DESIGN OF REUSABLE EMERGENCY RELIEF HOUSING UNITS USING GENERAL-PURPOSE (GP) SHIPPING CONTAINERS

José A. Peña, Purdue University Calumet; Kurt Schuzer, Purdue University Calumet

Abstract

The natural disasters that have occurred during the last decade have shown the need for temporary emergency housing that could be quickly dispatched and placed. The modular designs of the shipping containers make them very simple to be transported using ship, rail, air or truck transportation. Temporary housing designed using shipping containers would be easy to prefabricate at an off-site location or factory which could cut costs on traditional construction while increasing quality control and consistency. Shipping containers are readily available and, since they are built to adhere to strict standards, could be utilized for the purpose of relief housing. The solution proposed here is to utilize shipping containers as a shell to build durable and reusable emergency relief units that can be quickly dispatched to disaster areas. The use of shipping containers for housing would bring the advantage of modularity, ease of transport and assembly. These units can be arranged in multiple layouts and built to be self-sufficient in terms of water, power and waste disposal. The design includes considerations for reinforcement for windows and door openings, connection between modules, design of framing and partitions, insulation and flooring, design of foundations and the selection and placement of systems of water management and power generation and supply. This design considers small clusters or camps, each self-sufficient in terms of water and power management.

Introduction

The natural disasters that have occurred during the last decade have shown the need for temporary emergency housing that could be quickly dispatched and placed. The Asian tsunamis and earthquake of December, 2004, affected twelve countries causing over 150,000 deaths and at least a half million injured, and leaving five million homeless or without adequate access to safe drinking water, food or health service. After this event, the World Health Organization (WHO) issued a declaration entitled "focus on life", which states that the response to any disaster has one primary focus: enabling those who are affected to live, sustain their lives and enrich their livelihoods [1]. Sheltering and housing are indispensable to meeting this objective.

Researchers have identified three phases of rebuilding after disaster: emergency housing, temporary housing and permanent reconstruction [2], [3]. The function of temporary housing is to provide a covered, healthy living space with privacy and dignity during the period between the occurrence of a natural disaster and the achievement of temporary housing [4]. Ideally, this type of housing will be upgradeable, reusable and/or re-sellable.

Immediately after a disaster, when houses have been rendered inhabitable by its effect, the initial approach may be in the form of large emergency shelters such as gymnasiums and other facilities, or through the use of hotels to accommodate large numbers of victims [5]. In August, 2005, when Hurricane Katrina hit the southern coast of the U.S., the city of New Orleans made available a sports stadium as a shelter. The occupancy reached an estimated 12,000 people with insufficient water and food supplies, while high winds and flooding limited access by road to the stadium during the first days to provide additional supplies and management. During the weeks following the hurricane, tent cities were established in Biloxi, Mississippi, to shelter victims (Figure 1) [6].

Figure 1. Tent City in Biloxi, Mississippi [6]

After the January, 2010, earthquake in Haiti, the office of internal migration and its partners delivered more than

6,000 tarps, 3,345 items of plastic sheeting and 400 boxes containing a 10-person tent, blankets, water purifiers and materials for children to 36,000 people (Figure 2) [7], [8]. The displacement sites sheltering victims are in danger of becoming permanent slums [9].

Figure 2. Refugee Camp In Petionville, Haiti [8]

After four months of being sheltered in provisional locations, an estimated 85,000 victims of the earthquake and tsunami that hit Japan in March, 2011, temporary housing facilities that required skilled labor to be built started to be occupied (Figure 3) [10], [11].

Figure 3. Temporary Housing in Schichigahama, Japan [11]

The term housing indicates more extended help than temporary sheltering. The provisions of temporary housing in the form of mobile homes and travel trailers taken after Hurricane Katrina were considered inadequate, provoking complaints from residents and congressional hearings to determine the adequacy of the procedures [5].

The solution proposed in this study is to utilize shipping containers as a shell for building durable and reusable emergency relief units that can be quickly dispatched to disaster areas. These units can be arranged in multiple layouts and built to be self-sufficient in terms of water, power and waste disposal. The use of shipping containers for housing would bring the advantage of modularity, ease of transport and assembly. Each unit is designed from a container as a module with most of the major components needed for the emergency housing units pre-assembled off-site before its transportation. Modules can be combined to make up different complete housing units offering versatility to the design to meet the needs of different family sizes.

Construction of complex foundations would not be typically required, thus eliminating the need for major groundwork or excavation processes. Because of its original intended use and unibody design, cargo containers are able to carry large loads offering durability in harsh environments [12], [13].

The two most common sizes of shipping containers are 20 -foot and 40-foot long containers. These containers are commonly referred to as TEUs (twenty-foot equivalent units) and FEUs (forty-foot equivalent units). There are less commonly available lengths on the market including 10-, 30- and 45-foot units. The standard width for shipping containers is 8 feet, with 8.5 feet and 9.5 feet as standard heights [14]. Shipping containers are constructed of weathering or Cor-Ten® steel, which is characterized by forming a stable layer of oxides on the surface of the metal which provides resistance to weather conditions and slow deterioration in harsh environments. The steel panels are corrugated with a typical depth of one inch to provide extra rigidity and a larger moment of inertia [15].

According to estimates given by the World Shipping Council (WSC), as of May, 2011, there were approximately 28,535,000 TEUs representing roughly 18,605,000 units worldwide. The ratio of loaded TEUs to container inventories was reported as ranging from 4.5 to 4.7 between 1990 and 2002, before rising above 5—except for a dip to 4.97 in 2009—with a forecasted ratio of 5.52 for the year 2012. The average annual container disposal rate during the last decade has been approximately 5% of the fleet. This rate fell to 3.8% in 2010 and 4.5% in 2011, only rise to 5.3% in 2012 [16]. These estimates still represent a large number of containers to be disposed of. This overabundance of shipping containers is due to several factors; e.g., trade imbalances, repositioning costs, revenue generation, manufacturing and

leasing costs and usage preference. A large number of these containers remained stored and unused in ports around the world [17]. These unused containers take up valuable space at shipping docks while waiting to be loaded, repositioned to different locations, resold or disposed of [18]. Given the abundance of these unused shipping containers, it seems logical to try to solve this issue while addressing the over-arching issue of emergency relief housing.

The use of shipping containers as housing presents both advantages and disadvantages. On the one hand, shipping containers are essentially large uninsulated boxes with no openings to allow light and air to enter and circulate. Although there are some insulated containers called Refers used for temperature-controlled product transportation, the vast majority of containers has no insulation and is referred to as GP containers, or general-purpose containers. Since there is no insulation and the walls are relatively thin, these containers are not soundproof. GP shipping containers may also present other disadvantages, based on their previous use, if they encountered cargo spillage or chemicals used to paint and seal their plywood floors. However, these setbacks can be easily overcome. On the other hand, shipping containers allow for modular design providing ease of transport by ship, rail or trucks. Used shipping containers are available anywhere around the world from many distributors and they are built to adhere to strict rules of the International Organization for Standardization (ISO) [19], [20].

Dwellings incorporating shipping containers have been considered since as early as the mid-1960s as a result of an architectural interest in merging mobility and manufacturing into building construction. Attempts in Australia and Europe have shown how universal and flexible these shipping containers can be in creating homes and sometimes offices. Even though the history of reusing containers for housing in the United States is very short, they have been used in the design and construction of homes and offices [21], [22] demonstrating that the use of GP shipping containers may provide a valuable alternative as longer-term reusable emergency relief housing units.

Philosophy of Design

The Department for International Development of the United Nations on its transitional settlement and reconstruction after natural disasters report [23] states that affected communities should not be displaced or ressetled unless it is absolutely essential in order to avoid risks from physiscal hazard since displacement is likely to exacerbate the impact a disaster has on their livelihood. Planned camps are places where disaster victims find accomodations on purpose-built sites and a full-service infrastructue is provided [23]. It is also reccommended that the size of the camps be manageable to facilitate assembly, placement and removal in stages or phases.

The use of GP containers and the arragement of units into camps that can accommodate different size families is the objective of this project. Factors like strategic planning, selection of sites, camp management, versatility and options for phasing, development and expansion, water, power and health management were considered for the design and proposed layout. Particular attention was given to minimize the disruption of the livelihood of victims.

The unibody construction and the size of the GP containers presents various challenges. The design must take into account that these structures may be used for reasonably long periods, depending on the required amount of reconstruction and the time and resources required to perform it. The idea of increasing to a maximum the ratio of occupancy per unit area cannot be taken lightly, even though it may result in a decrease in the costs. Similar consideration may be taken when addressing the amount of modifications to the initial structure. The importance of keeping families together, preventing social conflicts and the spreading of disease and crime control are of paramount importance and could results in a minimization of the need for constant monitoring by emergency personnel which could distract them from other important duties [23].

In this design, different size units are considered in order to accommodate different size families consisting of two to six people. Each unit incorporates a small kitchen, bathroom and common area. The use of public showers was discarded due to the presence of minors which would have created the need for close monitoring of these areas. Although the possibility of using two-story units was initially considered, this option was discarded due to several reasons: 1) the area required for the placement of stairs; 2) the decreased capacity due to alterations would require large reinforcements in lower-level units; 3) the need for larger equipment for the erection of the top units; and, 4) the preference for standarization of the type and size of the foundations.

In general, the floor layouts were designed to simplify the fabrication and erection stages. The units were designed to be modular. The individual modules were designed to be put together in different arrangements or layouts and for interchangeability. A total of five different modules were designed and are presented here, combined in three different arrangements for single-family units (see Figure 4).

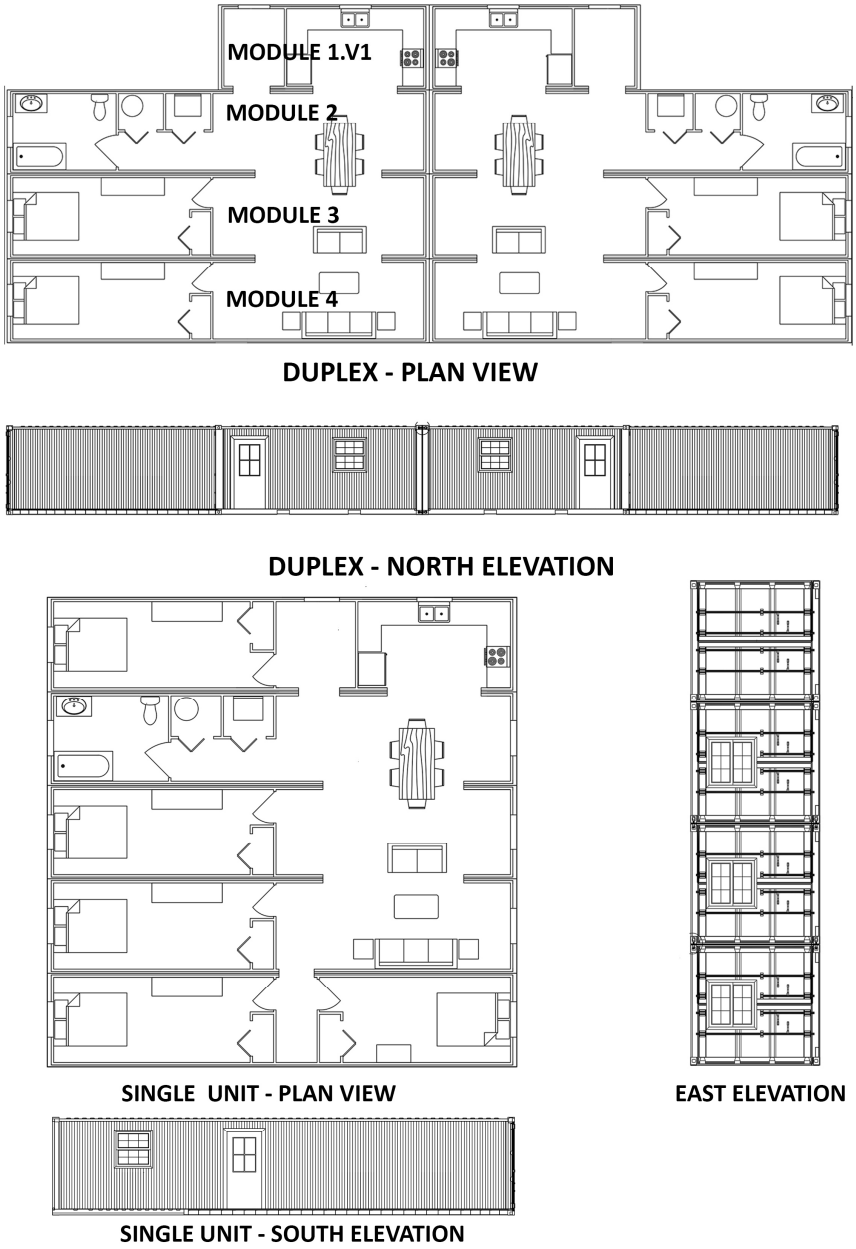

Figure 4. Module Design with Single and Duplex Units Alternative of Combination—Top Views and Elevations

The layout of the camp shown in Figure 5 accommodates up to 264 people using a combination of twenty-four duplex units and twenty single units; this layout is flexible and can be modified on demand. The layout was kept to this occupancy—with the single family units arranged in a combination of single separated or duplex units—to optimize the area and to meet the capacity of the power, water supply and waste treatment systems. In extreme cases, however, occupancy could be increased to 392 people—for example on the initial days after the disaster. The use of only duplex units without any need for modification of the standarized infrastructure is also possible.

Researchers have investigated the structural integrity of shipping containers [12], [13]. Transmission of loads through the walls was considered when openings were created for windows and doors as well as openings

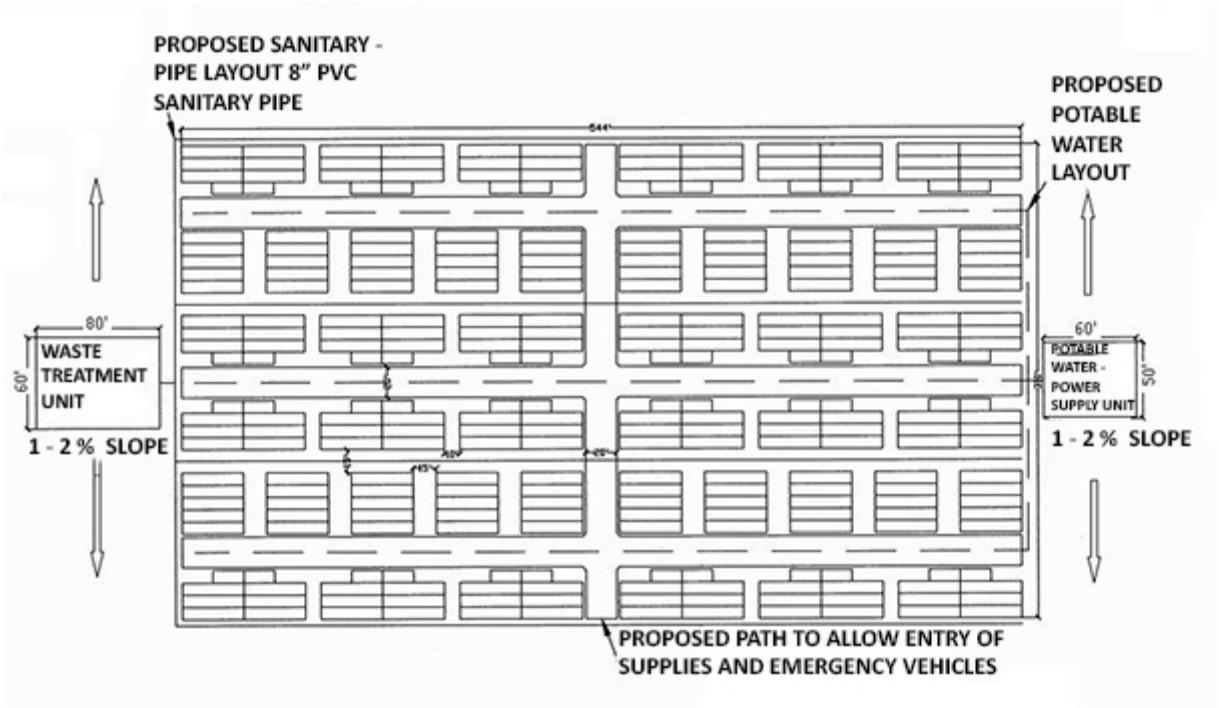

Figure 5. Emergency Relief Camp Layout Proposal with Power/Water Supply and Waste Treatment Systems.

inbetween the containers for an open concept making the interiors feel less box-like and claustrophobic. Due to the size of the openings, and in order to keep the integrity of the structure, reinforcement was found to be required. The use of steel tubing was selected for this purpose (see Figures 6 and 7).

Foundations

The floor of the containers is constructed of steel-beam boxes, C-channels or I beams, six inches deep, using corrugated metal and 1-1/8" thick plywood flooring [19]. The great majority of shipping container strength comes from their four corner posts, which transmit the loads from the corners to the support surface. These posts were kept intact to maintain the structural integrity of the container regardless of the desired configuration.

The size and style of foundations used in the emergency relief units were selected to carry stresses to different types of soils. The four corners of each container are designed to carry the loads of the container and its cargo. The type of foundations chosen were spread footing style shallow foundations with piers set on top to keep foundation layout simple and reduce time and costs. This type of foundation

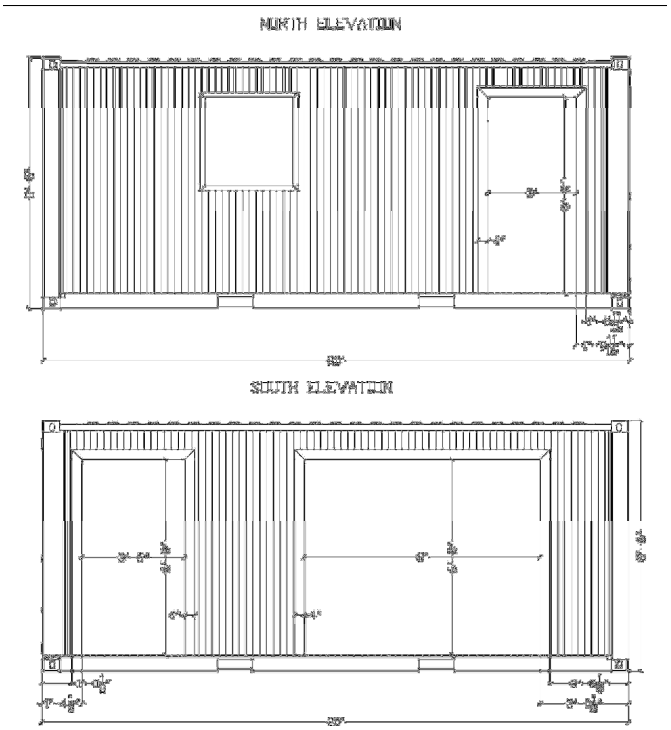

Figure 6. Doors and Windows Openings Dimensions.

provides overall flexibility in different soil conditions, as well as ease of placement.

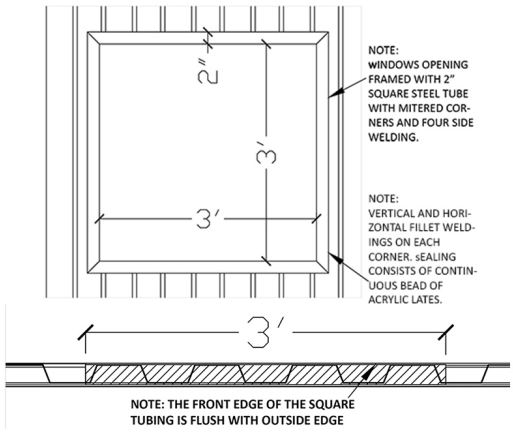

Figure 7. Detail of Window Reinforcement.

Soil-bearing capacity plays a vital roll in the design of the size and shape of the footings. Soil-bearing capacity can vary drastically from location to location. Given the unknown environmental conditions in which emergency relief units will be utilized, the worst possible soil conditions were used to design the footings; a soil-bearing capacity of two thousand pounds per square foot was used for the design.

The possibilty of these foundations being needed in regions with frost lines was considered in the design. The foundations used in the emergency relief units were designed for a frost depth of 48 inches. The total finished height of the pier was set at six feet to allow for a distance of two feet between the ground and the bottom of the modules. Keeping the units off the ground would help in preventing pest and insect infiltration, and reduce corrosion and deterioration (see Figure 8). The use of precast concrete elements will drastically reduce erection time and reduce time of installation. The proposed style of precast pier can be seen in Figure 9.

Module Connections

The fastening of the modules to the top of the piers needs to be strong but removable. The current method of securing GP shipping containers, whether on a ship, rail car or truck, is by twistlock-type fasteners that lock into each of the four corner castings. These fasteners are manufactured in various configurations. Steel plates were designed to be inserted in the top of the piers to carry and transmit the applied stresses and to serve as flat support surfaces for the twistlock mounts (see Figure 8). Once in position, the twistlock fasteners are locked. This method not only meets the requirements of strength and serviciability but also the condition of being removable and reusable.

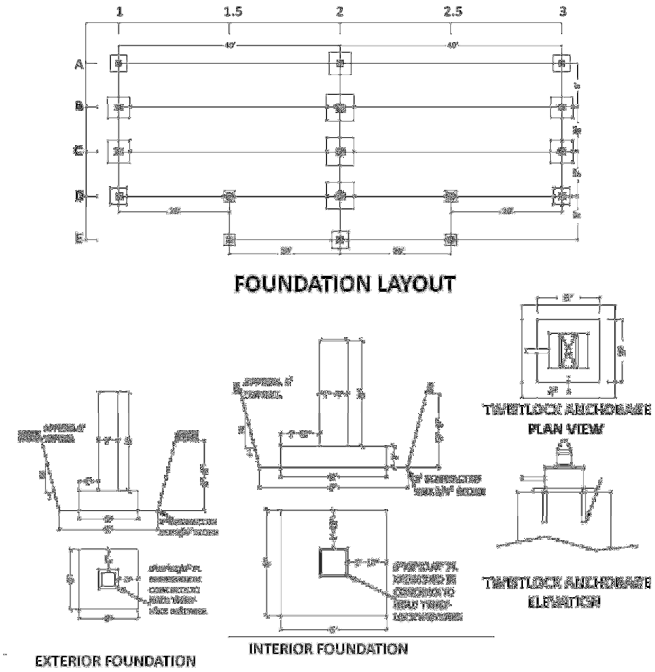

Figure 8. Foundation Layout—Dimension and Details of Exterior and Interior Foundations

The modules will be fastened to each other near the adjoining roof lines' removable connectors in the form of universal bridge clamp hooks with a maximum force capacity of twenty thousand pounds. This device eliminates the need for onsite welding to join the containers and reduces the time of assembly and removal.

The openings that had been cut in the sidewalls will be sealed using inflatable seals with a capacity of creating 20,000 pounds of force using air or water as an inflation medium. The seals are available in various shapes, sizes and materials (see Figure 10) [21]. Various options are also available to hold the seals in place such as an aluminum extrusion or retention clips. A non-reinforced DR4 foot base profile seal was selected for the sealing.

The seals include mitered corners and inflation valves that are accessible from the interior of the module. This method of sealing the gaps between modules is air and watertight, removable and reusable. To decrease assembly time onsite,

these seals are attached to all openings of modules two and four, chosen because of their interchangeable nature with all units. To protect and hide the seals after inflation, a renewable composite lumber—comprised of 95% recycled and natural materials requiring no finishing and which are rot and split resistant—was selected. The composite lumber spans across adjoining modules to close the openings on the sides and the top while an epoxy-coated steel plate covers the bottom of the opening.

Figure 9. Precast Concrete Piers [20]

Figure 10. Dynamic Rubber, Inc. Foot Base Profile Seals [21]

Interior Framing and Partitions

The interior framing selected is non-carrying load used solely for running mechanical and electrical components as well as a fastening point for insulation and drywall. In order to frame the interior spaces, 2-1/2", 20-gauge metal drywall studs separated 24 inches on-center were chosen due to their recyclable nature as well their reduced weight used with ½" thick drywall.

Insulation

Closed-cell polyurethane spray foam was selected as insulation as it provides extra sealing to openings and a high R value (R15.75) in the limited 2-1/2" depth, almost 50% higher than fiberglass [22-24]. Closed-cell polyurethane insulation also provides several other benefits such as being waterproof, durable and renewable.

Floor Covering

In an unaltered state, a typical GP shipping-container floor is made of 4'x8' 19-ply plywood, approximately 1-1/8" thick, secured to the cross members using self-tapping screws (see Figure 11) [19]. To decrease fabrication time and cost of the emergency units, the plywood floors will be sealed and leveled first with a skim coating of thinset, and then painted with "green" polyurethane coating to completely seal them [25].

Figure 11. Typical Shipping Container Flooring [19]

Site Infrastructure

In situations where there is no water or power available, as is usually the case in disaster areas, these types of infrastructure are necessary for the operation of society. Typically, infrastructure refers to roads, water supply, sewers and

electrical grids. The basic site layout shown in Figure 5 indicates the proposed locations of the potable water and power generating systems, and the location of the waste treatment system for the designed camp.

Wastewater Treatment

Perhaps the most important piece of infrastructure in any disaster is waste treatment. Bacteria, viruses and parasites are types of pathogens that can be found in wastewater that are hazardous to humans. Bacteria are microscopic organisms that are responsible for several wastewater diseases, including typhoid, paratyphoid, bacillary dysentery, gastroenteritis and cholera. Like bacteria, viruses are found on a microscopic level, but they are parasitic and can infect people through wastewater. Well-known diseases such as Hepatitis A, polio and viral gastroenteritis can be contracted from viruses in wastewater [26].

The options for waste treatment for this type of camp are limited, considering the characteristics of the site and the conditions of the area. A septic field is an impractical option in this type of development since the size of the area required would be too large and the cost of installation and closing too high. The use of composting toilets could be selected as a solution for the few days right after the disaster strikes, but it can be sustained for longer periods.

A mobile wastewater treatment system was the ideal system for the emergency camp shown since it offers the advantages of being portable, modular and customizable for any required demand whether large or small. It was determined that a system with a capacity of 90,000 gallons per day works for the layout shown. This type of mobile wastewater treatment system was specifically designed for remote camps, disaster relief and temporary events [27]. The other major advantage of using the system is its low maintenance requirements. The system contains only a few pumps, filters and distribution mechanisms that must be maintained on a regular basis [27]. The treatment technology referred to as AeroCell requires no chemical additions for proper operation, and no monitoring of controls testing of the AeroCell media has shown effective treatment to secondary and tertiary wastewater levels. Tertiary treatment levels are optimal because the water effluent can be released back into the most sensitive and fragile ecosystems.

Potable Water

Besides waste treatment, the second most important piece of infrastructure in a disaster is potable water. As previously mentioned, in wastewater, parasites can find their way into potable drinking water. Two of the typical types of parasites found in drinking water are protozoan and helminthes, which are more commonly referred to as parasitic worms. If ingested, these parasites can cause severe diarrhea and illness [26].

The selection of the potable water system could depend on the location and type of disaster. Several types of devices could be considered to meet specific demands. A containerized desalinization plant, which could take water from nearby sources such as the sea, rivers or lakes and turn it into potable water, could be considered. This type of system could also meet the calculated demand of 15,477 gallons per day, but would be a secondary option in the emergency layout if access by ground or air were not possible. Instead, a 20,000-gallon hydro-pneumatic storage tank would be used with a containerized reverse-osmosis unit. By using a pressurized water storage tank, no onsite water towers would need to be erected. This system would also eliminate the need for pumps to feed the individual units as well as a water tower.

In order for this system to function properly, the potable water would have to be brought in by ground or air, which may cause problems, depending on terrain. The water would first be put into a holding tank that would then be piped to a containerized reverse-osmosis unit that would feed the hydro-pneumatic tank. If water could not be brought to the site due to terrain restrictions, the containerized desalinization unit would take the place of the holding tank before the containerized reverse-osmosis unit.

Power Generation

Electricity is a key element in the layout of the emergency subdivision as well as the layout of each individual unit. Without electricity the wastewater and potable water systems would not be able to operate. Several forms of power generation such as wind and solar were researched for possible use in the emergency units, but due to the calculated 600KW daily demand, they proved to be insufficient.

A layout like the one shown in Figure 3 requires 900 kilowatts of power per day (including the standard 1.5 safety factor). A 900-kilowatt diesel generator pre-installed in a 40 -foot GP shipping container was selected. The generator would also require less specialized maintenance, and be easily transportable with the emergency units. The power would be distributed to the individual units through overhead transmission lines similar to traditional homes.

Site Grading

Grading the site properly as well as placing provisional roadways between the emergency relief units is the last major piece of site infrastructure. Without proper grading, the site could experience water "pooling" which would be detrimental for sanitation. To promote proper runoff, the site will be graded at a minimum slope of 1% from the center outwards north and south to keep water runoff away from the emergency relief units as well as the waste treatment, potable water and power generation facilities. This also becomes a major design consideration if multiple sites are to be placed next to one another. By having the runoffs going in only two directions, if multiple sites are placed next to each other, only the north and south sides would need a drainage ditch to transport the rainwater runoff away from the site(s), instead of on each of the four sides.

The pathways between the units are to be compacted ½" stone or, if possible, a single layer of asphalt surfacing material sloped at minimum 1%. The paths will be a minimum of twenty feet in width to promote efficient means of egress from the site, whether in a vehicle or on foot. By keeping the paths at a minimum of twenty feet in width, vehicles will be able to enter when the site is under construction; emergency vehicles will also be able to enter if needed during the life of the emergency relief unit.

Conclusions

The design of emergency relief housing units using GP shipping containers represents a feasible solution for housing of victims of natural disasters. The solution presented here presents several advantages among which are: the versatility of the system to be arranged according to the needs of the disaster area; the modularity of the system which allows for modification of the units presented here; the ability to be built off-site; the ease of transportation to the required area; and, the ability to be reusable and/or resellable.

References

[1] Protecting Health Following the Asian Tsunami. Humanitarian Health Action. World Health Organization. Retrieved July 17, 2012, from http://www.who.int/hac/crises/international/asia_tsunami/key_objectives/en/index.html

[2] Lizarralde, G., Johnson, C., & Davidson, C. (2010). *Rebuilding after Disaster – From emergency to sustainability* (Spon Press). New York.

[3] Nigg, J. M. (1995). Disaster Recovery as a Social Process. In Disaster Research Center- University of Delaware, *The disaster Recovery Process. Article 284.* (13pp.) Newark, Delaware.

[4] Global Facility for Disaster Reduction and Recovery (GFDRR), The World Bank and The Government of Haiti. (2011). *Haiti Earthquake Reconstruction – Knowledge Notes from DRM Global Expert Team for the Government of Haiti* (pp.1-48). Washington, DC: Retrieved July 17, 2012, from: http://www.gfdrr.org/gfdrr/sites/gfdrr.org/files/publication/GFDRR_Haiti_Reconstruction_KnowledgeNotes_0.pdf

[5] McCarthy, F. X. (2010). *FEMA Disaster Housing: From Sheltering to Permanent Housing.* (Publication No. 7-5700). Washington, DC. Government Printing Office.

[6] Federal Emergency Management Agency (2005). FEMA Tent City. Retrieved December 1, 2011, from http://semp.us/images/Biot589PhotoA.jpg

[7] Klarreich, K. (2010, January 31). Haiti Earthquake Diary. *The Christian Science Monitor.* Retrieved September 17, 2012, from http://www.csmonitor.com/World/Haiti-Earthquake-Diary

[8] Haiti Earthquake: One year later (2010). In *Britannica*. Retrieved December 1, 2011, from http://www.britannica.com/blogs/2011/01/haiti-earthquake-of-2010-one-year-later-picture-essay-of-the-day

[9] Sontag, D. (2012, August 15). Years After Haiti Quake, Safe Housing Is a Dream for Many. *The New York Times.* Retrieved September 17, 2012, from http://www.nytimes.com/2012/08/16/world/americas/years-after-haiti-quake-safe-housing-is-dream-for-multitudes.html?pagewanted=all

[10] Aftermath of the 2011 Tōhoku earthquake and tsunami. (2011). In *Wikipedia*. Retrieved November 8, 2011, from http://en.wikipedia.org/wiki/Aftermath_of_the_2011_T%C5%8Dhoku_earthquake_and_tsunami

[11] Temporary Housing in Schichigahama, Miyagi. (2011). In *Wikipedia*. Retrieved October 10, 2010, from http://en.wikipedia.org/wiki/File: Temporary_housings_for_tsunami_evacuees_in_Shichigahama.jpg

[12] Giriunas, K., Sezen, H., & Dupaix, R. (2012). Evaluation, Modeling and Analysis of Shipping Container Building Structures. *Engineering Structures*, *43*, 48-57.

[13] Borvik, T., Hanssen, A. G., Dey, S., Langberg, H., & Langseth, M. (2008). On the Ballistic and Blast Load Response of a 20-ft ISO Container Protected with Aluminum Panels Filled with a Local Mass – Phase

I: Design of Protective System. *Engineering Structures*, *30*, 1605-1620.

[14] About Containers. (2009.). Retrieved October 15, 2012, from http://www.containercontainer.com/ about_containers.aspx

[15] Container Corner Casting. (n.d.). Retrieved October 20, 2011, from http://www.containercontainer. com/ about _container s.aspx

[16] Nomura International PLC. – Annual report. (2010). Retrieved March 12, 2010, from http:// www.nomuranow.com/structuredinvestments/ resources/pdf/literature/it-products/nip_annual_ report _march_2010.pdf

[17] Rodrigue, J. P., Comtois, C., & Slack, B. (2009). *The Geography of Transport Systems*. (2th ed.). Routledge. New York.

[18] General Purpose (GP) Containers. Standard Packaging and Distribution of Goods. ISO 55.180.10 (n.d.). Retrieved September 30, 2012, from http:// www.iso.org/iso/home/store/catalogue_ics/ catalogue_ics_browse.htm? ICS1=55&ICS2=180&ICS310

[19] Container Flooring. (n.d.). Retrieved October 20 30, 2011, from http://www.marginup.com/ products /2854/Film-Faced-Plywood--FK-03.html

[20] Whites Precast Concrete. (n.d.). Retrieved October 20, 2011, from http://www.whitesprecast.com/ products.htm

[21] Dynamic Rubber, INC . (2007). Retrieved October 20, 2011, from http://www.dynamicrubber.com/ inflatable_seals/INFLATABLESEALPROFILES.html

[22] All about Shipping Containers – Intermodal Steel Building Units & Container Homes (2010). Retrieved October 15, 2011, from http://www.isbu-info.org/ all_about_shipping_containers.html

[23] Container Technology A-Z. Intermodal Steel Building Units & Container Homes (2011). Retrieved October 20, 2011, from http://www.isbu-info.org/ permalink/article_2010_march_shipping-container-technology_a-z.html

[24] Roofing Coating Paint – ACME Construction. (n.d.). Retrieved October 20, 2011, from http:// www.acmeok.com/index.php?news&nid=179

[25] Green Polyurethane Advantage. (n.d.). Retrieved October 15, 2011, from https:// www.gogreenworldproducts.com /Green-Polyurethane-Paints-(non-Isocyinate).html

[26] Pipeline – National Small Flows. (1996, July). *Wastewater Treatment Protects Small Community Life, Health.* (Vol 7, No. 3). Morgantown,WV.

[27] Mobile Wastewater Treatment system. (n.d.). Retrieved October 15, 2011, from http:// www.quanics .net/images/synergybrochlowres.pdf

Biographies

JOSE A. PEÑA is an Associate Professor of Civil Engineering Technology at the Department of Construction Science and Organization Leadership at Purdue University Calumet.

KURT SCHUZER is a graduate from the Construction Management and Engineering technologies at Purdue University Calumet.