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HYDRAULICS

FLOW IN OPEN CHANNEL

TOPIC 1.1- 1.3

by

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Chapter Description

Aims

Describe the hydraulic principles and apply the fundamental concept in analyzing flow in open channels.

Expected Outcomes

Able to define and analyse the uniform and non-uniform flow in open channel.

References

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5. Kay, M., “Practical Hydraulics”, Taylor & Francis, 2008
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FLOW IN OPEN CHANNEL

1.1 • Types of channel

1.2 • Types of flow

1.3 • Geometric characteristics of channel

Introduction

- Open Channel
  - A conduit in which a liquid flows with a free surface
  - Any flow path with a free surface, which means that the flow path is open to the atmosphere
- Open channel flow
  - The study of the physics of fluids flow in conveyances in which the following fluids forms a free surface and is driven by gravity

1.1 TYPES OF CHANNEL

- There are 2 types:

Natural open channel (river, creek)
All channels which have been developed by natural processes and have not been significant improved by humans

Artificial open channel (flume, canal)
All channels which have been developed by human efforts

Natural Open Channel

- All natural channels generally have varying cross-sections and consequently are non prismatic.
- A non prismatic channel varies in both the cross-sectional shape and bed slope between any two selected points along the channel length

Artificial open channel

Prismatic:

A prismatic channel has both a constant cross-sectional shape and bottom slope. Channels which do not meet this criteria are termed non prismatic.

Canal:

The term canal refer to a rather long channels may be either unlined or lined with concrete, cement, grass, wood, bituminous materials or artificial membrane.

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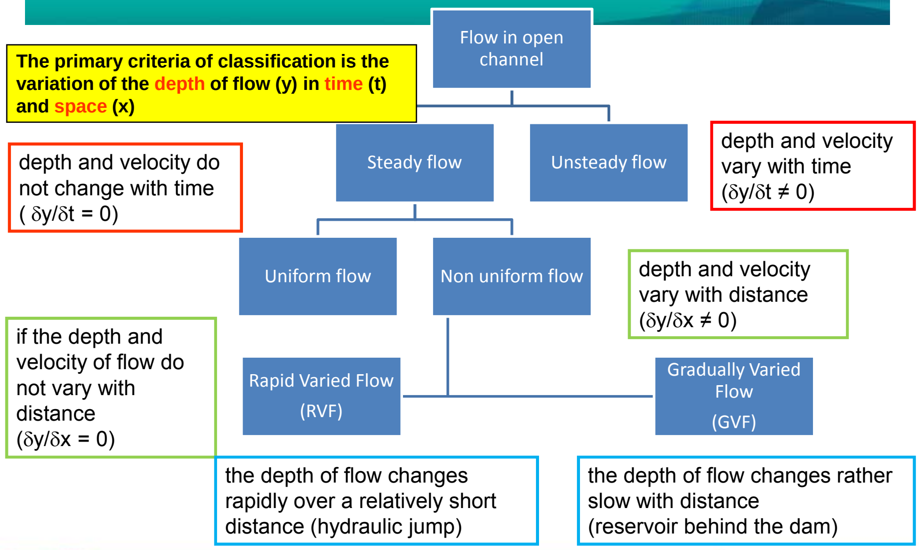
Flume:

In practice, the term refers to a channels built above the ground surface to convey a flow across a depression. Flumes are usually constructed of wood, metal, masonry or concrete. The term flumes is also applied to laboratory channels constructed for basic and applied research.

Culvert:

A culvert flowing only partially full is an open channel primarily used to convey a flow under highways, railroad embankments or runways.

1.2 TYPES OF FLOW



Flow classification

Depending on the ratio of the inertial forces to the viscosity

- Reynolds number

$$Re = vR/\upsilon$$

v = average velocity of flow
R = hydraulic radius, R = A/P
υ = kinematics viscosity = μ/ρ
μ = dynamic viscosity
ρ = density

- Re < 500 — Laminar flow
- 500 < Re <2500 — Transitional flow
- 2000 < Re — Turbulent flow

Flow are classified as homogeneous or stratified on the basis of the variation of density within the flow

Homogeneous : All spatial dimensions the density of flow is constant

Stratified : The density of the flow varies in any direction

The absence of a density gradient in most natural open-channel flows demonstrates that either the velocity of flow is sufficient to completely mix the flow with respect to density or that the phenomena which tend to induce density gradients are unimportant.

The importance of density stratification is that when stable density stratification exists, i.e., density increase with depth or lighter fluid overlies heavier fluid, the effectiveness of turbulence as mixing mechanism is reduced.

Depending on the magnitude of the ratio of inertial forces to gravity forces

Froude Number

$$Fr = v\ (gyh)^{1/2}$$

Where;

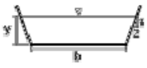
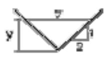
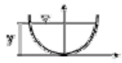
v = a characteristic velocity of flow
yh = hydraulic depth (yh) = A/T
A = flow area
T = width of free surface

Fr = 1, the flow is in a **critical** state with the inertial and the gravitational forces in equilibrium.

Fr < 1, the flow is in a **subcritical** state and the gravitational forces are dominant.

Fr > 1, the flow is in **supercritical** state and the inertial forces are dominant.

1.3 GEOMETRIC CHARACTERISTICS OF CHANNEL

Channal type	Area A	Wetted parmiter P	Hydraulic radius R	Top width T	Hydraulic depth D
	by	$\frac{by}{b+2y}$	$\frac{by}{b+2y}$	b	y
	$b+2y$	$b+2y\sqrt{1+z^2}$	$\frac{(b+zy)y}{b+2y\sqrt{1+z^2}}$	$b+2zy$	$\frac{(b+zy)y}{b+2zy}$
	zy^2	$2y\sqrt{1+z^2}$	$\frac{zy}{2\sqrt{1+z^2}}$	$2zy$	$\frac{1}{2}y$
	$\frac{2}{3}Ty$	$T+\frac{8}{3}\frac{y^2}{T}$	$\frac{2T^2y}{3T^2+8y^2}$	$\frac{3}{2}\frac{A}{y}$	$\frac{2}{3}y$
	$\frac{1}{8}(\theta - \sin\theta)$	$\frac{1}{2}\theta d_0$	$\frac{1}{4}\left[1-\frac{\sin\theta}{\theta}\right]d_0$	$2\sqrt{y(d_0-y)}$	$\frac{1}{8}\left(\frac{\theta - \sin\theta}{\sin\frac{\theta}{2}}\right)d_0$

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