ANNAMACHARYA UNIVERSITY
EXCELLENCE IN EDUCATION; SERVICE TO SOCIETY
ESTD, UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)
Rajampet, Annamayya District, A.P – 516126, INDIA

CIVIL ENGINEERING

Lecture Notes
on
Design & Drawing of Irrigation Structures

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PLATE-1

Design and draw a sluice taking off from a tank irrigating 200 hectares at 1000 duty. The tankbund through which the sluice is taking off has a top width of 2m with 2:1 side slopes. The top level of bank is +40.00 and the ground level at site is +34.50. Good hard soil for foundation is available at +33.50.

The sill of the sluice at off-take is +34.00. The maximum water level in tank is +38.00. The full tank level is +37.00. Average low water level of the tank is +35.00. The details of the channel below the sluice are as under. Bed level +34.00, FSL +34.50, Bed width 1.25m and side slopes are 1½ to 1 with top of bank at +35.50.

Step-1 :- Discharge through sluice barrel

Discharge = area / duty

= 200 / 1000

= $0.2\ m^3/s$

Step-2 :- Vent way of Sluice barrel

Head of water level = average low water level - Sluice sill

= 35.00 - 34.00 = 1.00 m

Driving head, h = 0.25 m

Consider, sluice as large orifice

$$Q = C_d A \sqrt{2gh}$$

$$0.2 = 0.6 * A \sqrt{(2 * 9.81 * 0.25)}$$

$$A = 0.151\ m^2$$

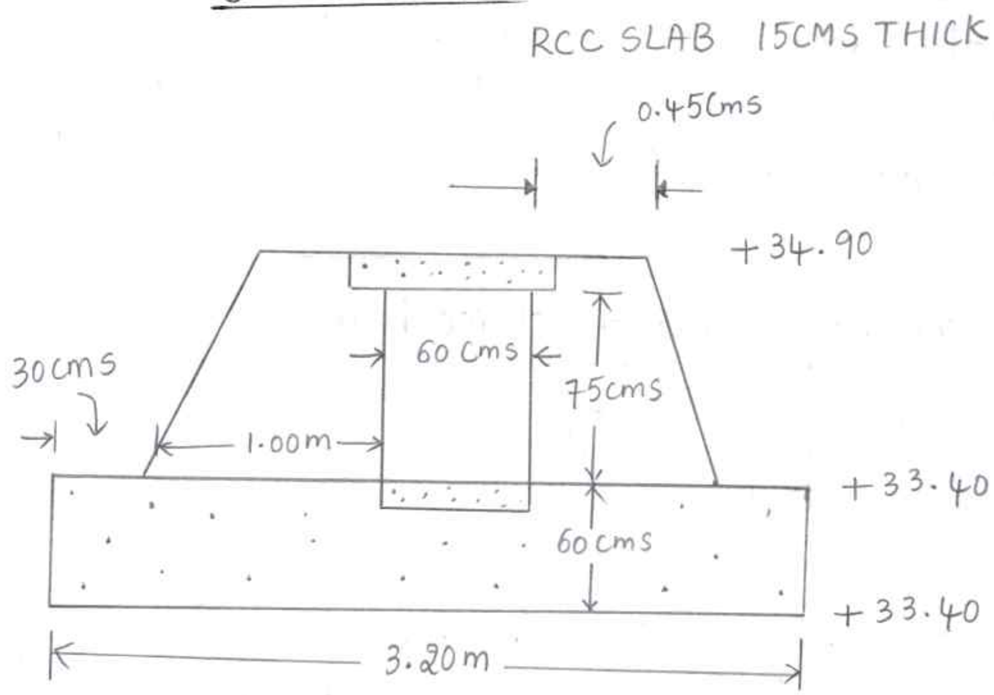
Dia = 45 cm

Provide 75cm x 60cm

Step-3 :- Components of Sluice barrel

1. Foundation - Concrete (60 cm th)
   - top level +34.00
   - bottom level +33.40
2. Side walls - Masonry
   - top width 0.45 m & base 1.0 m
3. Slab - RCC (15cm th)

Sluice barrel



Step-4 :- Checking slab thickness of sluice barrel.

Clear span = 0.6m

Effective span = $0.6 + (0.15/2) + (0.15/2)$

= 0.75 m

Height of Saturated soil

= bund top level - Slab top level

= 40.00 - 34.90

= 5.1m

Unit weight of Concrete = 2400 kg/m^3

Unit weight of Saturated soil = 2240 kg/m^3

Taking a meter width of slab

Total weight on slab = Self weight of slab + weight of Saturated soil

Self weight of Slab = 2400 × 0.75 × 0.15

= 270 kg

weight of Saturated Soil = 2240 × 5.1 × 0.75

= 8568 kg

Total weight on slab = 270 + 8568

= 8850 kg

Max B.M = $wL/8$

= $8850 * 0.75/8$

= 830 kg-m

= 8300 N-m

For 1:2:4 Concrete

Permissible bending stress in Concrete, $\sigma_{cb} = 5 N/mm^2$

Permissible tensile stress in steel, $\sigma_{st} = 230 N/mm^2$

$$B.M = \frac{1}{2} * \sigma_{cb} * j * k * b * d^2$$

we get effective depth = 9.7 cm

So assumed thickness of slab is safe i.e., 15 cm.

Step - 5 :- Earth pressure on side wall of Sluice.

$$\text{Earth pressure} = \frac{wh\,(1 - \sin\varphi)}{(1 + \sin\varphi)}$$

Horizontal Earth pressure at base

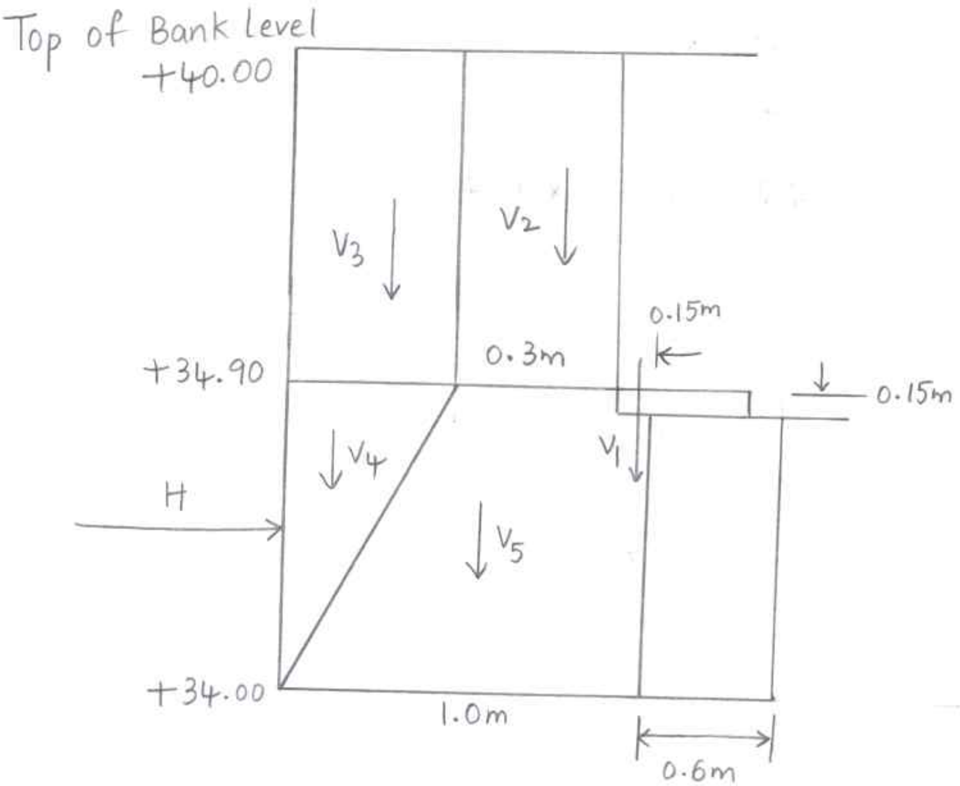
$= 2240 * (40.00 - 34.90) * (1 - \sin 30)/(1 + \sin\varphi)$

$= 4480\ kg/m^2$

Horizontal Earth pressure at top

$= 2240 * (40.00 - 34.90) * (1 - \sin 30)/(1 + \sin \varphi)$

$= 3808\ kg/m^2$



Total horizontal thrust, $H = (0.9/2)^* (4480 + 3808)$

$= 3730\ kg$

(3808 + 4480)

From base it acts at a height = (0.9) x 2 ------------

3

(3808 + 4480)

$= 0.44m$

Step - 6) :- Weight transmitted by Roof slab

weight transmitted by roof slab, $V_1 = 8850/2$

$= 4425\ kg$

This acts at a distance of 0.075m from the toe.

Step-7 :- Weight of Earth on side wall..

a) Weight of Earth on top side of wall beyond slab, V_2

$= 2240 * 0.3 * 5.1$

$= 3427$ kg

This acts at a distance of $(0.15 + 0.3/2) = 0.3$ m from the toe.

b) Weight of Earth stand on slope of wall

(i) Rectangular portion, $V_3 = 2240 * 5.1 * 0.55$

$= 6283$ kg

This acts at a distance of $(0.45 + 0.55/2) = 0.725$ m from the toe.

(ii) Triangular portion, $V_4 = 2240 * 1/2 * 0.9 * 0.55$

$= 555$ kg

This acts at a distance of $[0.45 + 2/3\,(0.55)] = 0.817$ m from the toe.

Step-8 :- Weight of wall

Unit weight of masonry $= 2100$ kg/m²

Weight of wall, $V_5 = 2100 * (0.9/2)(0.45 + 1.0)$

$= 1370$ kg

This acts at a distance of $\dfrac{(0.9)}{3} \times \dfrac{2(0.45+1.0)}{(0.45+1.0)}$

$= 0.39$m from the toe.

Step-9 :- Stability Analysis of Side wall.

Item	Force (kg)		Lever arm (m)	Moment (kg-m)
	Horizontal	Vertical		
V_1		4425	0.075	331.88
V_2		3427	0.3	1028.1
V_3		6283	0.725	4555.18
V_4		555	0.817	453.44
V_5		1370	0.3	411
H	3730		0.44	(-) 1641.2
Total		16060		5261.7

Arm of the resultant, $x = \Sigma M / \Sigma V$

$= 5261.7 / 16060$

$= 0.33\ m$

eccentricity, $e = (b/2) - x$

$= (1.0/2) - 0.33$

$= 0.17\ m$

allowable eccentricity $= b/6$

$= 1/6$

$= 0.17\ m$

So resultant is just in middle third

Maximum compression at toe.

$= \Sigma V / b (1 + 6e/b)$

$= [16060/(1)] (1 + 6^* 0.17)/1$

$= 3240\ kg/m^2 < 32500\ kg/m^2$

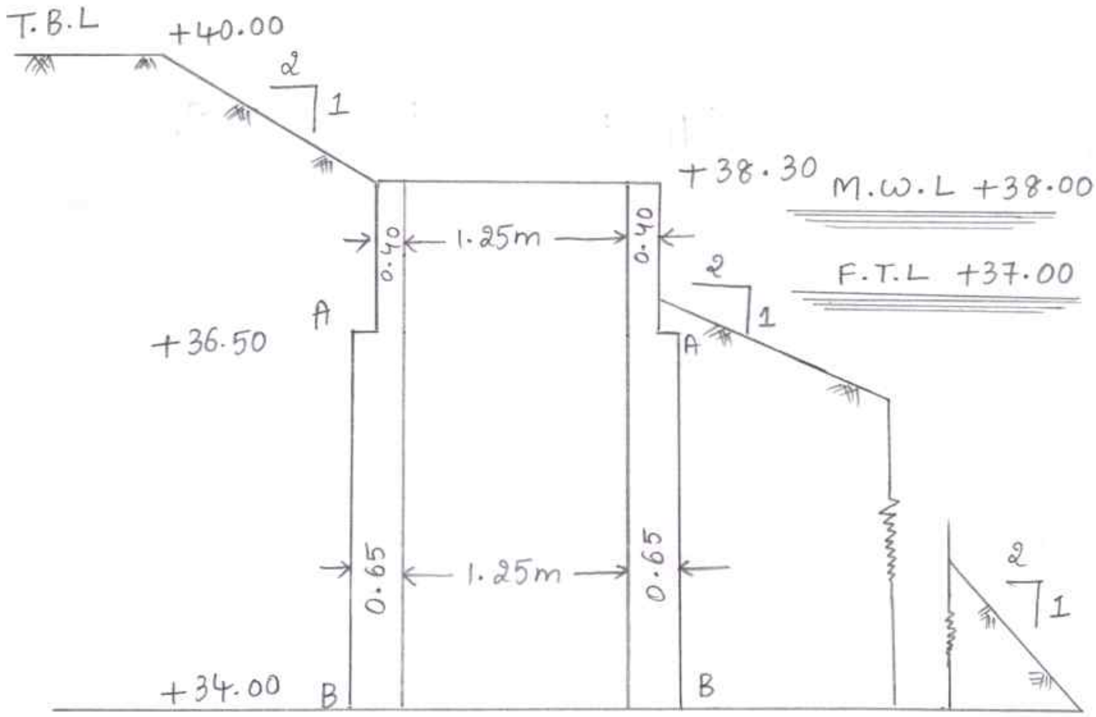
Maximum tension at heel

$= \Sigma V / b (1 - 6e/b)$

$= [16060/(1)] (1 - 6^* 0.17)/1 = 32\ kg/m^2 < 1250\ kg/m^2$

Hence safe.

Step-10) :- Tower head/well



well steining
- internal dia 1.25 m
- top level is 0.3 m above M.F.L
- worst condition is when well is empty
- thick cylindrical shell
- withstand radial earth pressure on outer side
- development of hoop compression within stress limits

Step-11) Radial earth pressure on tower head :

Rebhan's Graphical Method :

$$p = c * k * wh$$

Constant, $c = 1 + [(4.5 * A)/HL]$

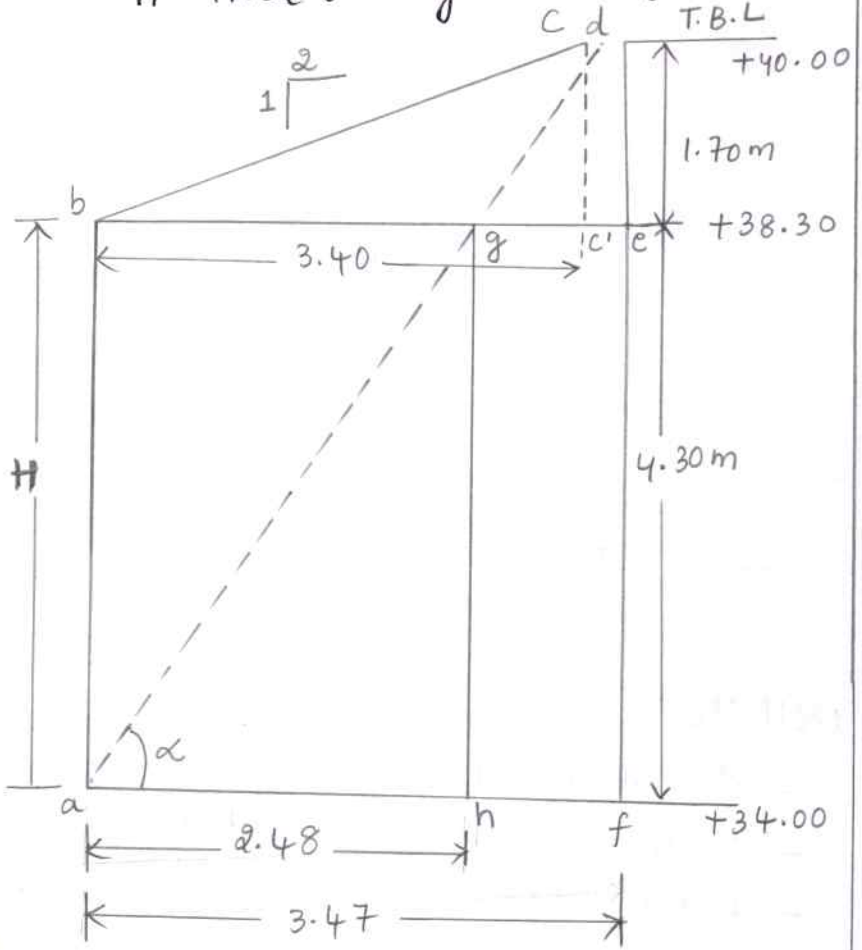
A = area of the fig 'bcdg'

H = Total height of wall

L = horizontal projection of 'ad'.

$$K = \frac{(1-\sin\varphi)}{(1+\sin\varphi)} = 0.33$$

'A' Area of Figure 'bcdg'



$\alpha = 45 + \theta/2$

θ = angle of repose

$= 30$

$\alpha = 60$

$\tan 60 = df/af$

$= 6.0/af$

$af = L = 3.47\,m$

$\tan 60 = H/ah$

$ah = bg = 2.48\,m$

$bc' = 2 * 1.7 = 3.4$

$cd = af - bc'$

$= 3.47 - 3.4$

$= 0.07\,m$

$A = (1.7/2) * (0.07 + 2.48)$

$= 2.17\,mm^2$

$C = 1 + [(4.5 * 2.17)/(4.3 * 3.47)]$

$= 1.65$

Radial pressure at +34.00

$= 1.65 * 0.33 * 2240 * 4.3$

$= 5291$ kg/m

Radial pressure at +36.50

$= 1.65 * 0.33 * 2240 * 1.8$

$= 2216$ kg/m

Step-12) Checking the thickness of well at +36.50

Use lames theory for thick cylindrical wells

radial pressure $= a + b/R^2$

hoop pressure $= a - b/R^2$

R = radius

a, b are constants

radius of outer periphery $= (1.25 + 0.45 + 0.45)/2$

$= 1.08\,m$

radius of inner periphery $= (1.25)/2$

$= 0.63\,m$

(a) Outside

$2216 = a + b/(1.08)^2$ ------ (1)

(b) Inside

$0 = a + b/(0.63)^2$ ------ (2)

$a = 3367$, $b = -1347$

Hoop compression at outer periphery

$= 3367 - (-1347)/(1.08)^2$

$= 4519\ kg/m^2 < 32500\ kg/m^2$

within permissible stresses in masonry hence safe.

Hoop compression at inner periphery

$= 3367 - (-1347)/(0.63)^2$

$= 6734\ kg/m^2 < 32500\ kg/m^2$

within permissible stresses in masonry hence safe.

Step-13) Checking the thickness of well at +34.00

radius of outer periphery $= (1.25 + 0.65 + 0.65)/2$

$= 1.28\,m$

(a) Outside

$5291 = a + b/(1.28)^2$ ----- (1)

(b) Inside

$0 = a + b/(0.63)^2$ ---- (2)

$a = 7000$, $b = -2800$

Hoop compression at outer periphery

$= 7000 - (-2800)/(1.28)^2$

$= 8708\ kg/m^2 < 32500\ kg/m^2$

within permissible stresses in masonry

Hence safe.

Hoop compression at inner periphery

$= 7000 - (-2800)/(0.63)^2$

$= 14000\ kg/m^2 < 32500\ kg/m^2$

within permissible stresses in masonry

hence safe.

Step-14) Specifications:

1. Foundation of Sluice barrel - C.C. 1:3:6
2. walls of sluice barrel & well - Stone masonry with pointing CM 1:4
3. Slab of Sluice barrel - R.C.C. 1:2:4

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PLATE-2

Design a cross drainage work to suit the following particulars :-

Canal :

discharge : 35 Cumec

bed width : 20 m

bed level : +40.00

Full supply level : +42.00

Ultimate bed level : +39.75

Ultimate full supply level : +42.50

average velocity in canal : 0.83 m/s

Left bank top width :- 5m

Right bank top width :- 2m.

Canal side slopes both inside and outside are 2:1 with embankment with a minimum cover of 1m over the hydraulic gradient.

Top of canal bank : +43.50.

average ground level on flanks of drain : +38.00 on bed level of the drain may also be taken as +38.00 at the point of crossing.

drain :

Catchment area : 8 km^2

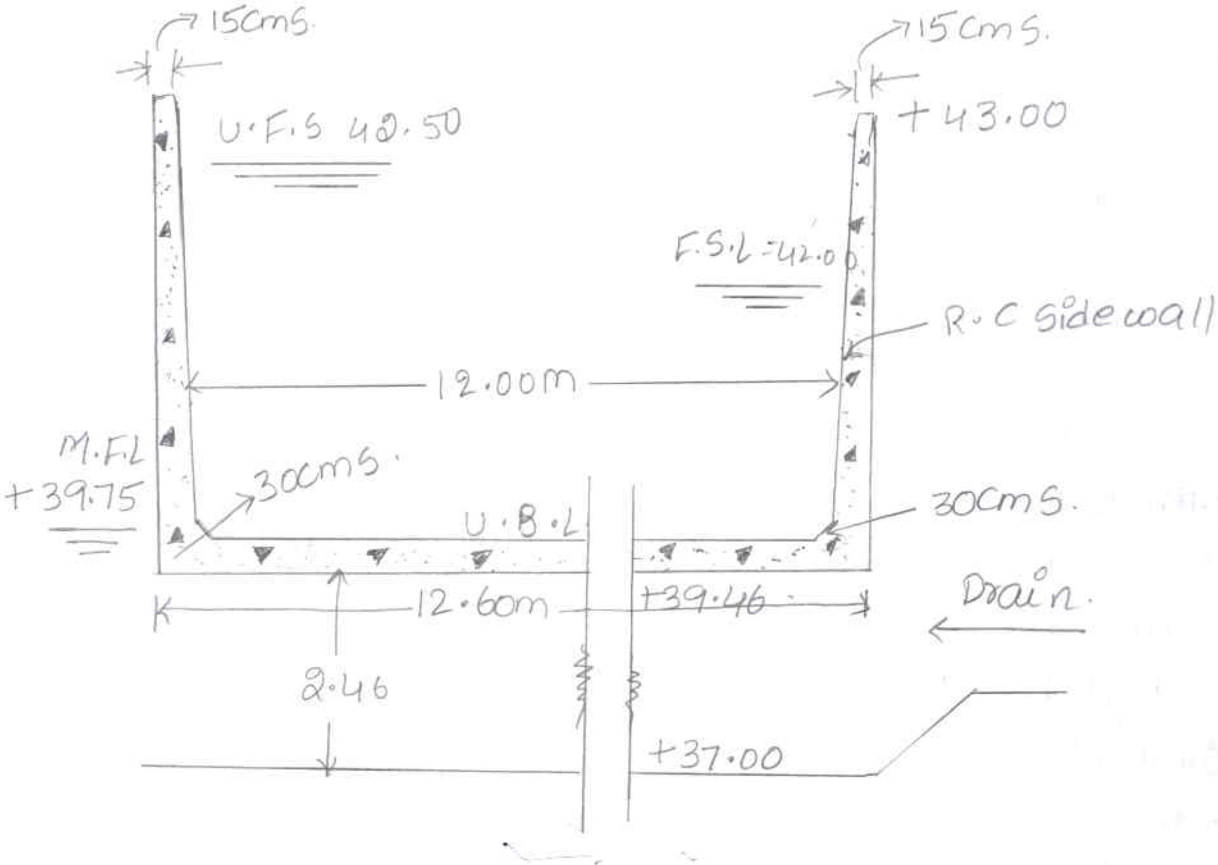
The maximum computed discharge is worked out of 60 cumec using a Coefficient C = 15 in Ryve's formula.

Maximum flood level of the drain at the site of crossing is +39.75 (observed)

average bed level of the drain at the site of crossing is +38.00.

Hard soil suitable for the foundation is met +37.00.

Step-1) Canal waterway through the trough.



width of trough = canal discharge / (full supply depth in trough * Maximum velocity)

Maximum velocity through the trough = lesser value of

(i) 2* normal velocity
= 2* 0.83 = 1.66 m/s

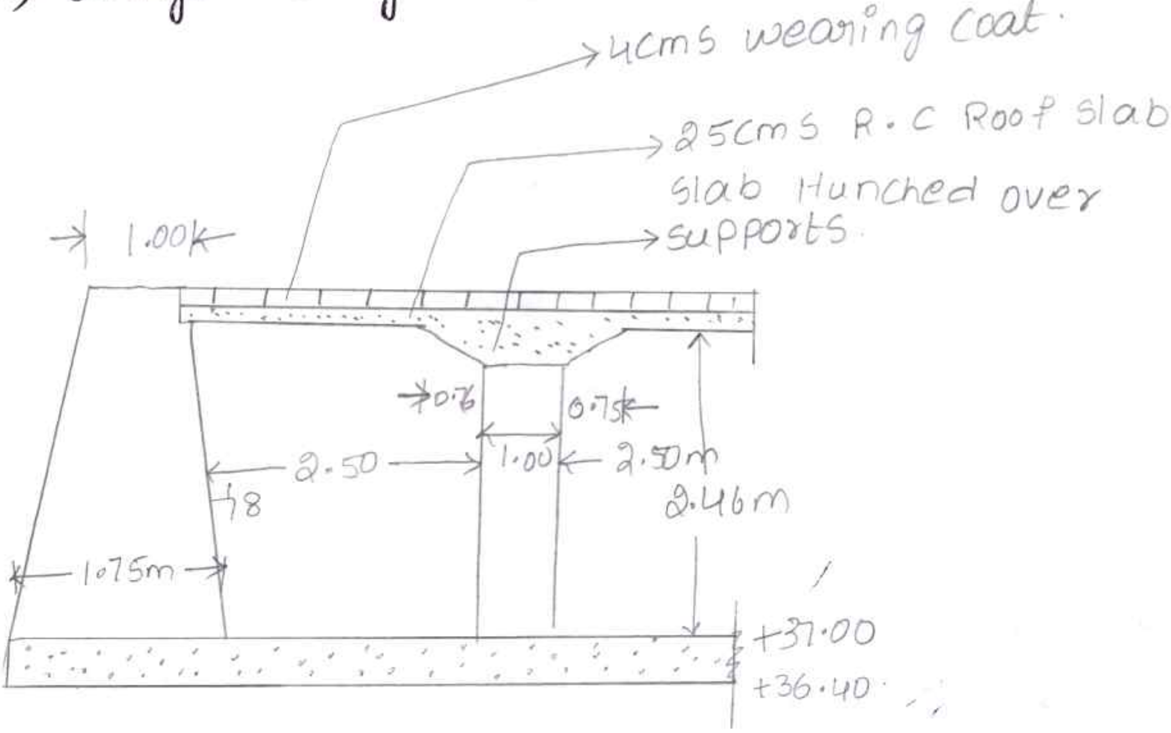
(ii) 1.5 m/s

The loss of head in the canal is quite negligible full suply depth in trough = 2m

width of trough = 35/(2* 1.5) = 12m

So provide RCC trough with a clear wid

Step -2) Drainage water way.



Length of waterway = drainage discharge / (depth of flow in drainage barrel * Velocity in drain barrel)

assume wearing coat thickness = 4m

RCC slab for the roof of drain = 25cm

So bottom level of RCC trough = +39.75 − 0.29 = +39.46

average bed level of the drain = +38.00

to reduce no. of vents of the aqueduct the bed of the drain is depressed to +37.00.

depth of flow in drainage barrel = 2.46m

velocity in drain barrel = 3.25m/s

Length of waterway = 60 / (2.46 * 3.25) = 7.5m

Provide 3 vents at 2.5m each.

Step-3 :- Canal trough

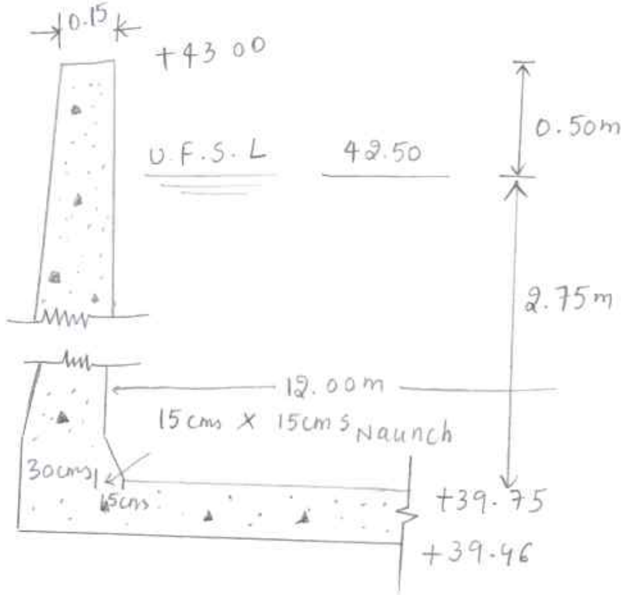
Designed for ultimate conditions only

Sill of canal trough = UBL = +39.75

Ultimate full supply level = +42.50

(i) Side walls :

the top of cantilever walls of trough is kept at 0.5m above UFSL and 15cm thick.



Max BM of cantilever $= wh^3/6$

$h = 42.5 - 39.75 = 2.75m$

Max $B.M = 1000 * 2.75^3/6$

$= 3466$ kg-m

$= 3466 * 10^4$ N-mm.

for 1:2:4 Concrete,

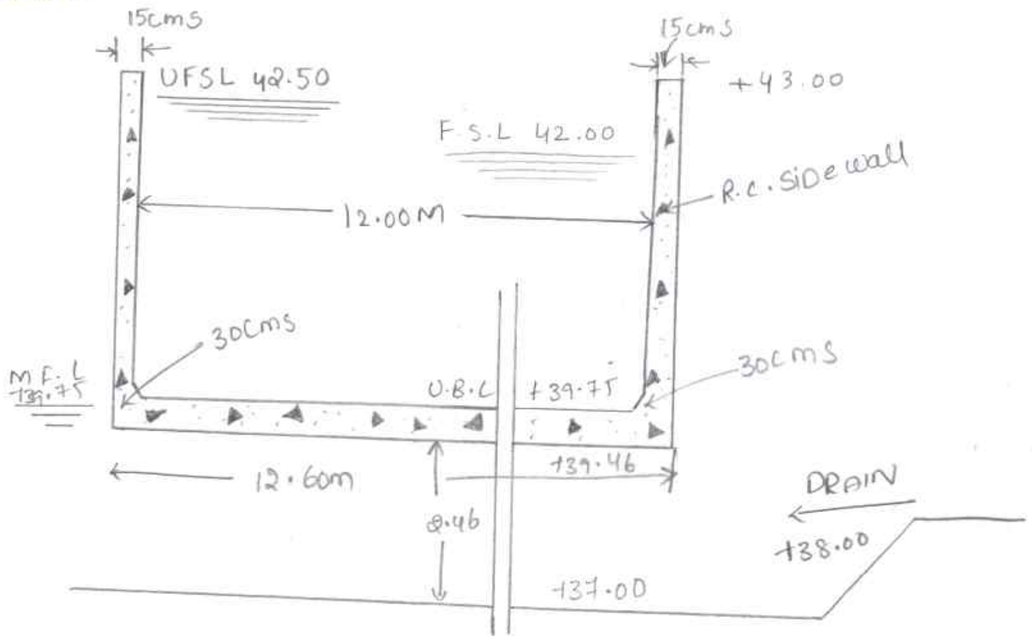
Permissible bending stress in concrete, $\sigma_{cb} = 5\ N/mm^2$

Permissible tensile stress in steel, $\sigma_{st} = 230 N/mm^2$

$BM = \frac{1}{2} * \sigma_{cb} * j * k * b * d^2$

we get effective depth $= 0.21m$.

So provide overall thickness 0.3 m.



Bottom slab is also roof slab for drainage barrel

eff span = 2.5m.

assume slab ~~thickness~~ thickness 0.25m

and wearing coat 0.04m.

Load per sq m of slab + wearing Coat = 0.29 * 2400 = 696 kg

Load of water = 1000 * 2.75 = 2750 kg

Total load = 3450 kg/sq.m.

Max B.M (3 Continuous Spans) occuring at intermediate supports

$= wl^2/10$ (IS 456)

Max BM = $3450 * 2.5^2/10$ = 2156 kg-m.

For 1:2:4 Concrete.

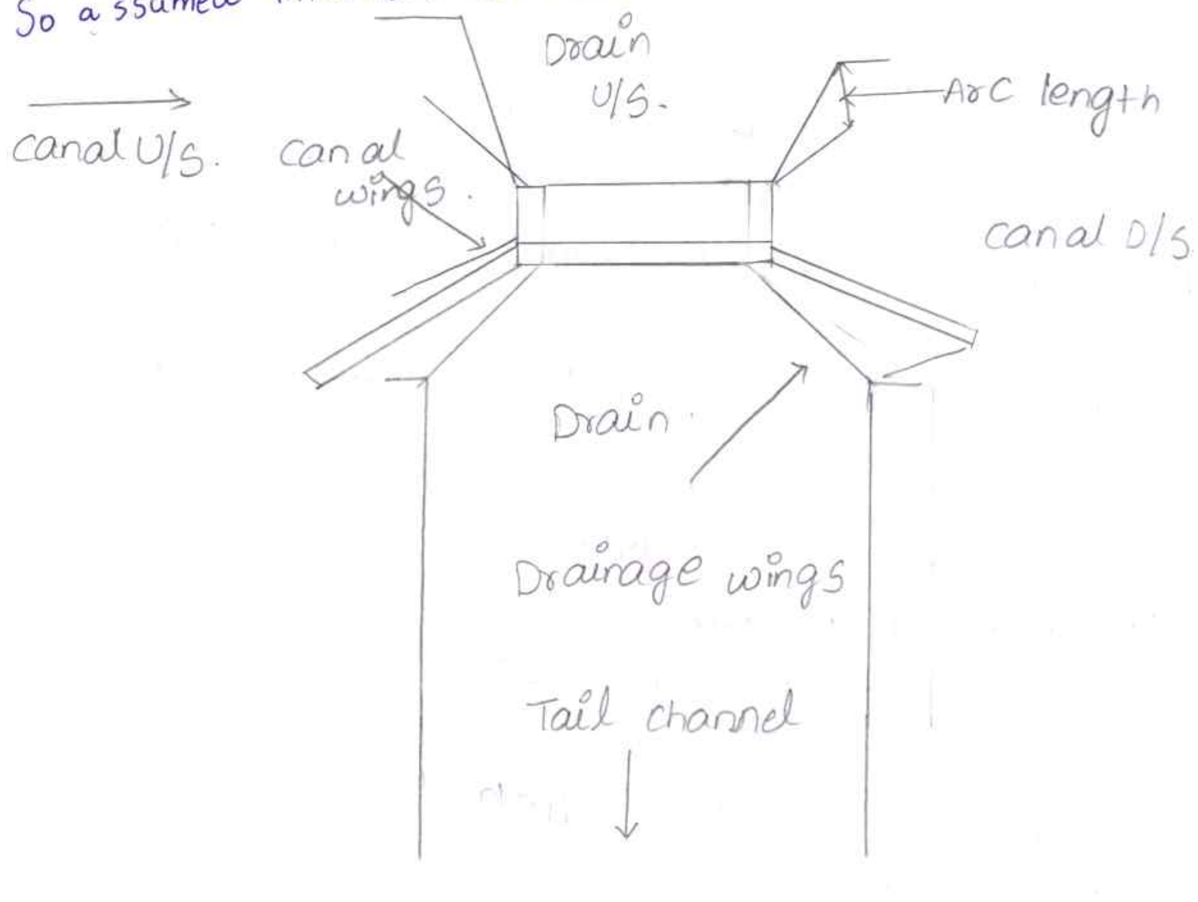
Permissible bending stress in concrete $\sigma_{cb} = 5 N/mm^2$

Permissible tensile stress in steel $\sigma_{st} = 230 N/mm^2$

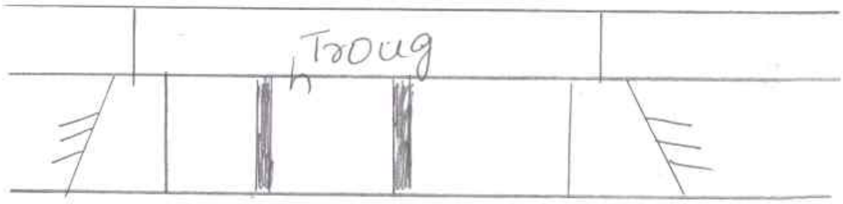
$B.M = 1/2 * \sigma_{cb} * j * k * b * d^2$

we get effective depth = 0.18m

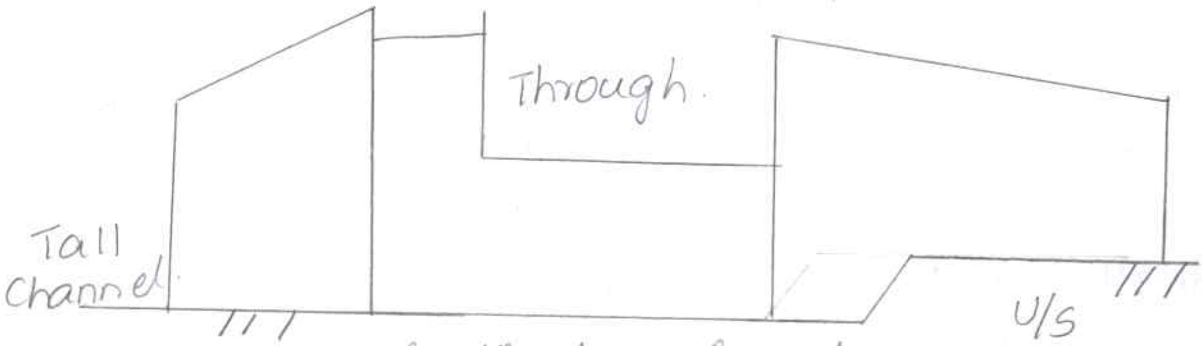
So assumed thickness of slab is safe i.e., 0.25m.



plan



longitudinal section along canal



Longitudinal section along drain.

Step-4) Fixing max flood levels of drainage

Max flood level = d/s MFL + afflux due to trough

afflux due to trough = $\left[1 + F_1 + (f_2 L/R)\right] v^2/2g$

$F_1 = 0.505$

$f_2 = a\left(1 + (0.3 * b/R)\right)$

$a = 0.003$; $b = 0.1$

Total length of siphon barrel, L = width of canal trough + side walls = $12 + 2 * 0.3 = 12.6\,m$

Hydraulic mean radius, $R = 2.5 * 2.46 * 3 / [(2.5 + 2.46) * 2 * 3]$

$= 0.62\,m$

afflux $= \left[1 + 0.505 + (0.00348 * 12.6/0.62)\right] 3.25^2/2 * 9.81$

$= 0.85\,m$

$= 39.75 + 0.85 = +40.60$.

Step-5) Tail channel of the drain :-

Prior to construction of structure BL = +38.00

MFL = 39.75

Depth of drain = 39.75 − 38.00 = 1.75m.

After construction of structure BL = + 37.00

MFL = 39.75

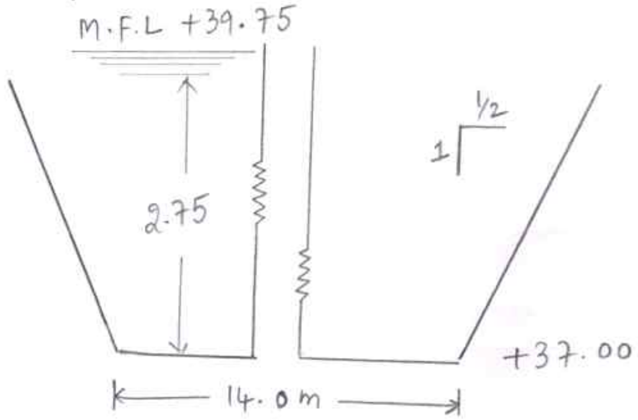
Depth of drain, D = 39.75 − 37.00 = 2.75m.

Assume limiting velocity = 1.5 m/s

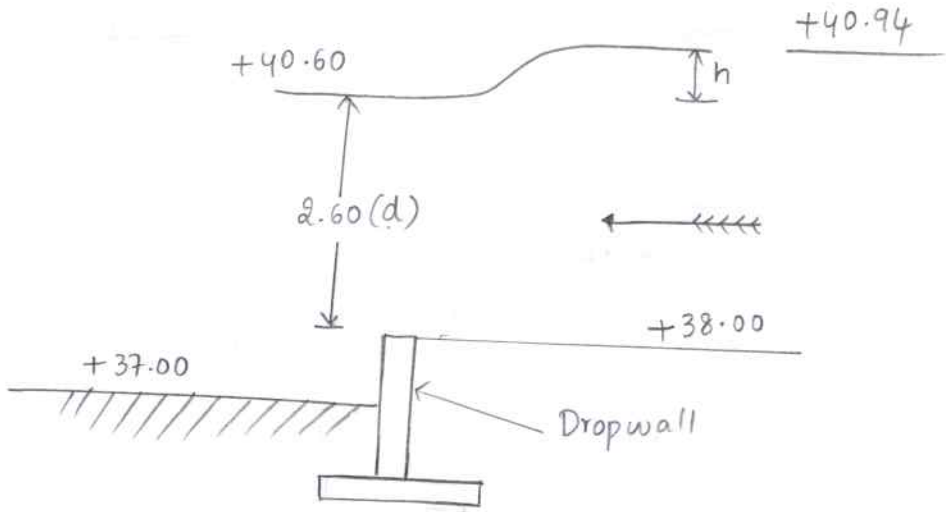
Area = discharge / velocity = 60/1.5 = 40 Sq m.

$40 = (B + 2.75/2)\ 2.75$

$B = 14m.$



Step-5) Afflux on drop wall



Length of dropwall b/w wing walls = 11 m

discharge per m length of drop wall, Q = 60/11 = 5.45 Cumec

Q = free weir (Broad Crested) + drowned weir

$$Q = 2/3\ Cd_1 \sqrt{(2g)}\ h^{3/2} + Cd_2\ d\left(\sqrt{2gh}\right)$$

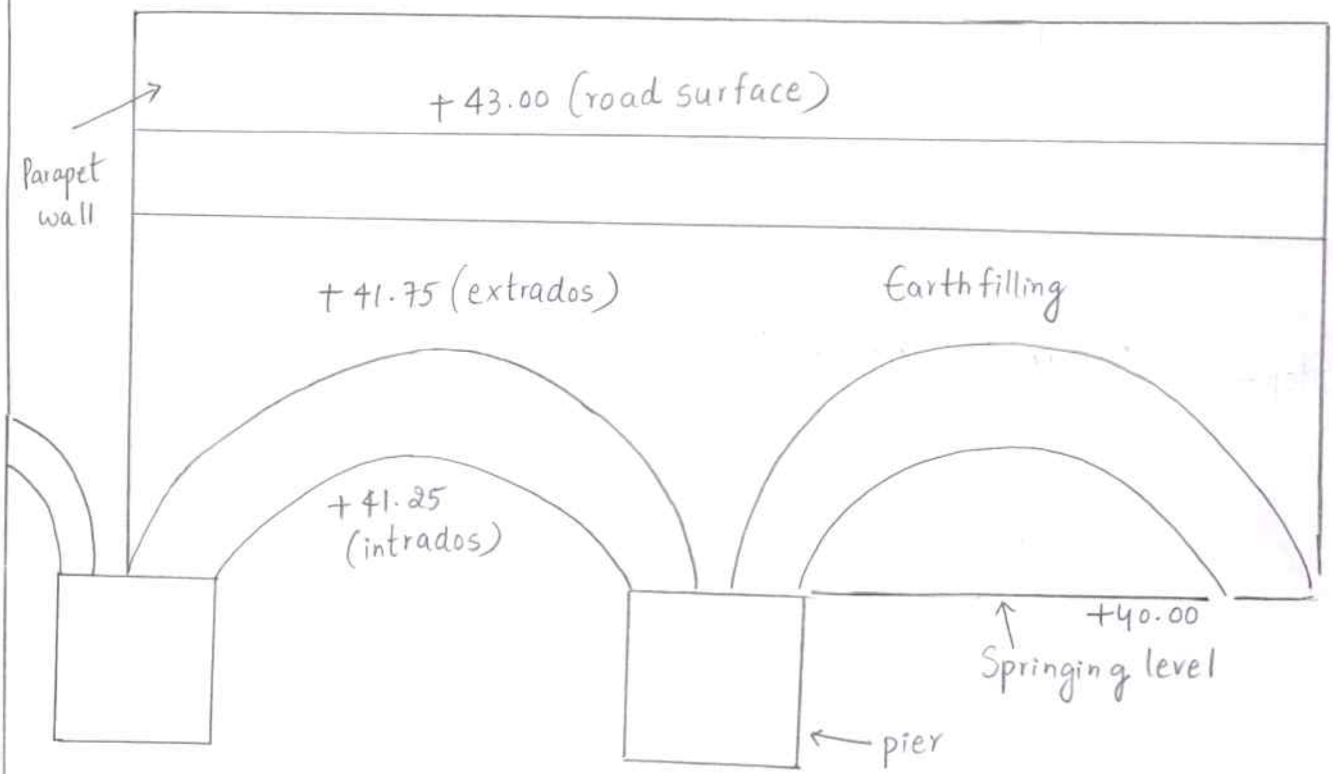
$d = 40.60 - 38.00 = 2.6m.$

$$5.45 = 2/3 * 0.6 \sqrt{(2 \times 9.81)}\ h^{3/2} + 0.75 * 2.6 * \sqrt{(2 * 9.81)}$$

afflux, $h = 0.34$ m

MFL over drop wall $= 40.60 + 0.34 = +40.94$

Step-6) Inspection track



width of roadway = 3.65 m b/w kerbs

Roadway carried over concrete semi-circular arches of thickness 0.5 m.

Springings of arches above drain water level as +40.00

Bottom level of arches (intrados) $= 40.00 + 2.5/2 = +41.25$

Top level of arches (extrados) $= +41.75$

Road ~~le~~ Surface level $= +43.00$

Earthfilling provided as cushion b/w arches and roadway

Suitably connected to canal transitions.

Step - 7) Foundations of abutments and piers :-

Bottom level = +36.40

Top level = +37.00

this is same as solid apron.

All this floor made as monolithic.

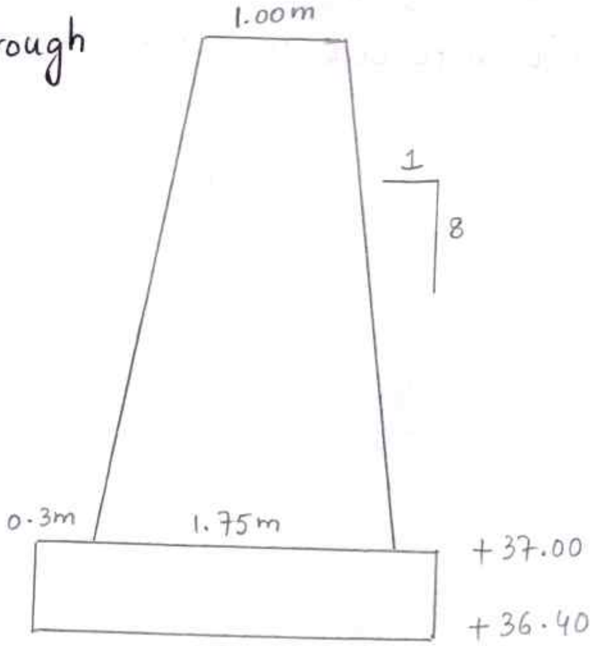
This distributes the load of structure evenly on the soil.

Capable of acting as an inverted arch to take care of uplift pressures.

However checked and verified so that they do not exceed the safe bearing capacity

Thickness of pier = 1.00 m.

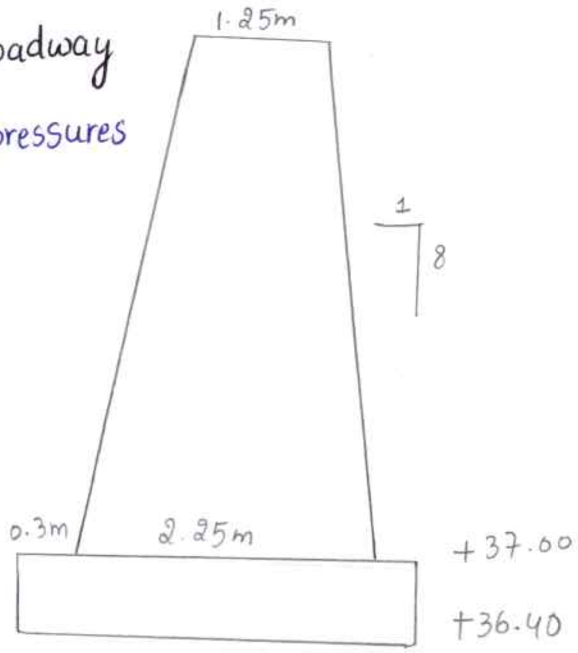
Abutment under trough



Abutment under roadway

Checked for earth pressures Surcharge

Checked for Max toe pressures



Step-8) arc lengths to fix the lengths of discharge wings.

d/s of drain

Canal FSL = +42.00

drainage bed = +37.00

difference = 5.00m

arc length = 5 * 4 = 20m.

U/s of drain

Canal FSL = +4200

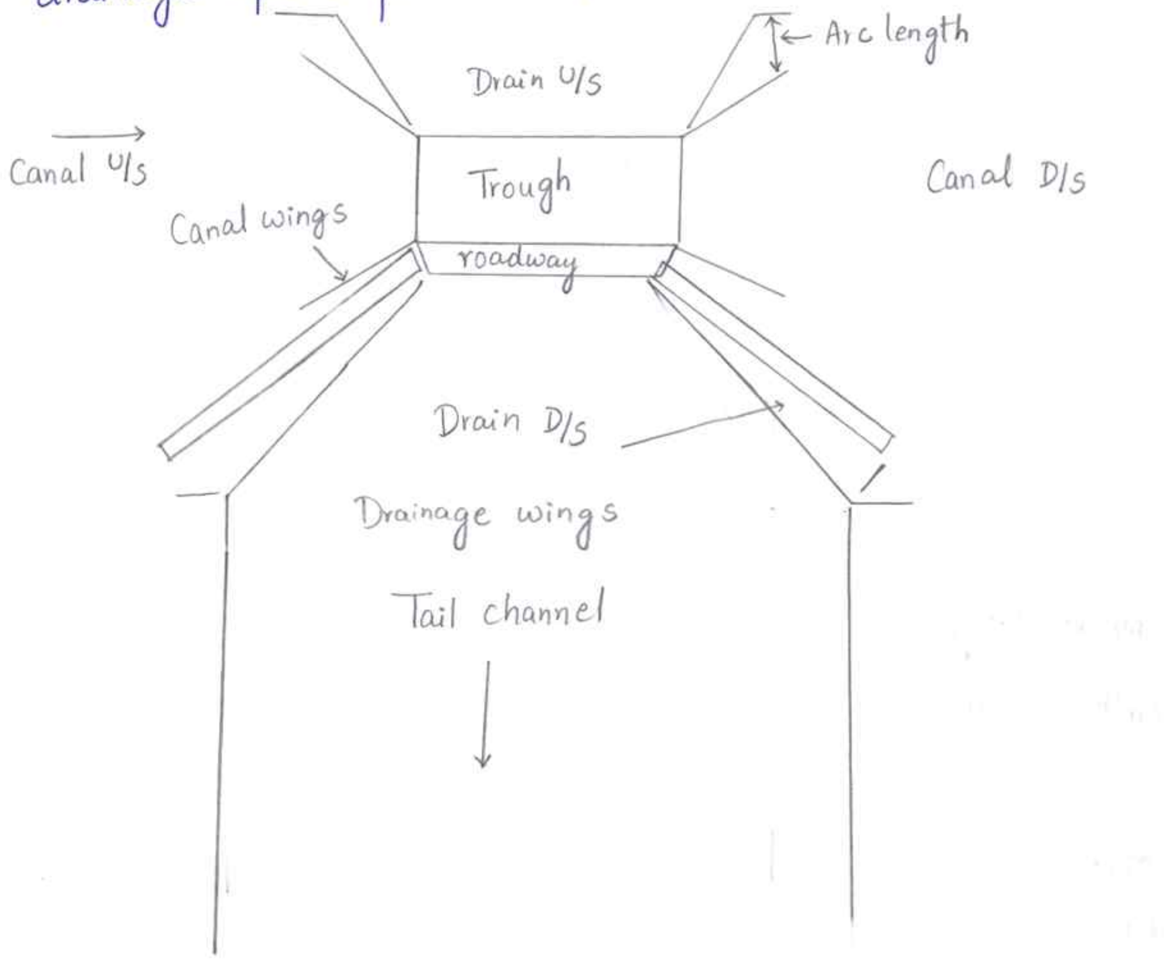
drainage bed = +38.00

difference = 4.00 m

arc length = 4 * 4 = 16m

distance b/w returns = 14 m (u/s and d/s)

drainage aprons provided upto end of drainage wings.



Plan

Step-9) Length of Canal wings and aprons

Uplift is maximum when canal is full & drainage empty.

Uplift = 42.00 − 37.00 = 5m.

Horizontal creep to travel up to end of abutment =

L + 2.05 (as per Bligh's theory)

assume drain floor thickness = 60cm

Total uplift resisted by concrete =

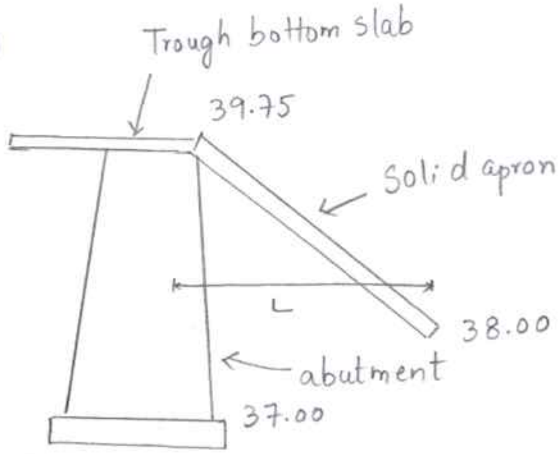
0.6 * (2.25 − 1) = 0.75m.

Residual head = 5 − 0.75 = 4.25m.

assume creep gradient 1 in 4

4.25 * 4 = L + 2.05

L = 15m

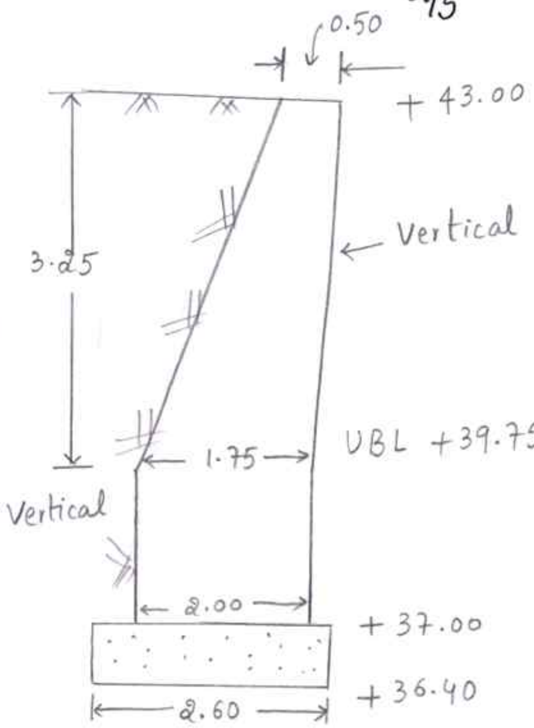


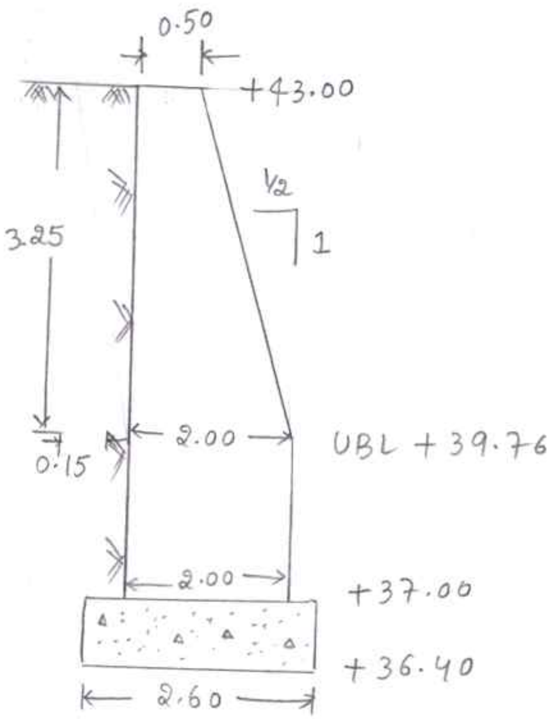
distance b/w wings = bedwidth

Step-10) Canal transitions:-

U/S

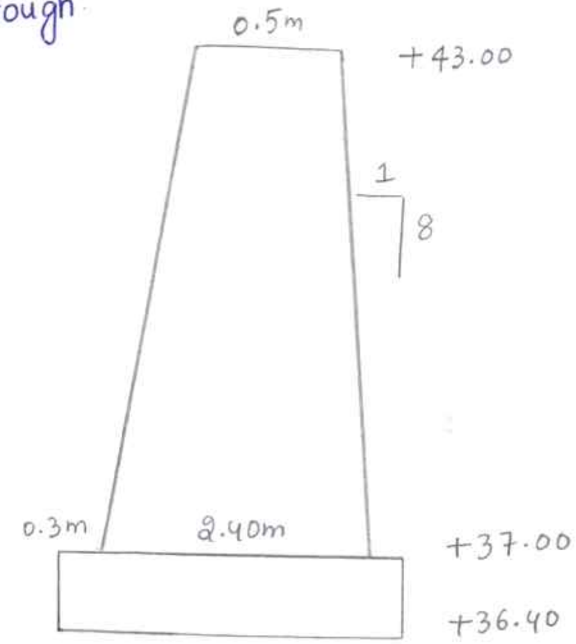
d/S



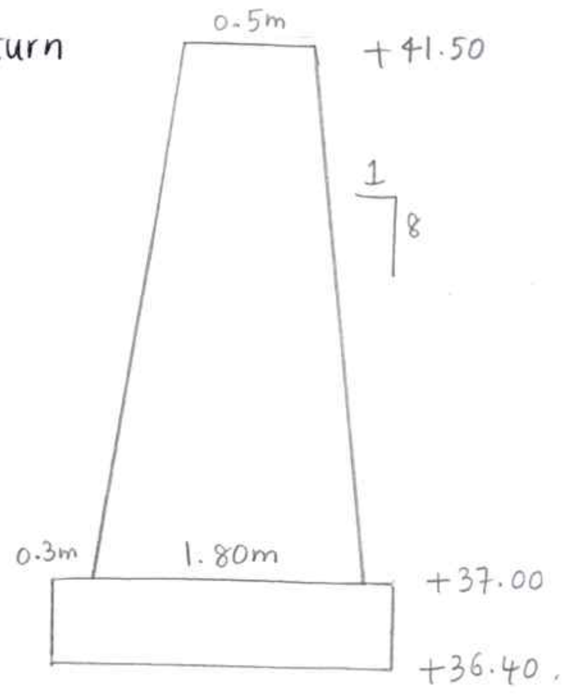


Step-11) Wings & returns of drain

U/S
At junction of trough

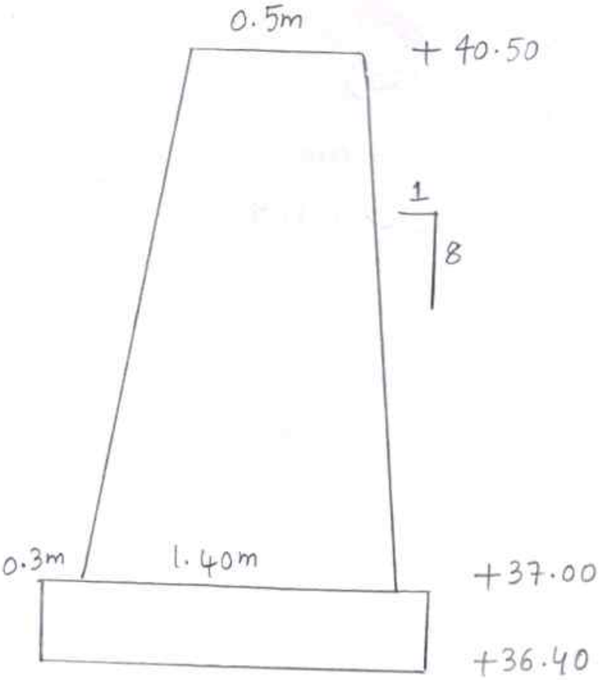


U/S
Level wing & return



d/s

Level wing & return



Step-12) Anchoring arrangement for piers / abutments & trough bottom slab.

Max uplift = MFL – trough bottom level
= 40.60 – 39.46 = 1.14m.

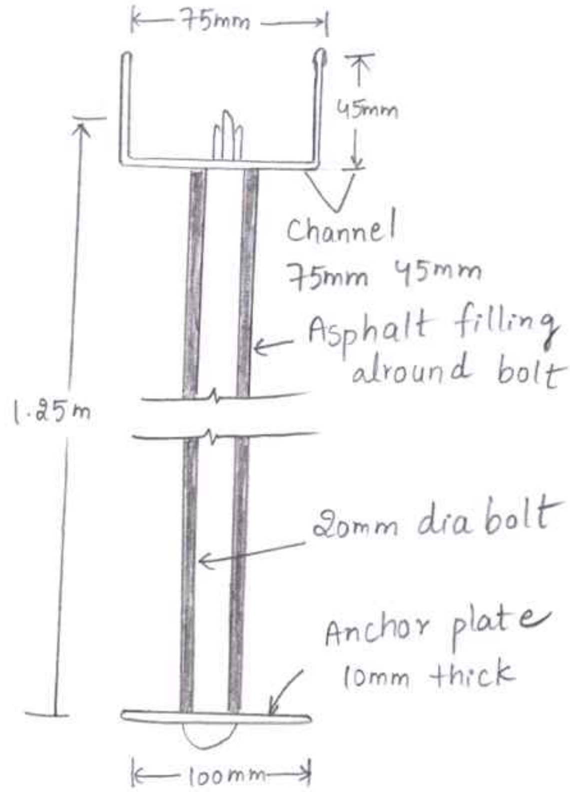
Counteract of roof slab =
0.29 * 2.25 = 0.65m

Net uplift = 1.14 – 0.65 = 0.5m.

Upward thrust acting on span =
2.5 * 12.6 * 0.5 * 1000 = 16000kg

1–20mm dia anchor bolt = 4000kg

No. of bolts required = 4Nos.



①

Step-13) Specifications :-

1. Foundations - piers, abutments, wings and returns - C.C 1:3:6
2. Solid aprons - CC 1:4:8
3. trough : RCC 1:1 ½ : 3 (M20)
4. Abutments, wings and returns - masonry 1:6 C.M.
5. arches - plain cement concrete (1:4:8)

CIVIL ENGINEERING

Design & Drawing of Irrigation Structures

PLATE-3

Problem : Design a canal drop (notch type) of 2m with the following data.

Hydraulic particulars	U/S Canal	D/S canal
Full supply discharge	4.0 m^3/s	4.0 m^3/s
Bed width	6.0 m	6.0 m
Bed level	+ 100.0 m	+ 8.00 m
Full supply depth	1.50 m	1.50 m
Full supply level	+ 11.50 m	+ 9.50 m
Top level of bank	+ 12.50 m	+ 10.50 m
Top width of bank	2m	2m
Half supply depth	1.0 m	1.0 m

Ground level at the site = + 10.50m. Good soil for foundation is available at +8.50m

Step-1) Notch

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

Consider two notches

i) Full supply depth

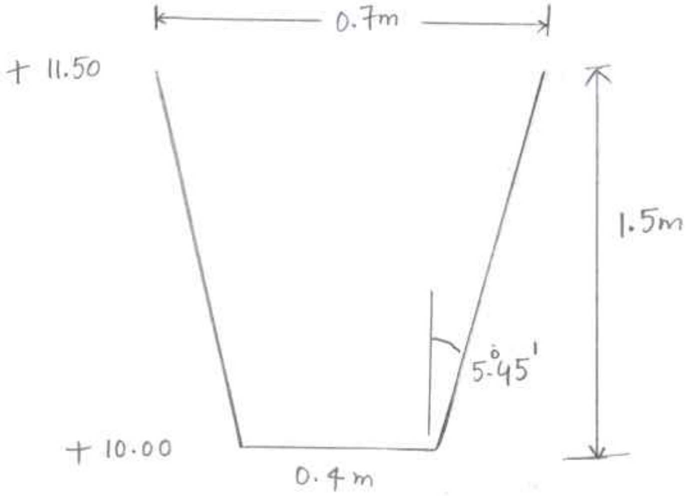
$$2 = (2/3) * 0.67 \sqrt{(2 * 9.81)} * L * 1.5^{3/2} + (8/15) * 0.67 \sqrt{(2 * 9.81)} \tan \theta/2 \; 1.5^{5/2} \quad \text{---- (1)}$$

ii) Half supply depth

$$1 = (2/3) * 0.67 \sqrt{(2 \times 9.81)} \times L \times 1.0^{3/2} + (8/15) * 0.67 \sqrt{(2 * 9.81)} \tan \theta/2 \; 1.0^{5/2} \quad \text{--- (2)}$$

By solving Equations (1) & (2)

$$L = 0.4m, \quad \theta/2 = 5^\circ 42'$$



Step-2) Length of drop wall

$7/8$ of U/s bed width of Canal

$= 6 * 7/8$

$= 5.25m$

Step-3) Top width of drop wall

15 to 30cm wider than length of notch pier

Length of notch pier = Half of the depth of water over sill of the notch.

depth of water over sill of the notch = 1.5m

Length of Notch pier $= 1.5/2$

$= 0.75m$

Top width of drop wall $= 0.15 + 0.75$

$= 0.9m$

adopt 1.0m

Step-4) Height of drop wall

depend upon depth of water cushion

Effective depth of water cushion = d/s full supply depth + x

x = difference of d/s bed level & apron top level.

for south Indian soils

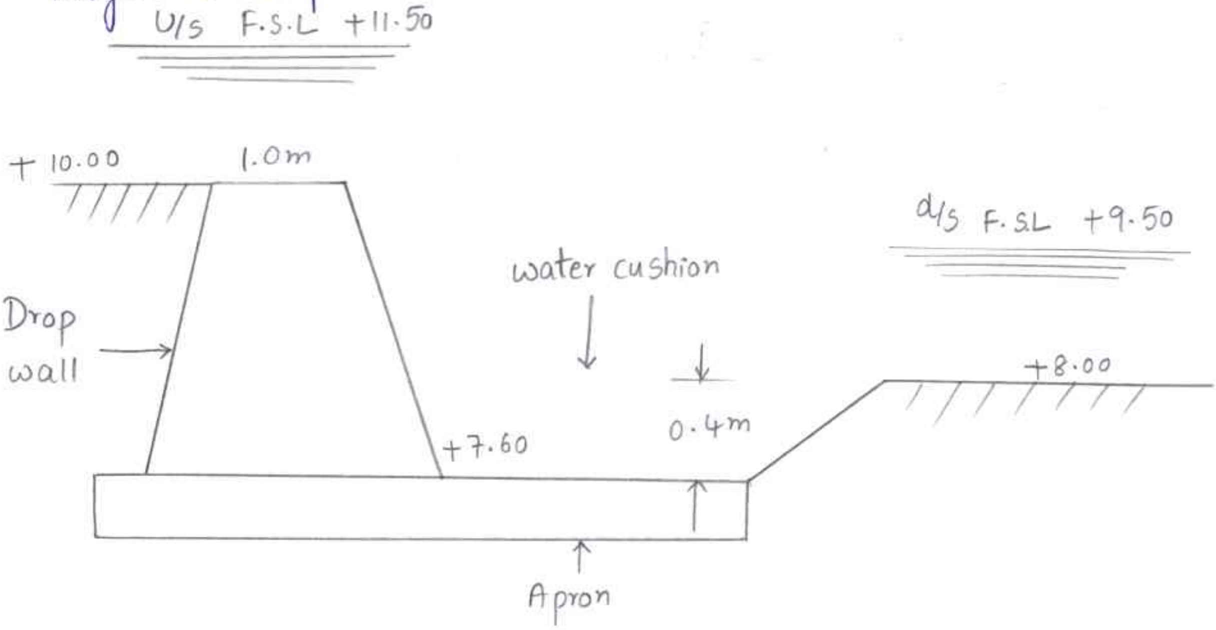
Effective depth of water cushion =

0.9 * depth of water over sill of notch * √drop

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

$x = 0.4\ m$

Height of drop wall = 10.00 − 8.00 − 0.4 = 2.4 m.



Step-5) Base width of drop wall

(height of drop wall + depth of water over sill of notch) / √Specific gravity of material

$= (2.4 + 1.5) / \sqrt{2.25}$

$= 2.6\ m$

Step-6) Length of floor (apron) of water cushion.

depth of water over sill of notch + 2 * √(depth of water over sill of notch * drop)

$= 1.5 + 2 * \sqrt{(1.5 * 2)}$

$= 5.0\ m$

Step-7) Thickness of floor (apron) of water cushion.

(1/2) * √(depth of water over sill of notch + drop)

$= (1/2) * \sqrt{(1.5 + 2)}$

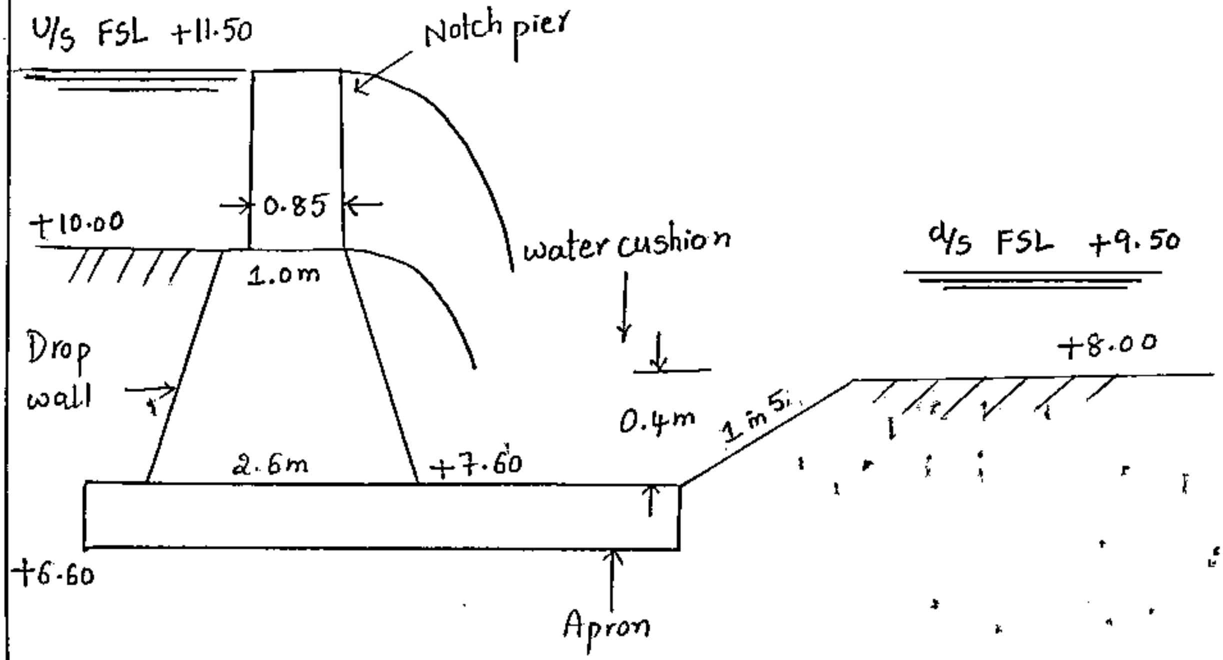
$= 1.0\ m.$

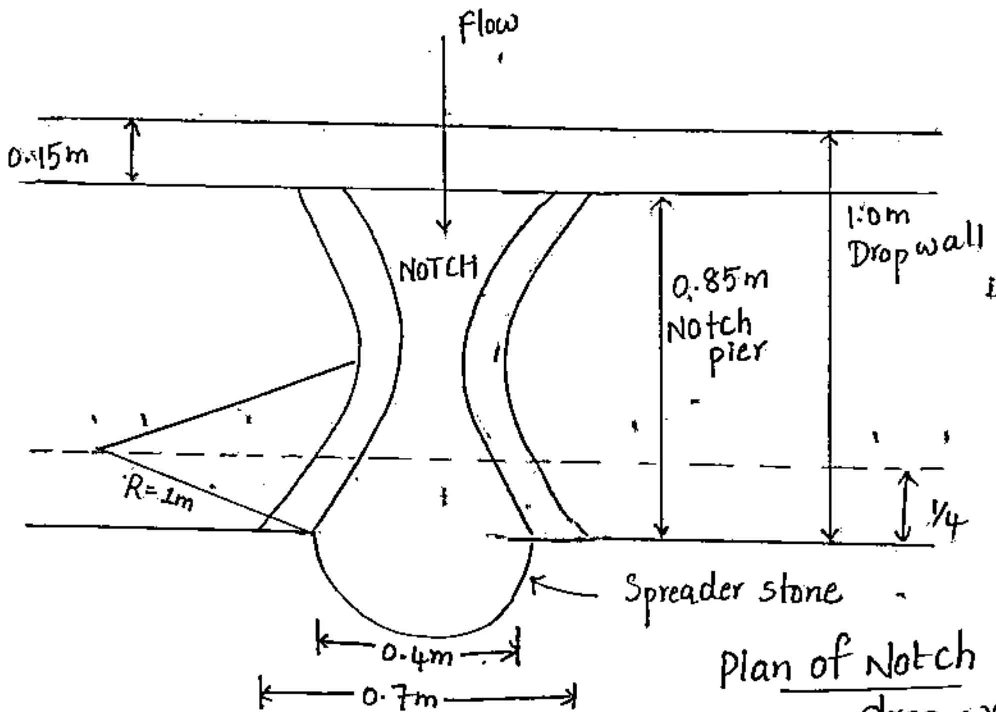
Step- 8) Notch pier

Top of Notch pier = FSL
= +11.50

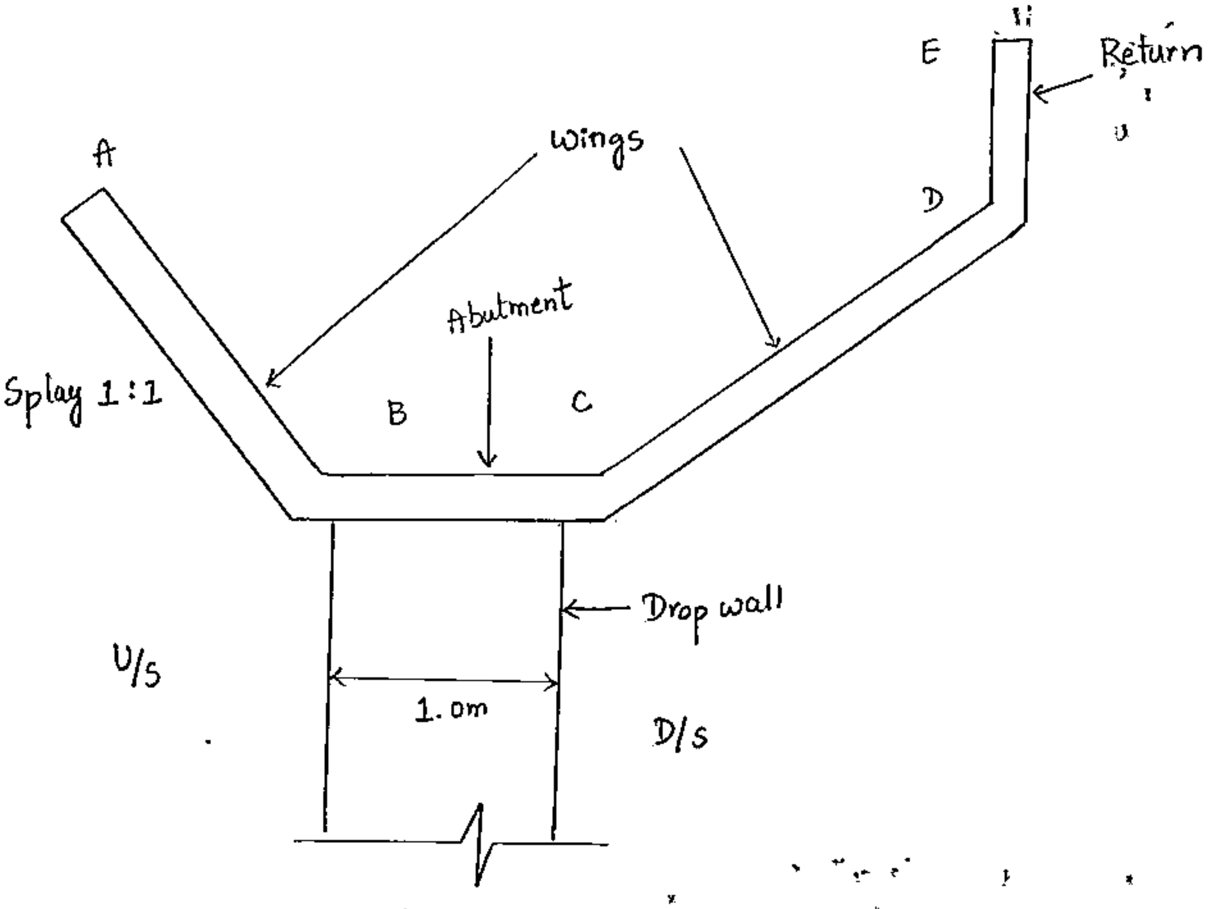
width of Notch = u/s full supply depth /2
= 1.5/2
= 0.75 m

Provide 0.85m.





Plan of Notch in drop wall

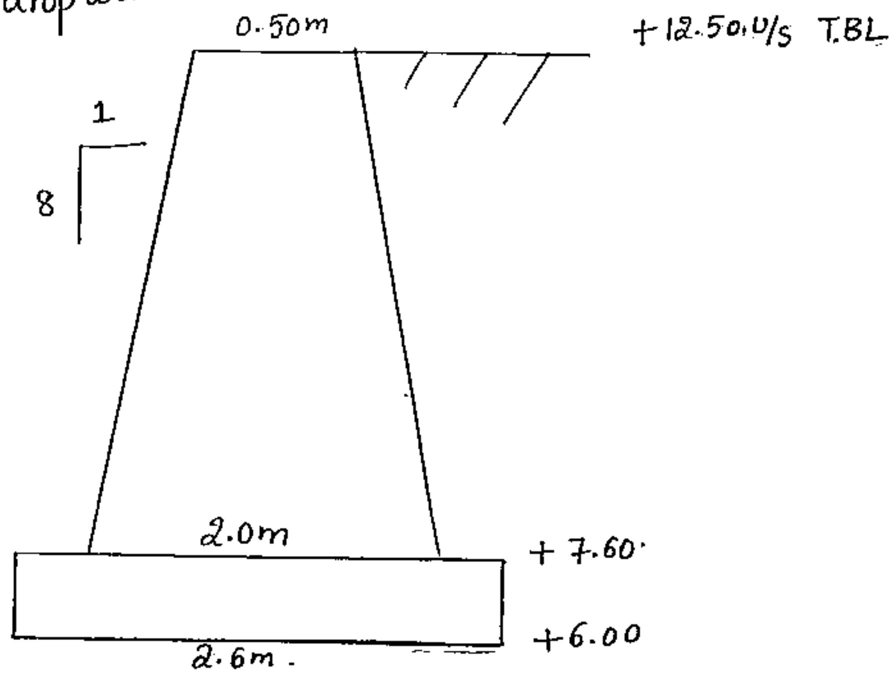


Plan

Step-9) Abutment (BC)

Length of abutment =

Base width of drop wall



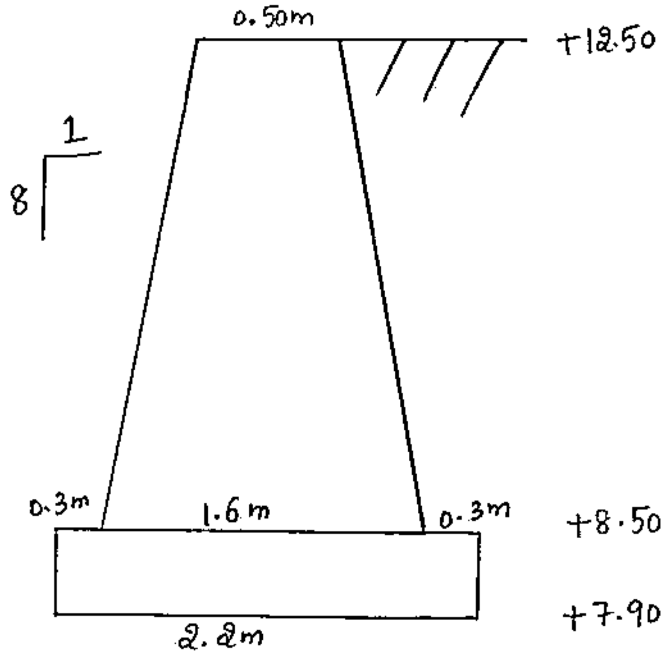
Base width = 0.4 * Height of Abutment

= 0.4 * (12.5 − 7.6) = 2.0 m

Step-10) Wing walls

U/S level wing AB

Splay 1 in 1



Base width = 0.4 * Height of wing

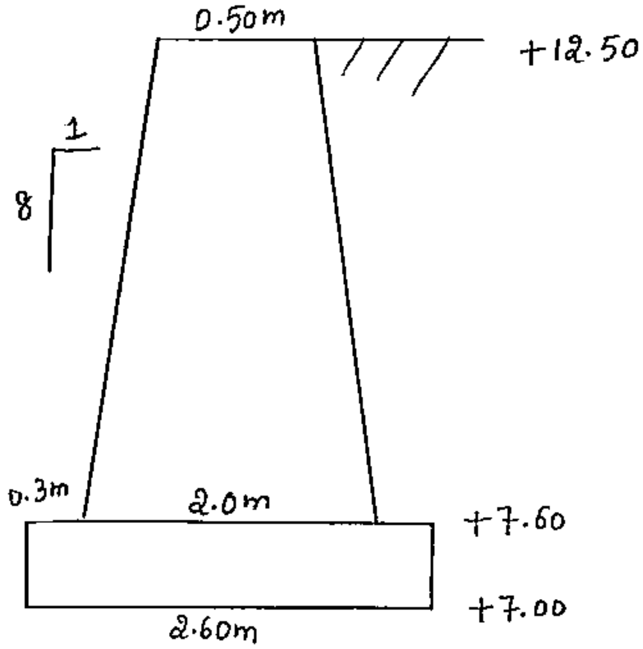
= 0.4 * (12.5 − 8.5) = 1.6 m.

D/S sloping wing CD :-

Splay – at +8.00

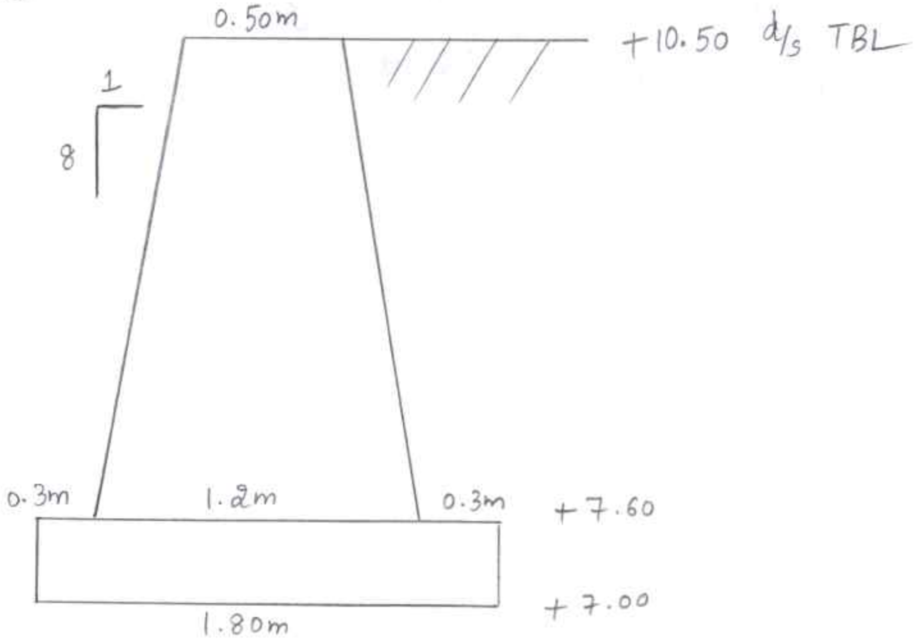
Distance b/w returns is 6.0 m

Section at 'C'.



Base width = 0.4 * Height of wing
= 0.4 * (12.5 − 7.6) = 2.0m.

Section at 'D' = Same as return.

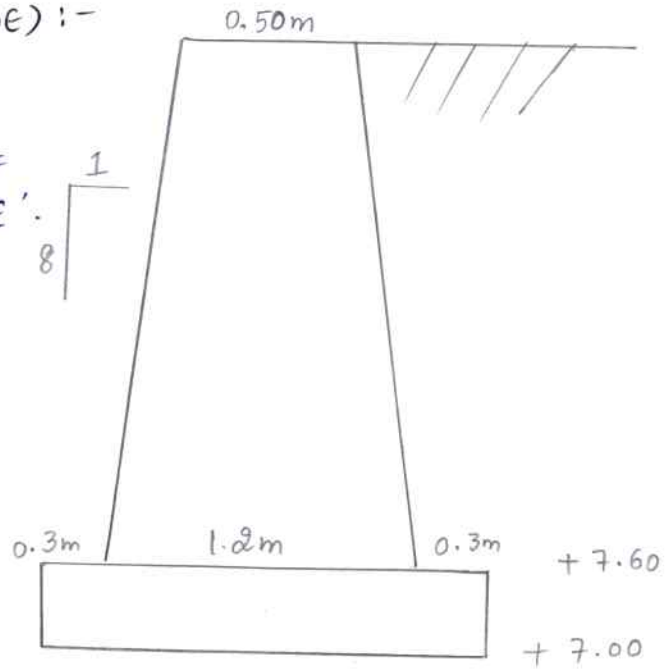


Base width = 0.4 * Height of wing
= 0.4 * (10.5 − 7.6) = 1.2m.

Step-11) Returns

d/s Returns (DE) :-

Section at 'D' =
Section at 'E'.



Base width = 0.4 * Height of return
= 0.4 * (10.5 − 7.6) = 1.2m.

Step-12) Specifications :-

1. Foundations of drop wall, abutments, wings and returns –
   C. C. 1:3 :6
2. Walls of dropwall, abutments, wings and returns – stone masonry with CM 1:4 & plastering with CM 1:4
3. Notch piers – R.C.C 1:2:4
4. Apron – C.C. 1:4:8

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EXCELLENCE IN EDUCATION; SERVICE TO SOCIETY
ESTD, UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)
Rajampet, Annamayya District, A.P – 516126, INDIA

CIVIL ENGINEERING

Design & Drawing of Irrigation Structures

PLATE-4

Problem : Design a canal drop (glacis type) with the following data.

Hydraulic particulars	U/s canal	D/s canal
Full supply discharge	$7.5 m^3/s$	$7.5 m^3/s$
Bed width	6.0m	6.0m
Bed level	+10.00m	+8.00m
Full supply depth	1.50m	1.50m
Full Supply level	+11.50m	+9.50m
Top level of bank	+12.50 m	+10.50m

Good Soil for foundation is available at +8.00m.

Step-1 :- Width of weir

A broad crested weir is proposed b/w abutments to cater to the discharge of the canal.

Width of the weir = fluming ratio * bed width of canal

width of weir = 0.75 * 6 = 4.5m

Drop	Fluming ratio
up to 1.2m	65%
1.2 to 3 m	75%
> 3 m	85%

Step-2 :- weir crest level :

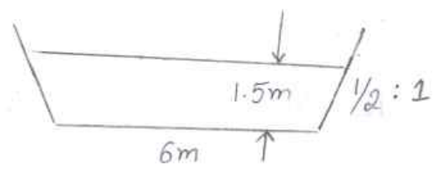
= u/s Total Energy line - depth of flow over the weir

u/s Total Energy Line :

$= u/s\ FSL + V^2/2g$

Velocity, $v = 7.5/[(1.5/2)*(6+7.5)]$

$= 0.74\ m/s$



u/s Total Energy line $= 11.5 + 0.75^2/2*9.81$

$= 11.5 + 0.028 = 11.528$

depth of flow over the weir :

$Q = (2/3) * Cd * Bt * D * \sqrt{(2gD)}$

D - depth of flow over the weir

Bt - width of weir

Cd - 0.62

$7.5 = (2/3) * 0.62 * 4.5 * D\sqrt{(2*9.81*D)}$

$D = 0.94m$

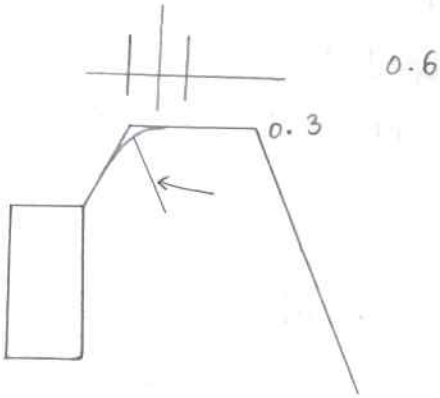
weir crest level = 11.528 − 0.94 = +10.58

Step-3 :– Length of weir crest :

= (2/3) * depth of flow over the weir

= (2/3) * 0.94 = 0.6m

Step-4 :– u/s glacis



Slope of glacis = ½ : 1

Slope rest on curtain wall • +10.58

Curtain wall width = 0.6m

radius

Join weir crest with a radius

Radius = depth of flow over the weir / 2

= 0.94 / 2

= 0.5m

Tangent length = radius * tan θ/2

$\tan \theta = 1/(1/2)$ $\theta = 63°26'$

Tangent length = 0.5 * tan 31°43'

Step-5 :– d/s glacis :

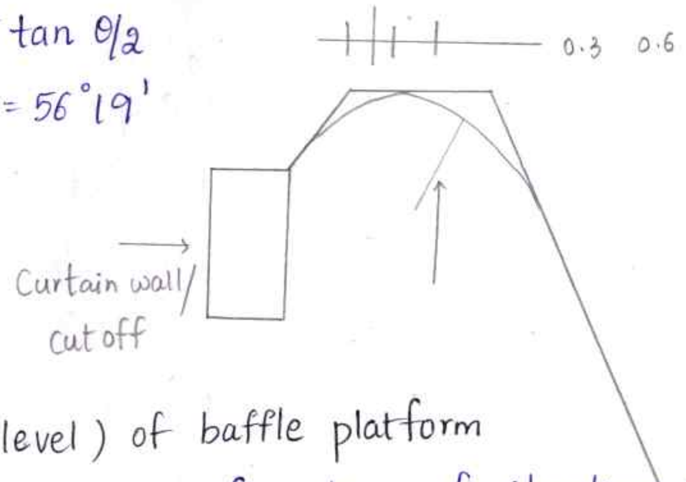
Slope of glacis = 2/3 : 1

Join weir Crest with a radius

Radius = depth of flow over the weir = 0.94m

Tangent length = radius * tan $\theta/2$

$\tan\theta = 1/(2/3)$ $\qquad \theta = 56°19'$



Step-6) Cill level (reduced level) of baffle platform

= d/s FSL - subcritical depth below formation of standing wave (hydraulic jump) for expanding d/s

Subcritical depth below formation of standing wave for expanding d/s = Subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s + Calculated drop - actual drop.

Subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s = 0.985 * (discharge / width of weir) 0.5 * Calculated drop $^{0.21}$

Calculated drop = actual drop / $K^{0.152}$

k = d/s bed width of canal / width of weir

K = d/s 6/4.5 = 1.33

Calculated drop = actual drop / $K^{0.152}$

$= 2/1.33^{0.152} = 1.914m$

Subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s = 0.985 * (discharge / width of weir)$^{0.52}$ * calculated drop$^{0.21}$

$= 0.985 * (7.5/4.5)^{0.52} * 1.914^{0.21} = 1.474m$

Subcritical depth below formation of standing wave (hydraulic jump) for expanding d/s = Subcritical depth below formation

of standing wave (hydraulic jump)
For parallel d/s + Calculated drop - actual drop

Subcritical depth below formation of standing wave (hydraulic jump) for expanding d/s =

$$1.474 + 1.914 - 2 = 1.388 m$$

reduced level of baffle platform
= d/s FSL - Subcritical depth below formation of standing wave (hydraulic jump) for expanding d/s

$$= +9.50 - 1.388 = +8.10$$

Step-7) Height of baffle wall
= Critical depth - hyper critical depth at formation of standing wave (hydraulic jump)

Critical depth = $[(\text{discharge}/\text{width of weir})^2/\text{acceleration due to gravity}]^{1/3}$

hyper critical depth at formation of standing wave (hydraulic jump) = $0.183 * (\text{discharge}/\text{width of weir})^{0.89} * \text{Calculated drop}^{-0.35}$

Critical depth = $[(\text{discharge}/\text{width of weir})^2/\text{acceleration due to gravity}]^{1/3}$

$$= [(7.5/4.5)^2/9.81]^{1/3}$$

$$= 0.66 m.$$

hyper critical depth at formation of standing wave (hydraulic jump) = $0.183^* (\text{discharge}/\text{width of weir})^{0.89} * \text{Calculated drop}^{-0.35}$

$$= 0.183 * (7.5/4.5)^{0.89} * 1.914^{-0.35} = 0.23 m.$$

height of baffle wall

= Critical depth − hyper critical depth at formation of standing wave (hydraulic jump).

Step - 8) thickness of baffle wall

$= (2/3)^*$ height of baffle wall

$= (2/3)^* \; 0.45 = 0.3m$

Step-9) Length of baffle platform

= 5.25 * height of baffle wall

= 5.25 * 0.45 = 2.4m

Step - 10) Cistern level

= d/s canal bed level − cistern depth

Cistern depth = minimum 0.15m for minor canals, 0.3m for main canals and branches below d/s canal bed level (or)

cistern depth = 0.1 * d/s water depth

= 0.1 * 1.5 = 0.15m

Cistern level = +8.00 − 0.15 = +7.85

Cistern flood joined deflector wall with a slope of 1 in 5

Step − 11) Length of cistern

1st Criterion :

5 * subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s

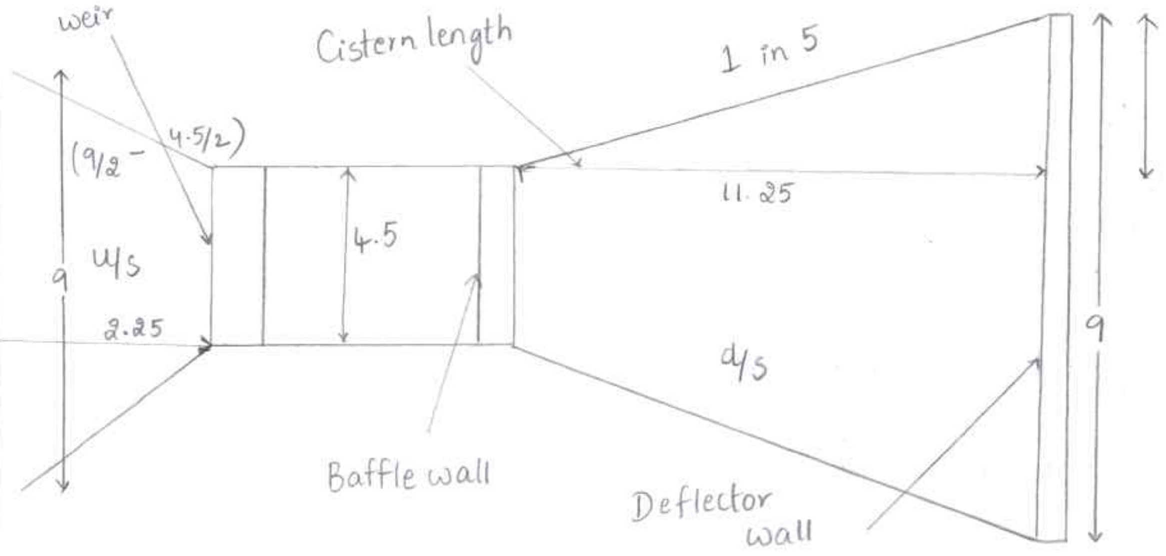
= 5 * 1.474 = 7.37 m

If soil of erodible nature, 6 * subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s

= 6 * 1.474 = 8.84 m

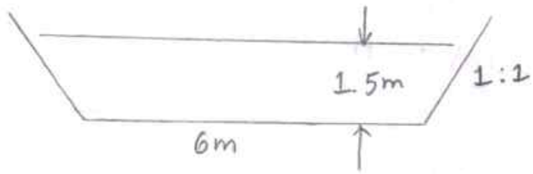
IInd Criterion.

Length of Cistern is the splay (1 in 5) of d/s wings.



Assuming 1 : 1 in canal cutting, width of water way at FSL

$= 6 + 1.5 + 1.5 = 9m$



Length of d/s transition of wings

$= (9/2 - 4.5/2) * 5 = 11.25m$

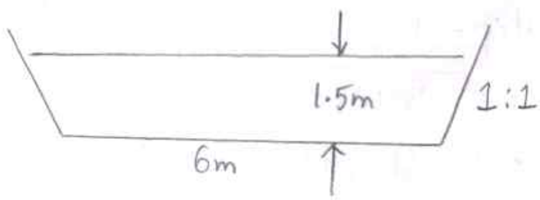
So length of Cistern = 11.25m.

Step-12) U/s transition of wings :-

the splay of u/s wings - 1 in 1

Assuming 1 : 1 in canal cutting, width of water way at FSL

$= 6 + 1.5 + 1.5 = 9m$



Length of u/s transition of wings

$= (9/2 - 4.5/2) * 1 = 2.25m$

Step-13) Revetments and bed pitching :

u/s

Length of side revetment = 3 * u/s water depth

$= 3 * 1.5 = 4.5m$

Bed pitching = Length of side revetment / 2

$= 4.5 / 2 = 2.25m$

Transition type - pot belly or onion.

Step-14) depth of u/s curtain wall / cut-off wall

Depth of u/s curtain wall = $(1/3)^*$ u/s fully supply depth

$= (1/3)^* \ 1.5 = 0.5m$

However provide 1m.

Bottom level of u/s curtain wall

= u/s canal bed level − 1.0

= +10.00 − 1.0 = +9.00

Step-15) depth of d/s curtain wall / cut-off wall

Depth of d/s curtain wall = $(1/2)^*$ d/s full supply depth

$= (1/2)^* \ 1.5 = 0.75m$

Bottom level of d/s curtain wall

= d/s canal bed level − 0.75

= + 8.00 − 0.75 = +7.25

Step-16) Check for scour depths :

u/s

R.L of bottom of u/s curtain wall = u/s FSL − 1.25 R

d/s

R.L of bottom of d/s curtain wall = d/s FSL − 1.5 R

Lacey's scour depth, $R = 1.375(q^2/f)^{1/3}$

R = depth of scour below maximum water level

q = discharge / meter run

f = Silt factor = 1.0

i) Checking u/s curtain wall for scour depth

length of u/s curtain wall = width of weir = 4.5m.

$R = 1.375 * [(7.5/4.5)^2/1.0]^{1/3} = 1.934$

$1.25R = 1.25 * 1.934 = 2.42m$

R.L of bottom of u/s curtain wall = u/s FSL − 1.25R.

$= +11.50 - 2.42 = +9.08$

This is same as calculated earlier.

ii) Checking d/s curtain wall for scour depth

length of d/s curtain wall = length of deflector wall = 9.0m

$R = 1.375 * [(7.5/9)^2/1.0]^{1/3} = 1.22m$

$1.5R = 1.5 * 1.22 = 1.83m$

R.L of bottom of d/s curtain wall = d/s FSL − 1.5R

$= +9.50 - 1.83 = +7.67$

This is higher than calculated earlier.

However it has to satisfy the exit gradient.

Step −17) check for EXIT GRADIENT (D/S)

MINIMUM EXIT GRADIENT FOR CLAYEY SOILS − 1 IN 3

$GE = (H/d)(1/\pi\sqrt{\lambda})$

$\lambda = (1+\sqrt{(1+\alpha^2)}/2$

$\alpha = b/d$

b = length of impervious floor = 17.90m

d = depth of the d/s cut off wall

$= 8.00 - 7.25 = 0.75m$

H = total head = Crest level − d/s bed level

$= 10.58 - 8.00 = 2.58m$

$\alpha = b/d = 17.9/0.75 = 23.87$

$\lambda = (1+\sqrt{(1+23.87)^2}/2 = 12.45$

$GE = (2.58/0.75)(1/\pi\sqrt{12.45}) = 0.31 \sim 1/3$

So increase depth to 1m and repeat

$\alpha = b/d = 17.9/1.0 = 17.9$

$\lambda = \left(1+\sqrt{(1+17.9)^2}\right)/2 = 9.46$

$GE = (2.58/100)(1/\pi\sqrt{9.46}) = 0.2731 < 1/3$

d/s cutoff taken down to $(8.0-1.0) = 7.00$

Step-18) Checking the thickness of baffle platform, cistern and the glacis

(A) using Bligh's Theory

(B) Using khosla's theory of "independent variables method".

(A) using Bligh's theory :-

Horizontal creep $= 0.6+0.3+0.3+0.6+0.5+1.65+2.4+0.3+11.25$
$= 17.9m$

Vertical creep $= (10.00-7.00)+(8.00-7.00) = 4m$

assuming a weightage of 2 for vertical creep

total creep $= 17.9+(2*4) = 25.9m$

Creep gradient along floor = uplift/creep
$= 2.58/25.9 = 1/10.04$

Key points for determination of residual uplift pressure

1. Under the toe of the glacis
2. Under the baffle wall.
3. at centre of the cistern
4. at d/s end of cistern.

1. Under the toe of the glacis :-

Horizontal creep $= 0.6+0.3+0.3+0.6+0.5+1.65 = 3.95m$

Vertical creep $= (10.00-8.1) = 1.9m$

total creep $= 3.95+(2*1.9) = 7.75m$

Head lost in creep $= 7.75/10.04 = 0.77m$

Residual uplift = 2.58 − 1.01 = 1.57m

thickness = 1.81 / (2.25 − 1) = 1.5m

2. Under the baffle wall :-

Horizontal creep increases by 2.4m

Total Creep = 7.75 + 2.4 = 10.15m

Head lost in creep = 10.15 / 10.04 = 1.01m

residual uplift = 2.58 − 1.01 = 1.57m

thickness = 1.57 / (2.25 − 1) = 1.25m

3. At centre of the cistern :-

Horizontal creep increases by 0.3 + (11.25 / 2) = 5.93m

Total creep = 10.15 + 5.93 = 16.08m

Head lost in creep = 16.08 / 10.04 = 1.6m

Residual uplift = 2.58 − 1.6 = 0.98m

thickness = 0.98 / (2.25 − 1) = 0.8m

4. at d/s end of cystern :-

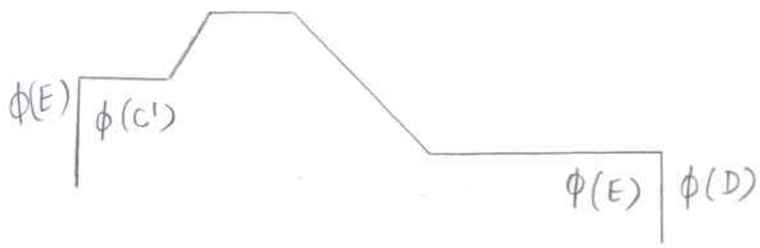
horizontal creep increases by (11.25 / 2) − 0.3 = 5.33m

Total Creep = 16.08 + 5.33 = 21.41m.

Head lost in creep = 21.41 / 10.04 = 2.13m.

Residual uplift = 2.58 − 2.13 = 0.45m.

thickness = 0.45 / (2.25 − 1) = 0.4m.



B) Using khosla's theory of "independent variables method".

At u/s curtain wall

$b = 17.9m$

$d = 10.00 - 9.00 = 1.00$ $\quad \alpha = b/d = 17.9$

2. Under the baffle wall = x + 20

$60/17.9 = x/11.55$

$x = 60 * 11.55/17.9 = 38.7$

$38.7 + 20 = 58.7\%$

$0.75 * 58.7\% = 44\%$

3. at centre of the cistern = x + 20

$60/17.9 = x/5.63$

$x = 60 * 5.63/17.9 = 18.9$

$18.9 + 20 = 38.9\%$

$0.75 * 38.9\% = 29.2\%$

4. at d/s end of cystern

$0.75 * 20\% = 15\%$

Thickness at key points :-

1. Under the toe of the glacis :-

uplift $= 50.1 * 2.58/100 = 1.29m$

thickness required $= 1.29/(2.25-1) = 1.05m$.

2. Under the baffle wall :-

Uplift $= 44 * 2.58/100 = 1.14m$

Thickness required $= 1.14/(2.25-1) = 0.95m$

3. at centre of the cistern.

Uplift $= 29.2 * 2.58/100 = 0.75m$.

Thickness required $= 0.75/(2.25-1) = 0.6m$

4. at d/s end of cystern :-

Uplift $= 15 * 2.58/100 = 0.4m$

Thickness required $= 0.4/(2.25-1) = 0.35m$.

$1/\alpha = 0.06$

$\phi(E) = 20\%$

$\phi(C') = 100 - 20 = 80\%$

At d/s curtain wall

$b = 17.9m$

$d = 8.00 - 7.00 = 1.00$

$\alpha = b/d = 17.9$

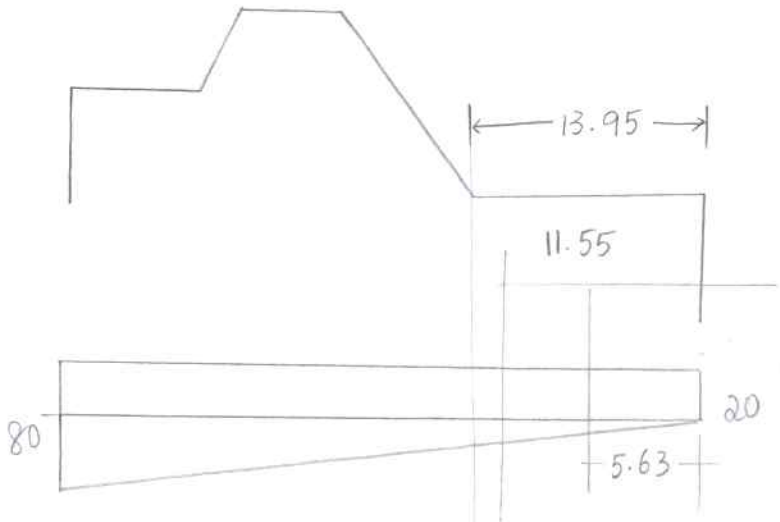
$1/\alpha = 0.06$

$\phi(E) = 20\%$

$\phi(C') = 14\%$

No corrections required due to less values.

Uplift pressure at key points



Uplift pressure at key points (75%)

1. Under the toe of the glacis = $x + 20$

$60/17.9 = x/13.95$

$x = 60 * 13.95 / 17.9 = 46.8$

$46.8 + 20 = 66.8\%$

$0.75 * 66.8\% = 50.1\%$

2. Under the baffle wall = x + 20

$60/17.9 = x/18.9 = x/11.55$

$x = 60 * 11.55/17.9 = 38.7$

$38.7 + 20 = 58.7\%$

$0.75 * 58.7\% - 44\%$

3. at Centre of the Cistern = $x + 20$

$60/17.9 = x/5.63$

$x = 60 * 5.63/17.9 = 18.9$

$18.9 + 20 = 38.9\%$

$0.75 * 38.9\% = 29.2\%$

4. at d/s end of cystern

$0.75 * 20\% = 15\%$

Thickness at key points :-

1. under the toe of the glacis

Uplift $= 50.1 * 2.58/100 = 1.29m$

Thickness required $= 1.29/(2.25-1) = 1.05m$

2. Under the baffle wall

Uplift $= 44 * 2.58/100 = 1.14m$

thickness required $= 1.14/(2.25-1) = 0.95m$

3. at Centre of the cistern

Uplift $= 29.2 * 2.58/100 = 0.75m$

Thickness required $= 0.75/(2.25-1) = 0.6m$

4. at d/s end of cystern

Uplift $= 15 * 2.58/100 = 0.4m$

Thickness required $= 0.4/(2.25-1) = 0.35m$

Khosla	Bligh
1. under the toe of the glacis 1.05m	1.5m

2. Under the baffle wall 1.25m

0.95m

3. at centre of the cistern 0.8m

0.6m

4. at d/s end of cystern 0.4m

0.35m

Unbalanced head due to formation of hydraulic jump (when canal full)

Unbalanced head due to formation of hydraulic jump = Subcritical depth below formation of standing wave (hydraulic jump) for parallel d/s − hyper critical depth at formation of standing wave (hydraulic jump)

$= 1.474 - 0.23 = 1.244\,m$.

3/4th of average of unbalanced head due to formation of hydraulic jump $= 3/4 * (1.244/2) = 0.467\,m$

Total head $= 0.467 + 1.29 = 1.757\,m$

Thickness required $= 1.757 / (2.25 - 1) = 1.4\,m$.

1. At the toe of glacis 1.4m and continue to end of baffle wall.
2. Reduce the thickness after baffle wall to 1.1m.
3. reduce the thickness further to 0.8m from centre of cistern and continue till end.
4. U/s side provide 1.0 m
5. Top 15 cm provided with rich Concrete.

Step −19) Abutments and wings.

U/s wings :−

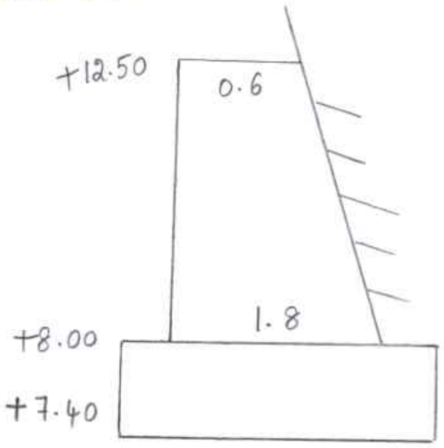
Top level same as u/s TBL

Foundation bottom +7.40

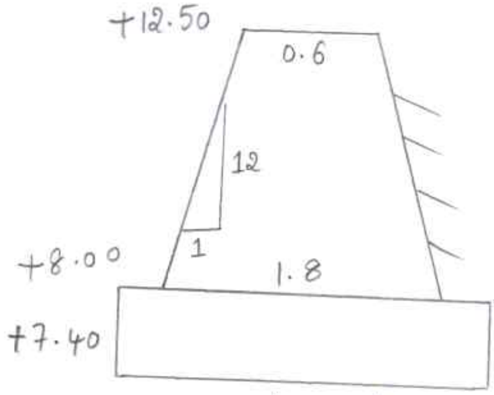
Splayed at 45 degrees

Keyed well into canal banks

Vertical face at junction of abutment and batter of 1 in 12 at its end.



at junction of abutment

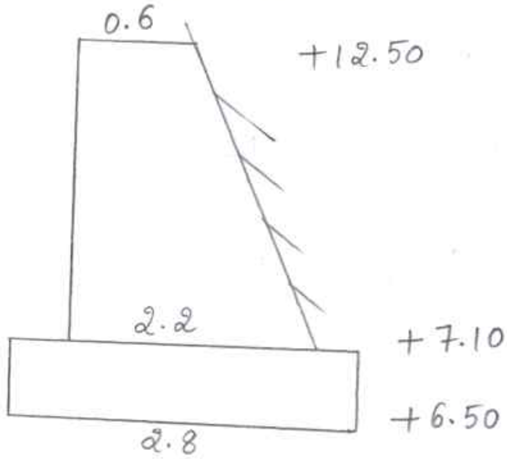


At end.

abutment

Top level same as u/s TBL

Foundation bottom +6.50

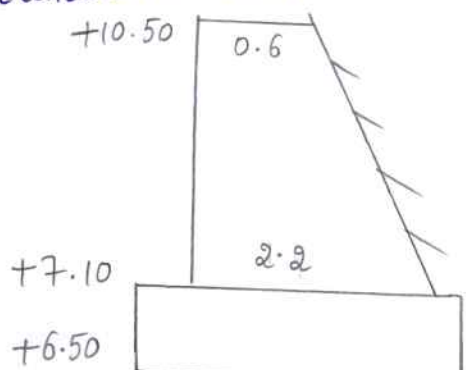


d/s slope wings :-

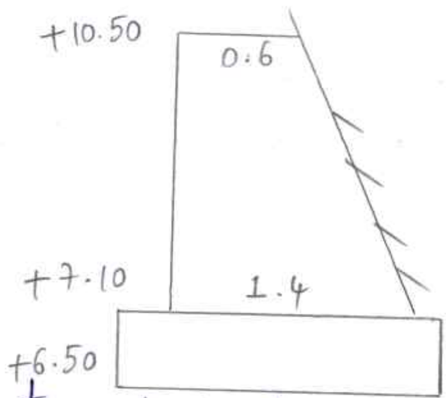
Top level at junction of abutment same as u/s TBL

Top level at junction of d/s level wing same as d/s TBL

Foundation bottom + 6.50.



at junction of abutment



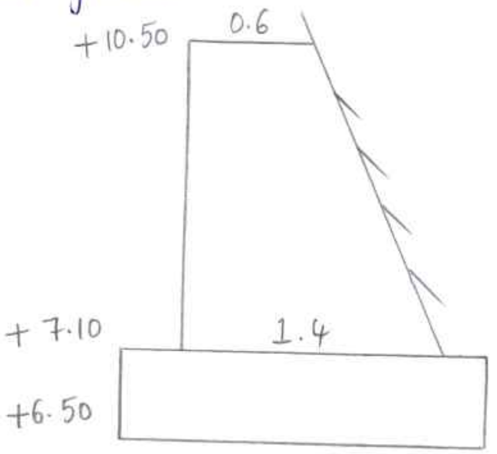
at junction of d/s level wing

d/s level wings :-

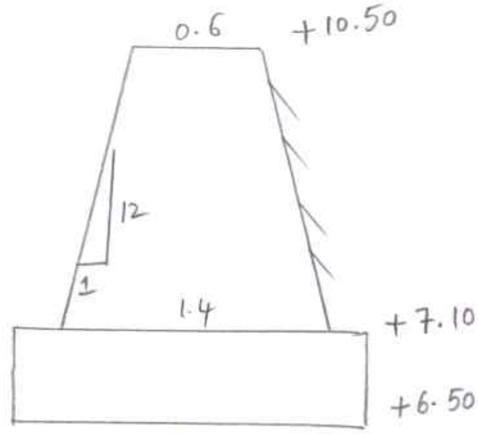
Top level same as d/s TBL

Foundation bottom +6.50

Vertical face at junction of sloping wing and batter of 1 in 12 at junction of return.



at junction of abutment



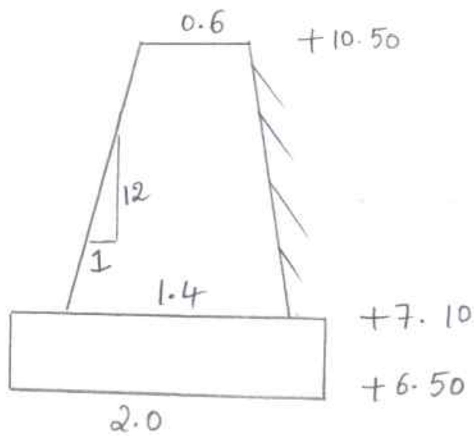
at junction of return

d/s return :-

Top level same as d/s TBL

Foundation bottom +6.50

batter of 1 in 12.



Step-20) Specifications :-

1. Foundations of glacis, abutments, cutoffs, wings and returns - C.C 1:3:6
2. walls of weir, abutments, wings and returns - Stone masonry with pointing CM 1:4
3. Baffle wall and Aprons - C.C 1:2:4

ANNAMACHARYA UNIVERSITY
EXCELLENCE IN EDUCATION; SERVICE TO SOCIETY
ESTD, UNDER AP PRIVATE UNIVERSITIES (ESTABLISHMENT AND REGULATION) ACT, 2016)
Rajampet, Annamayya District, A.P – 516126, INDIA

CIVIL ENGINEERING

Design & Drawing of Irrigation Structures

PLATE-5

Design and draw canal regulator cum road bridge with the following data. The right bank is 5m wide and left bank is 2m wide on both sides. The regulator carries a Roadway single lane designed for IRC loading class A. Provide clear freeboard of 1m above FSL for the road bridge. Good foundations are available at +19.00. Assume the ground level at the site as +22.00.

Description	Upstream	Downstream
Full supply discharge	20 Cumec	16 Cumec
Bed width	15m	15m
Bed level	+20.00	+20.00
Full supply depth	2m	1.75m
Full supply level	+22.00	+21.75

step-1 :- Ventway

a) Sluice discharge formula

discharge through ventway, $Q = 16 m^3/s$

drop, $h = 0.25m$

discharge through submerged orifice, $Q = C_d A \sqrt{2gh}$

$$16 = 0.75\, A \sqrt{(2 * 9.81 * 0.25)}$$

$$A = 9.64 \text{ Sq m}$$

depth of ventway = 1.75m

Length of Vent = 9.64 / 1.75

= 5.5 m

Constriction ratio should be 60 to 50%.

Constriction ratio = length of vent / canal bed width

= 5.5 / 15

= 37 %

Use constriction ratio 50%, length of vent = 7.5 m

Provide 3 vents, each 2.5 m

Height of vent = 9.64 / 7.5

= 1.3 m

Raise of sill level over bed level = 1.75 − 1.3

= 0.45 m

Sill of regulator = +20.45

$$Q = C * B_t * D^{3/2}$$

Q = d/s discharge

C = Coefficient depend on drowning ratio.

$$\text{drowning ratio} = \frac{\text{d/s depth of submergence over sill}}{\text{U/s depth of submergence over sill}}$$

Bt = Clear throat width b/w abutments

D = depth of crest below U/s total energy line

Drowning ratio	C
100	1.05
90	1.49
85	1.58

depth of submergence over sill = elevation of total energy line − regular sill level

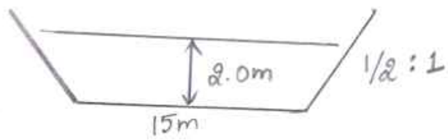
elevation of total energy line = FSL + energy head

$$= FSL + v^2/2g$$

U/s depth of submergence over sill

Velocity, $v = 20/[[2/2](15+17)]$

$= 0.63 m/s$



Elevation of total energy line $= 22.00 + 0.63^2/(2*9.81)$

$= 22.02$

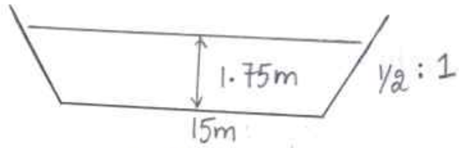
U/s depth of submergence over sill $= 22.02 - 20.85$

$= 1.57 m$

d/s depth of submergence over sill

Velocity, $v = 16/[(1.75/2)(15+16.75)]$

$= 0.57 m/s$



Elevation of total energy line $= 21.75 + 0.57^2/(2*9.81)$

$= 21.77$

d/s depth of submergence over sill $= 21.77 - 20.85$

$= 1.32 m$

$$\text{drowning ratio} = \frac{\text{d/s depth of submergence over sill}}{\text{u/s depth of submergence over sill}}$$

$= (1.32/1.57)\,100$

$= 84\%$

For 84 % $C = 1.58$

$Q = C * Bt * D^{3/2}$

$16 = 1.58 * Bt * 1.57^{3/2}$

$Bt = 5.14 m$

Provide length of vent as 6.0m with 3 vents, each 2m.

Step-2) Roadway

For IRC class 'A' loading, single lane of traffic

Clear width = 3.65m between kerbs

Slab thickness = 200mm

kerb width = 0.23m

kerb height = 0.3m

Wearing coat = at centre 7.5cm, at edges 5cm

Bottom level of road slab = 1m above u/s FSL

= +23.00

Road top level = 23.275 or 23.28

either side of roadway steel hand rails are provided.

Step-3) Shutters

shutter top level - 0.3m above u/s FSL

Shutter rest in 8cm deep groove in the sill

shutter lifted above u/s FSL should be 0.25m

clearance b/w shutter and bottom of hosting platform should be 0.3m.

if one shutter

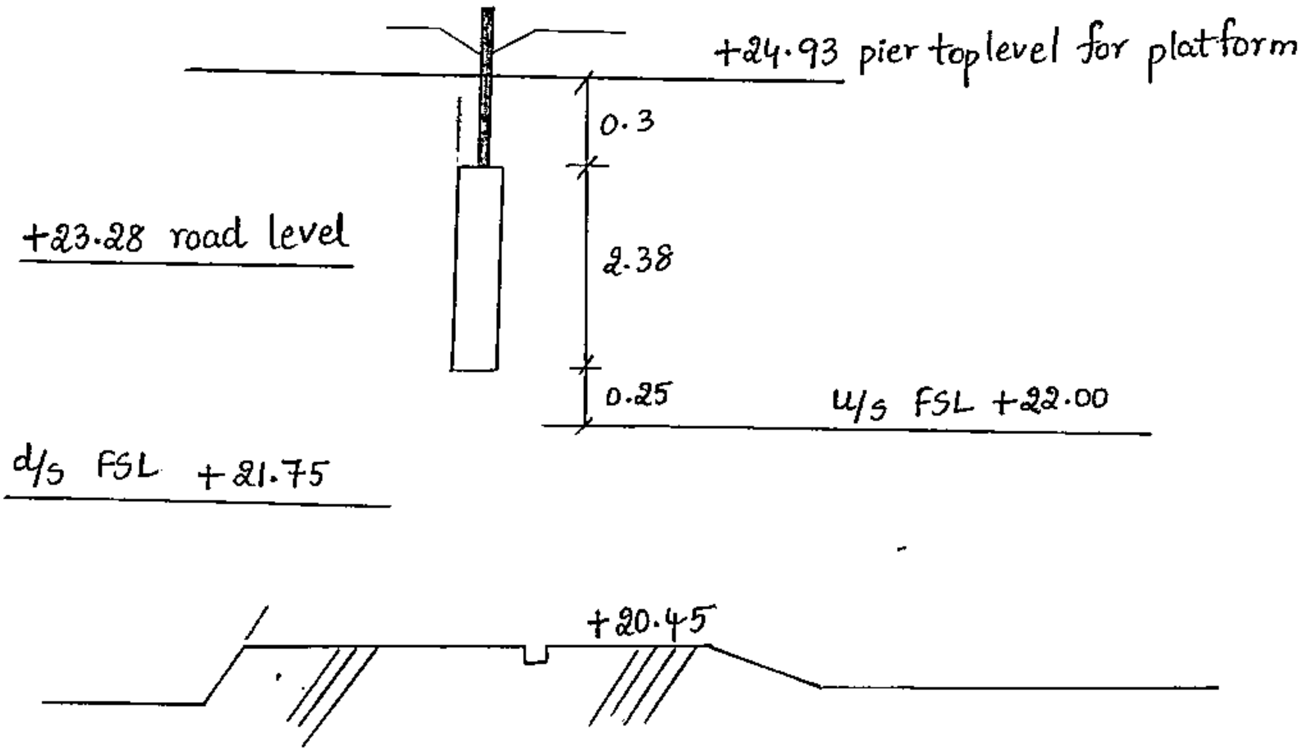
Height of shutter = 0.08 + 2 + 0.3 = 2.38m

pier top level = 22.00 + 2.38 + 0.25 + 0.3

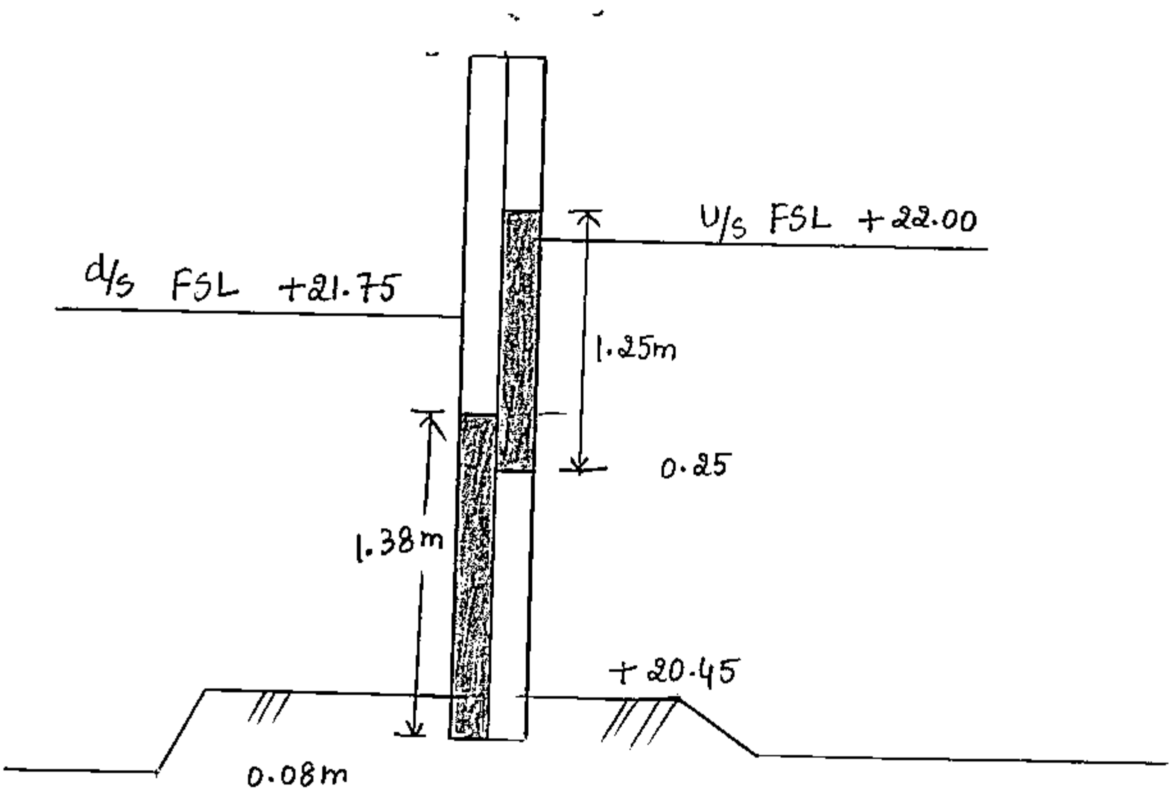
= +24.93

this is 1.65m (24.93 - 23.28) above road level, look awkward.

if one shutter :—

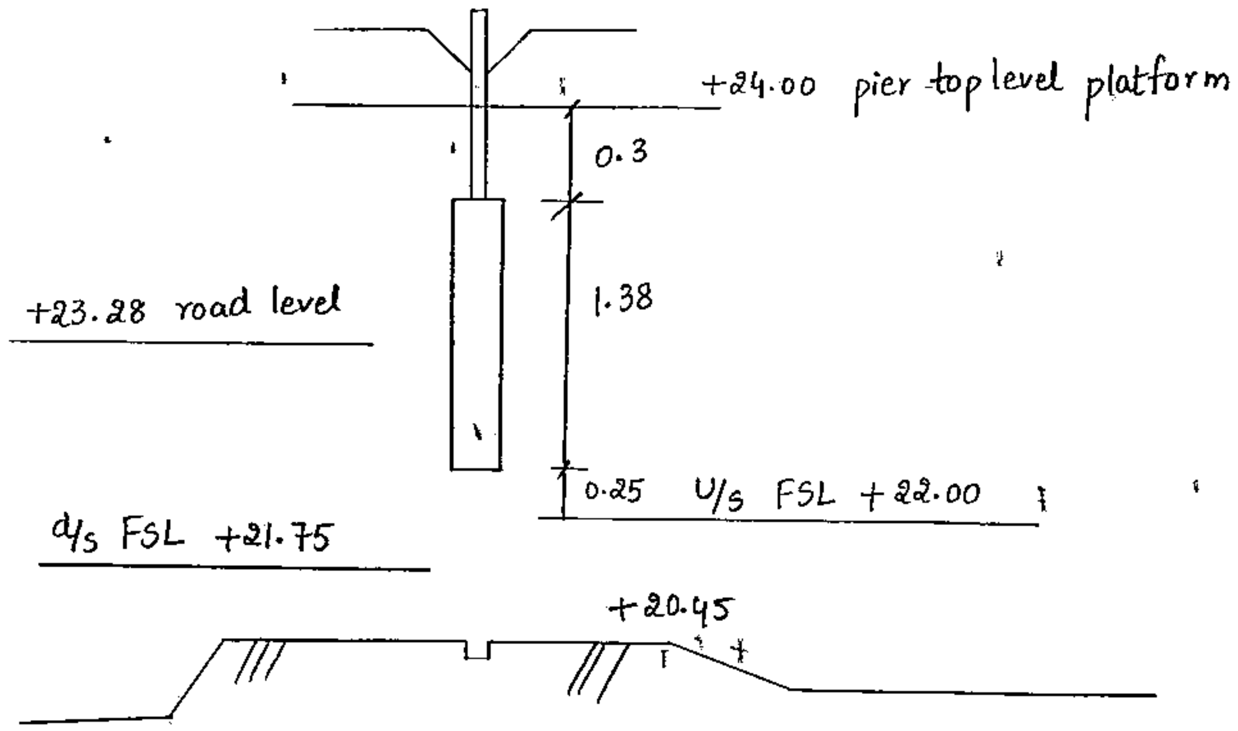


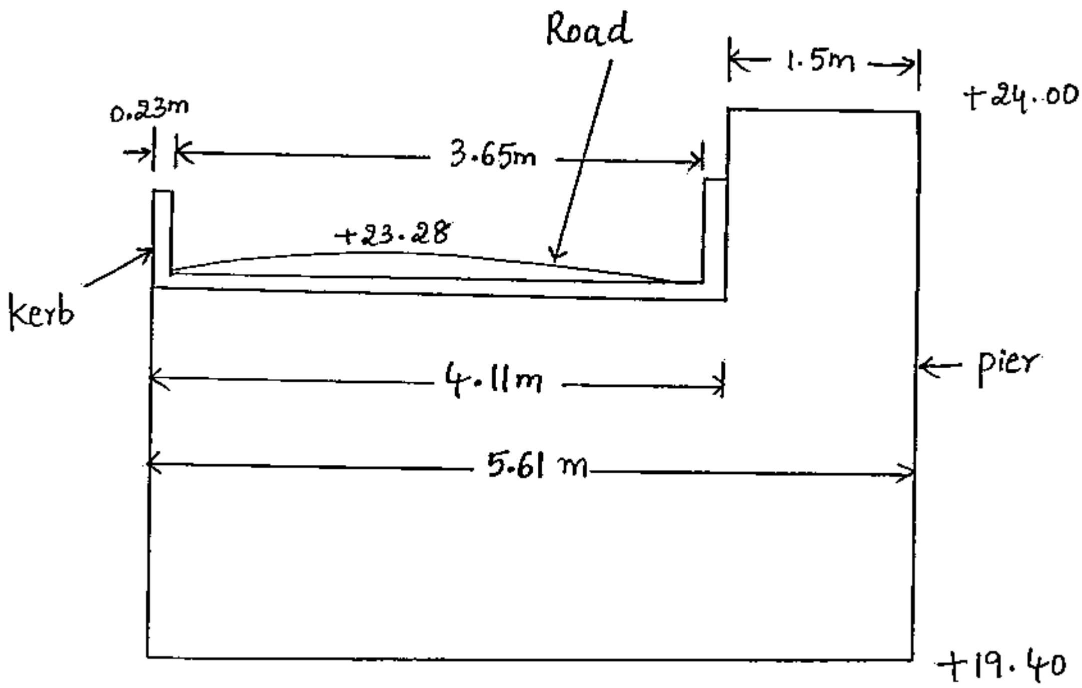
So provide 2 Shutters



pier top level (operating platform) = +22.00 + 0.25 + 1.38 + 0.3

= +24.00


+24.00 pier top level platform
0.3
1.38
+23.28 road level
0.25
U/s FSL +22.00
d/s FSL +21.75
+20.45


Road
1.5m
+24.00
0.23m
3.65m
+23.28
Kerb
4.11m
pier
5.61 m
+19.40

Step-4) Piers

Thickness of pier = 1.0m

Length of pier = 3.65 + 0.46 + 1.5 = 5.61m

Road width = 3.65 m

Kerbs (2Nos) = 0.23 * 2 = 0.46 m

Shutter operating platform = 1.5m

Omitting the cut waters

pier foundation top level = +19.40

pier foundation bottom level = +18.80

Step-5) Stability analysis of pier

The load taken by the pier will be for a length of 3m (thickness of pier + half of vent on either side = 1.0 + 1.0 + 1.0)

i) <u>Weight of road</u>

a) Road slab = 3 * 4.11 * 0.2 * 2400 = 5918 kg

b) Kerbs = 2 * 3 * 0.23 * 2400 = 994 kg

c) wearing coat = 3 * 3.65 * (0.075 + 0.05) / 2 * 2400 = 1643 kg

Total = 8555 kg

This acts at a distance of (4.11/2) = 2.05 m from the toe.

ii) <u>Weight of pier under the road portion</u>

= 4.11 * 1.0 * (23.00 − 19.40) * 2100

= 31072 kg

This acts at a distance of (4.11/2) = 2.05m from the toe

iii) <u>Weight of pier under the operating platform</u>

= 1.5 * 1.0 * (24.00 − 19.40) * 2100

= 14490 kg

This acts at a distance of (4.11 + (1.5/2)) = 4.86 m from the toe

iv) Water thrust on the pier (Horizontal thrust)

$= 1000 * (2.0^2/2) * 3.0$

$= 6000 kg$

This acts at a height of $(2.0/3) = 0.67 m$ from the toe.

Taking moments of all forces about toe.

	Force (kg)		Lever arm (m)	Moment (kg-m)
	Horizontal	Vertical		
i) weight of road		8555	2.05	17538
ii) weight of pier under the road portion		31072	2.05	63698
iii) weight of pier under the operating platform		14490	4.86	70421
iv) water thrust on the pier	6000		0.67	(-) 4020
Total		54117		147637

Arm of the resultant, $x = \Sigma M / \Sigma V$

$= 147637 / 54117$

$= 2.73 m$

eccentricity, $e = (b/2) - x$

$= (5.61/2) - 2.73$

$= 0.07 m$

allowable eccentricity $= b/6$

$= 5.61/6$

$= 0.94 m$

So resultant is within middle third.

Maximum compression at toe

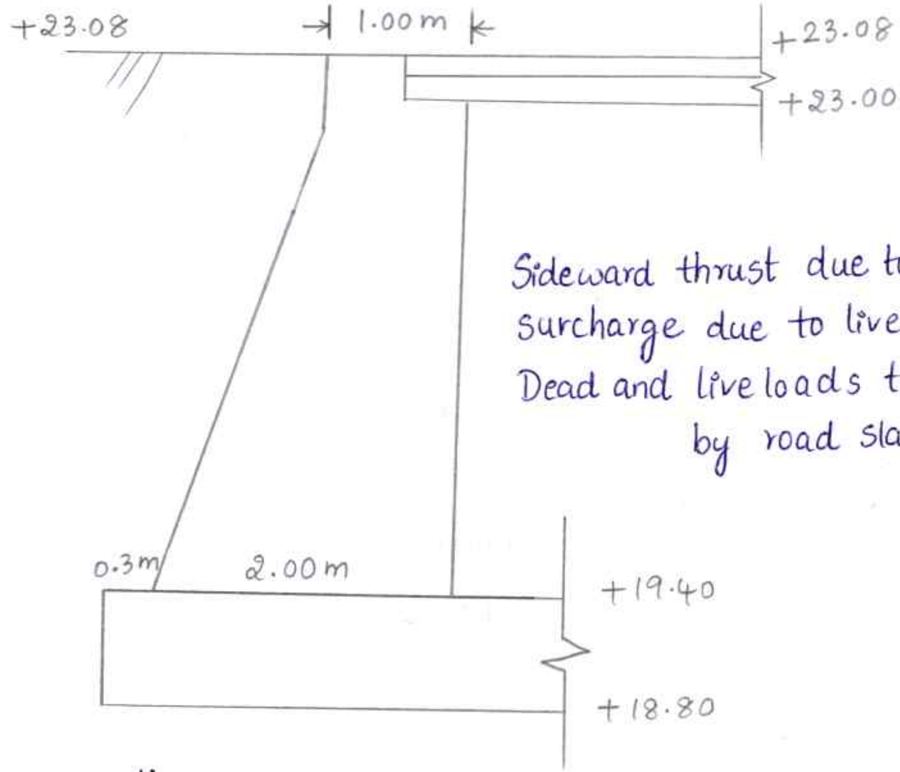
$= \Sigma V / b (1 + 6e/b)$

$= [54117 / [(5.61) (1 + (6 * 0.07) / 5.61]]$

$= 10360 \text{ kg/m}^2 < 32500 \text{ kg/m}^2$

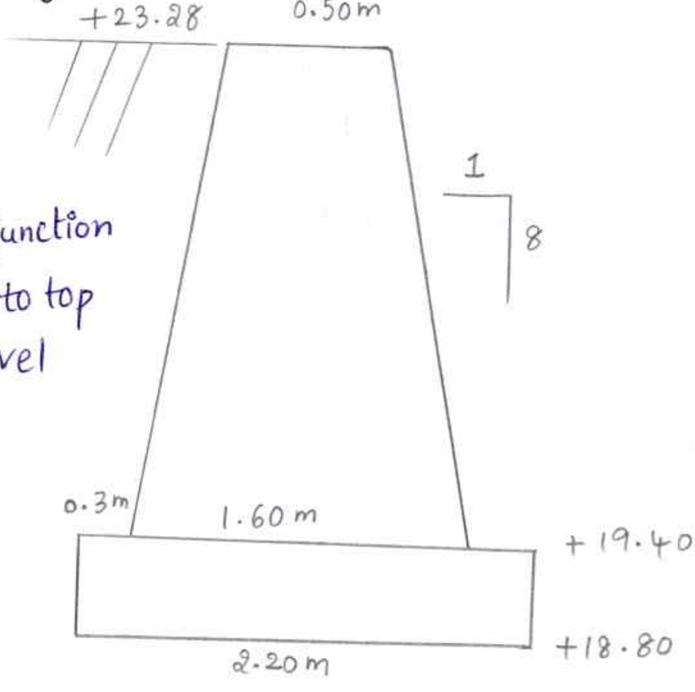
Hence safe.

Step-6) Abutment



Sideward thrust due to earth
surcharge due to live load
Dead and live loads transmitted by road slab

Step-7) Wing walls



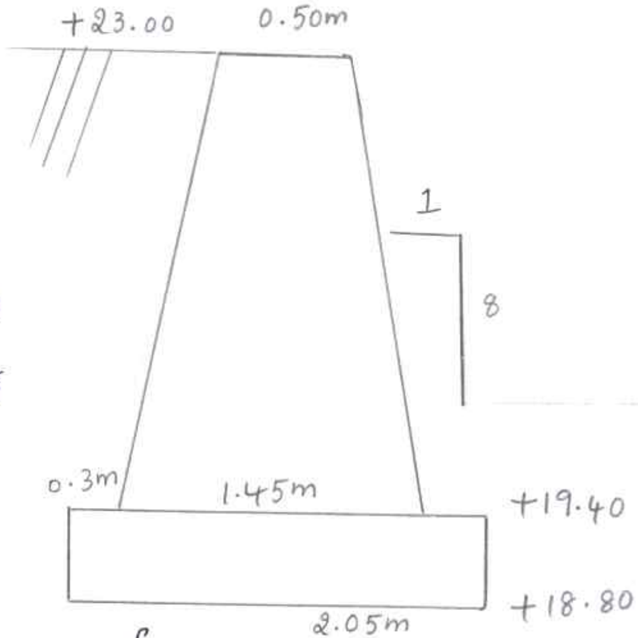
Sloping from junction of abutment to top of bank level

U/s +23.28 to +23.00
d/s +23.28 to +22.75

Basewidth = 0.4* Height of abutment

= 0.4* (23.28 − 19.4) = 1.60m

Step−8) Level wing & return



Top level

u/s +23.00

d/s +22.75

Base width =

0.4* Height of abutment

= 0.4* (23 − 19.4)

= 1.45m.

Step−9) Splay of wings

Depend on length of Solid apron

At the end of solid apron distance b/w returns same as canal bed width

Step−10) Solid apron

Prevent seepage when water on u/s and no water on d/s

Assume bed material is sandy soil

Hydraulic gradient in soil 1/10

Max uplift just d/s of shutter

Length of apron = 10* 2 = 20m

u/s = 6m

Under regulator = 5.6 m

Balance = d/s

U/s

Provide thickness as 0.3m

d/s

assume shutter located in centre of operating platform

Length of creep = $6 + 1.5/2 = 6.75\,m$

Head lost in creep = $6.75/10 = 0.675\,m$

Residual uplift = $2 - 0.675\,m = 1.325\,m$

Thickness of apron = Residual uplift / (Sp. gravity of apron material − Sp. gravity of water)

$= 1.325/(2.25-1) = 1\,m$

Gradually reduced to 0.6m at end of apron.

Step-11) Revetments

Length 5m

Thickness = 0.45m

Both u/s & d/s

Bed & slopes

Step-12) Specifications

1. Foundations - CC 1:3:6
2. Apron - CC 1:4:8
3. Abutment, piers, wings, returns - coarse stone masonry in cm 1:3
4. Road slab - RCC 1:2:4
5. Weep holes - wing walls and abutments.