HYDRAULIC STRUCTURES

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SECTION B

Submitted to

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Question# 01

Answer To Part (a)

Culvert

A culvert is a tunnel structure that allows running water to pass under a roadway or railway. Culvert is also useful for water drainage or bridging the gap over a physical obstruction.

CauseWay

While a causeway is a raised roadway, railway or track constructed across low laying typically wetlands. It would generally exist along costal terrains. It would be constructed in the format of an embankment or berm as such. Causeway can be constructed of earth-fill, wood or concrete.

Question # 01
part (b)
Answer

Cross Drainage Work

When a natural drain crosses or intercepts an irrigation canal it becomes necessary to construct some suitable structure to carry forward the canal safely, as these works are constructed for crossing the drainage they are termed as "cross drainage work".

Canals constructed for irrigation purposes, while carrying water from headworks to crop field have to cross few natural drainage streams, to cross these drainages safely some suitable structures are required to be constructed, known as cross-drainage works (CDWs).

It may be achieved in two ways;

1) The alignment of irrigation canal should be changed to avoid its crossing with drain.

2) The drain itself may be diverted to the adjoining stream to avoid the crossing. But in practice it may become impossible to avoid such a crossing, then there is no other alternative but to construct a structure to carry the canal across the drain.

Need/Necessity Of Cross Drainage Works;

→ Natural drainages are not crossed by watershed canals while in actual orientation of canal network, this ideal condition may not be available and the obstacles like natural drainages may be present across the canal. Therefore It is necessary that the cross drainage work must be provided for running of irrigation system.

→ At crossing points of canal and drainage the water may get intermixed therefore to maintain the smooth running of the canal considering the design discharge, the cross drainage works are required.

→ The site condition of the crossing point may be such that without any suitable structure, the water of the canal & drainage cannot be diverted to their natural directions. Therefore cross drainage works must be provided to maintain their natural direction of flow.

Types Of Cross Drainage Works

Type 1

Irrigation Canal Passes over the Drainage:

Such condition involves the construction of the following

a) Aqueduct

Aqueduct is defined as "The hydraulic structure in which the irrigation canal is taken over the drainage.

This structure is suitable for the condition when the bed level of the canal is above the highest flood level of drainage. In such case the drainage water passes clearly below the canal

b) Siphon Aqueduct

In a hydraulic structure where the canal is taken over the drainage, but the drainage water cannot pass clearly below the canal. rather it flows under siphonic action therefore it is known as siphon aqueduct. This type of structure is suitable for the conditions where the bed level of canal is below the highest flood level.

Type II : Drainage Passes Over the Irrigation Canal

a) Super Passage

Those types of hydraulic structures in which the drainage is taken over the irrigation canal is known as super passage.

This type of structure is suitable for the condition when the bed level of drainage is above the full supply level of the canal. In this case the water of canal passes clearly below the drainage.

b) Siphon Super Passage

The type of hydraulic structure in which the drainage is taken over the canal, but the canal water passes below the drainage under siphonic action is known as siphon super passage. This type of structures are suitable for the condition when the bed level of drainage is below the full supply level of the canal.

Type III: Drainage & Canal Intersect Each Other at same level

a) Level Crossings

When the bed level of canal & the stream are approximately the same & quality of water in canal and stream is not much different so in such conditions the cross drainage works constructed is called level crossing. where water of canal & stream is allowed to mix. Level crossings consists of following components
i) Crest wall ii) Stream regulator
iii) Canal regulator.

b) Inlet & Outlet

When irrigation canal meets a small stream or drain at same level, drain is allowed to enter the canal as in inlet. At some distance from this inlet point, a part of water is allowed to drain as outlet which eventually meets the original stream.

~~Some~~ Stone pitching is required at inlet and outlet.

Stone pitching protects the bed and banks of the inlet & outlet. This type of cross drainage is called inlet & outlet.

Question # 02 –

Answer To Part a)

Difference between Weir & Barrage

	Weir	Barrage
1	A weir is a barrier that is built across a stream or river to raise the water level on the upstream side or to divert the water flow for different purposes.	Barrage is a type of weir with adjustable gates to control the water flow according to need.
2	Weir has low control on water flow	Barrage has high control on water flow and water levels by operation of gates.

3	The structures of weir are bulkier (heavily built)	The structure of barrage is slight
4	Low construction cost of weir	Construction cost of barrage is high
5	Excessive afflux in high floods	High floods can be passed with minimum afflux.
6	In weirs shutters are provided in part length and are of smaller height, 2m	Barrages are gated over the entire length and gates are of greater height.
7	Chances of silting on upstream side of weir are more due to high set crest.	Silt removel is done through under slucies
8	In weirs no means of transport communications across stream or river.	A road or a rail bridge can be conveniently & economically combined with a barrage wherever necessary.

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Question # 02

Answer To Part (b)

Reynolds Number

→ Reynold number is a dimmensionless number which describes the physical characteristics of flow OR

→ The ratio of inertial forces to viscous forces and a convenient parameter for predicting if a flow condition will be laminar or turbulent

Mathematically;

$$Re_D = \frac{\rho V D}{\mu} = \frac{VD}{\nu}$$

where

Re_D = Reynold Number

ρ = Fluid Density (kg/m^3)

V = Flow velocity

μ = dynamic viscocity
ν = kinematic viscosity $\nu = \frac{\mu}{\rho}$

→ Reynold Number For Laminar

For laminar flow the reynold number is less then 2000 i.e $Re < 2000$
Also the velocity of the particles is low and they move in straight path.

→ Reynold Number For Turbulent

The flow in which the particles moves with higher velocity and the reynold number for turbulent flow is greater then 4000 i.e

$$Re > 4000.$$

→ Neither Laminar Nor Turbulent OR Transition

The phase at which the flow changes from laminar to turbulent is known as transition flow the reynold number for transition is in between 2000 to 4000

$$Re = 2000 - 4000$$

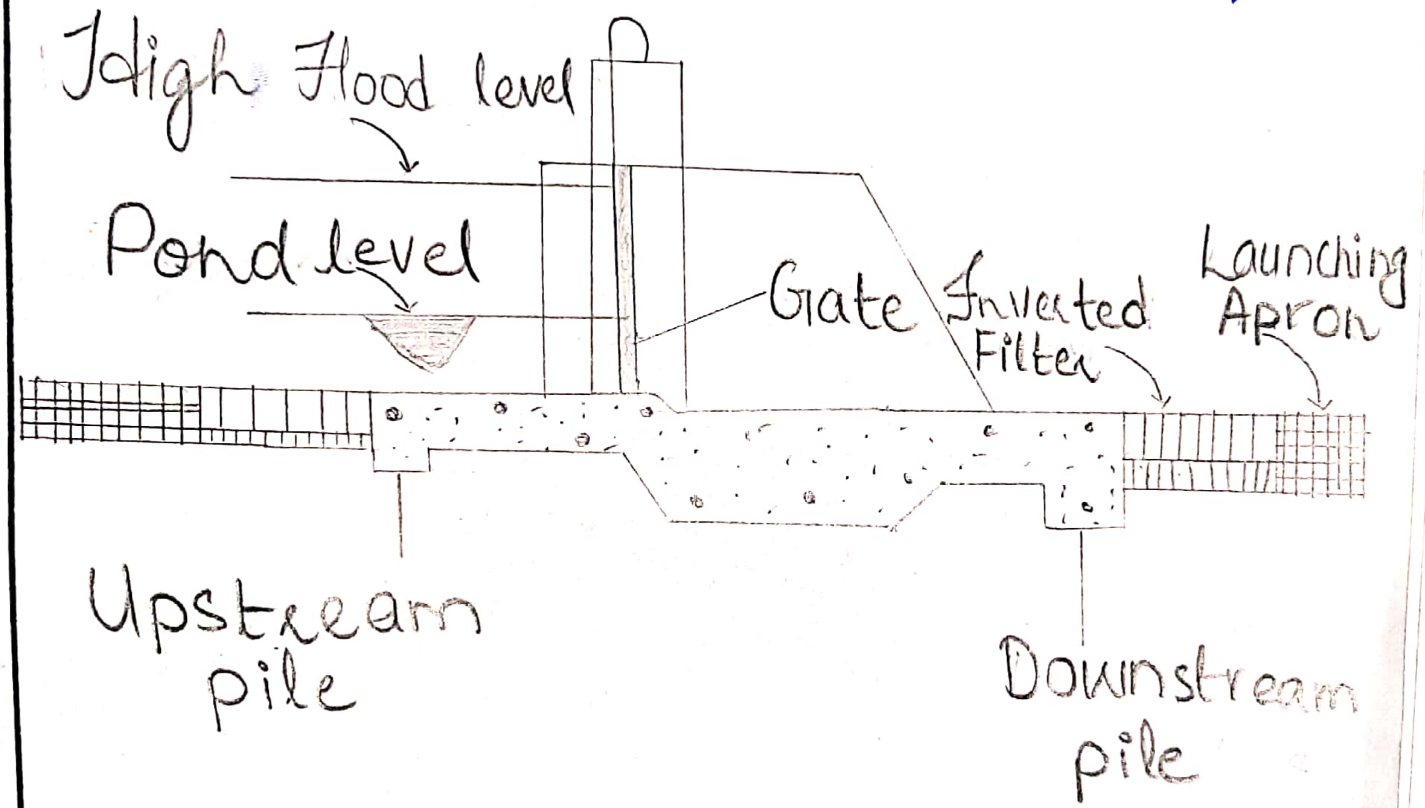
→ Lower Critical Velocity

The velocity at which the flow changes from laminar to transition is known as lower critical velocity.

→ Higher Critical Velocity

The velocity at which the flow changes from transition to turbulent is known as higher critical velocity.

Answer To Question 3 part(a)



Components Of Barrage

Question # 03

Answer To Part (b)

To predict the maximum or equilibrium scour depths, several formulae based on experimental results have been proposed. In general these assume the relationship

$$y_s/b' = \phi(y_0/b', Fr, d/b')$$

where, b' is the pier width
y_0 is upstream flow depth,
d is the sediment size
& Fr is the flow Froude Number.

Lauren's (1962), his experimental results underestimate the scour depths, compared to many Indian experiments (Inglis, 1949) which suggest the formula (approach flow is normal to the bridge piers)

$$y_s/b' = 4.2(y_0/b')^{0.78} Fr^{0.52}$$

The India field data also suggests that the scour depth should be taken as twice the regime scour depth.

In the case of live beds (a stream with bedload transport) the formula

$$y_s/y_0 = (B/b')^{5/7} - 1$$

This formula predicts the maximum equilibrium scour depth.

Question#04

Given Data

Live load = 1500 lb/ft^2

Dead load = 300 lb/ft^2

Angle of repose, $\theta = 30^\circ$

Section = 15'x 15'

Thickness = 0.92 m = 3 ft

Unit weight of soil = 100 lb/ft^3

f_y = 60 ksi

Unit weight of R.C.C concrete = 156 lb/ft^3

(plain concrete unit weight is 150 lb/ft^3 but we consider R.C.C. concrete i.e 156 lb/ft^3).

Solution

→ Self wt of slab

= thickness × Unit wt. of RCC concrete

$= 3 ft \times 156\ lb/ft^3$

$= 468\ lb/ft^2$

→ Total load

L.L + D.L + Self wt.

1500 + 300 + 468

$= 2268\ lb/ft^2$

→ Co-efficient of earth pressure

$$\frac{1 - \sin\theta}{1 + \sin\theta}$$

$$= \frac{1 - \sin(30^\circ)}{1 + \sin(30^\circ)}$$

$= 0.33$

→ Lateral Pressure

→ Vertical pressure at top

$(L.L + D.L)\,ka$

$(1500 + 300)\,0.33$

$= 594\ lb/ft^2$

→ Pressure of soil

$ka \times h \times$ unit wt. of soil

$0.33 \times (15' + 3') \times 100$

$0.33 \times 18 \times 100$

$= 594\ lb/ft^2$

→ Lateral pressure at top $= 594\ lb/ft^2$

→ Pressure at bottom

= top + pressure of soil

$= 594 + 594$

$= 1188\ lb/ft^2$