Sophia Ize-Iyamu

Open-Channel Flow: Bernoulli and Hydraulic Jump

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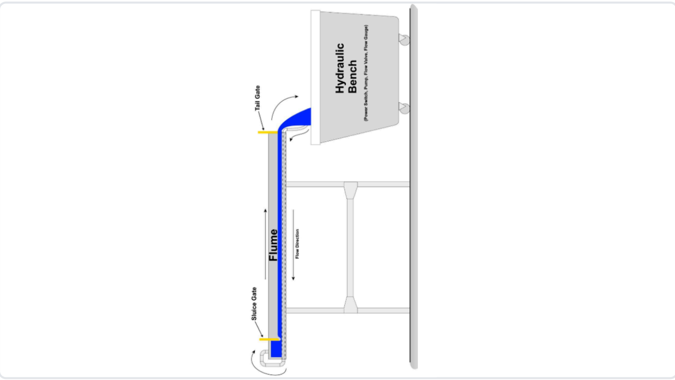
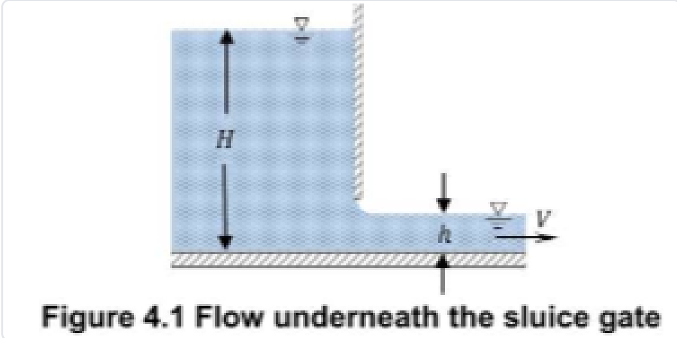
Experiment and analysis

A flume experiment verifying the Bernoulli equation and characterizing a hydraulic jump.

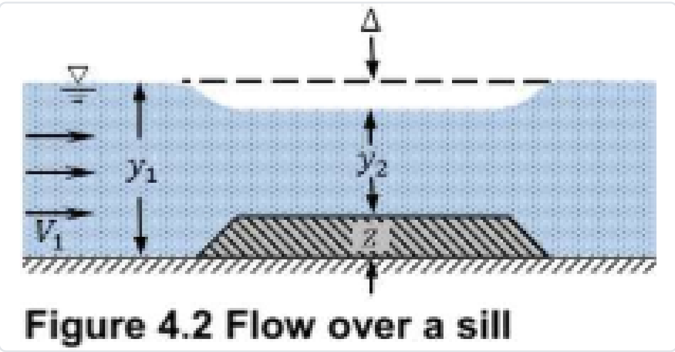
A fluid-mechanics flume lab with three aims: verify the Bernoulli equation, study flow over a submerged sill, and generate and classify a hydraulic jump. Theoretical downstream velocities agreed with measured values within about 0.15 m/s, and the hydraulic jump was characterized by its Froude number (theoretical 1.88 against a measured 2.16) with an estimated head loss near 5.6%.



Flume, sluice gate, and hydraulic bench apparatus schematic.



Flow underneath the sluice gate.



Flow over a submerged sill.

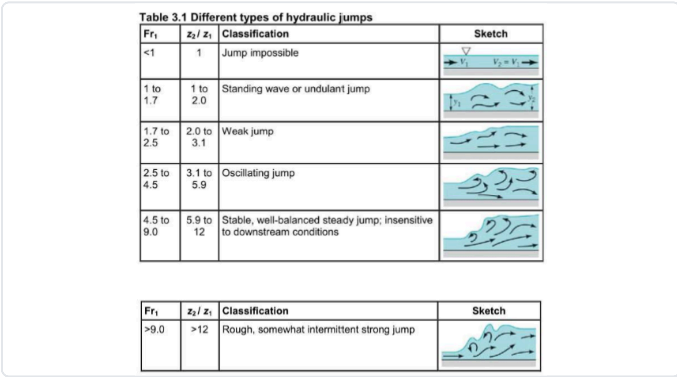


Table 3.1 Different types of hydraulic jumps

Fr_1	z_2 / z_1	Classification	Sketch
<1	1	Jump impossible	
1 to 1.7	1 to 2.0	Standing wave or undulant jump	
1.7 to 2.5	2.0 to 3.1	Weak jump	
2.5 to 4.5	3.1 to 5.9	Oscillating jump	
4.5 to 9.0	5.9 to 12	Stable, well-balanced steady jump; insensitive to downstream conditions	
>9.0	>12	Rough, somewhat intermittent strong jump	

Hydraulic-jump classification by Froude number and depth ratio.

Method

Using a flume with a sluice gate, tail gate, and submerged sill, flow rate and depths were measured, downstream velocity was derived from the Bernoulli relation, and the jump was classified by Froude number. Error sources, including neglected friction and instrument resolution amplified by the squared-depth term, were discussed.

SELECTED REFERENCES

- F. White, Fluid Mechanics (Bernoulli, open-channel flow, Froude number).
- D. Apsley, Hydraulics lecture notes, University of Manchester (hydraulic jump).