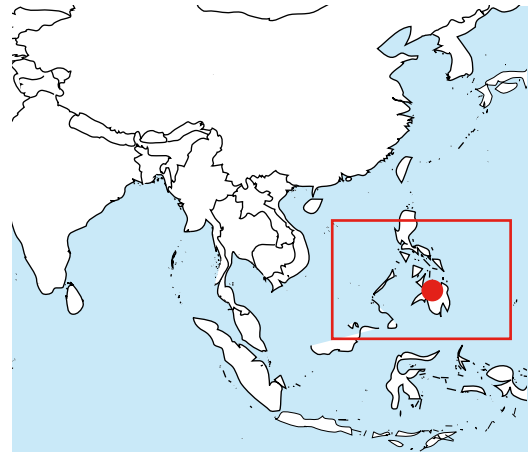


B.6 Philippines – 2011 – ‘Transitional-Shelter’



Summary information

Disaster: Typhoon, December 2011

Materials: Concrete footings, coconut wood frame, plywood floor, amakan walls and corrugated iron roof

Material source: Locally procured

Time to build: 5 days

Anticipated lifespan: 5 years

Construction team: 5 people

Number built: 1,823

Approximate material cost per shelter: 500 CHF

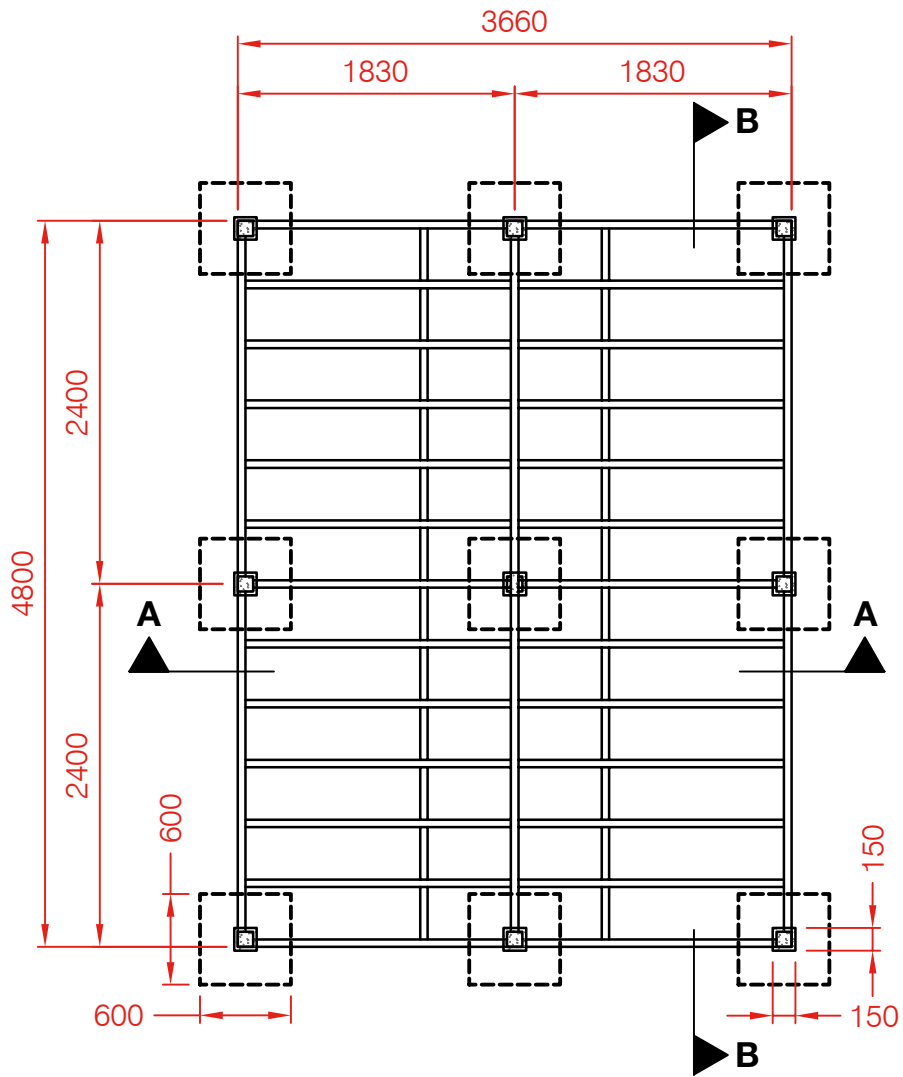
Shelter Description

This shelter is a rectangular structure with a single pitch roof and a covered floor area of approximately 4.8m x 3.7m. The shelter is supported on concrete piers and footings such that the first floor is raised approximately 750mm above grade. The floor and roof are framed with coconut wood beams and joists. The floor is plywood and the roof is corrugated metal roofing. The exterior walls consist of amakan (woven panels of bamboo or palm leaves) fastened to the coconut wood frame. The light weight wood frame can be lifted off the concrete piers and moved to a different location by a small number of people. As designed, the shelter has one door and two windows.

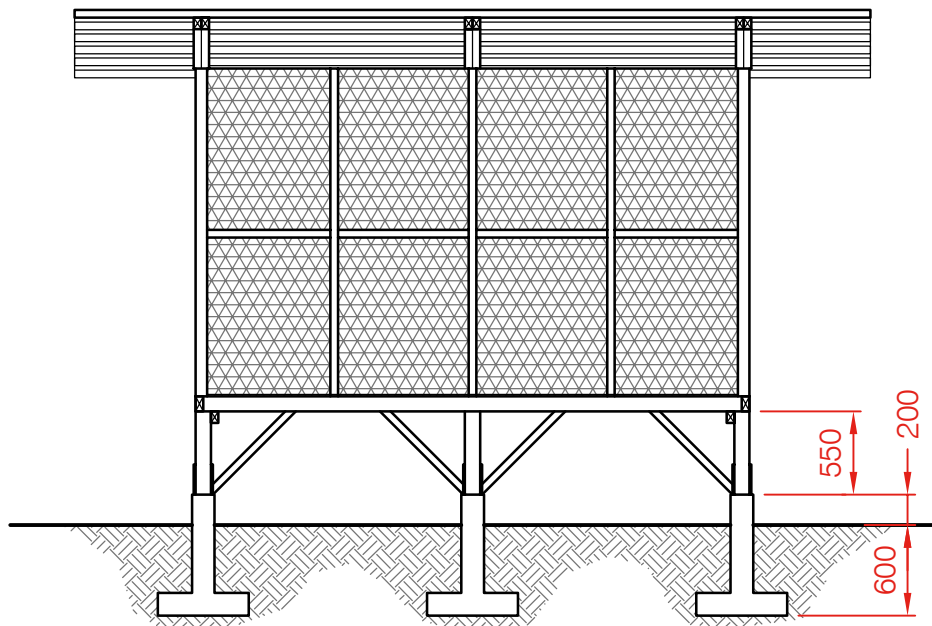
Shelter Performance Summary

The timber framing should be relatively durable, provided it is properly treated prior to construction. The timber framing and amakan wall panels can be built with locally sourced materials, and the simple construction reduces the need for skilled labor. Provided the wood posts and roof rafters are adequately anchored to their supports the shelter should perform satisfactorily, but damage should be expected during strong storms. The adequacy of the floor and roof framing is dependent on the use of high quality wood. To ensure good performance of the floor and roof framing, all the beams supporting floor joist and roof rafters should be doubled up.

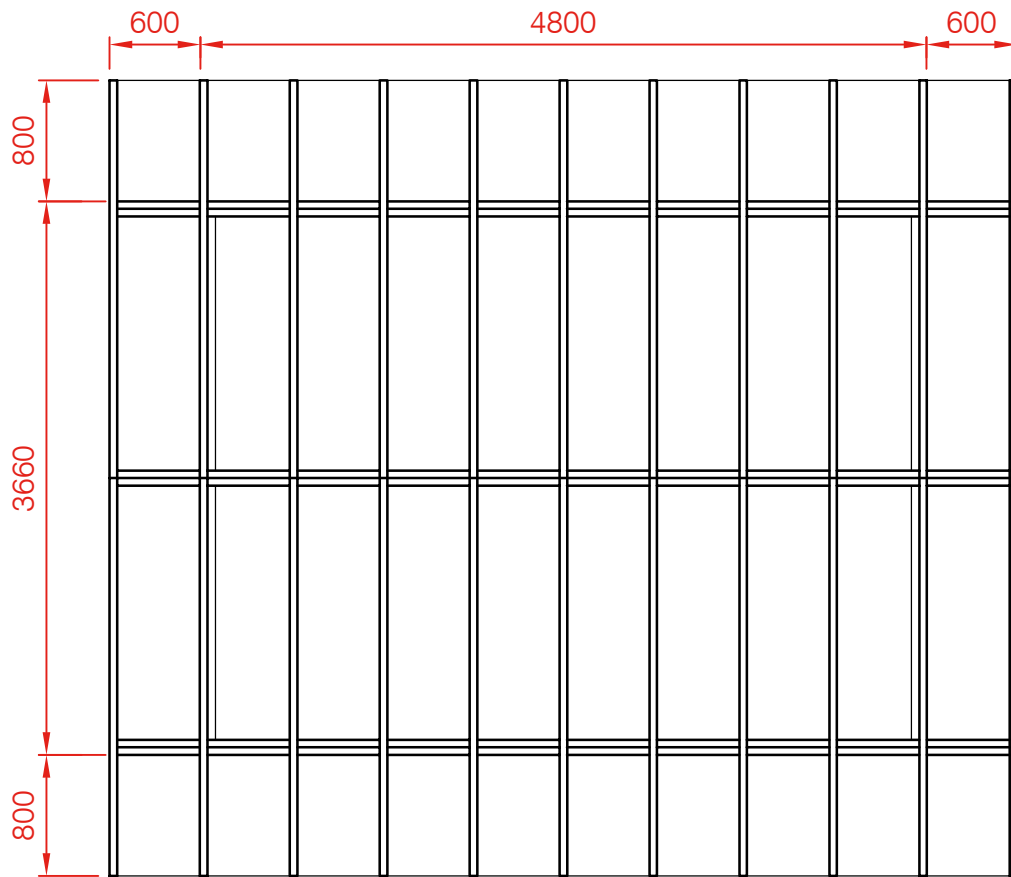
Plans



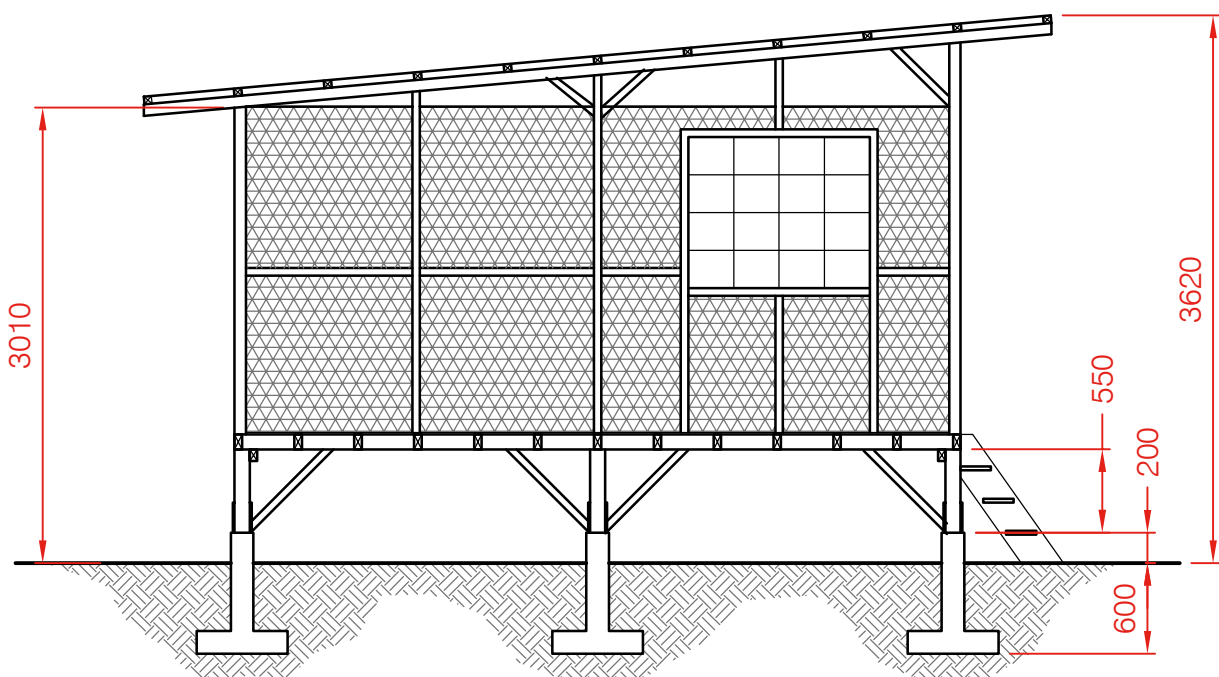
Floor plan



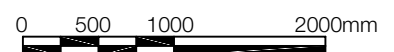
Section A-A



Roof Framing Plan



Section B-B



Durability and lifespan

The concrete piers are very durable, however coconut wood and plywood are not naturally rot resistant and should be treated to resist fungal and insect attack. Otherwise the timber portions of the building may need to be replaced before the concrete components reach the end of their life.

Based on the construction of the wall panels, it is likely they will be blow off the building during strong storm events.

Performance analysis

Adequate performance of this shelter is dependent on proper connections between all of the components. Without the connections between the timber framing and the concrete piers, the shelter will not be able to withstand the potential wind and earthquakes for this area. In addition, adequate performance of the shelter is dependent on selection of high quality timber. Proper site analysis is necessary prior to construction to determine appropriate finished floor heights to provide any mitigation of flood hazards.

| Hazard* | Performance |
|--------------------|---|
| Earthquake HIGH | GREEN: Given the light weight of the shelter, expected seismic loads are less than the expected wind loads, and provided all components are properly connected, the shelter should withstand seismic events with little to no damage. |
| Wind HIGH | AMBER: The expected wind loads are much larger than the seismic loads. Localised damage of some framing members should be expected during large storms, but collapse of the shelter is not expected. If the walls are removed prior to a storm, expected damage should be minimized and possibly eliminated. |
| Flood LOW | GREEN: The floor is raised significantly above adjacent grade, and provided the shelter is properly anchored to the concrete piers, should offer excellent protection from flood waters |
| Fire LOW | AMBER: The components of the structural system are flammable, and will not offer significant fire resistance. Fortunately the small floor plan along with the door and windows should provide adequate egress making it easy for occupants to exit before being harmed. The design is individual units thus to plan each house with good separation will reduce the risk of fire spread. |

* See section A.4.5 Performance analysis summaries

Notes on upgrades

All timber beams that support floor joists and roof rafters can be increased in width or depth to provide additional strength for floor and roof loads.

The knee braces at the roof could be modified to provide bracing throughout the entire bay to increase the lateral resistance, and limit the amount of damage the framing during storms.

It is possible to upgrade the walls with plywood to provide more permanent construction and improve the lateral resistance.

The best way to improve performance of the shelter design to wind loads is to increase the size of the timber framing.

Assumptions

- ↘ Design wood values were assumed equivalent strength to Spruce-Pine-Fir South, No 1.
- ↘ Lateral foundation loads are resisted by lateral soil bearing on the piers and friction on the bottom of the footings.
- ↘ Foundation uplift forces are resisted only by the weight of the shelter and soil on top of the footing. Any frictional resistance of between the foundation and soil are ignored.
- ↘ In addition to the International Building Code, the shelter was also analyzed against the National Building Code of the Philippines.

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.
- 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.
- Locate shelters safe distance away from trees which may fall in a storm.

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.
- Ideal proportions for concrete are 1:2:3, cement:sand:gravel (all by volume). Only add enough water to allow the concrete to be placed. Excess water reduces durability and will cause more cracking of the finished slab. If concrete is mixed in batches, maintain consistent proportions for all batches. See [1.3.1 Concrete](#)

Foundation

- Verify that the soil under the footing is free of organic materials, and that any soft spots have been compacted. Ground surface should be flat and level prior to placing the concrete.
- Ensure that all reinforcement is located as detailed on the drawings prior to placement of concrete.
- Make sure the tops of the piers are in their proper location and that the tops are level, otherwise construction of the shelter framing may be difficult.

Wall and Roof

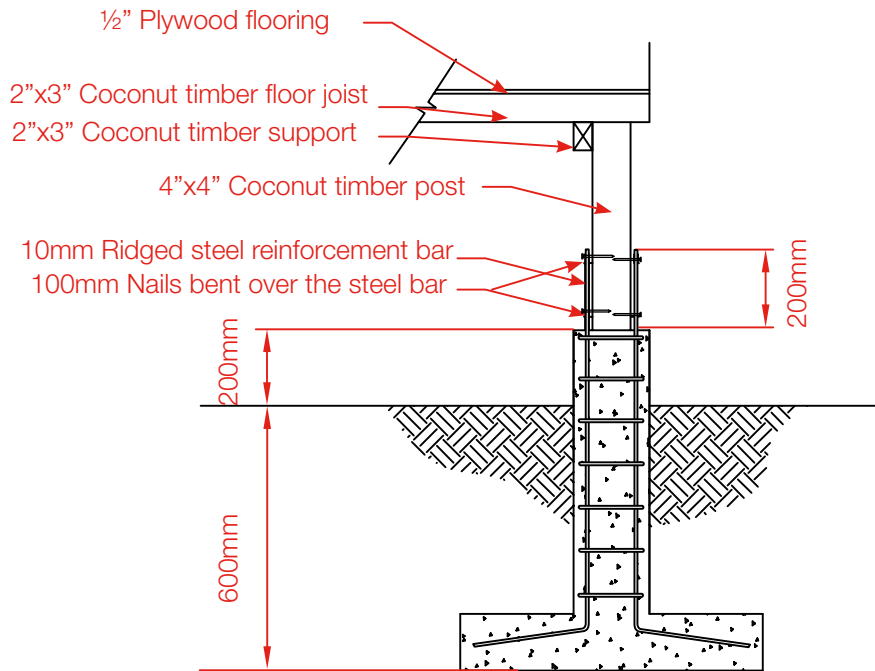
- All framing should be adequately nailed together, and nails should not split or crack the wood framing. Verify the proper number of nails are provided and the proper size is used in each connection. Use of toe nailing should be avoided.
- All wood framing in direct contact with concrete should have tarpaper or other barrier between the two materials to help prevent rot.
- Verify all the hurricane straps or other anchoring systems are properly installed, as they are required for the roof to resist wind uplift pressures. Also insure that the posts are properly anchored to the concrete piers.
- If pressure treated wood is used, hot dip galvanized fasteners should be used, as most preservatives are corrosive to mild steel.
- It is important to make sure all the anchors fastening the roof panels are properly installed. Wind blow metal roofing can cause serious injury.
- The roofs do not have additional bracing, but this should not prove to be an issue. Monosloped roofs with sheathing typically do not require additional bracing, unlike gable roofs.

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 |
|---------------------------------|--------------------------|----------|----------------|-------------|
| Foundations | | | | |
| Portland Cement | | 5 | Bags | 42.5 kg/bag |
| Gravel | | 0.1 | m ³ | |
| Sand | | 0.1 | m ³ | |
| Steel reinforcement | 10mm dia x 6m long | 12 | Bar | |
| Steel reinforcement | 8mm dia x 6m long | 3 | Bar | |
| Main Structure | | | | |
| Timber 2 | 89mm x 89mm x 3.7m | 4 | Piece | |
| Timber 2 | 38mm x 64mm x 3.7m | 23 | Piece | |
| Timber 2 | 38mm x 89mm x 2.4m | 6 | Piece | |
| Timber 2 | 38mm x 38mm x 3.7m | 32 | Piece | |
| Timber 2 | 38mm x 38mm x 2.4m | 28 | Piece | |
| Covering – Wall and Roof | | | | |
| Bamboo slats | | 3 | Bundle | |
| Amakan | 1.2m x 2.4m | 13 | Sheet | |
| Plywood 2 | 1.2m x 2.4m | 6 | Sheet | |
| Plywood | 1.2m x 2.4m | 2 | Sheet | |
| Sheet 2 | 3.1m long | 14 | Sheet | |
| Fixings | | | | |
| Umbrella nails | 51mm long | 1 | kg | |
| Common nails | 102mm long | 6 | kg | |
| Common nails | 64mm long | 4 | kg | |
| Common nails | 38mm long | 1 | kg | |
| Wire 1 | | 2 | kg | |
| Vulcaseal | | 0.5 | Litre | |
| Hinges | | 1 | Pair | |
| Tools | | | | |
| Spade | | 2 | Piece | |
| Hoe | | 2 | Piece | |
| Wheelbarrow | | 1 | Piece | |
| Framing hammer | | 2 | Piece | |
| Hand saw | | 2 | Piece | |
| Gloves | | 4 | Pair | |

Footing details



B.7 Philippines – 2011 – ‘Transitional-Shelter’



Summary information

Disaster: Typhoon, December 2011

Materials: Reinforced concrete columns, masonry and timber walls, timber roof framing with metal siding

Material source: Locally and internationally procured

Time to build: 12 days

Anticipated lifespan: 5 years

Number built: 250

Approximate material cost per shelter: 1,550 CHF

Approximate project cost per shelter: 2,000 CHF

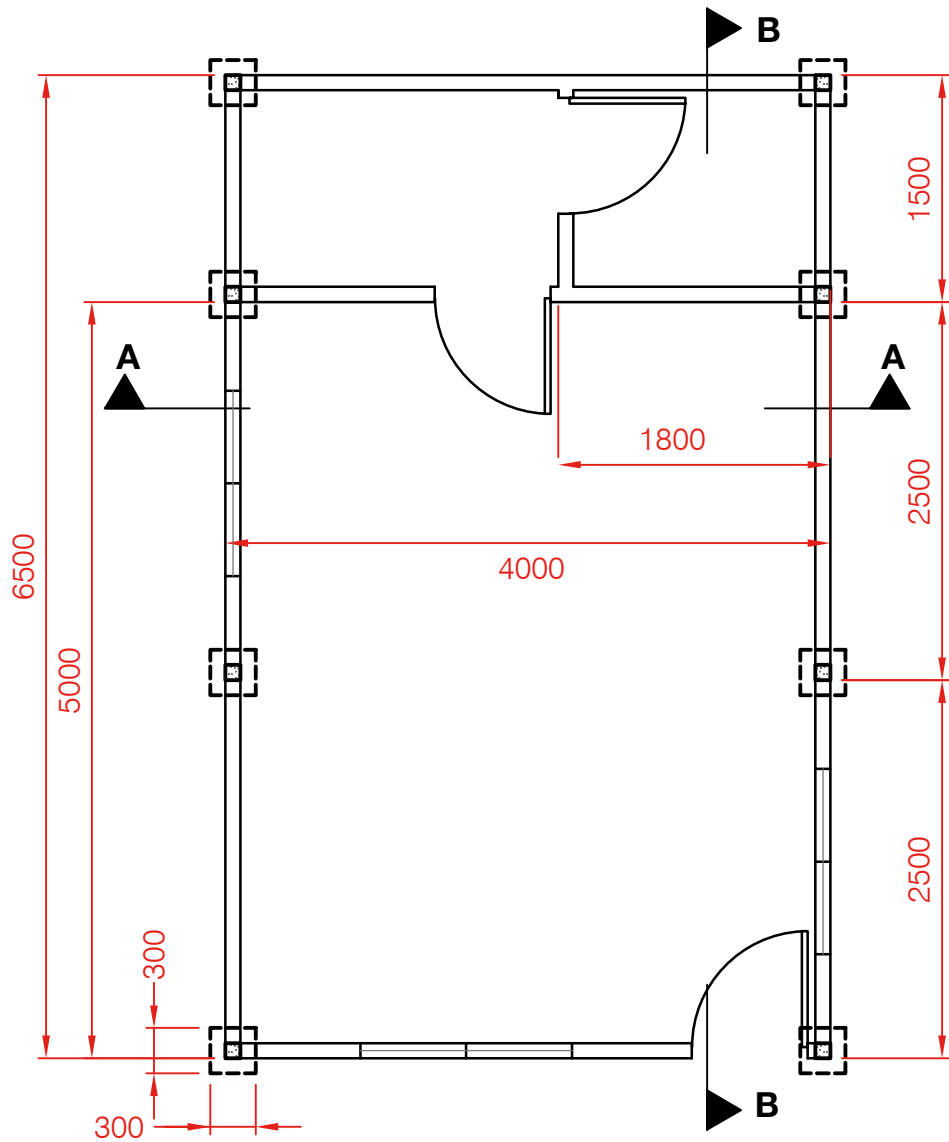
Shelter Description

This shelter is a rectangular structure with a gable roof and a covered floor area of approximately 4.0m x 5.0m with a covered bathroom and vestibule of approximately 4.0m x 1.5m. The exterior walls have a half height concrete masonry wall with wood framing on top up to the eaves. The roof consists of timber trusses and purlins supporting corrugated metal roofing. The roof framing is supported by eight precast concrete columns located within the exterior walls. The concrete columns and masonry walls are embedded in the ground, and the plans do not specifically call for footings. The floor is a cast in place concrete slab, and the bathroom has a below grade septic tank. The modular construction for the shelter allows for expansion in both horizontal directions with only minor modifications to the core shelter. It is also possible to deconstruct the shelter for relocation and/or to be included in permanent construction. As designed, the shelter has two doors and two windows.

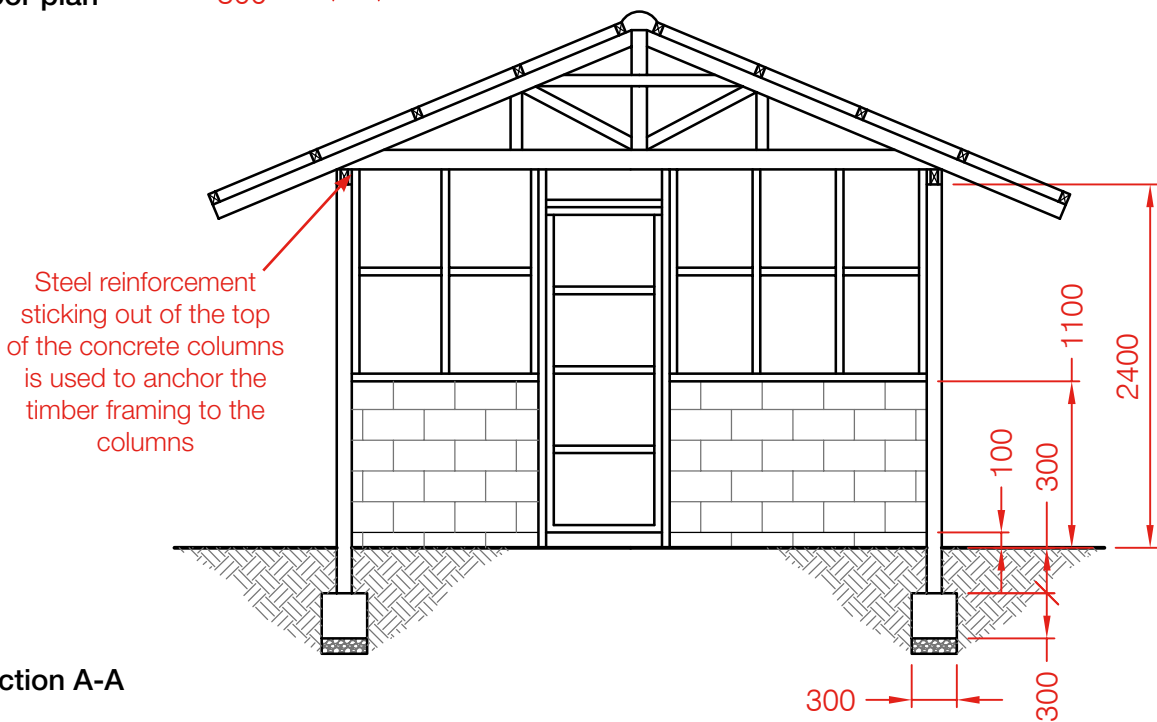
Shelter Performance Summary

The concrete and masonry components of the shelter are very durable materials, and provided the timber components are treated, the shelter should be durable with a decent design life. The use of precast concrete columns allows for quick construction of the roof to provide covered shelter while the exterior walls are constructed, and allow for possible re-use in more permanent construction. Provided the timber framed portion of the walls are properly anchored to the lower masonry walls and to the roof framing, the performance of the shelter for lateral wind and seismic loads should be adequate. However, there is not enough shelter weight to resist uplift loads for full wind speeds. Provided the roof trusses are adequately braced at each panel point the wood framing is adequate with the exception of the truss overhangs. The large overhangs of the top chords are not sufficiently strong to resist the anticipated uplift loads from a full storm.

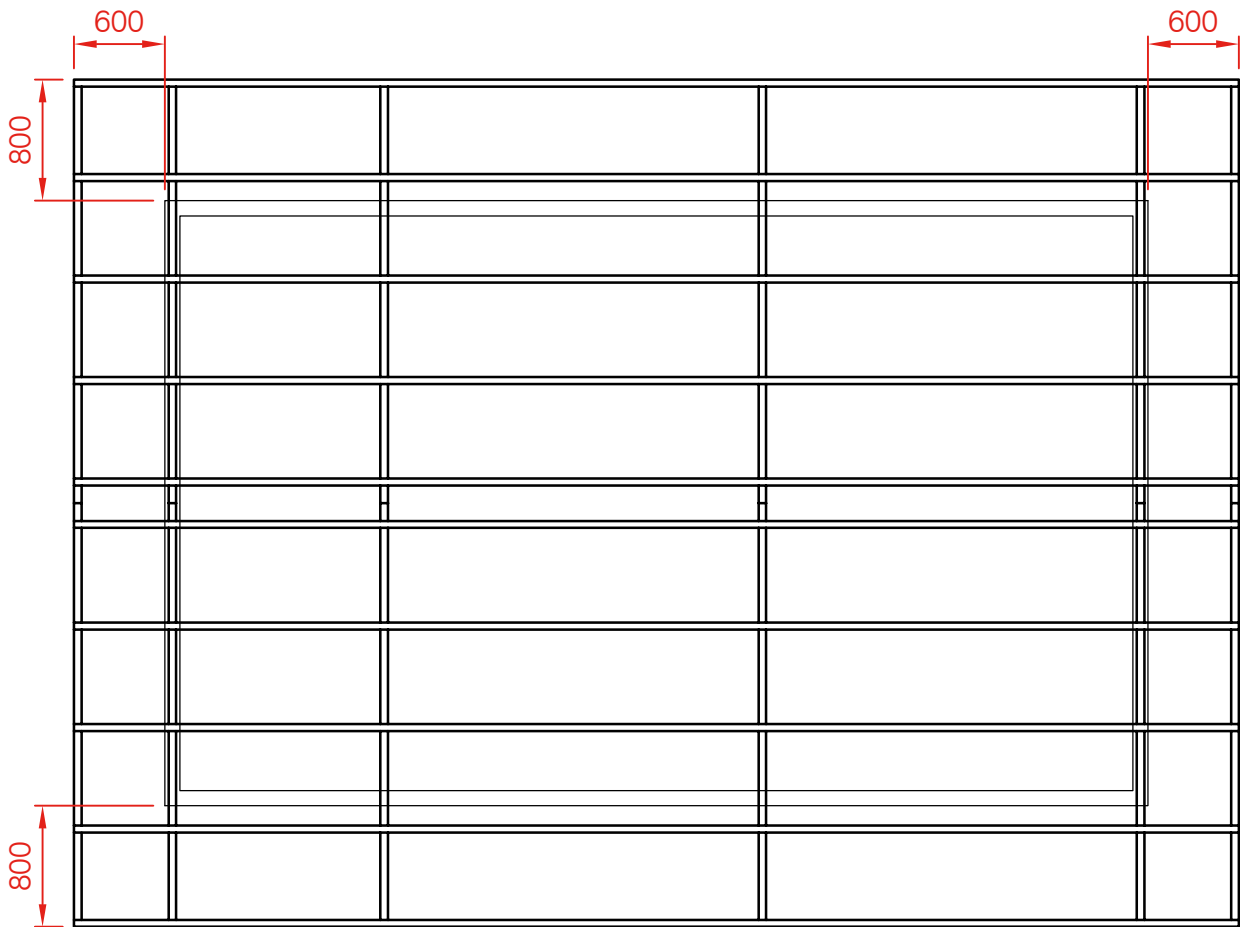
Plans



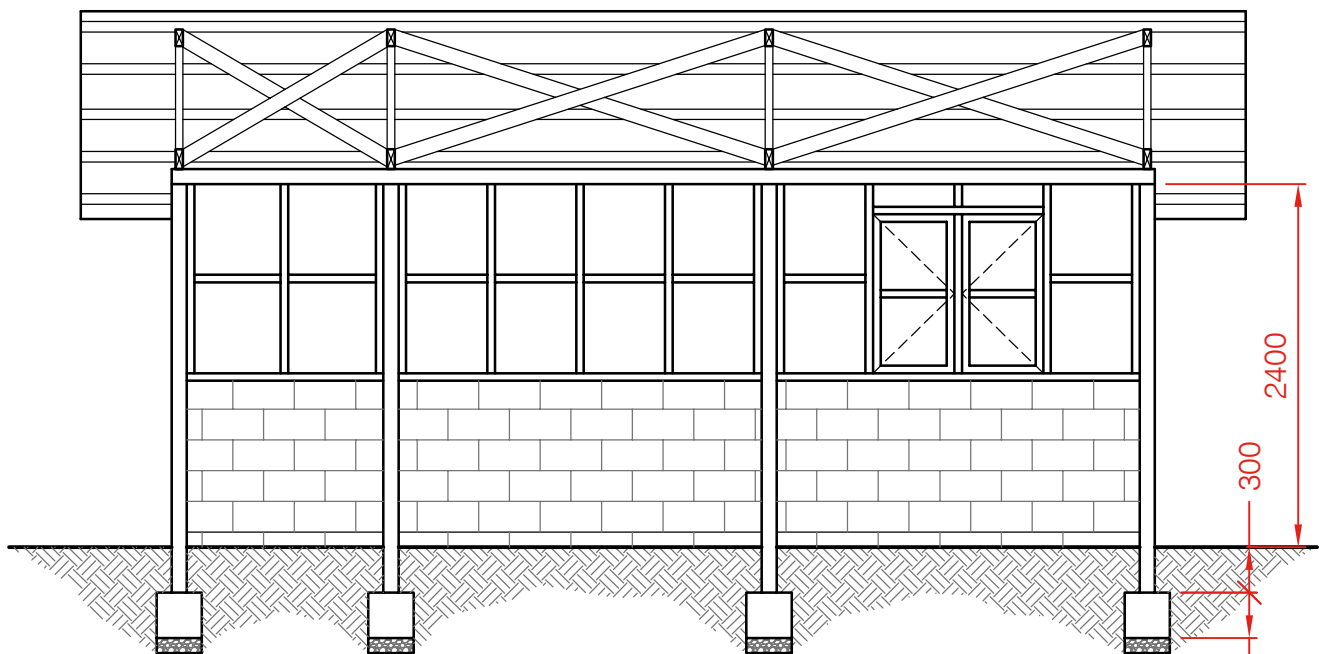
Floor plan



Section A-A



Roof Framing Plan



Durability and lifespan

The masonry and concrete portions of the shelter are very durable. However, coconut wood and plywood are not naturally rot resistant and should be treated to resist fungal and insect attack. Otherwise the timber portions of the building may need to be replaced before the concrete and masonry components reach the end of their life.

Performance analysis

Adequate performance of this shelter is dependent on proper connections between all of the components. Without the connections between the roof framing, the concrete columns and the timber/masonry exterior walls, the shelter will not be able to withstand the potential wind and earthquakes for this area. In addition, the shelter does not weigh enough to resist wind uplift loads, nor are the truss top chords large enough to resist the uplift pressures on the eaves. Proper site analysis is necessary prior to construction to determine appropriate finished floor heights to provide any mitigation of flood hazards.

| Hazard* | Performance |
|--------------------|---|
| Earthquake HIGH | AMBER: Given the light weight of the shelter, expected seismic loads are less than the expected wind loads. Provided the exterior walls are properly connected, they are adequate to resist the lateral loads as shear walls. |
| Wind HIGH | RED: As for earthquake loads, the exterior walls should be sufficient to resist the lateral wind loads provided the walls are adequately attached. However, there is not sufficient weight to resist uplift, and the columns should either be extended further into the ground or the footing on bottom increased. In addition, the roof overhang should be shortened, or the size the top chord increased to prevent failure of the roof trusses. |
| Flood LOW | AMBER: The floor is not significantly elevated relative to the surrounding grade. However the structural components of the shelter at grade are concrete and masonry, which are relatively flood resistant materials. |
| Fire LOW | AMBER: The concrete and masonry components of the framing are very fire resistant, but the wooden framing in the roof is not. The roof may be able to survive a brief fire that was quickly extinguished. |

* See section [Performance analysis summaries](#)

Notes on upgrades

The masonry walls can be extended full height to provide a more durable wall system, but attention must be given to how the masonry is connected to the concrete columns and roof framing to ensure the walls will not collapse on the occupants.

The design of the shelter could be modified such that the concrete columns are the primary lateral system by fabricating them longer and embedding them further into the ground. The advantage being that the infill walls could be modified and/or removed without affecting the performance of the shelter.

In areas where flooding is a significant risk, the design can be easily modified to add more fill inside the shelter to raise the elevation of the concrete floor slab above the surrounding grade. Care should be taken though to ensure the ceiling height is sufficient for the occupants.

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

Reducing roof overhang will reduce shading, but will improve performance in strong winds by reducing uplift.

Assumptions

- ↘ Analysis is based on a compressive capacity of masonry of 2,100 kPa, a tensile capacity of masonry of 138 kPa, and a concrete compressive strength of 20 MPa.
- ↘ Design wood values were assumed equivalent strength to Spruce-Pine-Fir South, No 1.
- ↘ Roof truss top chords are fully braced by the purlins, and the bottom chord of the roof trusses are braced at each panel point.
- ↘ Plywood is nailed at 150mm on centre along the panel edges, and at 300mm in the middle of the panel.
- ↘ 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 exterior masonry walls extend down to the top of the concrete column footing, and sit on the footing to help resist wind uplift forces.
- ↘ The shelter was analysed against the National Building Code of the Philippines and the [International Building Code \(IBC\) 2009](#).

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 concrete and masonry 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

- Inspect the fabrication of concrete columns to ensure correct placement of reinforcement before concrete is poured. Adequate reinforcement and its position are important to structural capacity.
- Before columns are placed in the ground, inspect to ensure there is no damage such as cracking, chipping, or exposed reinforcement. Also verify the embedded anchor bolts are present.
- Inspect timber to ensure that pieces are straight, not twisted or bowed, free of knots, and not cracked.
- Blocks 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.

Foundation

- Verify that the soil under the foundations and the floor slab are free of organic materials, and that any soft spots have been compacted. The ground surface should be level prior to constructing the shelter.
- Verify concrete columns are sufficiently embedded in the soil.
- Make sure the columns are in their proper location, plumb, and the tops are level before soil is compacted around them. Otherwise construction of the steel roof truss will be difficult.
- Ensure steel reinforcing for the piers is installed, especially if the veranda is left open.

Wall and Roof

- Masonry Blocks should be laid level, and joints should overlap between courses (running bond).
- All joints between blocks should have mortar between them. Ideally mortar joints should be between 6mm and 13mm thick. All exposed mortar joints should be recessed slightly from the face of brick.
- All framing should be adequately nailed together, and nails should not split or crack the wood framing. Verify the proper number of nails are provided and the proper size is used in each connection.
- All wood framing in direct contact with masonry should have tar paper or another barrier between the two materials to help prevent rot.
- Verify all the hurricane straps are properly installed, as they are required to resist wind uplift pressures.
- If pressure treated wood is used, hot dip galvanized fasteners should be used, as most preservatives are corrosive to mild steel.
- Ensure that all the anchors fastening the roof panels are properly installed.

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 |
|---------------------------------|--------------------------|----------|----------------|----------------------------|
| Foundations | | | | |
| Portland cement | | 41 | Bags | 42.5 kg/bag |
| Gravel | | 3.5 | m ³ | |
| Sand | | 4 | m ³ | |
| Steel reinforcement | 10mm dia x 6m long | 30 | Bar | |
| Concrete column | 102mm x 102mm x 3.1m | 8 | Piece | |
| Main Structure | | | | |
| Timber 1 | 38mm x 114mm x 4.3m | 4 | Piece | |
| Timber 1 | 38mm x 89mm x 3.1m | 16 | Piece | |
| Timber 1 | 38mm x 64mm x 3.7m | 53 | Piece | |
| Timber 1 | 38mm x 38mm x 3.1m | 50 | Piece | |
| Covering – Wall and Roof | | | | |
| Concrete masonry | 102mm Standard | 400 | Piece | |
| Plywood 1 | 4.7mm thick | 17 | Sheet | 1.2m x 2.4m sheets |
| Plywood 1 | 6.4mm thick | 0.5 | Sheet | 1.2m x 2.4m sheets |
| Sheet 2 | 0.4mm x 3.1m | 18 | Sheet | |
| Ridge cap | 0.4mm x 0.9m x 2.4m | 2 | Piece | |
| Plumbing | | | | |
| Water closet | | 1 | Piece | Buhos type |
| Floor drain | 102mm x 102mm | 1 | Piece | Plastic |
| PVC wye | 102mm x 51mm | 1 | Piece | |
| PVC 90 deg elbow | 102mm | 1 | Piece | |
| PVC tee | 102mm | 1 | Piece | |
| PVC P-trap | 51mm | 1 | Piece | |
| PVC pipe | 102mm dia x 3 m | 1 | Piece | |
| PVC pipe | 51mm dia x 3m | 0.5 | Piece | |
| Fixings | | | | |
| Roofing nails | 64mm long | 3.5 | kg | Twisted shank |
| Common nails | 102mm long | 4.5 | kg | |
| Common nails | 76mm long | 7 | kg | |
| Common nails | 64mm long | 2 | kg | |
| Common nails | 51mm long | 5.5 | kg | |
| PVC solvent cement | | 1 | Can | 100 cm ³ can |
| Wire 1 | | 1 | kg | |
| Vulcaseal | | 3 | Pack | 220g per packs |
| Hinges | 51mm x 102mm | 12 | Piece | Brass |
| Door | | 2 | Piece | Include frame and hardware |
| Window | | 2 | Piece | Include frame and hardware |