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Section	B
Subject	Hydralic structure
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Ans; "Stage discharge relationship for a concrete rectangular Box culvert;

"Given Data;"

Width = 1.4m
Height = 0.9m
Length = 26m
Slope = 1:1000
mannings; η = 0.013
Square edged entrance; K_e = 0.5
Range = 0-3m

"Solution;"

$H/D \leq 1.4m$

$H < 0.9m$

Discharge is given by;

$$Q = 2.92 y_0 \left[1.2 y_0 / 1.2 + 2y_0 \right]^{2/3} \quad \text{— "A"}$$

y_o (m)	Q ($m^3 s^{-1}$)	y_c (m)
0.3	0.299	0.166
0.6	0.785	0.317
0.9	1.330	0.451

※ By putting values of "y_o" we will get the corresponding discharge.

- $$Q_1 = 2.92(0.3)\left[1.2(0.3)/1.2+2(0.3)\right]^{2/3}$$
$$= 0.299 \ m^3/s$$

- $$Q_2 = 2.92(0.6)\left[1.2(0.6)/1.2+2(0.6)\right]^{2/3}$$
$$= 0.785 \ m^3/s$$

- $$Q_3 = 2.92(0.9)\left[1.2(0.9)/1.2+2(0.9)\right]^{2/3}$$
$$= 1.330 \ m^3/s$$

"Critical depth";

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} \quad \text{— "A"}$$

$$q = \frac{Q}{B} \quad \text{— "B"}$$

By putting values in eq "B".

$$q_1 = \frac{Q_1}{B} = \frac{0.299}{1.4} = 0.213$$

$$q_2 = \frac{Q_2}{B} = \frac{0.785}{1.4} = 0.561$$

$$q_3 = \frac{Q_3}{B} = \frac{1.330}{1.4} = 0.95$$

Now by putting values in eq "A".

$$y_{c_1} = \left(\frac{q_1^2}{g}\right)^{1/3} = \left(\frac{(0.213)^2}{9.81}\right)^{1/3} = 0.166\,m$$

$$y_{c_2} = \left(\frac{q_2^2}{g}\right)^{1/3} = \left(\frac{0.561^2}{9.81}\right)^{1/3} = 0.317\,m$$

$$y_{c_3} = \left(\frac{q_3^2}{g}\right)^{1/3} = \left(\frac{0.95^2}{9.81}\right)^{1/3} = 0.451$$

At the inlet over a short reach;

$$“H = y_0 + \frac{V^2}{2g} + K_e \cdot \frac{V^2}{2g}”$$

$V_1 = 1.142\ m/s$

So;

$$H_1 = y_{0_1} + \frac{V^2}{2g} + K_e \cdot \frac{V^2}{2g}$$

$$= 0.3 + \frac{(1.142)^2}{2(9.81)} + 0.5\left(\frac{(1.142)^2}{2(9.81)}\right)$$

$$\boxed{= 0.399\ m}$$

$$H_2 = 0.6 + \frac{(1.142)^2}{2(9.81)} + 0.5\left(\frac{(1.142)^2}{2(9.81)}\right)$$

$$\boxed{= 0.699\ m}$$

$$H_3 = 0.9 + \frac{(1.142)^2}{2(9.81)} + 0.5\left(\frac{(1.142)^2}{2(9.81)}\right)$$

$$\boxed{= 0.999\ m}$$

y_0 (m)	H(m)	Q(m^3s^{-1})
0.3	0.399	0.299
0.6	0.699	0.785
0.9	0.999	1.330
orifuce > 0.9 "1.2D"	1.08 →	1.477 By interpolation.

"2" $H/D \geq 1.4$

"a"; For orifice flow;

$$Q = C_d\,(1.4 \times 0.9)\left[2g\left(H - D/2\right)\right]^{1/2}$$

$$Q = 0.62\,(1.4 \times 0.9)\left[2(9.81)\left(1.08 - \frac{0.9}{2}\right)\right]^{1/2}$$

$$\boxed{Q = 2.746\ m^3/s}$$

The following results are obtained.

H(m)	Q(m^3s^{-1})	y_o(m)
1.08	2.746	>0.9

→ no orifice flow exists.

"b" For pipe flow the energy equation gives;

$$H + S_oL = D + h_L$$

Where;

$$h_L = k_e\frac{V^2}{2g} + (Vn)^2\frac{L}{R^{4/3}} + \frac{V^2}{2g}$$

Thus;

$$Q = 2.08(H - 0.57)^{1/2}$$

During rising stages the barrel flows full from H = 1.08m and during falling stages the flow becomes free-surface flow when H = 0.999m.

"The following table summarizes the result";

H (m)	Q (m³/s)	Type of flow
Rising stages;		
0.399	0.299	open channel
0.699	0.785	open channel
0.999	1.330	open channel
1.080	1.477	pipe flow
2.000	2.487	pipe flow
3.000	3.242	pipe flow
Falling stages;		
2.000	2.487	pipe flow
1.080	1.477	pipe flow
0.999	1.330	pipe flow
0.699	0.785	open channel
0.399	0.299	open channel

Ans: 02 "Loads on Bridge foundation due to Scour;"

- The errosion caused by flowing water resulting in removal of earth, sand, or silt from the foundation of the bridge in river is known as Scour.
- Scour is the most concerned issue for safe design and maintenance of hydraulic structures. Scour is one of the leading causes of Bridge failure causing a huge amount of economical and social loss.
- The Scour removes the bed material around the foundation of the bridge resulting in exposure of foundation and endanger the stability of the bridge. The Scour is responsible for about 60% of bridge failures resulting in loss of lives and huge amount of economic loss.

- Scour exposes the bridge foundations and thus greatly effect and reduces the buckling capacity (resistance) of piles as well as reduces the lateral capacity of piers. Additionally, Bridges subjected to scour become more vulnerable during floods period.

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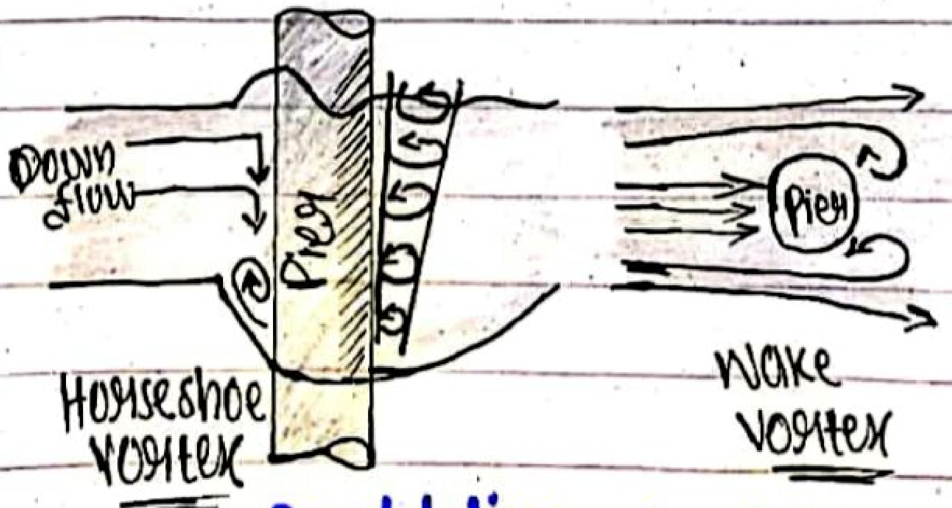
❖ "Working mechanism of Scour"

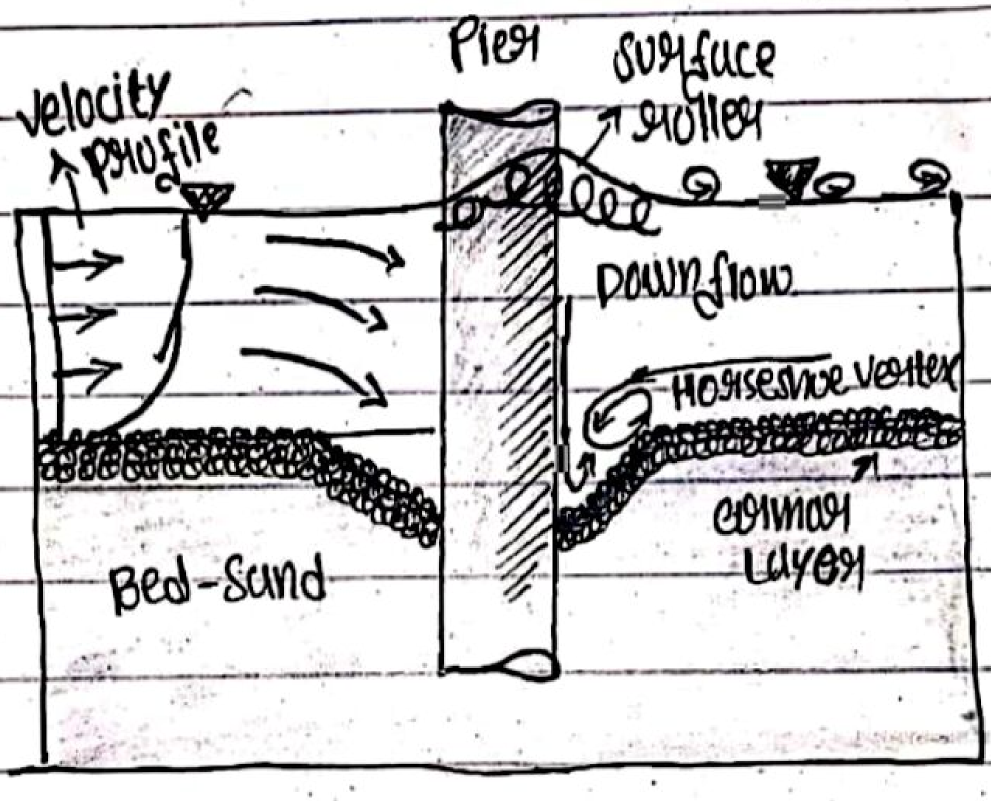
- At the obstruction in form of abutment or pier, The undirectional flow changes into three dimensional and the flow accelerates around the nose as the water pileup in front face of the obstruction.
- This phenomenon results in formation of vertex at the base of the pier which is called horseshoe vertex. While the vertix formed in the vertical direction downstream of the pier is called wake vortex.



Presentation of vortex

- The pileup of water due to obstruction due to deceleration of flow due to stagnation pressure of water results a downward flow which results to horseshoe vortex. Thus the vertical component of the downward flow causes erosion around the bed of the pier.
- In the practical case the river bed is generally composed of mixture of various sizes of different materials. Due to washing out of finer material an armor layer is formed of coarse material which protects from further scouring the underlying finer particle. Due to armour layer the clear water regime can be extended as the value increases of critical velocity.

Armor layer:


Pier
Surface roller
velocity profile
Down flow
Horseshoe vortex
Bed-Sand
armor layer