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ASSIGNMENT

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SECTION: B

SUBJECT: Hydraulic Structures

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LOADS ON BRIDGE FOUNDATION DUE TO SCOUR AND THEIR MECHANISM:

SCOUR:-

Scour is one of the greatest reason that leads to bridge failure. It is one of the most concerned issues for safe design and maintenance of hydraulic structures.

Scour removes the bed materials around the foundation of the bridge which results in exposure of the foundation and endanger the stability of the bridge. Scour is accountable for about 60% of bridge failure.

The erosion caused by flowing water resulting in removal of sand, earth or silt from the bottom of the river is called scour.

The scour around obstruction in waterway is called local scour.

The scour due contraction of waterway is called contraction scour.

The scour due to continuous flow of water over a long period of time the occurring scour is called degradation or aggradation.

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MECHANISM OF SCOUR.

At the obstruction in form of pier or abutment, the unidirectional flow changes into three dimensional as the water pileup in front face of the obstruction and the flow accelerates around the nose. This phenomenon results in formation of vortex at the base of the pier known as horseshoe vortex and vortex form in the vertical direction downstream of the pier known as wake vortex.

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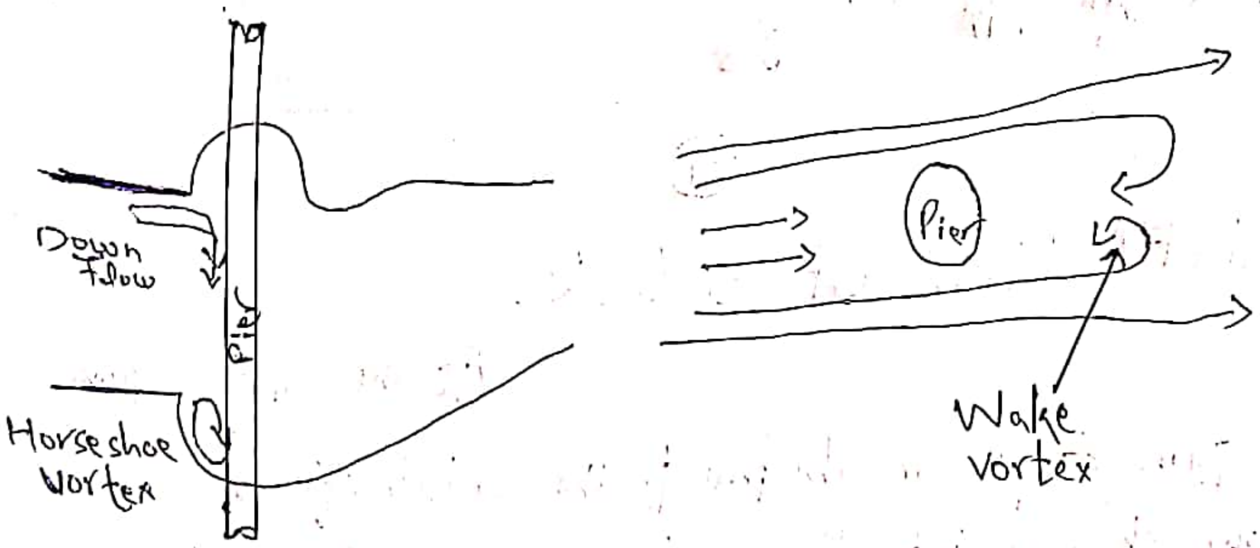

Presentation of vortex around a circular pier

The pileup of water due to obstruction because of deceleration of flow due to stagnation Pressure of water causes a downward flow results in horseshoes vortex. The vertical component of the downward flow causes erosion around the base of the pier.

Due to rolling of unstable shear layers at the surface of the pier wake vortex are generated at the separation line and moves forward with flow downstream of the pier. It can be shown in fig;

In the practical case the river bed is generally composed of mixture of different sizes of material. Due to washing out of finer materials an armor layer is formed of coarser material which protect the underlying fine particales from further scour. Due to the presence of armor layer the clear water regime can be extended as the value of critical velocity increases. The armor layer is shown.

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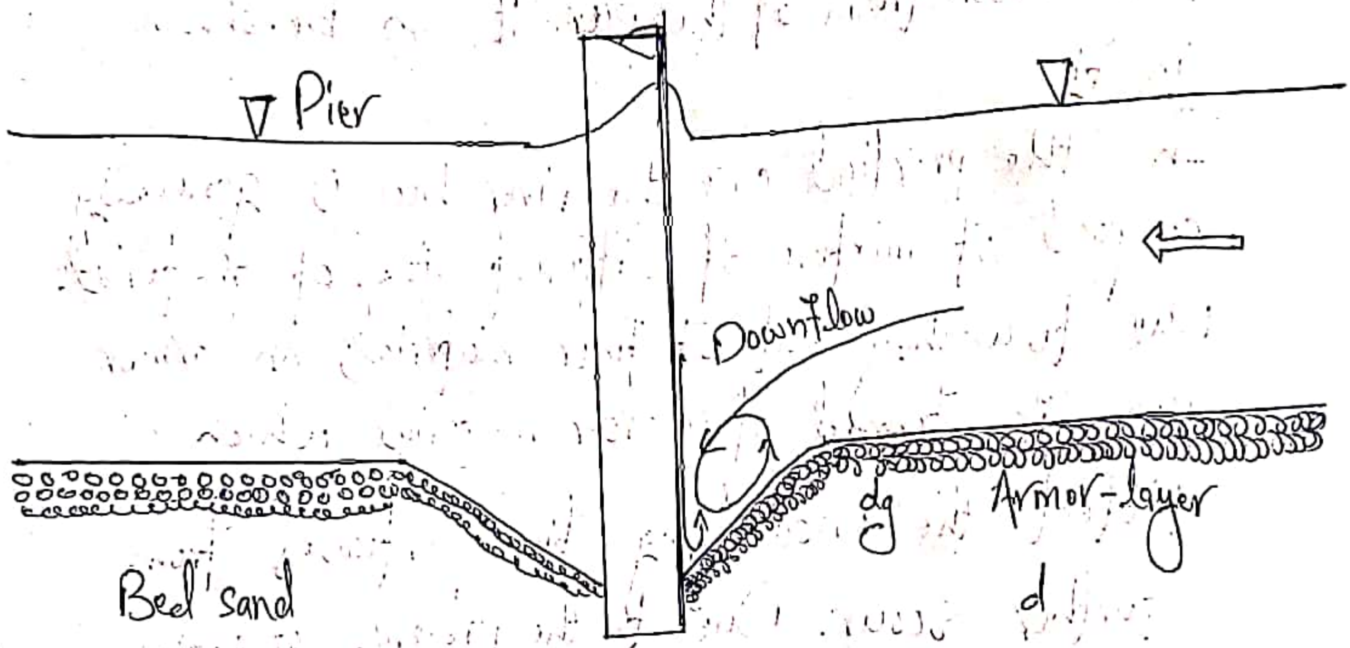

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8:

Sol: Given Data

Width = 1.3 m

Height = 0.8 m

Length = 33 m

Slope = 1:1000

mannings ; n = 0.013

Square edged entrance ; Ke = 0.5

Range ; = 0 – 3 m

⟹ Here

H/D ≤ 1.3 m

H < 0.8 m

$Q = 2.92 Y_0 [3.2 Y_0 / 3.2 + 2 Y_0] \rightarrow$ "A"

y_0 (m)	Q ($m^3 s^{-1}$)	y_c (m)
0.3	0.299	0.175
0.5	0.614	0.283
0.8 (=D)	1.144	0.428

By putting values of y_0 in "A"

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

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

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

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

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

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

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⇒ Critical depth:

$$Y_c = \left(q^2/g\right)^{1/3} \rightarrow (B)$$

$$q = Q/B \rightarrow (C)$$

By putting values in eq (C)

$$q_1 = Q_1/B = \frac{0.299}{1.3} = 0.230$$

$$q_2 = Q_2/B = \frac{0.614}{1.3} = 0.472$$

$$q_3 = Q_3/B = \frac{1.144}{1.3} = 0.88$$

Now by putting values in eq (B)

$$Y_{c_1} = \left((0.230)^2/9.81\right)^{1/3} = 0.175$$

$$Y_{c_1} = 0.175$$

$$Y_{c_2} = \left((0.472)^2/9.81\right)^{1/3} = 0.283$$

$$Y_{c_2} = 0.283$$

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(11)

$$Y_{c_3} = \left((0.88)^2/9.81\right)^{1/3} = 0.428$$

$$Y_{c_3} = 0.428$$

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Now, At the inlet over a short reach;

$$H = Y_0 + \frac{V^2}{2g} + K_e \frac{V^2}{2g}$$

$$V = 1.142 \text{ m/s}$$

So,
$$H_1 = Y_0 + \frac{V^2}{2g} + K_e \frac{V^2}{2g}$$

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

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

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

$$\boxed{= 0.599 \text{ m}}$$

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

$$\boxed{= 0.899 \text{ m}}$$

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Y_o (m)	H (m)	Q ($m^3 s^{-1}$)
0.3	0.399	0.299
0.5	0.599	0.614
0.8	0.899	1.144
Orifice > 0.8	0.96	1.251
1.2D		By Interpolation

$\Rightarrow H/D \geq 1.3$

For orifice flow,

$$Q = C_d\,(1.3 \times 0.8)\left[2g\,(H - D/2)\right]^{1/2}$$

$$= 0.62\,(1.3 \times 0.8)\left[2(9.81)\left(0.96 - \frac{0.8}{2}\right)\right]^{1/2}$$

$$= 9.46\ m^3/s$$

The following results are obtained

H (m)	Q (m^3/s)	Y_0 (m)
0.96	9.46	> 0.8

=> For pipe flow the 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 = ~~0.98~~ 0.96 m and during falling stages the flow becomes free-surface flow when H = 0.899 m

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The following table summarizes the result

H (m)	Q (m^3/s)	Types of flow
Rising stages		
0.399	0.294	Open channel
0.599	0.614	Open channel
0.899	1.144	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