Design Team-Sedimentation Tank Updates, Spring 2015

David Gold

May 13, 2015

Table of Contents

Part I: Problem Definition

Introduction

This semester the sedimentation tank design code and design drawing code were updated to incorporate changes suggested by field engineers in Honduras as well as new innovations from recent AguaClara research.

These updates included:

- Reorganizing the elevations section of the sedimentation tank file
- Adding vents along the top of the inlet manifold to allow air to escape when the tank is filled.
- Correcting the diffuser pipe positions to reflect what has been fabricated in Honduras.
- Reconfiguring the floc hopper bottom to account for the removal of the sludge drain.
- Adding small slopes at the ends of the bottom of the sed tank to prevent sludge settlement in the corners where the diffuser pipes don't reach.

Design Details

Creation of Elevations Section

In order to effectively reorganize the design script without compromising the outputs of any of the functions, it was critically important to keep track of the inputs and outputs of each function. When creating a new area for all elevation calculations, it was insured that all inputs to each calculation proceeded the new area, while all calculations that required elevations as inputs followed the new area. To achieve this, a spreadsheet was built that listed every elevation calculation and its inputs and outputs. Using this information, a location for the new area was hypothesized and all inputs and outputs were grouped as either proceeding or following the area. It was concluded that the new area should be inserted between the sections “Side Slopes” and “Floc weir hopper, hopper drain and tank height”. The spreadsheet used to make this determination can be found here. A piece of the spreadsheet can also be found in Figure 1 below:

1	Name	Inputs	Section of Input	Used in	Section of Output	Description
14				Vol.SedManifoldEst	Residence Time Estimate	
15	Z.SedSideSlopes	Plant.Origin2	Expert inputs I think	Z.SedFlocWeir	Elevations	Top of the side slopes
16		H.SedSludge	Sludge Drain			
17		ND.SedJetReverser	Sludge Drain Cover			
18		H.SedSideSlopes	Side Slopes			
19	Z.SedFlocWeir	Z.SedManifoldPipe	Elevation	Z.SedLamellaBottomMin	Elevations	Height of the top of the floc weir
20		ND.SedManifold	Prelim Dimensions Calcs	H.SedFlocWeir	Floc Weir Hopper, Hopper Drain..	
21		T.ConcreteMin	Expert inputs I think	H.SedHopperBackSlope	Elevations	
22		Z.SedSideSlopes	Elevation			
23		H.SedSlopesToFlocWeirMin	Another file			
24		Q.Train	Input			
25		Q.PlantMaxLF	Expert inputs I think			
26	Z.SedLamellaBottomMin	Z.SedFlocWeir	Elevation	Z.SedLaunderMin	Elevations	Minimum Z of the Bottom of the plate settlers
27		H.FlocWeirToLamellaMin	Expert inputs I think			
28	Z.SedLaunderMin	Z.SedLamellaBottomMin	Elevation	Z.SedChannelBottomMin	Elevations	Minimum Z of the Sed Launder Pipe
29		L.SedPlate	Plate Length	Z.SedLaunder	Elevations	
30		T.SedPlate	Expert inputs I think			
31		AN.SedPlate	Expert inputs I think			
32		T.ConcreteMin	Expert inputs I think			
33		ND.SedLaunder	Prelim Dimensions Calcs			
34	Z.SedChannelBottomMin	Z.SedLaunderMin	Elevation	H.SedHopperAngleFit	Floc Weir Hopper, Hopper Drain..	Minimum Z of the Channel Bottom
35		ND.SedLaunder	Prelim Dimensions Calcs	Z.ChannelBottom	Elevations	
36		H.SedWeirExit	Exit Channel Design			

Figure 1: Example of Organizational Spreadsheet

Addition of Air Vent Holes

The next task after reorganizing the elevations section of the design script was to size the air vent holes to be drilled in the top of the inlet manifold. The purpose of the air vents is to release air from the manifold while the tank is initially filling to avoid the pipe being raised out of place by buoyant force. Before creating the design algorithm to size the air vent holes, the governing constraint had to be identified. After consulting with Dr. Monroe Weber-Shirk and AguaClara Engineer Drew Hart, it was determined that the governing constraint should be to release all air from the inlet manifold before the water level in the sedimentation tank rose above the midpoint of the pipe. To meet this constraint, the upward velocity inside of the manifold pipe must equal the upward velocity of the surrounding water in the sedimentation tank. This upward velocity can then be multiplied by the area of the water surface inside the pipe to find the minimum flow rate of air out of the vent.

Once this flow rate had been found, the orifice equation was used to determine the diameter of the air vent. A maximum allowable air vent size was determined, and code was written to include multiple air vents should the calculated diameter exceed this maximum. Sample air vent sizing calculations can be found below. Figure 2 shows an example of an air vent in a manifold pipe.

Minimum total flow rate through vents:

$$Q_{SedAirMin} := V_{UpPipeMid} \cdot L_{SedManifoldPipeActive} \cdot innerdiamter(ND_{SedManifold}, PS_{Default})$$

Estimated Vent Diameter:

$$D_{SedAirVentEst} := \sqrt{\frac{4 \cdot Q_{SedAirMin}}{\pi \cdot Pi_{VenaContracta} \cdot \sqrt{2 \cdot g \cdot \Delta h_{SedManifoldBuoyant}}}}$$

Number of Vents required:

$$N_{SedAirVents} := \left| \begin{array}{l} N \leftarrow 1 \\ \text{while } \frac{D_{SedAirVentEst}^{2}}{N} > D_{SedAirVentMax}^{2} \\ \quad N \leftarrow N + 1 \\ \text{return } N \end{array} \right.$$

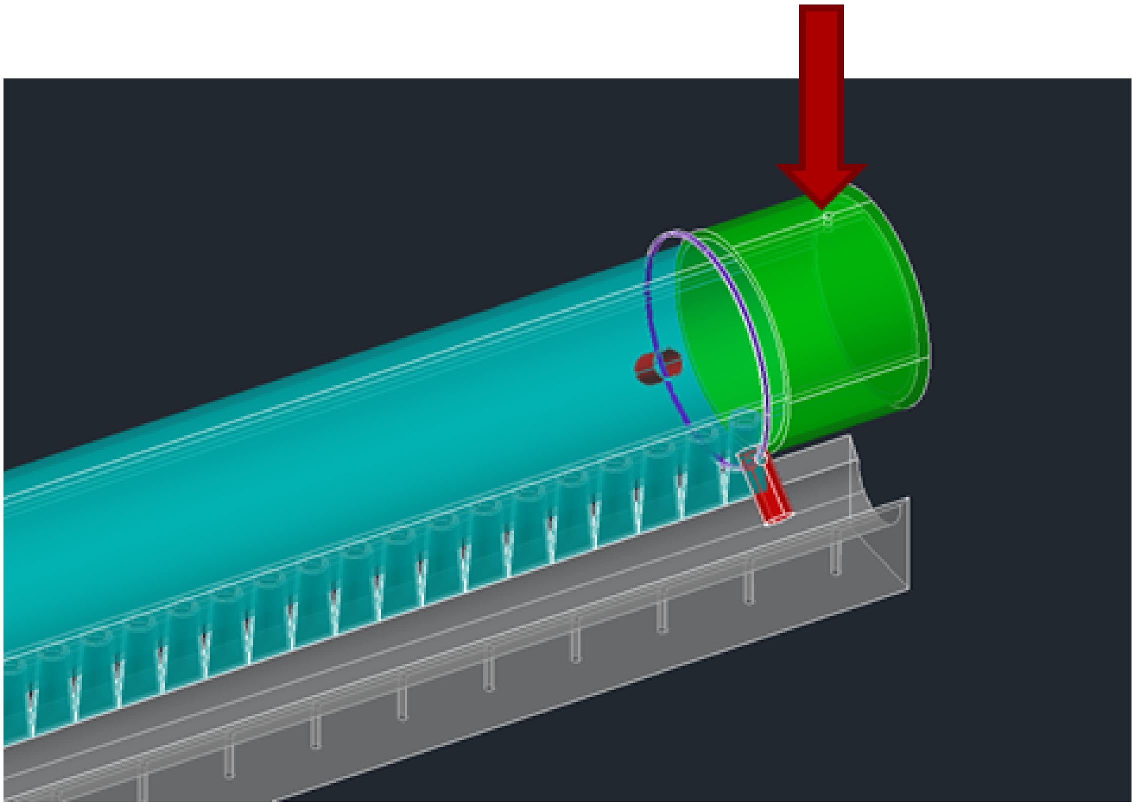

Figure 2: Air vent placement

Diffuser Placement

In order to mirror the configurations of plants being constructed in Honduras, the diffuser positions from the inlet manifold needed to be recoded. The current code does not take into account the spacing between the start of the inlet manifold pipe and the floc weir, nor does it properly account for the cap at the end of the manifold. The first step to solving this problem was to create variables to account for the necessary spacings, and add them into the Expert Inputs file. The three new variables created can be found in Table 1.

Table 1: New Variables for diffuser placement

Variable	Definition
L.SedManifoldPipeFromFlocWeir	Length of fixed pipe jutting out from floc weir (currently 2 cm)
L.SedManifoldPipeFromTankEnd	Space between end of manifold and tank wall (currently 2 cm)
L.SedDiffusersToEnd	Spacing from last diffuser to end of manifold cap (currently 3 cm)

Using these variables, the Active Length of the sedimentation tank manifold was recalculated to accurately reflect the tank geometry.

$$L_{SedManifoldPipeActive} := L_{SedUpflow} - L_{SedManifoldPipeFromFlocWeir} - L_{SedManifoldPipeFromTankEnd} - CapThickness(ND_{SedManifold}) =$$

The calculation for the number of manifold ports was then updated to incorporate the active length of the manifold and include spacing values S.Fitting (to account for the coupling between the fixed pipe stub and the removable section of the manifold) and L.SedDiffusersToEnd.

$$N_{SedManifoldPorts} := floor\left(\frac{L_{SedManifoldPipeActive} - S_{Fitting} - L_{SedDiffusersToEnd}}{B_{SedManifoldPort}}\right) =$$

Once the sedimentation tank design code was updated, the drawing file needed to be updated to reflect these changes. To achieve this, the x coordinate of the origin point for the manifold ports drawing function was changed as was the x coordinate of the origin point for the diffuser drawing function. The code for the new origin point can can be found below.

$$\left[Plant_{Origin_0} - L_{Sed} + T_{SedDiffuserWall} + \left(W_{SedInletChannelPreWeir} + T_{ChannelWall}\right)\cdot\left(EN_{InletChannelGeom} = Inlet_{FullDepth}\right) + L_{SedHopper} + L_{SedManifoldPipeFromFlocWeir} + \left(S_{Fitting}\right) + \frac{L_{SedDiffuserOutlet}}{2}\right]$$

A drawing of the output from the current manifold code can be seen in Figure 3 and the output from the newly coded manifold can be found in Figure 4.

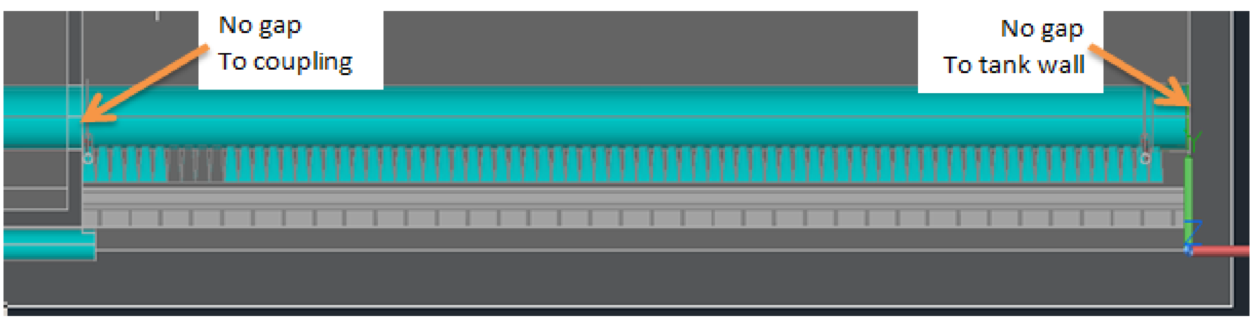

Figure 3: Current Diffuser layout

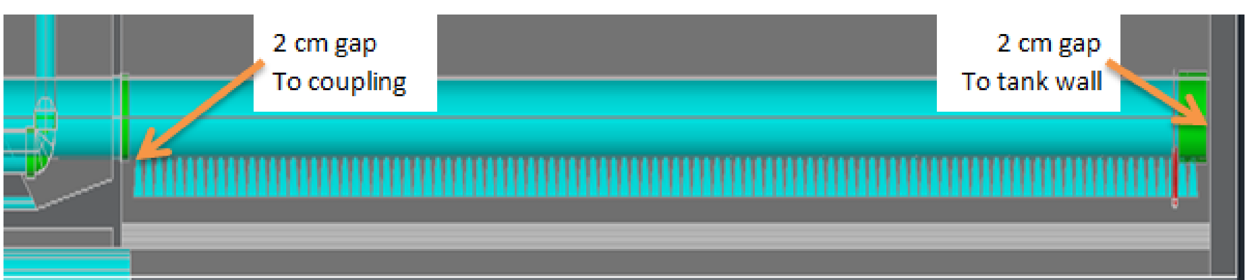

Figure 4: New Diffuser Layout

<u>Floc Hopper Lowering</u>

Once the sludge drain had been removed from the sedimentation tank design script by Drew Hart, the floc hopper had to be lowered to ensure that it did not intersect with the inlet manifold. Figure 5 shows a schematic of the final floc hopper layout.

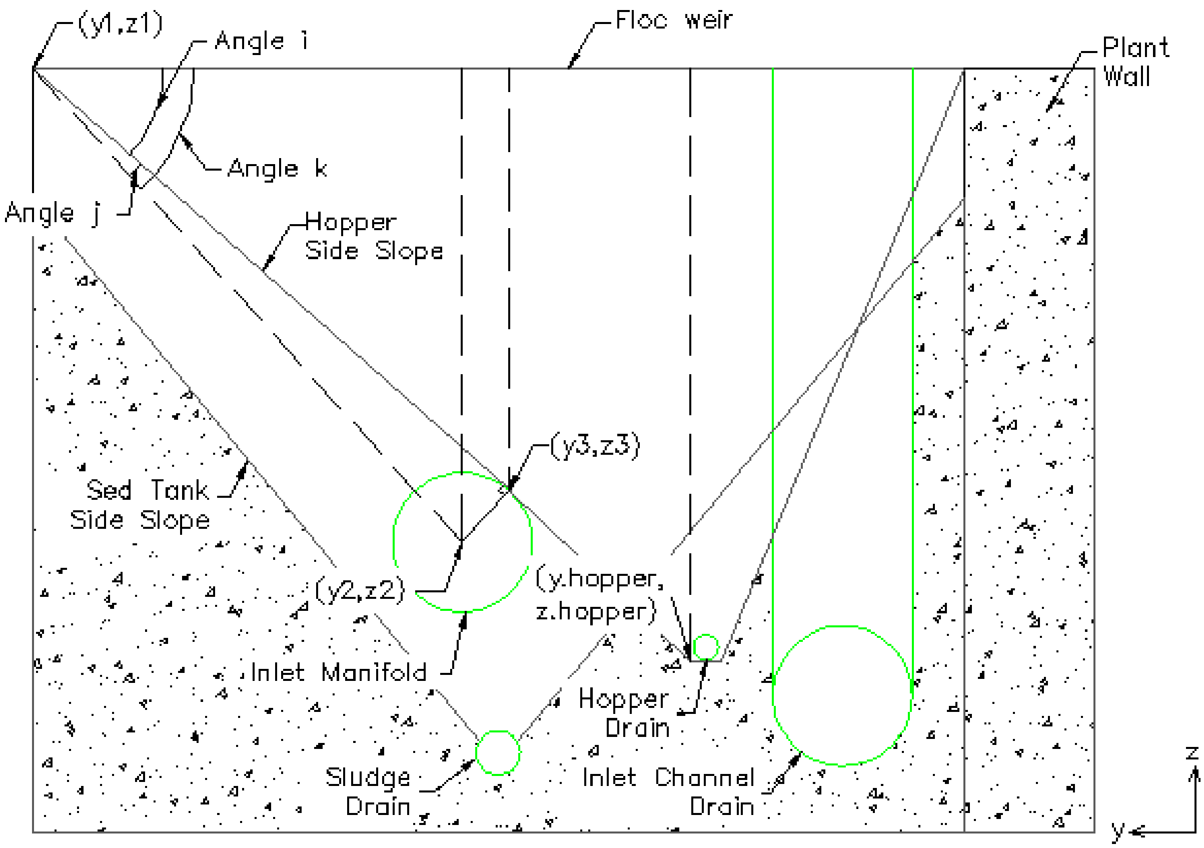

Figure 5: Floc Hopper Elevation

In order to ensure that the floc hopper side slope did not intersect with the inlet manifold, the elevation of the floc hopper bottom had to increased so that the side slope was tangent to the inlet manifold. This slope was determined by first finding the slope between the floc hopper corner, (y1,z1) in figure 5, and the center of the inlet manifold, (y2,z2) in figure 5.

$$j = atan(ConRadius(ND.ManifoldPipe)/((y1-y2)^2+(z1-z2)^2)^{.5}))$$

Once this angle has been found, the angle between the horizontal and the the line from the floc weir corner to the inlet manifold center is found.

$$k = atan((z1-z2)^2)/(y1-y2)^2$$

Once the angle from the horizontal to the line from the corner of the floc weir to the inlet manifold center is known, the slope from the floc weir corner to the tangent of the inlet manifold can be found by subtracting angle j from angle k:

$$i = k - j$$

Finally, the elevation of the floc weir bottom can be determined from the following equation:

$$z.hopper = z1 - tan(i) * y.hopper$$

<u>Sedimentation Tank Bottom Slope</u>

A small sloped section was added to the end of the sedimentation tank to prevent sludge from building up in the tank corners. This section was created using the Wedge3D drawing function. The wedge was designed to have a length equal to the width of the sedimentation tank, a width equal to the space between the end of the sedimentation tank and the end of the last diffuser and a height equal to the distance from the bottom of the jet reverser to the bottom of the inlet manifold.

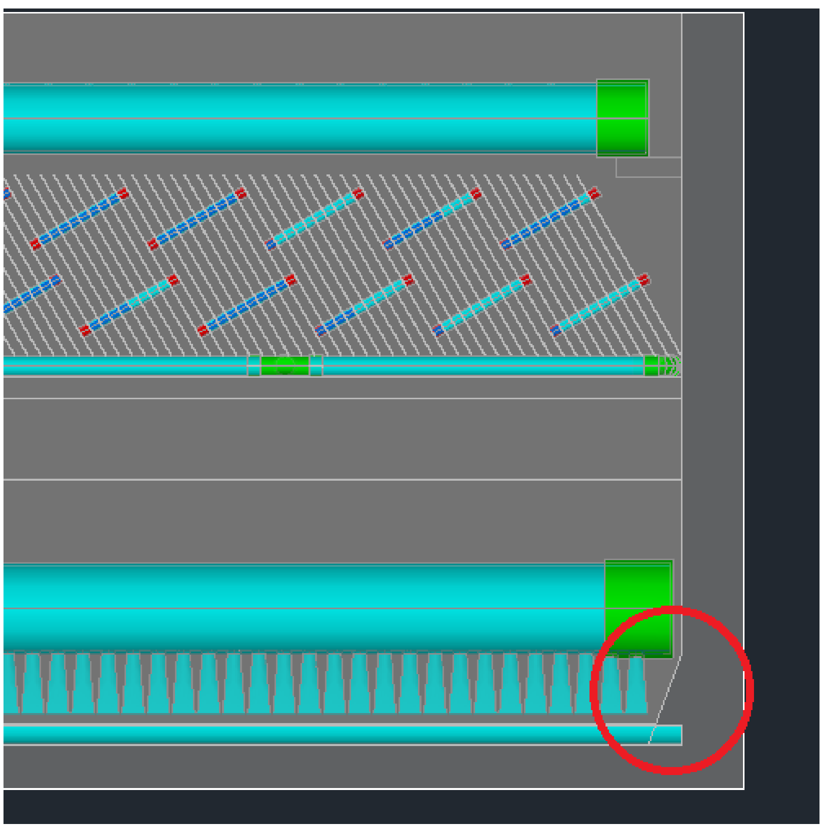

Figure 6: Sed Tank Bottom Slope

Part II: Documentation

Problems Encountered

The main challenges encountered were the occurrence of pieces of code that seem out of date or out of place and have no accompanying explanation. Examples of these problems include the the calculations for multiple bays per sedimentation tank or the geometry calculations for an inlet manifold that passes through the floc hopper at a 45 degree angle. It seems as though previous changes to the code have been made by simply changing as small of a piece of the code as possible so as not to corrupt other sections of the script. Although this is an understandable action, it makes looking at the script to one unfamiliar with it very difficult.

Accomplishments

3/6/15

The first task completed this semester was the reorganization of the elevation calculations by grouping them in their own area of the script. Once the new location and order for the elevations area had been determined, the process of removing the calculations for the 45 degree elbow on the manifold between the inlet channel and the sediment tank we begun.

3/20/15

The design algorithm for the air vent holes has been completed and entered into a draft of the updated design code.

4/10/15

The diffuser pipe positions have been updated to to reflect what has been fabricated in Honduras. Prior to this fix, the number of diffusers calculated did not comply with the spacial constraints of the fittings used in Honduras. The code was updated so that the diffusers would begin 2 cm away from the end of the coupling that connects the manifold pipe in the active part of the sedimentation tank to the one that goes through the floc weir, and 3 cm from the end of the manifold pipe that is capped. A 2 cm spacing was also added from the end of the manifold pipe to the end wall of the sediment tank.

All changes to the sedimentation tank code thus far this semester were committed to the server on April 6th. Three files were committed: SedimentationTank_dfg42, SedimentationTankAC_dfg42 and ExpertInputs_dfg42.

4/27/15

The majority of the work to remove the sludge drain from the sedimentation tank design script was completed by Drew Hart during the week of April 20th. The removal of the sludge drain and the subsequent lowering of the inlet manifold necessitated the relocation of floc hopper drain. The floc hopper drain was moved to the side by Drew during the process of removing the sludge drain. A problem arose however when it was discovered that the side slope of the floc hopper intersected with the lowered inlet manifold, which could potentially block flocs from setting to the bottom of the floc hopper. In order to fix this, the sedimentation tank team was assigned to perform calculations to raise the hopper bottom and determine new hopper side slopes that would prevent such intersections. These calculations were completed on April 26th and committed to the design server.

5/6/15

A slope has been added to the end of the sedimentation tank in order to prevent buildup of sludge at the corner of the wall.

Future Work:

The floc hopper side slopes are currently shallower than optimal according to Dr. Monroe Weber-Shirk. Future teams should investigate ways that the floc hopper geometry could be modified in order to accommodate steeper slopes. The floc hopper drain may also be modified to incorporate a constant drip system. The geometry of the plate setters is also in need of investigating, since the current CAD drawing does not show the final plate touching the wall of the sedimentation tank.