Maxfield Scrimgeour
Flow Visualization
12/7/2016

Team Third Image: Karman Vortex Street

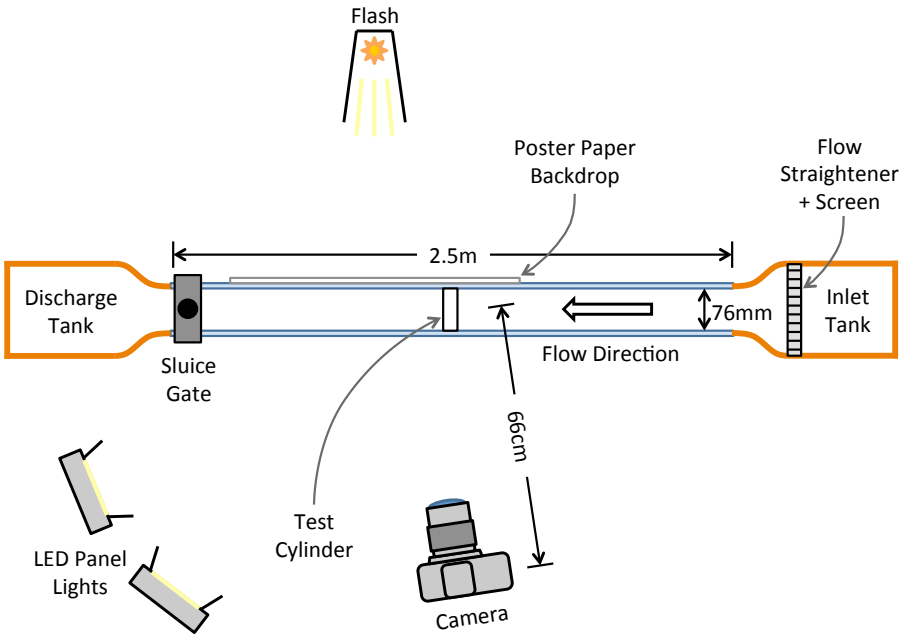
With help from: Peter Brunsgaard, Jeremy Parsons, and Joseph Straccia

Background

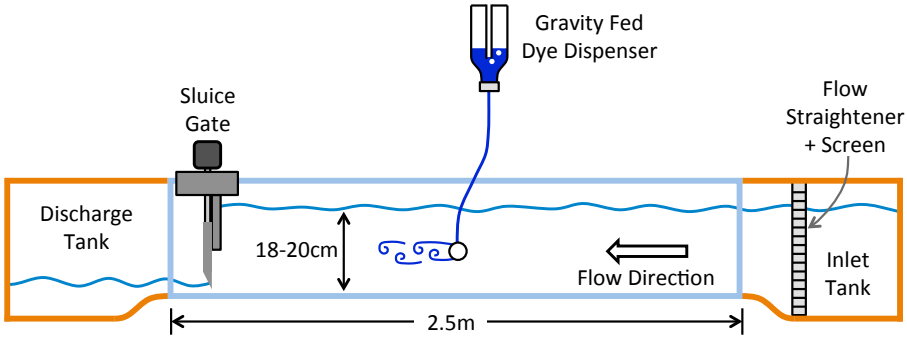
The Karman Vortex Street was something that our group had been looking to complete since the first team image in the flow visualization class. For the final image we were able to produce a Karman Vortex Street using the flume in the ITLL and lots of patience. The Karman Vortex Street is a classic example of flow visualization. To capture this image a test run was completed a few weeks before to make sure that the desired flow situation could be achieved. This proved to be possible and so another experiment was conducted to achieve the image that is seen above. This experiment was done in conjunction with Peter Brunsgaard, Jeremy Parsons and Joseph Straccia.

Setup

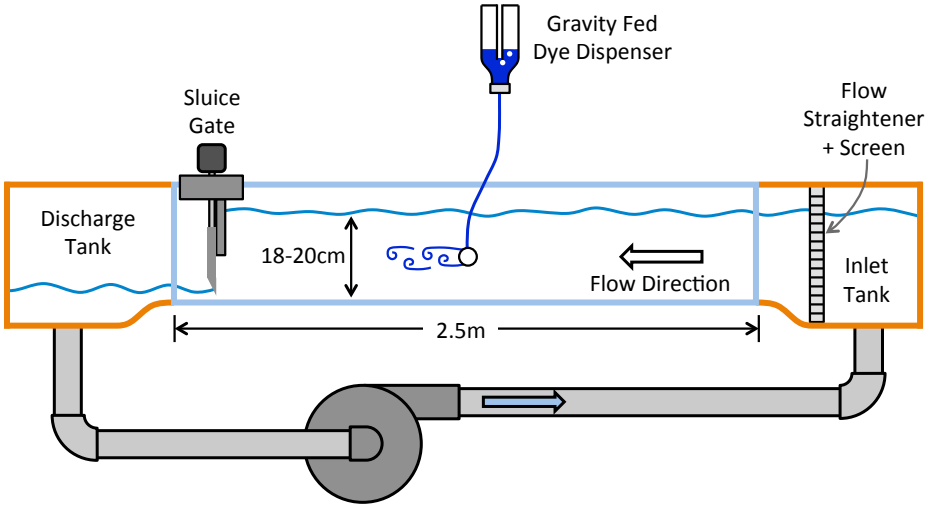
This image was captured using a 2.5m flume in the basement of the ITLL. This flume provides a channel for flowing water down in a uniform field towards an object. Within the flume was a cylinder that Joseph made which allowed for dye to be inserted into the flow. The following diagrams have been designed by Joseph Straccia to illustrate the setup of the experiment.



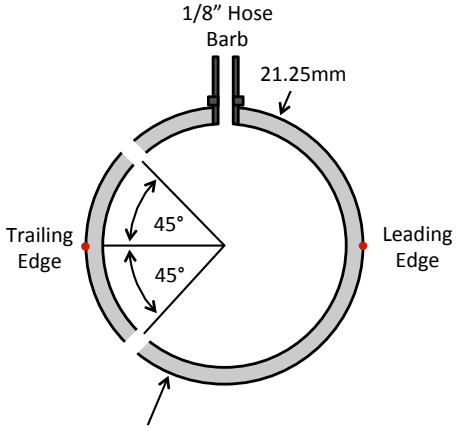
Experimental Setup



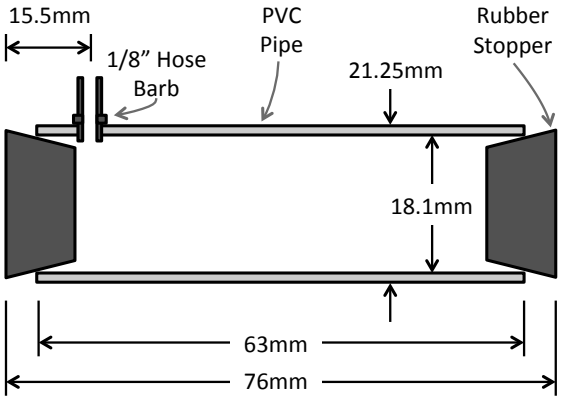
Flume Layout



Flume layout



Cylinder and dye injection



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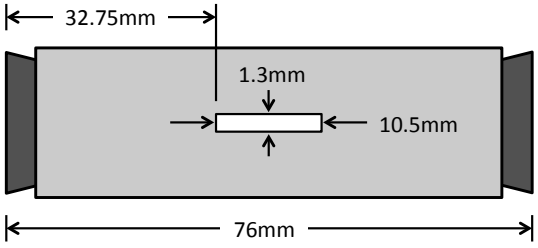

Cylinder and Dye injection

In order to create a Karman Vortex Street the flow must be laminar and ideally have a Reynolds number below 200. Using the flow meter in the flume the velocity could be calculated which allows for the Reynolds number to be found.

$$Re = \frac{UD}{v} = \frac{0.135 * .476}{1.004 * 10^{-6}} = 64.13$$

This Reynolds number of 64.13 is slightly on the low end of the 70-200 Re number which is required for a 2D replication of this phenomenon. As the water particles move from the stream towards the cylinder the pressure in the flow changes. As some particles flow over the different sides of the cylinder pressure differenced on the backside of the cylinder pull the flow from the other side towards the low-pressure area. This pulling with the different pressures creates the vortex behind the cylinder. The difference in pressure is constantly counteracting each other, which is why the vortices are alternating in the wake of the cylinder (NASA). In this photo the vortices are barely offset and breakdown as they move with the flow. This is suspected to be from the slightly low Reynolds number producing more symmetric vortices and a developing Karman Vortex Street. The breaking up of the vortices towards the end of the flow is likely due to the vorticity of the boundary layer where the flow comes in contact with the sides of the flume. The mixing of the dye with the water likely also contributes to the dissipation of the vortices in the image. These phenomena of the Karman Vortex Street can be seen in many different places such as clouds and other laminar flow regions where cylinders are encountered.

Visualization Technique

To create this image the dye in the photo was mixed with 95% Ethanol to create a density neutral dye. This mixing helped alleviate the Raleigh Taylor instabilities in the diffusion of the dye. In order to visualize the flow better and light the dye two LED panel lights were used as well as a remote flash diffused through a white sheet of paper behind the flow. There was also background light from the ITLL lab to the left and right of the setup. The flow of the dye could be managed with a separate reservoir, which had a pressure release hole and could determine how much dye was added to the flow based on the relative position to the cylinder. The width of the flow behind the cylinder is just slightly less than 2” top to bottom.

Photographic Technique

The field of view in this image is approximately 4” high x 12” in length. This was cropped down from the original image to provide a focus purely on the flow. There were many bubbles that were eliminated from the original photo, which provided distractions for the viewer. The contrast and color of the photo was altered slightly to change the color and the background intensity. The camera was positioned at

approximately 26” from focal plane to the body of the camera. The camera details are as follows.
Camera: Canon 7D DSLR
Lens: Canon 24-70mm
Aperture: f/6.3
Shutter: 1/200
ISO: 1000

Original Unedited Photo

Conclusion

This image did a very good job of capturing a Karman Vortex Street for the equipment that was available. There was a lot of time put into this photo and I am happy with the way that it turned out. The physics of the flow are very well illustrated in the image. To improve upon this image I would like to see a wider flume used so the boundary conditions had a smaller effect on the flow and be able to try the dye multiple times to assure that the density is as closely matched as possible. Overall capturing this image was a cool experience and I am very happy to have participated in this experiment.

Source

"SCIENCE FOCUS: VON KARMAN VORTICES." *NASA*. NASA, n.d. Web. 08 Dec. 2016. <http://disc.sci.gsfc.nasa.gov/education-and-outreach/additional/science-focus/ocean-color/science_focus.shtml/vonKarman_vortices.shtml>.