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Steve Beyers' Individual Contribution Page

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During this semester our team has been investigating the Inlet Manifold with members of the Agua Clara team. I began the course with the personal advantage of over 20 years of consulting engineering experience, including several years leading the environmental services group at a central NY consulting engineering firm that, among other projects, was involved with municipal and industrial water and wastewater design and the related problem-solving efforts this involves. The value of this experience melded well with the strong data skills, creativity, design, and visualization skills of my team members to produce a successful semester of research and design improvements.

My personal contributions have included the following:

1. Making models to demonstrate various hypotheses:
    a. Using household tools and plumbing parts, several models of inlet manifolds were built, first at 1-1/2" diameter (PVC) size; then at ¾" diameter (Type L copper); then at ½" diameters (Type M copper) size. Holes were drilled in these models using a standard variable-speed drill to create scale-models of the distribution header piping size resulting from the Agua Clara design tool (16 evenly-spaced holes with total area approximately equal to the cross-section of the pipe). While these models were not as uniform and burr-free as the models generated by our shop experts, they allowed rapid early testing (at home) which helped guide development of better models for lab use.
    b. Using a combination of available parts and acrylic material purchased from a local home goods store, I created an approximate scale-model (1/12" scale) sediment tank complete with inlet box (with overflow weir); inlet tube; sloped bottom section, inlet pipe (1/2" copper); lamella plates, and launder pipes. Due to leakage and other minor issues with the first model, a second model was needed (and created) to continue tests.
    c. Conducted home tests (flow tests using the inlet manifold models and dye tests involving the scale model) that established new probable imbalance concerns and generated schematic solutions to those concerns. Concerns included angled flow discharge that creates higher-than-anticipated exit velocities (which could create higher levels of floc breakup in a full-scale system) as well as potentially creates circular motion within the sediment tank as opposed to the "gently rising uniform vertical" flow desired; as well as "dead zones" created by the incomplete distribution of lamella plate entrance area along the full cross-section of the tank. Solutions included small baffles inserted along the distribution pipe to intercept and stop horizontal flow; varied hole spacing; various outlet nozzle types, etc.
    d. Devised a simple visual manometer to measure pressures (when pressure sensors were unreadable due to excessive noise in the signal and signal drift). This simple device undeniably substantiated the existance and amount of pressure recovery effect in our model.
    e. Created a clear model with three outlets to investigate various nozzlee configurations using two types of testing, namely, (1) dye testing and (2) particle testing with small plastic beads.
    f. Created another 1/12th scale tank model with installed sludge drain (all acrylic parts) to investigate floc slduge withdrawal design issues and leakage rates for a prototype solution.
    g. Also created multiple smaller design solutions for various aspects of our study (nozzle types,
2. Established base formulas and provided calculation spreadsheets to help predict the existence and magnitude of pressure recovery (also known in the HVAC industry as static regain), and proposed changes in hole spacing and piping orientation to eliminate those theoretical imbalances. Those potential solutions included:
    a. Maintaining the same hole spacing and sizes, but modifying the spacing so that the discharge in any portion of the tank is similar despite non-uniform discharge at individual holes. Simply put, holes that discharge less are closer together, while holes that discharge more are farther apart, such that the average discharge per unit length is equal.
    b. A different inlet pipe orientation such that flow is split at a tee located in the center of the distribution pipe and allowed to distribute equally to discharge ports located along the pipe sections leading towards the two ends. This creates a situation in which the maximum horizontal flow and velocity is only half of the original, and therefore flow pressure imbalances (which are related to the square of the velocity) are cut in fourth. Calculations reveal that this innovation, combined with a slight increase in the number of exit holes, reduced exit velocity to levels below the original design maximum, which was the velocity in the feed pipe.
3. Produced calculations to estimate the impact of the removal of launder (a design option we investigated based on dye tests which showed no benefit to the launder).
4. Helped suggest and implement methods of directly measuring water discharge from first and last holes along the port in order to check behavior against theory and "calibrate" potential solutions.
5. Help lead a "classroom" work session to compare calculations, predictions, and theoretical understanding of the problems we have been tasked to solve.
6. Demonstrated how dye testing can be used to show rolling and circulating motion in the tank.
7. Demonstrated how molasses can be used to simulate thick, sticky sludge that may not drain easily from the tank, in addition to creating yummy and nutrious cookies.
8. Learned how to film and down-load film shorts onto YouTube to demonstrate behavior.

The efforts with our team were rewarding and fun. More accurate models and careful testing helped develop solutions that were optimized for both low cost and ideal (most even) distribution. The flow behavior qualitatively shown matched well to the quantitative (mathemtical) modeling, giving us a high degree of confidence in our solutions. Based on this success, I will be traveling to Honduras in hopes of putting one or more of these recommended improvements into practice (as well as to learn about other issues that might be solved in future years).