DEVELOPMENT OF A LIGHTWEIGHT, PORTABLE, RECYCLABLE EMERGENCY SHELTER UNIT

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Abstract

Each year thousands of Americans are left homeless by natural disasters. In addition, thousands more are permanently homeless, living on our cities streets and parks. When homelessness occurs, emergency agencies like the Federal Emergency Management Agency and the American Red Cross are often tasked with providing emergency shelter for these unfortunate individuals. Unfortunately, the current system of supplying shelter is both complex and costly. Generally, emergency shelter consists of either large tents supplied by the military or through the use of mobile homes. Both systems are expensive and logistically difficult. This project proposes to develop and test a new system of providing emergency shelter. At the core of this system will be the development of a recyclable shelter unit composed of a recyclable corrugated board material. These shelter units will be designed for short-term use, usually up to three months, and can then be totally recycled. The units will be both lightweight and inexpensive and will consist of a set of corrugated board panels, which can be carried and assembled by no more than two persons. Setup and connections will be designed to be easily assembled by unskilled individuals using simple tools. After an emergency, the units can be trucked or air lifted into disaster struck areas to provide almost immediate shelter. In winter climates, these shelters can again be delivered by truck directly to the homeless to provide shelter from the dangerously harsh temperatures. After the initial need, the shelter can be easily de-constructed and the materials re-cycled. In addition to design considerations, this project will consider the economics of both the manufacturing and distribution of the shelters.

Keywords: Natural disasters; homeless; emergency shelter; recyclable; lightweight; inexpensive.

SECTION ONE: BACKGROUND

Disaster Relief

The United States, because of its geographic location and geologic make-up, has historically been prone to a variety of different types of natural disasters. These natural disasters include hurricanes, tornados, floods and earthquakes. For the purposes of this project, a natural disaster will be defined as a weather / geologic event classified by the federal government as qualifying for federal disaster relief.

Table 1: Natural Disasters in the United States

NATURAL DISASTERS IN THE UNITED STATES				
	DISASTER TYPE			
YEAR	HURRICANE	TORNADO	FLOODS	EARTHQUAKE
1990	0	9	5	1
1991	2	1	6	1
1992	2	13	14	2
1993	0	9	11	2
1994	2	4	6	1
1995	4	14	18	1
1996	3	11	19	2
1997	2	14	18	1
1998	4	18	18	1
1999	5	15	8	1
2000	0	9	6	2
2001	0	17	11	1
2002	1	16	17	2
TOTAL	25	150	157	18

According to the emergency management agencies such as American Red Cross, Federal Emergency Management Agency (FEMA), Virginia Department of Emergency Services, World Health Organization (WHO), and climatic data centers such as the California Geological Survey, Dartmouth Flood Observatory, National Hurricane Center, National Environmental Satellite Data and Information Service (NESDIS), National Center for Environmental Prediction (NCEP), National Oceanic and Atmospheric Administration (NOAA) and United States Geological Survey (USGS), there have been over 350 such natural disasters documented since 1990.

These disasters have taken their toll on the population of certain geographic sections of the United Stated in terms of lives, money and emotion. There have been hundreds of persons killed or injured as a result of natural disasters since 1990. In addition over 481,000 men, women and children were left homeless. It is these homeless men, women and children that will be the focus of this project

Table 2: Homeless left by Natural Disasters in the United States

HOMELESS LEFT BY NATURAL DISASTERS IN THE UNITED STATES				
	DISASTER TYPE			
YEAR	HURRICANE	TORNADO	FLOODS	EARTHQUAKE
1990	-	302	-	-
1991	-	-	-	-
1992	126,167	56+	-	5,046
1993	-	3	27,654	1,000+
1994	-	-	2,550	10,000+
1995	6,100+	475	36,725	-
1996	198,963+	892+	23,000	-
1997	-	4	548	-
1998	1,536+	-	10,116+	-
1999	2,500+	1505+	9,238	-
2000	-	59+	460	-
2001	-	536	11,351	-
2002	250+	100+	4781	-
TOTAL	335,516+	3,932+	126,423+	16,046+

Homeless in the United States

It is estimated that on any given night, there are at least 750,000 people in the United States without a permanent shelter. To put this number in perspective, these homeless outnumber the populations of San Francisco, Boston or Washington DC (General Information about Homelessness). Over the course of a year, between 1.3 million and 2 million people will experience homelessness. While every major city is making an attempt to assist the homeless, a recent survey taken in 27 major U.S. cities found that 37% of all emergency shelter requests went unmet (National

Coalition for the Homeless, 2002). The following chart illustrates the approximate number of homeless people in six large US cities.

Table 3: Homeless in the United States

HOMELESSNESS IN THE UNITED STATES	
CITY	**APPROXIMATE NUMBER OF HOMELESS**
NEW YORK	38,627 (Daily Report, 2004)
BOSTON	6,210 (Anderson et al., 2002)
CHICAGO	3,000 (Wright, 1995)
ATLANTA	12,000 (Blueprint to End Homelessness in Atlanta in Ten Years, 2003)
DALLAS	5,181 (Cold Weather Homeless Census Report, 2003)
MIAMI	4,000 (Homeless Wrap-up September 2002)

While these people are technically without homes, they are not always without shelter. Sheltering of the homeless generally falls into the following four categories:

1. Persons living on the street
2. Persons living in emergency or transitional shelters
3. Persons living in cars
4. Persons living in campgrounds

Of these four categories, those persons living on the street are the most critically in need of assistance. Living on the street is a dangerous proposition at best and a can be potentially life threatening at worst. In the harsher winter climates of the northern states, persons living on the street are subjected to significant injury or death from exposure to the lower temperatures. Several people living on the street die each year from exposure related incidents.

Current Methodology of Shelter Assistance

While there are several agencies, which assist the homeless in finding shelter, in most cities there is no methodology in place to assist those persons actually living on the streets. When the standard shelters are full there is no place for these people to go. They can be seen nightly in streets and alleys sleeping under blankets made of newspaper or cardboard. A system of providing emergency shelter for these persons could significantly reduce the amount of suffering these persons must endure.

In the case of natural disasters, after each event has been declared and even sometimes before the event has occurred, if the event is eminent, like in the event of a flood or hurricane, agencies within and outside of the federal government are mobilized to prepare to provide disaster relief. These agencies include the Federal Emergency Management Agency (FEMA), the Red Cross and others. The form of this relief varies from event to event, but generally includes, temporary shelter, food, clothing, and medical supplies. The temporary shelter provided could be broken down into two general categories: short term, and intermediate to long term. The short-term shelter provided usually takes the form of tents supplied by either FEMA or the military. These tents can be shipped into the disaster area by truck or helicopter within hours of the event to provide almost immediate shelter relief. The intermediate to long-term shelter generally takes the form of mobile homes. Again these are generally provided by FEMA.

After Hurricane Andrew, mobile homes were supplied by FEMA to help house the estimated 5,000 homeless (Tardanico, R., 1993). These mobile homes were either newly purchased for this event or supplied from storage areas set up throughout the country. Mobile homes such as the ones supplied by FEMA are generally 14 feet wide by 60 feet long and can cost anywhere from $12,000.00 to over $18,000.00. According to Bill Massey, from FEMA Region IV, Atlanta, smaller trailers, generally measuring 8 feet wide by from 20 to 30 feet long, can be purchased for approximately $9,000.00.

In addition to the substantial initial purchase cost, the use of mobile homes presents several other drawbacks. These include the following:

1. The purchase - The manufacturing process takes a significant amount of time. It generally only takes one day to manufacture a complete a single section mobile home after an order reaches the production line. According to the Manufactured Housing Institute, Arlington, Virginia, a typical mobile home manufacturer can usually produce 8 to 10 mobile home sections per day. However, there are often substantial backlogs. It is not unusual for manufacturers to be a month or more behind schedule.
2. Storage - To alleviate the problems encountered with the manufacturing process, the mobile home Units can be manufactured in advance and stored. The obvious problem with this is the cost of storage. Can these units be economically stored in strategic locations? In addition to the difficulty finding suitable storage areas, long term deterioration and potential vandalism of the units must be considered.
3. Transportation - The transportation process is also a lengthy process. Mobile homes are generally transported over existing highways by tractor-trailer. This means there must be clear truck access from the manufacturing plant to the emergency shelter site. It is often difficult, if not impossible, to access remote sites with this form of emergency shelter.
4. Disposal after use - A fourth problem is what to do with the units after the crisis is over. There are several possibilities. First, the units can be sold used on the

open market. This, of course, takes time and considerable administration involvement. A second option is to return the units back to their storage areas. The units must then be inspected and refurbished prior to the next use. This again involves both time and money.

To recap, the current methodology of providing disaster emergency shelter includes the following drawbacks:

- Initial Cost
- Storage Problems
- Transportation Difficulties
- Refurbishing And Reuse Difficulties

SECTION TWO: PROJECT OBJECTIVES

The primary purpose of this research project is to develop a new type of recyclable emergency shelter. It is envisioned that this shelter will be primarily made out of paper in the form of corrugated boards. The primary purpose of this emergency shelter will be to provide immediate shelter to people in times of an emergency. This means the shelter will minimally provide the following:

- Weather protection:
  - Rain
  - Snow
  - Wind
  - Temperature (protection from heat and cold)
- Protection from rodents, i.e., rats, mice, insects
- Security
- Ventilation

In addition to fulfilling the primary purpose of providing shelter, this new shelter system will alleviate the drawbacks of the currently used procedures. This new shelter system will be relatively inexpensive to manufacturer. It will be constructed out of readily available materials. It will be relatively lightweight and easily transportable. It will be easy to erect without the need for a high level of technical expertise and specialized tools. It will be designed for short to intermediate term use and will be able to be easily deconstructed and recycled. In short, the new shelter system will be:

- Inexpensive
- Easy To Transport
- Easily Erected
- Easily De-Constructed
- Easy To Recycle

SECTION THREE: DESIGN CONSIDERATIONS

The following is a list of the major design considerations, which must be addressed in this research.

1. Conceptual unit design -
   - Overall size of completed shelter
   - Number of occupants
   - Amenities to be considered, i.e., clothes storage, cooking, personal hygiene
2. Materials
3. Wall panel size
4. Wall panel configuration (shape)
5. Roof panel size
6. Roof panel configuration (shape)
7. Floor structure
8. Fenestration sizes and locations (windows)
9. Ingress/Egress sizes and locations (doors)
10. Security for the inhabitants
11. Connections -
    - Wall panel to wall panel connection (intermediate location)
    - Wall panel to wall panel connection (corner location)
    - Wall panel to roof panel connection at eave
    - Wall panel to roof panel connection at gable end
    - Roof panel to roof panel connection
    - Wall panel to floor panel connection
    - Connection of the shelter to the ground
12. Weather proofing -
    - Rain resistance
    - Snow resistance
    - Hail resistance
    - Resistance to heat gain
    - Resistance to heat loss
    - Wind resistance (to some degree)
13. Transportability
14. Ease of Assembly and Erection

SECTION FOUR: DESIGN SOLUTIONS

The following is a brief description of the shelter design specifications;

1. Shelter Unit Specifications

Unit Size-Single Occupancy		Unit Size-Double Occupancy	
Width:	6’-0”	Width:	8’-0”
Length:	7’-0”	Length:	10’-0”
Height @ centerline:	7’-6”	Height @ centerline:	7’-6”
Height @ eave:	5’-6”	Height @ eave:	5’-6”
Weight:	167 lbs	Weight:	274 lbs

2. Panel Specifications

Panel Material:	Georgia Pacific “Triple Wall” corrugated containerboard.
Panel Thickness:	Approximately ¾”, 1.875 cm This is a totally recyclable corrugated board material.
Panel Coating:	Michelman, Inc. Coating X300 Plus This is a totally recyclable waterproof coating, which can be both factory and field applied.

Panel Sizes:

Single Occupancy		Double Occupancy	
Corner Panels:	3’X2’X varies	Corner Panels:	2’X 2’ X varies
Side Wall Panels:	4’w X 5’-6”h	Side Wall Panels:	4’w X 5’-6”h
		End Panels:	4’w X varies
Roof Panels:	8’wX 10’l	Roof Panels:	10’w X 12’l
Floor Panels:	6’w X 8’l	Floor Panels:	8’w X 10’l

3. Connection Specifications

Factory connections:	Molded panel corners Glued panel joint splice plates Waterproof-hinged roof panels Waterproof-hinged floor panels
Field Connections:	1.5” steel drywall screws

4. Delivery And Unpacking Instructions

1. Shelter Unit Packages (SUP) are truck delivered or air lifted to the site.
2. Two persons will be required to carry the SUP to the actual erection site.
3. Un-strap the SUP (Photo 1,2).
4. Layout and identify shelter components. The SUP contains the following:
   A. 1-folded floor panel
   B. 4-Corner wall panels
   C. 2-Side wall panels
   D. 2-End wall panels
   E. 1-Folded roof panel
   F. 2-lengths of side wall panel to roof panel connector splines
   G. 4-lengths of end wall panel to roof panel connector splines

H. 2-lengths of side wall panel to floor panel connector splines
I. 4-lengths of end wall to panel floor panel connector splines
J. Screw connector package with washers
K. Weatherproofing joint tape

5. Assembly Instructions

STEP 1 Unfold floor panel and level to site contours
STEP 2-3 Erect corner panels and secure to floor panel using the wall panel to floor panel connector splines and screws included in SUP
STEP 4a Erect the sidewall panels and secure to floor panel using the wall panel to floor panel connector splines and screws included in SUP
STEP 4b Secure the sidewall panels to the corner panels using screws in screw package included in SUP
STEP 5a Erect the end wall panels and secure to floor panel using the wall panel to floor panel connector splines and screws included in SUP
STEP 5b Secure the end wall panels to the corner panels using screws in screw package included in SUP
STEP 6 Unfold and install the roof panel and connect to the wall panels using the wall panel to roof panel connector splines and the screws provided in the SUP
STEP 7 Install weatherproof tape over exposed panel edges.

The completed shelter unit will accommodate two adult individuals for a period of up to three months (90 days).

6. Disassembly

At the end of the intended use period the entire shelter can be broken down and be totally recycled.

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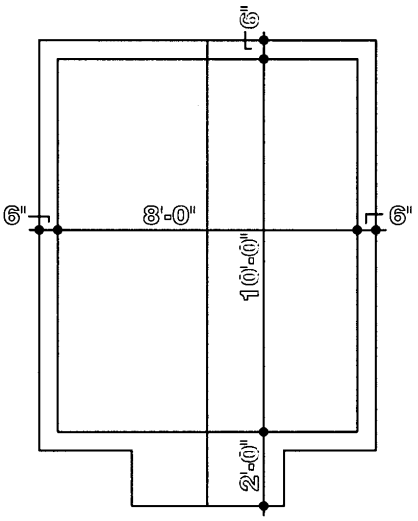
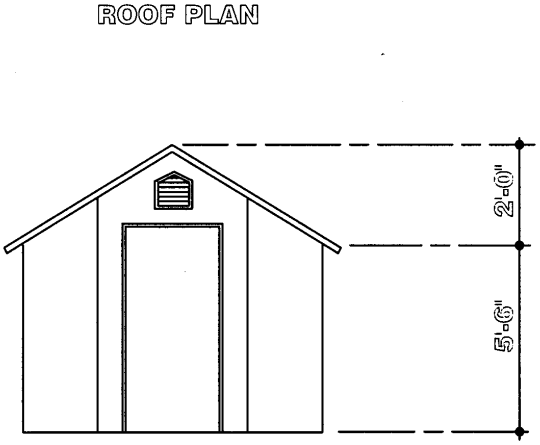
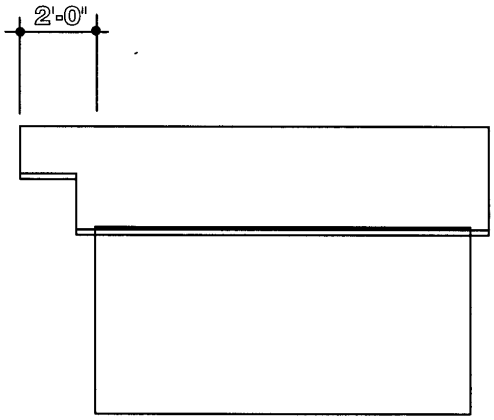
APPENDIX 1: CONCEPTUAL DESIGN



ROOF PLAN

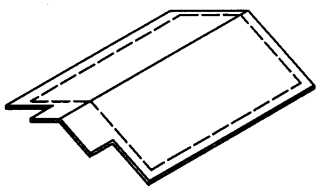


FRONT ELEVATION

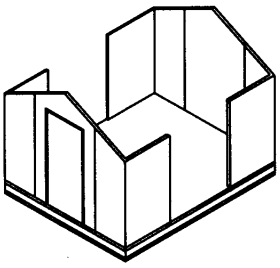


RIGHT SIDE ELEVATION

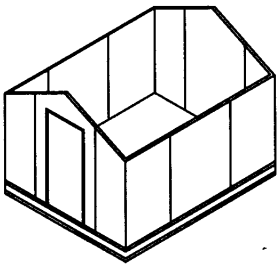
TWO PERSON EMERGENCY SHELTER
CONCEPTUAL DESIGN



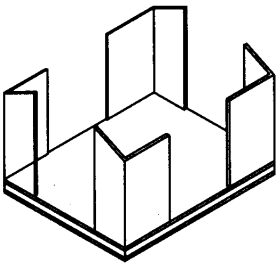
STEP SIX:
INSTALL SIDE ROOF PANELS



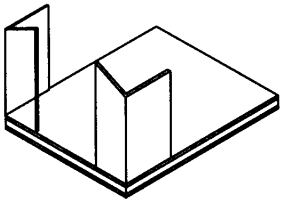
STEP FIVE:
INSTALL FRONT & REAR INFILL PANELS



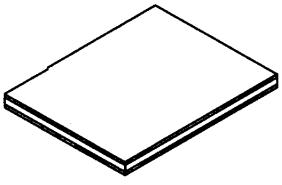
STEP FOUR:
INSTALL SIDE INFILL PANELS



STEP THREE:
INSTALL REAR CORNER PANELS

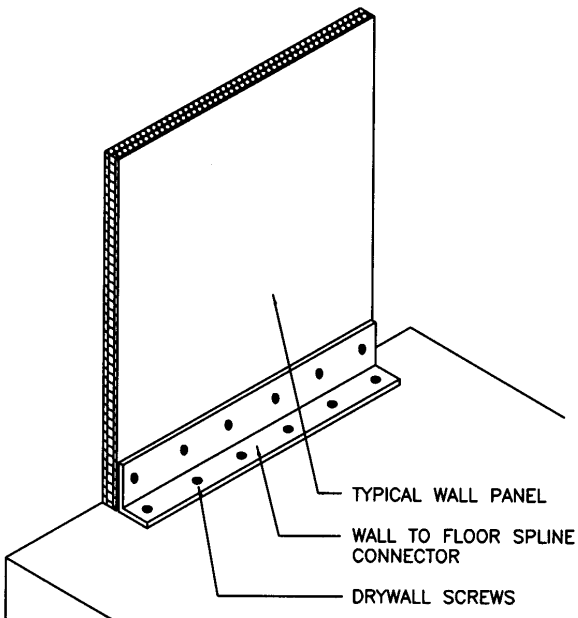


STEP TWO:
INSTALL FRONT CONER PANELS

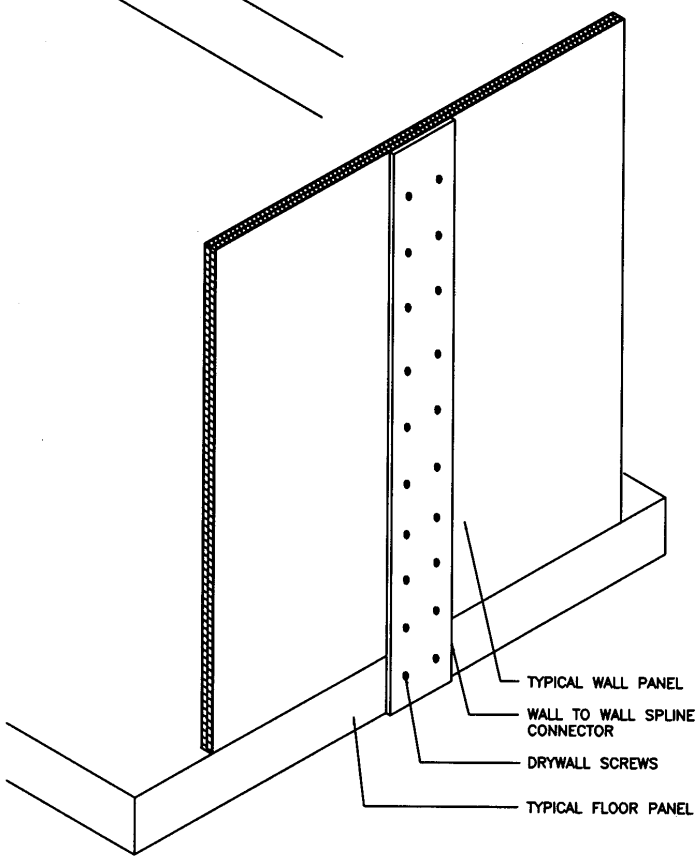


STEP ONE:
INSTALL FLOOR PANELS

TWO PERSON EMERGENCY SHELTER
CONCEPTUAL DESIGN



WALL TO WALL CONNECTION



WALL TO FLOOR CONNECTION