Sedimentation Tank Controls

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Abstract

Aguaclara plant operators have difficulty removing pipe stubs and launder caps when controlling the flow through the sedimentation tanks. The Sedimentation Tank Control Team is working to develop tools to aid in the removal of the pipe stubs and caps. Different techniques were examined; for the pipe stub, the slide hammer and lever were determined to be easy methods of removal and devices were fabricated and tested on a concrete testing apparatus. It was determined that the best option for the launder cap was to use a wing-nut expansion plug as an alternative to the PVC cap. The expansion plug may even be able to replace the pipe stub, which would eliminate the need for specialized removal tools. The team has determined the option for catwalks in the plant would only reduce the cost of construction for very large plants, would be difficult to implement and may create issues with the sedimentation tank controls.

1 Introduction

The sedimentation tank is the largest unit of an Aguaclara water treatment plant and still has quite a few challenges that require attention. This new subteam is aimed at solving some of these challenges. The first objective is to find a tool that could make it easier to remove caps which are used to close the outlet launder of sedimentation tanks (figure 2). In the same way, a tool is also needed to remove pipe stubs used to close the influent channel (figure 1). These tools would improve the cleaning process of the sedimentation tanks.

2 Methods

2.1 Apparatus

Meetings with Monroe and the workshop staff were helpful for brainstorming ideas of tools and procedures to make the first tests. We have purchased caps for 6" pipes, metal clamps and 6" pipe couplings. For our first experiments, 6" pipes will be used to test preliminary tools. Then, the actual pipe sizing of 8" will be used to test best tool options. We had a 6" pipe cut down to a small piece of approximately 10" long. This pipe and the coupling were placed in a

Figure 1: Sedimentation Tank Inflow Weir (San Nicholas)

Figure 2: Sedimentation Tank Effluent Launders (Atima)

Figure 3: 6" PVC Coupling and Pipe with 1/2" Steel Rebar Cross

concrete block to simulate the placement of the sedimentation tank inlet and effluent launder pipes, respectively. The concrete block was made by mixing 22.7 kg (50 lb) of Quikrete ® with water in a plastic tub by a volume ratio of cement/water around 2:1. More water than normal was added to make it easier to mix the concrete. Four small holes were drilled next to the bottom of each pipe so that two lengths of steel rebar could fit through each of them (figure 3) . The rebar was added to give the bottom of our pipes more stability under the concrete. Both pipes were submerged in concrete, filling half of their length with concrete and covering the metal bars completely (figure 4).

2.2 Pipe Stub Removal

Through various brainstorming and meetings with Professor Weber-Shirk, Heidi Rausch, and Paul Charles, different designs for the removal tool were created. The most promising and feasible of these designs are explored below.

2.2.1 Lever

The first technique to remove the pipe stub that will be explored will be a lever. The difficulty with using a lever would be having access to a fulcrum point. To solve this a shaft roughly the length of the pipe stub will be attached by a hinge to the end of the lever close to the pipe stub. This would allow for a fulcrum to be present regardless of the surroundings. A PVC pipe with holes could also be used in place of a metal bar shaft, as it is strong enough to endure the force

Figure 4: Concrete Filled Testing Apparatus

applied and does not rust in contact with water (figure 6). The system created was made of PVC pipes, half inch diameter steel rods and metal hooks (figure 5). Two holes slightly larger than the metal bars were drilled 1" below the top of the pipe in order to fit a metal bar across it. Two metal hooks were attached together by a standoff coupling nut to make the connection between the small metal bar across the pipe and the lever bar. The system performed reasonably and a low force had to be applied to take off the pipe stub. However, it was composed of many pieces weakly connected, which took some time to make it work appropriately without falling apart. To solve this problem, the hook could be welded into the smaller metal bar or small o-rings could be placed around the hook to keep it in place (figure 7).

Another way to solve this problem could be by connecting the system with flexible elbows and tees as hinges. A flexible elbow could be used to attach the lever to the PVC Fulcrum. By doing this, the adjustable heights of our PVC holes would be lost but the system would be more solid. Another improvement would be to substitute the metal hooks for a metal bar and use hinges to connect them. A flexible tee would be used as a connection between the lever bar and the connector middle bar and a fixed tee fitting would connect the middle bar to the bar across the removable PVC pipe. That way, o-rings would not be needed anymore and the system would have only three components: the metal level apparatus, the pipe to be removed and the PVC Fulcrum. After the symposium demonstration, we determined that the lever system was too fragile and that it would be easier for operators to use if it had fewer detachable parts and was more solidly connected.

Figure 5: Pipe Stub Removal by Lever and Eye Hooks

Figure 6: Adjustable PVC Fulcrum

Figure 7: O-Ring Stabilization for Eye Hooks

Figure 8: Slide Hammer Device

2.2.2 Slide Hammer

Another possibility would be to have a weight attached to a shaft with a stopper at the end. The mass would be thrown upwards to the stopper and the force would hammer the pipe stub upwards. The prototype slide hammer was made from three pieces of 1/2" steel rod welded together, and square steel pipe to act as the handle and mass (figure 8). The material for the slide hammer is steel in order to prevent the slide hammer from deforming when used. The slide hammer connects to the pipe stub by sliding a rod into holes slightly larger that 1/2" that were drilled approximately 1" below the top of the pipe stub (figure 9). The length of the rod was approximately 9". This length allowed the rod to slide into the holes from the inside diameter of the pipe but still be long enough to allow for error in the position of the slide hammer. A small steel rod was welded to the top of the slide hammer to act as a stop which the mass would hammer against. The square pipe that acts as the mass to the slide hammer was used because it provided the necessary weight and length. The tool was able to successfully remove a pipe stub when physical removal without a tool was unfeasible. While the slide hammer will not come in direct contact with water, it will be used around water and it may be dropped into water. As a result, it may rust over time. Other materials should be examined to see if the design could function with materials that will not rust. Other alterations should be made to improve the ease of use of the slide hammer. Such as replacing the square pipe with a round one, and attaching some material to the top of the slide to prevent the operator's fingers or skin getting pinched when bringing the slide upwards. When in use the slide hammer was fairly loud, so developing a way to reduce the noise the slide hammer generates should be explored. Another method of extracting a pipe stub could mirror that of a tent stake remover, such as the design of the JackJaw (figure 10 JackJaw). The design would have to be altered to deal with the larger diameter of the pipe when compared to the stake.

Figure 9: Slide Hammer Connection to Pipe Stub

Figure 10: Jack Jaw Tent Anchor Remover

2.3 Launder Cap Removal

After meeting with Monroe, Heidi and with Paul Charles, there are several options to be considered for improving the ease with which the plant operators can remove the caps put on the effluent launders of the sedimentation tanks. As these caps are only used to close off one sedimentation tank at a time for cleaning or maintenance, the device or mechanism for their removal does not need to be easily transferred or used on other launders as the pipe stub removal device does.

The first option to be considered is cutting a slit or a notch in the side of the PVC cap. The notch would be short enough that a seal could still be created when the cap was fully on the launder, but long enough/wide enough that when the operator needed to remove the cap, he or she would be able to bend the edge of the cap to pry it loose. The concern with this idea is that there would potentially be leakage due to the slit and also that the large PVC caps (6" and 8") would still be difficult to manipulate even with the notch. Another (remote) possibility would be that the cap could break where you created the notch, since you are trying to the bend the pipe there.

The second option to be considered is to replace the cap with a T-connector with caps on either end. In this scenario, the T would give the operator something to hold on to while he unplugged the effluent launder. The T would also provide an area for the operator to use a simple lever. A potential downside of this option is the width of the channel being too narrow to allow for the T and also to provide enough space for the operator to pull the T back. This design also requires more large PVC parts which are expensive. The design team has been consulted about the channel width, and we will consult the plant design to determine how much space will be available.

The final option we are planning on investigating is a lever with a wide fork on the end. The fork would slip on either side of the effluent launder and then by using the wall, the lever would pop the cap off. This is the last option we intend to investigate because it would require construction of both the lever and the fork out of a strong material such as steel. One of the concerns with this idea is constructing a strong enough lever so that it would not bend. Another concern is that the material would need to be water-resistant because it would come in contact with the the water in the effluent channel. In order to fabricate the fork, a 8" x 8" steel plate with 1/2" thickness was ordered from McMaster Carr. A semi-circle will be cut from the plate so that it will fit around the pipe (figure11). Because the allowances for this cut are very small (must be large enough to fit around the pipe but still smaller than the diameter of the cap) we were unable to cut it using a band saw. The plasma cutter in the shop is the only tool that would be able to cut the steel plate to our specifications.

Alternative capping methods were also investigated. The team discovered several options such as a Fernco cap, a US Plastic Corp Quick Cap, and a Wing Nut Expansion Plug. The Wing Nut Expansion Plug 12was ordered from McMaster Carr and was tested to be water tight through a simple test. It is also easily removable, as the tightness of the cap is adjusted with the wing nut

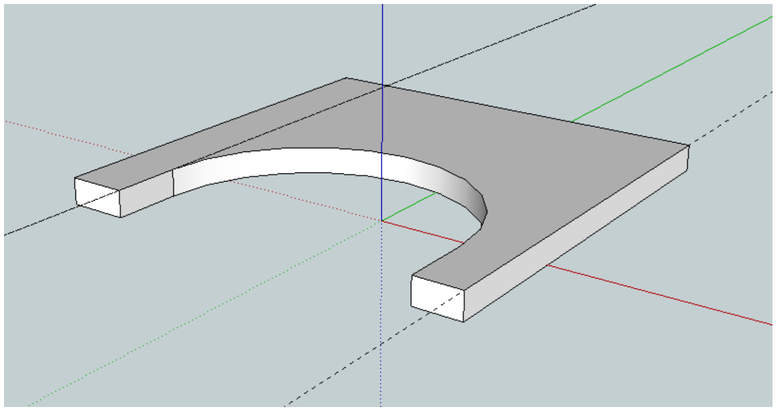

Figure 11: Drawing of Cap Removal Fork

Figure 12: Wing Nut Expansion Plug (McMaster Carr)

and can be simply loosened or tightened by the operator.

2.4 Catwalks / Bridge

Currently, the AguaClara plant operators access the pipe stubs, the effluent launder caps, the sedimentation tanks, the baffles, the plate settlers etc. by walking on the walls of the sedimentation tank and the weirs. The Sed Tank Controls team has investigated the use of movable catwalks that would span the sedimentation tanks and flocculators. These could potentially improve the safety of the operators and allow for an AguaClara plant to meet the safety regulations of the countries such as the United States, who have more stringent guidelines than Honduras. Julia Morris was consulted about her work on design modification cost savings and according to her work, removing the walls from the sedimentation tanks would save about $1000. Prefabriacated catwalks range in cost for the length of the catwalk. Sixteen to twenty-four foot catwalks range in price from $550 to $910, which does not factor in the labor costs of installing the catwalk. If the catwalk replaces only one wall, the cost is approximately break even. If the catwalk replaces multiple walls, the cost of construction would reduce by approximately $1000 per wall after the first wall. At a minimum, the catwalk would have to replace two walls in order for there to be a reduction in the cost. The current design specifies one bay per tank, so using catwalks with this design would only result in an increase in the costs. While catwalks with the current design may prove useful enough that even with no reduction in cost it would still be beneficial to replace the wall with it, the benefit gained would have to justify an additional cost of construction. However, the additional benefits currently do not seem to out way the costs of purchasing and installing a catwalk.

For a catwalk to be used in an AguaClara plant, there would need to be more than two sedimentation bays since the flow would be stopped when a bay is being clean. There would be no cost reduction if a catwalk was added and the sedimentation walls were not removed. This constricts the use of catwalks to larger plants for it to make economical sense. Furthermore, the number of sedimentation tanks would need to be even if the number of bays were to be reduced to two. This added constraint reduces the number of plants that would benefit from a catwalk system even more. The length of the sedimentation bays would have to be greater than approximately three meters to gain a benefit from using a catwalk. If the bay is short, the operator would be able access the entire area of the bay, and having a catwalk across the bay would not ease the operator's task. A further consideration was connecting the catwalks in such a way that would not interfere with the weir system for the influent and effluent channels into the sedimentation bays. The catwalk may cover the influent channel and thus prevent the use of a pipe stub to stop the flow to the bay.

3 Conclusions

3.1 Launder Cap Removal

The Sedimentation Tank Controls team has determined that the best option for improving the ease of removing the caps from the effluent launder is to replace the PVC cap with a Wing Nut Expansion Plug 12. This decision was the result of several different factors, both economic and technical.

The PVC cap with the slits along the edges did not result in a more flexible cap. The PVC cap was almost as rigid as it was without the slits and it required a great deal of strength to bend it at all, let alone remove it from the effluent launder. Not only did this option not improve the ease of removal, but it would require the same cost of the PVC cap with an additional labor cost and the added difficulty of cutting the slits on a rather large cap.

The lever fork removal device was also deemed an infeasible solution when the plasma cutter failed to cut the steel sheet. The steel was too thick and the plasma cutter was unable to make the semi circle incision13. In addition to the

Lever Fork Material Costs	6”	8”
PVC Cap	$13.98	$32.78
Steel Sheet 8” x 8”	$51.79	$70.36
6’ of 1/2” Steel Rod	$13.89	$13.89
Total	$79.66	$117.03

Table 1: Cost of Lever Fork

Cap Alternatives	6”	8”
Constructed Steel Fork	$79.66	$117.03
Air Inflatable Test Plug	$92.06	$165.90
United States Plastic Corp Quick Cap	$13.95	$28.07
Fernco Cap	$15.45	Not Available
PVC Cap with Slits	$13.98	$32.78
Wing Nut Expansion	$22.07	$41.81

Table 2: Cost Comparison of Capping Alternatives

fact that we were unable to fabricate the lever fork, a preliminary cost analysis showed that the cost of the materials for the fork would be significantly higher than some of the alternative cap options1, not including any additional labor or tools needed for fabrication. It was important to remember that the main goal was to make the process of removing the caps easier for the operators, and that the additional steps needed to fabricate tools such as the lever fork may actually make it more difficult.

Among the several options available for capping the effluent launder, the group chose the wing nut expansion plug based upon the following reasons: first the wing nut expansion plug is readily available from a trusted supplier (McMaster Carr). Second, removal of the plug did not require any prying/pulling or physical strength. Third, the cost of the plug was comparable to the cost of a PVC cap2, even though it may have been more expensive than some of the other capping alternatives, it was in the same order of magnitude. Finally, the plug can be ordered from a distributer, it is available in both the 6” and 8” size, and it does not require additional fabrication or alterations.

3.2 Pipe Stub Removal

3.2.1 Cost Analysis

As part of the final process for determining which process is the best option for pipe stub removal, the team performed a simple cost analysis of the slide hammer and the lever. We analyzed the cost per unit for each material required, the amount of each material used, and the total cost of each tool. We found that the costs of fabricating the slide hammer3 and the lever4 are both under $20. Although the cost of the lever is lower than the cost of the slide hammer, the difference is not enough to be the determining factor in the design selection.

Figure 13: Failed Lever Fork

Next, the team would like to investigate the ease with which each implement was fabricated and which would be easier to produce in Honduras. Each implement has different pros and cons that may be subjective to the person using it. The lever system developed is simple to assemble, is less likely to rust, and is quiet, although it is comprised of multiple parts that may come apart and the lever may slide when the set up is not ideal. The slide hammer is one contained unit and is fairly intuitive to use, but it requires welding to fabricate and is made from rustable materials. Without further inputs about preferences, particularly from the operators that would be using the tools, the team has found it difficult to determine which tool to continue with. Furthermore, it has proven difficult to determine the exact materials that would be available in Honduras, so the team has been unable to determine which tool would be easier to produce in Honduras. Finally, Monroe proposed using the wing-nut expansion plug as a replacement to the pipe stubs, which may be a viable option depending on the number of inlet pipes that enter a specific sedimentation bay. Due to the difficulty of determining the materials available and the ease of various fabrication techniques in Honduras, the team has decided to proceed to developing a method for monitoring the level of a floc blanket.

3.3 Catwalks / Bridge

There are numerous constrictions and possible complications of using a catwalk, and there appears to be no cost reduction when a catwalk is used to replace one wall. Therefore the use of catwalks do not seem practical for a generic

Slide Hammer	Unit	Unit Cost	Cost of Use
1/2" Steel Rod	6 ft	$13.89	$8.49
3/2" Rectangular Steel Tube, 0.12" Thickness	1 ft	$11.67	$8.75
Shick Absorbing Foam Tap	10 ft roll	$24.68	$1.23
Total			$18.47

Table 3: Slide Hammer Costs

Lever	Unit	Unit Cost	Cost of Use
1/2" Steel Rod	6 ft	$13.89	$2.32
Open-Eye Routing Eyebolt	10 pack	$8.65	$1.73
Coupling Nut Grade 5 Steel	1	$0.28	$0.28
Buna-N O-Rings	1 package	$2.86	~$0.46
1" PVC	5 ft	$5.27	$2.11
Total			$6.89

Table 4: Lever Costs

AguaClara plant. There may be specific cases or plants in which a catwalk may be helpful, however this would require a large flow rate plant with numerous large sedimentation bays. The size of a plant that would benefit from a catwalk would be far larger than the current largest plant in San Nicolas. If a sufficiently large plant were to be designed and built the use of catwalks should be investigated again for that specific plant.

4 Future Work

The wing-nut expansion plug should be implemented in an Aguaclara plant, and feedback from an operator should be gathered to determine if it would be a proper replacement for the PVC cap currently used. The operator should also report on the effectiveness of the lever or slide hammer, and whether they can be easily constructed in Honduras. The use of catwalks can be re-examined if a large plant is constructed with a significant number of sedimentation tanks.