Hydraulic Structures

Assignment 2

Submitted by

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Section A

Submitted to

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Q: No: 1:-

Establish the stage discharge relationship for a concrete rectangular box culvert use suitable data of your own choice.

Given Data:-

Width = 1.6m

Height = 0.9m

Length = 32m

Manning's $n = 0.013$

$Ke = 0.5$

Range of head water level of investigation = 0 - 3m.

Solution:-

$H/D \leq 1.6$

$H < 0.9m$

$\Rightarrow \quad Q = 2.92 y_0 \left[1.2 y_0 / 1.2 + 2Y_0\right]^{2/3}$ — (1)

Y_o (m)	Q ($m^3 s^{-1}$)	Y_c (m)
0.3	0.299	0.152
0.6	0.785	0.290
0.9	1.330	0.413

Now by putting values of y_o in eq ①.

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

$$Q_1 = 0.299\ m^3/s$$

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

$$Q_2 = 0.785\ m^3/s$$

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

$$Q_3 = 1.330\ m^3/s$$

Critical Depth:

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

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

Putting values in eq (B), we get

$$q_1 = \frac{Q_1}{B} = \frac{0.299}{1.6} = 0.186$$

$$q_2 = \frac{Q_2}{B} = \frac{0.785}{1.6} = 0.490$$

$$q_3 = \frac{Q_3}{B} = \frac{1.330}{1.6} = 0.831$$

By Putting values in eq (A)

$$y_{c_1} = \left(\frac{q_1^2}{g}\right)^{1/3}$$

$$y_{c_1} = \left[\frac{(0.186)^2}{9.81}\right]^{1/3} = \boxed{0.152}$$

$$y_{c_2} = \left(\frac{q_2^2}{g}\right)^{1/3} = \left[\frac{(0.490)^2}{9.81}\right]^{1/3}$$

$$y_{c_2} = 0.290$$

$$y_{c_3} = \left(\frac{q_3^2}{g}\right)^{1/3} = \left[\frac{(0.831)^2}{9.81}\right]^{1/3}$$

$$y_{c_3} = 0.413$$

Also;

$$H = y_o + \frac{v^2}{2g} + ke.\frac{v^2}{2g}$$

$$V = 1.142\ m/s$$

Hence,

$$H_1 = y_{o_1} + \frac{v^2}{2g} + ke.\frac{v^2}{2g}$$

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

$$H_1 = 0.399m$$

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

$$H_2 = 0.699m$$

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

$$\boxed{H_3 = 0.999m}$$

Y_o (m)	H (m)	Q ($m^3 s^{-1}$)
0.3	0.399	0.299
0.6	0.699	0.785
0.9	0.999	1.330
orifice > 0.9	1.08	1.477
1.2 D	⟶	By interpulation

$$H/D \geq 1.6$$

(a) For orifice flow;

$$Q = Cd(1.6 \times 0.9)\left[2g\left(H - \frac{D}{2}\right)\right]^{1/2}$$

$$= 0.62(1.6 \times 0.9)\left[2(9.81)\left(1.08 - \frac{0.9}{2}\right)\right]^{1/2}$$

$$Q = 2.630\, m^3/sec$$

The following results in the table are obtained;

H (m)	Q ($m^3 s^{-1}$)	Y_o (m)
1.08	2.630 ~~1.394~~ m^3/s	0.9

(b) For pipe flow energy equation gives,

$$H + S_o L = D + h_L$$

where,

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

so,

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

During rising stages the barrel flows full from ~~[illegible]~~ H = 1.08 m and during falling stages the flow becomes free-surface flow when H = 0.999 m. The following table (on next page →) summarizes the results:

The following table summarize the result.

H(m)	Q (m^3/s)	Type of Flow
0.399	0.299	open channel
0.699	0.785	open channel
0.999	1.330	open channel
1.080	1.477	Pipe Flow
2.00	2.487	Pipe Flow
3.00	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.

formed

Loads ON Bridge Foundation Due TO Scour:-

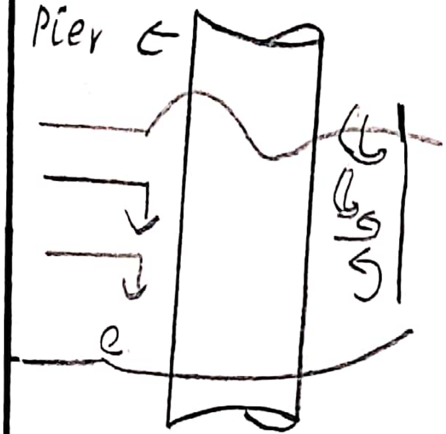
Loads due to flood actions that results in scour are a leading cause of bridge failure, while seismic actions that induce lateral forces may lead to high ductility demand that exceeds pier capacity. When combined seismic actions and scour can lead to effects that depend on the governing scour condition affecting a bridge.

For safe design and maintance of hydraulic structures, scour is the most concern issue and is one of the leading causes of Bridge failure. Also in the failure of well foundation, the well cap made of stone masonary would be fail in bending. Other types of load acting on bridge foundation may be gravity load, shearing load, lateral earth pressure which contribute to the effect of scour in applying load on bridge foundation.

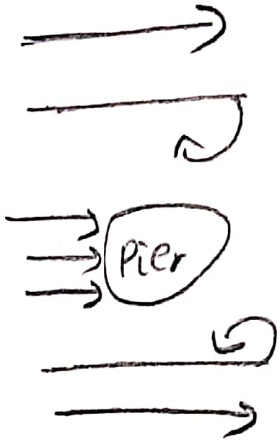
Working Mechanism OF Scour:-

The obstruction in the 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 of the obstrution. This phenomenon results in formation of "vortex" at the base of pier which is called haseshoe vortex. While the vortex formed

In the vertical direction downstream of the pier is called wake vortex.



Horseshoe vortex



wake vortex

The pileup of water because of obstruction, deceleration of flow, due to stagnation pressure of water results a downward flow which results to horseshoe vortex. Thus erosion is caused around the bed of the pier due to vertical component of downward flow.

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. As the values of critical velocity increases, the clear water regime (because of armor layer) can be extended.