Abstract. The Cambodian Children’s Fund has a ~200,000 US Gallon swimming pool requiring a treatment system. To treat the water, the pool will be modified to 145,000 US Gallons and use a 5 Hp centrifugal pump to provide an 8 hour turnover rate. Diatomaceous Earth (DE) cartridge filter combined with an automated chemical treatment system will provide clean, safe and low maintenance pool operation. Additionally, as the site does not have sufficient power for the treatment system, tracking solar panels will be installed to meet the demand. Each component of the design and construction costs are project at total cost of 115,000 USD.

1 Introduction

The Cambodian Children’s Fund (CCF) is a non profit organization that offers various services for under privileged Cambodian children, such as nutrition and housing, and medical treatment [1]. The CCF’s newest project is the Kids Camp, located in a rural setting outside the city of Phnom Penh [2] where they have recently built a swimming pool structure with the approximate capacity of 200,000 US Gallons. Before safe use of the pool can begin, a comprehensive water treatment system is required.

The designed water treatment system must be compatible with the current structure. In addition to the site specific limitations, the design must safely treat the water, for a maximum load of 50 people, in accordance with the standards of Australia [3] since the climates are comparable.

The proposed treatment system has been synthesized based on a feasibility analysis of the design components. The criteria deemed most applicable for the CCF are as follows. To compensate for the assumption that the current personnel of the Kids camp are not qualified pool operators, user-friendly treatment options were selected. To minimize capital and long term costs, the use of sustainable resources and local materials were maximized. It should also be noted that there is no source of power at the site, to meet this demand, solar technology will be utilized.

2 Conceptual Design

Figure 1 depicts the three vital aspects of a pool’s treatment system; circulation, filtration and disinfection.

Each component of the design will be described in the order as the water flows through the system. Pumps move water through the treatment system as well as circulating the stagnant water within the pool. Filtration is accomplished in two stages. Initial filtration is required to prevent large objects such as debris from entering the plumbing network. The secondary stage of filtration is provided by a cartridge Diatomaceous Earth (DE) filter which removes the remaining suspended-solids that pass through the initial filtration. The third stage of the treatment cycle is disinfection, using the industry standard: Sodium Hypochlorite (NaOCl). Finally, as the Kids Camp is without a dependable electric power grid, an independent power source has been considered using solar energy.

3 Design Synthesis and Analysis

3.1 Consideration for Existing Pool

A number of modifications were required to meet the design constraints without jeopardizing the integrity of the pool. It became apparent that installing a plumbing network would be difficult as extensive alterations would be required. Additionally, the current pool shape consists of sloped walls from the floor to the pool deck. This shape creating a large volume of water to treat, without adding capacity, as swimmers would theoretically be in contact with the sides. Perimeter sub-walls were designed to meet the previous limitations.
By constructing a vertical sub-wall around the perimeter of the pool, see Figure 2, the volume of water was reduced to 145,000 US Gallons. Lowering the treatment systems requirements. It also provided a cavity to run the previously non-existent plumbing network in and it could be utilized to incorporate a ballast for the water displaced by the swimmers, Figure 3. For 50 swimmers usually 3 to 5 cubic meters are displaced.

![Fig. 3. Perimeter Modification.](image)

3.2 Pump and Filter Selection

Guidance on filter selection was provided by a University of Guelph, Certified Aquatic Technician [4]. It was found that large pools often use a DE filter system because of the efficient backwashing, the low pressure-head losses, and they require minimal maintenance. For the CCF pool, four Pentair quad-DE cartridge filters running in parallel were chosen to minimize the pressure head losses incurred by using a single filter. The pressure head losses across the filter were calculated to be 5.8 feet per filter, this head loss was needed for the pump selection.

The modified Bernoulli equation formulated by White [5], was used to calculate total hydraulic head losses in the system. As the losses across the filter were known, the remaining calculations necessary for the pump selection include: elevation head losses, minor losses, friction losses, and velocity flow losses. The minor and frictional losses were calculated using the respective published values from White [5] to size the pump. Pump head losses for the treatment system were found to be 33 ft in total with a system flow rate of 300 gpm. The Pentair EQ-Series 500, 5 HP pump was selected because of the high efficiency rate seen in the pump curve and it is, National Sanitary Foundation (NSF), certified.

3.3 Treatment Selection

The choice to use NaOCl as a chemical disinfectant presents the following questions. How much is required? or more specifically, what is a safe concentration of NaOCl? and how quickly will it decay? Australian health department states that a minimum concentration of 1 part per million of free chlorine is required [3]. Determining a chlorine decay rate from literature was not possible as most literature was focused on residual levels in drinking water rather than swimming pools. Local experts were able to provide an approximate mass of NaOCl required for a given volume of water during a Canadian summer for 2 day 'shock and decay' treatment style [3]. To calibrate equivalent amount of NaOCl for Cambodian conditions, such as higher temperatures and more intense Ultra-Violet light A mass balance was used to determine the consumption of NaOCl in the pool NaOCl. The results of the analysis state 2.0 kg is required for the CCF pool every 2 days. Utilizing a more efficient, automated chlorinator, the amount of NaOCl decreases by 10 percent 1.8 kg over 2 days.

3.4 Power Supply

The need for solar power stems from the ‘unstable power grid’ at the CCF site. The necessary supply of the solar power system is based on the draw of the electrical components of the water treatment system refer to Figure 1. The demand was calculated to be 38.5 kWh, assuming the treatment system operates for 16 hours and has 8 hours of downtime. The required system demand needs 4 Lorentz Etatrak 1500 tracking solar panels, an inverter/charger, and 6 batteries.

4 Conclusion/Recommendations

Some major limitations in designing this project was the limited amount of local resources, thus, criteria could be further optimized with more detailed knowledge of local resources. For a pool of this magnitude, using solar power is not recommended because the majority of the design costs are from having enough battery storage to treat the pool.

References