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Section	A
Deptt	Civil Engg.
Assignment	Hydraulic Structure

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Stage discharge Relationship for a concrete rectangular box culvert:

Given data:

Width = 1.4 m

Height = 0.9 m

Length = 26 m

Slope = 1 : 1000

mannings = n = 0.013

edge entrance = K_e = 0.5

Range = 0 - 3 m

Solution:

$$H/D \leq 1.4 m$$

$$H < 0.9 m$$

Discharge is given by:

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

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_0' we will get the corresponding discharge.

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

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

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

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

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

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

Critical depths:

$$y_c = (q^2/g)^{1/3} \longrightarrow (1)$$

$$q = Q/B \longrightarrow (2)$$

By putting values in eq. (2)

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

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

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

Now by putting values in eq. ①

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

$$y_{c_2} = \left(\frac{q_2^2}{g}\right)^{1/3} = \left(\frac{(0.51)^2}{9.81}\right)^{1/3} = 0.317\,m$$

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

At the inlet over a short reach.

$$H = y_o + \frac{V^2}{2g} + K_e \cdot \frac{V^2}{2g}$$

So,

$$H_1 = y_{o1} + \frac{V^2}{2g} + K_e \cdot \frac{V^2}{2g}$$

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

$$= 0.399\,m$$

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

$$= 0.699\,m$$

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

$$= 0.999\,m$$

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 interpolation

$H/D \geq 1.4$

(a) for orifice flow:

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

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

$$Q = 2.746 \ m^3/s$$

The following results are obtained;

H (m)	Q ($m^3 s^{-1}$)	y_o (m)
1.08	2.746	> 0.9 no orifice flow exist.

For pipe flow the energy equation gives.

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

where,

$$h_L \quad K_e \frac{V^2}{2g} + (V_n)^2 \frac{L}{R^{4/3}} + \frac{V^2}{2g}$$

Thus

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

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

The following tables summarize the result:

H (m)	Q ($m^3 s^{-1}$)	Type of flow
Rising stage		
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	piple flow
3.000	3.242	pipe flow
Falling stage		
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

Loads on bridge Foundation:

Engineers considered three main types of loads, dead load, live load and enviromental loads:

Dead Loads:

It include the weight of the bridge itself plus any other permanent object affixed to the bridge, such as tool booths, highway signs, guardrails, gates or a concrete road surface.

Live loads:

Are temporary loads that act on a bridge such as cars, trucks, trains or pedestrains.

Enviromental Loads:

Are temporary loads that act on a bridge and that are due to weather or other enviromental influences, such as wind from hurricanes, tornados or high guts; snow and earthquakes. Rainwater collecting might also be a factor if proper drainage is not provided.

Values for these loads are dependent on the use and location of the bridge.