Note on the assessment:

The following is an excerpt from the book Post-disaster shelter: 10 Designs, IFRC, 2013. Inclusion of this design is for information purposes and does not necessarily imply best practice. Designs are site specific.

Assessments were conducted against hazard data for each location by structural engineers using the International Building Code (IBC) 2012, and National Building Codes as applicable.

Risk to life or risk of structure being damaged

The performance of the shelter was assessed on whether or not the shelter was safe for habitation. As a structures may deform significantly under extreme hazard loading without posing a high risk to life, each shelter was also assessed on the risk of it failing or being damaged.

Classification of hazards

For the purposes of this assessment, the earthquake, wind and flood hazards in each location have been classified as **HIGH**, **MEDIUM** or **LOW** These simplified categories are based on hazard criteria in various codes and standards as applicable to lightweight, low rise buildings, and statistical assumptions about the likelihood of hazard occurring.

A fuller description is of the methods used is available in Section A of Post-disaster Shelters: 10 Designs, IFRC, 2012.

Classification of performance

The performance of each shelter has been categorised using a **RED**, **AMBER** or **GREEN** scheme.

Performance analysis summaries

The shelter review is summarised in a table titled 'performance analysis'. This table provides an overall summary of the robustness of the shelter. The table assesses the performance of the shelter with respect to the hazards at the given location.

See A.4.4 Classification of Performance in the book

See A.4.3 Classification of Hazards in the book

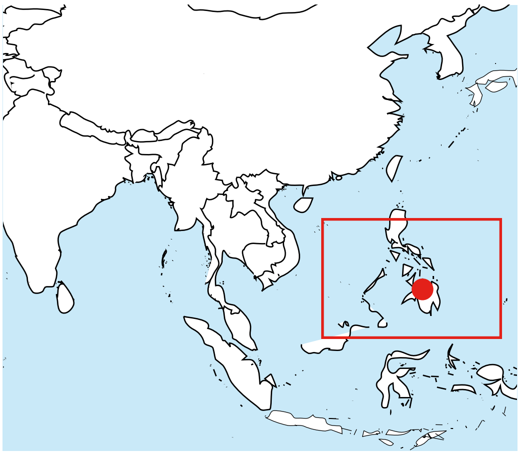
Example of a Performance analysis

Hazard	Performance
Earthquake LOW	**AMBER**
Wind MEDIUM	**RED**
Flood HIGH	**GREEN**
Fire LOW	**AMBER**

Structure is expected to deflect and be damaged under earthquake loads.

Structure is expected to fail under wind loads.

B.6 Philippines – 2011 – 'Transitional-Shelter'



Summary information

Disaster: Typhoon, December 2011

Materials: Concrete footings, coconut wood frame, plywood floor, amaken walls and corrugated iron roof

Material source: Locally procured

Time to build: 5 days

Anticipated lifespan: 5 years

Construction team: 5 people

Number built: 1,823

Approximate material cost per shelter: 500 CHF

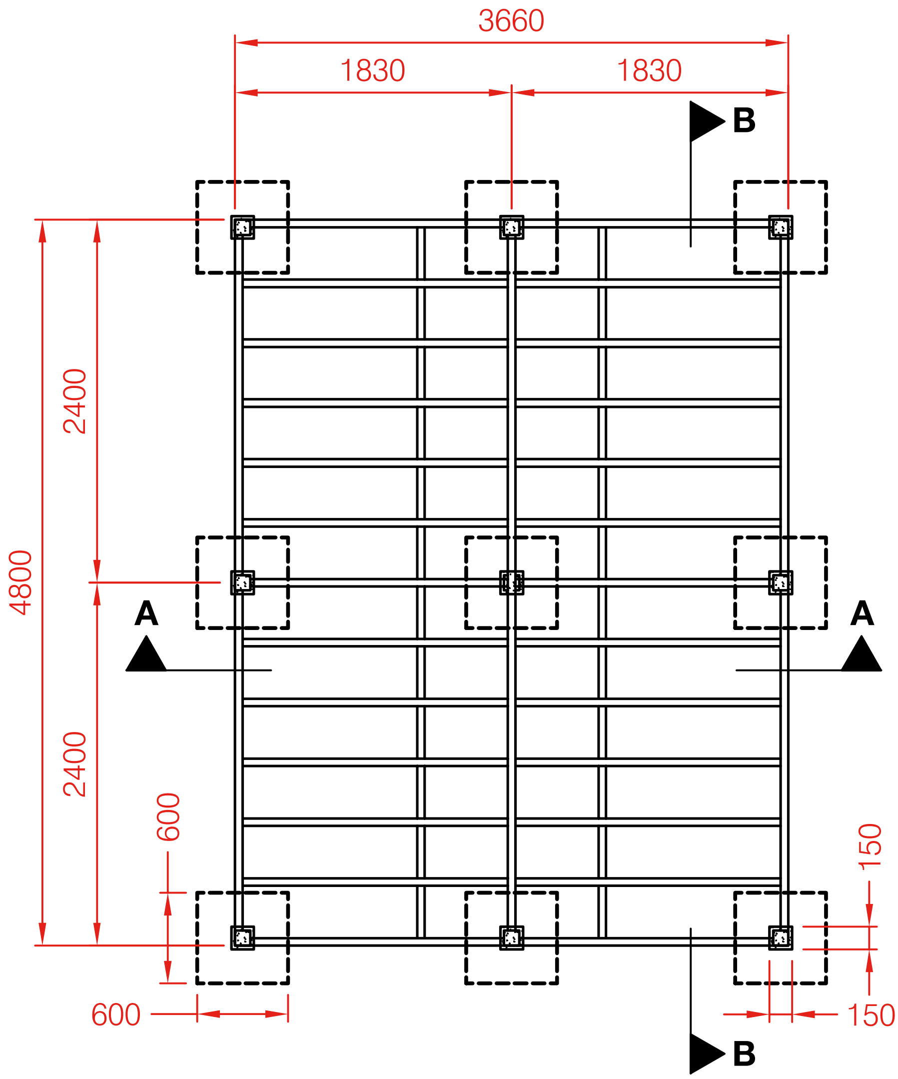
Shelter Description

This shelter is a rectangular structure with a single pitch roof and a covered floor area of approximately 4.8m x 3.7m. The shelter is supported on concrete piers and footings such that the first floor is raised approximately 750mm above grade. The floor and roof are framed with coconut wood beams and joists. The floor is plywood and the roof is corrugated metal roofing. The exterior walls consist of amakan (woven panels of bamboo or palm leaves) fastened to the coconut wood frame. The light weight wood frame can be lifted off the concrete piers and moved to a different location by a small number of people. As designed, the shelter has one door and two windows.

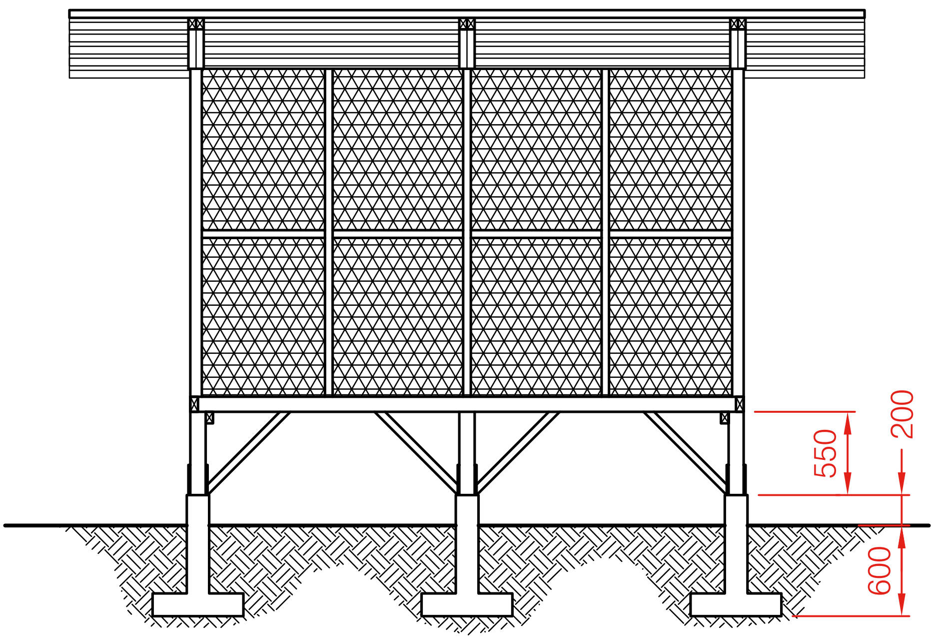
Shelter Performance Summary

The timber framing should be relatively durable, provided it is properly treated prior to construction. The timber framing and amakan wall panels can be built with locally sourced materials, and the simple construction reduces the need for skilled labor. Provided the wood posts and roof rafters are adequately anchored to their supports the shelter should perform satisfactorily, but damage should be expected during strong storms. The adequacy of the floor and roof framing is dependent on the use of high quality wood. To ensure good performance of the floor and roof framing, all the beams supporting floor joist and roof rafters should be doubled up.

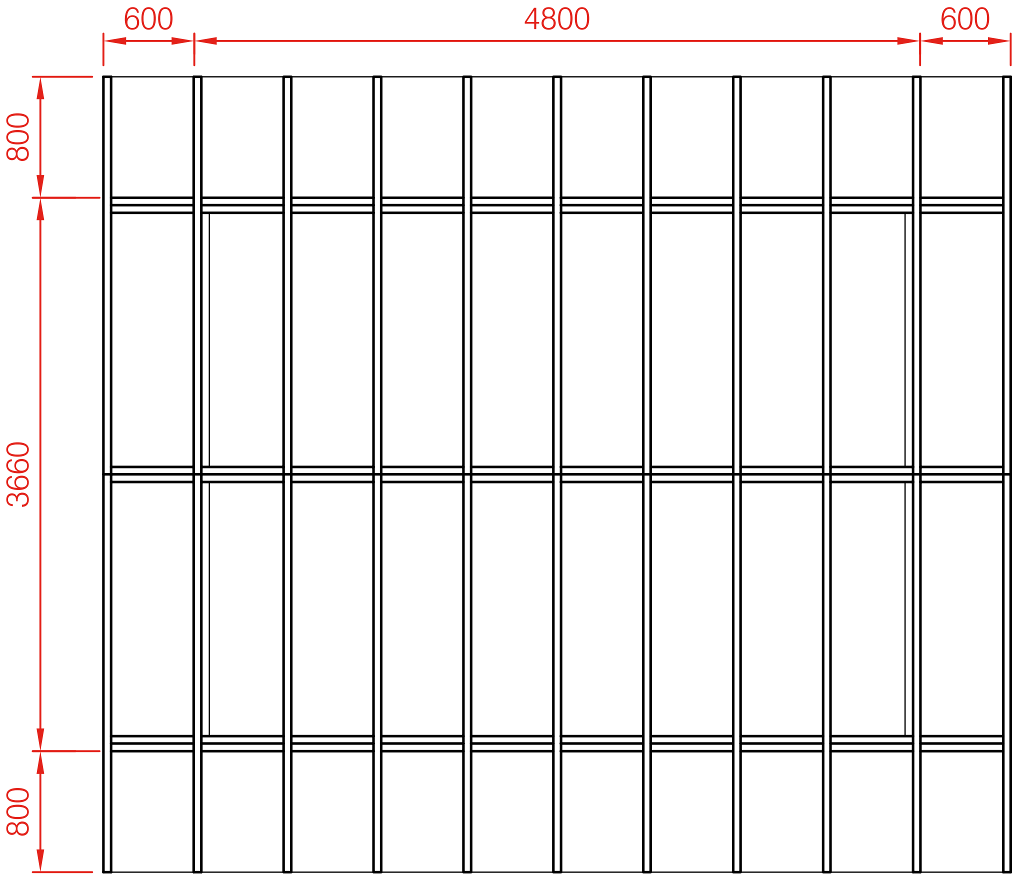
Plans



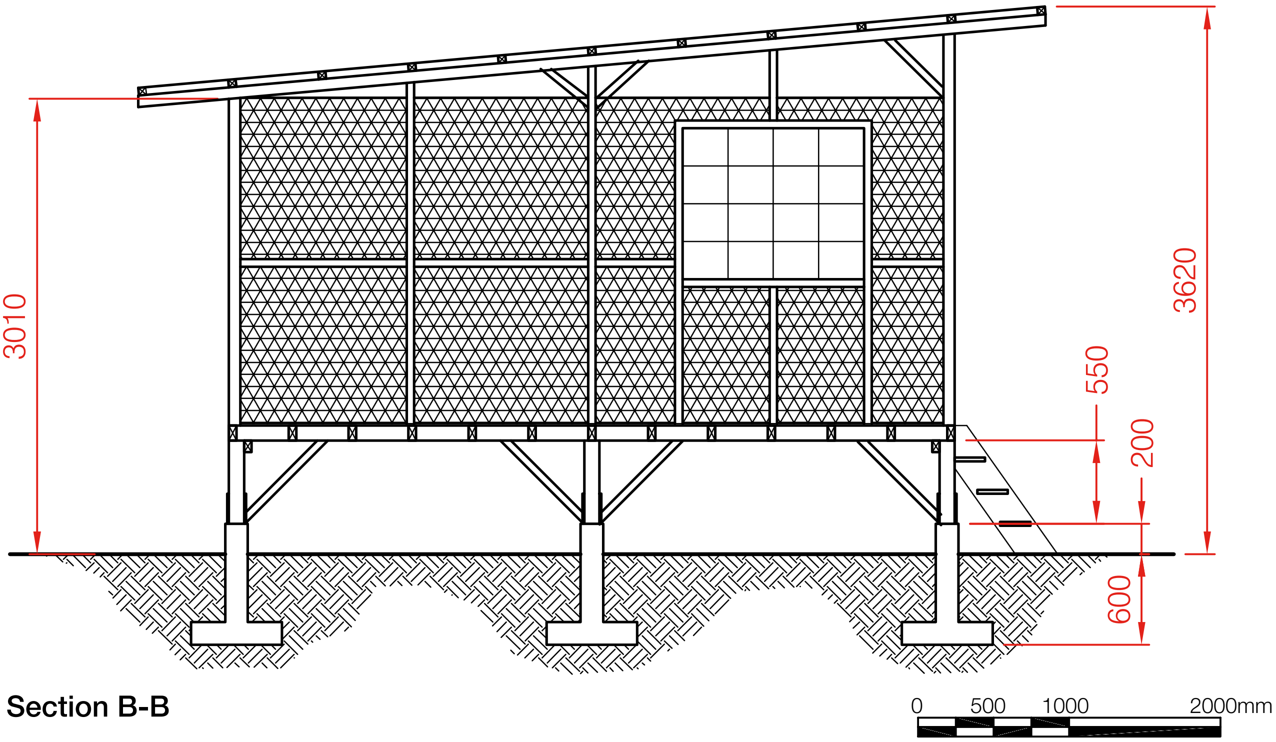
Floor plan



Section A-A



Roof Framing Plan



Section B-B

Durability and lifespan

The concrete piers are very durable, however coconut wood and plywood are not naturally rot resistant and should be treated to resist fungal and insect attack. Otherwise the timber portions of the building may need to be replaced before the concrete components reach the end of their life.

Based on the construction of the wall panels, it is likely they will be blow off the building during strong storm events.

Performance analysis

Adequate performance of this shelter is dependent on proper connections between all of the components. Without the connections between the timber framing and the concrete piers, the shelter will not be able to withstand the potential wind and earthquakes for this area. In addition, adequate performance of the shelter is dependent on selection of high quality timber. Proper site analysis is necessary prior to construction to determine appropriate finished floor heights to provide any mitigation of flood hazards.

Hazard*	Performance
Earthquake HIGH	**GREEN:** Given the light weight of the shelter, expected seismic loads are less than the expected wind loads, and provided all components are properly connected, the shelter should withstand seismic events with little to no damage.
Wind HIGH	**AMBER:** The expected wind loads are much larger than the seismic loads. Localised damage of some framing members should be expected during large storms, but collapse of the shelter is not expected. If the walls are removed prior to a storm, expected damage should be minimized and possibly eliminated.
Flood LOW	**GREEN:** The floor is raised significantly above adjacent grade, and provided the shelter is properly anchored to the concrete piers, should offer excellent protection from flood waters
Fire LOW	**AMBER:** The components of the structural system are flammable, and will not offer significant fire resistance. Fortunately the small floor plan along with the door and windows should provide adequate egress making it easy for occupants to exit before being harmed. The design is individual units thus to plan each house with good separation will reduce the risk of fire spread.

* See section A.4.5 Performance analysis summaries

Notes on upgrades

All timber beams that support floor joists and roof rafters can be increased in width or depth to provide additional strength for floor and roof loads.

The knee braces at the roof could be modified to provide bracing throughout the entire bay to increase the lateral resistance, and limit the amount of damage the framing during storms.

It is possible to upgrade the walls with plywood to provide more permanent construction and improve the lateral resistance.

The best way to improve performance of the shelter design to wind loads is to increase the size of the timber framing.

Assumptions

- Design wood values were assumed equivalent strength to Spruce-Pine-Fir South, No 1.
- Lateral foundation loads are resisted by lateral soil bearing on the piers and friction on the bottom of the footings.
- Foundation uplift forces are resisted only by the weight of the shelter and soil on top of the footing. Any frictional resistance of between the foundation and soil are ignored.
- In addition to the International Building Code, the shelter was also analyzed against the National Building Code of the Philippines.

Potential Issues

Site Selection

- Site selection is the best way to mitigate flood hazards. Select sites on higher ground and away from flood hazards. Provide proper drainage around shelters to prevent accumulation of rain water. Locate shelters a minimum of 10 meters from ravines, or as required by local authorities.
- For sites where soil liquefaction during an earthquake may be a hazard (near river beds, coastal areas with sandy soils and high water tables) the shelter could be seriously damaged in an earthquake. The heavy weight of the building components could seriously injure any occupants of the shelter.
- Locate shelters safe distance away from trees which may fall in a storm.

Materials

- Inspect timber to ensure that pieces are straight, not twisted or bowed, free of knots, and not cracked.
- Cement should be a fine grey powder. If there are larger pieces in the sacks, it is an indication that the cement has at least partially set and may not produce sound concrete.
- Ideal proportions for concrete are 1:2:3, cement:sand:gravel (all by volume). Only add enough water to allow the concrete to be placed. Excess water reduces durability and will cause more cracking of the finished slab. If concrete is mixed in batches, maintain consistent proportions for all batches. See I.3.1 Concrete

Foundation

- Verify that the soil under the footing is free of organic materials, and that any soft spots have been compacted. Ground surface should be flat and level prior to placing the concrete.
- Ensure that all reinforcement is located as detailed on the drawings prior to placement of concrete.
- Make sure the tops of the piers are in their proper location and that the tops are level, otherwise construction of the shelter framing may be difficult.

Wall and Roof

- All framing should be adequately nailed together, and nails should not split or crack the wood framing. Verify the proper number of nails are provided and the proper size is used in each connection. Use of toe nailing should be avoided.
- All wood framing in direct contact with concrete should have tarpaper or other barrier between the two materials to help prevent rot.
- Verify all the hurricane straps or other anchoring systems are properly installed, as they are required for the roof to resist wind uplift pressures. Also insure that the posts are properly anchored to the concrete piers.
- If pressure treated wood is used, hot dip galvanized fasteners should be used, as most preservatives are corrosive to mild steel.
- It is important to make sure all the anchors fastening the roof panels are properly installed. Wind blow metal roofing can cause serious injury.
- The roofs do not have additional bracing, but this should not prove to be an issue. Monosloped roofs with sheathing typically do not require additional bracing, unlike gable roofs.

Bill of quantities

The bill of quantities in the table below is for the shelter as it was built, without the design alterations suggested here. It does not take into account issues such as which lengths of timber are available and allowances for spoilage in transport and delivery.

Item See annex I.1	Additional Specification	Quantity	Unit	Comments
Foundations				
Portland Cement		5	Bags	42.5 kg/bag
Gravel		0.1	m^3	
Sand		0.1	m^3	
Steel reinforcement	10mm dia x 6m long	12	Bar	
Steel reinforcement	8mm dia x 6m long	3	Bar	
Main Structure				
Timber 2	89mm x 89mm x 3.7m	4	Piece	
Timber 2	38mm x 64mm x 3.7m	23	Piece	
Timber 2	38mm x 89mm x 2.4m	6	Piece	
Timber 2	38mm x 38mm x 3.7m	32	Piece	
Timber 2	38mm x 38mm x 2.4m	28	Piece	
Covering – Wall and Roof				
Bamboo slats		3	Bundle	
Amakan	1.2m x 2.4m	13	Sheet	
Plywood 2	1.2m x 2.4m	6	Sheet	
Plywood	1.2m x 2.4m	2	Sheet	
Sheet 2	3.1m long	14	Sheet	
Fixings				
Umbrella nails	51mm long	1	kg	
Common nails	102mm long	6	kg	
Common nails	64mm long	4	kg	
Common nails	38mm long	1	kg	
Wire 1		2	kg	
Vulcaseal		0.5	Litre	
Hinges		1	Pair	
Tools				
Spade		2	Piece	
Hoe		2	Piece	
Wheelbarrow		1	Piece	
Framing hammer		2	Piece	
Hand saw		2	Piece	
Gloves		4	Pair	

Footing details