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IRRIGATION ENGINEERING

[BTAI 2201]

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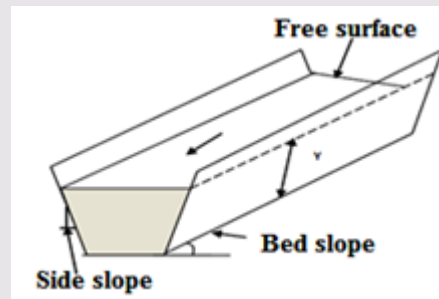
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Flow in Open Channels

- ❑ There are two kinds of flow: **Open channel** and **pipe**.
- ❑ The important difference is that open channel flow has free water surface whereas pipe flow does not have free water surface.

Open Channels

- ❑ Open channels receive water from natural streams or underground water and convey water to the farm for irrigation.
- ❑ Open channels have free surface. **The free surface is subjected to atmospheric pressure.**
- ❑ The basic equations used for water flow in open channels are *continuity equation*, *Bernoulli equation* and *Darcy-Weisbach equation*.





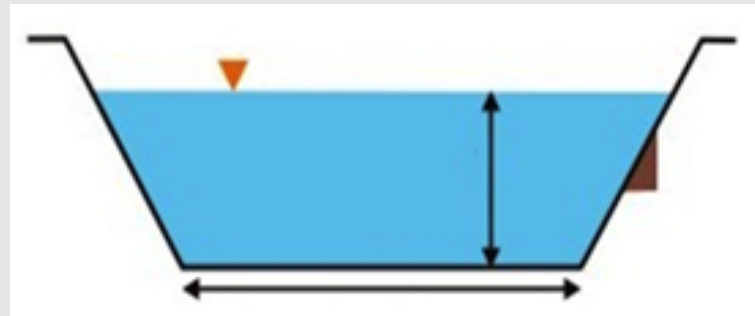
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Types of Open Channel

(a) Prismatic and Non-prismatic Channel

- A channel in which the cross sectional shape, size and the bottom slope are **constant over long stretches** is termed as prismatic channel.
- Most of the man-made or artificial channels are prismatic channels. The rectangular, trapezoidal, triangular and half-circular are commonly used shapes in manmade channels.
- All natural channels generally have varying cross section and consequently are non-prismatic.





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Types of Open Channel

(b) Rigid and Mobile Boundary Channel

- Rigid channels are those in which the boundary or cross section is not deformable. The shape and roughness magnitudes are not functions of flow parameters. In rigid channels the flow velocity and shear stress distribution are such that no major scouring, erosion or deposition takes place in the channel and the channel geometry and roughness are essentially constant with respect to time.
- Channels are classified as mobile channels when the boundary of the channel is mobile and flow carries considerable amounts of sediment through suspension and is in contact with the bed. In the mobile channel, depth of flow bed width, longitudinal slope of channel may undergo changes with space and time depending on type of flow. The resistance to flow, quantity of sediment transported and channel geometry all depend on interaction of flow with channel boundaries.



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Types of Open Channel Flow:

Open channel flow can be classified based on variation of flow properties such as depth of flow, velocity etc. with respect to time and space.

(a) **Steady and Unsteady Flow:**

Flow is steady if the velocity and depth are constant with respect to time. If the depth velocity or discharge changes with time, the flow is termed as unsteady.

Flood flows in rivers and rapidly varying surges in canals are examples of unsteady flow.

(b) **Uniform and Non-Uniform Flow:**

If the flow properties, say the depth of flow and discharge in an open channel remain constant along the length of the channel, the flow is said to be uniform.

A prismatic channel carrying a certain discharge with a constant velocity is an example of uniform flow.



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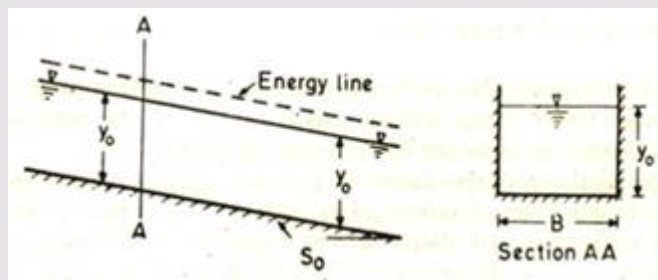
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Types of Open Channel Flow:

If the flow properties such as depth and discharge vary with distance along the channel is termed as non-uniform flow.

In uniform flow, the gravity force on the flowing water balances the frictional force between the flowing water and inside surface of the channel, which is in contact with the water.

In case of non-uniform flow, the friction and gravity forces are not in balance





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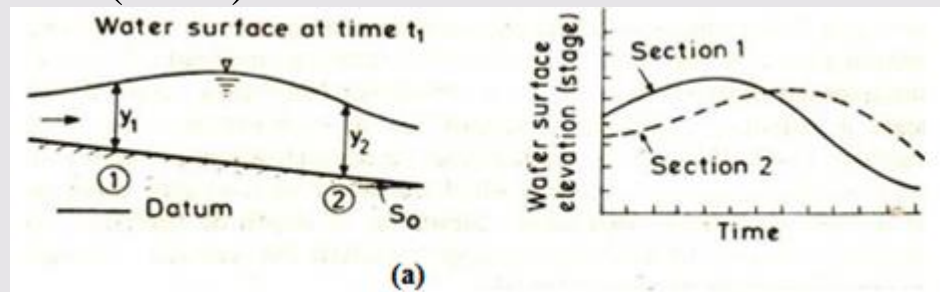
Types of Open Channel Flow:

(c) Gradually Varied Flow and Rapidly Varied Flow:

The non-uniform flow can be classified as gradually varied flow (GVF) and rapidly varied flow (RVF).

Varied flow assumes that no flow is externally added to or taken out of channel system and hence the volume of water in a known time interval is conserved in the channel system.

If the change of depth is gradual so that the curvature of streamlines is not excessive, such a flow is said to be gradually varied flow (GVF).



y_1 and y_2 are the depth at section 1 and 2, respectively. In GVF, the loss of energy is essentially due to boundary friction.

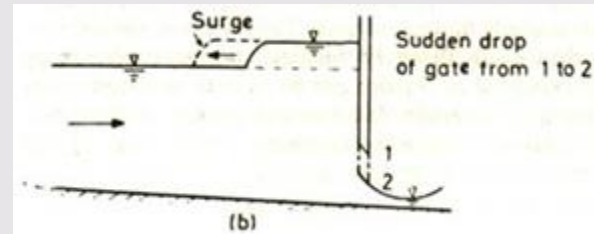
Distribution of pressure in the vertical direction may be taken as hydrostatic.



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Types of Open Channel Flow:

If the curvature in a varied flow is large and the depth changes appreciably over short lengths, then the flow is termed as a varied flow. It is a local phenomenon. The examples of RVF are hydraulic jump and hydraulic drop.



(d) Spatially Varied Flow:

Addition or diminution of water along the course of flow causes non uniform discharge and the resulting flow is known as spatially varied flow (SVF). Hydraulic behaviour of spatially varied flow with increasing discharge (case of drainage channel) is different in certain respects from that of spatially varied flow with decreasing discharge (in case of irrigation channel).



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Types of Open Channel Flow:

i) Spatially Varied Flow with Increasing Discharge

In this type of spatially varied flow, an appreciable portion of the energy loss is due to the turbulent mixing of the added water and the water flowing in the channel.

The momentum equation is more convenient than the energy equation in solving spatially varied flow with increasing discharge. From a practical viewpoint, the high energy loss seems to make channels designed for such spatially varied flow hydraulically inefficient, but physical circumstance and economical considerations sometimes make the use of such channels desirable.



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Types of Open Channel Flow:

ii) Spatially Varied Flow with Decreasing Discharge

These types of spatially varied flow may be treated as a flow diversion where the diverted water does not affect the energy head. This concept has been verified by both theory and experiments. Therefore, the use of the energy equation is more convenient in solving spatially varied flow with decreasing discharge.

The theory of spatially varied flow with decreasing discharge was probably employed first in the design of lateral spillways or side spillway weirs.

The spatially varied flow with decreasing discharge is encountered in the design of irrigation water conveyance system whereas with increasing discharge in design of surface and subsurface drainage systems.



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