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HYDRAULICS

UNIFORM FLOW IN OPEN CHANNEL
TOPIC 2.1

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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4. Larock, Bruce E., “Hydraulics of Pipelines System”, CRC Press,2000
5. Kay, M., “Practical Hydraulics”, Taylor & Francis, 2008
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UNIFORM FLOW IN OPEN CHANNEL

2.1

- Resistance of flow formula

Definition

- The depth, flow area and velocity at every cross section are constant.
- The energy grade line, water surface and channel bottom are all parallel; that is,

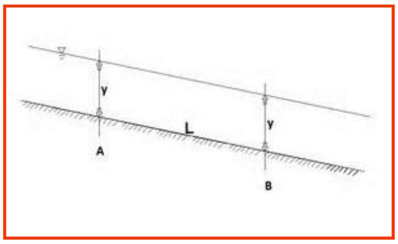
  $S_f = S_w = S_o$

  where;

  S_f = slope energy grade line

  S_w = slope of the water surface

  S_o = slope of the channel bed



- In general, uniform flow can occur only in very long, straight and prismatic channel.

2.1 : RESISTANCE OF FLOW FORMULA

In open channel flow, resistance equations for uniform flow:

a) Chezy formula

b) Manning formula

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2.1.1 Chezy Formula

This equation was developed by a French engineer, Antoine Chezy around the year 1768. The fundamental basis

$$V = C\sqrt{RS}$$

where;

V = average velocity

C = coefficient

R = hydraulic radius, (A/P)

S = slope of the energy grade line (dimensionless)

The value of *C,* which is the Chezy resistance factor can be computed from the G.K. Formula and the Bazin Formula.

a) Ganguillet Kutter Formula (Swiss, 1869)

$$C = \frac{41.65 + \frac{0.00281}{S} + \frac{1.811}{n}}{1 + \frac{n}{\sqrt{R}}\left[41.65 + \frac{0.00281}{S}\right]}$$

Imperial Unit

$$C = \frac{23 + \frac{1}{n} + \frac{0.00155}{S}}{1 + \frac{n}{\sqrt{R}}\left[23 + \frac{0.00155}{S}\right]}$$

SI Unit

b) Bazin Formula (France, 1897)

$$C = \frac{157.6}{1 + m/\sqrt{R}}$$

Imperial Unit

$$C = \frac{87}{1 + m/\sqrt{R}}$$

SI Unit

Table 2.1 Value m for Bazin formula

Description of channel	**Bazin's *m***
Very smooth cement of planed wood	0.11
Unplaned wood, concrete or brick	0.21
Ashlar, rubble masonry or poor brickwork	0.83
Earth channels in perfect condition	1.54
Earth channels in ordinary condition	2.36
Earth channels in rough condition	3.17

Source:

2.1.2 Manning Formula

This formula was later adapted to obtain a flow measurement.
This is done by multiplying both sides by the area.

$$Q = \frac{1.49}{n} A R^{2/3} S_f^{1/2}$$ Imperial Unit

$$Q = \frac{1}{n} A R^{2/3} S_f^{1/2}$$ SI Unit

Manning's equation is the **most widely used** of all uniform-flow formulas for open channel flow, because of its simplicity and satisfactory results it produces in real-world applications.

Table 2.2 Manning's Roughness coefficient, n

Material	Manning *n*	Material	Manning *n*
Natural Streams		*Excavated Earth Channels*	
Clean and Straight	0.030	Clean	0.022
Major Rivers	0.035	Gravelly	0.025
Sluggish with Deep Pools	0.040	Weedy	0.030
		Stony, Cobbles	0.035
Floodplains	0.035	*Non-Metals*	
Pasture, Farmland	0.050	Finished Concrete	0.012
Light Brush	0.075	Unfinished Concrete	0.014
Heavy Brush	0.15	Gravel	0.029
Trees		Earth	0.025

Source:

Factors Affecting Manning's Coefficient

- Surface Roughness
- Vegetation
- Channel Irregular
- Channel Alignment
- Silting and Scouring
- Obstruction
- Size and Shape of Channel
- Stage and Discharge
- Seasonal Change
- Suspended Material and Bed Load

EXAMPLE 2.1:

Water flows in a rectangular concrete open channel (n = 0.012) that is 12.0m wide at a depth of 2.5 m. The channel slope is 0.0028. Find the water velocity and flow rate using Manning's equation.

EXAMPLE 2.2:

A trapezoidal channel with 3 m width and bed slope 1 in 5000 is proposed to be built. The depth of flow is approximately 1.2m and the side slope is 1(V):2(H). Calculate the flow rate with these formulas:

i. Manning (n=0.025)
ii. Ganguilet-Kutter (n=0.025)
iii. Bazin (m=1.3)

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