FLOW OVER A DAM SPILLWAY
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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 flow patterns over a spillway, including different spillway toes.
- Become familiar with the equation that quantifies the discharge over a spillway.
- Determine the discharge coefficient $C$ for a spillway.
- Analyze and discuss about the results.

3. Theory

Spillways are hydraulic structures typically used to control overflows in dams. The crest shape of a spillway is one of the most important design features of an overflow spillway. These shapes coincide with the lower water profile of an aerated nappe over a sharp-crested weir. The purpose of this shape is to minimize negative pressures on the spillway, which may cause severe damages to its surface. Figure 1 shows the hydraulic variables included in a spillway.

![Figure 1: Typical Overflow Spillway](image)

The flow rate over a spillway can be calculated using the equation 1.

$$Q = CLH^{3/2}$$

where,

- $Q$ = Flowrate (m$^3$/s).
- $C$ = Discharge Coefficient.
- $L$ = Spillway length. $L = 0.076$ m (3 in)
- $H_d$ = Upstream height (m). The datum is located on the top of the spillway.
- $H_e$ = Total energy head (m). The datum is located on the top of the spillway.
- $h$ = Spillway height (m).
Equation 1 can be re-written as:

\[ Q = k H_e^{3/2} \]  \hspace{1cm} (2)

where \( k = CL \).

Applying natural logarithmic properties to the equation 5, a linear equation with slope \( m = 3/2 \) and intercept equal to \( \log k \) is obtained.

\[ \ln Q = \frac{3}{2} \ln H_e + \ln k \]  \hspace{1cm} (3)

This equation has a linear format, at which the slope is equal to 3/2 and the y-intercept is equal to \( \ln(k) \). Moreover, the spillway discharge coefficient can be determined as

\[ C = \frac{e^{\ln k}}{L} \]  \hspace{1cm} (4)

On the other hand, the toe of an overflow spillway is a transition between the falling water and the channel at the base of a dam. This part of the structure must be designed to resist extreme forces caused by the water. Additionally, spillway toes may be also designed to dissipate the energy of the flow over a dam in order to minimize scour problems downstream.

4. Experimental Procedure

The objective of this experiment is to determine the discharge coefficient \( C \). The experiment has the following procedure:

- The spillway will be installed in the flume, which has to be leveled. Two different spillway toes will be tested: The sloping apron, and the ski jump. Therefore, two trials are required.
- Set up the vernier in zero, locating the datum on the top of the spillway. Then locate the zeroed vernier about 15 cm upstream of the spillway.
- Each trial consists of five (5) flow rates: 0.5, 0.7, 0.9, 1.1, and 1.3 L/s. Measure the exact flow rate and the upstream depth of water.
- Use the following tables as guide to record the experimental data. The length and the width of the channel will be given in the lab.

### Experimental data for sloping apron

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<th>Trial</th>
<th>Volume (L)</th>
<th>Time (sec)</th>
<th>Flowrate (m³/s)</th>
<th>Upstream Height (m)</th>
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### Experimental data for ski jump

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5. Calculations

- Calculate the total energy head $H_e$.
- Graph the experimental data ($\ln Q$ vs $\ln H_e$) and fit a linear equation ($y = mx + b$).
- Calculate $m$=slope of the linear equation, $\ln(k)$=y-intercept of the linear equation, $k$, and $C$.
- Analyze the results.

6. Analysis and discussion of the results

- Are the values of $m$ (linear equation) the expected value of 3/2?
- Compare the discharge coefficient calculated for both cases. Do you expect them to be different? Explain.
- Describe the differences between the flow profile generated by the sloping apron and the ski jump spillway toes.
- Do you expect the spillway toe affect the hydraulic capacity of the spillway? Explain.

7. Content of the report

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

- Introduction and objectives
- Theory
- Experimental procedure
- Experimental data
- Calculations: Explain in detail the procedure and include the Excel tables.
- Analysis and discussion of results
- References

8. References used for this guide


