GOVERNMENT ENGINEERING COLLEGE JHALAWAR

DEPARTMENT OF CIVIL ENGINEERING, 8th Semester

SUBJECT: WATER RESOURCES ENGINEERING-II (8CE1A)

SUBJECT TEACHER: Mr. UTKARSH NIGAM, ASST. PROF.

MODELTEST PAPER-UNIT 1

CANAL REGULATION AND CROSS DRAINAGE WORKS(UNIT-1)

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1. What do you mean by canal regulation work and Canal Falls. Write types of Canal falls

2. Explain different regulations works and components.

3. Draw a neat sketch of Sarda Fall and enlist its various components.

4. What are the different cross drainage works. What are the factors considered in selecting suitable sites. Expail in detail with neat diagram. (Aqueduct, Syphon aqueduct, super passage, canal syphon, inlet and outlets, cross leveleing etc.)

5. Explain Canal Falls briefly and Design a 1.5 m Sarda type fall for a canal having discharge of **50** cumecs with the following:

Bed Level of U/S = **203.5 meter.**

Side slopes of Channel = 1:1.

Bed Level of D/S = **202.0 meter.**

Full supply level U/S = **2 meter.**

Bed width U/S and D/S = **35 meter.**

Soil = Good Loam

Assume Khosla's Theory**.**

MODELTEST PAPER-UNIT 2

TUTORIAL/ ASSIGNMENT SET NO. 2: DIVERSION HEADWORKS (UNIT-2)

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6. What is diversion headwork.

7. What are the different factors for suitable site (location) for canal head works.

8. What are the different types of diversion headworks., Explain the different components of diversion headworks

9. Explain Bligh's creep theory in detail.

10. Explain Khosla's Theory with description of all special cases.

11. What do you mean by Silt Excluder and Silt Ejector.

12. Discuss Enery Dissipation in Detail.

Answer 1.

① <u>Regulation Works:</u> The Water entering the main Canal from the river has to be diverted / divided into different branches and distributories w.r.t. demand. This process is called Canal Regulation. Work.

- The Works constructed to control and regulate discharge, depth, Velocity in canal are called Canal Regulation Works.

- eg. falls, Regulators, Escape, Flumes, outlets. Modules.

Falls: A Canal fall is a structure constructed across a channel to permit lowering down of Water Level in order to dissipate the surplus energy possesed by falling Water which may otherwise Scour the bed and banks of the channels,

Necessity & Location of falls-

1. No loss in command area of channel
2. The FSL of canal remains below the ground level for 0.75 to 0.5 kms.
3. Sudden drop of slope of GL.

② Classification / Types of falls:

1. Ogee falls.
2. Rapids.
3. Trapezoidal Notch falls
4. Stepped falls
5. Well type fall / Cylinder fall.
6. Vertical Drop / Sarda type fall. ✓
7. Straight Glacis fall ✓
8. Montague / Parabolic fall
9. Inglis fall or Baffle falls.
10. Meter or Non-meter fall.

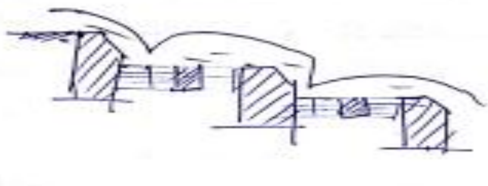
(Glacis is suitable)
(Broad Crest)

① Ogee

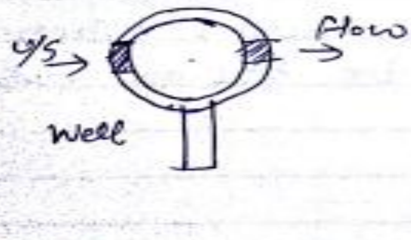
② Rapids 1:15 to 1:20 slopes.

③ Trapezoidal Notch fall

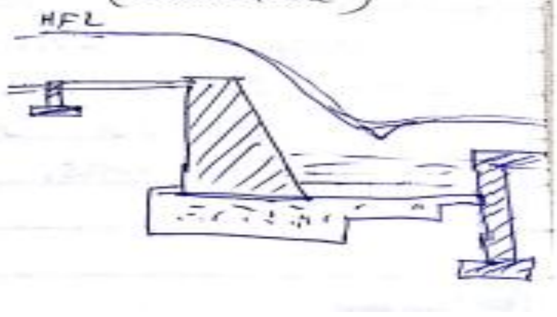
④ stepped falls.



⑤ Well type fall (cylindrical fall)



⑥ Vertical Drop (Sarda fall)



Answer 2.

Elements / Components :-

(A) CISTERN OR CISTERN ELEMENT :

- Provided on d/s of Crest Wall to dissipate surplus energy.
- To reduce impact of Jet, dissipating energy.
- Sloping / Straight glacis, Cistern and roughening devices.

Cistern ↓
(1) Vertical impact
(2) Horizontal Impact
(3) Inclined Impact.
(4) No Impact.

(1) Staggered blocks.
(2) Arrows, (3.) Dented sill.
(4) Deflector.
(5) Biff Wall.
(6) Ribbed pitching.

Distributory Head Regulator / Canal Head Regulator:

- Provided on a canal taking off from a main canal / River. Provided u/s of a barrage at 90° to 110° alignment to control sediment entry.

Functions :- (1.) Regulation of Flow, (2) Water level maintenance
(3.) Discharge control.
(4.) Sediment entry control.
(5.) Maintain min. depth and Water level in off taking canal.

CROSS-REGULATORS ⇒ - Provided on parent channel at the d/s of the off take to head up the parent channel to draw required supply.

Functions :- (1) Effective regulation of entire canal system.
(2) Head up of water level.
(3) Regulate discharge
(4.) Close supply d/s of parent canal for repairs, constructions.
(5) Control water surface slopes.
(6) Absorb fluctuations in the various sections of canal system.

CANAL-ESCAPES: - Canal Escape is a structure constructed on an irrigation channel for the disposal of surplus water from the channel.

Necessity:- (1.) Mistake or difficulty in regulation at the head of a channel.
(2.) Heavy rainfall in upper reaches.
(3.) Sudden closure of outlet by cultivator.
(4) Sudden closure of any off-taking due to breach.
(5.) To prevent entry of surplus water into city or to prevent overtopping of canal banks.

Types of Escapes:- ① Surplus Water Escapes
② Canal Scouring Escapes
③ Tail Escapes

Regulator type Escape and weir type Escape.

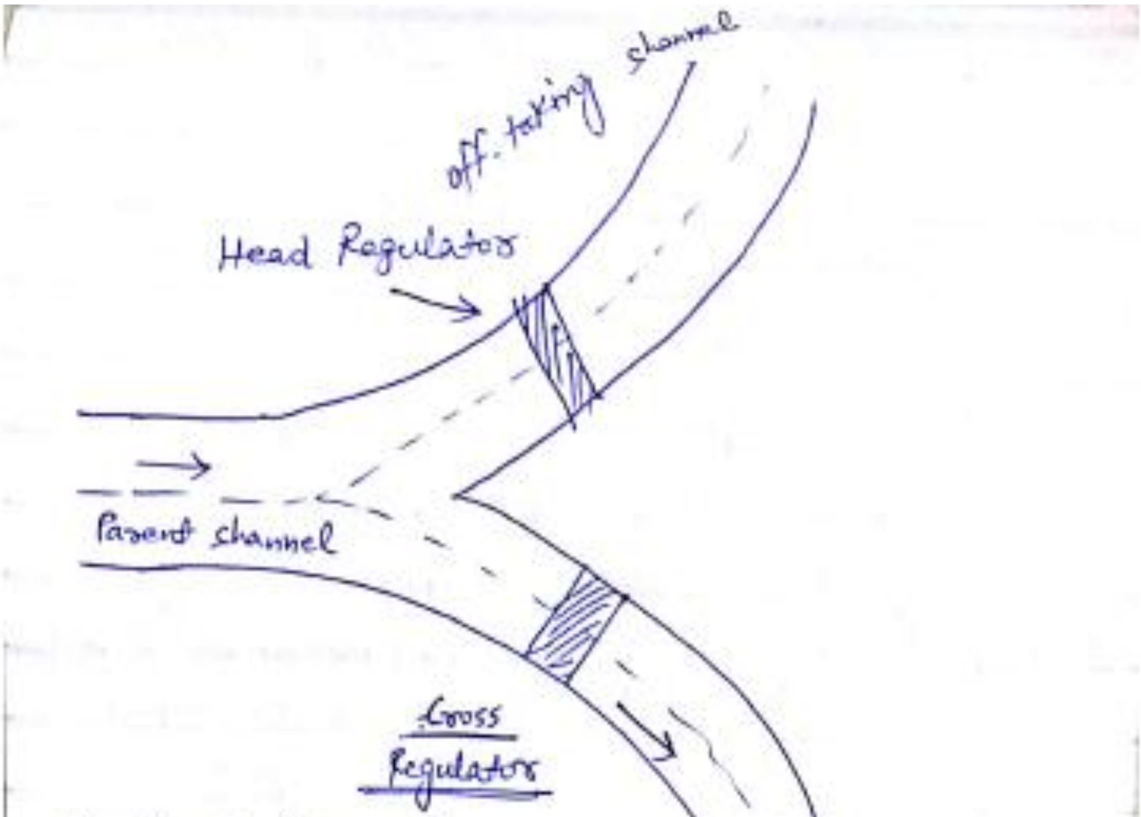
Metering flumes - used to measure discharge by providing narrow sections within the canal.

Types - ① Venturi flumes → $Q = C_d \cdot \frac{a_1 a_2}{\sqrt{a_1^2 - a_2^2}} \sqrt{2gh}$

② Standing wave flumes (Hydraulic Jump) → $Q = 1.7\, C_d \cdot L \cdot H^{3/2}$

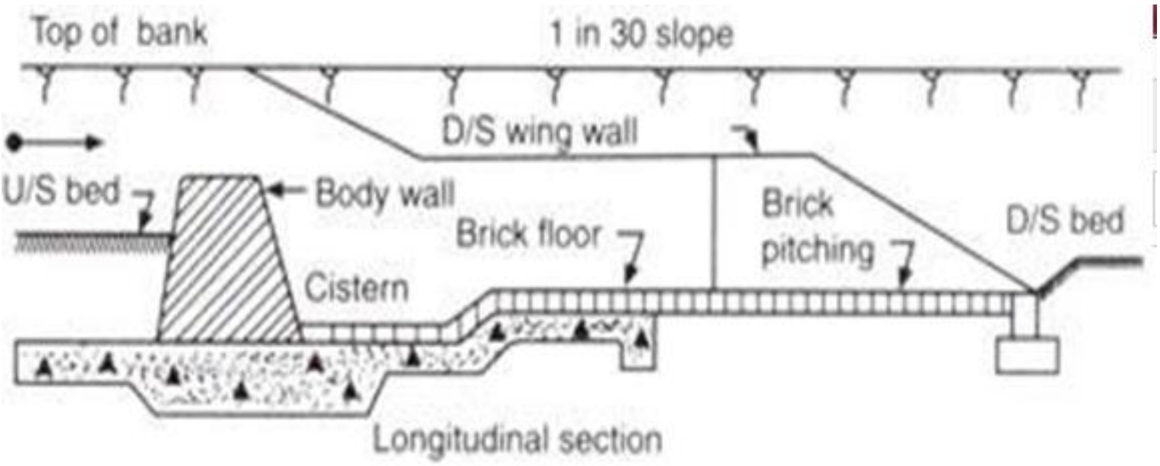
Canal outlets & Modules:- outfall of canals. (B) Width of the canal.

- Small structure at the head of Water Course so as to connect it with minor or a distributory channel.

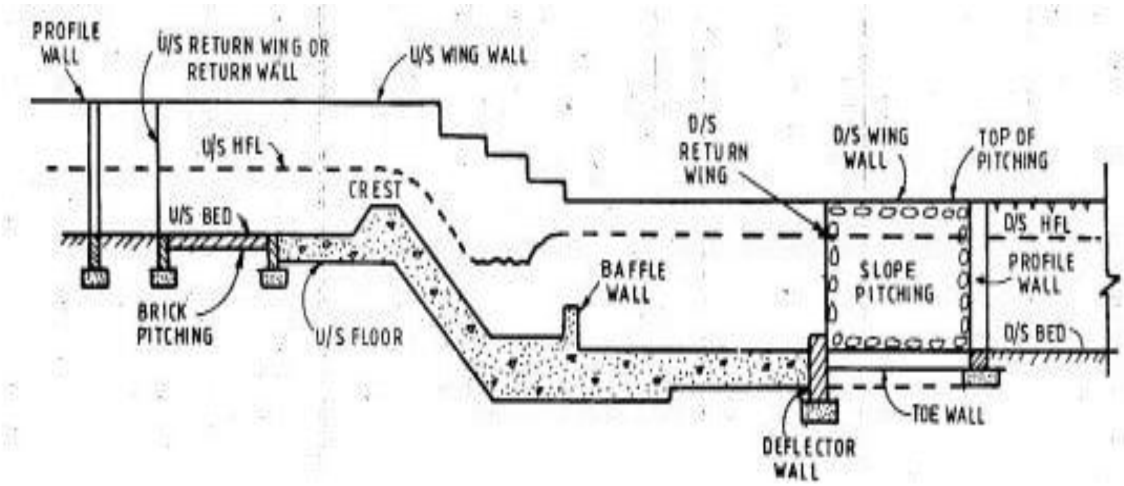


Head Regulator & Cross-Regulator

Answer 3.



Sarda fall



Glacis Falls

Answer 4.

CROSS-DRAINAGE WORKS:

Necessity of Cross drainage Works:

- Cross drainage Work is a Structure Constructed for carrying a canal across a natural drainage or river intercepting the canal.
- When canal is aligned as Control Contour canal it requires numbers of Cross drainage works

Types of CD Works: (A) Canal over drain:

- Aqueduct (bed above HFL), - Syphon Aqueduct (bed below HFL).

(B) Drain over Canal:

- Super Passage (bed above HFL), - Canal Syphone (bed below HFL).

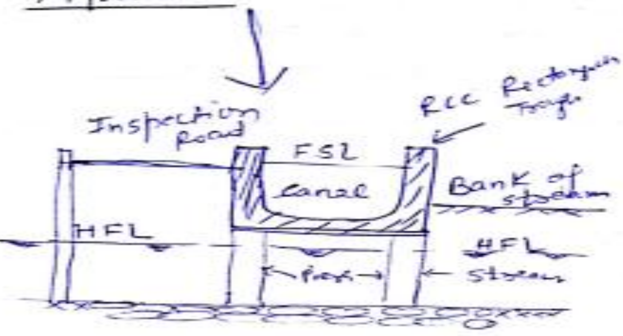
(C) Canal and drain at Same Level:

- Inlet and outlet, - Level Crossing.

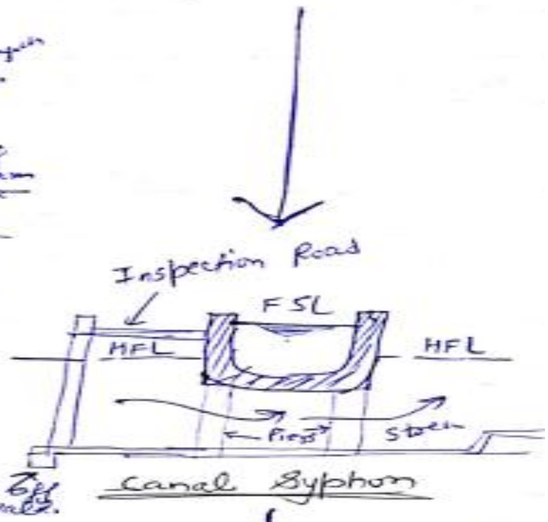
Selection of Suitable type of CD Work:

(1) Relative level and discharges.
(2) Type of Flow
(3) Size of Drain (small → Syphon Aqueduct, Large → Aqueduct)
(4) Material of construction
(5) foundation
(6) Cost of Earth Work.
(7) overall cost
(8) Provision of Road bridge (9) Subsoil Water table.

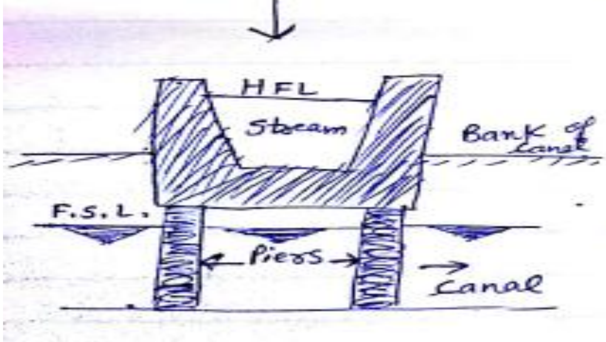
Aqueduct



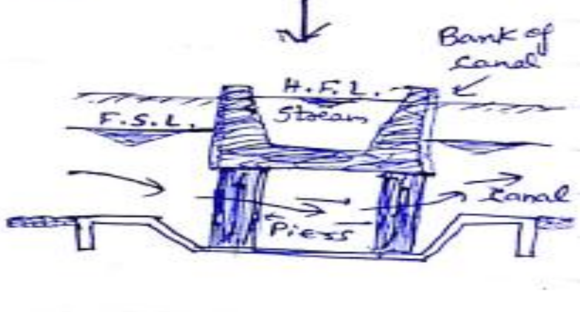
Siphon Aqueduct



Super Passage



Canal Syphon



Answer 5.

(1.)

CANAL-FALLS:- A canal fall is an hydraulic/irrigation structure constructed across a canal to lower down its water level and destroy the surplus energy liberated from the falling water which may otherwise scour or erode the banks of the canal.

TYPES OF FALL:- 1. OGEE FALL, 2. RAPID FALL, 3. STEPPED FALL, 4. NOTCH FALL, 5. VERTICAL DROP FALL, 6. GLACIS FALL. (SARDA-FALL)

Design of SARDA FALL - EXPLAINED THROUGH NUMERICAL/EXAMPLE:

Given Data. 1. Full supply Discharge $\frac{U/S}{D/S}$ = $\frac{50 \text{ Cumec.}}{50 \text{ Cumec.}}$

2. Full supply Level $\frac{U/S}{D/S}$ = $\frac{203.50 \text{ m}}{202.0 \text{ m}}$

3. Drop = 1.5 m, 4. Bed width $\frac{U/S}{D/S}$ = $\frac{35\text{m}}{35\text{m}}$, 5. Full supply level (depth) $\frac{U/S}{D/S}$ = $\frac{2\text{m}}{2\text{m}}$

6. Side slope = 1:1. 7. Safe exit Gradient = $\frac{1}{5}$.

Use Khosla's Theory. [Crest wall, Cistern, Impervious floor. U/S, D/S wing wall, D/S bed & side pitching]

1. CREST WALL ① Q = 50 cumec > 14 Cumec. ∴ Trapezoidal Crest should be provided.

② Length of Crest wall = width of D/S = 35m

③ For Trapezoidal Crest wall, $Q = 1.99 \cdot L \cdot H^{3/2} \cdot \left(\frac{H}{B}\right)^{1/6}$

(Q → 50 cumec, L → 35m, H → ??, B → $B = 0.55\sqrt{H+d}$)

$B = 0.55\sqrt{H_L + h_2}$ (H_L → Drop, h_2 → depth = 2m)

$B = 0.55\sqrt{2+1.5}$

∴ $B = 1.10\text{m}$

∴ Putting all Values $Q = 1.99 \cdot L \cdot H^{3/2} \cdot \left(\frac{H}{B}\right)^{1/6}$

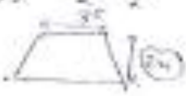
$50 = 1.99 \cdot 35 \cdot H^{3/2} \cdot \frac{H^{1/6}}{(1.1)^{1/6}}$

∴ $H = 0.83\text{m}$

④ Velocity of Approach: $V_a = \frac{Q}{\text{Area}} = \frac{50}{(35+2.0) \cdot 2.0}$

$V_a = 0.68 \text{ m/s}$

Area of Trapezoidal $A = (\text{width} + y) \cdot y$ (width = 35, y = 2)



⑤ Velocity Head $= \frac{V_a^2}{2g} = \frac{(0.68)^2}{2 \times 9.81} = 0.02\text{ m}$,

U/S Total Energy Line (TEL) = U/S FSL + 0.02 m = 203.5 + 0.02 = 203.52 m

⑥ R.L. of Crest = U/S TEL − H = 203.52 m − 0.83 m = 202.69 m

(2.)

total Energy Line

D/S T.E.L. = D/S F.S.L. + H_a = 202.0 + 0.02 = 202.02 m

(7) Height of crest above D/S bed,

d = Crest Level − d/s bed level = 202.70 − 200 = 2.70 m

d/s bed level = d/s F.S.L − D2 = 202.0 − 2.0 = 200 m

Final Conclusion:- (a) Provide Trapezoidal Crest with Top width 1.10 m (a), U/S slope 1:3 (b) and D/S slope 1:8 (c)

Bottom width of crest wall = 1.10 m (a) + 1.0 m (b) + 0.375 m (c)

Top surface of crest is capped with 20 cm thick cement concrete 1:2:4.

2. CISTERN-DESIGN:

(1) Length of Cistern, $L_c = 5\sqrt{H \cdot H_L}$

$L_c = 5 \times \sqrt{0.83 \times 1.5} = 5.58$ m

Say $L_c = 5.60$ m

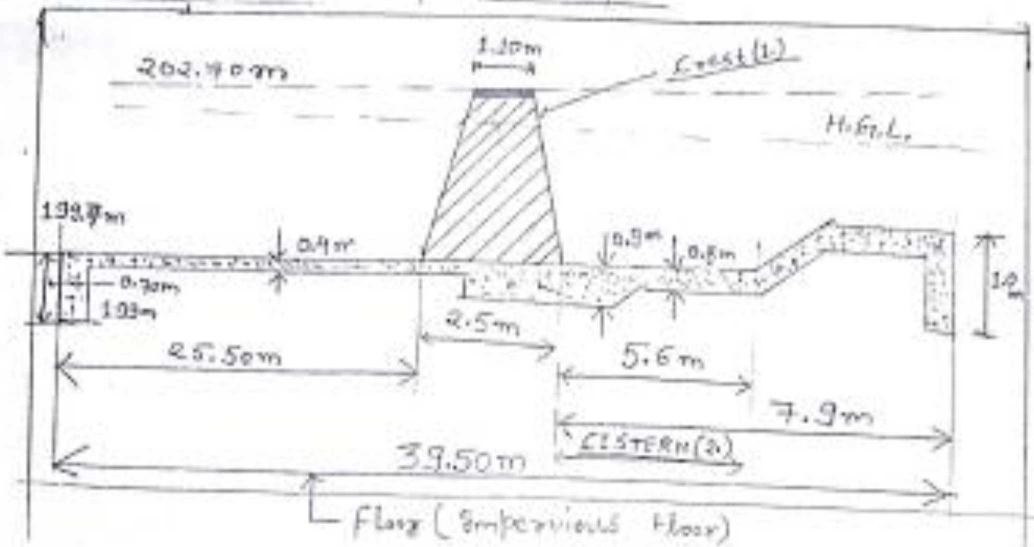
(2) Depth of Cistern, $x = \frac{1}{4}(H \cdot H_L)^{2/3} = \frac{1}{4} \times (0.83 \times 1.5)^{2/3} = 0.289$ m

Say $x = 0.3$ m.

(3) Reduced level of Cistern (R.L. of Cistern) = d/s bed − x = 200 − 0.3 = 199.70 m

(4) Height of crest wall above cistern bed level = d + x = 2.70 + 0.3 = 3.0 m

(5) Provide U/S bed pitching for a length D = 2.0 m (U/S supply). Pitching should be sloped upto 1:10 slope



3. IMPERVIOUS-FLOOR:-

(1) Depth of u/s cut-off, $d_1 = \frac{D_1}{3} = \frac{2.0}{3} = 0.67m = 0.70m$

Depth of D/S cut-off, $d_2 = \frac{D_2}{2} = \frac{2.0}{2} = 1.0m$

(2) Exit Gradient (Given $\frac{1}{5}$) $= G_E = \frac{H_s}{d_2} \cdot \frac{1}{\pi\sqrt{\lambda}}$

| H_s = crest level − d/s bed level = 202.7 − 200 = 2.70 m
| $G_E = 1/5$

$\therefore \frac{1}{5} = \frac{2.70}{1.10} \cdot \frac{1}{\pi\sqrt{\lambda}} \Rightarrow \sqrt{\lambda} = 4.297$

$\boxed{\lambda = 18.46}$

As $\lambda = \frac{1+\sqrt{1+\alpha^2}}{2} \Rightarrow 18.46 = \frac{1+\sqrt{1+\alpha^2}}{2} \Rightarrow \boxed{\alpha = 35.90}$

Total Length of Floor $= \alpha \cdot d_2 = 35.90 \times 1.0m$

$\boxed{b = 35.90m}$

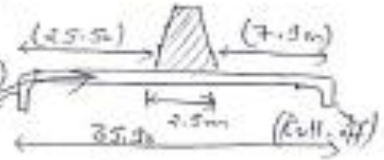
(3) Minimum length of d/s impervious floor $= l_d = 2(\text{water depth} + 1.2) + H_L$

$l_d = 2(2+1.2) + 1.5 = 7.9m$

$\boxed{l_d = 7.9m}$

(4) Minimum Length of u/s floor, $l_u = 35.90 - 2.5 - 7.9$ (crest, cistern head)

$\boxed{l_u = 25.50m}$



(5). FLOOR-THICKNESS ⇒

(a) At d/s of Crest Wall ⇒ Residual Head $(h_r) = 0.30 + (2.7 \times 0.289)$

$h_r = x + (h \times \phi_h)$

$\boxed{h_r = 1.08m}$

Thickness, $\boxed{t = \frac{h_r}{G-1}} \Rightarrow t = \frac{1.08}{2.24-1} = \frac{1.08}{1.24}$

$\boxed{t = 0.90m}$

Provide 0.2m thick brick on edge over 0.70m thin concrete 1:2:4.

(b) At 3m from d/s of toe of Crest Wall ⇒ $h_r = 0.30 + (0.227 \times 2.7)$

$\boxed{h_r = 0.913m}$

$t = \frac{h_r}{2.24-1} = \frac{0.913}{1.14}$ $\boxed{t = 0.8m}$

(c) At 5.6m from d/s toe of Crest Wall ⇒ $h_r = 0.30 + (0.17 \times 2.7)$

$h_r = 0.76m$

thickness $= t = \frac{0.76}{1.14} = 0.61m$

$\boxed{t = 0.6m}$

(4.)

(d) At the end of d/s floor / u/s floor till crest:

(0.3m will not used) $h_r = 0.\cancel{1}2 - 2.7 = 0.328m$

thickness $t = \frac{h_r}{G-1} = \frac{0.328}{2.24-1} = \frac{0.328}{1.24} = 0.26$

$\boxed{t = 0.4m}$

4. U/s Wing Walls: Radius = 5 to 6 times H

$= 5 \times 0.83$ to 6×0.83

$= 4.15$ to $4.98m$

Say $\boxed{R = 4.50m}$ ∴ Provide U/s Wing walls with radius 4.5 subtending 45° angle.

Top level of wing wall = 203.5 + 0.5 (free board)

= 204.0 m

5. D/s wing walls: Length of D/s wall $= 6\sqrt{H \cdot H_L}$

$= 6 \times \sqrt{0.83 \times 1.5}$ → (H.L)

$= 6.70 m$

Top level = 202 + 0.5 = 202.5 − 200 = 2.5m → Height of wing wall.

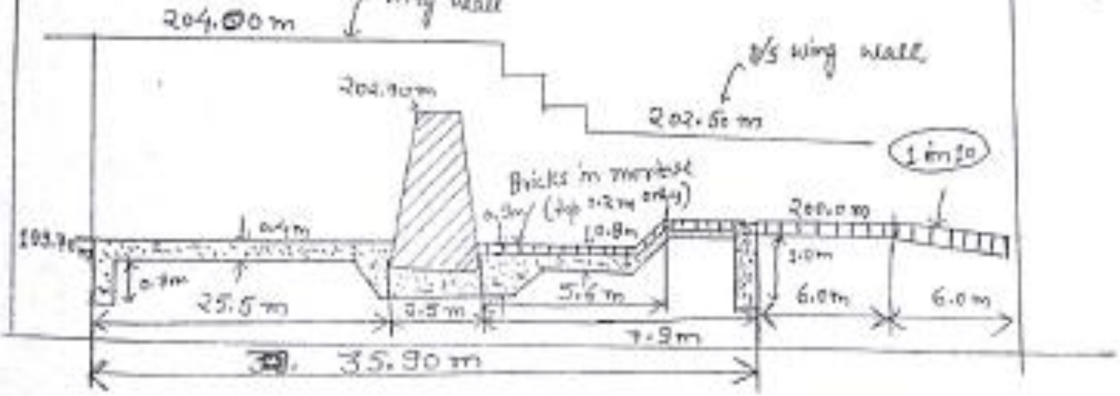
Total length of d/s wing walls = 6.70 + 7.5 = 14.2m.

6. D/s Bed Pitching:- length $= 9 + 2H_L = 9 + 2 \times 1.5$

$\boxed{\text{Length} = 12m}$

Provide horizontal pitching upto 6m and then at slope of 1:10, provide remaining pitching of 6m.

7. D/s Side (~~Bed~~) Pitching:- Provide Horizontal pitching of full length. Provide 20cm thick side pitching



Answer 6, 7.

HEADWORK – A hydraulic structure constructed across a river for the purpose of raising water level in the river so that it can be diverted into off taking canal is called Head Work.

Head Work → (1) Storage (Dams) (spurs, bunds)
→ (2) Diversion → (1.) Temporary Diversion Headwork
(weir, Barrage) → (2.) Permanent Diversion Headwork.

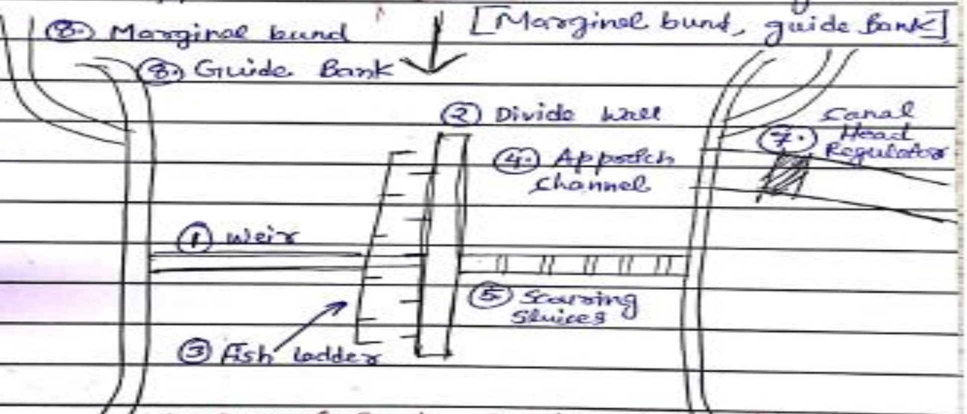
SUITABLE-SITE – (1) River section is narrow and well defined.
(2.) River should have high, well defined submersible banks.
(3.) Good foundation.
(4) Material should be easily available.
(5) At diversion headwork river should be straight.
(6.) Suitable arrangement for diversion.
(7.) Site should be easily Accessible.
(8.) Canal (off-taking) should be economical and having large command area.
(9.) overall cost should be minimum.

Location depend upon stage of river → (1.) Rocky or Hilly stage
Best-suited → (2.) Boulder stage.
(3) Trough or Alluvial stage
(4) Delta stage

Answer 8.

Different Parts of DIVERSION HEADWORKS:

1. Weir or Barrage
2. Divide wall or groyne
3. Fish ladder
4. Pocket or Approach channel
5. Scouring sluices.
6. Silt Prevention devices
7. Canal head Regulator
8. River training works [Marginal bund, guide bank]



Component Part of Diversion Headwork

(24.) WEIR: Weir is a solid construction put across the river to raise the water level in the river and to divert the water into the canal.

Types of Weir ⇒ (A) Depending upon Criteria of design of floors.

[1.] Gravity, [2.] Non- Gravity.

(B) Depending upon material and Design features.

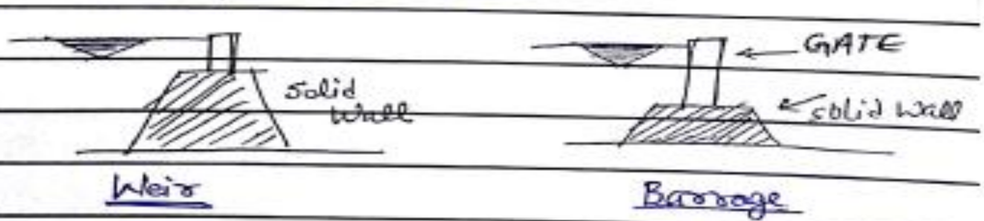
[1.] Vertical Drop Weir

[2.] Sloping Weir (A) Masonry or concrete slope weir. (B) Dry stone slope weir.

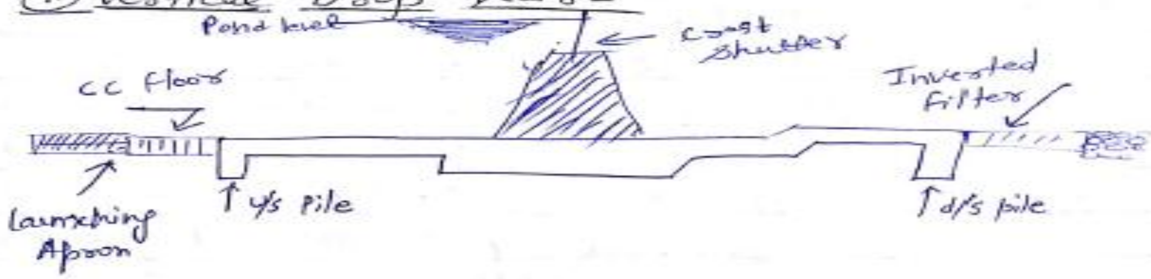
[3.] Parabolic Weir.

[4.] Rock fill Weir.

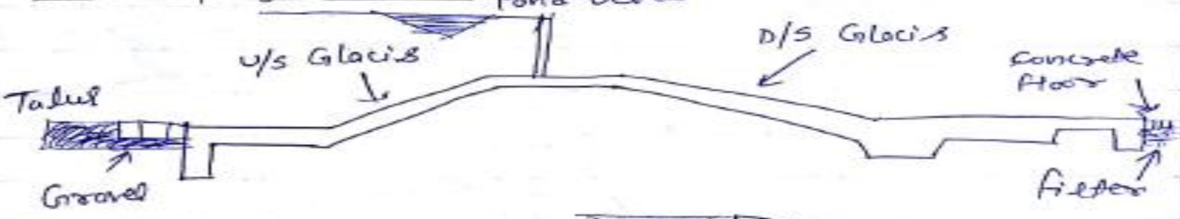
(25) BARRAGE :- It is that hydraulic structure in which heading up of water is affected by the gates alone
- function is similar to Weir.



(1) Vertical Drop Weir -

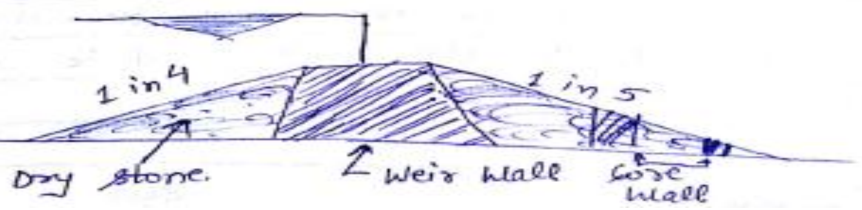


(2) Sloping Weir -



(3) Parabolic Weir -

(4) Rockfill Weir -



Answer 9.

DESIGN OF IMPERVIOUS FLOOR FOR SUB-SURFACE FLOW ⇒

- Foundation Seepage or Sub-Surface Flow may cause harm in two ways. ①
① Piping, ② uplift.

- In 1895- group of Anglo-Indian Engineers. Performed and Confirmed Darcy's law for Seepage in granular soil.

- In 1912 Bligh advanced theory, 1932 Lane analyzed 200 dams. - gave weighted theory.

BLIGH'S THEORY: - Design of impervious floor or apron is directly dependent on the possibility of percolation in porous soil on which apron is built.

- Bligh assumes hydraulic slope or gradient is constant throughout impervious length of the apron.

- Bligh assumes that percolating water creeps along contact of base profile of apron to the length of travel,

- Total Creep length $L_c = 2d_1 + l + 2d_2$

Coefficient of creep $C = \frac{L}{H}$

VRSU BOOK Percolation Coefficient $C = \frac{H}{L}$ Sign........................

Design Criteria - (1.) safety against piping.
(2.) Safety against uplift pressure.

(1) Safety against Piping: - Length of Creep should be Sufficient to provide a Safe hydraulic gradient according to type of soil.

- Safe creep length $L = C \cdot H$
- C = Coefficient of Creep. $= \frac{1}{\mathcal{L}} = \frac{L}{H}$

(2) Safety against uplift: - let h' = uplift Pressure at any point.

- uplift pressure $= W \cdot h'$ — (1.)
- If $t \to$ thickness of floor at any point
  $\rho \to$ specific gravity of the floor material

The downward force
- (Resisting force) per unit area, $= t w \rho$ — (2.)

Equating (1.) & (2.)

$$Wh' = tw\rho$$

$$h' = t\rho$$

$$h' - t = t\rho - t$$

$$h' - t = t(\rho - 1)$$

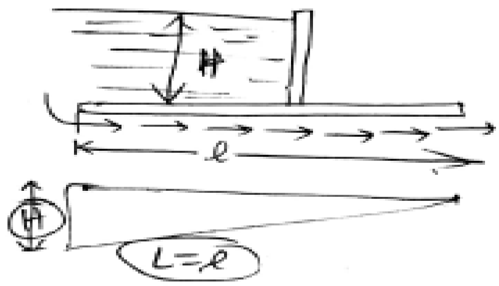
$$t = \frac{h' - t}{\rho - 1} = \frac{h}{\rho - 1}$$

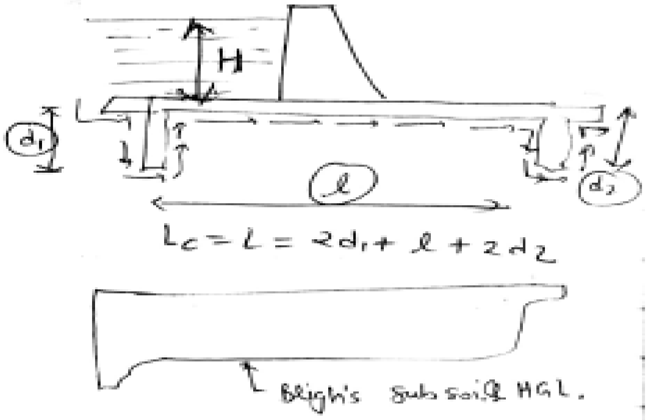
$$t = \frac{h}{\rho - 1} = \frac{h' - t}{\rho - 1}$$

- Providing factor of safety $\to 4/3$,

$$t = \frac{4}{3} \cdot \frac{h}{\rho - 1}$$

Sign.........................





LANE's Weighted Creep Theory (1932):

After analyzing over 200 dams world wide he gave a weighted factor of 3 instead of 2 given by Bligh for vertical cutt off only.

Limitition of Bligh's Theory:

1. No distinction between vertical & horizontal cutt-off.
2. Holds good if ~~depth~~ distance between two pile is greater than twice their depth.
3. Do not give idea of exit gradient. (gradient must be well above critical)
4. No difference between outer and inner face of sheet pile. Actually outer face is more effective.
5. Intermediate sheet pile of less depth then outer will be ineffective except local redistribution of pressure.
6. Loss of head will not be in proportion of creep-lengths.
7. Does not specify provision of d/s sheet pile. but is necessary for preventing undermining as it start from tail end.

VRSU BOOK

Sign.........................

Answer 10.

KHOSLA'S - THEORY :- - Bligh theory was used for designing after 1910/12 but many structures have failed and in 1926-27 some siphons on Upper Chenab Canal were designed on Bligh gave trouble.

- During investigations it was found that actual pressures were quite different those were calculated

- The Investigations were carried out by Dr. A.N. Khosla and his associates known as Khosla's theory gave following conclusion.

(1) outer face of end sheet pile is much more effective then inner face.

(2) Intermediate sheet pile of size less then outer is ineffective except local redistribution of pressure.

(3) Undermining (piping) starts from tail end d/s end.

(4) Deep vertical cut off is essential ~~for~~ at downstream, to prevent piping.

EXIT- GRADIENT : - It may be defined as the hydraulic gradient or pressure gradient of sub soil at the downstream or exit end of the floor.

$$G_E = \frac{H}{d} \cdot \frac{1}{\pi\sqrt{\lambda}}$$

$$\lambda = \frac{1+\sqrt{1+\alpha^2}}{2}, \quad \alpha = \frac{b}{d}$$

Safe Exit Gradient: - The exit gradient should be always be less than the critical hydraulic gradient.

It is that hydraulic gradient at which soil particles will be lifted in order to cause undermining or piping.

$$\text{Safe exit gradient} = \frac{\text{Critical Hydraulic gradient}}{\text{Factor of Safety}}$$

→ Permissible exit gradient → Fine Sand - 1/6 to 1/7
G_i
Coarse sand - 1/5 to 1/6
Shingle - 1/4 to 1/5

Answer 11.

Silt Excluder, (28) Silt Ejector

- These are called Silt Control devices. because these controls the entry of silt and sediments in-to the canal.
- SILT - EXCLUDER - (1) This prevents entry of silt in the canal. exclude silt entry in canal.
- SILT - EJECTOR. (2) Made in front of canal Head regulator
(3) Rectangular tunnels.
(4) Two part Horizontally. Top Part - Enter in Canal
Bottom Part - Flow through tunnel, d/s side discharge at bottom.
- SILT EJECTOR - (1) This extracts and remove the silt that is already entered in the canal.
(2) Made at a distance apart after head regulator
(3) Horizontal diagram Wall/slabs.
(4) Under diaphragm slab tunnels made to eject the silt.

Answer 12.

ENERGY DISSIPATION

- Dissipation of the Kinetic energy generated at the base of a spillway for bringing the flow into the downstream river to the normal (pre-dam) condition in as short of distance possible.

CLASSIFICATION

1. Based on hydraulic Action: ① Hydraulic Jump stilling basin. ② roller buckets. ③ Impact & pool diffusion. ④ Ski Jump, plunge pools.
2. Based on Mode of dissipation: ① Horizontal - HJSB. ② Vertical - Ski-Jump plunge pools. ③ Vertical downward - free Jets. ④ Upward - roller bucket.
3. Based on Geometry or form of the main flow, - expansion, - Contraction, Counter acting flow impact
4. Based on Geometry or form of the structure
   - stilling basin → Hydraulic Jump → With or without chute blocks, baffle piers.
   - Buckets.
   - Roller buckets - solid & slotted.

Principal types of Energy Dissipators:

1. Hydraulic Jump stilling basins.
2. Free Jets and trajectory buckets.
3. Roller buckets,
4. Dissipation by spatial Hydraulic Jump.
5. Impact type energy Dissipators.

VASU BOOK Sign.........................

ENERGY - DISSIPATOR :- These are those structures constructed at d/s of dam or spillway to dissipate the surplus energy liberated after water release from Dams or spill ways.

- This functions easy removal of water from the spillway without damage.

any,

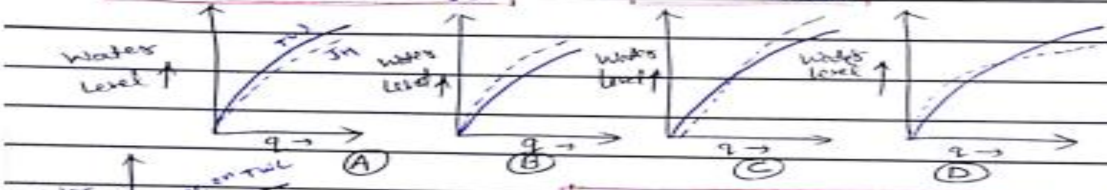
Types - ① Hydraulic Jump type, ② Trajectory Buckets ③ slotted bucket. ④ Jet trajectory. ⑤ Rotatory Buckets.

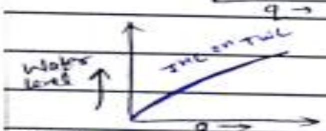
Tail Water Curve and Jump Height Curve TWC, JHC

q and Tail Water Depth — q and y_2

$$y_2 = \frac{y_1}{2} + \sqrt{\frac{y_1^2}{4} + \frac{2q^2}{g y_1}}$$

$$\Delta E = \frac{y_2 - y_1}{4 y_1 y_2}$$





$$y_2/y_1 = \frac{1}{2}\left[\sqrt{1+8F_1^2} - 1\right]$$

(1) (Ideal Condition)

Solutions of Problems A, B, C, D

(A) → (1) slopping apron above river bed, (2) roller bucket type of energy dissipator
(3) Providing higher apron level.

(B) → (1) Ski-Jump bucket.
(2) Sloping apron above river bed.
(3) Constructing a subsidiary dam below the main dam
(4) Providing upward slope.

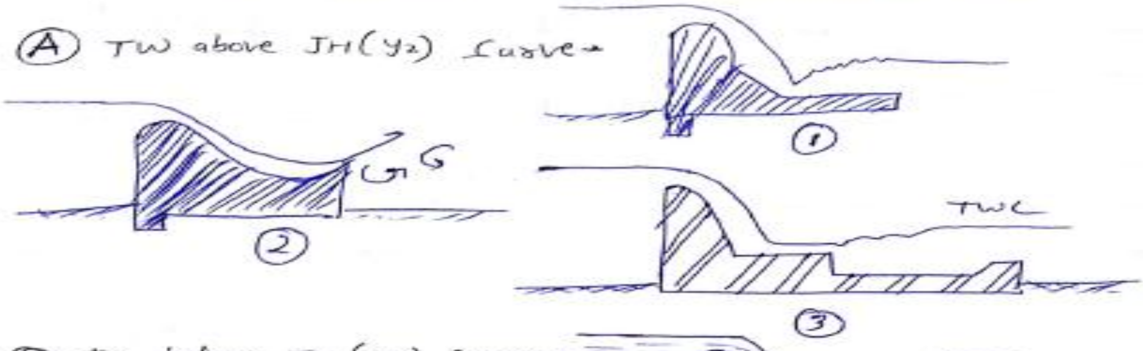
(C) → (1) sloping apron partly above and partly below river bed.
(2) Hydraulic Jump and flip bucket.

(D) → (1) Horizontal cum sloping Apron.

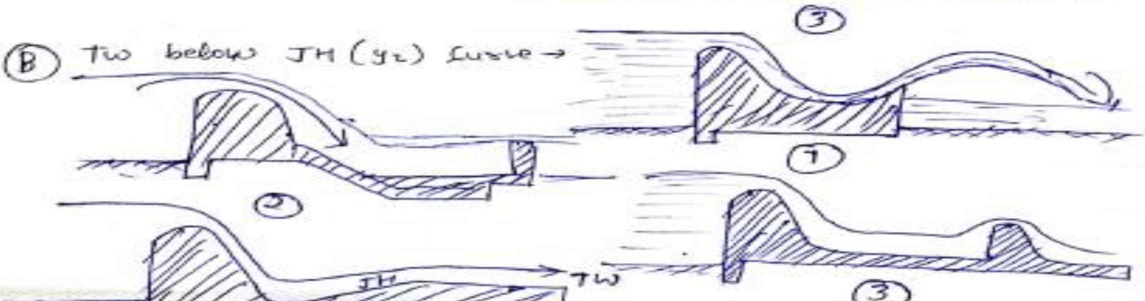
Stilling Basin ⇒ chute block, Baffle block, end/Denated Sill.
USBR Type I, II, III, IV.

(1) Ideal Condition →
JHC, TWC on same level.

(A) TW above JH(y_2) Curve →



(B) TW below JH(y_2) Curve →



(C) TW above y_2 at low q, TW below y_2 at high q ⇒

(D)