Ocho Balay: The Design and Developmental Construction of a Typhoon Shelter for the Rural Areas in the Philippines

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By

ROWELL RAY LIM SHIH

Cebu, Philippines

ABSTRACT

The objective of this study is the design and development of a typhoon shelter for the rural communities of Cebu, Philippines. This study also aims to establish a continuation of the successful *I-Siguro Daan* Transitional Shelter which was successfully deployed in 2014 after the onslaught of Typhoon Yolanda. In order to develop the methodological design of the Permanent Shelter, the author presented several factors into consideration: the understanding how the rural communities use the *present I-Siguro Daan Transitional Shelter*; to further develop and improve the interior space of the shelter; to propose a more roof design; and to design a sustainable toilet and kitchen area for the users. Aside from using surveys and interactions with the rural communities, one of the methodologies used in this design process involves the process of *Exploratory Design*, which focuses on gaining the understanding how the communities use the present *I-Siguro Daan Transitional Shelter*. The study also uses the process of Design based Research that is the development and implementation of design through collaboration among different disciplines.

1. INTRODUCTION

In 2013, typhoon Haiyan devastated the central Visayas, killing more than 7,000 people, mostly in the rural communities and shorelines. More than 360,000 houses in Eastern Visayas were totally destroyed by Super Typhoon Haiyan, thus highlighting the importance of typhoon-resistant architecture. Many studies on resettlement projects in the Philippines show that beneficiaries' greater involvement in the construction of their houses shows advantages that are not normally associated with agency-driven. The Philippines is a rapidly developing country which experiences the problem of rapid family formation, poor housing and an increased scarcity of land. Housing shortage is particularly serious in the urban areas, combined with the rising cost of construction. The local housing construction is largely a private sector activity although the government is now beginning to take a more active role. Traditional housing made from locally available materials is the only form of housing available to the poorest families and lacks any typhoon resistant features. These traditional houses can be found in the coastal and rural areas of the country and since they are weak, many of them are destroyed annually. The importance of and need for disaster shelters are increasing globally, as no nation is immune from the effects of natural disasters. An important step governments should take around the world would be to prepare for disasters in terms of adaptation and infrastructure resilience.

1.1 Statement of the Problem

Post disaster shelters made from materials that can be upgraded or re-used in more permanent structures is vital to any community that is affected by natural calamities. These transitional shelters can be relocated from temporary sites to permanent locations and are designed to facilitate the transition by affected

populations to more durable shelters. Transitional shelters respond to the fact that post disaster shelter is often undertaken by the affected population themselves and that this resourcefulness and self-management should be supported. The Philippine Government fell short of providing permanent shelters to some of the most affected communities. The purchase of available land, high cost of materials and labor have likewise contributed to the delay of these shelters. There is an urgent need of permanent, sustainable and affordable shelters for the victims of these typhoons and other calamities.

1.2 Research Questions

In this paper, the author wishes to identify the following questions: First, what are the challenges in the design and development of a typhoon shelter for the Philippines? Ever since the first prototype of the *I-Siguro Daan* transitional shelter was contributed to the affected communities, the designers and architects have been planning and developing a permanent shelter for the families. Secondly, the author would therefore want to identify the constraints and limitations in designing a Typhoon permanent shelter using the same design parameters of *I-Siguro Daan* Transitional Shelter. Third, the author would also like to know the possibilities in reducing the initial cost without sacrificing the structural characteristics of the shelter. Fourth, the author would recommend the directions and study of the proposed typhoon shelter in the Philippines and how it can help designers in their quest for sustainable housing design in the future.

1.3 Research Objectives

The objective of this research is to design and develop a Typhoon permanent shelter as a continuance of the previous original work of the *I-Siguro Daan* Transitional Shelter. The proposed typhoon shelter must require the same or close to the minimum on-site construction activities, workers and equipment while using the available local resources. The aim of the study is not to improve the *I-Siguro Daan* Transitional but to provide a transition to the permanent shelter design. Specifically, the aim of this research is to be able to conceptualize, design and develop a permanent typhoon shelter for a single family based upon the original groundwork of the *I-Siguro Daan* Transitional Shelter. The shelter must likewise be affordable without sacrificing the structural integrity of the project and must be culturally sensitive to the Filipino community.

1.4 Significance of the Study

There is an enormous need for resilient shelters in the Philippines because it is one of the countries that have the greatest number of natural disasters and incidence of flooding in the world. In the Philippines, the continued use of schools and gymnasiums as evacuation centres may cause further disruption to the normal livelihoods and activities of people, especially those who have not been directly affected by a disaster. The knowledge gathered in this paper will be useful for architects and designers to improve the

design and use of emergency and permanent shelters. The author hopes that this research will inspire and motivate researchers to further investigate new sustainable solutions into typhoon resistant shelters.

2. CONCEPTUAL FRAMEWORK

In this study, the author adheres to some principles in the design of a permanent shelter for the affected Filipino families. There is a need to better understand how shelter recovery processes employed by stakeholders lead to eventual infrastructure system outcomes. Thus, this chapter outlines the conceptual framework of the *Ocho Balay* typhoon shelter. The author cannot stress enough how significant a sustainable shelter that is used and maintained by communities over time is very much needed in developing countries like the Philippines. Finally, the "3L", *Local Technology*, *Local Materials* and *Local Labour* strategy has been used in the design framework of the study. These are summarized into the following sub-chapters of the study.

2.1 Features of the Proposed Typhoon Shelter

The author designed the proposed shelter according to the guidelines of the *Sheltering from a Gathering Storm* project and from the United Architects of the Philippines. From these studies, the following are the features of the proposed typhoon shelter: (1) *Modularity*, (2) *Allow for incremental growth*, (3) *The use of locally sourced materials and use of simple tools*, (4) *Adaptability*, (5) *Minimalist Design* and (6) *Cultural Sensitivity*.

2.1.1 Modularity

Allowing for easy fabrication is also one of the main objectives of the design of the shelter. The interacting components are composed of similar parts that can be easily replaced if one or many fail. The main structure of the housing is designed stronger than traditional housing as all parts are securely connected. Finally, the shelter can easily be constructed and, if further required, be easily transported to another location. Furthermore, the shelter, because of its unique roof design, can easily be expanded. These spaces allow for rapid expansion when the families upgrade their financial status.

2.1.2 Allow for Incremental Growth

Flexibility for expansion of the shelter means that the interior is more free and flexible. Both the interior and exterior can be changed and adapted to new needs and are allowed to be developed by division. The proposed shelter has key assets and functions physically distributed so that they are not all affected by a given event at one time and have various ways of meeting a given need.

2.1.3 Easily Accessible and Locally Sourced Materials

Easily accessible and economic materials are an important factor when constructing permanent structures. It is therefore important to analyse the context of the location of the shelters. With this knowledge, the designer can implement materials local in the area and define appropriate construction techniques for the design. The basic materials used in the shelter are: (1) Coco Lumber; (2) Amakan and (3) Bamboo Splits. Coco Lumber is a hardwood substitute from the coconut palm trees found in the Philippines. It is a new timber resource that comes from plantation crops and offers an alternative to rainforest timber. As for the walls, Amakan offers a cheap yet durable alternative. The use of concrete board and plywood can also be used in the future when the families are able to upgrade their economic status.

2.1.5 Simplicity

The author presents the importance and benefits to designing and maintaining a simple typhoon shelter. Simple shelters for the commons are much easier to communicate and communication includes both documentation and comprehension. By naming the shelter in common native language, the commons can actually relate it to their own culture. A simple shelter or structure can easily be documented with a smaller model and fewer drawings/annotations which would lead to improved comprehension by stakeholders. A shared understanding is critical to maintaining alignment across stakeholders and the design team members, and ensuring an efficient implementation. The lesser the moving parts are, the more straightforward is the deployment. Then once in production, the shelters are more easily scaled and monitored. It allows the designer to be more productive since there is less complexity to track and fewer points of impact when making changes.

2.1.6 Cultural Sensitivity

Strengthening individual identity and sense of community is one of the main objectives of the proposed shelter. The way individuals react following a disaster is in part shaped by their culture, history, and other sociocultural factors. Thus, a strong awareness of local cultural principles is the first step to a culturally sensitive shelter in disaster affected areas. The shelter design adapts to the local tropical climate conditions. It also employs passive cooling principles and has ample natural light during the day.

3. RESEARCH METHODOLOGY

3.1 The Participatory Design Method: Involving the Affected Community

The process of community participation was also used in the final design of the proposed permanent shelter. This is significant because the re-housing process involves major change and requires a profound restructuring of daily life of the community. During the rehousing process, the housing living space

appropriation are important aspect because the affected families face a process that can break with previous modes of life, and required and rethinking of the space appropriation form and the established identity relations. There is a need for the participation of the affected communities as a condition for a perfect future space appropriation. The author of this paper proposes reciprocity between the shape and the use and the experience for different people and different times.

3.2 Surveys and Interviews

Field research, interviews and surveys were being used as one of the basis for the final of the shelter. In this methodology, the author gathered data analysis from the beneficiaries of the *I-Siguro Daan* Shelters, particularly from the Northern part of Cebu after Typhoon Haiyan. Field research and surveys were being done by the author from the beneficiaries of the permanent socialized housing units donated by various non-government groups and organizations headed by the Philippine Action for Community led Shelter Initiatives (PACSI), the Slum Dwellers International (SDW), Asian Coalition for Housing Rights (ACHR) and the Real Equity For All (REAL). These various organizations donated socialized housing for the homeless and families distraught by natural and man-made disasters. The field research was held last November 12 to 17, 2018 together with professors from Cardiff University. The author conducted a survey for a total of 50 family housing beneficiaries. The permanent housing given had a size of 28 square meters (4 x 7 meters) with drainage, lighting and other fixtures. The main objective of the surveys and interviews was the user satisfaction rate and use of the shelters by the beneficiaries. The families of the beneficiaries of the housing projects were generally cooperative the study and the final data analysis were done on the sixth day. The survey also included community group discussions as well as focus-group discussions with NGO (non-government units) aid local Filipino construction workers and local officials.

DESIGN OF THE OCHO BALAY SHELTER

The proposed shelter is based on the traditional Filipino House, the *Bahay Kubo*. The design solution explores a solution against typhoons and the design can also be adapted to any climate where timber is available and considering the local building techniques. The spaces of the interior of the shelter can be divided into two parts: (1) *Living Module* and the (2) *Sleeping Module*. These spaces also encourage communal activity, which allows social gatherings and activities and is an important cultural trait of the Filipino family. Walls are constructed of breathable materials for better thermal comfort and allow views from the inside to the outside while allowing natural cross ventilation. The following are the main key characteristics of the proposed shelter such as the use of the *Bent Structure*. By definition, a *Bent Structure* is a transverse rigid frame similar to that of the three-hinged arches (Benson, T.). In this study,

the *Bent Structure* structural system, made of coco lumber, was used as shown in Figure 2. The resulting design will result in slanted walls on the exterior Figure 1.

Figure 1. Slanted Exterior Walls of the Shelter and corner wall (exposed)

The slanted walls will make the interior appear larger while providing more storage. The sides can also be safely extendable in all directions when the families improve their financial status in the future. This can also be seen as a strategy for continuous growth and improvement. Work or improvements done on one side can be easily upgraded on the other side in a more permanent way with a more resistant material.

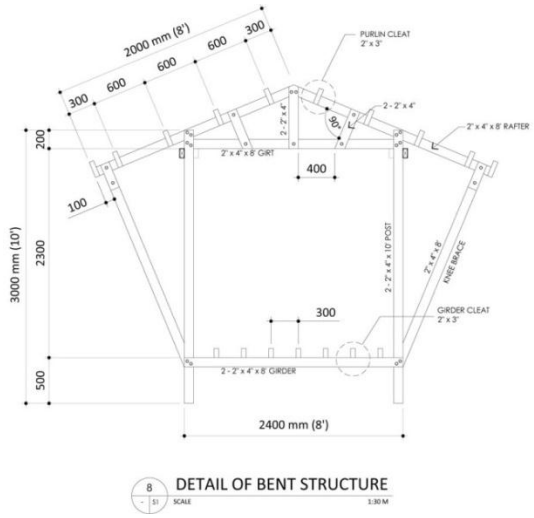

Figure 2. Detail of the Coco Lumber Bent Structure of the proposed shelter

The author also paid homage to the local Philippine Architecture. The proposed unit was designed after an extensive analysis of local architecture while respecting the local traditions and culture so as to enhance the feasibility of replication and maintenance of the shelters by the beneficiaries. Furthermore, this will reduce their vulnerability to future hazards. In terms of cost, the estimated budget for each unit is Ninety Nine Thousand Seven Hundred Seventy Seven and Thirty Centavos

(₱99,775.30) or the amount of US$ 1, 904.66 as of January 8, 2019 with a floor area of 19 square meters for a family of five (5). Making each unit affordable will obviously allow for more housing unit to be built and therefore will result in more beneficiaries having a shelter of their own. The author also aims to reach more people with less, instead of reaching less people with overly expensive shelters. The shelter also offers a flexible solution which at the same time is moderate in cost. The use of the Hip Roof (*Quatro Aguas*) Design was also chosen in this study Figure 3. The proposed unit has a simple rectangular building form with hip roof at 30% to enable easy construction by the local workers.

Figure 3. The Hip Roof "Quatro Aguas" Design was used in this shelter

The short overhang design can effectively reduce the impacts of wind force that is the main cause of damage to the roof structure during a typhoon. The author likewise recognizes the importance of the Slanted Wall Design, as applied to *the I-Siguro Daan Shelter* seriesThe slanted roof encourages rainwater harvesting for the families. Rainwater can be collected for toilet use and/or for urban gardening systems. Building the toilet and kitchen with hollow blocks and reinforced concrete will also provide opportunity to incorporate training program for masons and thus improve the construction quality in the foreseeable future. The main structural material used in the shelter is Coco Lumber (Figure 4), which is very abundant in the Philippines.

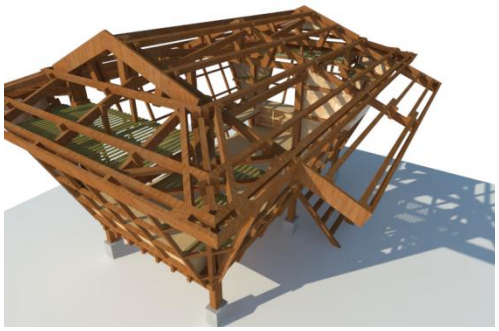

Figure 4. The use of Coco Lumber Framing as the main structural material for the Shelter.

5.1 The Main Shelter

The main shelter was designed as a safe typhoon shelter. It was designed with materials to protect the inhabitants and their property during a typhoon. The main shelter can have a lifespan of at least 8 to 10 years and offers a structure for future expansions. The main shelter is divided into two (2) parts, the *Living Module* and the *Sleeping Module*. The spaces on the walls serve as sleeping areas and or storage spaces. The main shelter (Figure 5) can safely house a family of five (5) members, which is more than enough of the average size of a typical Filipino family.

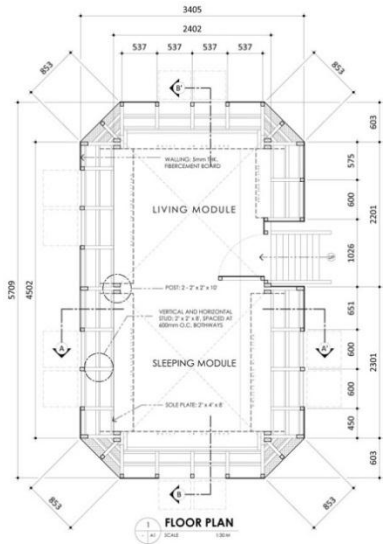

Figure 5. Floor Plan of the main Shelter Unit.

5.2 Materials

The wooden main structure of the shelter is composed of coco lumber. The substructure of the walls are made up of coco lumber, which is a locally known material and easy to purchase. The walls are made up of cement boards, *Amakan* or bamboo stripes to allow cross ventilation and thermal comfort during the day. The elevated floor is made up of fiber cement boards or bamboo stripes. Lockable windows made of wooden shutters enhance the cross ventilation and thermal comfort while fascia boards and short overhangs of the roof minimize the negative forces on the roof during a typhoon. The roof is made up of GI Corrugated sheets on coco purlins and reinforced with the traditional umbrella nails, which can help in securing the roof during a strong typhoon. The height of the floor level is 900mm but nevertheless can be adjusted according to the site location (Figure 76 and Figure 7). Depending on the site location and potential hazards of the area, the height of the post can be adjusted, especially in flood prone areas.

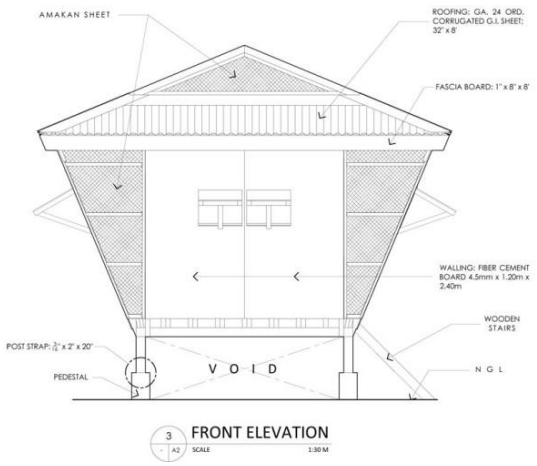

Figure 6. Front Elevation. Shown here with the elevated stilts and Amakan Sheet for added ventilation.

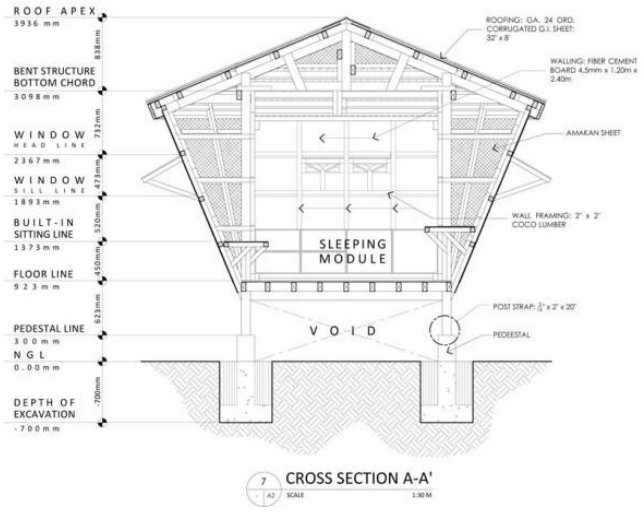

Figure 7. Cross Section of the Proposed Shelter.

Figure 8. Exterior Perspective of the Main Shelter

5.3 Kitchen and Toilet

The open Kitchen and Toilet (Figure 9) is a separate unit which can be built in the backyard or placed within the boundaries of the shelter and can be accessible from the outside. These two functional units are positioned together to save on plumbing cost and share the same water system. Although it is a separate unit, the Kitchen and Toilet can be placed anywhere near the main shelter where privacy and or accessibility is important. From the elevation (Figure 10and Figure 110 the main material used in the toilet is concrete hollow blocks. The roof is made of Galvanized Iron Sheets and painted white to reduce interior heating. The toilet is connected to a portable septic tank composed of two chambers Figure 12 shows the exterior perspective of the proposed Toilet and Kitchen.

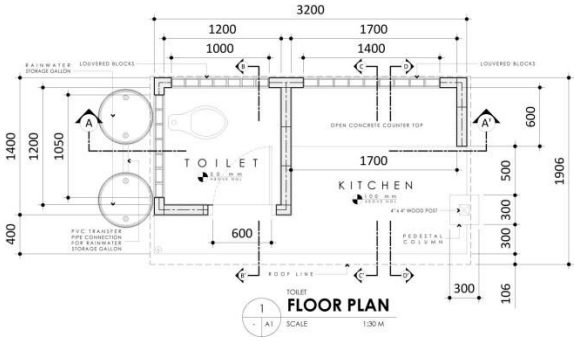

Figure 9. Toilet Floor Plan.

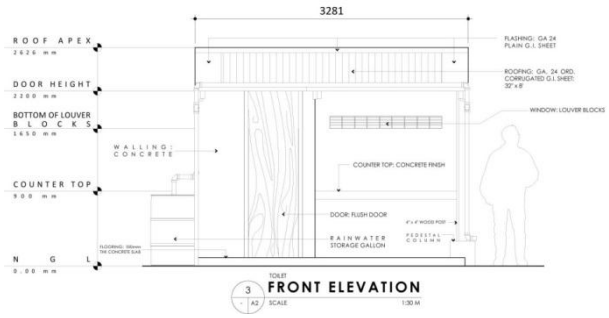

Figure 10. Toilet Front Elevation.

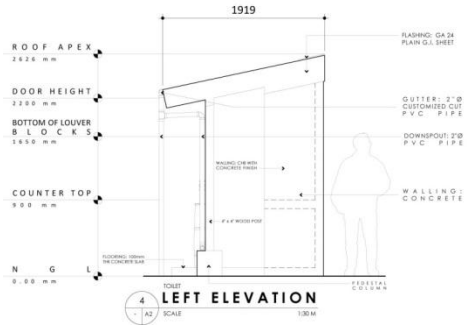

Figure 11. Toilet Left Elevation

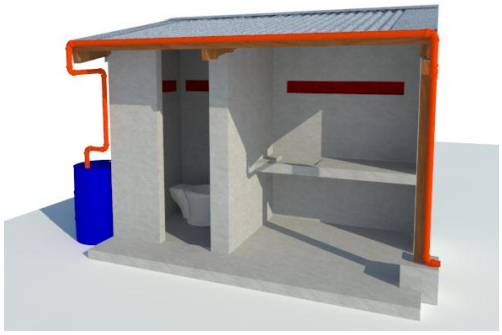

Figure 12. Exterior Perspective View of the Toilet and Kitchen area.

5.4 Rainwater Harvesting

Rooftop rainwater harvesting is the most common technique of rainwater harvesting for domestic consumption. In rural areas, this is most often done at small-scale. Rainwater harvesting can supplement water sources when they become scarce or are of low. Rainwater is collected on the roof and transported with gutters to a storage reservoir, where it provides water at the point of consumption for the families. In this design (Figure 13), Rainwater are collected in the gutter of the roof and then channelled down via pipes to a plastic water container tank near the comfort room.

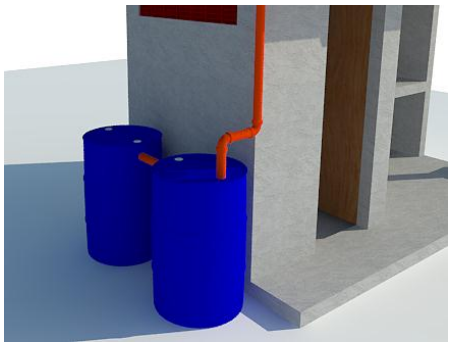

Figure 13. A simple rainwater harvesting system.

5.5 Cost Estimates

The shelter is divided into two main components: (1) The main shelter (Figure 14), where the living and sleeping spaces are located and (2) the basic outdoor kitchen and Toilet, which is separate from the main shelter. The total costs of the Ocho Balay Typhoon Shelter was estimated to be around ₱99,775.30 (US$ 1,904.66 as of January 8, 2019) with a floor area of 19 square meters for a family of five (5). Making each unit affordable will obviously allow for more housing unit to be built and therefore will result in more beneficiaries having a shelter of their own.

Figure 14. Scale model of the Ocho Balay Typhoon Shelter. The structural framings are shown here in detail.

5.6 Structural Wind Load Analysis

The main shelter was subjected to structural and wind load analysis using STAAD pro Version 2007 (build 04). The author has requested Engineer Wallace Lestane, a well-known structural engineer in the country, to find the maximum wind velocity that the Bent Structure can withstand. Using the National Structural Building Code of the Philippines as reference, the maximum wind velocity that the Bent Structures can withstand is 250 kph. According to the latest documents from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the highest category for a Super Typhoon is more than 220 kph (kilometres-per-hour). The analysis proves that the proposed shelter is safe, especially during the onslaught of a super typhoon. However, this does not mean that other parts of the shelter are immune to the onslaught of a super typhoon. The structure needs to be further analysed in a wind tunnel scenario and computer simulations can also help in the analysis. These tools are, however, not available in our country and can be used for further studies in the future.

6. CONCLUSIONS AND THESIS STATEMENTS

6.2 Conclusions

An increase in the severity of natural disasters combined with an increase in human populations and high density urban populations specifically, results in large numbers of displaced peoples following a natural disaster that strikes an urban region. Natural disasters continue to leave thousands of Filipino people homeless every year, forcing them to seek refuge without any other alternatives. On many occasions, the local government cannot cope with the affected families and therefore limiting their resources. In addition to this, the difficulties to sustain these families in a dignified way, becomes increasingly complex, leading to the collapse of traditional solutions and strategies. As architects and designers, is at this moment when innovation and creativity play an important role in construction practices, ultimately creating a quicker

and more efficient construction model that can be replicated after natural disasters. In this study, the author proposed the *Ocho Balay*, a typhoon shelter that is within reach of more people, both socio-economically and geographically. This shelter will hopefully be a stepping stone on the journey towards a brighter future for the beneficiaries in the Filipino's pursuit of a better quality of life, especially after the traumatizing effects of a natural disaster.

6.2 Thesis Statements

1. The Bent Structure main structural system, made of coco lumber, was used in the proposed typhoon shelter. The resulting design will result in slanted walls on the exterior. The slanted walls will make the interior appear larger while providing more storage. The resulting design made the interior more flexible which can be adapted to new needs and allowing these spaces to be developed by division. Therefore the families control the expansion of their housing based on their needs and resources.
2. The use of *Local Materials, Local Labour,* and *Local Technology* has been used in the design of the shelter. Furthermore, the design is being sensitive to the Environmental Dimension, Economic Dimension and the Social Dimension aspects of the community and users. This was designed after an extensive analysis of local architecture while respecting the local traditions and culture.
3. The use of onsite materials is an affordable and environmentally sustainable solution; reducing transport, fuel and construction costs while providing work opportunities for the families, thus improving the local economy.
4. The shelter also encourages the architects and beneficiaries to develop a flexible design process which enabled occupants to play an active part in the design of their own homes.
5. In social dimension, local residents are fully engaged in the entire process of reconstruction. The design allows empowerment to the community as the families can construct, upgrade or modify the shelters mainly with local manpower and simple tools that are easily available. They could easily improve and maintain the *Ocho Balay* shelters in the future and exploit this technology as a means of earning their livelihood.
6. Involving the population in the house construction and change of the neighborhood morphology enables the adaptation to the population real needs and develops the strong sense of belonging and affection which is fundamental to the well-being of the residents.
7. Rainwater harvesting was added as a design feature in the *Ocho Balay* Shelter. This can supplement water sources when they become scarce or are of low quality like brackish groundwater or polluted surface water in the rainy season. This is a simple, low-cost technique that requires minimum specific expertise or knowledge and offers many benefits.

8. The estimated cost for each unit is ₱99,775.30 (US$ 1,904.66 as of January 8, 2019) with a floor area of 19 square meters for a family of five (5). Making each unit affordable will obviously allow for more housing unit to be built and therefore will result in more beneficiaries having a shelter of their own.
9. The resulting permanent shelter is therefore the most affordable while providing sufficient protection from incoming typhoons. The proposed shelter can significantly improve the economic and social status for a family of five (5) while providing opportunities for further improvement.
10. Wind velocity analysis has shown that the Bent Structure, the basic structural unit of the shelter, can withstand a typhoon of 250 kph (kilometres-per-hour). The analysis was done using a simulation program and the National Structural Building Code of the Philippines as reference.
11. According to the latest documents from Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), the highest category for a Super Typhoon is more than 220 kph (kilometres-per-hour).
12. In contrast to the *I-Siguro-Daan* Transitional Shelter, the proposed Ocho Balay further added various design features that increases both the functionality and aesthetics. The final design was the result of painstaking studies and surveys of the previous users and beneficiaries. The resulting design was a careful analysis of the end users, which is one of the unique features of the shelter.

7. RECOMMENDATIONS FOR FUTURE STUDIES

Housing is perhaps the biggest problem of actual societies since it is a basic human need. This is especially relevant during the advent of natural disasters, such as the once-in-a-lifetime-anomaly-of-nature, typhoon Haiyan. Because of this, the importance of this study cannot be undervalued and thus, the design of the proposed *Ocho Balay* must be in continual improvement in order to provide quality and durable shelters for the rural areas of the Philippines. The author recommends further study through the use of several scientific analyses. For example, the resiliency can be quantified through actual experiments of the structural analysis of different types of materials, in this case, the use of coco lumber. There is a need for further validation on the load bearing structure (civil engineering analysis) which can result in a huge potential that can save materials and provide high resiliency against typhoons. There is also a need to develop a climate responsive shelter and energy calculations and simulations can be quite useful. Other ccomputer simulations can also be used in this analysis and must be further verified through actual real world model. Thus, the design and effectiveness of the shelter has an inherent capacity for further development.