Disaster Shelter in the Philippines: Addressing the Occupants' Needs During and After Typhoon

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Abstract – *The study aimed to develop a disaster shelter (DS) capable of enduring the strength of a 300 km per hour typhoon and has the provisions of a small dwelling complete with food, water and on-and-off grid electricity supply. The study utilized a descriptive-evaluative research design of which technical people in the fields of architecture and engineering and non-technical residents of Naga City were asked regarding the acceptability of the DS. Data gathered were analyzed using weighted mean and a computer software particularly STAAD was used for structural designing. The shelter developed which is primarily made of reinforced concrete was designed with the following considerations: reinforced concrete is a material proven for strength and durability, second floor level was a safe elevation against flood, North and East facing walls were against the strongest wind pressures, the galvanized iron roof required shielding from the strong wind, and the shelter has to address the needs of the occupants during and after the disaster. The structure was found capable of resisting a strong earthquake and a typhoon wind velocity of 300 km. per hour. In terms of its acceptability, Disaster Shelter was rated by respondents as very satisfactory. This rating may have been influenced by the actual appearance of the building and its features which ensure the safety of the shelter against flood and provides for the most immediate needs of would-be occupants. The study showed that ensuring the safety of people near or in their place of residence would be more advantageous to the people themselves but also to the government in terms of ensuring safety and management of risks and difficulties.*

Keywords – *Disaster Shelter, Typhoon Shelter, Disaster Management, Typhoon Risks, Typhoon Difficulties*

INTRODUCTION

Based on the 2017 World Risk Index of the United Nations, the Philippines has consistently been considered as one of the countries with very high chance of disasters, ranking 3rd most vulnerable country out of 171[1]. The WRI takes into consideration the country's risk of exposure to nature disasters such as typhoons, earthquakes, flooding, drought, etc. and its societies' coping, adaptation and susceptibility. As an archipelago located in the Pacific typhoon belt, the Philippines experience around 20 tropical cyclones in a year, around 10 of which become typhoons [2]. Typhoons bring destruction to many properties, private and public alike, due to strong winds and flooding. Destruction of houses, especially those made of light materials continuously lead to forced evacuation of many families.

The national and local governments have intensified efforts on disaster risk reduction management. Part of such effort is providing for evacuation needs of vulnerable populations in times of disaster threats. However, these efforts to assist victims of typhoons, floods, and other calamities have been very costly [3] and draining government funds which have been allocated for other services. The use of existing structures, especially of school buildings as evacuation centers has disrupted classes and resulted in damages due to overcrowding and lack of monitor on proper use. To avoid such problems, the building of permanent evacuation centers has been urged; in fact, in 2015, a house bill in the Philippine congress (HB 5867) [4] was proposed requiring the construction of permanent evacuation centers in every city/municipality.

To the researcher, this proposal of building evacuation centers would not really answer the needs of the affected people. In fact, the people, especially the elderly, who were evacuated to the evacuation centers are usually confronted with more risks and difficulties. Difficulties such as lack of food, medical supplies, hygiene problems and privacy issues are usual concerns [5]. Risks include a high susceptibility to communicable, food and water-borne diseases [6]. Regardless of the natural hazard type, infectious diseases are observable after natural hazards due to health system weakness and the disruption of basic needs [7]. Conditions in evacuation centers, especially lack of privacy and commonality of certain areas lead to high risks of crimes such as rape, stealing or voyeurism [8].

The way of securing the people in their places of residence thus preventing them from leaving their homes, is by providing for their needs during and after a disaster. Foremost among these needs is a safe shelter complete with living spaces such as for sleeping, dining, storing food and clothing, washing and toilet and bath. Also needed are provisions particularly food, water for drinking and washing, medical and house supplies, and electricity supply.

Because almost all of the destructive typhoons that passed the Philippines were from the East going towards the North West [9],[10], the sides of a shelter gravely threatened by strong wind forces are the Eastern and the Northern sides. Building strategies must be made to ensure the safety on these sides of the shelter. But aside from designing for safety the shelter must be designed to provide for the other needed living spaces as mentioned.

Ensuring safety of the people in the shelter is not enough during disaster such as typhoons and flood; the shelter must have the provisions that occupants need during and after the disaster and that will last until the situation turns back to normal.

Objectives of the Study

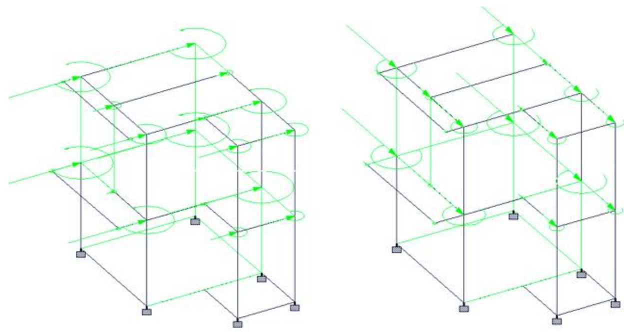
This study aims to develop a disaster shelter (DS) designed to withstand without damage the strength of strongest typhoon that would visit the Philippines. Such shelter will be provided with the basic amenities of a small dwelling such as living room com bedroom, a pantry, and toilet and bath; and provided with electricity and water supply.

Specifically, this study intended to (1) design a Disaster Shelter; (2) determine DS acceptability in terms of strength and stability; (3) determine the acceptability of the Disaster Shelter in terms of addressing the needs of the occupants during and after a typhoon.

Materials and Methods

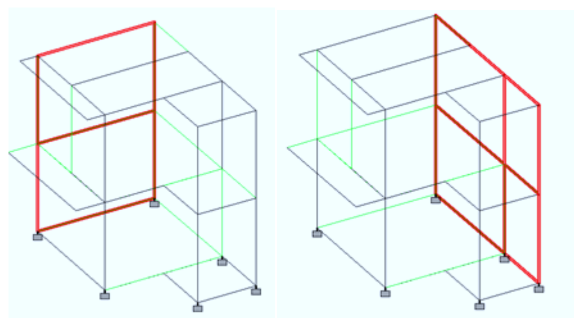
This study utilized a descriptive-evaluative research design, whereby the worthiness of this study was carefully appraised [11]. Hence, the perceptions of selected groups on the acceptability of the Proposed Disaster Shelter were determined.

The study that used as main variables the Disaster Shelter and the Needs of the occupants during and after a typhoon was proposed. It discussed the needs of the occupants on safety and efficiency of the shelter particularly pertaining to strength of roof, structure and strength of walls, rainwater infiltration, safety against flood and the overall strength of the structure. Also, discussed were the required living spaces and the needed provisions such as food, water for drinking and washing, medical and house supplies, and electricity supply. The study was undertaken in Socorro St, Villa Sorabella Subdivision, Barangay Concepcion Grande in Naga City where the Disaster Shelter model was constructed.



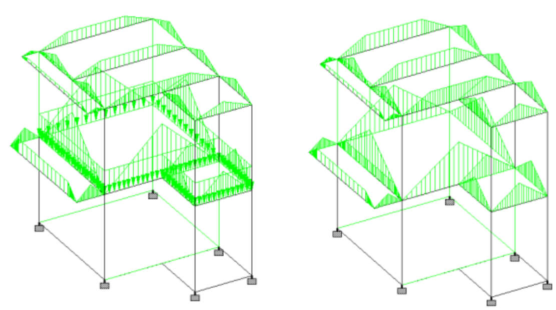
a. Earthquake Forces along East-West direction

b. Earthquake Forces along North-South direction



c. 300 km per hour Wind Forces on the Northern Side

d. 300 km per hour Wind Forces on the Eastern Side



e. Dead Loads.

f. Live Loads

Figure 1. Loads Affecting the Structure

The study utilized data gathered from personal experiences and news reports on disasters brought by typhoons, floods, and earthquakes. It also referred from completed studies on disasters, as well as, from data provided by the National Structural Code of the Philippines and from other sources pertinent to the structural design of structures.

STAAD, a design software used for structural designing of different engineering structures was used for analyzing the structure. The structure carried the following loadings:

Earthquake Load (E), according to the following design parameters in UBC 1997: seismic zone 4 (z=0.4), importance factor (I = 1.0), response modification factor (R=10), a seismic period (P=0.3 sec), and a soil profile type (S_{Typ}=1) [12].

Wind Load (WL): 300 km per hour wind

Dead Load (D): Self weight for the whole structural frame, 1.0 kilopascal for roof, 2.4 kilopascals for second floor slab, and 2.1 kilopascals.

Live Load (L): Second floor loading of 2.0 kilopascals, used for residential loadings and roof live load (Lr) of 1.4 kilopascals.

After providing the various loads, Figure 1, the software was made to generate the various forces and moments forces affecting the structures from the combination of loads provided. The following load combinations were observed:

First loads combination: 1.2 D + 1.6L + 0.5Lr
Second loads combination: 1.2 D + 1.6Lr + 1.0L
Third loads combination: 1.2D +1.0W + L + 0.5Lr
Fourth loads combination: 1.2 D + 1.0E + L
Fifth loads combination: 0.90D + 1.0W
Sixth loads combination: 0.90D + 1.0E

where, D is the dead load, L the live load, Lr the roof live load, E the earthquake load, W the wind load.

The model of the disaster shelter was generally constructed using reinforced concrete, concrete hollow blocks, metal purlins and galvanized iron sheets for roof which was adequately secured to purlins using screws and wooden washers as fasteners.

The research instrument was made to evaluate the acceptability of the prototype. The instrument was self-made and was designed to collect the data relative to the respondents' perceived adequacy of the structure against strong winds and flood; and adequacy of provisions for food, water, electricity, and personal needs. The respondents of the study were eight technical persons in the fields of architecture and engineering and nine non-technical residents of Naga City. Likert scale was used with 5.0 as very satisfactory, 4.0 as satisfactory, 3.0 as neutral, 2.0 as not satisfactory, and 1.0 as not very satisfactory. Weighted mean was used for the treatment of data.

RESULTS AND DISCUSSION

Design of a Disaster Shelter

The shelter on Figure 2 was designed as a reinforced concrete structure located at the second-floor level consisting of a 4 meters x 5 meters main structure and a 1.5 meters x 2.0 meters wing. The 20 square meter area was intended to function as living area, dining and sleeping while the 3 square meter area was provided for the toilet and bath, Figure 3.

Figure 2. Façade of Disaster Shelter Facing West

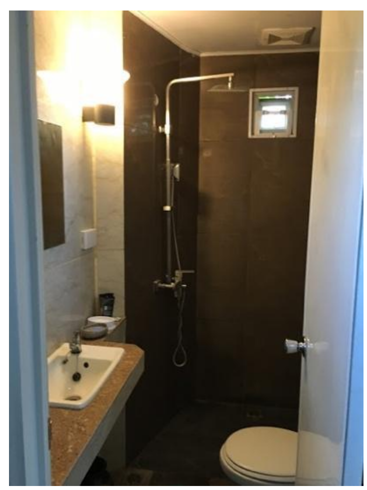


Figure 3. Toilet, Bath and Washing Area

Its walls facing the North and East directions were made to contain fewer windows or no window, Figure 4 and Figure 5. Its galvanized iron roof was concealed by higher walls and concrete gutter. Its windows were of sliding or awning type and the exterior doors were of the solid wood type. It was provided with water and electricity from the respective water and power utilities.

Figure 4. Wall at the North Side

Figure 5. Small Window at the East Wall

A simple rainwater harvester, Figure 6, [13] and a solar-power-generated standby source, Figure 7, [14] and generator were made available.

Figure 6. Simple Rainwater Harvester

Figure 7. Solar Panel for Standby Power Supply

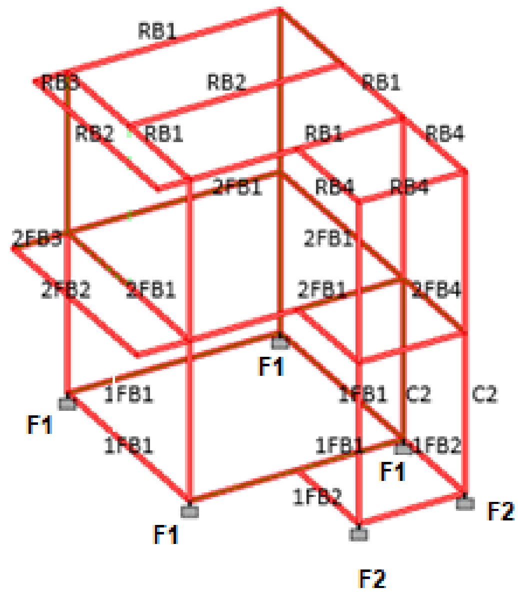


Figure 8. Structural Frame of the Disaster Shelter

The structure, Figure 8, has six footings, four at the main structure and two at the restroom. As shown in Table 1, the footings at the main structure were 1.0-meter x 1.0-meter x 0.30 meter reinforced with 6 pieces 16mm Ø RSB in both directions while the others were 0.80-meter x 0.80-meter x 0.30 meter and reinforcement of 5 pieces 16mm Ø RSB in both directions. The columns at the main structure were 0.25-meter x 0.25-meter square cross-section with 4 pieces 16mm Ø RSB reinforcement, while the other two columns were 0.20-meter x 0.20-meter square section with 4 pieces 12mm Ø RSB reinforcement. The footing tie beams were 0.20-meter x 0.20-meter rectangular section reinforced with 4 pieces 12mm Ø RSB reinforcement. The second-floor beams (2FB1) of the structural frame were 0.20-meter x 0.30-meter rectangular section reinforced with 6 pieces 16mm Ø RSB reinforcement. The roof beams were also 0.20-meter x 0.30-meter rectangular section but reinforced with 6 pieces 12mm Ø RSB reinforcement.

DISCUSSIONS

Reinforced concrete was used as the primary material in the construction because of its high resistance against weathering action, chemical attack, and abrasion that make it highly durable [15].

Table. 1. Sizes and Reinforcements of Structural Members

DESIGNATION	SIZE (meter x meter)	LENGTH (meter)	TOP BARS (RSB – Reinforcing Steel Bars)	BOTTOM BARS (RSB)
ROOF BEAMS				
RB1	0.20 x 0.30	4.0	3 pieces – 12mm diameter	3 pieces – 12mm diameter
RB2	0.17 x 0.30	4.0	2 pieces – 12mm diameter	2 pieces – 12mm diameter
RB3	0.20 x 0.30	1.0	2 pieces – 12mm diameter	2 pieces – 12mm diameter
RB4	0.20 x 0.30	2.0	3 pieces – 12mm diameter	2 pieces – 12mm diameter
SECOND FLOOR BEAMS				
2FB1	0.20 x 0.30	4.0	3 pieces – 16mm diameter	3 pieces – 16mm diameter
2FB2	0.17 x 0.30	4.0	2 pieces – 12mm diameter	2 pieces – 12mm diameter
2FB3	0.20 x 0.30	1.0	2 pieces – 16mm diameter	2 pieces – 16mm diameter
2FB4	0.20 x 0.30	2.0	3 pieces – 12mm diameter	2 pieces – 12mm diameter
GROUND FLOOR BEAMS				
1FB1	0.20 x 0.20	4.0	2 pieces – 12mm diameter	2 pieces – 12mm diameter
1FB2	0.20 x 0.20	2.0	2 pieces – 12mm diameter	2 pieces – 12mm diameter

COLUMN	SIZE (meter x meter)	LENGTH (meter)	REINFORCEMENTS
C1	0.25 x 0.25	3.0	4 pieces – 16mm diameter (ground floor columns, except as indicated)
C2	0.20 x 0.20	3.0	4 pieces – 12mm diameter (all second floor columns)

FOOTING	SIZE (meter x meter)	THICKNESS(meter)	REINFORCEMENTS
F1	1.00 x 1.00	0.30 m	6 pieces – 16mm diameter bothways
F2	0.80 x 0.80	0.30 m	6 pieces – 16mm diameter bothways

The shelter was also constructed on the second-floor level to protect it from the flood [16]. Because typhoons usually enter the Philippines from east to west but also towards the north [10], no window or fewer windows were made in the North side (Fig. 3.) and East side (Fig. 4). Also, to shield the galvanized iron roof from the strong wind, the surrounding walls were made higher than the roof, the purlins holding the roof were strongly embedded to the concrete roof beams and the gutter was of made of concrete to protect itself and the roof [17]. To address the needs of the occupants during and after the disaster, the space requirements for sleeping, cooking, washing, toilet, and bath were provided [18]. Potable water supply in containers have always been provided for before the occurrence of typhoons and the shelter is connected to a water utility company; however, in case of water supply stoppage, domestic water needs have to be served by rainwater collector. The use of rainwater for domestic use has been done in other countries [19]. The shelter was connected to the main supply but it has a solar panel and a generator that served as a standby power supply.

The sizes and reinforcements of the structural members were generated based on the assumed capability of the structure that was designed to the resist a strong earthquake and a super typhoon with a wind velocity of 300 km. per hour, while the NSCP code requirement is 250km per hour only [20]. A live load of 1.9 kilo-Newton per sq. meter was used in the analysis.

Acceptability of the Disaster Shelter in Terms of Strength and Stability

As shown in Figure 9, there were four factors used to answer this question, to wit: the strength of roof, stability, and strength of walls, efficiency against rain and water filtration and safety against the flood. DS strength and stability was placed in the graph to show the average weighted mean (AWM) of the four factors. The non-technical group rated Efficiency Against Rainwater Infiltration as the lowest (AWM = 4.78), while the technical group gave an equal rating for Strength of the Roof, Efficiency Against Rainwater Infiltration and Safety Against Flood (AWM=4.88), its lowest. The non-technical group rated Safety Against Flood as the highest (AWM=5.0) while technical group rated Stability and Strength of Walls as its highest (AWM=5.0).

Both were fairly close in their rating of the DS Strength and Stability with AWM=4.89 for the non-technical group and AWM=4.91 for the technical group. The total average weighted mean (AWM) for this question from both groups was computed to be AWM=4.90, considered very satisfactory.

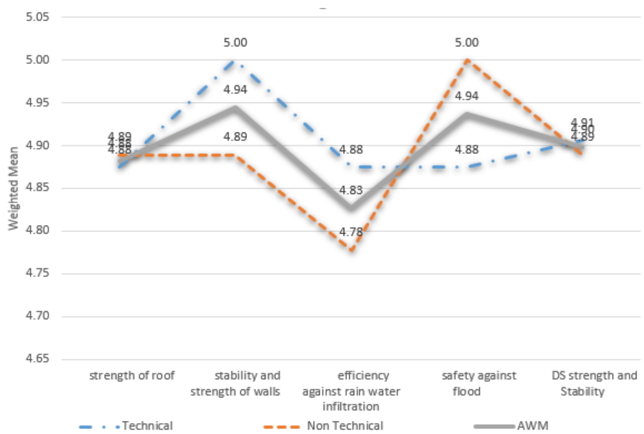


Figure 9. Acceptability of the DS in terms of Strength and Stability

All the ratings given were within the very satisfactory range of the Likert scale. The location of the disaster shelter was probably considered by the non-technical group why it was rated AWM=5.0 for Safety Against Flood. The technical group must have considered the orientation of the structure and use of concrete for all walls as reasons why it gave AWM=5.0 for Stability and Strength of Walls. However, even if the rating of very satisfactory AWM=4.78 was given for Efficiency Against Rainwater Infiltration, the non-technical group must have a different alternative to further improve on this factor.

The findings implied that relative to strength and stability the disaster shelter was found sufficient.

Acceptability of the Disaster Shelter in Terms of Addressing the Needs of the Occupants

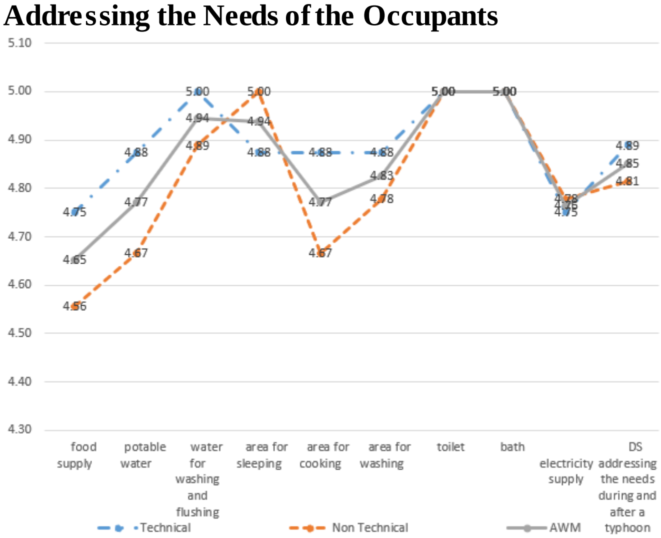


Figure 10. Acceptability of the DS in Terms of Addressing the Needs of the Occupants

Nine factors were used for this question: food supply, potable water, water for washing and flushing, area for sleeping, area for cooking, area for washing, toilet, bath, and electricity supply. DS Addressing the Needs After the Disaster was also placed in the graph to show the AWM of the nine factors. As shown by Figure 10, the non-technical group rated food supply as the lowest (AWM=4.56), while the technical group rated both Food Supply and Electricity Supply as the lowest (AWM=4.75). The non-technical group gave Area for Sleeping as highest rating (AWM=5.0) and the technical group also gave Water for Washing and Flushing the highest rating (AWM=5.0). Moreover, both groups have also rated toilet and bath as among their highest (AWM=5.0). Both non-technical and technical groups were also fairly close in their rating of the DS Addressing the Needs After the Disaster with AWM=4.81 and AWM=4.89, respectively. The total average weighted mean (AWM) for this question from both groups was computed to be AWM=4.85.

The results showed that the respondents were very satisfied with the acceptability requirements of the Disaster Shelter as indicated by all factors, except for Food Supply which was rated by the non-technical group as Satisfactory (AWM=4.56). Although, the provisions for Potable Water and Area for Cooking indicated that improvements would significantly improve the acceptability rating of the disaster shelter.

It implied that the preparation for food supply must consider that refrigeration would not be working because the power generated from solar panel has been intended for low power utilization while the standby power generator would be programmed to run for only few hours in the evening to conserve on the use of gasoline. Only canned and other preserved foods could supply the food needs; thus, sufficient quantity of canned and preserved foods should be available. Several number of water-filled containers should always be available in the shelter. The shelter should also have a gas stove with a ready supply of gas.

CONCLUSION AND RECOMMENDATIONS

Second floor level location of the shelter ensured safety against flood in the area. The strong wind directions were adequately shielded by concrete walls; while the roof was made secure by the concrete gutter and the surrounding concrete walls. Its windows and doors were ensured of water tightness. The 4 meters x 4 meters portion of the main structure area was considered sufficient for sleeping, dining, and cooking needs. While the 1.5 meters x 2.0 meters wing, would adequately serve as toilet, bath and wash area. Water and electricity were available from the water and power utilities but the shelter was provided with emergency potable water supply from the dispenser, rainwater collected for flushing and washing, electricity from solar-power-generated standby source and a generator.

The shelter was found strong in resisting a 300 km per hour wind and capable of carrying a roof dead load of 1.0 kilopascal, a floor dead load 2.4 kilopascals, a roof live load of 1.4 kilopascals and a floor live load of 1.9 kilopascals (200 kilograms per square meter) [21]. It has the capability to withstand the strongest earthquake that could happen in its classified seismic zone (zone 4).

All households in typhoon and flood-prone areas should be encouraged to incorporate in their existing house or in a proposed house the design of the Disaster Shelter [22]. Any shelter design should follow the ideas adopted in the design and construction of this Disaster Shelter. The ground floor of Disaster Shelter should be utilized for other functions. Concrete hollow blocks walls for enclosing the ground floor would further strengthen the structure [23].

In terms of strength and stability, acceptability level was high (AWM=4.9). This showed confidence in the materials and methods used in the construction or installation of the roof, walls, doors, and windows. It, however, implied the need for improvement in the efficiency against rainwater infiltration.

Other alternative materials and methods pertaining to waterproofing, as well as better window and door designs must be researched to further improve on the Efficiency Against Rainwater Infiltration requirement can be used in further studies. Other concepts that would further improve the design and strength, reduce the cost and enhance the acceptability of the shelter may be explored.

The development of the disaster shelter which was designed to address the needs of the occupants during and in the aftermath of a typhoon provided an additional input to disaster management. It showed that ensuring the safety of people near or in their place of residence would be more advantageous to the people themselves but also to the government in terms of ensuring safety and management of risks and difficulties.

The Disaster Shelter was found acceptable in addressing the needs of the occupants after a disaster (AWM=4.85), particularly food supply, potable water, water for washing and flushing, area for sleeping, area for cooking, area for washing, toilet, bath, and electricity supply. However, an improvement in the food supply and electricity supply would further enhance acceptability.

The disaster shelter was designed as a complete house for a couple in normal times but could serve one big family in times of disaster. In order to economize on the cost and still avail of the refuge provided by the shelter, a bigger family house could be constructed such that it would be composed of the Disaster Shelter and indigenous construction for other areas of the house. The shelter, being very strong, would serve as the anchorage of the house.

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