UNIFORM FLOW and ITS FORMULAS
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1. Outcomes

T2: Select and conduct civil engineering experiments to meet a need, and analyze and evaluate the resulting data.
P2: Organize and deliver effective written, verbal, graphical and virtual communications.

2. Objectives:

- Observe the characteristics of uniform flow.
- Become familiar with the different uniform flow formulas: Manning, Chezy, and Darcy Weisbach –Colebrook-White (DW-CW).
- Determine the different friction factors for each uniform flow formula.
- Analyze and discuss about the results.

3. Theory

Uniform flow can be represented by three different equations: Manning’s equation, Chezy’s equation, and Darcy-Weisbach’s equation (originally developed for pipes but it may also be used for open channels).

Manning’s equation:
\[ V = \frac{1}{n} R^{2/3} S^{1/2} \]

Chezy’s equation:
\[ V = C \sqrt{RS} \]

DW-CW:
\[ V = -2 \sqrt{8gRS} \log \left[ \frac{k_s}{14.8R} + \frac{2.5v}{4R \sqrt{8gRS}} \right] \]

which is obtained from combining:
\[ \frac{1}{\sqrt{f}} = -2 \log \left[ \frac{k_s}{3.7d} + \frac{2.5}{Re \sqrt{f}} \right] \text{ with } h_f = \frac{f}{d} \frac{L}{2g} \]

where,
\[ V = \text{Velocity (m/s)} \]
\[ R = \text{Hydraulic Radio (m) = Flow Area / Wet Perimeter} \]
\[ S = \text{Slope} \]
\[ n = \text{Manning's roughness coefficient} \]
\[ C = \text{Chezy's roughness coefficient} \]
\[ g = \text{Gravity (m/s}^2) \]
\[ v = \text{kinematic viscosity (m}^2/\text{s}) \]
\[ Re = \text{Reynolds number} \]
\[ k_s = \text{absolute roughness (m)} \]
\[ d = \text{Diameter of a pipe (m)} = 4R \]
\[ L = \text{Length (m)} \]
\[ h_f = \text{friction loss. (m)} \]
\[ f = \text{Darcy-Weisbach friction factor} \]
The friction coefficients of those three equations may be related by combining them, as following:

Chezy’s C and Manning’s n:
\[ C = \frac{R^{\frac{1}{6}}}{n} \]

Chezy’s C and Darcy-Weisbach’s f:
\[ f = \frac{8g}{C^2} \]

4. Experimental Procedure

The objective of this experiment is to determine the Manning’s \( n \), Chezy’s \( C \), and Darcy-Weisbach’s \( f \) for two different roughnesses: a smooth section and a rough section.

- A rough surface will be installed on one portion of the flume; so, the channel will be divided in two sections: a rough section (upstream) and a smooth section (downstream).
- Place one vernier scale over the smooth section and the other over the rough section, and set up the datum in zero (the bottom).
- Nine trials need to be performed in this experiment by combining three different slopes (positives) with three different flowrates.
- Initially, set up and measure the initial slope. Then, perform three different flowrates: 1.0, 1.5, and 2.0 L/s. Use the pipe-flow indicator to approach the flowrate and determine the accurate flowrate by using the pipe-volumetric indicator and the stop watch (timing 10L).
- Measure and record the depth of water in both the smooth and the rough surfaces.
- Change the slope and repeat the experiment.
- Use the following table as guide to record the experimental data. The length and the width of the channel will be given in the lab.

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<th>Experimental data</th>
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<td><strong>Trial</strong></td>
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5. Calculations

The calculation includes the following procedure:

- Calculate the Manning’s $n$ for both the smooth and the rough sections and for each trial by using the experimental data and the Manning’s equation. Remember to use the hydro-geometric relationships and the continuity principle.

- Calculate the Chezy’s $C$ and the Darcy-Weisbach’s $f$ from the Manning’s $n$ previously calculated.

- Determine the average Manning’s $n$, Chezy’s $C$ and the Darcy-Weisbach’s $f$.

6. Content of the report

It is required to submit a formal report by next class. The report should cover the following:

- **Theory**: In addition to the theoretical background that you consider appropriate, demonstrate the following relationships by using the equations above explained.

  \[
  C = \frac{R^{1/6}}{n}
  \]

  \[
  f = \frac{8g}{C^2}
  \]

- **Experimental procedure**
- **Experimental data**
- **Calculations**
- **Analysis and discussion of results**

7. References used for this guide


