CE 3105 - Mechanics of Fluids Laboratory

Experiment 8: Open Channel Hydraulics - Manning's n

bit.ly/CE3105-Mannings

1 Objectives

- Calculate Manning's Coefficient in a Flume
- Observe the behavior of a Hydraulic Jump

2 Theory

Natural and man-made open channels are of interest to engineers. The Manning's equation is a fundamental equation governing open channel flow and is given by

$$Q = \frac{K_n}{n} A R^{2/3} S^{1/2} \tag{1}$$

Where K_n is the conversion factor (1 for SI and 1.49 for English units); n is the Manning's roughness coefficient, A is the cross-sectional area and R is the hydraulic radius which is given as:

$$R = \frac{A}{W_p} \tag{2}$$

Where W_p is the wetted perimeter.

Figure 1 shows the open channel flume in the laboratory :

Figure 1: Open Channel Flume

Figure 2 shows the actual Hydraulic Jump in the laboratory experiment:

Figure 2: Hydraulic Jump in the Laboratory Experiment

Apparatus

A recirculating water flume (Figure 3), width 1 ft, comprising supply tank and two pumps, rectangular channel with level rails, depth gauges, total head tubes, bed tappings and downstream control gate.

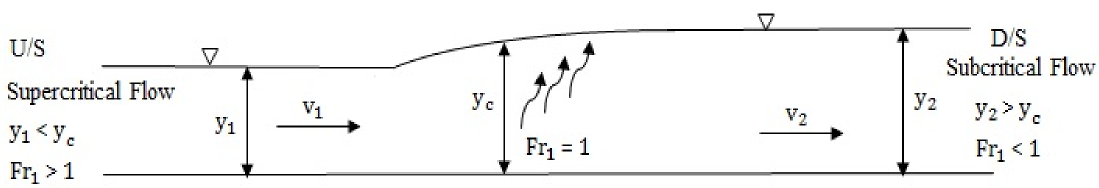

Figure 3: Recirculating Flume

Calibration Chart

The flowrate can be calculated using the calibration chart below (Figure 4). The y-axis is the difference of the manometers readings(ΔH) and the x-axis is the flowrate (Q). The following equation belongs to the "Large Orifice" line in the chart. The equation is based on the Log to base 10 and to obtain an accurate result, it should be rounded to 3 decimal places.

$$log(Q) = \frac{log(\Delta H) - 1.47}{2.096} \tag{3}$$

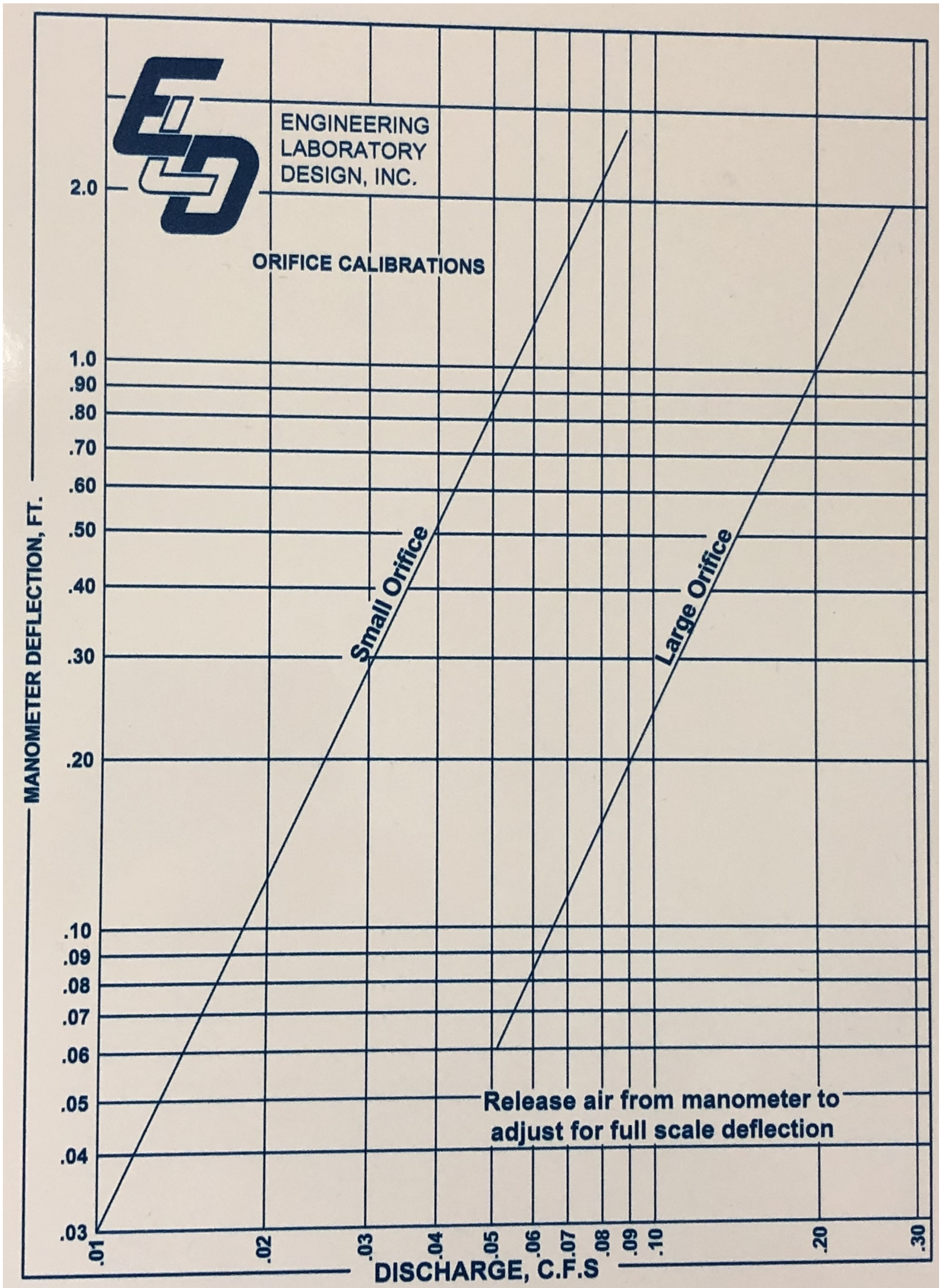

Figure 5: Calibration Chart

Depth Calculation

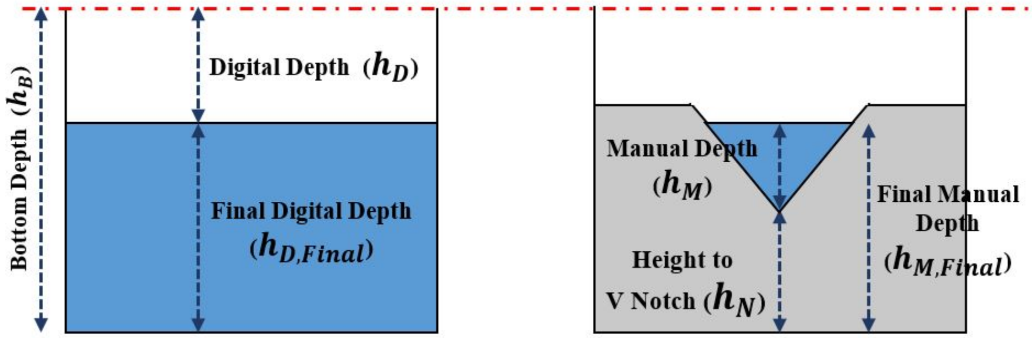

Figure 6: Manual Digital Depth

$$FinalDigitalDepth(h_D, Final) = h_B - h_D \tag{4}$$

Where h_B is 44 cm

$$FinalManualDepth(h_M, Final) = h_N + h_M \tag{5}$$

Where h_N is 9 in

3 Variables/Units

Variables	Description (Units)
Q	Flowrate (ft^3/s)
A	Cross-sectional Area(ft^2)
R	Hydraulic Radius (ft)
S	Channel Slope (dim)
n	Manning's roughness coefficient
W_p	Wetted Perimeter (ft)
b	Width of Channel (= 1 ft)
ΔH	Difference of the manometers (ft)
h	Depth (in or cm)

4 Procedure

Part 1

1. Ensure flume tailgate is not impending the flow.
2. Move the depth logger to the same elevation as the height of V notch and reset the value to zero.
3. Make sure the manometer valves corresponding to the selected orifice is open.
4. Ensure the manometers are free of air bubbles.
5. Open the Orifice to let flow into the flume.
6. Move the depth logger till it touches the top of the water level. Measure the height.
7. Repeat the procedure for 4 other flowrates keep the slope constant.

Part 2

1. Move the depth logger to top of one of the rocks and reset the value to zero.
2. Make sure the manometer valves corresponding to the selected orifice is open
3. Ensure the manometers are free of air bubbles.
4. Open the Orifice to let flow into the flume
5. Move the depth logger till it touches the top of the water level. Measure the height
6. Repeat the procedure for 2 other flowrates keep the slope constant
7. Repeat the above steps for a total of 3 different slopes
8. Raise the tailgate to observe hydraulic jump.

5 Calculations

Part 1

1. Use the calibration chart provided to calculate the flowate based on the difference of the manometers's readings.

2. Create a "Stage Discharge plot" of "log of Flowrate", Q (y-axis) vs. "Depth" y (x-axis).

3. Tabulate all results

Part 2

1. For each depth calculate the wetted perimeter and hydraulic radius.

2. Use the calibration chart provided to calculate the flowate based on the difference of the manometers's readings.

3. For each flowrate and depth calculate the Manning's n. Make sure you are using consistent set of units.

4. Calculate the mean and standard deviation of the computed Manning's n.

5. Create a plot of Flowrate, Q (y-axis) vs. $K_n A R^{2/3} S^{1/2}$ (x-axis). The slope will be equal to 1/n. Compare this value obtained graphically with the mean value obtained from individual calculations?

6. Tabulate all results

6 Interpretation Questions (for Report)

1. The Manning's coefficient for a bed rock channel flowing partially full is in the range of 0.035 - 0.050. How do your values compare to this reported range?

2. Why is it important to know the channel bed material in a river or a stream?

3. Many rivers and streams have submerged vegetation. How would these vegetation affect Manning's n?

4. What is the purpose of a Hydraulic Jump and where might it occur?

5. Errors between experiment and theory have 3 possible sources;

   (a) inadequate theory (assumptions violated)

   (b) errors in experimental measurement

   (c) calculation errors

   Which do you think are most significant in your experiment, and why?

CE3105 Mechanics of Fluids Laboratory
Department of Civil Engineering ,Texas Tech University

Experiment: Manning's n - Data Sheet
Date of Experiment: .... ,Name:....................
Experimental Data:
Temperature of water, $T=$ celsius
Water density, $\rho =$ (lb/ft^3) , Gravity, g= 32.2 (ft/s^2)

Part 1:

Trial	H_1	H_2	Manual Depth	Digital Depth
1				
2				
3				
4				
5				

Part 2:

Slope =			
Trial	H_1	H_2	Depth
1			
2			
3			

Slope =			
Trial	H_1	H_2	Depth
1			
2			
3			

Slope =			
Trial	H_1	H_2	Depth
1			
2			
3			

Instructor's Signature

For Calculation:

Part 1:

Trial	Depth	ΔH	Q
1			
2			
3			
4			
5			

Part 2:

Slope =					
Trial	W_P	R	ΔH	Q	n
1					
2					
3					

Slope =					
Trial	W_P	R	ΔH	Q	n
1					
2					
3					

Slope =					
Trial	W_P	R	ΔH	Q	n
1					
2					
3					