Hydraulic Structures

Assignment 2

Submitted by

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Section B

Submitted to

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Question #01

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

Given/Assumed Data

Width = 1.8m
Height = 0.8m
Length = 28m
Slope = 1:1000

manning; n = 0.013

Square edged entrance, ke = 0.5

Range = 0 – 3m

Required

Stage-Discharge Relationship

Sol:

$H/D \leq 1.8m$

$H < 0.8m$

Discharge is given by;

$$Q = 2.92 y_o \left[1.2 y_o / 1.2 + 2 y_o \right]^{2/3} \quad -(1)$$

Y_o (m)	Q (m^3/s)	Y_c (m)
0.3	0.299	0.141
0.5	0.614	0.228
0.8	1.144	0.345

By putting values of y_o in eq (1)

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

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

$$\rightarrow Q_2 = 2.92(0.5)\left[1.2(0.5)/1.2 + 2(0.5)\right]^{2/3}$$

$$Q_2 = 0.614 \, m^3/s$$

$$\rightarrow Q_3 = 2.92(0.8)\left[1.2(0.8)/1.2 + 2(0.8)\right]^{2/3}$$

$$Q_3 = 1.144 \, m^3/s$$

Critical Depth

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

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

By putting values in eq (ii)

$$q_1 = \frac{Q_1}{B} \Rightarrow \frac{0.299}{1.8} = 0.166$$

$$q_2 = \frac{Q_2}{B} \Rightarrow \frac{0.614}{1.8} = 0.341$$

$$q_3 = \frac{Q_3}{B} \Rightarrow \frac{1.144}{1.8} = 0.635$$

By putting values in eq (i)

$$y_{c1} = \left(\frac{(0.166)^2}{9.81}\right)^{1/3} = 0.141\,m$$

$$y_{c2} = \left(\frac{(0.341)^2}{9.81}\right)^{1/3} = 0.228\,m$$

$$y_{c3} = \left(\frac{(0.635)^2}{9.81}\right)^{1/3} = 0.345\,m$$

Now;

$$H = y_0 + \frac{V^2}{2g} + ke \cdot \frac{V^2}{2g}$$

$V = 1.142\ m/s$

$ke = 0.5$

So;

$$H_1 = y_{01} + \frac{V^2}{2g} + ke \cdot \frac{V^2}{2g}$$

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

$$= 0.399\ m$$

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

$$= 0.599\ m$$

$$H_3 = 0.8 + \frac{(1.142)^2}{2(9.81)} + 0.5\frac{(1.142)^2}{2(9.81)}$$

$$= 0.899\ m$$

Yo (m)	H (m)	Q (m^3/s)
0.3	0.399	0.299
0.5	0.599	0.614
0.8	0.899	1.144
Orifice > 0.8 "1.20"	0.96	1.251 By Interpolation

→ $H/D \geq 1.8$

For orifice flow

$$Q = cd\,(1.8 \times 0.8)\left[2g\left(H - D/2\right)\right]^{1/2}$$

$$= 0.62\,(1.8 \times 0.8)\left[2 \times 9.81\left(0.96 - \frac{0.8}{2}\right)\right]^{1/2}$$

$$Q = 2.95\ m^3/s$$

The following results are obtained

$H(m) = 0.96$

$Q(m^3/s) = 2.95$

$yo(m) = 0.8$

For the pipe flow energy equation

$$H + S_0 L = D + h_L$$

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=0.96m and and during falling stages the flow becomes free-surface flow when H=0.899m. The table on next page summarizes the result.

H (m)	Q (m^3/s)	Type of flow
Rising Stages		
0.399	0.299	Open channel
0.599	0.614	Open channel
0.899	1.141	Open channel
0.96	1.251	pipe flow
1	1.364	pipe flow
2	2.487	pipe flow
3	3.242	pipe flow
Falling Stages		
2	2.487	pipe flow
1	1.364	pipe flow
0.96	1.251	pipe flow
0.899	1.144	Open channel
0.599	0.614	Open channel
0.399	0.299	Open channel

Question #02

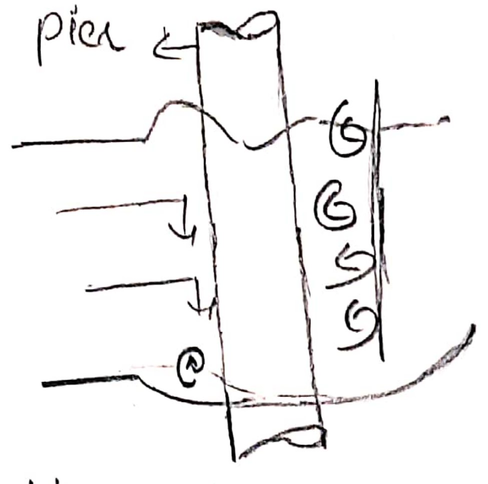
Loads on bridge foundation due to scour

Loads produced during flood actions that usually results in scour, are a leading cause of bridge failure, Seismic actions that include 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.

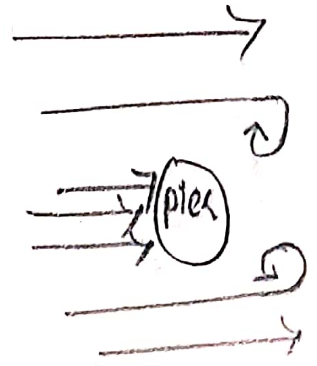
For safe design and maintance of hydraulic structures, scour is the most concern issue and is one of the leading causes of bridge failure. Also in the failure of well foundation, the well cap made of stone masonary would be failed in bending. Other types of load acting on bridge foundation may be gravity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

Work Mechanism Of Scour

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 of the obstruction. This phenomenon results in formation of "vortex" at the base of pier which is called horseshoe 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

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.