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.5 Peru (2007) - Timber Frame

Summary information

Location: Peru, Ica Province

Disaster: Earthquake 2007

Materials: Eucalyptus wood poles, bamboo matting, plastic sheeting, wire and nails, concrete slab

Material source: Mats and wood locally available, plastic sheeting imported, staples and staple guns imported.

Time to build: 2 days

Anticipated lifespan: 12 months minimum

Construction team: 4 people

Number built: 3000

Approximate material cost per shelter: 225CHF (2007)

Programme cost per shelter: 340CHF (2007)

Shelter description

The structure is a rigid box consisting of braced frames in both directions. The braced frames provide lateral stability. The eucalyptus timber frame has a flat roof and is covered with stapled plastic sheeting and nailed palm matting on all faces. The shelter is 2m high and 3m x 6m on plan. The bracing consists of crossed twisted wires. The 75mm diameter columns are connected horizontally with 50mm diameter horizontal members. The foundation and floor consists of an unreinforced concrete slab with cast in wire ties. The connections between members are made using bent nails.

Shelter performance summary

This very lightweight braced box shelter provides an effective temporary solution that can be easily disassembled and the materials re-used. It uses local materials and simple construction techniques, so can be built quickly. The very minor improvements that are recommended in this analysis would improve the performance and overall robustness of the shelter under normal gravity and seismic loads. However, significant modifications would be needed to improve its performance under wind loading.

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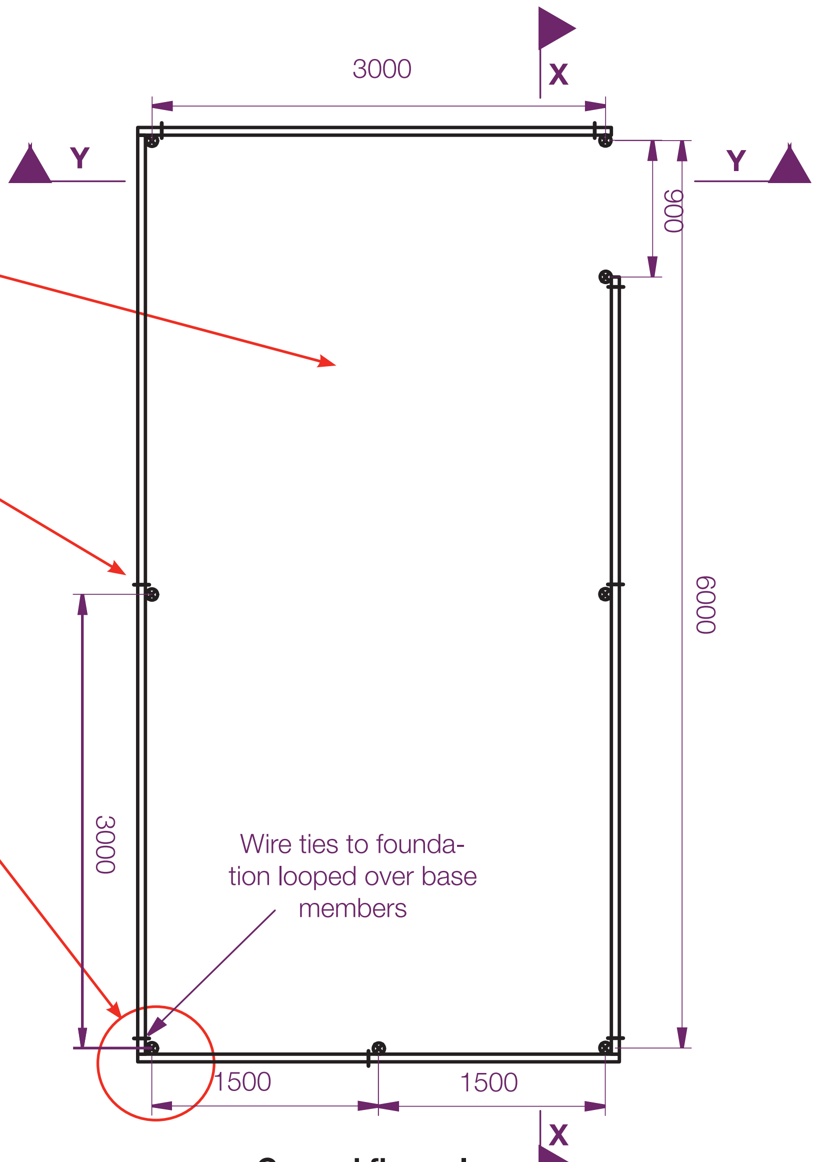
Plans and comments

CHECK: See Annex I.1 for the correct concrete mix for the slab. A layer of mesh reinforcement to increase tie pull out resistance is required.

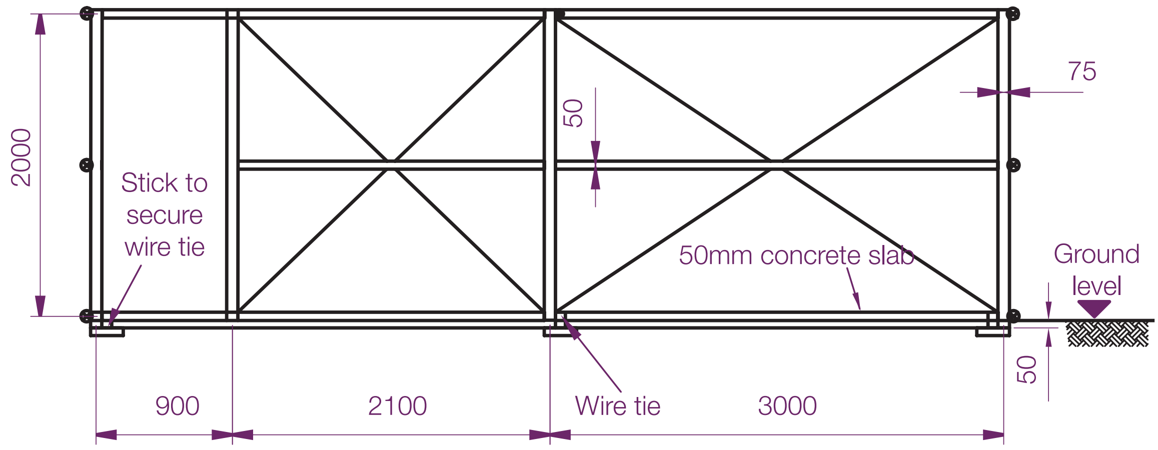
CHANGE: Use 8 columns to decrease the roof member spacing.

CHANGE: Two double wire ties are required per column, cast into the foundation and tied to the structure to prevent uplift under wind loads.

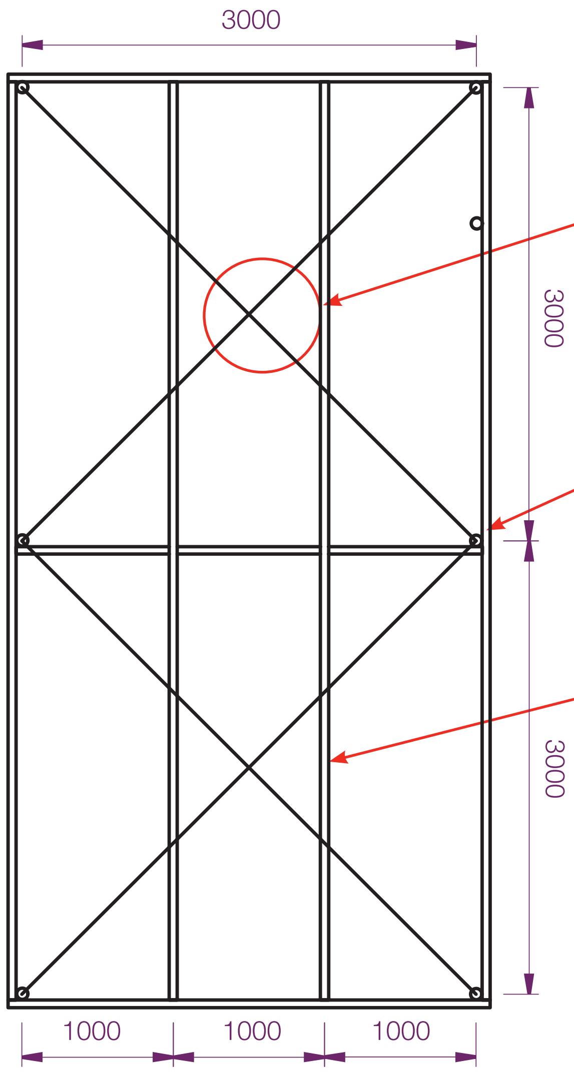
CHECK: The design and detailing of all connections is critical to the stability of the structure and should be checked.



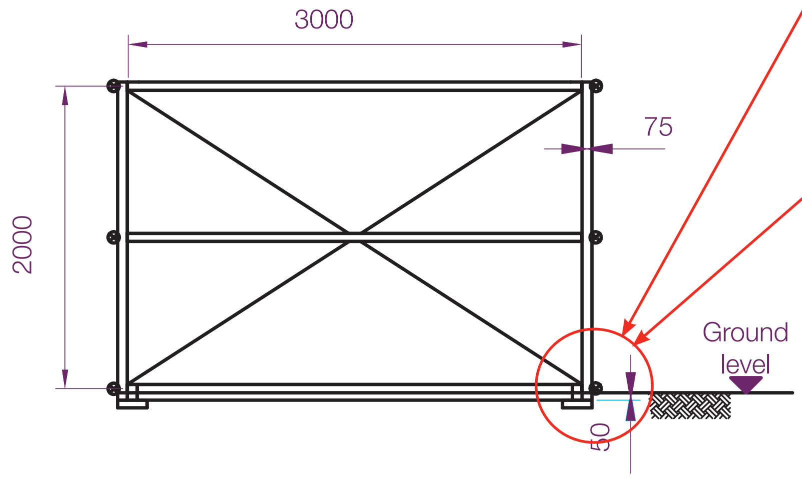
Ground floor plan



Section X-X



Roof Level Plan



Section Y-Y

CHANGE: Increase bracing to 10 strands of wire on end faces and roof to provide adequate resistance to wind pressures.

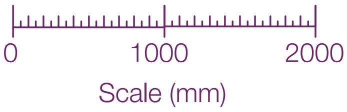
CHECK: All member sizes, particularly central columns and bracing, should be increased in accordance with design to local wind pressures.

CHECK: If the roofing is upgraded with a heavier material the roof member sizes must be increased accordingly.

CHANGE: Modify foundations to concrete bucket or embedded base plate foundations (see Section C.2) to prevent problems with uplift / sliding under wind loads. For example the columns could be securely tied into embedded concrete pockets.

CHECK: In areas known to have high local wind pressures adequate foundations and member sizes must be provided.

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



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Durability and lifespan

The shelter is demountable and could be easily moved from its foundation by cutting the wire ties.

The matting traps dirt and mould and is prone to breakage where stapled, the plastic sheeting may fail due to wear and tear and the timber is untreated. The shelter is not upgradable, but straw mats and frame could be reused. The timber frame can be reused, but the slab cannot, and a new foundation will be required if the shelter is moved.

Performance analysis*

The performance of the shelter under gravity and seismic loads alone is satisfactory. Under wind loads, modifications are required to strengthen the shelter.

Hazard	Performance
Earthquake HIGH	AMBER: Medium risk of failure. The shelter attracts low seismic loads and its performance is adequate. The resistance of the shelter to lateral loads is low so damage is expected. However since it is lightweight and relatively flexible it poses a low risk to the lives of the occupants when damaged.
Wind MEDIUM	RED: High risk of failure. The structure has insufficient resistance to wind loads. The structure must be more securely tied down to prevent uplift and the foundation size increased to prevent sliding. More bracing must be added in the walls and roof to provide sufficient lateral stability. Additional columns and roof members are also required.
Flood MEDIUM	RED: High risk of failure. The flood risk increases during El Nino period every 10-15 years. The shelter does not incorporate any flood protection strategies so in the case of flooding the damage would be great.

* See section A.4.5 Performance analysis summaries

Notes on upgrades:

Upgrading the roof with materials of a similar weight, for example lightweight metal sheets would not change the structural performance of the shelter. In order to upgrade the roof or walls with heavier and more substantial materials, such as plywood, the frame member sizes would need to be increased, connections strengthened and foundations upgraded to take the increased gravity and seismic loads.

Upgrading the shelter with masonry or other very heavy materials is not recommended as they 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 the lives of the occupants.

Assumptions:

- A stiff soil type (see Site Class D, 4 International Building Code (IBC) 2009) has been assumed in analysis of the structure. Softer soil, or soil of variable quality may adversely affect the performance of the existing shallow foundations. 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 pose a lives of the occupants.
- It is assumed that under wind pressures the plastic sheeting will not tear. This will transfer wind forces to the structure. This requires a maximum distance between staples of approximately 150mm on all edges.
- The foundations consist of 8 ties with 10mm * 10mm * 100mm sticks embedded below the 50mm thick concrete slab. The slab has wire mesh reinforcement at 25mm depth and there are 4 wires providing resistance per tie point.
- The roof members are slender and can only support a minimal dead load. It is assumed that there are no additional roof loads such as volcanic ash, sand or snow.
- All connections are sufficient to transfer the required forces between members.
- The plastic sheeting is assumed to be 'hand-taut' (not machine fixed) and will not flap in the wind.

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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	Material Specification See annex I.1	Quantity	Total	Unit	Comments
Structure - Foundations					
Portland cement	Concrete	2	2	bags	42.5kg/bag
Sand/Gravel	Concrete	1	1	m^3	Estimate only
Wire mesh reinforcement		18	18	m^2	
Main Structure					
Main columns (2m x 75mm dia.)	Timber 2	8	14.0	m	
Window column (1.6m x 75mm dia.)	Timber 2	1	1.6	m	
Beams (6m x 50mm dia.)	Timber 2	6	36.0	m	
Beams (5.1m x 50mm dia.)	Timber 2	2	10.2	m	
Beams (3m x 50mm dia.)	Timber 2	8	24.0	m	
Structure - Door					
Verticals (2m x 50mm dia.)	Timber 2	2	4.0	m	
Horizontals (0.9m x 50mm dia.)	Timber 2	3	2.7	m	
Covering – Wall and Roof					
Plastic sheet (4m x 6m)	Plastic		54	m^2	
Bamboo mats (2m x 3m)	-		54	m^2	
Fixings					
Galvanised AWG16 wire	Wire	130	130	m	Used in double lengths
Nails – 10d	Nails		3	kg	
Nails – 8d	Nails		2	kg	
Nails – 4d	Nails		1	kg	
Staples – 22/25	Staples	2000	2	box	
Hinge – 62.5mm steel		3	3	piece	
Knocker – 50mm steel		1	1	piece	
Padlock		1	1	piece	
Tools Required					
Hand saw		1	1	piece	
Shovel		1	1	piece	
Hammer		1	1	piece	
Pliers		1	1	piece	
Clippers		1	1	piece	
Wheel barrow		1	1	piece	
Industrial stapler		2	2	piece	
5m tape measure		1	1	piece	
7m plastic level pipe		1	1	piece	

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