

Structural Design of AguaClara Plants

June 12, 2011

Abstract

The AguaClara team at Cornell has focused on the unit process and hydraulic design of municipal drinking water treatment plants and has left the structural design to the Honduran engineers who are also responsible for site surveys and construction supervision. There are three opportunities for structural design work and research at Cornell. Although the structural design based on locally manufactured brick, re-bar, mortar and poured concrete columns is a common construction technique in Honduras, there may be opportunities to further optimize this construction technique and there may be alternate construction techniques that would be more cost effective. As a first step it would be beneficial to evaluate the current construction techniques using modern tools of structural analysis. The second opportunity is to begin to automate the structural design. The third opportunity for research would be to develop a set of material strength tests that could be used at AguaClara construction sites for quality control.

Students 1

Skills Structural engineering

1 Structural Analysis of AguaClara Plants

AguaClara plants use a poured concrete slab and stacks of bricks (see Figure1) with both horizontal and vertical re-bar for reinforcement. The relatively shallow tanks are approximately 1.6 m to 2 m deep and thus the hydrostatic forces are relatively small. This has made it possible to construct walls that are only 15 cm thick when finished.

The structural analysis of AguaClara plants should begin with an overview of structural analysis methods that could be applied to these tank walls. The methods should include both approximate analytical approaches and more sophisticated analytical methods that facilitate analysis of the entire structure. After the available tools are identified the structural design should be evaluated using one or more approaches. The failure modes need to be characterized with special attention to the need of the tanks to be waterproof and thus to have minimal cracking. After the structural design is evaluated, opportunities for



Figure 1: Poured slab reinforced foundation and bricks with both horizontal and vertical re-bar at the Agalteca water treatment plant.

improving the current design can be explored. For example, could the addition of a steel mesh on the outside of the brick that would be embedded in the plaster improve the strength of the walls? Could the amount of re-bar used in the walls be safely reduced?

There is some indication that reinforced masonry unit walls are sufficiently complex that they are beyond the computational scope of commercial structural design software. This assessment needs to be corroborated and if it is the case, then a strategy for design needs to be developed.

Another strategy would be to propose a different construction technique.

2 Automate Structural Design

A key innovation of the Cornell AguaClara team is the online AguaClara design tool that creates the unit process and hydraulic design for AguaClara facilities. The same scalable design approach could be used for the structural design as well. It is not yet clear if it is appropriate for the Cornell AguaClara team to design the structure. We will need to carefully address issues of liability if we provide structural design guidance. It should be possible to have the structural design reviewed by professional engineers prior to inclusion in the design tool to ensure that the structural designs are robust. The rationale for adding structural design to the online design tool is that it will further reduce implementation costs.

The structural design will need to be varied based on the availability of materials. This added complexity needs to be carefully assessed to create a design methodology that can scale globally.

3 Site Evaluation of Material Properties

The use of locally available materials often means that the strength of the materials is unknown or poorly characterized. This leads to uncertainty in the structural design and a need to include large factors of safety in the design. It would be very useful to develop test methods that could be implemented at the construction site to evaluate the strength of the material as well as to maintain quality control of construction. The test methods could be evaluated relative to laboratory test methods used in the Bovay test facility at Cornell.