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.2 Burkina Faso – 2009 – ‘Emergency Shelter’

Summary information

Disaster: Flood, September 2009

Materials: Concrete floor slab with timber framed walls and roof and plastic sheeting wall and roof covering

Material source: Locally procured, plastic sheeting imported

Time to build: 3 days

Anticipated lifespan: 2 years (limited by plastic sheeting covering)

Construction team: 4 people

Number built: 2,840

Approximate material cost per shelter: Unknown

Shelter Description

This shelter is a rectangular timber frame with a pitched roof and a covered floor area of 2.7m x 1.8m. The frame has plastic sheeting for both roof and wall covering, and one door on each short side.

The wall frame is made from timber panels that are pre-fabricated on the ground. The timber roof structure is nailed to these panels. Both walls and roof are reinforced with wire cross bracing. There is a knee braced timber framed along the roof ridge which supports the roof panels, and provides stability during construction. Wall and roof covering is fastened to the timbers using flat-head nails.

Shelter Performance Summary

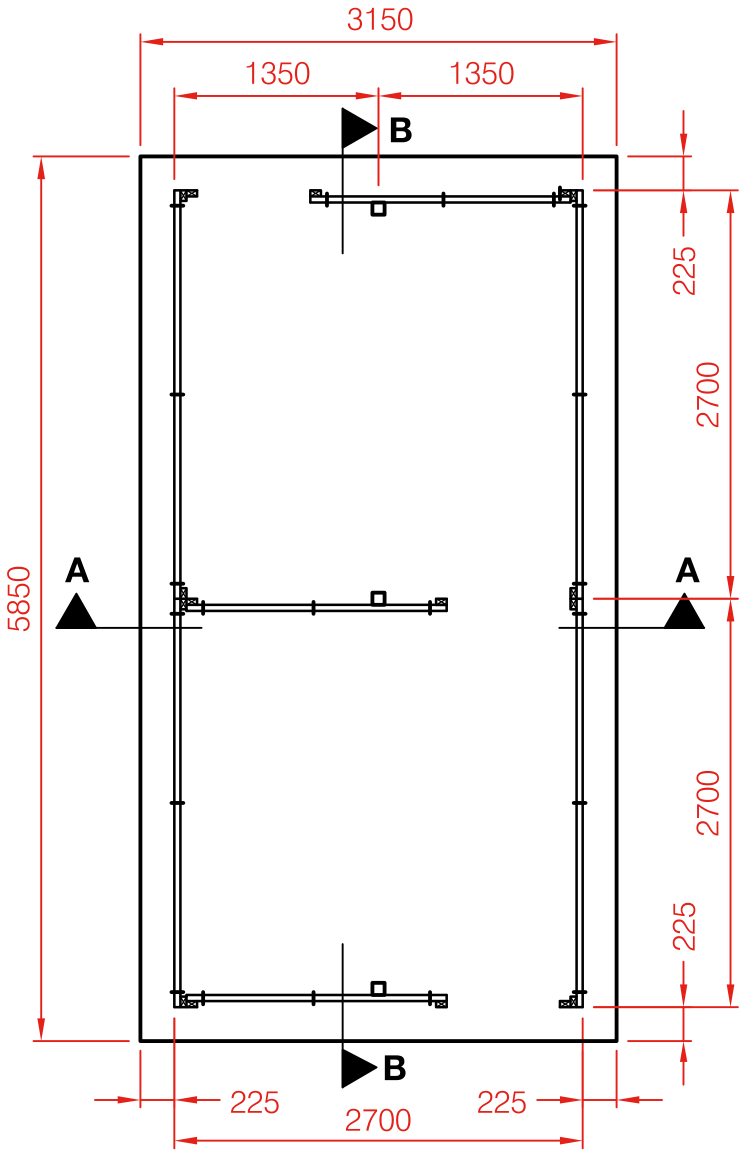
This style of construction uses locally available materials to create a lightweight shelter which can be constructed with unskilled labour. It offers a good short term solution and can be quickly deployed and constructed after a disaster. The frame is relatively simple to maintain and the sheeting can be replaced increasing the shelter’s lifetime.

Due to its light weight, it is ideal for areas of high seismic activity, and the plastic sheeting walls are sufficient for the light wind loads at this location.

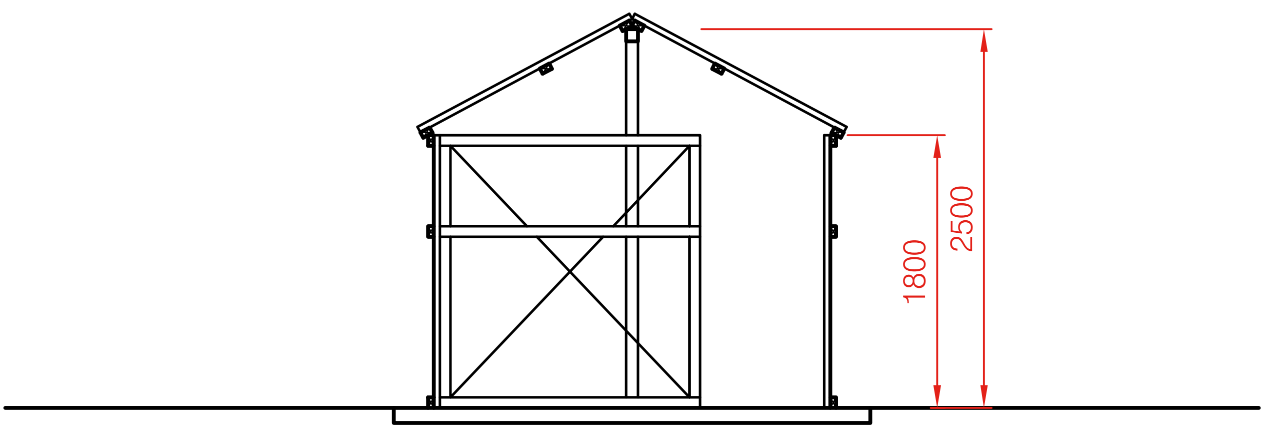
If this shelter is intended for use in areas with higher expected wind loads, the plastic sheeting covering may need to be removed or the timber members reinforced for the shelter to withstand full strength storms without being destroyed. If the wall and roof covering is upgraded to material such as plywood or boards, the panels and frames many need to be strengthened.

Since the floor is only a few millimetres above grade, it does not offer significant protection from flood waters.

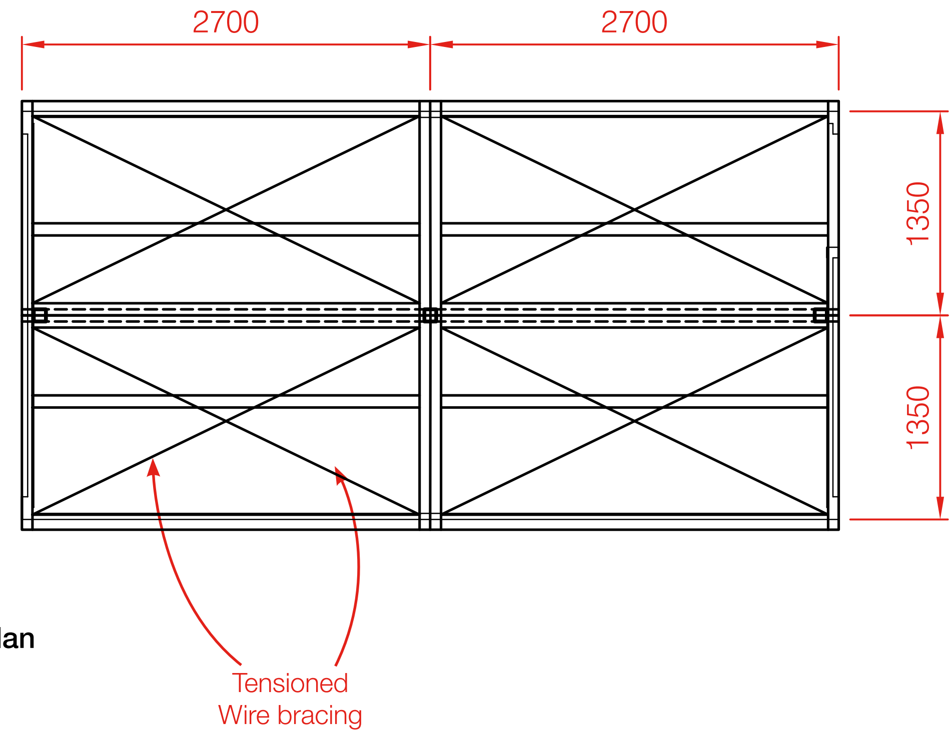
Plans



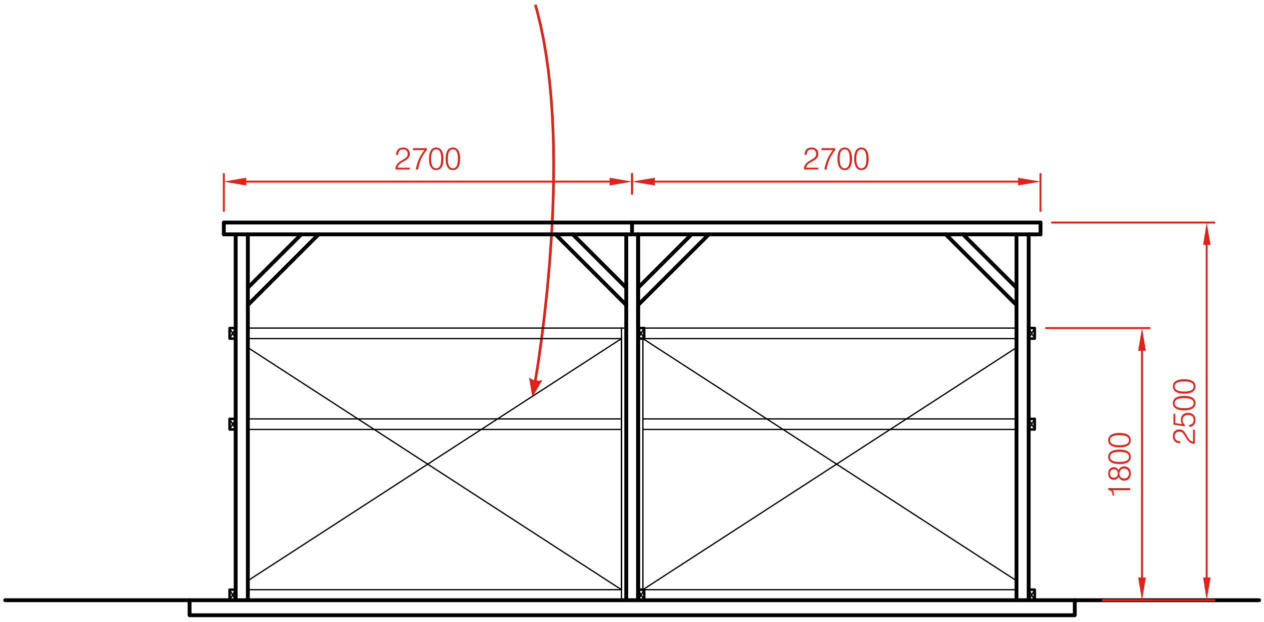
Floor plan



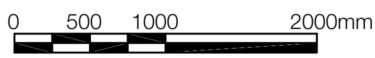
Section A-A



Roof Framing Plan



Section B-B



Durability and lifespan

Given the tropical climate in the summer and the presence of termites, it is unlikely that the framing will remain usable for extended periods of time unless the timber is treated before construction.

The plastic sheeting roof and walls are simple to install, but will not withstand many seasons before exposure to sunlight and wind causes them to deteriorate. It should be expected that high winds and/or windblown debris will rip or tear the covering. Plastic sheeting can be expected to last less than two years.

For these reasons it is not likely that these shelters will be incorporated into permanent housing, However the timbers may be re-used later if not damaged by insects.

Performance analysis

The performance of the shelter is good for seismic loads and the light wind loads in Burkina Faso. The shelter can provide shade from sun and rain for a limited period. Proper site analysis is necessary prior to construction to determine appropriate finished floor heights to provide any mitigation of flood hazards.

Hazard*	Performance
Earthquake LOW	**GREEN:** There are no expected seismic events for this location. In general structural framing is very light, all panels have wire cross bracing, and all wall panels are anchored to the concrete slab with wire ties. Therefore performance for seismic loads should be satisfactory.
Wind LOW	**GREEN:** Structural framing is sufficient for the wind loads at this location, but framing will need to be strengthened for this design to be used in areas of high wind speeds. The wall and roof covering will require replacement every few years, and wire tension requires regular checking and maintenance.
Flood HIGH	**RED:** The first floor of the shelter is only located a few millimeters above exterior grade and the wall construction will not prevent water from entering. As the shelter is currently designed The only defence against flood damage will be site selection.
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 means of egress make it easy for occupants to exit before being harmed.

* See section A.4.5 Performance analysis summaries

Notes on upgrades

Wire ties between individual wall panels and between wall panels and the concrete slab can be installed in a crossing pattern to increase the lateral resistance of the shelter.

The wire ties can be replaced by timber bracing. See the following note on fixing details for more detail.

Timber members can be preservative treated to resist rot and treated to resist termites. This will improve the durability of the construction materials.

The top timber member of the interior wall panel can be extended across the entire width of the shelter and connected to the wall panels and roof frame to help distribute lateral loads into the cross bracing.

The wood posts along the ridge can be anchored to the concrete slab with wire ties and/or nailed to the exterior wall panels to improve uplift resistance.

Upgrading the wall and roof covering to more durable materials such as planks or plywood should be approached with caution. In specific situations the plastic sheeting can be upgraded without affecting structural performance, but in general upgrading the covering will require strengthening the timber panels.

Raised floors could be built to improve performance during flooding of sites.

Burying the plastic sheeting in the ground outside the slab is a possible solution. Installing the plastic sheeting under the wall panels will cause conflicts with the wire ties that anchor the panels to the concrete slab.

Assumptions

- Timber framing is assumed as Southern Pine Grade No 2, or equivalent.
- The wooden dowels used to embed the wire ties in the concrete slab are sufficiently large and strong.
- The twisted wire joints are sufficiently strong.
- The individual timber panels are connected to each other and the roof beams are tied down to the wall panels with wire ties.
- All wire is at least 2.5mm diameter.
- Lateral foundation loads are resisted by friction between the concrete slab and the soil.
- The slab was assumed to be 75mm thick.
- Structural analysis does not include roof live load.
- Burkina Faso has no building code, so the International Building Code (IBC) 2009 was used for analysis.

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 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.
- Gravel for the concrete slab should ideally consist of sand and stone only. Fine and/or dusty soils should be avoided, and stone should not exceed 25mm in size.
- Ideal proportions for concrete are 1:2:3 (Cement : sand : crushed stone) (all by volume).
- Only add enough water to place the concrete. Excess water reduces durability and will cause cracking of the finished slab. If concrete is mixed in batches, maintain consistent proportions for all batches.
- Treat the timbers against termites as this can significantly enhance the durability of the frame.

Foundation

- Verify that the soil under the concrete slab is free of organic material, and that any soft spots have been compacted. Ground surface should be flat and level prior to concrete placement.
- The wood dowels for embedded wire ties should be at least 25mm from the top of the slab surface.
- Verify that all required wire ties are in place before concrete placement.
- Do not dump all the concrete on one side of the slab and push it across to the other side, as it will result in mainly stone on one side of the slab and mainly cement on the other. Instead place concrete on the ground in batches.
- The concrete floor slab also supports the structure, so it should have a flat, level and smooth finish.
- The slab should cure for at least three days before the shelter is installed. Immersing the slab with water or placing a plastic sheet on top of the concrete will improve curing.
- Raising the slab will help reduce flood risk.

Timber Framing

- Layout the timber members of each frame so that one side of the frame is free of sharp edges, nail heads or other items which could damage the sheeting. Install this side on the exterior of the shelter.
- Ensure proper nailing is used to attach timber panels and beams, and that wire cross bracing is securely fastened to the panels and is not loose.
- Verify that wire ties between concrete slab and the wall panels and between wall panels and roofing members are installed and are secure.
- Verify that the wire cross bracing in each wall and roof panel is installed in a taught condition.
- If pressure treated wood is used, use galvanized fasteners, as most preservatives corrode mild steel.

Wall and Roof

- Plastic sheeting for wall and roof covering should be installed neat and tight to the timber framing, and should not billow in the wind, Plastic sheeting can be damaged by flapping against the framing.
- Ensure that the plastic sheeting are fastened to timber framing with battening strips or fasteners with large heads or washers to avoid the fastener head from pulling through the sheeting.

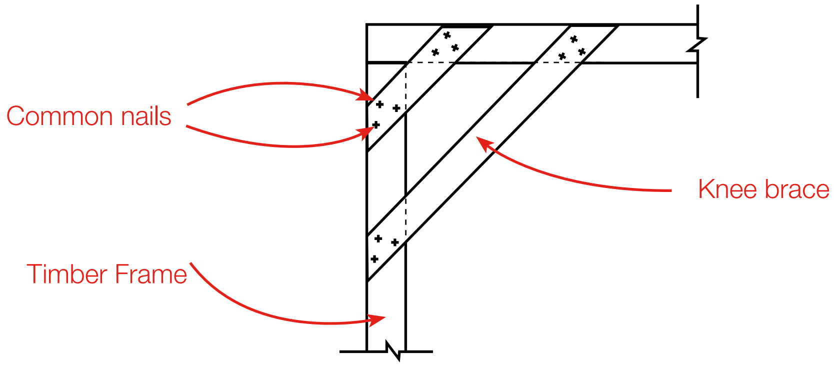
Bill of quantities

The table of quantities below is for the materials required to build the shelter. 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		2	Bags	42.5 kg/bag
Gravel		0.8	m^3	
Sand		0.6	m^3	
Water		280	Litre	
Main Structure				
Timber 2	70mm x 40mm x 2.7m long	28	Piece	Southern Pine No 2 or Equal
Timber 2	80mm x 80mm x 2.7m long	3	Piece	Southern Pine No 2 or Equal
Covering – Wall and Roof				
Plastic sheet	6m x 6m	3	Piece	note this is not IFRC standard dimensions, but is the size that was used in the field.
Fixings				
Wire 2	5m long	3	Piece	
Common nails	75mm long	1.5	Kg	
Roofing nails	32mm long	1.5	Kg	
Tools				
Spade		1	Piece	
Hoe		1	Piece	
Machete		1	Piece	
Wheelbarrow		1	Piece	
Trowel		1	Piece	
Framing hammer		1	Piece	
Hand saw		1	Piece	
Wire cutters		1	Piece	
Rope	0.9m long	1	Piece	The rope is used during construction to make measurements and to ensure the wall and roof panels are plumb
Gloves		1	Pair	

Note on fixing details

If timber were to be used instead of wire for cross bracing, attention should be given to the design of the joints and the bracing.



Possible timber knee bracing detail: by having dual braces the joint

Knee bracing is typically much less efficient that cross bracing. Cross bracing only puts axial loads in the members (i.e. along their length), which is the direction they are strongest. Knee bracing relies on bending the members, where they are weaker. Additionally, the forces developed in the knee braces are typically much larger than the forces in cross bracing, thereafter requiring stronger connections.