Objective:

Objectives of the experiment :-

- To measure water depth at both u/s and d/s of a weir.
- To determine the R_e and F_r.
- To determine and observe the state of flow.
- To determine critical depth.
- To observe the subcritical and supercritical flow.

Formula:

- Area of the x-section of the rectangular weir, $A = By$.

  B = flume width, y = depth of flow.
- Perimeter of the cross-section, $P = B + 2y$.
- Hydraulic radius, $R = A/P$.
- Hydraulic depth, $D = A/T$.
- Velocity of flow, $V = Q/By$.

  Q = discharge.
- Froude number, $F_r = \frac{V}{\sqrt{gD}}$.

  g = gravitational acceleration.
- Reynolds number, $R_e = \frac{VR}{\nu}$.

  ν = kinematic viscosity of water.

Sample calculation:

Discharge, $Q = 0.0150\ m^3/s$.

Flume width, $B = 0.3048\ m$.

Critical depth, $y_c = 0.0627\ m$.

Kinematic viscosity of water, $\nu = 0.8164 \times 10^{-6}\ m^2/s$ (at 29°c).

Cross-section 1:

depth of flow, $y = 0.198\ m$.

Area, $A = By = 0.3048 \times 0.198 = 0.0604\ m^2$.

Perimeter, $P = B + 2y = 0.3048 + 2 \times 0.198 = 0.7008\ m$.

Hydraulic radius, $R = A/P = \frac{0.0604}{0.7008} = 0.0862\ m$.

Hydraulic depth, $D = A/T = \frac{0.0604}{0.3048} = 0.1982\ m$.

Velocity of flow, $V = Q/By = \frac{0.0150}{0.0604} = 0.2483\ m/s$.

Froude number, $F_r = \frac{V}{\sqrt{gD}} = \frac{0.2483}{\sqrt{9.81 \times 0.1982}} = 0.1781$.

Reynolds number, $R_e = \frac{VR}{\nu} = \frac{0.2483 \times 0.0862}{0.8164 \times 10^{-6}} = 26217$.

As $R_e > 12500$ and $F_r < 1$, flow is subcritical turbulent.

Cross-section-2: $y = 0.0308\ m$.

~~$y = 0.198\ m$~~, $A = By = 0.0308 \times 0.3048 = 0.0094\ m^2$.

$P = 0.3048 + 2 \times 0.0308 = 0.3664\ m$.

$R = \frac{0.0094}{0.3664} = 0.0257\ m$, $D = \frac{0.0094}{0.3048} = 0.0308\ m$.

$V = \frac{0.0150}{0.0094} = 1.5957\ m/s$.

$F_r = \frac{1.5957}{\sqrt{9.81 \times 0.0308}} = 2.903$, $R_e = \frac{1.5957 \times 0.0257}{0.8164 \times 10^{-6}} = 50232$.

As $R_e > 12500$ and $F_r > 1$, flow is supercritical turbule

Discussion:

(i) As Reynolds number is greater than 12500, flow at both sections are turbulent.

(ii) As Flow at section 1 is subcritical (as $F_r < 1$) and at section 2 is supercritical (as $F_r > 1$). So, state of flow varies at different sections.

(iii) $F_r = 0.1781$ (sec. 1), $F_r = 1.5957$ (sec. 2) indicates that at section 1, gravity force is dominant and at section 2, Inertia force is greater than gravity force.

Assignment:

(1) Why the state of flow and critical depth of a river need to be determined?

Ans. Flow behaviour depends on the state of flow. In order to construct different structures in rivers and canals and to predict the river response the state of flow must be known.

The critical depth of flow is also very useful in determining different flow phenomena. For a given value of specific energy, the critical depth gives the greatest discharge; or conversely, for a given discharge, the specific energy is minimum for critical depth.

2) How can you determine that the flow in a river is subcritical, critical or supercritical without taking any measurement?

Ans: The flow in most rivers and canal is subcritical. In weir, hill slope inertial force is greater than gravity force and it is supercritical flow.

A stick placed in the water will create V pattern of waves downstream. If flow is subcritical, waves will appear in front of the stick. If flow is supercritical, no upstream waves will appear and the wave angle will be less than 45°.

Again, if we drop a piece of paper on flowing water, the wave will immediately go downstream if the flow is supercritical. If the flow is critical, the paper will stay in position for a while before moving downstream. If the flow is subcritical, waves will appear in front of the stick. If flow is supercritical, no upstream waves will appear and the wave angle will be less than 45°.

3) Reynolds no. and Froude no. which one is more significant in determining flow behavior of a river? Why?

Ans: Normally all river flows are turbulent. So, Reynolds no. is not as important as froude no. in case of rivers. As the state of flow in open channel is primarily governed by the gravity forces, relative to the inertia force, ~~so~~ the froude no. is the most important parameter to ~~in~~ indicate the state of flow.

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