Sedimentation Tank Hydraulics: Detailed Task List

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Week 2-4: Test retrofitted Marcala bottom geometry

- Clean and set up experimental apparatus and flocculator.
- Set up process controller.
- Fabricate retrofitted Marcala bottom geometry: 1 inch diameter pipe cut in half with width of 0.5 inch, glued on a 10cm x 10cm PVC block.
- Re-adjust inlet tube, tube settlers, tubing connections, and flow rates to be able to run Marcala experiment.
- Experimental conditions: the apparatus will be run at a turbidity of 100 NTU until sludge builds around the jet reverser. Then the turbidity will be decreased to 3 NTU to simulate plant conditions. Alum dosing will be 45 mg/L. Upflow velocity will be 1.3 mm/s.
- Take data of floc blanket growth rate, tube settler effluent turbidity.
  - We hypothesize that sludge will build up around the jet reverser forming an incline at the minimum angle of repose (23 degrees) which will simulate the bottom of the tank and flocs will then roll down this incline and be resuspended by the jet.
  - Deliverables: Video of sludge buildup and floc blanket formation under simulated plant conditions, floc blanket growth rate data, effluent turbidity data.

Week 5-6: Test hypothesis that the hindered sedimentation velocity of the floc blanket is equal to the upflow velocity at the floc-water interface during floc blanket operation.

- Three distinct floc blankets will be built under the following experimental conditions: turbidity of 100 NTU, alum dosing of 45 mg/L. The upflow velocity will be varied: 0.6 mm/s, 1.2 mm/s, and 1.8 mm/s.

- In each test, a floc blanket will be formed at a floc blanket height of 60 cm (defined from the bottom of the jet reverser to the floc-water interface of the floc blanket). Once the floc blanket is formed, flow will be shut off for 10 seconds and a series of images will be taken at 0.05 second intervals (the maximum speed of our camera).
- Each image will be subsequently analyzed to identify the position of the settling floc blanket over time.
- After these results are collected, an effective settling velocity will be measured by dividing the relative change in position of the floc blanket by time.
  - This hypothesis testing is critical to our understanding of fluid and solid interactions inside the floc blanket and could lead to a better understanding of hindered sedimentation occurring in the floc blanket.
  - Deliverables: three plots of the projected hindered sedimentation velocity immediately after flow is shut off.
- After collecting hindered sedimentation velocity data, allow floc blanket to settle completely over 24h
  - This analysis is important to help us determine a solids residence time in the floc weir to achieve the desired sludge concentration
  - Deliverables: A plot of the settling curve for each upflow velocity and corresponding TSS value for final sludge concentration.

Week 7-10: Test hypothesis that hydrodynamic pressure of the jet must exceed the maximum hydrostatic pressure of the debris on the incline for floc blanket formation.

- Experimental conditions: turbidity of 100 NTU, alum dosing of 45 mg/L, upflow velocity of 1.2 mm/s, varying radius of curvature of jet reverser.
- The jet velocity will be decreased until the jet is unable to resuspend particles (this indicates floc blanket failure).
- The jet velocity will be pulsed from a low flow rate back to a high flow rate so that the rate of solids return remains constant so that the hydrostatic pressure remains constant.
- The hydrostatic pressure will be recorded based upon concentration readings taken for a rectangular ROI for the image. The hydrodynamic pressure of the jet at contact with the debris flow will be calculated based upon the initial jet velocity and the radius of curvature.
- Compare the calculated hydrostatic and hydrodynamic pressures to test if the hypothesis holds.

  - We hypothesize failure occurs when hydrodynamic pressure equals hydrostatic pressure.
  - Deliverables: Data set showing radius of curvature, initial jet velocity, jet velocity at failure, concentration readings, calculated hydrostatic and hydrodynamic pressures.

- Prepare for Teach In (Week 8)
- Spring break (Week 9)

Week 11: Test the effect of upflow velocity on floc blanket formation and effluent performance

- Conduct several experiments with increasing upflow velocity.
- Use imaging data to determine average steady-state concentration of the floc blanket and the extent of flux across floc-water interface
- Determine maximum upflow velocity that will perform reliably below 3 NTU
  - The SRSF can easily handle an influent turbidity of 3 NTU, therefore we can afford to reduce the efficiency of the sedimentation tank by increasing the upflow velocity. The benefit of this is that the plan area of the sedimentation tank can be reduced and cut costs.

Week 12: Test the effect of energy dissipation rate of jet at contact with debris flow on performance

- Pulse high flow rates for thirty seconds, waiting at least five minutes between each pulse. Record effluent turbidity.
- We expect to observe delayed spikes in turbidity because high flow rates cause more floc break-up and smaller particles.

Week 13: Observe the effect of recirculation on floc blanket formation

- Build floc blankets under low turbidity and low dosing conditions (i.e. 3 NTU and 1.5 mg/L) with and without floc recirculation.
- We expect that the floc blanket forms more slowly without floc recirculation due to lower collision potential.

Week 14-15: Test parameters of interest for floc hopper geometry.

- Parameters of interest include the ratio of the plan view area of the floc hopper to the plan view area of the rest of the sedimentation tank, the volume of the floc hopper, the angle of the bottom of the hopper, the depth of flow and flow rate over the floc weir, rate of sludge removal from hopper.
- Build a settling curve of several floc blanket conditions to estimate a reasonable concentration and solids residence time for compression settling in the floc hopper for the three upflow velocities tested during Week 5.