Flow Visualization Over A Weir

Flow Visualization
MCEN 4228
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Introduction –

The purpose of this assignment was to visualize the flow over a submerged obstacle (weir). Specifically, the intent was to try and observe the mixing in the sheer layer caused by the upstream hump of a two-humped weir. To meet this goal the Armfield Open Channel Water Flume was used to provide laminar flow upstream of the weir. As the laminar flow reaches the weir, the flow gets disrupted and various flow phenomena (like sheer layers and vortices) can be observed.

Experimental Setup -

To see these phenomena and dyed water is injected at a slow rate into the flow. In order to view the interaction of two different layers in shear, water dyed red was injected into the flow upstream of the obstacle and water dyed green was injected into the flow at the top of the first hump. A picture of the experimental setup can be seen in Figure 1.

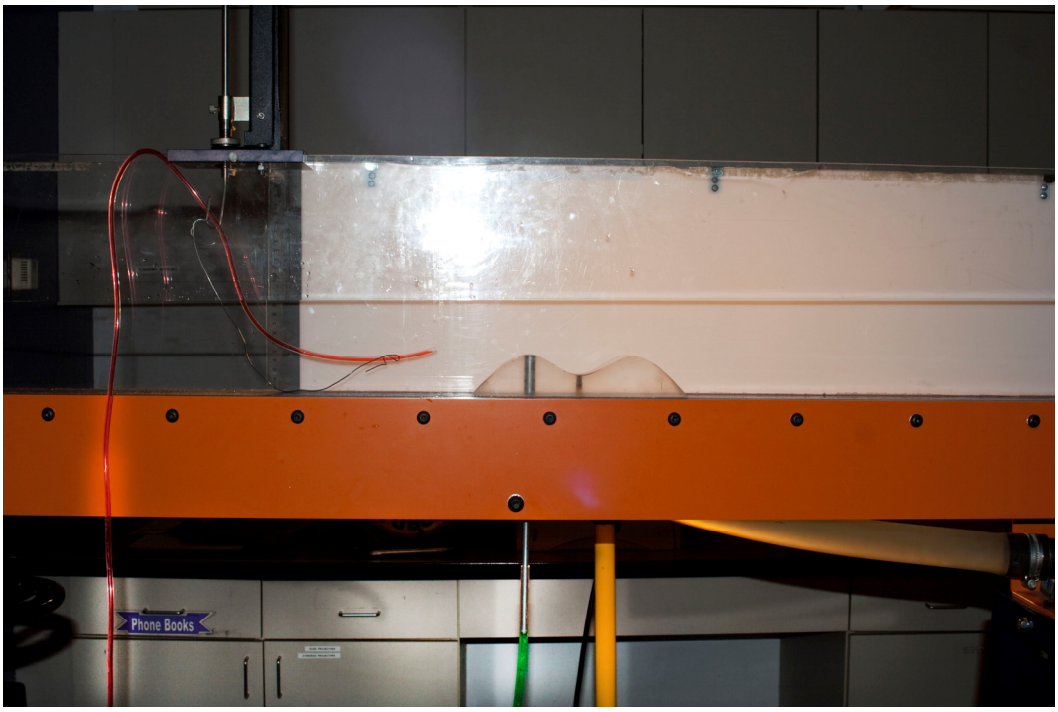

Figure 1: Experimental Setup

The dimensions of the cross-section of the flume's channel are 76 mm wide by 250 mm tall. However, the water flowing through the channel was only 95mm tall. Using a characteristic

distance of 0.9 m and the properties of water at room temperature, at the leading edge of the weir the Reynolds number is estimated to be 1.1 x10^4 by $R = \frac{\rho V D}{\mu}$[1]. With the complex shape of the weir a lower fluid velocity is expected in the depression between the to humps. The difference in velocities between the freestream and the depression are prime for a display of the Kelvin-Helmholtz instability. This can bee seen by a series of vortices throughout the shear layer.

Photographic Technique –

The field of view for the final image is approximately 13 cm tall by 38 cm wide. The distance from the weir to the lens was approximately 1 m. The camera and lens specifications are as follows:

- Camera: Cannon EOS Digital Rebel XT
- Original Image Size: 3456 x 2304 pixels
- Final Image Size: 3456 x 1143 pixels
- Lens: 28-200.0 mm
- Focal Length: 48 mm
- ISO: 100
- Aperture Value: f / 9
- Shutter Speed: 1/80

The flow was back-lit using two 500 W halogen lamps and a diffuser board to make the light even. The images were post-processed in Photoshop by adding a blue filter to remove the orange and brighten the image, curves to adjust the contrast, and auto tone for the final adjustment. The original and final images can be seen in Figure 2 and Figure 3.

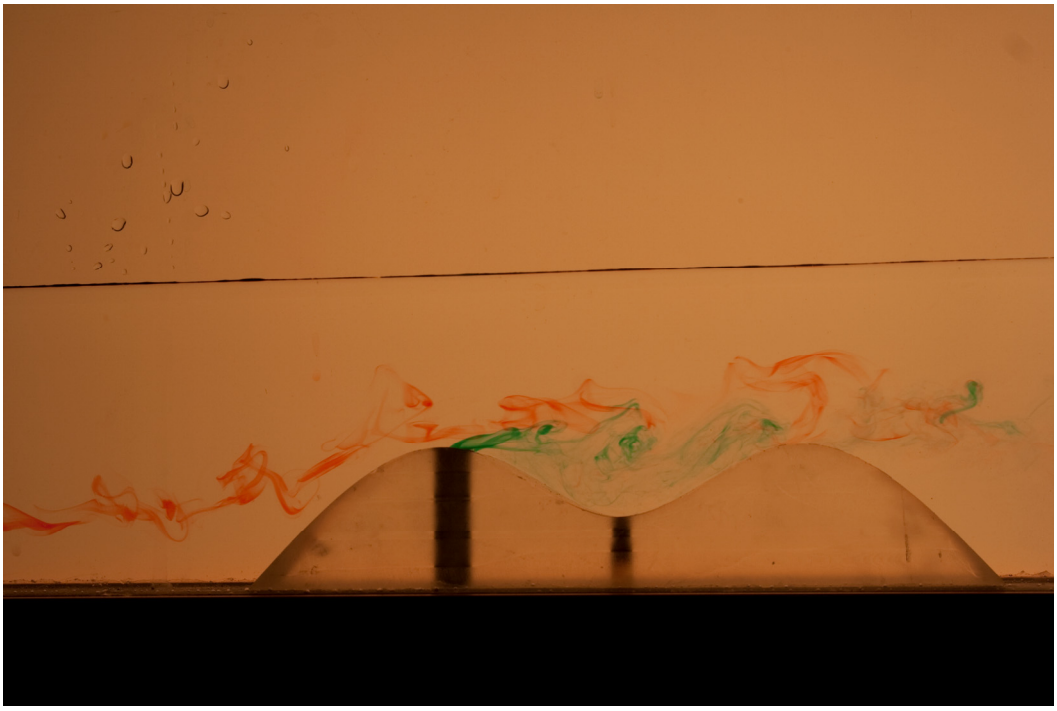

Figure 2: Original Picture

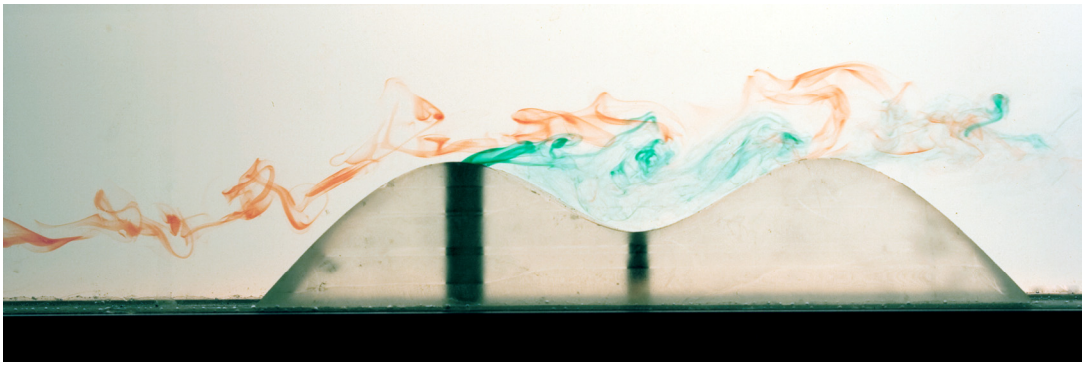

Figure 3: Final Picture

Final Remarks –

The final image fairly clearly shows the shear layer caused by the depression in the weir. The Kelvin-Helmholtz instabilities are not shown as clearly in this image as were observed during the experiments, however some vortices are present. In future images I would try to have a more horizontal (‘flat’) streamline of red dye approaching the weir so it would be easier to show the shear layer in the flow. In general, I think that this image does show the mixing between two flows of different velocities.

References -

[1] “Reynolds Number”, Glenn Research Center,
http://www.grc.nasa.gov/WWW/BGH/reynolds.html