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Establish the stage (head water level) - discharge relationship for a concrete rectangular box culvert, using the following data: width = 1.2m; height = 0.6m; Length = 30m; slope = 1 in 1000; manning's n = 0.013; square, edged entrance conditions; free jet outlet flow; range of headwater level for investigation = 0/3m; neglect the velocity of approach.

* **SOLUTION:-**

1 $H/D \leq 1.2$. For $H < 0.6$m, free flow open-channel conditions prevail. Referring to Fig. 10.6 and assuming that a step slope entry gives entrance control (i.e the depth at the inlet is critical, for $H = 0.2$m, ignoring entry loss $y_1 = (2/3) \times 0.2 = 0.133$m and $V_1 = 1.142\ ms^{-1}$. This gives the critical slope $(Vn)^2/R^{4/3} = 0.00424$. Therefore the slope of the culvert is mild and hence subcritical flow analysis gives the following results:

$$Q = 1.2y_0[1.2y_0/(1.2+2y_0)]^{2/3}(0.001)^{1/2}/0.013$$
$$= 2.92y_0[1.2y_0/(1.2+2y_0)]^{2/3} \quad (i)$$

Date:

y_0 (m)	Q ($m^3 s^{-1}$) (equation (i))	y_1 (m)
0.2	0.165	0.124
0.4	0.451	0.243
0.6 (=D)	0.785	0.352

At the inlet over a short reach,

$$H = y_0 + V^2/2g + K_0 V^2/2g \quad \text{(ii)}$$

The entrance loss co-efficient, K_o, is as follows:

for a square-edged entry, 0·5;
for a flared entry, 0·25;
for a rounded entry, 0·05;

Y_o (m)	H (m) (equation (ii))	Q ($m^3 s^{-1}$)
0·2	0·236	0·165
0·4	0·467	0·451
0·6	0·691	0·785
orifice ⟷ 0·6 ⟵ (1·2D =)	0·72 ⟶	0·817 by interpolation.

2. $H/D \geq 1·2$.

(a) For orifice flow.

$$Q = C_d (1·2 \times 0·6) [2g(H - D/2)]^{1/2}$$

With $C_d = 0·62$ the following results are obtained:

Date:

H(m)	Q($m^3 s^{-1}$)	Y_o (m) (equation (i))
0.72	1.29	> 0.6 → no orifice flow exists

(b) For pipe flow the energy equation gives

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

Where

$$h_L = K_e V^2/2g + (Vn)^2 L/R^{4/3} + V^2/2g.$$

Thus

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

H (m)	Q($m^3 s^{-1}$) (equation (iv))
Y_o = 0.6 (equation (i)) ←	
0.691	0.723
0.72 ←	0.805
1.00	1.364
2.00	2.487
3.00	3.242

During rising stages the barrel flows full from H = 0.72m and during falling stages the flow becomes free-surface flow when H = 0.691m.

The following table summarizes the results.

Date: ____________

H (m)	Q ($m^3 s^{-1}$)	Type of flow
Rising stages		
0.236	0.165	Open channel
0.467	0.451	Open channel.
0.691	0.785	open channel.
0.720	0.805	Pipe flow
1.00	1.364	Pipe flow
2.00	2.487	Pipe flow
3.00	3.242	Pipe flow
Falling stages		
2.00	2.487	Pipe flow
1.00	1.364	Pipe flow
0.72	0.805	Pipe flow
0.691	0.723	Pipe flow
0.691	0.785	Open channel
0.467	0.451	Open channel
0.236	0.165	Open channel.

Date:

* BRIDGE SCOUR:

Bridge Scour is the removal of sediment such as sand rocks from around bridge abutments or piers. Scour, caused by swiftly moving water, can scoop out scour holes, compromising the integrity of a structure.

In the United states, bridge scour is one of the three main causes of bridge failure. Where 46 of 86 major bridge failures resulted from scour near piers from 1961 to 1976.

* EFFECTS OF SCOUR:-

- Lowering the river bed level around pier.
- Destablize the foundation (Pier).

* MECHANISM OF SCOUR:-

⇒ Development scour hole:-

Vortex System formed in front of the obstruction, and has the form of horseshoe. River flow and boundary condition give rise to the energy of the vortex increased shear stress commence local sediment transport

⇒ Local Scour at Piers:

- occurs due to the acceleration of flow around the pier the formation of flow vortices.

* **PROTECTION:**

Gravel bags: Put around pies used for filter function to reduce flow but disadvantages handiling cost and potential damage to bags during installantion and after a time loose rock due to flow.