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.

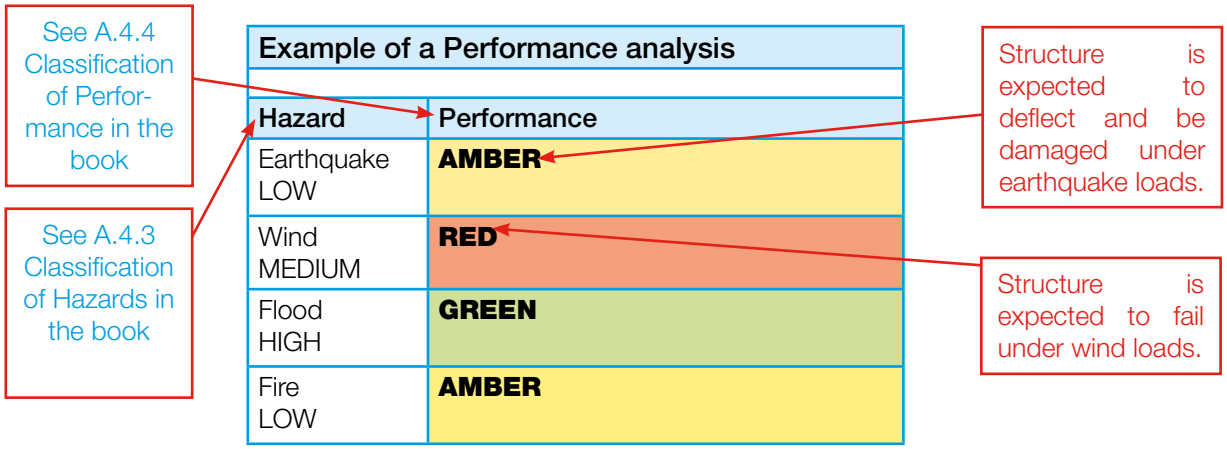
A fuller description is of the methods used is available in Section A of Post-disaster Shelters: 10 Designs, IFRC, 2012.

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.9 Pakistan – 2010 – 'One Room Shelter'

Summary information

Disaster: Flood, July 2010

Materials: Unreinforced brick exterior walls, tile roof supported on steel framing.

Material source: Locally procured

Anticipated lifespan: 10 years

Number built: 875

Approximate project cost per shelter: 1,300CHF

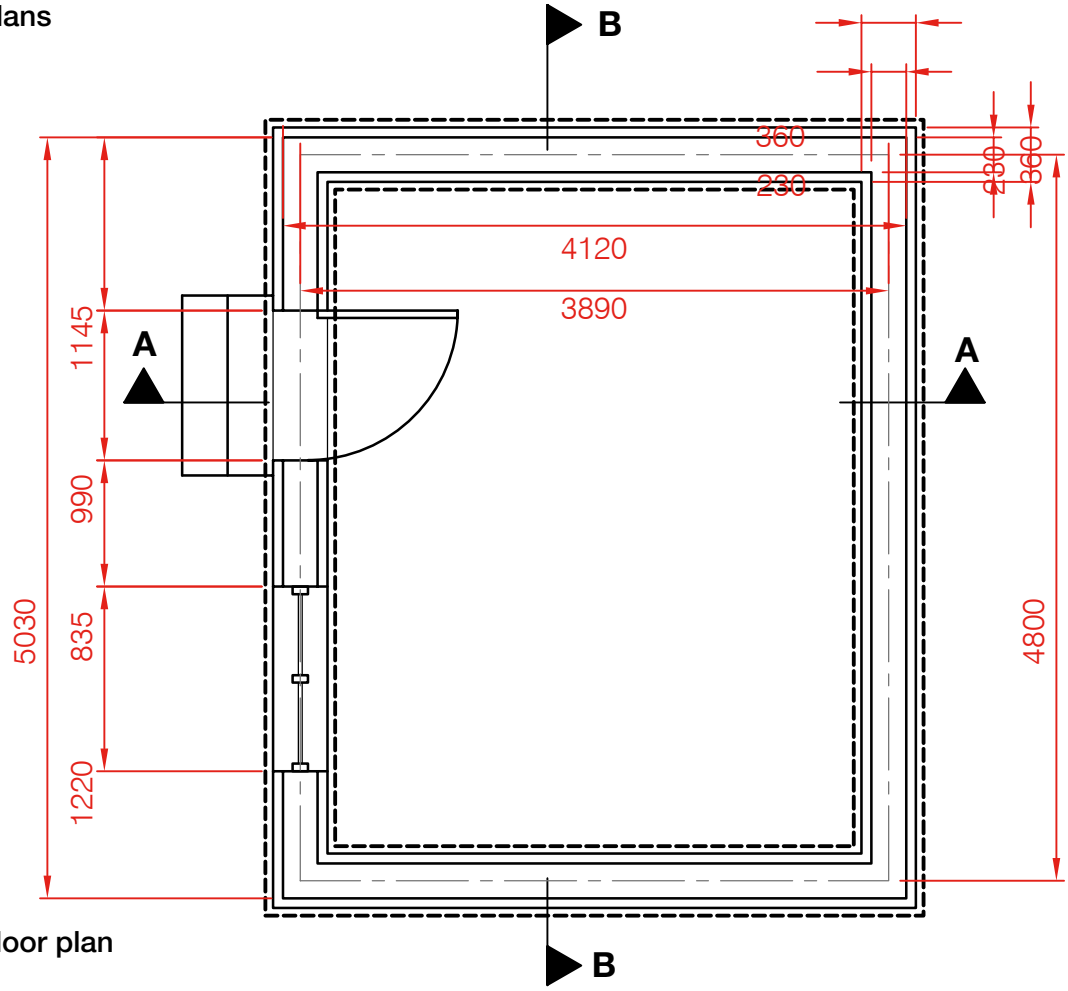
Shelter Description

This shelter is a rectangular structure with a flat roof with approximate dimensions of 4.8m x 3.9m. Walls are built with 230mm thick unreinforced fire burned brick walls supporting the roof. The roof is constructed with ceramic tiles supported on steel beams, and a cement plaster coating is placed on top of the tiles. The foundation consists of unreinforced brick footings and foundation walls. The mud plastered floor is raised a minimum of 610mm above the surrounding ground surface. As designed, the shelter has one door and one window, along with air vents near the top of the walls.

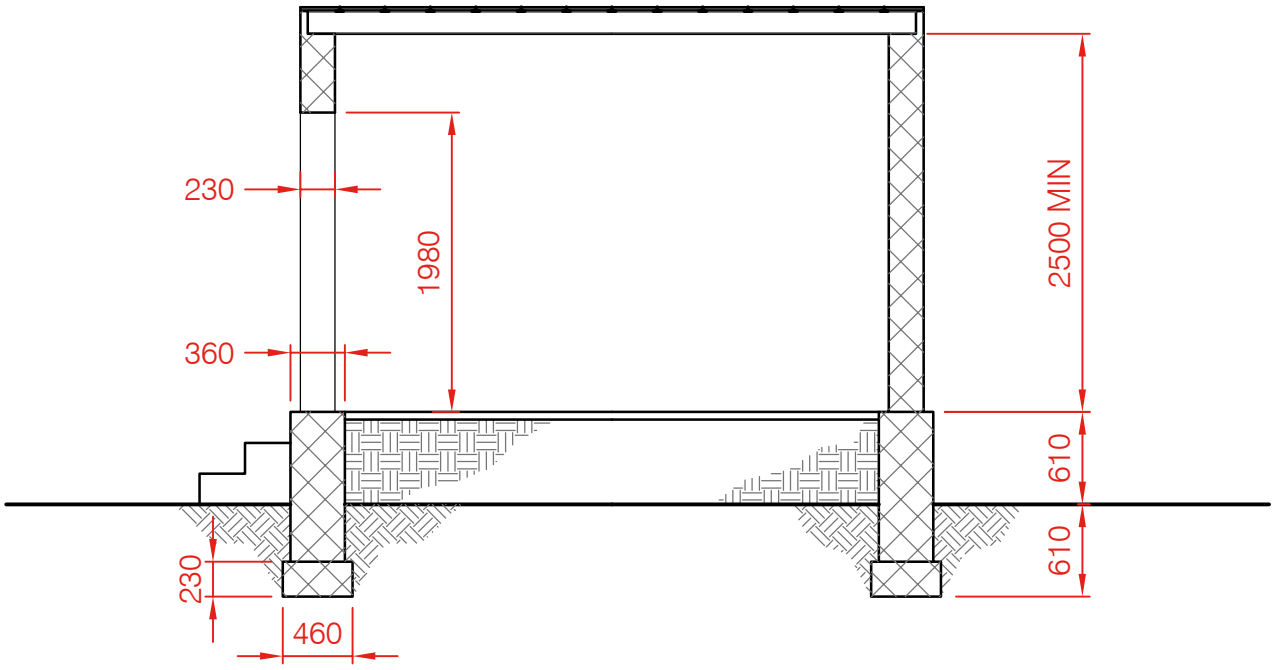
Shelter Performance Summary

The construction materials used for this shelter are high quality and very durable, and can produce a shelter with a long design life. In addition, the use of local materials simplifies the deployment for shelter construction, and should allow for a quick response to disaster situations. The brick walls and tile roof offer good resistance to wind loads, but given the weight of the building components, the performance under earthquake loads is not quite as good. The number of air vents at the top of the walls should balance the benefits of additional ventilation versus reductions of the vertical and lateral capacities of the walls.

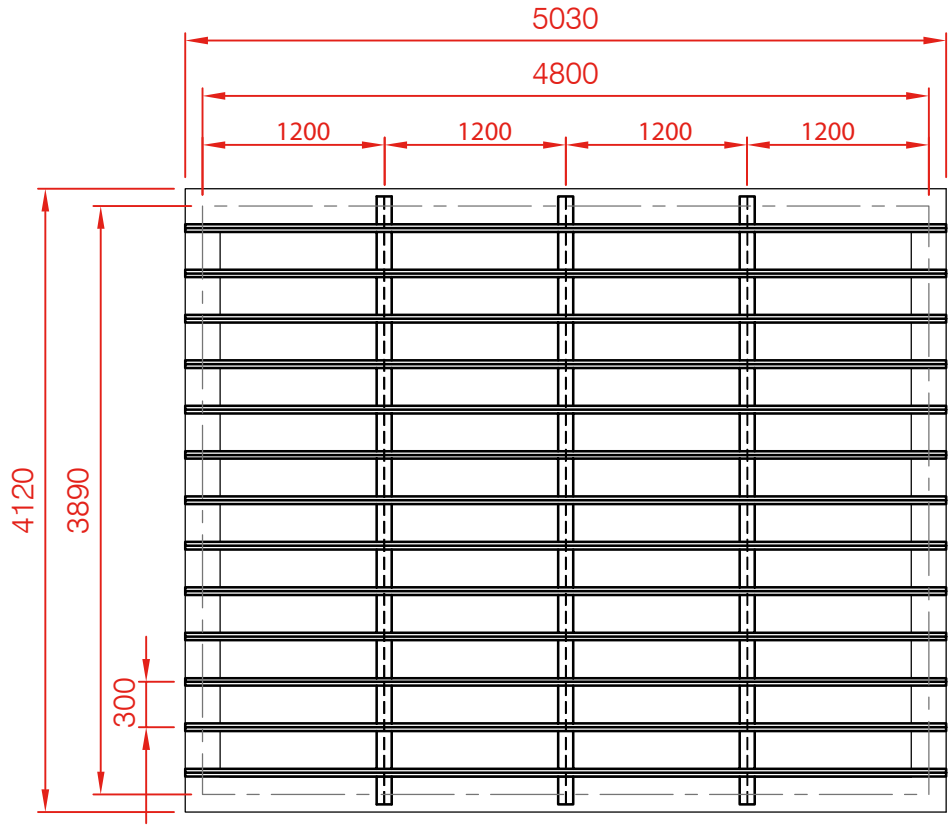
Plans



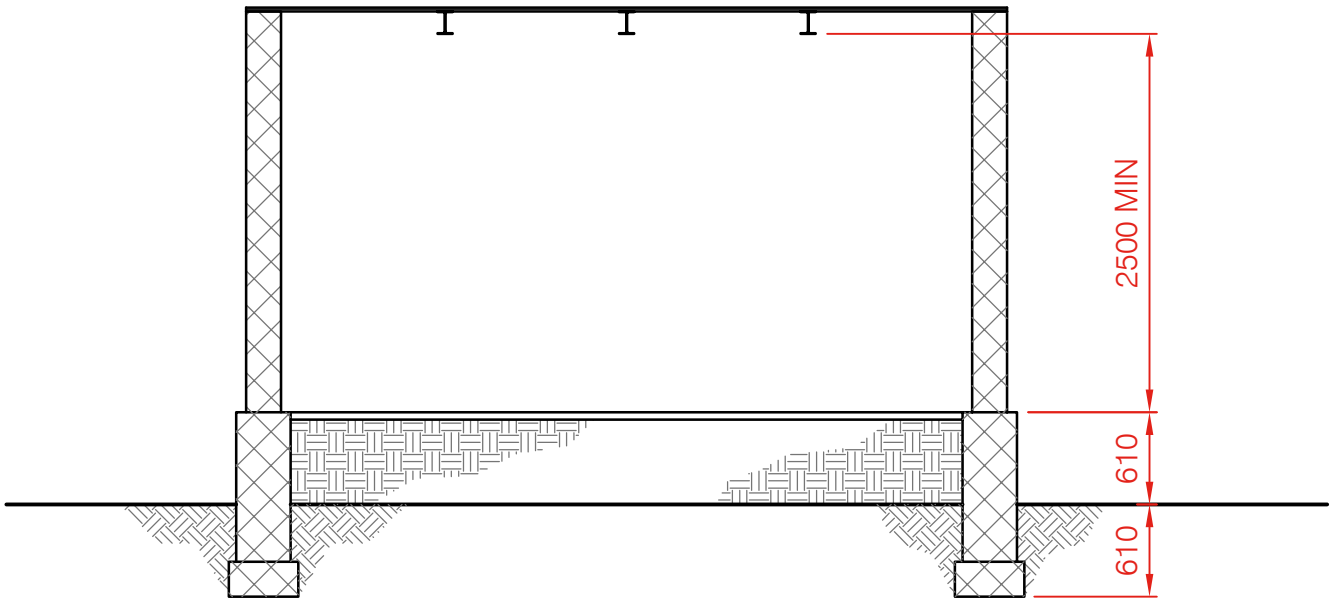
Floor plan



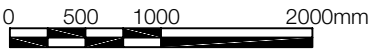
Section A-A



Roof Framing Plan



Section B-B



Durability and lifespan

In general this shelter is well designed and is constructed of high quality and durable materials, and should have a long expected lifespan provided it is properly maintained. If the fire burnt brick is replace with mud block the cost of the shelter with decrease, but so will the longevity.

Performance analysis

While the brick walls are not reinforced, they offer excellent resistance for wind loads. The heavy weight of the walls and roof increase seismic loads, and reduces the performance of the shelter. Proper site analysis is necessary prior to construction to determine appropriate finished floor heights to provide any mitigation of flood hazards.

Hazard*	Performance
Earthquake MEDIUM**	**GREEN:** With fired bricks and portland cement mortar, the 229mm thick brick walls have sufficient strength to resist the expected wind loads, and the weight of the structure is sufficient to prevent any overturning or sliding of the shelter during storms.
Wind MEDIUM	**AMBER:** The weight of the building components increases the seismic forces, but the wall have adequate resistance to meet the International Building Code. However, they do not meet the requirements of the Building Code of Pakistan, which has much more conservative provisions for the design of walls.
Flood HIGH	**GREEN:** The first floor of the shelter is elevated at least 610mm from the surrounding ground surface, and it is easy to modify the design to provide additional clearance if site specific situations required it.
Fire LOW	**GREEN:** With the exception of the steel framing, the components of the structural system are not flammable and should reduce the risk of significant fires. In addition, the small amount of flammable material expected in the shelter should not allow fires that are hot and long enough to significantly damage the steel framing. Consideration should be given to providing a second means of egress from the shelter in case the single door is blocked.

* See section A.4.5 Performance analysis summaries

** Although Pakistan has areas of high seizmic risk, this shelter was built in the Sindh Province, with a medium risk

Notes on upgrades

It is possible to increase the height of the roof, but analysis should be performed to verify that the extra height will not increase the wind or earthquake loads enough to cause performance issues.

Analysis should be performed before any additional openings are put into the shelter walls, as they will reduce the lateral load capacity of the shelter.

Assumptions

- Analysis is based on a compressive capacity of masonry of 2,100 kPa, and a tensile capacity of masonry of 138 kPa, and a steel strength of 248 MPa.
- The ceramic tiles in the roof provide lateral bracing for the steel framing.
- Lateral foundation loads are resisted by lateral soil bearing on the foundation walls.
- Foundation uplift forces are resisted only by the weight of the shelter, and any frictional resistance of between the foundation and soil are ignored.
- The performance of the shelter was compared against the requirements of both the International Building Code and the Building Code of Pakistan.

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. Locate shelters a minimum of 10 meters from ravines, or as required by local authorities.
- The weight of the building construction requires a stiff supporting soil to avoid settlement and possible cracking of the exterior walls.
- For sites where soil liquefaction during an earthquake may be a hazard (near river beds, coastal areas with sandy soils and high water tables) the shelter could be seriously damaged in an earthquake. The heavy weight of the building components could seriously injure any occupants of the shelter.

Materials

- Bricks for the masonry walls should be solid, not fractured, and free of honeycombs and voids.
- Mortar should be freshly mixed in small batches so it is used before it sets.
- Ensure steel framing is straight, and brush off any surface rust before installation.

Foundation

- Verify that the soil under the brick foundations and the floor slab are free of organic materials, and that any soft spots have been compacted. Ground surface should be flat and level prior to constructing the shelter.
- Bricks should be laid flat and level, and joints should overlap between courses (running bond).
- All joints between bricks should have mortar between them. Ideally mortar joints should be between 6mm and 13mm thick. All mortar exposed mortar joints should be tooled such that the mortar is recessed slightly from the face of brick. Mortar joints below grade do not need to be tooled.

Roof

- Steel beams should bear a minimum of 100mm into the brick walls.
- Ensure steel framing is set flat and level before installing ceramic tile.
- Pack cement plaster between ceramic tiles and steel framing to provide lateral support for the steel beams.

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
Main Structure				
Portland cement		26	Bags	42.5 kg/bag
Gravel		1	m^3	
Sand		4	m^3	
Water		940	liter	
Bricks		93,000	Piece	
Steel 1	5.8m long Tee	12	Piece	
Steel 1	152mm x 76mm x 4.3m beam	3	Piece	
Covering – Wall and Roof				
Ceramic tiles	304mm x 152mm	515	Piece	
Fixings				
Timber door	1m x 2 m	1	Piece	With frame, hinges, and locks
Timber window	0.9m x 1.2m	1	Piece	With frame, hinges, and locks
Tools				
Spade		1	Piece	
Hoe		1	Piece	
Wheelbarrow		1	Piece	
Framing hammer		2	Piece	
Hand saw		2	Piece	
Gloves		4	Pair	