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.

See Classification of Performance

See Classification of Hazards

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

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

Structure is expected to fail under wind loads.

B.4 Peru (2007) - Timber frame

Summary information

Disaster: Earthquake 2007

Materials: Bolaina (Bolayna) Timber frame with timber cladding and corrugated metal sheet roofing

Material source: All materials sourced locally and produced in local fabrication workshops

Time to build: 1 day (4 people -)

Anticipated lifespan: 24 months +

Construction team: 4 people with 1 engineer and 1 project manager to supervise

Number built: 2020

Approximate material cost per shelter: Unknown

Approximate project cost per shelter: 560CHF

Shelter description

The shelter has a Bolaina (Bolayna) timber braced frame, measuring 3m x 6m on plan with a single pitched roof at four degrees. The shelter is clad with tongue and groove solid timber board walls and a corrugated fibre cement sheet roof. It is 2.4m high and stands on a new or existing concrete floor slab. In instances where a new slab has been used, wire ties wrapped around nails have been cast into the slab and attached to the frame at all column locations to resist uplift. Where existing slabs have been used the shelter has been staked to posts installed outside the slab. The shelter is constructed as 6 panels which are then nailed together using connecting wooden members, connecting plates and plastic strapping. A central roof edge beam is attached to the panels and are purlins nailed on top of this to support the roof.

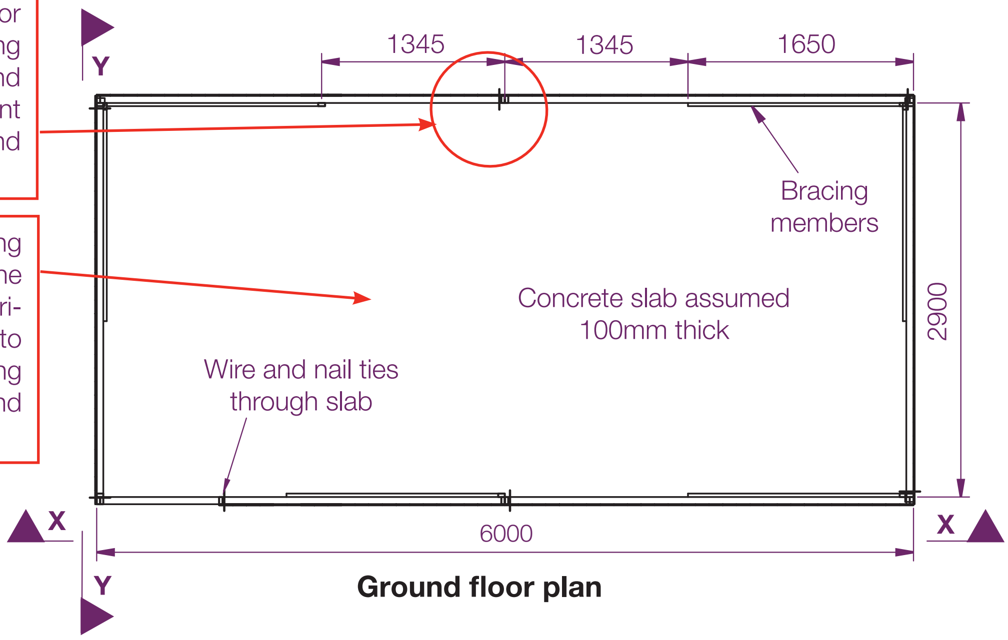
Shelter performance summary

This very lightweight, simple box-shelter offers a good design solution in areas vulnerable to seismic loading but does not perform well under wind loads. It uses locally sourced materials, and does not require specialist tools or equipment for assembly. Constructing it in panels has advantages in terms of speed of construction and quality control. However, member sizes need to be increased and the foundation fixing improved in order to provide a sound structure under gravity and seismic loads. More significant improvements are required to resist high wind loads which may not be practical, for instance large foundations. It is not suitable for upgrading into permanent housing in the long term. The timber should be treated to increase its durability and usefulness to the occupant in the event it is reused. If left untreated it will be more susceptible to rot and insects.

Plans and comments

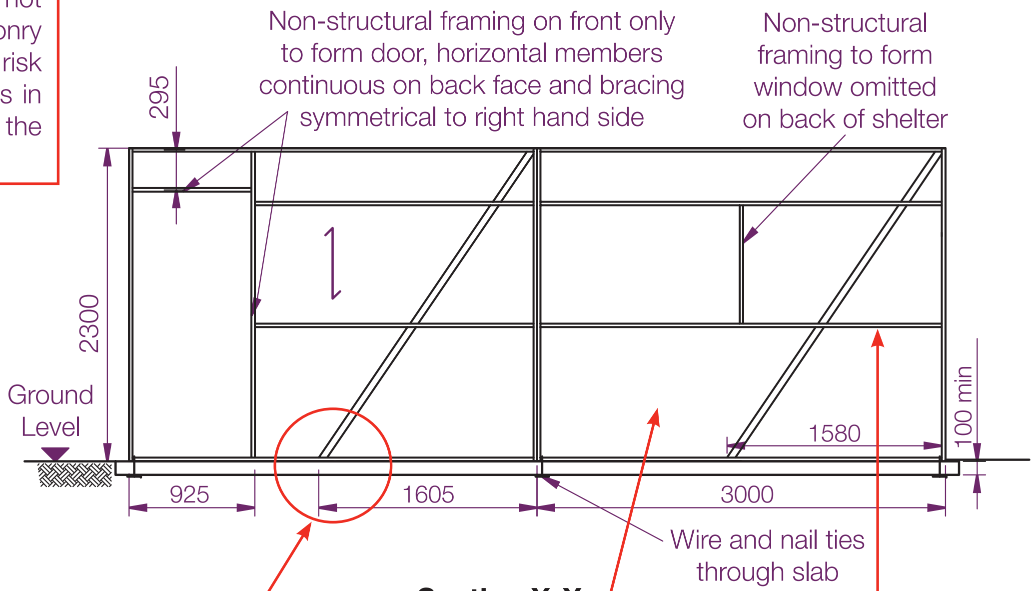
CHANGE: Increase column sizes or decrease spacing according to local wind pressures to prevent bending failure and excessive deflection.

CHECK: If an existing slab is used for the base, design appropriate anchor system to resist uplift and sliding forces under wind and seismic loads.



Ground floor plan

CHECK: Do not upgrade using masonry due to increased risk to life and increases in seismic forces on the structure.



Section X-X

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

CHANGE: Increase size of timber bracing members to take compression forces and move braces to meet at column base instead of floor beam.

CHECK: Fix timber wall planks to transoms using 6d nails at a maximum spacing of 150mm.

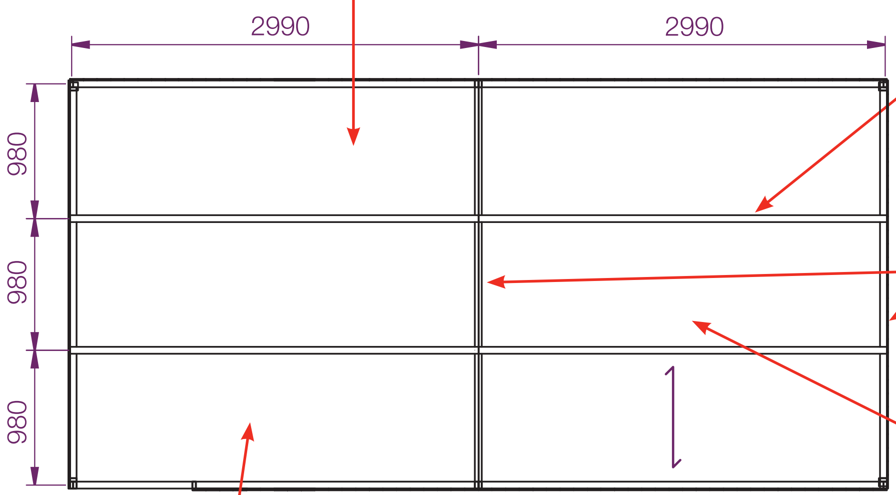
CHANGE: Increase the dimension of the nailed face of timber members to 50mm to avoid splitting when nailed.

CHECK: The fibre cement roof sheeting is heavier than alternative roofing materials such as corrugated steel sheeting. This increases the risk to life in the event of an earthquake or strong wind.

CHANGE: Decrease purlin spacing and use timber with a bigger section and depth

CHANGE: Increase the size of the central roof and eaves beams to take dead and wind loads.

CHANGE: Use crossed double wire ties as bracing in roof plane to provide stability under lateral loads.



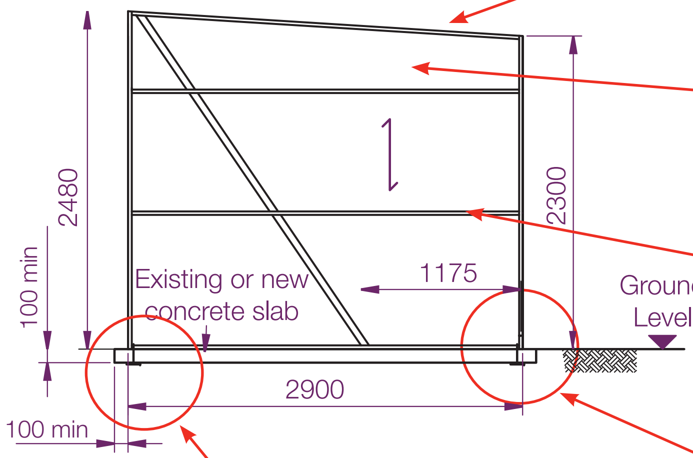
Roof Level Plan

CHECK: Fix roof sheeting using two 8d nails per roof sheet panel in 2mm oversize holes with washers, placed through the crown. Use a 70mm overlap and a seal between sheets for total weatherproofing.

CHANGE: Increase roof pitch to over 5 degrees to allow rain water run-off, and prevent deterioration of the roof.

CHECK: Increase timber plank thickness from 9.4mm to 12.5mm minimum to provide an adequate weather covering, or add plywood sheathing.

CHANGE: Space wall transoms at a maximum distance of 400mm to prevent excessive deflection and failure of the timber plank walls under wind loads and improve lateral stability.



Section Y-Y

CHECK: Design member connections for local hazard conditions by connecting members using wall plates and additional wood strips, and securing roof against uplift using plastic strapping

CHANGE: Use an alternative foundation solution to provide uplift and sliding resistance (see C.2, concrete pad or screw in ground anchor) against wind and seismic loads, or use three double wire ties per column when casting a new slab (28 in total).

CHECK: The soil type for the shelter location should be stiff, otherwise design foundations accordingly.

0 1000 2000
Scale Bar

Durability and lifespan

The shelters were intended to be upgraded, and for the materials to be reused.

Since the timber is untreated, the durability is poor and the members are susceptible to damp and rot.

Performance analysis*	
The performance of the shelter under gravity loads is inadequate. The roof should be strengthened by decreasing the purlin spacing and using larger roof and eaves beams. Further modifications are required to strengthen the building under seismic and wind loads.	
Hazard	**Performance**
Earthquake HIGH	AMBER: The performance of the shelter under seismic loads is inadequate. The roof should be strengthened and the size of the bracing in the plane of the wall must be increased and be connected to the base of the column. The shelter must be better tied to the foundations to prevent sliding. The resistance of the shelter to lateral loads is low so damage is expected. However, as the shelter is relatively lightweight and flexible it poses a low risk to life.
Wind MEDIUM	RED: The structure has insufficient resistance to wind loads. It must be more securely tied down to prevent uplift and sliding, in addition to the strengthening of the roof and wall bracing. In-plane wire cross bracing is required in the roof, the spacing of the wall transoms must be decreased and the columns strengthened to resist lateral wind pressures.
Flood MEDIUM	RED: The shelter does not incorporate any flood protection strategies and the connection of the shelter to the slab may be insufficient to hold the shelter during a flood.

* See section A.4.5 Performance analysis summaries

Notes on upgrades:

The shelter is most commonly upgraded by adding an internal partition. Wooden panel partitions improve the lateral stiffness. In many cases the shelter was insulated with polythene or plastic to retain heat in cold weather. If additional insulation is added, then further strengthening may be required.

The shelters were built with materials which were intended to be reused. However, since the timber is untreated, the durability is poor and the members not suitable for reuse in permanent housing.

In some cases modules have been joined together to form larger structures. In this case the internal walls must be retained, otherwise the shelter will become unstable. Nailed plywood walls would provide a more durable and stiff solution than the timber planking.

Upgrading the shelter with masonry or using heavy materials on the roof is not recommended. They will attract higher seismic loads, and collapse of a heavier roof or unreinforced masonry walls poses a serious risk to life.

Assumptions:

- Fibre cement roof sheeting is a relatively heavy sheet (see sheet 3 in annex I.1.3).
- Timber wall panneling is sufficiently fastened and of sufficient strength to transfer wind loads back to the frame without damage to the cladding.
- The connections between the six frame panels are of sufficient strength to transfer forces between frames and use the recommended plastic tape strapping and timber wall plates. Columns have been assumed not to act compositely, but adequately nailed connections are recommended.
- The primary roof beams and purlins are supported off the wall panels, and not from secondary supports.
- All connections are nailed with two nails and are assumed to act as pinned connections.
- It has been assumed that the shelter has been fixed to a newly cast 100mm thick minimum concrete slab using a double wire tie at each of the column locations (seven in total). Each wire tie consists of a single 6d nail with a double AWG 16 wire twisted around to leave the two free ends above the concrete. It has been assumed that the slab has one layer of square A142 mesh (see Annex I.1.2) reinforcement half way down.
- Fixings between members have been made using nails, but are of sufficient strength to transmit forces.
- A stiff soil type has been assumed.

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					
Portland Cement	Concrete	4	4	bags	42.5kg/bag
Sand	Concrete		.34	m^3	Estimate
Gravel	Concrete		.68	m^3	Estimate
Wire mesh Reinforcement		18	18.0	m^2	
Nails – 6d	Nails	7	7	Pieces	
Wire (16 AWG)	Wire	6	6.0	m	Estimate
Main Structure					
Columns – 25 x 50 (L=2.5m)	Timber 4	13	32.5	m	
Roof Beam – 25 x 50 (L=3m)	Timber 4	2	6.0	m	
Eaves Beams – 25 x 50 (L=2.9m)	Timber 4	2	5.8	m	
Eaves Beams – 25 x 50 (L=3.0m)	Timber 4	4	12.0	m	
Floor Beams– 25 x 50 (L=2.9m)	Timber 4	2	5.8	m	
Floor Beams – 25 x 50 (L=3.0m)	Timber 4	4	12.0	m	
Bracing – 25 x 50 (L=3.0m)	Timber 4	6	18.0	m	
Secondary Structure					
Purlins – 25 x 50 (L=3.0m)	Timber 4	4	12.0	m	
Wall Transoms – 25 x 50 (L=3.0m)	Timber 4	6	18.0	m	
Wall Transoms – 25 x 50 (L=2.9m)	Timber 4	4	11.6	m	
Wall Transoms – 25 x 50 (L=2.05m)	Timber 4	2	4.1	m	
Door & window framing – 25 x 50 (L=1.0m)	Timber 4	2	2.0	m	
Covering – Wall and Roof					
Fibre cement roof sheeting (1 x 3m sheet, 6.25 thick)	Sheet 3	6	6	Pieces	
Timber tongue & groove planks. 87.5 x 9.4 (L=2.48m)	Timber 4	68	169	m	
Timber tongue & groove planks. 87.5 x 9.4 (L=2.30m)	Timber 4	43	98.9	m	
Timber tongue & groove planks. 87.5 x 9.4 (L=0.42m)	Timber 4	10	4.2	m	
Timber tongue & groove planks. 87.5 x 9.4 (L=0.32m)	Timber 4	16	5.1	m	
Timber tongue & groove planks. 87.5 x 9.4 (L=1.01m)	Timber 4	16	16.2	m	
Timber tongue & groove planks. 87.5 x 9.4 (L=2.48 decreasing to 2.30m)	Timber 4	70	70	Pieces	

Fixings					
Nails – 8d roofing nails with protecting cap/ washer	Nails		0.5	kg	
Nails – 6d	Nails		1.6	kg	
Plastic Tape (10 x 150)		8	8	Pieces	For joints
Steel hinge 2.5”		7	7	Pieces	
Screws	Screws	3	3	Pieces	
Wood strips – 30 x 60 (L=3m)	Timber 4	2	6	m	
Wall plates – 60 x 60 x 9.4 thick	Timber 4	-	7.5	m	Corner plate reinforcement
Tools Required					
Hammer	-	1	1	Pieces	