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.

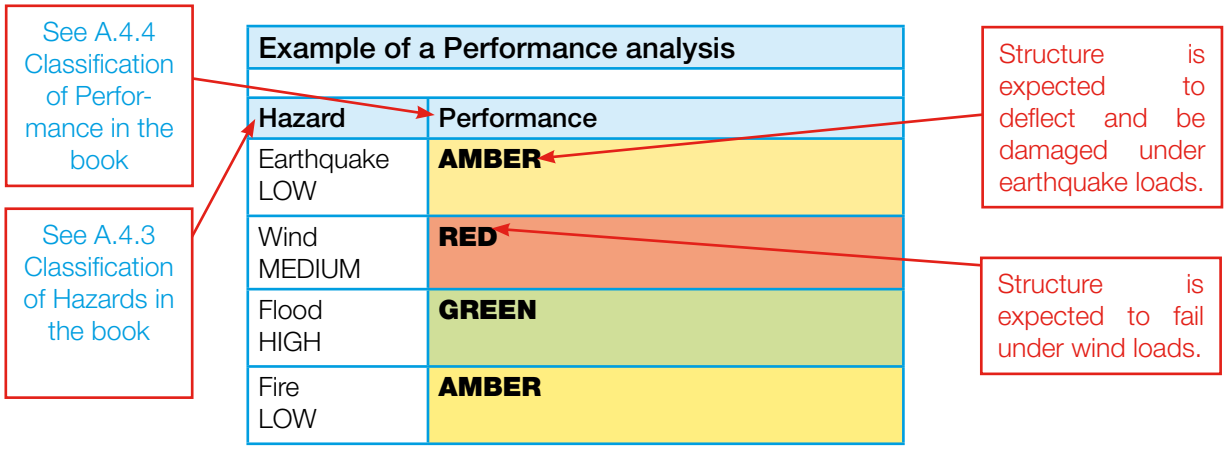
A fuller description is of the methods used is available in Section A of Post-disaster Shelters: 10 Designs, IFRC, 2012.

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.



B.1 Afghanistan – 2009 – 'Winterised Shelter'


Photo: Shaun Scales

Summary information

Disaster: Refugees returning from conflict, Winter 2009

Materials: Bamboo frames with plastic sheet walls and roof - to protect an existing tent

Material source: Internationally procured

Time to build: 3 days

Anticipated lifespan: 1 year

Construction team: 7 people fabricating frames, 5 people to assemble structures on site

Number built: 380. This design was later adapated and built in larger numbers in Pakistan following flooding

Approximate material cost per shelter: 270 CHF

Approximate project cost: 820 CHF - including all site winterisation works

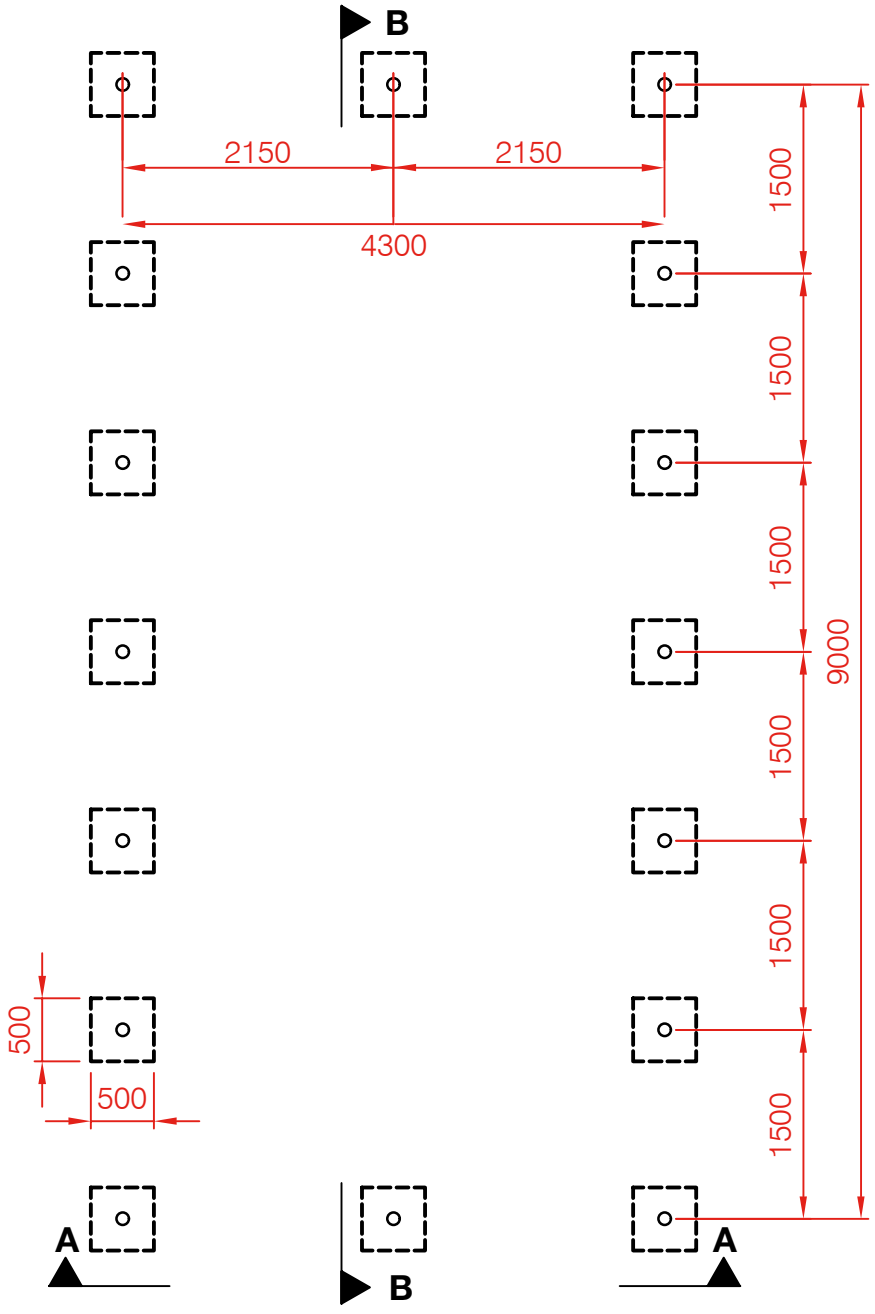
Shelter Description

This shelter was built to act as a shell to protect occupants living in tents. Each shelter contains one tent, erected inside the structure. It is rectangular in plan and has 1.8m tall side walls and a gable roof. The covered floor area is approximately 9m x 4.3m. The frames are constructed from bamboo poles. The frames are connected using plywood gusset plates and bolts. The walls and roof are plastic sheeting, and are supported on the bamboo frame and purlins. The floor is compacted soil. The shelter frames were shop fabricated in the camp and transported to the construction site. The frames are embedded into the ground for support.

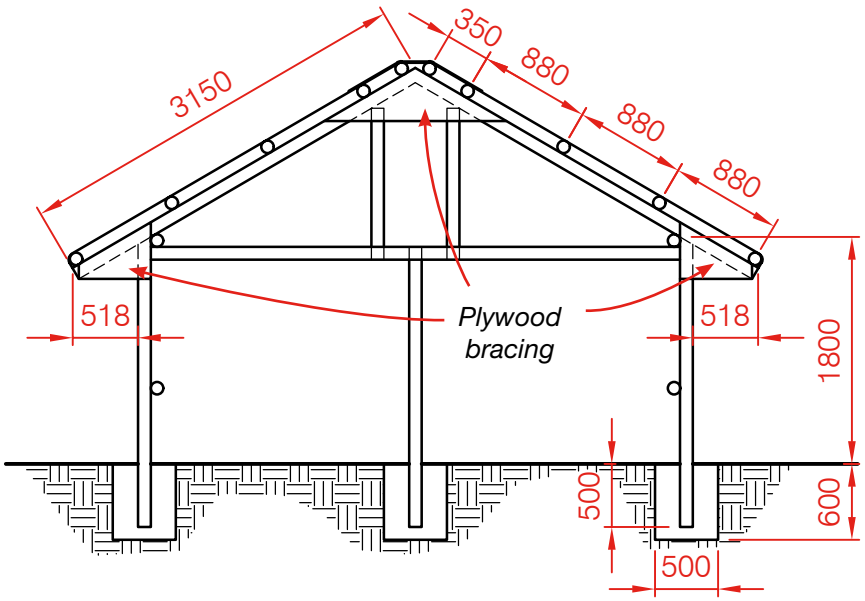
Shelter Performance Summary

This style of construction uses materials which create a lightweight shelter which can be quickly deployed in remote locations. The simple framing systems are well suited to mass fabrication using a mix of skilled and unskilled labour, and the light weight of the building framing does not require the use of heavy equipment for construction. Bamboo is a durable construction material, and is stronger than most wood species, but the plastic sheeting used for the walls and roof should only be considered temporary. The shelter frames should be able to resist the expected wind loads without failing the bamboo, but will most likely deflect significantly during strong storms. Given the relatively large span of the frames, snow loads can be problematic and occupants should be encouraged to reduce snow accumulation on the roof to prevent collapse.

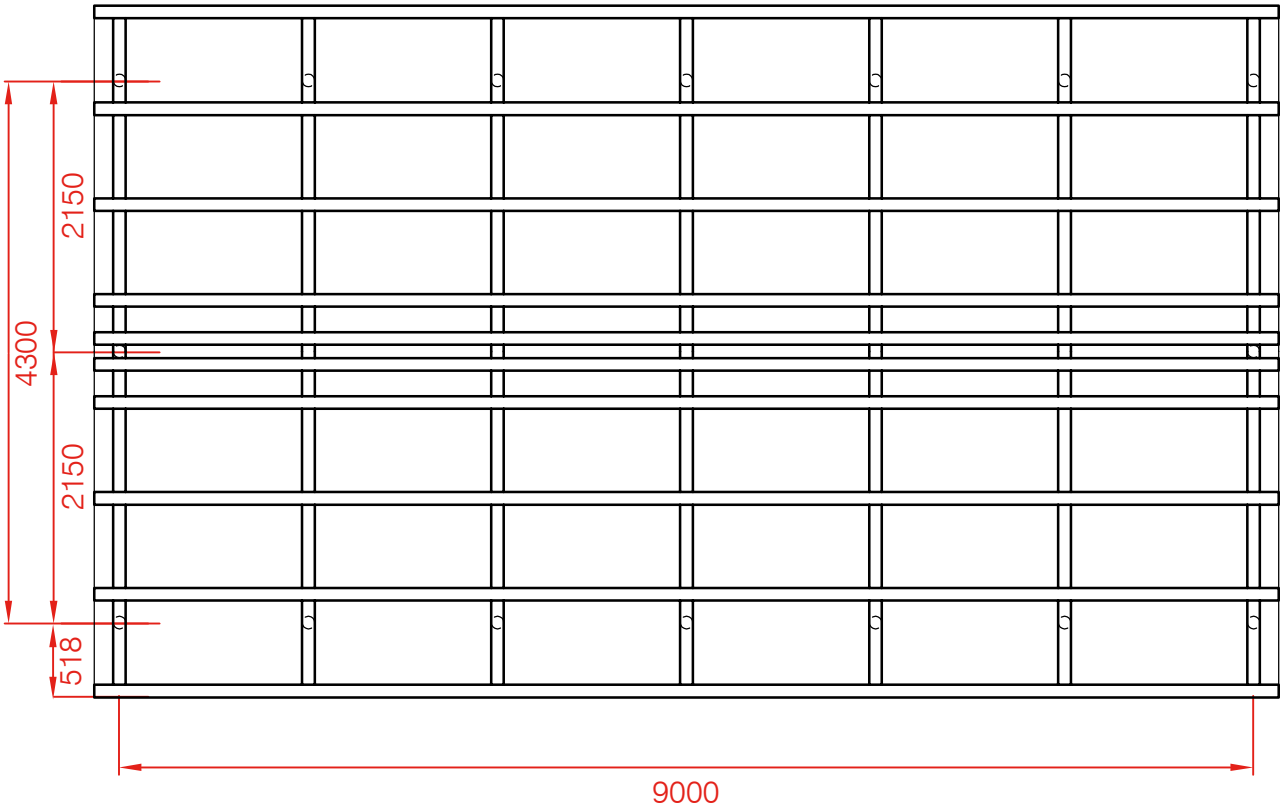
Plans



Floor plan

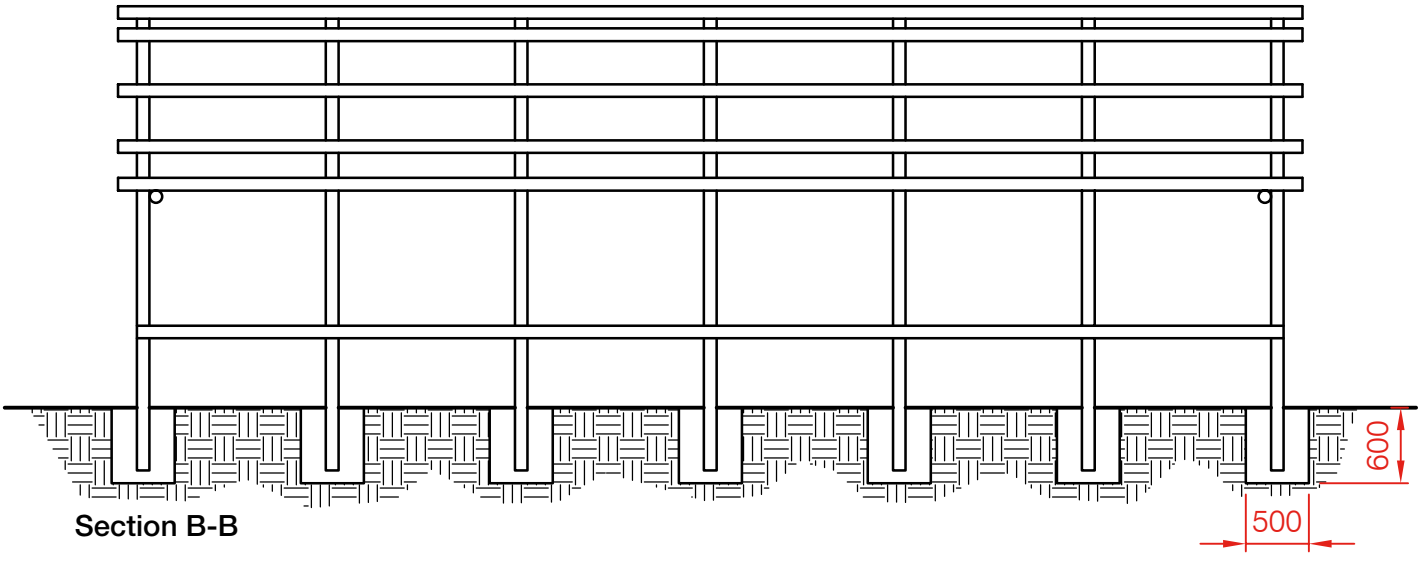


Section A-A



Roof Framing Plan

0 500 1000 2000mm



Section B-B

Durability and lifespan

The strength and durability of the shelter frames is dependent on constructing them with high quality and properly dried bamboo. While these shelters are intended to be temporary, the materials in the frame can potentially be re-used in permanent construction.

The plastic sheet roof and walls are simple to install, but will not withstand many seasons before they deteriorate due to UV exposure. It should be expected high winds and/or windblown debris will rip or tear the sheathing. Plastic sheets can be expected to last less than two years.

Performance analysis

The performance of the shelter is good for seismic loads, and should be able to withstand most wind storms without collapse. Snow should not be allowed to accumulate more than 300mm on the roof at any time. Proper site analysis is necessary prior to construction to provide any mitigation of flood hazards.

Hazard*	Performance
Earthquake HIGH	**GREEN:** The light weight construction of the frames are adequate to resist expected seismic events, and even if failure occurs it is unlikely to seriously injure the occupants.
Wind HIGH	**AMBER:** The bamboo frames should be able to resist expected wind pressures without collapse, but will likely deflect significantly, and permanent damage to the frames which will require repairs should be expected after strong storms. The wall and roof sheathing is not very durable, and will possibly require frequent replacement. The light weight shelter does not offer significant resistance to uplift loads, and could be picked up off the ground.
Flood LOW	**RED:** The floor of the shelter is the ground surface, and will not prevent flood water from entering the shelter. The only defence against flood damage will be site selection and adequate drainage provisions.
Fire LOW	**AMBER:** The components of the structural system are flammable, and will not offer significant fire resistance. The plastic sheeting is not fire retardant or fire resistant. Fortunately the small floor plan and two exits make it easy for occupants to escape before being harmed.

* See section A.4.5 Performance analysis summaries

Notes on upgrades

The walls and roof should not be upgraded with more permanent materials, as the bamboo frames are only adequate for a short expected design life, and would require significant reinforcement for use as a long term shelter.

The bamboo columns could be embedded into concrete piers to provide uplift resistance for wind loads.

In areas where flooding in a significant risk, the design can be easily modified to add more fill inside the shelter to raise the elevation of the floor above the surrounding grade. Care should be taken though to ensure the ceiling height is sufficient for the occupants.

Low height mud walls could be built to improve the thermal performance of the structure in cold weather.

Raised floors or platforms could provide protection against flooding.

It is not recommended to upgrade the plastic sheeting with more permanent materials. The tent frame is not sufficient for a shelter with a design life longer than 2 years

Assumptions

- The bamboo poles are assumed to be 8cm in diameter and have a 5mm wall thickness.
- Plastic sheeting is sufficiently attached to the bamboo framing to transfer wind loads to the frames. The capacity of the plastic or its connections to resist wind and snow loads was not analysed, given the temporary nature of this type of construction
- Lateral foundation loads are resisted by lateral soil bearing, and uplift loads are resisted by the shelter weight alone.
- Structural analysis does not include roof live loads.
- There is no building code for Afghanistan, so this shelter was only analysed using the International Building Code (IBC) 2012.

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.

Materials

- Inspect bamboo to ensure that pieces are straight, of uniform diameter, and free of cracks or other defects.

Foundation

- Verify poles are embedded in the soil the correct amount.
- Make sure the frames are in their proper location and plumb before soil is compacted around them.
- Verify that the soil under the shelter is free of organic material and compacted before construction of the structure.
- On sites at risk of flooding, elevated platforms could be built.

Bamboo Framing

- Ensure the plywood gussets are installed with the proper number, size, and location of screws and bolts.

Wall and Roof

- Plastic sheeting wall and roof sheathing should be installed neatly and tightly to the bamboo framing. The plastic sheeting should not flap in the wind, as it can be damaged by flapping against the framing.
- Ensure sheeting is fastened to the framing with battening strips or fasteners with large heads or washers to avoid fastener heads pulling through the plastic sheeting.

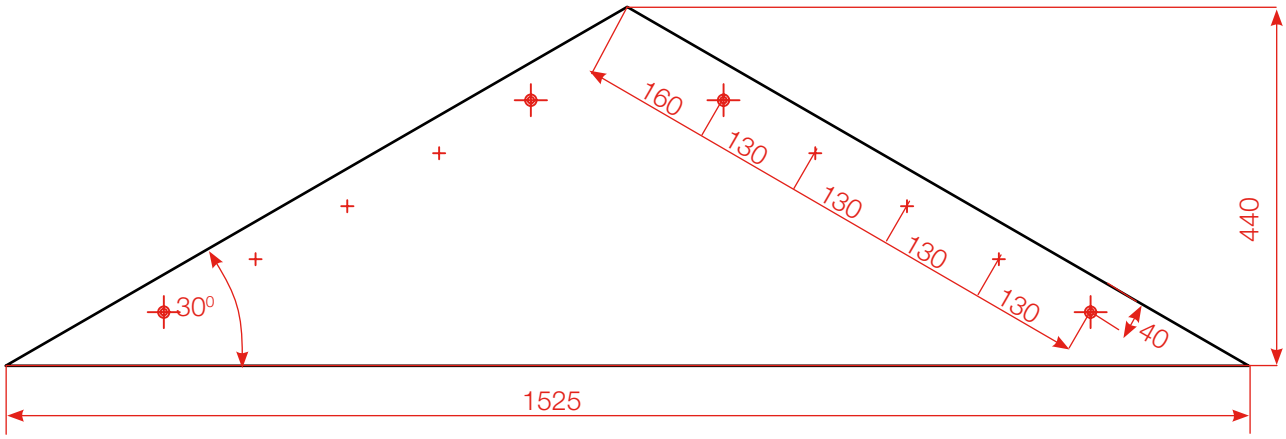
Bill of quantities

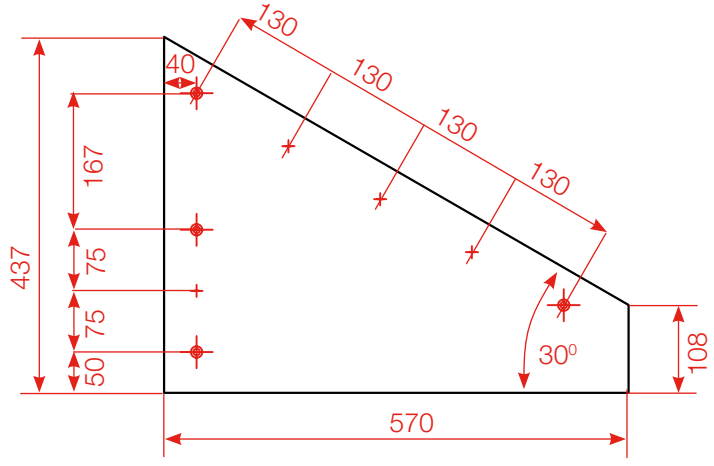
The bill of quantities in the table below is for the shelter as it was built, without the design alterations suggested here. It does not take into account issues such as which lengths of timber are available and allowances for spoilage in transport and delivery.

Item See annex I.1	Additional Specification	Quantity	Unit	Comments
Foundations				
Bamboo 1	10m long	24	Piece	7mm – 9mm diameter
Plywood 1	6mm thick	5	Sheet	1525mm x 1525mm sheets
Main Structure				
Plastic sheet		7	Sheets	5m x 4m sheets
Fixings				
Common nails	102mm long	1.6	kg	
Common nails	50mm long	2.5	kg	For fixing plastic sheeting
Bolts	6mm dia x 150mm	84	Piece	Include nut and 2 washers
Washers		1.0	kg	
Rope	5mm	60	m	Cotton rope
Tools				
Tools were used for many shelters and were centrally maintained by construction teams on site and in fabrication workshops. A generator and electric mitre saws were required for the cutting benches to prefabricate parts.				

Details

Cutting details for plywood roof truss bracing are illustrated below





8mm drill hole for 6mm diameter bolt

\+ Location for 50mm woodscrew