A Minimalistic Approach to Adaptive, Emergency Relief Structures Embodied by Promoting a Downsized Way of Life

by

Joseph Darnell Brown

A Thesis submitted to the Graduate Faculty of
Auburn University
in partial fulfillment of the
requirements for the Degree of
Master of Industrial Design

Auburn, Alabama
August 3, 2013

Keywords: Minimalism, Adaptive, Emergency Relief Shelter, Downsized

Copyright 2013 by Joseph Darnell Brown

Approved by

Christopher Arnold, Chair, Associate Professor
Clark Lundell, Professor and Head
Jerrod Windham, Associate Professor
Carl A. Exford, President, Exford Architects, Birmingham, Alabama

Abstract

The aftermath of a natural disaster can be devastating. Thus, we all must become aware of the importance of having a plan before and after their occurrence. The tornado that swept through Birmingham, Alabama, and Hurricane Katrina that devastated the Gulf Coast are examples of natural disasters that took the lives of and left people homeless. Often times after a natural disaster, people are dismantled psychologically, food is scarce, and homes are destroyed. Therefore, the development of a modular system, from a single building unit, will be beneficial. In the time of crisis, the last thing on a family's mind should be the concern of being homeless.

Given the recent natural disasters and a busy summer storm season expected in 2013, what a better time for us as a nation to reexamine the way we live and allocate resources for those in need. Amid a rapidly growing population and infrastructures the world's exposure to natural hazards is inevitably increasing; therefore, we cannot afford to continue allowing our appetites, dwellings, expenses and livelihoods to grow. With the economy in an upswing from 2009's fall, new, energy conscious innovations should be leading the surge into the future of emergency relief and community development. This approach first addresses the need for a plan to house individuals after being displaced due to natural disasters. Furthermore, this approach draws attention to the need for the United States to become more cognizant of the built environment and the manner in which we consume natural resources. Lastly, this approach introduces solutions for addressing a longer term, smaller community development which will utilize and transform emergency relief structures into permanent dwellings.

Acknowledgments

"God grant me the Serenity to accept the things I cannot change; courage to change the things I can; and wisdom to know the difference."

- Reinhold Niebuhr

The author would like to thank Carl A. Exford, President of Exford Architects, for his thoughts on the built environment, and for his unyielding devotion from inception to completion of this milestone. Furthermore, thanks are due to Department Head, Clark Lundell, Professor, Jerrod Windham, and Professor, Christopher Arnold for their support and deliberation that complimented and promoted achievement of this Masters of Industrial Design trek.

It is with adoration and earnest thanksgiving that I salute my mom, Mrs. Darlene H. Brown, for her words of encouragement and dedication throughout this long and tedious, yet rewarding and grateful expedition. Appreciation and love is extended to: Jennifer Brown, Clarissa Brown, Barbara Harris, LaShauntá Matthews and the Matthews Family, Donald Pugh, Halston Sleets, Matthew Harris, Wesley Davis, Cornelius Woods, Sean Kennedy, Exford LLC., and all others that kept me motivated along this journey. To anyone that I failed to mention, thanks, and may God continue to bless each of us is my prayer.

Style Used: APA

Software Used: Microsoft Word, Autodesk Revit Architecture, Adobe Photoshop, Rhinoceros, Adobe Acrobat, Autodesk AutoCAD

Table of Contents

List of Figures and Tables

List of Abbreviations

CIA	Central Intelligence Agency
EOP	Emergency Operations Plan
FEMA	Federal Emergency Management Agency
FRP	Fiber-reinforced Polymer
HDPE	High Density Polyethylene
SIP	Structural Insulated Panel

Introduction

A. Proposal and Literature Review

Problem Statement

Most do not become concerned with natural disasters until they or their family members are affected. Nevertheless, what if there were measures taken before hand that aided in a quick, less worrisome recovery for those following the aftermath of a natural disaster? Many lives could be spared from psychological and devastating hardships. According to reality statistics, about 40 million people move annually in the US. Nearly three-fourths of the United States population moves an average of once every five years. As a result of this constant relocation the cycle of embodied energy production continues. The single most important factor in reducing the impact of embodied energy is to design long life, durable and adaptable buildings. According to Kueber's (2008) article on embodied energy, "The greenest building is one that's already built."

As a culture, we should challenge ourselves to question how natural resources are used. One solution to address the overuse of resources and to relocation tendencies would be to create a portable, modular residence that could be added on to and even downsized to accommodate changes in a homeowner's needs. These are serious matters that we must prepare for. The development of a modular, emergency relief shelter is a useful solution to most, if not all of the above mentioned concerns.

Need for Study

Current emergency relief housing solutions have not adequately prepared us for the devastating aftermath of a natural disaster. Typically after a natural disaster, people are dismantled psychologically, food is scarce, and homes are destroyed. In the time of crisis, the last thing on a family's mind should be the concern of being homeless. Natural disasters are inevitable, thus, it is imperative that we look for a solution that addresses the concern of housing displaced individuals after their occurrence. The development of a modular emergency relief system will be beneficial, introducing a new approach to multi-faceted, modular, and sustainable design.

Literature Review

When analyzing the current lifestyle of the American culture, the concern to address the way we build and live, smaller rather than larger, is revealed. Furthermore, attention should be given to reduction that focuses on living with the necessities only needed to sustain life; this is the reality of what people are faced with after they have their homes destroyed by natural disasters. We should become aware of the importance of having a plan after any natural devastation. This research should stimulate one to think about the things we can do without and still sustain life. With this in mind, this review and ultimately this thesis will address the need for the following: creating an easily adaptable, modular system that provides emergency housing for the homeless after a natural disaster; creation of such a system that questions the cultural norms associated with buildings and incorporates only the minimums needed to sustain life. Emphasis will also be placed on the reduction of embodied energy to reduce waste and to increase effectiveness at a small scale. In addition, an analysis of the flaws of current solutions for emergency relief systems, such as the FEMA trailer, will be discussed.

Just as Henry Ford's assembly line, modular construction dates back over a hundred years. The idea of modular housing in the United States became prominent after World War II when returning troops were in need of small, economical housing. As a result of housing shortages, time did not permit traditional construction, thus modular construction was looked to more for rapid production. Hutchings (1996) writes, "modular construction is not only faster and more efficient, it also produces a better quality product than stick-built construction" (p. 4). When man invented machine, many of the flaws, dissimilarities, and inefficiencies of hand built homes were eliminated. Assembly line produced, factory built homes increase consistency and decreases error because of machine-based repetition. According to Hutchings (1996), “modular construction eliminates the need of doing a major portion of the construction work in the rain, wind, snow, or unbearable temperatures, which affects how construction workers perform” (p. 4). Often times, schedules are delayed due to incontrollable weather patterns. In some cases, to prevent damaging interior parts, the building has to be covered, which would be eliminated in prefabricated construction which is done completely within a factory. As technology and machinery begin to take new heights, construction methods evolved, offering several benefits to producers, clients, and the environment.

In design, the ideas of modularity and sustainability are not new concepts. As designers, it is the way we explore these terms that sparks innovation. One eventual benefit of modular homes is sustainability. The term sustainable encompasses a range of ideas from materials and technologies to efficiency and cost. History shows that Sustainability was even evident in Agrarian communities which heavily relied on the environment. The Industrial Revolution began to explore the energy of fossil fuels. As human begins to splurge and sustainable practices were overtaken by the need for time and productivity, the twentieth century began to expose problems of the exploitation of fossil fuel resources; utilization of non-renewable resources had become a way of life. Presently, because of the extensive use of nonrenewable resources, the twenty-first century is experiencing the threat of greenhouse emissions and impacts on the ozone layer; a topic which will be discussed later in this paper relative to the perspective of global warming.

The proliferation of mass-production generated by the Industrial Revolution made life much more convenient, but since its inception, the Earth’s natural resources have been exhausted at more rapid rates. The advent of complex machinery marked an unhealthy human to environment relationship, thus producing the world as we know it today.

According to McLamb (2008):

> As the Industrial Revolution dramatically changed every aspect of human life and lifestyles … from human development, health and life longevity, to social improvements … its human impact on natural resources, public health, energy usage and sanitation would not begin to register in the world's psyche until the early 1960s, some 200 years after its beginnings. (p.1)

Over the years, more efforts have been directed toward measuring and reducing the amount of embodied energy, or energy used to generate and occupy buildings. One way to address embodied energy is to design for modularity and portability. Staib (2008) writes:

> In America in the last quarter of the 19^{th} century the steel frames of the "Chicago School" represented the start of a long process of development that continued up until the creation of the post-war skyscrapers in New York and Chicago. On the other hand, there was also a booming industry of individually built, single family homes which, both as fixed and mobile homes, could be self-built by the residents thereby realizing countless variations of the American dream of building one's own home. (p.26)

Typical building construction should be reexamined. According to Staib (2008), "in principle, every building is a composition of walls, floors, and roof. Independent systems have been developed for each and every discrete section of a building over the years." (p. 9). Furthermore, smaller scale buildings will have to encompass several different systems within a defined space. Thus, individualized, sectioned spaces will not be feasible. Incorporating several functions within one space produces more sustainable, more easily adapatable, free flowing spaces. A prefabricated, modular sytem lends itself to this simplification while preserving adapatability. One of the most challenging aspects of developing a small living space is designing for one's personal belongings and incorporation of products essential for life. For example, Japanese architect Kazuya Morita's 557-square-foot "shelf pod" is a home that effectively takes advantage of wall space. The concept behind this design is an effective precedent study but should be altered to a maximum 200 square feet footprint and should be portable. Nevertheless, Morita's study, along with many others, are useful starting points for designing prefab, modular structures. One reason why smaller homes are more sustainable than larger homes is because fewer building materials and servicing. In addition, the larger a home is, the larger the HVAC and electrical systems have to be to comfortably service the home.

One way to approach reducing the impact of embodied energy is to design long life, durable and adaptable buildings. According to Kueber's (2008) article on embodied energy, "The greenest building is one that's already built."

Portable architecture has its place in a crowded city, especially in the event that a slot of land is not readily available to accommodate a new structure. Fairs writes (2009), "with urban centers increasingly running out of development space,… many architects are looking for new ways to slot small green buildings into the city without requiring additional infrastructure" (p. 248). With the ideas of portability, modularity, and sustainability, amalgamate, the fields of Industrial Design and Architecture work together.

This study will expound on the advantages of living in a portable, modular home. Modular homes that lend themselves to portability could be dismantled and moved to another location. This is yet another driving mechanism of this thesis, which promotes the idea of a portable home or RV. This will give homeowners the freedom to move their homes and relocate with ease, an important cultural aspect of the United States. According to Brenoff of AOL Real Estate (2011):

> Housing experts predict that demand for compact homes in the U.S. will increase in the coming decades. There is a fast-growing population who need less-expensive first-home options: single women, baby boomers who want to downsize, and recently graduated students. The idea also resonates with seniors who would like to age in place; by constructing one of these small homes in the backyard, they are able to live near an adult child and still maintain privacy and independence. (p.2)

Staib (2008) draws an analysis of prehistoric times with the quote, “To avoid having to search for the required building materials after each and every change of location, the nomads collected materials which could be quickly and easily assembled, after a time dismantled and simply taken with them” (p. 14). This goes to show us that the idea of portable housing can be traced back as far back as the existence of the nomads. It would be ideal to be able to move a house into any desired location. Most people do not remain at the same residence their entire lives; thus, portable housing would be very beneficial to them. In addition, portability could allow better matching of people to jobs who are currently unable to move to a better job becase they cannot sell their homes. Single-family houses are great for modular construction because they are built using a smaller footprint. As people graduate from college, they will soon be looking for smaller, economical dwellings to reside in. Staib writes (2008), “alongside mass housing construction in housing estates, there was great demand for single-family houses” (p. 25).

About 40 million people move annually in the United States and nearly one out of every five Americans move in an average year (Jasper, 2000). In the event of a natural disaster, those affected do not always have the option to move. Whether leaving a residence at one's will or because of distraught circumstances people could be benefit from a portable, prefabricated, modular residence that can be added on to or downsized to accommodate needs.

In addition to the growing need for smaller, more portable dwellings for economic reasons, it is important that designers address the concerns of emergency shelters. Sandoval (2010) writes, “The Unidad Dionisio team is developing a strategy to provide affordable, and self-sustaining shelters that evacuees can quickly construct with little actual training”. It is apparent that individuals are seeking to tackle this problem, but a solution to this problem still waits to be resolved. Sandoval (2010) goes further to state that:

> The basic shelter can accommodate two families during crisis times. It can then be adapted and fully outfitted for a single family home once the crisis has passed. Part of the urban planning phase of this project will involve developing settlement patterns that can be de-intensified to accommodate municipal standard road widths, so that the remaining shelters form a “pre-developed” community. The modular units can be relocated, or added on to another shelter to increase the living space, thus accommodating a range of housing needs post-disaster.

Similar to the vision of such a system, Buckminster Fuller’s vision and development of his Dymaxion House received criticism for its inflexible design which completely disregarded local site and architectural idiom, and its use of energy-intensive materials.

The incorporation of “sustainable” materials and practices and modularity is sometimes argued against because its initial cost can be more for construction. According to Shedroff

(2009), “sustainable solutions don’t always cost more than unsustainable ones” (1997, p. xviii). Most modern technology costs more from the onset, but the savings over the lifespan of the product usually exceeds this initial cost. For instance, incorporating solar panels into a building might cost a lot upfront, but the return it gives in reducing electrical cost, overtime will meet and exceed this price.

Shedroff (2009) goes on further to indicate that “Our economic system rarely includes all of the social and environmental costs and impacts of products and services of the items we buy, the producers of sustainable solutions try to compensate for these cost. Doing this can cost more up-front, but often costs less over time since these solutions may prevent problems later” (p. xviii). As Shedroff illustrates, it is important to analyze social and environmental impacts of a design.

Being affected by a natural disaster can alter the way we think and the way we reside. At times, a natural disaster can destroy belongings and homes, leaving families to start over in an emergency relief structure. Putting things into perspective, during the current economical times of the United States, our culture should really be looking at means of reduction instead of only being forced to resort to it after a natural disaster. The prices of food, gas, and other commonalities have all increased, making it more apparent why the conservation of resources and downsizing is important.

One of the first steps to take should be to reexamine how we build and occupy dwellings. A minimalistic approach will strip down, eliminating waste, thus circumventing the economic and energy-related problems we are presently faced with. The ideas that drive Sandoval’s concept are very similar to the approach of the design of the emergency relief system derivative of this thesis. The results of this thesis should encompass the use of an inclusive design that includes solving how one packages, ships, sets-up, and dismantles such a structure. The design will propose a modular emergency relief system that can house 1 - 4 persons after a natural disaster.

Objectives of Study

- To develop a low-cost, modular system that can be used in a variety of conditions.
- To design a system that can be easily set-up and disassembled by those who will occupy it.
- To develop a low-cost, modular system that can be used as a long-term shelter for individuals displaced after natural disasters.
- To develop a low-cost, modular system that can house a small, two person family, as well as be flexible enough to increase in size, through replication of systems, to house a two-four person family.
- To explore sustainable building materials and practices that can be incorporated into this design.
- To research New Orleans and Birmingham because these areas all have suffered from natural disasters.
- To explore the above mentioned areas and the available resources in Alabama, in an effort to use native, plentiful building materials.
- To develop a product and explain how it is packaged, shipped, packaging, assembled, disassembled, and how it provides storage.
- To show the application of the design.
- To include rules of modularity in the proposed system.
- To research the living aftermaths of: the 2005 Hurricane Katrina that devastated New Orleans, the April 2011 Tornado outbreak of Alabama, and the 2012 Hurricane Sandy that struck Eastern United States.

- To form my design criteria from research of the aftermath of recent natural disasters of the world.
- To make each system adaptable for each household and site characteristics.

Definition of Terms

Embodied energy- is defined as the sum of energy inputs (fuels/power, materials, human resources etc) that was used in the work to make any product, from the point of extraction and refining materials, bringing it to market, and disposal / re-purposing of it. Embodied energy is an accounting methodology which aims to find the sum total of the energy necessary for an entire product lifecycle. This lifecycle includes raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition.

Holism- is the idea that all the properties of a given system (physical, biological, chemical, social, economic, mental, linguistic, etc.) cannot be determined or explained by its component parts alone. Instead, the system as a whole determines in an important way how the parts behave. The term holism was coined in 1926 by Jan Smuts.

Minimalism- describes movements in various forms of art and design, especially visual art and music, where the work is stripped down to its most fundamental features. As a specific movement in the arts it is identified with developments in post–World War II Western Art, most strongly with American visual arts in the late 1960s and early 1970s. It is rooted in the reductive aspects of Modernism, and is often interpreted as a reaction against Abstract expressionism and a bridge to Postmodern art practices.

Modularity- the degree to which a system's components may be separated and recombined.

Sustainability- the capacity to endure

Prefabricated homes- often referred to as prefab homes, are specialist dwelling types of prefabricated building, which are manufactured off-site in advance, usually in standard sections that can be easily shipped and assembled

Presumptions

- An emergency relief system will be beneficial for those affected by natural disasters.
- Natural disasters occur often in the United States.
- It is important to have a recovery plan prior to the occurrence of natural disasters.
- An approximation of the actual number of individuals displaced by natural disasters.
- The economy still has not fully recovered from its decline.
- Greenhouse gases and depletion of the ozone layer are problems.

Scope

- This study will develop a modular framing system that anticipates further development outside of the scope of this thesis project.
- This study will mostly address the concerns of native Alabama and native Louisiana residents who were affected by natural disasters from 2011 and 2005 respectively.
- This study will not develop, in its entirety, a mechanical, conditioning, electrical, or waste management system, but concepts for these systems will be addressed.
- This study will develop concepts for the interior layout and conceptualization of furniture which also can be further developed outside of the scope of this thesis project.

Limitations

- In developing a system for these states, heavy considerations will be placed on material usage and cost will be analyzed.

Procedures & Methods

A. Procedure:

- Analyze the way the American culture currently lives.

Method:

- Study the average size of families.
- Analyze the housing market to see how long people stay located at a particular residence.

B. Procedure:

- Include all areas of exploration in research so that this system can lend itself to be used after a natural disaster.

Method:

- Explore the environments and cultures of New Orleans, Louisiana; Birmingham, Alabama; Tuscaloosa, Alabama; and potentially, New Jersey, and New York because these areas all have suffered from natural disasters.
- Formulate a design that is based on the findings of this exploration.

C. Procedure:

- Identify New Orleans natives to ascertain their thoughts of the aftermath of the 2005 Hurricane Katrina.

Method:

- Conduct phone, email interviews with New Orleans natives.
- Analyze the survey to see their immediate needs, reoccurring responses etc.
- Draw conclusions from the survey.

D. Procedure:

- Develop a system that is modular.

Method:

- Research tradition building practices to derive a building unit.
- Model possible solutions.
- Analyze different ideations.
- Chose one design to develop.

E. Procedure:

- Incorporate sustainable practices.

Method:

- Research building materials in the United States.
- Develop a low-cost system which is able to be personalized for a particular culture and household size.

F. Procedure:

- How to educate occupants on how to use the system.

Method:

- Design the system so that occupants can easily assemble and disassemble it themselves.

Anticipated Outcomes

The deliverable of this project will be:

- A new approach to multi-faceted, modular, and sustainable design.
- Better preparation of housing the homeless after a natural disaster.
- The development of a low-cost, modular system, from a single building unit, that serves a dual purpose.
- A system that is portable, easily assembled, and disassembled by its consumer.
- A system that is adaptable and personalizable for each household and site.

This research project will:

- Address the need for emergency housing by implementing a measure that speeds up recovery after a natural disaster in a minimalistic, sustainable, and portable way.
- Take advantage of sustainable design.
- Optimize embodied energy by reducing the practice of wasting resources.
- Analyzing the current lifestyle of the American culture with concerns of addressing the way we build and live, and offering theory, energy statistics and data as to why downsized lifestyle should be promoted.

Long-range Consequences:

- Reduction of embodied energy that is associated with fabrication of new buildings.
- Stimulate one to consider the necessities of life and how one can sustain in a building that provides access to these necessities.
- Stimulation of the American culture to live in smaller, more sustainable dwellings.
- By adding more modules, this design will lend itself to become new, permanent construction.
- This system will present a solution that stimulates Americans to live as minimal as possible with the Necessities of Life.

1.0 Living Beyond Our Means

1.1. Sense of Scale

Why as a country must we do everything BIG? On several occasions, I have conversed with International Americans about the size of things in their native countries in comparison to those same things in the United States, and the information gained has been consistent across the board. Simply put, the underlying fact of the matter is that, Americans do things much bigger. Drawing analysis from Sarah Z. Wexler, writer at Allure Magazine, according to Megan Gibson of the U.S. Times Magazine, “from breast implants to megachurches to Hummers to McMansions, Americans supersize in many ways” (p. 1). In the year of 2009, the excess spending of Americans became apparent. Home foreclosures were at all time highs, the debt to savings ratio of Americans was as grim as it was since the Great Depression, sales from the Big Three automakers were dropping, the cost of living was higher, the unemployment rate soared, and the economy was flustered; America was on the brink of another recession. Wexler writes, “Americans had been guilty of living large - accumulating huge amounts of (it turns out apocryphal) wealth in the pursuit of supersizing our homes, cars, businesses, and food portions” (p. I).

Figure 1: Bruegger's, Inc., World's Largest Bagel Troy, New York, 2004
Photograph by Orlando Sentinel/Polaris

1.1.1. Energy Consumption

Larger objects, products, and food portions usually require the use of more energy. The United States possesses most of the resources to go big making it apparent that Americans are close to the top of most major resource consumption lists. Facts about the energy consumption of Americans make this argument quite relevant. The United States is the second largest energy consumer in the world. According to the Central Intelligence Agency (CIA) World Factbook, the United States is second to the European Union in external debt. Second to China, the United States consumes more resources than any other country.

One of the most apparent energy guzzlers of today is the American home. Wexler writes, “sizes of the average American home have increased 120% in the last 50 years. It's staggering. And in that time, the number of people who live in those homes has decreased” (p. 2). According to the United States Energy Information Administration, roughly 41% of total U.S. energy consumption in 2010 was used in buildings, or about 40 quadrillion Btu. With the economy still in the recovery process, the housing market beginning to reignite. Furthermore, the construction of inefficient buildings should be a thing of the past. We should be out with old and in with new approaches that foster a more energy conscious lifestyle. It is imperative that an approach towards a smaller, more energy conscious lifestyle is examined.

Figure 2: Biggest, Privately Owned Home in United States 90,000ft.[2]
Versailles House located in Windermere, Florida
Photograph by Orlando Sentinel/Polaris

1.2. Less is More: Mies van der Rohe

1.2.1 Modern Movement

The world renowned German-American architect, Ludwig Mies van der Rohe best states it in his noted aphorism, “Less is more”. Along with his other fellow pioneers of the Modern Movement of Architecture, Le Corbusier and Frank Lloyd Wright, Mies van der Rohe established a new architectural style that emphasized clarity and simplicity. Furthermore, this Modern Movement aimed to influence designers to create designs that were stringently derivative of their purpose. For instance, Mies van der Rohe’s Barcelona Pavilion is a Modernist example known for its simplistic form. To supplement this building, Mies van der Rohe also developed the Barcelona Chair. This can be deemed a cohesive design since both the building envelope and the furniture it comprises were both designed by the same architect. Features of these structures include the pavilion, an open floor plan and a roof supported by small plates which generated a floating roof appearance; the chair, which is heavily hand-crafted. With their simplistic, cohesive approaches, both the pavilion and the chair supplemented each other and are common in the field of architecture and industrial design.

Figure 3: Barcelona Pavilion

Further expounding upon Mies van der Rohe’s Barcelona Pavilion and Barcelona chair, this amalgamate presents a holistic approach to design. Holistic approaches seek to demonstrate the idea that a system in its entirety is greater than its individualized

Figure 4: Barcelona Chair

components. All-inclusive architectural and industrial designs are the essence of holism. Incorporating the ideas of inclusiveness and simplicity further aligns designs with a modern approach.

By following the dictum, “Less is more,” designs is done in a manner that omits excess and unnecessary detailing. Have you ever opened a product and found that some of the added buttons were only included for aesthetics? What about visited a building and wondered, what was the basis behind that extra set of doors that exceeded the requirement for the space? These extras might look good but are not necessarily required for the product to operate effectively. As designers, we should be reminded that the notion of less being more exists in its purest form when reflecting towards nature. Most the building blocks of the products and buildings we design can start from nature. For example, the Convertible Structure Solutions, Inc. uses the renewable, natural resource bamboo in its bio-fiber designed modular housing (Convertible. n.d. p.1). Other natural, unconventional building materials that are currently being explored are spider silk which can be spun into a variety of shapes and cardboard which can be used to build buildings without having to be processed into lumber.

The Modern Movement exposes materials, exhibits them in their true forms, and does not manipulate them to represent the likeness of another; the essence of an object’s use and purpose should be evident.

World War II spawned the demise of the Modern Movement. As many troops returned home they were in need of immediate housing thus quick modular structures were fabricated. Although, in this instance, troops were not affected by a natural disaster, an analysis of this displacement and housing can be compared to the same likeness of natural disaster displacement. The Case-Shiller index shows that U.S. housing prices declined at the beginning of the 20th century due to mass-production techniques that made construction more affordable. Nevertheless, "Unparalleled economic booms in the second half of the twentieth century resulted in an explosion of housing cost, size, and architectural befuddlement" (Gauer, p. 11).

1.2.2. Minimalism

Minimalism strips objects, buildings down to their bare essentials to reveal its underlying character and structure. The façade of a typical building is made of a few, basic building blocks: an exterior cladding and some sort of structural element. Other key components of the envelope of a building include the building's foundation and roof. Each of the elements, foundation, cladding, structure, and roof, has all been addressed in a plethora of ways. For example, there is the standard brick veneer, concrete masonry unit, and vinyl siding exterior cladding; slab on grade and t-shaped make-up foundation types; the typical structure for buildings is made from either metal or concrete members; lastly, the typical roofs are metal, polyvinyl chloride, and asphalt. With this in mind, what happens when designers explore non-conventional building materials to create structures? This can result in structures such as Shigeru Ban's recycled cardboard paper-tube design used to quickly and efficiently house disaster victims, or utilization of phase changing materials which are manipulated for comfort according to the temperature outside, or foundations made of used beer crates filled with sand and made watertight with tarpaulin roofs, the possibilities seem endless and should be explored further. A minimalistic approach to design

Figure 5: Paper Log House, Architect: Shigeru Ban

encourages exploration into a simplified way of life. The American Dream teaches, directly or indirectly, that a person will take a standardized test, soon decide on a college major, and then matriculate to the college or university of his or her or a parents' choice. After studies are complete, he or she then marries, finds a home, then begins a family; this becomes a rhythmic life cycle and to most is the American Dream, or so we have been taught. Much of that argument cannot but altered but the subject of the preconceived notion about a dream home to dwell in is worth revisiting. Gauer writes, "We live in an age of astonishing excess, when having and wanting more is a cultural mandate. We use our brains and energy to work hard, and big house or apartment is often the visible reward for our effort" (p. 12). "The ideal of a freestanding house with a yard is often cited as a primary cause of suburban sprawl. Yet it remains a staple of the American dream and a norm for much of the country" (Gauer, p. 7)

1.3. Homelessness Perspective

1.3.1. Homelessness in the United States

The United States is home to many of the wealthiest people in the world. From Microsoft's Bill Gates, to the Walton family of Wal-Mart, many have well above their means for living comfortably and to sustain life. On the other hand, Richard Florida, Editor at Large at The Atlantic Cities, writes that the National Alliance to End Homelessness estimates that six-hundred thousand Americans are currently homeless. This figure breaks down to display a distressingly high rate for the United States with 21 homeless per every 10,000 people across the country. According to the National Policy and Advocacy Council on Homelessness, in 2005, there were about 100 million people in the world who were categorized as homeless. This number is a small proportion of the seven billion population of the world, yet it is alarming.

Most people are fortunate to have homes and are not necessarily homeless from the onset. Whether mud, straw, light gauge steel, or masonry constructed, housing can be deemed an essential element to the development of many cultures. According to the author Barakat, "Housing is a complex asset, with links to livelihoods, health, education, security and social and family stability. Housing is also an extremely vulnerable asset, and the destruction of homes or their loss through displacement or dispossession is one of the most visible effects of conflict and natural disaster" (p. 1).In many instances, the path of a tornado's destruction can be seen. Moreover, there are some who are fortunate enough to escape natural disasters with minimum damage done to their homes; others have severe, yet fixable damage, while others lose their homes completely. Bumgarner writes, "Mankind has always faced nature's obstacles of disease, famine, flood, earthquakes, volcanoes, and other avenues to calamity" (p. 2). If completely destroyed, that American Dream home is gone or unavailable and most individuals are faced with the same immediate response of finding temporary housing.

1.3.2. Natural Disaster Displacement

With this in mind, let us now examine statistics of individuals displaced due to nature occurrences in nature. According to the United States Department of Housing and Urban Development, "a majority of homeless people counted were in emergency shelters or transitional housing programs, but nearly 4 in 10 were unsheltered, living on the streets, or in cars, abandoned buildings, or other places not intended for human habitation" (p.2).

Figure 6: Residents left Homeless after April 27, 2011
Belk Activity Center, Tuscaloosa, Alabama
Photograph by: Butch Dill/AP

1.4. Focus Abstracted

Amid the rapidly growing population, the world's exposure to natural hazards is inevitably increasing, therefore, we cannot afford to continue allowing our appetites, dwellings, and expenses grow. With the economy in an upswing from 2009's fall, new, energy conscious innovations should be leading the surge into the future of emergency relief and community development. This approach first addresses the need for a plan to house individuals after being displaced due to natural disasters. Furthermore, this approach draws attention to the need for the United States to become more cognizant of the built environment and the manner in which we consume natural resources. Lastly, this approach introduces solutions for addressing a longer term, smaller community development which will utilize and transform emergency relief structures into permanent dwellings.

2.0 Resource Reduction

2.1. Pre-Industrial Revolution

The Pre-Industrial Revolution prompted individuals to do more for themselves instead of relying upon the advancement of technology; communities were knit closely because of this. During this time, manufacturing was done with natural elements. For example, the windmill used wind power to turn grain into flour and clothing was made locally using animal hides and furs. This may seem a bit primitive for today's, modern society, but the fundamental issue of energy and resource conservation is the matter at hand.

2.2. Post-Industrial Revolution

The Industrial Revolution introduced machinery and more technologies. The hand-delivered, handwritten message was done away with by telephones, horse and buggy saw its demise to motor powered vehicles, and construction of roads and other infrastructure spurred as transportation and communication reached a new height. The growth of heavy industry brought a flood of new building materials—such as cast iron and steel for structures, and the curtain wall glass system. These building materials allowed architects and engineers to design and build structures that the world had only dreamed of. The function, size, and form of buildings now soared to new heights; the world had now become one non-cognizant of waste yet awed by its many explorations. Heavy machinery and mass production were among the advancements of the Industrial Revolution. Eventually, as the Industrial Revolution began in the 17th century but the environmental movement began in the 20th century, there was a noticeable yet unspoken rise in toxins and carbon emissions into the ozone layer; these big machines had to be powered in some form or fashion.

2.2.1. Natural Resource Depletion

The Industrial Revolution marked a major turning point in Earth’s ecology and humans’ relationship with their environment. In addition, the Industrial revolution had a great impact on the building industry. Mass production allowed architects and builders to apply ornamentation in amounts and details previously unseen to housing. Moreover, the Industrial Revolution brought with it profound effects on human development, health and life longevity, to social improvements and the impact on natural resources, public health, energy usage and sanitation.

As humans, well-being of ourselves and of the environment has been jeopardized for the ability to have things faster, more convenient, and readily available. When these conveniences become a devastating mockery, their effects should be examined, lessened and reversed. McLamb writes, “It wasn’t that the Industrial Revolution became a stalwart juggernaut overnight. It started in the mid-1700s in Great Britain when machinery began to replace manual labor. Fossil fuels replaced wind, water and wood, used primarily for the manufacture of textiles and the development of iron making processes” (p.1). The Industrial Revolution movement was a great facilitator of advancement that potentially became exploited.

With growth in mind, it is obvious that the Industrial Revolution propelled the world population. According to McLamb, human population growth is indelibly tied together with increased use of natural and man-made resources, energy, land for growing food and for living, and waste by-products that are disposed of, to decompose, pollute or be recycled. This exponential population growth led to the exponential requirements for resources, energy, food, housing and land, as well as the exponential increase in waste by-products" (p. 2).

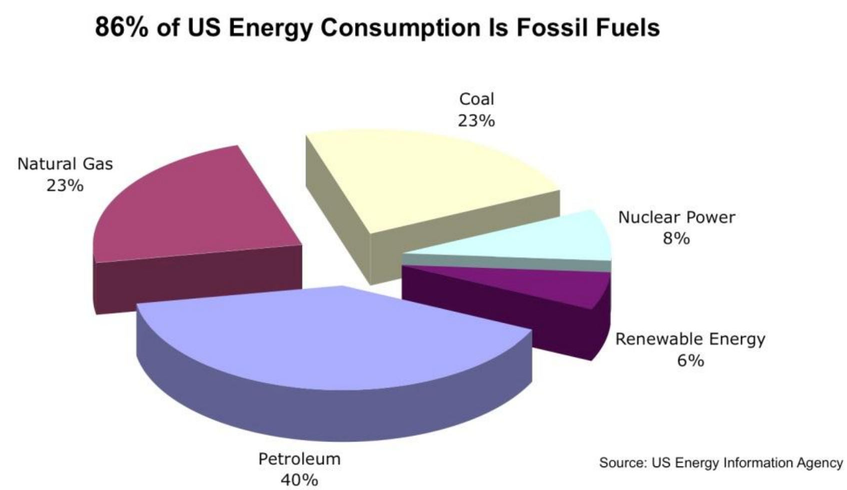


Figure 7: United States Fossil Fuel Consumption
US Energy Information

2.3. Embodied Energy

Edminister writes, "Embodied energy is the total energy necessary for an entire product lifecycle, including raw material extraction or harvesting, production, assembly, installation, use, disassembly or deconstruction, disposal or decomposition, and all associated transport" (p. 5). Everything man-made has a potential for embodied energy. This definition also includes re-purposing of materials. Before the onsite construction of a building even begins, a large sum of energy has already been expended. Mumma (1995) writes, According to the *Environmental Resource Guide*, produced by the American Institute of Architects, more than 30% of the energy consumed in the United States goes to making and maintaining buildings. Mumma (1995) goes on further to say:

> Every building is a complex combination of many processed materials, each of which contributes to the building's total embodied energy. The energy required to extract and process the raw material for an individual component, as well the energy used to transport the finished product to the job site and install it, all become part of the embodied energy cost of the completed structure. Furthermore, energy involved in maintaining an individual building component, and finally removing it and recycling it or otherwise disposing of it at the end of its useful life, can all be part of the embodied energy equation for a particular building material, depending on how the embodied energy is quantified. (p.1)

Embodied energy occurs in two forms in buildings, initial embodied energy and recurring embodied energy, and they are defined as follows:

The initial embodied energy in buildings represents the non-renewable energy consumed in the acquisition of raw materials, their processing, manufacturing, transportation to site, and construction. This initial embodied energy has two components:

Direct Energy

- Direct energy the energy used to transport building products to the site, and then to construct the building.

Indirect energy

- Indirect energy: the energy used to acquire, process, and manufacture the building materials, including any transportation related to these activities.

The recurring embodied energy in buildings represents the non-renewable energy consumed to maintain, repair, restore, refurbish or replace materials, components or systems during the life of the building.

There is significant variation in the amount of embodied energy in buildings. Initial embodied energy consumption depends on the materials used, the source of these materials, and how they are processed. The recurring embodied energy is related to the durability of the building materials, components and systems installed in the building, how well these are maintained, and the life of the building; the longer the building survives, the greater the expected recurring energy consumption.

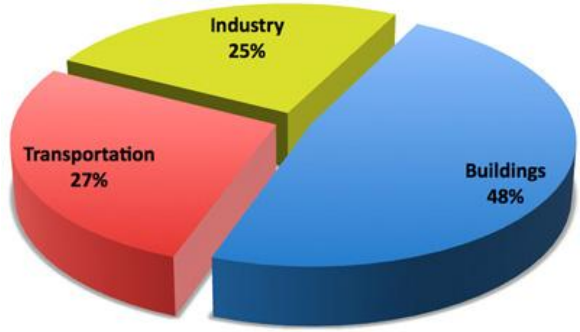


Figure 8: United States Energy Consumption
Graph: Architecture2030.org

One goal of designers should be to design around methods and guidelines that reduce embodied energy. As buildings become more energy efficient and the amount of operating energy decreases, embodied energy is optimized. Conversely, energy-free structures can be built for the same price as a conventional home with some tradeoffs, such as a smaller building envelope. Alternative, natural building technologies are available and should be explored for incorporation into structures.

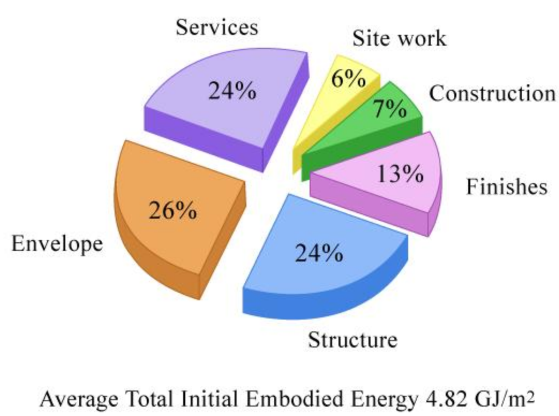


Figure 9: Typical Building Embodied Energy
MIT OpenCourseWare

2.4. Global Warming

The earth is warming at an alarming rate; immense forces of nature have been unleashed through a series of ever-increasingly devastating natural disasters, and humans, even the most brilliant engineers, have repeatedly failed to tame these forces. In fact, as of 2013, Earth's carbon dioxide level has hit 400 parts per million, which is almost twice that of the 280 parts per million level before the Industrial Revolution. The negative effect of the carbon footprint of humans and buildings has often been discussed relative to global warming.

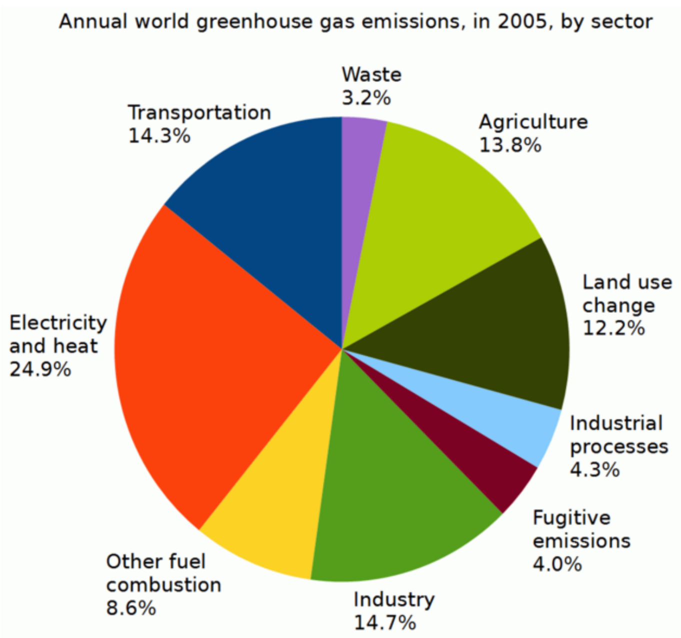


Figure 10
Timothy Herzog, 2009

Global warming is a growing concern; human life and the environment will reap the consequences of the perils of global warming, many in the form of natural disasters. Is there some validity to this argument that any of these events be pinpointed to the root of the cause of global warming? Seemingly, many things stem from the effects of global warming. The rise in the average temperature of Earth's atmosphere and oceans and its projected continuation has been a detriment on many crops and their preferred climate, disease has spread rampant because of transformation of ecosystems which has increased cohabitation with infectious organisms, the rise in sea level influences the severity of hurricanes and tornadoes. However, not all perceive the issue as due to manmade forces; “the dispute lies in whether or not the warming we are now experiencing simply reflects a natural turnabout in the recent global temperature trend or results from the polluting impact of human activities since the industrial revolution really began" (McGuire, p. 1).

The building sector contributes up to 30% of global annual green house gas emissions and consumes up to 40% of all energy. Given the massive growth in new construction in economies in transition, and the inefficiencies of existing building stock worldwide, if nothing is done, greenhouse gas emissions from buildings will more than double in the next 20 years" (Lemmet, p. 5). As a result, attention should be directed to modular, energy efficient homes as a way to reduce consumption and emissions.

3.0 Natural Disasters

3.1. Hurricanes

Hurricanes can potentially be devastating natural disasters. Hurricanes are a product of weather conditions found in certain regions of the world, including the tropical regions of the North Atlantic Ocean. Hurricanes are initially classified as Tropical Storms. It isn't until they reach over 48 miles per hour that they are classified as Hurricanes. Hurricanes can produce winds as high as 160 mph and even higher. Big or small, on average the Atlantic Ocean stirs up five to six hurricanes per year, dumping 2.4 trillion gallons of rain a day during their duration (Heinrich, p. 10).

Man has built structures five to ten feet up from the foundation, structures whose trusses are "toenailed" into the top of its walls, and levees that have failed, yet these provisions still have not shown to resist every aspect of the most powerful of hurricanes.

3.1.1. Hurricane Katrina

16,000…The Katrina Evacuees of the Houston Astrodome…On September 4th 2005, approximately 16,000 evacuees filled the floor of the Houston Astrodome…All seeking refuge from Hurricane Katrina's devastation in New Orleans… Sam saved her grandmother, who is unable to walk, on an air mattress from their flooded home in New Orleans…Sean Collins, and Ishmeal Fleming, both survivors of Hurricane Katrina, rest on cots in the Houston Astrodome on September 4th…The Art Room, set up by volunteers at the Houston Astrodome, provides art therapy to children affected by Hurricane Katrina and helps them to occupy the long hours spent inside the unfamiliar building… **-Sarah Regnier Video Account**

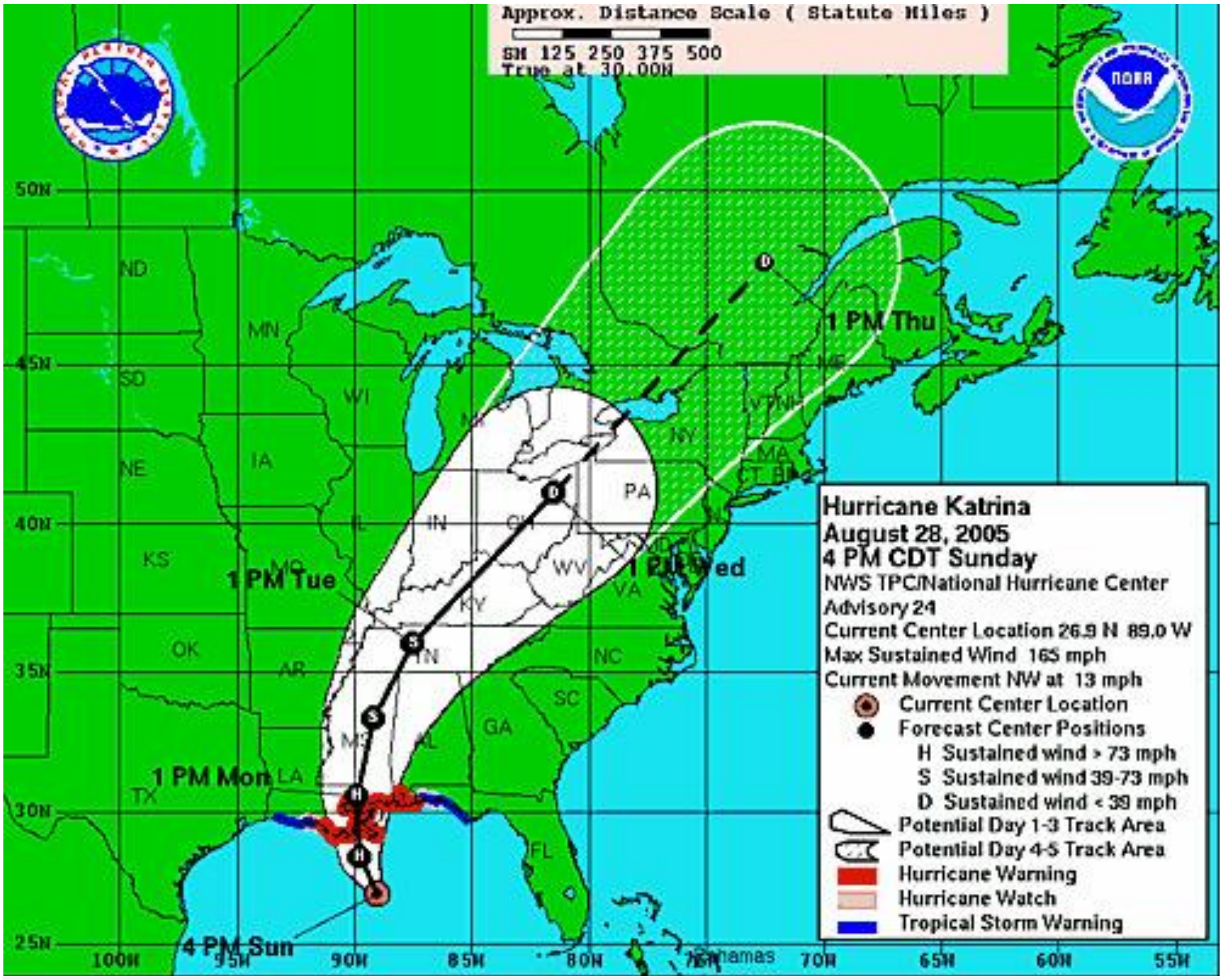


Figure 11: Intensity Forecast Weather Graphic
MIT OpenCourseWare

The costliest hurricane to hit landfall in the United State as of 2011, a Category 5 storm that slammed Louisiana in August of 2005, was known as Hurricane Katrina (Geology. n.d.). The above excerpt from Sarah Regnier describes the aftermath of Hurricane Katrina. Damages from Hurricane Katrina cost an estimated $91 billion. Moreover, the psychological and physical toll this hurricane brought with it remains with the country. Many people, animals, were left to fend for themselves after Hurricane Katrina. This meant that they were without food, water, power, medical supplies, or police protection. Only weeks after Hurricane Katrina, evacuees had populated various states of the United States, both near and far; displacement after Hurricane Katrina was evident.

3.1.1a. Survival Account of Hurricane Katrina Victims

The devastation after a natural disaster can be grim, distraught, and burdensome. According to Matthew Tull, PhD., two researchers at the University of Mississippi Medical Center performed a study of the negative impact of Hurricane Katrina on people. Their research revealed that approximately 40% were without electricity for 6 days or more, over 40% had some kind of damage to their home, and approximately 10% were without water for 6 days or more. The following account, from the Associated Press, of life after Hurricane Katrina vividly paints the picture of how individuals lived.

Meet the Thomas family, comprised of six children and Thomas's boyfriend whom arrived in Arizona a week after Hurricane Katrina struck. The Thomas family survived Hurricane Katrina by taking refuge in the attic of their four-bedroom brick house. After being rescued eleven hours later, the Thomas family pondered the questions of where would they live and work? When, if ever, would they go back home? What might they find when they did? Blank pages of a life story that suddenly had to be rewritten. After arriving in Arizona, their first accommodations were cots at Veterans Memorial Coliseum near downtown. The Thomas family eventually moved into a home that good patrons decided to offer to Hurricane Katrina evacuees, free of charge. In the same month of arriving in Arizona, Ms. Thomas went back to New Orleans to salvage whatever she could of her family's belongings. Ms. Thomas was distasteful of the idea of her family moving into a FEMA home thus, five years after first arriving in Arizona, Thomas and all six children live now in a mobile home in Buckeye.

3.1.1b. Characteristics of Disaster Recovery

A brief synopsis of the Thomas family's expedition after the occurrence of Hurricane Katrina can be generalized as: the natural **disaster struck**, the family had a latent, **waiting period** possibly with **depleting sources of safe food and water**, the Thomas family was **rescued** eleven hours later, after being rescued, the **psychological aspect of the disaster** became apparent, they were **relocated**, and then began to **procure shelter, food, and water**, the mother of the Thomas family **returned to home to salvage belongings**, **rebuilding efforts** start or **relocation** become **permanent**. The bold-faced type is the typical trajectory of a family after a natural disaster. Most disaster recovery efforts after a natural disaster are consistent with the outlined phases above. Government agencies and designers alike have sought resolutions that encapsulates all of these phases, with the FEMA trailer being one of the most common tenant of refuge.

3.1.2. Hurricane Sandy

On October 22nd, 2012, Hurricane Sandy hit the Mid-Atlantic and Northeast regions of the United States, lasting approximately nine days. Preliminary estimates of losses due to damage and business interruption are estimated at $65.6 billion, making it the second-costliest Atlantic hurricane, behind only Hurricane Katrina (Morgan, 2013).

3.1.2a. Survival Account

Figure 12: Hurricane Sandy Threat Image
Liberal Lamp Post, October 2012

In Middletown, New Jersey, evacuees fled to nearby churches because flooding had prevented most of them from using their cars to flee elsewhere. A few people slept stretched across chairs in the sanctuary after the storm. The nearest FEMA assistance center is in Union Beach, about five miles away. FEMA alone is faced with the challenge of trying to reach every individual affected but realistically this is impossible. Serna writes, “FEMA said 1,600 people are already using the agency’s help to live in motels or hotels. With 107,000 people qualified for similar accommodations, many places could soon be jam-packed if displaced Sandy victims don't stay with friends or family” (p.2). Norma McCarthy and her two sons stayed in their flooded, powerless home because their ideal evacuation site, a relative’s home, was also without power. McCarthy stated that she applied for FEMA assistance the day after Hurricane Sandy struck but was faced with weeks of waiting until her case came in contact with FEMA.

Irene Cramer and her husband Tommy had been displaced by Hurricane Irene in 2011 and sequentially by Hurricane Sandy. When the couple's home was damaged in Hurricane Irene, they stayed for nine weeks with relatives down the street. Hurricane Sandy has presented them with the toil of finding another place to stay. The demand for shelter after Hurricane Sandy was overwhelming for FEMA and even real estate agents. Reported by the Associated Press: "The number of people who need homes now is much greater than what all of the companies have combined is available," said John Meechan, a broker with Diane Turton Realtors in Point Pleasant Beach, New Jersey" (p. 3). Turton Realtors has also had people so desperate for shelter that they have bought homes ranging in the 400,000 dollar range just to reside in temporarily. "We've had people that have said, 'for the price of renting, I'll buy it and sell it next year,'" said Perry Beneduce of Diane Turton Realtors. Through this situation, it is apparent that ample services from FEMA are inadequate over a vast region. As a result, other measures, other emergency relief apparatuses, should be present to ease the strain that is put on FEMA.

In the world today, we see people fighting over food, a medical care system that some feel isn't just and is filled with discrepancies, and a corrupt justice system that seems to pick and chose. These things exist now and as well as during the aftermath of Hurricanes Katrina and Sandy but were as transparent as glass when needed most. "If you're going to have a city below sea level in hurricane country, you'd better have some disaster plans. And plans they had, but apparently those plans didn't include strengthening the levees or evacuating residents" (Dudley, p. 32). The Department of Homeland Security had planned ideas to prepare for emergency response scenarios such as Category 5 hurricanes. Yet, where were those plans after Hurricane Katrina? As a result, "Katrina underscores the urgent need to build a robust national preparedness and response system that can bend and flex to the unique circumstances of natural or human-caused catastrophes" (Dudley, p. 12).

3.2. Tornados

The local news interrupts our favorite TV series, news flashes indicate the weather has taken a turn for the worst, red blotches on the newscaster's Pulse-Doppler radar show inclement weather approaching, tornado sirens sound… We all are familiar with the destruction of a tornado. Tornadoes come in many shapes and sizes, but they are typically in the form of a visible condensation funnel, whose narrow end touches the earth and is often encircled by a cloud of debris and dust. Most tornadoes have wind speeds less than 110 miles per hour, are about 250 feet across, and travel a few miles before dissipating (Edwards, p1).

3.2.1. Alabama Tornados of 2011

Tornadoes occur most frequently in the continent of North America, within the Tornado Alley between the Rocky Mountains and the Appalachian Mountains. On April 27, 2011, the state of Alabama was struck by an outbreak of sixty-two tornadoes that spanned more than 1,000 miles leaving destruction on most of their paths. The tornadoes from that day made lasting impressions on Alabama, in the county of Tuscaloosa, as well as the city of Birmingham. These tornadoes were so fierce that buildings built to withstand such a blow didn't stand a chance. Analysis from the Center for Disease Control and Prevention

Figure 13: Residents look through debris in Trussville, Alabama after the tornados of April 27, 2011
Butch Dill, AP

found that unlike in other tornado outbreaks, the largest group of people who died were in single-family houses — not mobile homes (Stobbe, p. 1). As a result of these tornadoes, there were survivors who were faced with recovery after their homes' were destroyed.

4.0 Necessities of Life

After a natural disaster, it is likely that drinking water and the air is tainted, food is scarce, and homes are destroyed. Each of these elements, water, air, food, and shelter, are necessities of life; all of which can affect the well-being of an individual if temporary sources of each of these necessities are not restored.

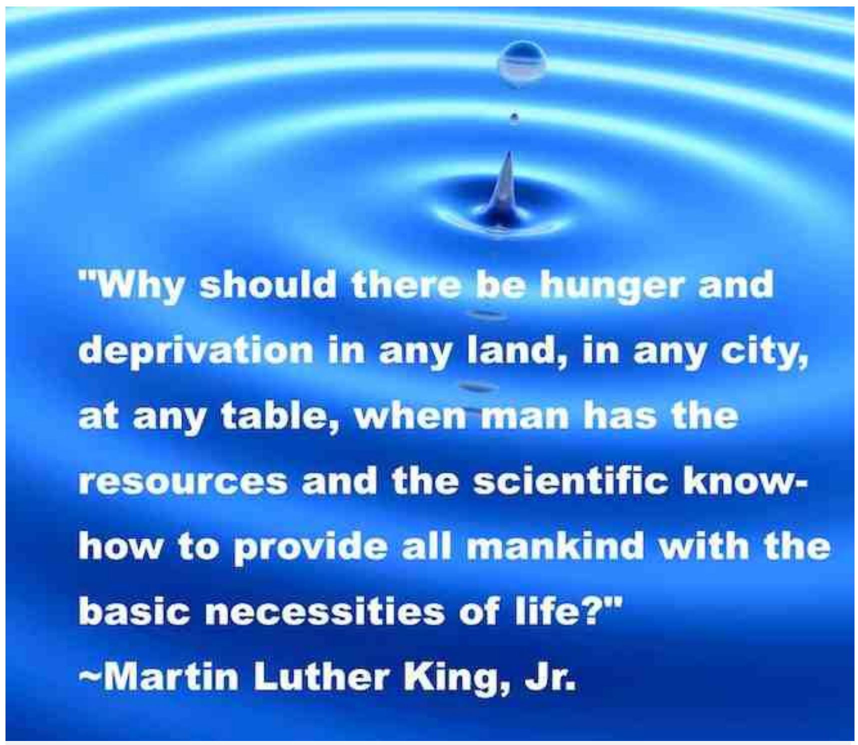


Figure 14: Dr. Martin Luther King Necessities of Life Quote
Butch Dill, AP

Psychologically, as living organisms, our most basic needs vital to survival include the need for water, air, food, and sleep. Hierarchy wise, these can be deemed the most basic and instinctive needs because all needs become secondary until these physiological needs are met. Nancy L. Young-Houser of AKG Magazine writes, “simply put, only when we are fed, warm and feel personally satisfied on a basic level will we then seek adequate shelter, i.e. if we are hungry and cold, those needs will always come first before we begin a search for adequate shelter, if not simultaneously” (p.1). With this in mind, the bare essentials to sustain life water, food, shelter, and health are examined for incorporation into emergency relief efforts.

4.1. Water

Two hydrogen atoms to one oxygen atom connected by covalent bonds, H2O, or water as we know it is imperative for human survival. A world without water would be impossible for all known life forms. Water is the pertinent part of the metabolic processes that are carried out within the body. Water is most commonly used by humans for agriculture and irrigation, ultimately the utilities needed to produce food. Consequently, water and food seemingly work hand-in-hand. The human uses of water seem endless. Humans use water as a scientific standard, for drinking, washing, transportation, chemical uses, heat exchange, fire extinction, recreation, and food processing.

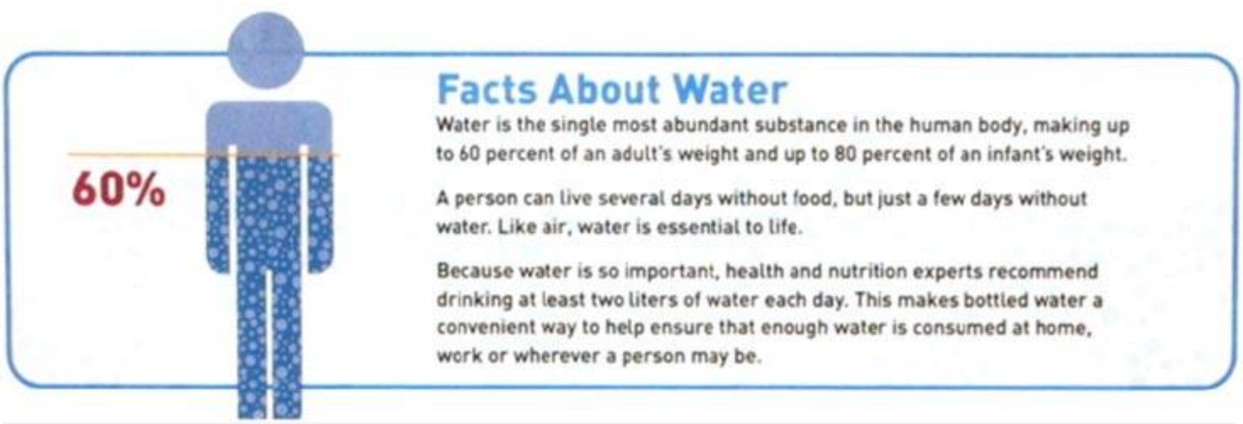


Figure 15: Facts About Water
Sourced By: SubhutiDharmananda, Ph.D., Director, Institute for Traditional Medicine, Portland, Oregon

It takes around 3,000 liters of water, converted from liquid to vapor, to produce enough food to satisfy one person's daily dietary need. This is a considerable amount, when compared to that required for drinking, which is between two and five liters. To produce food for the 6.5 billion or so people who inhabit the planet today requires the water that would fill a canal ten meters deep, 100 meters wide and 7.1 million kilometers long – that's enough to circle the globe 180 times. According to the water encyclopedia, the minimum water requirement for replacement purposes, for an "average" person, has been estimated to be approximately 3 liters (3.2 quarts) per day, given average temperate climate conditions (Gleick, p.1). As a result of these facts, it is only necessary to provide measures for obtaining drinking water after a natural disaster.

4.1.1. Purification

When a disaster strikes, water is the first necessity needed. Although survival is the first thing on the minds of disaster victims, one should make sure that the water that they are to obtain is safe to drink. The most readily effective and safe way to purify water is through boiling. In an effort to kill all pathogens, at sea level, the Center for Disease Control and Prevention recommends that you bring water to a rolling boil for 1 minute.

4.2. Food

After the first necessity, a safe water source has been established, one can began to solve food crisis. While the quote that “one will eat anything if hungry enough” suggests people will go to great lengths to obtain food, many do not result to this savage-like lifestyle. Many will go without food for extended periods and even starve before they eat something unfamiliar or unpleasing. In times of crisis, stress tends to alter thinking, triggering the above mentioned psyche to refuse peculiar foods. After a natural disaster, one can be left without power. Thus, alternative sources such as gas, solar power, and canned heat can be employed to prepare food.

4.2.1. Gas Utlilization

4.2.1a. Propane and Camping Stoves

Figure 16: Coleman PerfectFlow Propane Stove
MSRP: $60

Upon first response, gas is one of the most readily used and convenient power alternatives used for preparing food. Propane is a common, well-known power source, it is a short-term solution, but it cannot be safely used indoors. In addition to long-term cost implication and the potential for exposure to hazardous gases, propane wouldn’t be the most effective long-term solution. Camping stoves that use butane are another gas alternative to first response energy sources, but just as propane, they cannot be used indoors.

4.2.2. Solar Power

All life benefits from the sun and along with water the sun is essential. The natural, almost always readily, available rays of the sun can provide a cooking source providing the weather is clear. Solar ovens convert the ultra-violet rays of sunlight into infrared rays. The trapped infrared heat in the oven cooks food. To make a solar oven one needs only a few things, a conductor such as aluminum foil, cardboard, making a solar oven simple to create without the fume dangers of gas ovens. Solar ovens become limited in use dependent upon the amount of sunlight available. All in all, solar ovens provide the safest, most long-term, indoor alternative to cooking without electricity.

Figure 17: Global Sun Oven by Solar Town
MSRP: $245.00

4.2.3. Canned Heat

Many times, at picnics and receptions, canned heat is used to keep food items warmed until they are ready for use. This technology is reusable heating which is another immediate cooking source that can be employed after a natural disaster. These canisters use an alcohol-based, gel-like fuel that will not spill. A seven-ounce can burn for up to two hours.

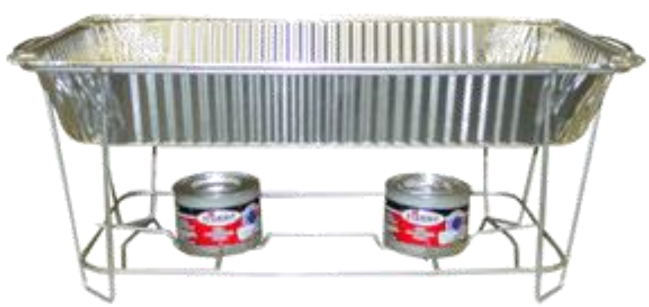


Figure 18: Reusable Heating Kit by Brennan's Catering
MSRP: $13

4.3. Public Health

4.3.1. Waste and Sanitation

Health is a priority. Natural disasters present various health implications after their demise. Carcasses, debris, and pathogens are present. An important concern is the question of how to eliminate waste. It is ideal at this point to seek an efficient alternative to current methods. Several non-conventional toilet options are available for waste elimination, including composting and chemical toilets.

4.3.1a. Composting

After a natural disaster, water may be scarce. Thus, it isn't ideal to use it for waste removal. When resources are limited, composting toilets serve as great tools for removing fecal matter when water is not present or does not lend itself to waste removal. A composting toilet is a dry toilet that uses a predominantly aerobic processing system that treats excreta, typically with no water or small volumes of flush water, via composting or managed aerobic decomposition. According to Envirolet, manufacturers of composting toilets, "A significant savings in water storage will result if the household is not on networked water supply. Combine this with wastewater re-utilization in irrigation and other household water reduction techniques and water storage costs can be cut by up to 60%" (n.d., p.1). Composting toilets can be designed with a suction fan which extracts odors. Composting toilets are stand-alone units and

Figure 19: Sun-Mar Excel Ne Non-Electrical Composting Toilet
MSRP: Approx. $1400

offer great recycling opportunities. Most food scraps and paper can be composted, things we would not dare to put into our conventional toilets. A couple setbacks of composting toilets are that they require upkeep by their owner and they must be installed correctly or they can cause a messy removal. In addition, composting toilets can become costly. Nevertheless, the recycling and environmental benefits of composting are the biggest setbacks of chemical toilets. Besides, composting human waste and burying it around tree roots, not edible plants, keep organic wastes productively cycling in the environment.

4.3.1b. Chemical Toilet

The "Porta-potty" is one type chemical toilet that most have seen or utilized before. The blue water at the bottom of the hole in a "Porta-potty" is an immediate signifier of chemical toilets. Common at large public events and on large charter buses, chemical toilets are another waste treatment option. They can be less expensive than composting toilets. As the name entails, chemical toilets use chemicals to deodorize the waste instead of simply storing it in a hole, or piping it away to a sewage treatment plant. One drawback of chemical toilets is the chemicals used to combat wastes. Some chemical toilets use formaldehyde which can be very irritating to the eyes, ears, skin, nose, and throat. To make chemical toilets easier on the body, formaldehyde is being replaced by other proprietary blends such as glutaraldehyde and quaternary ammonium

Figure 20: Chemical Toilet
PortaPotti

compounds, with non-staining dyes and nature-identical perfume oils. Additionally, enzyme hybrids are sometimes used.

4.4. Shelter

The challenge of addressing the need for shelter after a natural disaster is being taken on by many designers. As this review suggests, when rebuilding after a disaster, there are a number of options for doing so more effectively than with current practices. Sustainable approaches to rebuilding or adapting to existing structures invite emphasis upon modular construction and adaptive reuse. In addition, shelter can come in the form of communal dwellings as well as individual ones.

Shelter is a barrier of protection from the environment. Termites live in mounds, squirrels in dreys, hares in forms, eagles in eyries, bees live in hives, bats live in caves, and bears live in lairs. Homes or shelters can stimulate a sense of well-being, belonging, and comfort. When exposed to extreme conditions, the body is thrown out of sequence. If too cold, blood flow can be drastically reduced, blood vessels dilate instead of constrict, and eventually, a thirty-five degree Celsius body temperature hypothermia sets in; one can only put on some many articles of clothing to combat cold temperatures. Excessive sweating, dizziness, heat cramps, when too hot, a body temperature that exceeds thirty-five degrees Celsius can cause the body can slip into hyperthermia (McGraw, 1998). As a result, organisms tend to feel better psychologically when they have shelter. According to Nancy L. Young-Houser of AKG Magazine, “safety needs do not control our thoughts and behavior as do the basic physiological needs, but when the basic needs are satisfied, the second level of needing housing and shelter will automatically kick-in, becoming very active in our thoughts and desires” (p. 1). When nature’s rhythmic cycle is disrupted natural disasters occur and cause families to be disrupted from their customary dwelling. As a result, an efficient means for housing displaced individuals must be sought.

5.0 Government Assistant Programs & Responses

Hurricanes and other disasters have been historically menacing in the United States. Dating back to the 1960’s, many notable hurricanes have taken their toll. Hurricane Donna killed more than 360 people in 1960. In 1961, Hurricane Carla killed 46. In 1965, Hurricane Betsy killed 76 people. In 1969, Hurricane Camille killed over 250. In 1964, an earthquake measuring 9.2 on the Richter scale struck in Alaska killing one hundred thirty-one people and caused tsunamis to occur. As you can see, North America is no stranger to natural disasters, yet an effective relief plan still does not exist. Over time, the government has become better advocates for the safety and welfare of individuals after natural disasters, but disaster relief plans can be much improved to avert continued loss of life such as that which occurred after Hurricane Katrina in 2005.

5.1. Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA), established in the 1970’s by Jimmy Carter, was a step taken by the government to combat natural disaster relief unpreparedness. As defined by FEMA, a disaster is as a non-routine event that exceeds the capacity of the affected area to respond to it in such a way as to save lives; to preserve property; and to maintain social, ecological, economic, and political stability of the affected region.

Figure 21: FEMA Emblem

The primary purpose of FEMA is to coordinate the response to a disaster that has occurred in the United States and that overwhelms the resources of local and state authorities. An improvement over previous agencies and plans, FEMA was still unable to effectively address all natural disaster relief needs. After the terrorist attack of September 11, 2001, FEMA soon became nestled under the Department of Homeland Security, as a result, making it even more ineffective as a unit (Bumgarner, p 9). The unpreparedness of FEMA soon became evident approximately four years later when Hurricane Katrina devastated the Gulf coast region of the country.

Bumgarner writes,

> “FEMA’s performance during and after Hurricane Katrina, which struck New Orleans, Louisiana; Biloxi, Mississippi; and everywhere in between in late August 2005, has been held up as an instant classic example of FEMA losing sight of its mission. Many have criticized FEMA for departing from its disaster preparedness roots for the allure of antiterrorism planning and preparation. FEMA’s actions during the Hurricane Katrina crisis have been characterized as evidence of this misplacement of purpose” (pp. 9,10).

This ineffective response underscores why FEMA still fails to be the solution to those affected by natural disasters. FEMA has not effectively addressed emergency management, failing to adequately mitigate, prepare, respond, and recover.

5.1.1. FEMA Trailers & Earthquake shacks (cottages)

Figure 22: Earthquake Shack after Earthquake of 1906 in San Francisco, California
Photo by: San Francisco History Center, SF Public Library

The FEMA trailer is the United State Government's immediate form of manufactured, temporary housing for displaced individuals after a natural disaster. In comparison to tents, the FEMA trailer provides a longer term housing alternative. History demonstrates the use and need of such homes. In 1906, the San Francisco Earthquake prompted the use of earthquake shacks. The earthquake shacks were small cottages built to house over 16,000 residents of San Francisco. Characteristics of earthquake shacks included cedar-shingle roofs, fir floors and redwood walls. In addition, these cottages all were painted green to better blend into the parks and public squares in which they were erected. In 1907, these cottages began to become extinct to resurface, for preservation purposes, decades later in the 1980's. Subsequentially, in 1992, FEMA trailers emerged after South Florida's Hurricane Andrew. Individuals affected by Hurricane Andrew resided in these trailers for as long as two years.

5.1.1a. FEMA Trailers Usage

Figure 23: FEMA Trailer

Since Hurricane Katrina plagued the city, the use of FEMA trailers in New Orleans, Louisiana has become prevalent. The cultural landscape of New Orleans has been changed by the influx of these trailers with some becoming permanent homes seven years later. Areas affected by extreme flooding, as well as those that weren't, showcase FEMA trailers that house families. One of the first challenges of FEMA trailers is that they are still property of the United States Government. Thus, they are to be returned after use. However, some individuals opted to purchase their trailers from the government for $1,100, turning the temporary shelters into permanent homes. FEMA trailers may be cost friendly, but their building components, health implications and challenges offset this cost.

After Hurricane Katrina, flooded homes became environments for mold to thrive. To combat this fungal problem, the process of mold remediation has to be implemented before rendering homes safe to inhabit again, leading to a lack of habitable homes. In addition, homes abandoned or empty become dilapidated. These have also caused an inflation of leasing rates for apartments; thus, most working class storm victims cannot afford them. Without FEMA trailers, some people who do not own or rent homes would be unable to find any form of housing within the disaster area.

5.1.1b. FEMA Trailer Characteristics

FEMA trailers can be installed next to homes on lawns and driveways, as well as in FEMA home trailer parks. FEMA trailers are mass-produced and have a single bedroom, typically designed to accommodate two adults and two children. The typical FEMA trailer is 14'x22' in area, consists of a master bedroom with a standard size bed, a living area with kitchen and stove, bunk beds, and a bathroom with shower. Each trailer is equipped with electricity, air conditioning, indoor heating, running cold and hot water, a propane-operated stove and oven, a small microwave oven, a large refrigerator, and a few pieces of furniture attached to the floor;

usually a sofabed, a small table, and two chairs. Each trailer is elevated about two feet (0.6 m) above the ground, on concrete supports. There is only one door on the side of each trailer, which is accessible through a wooden or aluminum stairwell. There are also long ramps for wheelchair-using occupants.

Services for FEMA trailers are at times determined by locality. Electrical service to the FEMA trailers is installed by the local power company. The typical FEMA trailer has two propane tanks on the front of the trailer behind the master bedroom, which provide the hot water, indoor heating, and gas for the stove and oven. Running water for the trailer is usually provided by some sort of water source on the property, usually through a garden hose. Sewage is piped directly to an underground sewage main on the property. Most trailers have several windows which can be opened, as well as small light fixtures in each room.

5.1.1c. FEMA Trailer Formaldehyde Exposure

The FEMA trailer has become highly controversial. Accusations have flown about the exposure to formaldehyde when dwelling in these trailers. Formaldehyde gas -- the airborne form of a chemical used in a wide variety of products, including composite wood and plywood panels in the travel trailers that FEMA purchased to house hurricane victims -- is considered a human carcinogen, or cancer-causing substance, by the International Agency for Research on Cancer and a probable human carcinogen by the EPA. Since FEMA trailers are mass-produced and usually in high demand after a natural disaster, this means that they are produced and dispatched before many of the materials used in its assembly have cured and off-gassed. In addition, the high heat and humidity of Louisiana exacerbated this issue. Mary DeVany, an industrial hygienist from Vancouver, Washington states, “Typically with these plywood and particleboard materials … before assembly they're put in ovens that heat them to 130 degrees," she said. "This sets and bakes off the formaldehyde in the glues and resins. ... I'm not sure that happened in this case because the trailers were made so fast" (Brunker, p. 1). Health issues have resulted from extended exposure to FEMA trailers. Residents have reported breathing difficulties, persistent flu-like symptoms, eye irritation, and nosebleeds because of the formaldehyde levels present. According to tests performed by the Sierra Club, several FEMA trailers revealed some 83% had levels of formaldehyde in the indoor air at levels above the EPA recommended limit. NBC News supports this claim by reporting formaldehyde concentrations as high as 0.34 parts per million – a level nearly equal to what a professional embalmer would be exposed to on the job. Government tests revealed that the formaldehyde levels of FEMA trailers were about five times of the exposure levels of traditional homes. Anthony Dixon, a New Orleans resident says he developed asthma while living in a FEMA trailer for two years, and many others have reported similar health problems. The government has since stated that the formaldehyde present in past FEMA trailers was a result of poor construction and fabrication and building materials. It is apparent that in situations, when mass quantities of emergency relief shelter is necessary, FEMA's existing source is inadequate to the actual short-term needs of residents and victims.

5.1.1d. FEMA Trailer Storage

Another big concern inhibiting the effectiveness of FEMA trailers is their inability to be appropriately stored. Since FEMA trailers come in standard 14' x 22' sizes, their bulky footprints do not lend themselves to be efficiently stored, or disassembled for storage. As a result, many FEMA trailers are stored in reserved lots throughout states. Cases in Mississippi revealed the storage problem and lack of use of FEMA trailers. In Purvis, Mississippi, FEMA has 3 storage yards, one in Purvis with over 18,000 trailers, one in Hope Arkansas with 10,500+ trailers and a third yard in Mississippi with around 3,500 trailers. Many of these trailers were returned after short-term emergency use. Because of the difficulty in storage and the short-term nature of the trailers, they become obsolete after being returned to FEMA.

5.2. American Red Cross

Figure 24: American Red Cross

Founded by Clara Barton on May 21, 1881, the American Red Cross is a private, non-profit organization that provides relief to victims of disaster and helps people prevent, prepare for, and respond to emergencies. The differences between and essential roles of both FEMA and the American Red Cross are as follows: The Red Cross is a nonprofit voluntary organization that responds to disasters regardless of their size and scope; FEMA is a federal government agency that helps in those disasters that have been declared disasters by president. Some of the FEMA's work involves community recovery, such as rebuilding bridges, roads, and public buildings. The Red Cross provides assistance to meet individual humanitarian needs. Also, under the federal response plan, the Red Cross and FEMA have separate responsibilities. The Red Cross is responsible for "mass care"- providing food, shelter, bulk distribution of disaster relief supplies, first aid, and disaster welfare information. FEMA is directly responsible for "information and planning" and "urban search and rescue," and the overall coordination of any activities conducted under the federal response plan.

5.3. Common Challenges after a Natural Disaster

Many of the challenges faced by individuals after a natural disaster are consistent, most of which are derivatives of the previously mentioned necessities of life. One should have an emergency preparedness plan that includes food, water and fuel for at least two weeks. According to the government, every family should have emergency food on hand. From the onset of the disaster, most residents are without power. According to CNN, residents affected by Hurricane Sandy were without power for eleven plus days. Starting August 31, 2005, Hurricane Katrina caused widespread power outages throughout Louisiana, Mississippi, Alabama, Florida, Kentucky and Tennessee. As a result of power outages after a natural disaster, power generators become a scarce, in-demand commodity. It is ideal to procure a good generator early and to have at least a week's worth of fuel on hand.

Next, another big challenge faced after a natural disaster is food acquisition. Consequently, an emergency food supply is essential. For an immediate response for food after a natural disaster, a popular choice for survival food is the military style Meals Ready to Eat (MRE's). Eventually, canned and dehydrated foods can become available. In addition, canned and dehydrated foods are ideal to have stocked because they keep best and are easy to fix with no cooking. Because grocery stores may be inaccessible or emptied already of food, it is ideal to have two weeks of food stored up for every person in the family.

Figure 25: Meals Ready to Eat
By Ameriqaul

After power and food have been reestablished, water is needed and should be sought out simultaneously with the food search efforts. After a natural disaster, one can almost expect local water treatment facilities to lose power thus losing the ability to provide fresh water. With this in mind, water should be stored especially if a natural disaster seems to be approaching. Water can be stored in bathtubs and can also be purchased in bulk, five gallon reservoirs at local stores. On average, a gallon per day should be allotted per each member of the household.

Lastly, fuel, batteries, and charcoal are ideal to have available after a natural disaster. Fuel is important to have because it can power generators and of course, vehicles. Gas stations will rapidly run out of gas and can lose power as well, thus making it ideal to have gas reserves stored. Whether alkaline, solar powered, or rechargeable, batteries are ideal to have on hand because they can power generators, cooking devices, flashlights, lamps, emergency radios and other powered sources. Charcoal is ideal to have because it can be used to grill foods until power is available.

Government programs such as FEMA are designed to respond after a natural disaster but they cannot reach everyone immediately after to provide emergency resources. Natural disasters can spur a survival instinct, thus psychologically provoking one to do things he or she is not accustomed to doing. As a result, it is a fact that looting and fighting become prevalent. Death can become rampant as well because of acts of violence and carelessness.

No one knows when a natural disaster will strike and how it will affect them. Thus, it is ideal to be prepared for the worst. The Federal Emergency Management Agency and American Red Cross work simultaneously to meet the needs of the affected after a natural disaster. Congressional investigations have revealed that the two “did not have a logistics capacity sophisticated enough to fully support the massive number of Gulf coast victims." One can only speculate whether or not meticulous preparation would have still sufficed in the event of Hurricane Katrina. Natural disasters occur frequently and often times unexpectedly, therefore, it can be impossible to gauge what is needed per every given scenario. According to Kates and Pijawka, “the reconstruction period of time, which can run from months to years, is concerned with the rebuilding or replacement of destroyed structures and other capital possessions” (cited in Bumgarner, p. 31). Nevertheless, having emergency relief measures in place that assists and a structure that is readily available for housing, still remains a work in progress for FEMA and the United States Government.

6.0 Housing Analysis and Alternatives

After suffering the loss of everything during a natural disaster, most families are thankful to have almost any form of shelter. However, natural disaster recuperation shouldn't be the cause that spurs one to begin to live smaller. In support, statistics of the housing market will be presented to demonstrate the modesty of alternative, smaller lifestyles. Natural disasters are the most common cause for an emergency relief shelter, yet such shelters can also be adapted to become more permanent settlements.

6.1. Predicted Housing Market

During the economic crisis of 2008 and 2009, it was not uncommon to peruse the newspaper and see a local ad for an appraised house advertised at a much lesser value. A nationwide depression was evident, houses were advertised below their relative value, yet no one was buying. "For young families buying their first home or mature adults wanting to downscale, smaller houses make sense. Single adults or couples without children are also prime candidates for small homes" (Tremblay, p. 1).

When thinking about the future of building, one should have the outlook of "building what we need and will use". Often times, with more space, we are inclined to bring in more furniture, décor, or unneeded items. When in a smaller envelope, we can still decorate and live with needed objects but without excess. "Extra space will cost you in several ways: money and time to decorate, clean, and maintain; energy to heat and cool all that space" (Tremblay, p. 2).

6.1.1. Single Women, Recent Graduates

The future of housing anticipates an increased need for housing, smaller housing, that accommodates single-families, recent graduates, and the elderly. According to the United States Census and the America's Families and Living Arrangements: “2010, the average household size declined to 2.59 in 2010, from 2.62 people in 2000. This is partly because of the increase in one-person households, which rose from 25 percent in 2000 to 27 percent in 2010, more than double the percentage in 1960 (13 percent)”. There has been an increase in the number of young adults who have turned to moving back in with their parents. In addition, more families are more inclined to either rent or live with friends or relatives. It is evident, low-priced, smaller housing solutions can start to reach many.

6.2. Relocation Prevalence

The prevalence of relocating is striking. Whether a job promotion, tired of living in the same place, statistics show that people move frequently and do not stay at one particular residence long. One City Data blogger wrote, “For the past 10 years, I haven't stayed in one spot for longer than 11 months. I used to move every 4 or 5 months. Nowadays, I've slowed down, and only move maybe once every 10 months or so on average. I figure someday I'll buy a house and that'll be the end of all these rapid

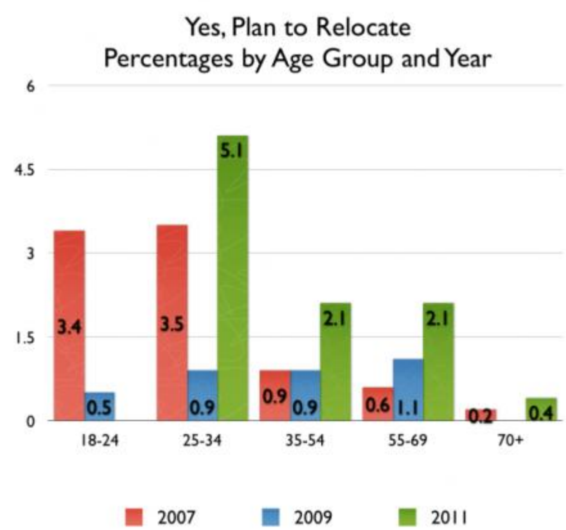


Figure 26: Relocating Plans by Age Group and Year
By Bob Adams in Slider, Statistics

moves. Until then, I'm enjoying my mobility. I never complain about where I live because if I don't like it, I just up and move" (p.1). There are several indicators of the prospective outlook for homes evident from this blog alone. The blogger has not resided in a single home more than 11 months. According to other statistics this is true of many others when we note that nearly one out of every five Americans move in an average year (Jasper, 2000). This is the lifestyle of some; thus one of the questions that should be addressed is how to accommodate frequent movers with a home that moves with them. "Affordable to build or buy, inexpensive to maintain, energy efficient and environmentally conscious, small homes are the housing of the future… "Smaller living units may be detached, site-built, single-family homes; manufactured homes" (Tremblay, p. 1).

6.3. Small Homes

What one calls a home varies in size around the world. From structures without complete enclosure to the environment, to one room huts, to some families that live in homes that have less frequently occupied guest rooms, overall, we have seen homes grow with wealth, especially in Western countries. Dating back to 1970, the average size of the American home has grown by fifty percent. A bigger home has been the trend over the past forty years, yet, as of recently, this trend has been slowly

Figure 27: Tiny Surf Shack Home
By Molecule Homes, an architecture duo of Santa Cruz, California

counteracted by the trend to go smaller. Tremblay writes, “Many individuals and families have discovered that small houses best meet their needs and lifestyles... A general misconception exists concerning small spaces and quality. To some people, small connotes cheap or less desirable. Small spaces in fact can be jewel-like, ideal places for living” (p. 1). Other factors than a growing trend in the population of recent graduates and single families are indicative of the surge to look into a smaller home and include benefits such as trading quantity for quality especially relative to materials, opting in for a smaller and sometimes no mortgage, having a smaller living environment that costs less to maintain and air condition, and alleviation of the depreciation factor commonly associated with a bigger, less energy efficient home.

Others that live in a smaller home have gone on further to expound on their experiences most of which have increased psychological morale and family bonds: smaller homes increase the likelihood of families partaking in more family time, a smaller home inspires one to get to know neighbors in a more intimate fashion, smaller homes increase home security and a feeling of safety, a smaller home increases options for residency immediate to infrastructure, a smaller home increases parental awareness because of the immediate proximity of rooms, and smaller homes increase health because it does not have as many unoccupied areas within it that could harbor dust. The benefits of smaller homes are effective solutions for housing individuals affected by natural disasters. One major hindrance of conceiving a smaller home alternative over a bigger home is that most building codes require a minimal square footage. Building codes change every year, thus presumably a factor that will be dealt with as more and more people seek smaller homes. Nevertheless, smaller homes should make living easier, more economical and more efficient.

6.4. Housing Alternatives: Modular Construction

Many of the concepts of holism, minimalism, and embodied energy can all be tackled by modularity. Modular construction is prefabricated, mass assembled components unified to make a whole. More emphasis has been placed on modular construction as builders, developers, architects, engineers and public works agencies are looking for innovative construction techniques and project cost savings. The modular house of the future will encompass all of this and more. Modular constructed buildings can lend themselves to short-term, immediate response structures associated with emergency relief or military housing, and for long-term, permanent structures such as health care and industrial facilities, and fast food restaurants. Principles for modularity, design specifications and rubrics can all be specific to a particular modularly constructed building type.

Modular construction typically has the following advantages (Wise geek.Reffit, 2007):

- Faster completion because the building frame and site are typically completed simultaneously.
- Indoor construction which isn't halted by weathering and rain days, and which also promotes a healthier environmental impact; any chemicals used to produce products of the modular construction are kept within the confines of the factory where it is being fabricated.
- Modular construction promotes flexibility in relocating, adding rooms, and cost ramifications.
- Materials are wasted less in modular construction. Mass production typically means the same parts are constantly built. As a result, the manufacturer has records of exactly what

quantities of materials are needed for a given job. In contrast, waste from a site-built dwelling may typically fill several large dumpsters.

Salomon writes, “It doesn’t take a PhD in physics to see the energy cost is a direct correlation of cubic feet; It is easier to reduce the embodied energy of a house by making the house smaller than by searching for low-embodied energy materials” (Salomon, p. xii). The bigger picture of the modular movement should be counteracting the long-term effects that bigger structures have on the environment with rewards of cost and energy reduction, presented holistically through modularity.

7.0 Design Principles for Small Dwellings

As defined by James Gauer, author of the New American Dream: Living Well in Small Homes, this section outlines the characteristics that good dwellings should have:

7.1. Proportion

Proportion is sensorially depicted by humans. Thus, it is important that it is effectively implemented in a structure. The human eye is keen to orthogonal shapes such as rectangles and squares. In a well proportioned space the dimensions all relate. Proportion is intuitively sensed and good proportions can make a smaller space seem bigger than it actually is. According to James Gauer, "proportion establishes a coherent system of visual relationships in building and spaces of any size. It bestows aesthetic consistency on disparate functional and technical components" (p. 28). Proportion can be derived from interlocking spaces and strict hierarchy.

7.2. Modularity

Previously discussed, modularity is the modern method of achieving proportion and economy simultaneously. Humans can identify and relate to modularity because it is derivative of the proportions of the human body. Modularity is usually compromised of prefabricated components which regulate the proportions of systems as a whole.

7.3. Scale

"If a small house is to look like something more than a human-sized wren coop an architect with a keen eye for scale must study the size and placement of ceiling, doors, windows, stairs, trim, and all the other elements that add up to an architectural whole" (Gauer, p. 81). The scale of FEMA trailers are not conventional; thus they do lend themselves to modular manipulation.

7.4. Transparency and Spatial Layering

Changes in ceiling heights, flooring, and materials can suggest layering. The human perception is heavily driven by what the eye senses. The sense of a bigger space can be achieved without increasing square footage by increasing interlocking spaces that open to each other and to nature. Optimal transparency in a structure allows sight from the front, back, and side; panorama views should be achieved through layering. The open plan creates spatial layering that eliminates fully enclosed rooms. In an open plan, smaller spaces can defined by cabinetry and floating wall planes; Architect, Mies van der Rohe was a mastermind at creating this illusion. Transparency can be heavily influenced by the incorporation of glass. Careful consideration of transparency and spatial layering can transform interior spaces and promote a consistent relationship between interior and exterior spaces.

7.5. Hierarchy and Procession

Usually in smaller structures, only one space can be large and all other spaces must be deferentially smaller. Excess space is to be avoided in this hierarchy. According to Gauer, "the differences between spaces, whether functional or symbolic, indicate their relative importance in a dwelling's composition and therefore in its hierarchy" (p. 108). The living or multipurpose room usually is the largest room in a layout because it lends itself to the most traffic and activity. Space can be defined both two dimensionally and three dimensionally. Thus, volume comes into play. Entering directly into a space prevents procession. Thus decreasing the sensory illusion of a bigger space.

7.6. Light

Light is important in good design. Taking advantage of natural light makes design perceptible. The natural cycle of the sun can produce advantageous results with cross ventilation, passive heating technologies, illuminated voids, and shade and shadow. The orientation of openings in a structure helps manipulate light. The primary space of a dwelling should have the best orientation to daylight.

7.7. Multifunctionalism

A program of spaces of a structure designates certain square footages distinctive to each space's role. Until the Renaissance, families resided in homes that had one room that was designated for eating, sleeping, cooking, bathing, and socializing. Partitions and screens were used whenever privacy was needed. Open plans increase function in a smaller square footage, prompting users to do more with less.

7.8. Simplicity

Simplicity is essential in a small structure. Overdecoration can make the space feel crowded instead of conveying the perception of depth. Variation in door and window sizes is an example of designing against simplicity. "A small house or apartment is no place to be fussy… A clear, straightforward plan with a single strong architectural idea will make the most of limited space" (Gauer, p. 177).

7.9. Economy

"If three rooms meet the requirement of your family, or if they are all you can afford, why build more?" (Gauer, 2004, p. 191).

Implementation of these philosophies of design are essential in effectively designing more permanent structures for emergency relief.

8.0 Design

8.1. Stages and Characteristics of Disaster Recovery

Most Americans cannot even imagine the thought of a natural disaster taking everything from them at an abrupt instance, so people usually are not prepared for these unexpected occurrences. The main goal of this study is to implement measures and infrastructure for those affected by natural disasters that aid in immediate, first prong response of recovery. As defined by Bumgarner, referencing writers Kate and Pijawka, there are four stages or prongs of disaster recovery which include:

- 1st Prong: Emergency Period, spans from a couple of days to a few weeks. This is the period immediately following the response phase of emergency management and constitutes the portion of recovery that is guided by the EOP, Emergency Operations Plan, which had been activated due to the emergency.
- 2nd Prong: Restoration Period, repairs to utility services made, debris is removed, evacuees are returned to the community and to their homes, and the various damaged homes and buildings are repaired. This period of recovery can take from weeks to months, depending upon the reparative resources available.
- 3rd Prong: Reconstruction-replace Period, concerned with the rebuilding or replacement of destroyed structures and other capital possessions. This period can take months to years.

- 4th Prong: Development Period, long after the disaster when the community sees fit to place the calamity in its proper historical perspective. Community seeks to improve itself and recovery is complete.

Of these four prongs, the essence of this design is foremost concerned with the first prong, Reconstruction-replace and Development. Natural disaster occurrences can often be anticipated by weather forecast, yet the severity, destruction and aftermath of these disasters seem to always take nations by surprise. To name a few, time, nature, and weather patterns have revealed the dynamics and prevalence of natural disasters. Spanning from 2001-2012, fifteen severely catastrophic natural disasters have occurred in the United States. Yet, some still are caught off guard by their occurrences. At other times, natural disasters are unavoidable thus emergency management preparation is imperative.

As discussed earlier, government agencies are tasked with both preliminary and post matters referencing natural disasters, but natural disaster after disaster has proven that the government cannot do it all by themselves. Stages of natural disaster recovery often spur rebuilding or involves temporarily, and sometimes, permanently re-housing families. With this in mind, bringing aid to affected individuals after and during each of the aforementioned prongs helps reignites the psychological sense of belonging that likely has been stripped from these individuals. After adversity, many people seek help.

Those affected by natural disasters should not be burdened with finding shelter. A predisposed plan can effectively combat challenges that may arise when trying to help the affected through this transition. In the instance of Hurricane Katrina, most of the help, which came in the form food and housing, did not reach affected individuals because infrastructure was destroyed or blocked. Although Hurricane Katrina presented far more extreme circumstances than any of the other natural disasters that occurred in the United States between 2001 and 2012, analyzing the flaws and preparing for the worst, as such, can effectively aid in emergency management.

It is important that a housing solution for displaced victims addresses the psychological and well-being concerns of families. Often times after a natural disaster, families are separated and dispersed to various emergency relief shelters. It can be generalized that this happens to swiftly aid victims and to promote safety. An all-terrain deployable, prefabricated modular, emergency shelter could alleviate this psychological strain, allowing families to focus more on the Reconstruction-replace Prong.

Furthermore, preparation can include a longer term plan that brings communities together after a natural disaster. Individual homes will have been destroyed. Thus, the subconscious notion of solitary and confined dwellings can be revisited. Introduction of communal arrangements can drive the latter of the Reconstruction-replace Period, spilling over into the core of the Development Period. A more harmonious relationship is essentially established amongst nature and community in a minimalistic manner, thus encouraging a cultural way of life that once existed yet has been largely abandoned in the modern society.

This study proposes information to supplement the design of an emergency relief shelter that uses minimalistic practices and design features to addresses the concerns of a first response housing solution for displaced individuals after natural disasters. A longer term, broad scope of this design could be that it promotes an alternative for a downsized, permanent dwelling that is advantageous relative to the environment and potentially spurs community development.

8.2. Cost Analysis

The overall cost of mass-producing the envelope of the unit is approximately $909 per displaced home and is based on the following figures of displacement after a natural disaster and FEMA's current allotment for natural disaster relief:

Cost Analysis

- FEMA currently allots $100,000,000 per year for Emergency Food/Shelter (Department, p. 154)
- An analysis of Major Disasters over an 11 year span, 2001-2012, was made.
- This gave us an idea of the total budget FEMA allotted over 11 years:

  1000,000,000 x 11 = $1,100,000,000 over 11 yrs
- Over this 11 year span, there were approximately 1,210,058 Damaged/destroyed homes.
- When dividing this total displaced, 1,210,058, into the total budge over 11 years, $1,100,000,000 / 1,210,058 = that gives us approximately $909 per displacement/home.

- Each system will be for 1-4 persons or an average of 2 people. 2 x $909 = $1818. If reused 4 times, the total figure from this cost analysis delivers an estimate of $7272.00.

Uncontrollable Variables

- The FEMA budget changes on a yearly basis.
- Storms are unpredictable.

  The $909 mass production figure is a ballpark estimate.

Approximate Number of People Displaced and/or Homes Damaged by Natural Disasters in the United States from 2001-2012						
Year	Disaster	Fatalities	Damage	Article	Location	Approx. # Displaced; damages
2012	Cyclone	109	$75,000,000,000	Hurricane Sandy	Eastern United States	131,327+
2011	Tornado	160	$69,000-3,000,000,000	2011 Joplin Tornado	Joplin, Missouri	7,000 Homes destroyed; 850 damaged
2011	Tornado	346	$10,000,000,000	April 25-28, 2011 Tornado outbreak	Alabama, Tennessee, Mississippi, Georgia, Arkansas, and Virginia	23,553 homes damaged and destroyed
2011	Flood	20	$2 to $4 billion	2011 Mississippi River Floods	Mississippi River Valley	1,300 Memphis and Tennessee 24,500 Mississippi& Louisiana; 200 Missouri
2010	Flood	20		June 2010 Arkansas floods	Albert Pike Recreational Area near Langley, Arkansas	
2009	Tsunami	31		2009 Samoa earthquake	American Samoa and nearby islands	3,000 homeless
2008	Tornado	59		2008 super Tuesday tornado outbreak	Tennessee, Arkansas, Kentucky, Alabama, and Illinois	Over 204 homes destroyed
2007	Fire	14		California wildfires of October 2007	California	1,500+ homes destroyed
2005	Cyclone	1,836	$84,000,000,000 – $120 billion	Hurricane Katrina	Florida, Louisiana, Mississippi, Alabama	Approx. 288,700 homes destroyed;
2005	Cyclone	120	$10,000,000,000	Hurricane Rita	Louisiana	275,000 according to the Red Cross
2005	Tornado	25	$92,000,000	Evansville Tornado of November 2005	Missouri, Indiana, Kentucky, Ohio	3,328+ homes & trailers destroyed
2004	Cyclone	124	$19,000,000,000	Hurricane Ivan	Texas, Florida, East Coast	18,560+
2004	Cyclone	49	$9,000,000,000	Hurricane Frances	Florida	
2004	Cyclone	10	$15,000,000,000	Hurricane Charley	Florida	123,292+ homes
2001	Cyclone	41	$5,500,000,000	Tropical Storm Allison	Texas, Louisiana, Pennsylvania	30,000 homeless; 2,744 homes destroyed
						1,210,058+

Figure 28: Natural Disasters List,
Yahoo Voices and Wikipedia

8.3. Design Methodology

8.3.1. Design Criteria

A list of criteria was established for development of the emergency relief structure. Focus on this criteria throughout the design process promoted consistency, increased thoroughness, and ensured that the design was optimized for its intended, immediate purpose.

- The system should be prefabricated and modular.
- This system should incorporate sustainable building materials that are native to Alabama.
- The system should be low cost and modular.
- The system should optimize packaging.
- The system should optimize shipping.
- The system should be easy assembled and disassembled.
- The system should be passively ventilated.
- The system needs a temporary source of water.
- The system should provide a way for occupants to clean themselves and pass waste.
- The system should be adaptable.

8.3.2. Modularity and Tongue & Groove Connections

The design of the system is derivative of a modular 4' x 8' grid. The 4' x 8' grid is common in building construction because building materials, especially sheathing, come standard in this size. For example, the standard size of plywood sheets and gypsum board is 4' x 8'. In addition to material usage, the 4' x 8' grid is used because its dimension lends itself to transportation on a long bed pick-up truck. This would be very convenient for reaching areas that typical 45 foot trucks cannot maneuver in because of partial road blockage.

Figure 29: Long bed pickup truck transporting plywood

The floor plan of the emergency relief system is approximately $152ft.^2$ and accommodates 1-4 persons. According to the United States Census and the America's Families and Living Arrangements, in 2010, the average household size was 2.6 persons. Furthermore, the system accommodates 1-4 persons because its minimal square footage will only lend itself to providing distinct sleeping arrangements, and also provide hygiene amenities, without jeopardizing the comfort of its inhabitants. In the event of a family that exceeds four persons, an additional system could be deployed. The envelope of the system is derivative of 12, 4' x 8' wall panels. The layout of the plan is: a double bed which could be ideal for a couple, a bunkbed which could provide sleeping quarters for two children, a paneled dresser with four compartments, and a clothes hanging rack, a shower and a toilet; these items are shipped with the immediate response system. The floor plan was designed to allow its inhabitants to feel at home even after the devastation of a natural disaster. The plan maximizes function in the most minimal square footage all while leaving enough room for comfort.

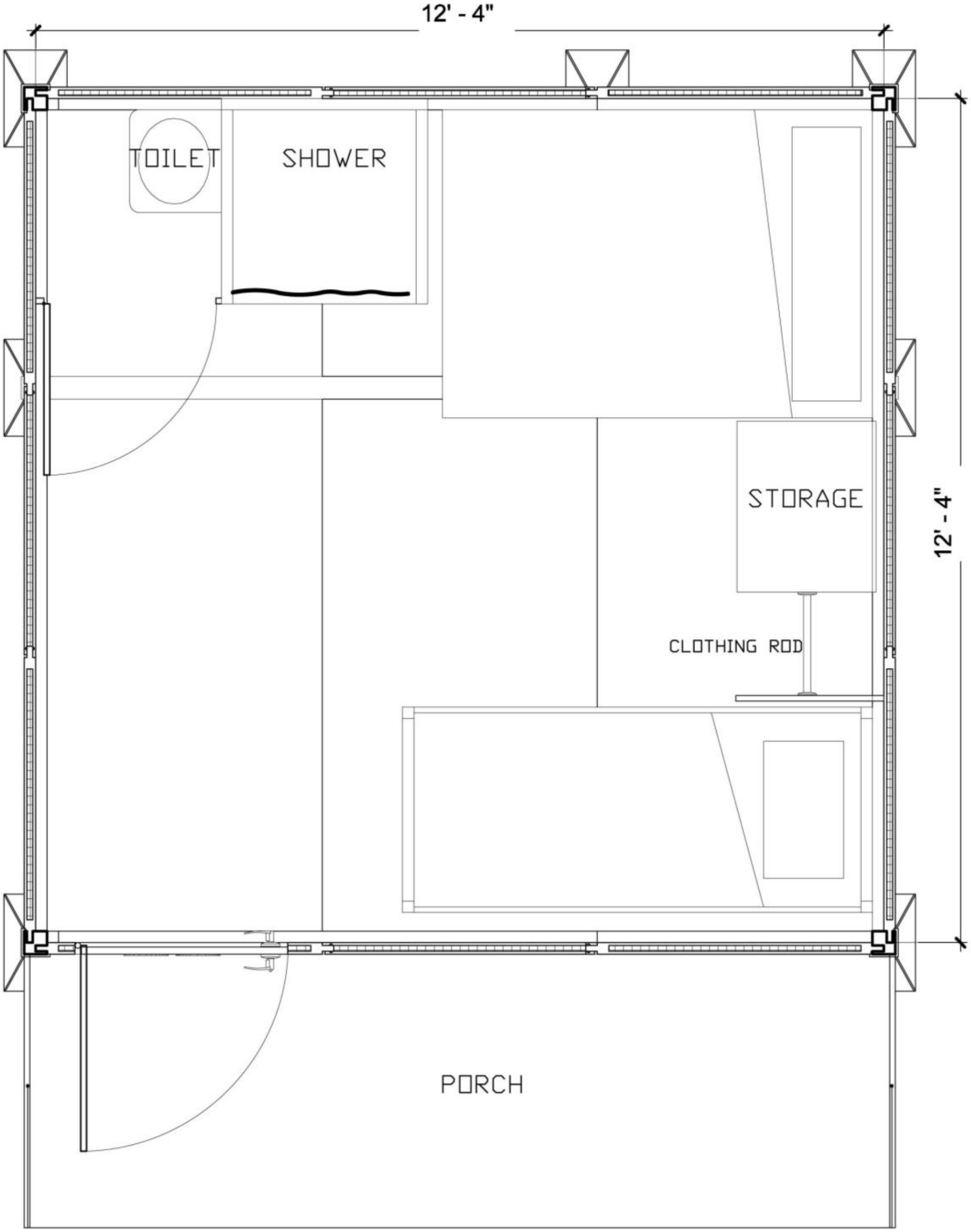


Figure 30: Floor Plan

One will find variance in the wall, floor, and roof panels when analyzing their sizes. Floor panels must carry more weight than roof panels, thus the only difference in the floor and roof panels is thickness. The wall panels are 2" thick, the floor and frame is 4" thick and the roof panels are 2" thick. The wall panels are structural and along with their tongue and groove connections, eliminate the need for intermediate columns.

The emergency relief system is designed to have friction fit tongue and groove connections. Tongue and groove connections are ideal because they are inherently strong connections and they allow assembly without tools. The tongue and groove allows for fewer detail connections and members, because panels and members snap into place; this makes every aspect of the emergency relief system intuitively easy to assemble. The roof system is 2 /12 sloping to a height of ten feet, thus the only equipment needed would be a ladder. The small footprint of this system and its volume makes it ideal for efficiency and increases its comparability to other emergency relief system currently being conceptualized and/or marketed.

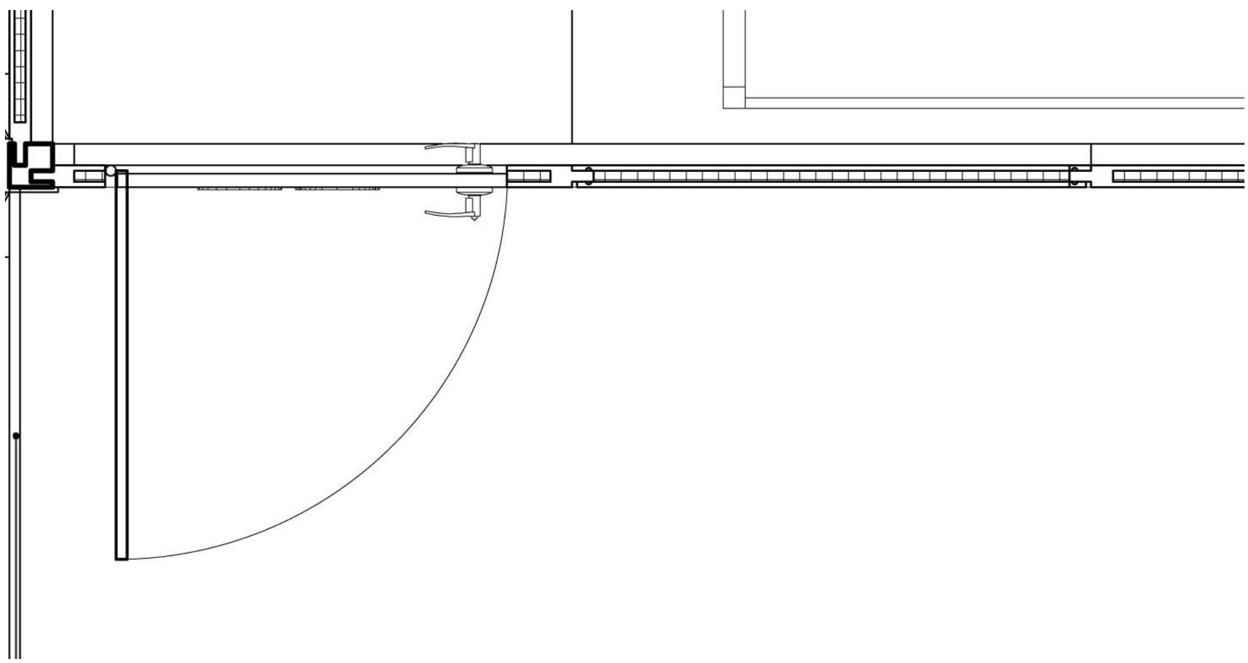


Figure 31: Tongue and Groove Connection at Door

8.4. Composition and Materials

The panels of the emergency relief system are all of the same composite. The panels of the emergency relief system are an extruded Structural Insulated Panel (SIP) exterior with a strong bio-fiber, structural core. The Structural Insulted Panels are made of a fiber-reinforced polymer or plastic (FRP) and CeraMix™ hard shell coating.

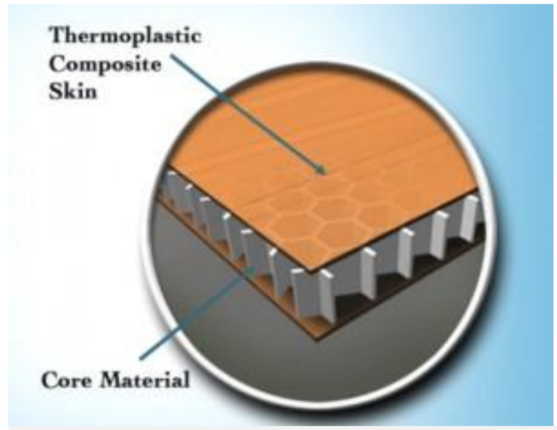


Figure 32: Structural Insulated Panel

SIP is extremely durable, strong and energy-efficient, thus why it is often used in building construction (Toothman, p. 4). SIP is an energy-efficient and offer a cost-effective alternative to traditional construction that reduces amounts of waste and labor, produces less expensive heating and cooling equipments inside the structure, produces flatter surfaces to work with, and can be manufactured using green friendly techniques with no CFC's or HCFC's (Toothman, p. 2).

Fiber-reinforced plastic is a composite material made of a polymer matrix reinforced with fibers. The fiber-reinforced plastic and CeraMix™ composite is an environmentally friendly, non-hazardous material that has significant strength and structural reinforcement characteristics, it is 100% water proof, chemical resistant, does not rot or decay, and is thermally stable.


Figure 33: CeraMix

(Convertible. n.d. p.1). In addition, FRP and CeraMix™ coatings provide impact resistance, reflects 98% of radiant energy, is fire retardant, does not fade or crack, and reduces manufacturing costs (Convertible. n.d. p.1).

Bamboo is a natural, non-food organic fiber, resource, which has strong tensile strength equal to mild steel (Convertible. n.d. p.1). The bamboo makes up the bio-fiber structural and insulating core of the panels of the emergency relief structure. The bamboo bio-fiber core allows for the use of fewer strengthening agents because of the natural inert strength of bamboo. This insulated core helps control the temperature within the structure. According to the Convertible Structure Solutions, Inc., the bamboo bio-fiber is 90% green.

Almost every aspect of the emergency relief system is made from the SIP and bamboo bio-fiber composition, excluding the extruded aluminum, structural columns that are located at the corners of the system, and the roof closure inserts. The adjustable footing foundations, per Ablenook Specifications, are also metal components because they come in direct contact with soil and erosion. Adjustable footings allow the height of the system to adapt to uneven terrain.

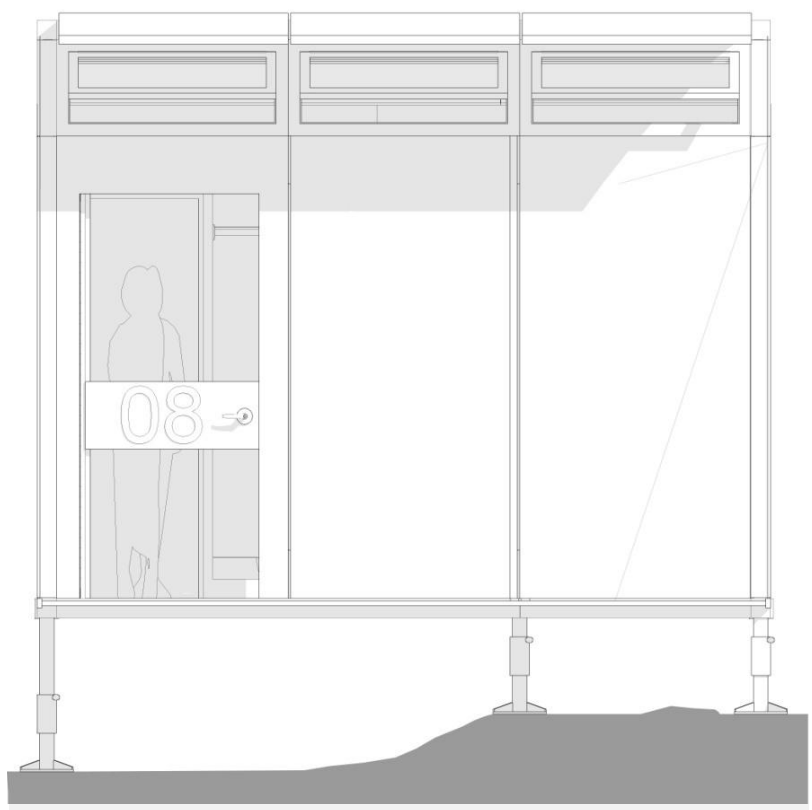


Figure 34: View of Adjustable Footings and Clerestory for Passive Lighting

The emergency relief system also includes other miscellaneous components. The glazing for the front door is frosted High Density Polyethylene plastic. The glazed inserts in the panels are plastic and come premanufactured in their respective panels. The front accent panel is the typical wall panel with a plastic wood laminate finish. Windows are premanufactured and are glass. Sustainability is optimized by taking advantage of opportunities for openings. The window systems act as clerestories and are implemented to take advantage of passive lighting and passive heating and cooling. Inhabitants can rely on natural sunlight during the sunlit hours of the day. The system has two, two feet, overhang attachments that direct water from the structure. The curved overhang is malleable plastic that can be rolled up and unrolled for packaging.

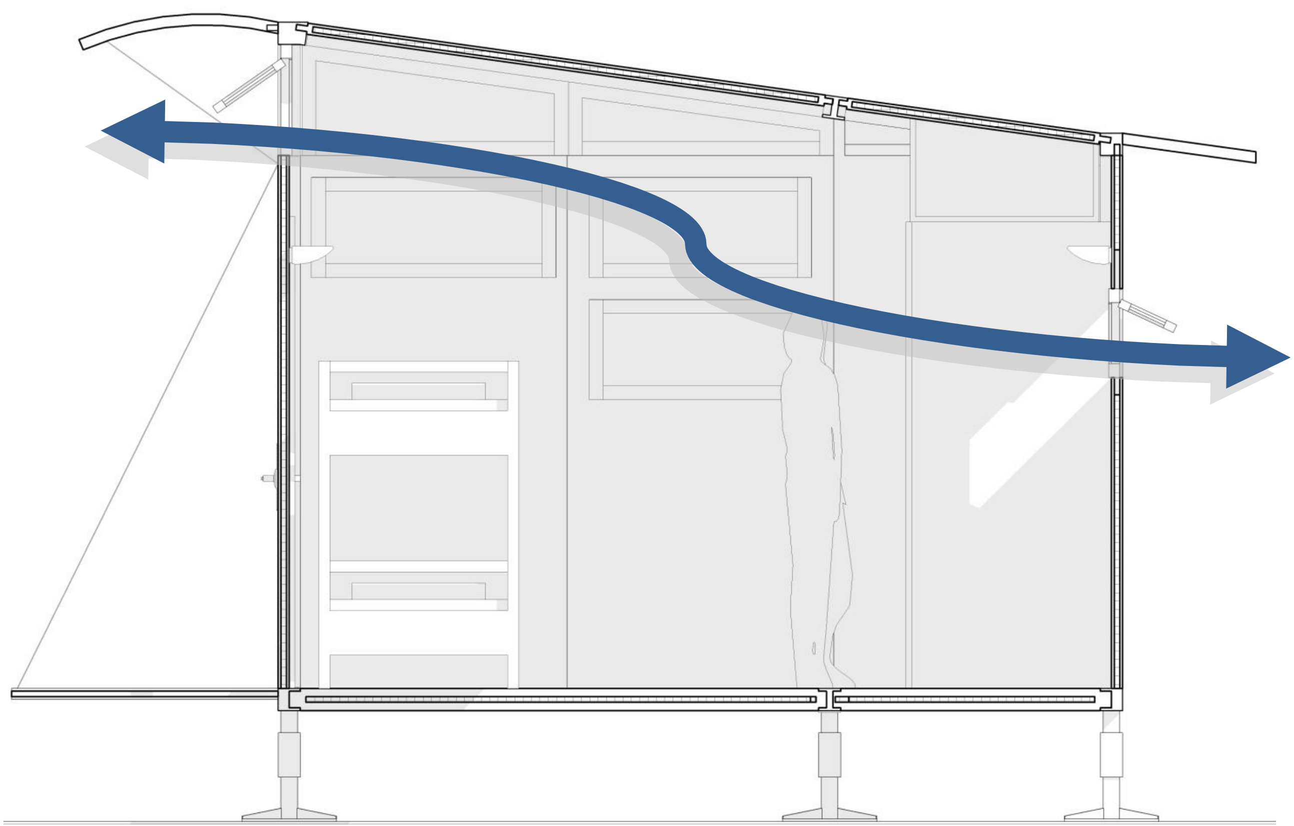


Figure 35: Passive Heating, Cross Ventilation Diagram

8.5. Packing, Shipping, & Distribution

One of the main benefits of modular construction should be that it can lend itself to more efficient packing, shipping, and distribution. This emergency relief structure optimizes the benefits of the flat pack and is ready-to-assemble upon delivery. The members of the emergency relief system are all within confines of eight feet. Thus, the parts can all fit in 4'W x 8'L x 6'H biodegradable boxes. Flat packing makes the system easy to package and ship because of the reduction of bulk. The systems easily lend themselves to being mass-shipped to their site of deployment. Flat packing increases the number of units that can be shipped per truck, allowing more systems to reach more people in disaster struck areas. An entire unit fits within two 4'W x 8'L x 6'H boxes. The standard 45 foot bed of a semi-truck trailer truck is approximately 8.5'W x 45'L x 9'H (Guide to. n.d.). Each system is design to fit within two flat packed boxes. As a result, the standard 45 foot truck can transport approximately five systems.

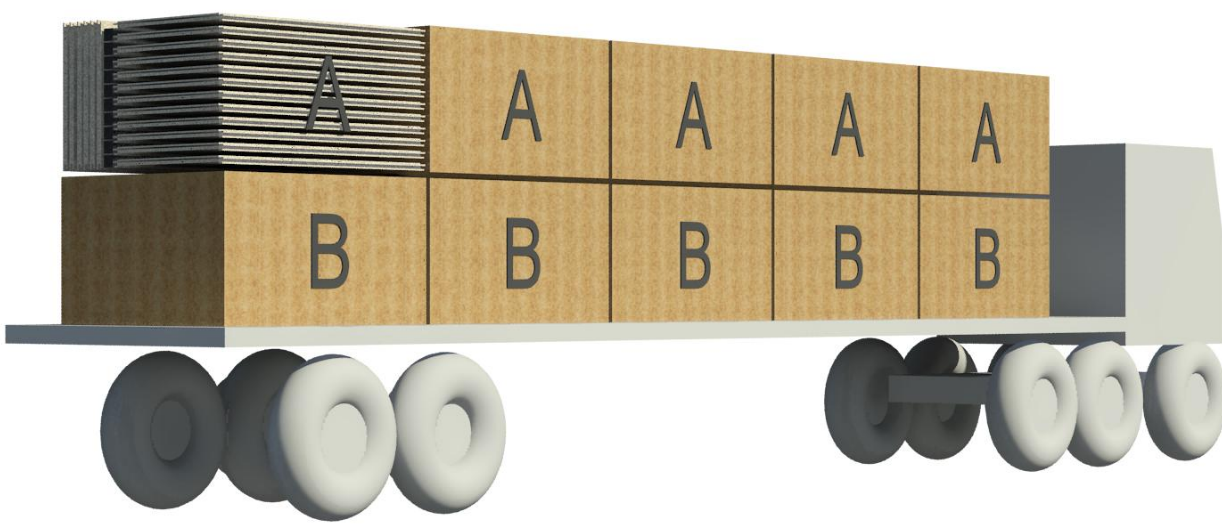


Figure 36: 45' truck transporting systems. Box A shows panels and framing.

Flat packing allows for easy distribution of the systems to site because those responsible for assembly will know that one system per site should have a box "A" and a box "B". Box "A" will be comprised of the wall paneling, floor paneling, and framing members. Box "B" consists of framing members, the water catchment reservoir, the paneled shower and the interior furniture systems.

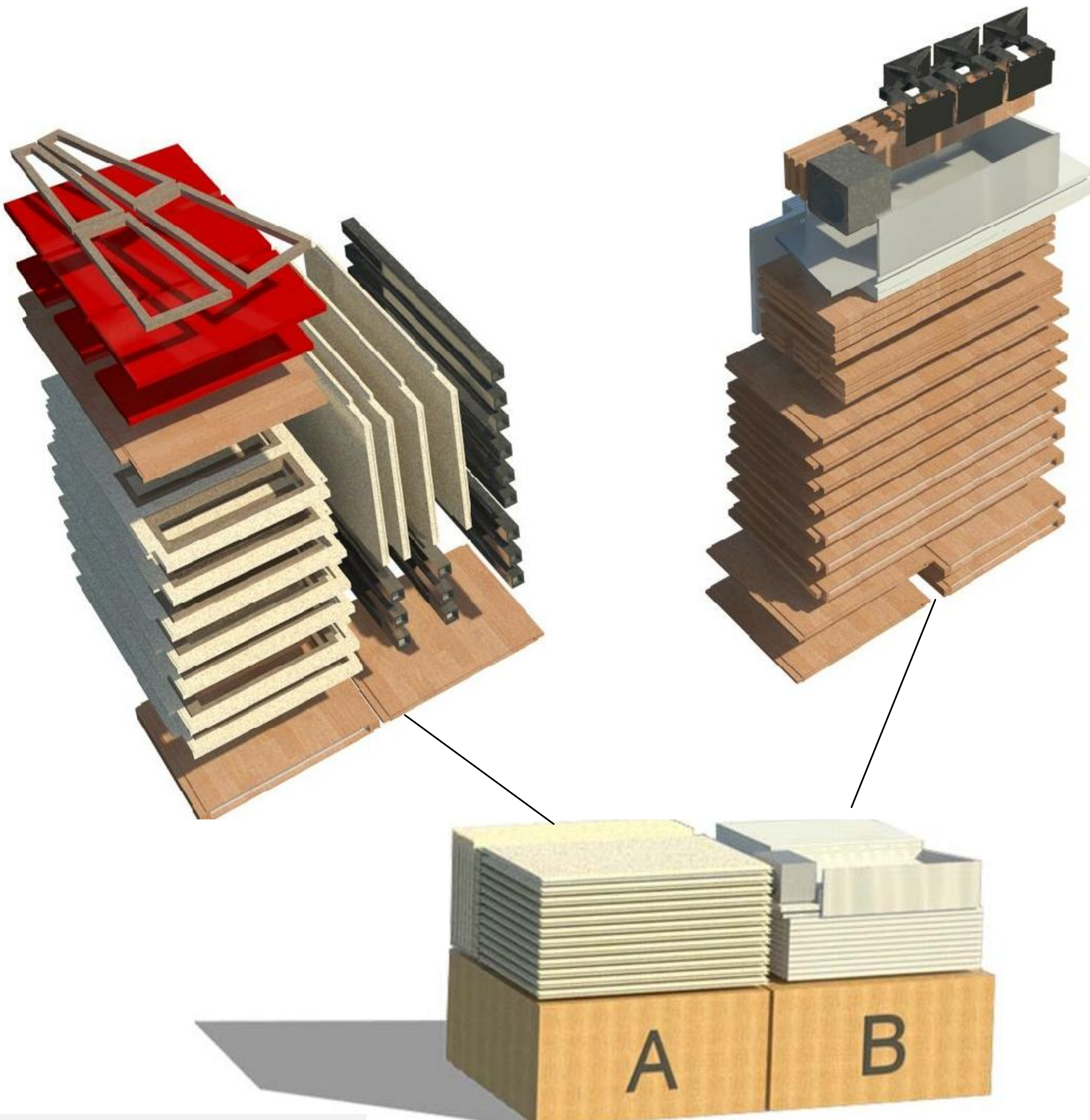


Figure 37: Packaging Content Exploded View

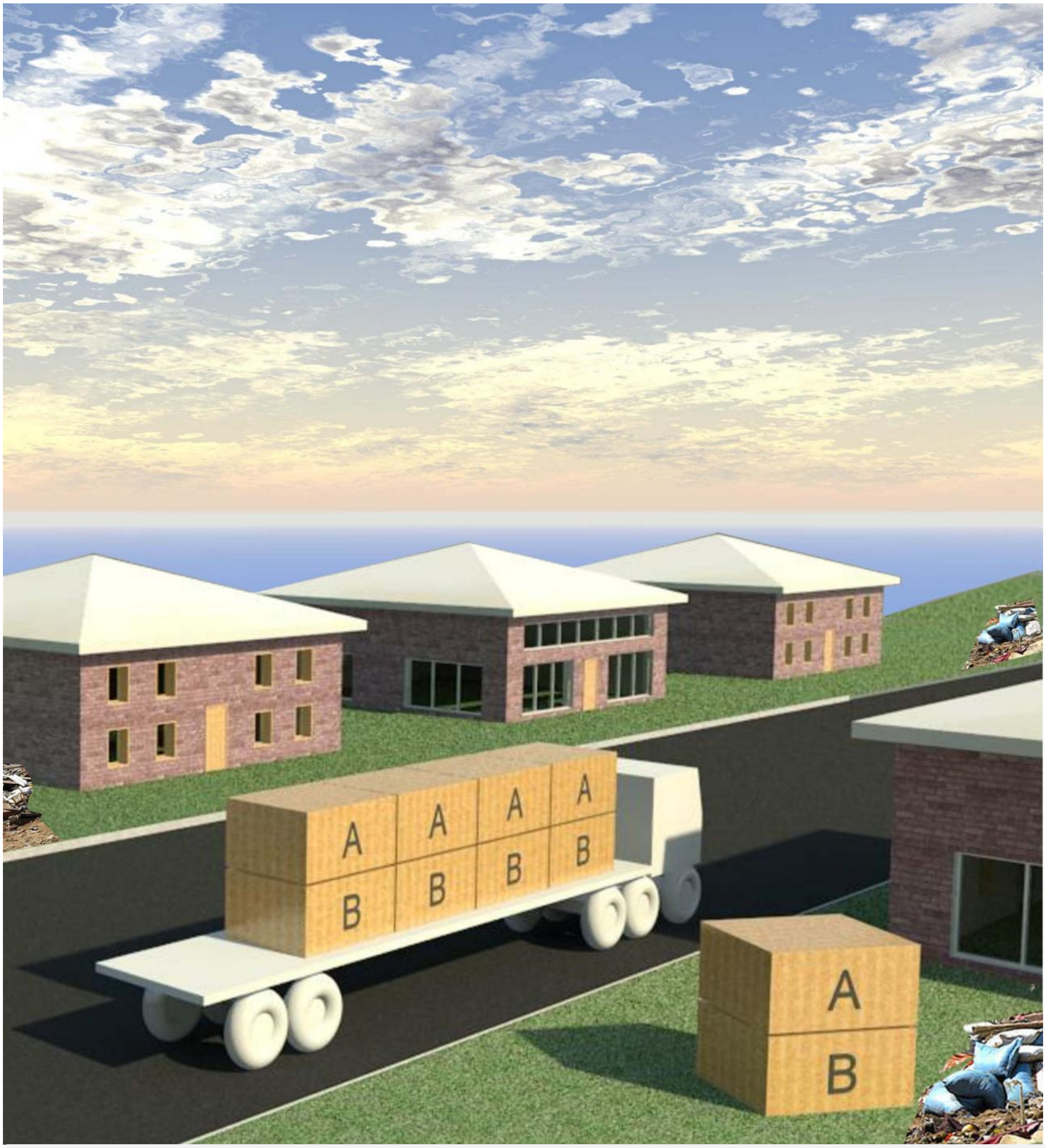


Figure 38: Site Distribution View

8.6. Assembly & Disassembly

Since the components are interlocking and require no tools to assemble, the emergency relief system can be assembled by unskilled labors in a short period of time. The system requires man-power of at least two persons to assemble. Each emergency relief system is packaged with an exploded view and instructions illustrating where each panel interlocks to the next.

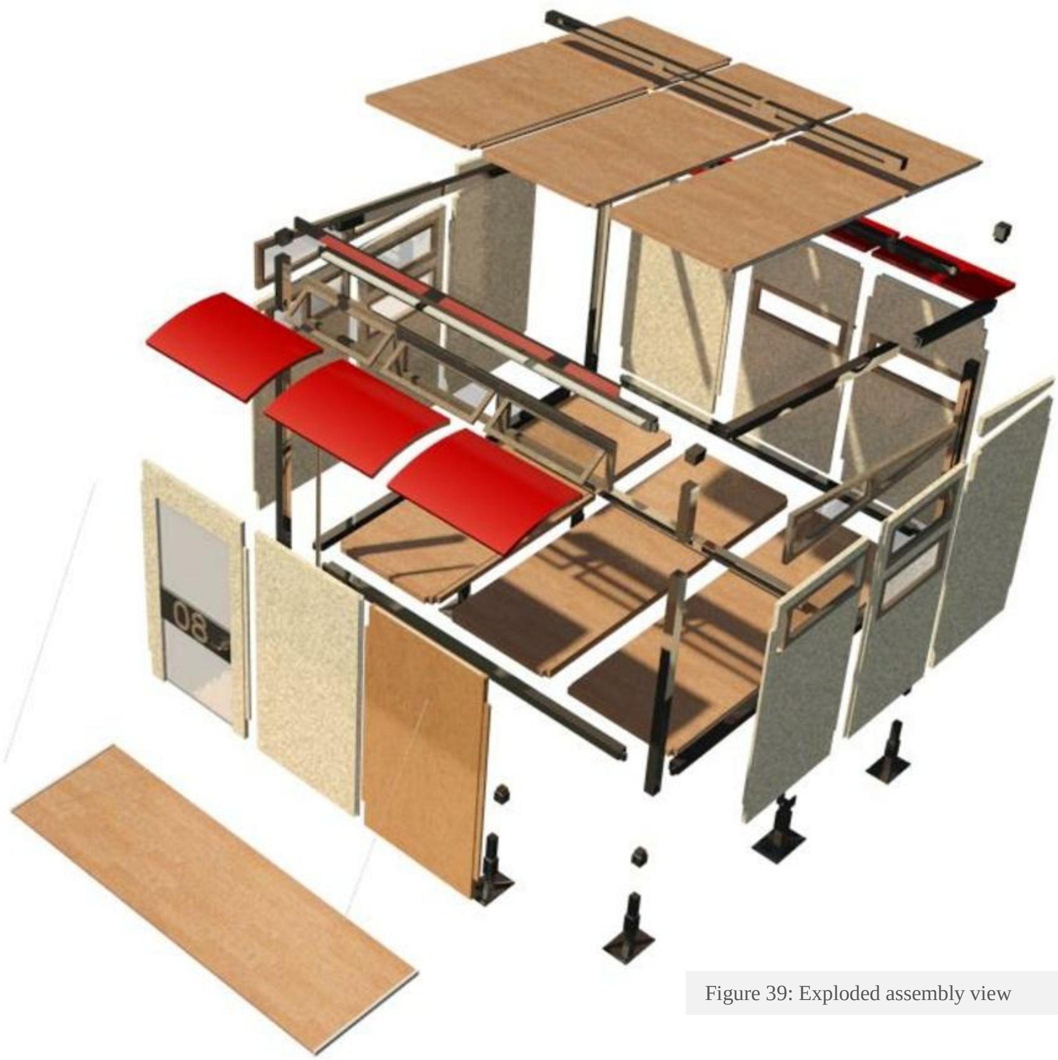


Figure 39: Exploded assembly view

Volunteers would be put in place to aid in assembly of the system. Step 1 of assembly: one would first start with assembly of the footings, lower frame and one front roof and Floor Framing assembly and Step 2 includes installation of the floor panels and remaining floor closure beam.

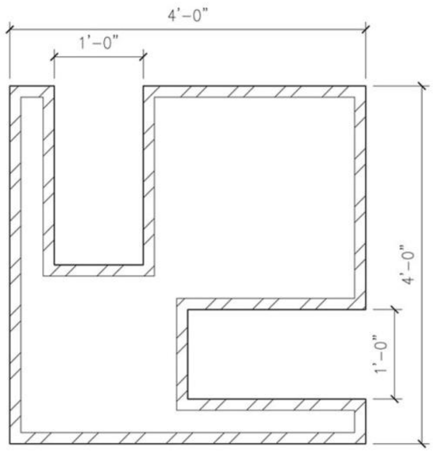


Figure 40: Extruded Aluminum Column Plan Detail

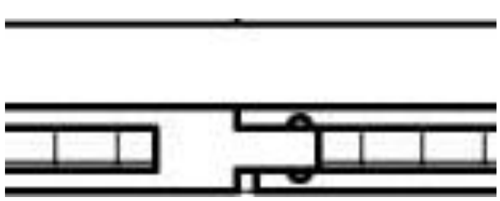


Figure 41: Wall Panel Interlocking Connection Detail

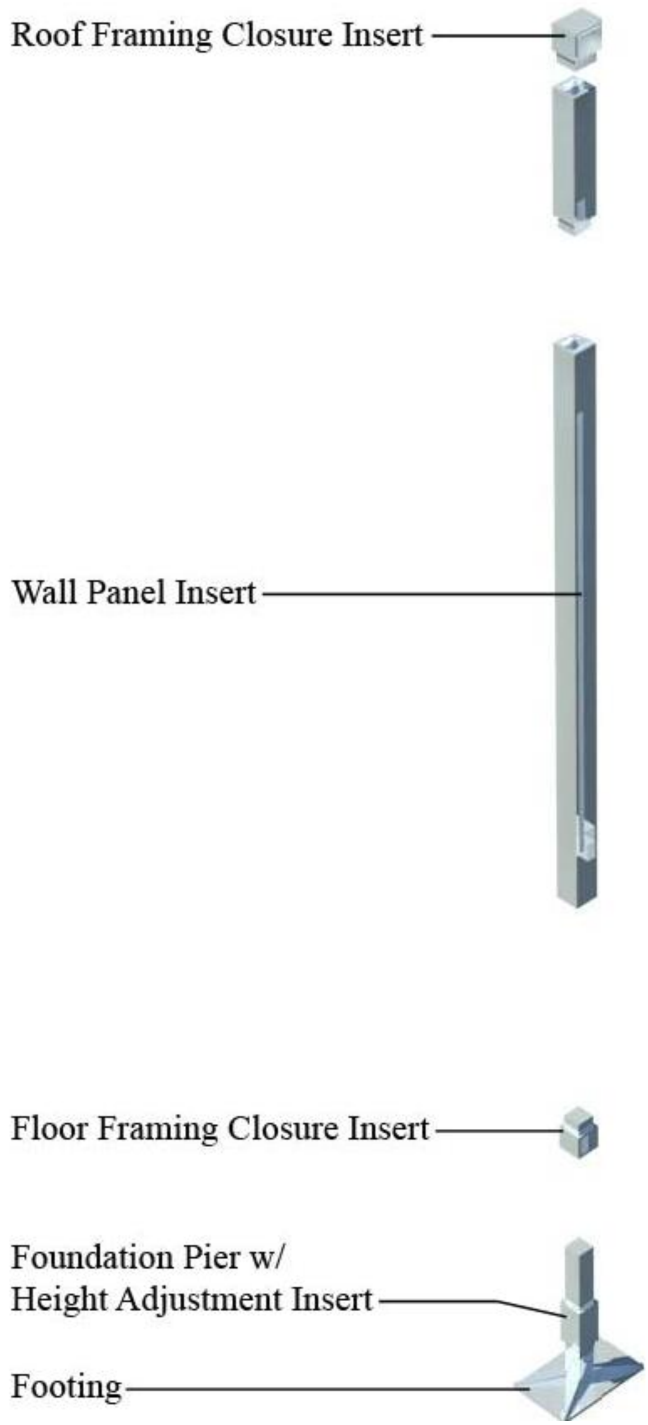


Figure 42: Floor and Roof Framing Detail

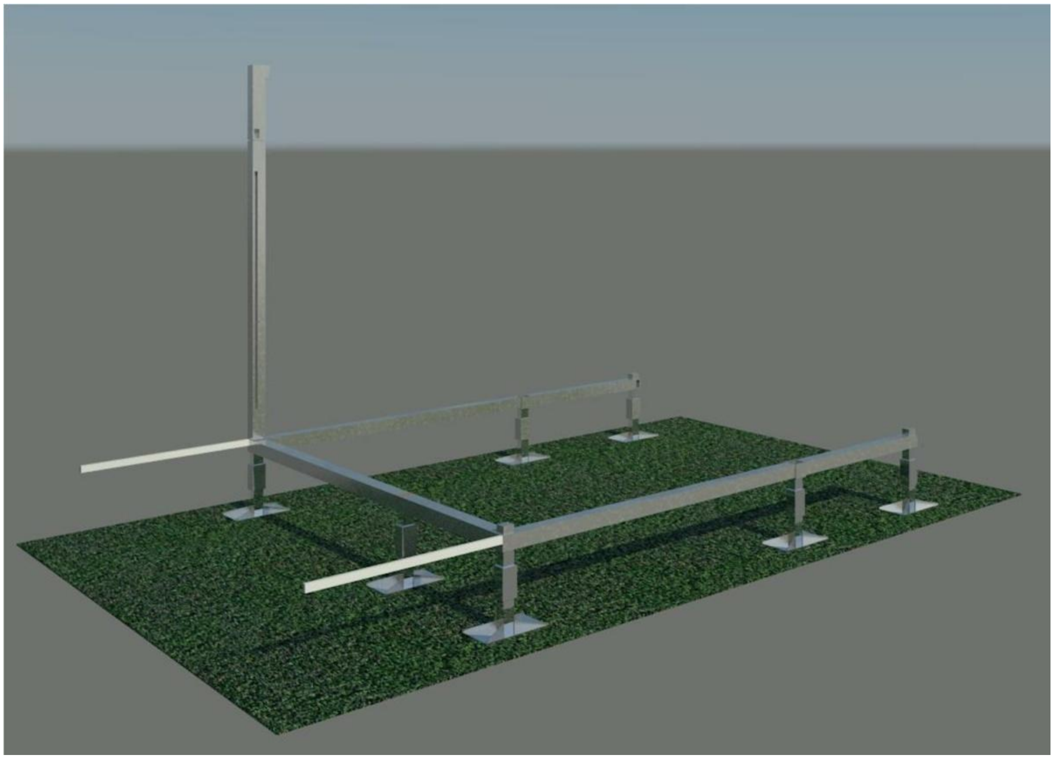


Figure 43: Assembly Step 1

Figure 44: Assembly Step 2

After installation of the floor system, installation of wall panels can began. Step 3: installation of back wall panels and side panels of only one side of the system. Also, the respective wall framing and closures are installed per the given starting side of installation.

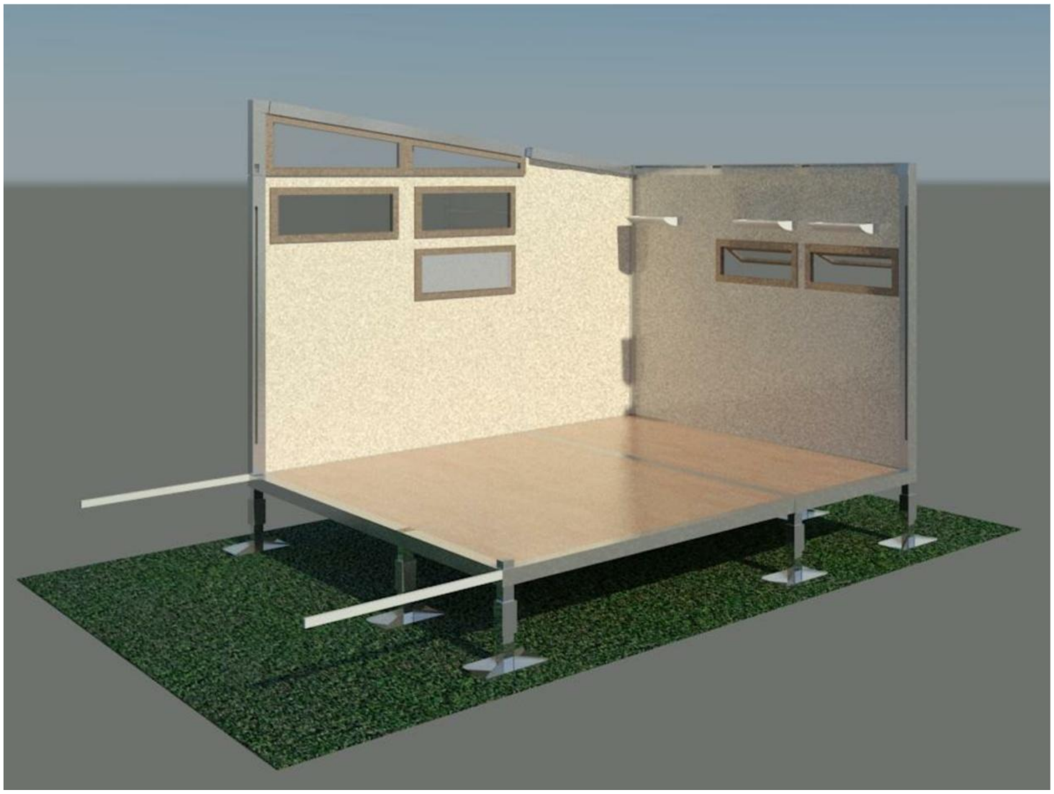


Figure 45: Assembly Step 3

Step 4 includes the assembly and installation of the water catchment system and furniture. Please note that the roof structure supports the water catchment system. Thus, it is not secured into place until after installation of the roof beam in Step 5.

Step 5 includes, the installation of the opposing side panels, the perpendicular spanning roof beam, the back, 4' long roof panels and closure beam, the porch, the front panels, all windows, and then the front 8' long roof panels and closure beam, respectively. Thereafter, the fourth roof insert closure is secured into place. All windows and panels have been installed in Step 5. Lastly, the canopies and overhangs are installed.

Figure 46: Assembly Step 4

Figure 47: Assembly Step 5

The system has an overhang and a canopy attachment on the north and south respectively. These were implemented to help direct water from the top of the building. The canopy attachment is malleable thus it can roll and unroll flat for flat packaging.

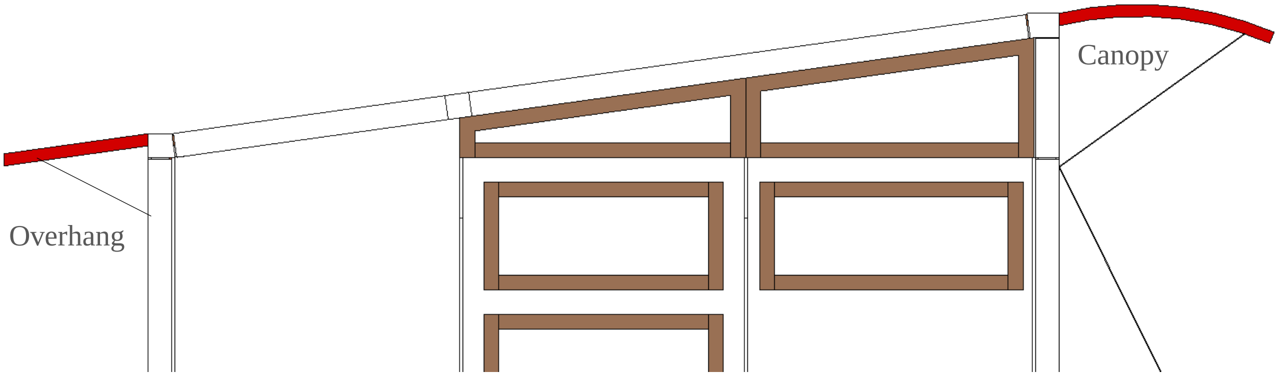


Figure 48: Canopy and Overhang

In addition to the overhangs, the system also has an option porch that can be added on in the future. This porch is 4 feet wide and gives residents a small gathering space outside of their living component.

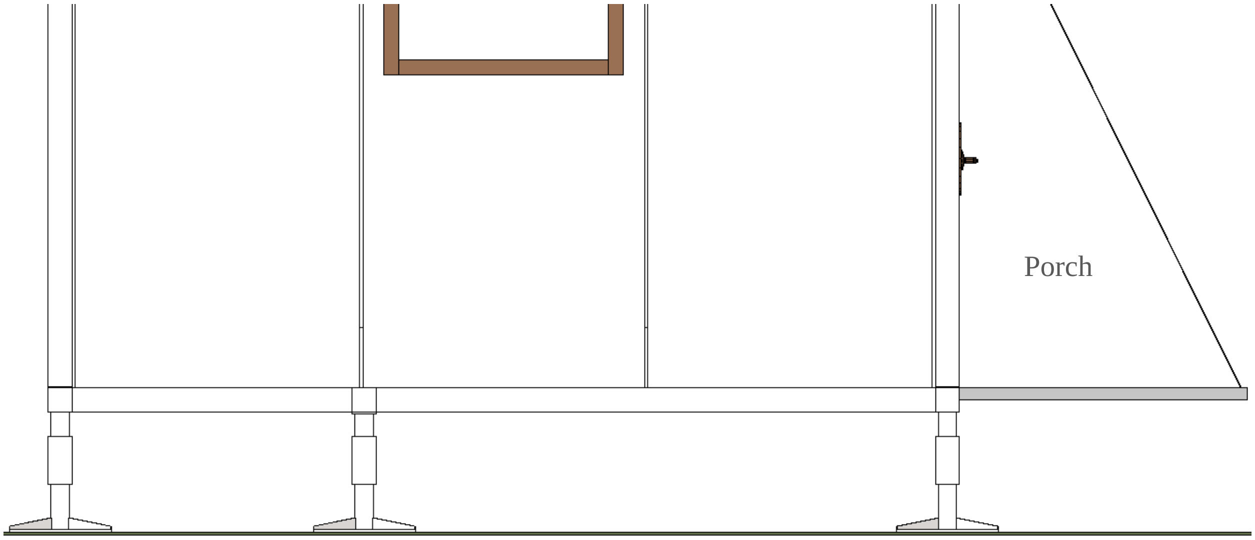


Figure 49: Porch addition

Figure 50: Panel Assembly

Figure 51: Clerestory & Miscellaneous Panel Assembly

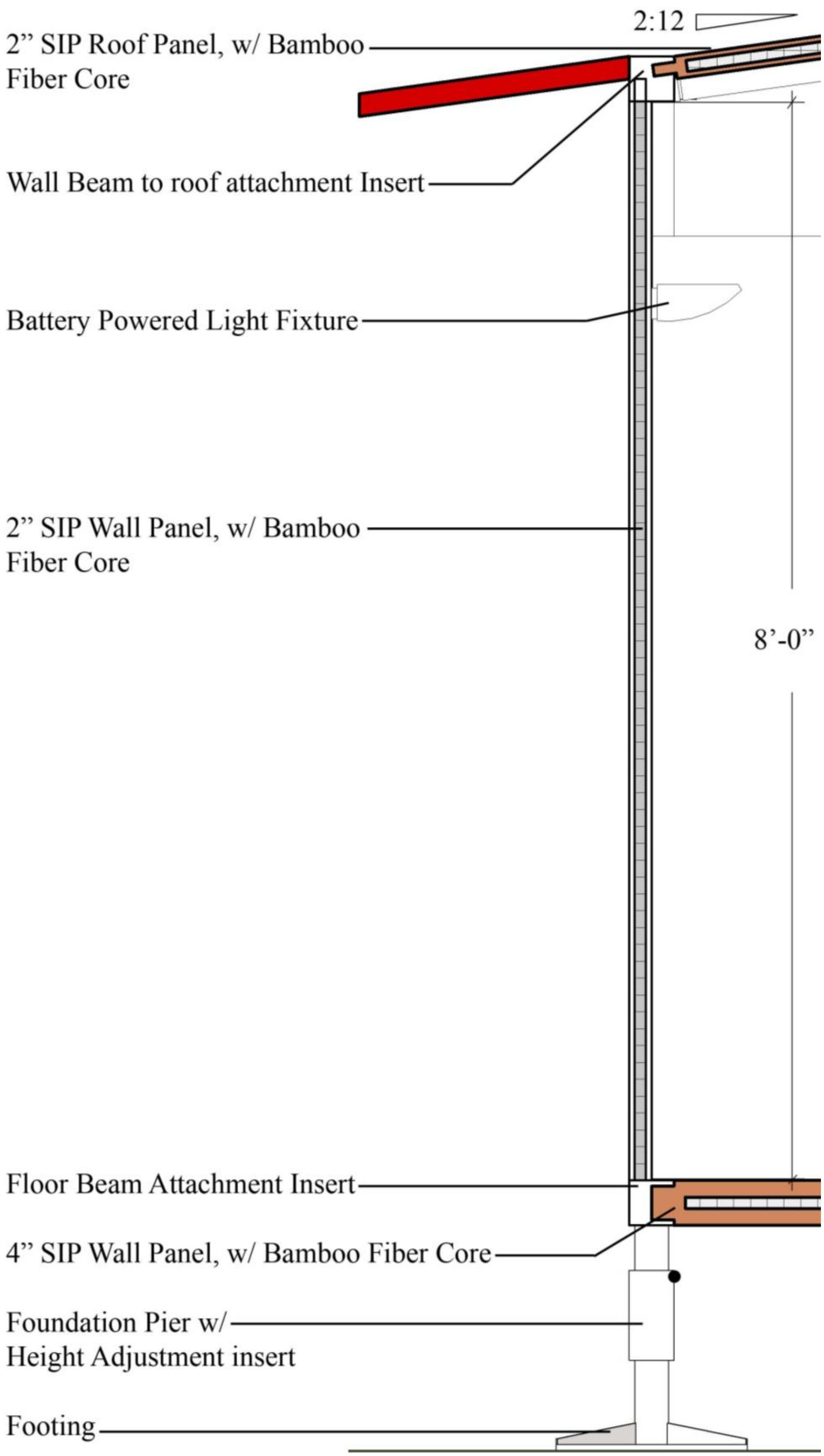


Figure 52: Wall Section Typical

8.7. Use

The system is used as a first response structure for emergency relief. The system serves as a first response to keeping its inhabitants sheltered and provides sleeping, shower, waste removal arrangements. The system also allows displaced individuals to dwell within it until they are ready to move on. The system lends itself to durability and some permanence providing power, a water line, and plumbing systems are established to serve the system. In the event that the displaced family or individual does not want to return their system, it also lends itself to being transported.

8.7.1. Water Supply and Waste Management

Water is supplied to the emergency relief system by taking advantage of water catchment technologies. The 2/12 slope of the paneled roof directs water to a water catchment reservoir that collects rainwater for plumbing usage. This passive technology is ideal after a natural disaster especially if water connections have been destroyed. The typical, tall water heater holds about 40 gallons of water, is 18 inches in diameter, and 46 to 60 inches in height (How much. 2012). The included water catchment reservoir is approximately 5' x 3' x 1', approximately 15' in volume; which makes it comparable to standard water heaters. 1" perforated inserts allow

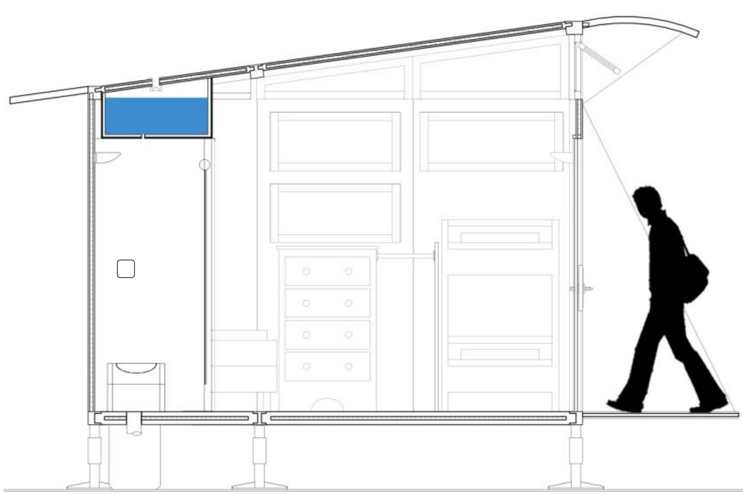


Figure 53: Section View

rainwater to collect into the catchment system. To prevent roof leaks, the roof is sealed by a rubber gasket. Incorporation of this catchment system allows occupants to shower and clean. The collected rainwater is not treated, thus is not potable water. Potable water would be procured by boiling or after the immediate response when plumbing has been reestablished.

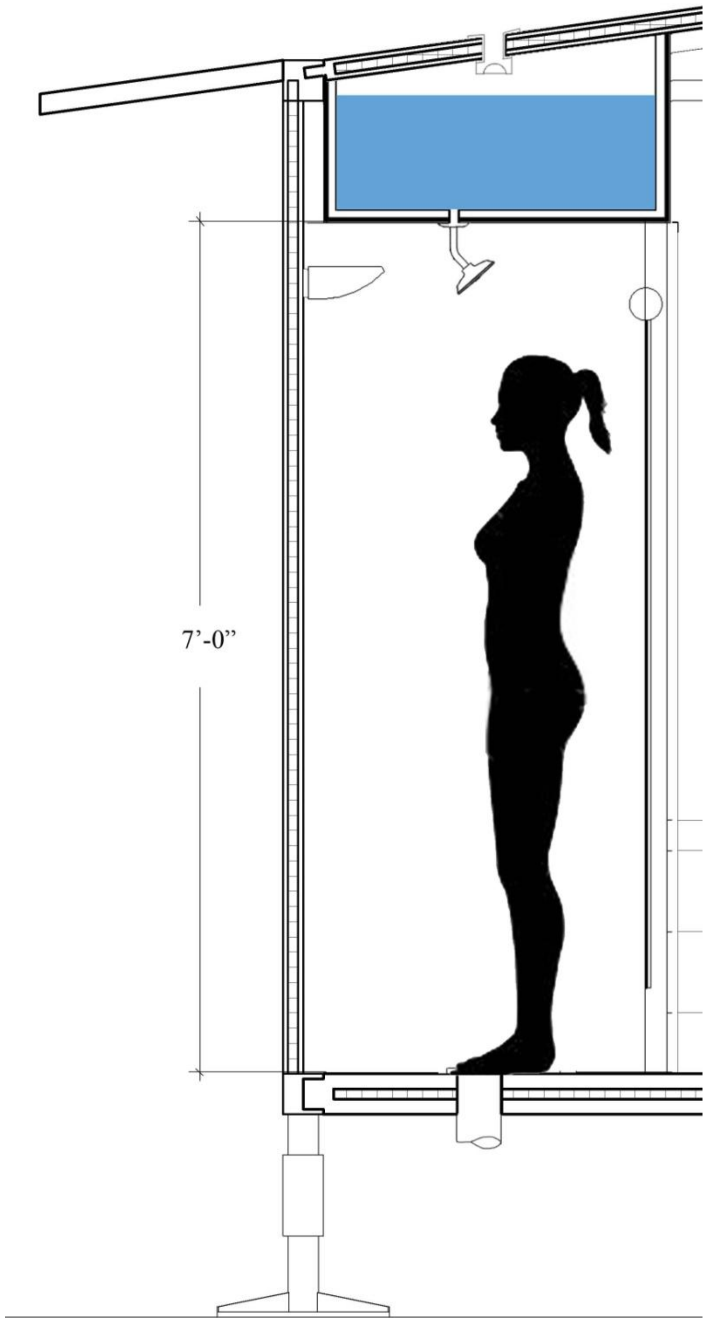


Figure 54: Wall Section view through shower and catchment system

The emergency relief system conceptually handles waste through a chemical toilet. The system would work by removing waste by means of an exterior waste collection reservoir which would then be serviced periodically by waste management trucks. Incorporation of this feature is in the emergency relief structure gives inhabitants the ability to use the restroom within their living quarters instead of resorting to an off-site facility. Further development of this concept would be expounded upon relative to a communal aspect.

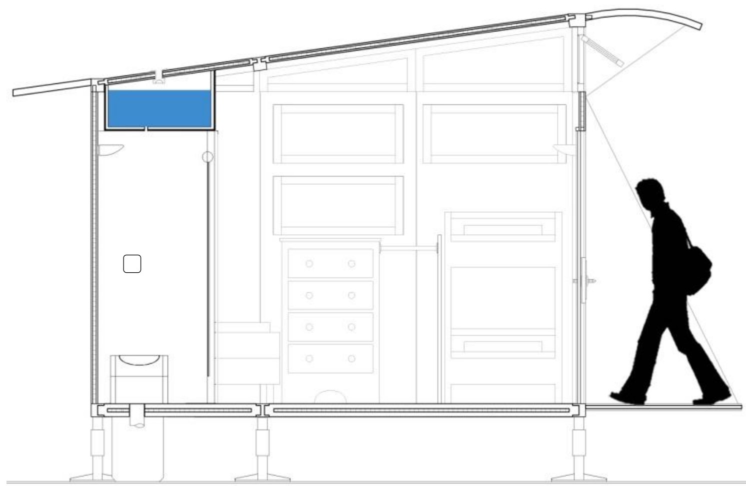


Figure 55: Section View through chemical toilet

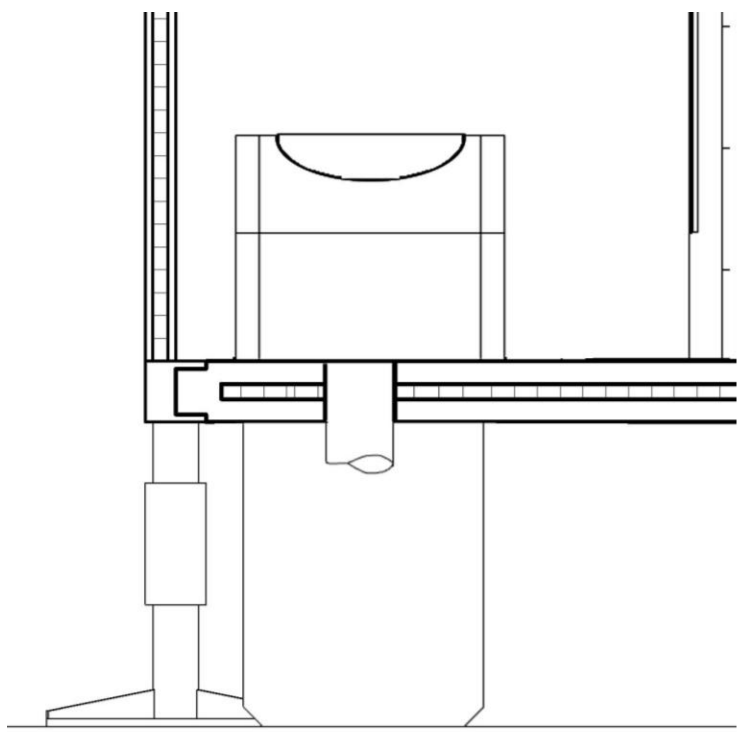


Figure 56: Enlarged Section view through chemical toilet

Privacy for the toilet is a door panel and a curtain for the shower. Also, hand sanitizer is dispensed and located above the toilet.

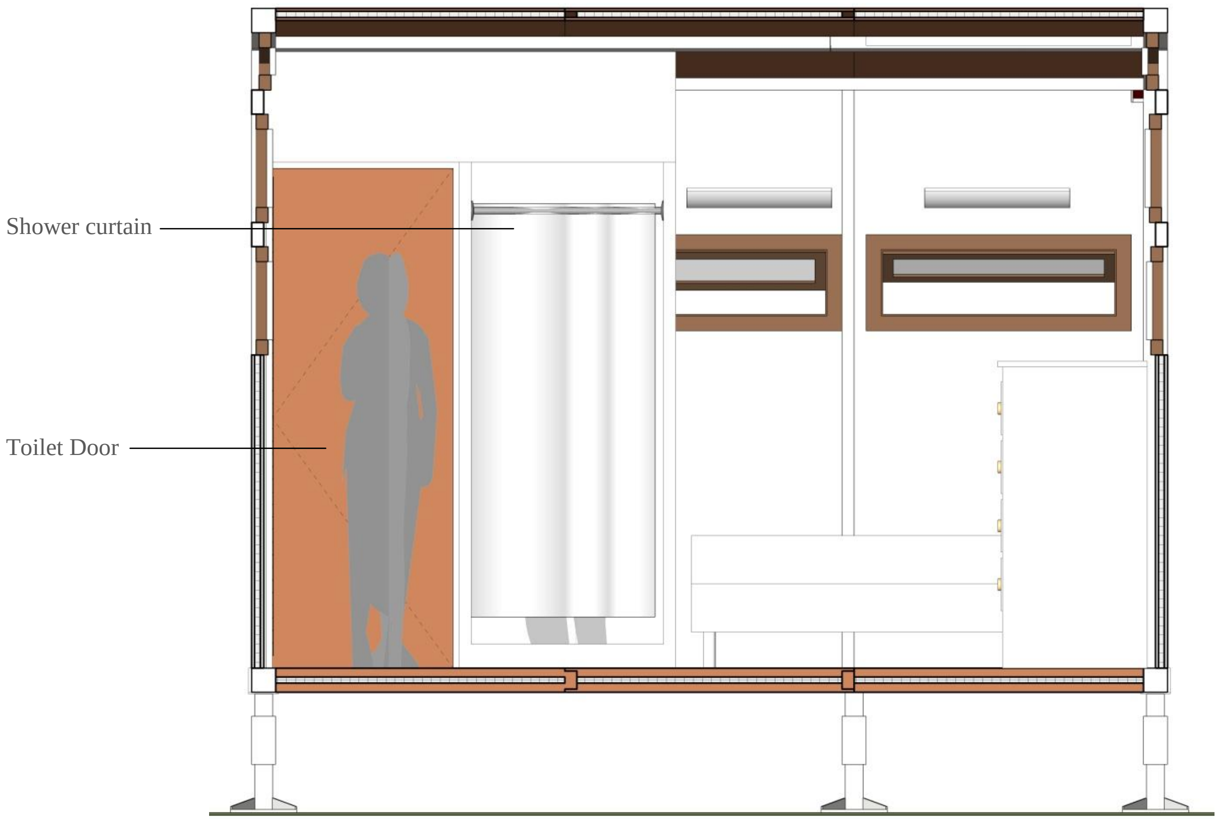


Figure 57: Section View looking at shower curtain and toilet door

8.7.2. Security, Food, and Temporary Power

` The door plate showcases the unit number and works in conjunction with the door hardware to provide security for the unit. Due to the first response, temporary, and immediate nature of the system, food will be administered by emergency relief representatives in the form of Meals Ready to Eat (MRE) and mass-produced cuisines. Camping stoves do not come standard with the unit and are optional as well. The panels come with a battery powered light fixtures which are the temporary source of light for the emergency relief system.

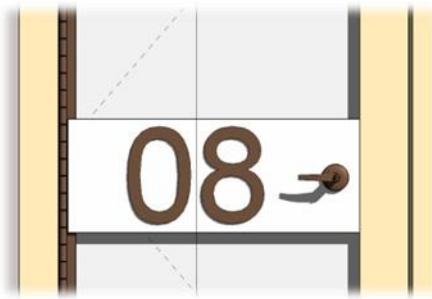


Figure 58: Door plate and hardware

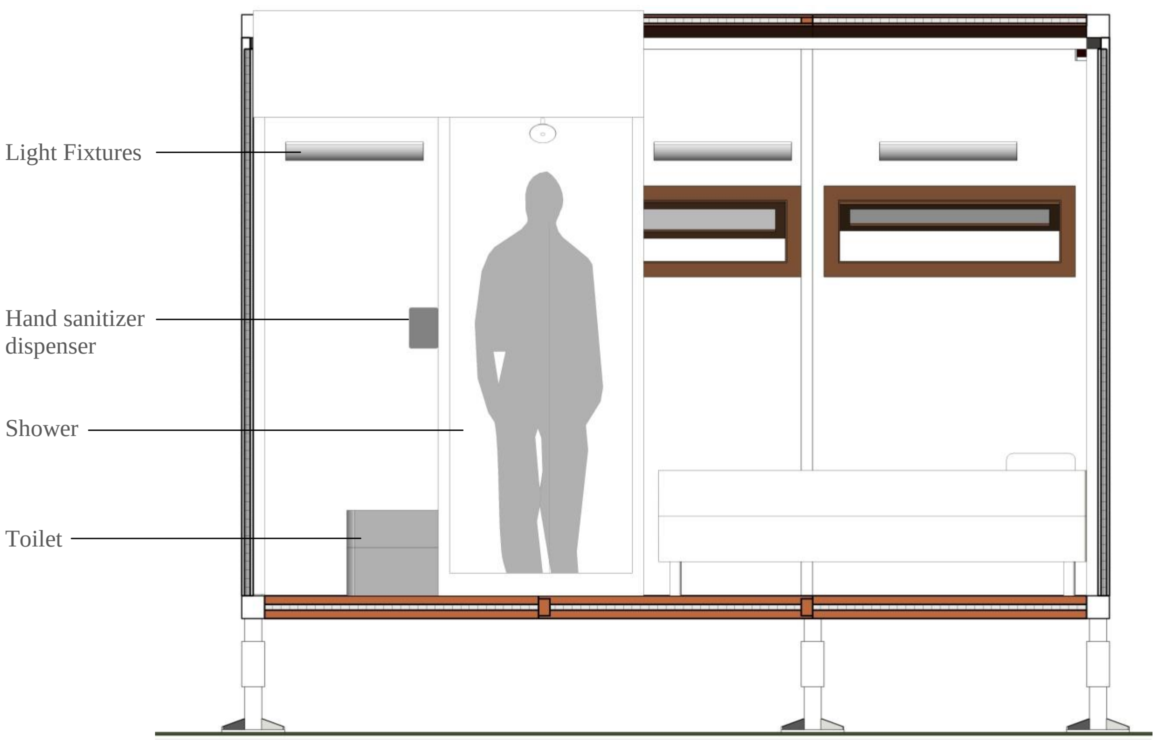


Figure 59: Section View looking at light fixtures

8.8. Storage and Portability

The system comes shipped, in Box B, with a dresser and clothes rack furniture system. This is ideal for the occupants to share, because each of them will have their own separate drawer. Clothes one doesn't want folded could be stored on the clothes rack.

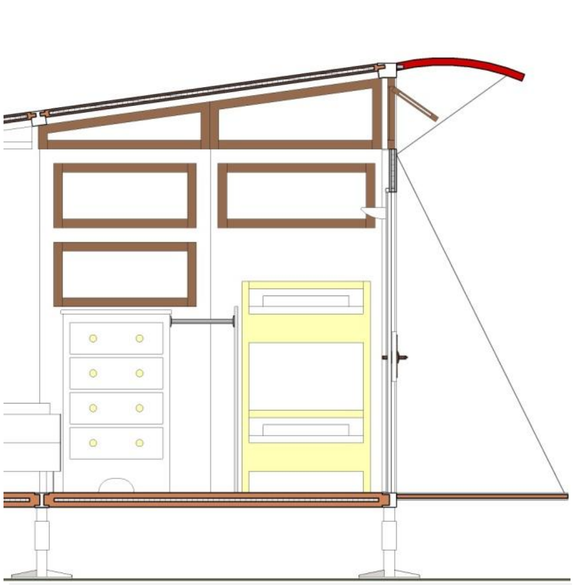


Figure 60: View of dresser and clothing rod hanger

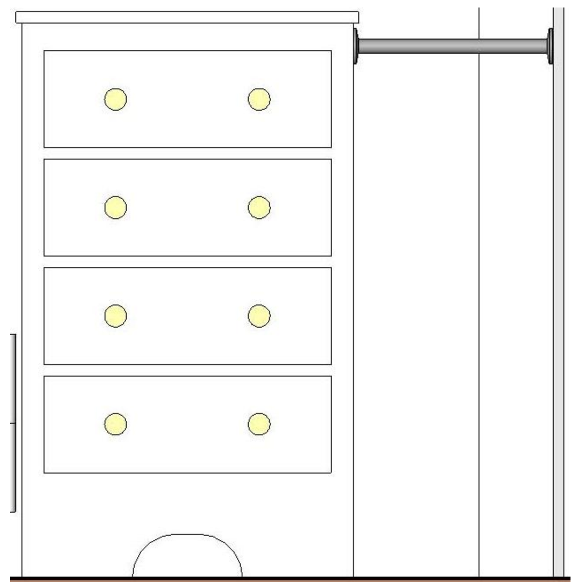


Figure 61: Enlarged view of dresser and clothes hanger

Flat packing makes the system easy to store and increases portability. Contrary to the FEMA trailer, this system can be disassembled and stored in 4'W x 8'L x 6'H boxes until its next use.

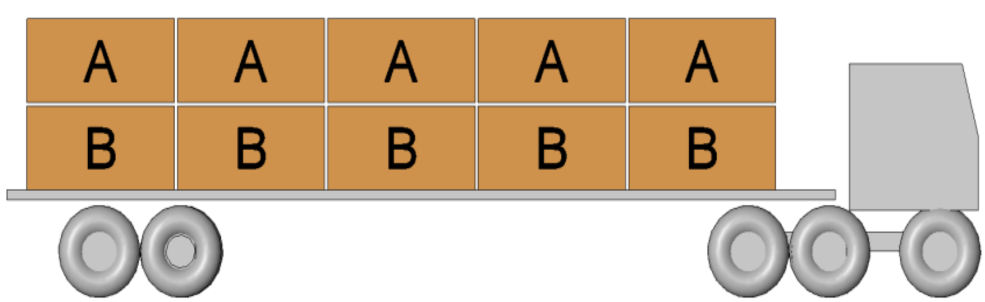


Figure 62: Portable

8.9. Sketches & Final Design Imagery

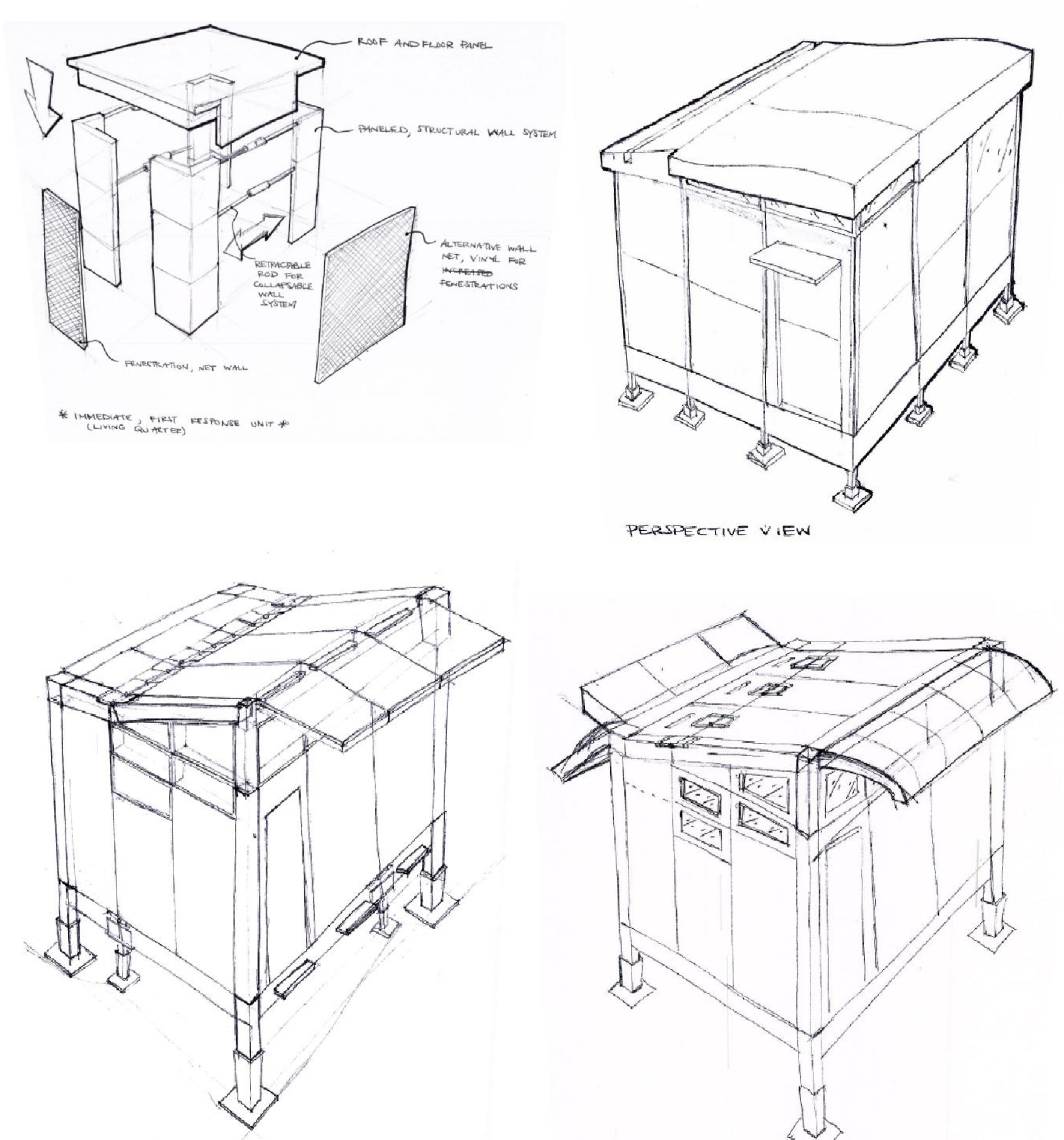


Figure 63: Sketches

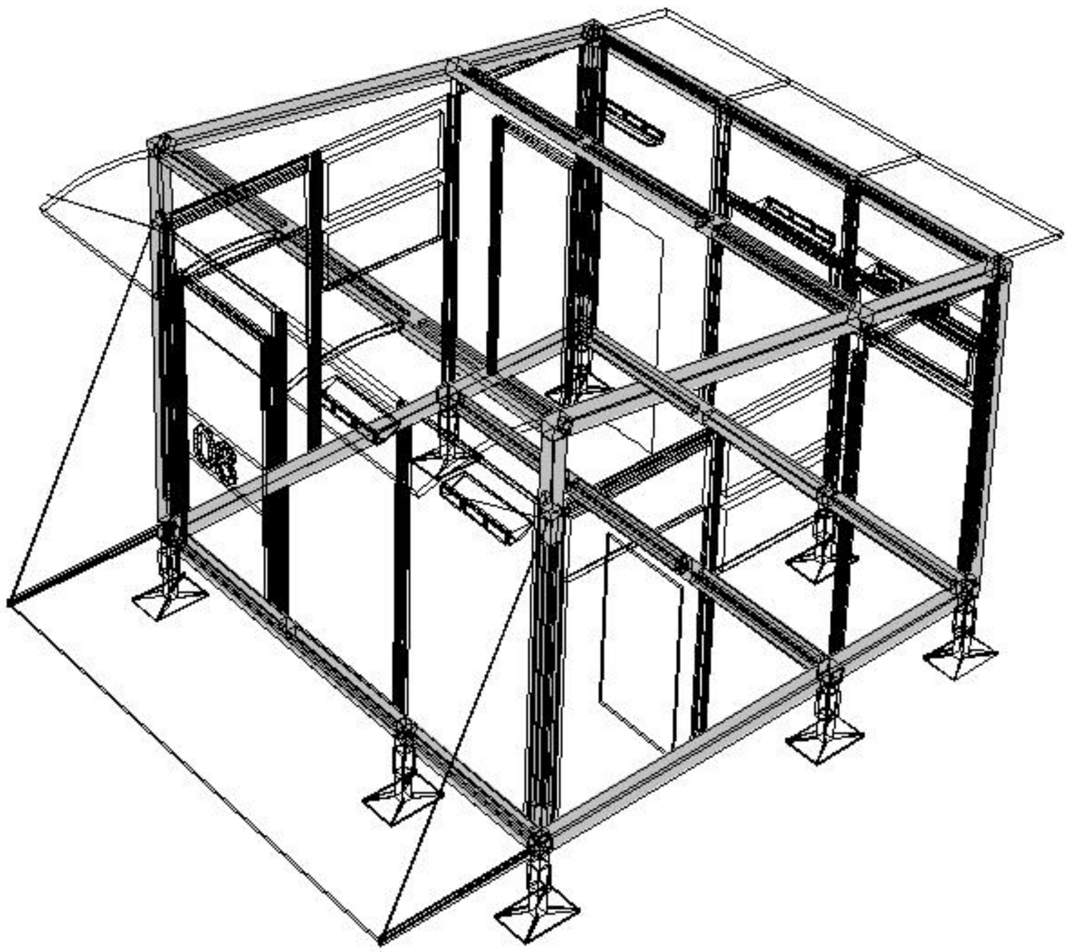


Figure 64: Wireframe View

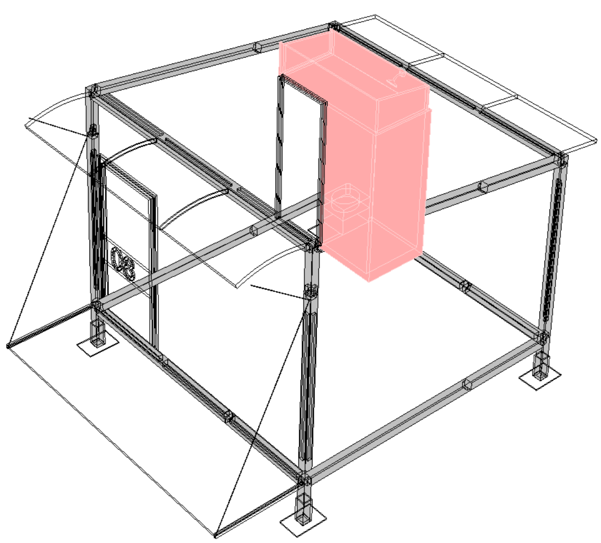


Figure 65: Plumbing Wireframe View

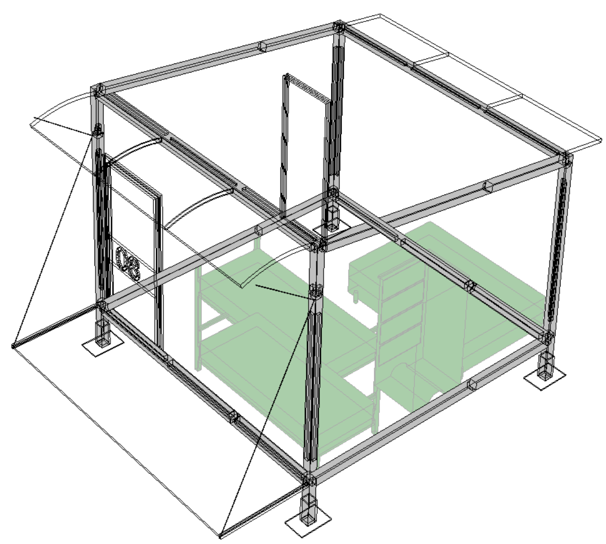
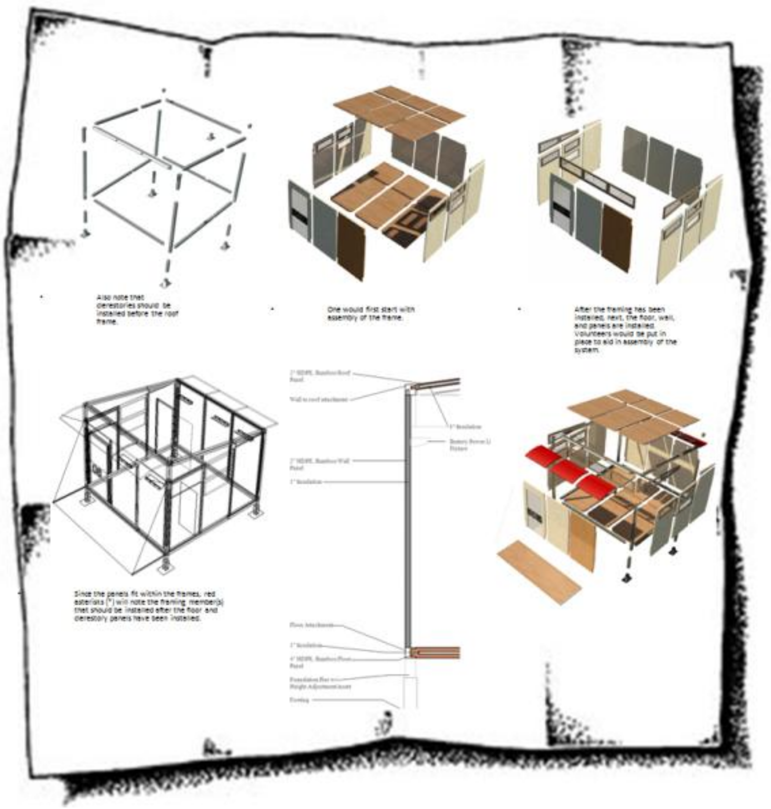


Figure 66: Furniture Wireframe View



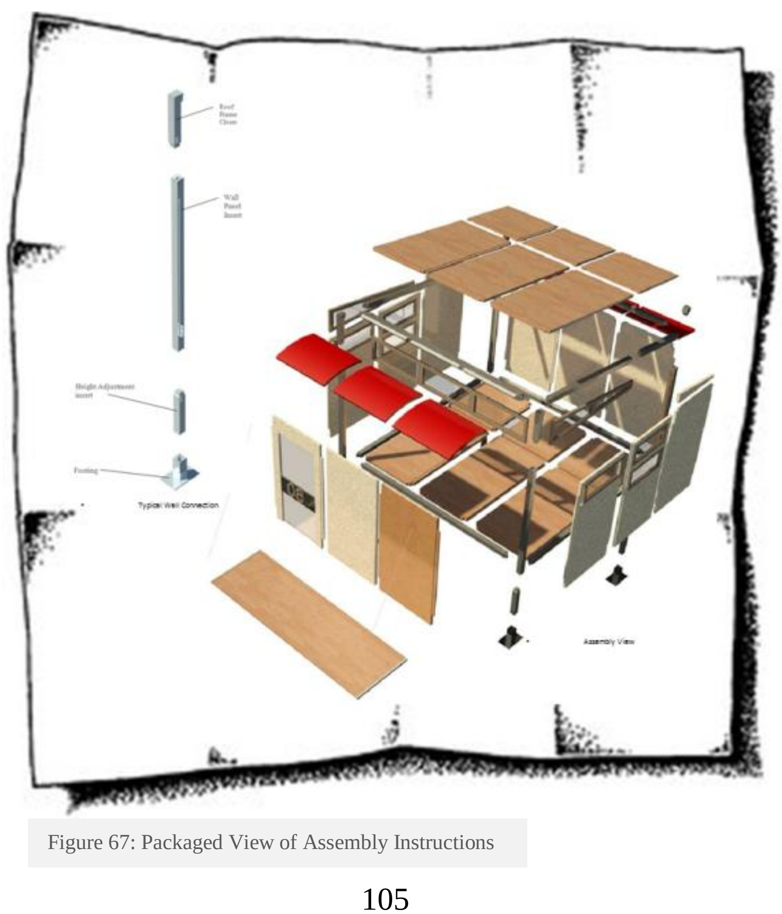


Figure 67: Packaged View of Assembly Instructions

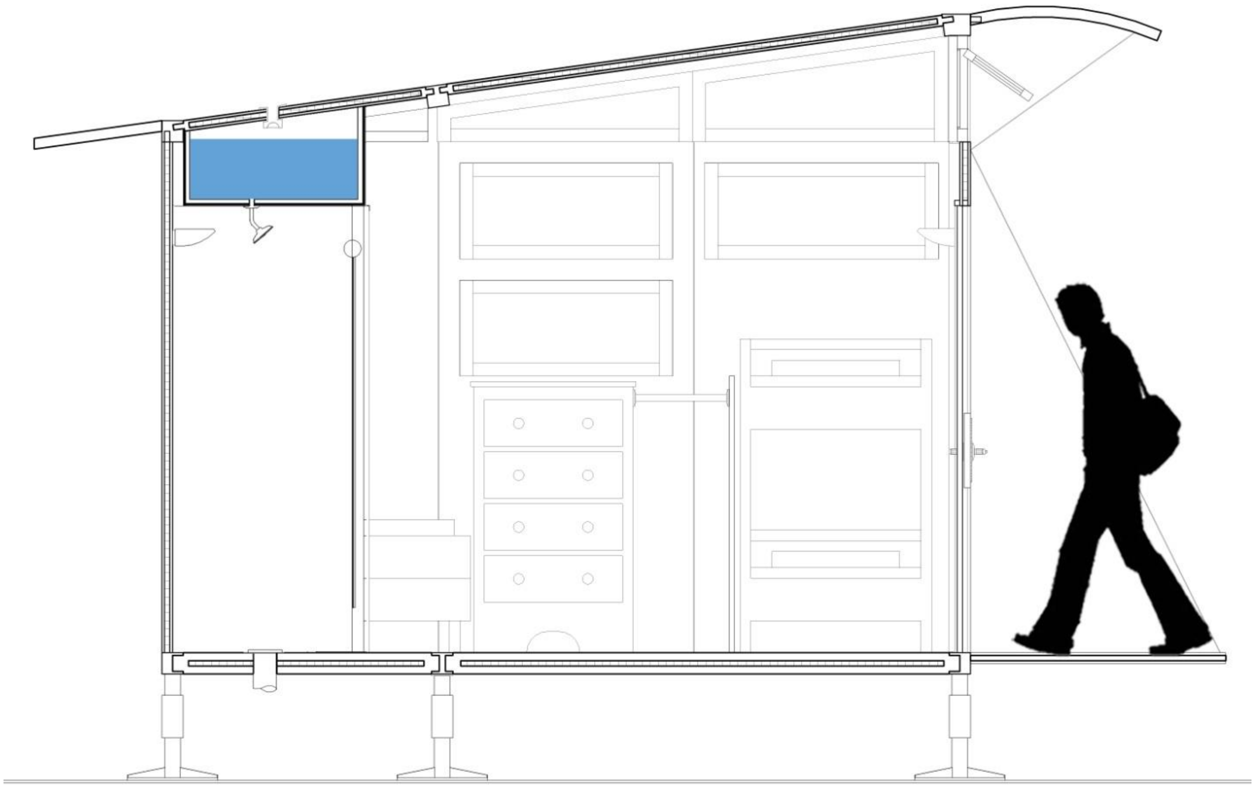


Figure 68: Building Section View

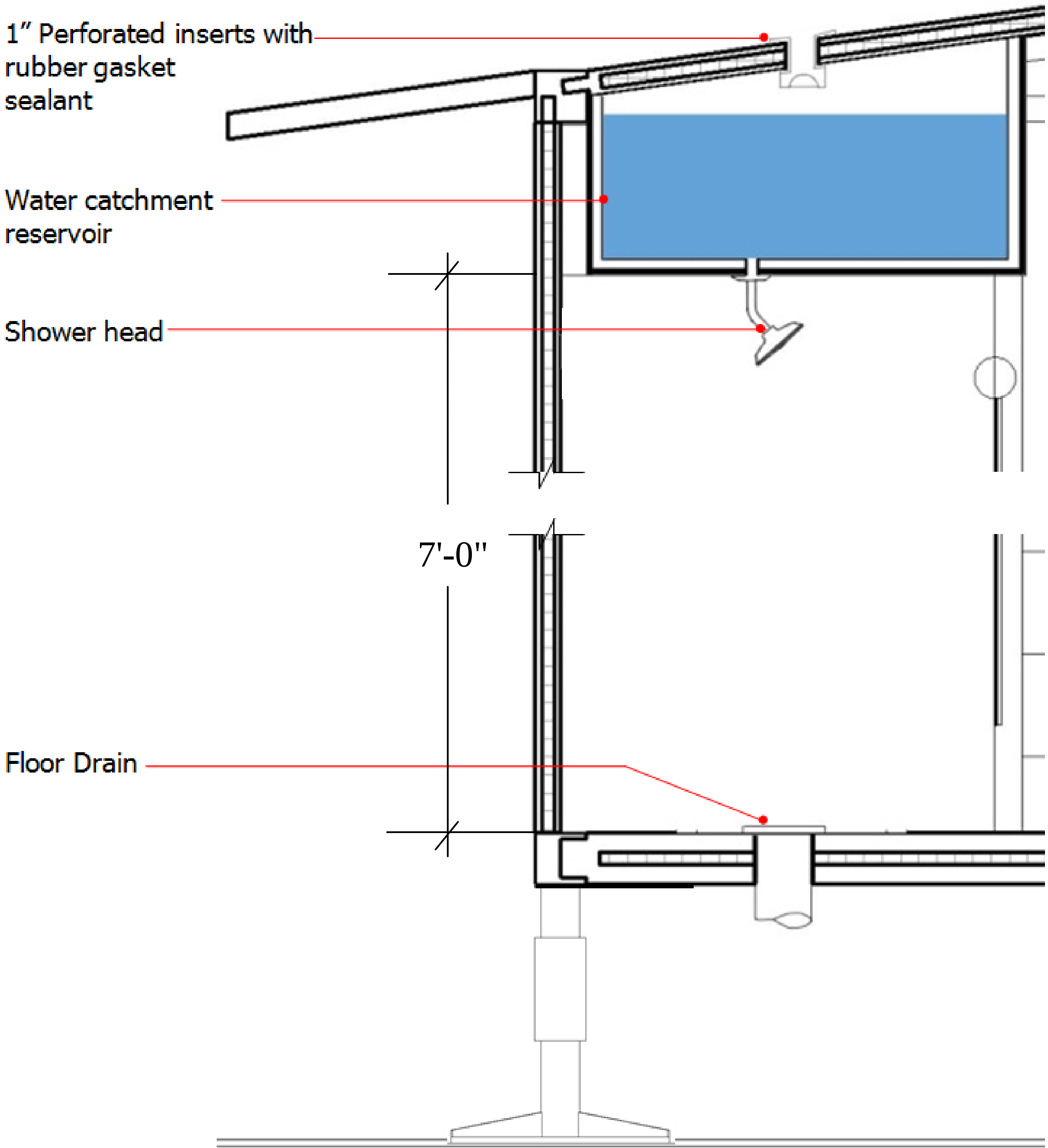


Figure 69: Enlarged Section through Shower

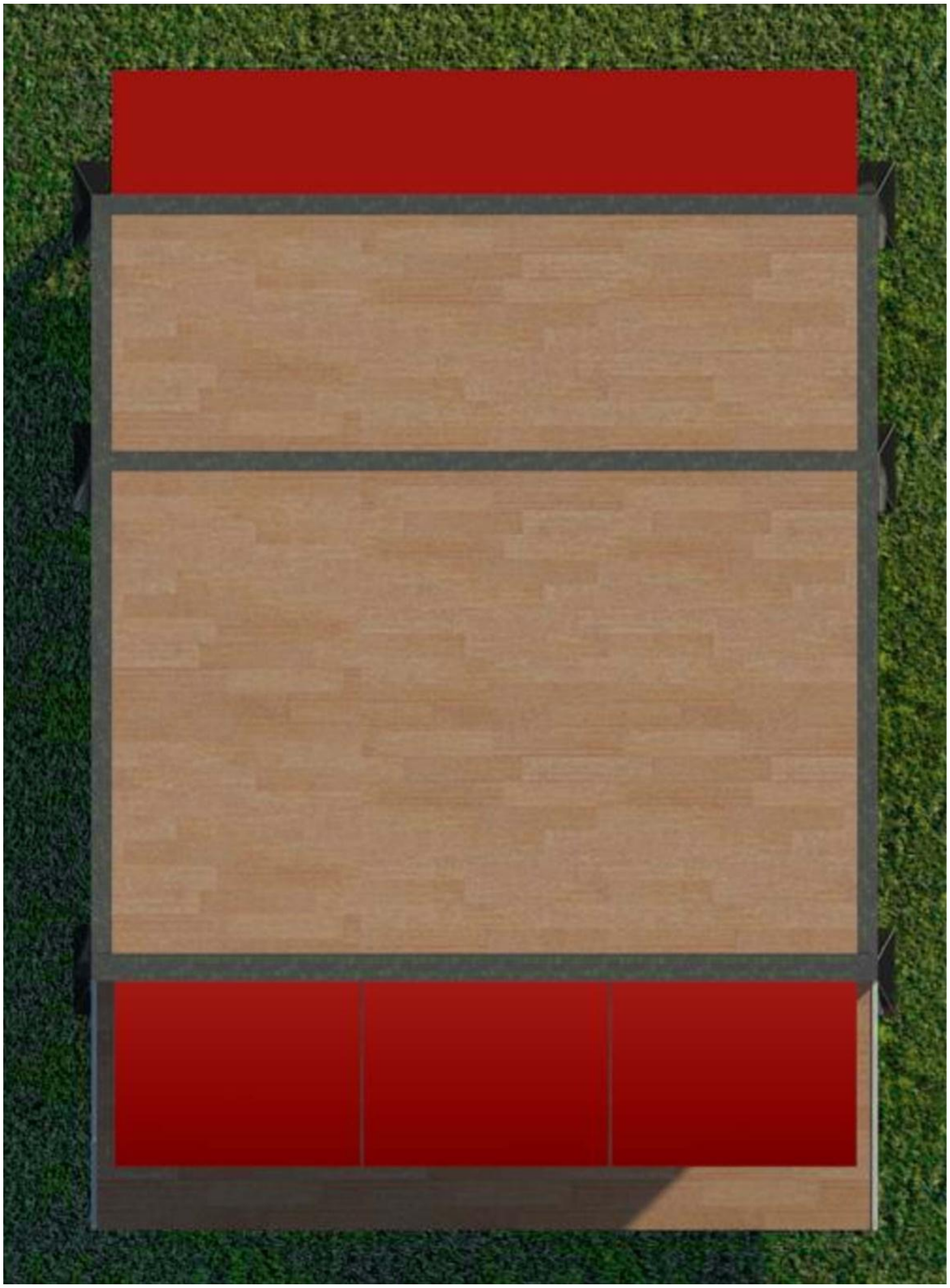


Figure 70: Site Plan

Figure 71: Front Elevation

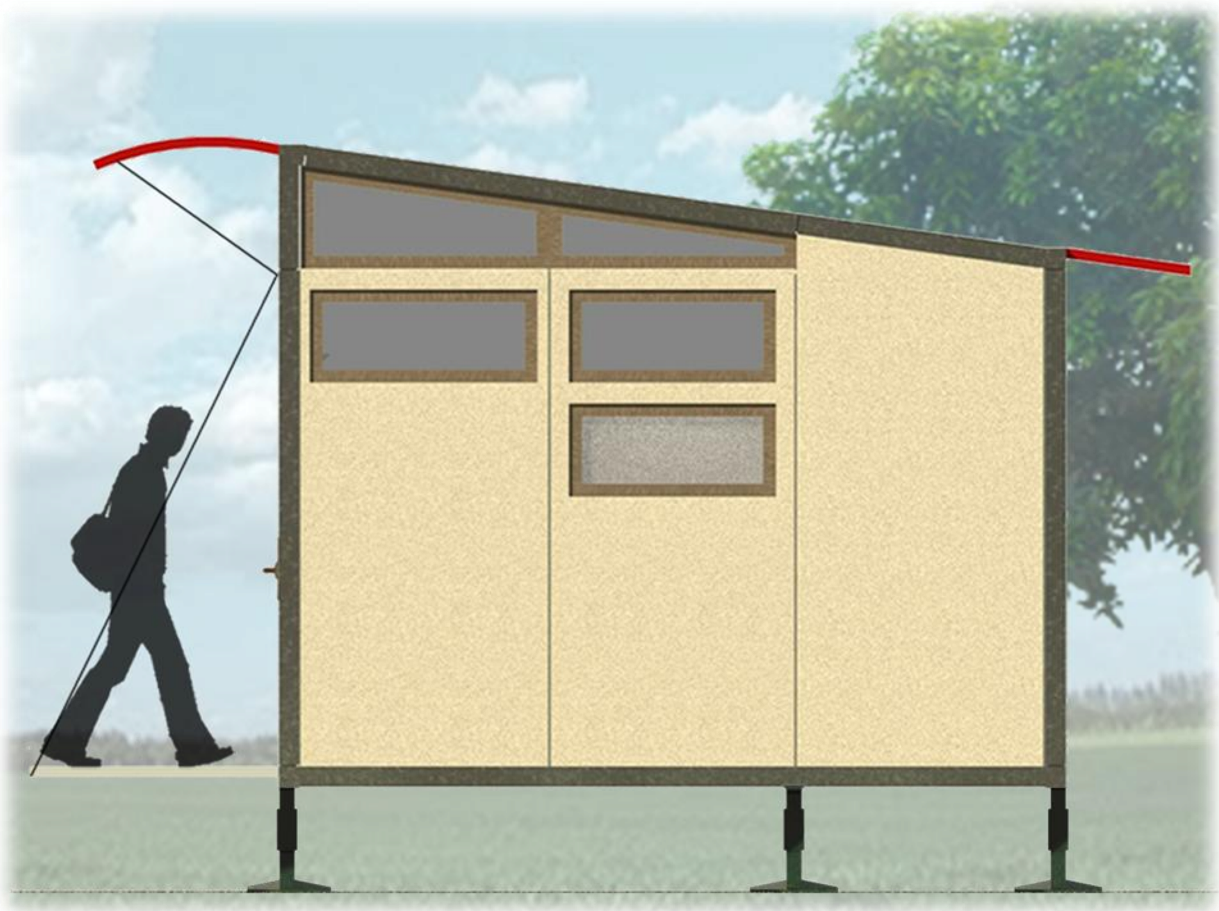


Figure 72: Right Side Elevation

Figure 73: Rear Elevation

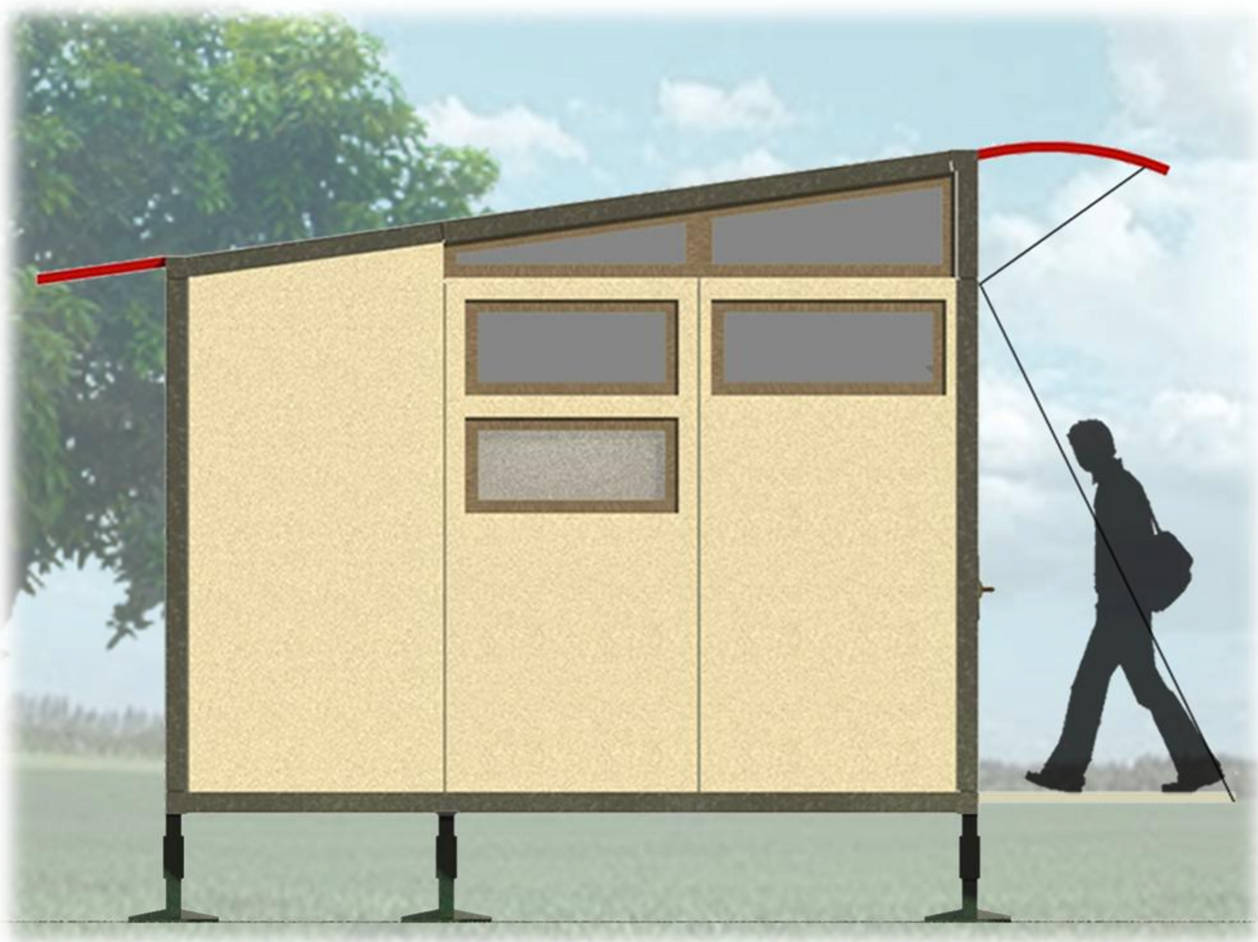


Figure 74: Left Side Elevation

Figure 75: Interior View at Dresser and Beds

Figure 76: Interior View from Entry

Figure 77: Perspective View

9.0 Application & Further Development

9.1. Design Criteria Applied

- The system should be prefabricated and modular.

  The system is design based on a 4' x 8' grid.

- This system should incorporate sustainable building materials that are native to Alabama.

  The system uses a structural insulated panel bamboo bio-fiber composite. According to the Convertible Structure Solutions, Inc., bamboo is a natural resource that is abundant in Tuskegee, Alabama and southern climates make it ideal for the growth and harvesting. Hence why the Convertible Structures Solutions, Inc. is using bamboo in their bio-fibers. In fact, the Convertible Structure Solutions, Inc. is in the process of opening a facility in Tuskegee, Alabama for the development of modular homes that uses this bamboo bio-fiber.

- The system should be low cost and modular.

  The system was designed as efficiently as possible, addressing natural disasters with a minimalistic approach and the necessities of life. The incorporation of passive heating and cooling, and water catchment technologies offsets the total cost of one unit.

- The system should optimize packaging.

  The system is packaged in a biodegradable, flat packed, 4'W x 8'L x 6'H box.

- The system should optimize shipping.

  The components of the system fit within a 4'W x 8'L x 6'H box which allows ease of shipping.

- The system should be easy assembled and disassembled.

  The system is intuitively easy to assemble and disassemble in a short period of time. Prior knowledge of construction techniques is not require, thus the system can be assembled by unskilled labors. An exploded view of assembly instructions is packaged with the unit.

- The system should be passively ventilated.

  Awning fenestrations on the front and back facades will allow air flow throughout the space. The fenestrations on the back facade are lower than those of the front, clerestory. This is a design feature that allows air to flow from the lower elevation to the higher, optimizing cross ventilation.

- The system needs a temporary source of water.

  A water catchment system is packaged in box B. This system is a passive technology which collects and stores rainwater for use by occupants.

- The system should provide a way for occupants to clean themselves and pass waste.

  A chemical toilet and a shower system is packaged in Box B. The chemical toilet has to be serviced periodically and the shower works with the water catchment system.

- The system should be adaptable.

  The system includes furniture that can be rearranged to accommodate the size of a 1-4 person family. The system has adjustable footings which allow assembly on even terrain. Also, the system lends itself to modular adaptation. In the event of growth or a family that exceeds 4 persons, another system can be assembled adjacent to the first.

9.2. Minimalism Applied

Research led to a direct focus on providing a solution that addresses the immediate (1-14 days) and intermediate response (14-30 days) of housing displaced individuals after a natural disaster. Future development of this research would focus on making the emergency relief structure ideal for permanency. The development of the subsystems, HVAC, plumbing, mechanical, and electrical, and application of minimalistic approaches to this emergency relief system could make it more socially accepted for permanence in communities. When several units are assembled adjacent, this begins to define the community block.

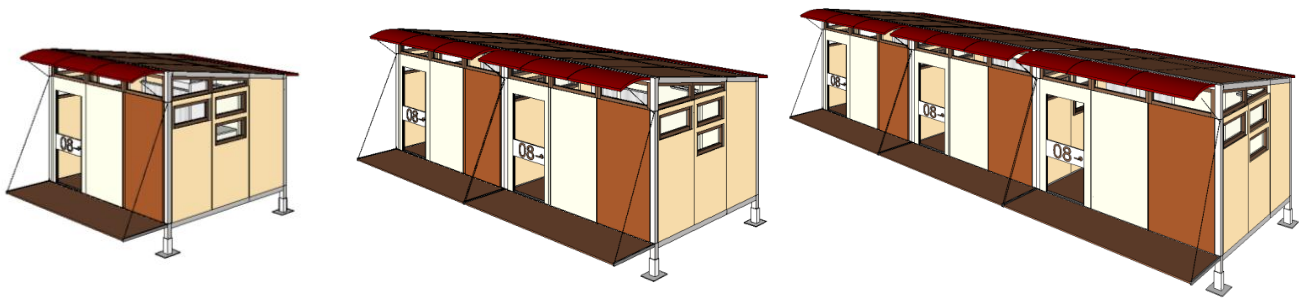


Figure 78: Units Adjacency Expansion View

This approach first addressed the need for a plan to house individuals after being displaced due to natural disasters. Minimalism is directly evident in the system with the exposure of the structure and is exhibited by the use of renewable, non-conventional materials such as bamboo. The use of materials such as bamboo and passive technologies for water catchment draws a connection between the need for the United States to become more cognizant of the built environment and the manner in which we consume natural resources. Next, once manufactured, the systems can be used disaster after disaster, thus optimizing embodied energy. Lastly, this approach introduced solutions for addressing a longer term, smaller community development which will utilize and potentially transform emergency relief structures into permanent dwellings. All in all, research revealed that a new approach to emergency relief structures and addressing the future of housing will be promising.

References

Ablenook. (2011). Ablenook: multi-use portable dwelling, patent pending, plug and play dwelling creation. Retrieved from: http://www.ablenook.com/gallery.

Anderson, M., & Anderson, P. (2007). *Prefab prototypes: site-specific design for offsite construction*. New York, N.Y.: Princeton Architectural Press.

Associated Press. August 26, 2010. *Life since katrina: back home or settled resettled afar, 3 survivors reflect on post-hurricane journey.* The New York Times. Retrieved from http://www.foxnews.com/us/2010/08/26/life-katrina-home-resettled-afar-survivors-reflect-post-hurricane-journey/

Barakat, S. (2003). *Housing reconstruction after conflict and disaster.* http://www.odihpn.org/hpn-resources/network-papers/housing-reconstruction-after-conflict-and-disaster

Brunker, M. July 23, 2006. *FEMA trailers 'toxic tin cans'?* http://risingfromruin.msnbc.com/2006/07/are_fema_traile.html

Bumgarner, J. (2008). *Emergency management: a reference handbook.* Santa Barbara, CA.: ABC-CLIO.

Cary of Yahoo Voices. (2009). Natural disasters of the decade: top ten natural disaster since 2000. Retrieved from: http://voices.yahoo.com/natural-disasters-decade-5125653.html.

Central Intelligence Agency. (2011). *Central intelligence agency: world fact book.* Retrieved from https://www.cia.gov/library/publications/the-world-factbook/rankorder/2079rank.html

CNN.

http://www.cnn.com/

Convertible Structure Solutions, Inc. (n.d.)

Retrieved from http://www.convertiblestructure.com/materials.html

Department of Homeland Security. (2013). Federal emergency management agency emergency food and shelter. Retrieved from: http://www.fema.gov/pdf/about/budget/11e_fema_emergency_food_shelter_dhs_fy13_cj.pdf.

Dudley, H. (2006). *Hurricane Katrina.* Detroit, MI.: Greenhaven Press.

Duran, S.C., & Hosey, L. (2007). *Green homes : new ideas for sustainable living*. New York, N.Y.: Collins Design/An Imprint of HarperCollinsPublishers.

Edminster, A. (2009). *Energy free: homes for a small planet.* San Rafael, CA.: Green Building Press.

Edwards, Roger. (2006). *The online tornado faq*. Storm Prediction Center

Retrieved from http://www.spc.ncep.noaa.gov/faq/tornado/

Envirolet. n.d.

Retrieved from http://www.envirolet.com/

Evans, B., Powell, J., & Talbot, R. (1982). *Changing design*. England: John Wiley & Sons Ltd.

Fairs, M. (2009). *Green design : creative sustainable designs for the twenty-first century*. Berkeley, CA: North Atlantic Books.

Gauer, J. (2004). *The new american dream: living well in small homes.* New York, N.Y.: The Monacelli Press, Inc.

Geology: news and information about geology. (n.d.). *What was the largest hurricane to hit the united states?*. Retrieved from: http://geology.com/hurricanes/largest-hurricane/

Gleick, P. H. (1996). Basic *water requirements for human activities: meeting basic needs." water international*.
Retrieved from: http://www.waterencyclopedia.com/St-Ts/Survival
Needs.html#ixzz2WbyIWXN6

Guide to truck trailers. (n.d.)
Retrieved from: www.wbmcguire.com/trucktrailerguide.html

Heinrich, Erik. (2013). *This or that survival debate: a rip-roaring game of either/or questions.* North Mankato, Minnesota.: Capstone Press

Herbers, J. (2004). *Prefab modern*. New York, N.Y.: Harper Design/An Imprint of HarperCollinsPublishers.

How Much Water Does Bath or Shower Use? (2012)
Retrieved from http://waterheatertimer.org/How-much-hot-water-does-bath-or-shower-use.html

Toothman, Jessika. (n.d.) How structural insulated panels work.
Retrieved from:
http://home.howstuffworks.com/homeimprovement/construction/materials/structural-insulated-panels3.htm

Hutchings, J.F. (1996). *Builder's guide to modular construction*. United States of America: The McGraw-Hill Companies, Inc.

Itō, Y. (2008). *Modular design for machine tools*. New York, N.Y.: McGraw-Hill Professional.

Jasper, James. M. (2000). Restless nation: starting over in america. United States: University of Chicago Press.

Kueber, P. (2008). *Embodied energy: the greenest building is one that's already built.* Retrieved from http://retrorenovation.com/2008/05/22/embodied-energy-the-greenest-building-is-one-thats-already-built/

Lemmet, Sylvie. (2009). *Buildings and climate change: summary for decision-making.* United Nations Programme Sustainable Buildings and Climate Initiative (UNEP SBCI).

Low embodied energy building materials. (2010). Retrieved from http://www.homeimprovementpages.com.au/article/Low_Embodied_Energy_Building_Materials

Mackenzie, D., Moss, L., Engelhardt, J., & Martyn, R. (1997). *Green design : design for the environment* . London: Lawrence King Publishing.

McGraw-Hill Companies. (1998). *Additional readings: hyperthermia and hypothermia.* Retrieved from: www.mhhe.com/biosci/ap/foxhumphys/student/olc/d-reading1.html

McGuire, Bill. (2002). Global catastrophes: a very short introduction. New York, U.S. Oxford University Press, Inc.

McLamb, Eric. (2011, September 18). http://www.ecology.com/2011/09/18/ecological-impact-industrial-revolution/

Middleton, M.H. (1969). *Group practice in design*. London: The Architectural Press.

Morgan, Curtis. (2013). Hurricane sandy ranked as second-costliest storm behind hurricane katrina. Miami Herald.
Retrieved from: http://www.miamiherald.com/2013/02/12/3231276/hurricane-sandy-ranked-as-second.html

Mumma, T. (1995). *Reducing the embodied energy of buildings. Home Energy Magazine Online January/February, 1995.* Retrieved from http://www.homeenergy.org/show/article/nav/remodeling/id/1105/magazine/89

National Society to End Homelessness. Retrieved from http://www.naeh.org/

Reffitt, Devin. M. (2007). *The benefits of modular construction.* Renal Business Today. Retrieved from: www.willscot.com/pdf/benefits-of-modular-construction.pdf

Salomon, Shay. (2006). *Little house on a small planet: simple homes, cozy retreats, and energy efficient possibilities.* Guilford, Connecticut. Lyons Press.

Sandoval, G., Barkhurst, K. (2010). *Refugio Dionisio: Emergency shelter - sustainable home design. The bunkminster fuller challenge*. Retrieved from http://challenge.bfi.org/application_summary/143#

Serna, J., Hennessy-Fiske, M., Bengali, S. November 09, 2012. *FEMA sending mobile homes for superstorm sandy victims.* Retrieved from http://articles.latimes.com/2012/nov/09/nation/la-na-nn-fema-mobile-homes-hurricane-sandy-victims-20121109

Shedroff, N. (2009). *Design is the problem: the future of design must be sustainable*. Brooklyn, N.Y.: Rosenfeld Media, LLC.

Staib, G., Dörrhöfer, A., & Rosenthal, M.J. (2008). *Components and systems : modular construction : design, structure, new technologies*. Basel, Switzerland: Edition Detail, Institut für internationale Architektur-Dokumentation.

Stobbe, Mike. (2012). *Alabama tornadoes 2011:most twister victims knew storm was coming, study says.* Retrieved from http://www.huffingtonpost.com/2012/04/27/alabama-tornadoes-2011-victims_n_1458162.html

Tremblay, K., Bamford, L. (1997) *Small house designs : elegant, architect-designed homes, 34 award-winning plans, 1,250 square feet or less.* Storey Communications.

United States Census and the *America's Families and Living Arrangements. (2010). U.S. census bureau reports men and women wait longer to marry. Retrieved from* http://www.census.gov/newsroom/releases/archives/families_households/cb10-174.html

United States Department of Housing and Urban Development. Retrieved from http://www.usa.gov/Agencies/Federal/Executive/HUD.shtml

United States Energy Information Administration. (2010). *Frequently Asked Questions.* Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1

Wexler, S. (2010). *Living large: from suvs to double ds---why going bigger isn't going better*. St. Martin’s Press.

WiseGeek.com. *What are the advantages of modular construction.* Retrieved from: http://www.wisegeek.com/what-are-the-advantages-of-modular-construction.htm

Young-Houser, N. *The Psychology of Housing and Shelter.* AKG Magazine. Retrieved from http://www.akgmag.com/article/The_Psychology_of_Housing___Shelter.htm