Water Tower Frame Design Using Locally-Sourced Wood in Rural Ecuadorian Villages

Summary Paper

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1 TARGET AUDIENCE

Individuals or non-governmental organizations (NGOs) designing rural water systems, Engineering students formulating a humanitarian engineering design project, Engineers designing with poorly characterized materials in an austere, constrained environment.

2 BACKGROUND

Rural water supply projects often require the construction of a village water tower. As part of the process of helping villages construct their own water systems, the non-governmental organization (NGO) Reach Beyond asks community members to gather local wood for tower construction. However, without detailed knowledge of the mechanical properties of the local wood, ensuring safety requires the tower to be significantly over-designed.

3 PURPOSE

This paper details the water-flow, material, and structural analyses performed on an existing water tower design and shows how the material burden can be reduced, ultimately providing a lighter, easier to build tower. The paper outlines a process that can be helpful in other similar rural development projects.

4 METHOD

Three separate analyses were used to address the engineering of the water tower with local lumber. First, a water flow analysis based on internal pipe flow produced reasonable tower heights given typical community geography and size. Second, a material analysis involved obtaining wood samples from Ecuador and conducting experimental tests to determine the material strength properties. A structural analysis, performed both analytically and numerically, calculated the stresses in the members due to the loading and compared them to the material strength properties obtained earlier.

5 RESULTS

Given typical Ecuadorian village geography and size, a tower that elevated water 7 m above the ground is deemed to allow adequate flow for most communities. Required tower height is more sensitive to village size than the water flow distance. The Ecuadorian wood is a hardwood, and relative to other North American hardwoods, is very dense, hard, strong, but not quite as stiff. Analysis by the United States Department of Agriculture (USDA) Forest Products Laboratory was inconclusive, but suggested that the wood was in the *Buchenavia* or *Terminalia* genus, although mechanical properties could not be matched against known published wood data. Results of 3D frame numerical analysis confirmed the structure was overdesigned and suggests a 15 cm x 15 cm main beam cross section is still more than adequate for stability while enabling enormous time and energy savings for communities in harvesting the required lumber.

6 IMPLICATIONS FOR TARGET AUDIENCES

Organizations working with similar water projects can utilize the results of this study as a comparison, or guide, in confirming the specifics of their project. More generally, the process followed herein could potentially be used as a model for managing the engineering uncertainties of rural development projects.