Development of Tent System for Emergency Applications

Rodnel O. TAMAYO*[1], Carla Joyce C. NOCHESEDA*[2], Nelson L. TUMIBAY*[3], Ronie S. ALAMON*[4]

Abstract

The tent system is developed to aid preparations for emergencies; the design can be adapted, and thus provide immediate shelter to people who may be displaced. A tent system can serve as temporary warehouse, field hospital and command center. Currently, no emergency tent designs are readily available in the market in the Philippines. This project researches on the various fabrics, textiles, tent design, and welding techniques that are locally available and make recommendations for an emergency tent system that can withstand at least 75kph wind. This enables groups, such as local government units or civil societies mitigate disaster risks in their areas. Tests like water resistance, water permeability, tearing, and tensile, are conducted on fabrics and textiles; while high quality welding and GI pipes are recommended for the design structure. The tent prototype undergone actual wind testing of 75kph. The use of bamboo to replace GI pipes is mentioned as one of the recommendations. Polycotton fabric performed best among locally available tent canvas materials effectively repelling water and contributing to a lighter tent system. Due to some constraints, the tent is designed and tested to only withstand a maximum 75kph wind speed and 2000 mm rainfall.

I. Introduction

In a report by the United Nations University's Institute for Environment and Human Security and the German Alliance Development Works, the Philippines is named as one of the top 10 countries facing the highest risk due to climate change together with Vanuatu, Tonga, the Solomon Islands, Guatemala, Bangladesh, Timor-Leste, Costa Rica, Cambodia and El Salvador.[1] As a result of climate change, more frequent extreme weather disturbances are expected.[2]

When typhoon Yolanda (international name Haiyan) strucked the Philippines in November 2013 forcing thousands of people out of their homes, a great need to provide emergency shelters to affected populace arose. Available temporary shelters immediately deployed after typhoon Yolanda mostly came from foreign stockpiles such as those from the United Nations High Commissioner for Refugees (UNHCR. However, because of the large number of affected people, available tents are not enough to meet the requirement.

The Department of Science and Technology then came out with a project entitled, "Development of Tent System for Emergency Applications" under its Quick Response Program. The project aimed to develop tent systems that can be used in case of emergencies to provide immediate shelter to people displaced by the calamity or disaster. A multipurpose tent will also be developed to serve various functions such as temporary warehouse, field hospital and command center. The tent systems manufacturing is meant to be fast and done not just by specialized tent manufacturers, but also by other manufacturing sectors such as the metalworking and the garments sector.

The tents must also be cost-effective and durable enough to serve as temporary shelter while the displaced residents are rebuilding their homes.

The availability of cost effective and easily produced tents will strengthen the country's capability to respond to emergencies especially on addressing critical needs such as shelters. Stockpiles of these tents can be set-up and ready to be deployed as the need arises.

General Objective:

To develop cost effective and easily produced tent systems for emergency use.

Specific Objectives:

To design, develop and evaluate tent systems for the following applications:

a. Shelter for a family with maximum 5 members;
b. Shelter for a family with maximum 7 members; and
c. Multipurpose tent

II. Stakeholders expectations and technical requirements

The project team met with a few of the target stakeholders such as the Philippine Red Cross that are mostly involved in the distribution of emergency shelters during calamities; and

*1 *Chief Science Research Specialist, Materials and Process Research Division Metals Industry Research and Development Center Bicutan, Taguig City Philippines*

*2 *Science Research Specialist II Metals Industry Research and Development Center Bicutan, Taguig City Philippines*

*3 *Senior Science Research Specialist Metals Industry Research and Development Center Bicutan, Taguig City Philippines*

people affected by typhoon Yolanda who are still living in temporary shelters six (6) months after the calamity in affected areas of Leyte and E. Samar such as Tacloban, Guian, etc.

In the Leyte and E. Samar areas, where after ten (10) months since typhoon Yolanda strucked the Visayas, few families still resides in temporary shelters donated by the United Nations; these shelters are designed to be used for only six months.[3] The project team consulted some of these families and asked for feedbacks as to their experience living in such emergency tents more than the designed ideal usage time. The respondents mentioned that the reason for their prolonged stay in these shelters is that the local government has not provided them of a permanent housing. They are part of the illegal settlers who used to live near waterways, while others used to live near what the government now considers as permanent danger zone. They say a tent with high headroom is what they prefer since they have to duck to get in and out of the UNHCR tents. At noontime, they have to stay outside these tents because the heat accumulates inside and becomes unbearable.

III. Materials Testing

A. Fabrics

Six fabrics for the canvas were evaluated. Choosing the canvas for testing relies mainly on its availability in the Philippine market so that the goal of carrying out the production and fabrication anywhere in the Philippines is highly possible.

a.1) Cotton/Polyester Mix

This fabric has 35% Cotton, 65% Polyester mix combination with strong texture and good strength. This fabric is readily available in Divisoria, Manila in a variety of colors. Its mass per unit area is about 200 to 400 g/m2.

a.2) Taffeta

Taffeta is a 100% woven and coated polyester fabric. It is typically used as car cover, bag, luggage, tent, beach-chair, etc. It is known to be waterproof and lightweight.

a.3) Rubberized Taffeta

Rubberized taffteta has the same property as that of the taffeta fabric. The difference is that the other side of the rubberized taffeta is coated with rubber making the fabric more durable and less prone to tearing and greatly increasing its waterproofing properties.

a.4) Vinyl Tarp

Vinyl tarps are mostly for industrial use and are waterproof. It has high abrasion resistance. They resist oil, acid, grease and mildew. The vinyl tarp is ideal for agriculture, construction, industrial and trucks. They also have a high tear strength.

a.5) Polyethylene tarp/Laminated Sack

A polyethylene tarp is a laminate of woven and sheet material. The center is loosely woven from strips of polyethylene plastic, with sheets of the same material bonded to the surface. This creates a fabric-like material that resists stretching well in all directions and is waterproof. When treated against ultraviolet light, these tarpaulins can last for years exposed to the elements, but non-UV treated material will quickly become brittle and lose strength and water resistance if exposed to sunlight.

a.6) Heavy duty canvas

Canvas fabric is an extremely heavy-duty plain or duck woven fabric, ideal for making sails, tents, marquees, backpacks, tarpaulins, and other items for which sturdiness is required. It is also naturally breathable, and its ability to regulate temperature and moisture makes canvas fabric unique. This fabric though not readily waterproof has to be coated.

The fabrics have undergone testing as shown in Table 1. The results show that, for tensile test, it is the polycotton fabric and the heavy duty canvas that meet the minimum breaking force requirement of 650 Nm based on specifications of the UNHCR tents. This fabric is not readily available with waterproof coating, hence, preparations have to be done on the fabric. This material is particu-

Table 1. Summary of results for tests conducted on all fabrics

Fabric	Tensile 650Nm	Tearing 100N	Water resistance	Water vapor absorbed
Polycotton	√	√	√	√
Heavy Duty Canvas	√	√		
Vinyl Tarp		√	√	√
Rubberized Taffeta			√	√

*4 *Science Research Specialist II*
Metals Industry Research and Development Center
Bicutan, Taguig City
Philippines

larly considered because of the information provided by the UK Aid regarding their tent canvas as a cloth with applied coating that performed well per their specifications.

Tensile test for sewn assembly was also conducted. Most of the tents deployed according to feedbacks from LGUs tend to fail on the sewn parts of velcro-canvas and canvas connection. This test is governed by ASTM D-1683. Table 2 illustrates the results of the tensile test for sewn assembly.

As illustrated, it is best to sew the polycanvas fabrics twice and use adhesive to join them; it has a seam breaking strength of 467 N. A strap sewn on the polycanvas fabric with heat press has a breaking strength of only 266 N. There is no standard available to compare the above results. It can only be used as benchmark for the various strength the sewn assemblies can provide. The sewn assembly breaking strength test made it clear that, to ensure any strap remains attached to the fabric, it should be sewn tracing the perimeter of the strap or velcro and heat pressed.

Table 2. Results of tensile testing of sewn seam assembly

Sewn Assembly Sample	*Seam Breaking Strength, N*
Folded, twice sewn	392
Sewn only	206
With adhesive only	146
Twice sewn with adhesive	467
Sewn with adhesive	321
Sewn strap with heat press	266
Plastic material	510
Velcro strap with adhesive 8 inches	1491
Velcro strap with adhesive 4 inches	1251
Velcro strap with adhesive 2 inches	125

IV. Availability and Cost

Materials used are readily available in the Philippine market as this is the primary direction of this project - to use materials that are easily sourced locally. The materials are sourced in Binondo, Manila widely known for tent materials. While there is no standard name for fabric/canvas the best way to acquire the canvas is to bring a sample. The price range of the fabrics/canvas varies from 80 to 130 pesos per yard (Php 80-130).

Figure 1. Assembled Emergency Tent System

V. Design Realization Process

The Project Management and Engineering Design Services Office (PMEDSO) of the Department of Science and Technology (DOST) has the sole task of providing the working design for the project. They will be further referred to in this paper as the designers. They worked under the following design considerations and criterion: First, the design is based on the UNHCR standard except for some specifications, i.e. the use of GI pipe as frame material, use of fabrics that are commonly available in the country. The main advantage of the design is that labor and materials can be sourced locally.

Second, the designers performed a structural analysis to test the structural integrity of the tent in the conditions specified in the standards that the project team agreed to follow. Unfortunately, not all conditions and factors can be included in the analysis i.e. interaction between frame and fabric, interaction between fabric and wind, etc. and that is where actual testing comes into play and where the designers can learn practical things about the design so that they can modify them accordingly.

Third, adjustments to the height of the tent were considered when this issue was raised during the 2014 midyear planning meeting. The design intent is to standardize the length of the leg, rafter and ridge for easier fabrication and interchangeability.

Fourth, the design team decided that the straps and other mounting implements between the fabric and frame, tent and ground, rope and fabric will be determined as the project goes along the fabrication process.

VI. Tent Manufacturing Guidelines

The first part of the manufacturing guidelines discusses the shape, type, size and construction of the tents: Three (3) types of tents that varies in size designated as R-22 with maximum floor area of 22 m2; R-32 with maximum floor area of 32m2; R-50 with maximum area of 50m2. The variation in size of the tents is made so as to address different uses and functions such as for small family of at least 5, at least 7, atleast 9 or as hospitals, headquarters, command centers. The tent consists of two (2) major layers, namely: the outer canvass and the main canvas. Ideally, there should be a continuous distance of 135 mm between the outer canvas to the main canvas for ventilation purposes. But based on demonstrations the project team conducted, the availability of space to where the tent is pitched will determine if this distance is achieved.

The outer layer of the tent should be made ideally from a polycanvas having a ripstop weave. The ripstop weave is essential because in manufacturing jobs where stitiching is required, the stitch adheres and stays on the canvas better.

Figure 2. Interior of the Emergency Tent System

VII. Bamboo Tent

A tent design where bamboo replaced the GI pipes was included in the terminal report. Though not fabricated with an actual prototype, the design will give an option to institutions who may choose to adapt the tent design and to replace the GI pipes with indigenous material such as bamboo.

There are many advantages of using bamboo instead of GI pipes. First, it is better in terms of reducing the overall weight of the tent assembly. Second, it is readily available in many areas in the country. The design takes into consideration the specie of bamboo that is thick enough and is strong enough to carry the weight when the tent is full function. Bamboo is the tallest perennial grass that belongs to the Graminae family. Due to the long cylindrical woody stem strength and ease of workability, bamboo is a versatile material for a variety of economic uses: handicraft and furniture; farm implements; fishpen, fishcages and other fishing gears; banana props; musical instruments; pulp and paper; and house construction. Aside from these, young bamboo shoots of some species are edible.

Demand for bamboo in the Philippines is steadily increasing. However, the demand is not being currently met. Bamboo production is, therefore, a potential source of income for agroforestry farmers.

Though bamboo, as a construction material is widely used in the Philippines, no data is available as to the tensile strength of various bamboo with considerable diameter such as intended for the tent prototypes.

VIII. Conclusion

The DOST-MIRDC's emergency tent prototype is made of polycanvas fabric which is composed of a waterproof plastic based fabric on one side and a woven fabric type on the other, that can be sewn or heat pressed. The fabric undergone testing such as: tensile test, tearing test, water resistance and water absorption tests. The polycanvas fabric lead all locally available fabrics in terms of exhibiting the best value in almost all the tests conducted. Using GI pipes as one of the main materials for the emergency tent also provides advantage as it can be easily sourced locally.

The development of emergency tent prototypes allowed the possibility of a more effective way of putting forth preparedness during disasters in the country. The DOST-MIRDC's initiative to develop emergency tents does not only address the needs of Filipinos in emergency situations but also increases their awareness on the availability of local materials that can be used by different localities and municipalities during unwanted circumstances brought by unpredictable changes in their environment.

Moreover, the project allowed both the national government and the Local Government Units to have a more reliable emergency preparedness plan by adopting the emergency tent prototypes to provide temporary shelters to people displaced by calamities.

IX. Recommendation

Due to several issues that emerged during the testing of the emergency tent prototypes, the following recommendations are provided:

- Improve the strength of the straps by tracing its perimeter while stitching to ensure that the stitches are more secure. It can further be strengthened with the use of adhesive or heat press.
- Ensure the detail and accuracy of the welding and size of the GI pipes to allow interchangeability of pipes when assembling the frame of the tent. This will make the assembly process faster.
- Localizing the manufacture of the tents by encouraging the LGUs to weld their own GI pipes and sew their own fabrics. This process will not only lessen the cost of production but will also make the availability of the tent in every LGU possible.

X. References

1. Alave, K.L. (2011). Philippines ranks third on climate change vulnerability list. Inquirer.net. Retrieved from http://globalnation.inquirer.net/14987/philippines-ranks-third-on-climate-change-vulnerability-list

2. Mathiesen, K. (2015). Extreme weather already on increase due to climate change, study finds. The Guardian. Retrieved from https://www.theguardian.com/environment/2015/apr/27/extreme-weather-already-on-increase-due-to-climate-change-study-finds

3. World Design Organization. (N.D.) The Refugee Housing Project. Refugee Housing Unit. Retrieved from http://wdo.org/site-project/refugee-housing-unit/