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

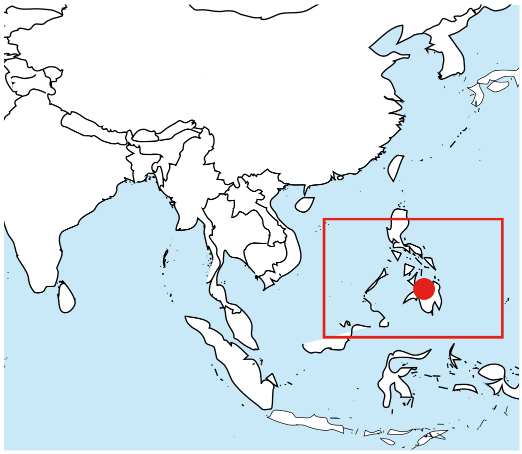
Example of a Performance analysis

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.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

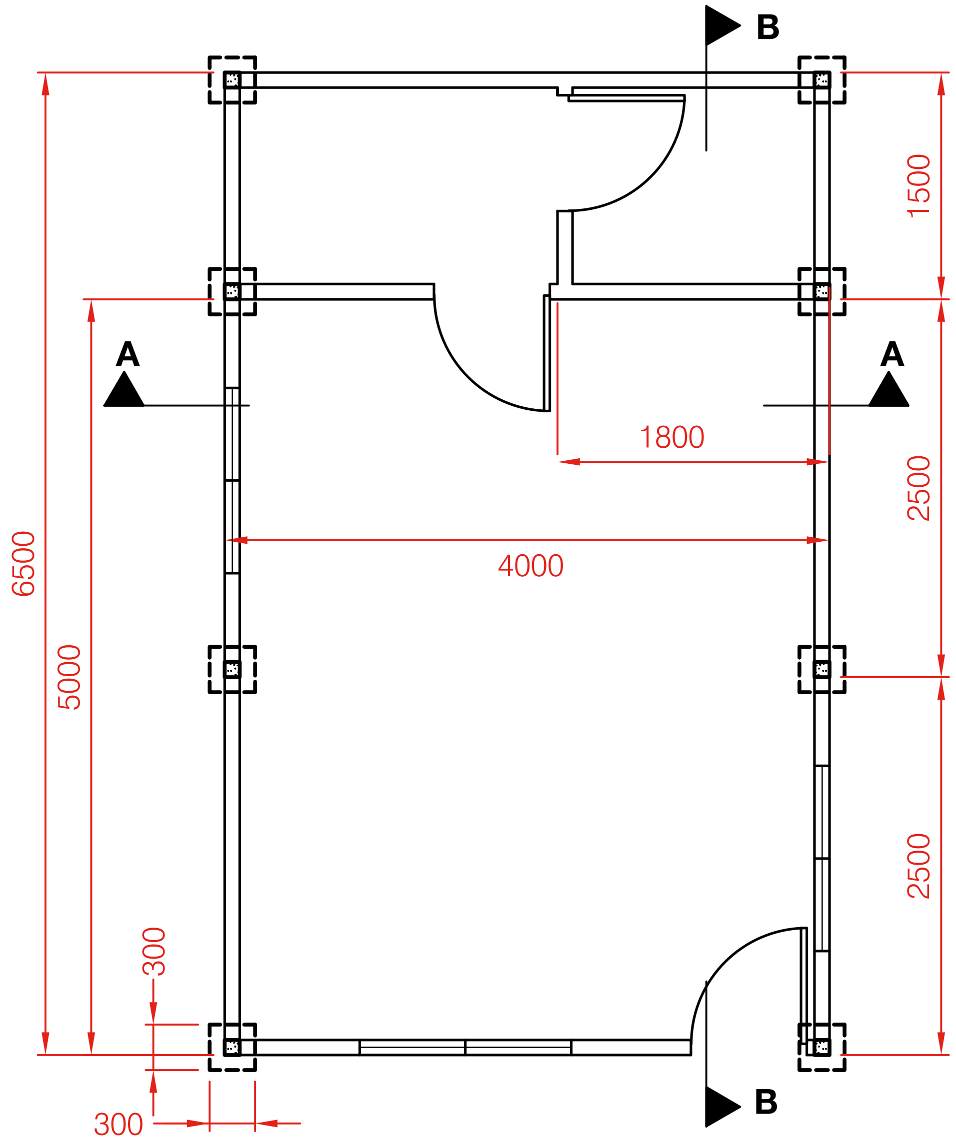
Shelter Description

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.

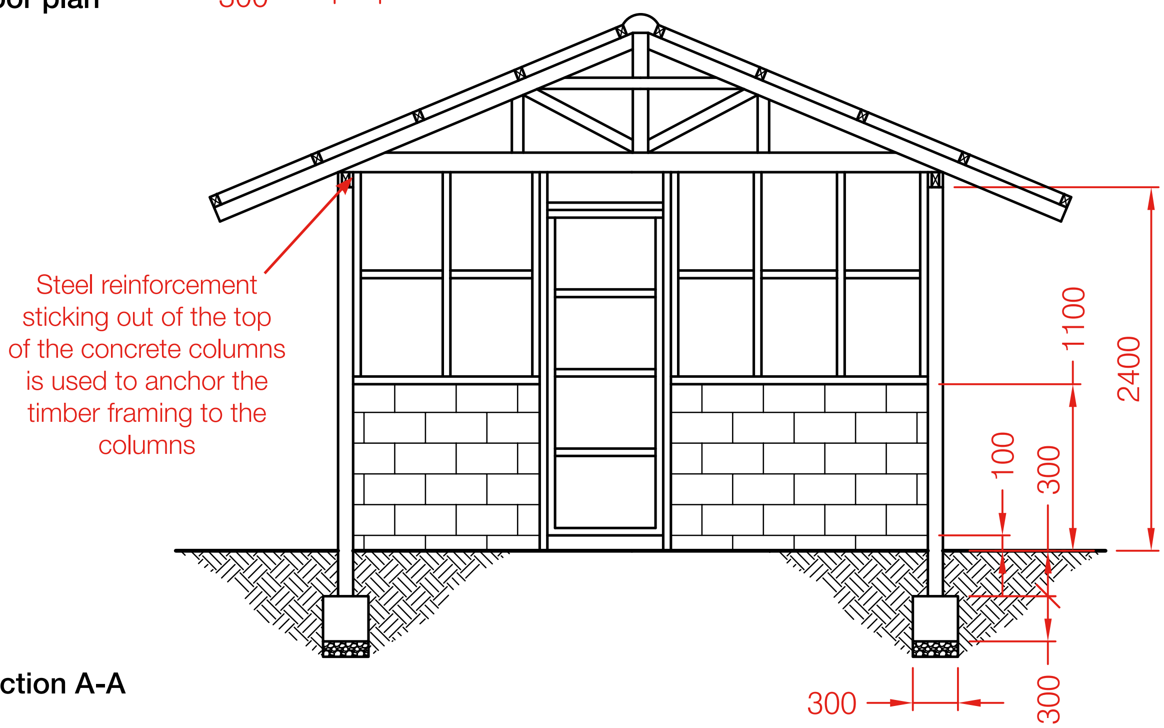
Shelter Performance Summary

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.

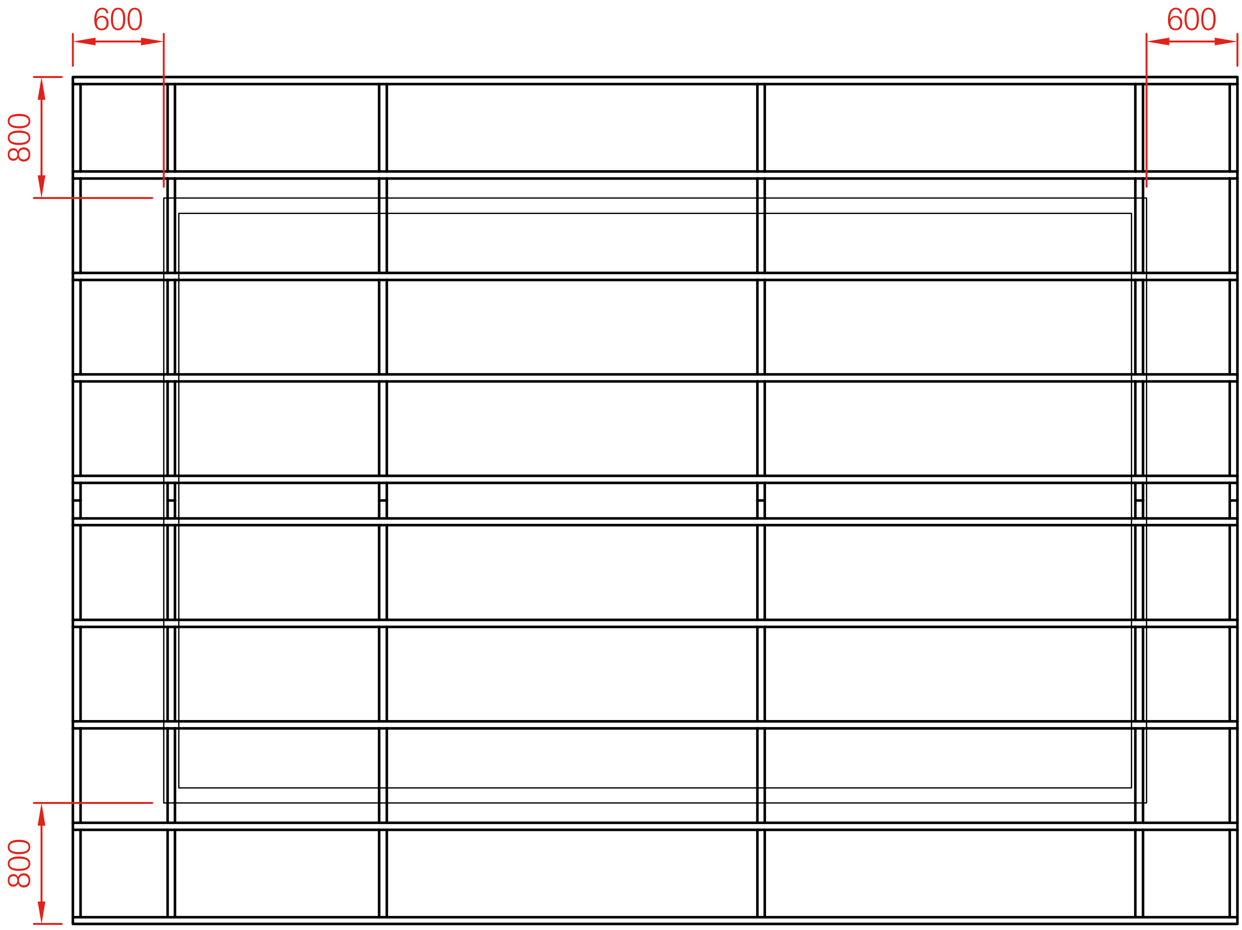
Plans



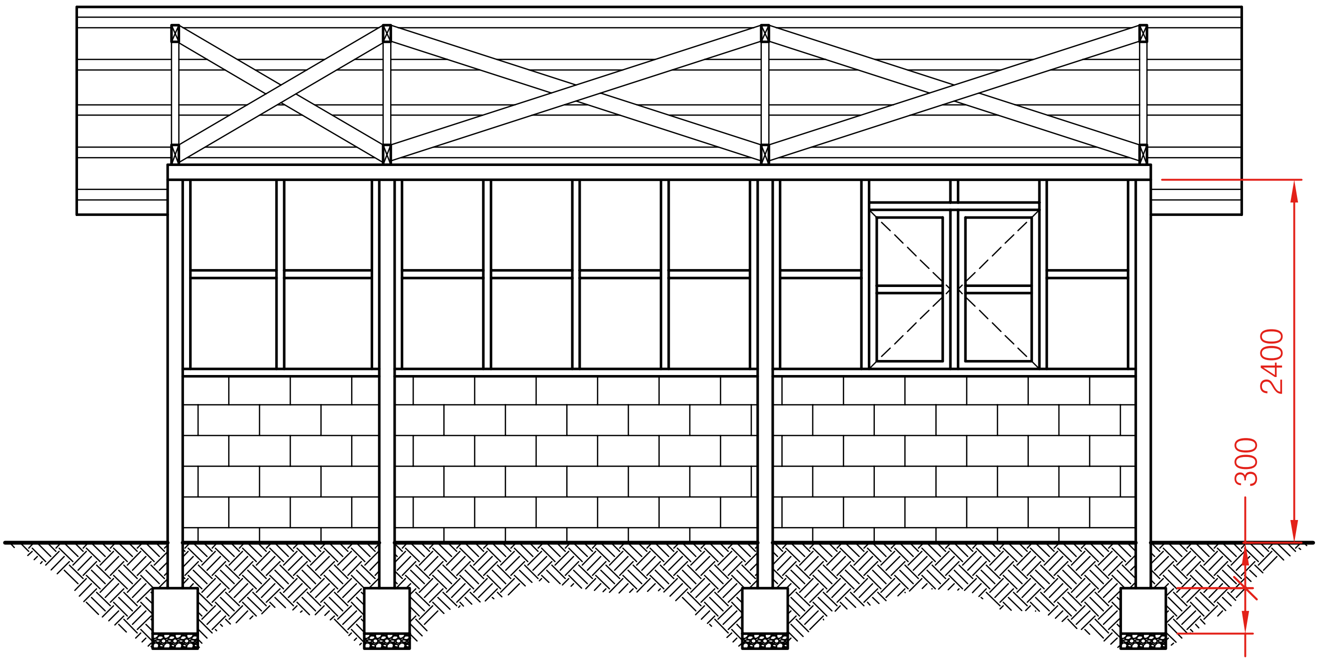
Floor plan



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