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Subject: Irrigation & Hydrolics Structures

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Q1:) a) Define open channel. what is meant by prismatic and non prismatic open channels?
b) Discuss in detai types of flow in open channels.

Ans 1:) a-) <u>open channel</u>:> open channel hydraulics, a subject of great importance to civil engineers, deals with flows having a free surface in channels constructed for water supply, irrigation drainage and hydroelectric power generation; in sewers culverts, and tunnels flowing partially full; and in natural streams an rivers.

> An open channel is a duct in which the liquid flows with a free surface.

> This is in contrast with pipe flow in which the liquid completely fills the pipe and flow under pressure.

> The flow in a pipe takes place due to difference of pressure (pressure gradient) whereas in open channel it is due to the slope of the channel bed (i.e; due to gravity).

* **Prismatic channels**: prismatic channels: a channel is said to be prismatic when the cross section is uniform and the bed slop is constant.

> Prismatic simply means the cross-section is the same at any location across the long axis of beam.

* **Non-prismatic channels**: when either the cross section or the slope (or both) change, the channel is referred to as non-prismatic. it is abvious that only artifical channel can be prismatic

* The channel in which the cross section shape, size and the bottom slope ~~cons~~ are constant is termed as prismatic channels

> All natural channels generally have varying cross section and consequently are non-prismatic.

Ans (is) b:> **Types of flow in open channels:**

The flow in an open channel can be classified into the following types.

A). Uniform & non-uniform flow

> If for a given length of the channel the velocity of flow, depth of flow, slope of the channel and cross-section remain constant the flow is said to be uniform.

> otherwise it is said to be non-uniform

> Non-uniform flow is also called varied flow further classified as:

* Gradually varied flow (GVF) where the depth of the flow changes gradually along the length of the channel.

* Rapidly varied flow (RVF) where the depth of flow changes suddenly over a small length of the channel. for example, when water flows over an overflow dam there is a sudden rise (depth) of water at the toe of the dam. & a hydraulic jump forms.

B). Steady and unsteady flow: > The flow is steady when at a particular section, the depth of the liquid and other parameters (such as velocity area of cross section discharge) do not change with time. In an unsteady flow the depth of flow and other parameters change with time.

C):> Laminar and turbulent flow:>

> The flow in open channel can be either laminar or turbulent. In practice however, the laminar or turbulent in flow occurs very rarely. the engineer is concerned mainly with turbulent flow in the case of open channel Reynold's number is defined as:

$$Re = \frac{\rho V R}{\mu}$$

where V = mean velocity of flow of water

R = hydraulic radius or hydraulic mean depth = $\frac{\text{area of flow (wetted area)}}{\text{wetted perimeter}}$

$= \frac{A}{P}$

ρ & μ = density and viscocity of water.

D). Sub-critical, critical & supercritical flow:

> The criterion used in this classification is what is known by froude number, Fr which is the measure of the relative effects of inertia forces to gravity force.

$$Fr = \frac{V}{\sqrt{g D_h}}$$

where V = mean velocity of flow water

D_h = hydraulic depth of the channel

$$= \frac{\text{area of flow (wetted area)}}{\text{water surface width}} = \frac{A}{T}$$

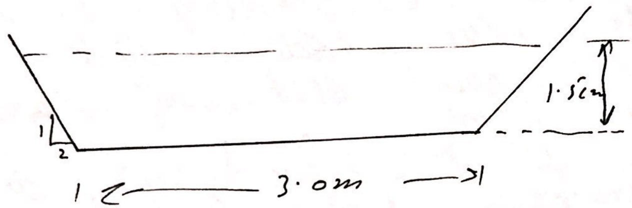
For open channel flow

$Fr < 1$ sub critical flow

$Fr = 1$ critical flow

& $Fr > 1$ supercritical flow

Q3 a:) open channel of width = 3m as shown, bed slope = 1:5000, d = 1.5m find the flow rate manning equation, n = 0.025.



Ans:) Given data:

width => $b = 3m$

bed slop = $S_e = 1:5000$

$d = 1.5m$

$n = 0.025$

Sol:- using maning eq to find flow rate

we have $V = \frac{1}{n} R_h^{2/3} \sqrt{S_e}$

Cross sectional Area

$A = 0.5 \times (3+9) \times 1.5 = 9m^2$

(7)

wetted perimeter

$$P = 2\sqrt{b^2+d^2}+3$$

$$P = 2\sqrt{3^2+1.5^2}+3 = 9.708$$

> Hidraulic Radius

$$R_h = A/P \Rightarrow 9/9.708 = 0.927$$

Now putting in eq

$$V = \frac{1}{n} R_h^{2/3} \sqrt{S_e} \Rightarrow V = \frac{1}{0.025} \times 0.927^{2/3} \sqrt{1/3000}$$

$$V = 0.538 \, m/s$$

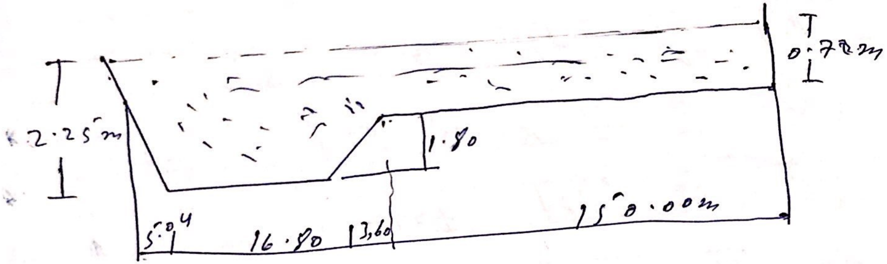
$$Q = VA \Rightarrow 0.538 \times 9 \Rightarrow \boxed{4.84 \, m^3/s = Q}$$

Ans.

(8)

25

Ans b:) open channel as shown, bed slope = 69:1584, Find the flow rate using chezy equation, C = 35



~~open~~ channel

sol:) $V = C\sqrt{R_h S}$ — ①

Cross sectional Area

$$A = \frac{2.52 \times 5.04}{2} + 2.52 \times 16.8 + \frac{0.72 \times 2.52}{2} \times 3.6 + 0.72 \times 150$$

$$= 162.52\ m^2$$

(9)

wetted perimeter

$$P = 0.72 + 150 + \sqrt{1.8^2 + 3.6^2} + 16.8 + \sqrt{2.5^2 + 5.04^2}$$

Hydraulic Radius:

$$= 177.18\,m$$

$$R_h = A/P = 162.5/177.18 = 0.917$$

Chezy equation $= V = 35\sqrt{0.917 \times 0.69 / 1584}$

$$= 0.7\,m/s$$

$$Q = VA = 0.7 \times 162.52 = \boxed{113.84\,m^3/s}$$

Q3: a:) Briefly describe classification of channel bed slops.

A $\frac{9i}{25}$:) Classification of Channel-Bed Slopes..

> The slope of the channel bed can be classified as:

1 :) critical slope :) The bottom slope of the channel is equal to the critical slope. In this case $S_0 = S_c$ or $y_n = y_c$

2) mild slope: The bottom slop of the channel is less than the critical slope in this cas $S_0 < S_c$ or $y_n > y_c$

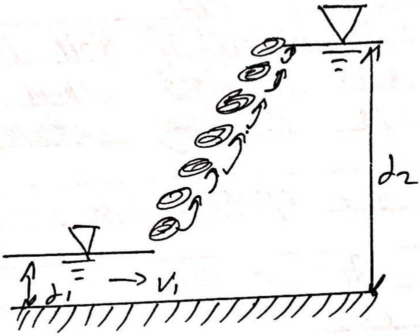
3) steep slope :) The bottom slope of the channel is greater than the critical slope. In this case $S_0 > S_c$ or $y_n < y_c$

4) Horizontal slope :) the bottom slope of the channel is equal to zero (horizontal bed). in this cas $S_0 = 0.0$

5) <u>Adverse slope:</u> the bottom slope of the channel rises in the direction of the flow (slope is opposite to direction of flow). In this case S_o = negative.

* The first letter of each slope type sometimes is used to indicate the slope of the bed. So the above slope are abbreviated as C, M, S, H, and A, respectively.

Ans 3.5 b) (12) A 3-m wide rectangular channel carries 15 m^3/s of water at a 0.7 m depth before entering a jump. compute the dowstream water depth and the critical depth



solution :-

$$q = \frac{15}{3} = 5\ m^3/s\text{-}m$$

$$d_c = \sqrt[3]{\frac{5^2}{9.81}} = 1.366\,m$$

$$V_1 = \frac{q}{d_1} = \frac{5}{0.7} = 7.14\,m/s$$

(13)

$$F_{r1} = \frac{V_1}{\sqrt{g d_1}} = \frac{7.14}{\sqrt{9.81 \times 0.7}} = 2.72$$

$$\frac{d_2}{0.7} = \frac{1}{2}\left(\sqrt{1+8(2.72)^2}-1\right)$$

$$d_2 = 2.365m$$

X ———— X ————

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Ex 45: Design practical profile for a gravity dame with the following data:

* Maximum depth of water in the reservoir

  $H = 30\ m$

* Specific gravity of dam material,

  $G = 2.4$

* Allowable compressive stress for the dam masonry $\sigma_{all} = 120\ T/m^2$

* Height of wave $= 1.2 m$ & $\mu = 0.7$

* No uplift pressure, $C_u = 0$

Solution:

① H limiting $= \frac{\sigma_{all}}{\gamma_w (G - (C_u + 1))} = \frac{120 \times 1000}{1000(2.4 - 0 + 1)}$

H limiting $= 35.294 m > H_w = 30 m$

so it is low Gravity Dam.

② Top width "a"

Free board $= 1.5\ h_{wave} = 1.5 \times 1.2$

$F.B = 1.8 m$

height of Dam $= H_D = H_w + F.B = 30 + 1.8$

$H_D = 31.8 m$

$a = 14\%$ of HD

$a = 0.14 \times 31.8$

$\boxed{a = 4.452\ m}$

(J) Base width "b'" (with out off set)

i) – For No sliding criteria

$$b' = \frac{HW}{\mu G} = \frac{30}{0.7 \times 2.4}$$

$b' = 17.85$

$\boxed{b' \cong 18m}$

(ii) – For No tension criteria.

$$b' = \frac{HW}{\sqrt{G}} = \frac{30}{\sqrt{2.4}}$$

$\boxed{b' = 20m}$

use $\boxed{b' = 20m}$

#(16)

(4) Depth of vertical portion on u/s side

$h' = 2a\sqrt{G-C_u}$

$h' = 2 \times 4.5\sqrt{2.4-0}$

$h' = 13.94m$

$h' = 14m$

(5) upstream off set $= \frac{a}{16}$

$= \frac{4.5}{16}$

$= 0.28m$

(6) Depth below the water level to the end of inclined portion in U/S $= 3.14a\sqrt{G}$

$= 3.14 \times 4.5\sqrt{2.4}$

$= 21.6m.$

(7) Total width at the base of the dam

$b = b' + \frac{a}{16} = 20 + 0.28$

$b = 20.28m$

(8) $\tan\alpha = \frac{b'}{H} = \frac{20}{30}$

$\alpha = \tan^{-1}\left(\frac{2}{3}\right)$

$\boxed{\alpha = 44.42^\circ}$

(9) Depth of vertical portion on D/s (from ... on u/s side)

$\tan\alpha = \frac{a}{d'} = \frac{4.5}{d'} \Rightarrow \tan\alpha = \frac{4.5}{d'}$

$\frac{3}{2} d' = 4.5$

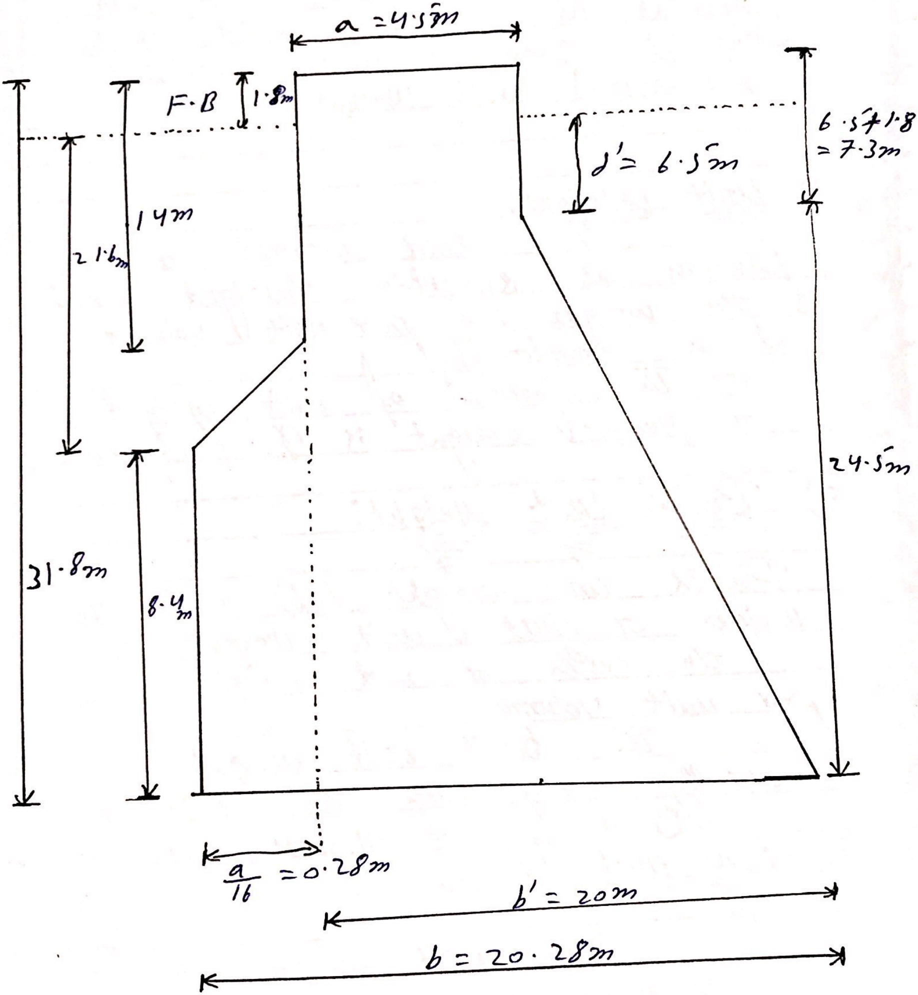
$d' = \frac{4.5 \times 3}{2}$

depth of vertical portion $\boxed{d' = 6.5\,m}$

$d = d' + FB = 6.5 + 1.8$

$\boxed{d = 7.3\,m}$

(18) Last page



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