OPEN CHANNEL FLOW

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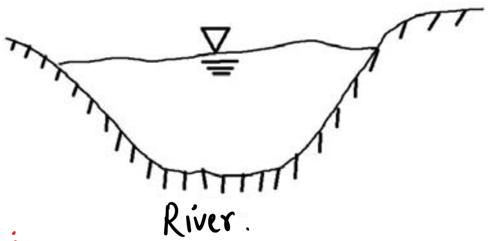
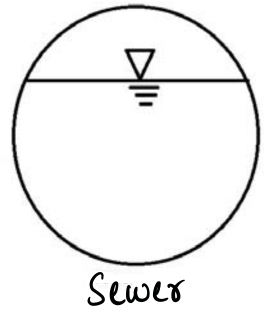
(EX IES)

CONTENTS

1. INTRODUCTION

An open channel flow is a conduit in which liquid flows with a free surface.





NOTE :

The free surface is an interface between the moving liquid and overlying fluid which will have constant pressure.

In our case, Moving liquid in most of time is water.
And in terms of gauge pressure it is zero.

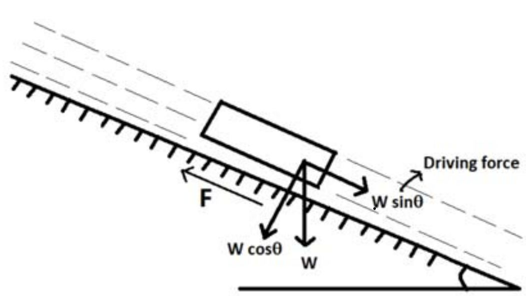
Gauge Pressure = Absolute Pressure − Reference Pressure. (ATM)

Flow in natural rivers, stream, rivulets, Torrent, Canal, Sewers carrying the sewage, road side drain / gutter etc., are the examples of open channel flow, as there exists free water surface.

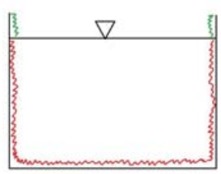
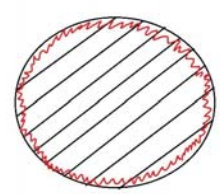
Basically, all open channel have a bottom slope and the mechanism of flow is similar to the movement of mass down an inclined plane, due to gravity.

The component of weight of liquid along the slope act as a driving force and the boundary resistance at the perimeter act as a Resisting force.

Since, flow in open channel is generally turbulent, effect of surface tension is negligible; hence gravitational force becomes the driving force.



Comparison of OCF and Pipe flow.

OCF	PIPE FLOW
• OCF must have a free surface	No free surface is available.
• A free surface is subjected to atmospheric pressure.	No direct atmospheric pressure is available. Only Hydraulic pressure exist.
• Here flow take place due to gravity.	Here flow take place due to pressure difference.
• Since gravitational force is governing force here analysis is done by FROUDES NUMBER.	Here Analysis done by Reynold's number.
• The depth of flow, discharge, slope of channel at bottom & of the free surface are interdependent.	Here, there is no dependency in between these parameters.
• The c/s may be of any form circular, rectangular, triangular compound or incase of natural stream it is irregular along the flow direction.	The c/s of pipe is generally kept circular.
• The relative roughness changes with level of free surface. 	The relative roughness is a fixed quantity. 
• Flow area is determined by geometry of channel plus the level of free surface which is likely to change along the flow direction and with time as well.	Flow area is fixed by pipe dimension and is usually same along the flow direction.
• Hydralic gradient line coincide with free water surface.	HGL is usually above the conduit.

NOTE:

Total Energy E_T = Datum (elevation) energy + Pressure energy + Kinetic energy

$$E_T = mgz + P_w V + \frac{1}{2}mv^2$$

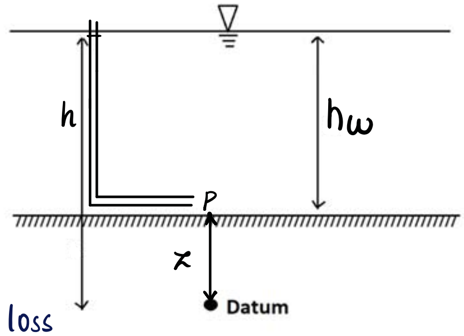
$$\text{Energy / weight } (H) = z + \frac{p}{\gamma} + \frac{v^2}{2g}$$

H = Datum head + Pressure head + Kinetic head.

(Datum head + Pressure head) = Hydraulic Head.

Sum of datum head and Pressure head = Hydraulic head (h).

$$h = z + p/\gamma$$



$$P_w = \frac{W_w}{A_w} = \frac{\gamma_w V_w}{A_w} = \frac{\gamma_w A_w h_w}{A_w} = \gamma_w h_w$$

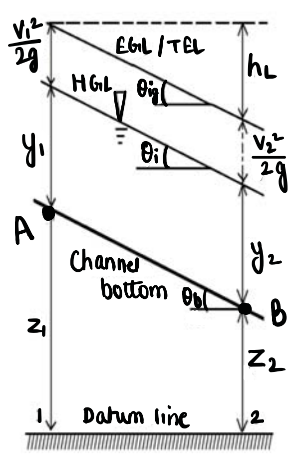
$$\frac{P_w}{\gamma_w} = h_w$$

$$i = \text{Hydraulic Gradient} = \frac{\text{Hydraulic Head loss}}{\text{length of flow}}$$

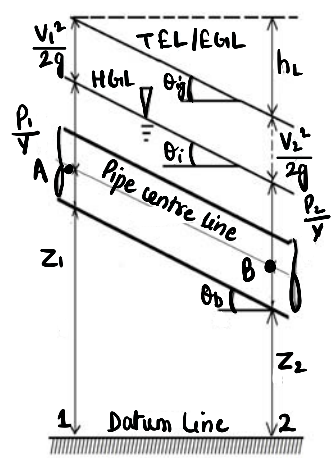
$$i = \frac{h_1 - h_2}{L} = \frac{(z_1 + hw_1) - (z_2 + hw_2)}{L} = \frac{\left(z_1 + P_1/\gamma + \frac{V_1^2}{2g}\right) - \left(z_2 + P_2/\gamma + \frac{V_2^2}{2g}\right)}{L}$$

Line, Slope of which indicates Hydraulic gradient is termed as HGL.

Line, Slope of which indicates energy gradient is termed as TEL.

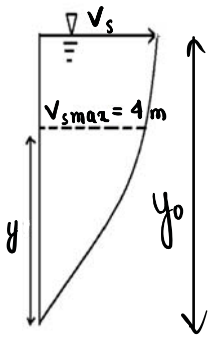


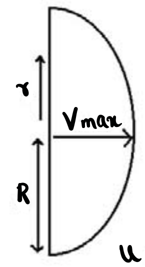
Velocity distribution in case of OCF is logarithmic or power law distribution.



In case of pipe flow velocity distribution is parabolic (for laminar flow).

$$\frac{u_m - u}{u^*} = \frac{1}{K} \ln \frac{y}{y_0}$$





$$u = u_{max}\left(1 - \frac{r^2}{R^2}\right)$$

NOTE :

Different forces which may act over the fluid flowing in conduit are as follows:

1. <u>Inertia force</u> : It is the property common to all the body that remains in their state either rest or motion unless some external cause is introduce, to make them alter their state.

   It is a product of mass and acceleration.

$$f_i = ma = \rho . L^3 . \frac{V}{T}$$

$$\boxed{F_i = \rho L^2 V^2}$$

2. <u>Gravity force</u> : It is the force due to own weight of body.

$$f_g = mg = \rho V g = \rho L^3 g$$

$$\boxed{f_g = \rho L^3 g}$$

3. <u>Viscous force</u> : This force is due to resistance of fluid against deformation which develops between different layer of fluid.

$$f_\mu = LA = \mu \frac{du}{dy} L^2 = \mu \frac{V}{L} L^2$$

$$\boxed{f_\mu = \mu V L}$$

<u>Reynold's Number</u> :

It is a dimensionless number that signifies the dominance of inertial force over viscous force

$$R_e = \frac{f_i}{f_\mu} = \frac{\rho L^2 V^2}{\mu V L}$$

$$\boxed{R_e = \frac{\rho V L}{\mu}}$$