Note on the assessment:

The following is an excerpt from the Book Transitional Shelters: 8 Designs, IFRC, 2012, available from www.sheltercasestudies.org. 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 Uniform Building Code (UBC) 1997, National Building Codes and international seismic codes. Below is a summary of the approach used.

Risk to life or risk of structure being damaged

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

For lightweight shelters, the risk that falling parts of the building would severely injure people is reduced.

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 Transitional Shelters: 8 Designs, IFRC, 2012.

Classification of performance

The performance of each shelter has been categorised using a **GREEN**, **AMBER**, or **RED** scheme. This classification is for the risk of the structure failing or being damaged, and not the risk of people being injured.

Classification used in Section B for the performance of structures	
Classification	Meaning of classification
GREEN:	Structure performs adequately under hazard loads
AMBER:	Structure is expected to deflect and be damaged under hazard loads
RED:	Structure is expected to fail under hazard loads

Performance analysis summaries

Each shelter review in Section B has 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.

Performance analysis (example)	
Hazard	**Performance**
Earthquake LOW	AMBER:
Wind MEDIUM	RED:
Flood HIGH	GREEN:

See Classification of Performance

See Classification of Hazards

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

Structure is expected to fail under wind loads.

B.3 Pakistan (2010) - Timber frame

Summary information

Location: Pakistan – Khyber Pakhtunkhwa and Gilgit-Baltistan (Northern Areas)

Disaster: Flood, July 2010

Materials: Timber frame, corrugated steel sheet roofing and plastic sheeting (bricks and roof insulation locally sourced by homeowners)

Material source: Timber: local. Roof sheeting: internationally and locally procured

Time to build: 1 day

Anticipated lifespan: 24 months

Construction team: 4 people

Number built: 10,000

Approximate material cost per shelter: 500CHF

Shelter description

The shelter consists of 7 triangular frames, connected by a ridge pole. The ridge pole is supported by two 2.74m high vertical columns at each end. The shelter is 4.3m x 5.7m on plan. It has a low (0.9m) brick wall constructed inside the frame to provide protection against flood damage and retain warmth. The roof is pitched at 44 degrees and is made of corrugated steel sheeting. The sheeting is nailed to purlins that span between the frames. The roof sheeting is laid on top of locally available insulating material and plastic sheeting. The foundation of the shelter is provided by burying the rafters and columns approximately 0.3m in to the ground on top of stone footings. Guy ropes over the roof sheeting have been used to help prevent uplift under wind loads.

Shelter performance summary

This shelter presents a simple, low-cost transitional shelter option that is quickly constructed and appropriate for cold climates. The addition of A-bracing in the triangular frame and more robust foundations would significantly increase the performance of this shelter under seismic and wind loading and would be strongly recommended. The shelter uses locally sourced materials that are familiar to the occupants and do not require specialist tools or equipment for assembly. The framing materials can be substituted, for example bamboo or cut timber can be used as an alternative to the timber poles detailed here. This shelter has been provided as 'kit' which does not include the low level wall which can be provided by the occupants. Alternatives to brick include concrete blocks, unfired earth bricks and timber.

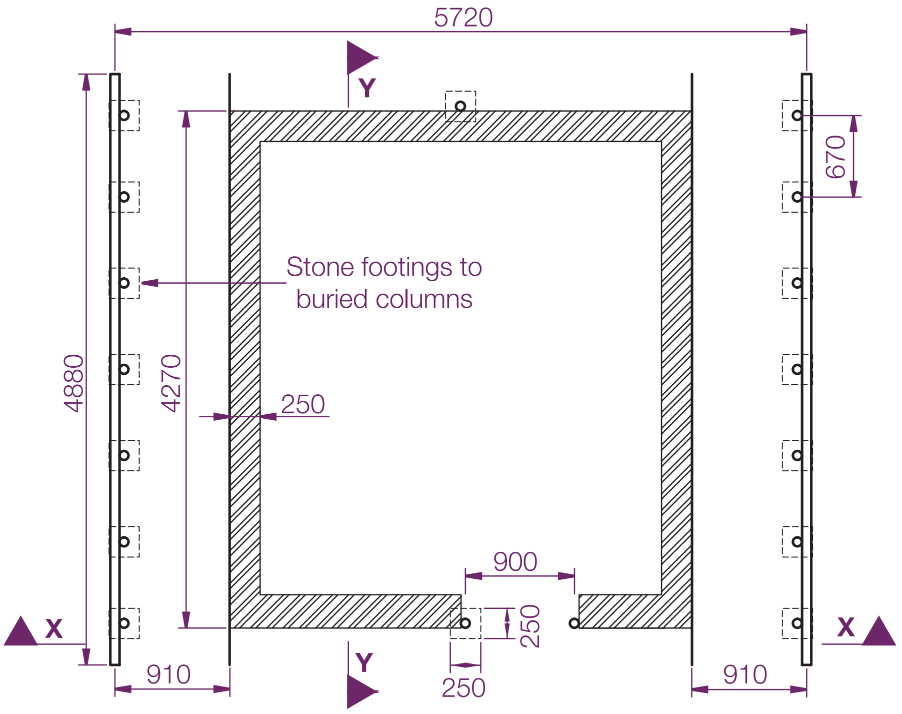
Plans and comments

CHECK: In areas known to have higher local wind pressures, adequate foundations and member sizes must be provided to account for this.

CHANGE: Treat timber members to prevent rot and insect degradation.

CHECK: Can also be constructed using bamboo members. In this case the appropriate number of members, sizes and fixing details should be designed accordingly.

CHECK: Check that the soil type for the shelter location is stiff, otherwise design foundations accordingly.



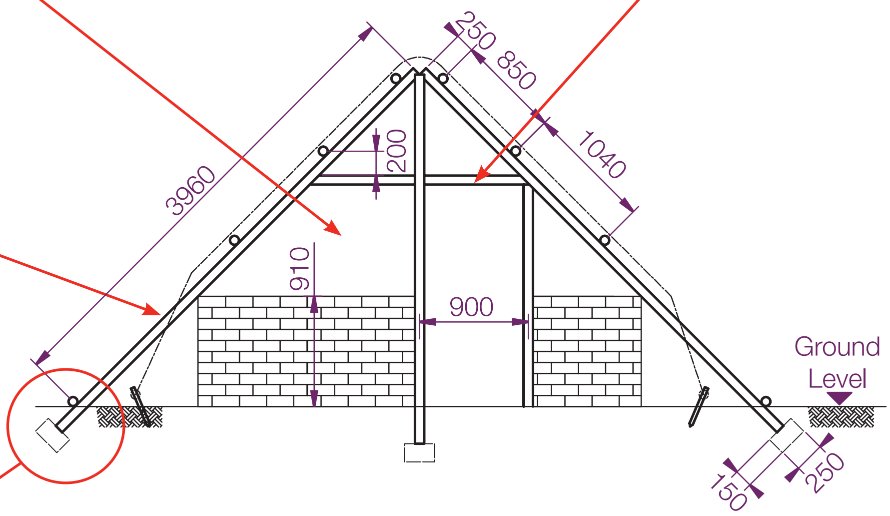
Ground floor plan

CHANGE: Add timber A-bracing member to all triangulated frames to withstand wind and snow loads (7 total).

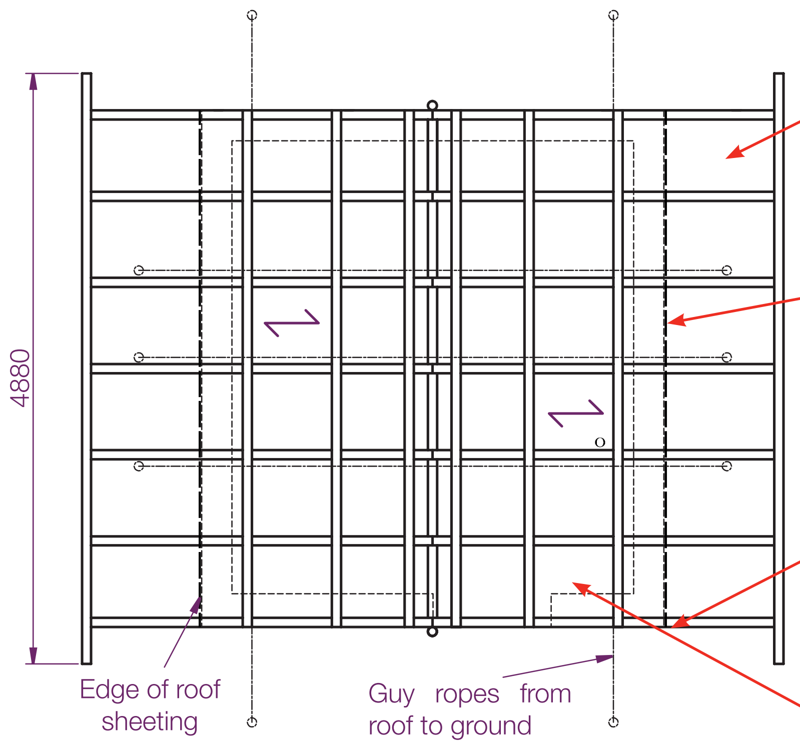
CHECK: Plastic wall sheeting should be connected back to the timber studs using 8d nails at 50mm centres on all sides.

CHANGE: Add purlins just below top of wall to support the edge of the roof sheet and transfer wind and snow loads back to the main frame. The roof sheet should be nailed to this purlin at every crest using nails and rubber washers.

CHANGE: Use an alternative foundation solution to provide uplift and sliding resistance against wind and seismic loads. (See concrete pad foundations and ground anchors in section C.1)



Section X-X



Roof Level Plan

CHANGE: Provide cross bracing ties in the roof plane in order to increase longitudinal stability.

CHECK: Nail the roof sheets at every crest at the eaves, at the ridge and at every other crest at intermediate purlins. Use roofing nails and rubber washers.

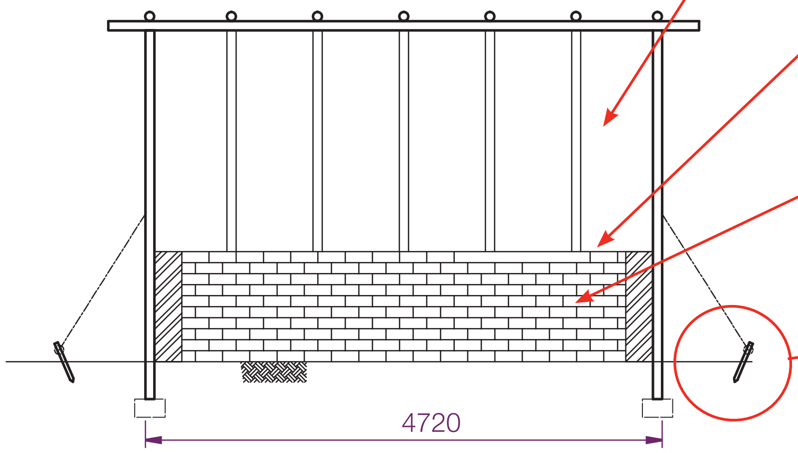
CHECK: Do not extend the roofing beyond the top of the low level wall, or wind loads will increase.

CHANGE: Increase the number of triangulated frames and purlins (decrease the spacing) according to design for expected snow drift loads.

CHECK: Do not raise the masonry above 0.9m as it will increase the risk to life and will increase the seismic forces on the structure.

CHECK: The walls will not resist seismic loads and may collapse in an Earthquake event.

CHECK: Use guy ropes to help prevent uplift of the shelter. To ensure good performance under wind loads alternative foundation solutions should also be provided.



0 1000 2000
Scale Bar

Section Y-Y

Durability and lifespan

It is expected that the materials in this shelter kit will eventually be used for rebuilding permanent housing, and it is designed to be easily dismountable with reusable materials.

The timber is not treated so will rot where buried in moist ground, but acacia timber does have natural resistance to termite attack. Treatment would be recommended where timbers will be re-used in permanent homes.

Performance analysis*

The performance of the frame under gravity and seismic loads is satisfactory. In-plane bracing and A-frame bracing in the roof would improve the stability of the shelter. For extreme snow loads additional purlins and rafter frames are required to support the roof sheeting and reduce the stresses in the members in addition to the inclusion of A-frame bracing.

Hazard	Performance
Earthquake HIGH	AMBER: An alternative foundation solution is required to resist uplift and sliding forces. The masonry walls perform poorly under seismic loads but are low. The shelter frame is however lightweight and flexible, therefore posing a low safety risk in the case of damage.
Wind LOW	RED: The shelter does not perform adequately under wind loads. A-Bracing in the triangular frames and an additional purlin at the eaves must be provided to ensure the rafters and purlins can withstand the wind pressures. In plane bracing in the roof and anchor foundations are also required to resist uplift and sliding.
Flood HIGH	AMBER: High rainfall leads to high run-off and mud flows from high ground. Brick walls laid using cement mortar provide flood protection along with the use of sandbags. No specific checks have been carried out to verify the performance of the wall in this case.

* See section A.4.5 Performance analysis summaries

Notes on upgrades:

Alternative wall materials such as nailed plywood sheeting or timber boarding can be used if the recommendations for wind pressure and snow resistance are taken into account. The roof should not be extended to ground level unless rafter sizes are increased to take the resulting higher snow loads.

Masonry should be kept to low levels only. Upgrading the shelter with very heavy materials to a high level or on the roof is not recommended as they will attract high seismic loads causing the structure to perform poorly in an earthquake. Collapse of a heavy roof or unreinforced masonry walls poses a serious risk to life.

Assumptions:

- The front and back of the structure will be clad with plywood or plastic. It is assumed that the cladding is fastened sufficiently well to transfer wind loads back to the frame.
- Plastic sheeting is not pulled taut between purlins and rafters; the corrugated roof sheeting transmits wind and snow forces directly to the timber frame. It has been assumed that fibrous matting will be used as insulation. If heavier straw coverings are to be used, the structure should be checked accordingly.
- The corrugated sheeting stops just beyond the masonry wall and does not extend outwards to the ground.
- The columns and rafters are assumed to be embedded by 0.3m into the soil.
- The brick wall is not connected to the frame, but where wind pressures act outwards, it will impose a horizontal force on the rafters at the top of the wall. The wall has been assumed to be free standing and made with the best available mortar quality.
- Joints are fixed with nails but are strong enough to transmit forces between members. The detailing of all connections is critical to the stability of the structure and should be checked for individual cases.
- A stiff soil type has been assumed in analysis of the structure. For sites where liquefaction may be a hazard (near river beds, coastal areas with sandy soils and high water tables), the shelters could be seriously damaged in an earthquake but such damage is unlikely to risk life.
- Existing foundations are formed by poles bearing down onto a stone footing at least 200 x 200mm x 100mm thick.

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 (Dimensions in mm)	Material Specification See annex I.1	Quantity	Total	Unit	Comments
Structure - Foundations					
Stone Bases 200 x 200 x 100 (thick)	-	16	16	Pieces	
Guy rope stakes 75mm dia. (L = 1m)	Timber 3	10	10	m	
Main Structure					
Vertical columns 75 dia. (L=3.05m)	Timber 3	2	6.1	m	
Inclined rafters 75 dia. (L=4.27m)	Timber 3	14	60	m	
Ridge beam 75 dia. (L=4.27m)	Timber 3	1	4.3	m	
Floor footing beams 75 dia. (L=4.88m)	Timber 3	2	9.8	m	
Secondary Structure					
Roof Purlins 75 dia. (L=4.27m)	Timber 3	6	26	m	
Covering – Wall, Roof and Floor					
Roof Sheeting 1.85m x 0.75m	Sheet 1	24	33	m^2	
Insulation Material	-	-	27	m^2	
Plastic Sheeting 4m X 6m	Plastic	3	72	m^2	
Masonry 215 x 102 x 65 clay bricks	-	2100	3	m^3	Material provided by homeowner
Fixings					
Galvanised Nails – 10d	Nails	1	1	kg	Exact number determined by fixing guidance
Galvanised Nails – 20d	Nails	1	1	kg	
Galvanised steel washers – 1.5" diameter	-	100	100	pieces	
Round rubber washers – 1.5" diameter	-	100	100	pieces	
Polyethylene rope – 12mm diameter	-	-	50	m	For guy ropes
Rope – 9.4mm diameter	-	-	100	m	Exact use unknown
Tools Required					
Hammer	-	1	1	piece	
Hand saw	-	1	1	piece	
Shovel	-	1	1	piece	
Pick axe	-	1	1	piece	
5m tape measure	-	1	1	piece	