



SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

S.R.M NAGAR, KATTANKULATHUR - 603203.



**CE3665 IRRIGATION DESIGN AND ENVIRONMENTAL
DRAWING LABORATORY MANUAL
(SIXTH SEMESTER)**



DEPARTMENT OF CIVIL ENGINEERING

REGULATION 2023

Academic year 2025-26 (Even)

PREFACE

This instruction manual has been prepared by the DEPARTMENT OF CIVIL ENGINEERING to facilitate instruction during practical classes and further to be used as a reference manual by the Civil Engineering students of this college. This manual covers explanation of experiments included in the syllabus as per Autonomous Regulation 2023 in Environmental Engineering Laboratory for the B.E Degree Course. Any suggestions for the improvement of the manual will be gratefully received.

Prepared by

Mr. N. VINOTH KUMAR /A. P (Sr.G)

Staff-Incharge

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To produce graduates who can understand their ethical, environmental as well as professional responsibilities so that they appreciate the impact of the engineering solutions which have sustainability over society and the nation.
2. To develop the graduates who will exhibit strong technical ability to create & synthesize data using relevant tools and concepts, for providing sustainable solutions to civil engineering problems and projects.
3. To equip the graduates with suitable skills making them industry ready when they leave the portals of the Institute and to become a competent distinguished Professional Civil Engineer.
4. To produce students who can exhibit attitude, professionalism, ability to communicate with team members and adapt to the latest technology by engaging themselves in life-long learning

2. PROGRAMME OUTCOMES (POs):

After going through the four years of study, our Civil Engineering Graduates will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
2	Problem analysis	Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	Design/development of solutions	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.
4	Conduct investigations of complex problems	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions
5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.

6	The engineer and society	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice
7	Environment and sustainability	Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
11	Project management and finance	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments
12	Life-long learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

3. PROGRAM SPECIFIC OUTCOMES (PSOs):

By the completion of Civil Engineering program the student will have following Program specific outcomes

1. Establish a Civil Engineering career in industry, government or academic field and achieve professional expertise as appropriate.
2. Execute innovation and excellence in Civil engineering problem solving and design in global and societal contexts.
3. Commit to lifelong learning and professional development in the Civil Engineering field to stay updated in technology, research topics and contemporary issues.
4. Understand the fundamentals of Civil Engineering in commercial contexts and in expediting construction projects.

**CE3665 IRRIGATION DESIGN AND ENVIRONMENTAL
DRAWING LABORATORY**

OBJECTIVES:

- To learn the knowledge of design and drawing of tank components in details showing plan, elevation and cross section.
- To gain the knowledge of design and drawing of cross drainage works in details showing plan, elevation and cross section.
- To understand the knowledge of design and drawing of canal regulation structures in details showing plan, elevation and cross section.
- To learn the knowledge of design and drawing of water supply and treatment components.
- To learn the knowledge of design and drawing of sewage treatment and disposal components.

PART A: IRRIGATION ENGINEERING

5

1. TANK COMPONENTS

Fundamentals of design - Tank surplus weir – Tank sluice with tower head - Drawings showing foundation details, plan and elevation

5

2. CROSS DRAINAGE WORKS

General design principles - Aqueducts – Syphon aqueduct (Type III) – Canal drop (Notch Type) – Drawing showing plan, elevation and foundation details.

11

3. CANAL REGULATION STRUCTURES

General Principles - Direct Sluice - Canal regulator - Drawing showing detailed plan, elevation and foundation details.

PART B: ENVIRONMENTAL ENGINEERING

4. WATER SUPPLY AND TREATMENT

12

Design and Drawing of flash mixer, flocculator, clarifier – Rapid sand filter – Service reservoirs Pumping station.

5. SEWAGE TREATMENT & DISPOSAL

12

Design and Drawing of screen chamber - Grit channel - Primary clarifier - Activated sludge process – Aeration tank – Trickling filter – Sludge digester – Sludge drying beds – Septic tanks and disposal arrangements.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course, learners will be able to

1. Design and draw tank components in details showing plan, elevation and cross section.
2. Design and draw cross drainage works in details showing plan, elevation and cross section.
3. Design and draw canal regulation structures in details showing plan, elevation and cross section.

4. Design and draw water supply and treatment components.
5. Design and draw sewage treatment and disposal components.

TEXTBOOKS:

1. Satya Narayana Murthy Challa, —Water Resources Engineering: Principles and Practicel, New Age International Publishers, New Delhi, 2004.
2. Garg, S.K., —Irrigation Engineering and Design of Structuresl, New Age International Publishers, New Delhi, 2023.
3. Manual on Water Supply and Treatment, CPHEEO, Government of India, New Delhi, 2024.
4. Manual on —Sewerage and Sewage Treatment Systems- Part A, B and Cl CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
5. Qasim, S. R. "Wastewater Treatment Plants, Planning, Design & Operation", CRC Press, New York, 2018.

REFERENCE BOOKS:

1. Mohanakrishnan. A, —A few Novel and Interesting Innovative Irrigation Structures: Conceived, Designed and Executed in the Plan Projects in Tamil Nadull, Publ. No. 44 and Water Resources Development & Management Publ.No.43, IMTI Thuvakudy, Trichy, 2011.
2. Raghunath, H.M. —Irrigation Engineeringl, Wiley India Pvt. Ltd., New Delhi, 2011.
3. Sharma R.K.,—Irrigation Engineering and Hydraulic Structuresl, Oxford and IBH Publishing Co., New Delhi, 2017.
4. Peary, H.S., ROWE, D.R., Tchobanoglous, G., —Environmental Engineeringl, McGraw-Hill Book Co., New Delhi, 1995.
5. Metcalf and Eddy, —Wastewater Engineering, Treatment and Reusel, Tata McGraw Hill, New Delhi, 2014.
6. Qasim, S.R., Motley, E.M and Zhu.G. "Water works Engineering – Planning, Design and Operation", Prentice Hall, New Delhi, 2009.

Laboratory Specific Instructions to Students

- 1) All the students are expected to come with shoe, uniform, observation note book, record note book, pencil, eraser, sharpener, scale, divider, graph sheets etc. whenever they come for the laboratory class.
- 2) Before doing any design, students should have a clear idea about the principles of that design. They should come with drawing sheets, observation note and drawing aids . Viva questions will be asked by the Staff regarding the particular design.
- 3) All students are advised to come with completed record sheets of previous experiments; defaulters will not be allowed to do their experiment.
- 4) Observe good housekeeping practices. Work areas should be kept clean and tidy at all times.
- 5) Do not make erratic sound inside the lab and disturb others

NOTE:

The dimensions of drawing furnished in the manual are for reference, the actual dimensions of the drawing may vary depending upon the design data

Ex. No	Name of the Experiments
1	Tank Surplus Weir
2	Tank Sluice with Tower Head
3	Aqueduct
4	Syphon Aqueduct
	Canal Drop
5	Canal Regulator
6	Flash Mixer
7	Flocculator
8	Clarifier
9	Rapid Sand Filter
10	Service connection for water supply & Drainage
11	Screen Chamber
12	Grit Channel
13	Primary Clarifier
14	Trickling Filter Sludge
15	Digester
16	Sludge Drying Beds
17	Septic Tank and Disposal arrangements
18	Canal Escape
	TOPIC BEYOND SYLLABUS
19	Man Hole and Sewer Connections

IRRIGATION ENGINEERING

Ex. No.	TANK SURPLUS WEIR
Date:	

The following details refer to a tank surplus weir:

1. Combined catchment area 3000 hectares
2. Free catchment area 1200 hectares
3. Ryve's coefficient 'C' 6.5 (Combined)
4. Ryve's co-efficient 'c' 1.5 (Intercepted) | $c = \frac{C}{3} \& \frac{c}{5}$
5. Bed level of the tank (Surplus course) +50.20m
6. Ground level at site +49.20m
7. Maximum Flood level (Flood Storage) +52.50m
8. Full Tank level in the tank +51.00m | Effective storage max 1m
9. Top of rivetement in u/s +53.80m
10. Top of Bund level +54.80m
11. Top width of Bund +3.00m
12. Hydraulic gradient +1 in 4
13. Slope of the bund in front $1\frac{1}{2} : 1$
- in rear 2 : 1
14. Soil below ground level red earth upto + 48.00
15. Automatically falling shutters 1m height to be provided on the crest

(Top width of Bund is 3.00m)

Design the surplus weir with all component parts

Draw the following views to suitable scale

1. Half plan at top. half plan at foundation
2. Cross. Sectional Elevation
3. Half elevation facing Down stream side and Half elevation facing upstream side.

Design:

1. Maximum Flood Discharge (or) Run-Off

Using Ryve's formula.

$$Q = CM^{\frac{2}{3}} - cm^{\frac{2}{3}}$$

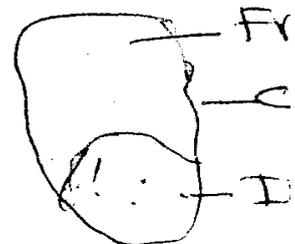
Now.

Q = Discharge (OR) max. run off in m³/sec

C = Ryve's coefficient for combined catchment area | = 6.5

M = Combined catchment Area in sq.km.

$$= \frac{3000}{100} = 30 \text{ sq.km.}$$



$c =$ Ryve's Co-efficient for intercepted catchment area } = 1.5

$m =$ Intercepted catchment area in sq.km.
 $\frac{3000 - 1200}{100} = 18 \text{ sq.km.}$

$$Q = 6.5 \times (30)^{2/3} - 1.5 (18)^{2/3} = 52.52 \text{ m}^3/\text{sec}$$

2. Length of weir :

Weir formula.

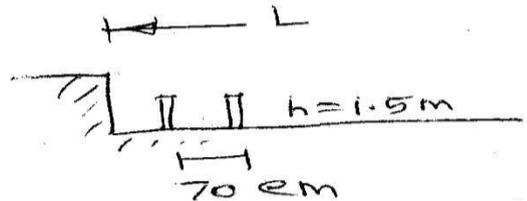
$$Q = 2/3 c_d L \sqrt{2g} H^{3/2}$$

$$52.52 = 2/3 \times 0.562 \times L \times \sqrt{2 \times 9.81} \times 1.50^{3/2}$$

Where.

- Q = Discharge in m³/sec
- C_d = Co-efficient of discharge 0.562
- L = Length of the weir in m
- g = 9.81 m/sec²
- H = Head of water in m 1.50m.

Now solving the equation.
 $L = 17.22\text{m.}$



Adopt a length of 18m allowing for some obstruction in the flow.
 Dam stones are used to fix the automatic falling shutters and also to store water upto M.W.L

Assume their size as 200 x 200 and @ 700 mm o/c
 No :- of clear span of Dam stones = $\frac{18 \times 1000}{700} = 25.7 \text{ say } 26.$

60cm x 60cm
 etc
 15 x 15cm
 1000 c/c
 0.1h
 each end

∴ No of dam stones = 25 Nos.
 Width occupied by dam stones = $0.2 \times 25 = 5.00\text{m}$

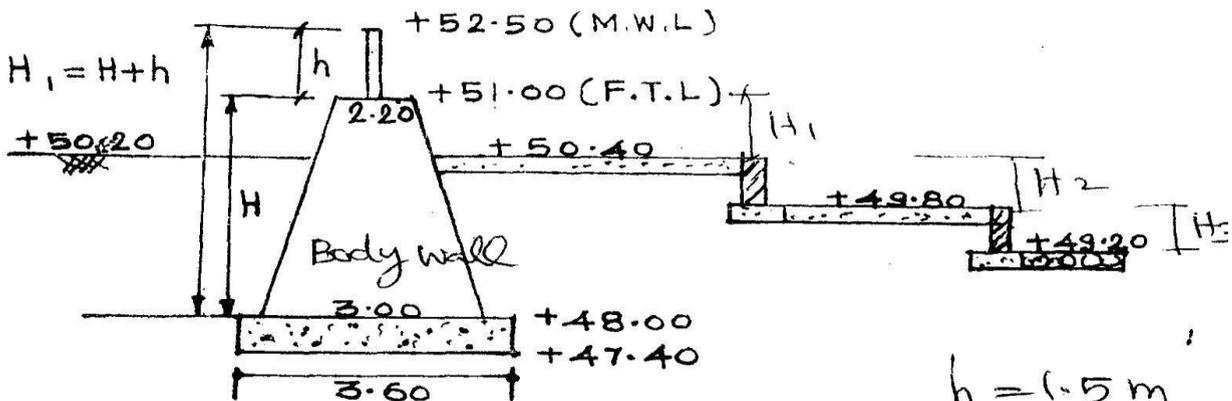
Provide an extra allowance at 200m for end contraction.
 ∴ Total length of the weir = $18 + 2 + 5 = 25.00\text{m.}$

Length of weir = 25.00m.

26 x 2 (0.1 h)

H = FTL - Foundation Level

3. Design of weir Body Wall



Crest width or Top width of Body wall } $b = 0.552 (\sqrt{H} + \sqrt{h})$ $H = 3.00\text{m}$
 (Refer the fig)
 $= 0.552 (\sqrt{3.00} + \sqrt{1.50})$
 $= 1.637\text{m}.$

But min width is given as 2.20 m.

Base width of foundation = $B = \frac{H_1}{\sqrt{\delta}}$

where δ = density of Masonry

$\delta = \text{Density of the masonry} = 2.25$ } $= \frac{4.50}{\sqrt{2.25}}$
 $= 3.00\text{m}.$

$H_1 = H + h = 3.00 + 1.50 = 4.50\text{m}.$

Adopt

Top width = 2.20m
 Bottom width = 3.00m.

4. Foundation

Foundation level + 48.00m

Adopt 60cm thickness of foundation.

∴ Bottom level of foundation concrete is
 $+ 48.00 - 0.60 = + 47.40\text{m}.$

∴ Total width of foundation concrete
 $= 3.00 + 2 \times 0.30$
 $= 3.60\text{m}$

Up Stream Side Apron :

Generally the apron is required on the down stream side of the weir. However a puddle clay apron is provided as shown in the fig.

6. Down Stream Side Apron :

The ht. of Fall = F. T. L - G. L
 $= 51.00 - 49.20$
 $= 1.80\text{m}$

stepped Apron

Adopt 3 steps each having a vertical fall of 0.60m :

1 st Step solid apron fall = 0.60 m
 2 nd Step solid apron fall = 0.60 m
 3 rd Step talus Apron fall = 0.60 m
 $= 1.80\text{m}$

The 1st and 2nd apron is of 45cm. thick in c.c 1 : 2 : 6 and the ends are retained by stop walls of 45cm thick.

7. Width of Apron :

the max fall = 0.6 + 1.5
 width of apron = $2(0.6 + 1.5)$
 $= 4.20\text{m}.$

2 to 3 times
 $(H_2 + h)$

Adopt a width of 5.00 m.

8. Design of Abutment

Ht of abutment = T. B. L - G. L
 $= 54.30 - 49.20$
 $= 5.60\text{m}.$ (H)

2.5 (H₂ + h) to
 $5(H_2 + h)$

Adopt a min width as 45 cm
 Base width = 0.4H
 $= 0.4 \times 5.60$
 $= 2.24$ say = 2.30.
 Total width of concrete = $2.30 + 2(0.30)$
 $= 2.90\text{m}.$

Adopt 45cm thickness for return wall and wing wall also

9. Design of return wall

Ht of return at u/s side = 3.40

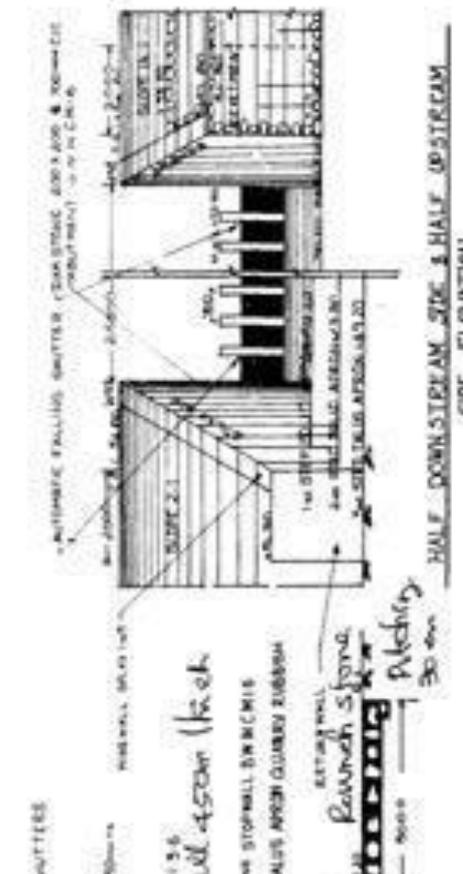
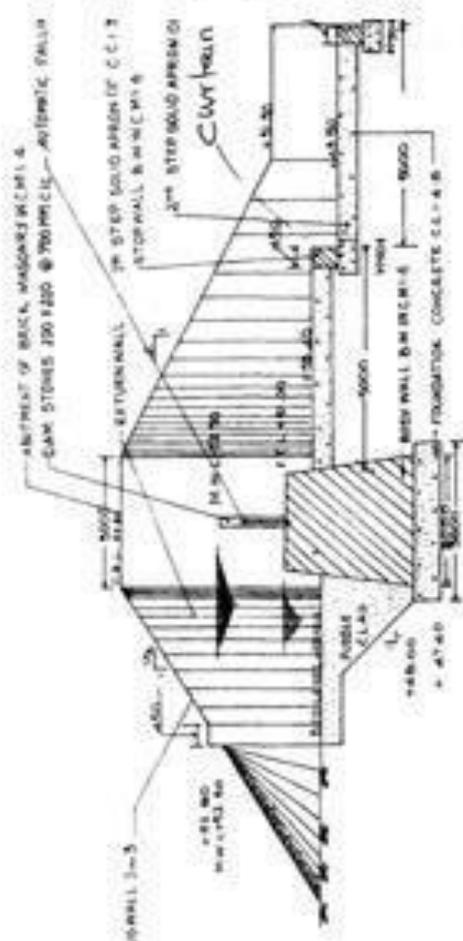
∴ Total width } = $0.4 \times 3.40 + 2 \times 0.30$
 at foundation } = $1.36 + 0.60$
 $= 1.96\text{m}.$

(52.8 - GL)
 $= 52.8 - 49.20$
 $= 3.6$
 1.90m. (say)

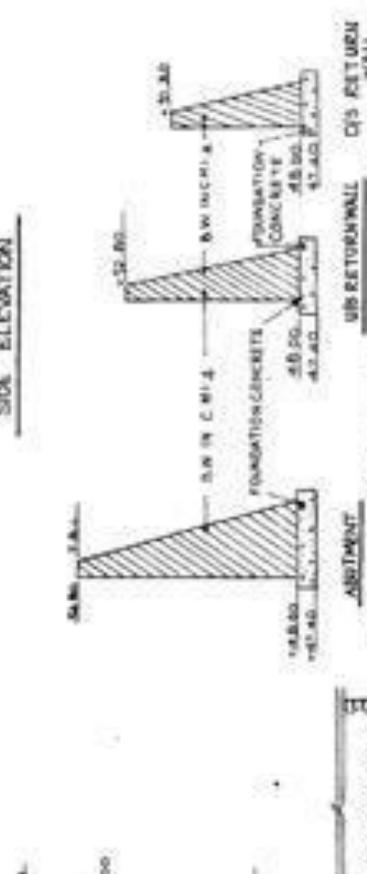
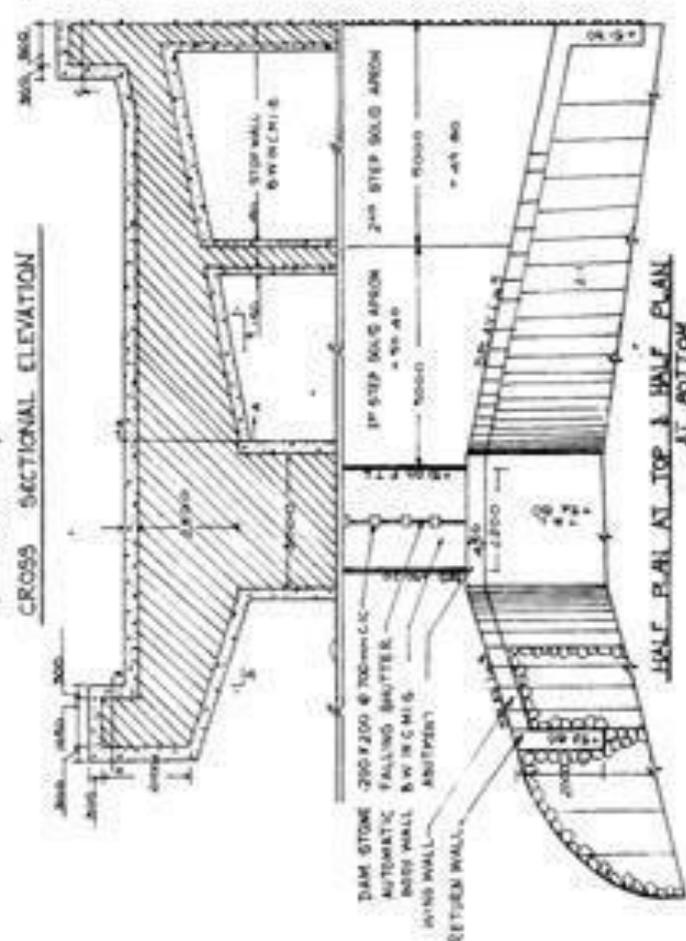
D/s height = 0.4 Hr
 $= 0.4 \times 1.80$
 $= .720$ say 0.8m.
 Total width = $0.9 + 0.6 = 1.50\text{m}.$
 at foundation = 2.)

(51.30 - 49.20)

APERTURE OF BRICK MAGAZINE 12 CM x 12 CM
 DAM STONES 200 X 200 @ 700 MM C.C. - AUTOMATIC FALLING



will 45cm thick
 1st STOP WALL 8 IN C.M. 1:6
 2nd STOP WALL 8 IN C.M. 1:6
 1st STEP SOLID APRON OF C.C. 1:2
 2nd STEP SOLID APRON OF C.C. 1:2
 CURTAIN
 BODY WALL 8 IN C.M. 1:6
 FOUNDATION CONCRETE C.C. 1:4:8
 PUBLE CLAS



HYDRAULIC PARTICULARS	
CONCRETE CATCHMENT AREA	100%
FREE CATCHMENT AREA	100%
TANK BED LEVEL	+83.20
WTE GROUND LEVEL	+77.50
MAX WATER LEVEL	+81.10
FULL TANK LEVEL	+84.90
TOP ROAD LEVEL	+84.90
ONE SOLE BELOW G.S.	+84.00
ONE SOLE ABOVE G.S.	+85.00

TANK SURPLUS WEIR

Ex. No.	TANK SLUICE WITH TOWER HEAD
Date:	

Design a tank Sluice with a tower head for the following hydraulic Particulars.

Ayacut	.....	68.6 hectares
Duty	.....	723 hect/cumec
Top width of Bund	.....	1.80m
Front Slope	.....	1½:1
Rear Slope	.....	+2:1
Tank Bund level	.....	+20.20m
Maximum water level	.....	+18.90m
Full tank level	.....	+18.30m
Highest field level	.....	+14.60m
Lowest field level	.....	+12.20m.

Assume any other relevant data.

Wing walls are to be constructed on the upstream side of the bund for regularizing thro' a well of 1.20m dia. Revetement is 45cm over gravel packing of 15cm thick.

Draw the following views to a suitable scale

- (1) Longitudinal Section
- (2) Half plan at top and half plan at foundation level
- (3) Details of plug
- (4) Section thro' tunnel and Barrel
- (5) Sectional elevation on upstream side

Design :

Discharge :

Ayacut = 68.6 hectares

Duty = 723 hect/cumec

$$\text{Discharge} = \frac{\text{Ayacut}}{\text{Duty}} = \frac{68.6}{723}$$

$$= 0.09488$$

$$= 0.095 \text{ m}^3/\text{sec}$$

Sill Level:

The down stream side bed level is generally fixed as the average value of the highest field level and mean between the highest and lowest field levels.

$$\left. \begin{array}{l} \text{The mean between the highest} \\ \text{and the lowest field level} \end{array} \right\} = \frac{14.60 + 12.20}{2}$$

$$= \frac{26.80}{2}$$

$$= +13.40\text{m}$$

$$\left. \begin{array}{l} \text{The mean of the above and} \\ \text{the highest field level} \end{array} \right\} = \frac{13.40 + 14.60}{2}$$

$$= 28.00/2$$

$$= +14.00\text{m.}$$

∴ Hence sill level is fixed at + 14.00m.

(b) Vent way (Barrel)

The area of the ventway of the sluice must be such that it can draw normal supply of water when the tank is at the lowest water level or a level at which the tank supply is always available to be drawn during normal dry period.

Lowest water level:

The lowest water level is assumed 2m above the sill level: ie + 16.00m.

Aliter :

The depth of storage in the tank is;

Full Tank level - Sill level = depth of storage

$$18.30 - 14.00 = 4.30$$

Average depth is assumed as 2.15m (or) 2.00m. ∴ above sill level

The lowest water level is

$$+14.00 + 2.00 = +16.00\text{m.}$$

Assuming pipe flow in the Barrel; the formula to be used is

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

Where,

$$Q = \text{Discharge} = 0.095\text{m}^3/\text{sec}$$

$$C_d = \text{co-efficient of discharge} = 0.6 \text{ (assume)}$$

$$A = \text{Area of the section in m}^2$$

$$g = \text{acceleration due to gravity} = 9.81\text{m}/\text{sec}^2$$

$$h = \text{Difference in level between } \left. \begin{array}{l} \text{lowest water level and sill level} \end{array} \right\} = 2.00\text{m.}$$

$$\therefore 0.095 = 0.6 \times A \times \sqrt{2 \times 9.81 \times 2.00}$$

$$A = 0.025\text{m}^2$$

If we assume a square Barrel; the

$$\therefore \text{Side} = 0.16;$$

But the vent way should allow sufficient head way for cleaning the debris and also for repairing.

Hence assume a rectangular minimum section (or) Vent way (or) Barrel to be provided as 60cm × 75cm:

$$\begin{aligned} \therefore \text{Area of the Barrel section} &= 0.6 \times 0.75 \\ &= 0.45\text{m}^2 > 0.025\text{m}^2 \end{aligned}$$

It is greater than the required area as per design calculation.

Hence provide a rectangular section of a Barrel of size 60 cm × 75 cm.

The barrel will have masonry side walls. The roof will be of R.C slab.

Provide the foundation concrete of 1: 4: 8 of 50cm thick and wearing coat of 1: 3: 6: 7 cm thick which is serving as a floor for the barrel in between the side walls.

Provide R.C.C Roofslab of 20 cm as over all thickness.

(c) Plug Hole

The size of the orifice in the plug stone is generally calculated so as to pass the full supply with 0.30m head over the plug hole platform.

Using Discharge formula

$$Q = c_d A_1 \sqrt{2gh}$$

$$Q = (\text{full supply}) \text{ discharge} = 0.095\text{m}^3 / \text{sec}$$

$$A_1 = \text{area of plug hole}$$

$$h_1 = \text{head of water} = 0.3\text{m.}$$

$$c_d = 0.6 \text{ (assume)}$$

$$g = 9.81 \text{ m sec}^2$$

$$0.095 = 0.6 \times A_1 \sqrt{2 \times 9.81 \times 0.3}$$

$$A_1 = 0.054\text{m}^2$$

$$\therefore \text{Dia of the plug hole} = 26\text{cm.}$$

\therefore Provide a plug Hole of 30cm diameter.

(a) Design of Bottom vent :

This vent is brought into use only when the water in the tank is less than 1.20m over the floor of the sluice. And at the other times this vent is completely closed by a slab of stone. This vent is made of sufficient size to pass full supply with 0.15m head.

Using Discharge formula. $Q = c_d A_2 \sqrt{2gh_2}$

$Q = \text{Discharge} = 0.095 \text{m}^3/\text{sec}$

$C_d = \text{Co-efficient of discharge} = 0.6 \text{ (assumed)}$

$A_2 = \text{Area of the vent size}$

$g = 9.81 \text{m}/\text{sec}^2$

$h_2 = \text{head of water} = 0.15 \text{m.}$

$0.095 = 0.6 A_2 \sqrt{2 \times 9.81 \times 0.15}$

$A_2 = 0.092 \text{m}^2.$

Assume a square vent of size $35 \text{cm} \times 35 \text{cm}$

∴ Vent size is $35 \text{cm} \times 35 \text{cm}.$

(e) Tower Head :

The tower head consist of a circular masonry well as shown in the drawing.

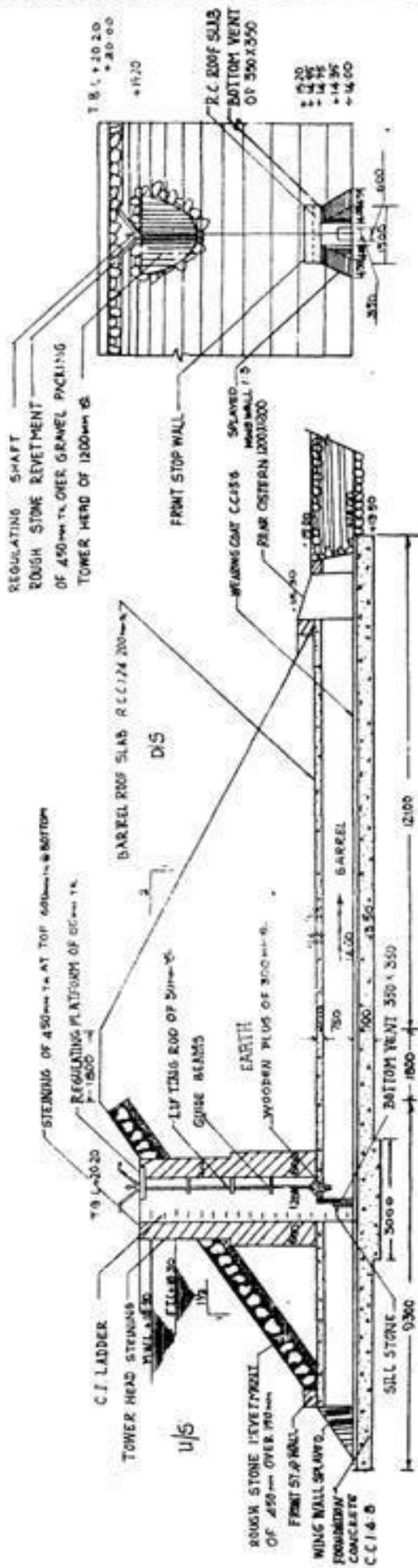
Generally these wells are not less than 1.20m in the internal diameter and have their top taken at least 30cm above MWL of the tank. The bottom of the well rests directly on the foundation concrete of the sluice.

The well steining is designed as a thick cylindrical shell of 45cm thickness over all at top and 60cm at bottom to withstand max earth pressure and hoop compression.

In the tower head the regulating (or) lifting rods are supported by guide beams. At top half the diameter of the well is covered by regulating plat-form.

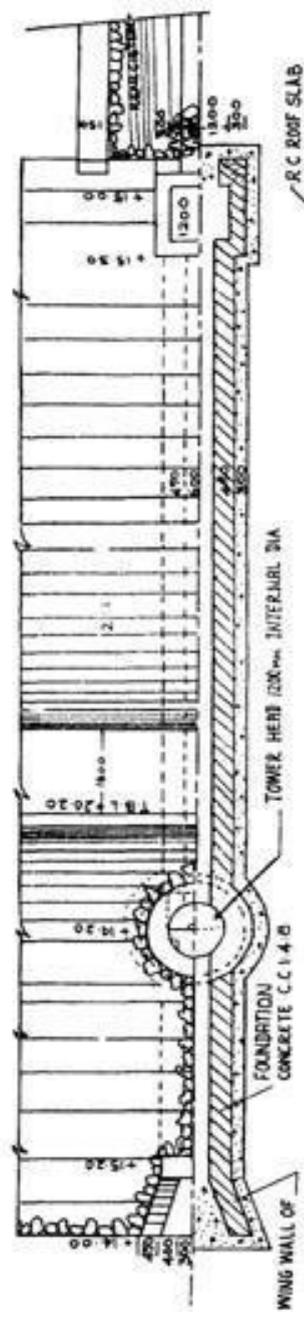
(f) Cistern in rear of the Barrel :

This serves to retain the slope of the banks and of the irrigation channel. This cistern enables to take off more than one channel thro separate opening in its side walls. On this case only one channel is proposed in rear and width of opening is kept as bed width of the channel. This cistern also functions as a stilling basin for the rushing water thro the barrel and reduces any passible Scour of the channel. Further to reduce the scour in the channel, the bed and side rivetements are provided upto 2.00m length from tail end of barrel.

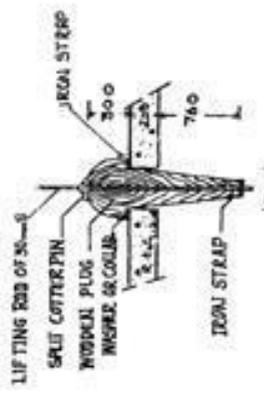


FRONT ELEVATION

LONGITUDINAL SECTION



HALF PLAN AT TOP
HALF PLAN AT BOTTOM



DETAILS OF PLUS

TANK SLUICE WITH
TOWER HEAD

D.1

Ex. No.	AQUEDUCT
Date:	

Design a suitable cross-drainage work, given the following data at the crossing of a canal and a drainage.

Canal

Full supply discharge	= 32 cumecs
Full supply level	= R.L. 213.5
Canal bed level	= R.L. 212.0 m.
Canal bed width	= 20.
Trapezoidal canal section with $1\frac{1}{2} H : 1 V$ slopes.	
Canal water depth	= 1.5 m.

Drainage

High flood discharge	= 300 cumecs.
High flood level	= 210.0 m.
High flood depth	= 2.5 m.
General ground level	= 212.5 m.

Solution. Since the drainage is of a large size, work of type III will be adopted. Further, because the canal bed level (212.0 m) is much above the H.F.L. of drainage (i.e. 210.0 m) an **aqueduct** will be constructed. The earthen banks of the canal will be discontinued and the canal water taken in a concrete trough. For effecting economy, the canal shall be flumed.

Step 1. Design of Drainage Waterway

Lacey's regime perimeter = $P = 4.75 \sqrt{Q}$

where Q = High flood discharge of drain
= 300 cumecs (given)

$$P = 4.75 \cdot \sqrt{300} = 82.3 \text{ m.}$$

Let the clear span between piers be 9 m and the pier thickness be 1.5 m.

Using 8 bays of 9 m each, clear waterway = $8 \times 9 = 72$ m.

Using 7 piers of 1.5 each, length occupied by piers = $7 \times 1.5 = 10.5$ m.

Total length of waterway = $72 + 10.5 = 82.5$ m

Step 2. Design of Canal Waterway

Bed width of canal = 20.0 m.

Let the width be flumed to 10.0 m.

Providing a splay of 2 : 1 in contraction, the length of contraction transition

$$= \frac{20 - 10}{2} \times 2 = 10.0 \text{ m}$$

Providing a splay of 3 : 1 in expansion, the length of expansion transition

$$= \frac{20 - 10}{2} \times 3 = 15 \text{ m}$$

Length of the flumed rectangular portion of the canal between abutments = 82.5 m (provided).

In transitions, the side slopes of the canal section will be warped in plan from the original slope of $1\frac{1}{2} : 1$ to vertical.

Step 3. Head loss and bed levels at different sections.

At Section 4-4

At section 4-4, where the canal returns to its normal section, we have
Area of trapezoidal canal section

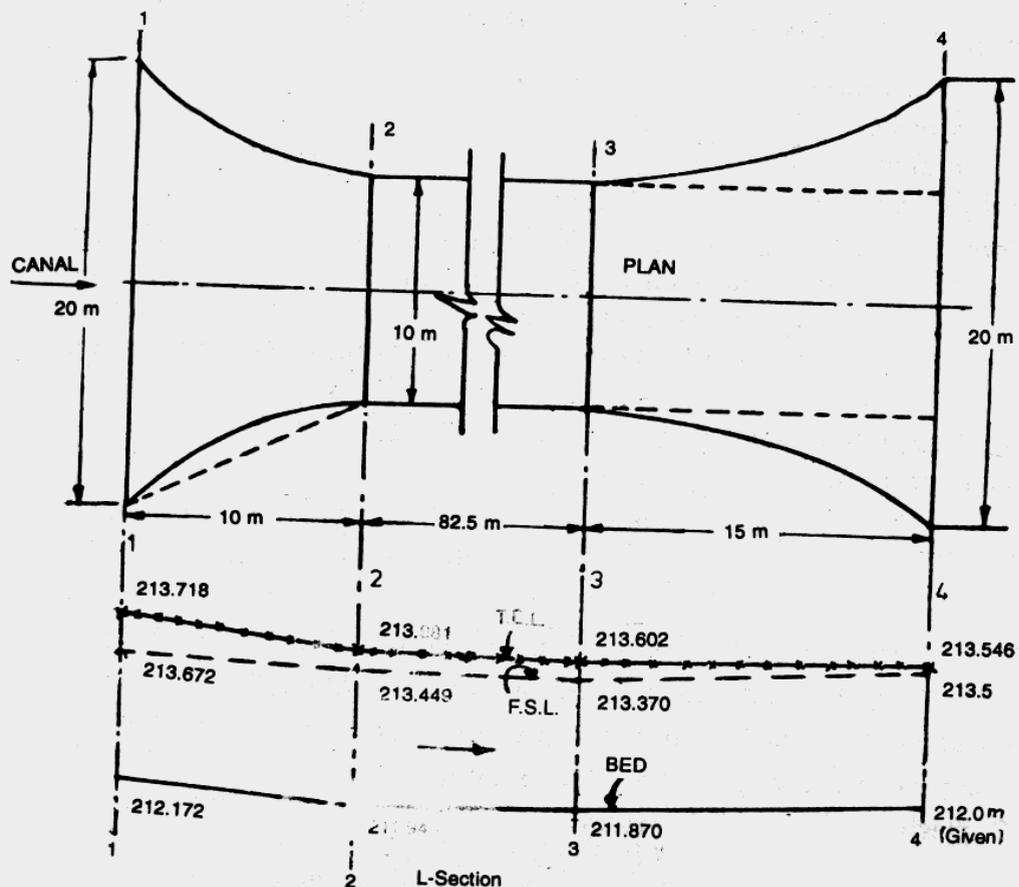
$$= (B + 1.5y) y$$

$$= (20 + 1.5 \times 1.5) 1.5 = 22.5 \times 1.5 = 33.75 \text{ m}^2$$

$$\text{Velocity} = V_4 = \left(\frac{Q}{A} \right) = \frac{32}{33.75} = 0.947 \text{ m/sec}$$

$$\text{Velocity head} = \frac{V_4^2}{2g} = \frac{(0.947)^2}{2 \times 9.81} = 0.046 \text{ m}$$

R.L. of bed at 4-4 = **212.0 m** (given)



Plan and Section of Canal Trough

R.L. of water surface at 4-4 = $212.0 + 1.5 = 213.5 \text{ m}$

R.L. of T.E.L. at 4.4 = $213.5 + 0.046 = 213.546 \text{ m}$

The known condition of 4-4 shall now be utilised for finding the bed levels etc. at 3.3.

At Section 3-3

Keeping the same depth of 1.5 m throughout the channel, we have at section 3.3 :

Bed width = 10 m

Area of channel = $10 \times 1.5 = 15 \text{ sq m}$

$$\text{Velocity} = V_3 = \frac{32}{15} = 2.13 \text{ m/sec}$$

$$\text{Velocity head} = \frac{V_3^2}{2g} = \frac{(2.13)^2}{2 \times 9.81} = 0.232 \text{ m}$$

Assuming that the loss of head in expansion from section 3-3 to section 4-4 is taken as

$$\begin{aligned} &= 0.3 \left[\frac{V_3^2 - V_4^2}{2g} \right] \\ &= 0.3 [0.232 - 0.046] \\ &= 0.3 \times 0.186 = 0.0558 \text{ m ; say } \mathbf{0.056 \text{ m}} \end{aligned}$$

$$\begin{aligned} \text{R.L. of T.E.L. at section 3-3} &= \text{R.L. of T.E.L. at 4-4} + \text{Loss in expansion} \\ &= 213.546 + 0.056 = 213.602 \text{ m} \end{aligned}$$

$$\begin{aligned} \therefore \text{R.L. of water surface at 3-3} &= \text{R.L. of T.E.L. at 3-3} - \text{Velocity Head} \\ &= 213.602 - 0.232 = \mathbf{213.370 \text{ m}} \end{aligned}$$

$$\begin{aligned} \text{R.L. of bed at 3.3} & \\ &= 213.370 - 1.5 = \mathbf{211.87 \text{ m}} \end{aligned}$$

At Section 2-2

From section 2-2 to 3-3, the trough section is constant. Therefore, area and velocity at 2-2 are the same as at 3-3. But from 2-2 to 3-3, there is a friction loss between 2-2 and 3-3 which may be computed by Manning's formula as equal to

$$H_L = \frac{n^2 \cdot V^2 \cdot L}{R^{4/3}}$$

where n is rugosity coefficient whose value in concrete trough may be taken as 0.016; and L is the length of trough = 82.5 m.

$$\text{Area of trough section } (A) = 10 \times 1.5 = 15 \text{ sq m}$$

$$\text{Wetted perimeter } (P) = 10 + 2 \times 1.5 = 13 \text{ m}$$

$$\text{Hydraulic mean depth } (R) = \frac{A}{P} = \frac{15}{13} = 1.16 \text{ m}$$

$$\text{Velocity in trough} = \frac{Q}{A} = \frac{32}{15} = 2.13 \text{ m/sec}$$

$$\begin{aligned} \therefore H_L &= \frac{(0.016)^2 \times (2.13)^2 \times 82.5}{(1.16)^{4/3}} \\ &= 0.0787 \text{ m ; say } \mathbf{0.079 \text{ m}} \end{aligned}$$

$$\begin{aligned} \text{R.L. of T.E.L. at 2-2} &= \text{R.L. of T.E.L. at 3-3} + \text{Friction loss in trough} \\ &= 213.602 + 0.079 = 213.681 \text{ m} \end{aligned}$$

$$\begin{aligned} \text{R.L. of water surface at 2-2} & \\ &= 213.681 - 0.232 = \mathbf{213.449 \text{ m}} \end{aligned}$$

$$\begin{aligned} \text{R.L. of bed at 2-2} & \\ &= 213.449 - 1.5 = \mathbf{211.949 \text{ m}} \end{aligned}$$

At Section 1-1

Loss of head in contraction transition from 1-1 to 2-2

$$\begin{aligned}
 &= 0.2 \left(\frac{V_2^2 - V_1^2}{2g} \right) \\
 &= 0.2 \left[\frac{(2.13)^2 - (0.947)^2}{2 \times 9.81} \right] \\
 &= 0.2 [0.232 - 0.046] = \mathbf{0.037 \text{ m}}
 \end{aligned}$$

R.L. of T.E.L. at 1-1 = R.L. of T.E.L. at 2-2 + Loss in contraction

$$= 213.681 + 0.037 = \mathbf{213.718 \text{ m}}$$

R.L. of water surface at 1-1

$$= 213.718 - 0.046 = \mathbf{213.672 \text{ m}}$$

R.L. of bed at 1-1

$$= 213.672 - 1.5 = \mathbf{212.172 \text{ m}}$$

All the bed levels, F.S.L. and T.E.L. are plotted

Step 4. Design of Transitions

(a) *Contraction Transition.* Since the depth is kept constant, the transition can be designed on the basis of Mitra's Hyperbolic transition equation given as :

$$B_x = \frac{B_n \cdot B_f L_f}{L_f B_n - x (B_n - B_f)}$$

where $B_f = 10 \text{ m}$

$B_n = 20 \text{ m}$

$L_f = 10 \text{ m}$

Substituting we get

$$B_x = \frac{20 \times 10 \times 10}{10 \times 20 - x (20 - 10)} = \frac{2,000}{200 - 10x}$$

For various values of x lying between 0 to 10 m, various values of B_x are worked out, as shown below in Table 2. The distance x is measured from flumed section *i.e.* 2-2, as shown in Fig.

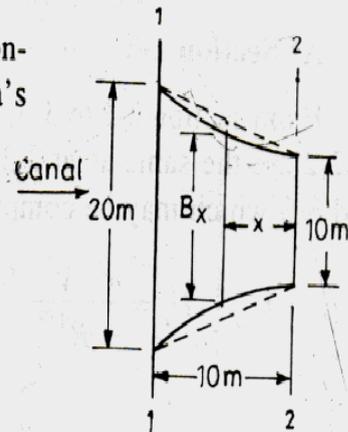


Table 2

x in metres	0	2	4	6	8	10
$B_x = \frac{2,000}{200 - 10x}$ in metres	10.0	11.11	12.5	14.29	16.67	20.0

The contraction transition can be plotted with these values.

Expansion Transition. In this case $B_n = 20$ m, $B_f = 10$ m, and $L_f = 15$ m.

Using Eqn. (14.2), we get

$$B_x = \frac{B_n \cdot B_f \cdot L_f}{L_f \cdot B_n - x(B_n - B_f)}$$

$$= \frac{20 \times 10 \times 15}{15 \times 20 - x(20 - 10)} = \frac{3,000}{300 - 10x}$$

For various values of x lying between 0 to 15 m, various values of B_x are worked out by using the above equation, as shown in Table 3.

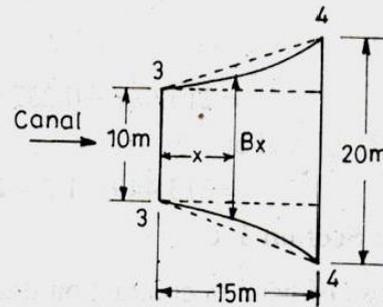


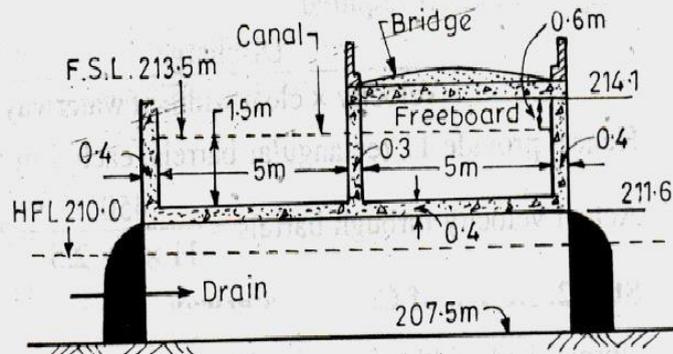
Table 3

x in metres	0	2	4	6	8	10	12	14	15
$B_x = \frac{3,000}{300 - 10x}$ in metres	10.0	10.71	11.54	12.5	13.64	15.0	16.67	18.75	20.0

The expansion transition can be easily plotted with these values.

Step 5. Design of Trough

The trough shall be divided into two equal compartments of 5 m each and separated by an intermediate wall of 0.3 m thickness. The inspection road shall be carried on the top of left compartment as shown in Fig.



A freeboard of 0.6 m above the normal water depth of 1.5 m is sufficient, and hence, the bottom level of bridge slab over the left compartment can be kept at $1.5 + 0.6 = 2.1$ m above the bed level of the trough. The height of the trough will, therefore, be kept equal to 2.1 m. The entire trough section will be constructed in monolithic reinforced concrete and can be designed by usual structural methods. The tentative thicknesses may be used as follows :

Outer walls = 0.4 m thick

Bottom slab of trough = 0.4 m thick

The intermediate partition wall is to be extended in the transitions so as to provide the necessary clear width of 10 m. The detailed drawing of the aqueduct is illustrated in attached chart

SYPHON AQUEDUCT

A SYPHON AQUEDUCT

PROBLEM :

The following details refer to the particulars of a canal to be taken across a drain:

- CANAL : Bed width 15m
- Bed level +25.00m
- Depth at F.S.L 2m
- Discharge 30m³/sec
- Side slope 1½:1
- DRAIN : Bed width 25m
- Bed level +23.30m
- M.F.L +25.20m
- Discharge +70m³/sec
- Side slope 1½:1
- General G.L +25.00m

Maximum allowable velocity in the aqueduct canal - 1.5m/sec MFL +25.20 FSL +27.00
 Maximum allowable velocity through the Drain - 2.5m/sec (3m/sec) +23.20 CANAL
 The soil is loam with a percolation gradient of 1 in 4. DRAIN

Good foundation is available at +23.30m. Design and draw

1. Half plan at top and half plan at foundation.
2. Longitudinal section.
3. Cross section of the drain.

SOLUTION :

Since the canal bed level is below the maximum flood level of the stream but above its bed level, the structure "SYPHON AQUEDUCT" is designed.

- 1) Design of canal trough :
- Discharge = 30m³/sec
 - ∴ Area = $\frac{Q}{V} = \frac{30}{1.5} = 18.33\text{m}^2$
 - F.S.D = 2.0m

∴ Width required = $\frac{13.33}{2} = 6.67\text{m}$ or say 7.00m
 Free board allowed = 0.45m

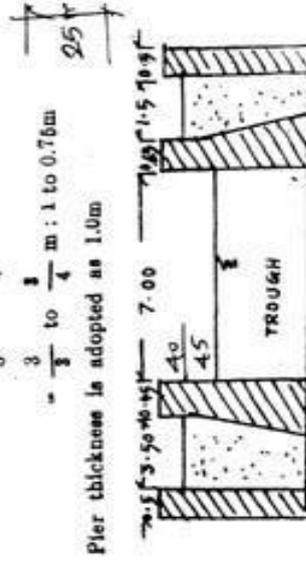
2) Retaining wall :-

Let the top width be 0.45m
 Bottom width = 0.70m + H
 ∴ Bottom width = 0.7 + 2.45 = 1.72m = 1.80

3) Design of vent for drain

Discharge = 70m³/sec
 Width = 25 m
 Width of each vent way is limited to 8m.
 Pier thickness = $\frac{S}{3}$ to $\frac{S}{4}$;
 = $\frac{3}{3}$ to $\frac{3}{4}$ m : 1 to 0.75m

Pier thickness is adopted as 1.0m



Check for End Contraction :-

Bed width of drain = 25m
 Assuming the No. of Vents as 5.
 Width of crossing = (5 × 3.0) + (4 × 1.0)
 = 15 + 4 = 19.0m
 Amount of Contraction = 25 - 19 = 6.0m
 Maximum width of contraction allowable is about 2
 In this case = $\frac{6.0}{25} \times 100 = 24\%$. (6%)
 It is less than 25% and hence O.K.
 ARCH VENTWAY : (DRAIN) (25%)
 Discharge through one vent = $\frac{70}{5} = 14\text{m}^3/\text{sec}$.

20 Bed level of canal = +2.25
 $R < c$ sub (allow) to cm
 Area required = $\frac{Q}{V} = \frac{16}{2.5} = 6.4 \text{ m}^2$
 Adopt Arched vent. $Y - \text{Rise} = \frac{S \cdot 1.0}{6} = \frac{S}{6}$

Part of the
 Bed level of top
 Allowable velocity
 through the drain = 2.5

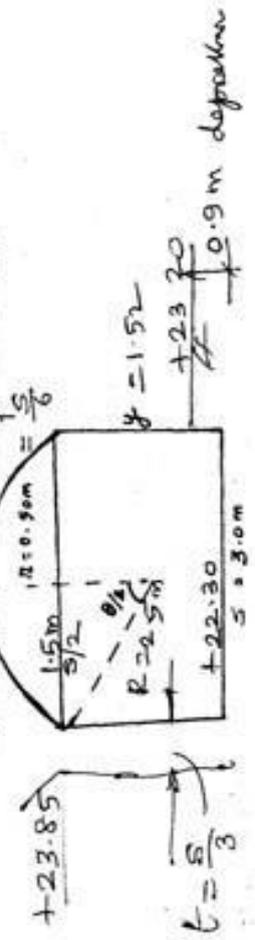
$Y - 0.9 \text{ m}$
 $(2R - r) r = \frac{S}{2} \times \frac{S}{12}$
 $(2R - 0.5) 0.5 = \left(\frac{3.0}{2}\right)^2$

$(R - 0.25) = 2.25 \text{ m}$
 $R = 2.25 + 0.25 = 2.5 \text{ m}$
 $\sin \frac{\theta}{2} = \frac{1.5}{2.5} = 0.6$
 $\therefore \theta = 74^\circ$

Triangle
 $\text{Area of Arched A} = \frac{\theta}{360} \times \pi R^2 - \frac{1}{2} S(R - r)$
 $= \frac{74}{360} \times \pi \times 2.5^2 - \frac{1}{2} \times 3.0 (2.5 - 0.5)$
 $= 1.034 \text{ m}^2$

Remaining Rectangular area required = Area calculated -
 $= 5.60 - 1.03 = 4.57 \text{ m}^2$

Area of Arch section = $\frac{4.57}{3.0} = 1.52 \text{ m}^2$
 $\therefore Y = \frac{4.57}{3.0} = 1.52 \text{ m}$
 $\therefore Y = 1.52 \text{ m}$



Thickness of Arch :-
 $t = 0.35 \sqrt{R}$ in metres
 $= 0.25 \sqrt{0.25} = 0.396 \text{ m}$
 Adopt 0.45 m Thickness.

To find bottom level of Barrel portion :-

$\therefore = 24.60$
 $= 22.75$
 The total loss taking place in the barrel comprising of Entry
 Friction loss and Exit loss

$h_1 = \frac{V^3}{2g} + \frac{f l V^3}{R_1 2g} + \frac{V^3}{2g} (1.5 + \frac{f l}{R_1})$
 $h_1 = \frac{V^3}{2g} \left[1.5 + \frac{f l}{R_1} \right]$

$f =$ co-efficient of friction (can be assumed between 0.003 to 0.006.)

R.L. of concrete bottom of Arch top = +24.80m
 Thickness of Arch = 0.45m.
 R.L. of crown point = +24.80 - 0.45 = +23.35m

Rise = 0.50m
 Springing level of top of pier = +24.35 - 0.50 = 23.85m.
 \therefore Bottom level of top pier = +23.85 - 1.52 = 22.33 say 22.30
 Good foundation available at +22.50m (given) and hence o.k.

Abutment :

Top width = $0.60 + \frac{R}{5} = \frac{R}{10}$ in metre

Say = 1.30m
 $= 0.60 + \frac{2.5}{5} = \frac{0.5}{10} = 1.15 \text{ m}$

Rear Batter = $\left(\frac{1}{25}\right) \times \frac{S}{R} = \left(\frac{1}{25}\right) \times \frac{3.0}{0.5} = 0.24$

Say = i

Adopt i batter & Bottom width = 1.30 + 0.65 = 1.95 = 2.00m

Wing Wall :

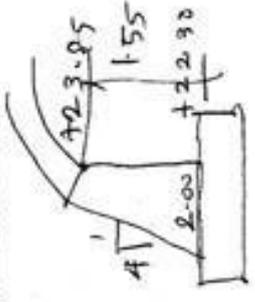
M.F.L. of drain = 25.20m
 Assume top of wingwall as +25.50m
 Concrete level = 22.30

$H = 3.20 \text{ m}$

Top width assumed as 0.45

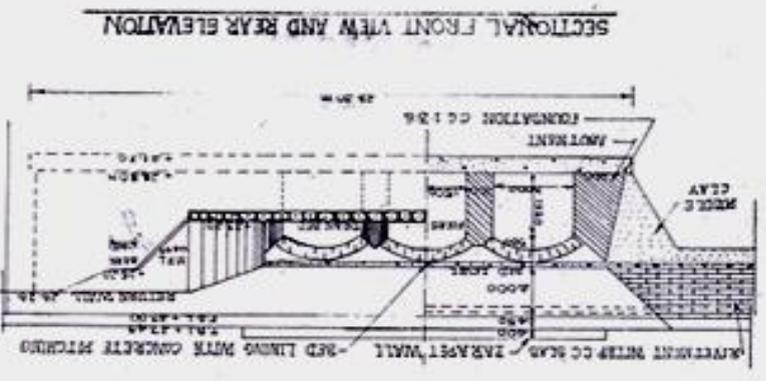
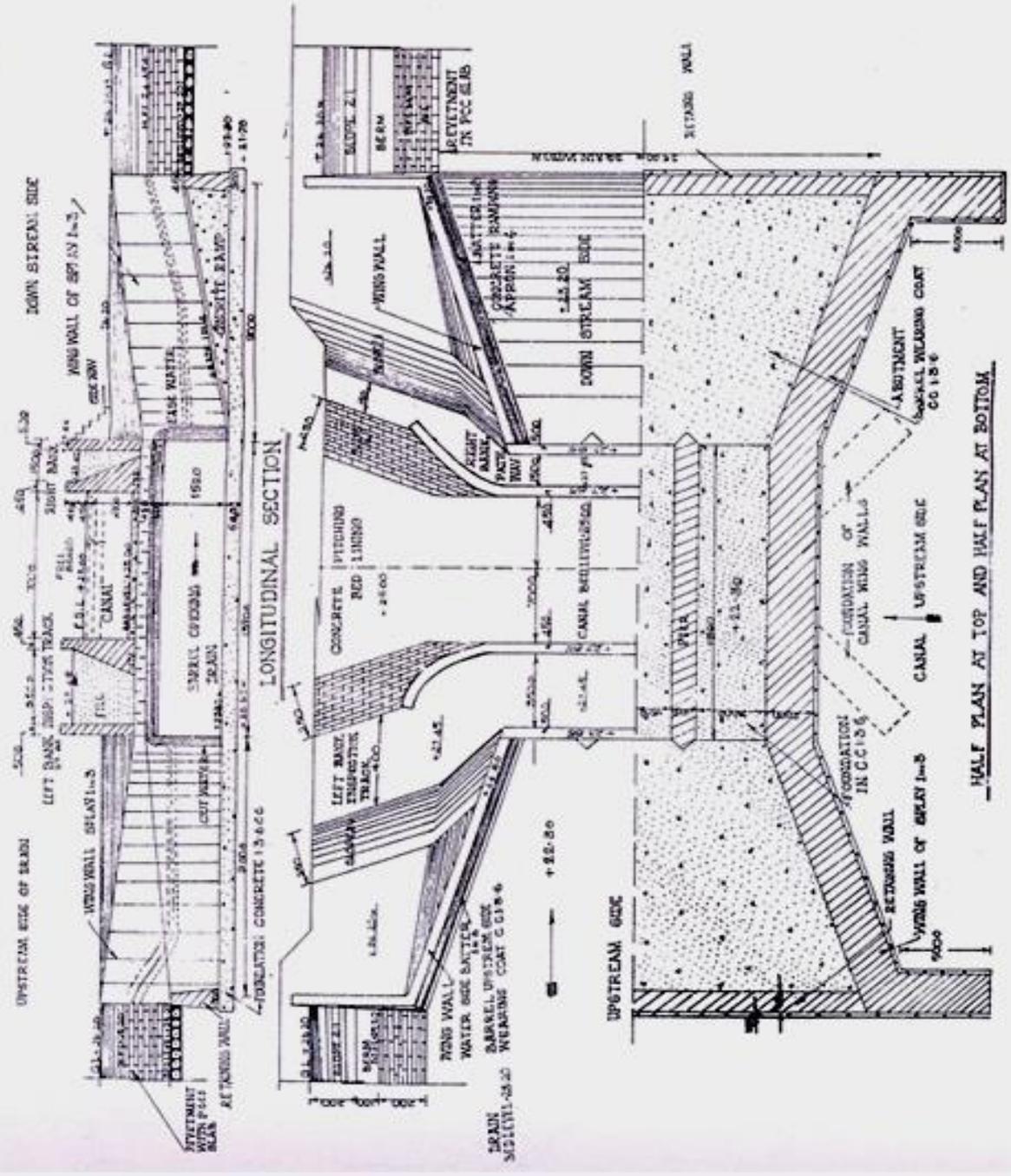
\therefore Bottom width = $0.4 H = 0.4 \times 3.20 = 1.28 \text{ m}$

Say = 1.50m



HYDRAULIC PARTICULARS CANAL DRAIN	
DESIGNER	25-11-54
DATE	25-11-54
PERMISSIBLE VELOCITY	25-11-54
FULL SUPPLY LEVEL	25-11-54
DESIGN VELOCITY	25-11-54
NUMBER OF VENTS	25-11-54
SIZE OF VENT	25-11-54

18



A SYPHON AQUEDUCT

Ex. No.	CANAL DROP (NOTCH TYPE)
Date:	

Design a notch type canal drop for a fall of 1.50m with the following particulars.

Full supply discharge = 5.4 cumecs.

Data particulars	U/S side	D/S side
Bed width	5.00m	5.00m
Full supply level	+9.20m	+7.70m
Bed level	+8.00m	+6.50m
Surface fall	1 in 4000	1 in 4000

Slope protection by stone revetement 30cm over gravel may be provided. The flooring for water cushion is in concrete. Good foundation is available at +6.00m.

Draw the following views.

1. Longitudinal section through the centre line of the canal.
2. Plan half at top and half at foundation.
3. Elevation half full and section.
4. Section of wing wall.

DESIGN :

Assumptions :

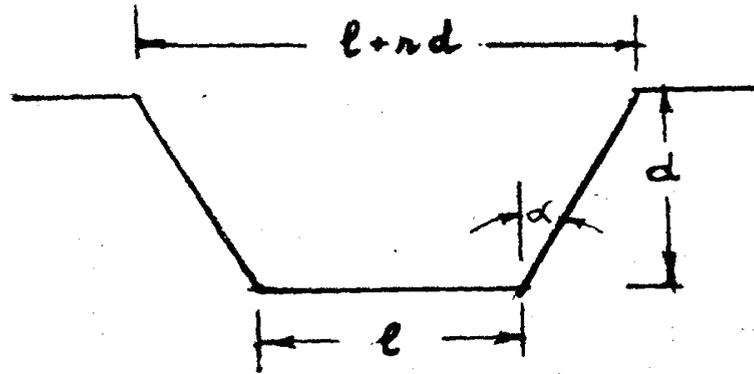
1. Tank Bund level in the upstream side is assumed to be of 1.20m higher than the F.S.L of U/S side.
2. Tank Bund level in the Down stream side is to be 0.90m lower than the Tank Bund level of u/s side.
3. Width of Bund at top may be provided as 3.00m in U/s and D/s

1. Design of Drop Wall:

$$\begin{aligned} \text{Number of Notches} &= \frac{\text{Bed Width}}{1\frac{1}{2} \text{ time F.S.D}} \\ &= \frac{5.00}{1\frac{1}{2} \times 1.20} \\ &= 2.78 \text{ (or) } 3 \text{ nos} \end{aligned}$$

Provide 3 Nos of notches :

2. Design of trapezoidal notches :



Discharge = $Q_1 + Q_2$

$Q = Q_1 + Q_2$

Where, $Q =$ Discharge thro' triangular notch

= [REDACTED]

$$Q_1 = \frac{8}{15} C_d \tan \alpha L \sqrt{2g} d^{5/2}$$

Where $C_d =$ Coefficient of discharge
 - Half of notch angle

$d =$ depth of flow = F.S.D.

$Q_2 =$ Discharge thro' rectangular notch

$$Q = \frac{2}{3} C_d \alpha \sqrt{2g} d^{5/2} + \tan \alpha + \frac{2}{3} C_d L \sqrt{2g} d^{3/2}$$

and $\tan \alpha = \frac{n/2}{3/2}$

Here $Q = 2.96 C_d d (1 + 0.4nd)$

Full supply discharge = 5.40 cumecs.

$$\left. \begin{array}{l} \text{discharge thro' each notch} \\ \text{for full discharge} \end{array} \right\} = \frac{5.40}{3} = 1.80 \text{ cumecs}$$

$$\left. \begin{array}{l} \text{Discharge thro' each notch} \\ \text{at half supply} \end{array} \right\} = \frac{1.80}{2} = 0.90 \text{ cumecs.}$$

The notch is designed in such way that at half supply the depth of water in the canal is $2/3^{rd}$ of full supply Depth.

At Full discharge ; $d =$ Full supply, depth = 1.20.

At half discharge ; $d_1 = \frac{2}{3}$ Full supply, depth = $\frac{2}{3} \times 1.20 = 0.8 \text{ cm.}$

At Full supply discharge

$Q = 1.80 \text{ cumecs ; } d = 1.20 \text{ m.}$

Assume $C_d = 0.70$

$$Q = 2.96 \times C_d \times d^{3/2} (1 + 0.4nd)$$

$$\therefore 1.80 = 2.96 \times 0.70 \times (1.20)^{3/2} (1 + 0.4n \times 1.20)$$

$$1 + 0.4n = 0.661 \quad \text{--- (1)}$$

At Half supply discharge,

$$Q = 0.90 \text{ cumecs ; } d = 0.80 \text{ m}$$

Assume $C_d = 0.70$

$$Q = 2.96 C_d d^{3/2} (1 + 0.4nd)$$

$$= 2.96 \times 0.70 (0.80)^{3/2} (1 + 0.4n \times 0.80)$$

$$1 + 0.32n = 0.607 \quad \text{--- (2)}$$

$$1 + 0.4n = 0.661 \quad \text{--- (1)}$$

$$1 + 0.32n = 0.607 \quad \text{--- (2)}$$

$$0.16n = 0.054$$

$$n = 0.3375 \text{ and}$$

$$l = 0.499$$

Now,

Provide Bottom width of notch as 0.50m.

To eliminate the error in the cross-section due to approach velocity.

$$\begin{aligned} \text{Top width} &= 1 + nd \\ &= 0.50 + 0.3375 \times 1.20 \\ &= 0.735 \\ \text{say} &= 0.80\text{m.} \end{aligned}$$

Provide top width of notch as a 0.80m

The width of canal at drop wall can be $\frac{7\text{th}}{8}$ of Bed width of up stream.

$$\frac{7}{8} \times 5.00 = 4.375\text{m.}$$

$$\begin{aligned} \text{Total top width of notches} &= 3 \times 0.80. \\ &= 2.40\text{m.} \end{aligned}$$

Adopting the intermediate and end pier to be of 0.50m.

$$\begin{aligned} \text{Total top width of piers} &= 4 \times 0.50 \\ &= 2.00\text{m} \end{aligned}$$

$$\begin{aligned} \therefore \text{Total length of Drop Wall} &= 2.40 + 2.00 \\ &= 4.40 > 4.375\text{m Hence O.K.} \end{aligned}$$

$$\begin{aligned} \text{Thickness of drop wall} &= \frac{1}{2} \text{ F.S.D} \\ &= \frac{1}{2} \times 1.20 \\ &= 0.60\text{m.} \\ &(\text{or}) \end{aligned}$$

$$\left(\frac{d}{2} + 15 \right) \text{ to } \left(\frac{d}{2} + 30 \right) \text{ in cms.}$$

$$= \frac{120}{2} + 15 \text{ to } \frac{120}{2} + 30$$

$$= 75 \text{ cm to } 90 \text{ cm.}$$

∴ Provide 80cm as thickness of drop wall

Lip Projection :

Lip stone is to be projected towards down stream side to reduce the direct vibration of the body wall and should not be less than $\frac{1^{\text{th}}}{4}$ of full supply depth.

$$= \frac{1}{4} \times \text{F.S.D}$$

$$= \frac{1}{4} \times 1.20 = 0.30$$

4. Body wall Design:

Full supply Depth = F.S.D = $d = 1.20 \text{ m.}$

Height of fall = $h = 2.00 \text{ m.}$

$$\text{Top width} = \frac{h}{2} + 15 \text{ to } \frac{h}{2} + 30 \text{ in cms}$$

$$= 100 + 15 \text{ to } 100 + 30$$

$$\text{say} = 120 \text{ cm.}$$

Provide 120cm as Top width

$$\text{Bottom width (or) Base width} = \frac{h + d}{\sqrt{f}}$$

$f = \text{density of the material}$

$$= 2.25 \text{ Kg/m}^2$$

$$= \frac{1.20 + 2.00}{\sqrt{2.25}}$$

$$= 2.13 \text{ m}$$

$$\text{say} = 2.20 \text{ m.}$$

Provide

$$\text{Top width} = 1.20 \text{ m}$$

$$\text{Bottom width} = 2.20 \text{ m.}$$

Thickness of foundation concrete can be taken as

$$= 0.55 \sqrt{d + h}$$

$$= 0.55 \sqrt{1.20 + 2.00}$$

$$= 0.90 \text{ m}$$

Provide 1.00m depth of concrete.

5. Design of water cushion

The following empirical formula is used to design

$$X + d_1 = \frac{1}{1.10} d \sqrt{h}$$

Where.

$d_1 = \text{Full Supply depth on d/s side}$

$$= 1.20 \text{ m.}$$

$X = \text{depth of water cushion}$

$$X + 1.20 = \frac{1}{1.10} + 1.20 \sqrt{2.00}$$

$$x = 0.340\text{m}$$

Minimum depth of water cushion is 500mm

D/S Bed level = + 6.50

Foundation level = + 6.00

Hence, Provide 50cm depth of water cushion for energy dissipation of the fall.

Length of water cushion.

$$L = d + 2\sqrt{dh}$$

$$= 1.20 + 2\sqrt{1.20 \times 2.00}$$

$$= 4.59\text{m}$$

$$\text{say} = 4.50\text{m}$$

Provide a length of 4.50m

6. Revetement, Apron and pitching :

1 Length of revetement on U/S side

$$= 3d$$

$$= 3 \times 1.20 = 3.60\text{m}$$

$$\text{say} = 4.00\text{m}$$

Provide 4.00m length of revetement on U/S side

2. Bed Pitching on U/S side

$\frac{1}{2}$ of the above length

$$= \frac{1}{2} \times 4.00 = 2.00\text{m}$$

The R.R. Stones are laid over a 30cm thick gravel bed and having a total depth of 500mm

3. Revetement on D/S side after the water cushion

$$= 3(d + h)$$

$$= 3(1.20 + 1.50)$$

$$= 3 \times 2.70 = 8.10\text{m}$$

$$\text{say} = 9.00\text{m}$$

Provide 9.00m length of revetement on D/S side

4 Bed pitching on D/S side:

$\frac{1}{2}$ of the above length

$$= \frac{1}{2} \times 9.00 = 4.50\text{m}$$

5. Main apron Width at water cushion :

$$= \text{Length of drop wall} + \frac{1}{2} \text{ of full supply depth on u/s side}$$

$$= 4.40 + \frac{1}{2} \times 1.20$$

$$= 5.00\text{m}$$

The width of D/S main apron can be taken as the width of D/S section of canal.

The U/S side wing walls are provided at the joining point of apron and in the down stream side. wing walls are proposed at the oint joining at main apron and at full supply level in down stream side.

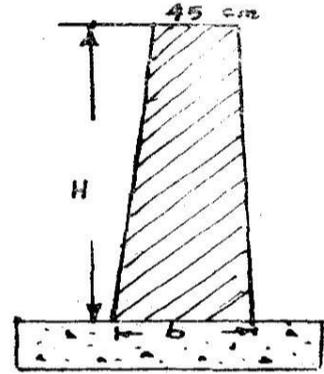
Top of wing wall is provided with 450mm Thickness

7. **Abutments, wing walls and Return walls :**

1. **Abutment :**

$$\begin{aligned} \text{Height - U/S side T.B.L - Top of foundation} \\ &= 10.40 - 6.00 \\ &= 4.40\text{m} \end{aligned}$$

$$\begin{aligned} b &= \text{Base width} = 0.4H \\ &= 4.4 \times 0.4 \\ &= 1.76\text{m say} \\ &= 1.80\text{m.} \end{aligned}$$



2. **U/S side wing wall**

$$\begin{aligned} \text{Height} &= \text{U/S side F.S.L - Top of foundation level} \\ &= 9.20 - 6.00 \\ &= 3.20\text{m.} \end{aligned}$$

$$\begin{aligned} \text{Base width} &= 0.4 \times H \\ &= 0.4 \times 3.20\text{m} \\ &= 1.20\text{m say} \\ &= 1.30\text{m.} \end{aligned}$$

The wing wall is having a base width of 1.30m at end and 1.80m at abutment:

3. **D/S side wing wall :**

$$\begin{aligned} \text{Height} &= \text{D/S side Bund level - Foundation top} \\ &= 9.50 - 6.00 \\ &= 3.50\text{m.} \end{aligned}$$

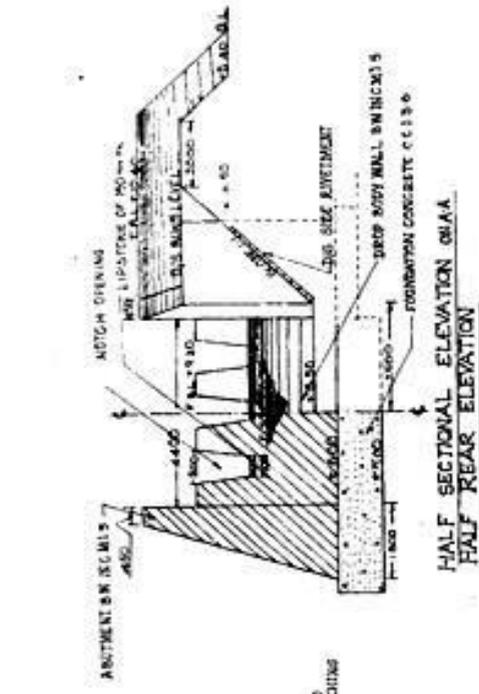
$$\begin{aligned} \text{Base width} &= 0.4 \times 3.50 \\ &= 1.40\text{m.} \end{aligned}$$

4. **D/S side return wall :**

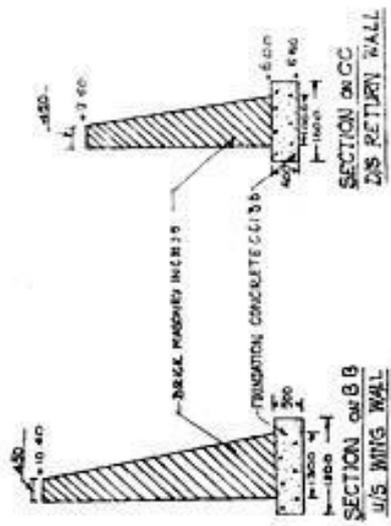
$$\begin{aligned} \text{Height} &= \text{D/S F S.L - Foundation level} \\ &= 7.70 - 6.00 \\ &= 1.70\text{m.} \end{aligned}$$

$$\begin{aligned} \text{Base width} &= 0.4 \times H \\ &= 0.4 \times 1.70 \\ &= 0.68\text{m say} \\ &= 1.00\text{m.} \end{aligned}$$

The return wall top is extended upto Berm level

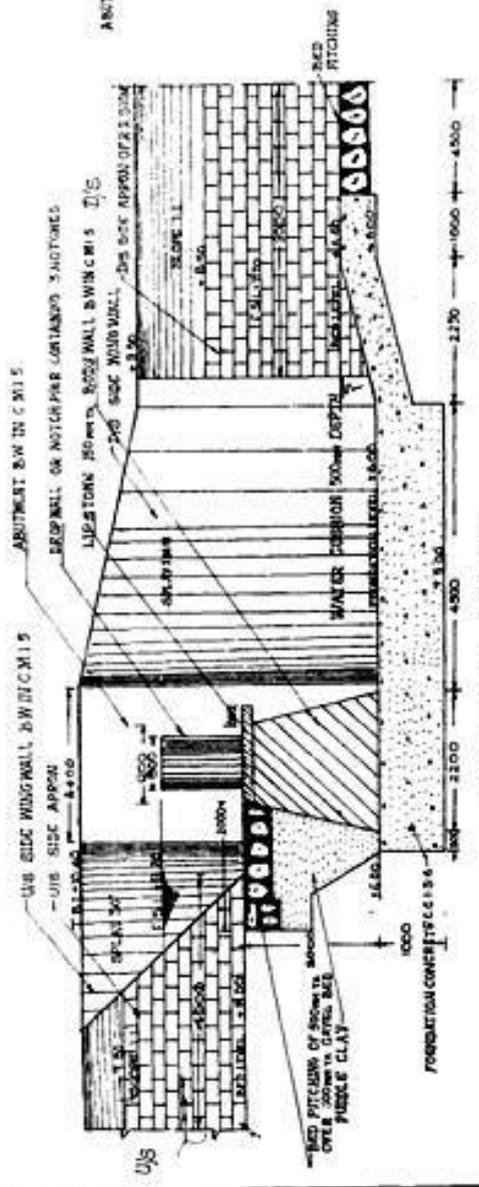


HALF SECTIONAL ELEVATION ON A
HALF REAR ELEVATION

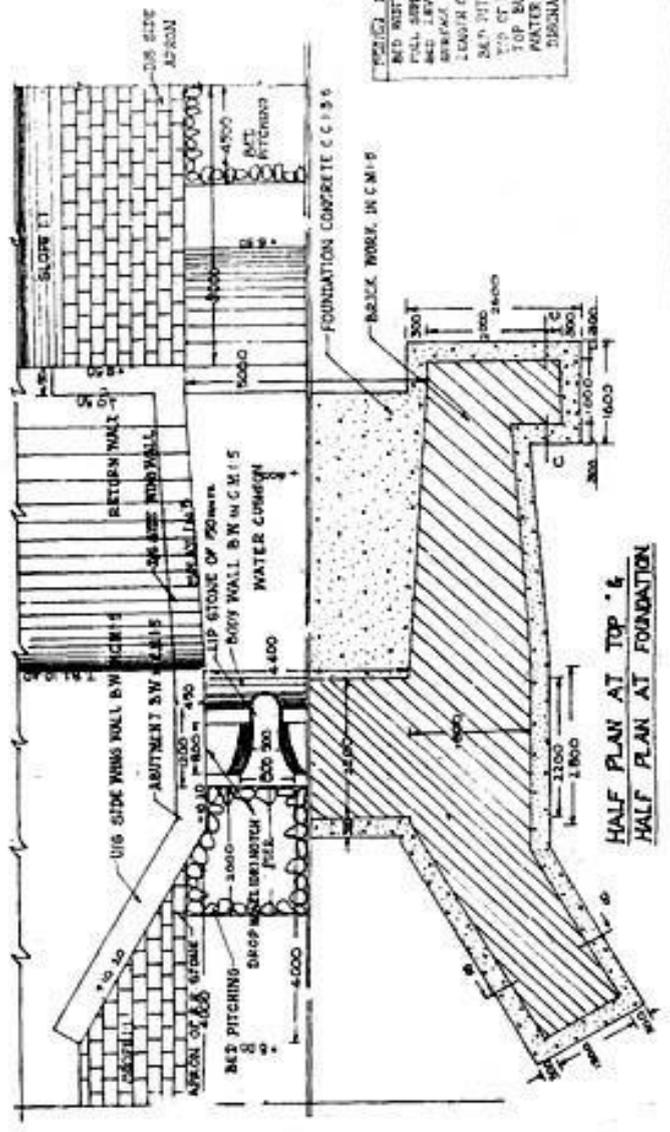


SECTION ON B B
U/S WING WALL

PERMITS PARTIAL DEPTH	2.5	3.0
RED WASH	5.0	5.0
FULL SUPPLY LEVEL	4.20	4.70
RED LEVEL	4.10	4.70
BRIDGE WALL	2.40	2.40
LENGTH OF ABUTMENT	4.00	3.00
NO. OF PITCHING	2.5	4.5
% OF FOUNDATION	4.00	6.00
TOP BANK LEVEL	5.40	5.90
WATER CURB	5.40	5.90
DESIGNATOR	S C	CM 1:5



LONGITUDINAL SECTION



HALF PLAN AT TOP &
HALF PLAN AT FOUNDATION

CANAL DROP

Ex. No.	CANAL REGULATOR
Date:	

A CANAL ESCAPE

PROBLEM :-

Design a canal escape for the following hydraulic particulars:

Discharge through canal	= 15 cumec
Discharge through the escape	= Half full supply
F S L	= + 32.00m
Bed level	= + 30.50m
Bed width	= 12.00m
Allowable velocity	= 1.00m/sec
G.L at site	= + 30.50m
Top width of the bank	= 3 00m

Good soil for foundation is available at +29.20m Provide a two vented structure with suitable shutter arrangements.

- Draw
- 1) Sectional plan
 - 2) Cross section thro' end spans
 - 3) Elevation

DESIGN

Full supply Discharge	= 15.00 cumec
Discharge thro' Escape	= $\frac{1}{2} \times 15 = 7.50 \text{ m}^3/\text{sec}$
Sill level is taken as the B.L of canal	= + 30.50
Depth of flow over the sill	= 32.00 - 30.50
	= 1.50m

Vent way

Adopt a vent hight of 1.00m
 \therefore Head over the vent = 1.50 - 1.00 = 0.50m = h

$$\text{Discharge} = C_d \times A \times \sqrt{2gh} = 7.50 \text{ m}^3/\text{sec}$$

Assume $C_d = 0.78$; Area = $L \times 1.00$

Where L = width of the vent way

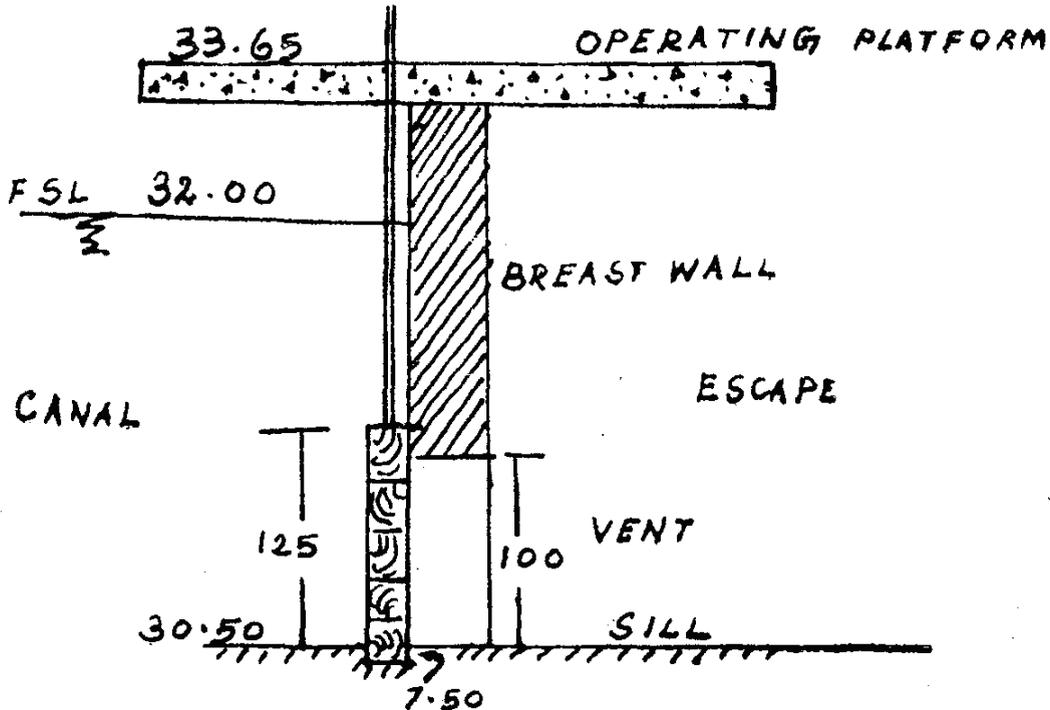
$$\therefore L = \frac{7.50}{0.78 \times \sqrt{2 \times 9.81 \times 0.50}} = 3.20\text{m}$$

Two vents are provided

\therefore Size of each vent = 1.60m \times 1.00m.

R L of the operating platform

The size of the shutter is slightly bigger than the size of the vent with 25cm above the vent hole and 7.50cms below the sill level (Refer the fig:)



(Fig)

R.L of the bottom of the operating platform is fixed at 33.50m

PIER and ABUTMENTS

The span width = 1.60m

$$\therefore \text{The thickness of the pier} = \frac{\text{Span}}{3} = 0.60 \text{ (approx)}$$

Assume the top width of the abutment as 45 cms Assuming a thickness of 30 cms for base concrete for the foundation.

$$\begin{aligned} \text{Height difference} &= \text{Crown level of the arch} - \text{Top level of concrete} \\ &= 33.00 - 29.50 = 3.50\text{m.} \end{aligned}$$

$$\therefore \text{Base width of abutment} = 0.4 \times 3.50 = 1.40\text{m.}$$

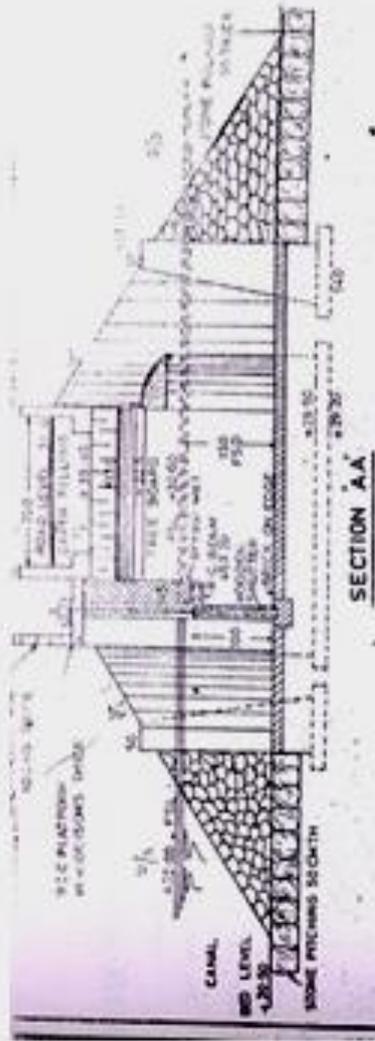
BED PITCHING

Assuming the bed soil is loamy,
the creep length = $5.00 \times h$
= $5.00 \times 1.60 = 8.0\text{m.}$

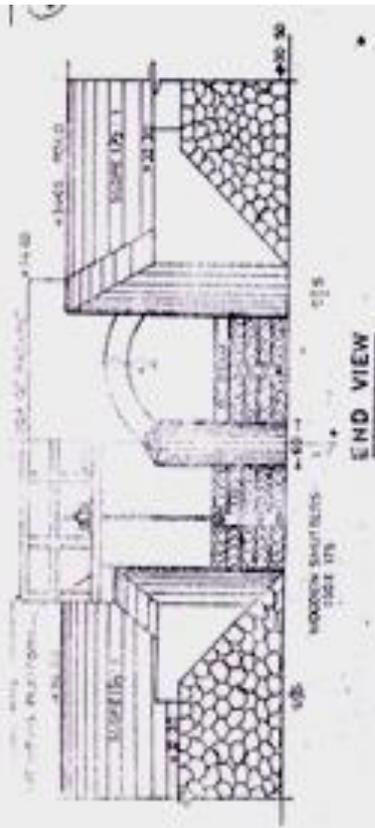
Length of pier portion = 4.50m

Required length of bed pitching = $8.0 - 4.50 = 3.50\text{m.}$

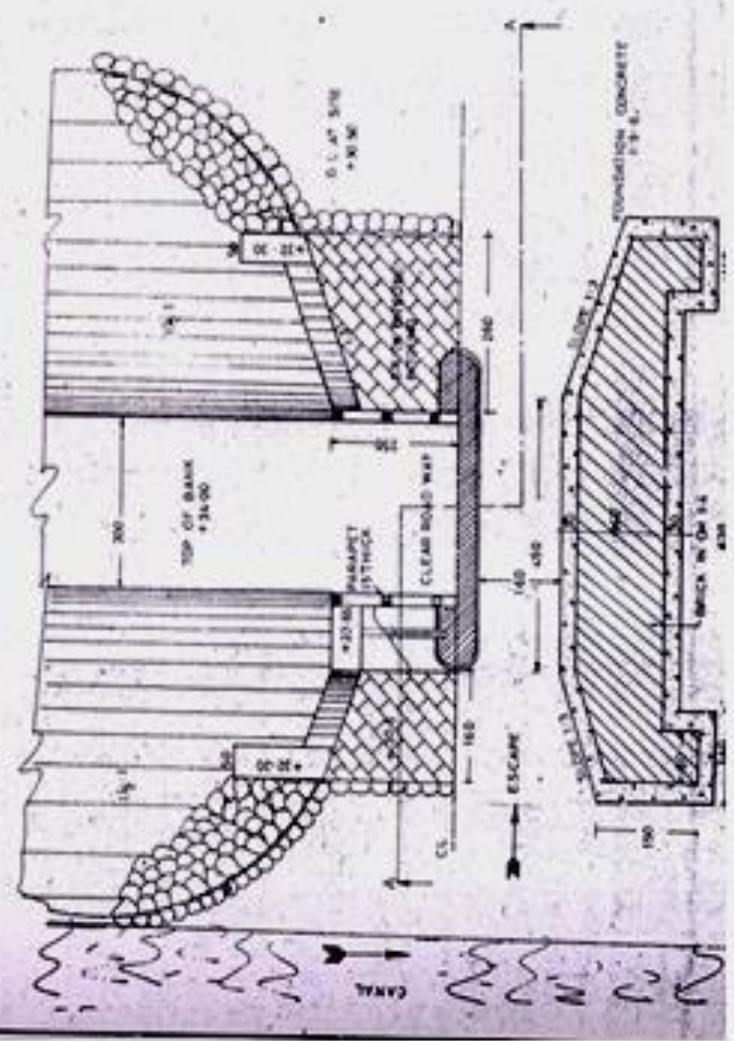
Provide brick on edge bed pitching for 1.60m on the U/S side and. 2.60m on the D/S side.



SECTION AA



END VIEW



HYDRAULIC DATA

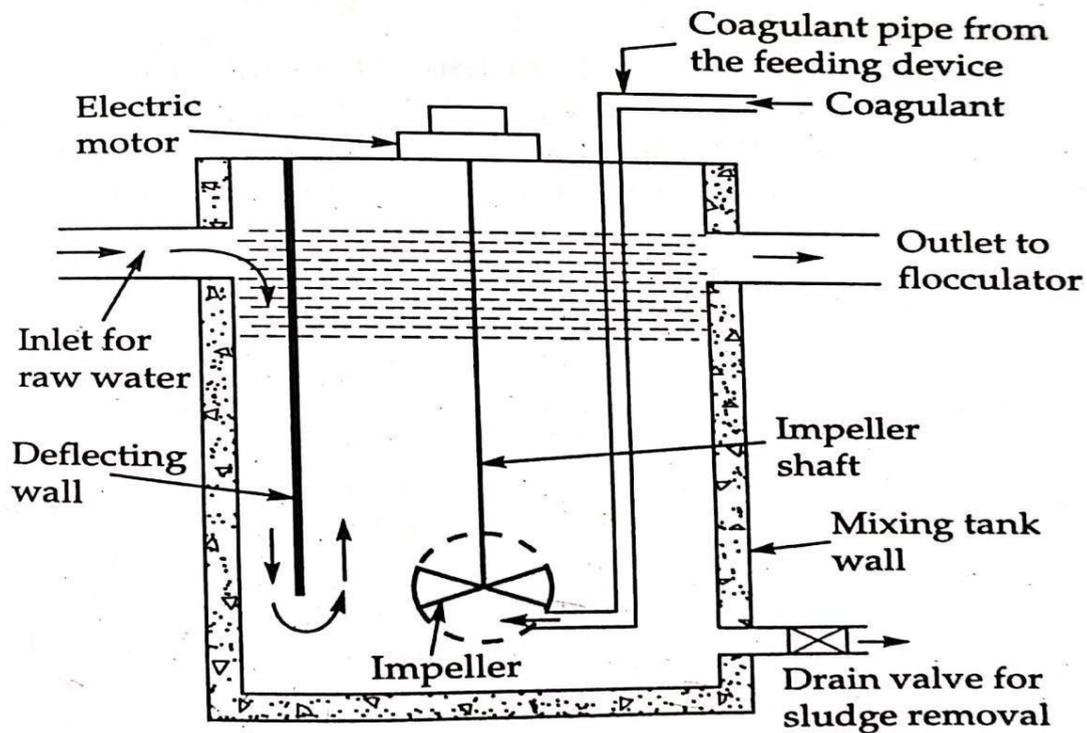
1	2	3	4
5	6	7	8
9	10	11	12

ALL DIMENSIONS ARE IN CMS

CANAL ESCAPE

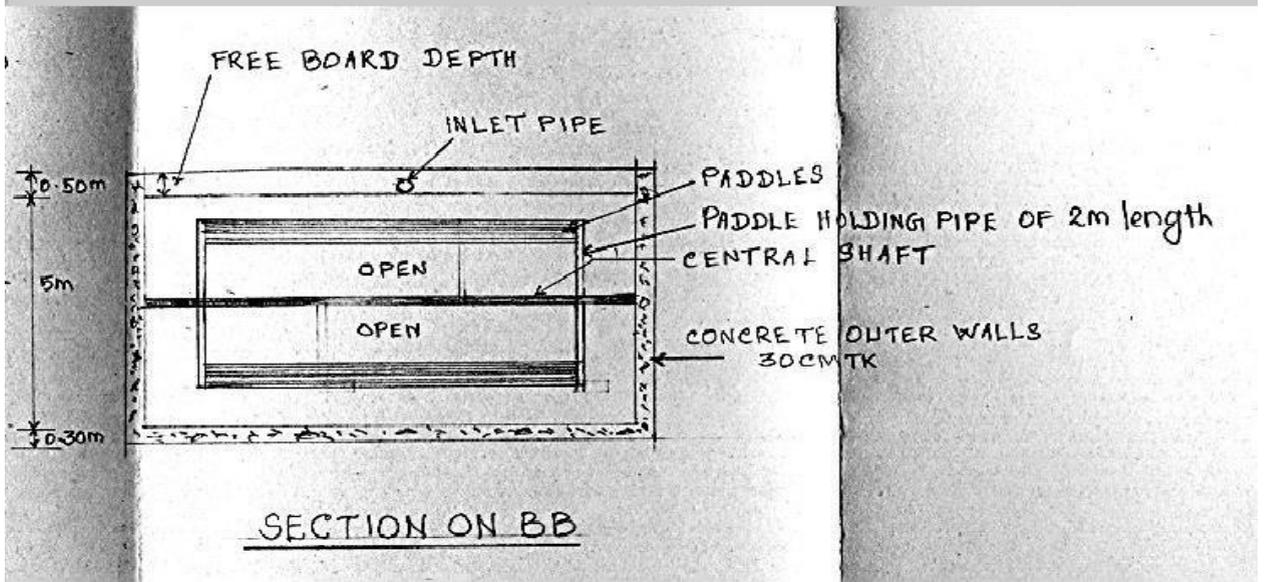
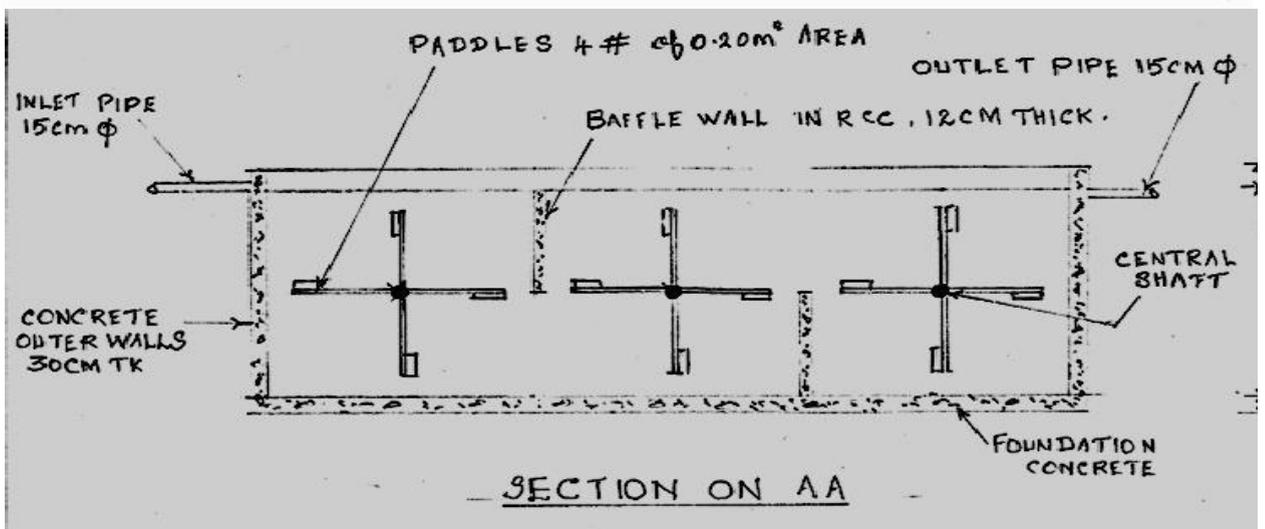
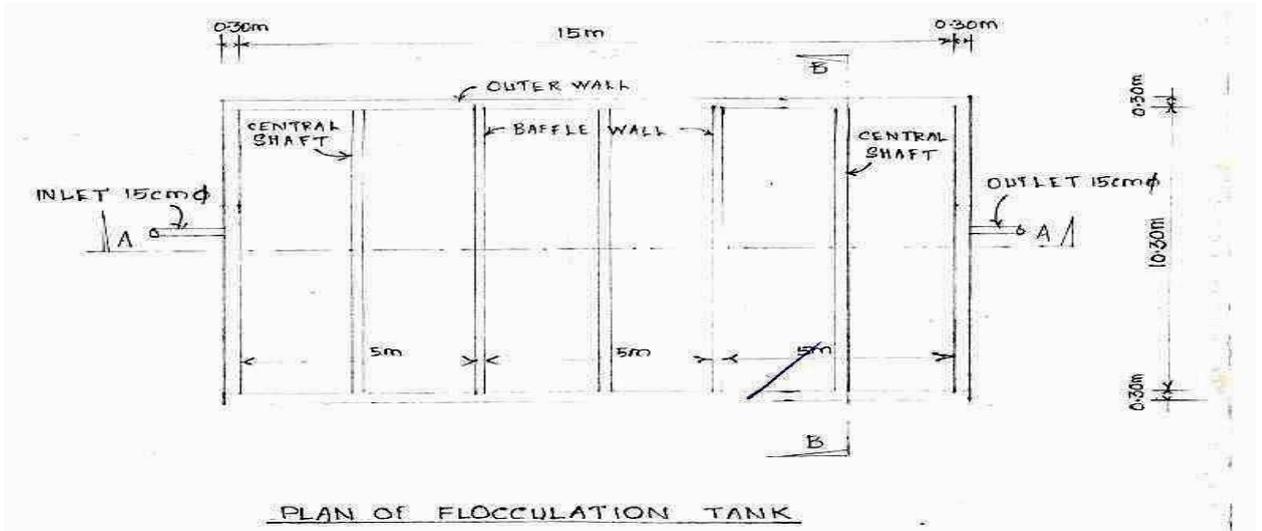
Ex. No.	FLASH MIXER
Date:	

In a rapid mixing tank alum of 45mg/lit is blended with the flow of 50000 m³/day with a detention period of 2mins and a fan type turbine with 6 plate impeller are used. Take $K=1.65$. Determine the dimensions of the tank, power input, velocity gradient and dimensionless number.



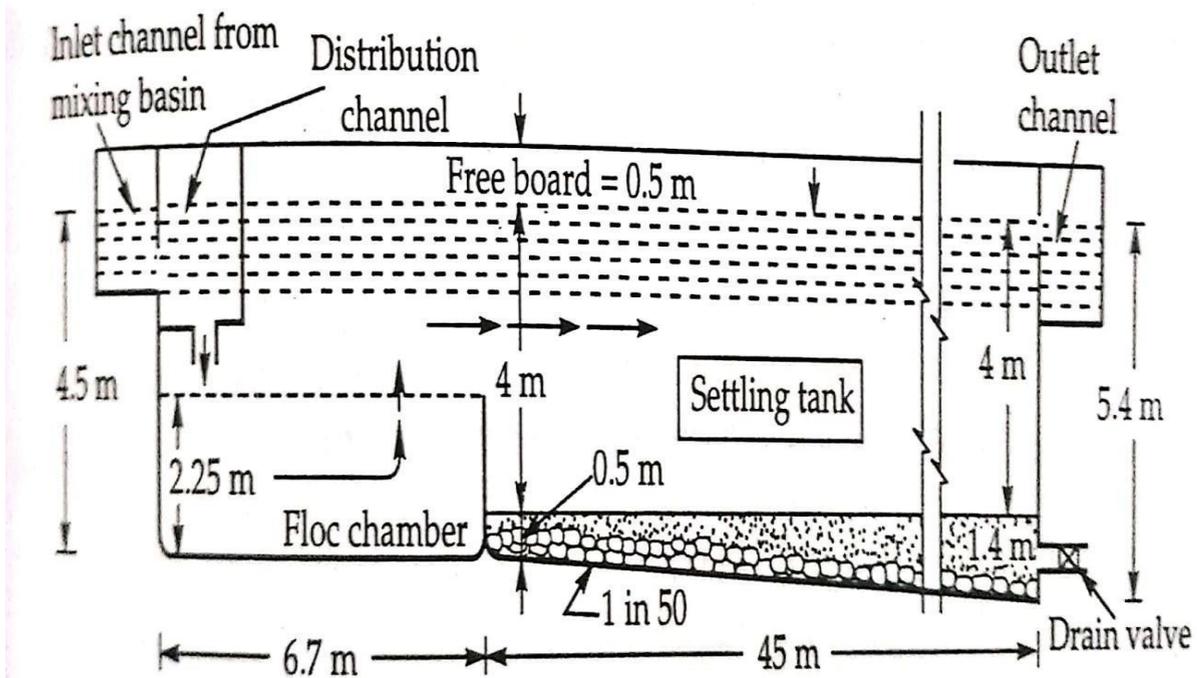
Ex. No.	FLOCCULATOR
Date:	

Design a flocculator for a design to be treated equal to $300\text{m}^3/\text{h}$. Assume suitable permissible values of various parameters of design. Assume a temperature of 20°C .



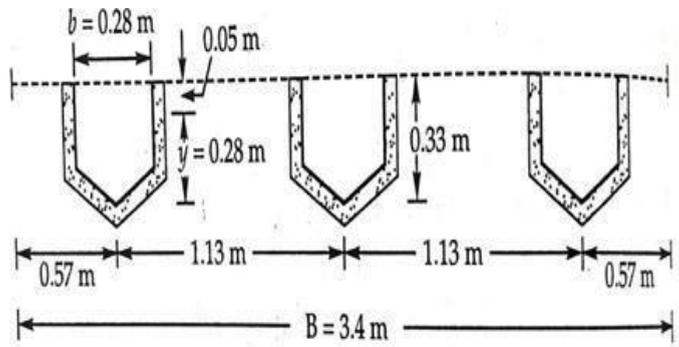
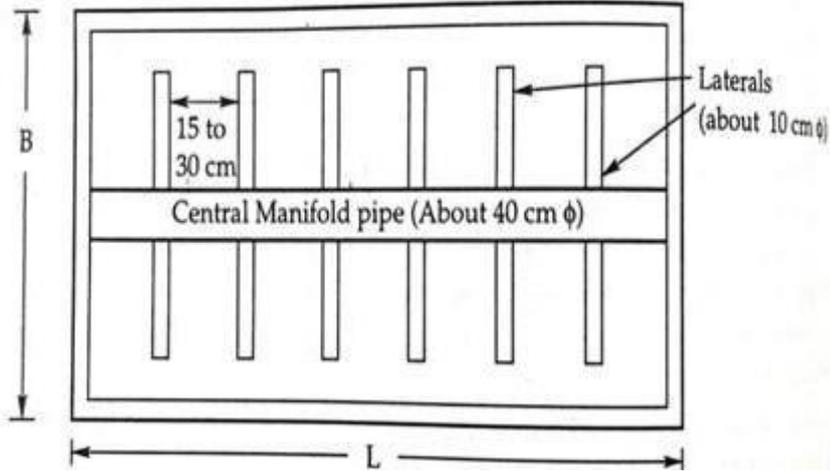
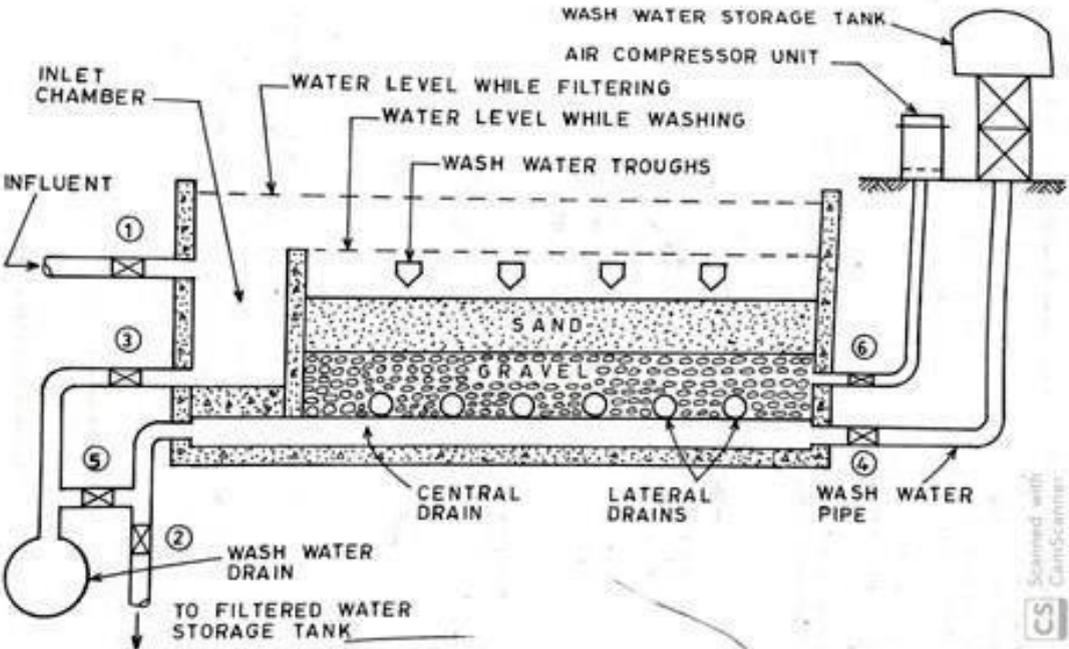
Ex. No.	CLARIFIER
Date:	

Design a Clarifier (coagulation cum sedimentation tank) with continuous flow for a population of 60,000 persons with a daily per capita water allowance of 120 liters. Make suitable assumptions wherever needed.

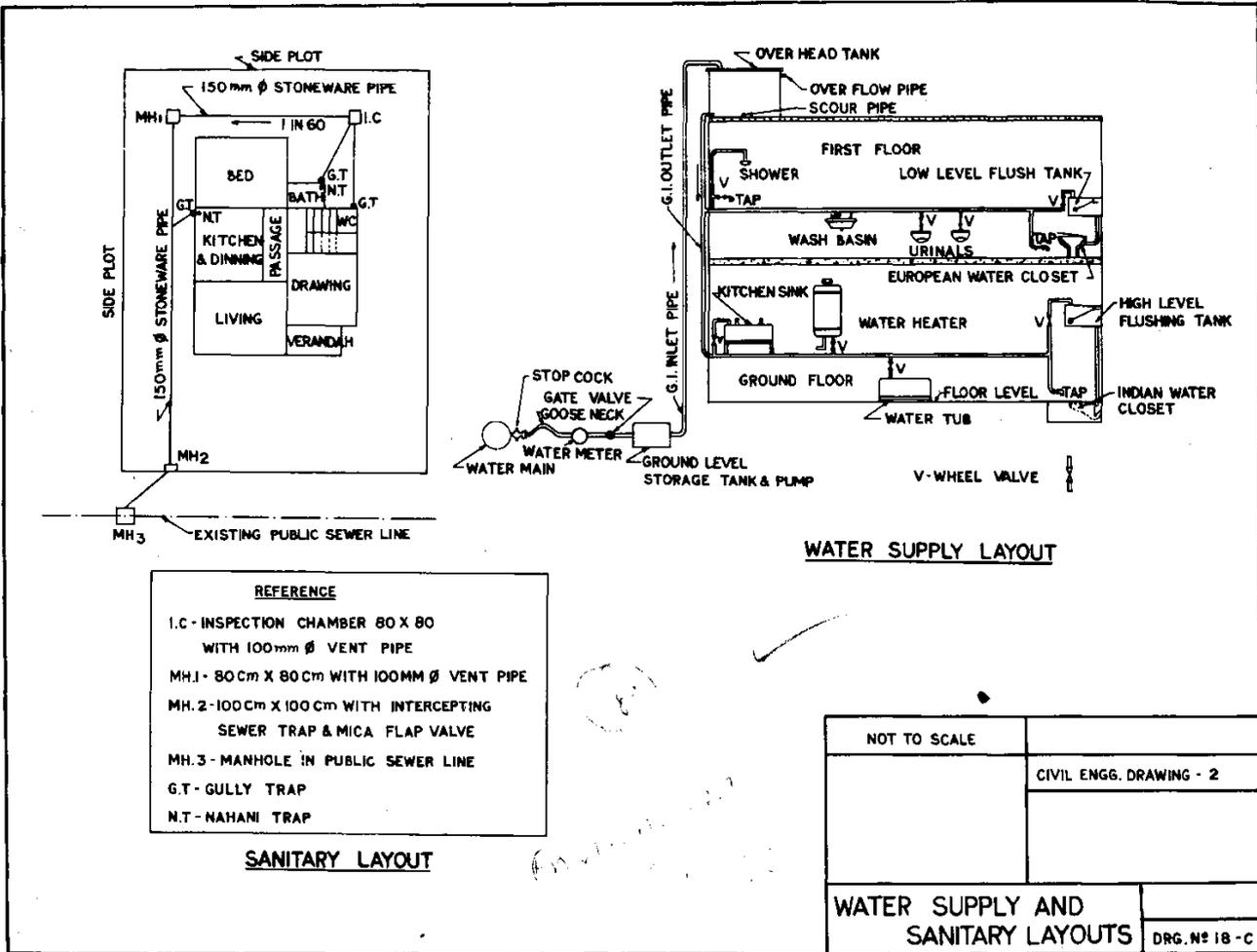


Ex. No.	RAPID SAND FILTER
Date:	

Design the approximate dimensions of a set of rapid sand filters for treating water required for a population of 50000; the rate of supply being 180 litres per day per person. The filters are rated to work 5000 litres per hour per Sq. m. Assume suitable data necessary.

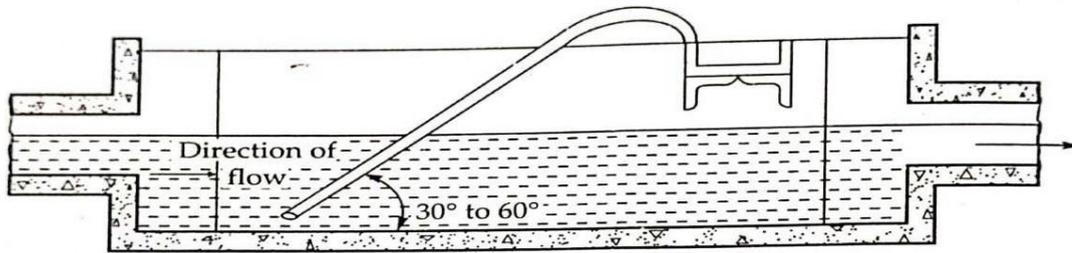


Ex. No.	HOUSE SERVICE CONNECTION FOR WATER SUPPLY & DRAINAGE
Date:	

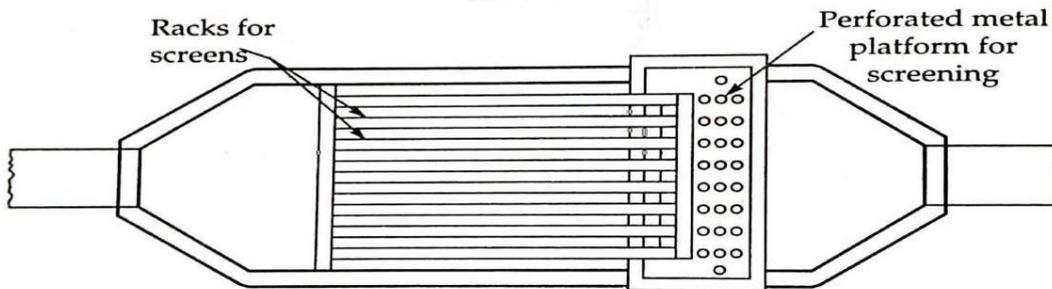


Ex. No.	SCREEN CHAMBER
Date:	

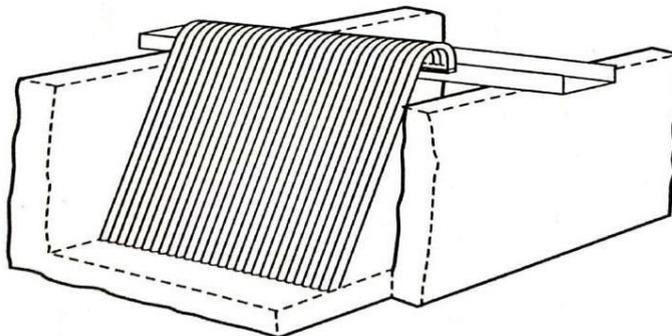
Estimate the screen requirement for a plant treating a peak flow of 60 million litres per day of sewage.



(a) Section



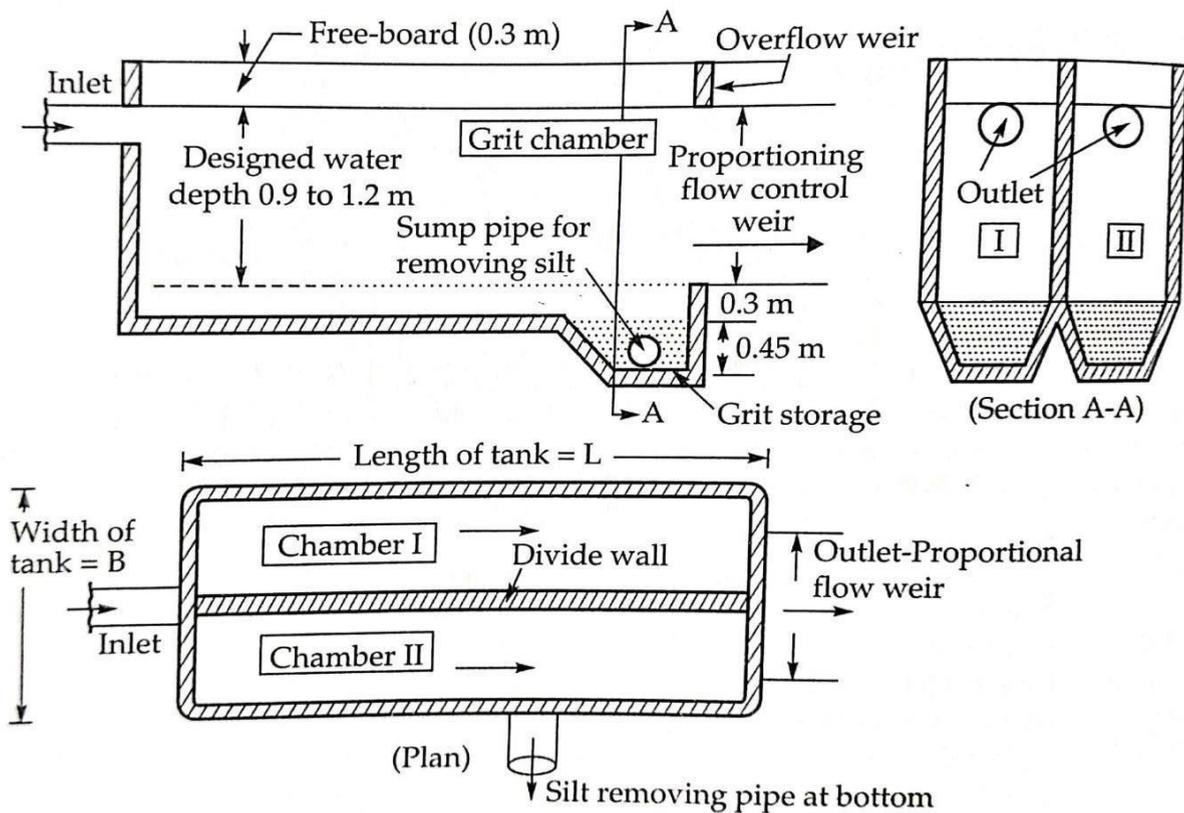
(b) Plan



(c) Prospective view

Ex. No.	GRIT CHANNEL
Date:	

A rectangular grit chamber is designed to remove particles with a diameter of 0.2mm, specific gravity 2.65. Settling velocity for these particles has been found to range from 0.016 to 0.022 m/sec, depending on their shape factor. A flow through velocity of 0.3 m/sec will be maintained by proportioning weir. Determine the channel dimensions for a maximum wastewater flow of 10,000 cu m/day.



Ex. No.

PRIMARY CLARIFIER

Date:

In a rapid flash mixing tank, alum of 45mg/lit is dispersed for a flow of 50000m³/day with a detention period of 2 minutes.

Determine the dimension of the square tank, power input and velocity gradient.

Solution:

$$\text{Alum dosage} = 45 \text{ mg/lit}$$

$$\text{detention period} = 2 \text{ minutes.}$$

$$\text{Total flow} = 50000 \text{ m}^3/\text{day.}$$

$$\text{Volume of tank} = \frac{50000 \text{ m}^3}{24 \times 60 \times 60} \times 2 \times 60$$

$$V = 69.4 \text{ m}^3.$$

Assume diameter of inlet and outlet pipe is 0.30m.

diameter of alum tank pipe = 0.15m.

$$\text{assume depth of tank} = 3.0 \text{ m.}$$

$$\therefore \text{Area of tank} = \frac{69.4 \text{ m}^3}{3.0} = 23.15 \text{ m}^2.$$

Assume the tank is square in shape.

$$\therefore \text{Side of tank} = \sqrt{23.15 \text{ m}^2} = (4.81 \text{ m} \times 4.81 \text{ m}).$$

Say 5m x 5m.

Allow a free board of 0.5m.

∴ Dimensions of the tank = 5m x 5m x 3.5m.

POWER INPUT:

$$\text{Power, } P = K \cdot \rho \cdot n^3 \cdot D^5$$

where,

K = constant (1.60),

n = number of revolution, [assume 250 rpm]

D = diameter of rod, [assume 0.3m]

ρ = density of water (1000 kg/m³).

$$\therefore P = 1.6 \times 1000 \times 250^3 \times 0.3^5$$

$$P = 60.75 \times 10^6 \text{ watts.}$$

VELOCITY GRADIENT:

$$G = \left[\frac{P}{\mu \cdot V} \right]^{1/2}$$

where,

G = velocity gradient.

μ = viscosity of water @ standard temperature, (1.01 × 10⁻³).

V = volume of tank

Baffle wall height above water level = 0.90m (1/3)

Baffle wall height below water level = 0.60m (2/3).

Viscosity of water = μ = 1.01 × 10⁻³ Ns / m².

Volume of Tank = V = (5 × 5 × 3.0) m³.

$$\therefore \text{Velocity gradient, } G = \left[\frac{60.75 \times 10^6}{1.01 \times 10^{-3} \times (5 \times 5 \times 3)} \right]^{1/2}$$

$$G = 28319.25 \text{ s}^{-1}$$

RESULTS:

1. SIZE OF THE FLASH MIXING TANK,

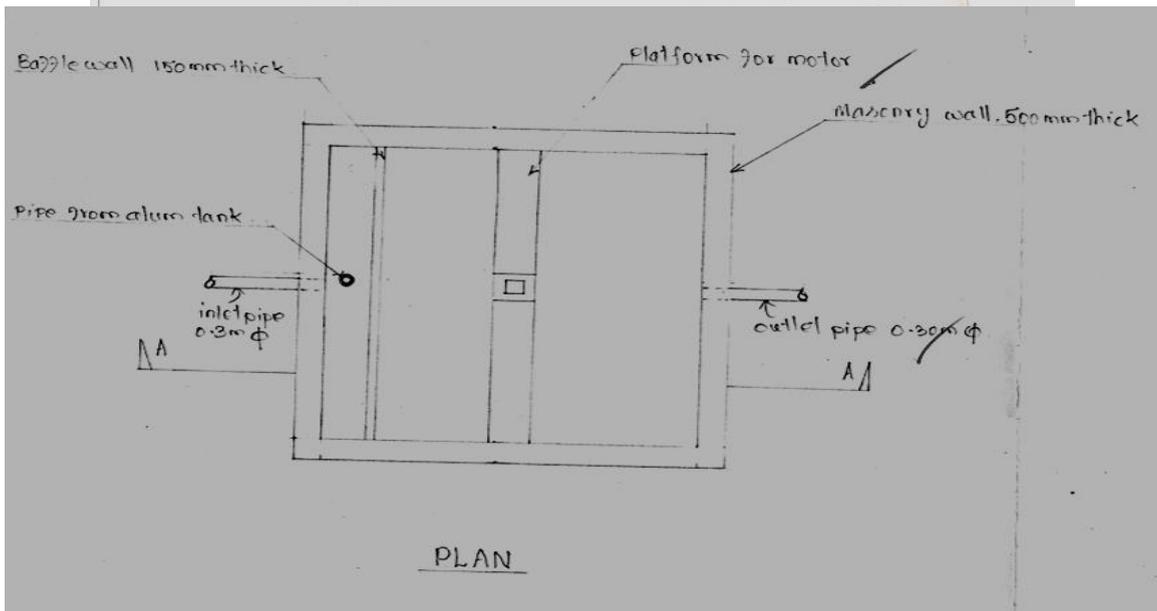
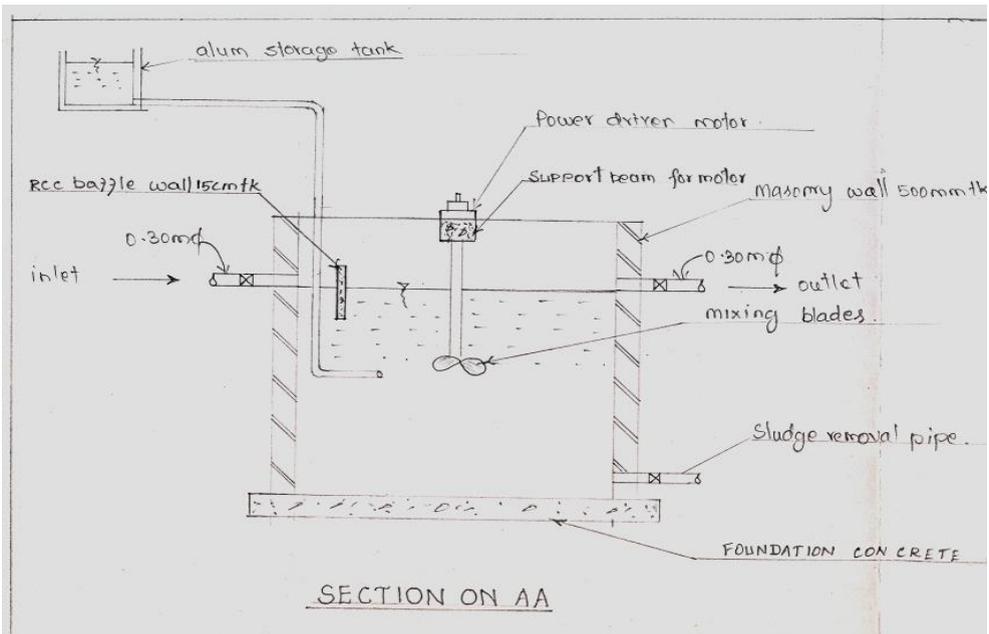
LENGTH = 5.0m.

WIDTH = 5.0m.

DEPTH = 3.5m.

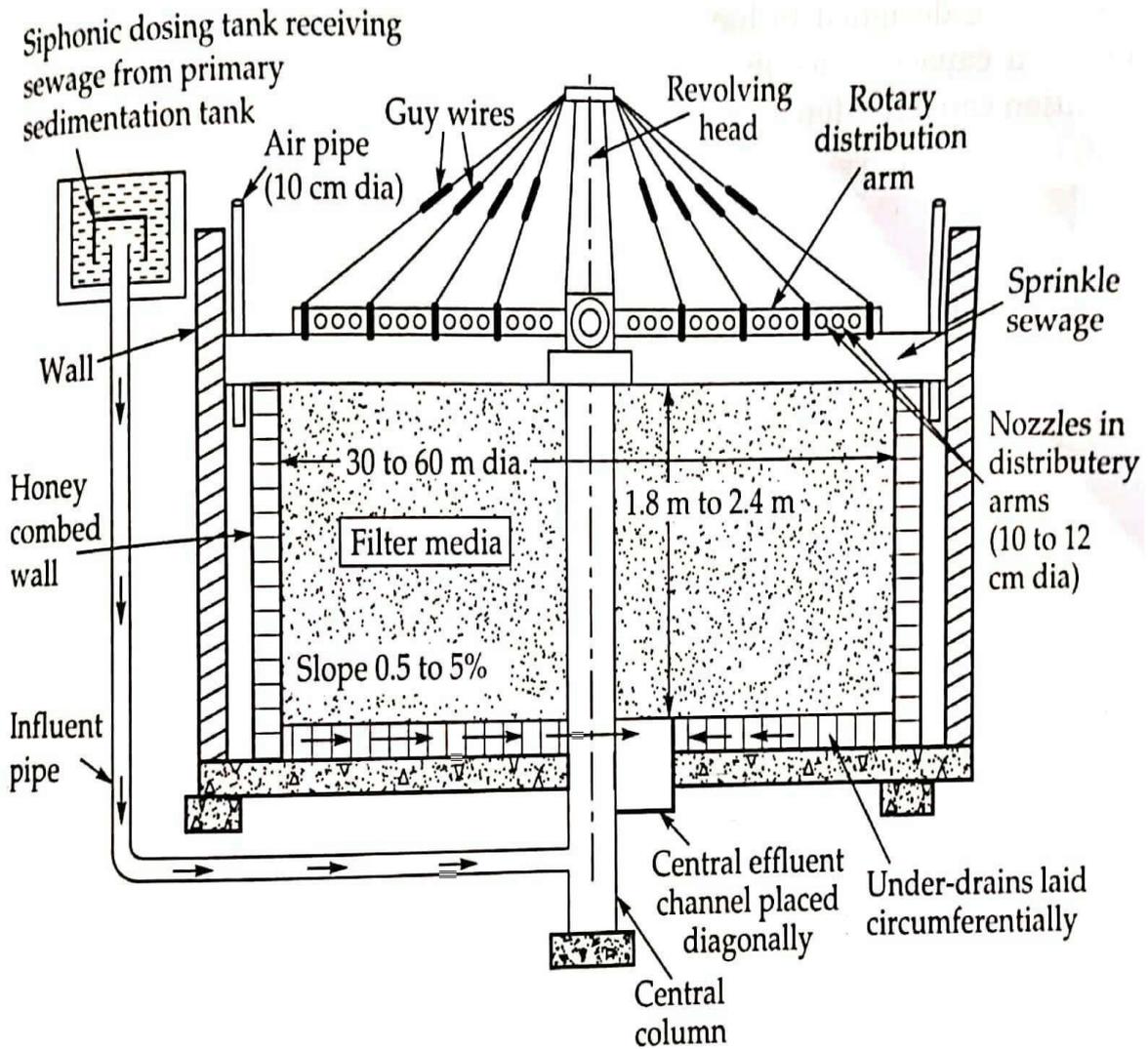
2. POWER INPUT, P = 60.75 × 10⁶ Watts.

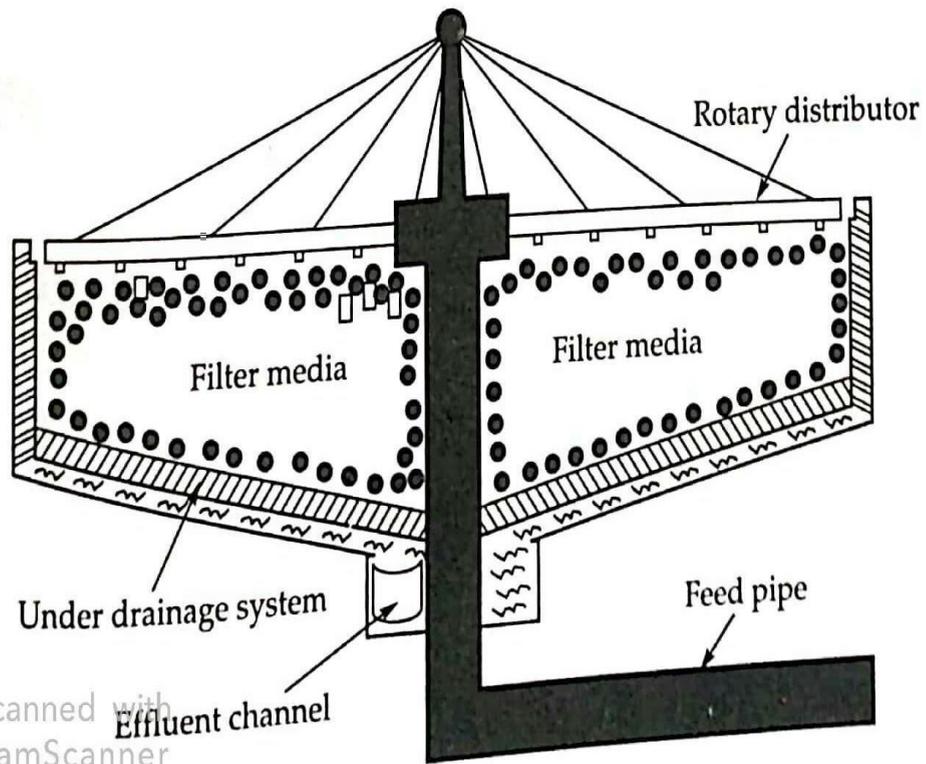
3. VELOCITY GRADIENT, G = 28319.25 s⁻¹



Ex. No.	TRICKLING FILTER
Date:	

Design suitable dimensions of circular trickling filter units for treating 5 million litres of sewage per day. The B.O.D of sewage is 150 mg/l. Also design suitable dimensions for its rotary distribution system, as well as the under drainage system.

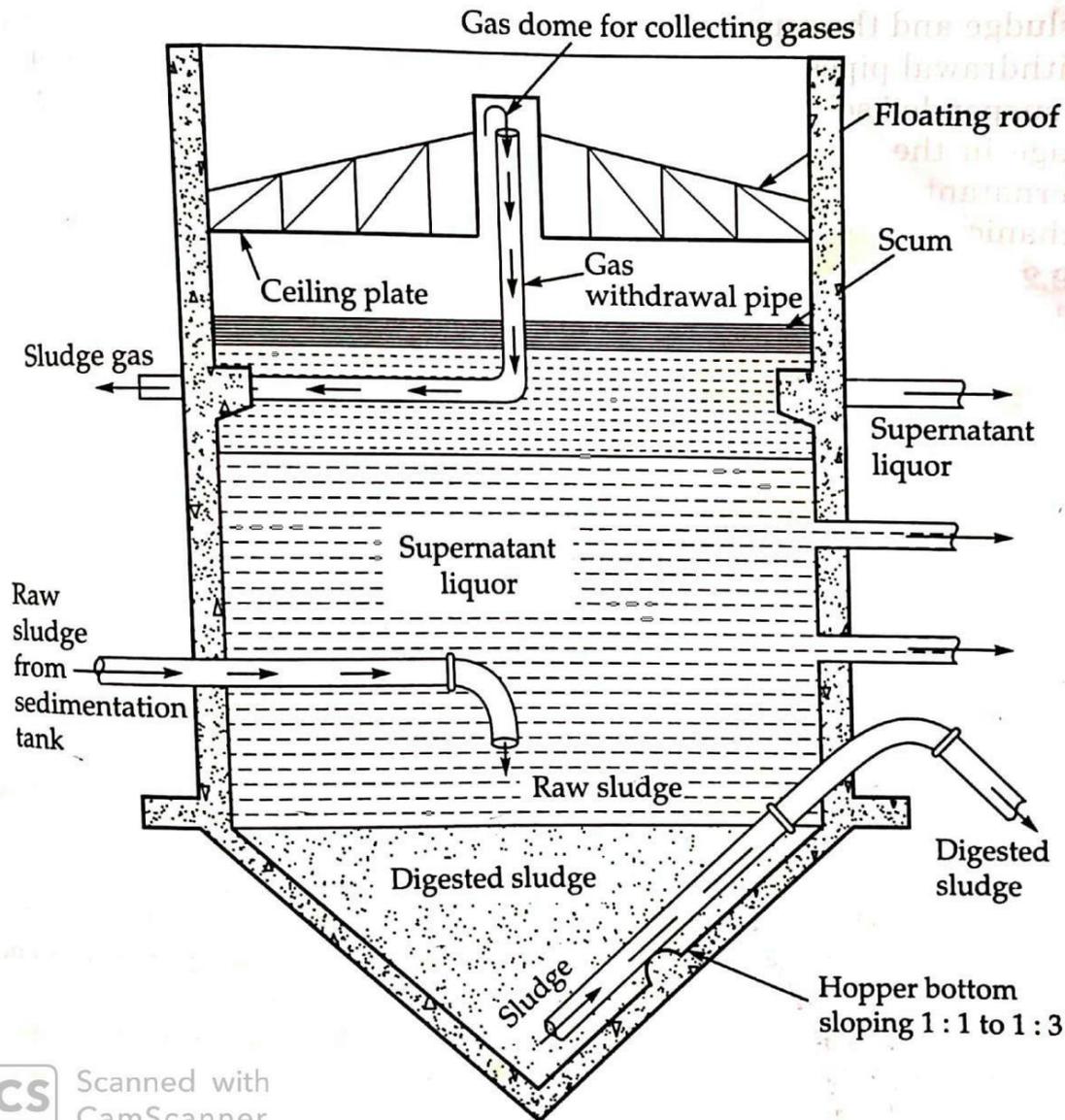




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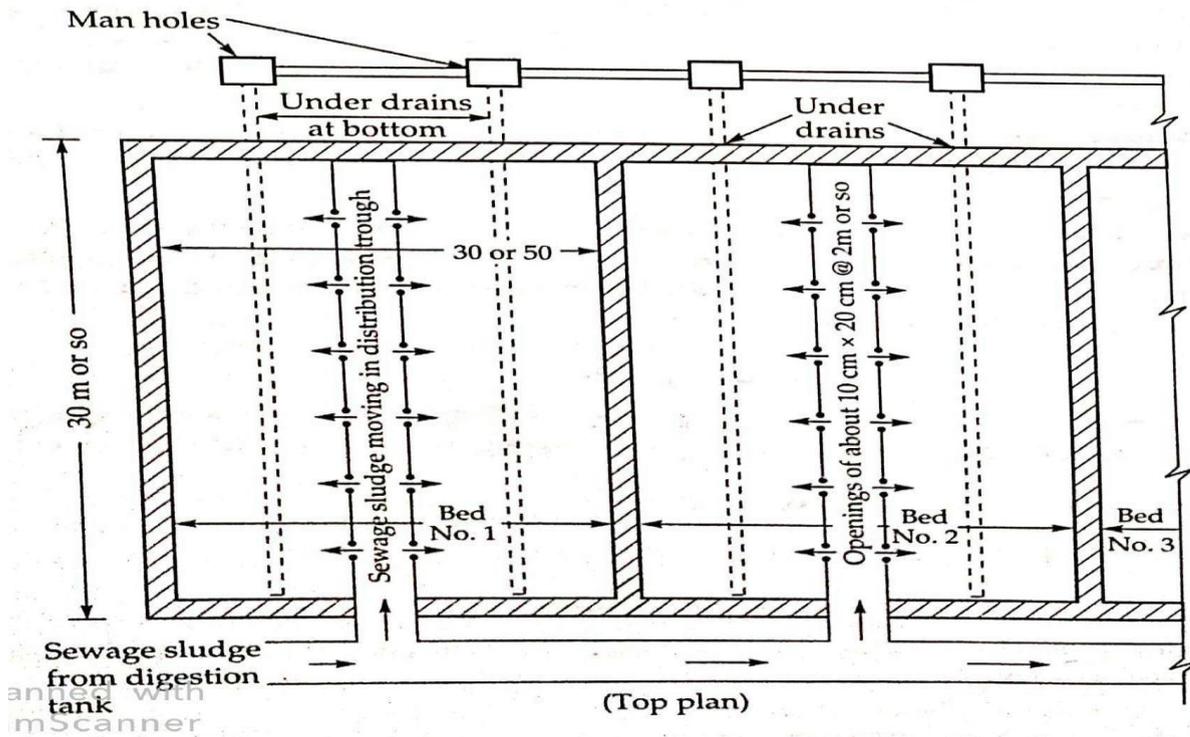
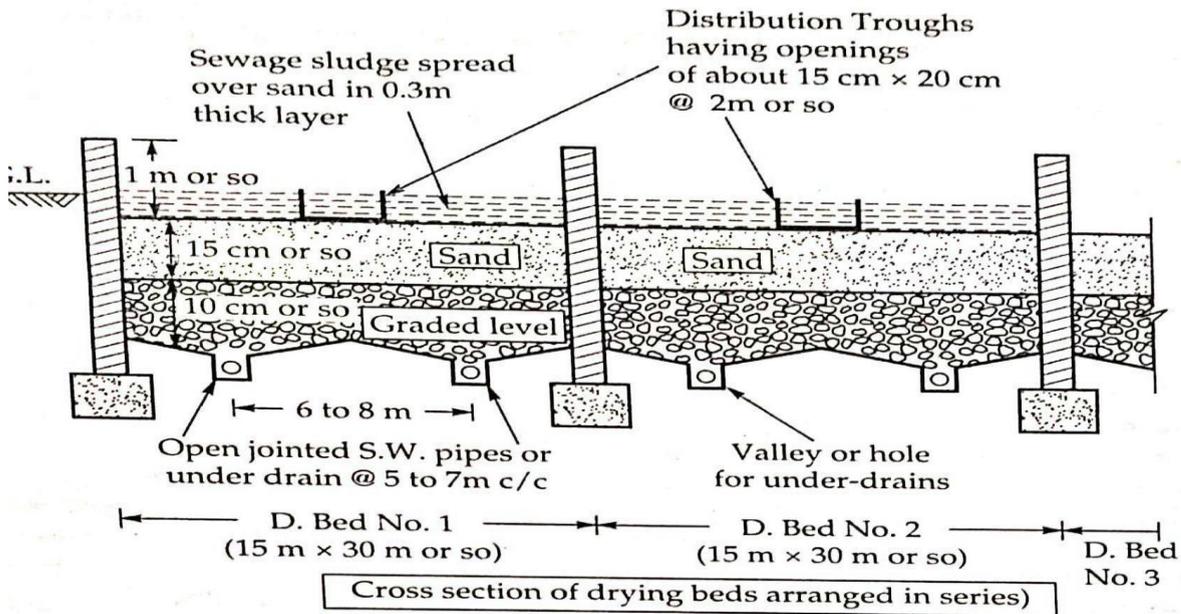
Ex. No.	SLUDGE DIGESTER
Date:	

Design a sludge digester tank for 40000 people. The sludge content per capita per day is 0.068kg. The moisture of the sludge is 94%. The specific gravity of the wet sludge is 1.02 and 3.5 percent of the digester volume is daily filled with fresh sludge which is mixed with the digested sludge.



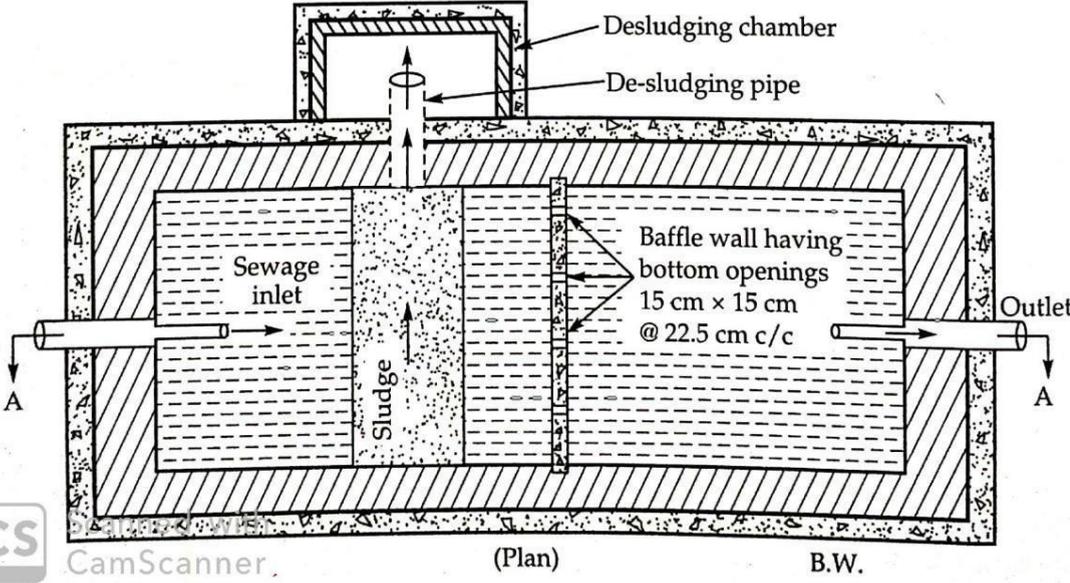
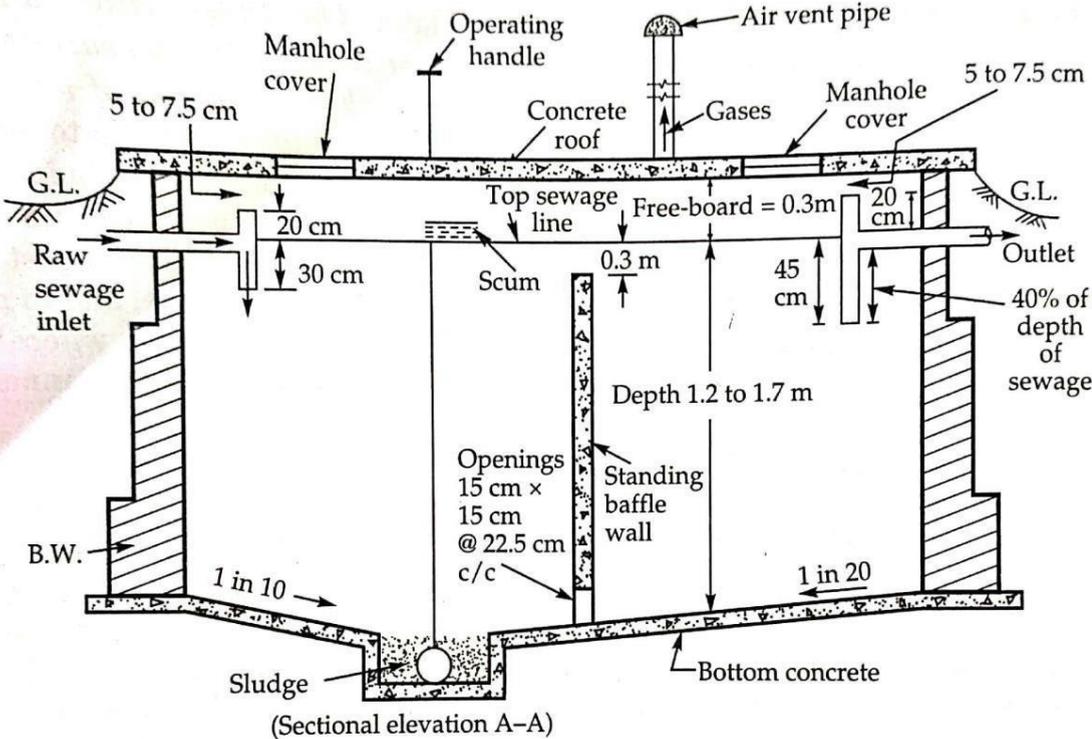
Ex. No.	SLUDGE DRYING BED
Date:	

Calculate the area of land required for drying the sludge from the digestion tank for 40000 population. The sludge content per capita per day is 0.068kg. The moisture of the sludge is 94%. The specific gravity of the wet sludge is 1.02 and 3.5 percent of the digester volume is daily filled with fresh sludge which is mixed with the digested sludge. Also design the dimension of the bed.

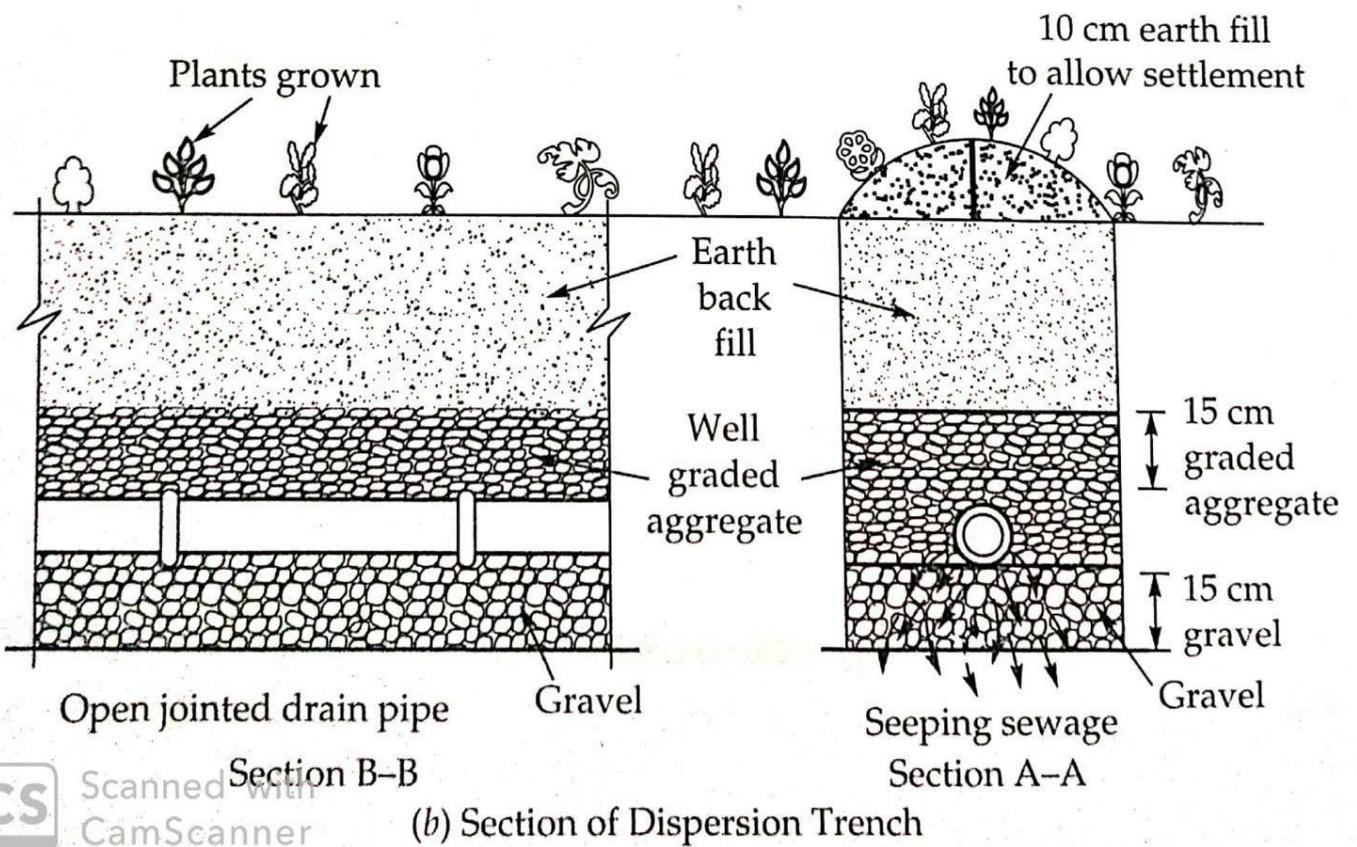
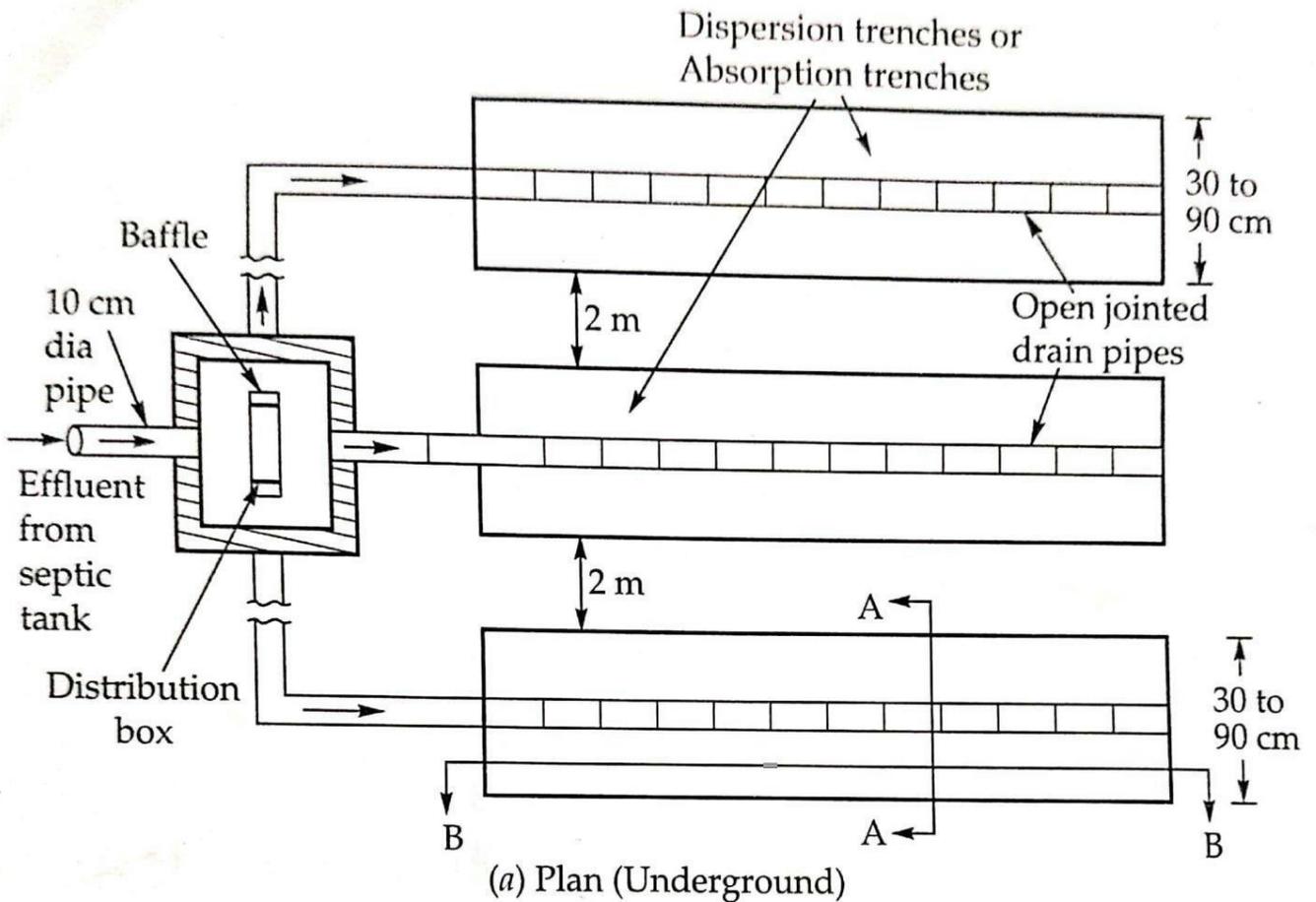


Ex. No.	SEPTIC TANK AND DISPOSAL ARRANGEMENT
Date:	

Design the dimensions of a septic tank for a small colony of 150 persons provided with an assured water supply from the municipal headworks at a rate of 150l/person/day. The percolation rate for the percolation test carried out at the site of the absorption field may be taken as 3 minutes. Assume any data you may need



CS CamScanner



A CANAL ESCAPE

PROBLEM :-

Design a canal escape for the following hydraulic particulars:

- Discharge through canal = 15 cumec
- Discharge through the escape = Half full supply
- F S L = + 32.00m
- Bed level = + 30.50m
- Bed width = 12.00m
- Allowable velocity = 1.00m/sec
- G.L at site = + 30.50m
- Top width of the bank = 3.00m

Good soil for foundation is available at +29.20m Provide a two vented structure with suitable shutter arrangements.

- Draw
- 1) Sectional plan
 - 2) Cross section thro' end spans
 - 3) Elevation

DESIGN

- Full supply Discharge = 15.00 cumec
- Discharge thro' Escape = $\frac{1}{2} \times 15 = 7.50 \text{ m}^3/\text{sec}$
- Sill level is taken as the B.L of canal = + 30.50
- Depth of flow over the sill = 32.00 - 30.50 = 1.50m

Vent way

- Adopt a vent height of 1.00m
- Head over the vent = 1.50 - 1.00 = 0.50m = b
- Discharge = $C_d \times A \times \sqrt{2gh} = 7.50 \text{ m}^3/\text{sec}$
- Assume $C_d = 0.78$; Area = $L \times 1.00$
- Where L = width of the vent way

$$\therefore L = \frac{7.50}{0.78 \times \sqrt{2 \times 9.81 \times 0.50}} = 3.20\text{m}$$

- Two vents are provided
- Size of each vent = 1.60m \times 1.00m.

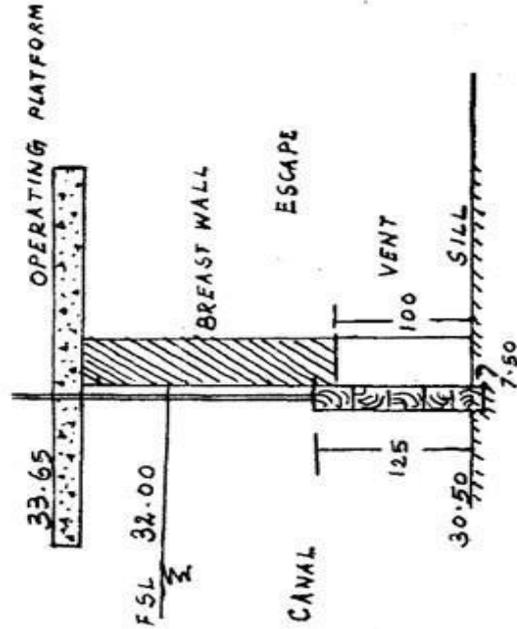
Ex. No.

Date:

CANAL ESCAPE

R L of the operating platform

The size of the shutter is slightly bigger than the size of the vent with 25 cm above the vent hole and 7.50cms below the sill level (Refer the fig):



(Fig)

R.L of the bottom of the operating platform is fixed at 28.50m
PIER and ABUTMENTS

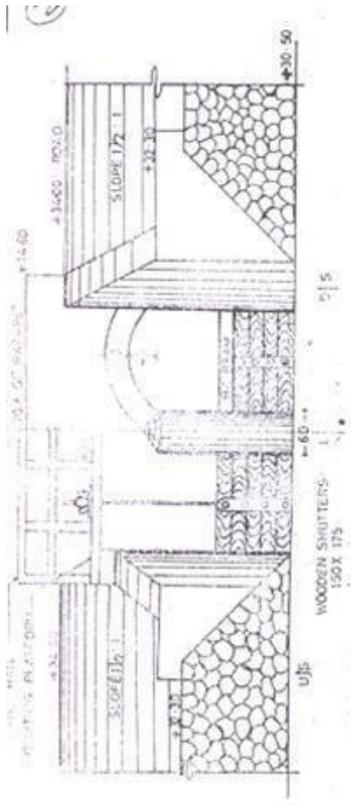
- The span width = 1.60m
- The thickness of the pier = $\frac{\text{Span}}{3} = 0.60$ (approx)

Assume the top width of the abutment as 45 cms Assuming a thickness of 30 cms for base concrete for the foundation.

- Height difference = Crown level of the arch - Top level of concrete = 33.00 - 29.50 = 3.50m.
- Base width of abutment = $0.4 \times 3.50 = 1.40\text{m}$.

BED PITCHING

- Assuming the bed soil is loamy,
- the creep length = $5.00 \times h$
= $5.00 \times 1.60 = 8.0\text{m}$.
- Length of pier portion = 4.50m
- Required length of bed pitching = 8.0 - 4.50 = 3.50m.
- Provide brick on edge bed pitching for 1.60m on the U/S side and 2.60m on the D/S side.



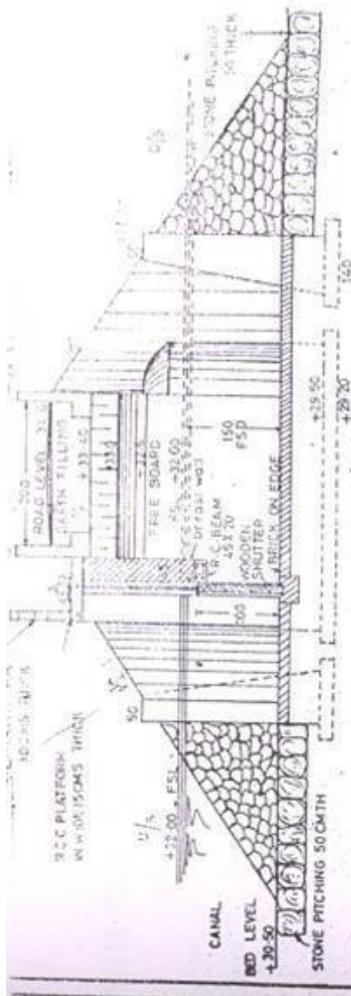
END VIEW

HYDRAULIC DATA

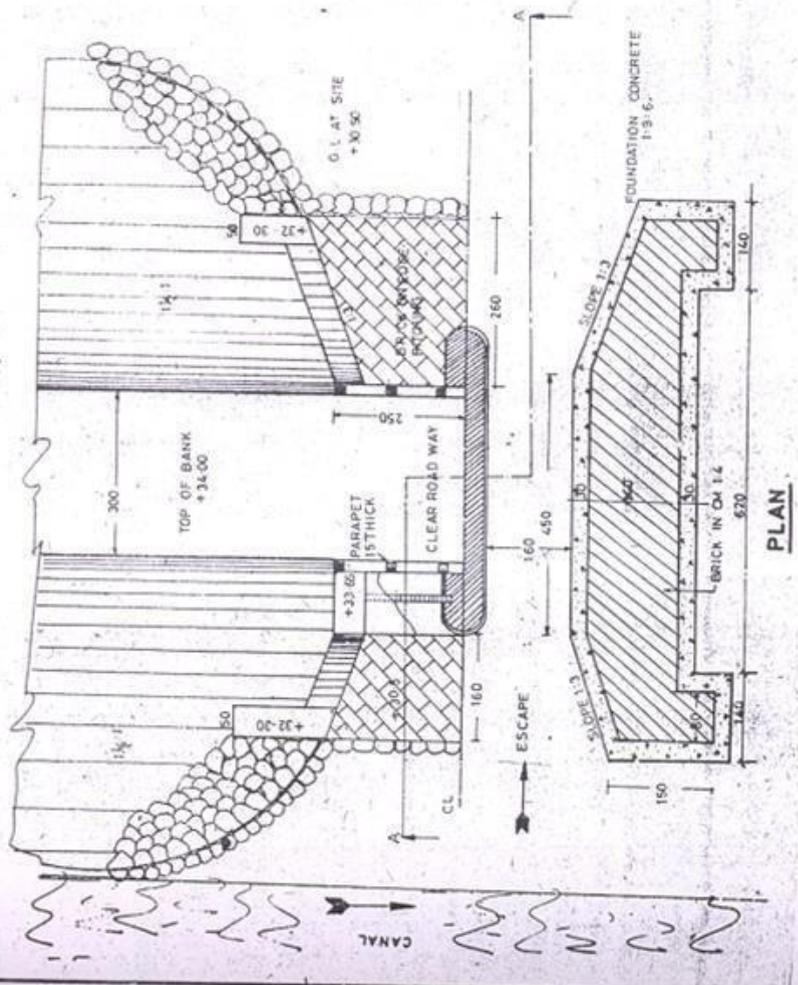
- 1 DISCHARGE THROUGH CHANNEL 3 M³/SEC
- 2 DISCHARGE THROUGH ESCAPE 75 M³/SEC
- 3 F.S.D. -32.00 M
- 4 S.L. LEVEL 1.50 M
- 5 F.S.D. 4.30 M
- 6 S.L. AT SITE 4.30 M
- 7 TOP OF BANK 2 M
- 8 VELOCITY OF FLOW 1 M/SEC
- 9 BED WIDTH 12.00 M

ALL DIMENSIONS ARE IN CMS

CANAL ESCAPE



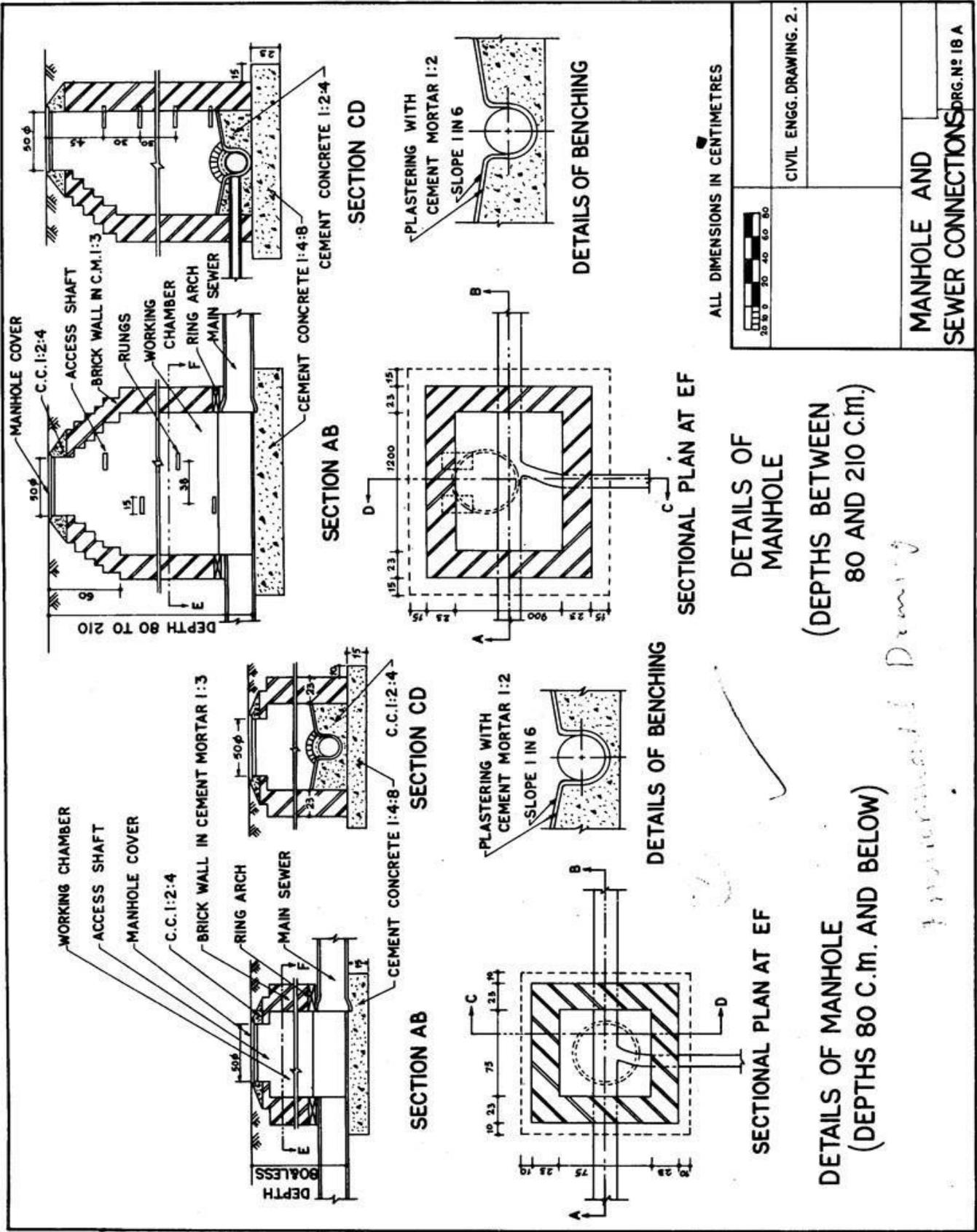
SECTION AA



PLAN

TOPIC BEYOND SYLLABUS

Ex. No.	MANHOLE AND SEWER CONNECTION
Date:	



DETAILS OF
MANHOLE
(DEPTHS BETWEEN
80 AND 210 C.M.)

DETAILS OF MANHOLE
(DEPTHS 80 C.M. AND BELOW)

Practical Drawing

VIVA VOCE QUESTIONS

Aqueduct The hydraulic structure in which irrigation canal is passing over the drainage is known as aqueduct. This structure is suitable when bed of canal is above the highest flood level of drainage. In this case, the drainage water passes clearly below the canal.

Base Period the time period that elapses from the instant of sowing to instant of harvesting is called crop or base period.

Canal escapes are the safety valves of canals & must be provided at regular intervals depending upon the importance of channel & availability of suitable drainage for the disposal of the exposed water.

Canal Outlet is a masonry structure through which water is admitted from the distributary into a watercourse. It also acts as a discharge measuring device.

Canal regulator Structure at the head of canal taking off from a reservoir may consist of number of spans separated by piers and operated by gates.

Canal Siphon if the FSL of the canal is sufficiently above the bed level of the drainage trough, so that the canal flows under syphonic action.

Cross-Drainage Work is an irrigation project, when the network of main canals, branch canals, distributaries, etc. are provided, then these canals may have to cross the natural drainages like rivers, streams, etc. at different points within the command area of the project. The crossing of the canals with such obstacle cannot be avoided. So, suitable structures must be constructed at the crossing point for the easy flow of water of the canal and drainage in the respective directions.

Diversion Headwork any hydraulic structure, which offers water to the off taking canal, is called diversion headwork.

Canal Fall Generally, the slope of the natural ground surface is not uniform throughout the alignment. Sometimes, the ground surface may be steep and sometimes it may be very irregular with abrupt change of grade. In such cases, a vertical drop is provided to step down the canal bed and then it is continued with permissible slope until another step down is necessary. This is done to avoid unnecessary huge earth work in filling.

Divide wall is a long wall constructed at right angles to the weir or barrage, it may be constructed with stone masonry or cement concrete. On the upstream side, the wall is extended just to cover the canal head regulator and on the downstream side it is extended upto the launching apron.

Gravity Dam is a structure which is designed in such a way that its own weight resist external forces and it is more durable.

Gross commanded area it is the total area bounded within the irrigation boundary of a project. It includes the cultivable as well as uncultivable areas.

Irrigation is artificial application of water to land for supplementing the naturally available moisture in the root-zone soil for the purpose of agricultural production.

Inlets and Outlets. An inlet is a structure constructed in order to allow the drainage water to enter the canal and get mixed with the canal water and thus to help in augmenting canal supplies. Such a structure is generally adopted when the drainage discharge is small and the drain crosses the canal with its bed level equal to or slightly higher than the canal F.S.L.

Level Crossing In this type of cross-drainage work, the canal water and drain water are allowed to intermingle with each other. A level crossing is generally provided when a large canal and a huge drainage (such as a stream or a river) approach each other practically at the same level.

Storage head works: when a dam is constructed across a river valley to form a storage reservoir, it is known as storage head works. The water is supplied to the canal from this reservoir through the canal head regulator. Again this reservoir serves the multipurpose functions such as hydro-electric power generation, flood control, fishery, etc.,

Super passage When the FSL of the canal is sufficiently below the bottom of the drain trough, so that the canal water flows freely under gravity.

Syphon Aqueduct if the HFL of the drain is higher than the canal bed and the water passes through the aqueduct barrels under syphonic action.

Tank Sluice is an opening in the form of a culvert or a pipe running through or under the bank bund, and supplying water from the tank to the distributary channel below, to meet the irrigation or other water requirements, as and when needed. Suitable wing walls and other bank connections are also provided as required at the head and tail end of the culvert

Weir The major part of the water is achieved by a raised crest or a small part is achieved by raising shutters then this barrier is known as weir.

Environmental Engineering

Activated sludge An active population of microorganisms used to treat wastewater, or the process in which the organisms are employed.

Aeration Intimate contact of the atmosphere and water to add air (oxygen) to the water. The term is also applied to gas stripping where an undesirable gas is removed from the water.

Anaerobic process A process which only occurs in the absence of molecular oxygen.

Attached growth reactor A reactor in which the microorganisms are attached to engineered surfaces within the reactor. Examples of attached growth reactors are the trickling filter and the rotating biological contactor.

Biochemical oxygen demand (BOD) The amount of oxygen required to oxidize any organic matter present in a water during a specified period of time, usually 5 days. It is an indirect measure of the amount of organic matter present in a water.

Biofilm A film of microorganisms attached to a surface, such as that on a trickling filter, rotating biological contactor, or rocks in natural streams.

Catchment - Area from which rainwater is received by a river.

Chemical oxygen demand (COD) The amount of oxygen required to oxidize any organic matter in the water using harsh chemical conditions.

Clarifier (sedimentation basin) A tank in which quiescent settling occurs, allowing solid particles suspended in the water to agglomerate and settle to the bottom of the tank. The solids resulting from the settling being removed as sludge.

Coagulation Particle destabilization to enhance agglomeration.

Colloids Small particles which have a negligible settling velocity. These particles have a very small mass so gravitational force is low compared to surface frictional forces. Typical colloidal sizes range from 10⁻³ mm to 1 mm.

Communication pipes: It is a pipe taking off from the ferrule for the house connection. It is owned and managed by the water supply authority. Communication pipe terminates at the boundary of the consumers premises.

Design Period The future period for which a provision is made in the water supply scheme is known as design period.

Discrete settling Settling in which individual particles settle independently, neither agglomerating or interfering with the settling of the other particles present. This occurs in waters with a low concentration of particles.

Disinfection The process of killing the infective bacteria from the water and making it safe to the user is called disinfection.

Dissolved oxygen (DO) The amount of molecular oxygen dissolved in water.

Dilution Factor is defined as the ratio of the amount of river water to the amount of the sewage

Domestic water demand The quantity of water required in the houses for drinking, bathing, cooking, washing etc is called domestic water demand and mainly depends upon the habits, social status, climatic conditions and customs of the people. As per IS: 1172-1963, under normal conditions, the domestic consumption of water in India is about 135 litres/day/capita.

Effluent The fluid exiting a system, process, tank, etc. An effluent from one process can be an influent to another process.

Effluent based standards Standards which set concentration or mass per time limits on the effluent being discharged to a receiving water.

Facultative A group of microorganisms which prefer or preferentially use molecular oxygen when available, but are capable of using other pathways for energy and synthesis if molecular oxygen is not available.

Ferrule: It is gunmetal or bronze screwed into the hole drilled in CI pipe mains. Communication pipe takes off from the ferrule. The pressure in the domestic supply and equal distribution among the house connection are effected by adjusting the ferrule opening. Normally the ferrule opening is equal in area to the area of flow in communication pipe.

Fixed solids (FS) are the solids that do not volatilize at 550°C

Fixed suspended solids (FSS) is the matter remaining from the suspended solids analysis which will not burn at 550°C. It represents the non-filterable inorganic residue in a sample.

Filtration The process of passing the water through beds of sand or other granular materials is known as filtration.

For removing bacteria, colour, taste, odours and producing clear and sparkling water, filters are used by sand filtration 95 to 98% suspended impurities are removed.

Flocculant settling Settling in which particle concentrations are sufficiently high that particle agglomeration occurs. This results in a reduction in the number of particles and an increase in average particle mass. As agglomeration occurs higher settling velocities result.

Hardness The sum of the divalent cation concentrations expressed as meq/L or mg calcium carbonate per liter [mg CaCO₃/L]. It is important because hard waters require increased amounts of soap for bathing or washing clothes and because of scale formation on piping, cooking vessels, water heaters, boilers, heat exchangers, etc.

Heterotrophic A group of organisms which obtain carbon for synthesis from other organic matter or proteins.

In situ treatment Treatment of a waste in place, as opposed to pumping or digging the waste up and then treating it.

Infiltration The movement of water from the surface of the land through the unsaturated zone and into the groundwater. This occurs during and immediately after precipitation events. It can also occur at the bottom of lakes and rivers.

Influent The fluid entering a system, process, tank, etc. An effluent from one process can be an influent to another process.

Intakes are structures which essentially consists of opening, grating or strainer through which the raw water from river, canal or reservoir enters and carried to the sump well by means of conducts water from the sump well is pumped through the rising mains to the treatment plant.

Mixed liquor suspended solids (MLSS) The total suspended solids concentration in the activated sludge tank.

Mixed liquor volatile suspended solids (MLVSS) The volatile suspended solids concentration in the activated sludge tank.

Organic compound Any compound containing carbon except for the carbonates (carbon dioxide, the carbonates and bicarbonates), the cyanides, and cyanates.

Primary treatment Treatment which includes all operation prior to and including primary treatment, e.g., bar screening, grit removal, comminution, and primary sedimentation.

Per capita demand If 'Q' is the total quantity of water required by various purposes by a town per year and 'p' is population of town, then per capita demand will be

$$\text{Per capita demand} = \frac{Q}{P \times 365} \text{ litres/day}$$

Reaeration The dissolving of molecular oxygen from the atmosphere into the water.

Saddle: it is used in place of ferrule for mains of AC or PVC pipes

Screens are fixed in the intake works or at the entrance of treatment plant so as to remove the floating matters as leaves, dead animals etc.

Secondary treatment In wastewater treatment, the conversion of the suspended, colloidal and dissolved organics

remaining after primary treatment into a microbial mass which is then removed in a second sedimentation process. Secondary treatment included both the biological process and the associated sedimentation process.

Sedimentation The gravity settling, and thus removal, of materials more dense than the suspending fluid.

Service pipe: it is the part of the house connection beyond the stop cock. It is owned and maintained by the consumer. No pumps shall be installed on this pipe.

Sludge A mixture of solid waste material and water. Sludges result from the concentration of contaminants in water and wastewater treatment processes. Typical wastewater sludges contain from 0.5 to 10 percent solid matter. Typical water treatment sludges contain 8 to 10 percent solids.

sludge age is defined as the average time for which particles of suspended soil remain under aeration

Sludge Volume Index is defined as the volume occupied in ml by 1 gm of solids in the mixed liquor after settling for 30 minutes and is determined experimentally

Softening The removal of divalent cations by precipitation or ion exchange.

Sterilization The destruction or inactivation of all microorganisms.

Suspended growth reactor A reactor in which the microorganisms are suspended in the wastewater. Examples of suspended growth reactors are activated sludge reactors and anaerobic digesters. See attached growth reactor.

Total dissolved solids (TDS) is the amount of dissolved matter in the water.

Total solids (TS) is the amount of organic and inorganic matter which is contained in a water.

Total suspended solids (TSS) is the amount of suspended (filterable) matter in a water.

Trickling filter An attached growth biological process in which the microbial film is attached to non-moving rock or plastic media.

Ultimate biochemical oxygen demand (BOD_u) The total amount of oxygen required to oxidize any organic matter present in a water, i.e. after an extended period, such as 20 or 30 days.

Volatile solids (VS) is the amount of matter which volatilizes (or burns) when a water sample is heated to 550°C.

Volatile suspended solids (VSS) is the non-filterable residue remaining after firing the total suspended solids at 550°C. See total suspended solids and fixed suspended solids.

Water main: A water supply pipe vests in the administrative authority for the use of public or community.

Watermeter: It is installed to measure the flow. It is an integrating meter that it records the total flow upto the time of measurement.

Wastewater Consumed or used water from a municipality or industry that contains dissolved and/or suspended matter.