) Ground level below weir slopes off in a length of 5m fall to – +100.5m
g) Tank bund level – +105m
h) Top width of tank bund – 2m
i) Side slope of bund on either side – 2:1
j) Ryve's coefficient for combined catchment – 9
k) Level of hard rock strata - +100m

CIV605.5 L4

Draw to a suitable scale

1) Half plan at top and half plan at foundation [20]
2) Longitudinal section [15]
3) Half cross section along the drop and half elevation [10]

CIV605.6 L4

CI CCI HOD

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v) Level of hard rock strata - +100m

CIV605.5 L4

Draw to a suitable scale

4) Half plan at top and half plan at foundation [20]
5) Longitudinal section [15]
6) Half cross section along the drop and half elevation [10]

CIV605.6 L4

CI CCI HOD

04/04/16.

PART-B

DESIGN OF CANAL DROP.

1). Design a canal Drop with following details.

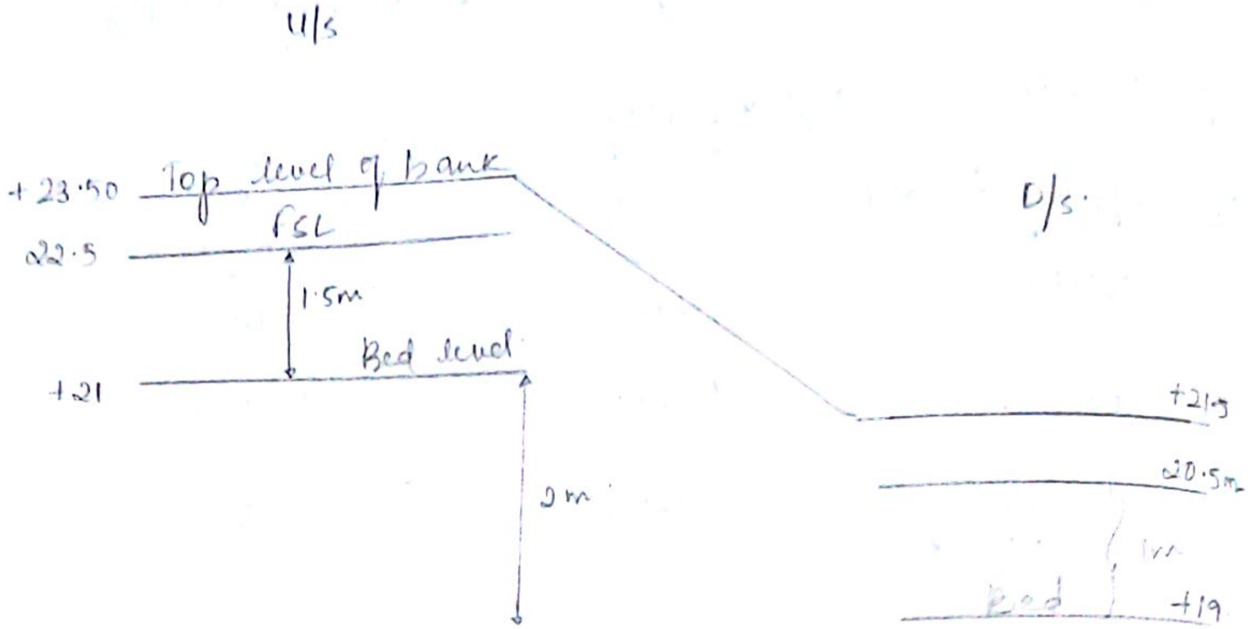
Particulars	u/s of drop.	d/s of drop.
Full supply discharge.	4 m³/s.	4 m³/s.
Bed width	6 m	6 m.
Bed level.	+ 21.00	+ 19.00.
Full supply depth	1.5 m	1.5 m.
Full supply level	+ 22.5	+ 20.5
Top width of bank.	2 m	2 m.
Top level of bank	+ 23.5	+ 21.5 m

canal side slopes are 1:1 in cutting and 1½:1 in filling, half supply depth = 1m, G.L @ site = +121.5 m, foundation soil is @ + 19.50 m. Draw to a suitable scale

* Half plan at top and half plan at foundation
* Longitudinal section.
* c/s showing half elevation and half section.

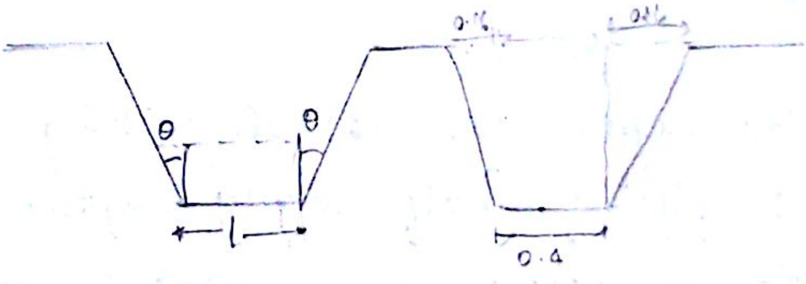
Soln. Trapezoidal notch - to reduce end contraction and flume

$$Q = \frac{8}{15}\sqrt{2g}\, H^{5/2} c_d \tan\theta + \frac{2}{3} c_d \sqrt{2g}\, L H^{3/2}$$



a) Design of trapezoidal notch:

Let us assume two notches are provided, to pass the discharge from u/s to d/s section.



$$Q = \frac{2}{3} C_d L \sqrt{2g} H^{3/2} + \frac{8}{15} C_d \sqrt{2g} H^{5/2} \tan\theta.$$

Full supply discharge, $Q_1 = \frac{4}{2} = 2 \, m^3/s$.

Q_2, Half supply discharge, $= \frac{2}{2} = 1 \, m^3/sec$.

Full supply depth $H_1 = 1.5m$ Half supply depth $H_2 = 1m$

$C_d = 0.7$ (assumed).

$$2 = \frac{2}{3} \times 0.7 \times L \times \sqrt{2 \times 9.81} \times (1.5)^{3/2} + \frac{8}{15} \times 0.7 \times \sqrt{2 \times 9.81} \times (1.5)^{5/2} \tan\theta$$

FSD.

U/s $2 = 3.797\,L + 4.5569 \tan\theta$.

$$1 = \frac{2}{3} \times 0.7 \times L \sqrt{2 \times 9.81} \times (1)^{3/2} + \frac{8}{15} \times 0.7 \times \sqrt{2 \times 9.81} \times (1)^{5/2} \times \tan\theta.$$

U/s D

$1 = 2.067\,L + 1.653 \tan\theta$.

$L = 0.398 \simeq \underline{0.4\ m}$

$\tan\theta = 0.107$.

$\theta = 6.1°$

$\tan(6.1) = \frac{x}{1.5}$

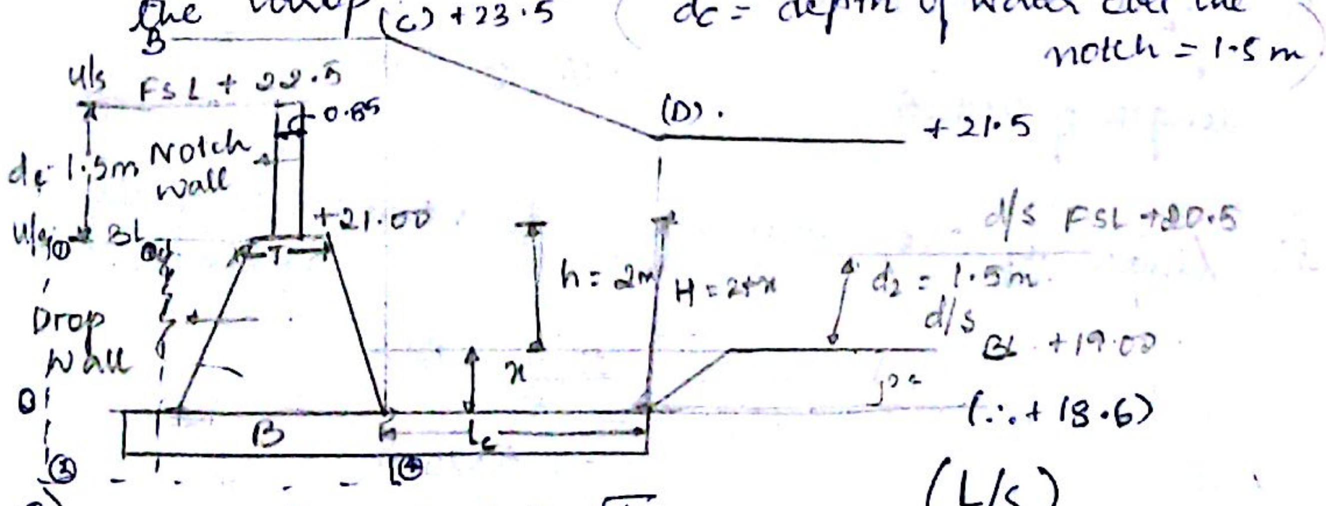
$x = 0.16$

Top width $= 0.4 + 2 \times 0.16$

$= 0.72\ m \simeq \underline{0.7\ m}$.

05/04/16

Design of drop wall and water cushion below the drop. (d_c = depth of water over the notch = 1.5 m)



(L/S)

a) $x + d_1 = 0.9\, d_c \sqrt{h}$.

To find the depth of water cushion, we use relation,

$x + 1.5 = 0.9 \times 1.5\sqrt{2}$

$x = 0.409.$

$x = 0.4\,m.$ → Fall level

b) Height of the drop wall,

$H = h + x$ — d_1 = depth of flow in u/s.

$= 2 + 0.4$

$H = 2.4\,m.$

c) $T = \frac{d_c}{2} + 0.15\,m$

$= \frac{1.5}{2} + 0.15 = 0.9 \simeq 1m.$

d) $B = \frac{H + d_c}{\sqrt{S}}$ — S = specific gravity of masonry = 2.25

$B = \frac{2.4 + 1.5}{\sqrt{2.25}} = 2.6\,m.$

e) $L_c = 1.5 + 2\sqrt{d_c h} = 1.5 + 2\sqrt{1.5 \times 2}$

↓ length of cushion.

$= 4.96 \simeq 5m.$

f) Length of drop wall, $L = \frac{7}{8} \times$ Bed width of the channel

$= \frac{7}{8} \times 6$

$= 5.25\,m.$

g) ~~Design a~~ Thickness of solid apron:

For thickness of solid apron, the

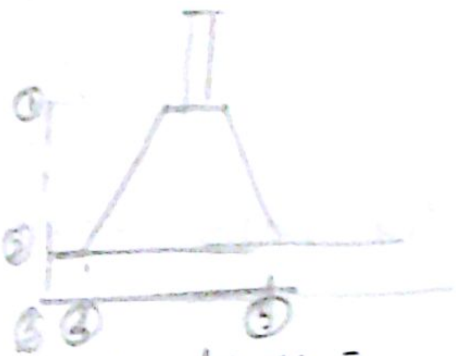
larger of two values is taken into account

(i) Minimum thickness to resist water impact,

$= \frac{1}{2}\sqrt{d_1 + h}$

$= \frac{1}{2}\sqrt{1.5 + 2} = 0.935 \simeq 0.94$ m

(ii) uplift
- → creep length
- → Hydraulic gradient - 1/4.
- → Assume thickness = 1 m.



$\frac{h_L}{\text{creep length}} = \frac{1}{4}$.

creep L = $h_L \times 4$ =

Total head = MWL - d/s ~~FT~~ MWL (Full supply level)

: 22.5 - 20.5

h_L = ~~2.5m~~ 2m

Total creep length = 4 × h_L

= 4 × 2.5

= ~~10m~~ 8m.

creep length = AB + BC + CD = 8m

2.4 + 1 + CD = 8m } x.

~~CD = 4.6 m.~~

⇒ Thickness of solid apron to resist uplift pressure.

- Assume thickness of solid apron = 1m.
- Assume hydraulic gradient = 1 in 4.
- Total creep length

Total creep length from u/s bed level to end of ~~...~~ drop wall.

$= (1)(2) + (2)(3) + (3)(4) + (4)(5)$.

$= 2.4 + 1 + 0.3 + 2.6$

$= 6.3$ m.

The head lost h_L upto the end of the drop wall $= \frac{\text{creep length}}{4}$

$h_L = \frac{6.3}{4} = 1.575$ m.

The total head, $h' =$ u/s FSL − d/s FSL

$= 22.5 - 20.5$

$= 2$ m.

Residual head, $h_r = h' - h_L$

$= 2 - 1.575$

$= 0.425$ m.

If one metre of concrete can resist 2.25m of uplift head, then residual head of 0.425m can be resisted by 1m of thickness of concrete.

(s.g. of water)

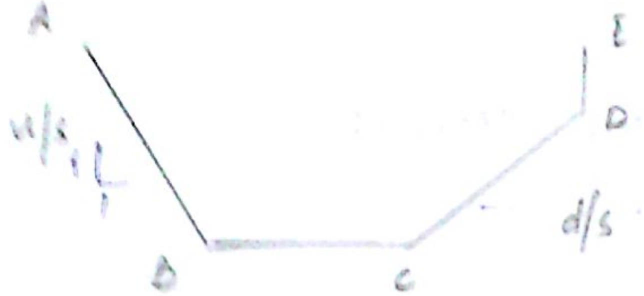
$2.25\,T = 1 \times h_r$

$2.25\,T = 1 \times 0.425$

$T = 0.189$. Hence 1t can resist.

Hence we are adopting 1m solid apron thickness.

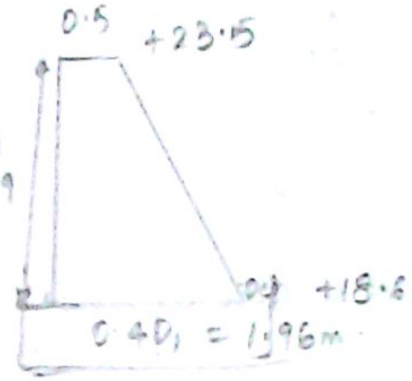
Design of Abutment and wing wall:.



plan.

Top width = 0.5 m

Abutment BC :

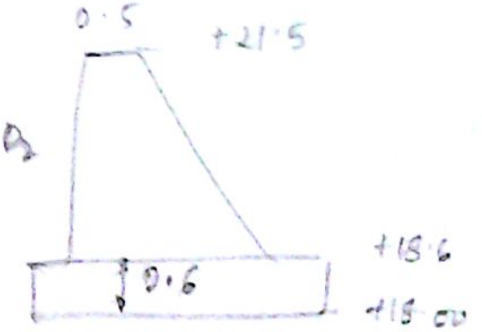


D_1 = 4.9 , thickness of apron = 1m.

length of base width = 0.4 × 4.9
= 1.96
≃ 2m.

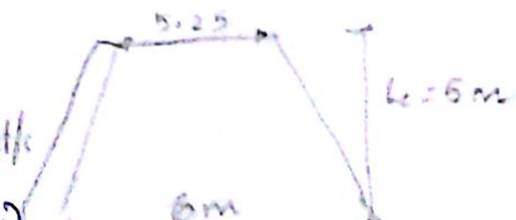
ii) ~~Abutment~~ u/s wingwall AB.
has same section as BC, a splay of 1:1 is provided till the wingwall & keyed into the channel.

iii) d/s wing wall CD.



D_2 = 2.9 m

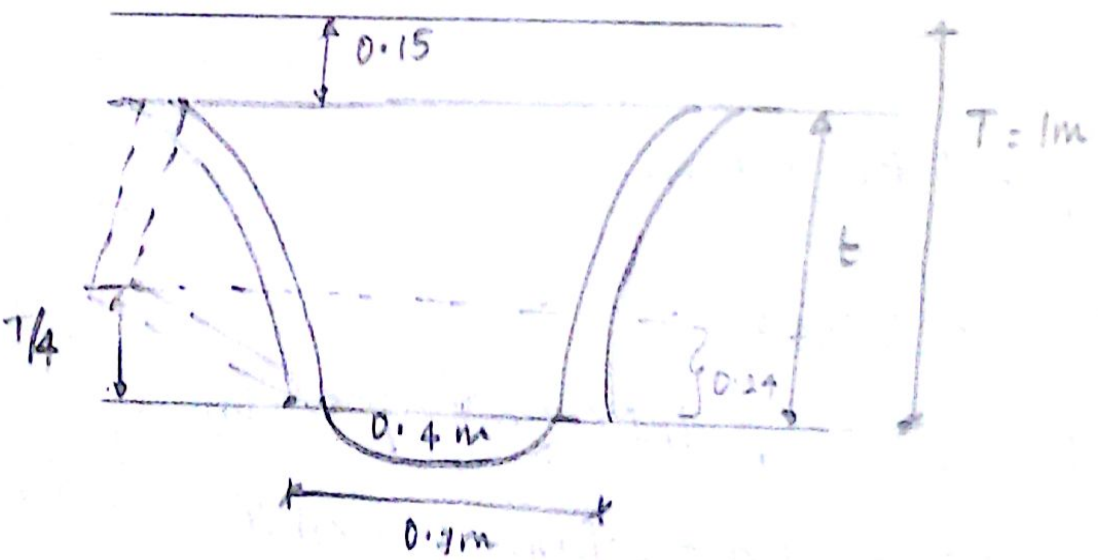
Base width = 2.9 × 0.4
= 1.16
≃ 1.2m



The splay in the d/s portion is decided by the change of the deep wall length (5.25m) to the d/s bed width (6m).

Return wall DE is same section as D/s wing wall :

Notch wall drawing (Plan) :



Width . notch plee,

d_1

$= \frac{1}{2} d_c$

$= \frac{1.5}{2}$

$= 0.75$ m

$\simeq 0.85$ m.

$= 1 - 0.85$

$= 0.15$ m. (1/2 feet) .

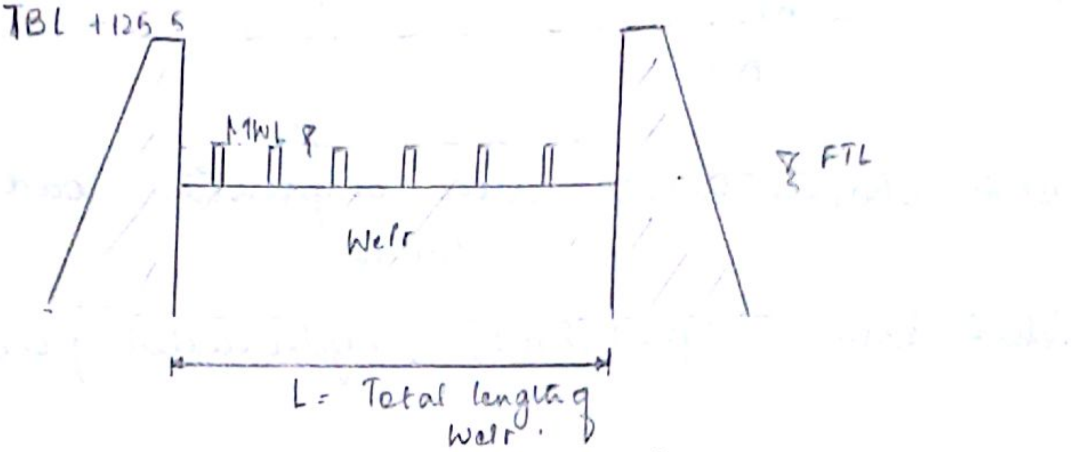
1 feet = 30cm

1/2 feet = 15 cm

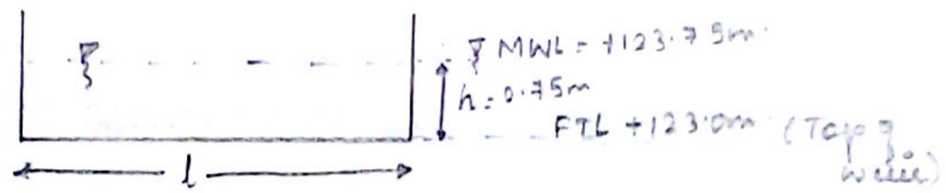
09/2/16

DESIGN OF SURPLUS WEIR.

L/S



L = clear length of flow (l) + length of dam stone



For flow through □lar weirs,

$$Q = \frac{2}{3} C_d \sqrt{2g}\, l\, h^{3/2}$$

Q by Ryve's formula is,

$$Q = C_1 M^{2/3} - C m^{2/3}$$

C_1 = Ryve's coefficient for combined catchment.

$= 9 \times (24.5)^{2/3} - 1.6 \times (20.4)^{2/3}$

$C_1 = 9.$

$Q = 63.97\ m^3/s.$

$C = 1.6$ [if not given, $C_1 = \frac{C}{5}$]

$$Q = \frac{2}{3} C_d \sqrt{2g}\, l\, h^{3/2}$$

M = combined catchment area = $24.5 km^2$

$C_d = 0.56$ (Assume).

m = intercepted catchment area = $20.4 km^2$

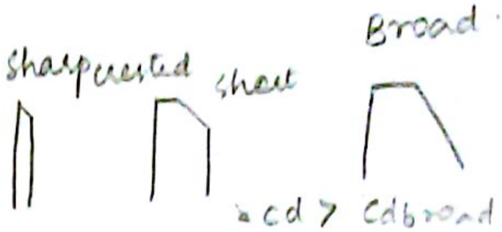
h = head = MWL − FTL

= 123.75 − 123

= 0.75 m.

$63.97 = Q = \frac{2}{3} \times 0.56 \times \sqrt{2 \times 9.81} \times l \times (0.75)^{3/2}$

$l = 59.56\,m \simeq 60\,m.$



Assuming 150mm x 150mm dam stones at 1m space.

No. of stones = No. of spaces − 1

= 60 − 1 = 59.

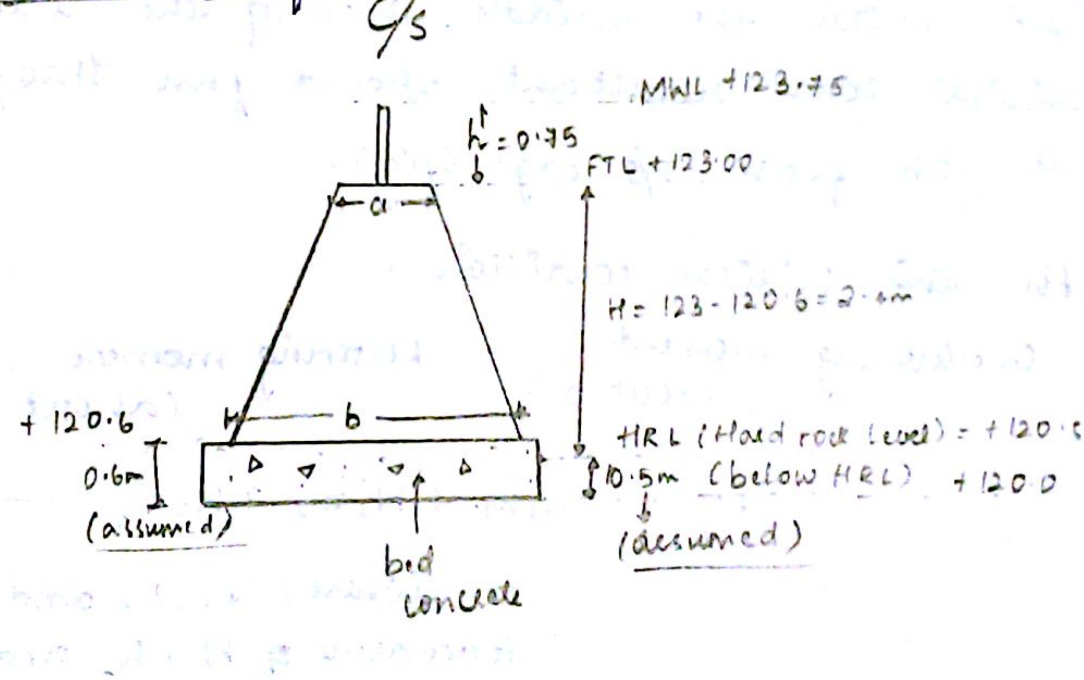
Length of dam stones = 0.15×59 = 8.85.

∴ Total length of surplus weir is,

$L = 60 + 8.85 = 68.85\,m \simeq 70\,m.$

Let us provide 70m long weir.

C/s dimensions of the weir:



Top width,

$a = 0.55(\sqrt{H} + \sqrt{h})$ [Bligh's Empirical Formula]

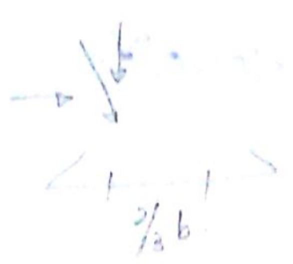
$a = 0.55(\sqrt{2.4} + \sqrt{0.75})$

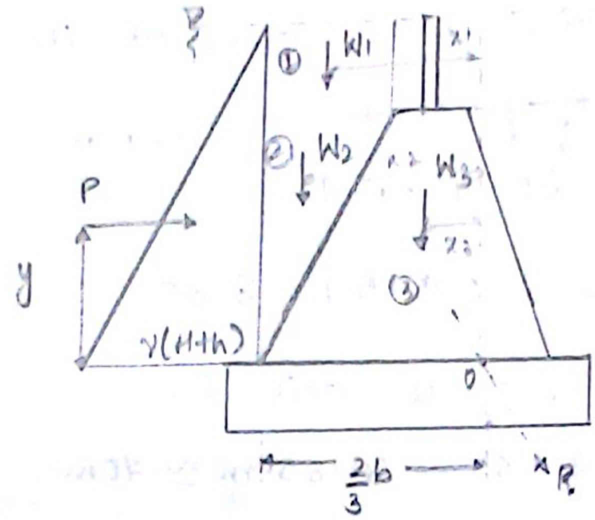
$a = 1.33\,m \simeq 1.3\,m.$

OM = RM

Overturning moment = restoring moment

$P = \gamma h^n$





Base width 'b' of the weir is fixed by stability against overturning. For stability resultant should lie within the middle third of the base. At critical condn resultant should pass through 'O' at $\frac{2}{3}b$ from u/s edge (fig).

For this critical condition,

Overturning moment (about 'O') = Restoring moment (about 'O').

$$Py = W_1 x_1 + W_2 x_2 + W_3 x_3 \quad \text{—— (1)}$$

where, x_1, x_2 and x_3 are lever arms of W_1, W_2 and W_3 from O.

Considering unit length of weir,

P = area of Δlar water pressure distribution.

$$= \frac{1}{2}\gamma(H+h)(H+h) = \frac{\gamma(H+h)^2}{2}$$

y = C.G. of Δlar pressure distribution.

$= \frac{1}{3}(H+h)$

$\left[\therefore P_y = \frac{\gamma (H+h)^3}{6} \right.$

γa_0 should be volume here unit length

$W_1 = \gamma a_1$, $W_2 = \gamma a_2$, $W_3 = \gamma a_3 \times S_m$

S.G of masonry

$S_m = \frac{\gamma_m}{\gamma_w}$.

From (1),

$\left. \frac{\gamma (H+h)^3}{6} = \gamma a_1 x_1 + \gamma a_2 x_2 + S_m \gamma a_3 x_3 . \right]$.

$\therefore \frac{(H+h)^3}{6} = a_1 x_1 + a_2 x_2 + S_m a_3 x_3$ — (2).

width

$a_1 = \left(\frac{b-1.3}{2}\right) \times 0.75$ height $= 0.375b - 0.4875$

$x_1 = \frac{2}{3}b - \frac{1}{2}\left(\frac{b-1.3}{2}\right) = 0.667b - \frac{0.5b}{4} - 0.325$

$= 0.416b + 0.325$

$a_1 x_1 = 0.156b^2 - 0.2028b + 0.1218b - 0.1584$

$\underline{a_1 x_1 = 0.156b^2 - 0.08b - 0.1584}$

$a_2 = \frac{1}{2} \times \left(\frac{b-1.3}{2}\right) \times 2.4 = 0.6b - 0.78$

$x_2 = \frac{2}{3}b - \frac{1}{3}\left(\frac{b-1.3}{2}\right) = 0.667b - b/6 - 0.2167$

$= 0.5b - 0.2167$.

$\underline{a_2 x_2 = 0.3b^2 - 0.26b - 0.168}$.

$a_3 = \frac{1}{2}(b+1.3) \times 2.4 = 1.2b + 1.56$

$x_3 = \frac{2}{3}b - b/2 = 0.166b.$

$a_3 x_3 = 0.2b^2 + 0.26b.$

Assuming.
$S_m = 2.25$
(S G of masonry)

∴ from ②,

$$\frac{(2.4 + 0.75)^3}{6} = (0.156b^2 - 0.08b - 0.158) + (0.3b^2 - 0.26b - 0.168) + (0.2b^2 + 0.26b) \times 2.25$$

$$5.21 = 0.906b^2 + 0.245b - 0.326.$$

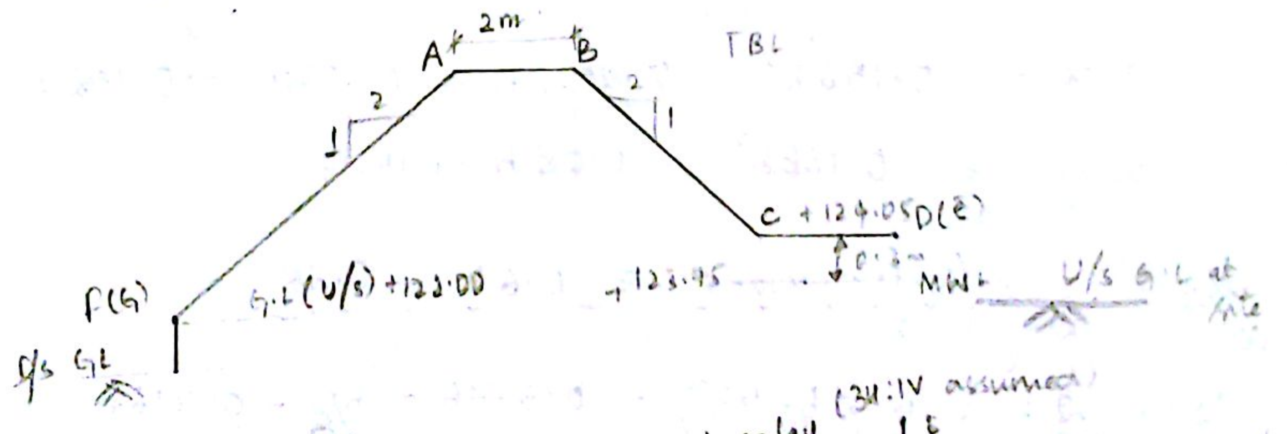
$$0.906b^2 + 0.245b - 5.536 = 0.$$

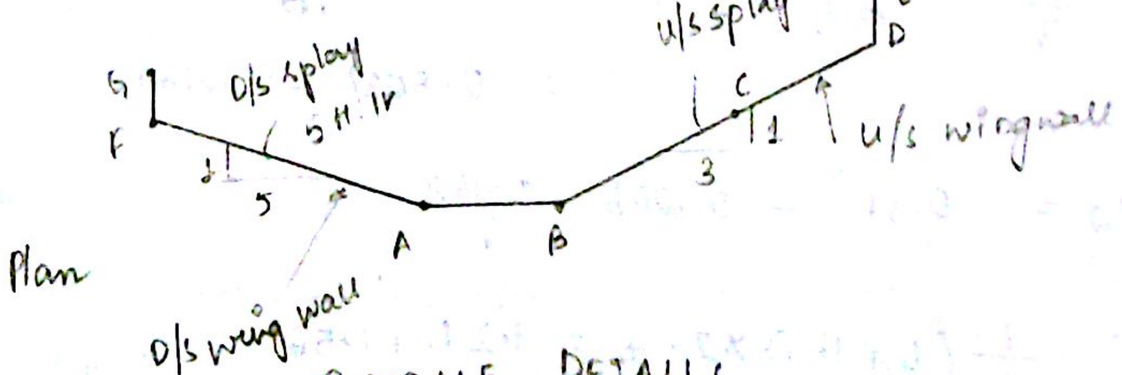
$$b = 2.34, \quad -2.61$$

∴ Let us provide, $b = 2.4m$.

11/02/16

Design of Abutments, wings and returns :-



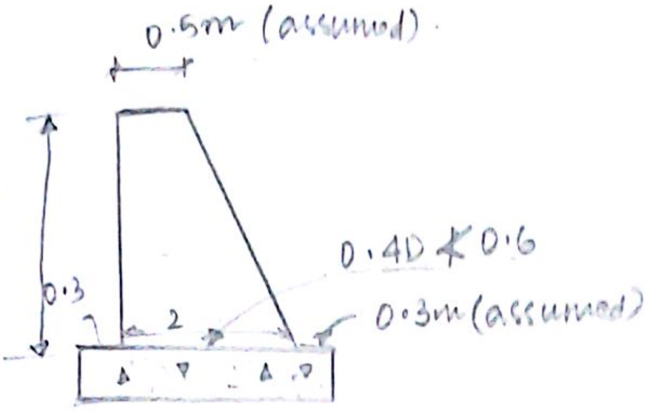


Plan

PROFILE DETAILS

C/s Details

For portion AB - Abutment



Abutments and wing walls are retaining structures.

Top width = 0.5m for all portions.

D = Height of earth retained.

base width = 0.4D ⊀ 0.6m.

For portion AB,

D = TBL - Top of bed concrete

= 125.5 - 120.6

= 4.9m.

∴ base width = 0.4 × 4.9 = 1.95 say 2m

For portion CD,

D = 124.05 - 120.6 = 3.45

∴ base width = 0.4 × 3.45 = 1.38 = 1.4 m.

Since portion DE is at same level as CD,

base width = 1.4m.

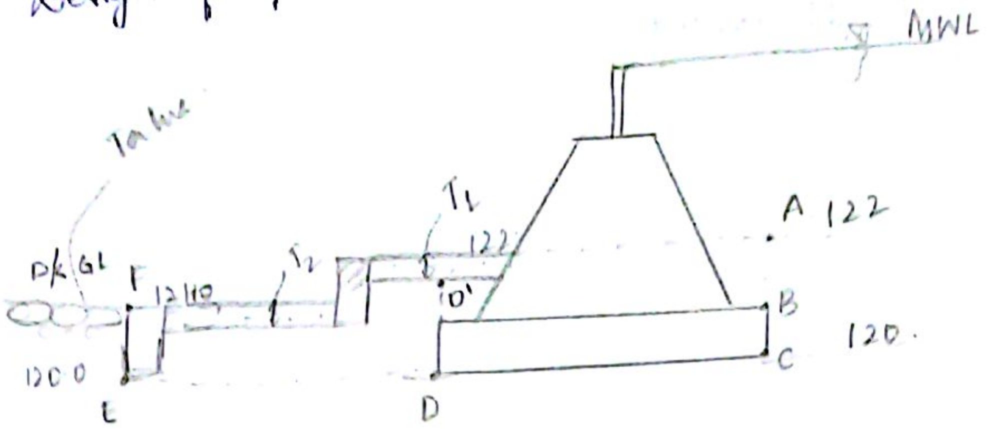
For portion FG,

D = 122.0 - 120.6 = 1.4m.

base width = 0.4 × 1.4 = 0.56.

∴ Provide base width = 0.6m.

Design of protection works (Apron).



If hydraulic gradient is 1:5. (assume).

$$\frac{h_L}{\text{creep length}} = \frac{1}{5} \quad \text{— (3).}$$

<u>Length of Apron:</u>

Apron length should be sufficient to manage total head loss.

Total head = MWL − d/s GL

= 123.75 − 121

= 2.75 m.

∴ From (3), if h_L = 2.75m,

Total creep length required = 5 × h_L

= 5 × 2.75

= 13.75m.

∴ AB + BC + CD + DE + EF = 13.75m.

1.4 + 0.6 + 3 + DE + 1m = 13.75

DE = 7.75m.

∴ Let us provide an apron length of 8m (3m − 1st step and 5m − 2nd step)

AB = 122 − 120.6 = 1.4m

BC = 0.6m

CD = 2.4 + 0.3 × 2 = 3 m

EF = 121 − 120 = 1m

Reservoir Planning

Types of Reservoirs

Since specific gravity of concrete is 2.25.
We can assume that 1m of concrete can resist.
2.25m of uplift head.

$\therefore$ $2.25T_1$ = upto Residual uplift head below 1st apron (at D').

= Total h_L - h_L upto D' (for creep from A to D')
— (4).

Using (3).
h_L upto D' = $\frac{\text{creep upto D'}}{5}$

$= \frac{AB+BC+CD+DD'}{5}$

h_L upto D' $= \frac{1.4+0.6+3+2-T_1}{5}$

$\therefore$ From (4).

$2.25T_1 = 2.75 - \frac{(7-T_1)}{5}$

$2.25T_1 = \frac{13.75-(7-T_1)}{5}$

$11.25T_1 = 13.75 - 7 + T_1$

$10.25T_1 = 6.75$

$T_1 = 0.658$

To account for unknown situations, Let us increase T_1 by say 15 to 20%.

∴ Actual thickness of 1st step apron,

$= 1.2 \times 0.65 = 0.8 m$. $\left(\frac{20}{100} \times 0.65\right) + 0.65$
$0.65 (0.2 + 1)$

By similar analysis for 2nd step, using format of (4)

$2.25 T_2 =$ Residual u/p upto D_2

$= 2.75 - \frac{\text{Creep upto } D_2}{5}$ —(5).

$= 2.75 - \frac{AB + BC + CD + DD_1 + D_1D_2}{5}$

$= 2.75 - \frac{1.4 + 0.6 + 3 + 3 + (1 - T_2)}{5}$

$= 2.75 - \frac{8 + (1 - T_2)}{5}$ $\frac{9 - T_2}{5}$

$11.25 T_2 = 13.75 - 8 + T_2$ $\frac{13.75 - 9 + T_2}{5}$

$T_2 = \frac{5.75}{3.25} =$ $T_2 = 0.463$

$T_2 = 0.46 \simeq 0.5 m$

For further protection provide Talus of 4m length (3 to 5m assumed).

WT = 2 + 2(2 × 5.5)
= 24 ≈ 26m