IQRA NATIONAL UNIVERSITY PESHAWAR

DEPARTMENT OF CIVIL ENGINEERING

SUBJECT: HYDRAULIC STRUCTURES
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SECTION: C

Q.NO (01)

a) Differentiate b/w Culvert & Causeway?

ANSWER (01 A)

CULVERT: A culvert is a structure that allows water to flow under a road, rail road, trail or similar obstruction from one side to another. Typically embedded so as to be surrounded by soil, a culvert may be made from a pipe, reinforce concrete or other material. In United Kingdom, the word can also be used for longer artificially buried watercourses.

The process of removing culverts to restore open-air watercourses is known as day lighting. In the UK the practices is also known as de-culver-ting.

CAUSEWAY: A Causeway is a track, road or railway on the upper point of an embankment across "a low or wet place or piece of water". It can be constructed of earth, masonry, wood or concrete.

OR

A road that is raised, so as to be above water, marshland and similar low-lying obstacles. Originally causeways were much like dykes, generally pierced to let water through, whereas many modern causeways are more like bridges or viaducts.

b) Define cross drainage work. Why it is necessary? Explain different types of cross drainage work in detail.

ANSWER (01 B)

CROSS DRAINAGE WORK: A Cross Drainage Work is a structure carrying the discharge from a natural stream across a canal intercepting the stream. Canal comes across obstruction like rivers, natural drain and other canals. The various types of structure that are built to carry a canal water across above mentioned obstruction or vice versa are called cross drainage work.

It is generally a very costly item and should be avoided by:

- Diverting one stream into another.
- Changing the alignment of the canal so that it crosses below the junction of two steam

Why it is necessary?

A cross drainage work also called (CD Work) is a structure built on a canal where it is crosses a natural drainage such as a stream or a river. The canal are preferably, aligned on the watershed so that there are no drainage crossings. However it is not possible to avoid the drainages in the initial reach of a main canal because it takes off from a diversion head works or storage work located on a river which is a valley. The canal therefore require a certain distance before it can mount the watershed or ridge. In this initial reach, the canal is usually contour canal and it is intercepts a number of natural drainage flowing from the watershed to the river.

It is necessary for the canal to leave the water for a short distance where the water takes a sudden small loop and it is not possible to align the canal along the loop. In this case the canal intercept the drainage which carry the water of the pocket b/w the canal and the watershed and hence the cross drainage work are required.

Types of cross drainage works

Depending upon levels and discharge, it may be of the following types:

Cross drainage works carrying canal across the drainage:

An Aqueduct: When the HFL of the drain is sufficiently below the bottom of the canal such that the drainage water flows freely under gravity, the structure is known as Aqueduct.

- In this, canal water is carried across the drainage in a trough supported on piers.
- Bridge carrying water
- Provided when sufficient level difference is available between the canal and natural and canal bed is sufficiently higher than HFL.

Siphon Aqueduct: In case of the siphon Aqueduct, the HFL of the drain is much higher above the canal bed, and water runs under siphon action through the Aqueduct barrels.

- The drain bed is generally depressed and provided with pucca floors, on the upstream side, the drainage bed may be joined to the pucca floor either by a vertical drop or by glacis of 3:1. The downstream rising slope should not be steeper than 5:1. When the canal is passed over the drain, the canal remains open for inspection throughout and the damage caused by flood is rare. However during heavy floods, the foundations are susceptible to scour or the waterway of drain may get choked due to debris, tress etc.

Super passage: The hydraulic structure in which the drainage is passing over the irrigation canal is known as super passage. This structure is suitable when the bed level of drainage is above the flood surface level of the canal. The water of the canal passes clearly below the drainage.

- A super passage is similar to an aqueduct, except in this case the drain is over the canal.
- The FSL of the canal is lower than the underside of the trough carrying drainage water. Thus, the canal water runs under the gravity.
- Reverse of an aqueduct

Canal Siphon: If two canals cross each other and one of the canals is siphoned under the other, then the hydraulic structure at crossing is called “canal siphon”.

- In case of siphon the FSL of the canal is much above the bed level of the drainage trough, so that the canal runs under the siphon action.
- The canal bed is lowered and a ramp is provided at the exit so that the trouble of silting is minimized.
- Reverse of an aqueduct siphon.

Q.NO (02)

a) Differentiate b/w Weir & Barrage?

ANSWER (02 A)

WEIR: A weir is a small barrier built across a stream or river to raise the water level slightly on the upstream side; essentially a small-scale dam. Weirs allow water to pool behind them, while allowing water to flow steadily over top of the weir. Additionally, the term weir can be used to refer to the crest of a spillway on a large embankment dam.

Weirs can be constructed out of several different materials, depending on their age and purpose. Wood, concrete, or a mixture of rocks, gravel, and boulders can all be used to construct a weir.

BARRAGE: A heavy barrier of artillery fire to protect one’s own advancing or retreating troops or to stop the advance of enemy troops. Or

A barrage is a type of low-head, diversion dam which consists of a number of large gates that can be opened or closed to control the amount of water passing through. This allows the structure to regulate and stabilize river water elevation upstream for use in irrigation and other systems. The gates are set between flanking piers which are responsible for supporting the water load of the pool created. The term barrage is borrowed from the French word “barrier” meaning “to bar”.

b) Define Reynolds's Numbers. What will be the limit of Reynolds's Numbers for Laminar, Turbulent and Neither Laminar nor Turbulent Flow? Also define lower and higher critical velocity.

ANSWER (02 B)

REYNOLDS NUMBER: The Reynolds number is the ratio of inertial forces to viscous forces within a fluid which is subjected to relative internal movement due to different fluid velocities.

Or

The Reynolds number (Re) is an important dimensionless quantity in fluid mechanics used to help predict flow patterns in different fluid flow situations. At low Reynolds numbers, flows tend to be dominated by laminar (sheet-like) flow, while at high Reynolds numbers turbulence results from differences in the fluid's speed and direction, which may sometimes intersect or even move counter to the overall direction of the flow (eddy currents).

There are in general three types of fluid flow in pipes

- Laminar
- Turbulent
- Transient

LIMITS:

The flow is laminar when $Re < 2300$

The flow is transient when $2300 < Re < 4000$

The flow is turbulent when $4000 < Re$.

LOWER CRITICAL VELOCITY: A velocity at which laminar flow stops. Or

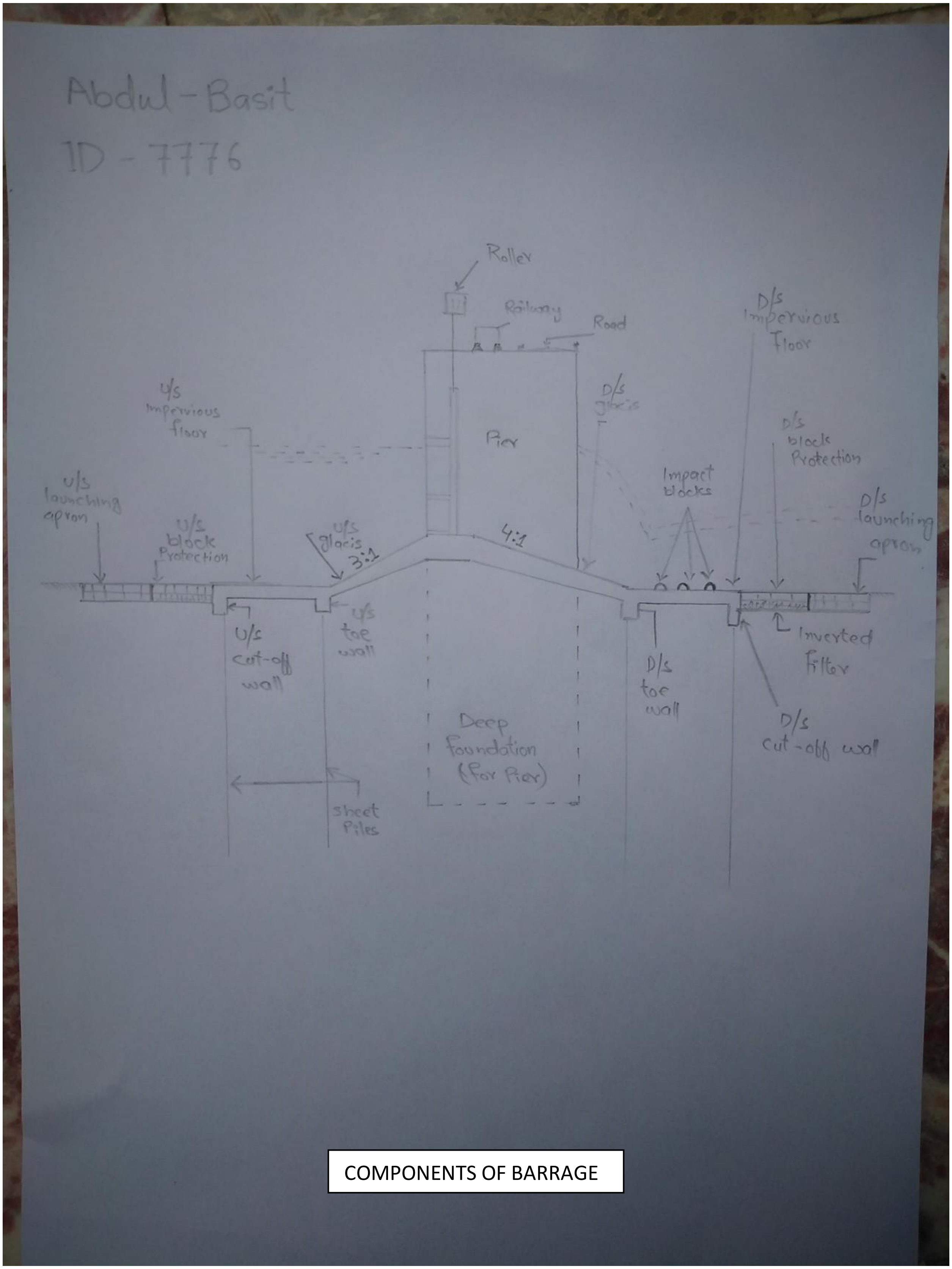
The velocity at which the flow enters from laminar to transition period is known as Lower Critical Velocity. There is a transition period in between laminar and turbulent flow. It has been experimentally found that when a laminar flow changes into turbulent, it does not change abruptly. But there is transition period between two types of flows.

UPPER CRITICAL VELOCITY: A velocity at which turbulent flow starts. Or

A velocity in which flow enters from transition period to turbulent flow is known as upper or higher critical velocity.

Q.NO (03)

a) Draw neat sketch of barrage showing its different components.



COMPONENTS OF BARRAGE

Q.NO (03 B)

How would you predict/analyze maximum or, equilibrium scour depth based on experiment on formula.

ANSWER:

Due to complex mechanism of scouring and the said disadvantages of physical modeling tool, numerical approaches are of interest. Based on extensive literature review, large amount of numerical methods has been initiated and majority of them is empirically based and focuses on maximum scour depth (DS) prediction.

EXPERIMENT:

The experiment is carried out with physical model constructed in the hydraulic laboratory. At an undistorted geometric scale of 1:75, the model body composes of three main parts.

- The upstream boundary
- The control structure consists of dam body, inlet piers, radial gates and chute spillway with flip bucket.
- The downstream boundary

Layout of the spillway physical model is illustrated as:

$$h = 0.17851Q^{0.523149}$$

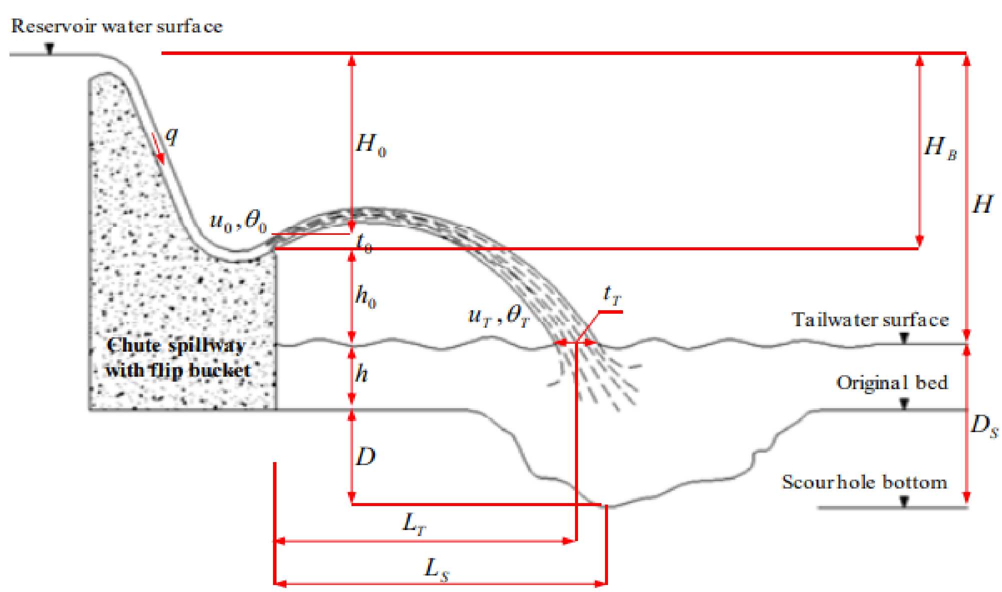
Where h (m) is the tail water depth and Q (m3/s) is the discharge.

Existing formulas of maximum scour depth (DS)

All 28 prediction formulas of DS (1932-2007) are summarized as below. Fig. defines all the parameters used in these methods.

$$D_S = k\frac{q^x H^y}{d^z}.$$

Where Q (m3/s/m) is the discharge per unit width, H (m) is the head drop between reservoir water surface and tail water surface, d (m) is the characteristic particle size of bed material, k is the constant, and x, y and z are the exponent coefficient of q, H and d, respectively.



Existing formulas of impact location (LS)

Three different methods were applied for non-submerged jet (from bucket lip to point of impingement). It means that these three methods can estimate only the horizontal distance (LT) between the bucket lip and point of impingement on the tail water surface.

$$L_S = \frac{1}{gk_0^2}\ln(1 + 2k_0 u_{0X}\alpha) + (h_0 + D_S)\tan(90 - \theta_T).$$

Where KR is the reduction coefficient due to air resistance, φ is the coefficient of spillway head loss, t0 (m) is the jet thickness at the end of flip bucket and H0 =HB – t0.

RESULTS AND DISCUSSION

Three existing formulas were applied respectively to estimate DS and LS, and their results were compared with the experimental ones. Although the formula alone performs well in predicting DS, the combination of Mason-B (for low Q), Taraimovich (for medium Q) and Mason A (for high Q) provides much better results. Each individual method has its own limitation and therefore does not work well with different ranges of Q. In case of LS prediction, similar situation is observed. The combination for low and high Q) and (for medium Q) yields more accurate results than using formula alone. Based on the experimental outputs, a new DS method was established and it is functional with the easily available data (Q and h). For DS prediction, the combined method of Mason-B, Taraimovich and Mason-A is recommended when there are sufficient input data. It is expected to provide more accurate results than the proposed formula because many factors (variables) are associated. However, in data-constraint situation, the new DS formula would be more feasible.

Q.NO (04)

A box culvert is to be designed having inside dimensions 15ft*15ft. the culvert is subjected to L.L of 1.5kips/ft2 and superimposed D.L of 300Ib /ft2. Unite weight of soil is 100 Ib/ft3. Angle of repose is 30. Use 1:2:4 concrete and fy = 60 ksi steel. Design the box culvert.

ANSWER:

Given data

$L.L = 1.5\ Kip/ft^2$

$D.L = 300\ lb/ft^2$

$\theta = 30^\circ$

unit weight of soil $= 100\ lb/ft^3$

Dimension $= 15' \times 15'$

f_y = 60ksi Steel.

concrete = 1:2:4 = M15

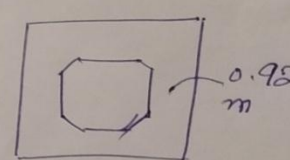
Sol ① Load calculation.

Total Load on Top = Self weight + L.L + D.L

Self wt $= 3 \times 15 = 45\ KN/m^2$

w = Total Load $= 1.5 + 0.939 + 0.3$

$w = 2.739\ kip/ft^2$



② co-efficient of earth pressure

$$K_a = \frac{1 - \sin\theta}{1 + \sin\theta} = \frac{1 - \sin(30)}{1 + \sin(30)}$$

$K_a = 0.33$

Lateral pressure due to (D.L + L.L)

= Total vertical load (L.L + D.L) × Ka

$= (1.5 + 0.3) \times 0.33$

$= 0.594\ kip/ft^2$ // $28.4\ KN/m^2$

⇒ Lateral pressure due to Soil.

$K_a \times \gamma_{soil} \times h$

$0.33 \times 0.1 \times 18$

$= 0.594 \ kip/ft^2$ // $28.4 \ kN/m^2$

⇒ Lateral pressure at top

Lateral pressure due to (L.L+D.L)

$= 0.594 \ kip/ft^2$ or $28.4 \ kN/m^2$

⇒ at Bottom lateral pressure due to (D.L + L.L) + Lateral pressure due to soil.

$= 1.188 \ kip/ft^2$ or $56.88 \ kN/m^2$