UNIFORM FLOW

An open channel may be defined as a passage in which liquid flows with its upper surface exposed to atmosphere. In open channels the flow is due to gravity, thus the flow conditions are greatly influenced by the slope of the channel.

The various types of channels are:

1. Natural channel. It is the one which has irregular sections of varying shapes, developed in a natural way. Examples: Rivers, streams etc.

2. Artificial channel. It is the one which is built artificially for carrying water for various purposes. They have the cross-sections with regular geometrical shapes (which usually remain same throughout the length of the channel).

Examples: Rectangular channel, trapezoidal channel, parabolic channel etc.

3. Open channel. A channel without any cover at the top is known as an open channel. Examples: Irrigation canals, rivers, streams, flumes and water falls.

4. Covered or closed channels. The channel having a cover at the top is known as a covered or closed channel. Examples: Partly filled conduits carrying public water supply such as sewerage lines, underground drains, tunnels etc. not running full of water.

5. Prismatic channel. A channel with constant bed slope and the same cross-section along its length is known as a prismatic channel. The prismatic channels can be further subdivided as: (i) Exponential channel. It is the one in which area of cross-section of flow is directly proportional to any power of depth of flow in channel. Examples: Rectangular, triangular and parabolic channels.

(ii) Non-exponential channel. Trapezoidal and circular channels are non-exponential channels

TYPES OF FLOW IN CHANNELS

The flow in channels is classified into the following types, depending upon the change in the depth of flow with respect to space and time:

1. Steady flow and unsteady flow
2. Uniform flow and non-uniform (or varied) flow
3. Laminar flow and turbulent flow
4. Subcritical flow, critical flow and supercritical flow.

Steady Flow and Unsteady Flow

When the flow characteristics (such as depth of flow, flow velocity and the flow rate at any cross-section) do not change with respect to time, the flow in a channel is said to be steady.

Mathematically, $\partial y/\partial t = 0$, $\partial V/\partial t = 0$, or $\partial Q/\partial t = 0$.

where y, V and Q are depth of flow, velocity and rate of flow respectively.

The flow is said to be unsteady flow when these flow parameters vary with time.

Mathematically, $\partial y/\partial t \neq 0$, $\partial V/\partial t \neq 0$, or $\partial Q/\partial t \neq 0$

Uniform and Non-uniform (or varied) Flow

Flow in a channel is said to be uniform if the depth, slope, cross-section and velocity remain constant over a given length of the channel.

Mathematically, $\partial y/l = 0$, $\partial V/l = 0$

Uniform flows are possible only in prismatic channels only. A uniform flow may be either steady or unsteady, depending upon whether or not the discharge varies with time; unsteady uniform flow is rare in practice

Flow in a channel is said to be non-uniform (or varied) when the channel depth varies continuously from one section to another.

Mathematically, $\partial y/l \neq 0$, $\partial V/l \neq 0$.

Varied flow may be further classified as:

(i) Rapidly varied flow (R.V.F.). In this type of flow depth of flow changes abruptly over a comparatively small length of channel.

Examples: Hydraulic jump and the hydraulic drop.

(ii) Gradually varied flow (G.V.F.). In this case the change in depth of flow takes place gradually in a long length of the channel.

Laminar Flow and Turbulent Flow

The flow in the open channel may be characterised as laminar or turbulent depending upon the value of Reynolds number, defined as:

$Re = \rho VR/\mu$

where, V = Average velocity of flow in the channel, and

R = Hydraulic radius (defined as the ratio of area of flow to wetted perimeter)

When Re < 500 ...flow is laminar

Re > 2000 ...flow is turbulent

500 < Re < 2000 ...flow is transitional.

Subscritical flow, Critical Flow and Supercritical Flow

Since gravitational force is a predominant force in the case of channel flow, therefore Froude

number, $Fr = V/\sqrt{gD}$

= (where V and D are the mean velocity of flow and hydraulic depth of the

channel respectively) is an important parameter for analysing open channel flows. Depending upon Froude number the channel flow may be characterised as:

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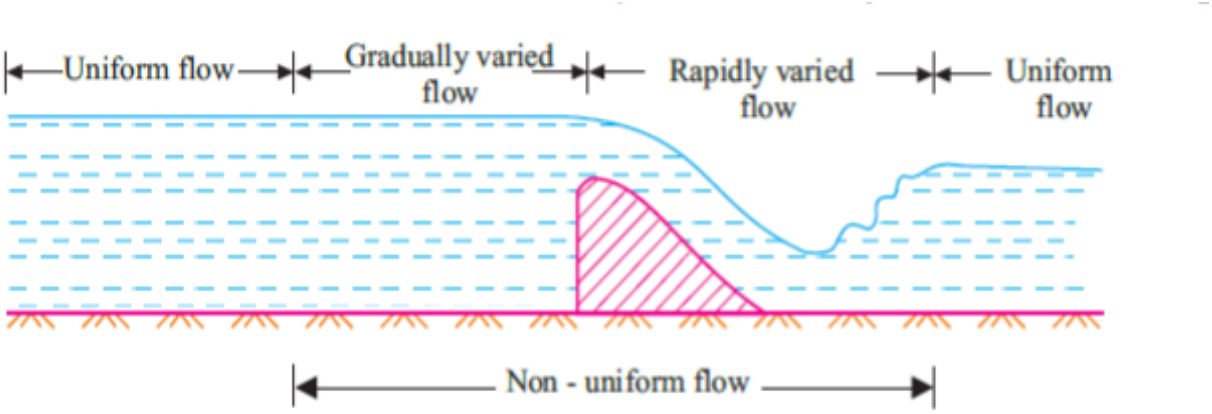

(i) When Fr < 1 (or V < $\sqrt{gD}$): The flow is described as subcritical (or tranquil or streaming)

(ii) When Fr = 1: The flow is said to be in a critical state.

(iii) When Fr > 1: The flow is said to be supercritical (or rapid or shooting or torrential) Some of the types of channel flow are shown in Fig.