Post Disaster-Relief Developmental Community Model

Multidisciplinary Capstone with the Department of Defense

Systems Eng., Civil Eng., Mechanical Eng., Electrical Eng., and Eng. Management

H2H Development Blog

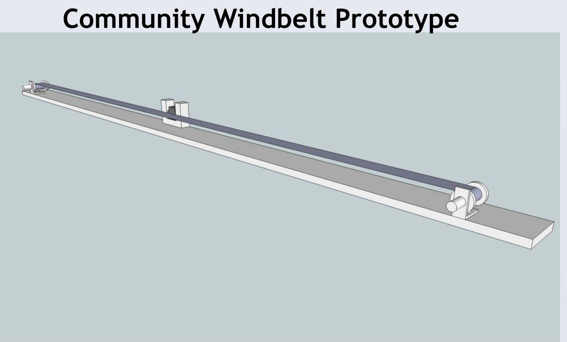
ABSTRACT

In disaster stricken areas, there is an abundance of immediate disaster relief in the form of tent camps and drop in relief packages. There exists a need for post disaster-relief development focusing on reconstructing the infrastructure for a better future. This presentation addresses this need in the earthquake stricken country of Haiti and showcases the system design for a sustainable post disaster-relief solution and framework for a community building process replicable in any disaster zone around the world. The systems approach allows the design to mold to the end users' needs while applying an engineering solution to each of the four problem areas: shelter, water, waste, power. The end product of this system design is a community of six homes constructed by the 6 families who are to occupy the homes that provides 878 square feet living space per family, 15 gallons of potable water per person, and enough electricity to light the houses and the streets. The required materials to build an entire community are to be shipped to the disaster zone in one shipping container. The design emphasizes the integration of humans in the system allowing victims in a disaster zone to redevelop their homes and their lives.

POWER SUBSYSTEM

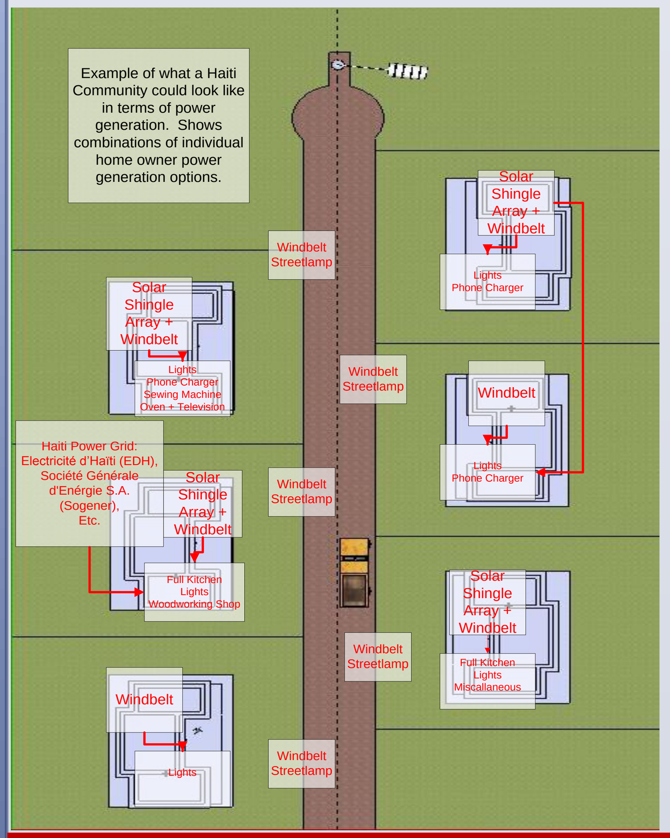
The power system revolves around renewable energy options without the need for large amounts of infrastructure. Windbelts are cheap and efficient energy generators based on flutter oscillation. They are able to operate in wind speeds as low as 2 m/s and are able to generate up to 1 kWh of energy per month. Each home will be equipped with three Windbelts to power LED light bulbs for both indoor and outdoor lighting. In addition to Windbelts, each home will be able to add a solar shingle array to their roof. These install exactly like normal shingles, but are photovoltaic solar cells, and most importantly will be able to preserve the aesthetic appeal of Haitian homes. Array sizes can be anywhere from 5 to 65 square meters, able to generate 1.89 to 24.57 kWh a day. The smaller size arrays will be able to power some extra lighting as well as cell phone chargers, with largest size array offering a full kitchen. The most important thing about these options is that they are based on the individual homeowner's desires, based on their unique power needs and financial capabilities.

Community Windbelt Prototype

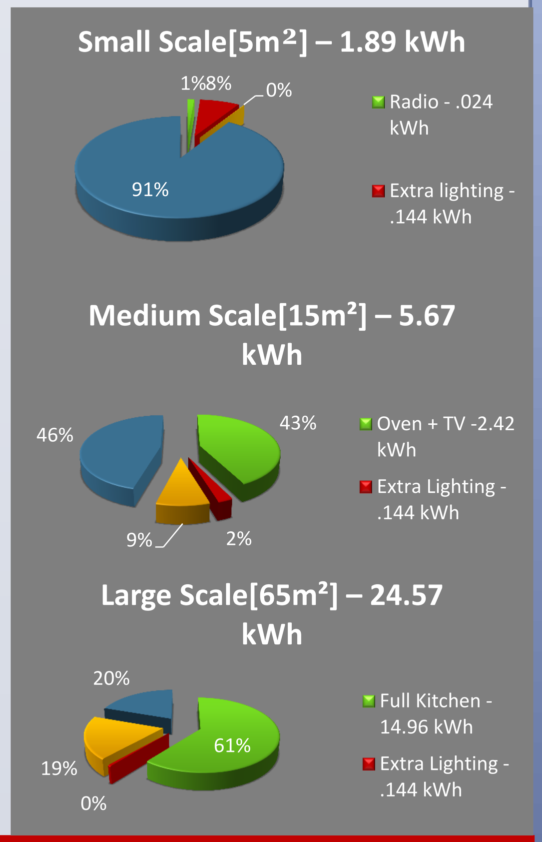


DOW Solar Shingles

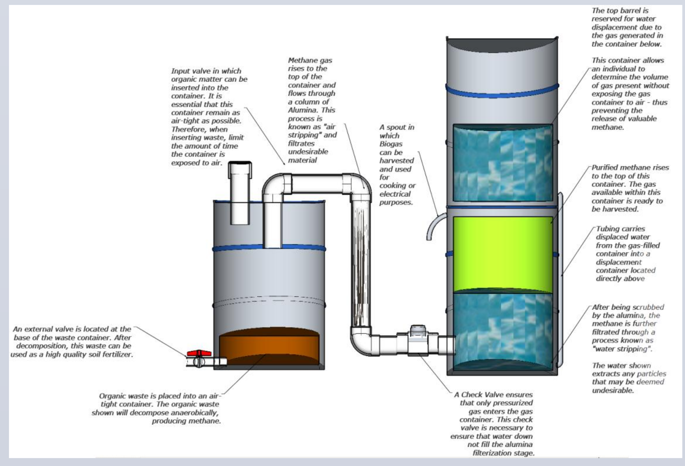
Community Power System Integration Example



Solar Shingle Array Options

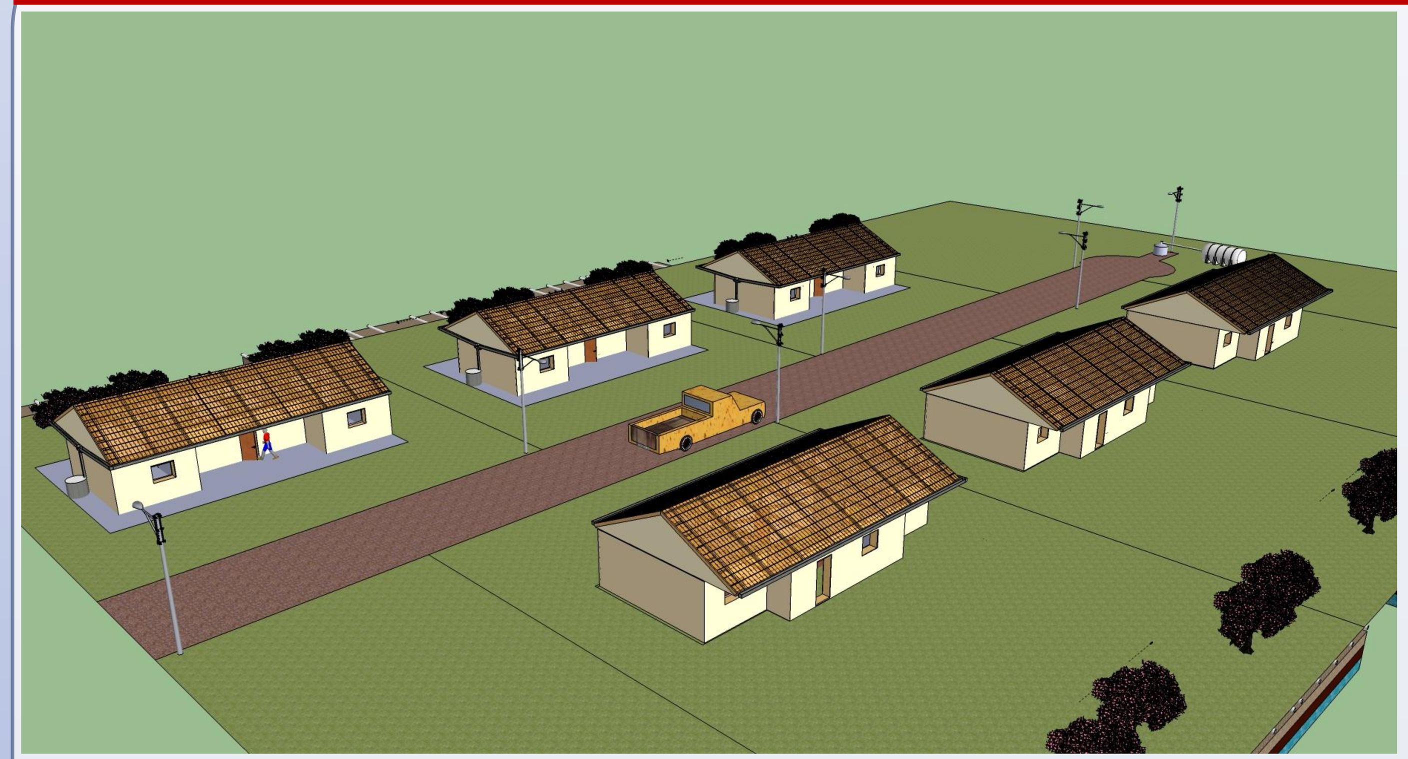


WASTE SUBSYSTEM



Human waste is one of the largest contaminants of water in Haiti. A biogas generation system is a closed process that uses anaerobic digestion of organic waste to produce methane gas. The methane gas produced by the waste of one family is enough fuel to cook for one day. A byproduct of the Biogas Generation is a the decomposed waste that can be used as a fertilizer. This solution contributes to decontaminating water sources, provides fuel, encourages farming, and can help regenerate Haiti's forests.

COMMUNITY DESIGN AND INTEGRATION

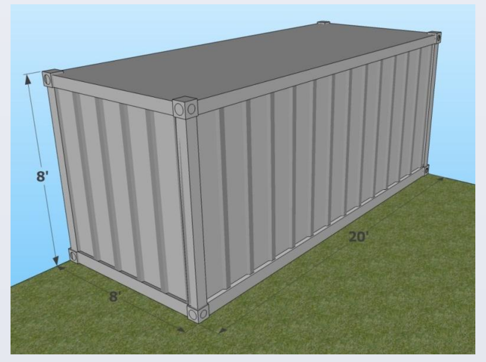


Problem Solving Methodology

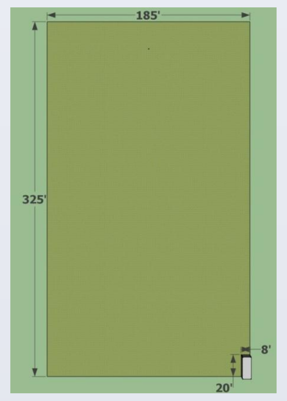
The majority of disaster relief funds go towards immediate relief such as tent camps, with some funds moving toward transitional housing 2 years after the disaster. Many of the transitional homes are abandoned because of lack of security and quality of life. Thus, there exists a need for a low cost developmental solution that builds trust in neighbors and provides a quality of life that benefits the future of the country.

For Post Disaster-Relief Development to be successful, it is essential that a community of individuals is established. By involving the members of the community in the building process, relationships are fostered and overall morale increases. Change does not come from external aid alone, the victims of a disaster must be part of the solution.

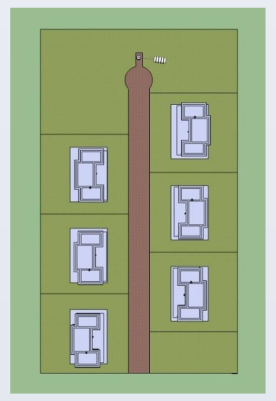
The system design creates a sense of interdependency; each person in the community is committed to help with its construction. Furthermore, community productivity is increased as each house will be developed iteratively, each stage in the houses' building process cascading one after another, similar to the Assembly Line.



All materials and tools for a Community fit in a Standard 8'x20' Shipping Container



The Shipping Container supplies a land 375 times larger

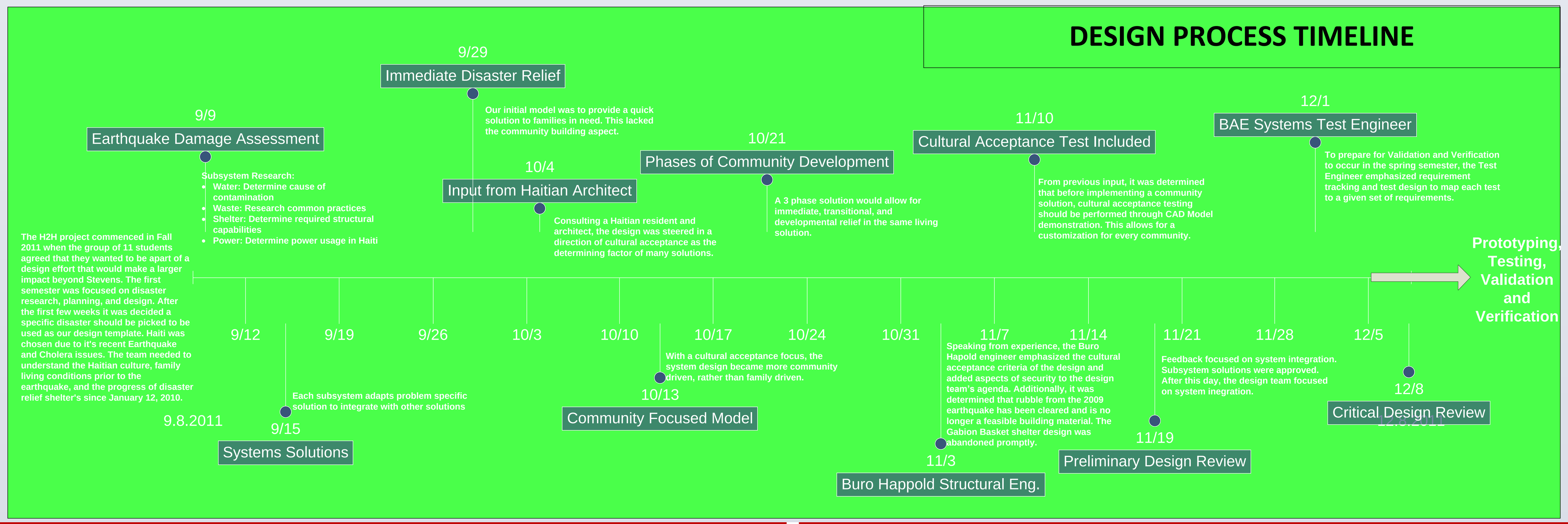


And this land will become a Community of six homes to 36 Haitian people

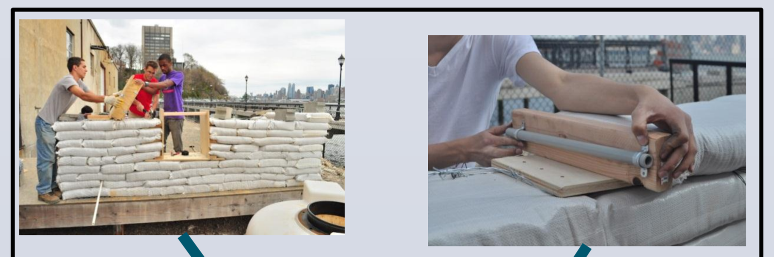
1 Container Contains

- Instruction Manual
- All lumber needed in the system
- All materials for Earthbag structure
- Biosand Filter Mold
- Rain Collection System
- Windbelts and Street Lamps
- Required Tools

DESIGN PROCESS TIMELINE

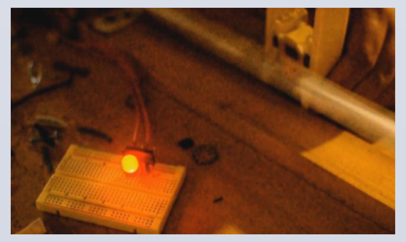


VALIDATION



Example Page of Instruction Manual

Construction Process Documentation



Windbelt Concept Validation

Biosand Filtration working Model

LOGISTICS

Picking a Site → Finding Families → Cultural Acceptance Testing —Rejected→ Customize Design

Accepted

Color Key: Engineering Team; Project Manager and Local Labor; Inhabitants

Phase I: Preparation — 10 Days

	Full time Shift 1	Full time Shift 2
Raking	4	4
Foundations	3	3
Plumbing Assist	2	2

Phase II: Construction — 105 Days

	Shift 1	Shift 2
Walls	5	5
Prefab (roof, gutter)		3
Biosand Filter	2	
Shallow Well	3	
Structural	Contractor	
Electric	Contractor	

Phase III: System Integration — 14 Days

	Shift 1	Shift 2
Roof installation		6
Stucco/Paint	6	
Flooring	4	
Windbelt & Lights		2

Operation and Maintenance

Street Light Maintenance	1 person as needed
Windbelt Maintenance	1 person as needed
Shallow Well Cleaning	2 people, Once per year
Stucco Repair	1-2 people as needed (about Once every 2-3 years)
Filter Cleaning	1 Person per household, monthly

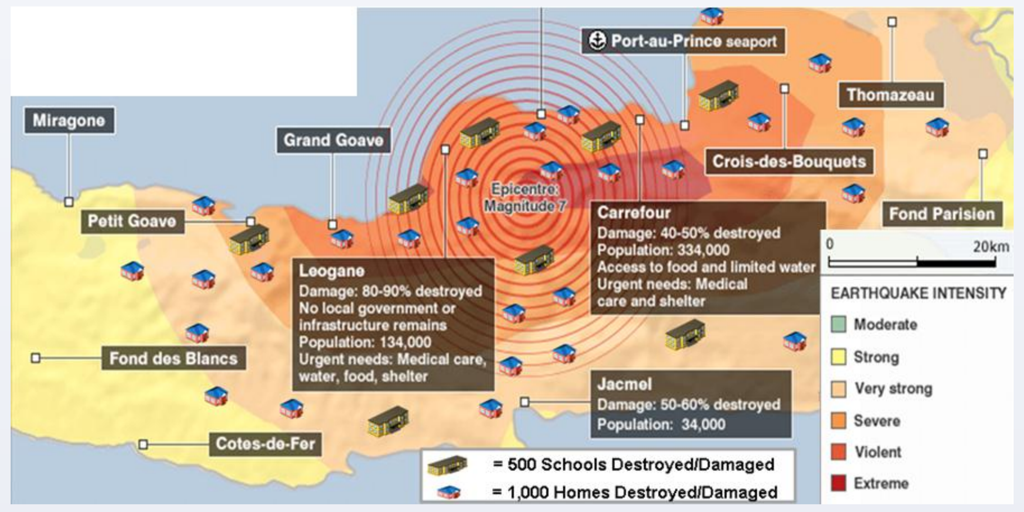
Material Cost $ 22,500

Tooling Cost $1,000

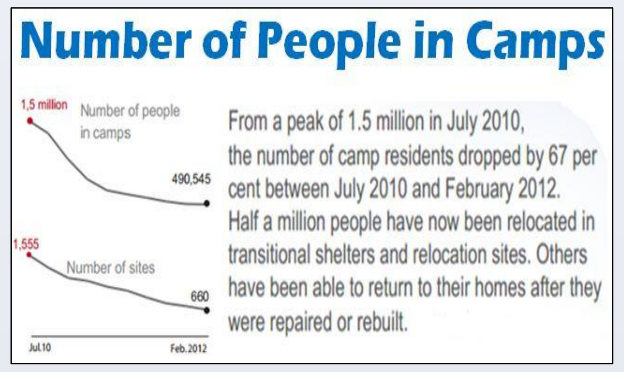
Contracting Cost $600

Total Community Cost $24,100

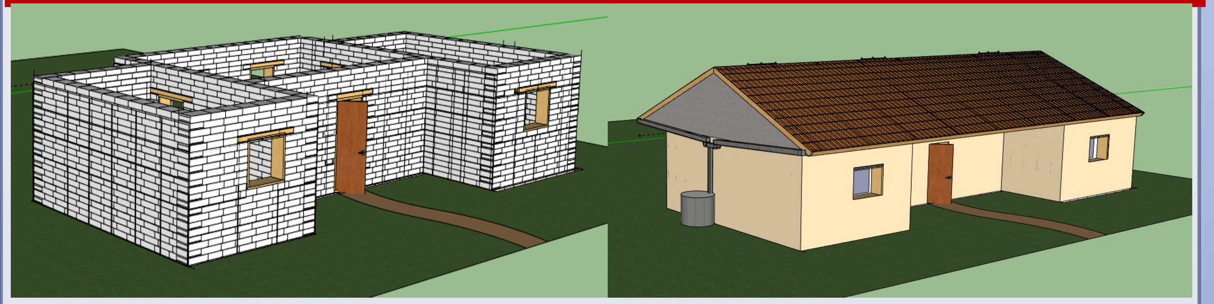
BACKGROUND



- 86% of Port-au-Prince lived in Slums Prior to Earthquake
- 67% of Port-au-Prince residents don't have access to Tap water
- Only half of the people in Port-au-Prince have access to Latrines

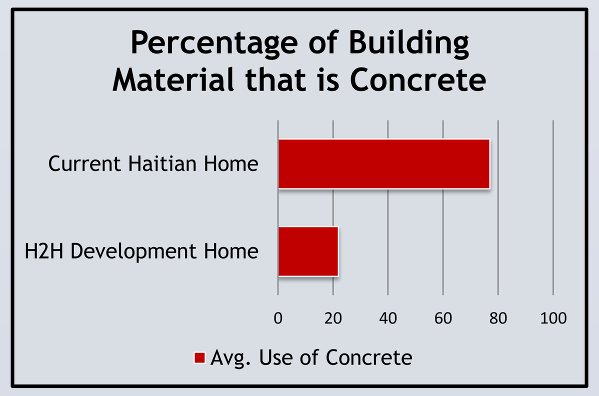


SHELTER SUBSYSTEM

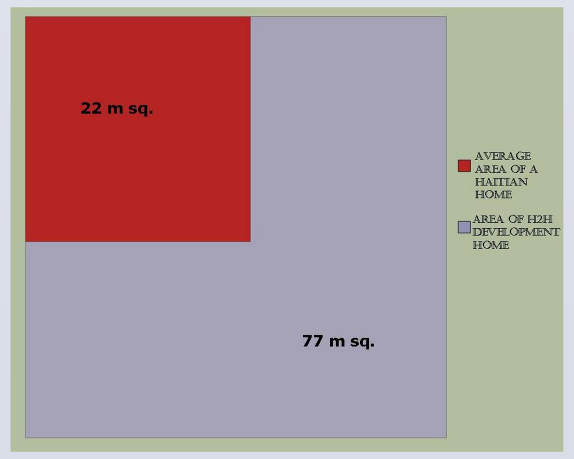


- Shelter System was developed after analyzing the environment in Haiti
- Low cost solution that incorporates local resources
- Earthbag homes use soil as a substitute to concrete
- Can be built with 85% unskilled labor

- Earthbag system allows for end-users to build unique housing structures
- Offer superior protection in high-winds and seismic activity
- Due to thermal properties of soil, Earthbag dwellings are extremely efficient with regards to heating and cooling



Comparison of Overall Area of Homes



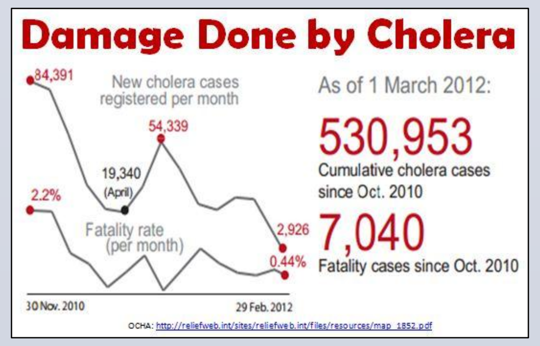
The graphs displayed above illustrate the effectiveness of an Earthbag house. With reference to the Economic Model, one can see that its possible to have a larger house, for less cost, while simultaneously reducing the house's environmental footprint.

WATER SUBSYSTEM

Water Subsystem design incorporates 3 off-grid water solutions:

- **Rain Water Collection:** 25% of water can be collected given area of roof in design
- **Shallow Well:** provides up to 40% of the community's water need
- **Biosand Filtration:** capable of removing E.Coli and Cholera from contaminated water
- **Gray water recycling system:** closed system for non-consumption water

Combining water collected through the subsystem leads to a reduction of dependency on water trucks by 65%



Percentage of a Family's Water Needs Collected by Rain Water Collection