

IFRC bamboo frame for emergency shelters and emergency roofs

Technical sheets

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***IFRC bamboo frame for emergency shelters and emergency
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IFRC bamboo frame for emergency shelters and emergency roofs

Technical sheets

IMPORTANT NOTICE

The drawings and information provided in these technical sheets must be treated as guidance and examples only and evaluated for suitability in the context of specific local conditions. Risk is inherent in shelter design after natural disaster, and caution must be exercised so as not to increase the threat to disaster affected persons. Users of this document do so solely at their own risk.

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Acknowledgements

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Lead contributor: Shaun Halbert

These technical sheets have been created based on the work and research on Reciprocal frame roof shelters, by Shaun Halbert. The Reciprocal frame shelter kits are made of bamboo or steel and use less material than traditional structures while being able to bear significant weight.

The Reciprocal frame has shown many benefits especially in terms of simplicity and time-saving installation, reliability, sturdiness, low financial cost, and use of local materials associated with the IFRC shelter kit.

These technical sheets present three basic models using the Reciprocal frame made of bamboo to build emergency shelters or repair a roof temporarily. Note that the Reciprocal frame adapts very well to various contexts and environments – hot, cold, or winter weather.

For more information on the Reciprocal frame and to follow its latest evolution/improvements achieved throughout trainings and workshops, please visit www.reciproboo.org.

1.

Standard bamboo shelter model

1. Summary information

Materials: IFRC shelter kit and bamboo poles

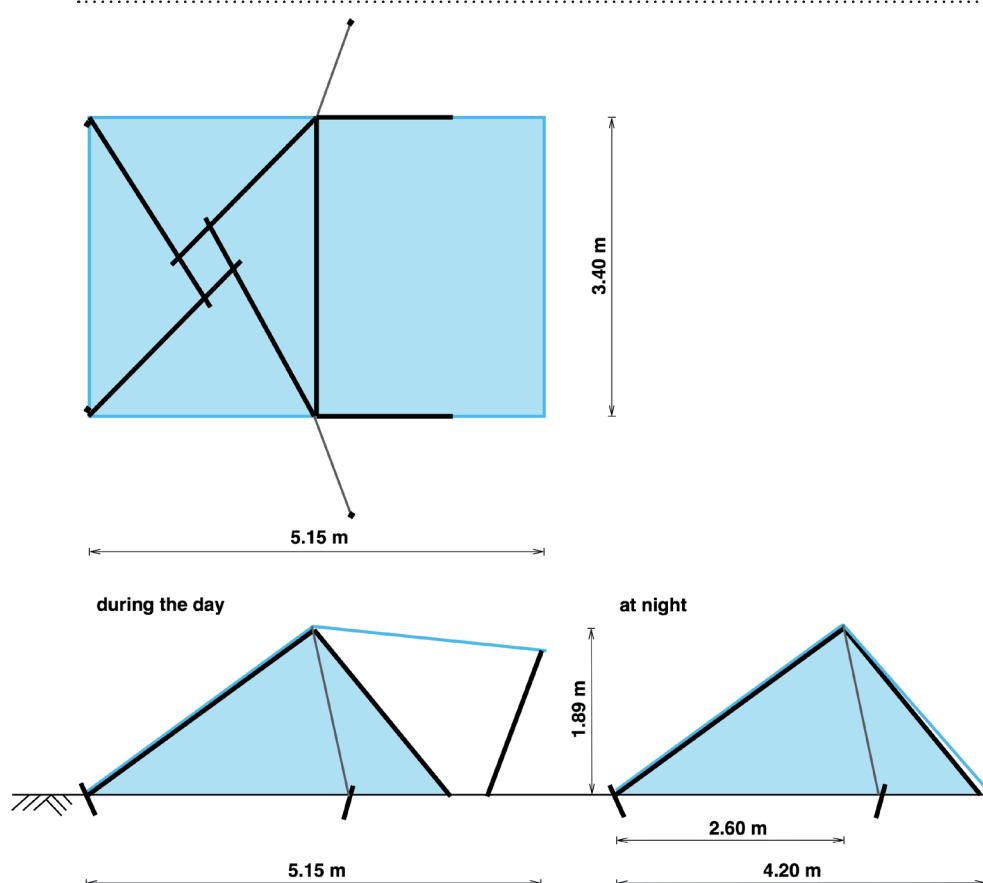
Material source: available in Emergency Items Catalogue and locally procured

Time to build: 1 hour for basic structure + additional hours for improvements

Construction team: 3 people

Shelter description: this emergency shelter has a rectangular shape, pitched roof. Covered floor area: 3.40 x 5.15m (17.5m²). The frame has plastic sheeting (tarpaulin) for both roof and wall covering, and one entrance at the front or side.

2. Plans



3. Materials and tools, including bill of quantities (BoQ)

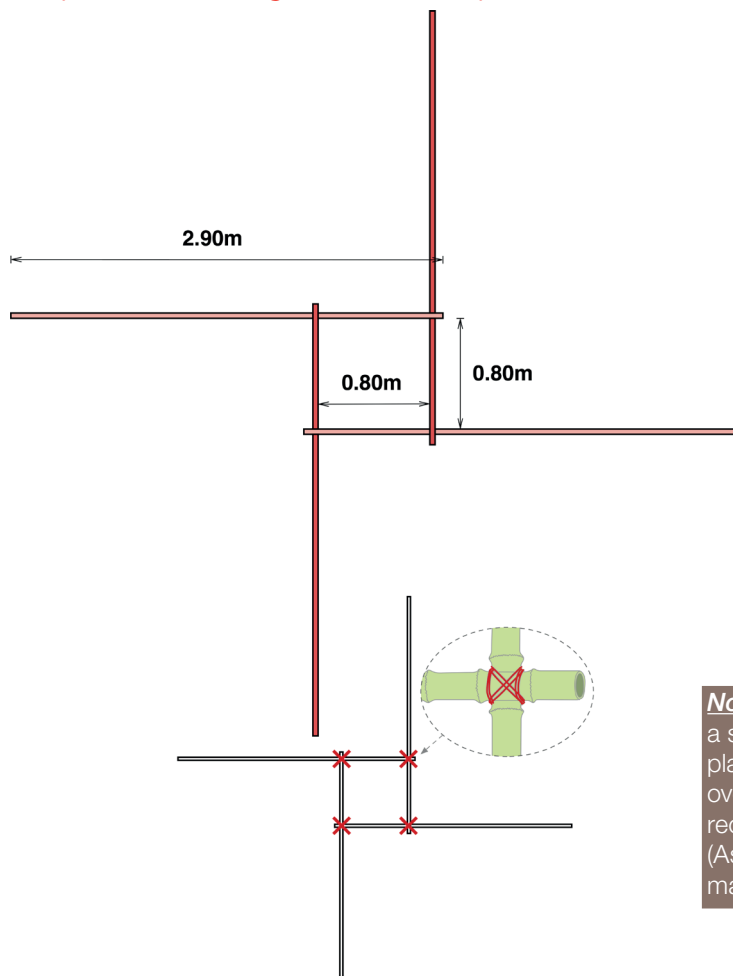
The table of quantities below is for the materials required to build the standard shelter model. It does not take into account issues such as which lengths of bamboo are available and allowances for spoilage in transport and delivery.

The materials for the structure and stakes should be locally sourced. The other materials and tools are available in the Emergency Items Catalogue (EIC).

Item	Specifications	Q	EIC Code / source	Alternatives/ comments
IFRC SHELTER KIT				
Tarpaulin	Size: 4 x 6m Woven plastic, white/white	2	HSHETARPW406	IFRC standard
IFRC shelter tool kit	Tools and fixings	1	KRELSHEK01	IFRC standard
STRUCTURE				
Bamboo (roof frame)	Length: 2.90m Diameter: 45mm (range 30-60) Dry, mature, treated	4	Locally sourced	Green bamboo (reduced resistance)
Bamboo (ridge pole)	Length: 3.50m Diameter: 45mm (range 30-60) Dry, mature, treated	1	Locally sourced	Green bamboo (reduced resistance)
Bamboo (support pole)	Length: 2.45m Diameter: 45mm (range 30-80) Dry, mature, treated	2	Locally sourced	Green bamboo (reduced resistance)
Bamboo (for entrance) (optional)	Length: 2.00m Diameter: 45mm (range 30-60) Dry, mature, treated	2	Locally sourced	Ropes tied to trees or existing poles
ADDITIONAL ANCHORING & FIXING				
Stake	Length: 450mm, diameter: 40-50mm, wood	4	Locally sourced	Bamboo
Rope (for frame)	Length: 4.00m (total length: 16m) Diameter: 6mm minimum Sisal/hemp, twisted	4	HSHEROPE06S	Polypropylene
Lashings (for frame and tarpaulins)	Length: 2.00m (total length: 44m) Diameter: 2-4mm Sisal/hemp, twisted	22	Locally sourced	Bamboo strip, coconut fibre, wire, rubber strip
ADDITIONAL ANCHORING & FIXING				
Measuring tape	Length: 5m, 19mm tape, metric and inch, rolling case	1	EMEATAPMRO52	
Sledge hammer	Length: 250mm, hardened steel, wood handle, weight: 1200g	1	ETOOHAMMSL10	Claw hammer

4. Installation guidelines

Step 1: assembling the bamboo poles to create the roof frame



Materials:

- 4 poles (length: 2.90m)
- 4 lashings (length: 2.00m)

Tools:

- handsaw, machete, measuring tape

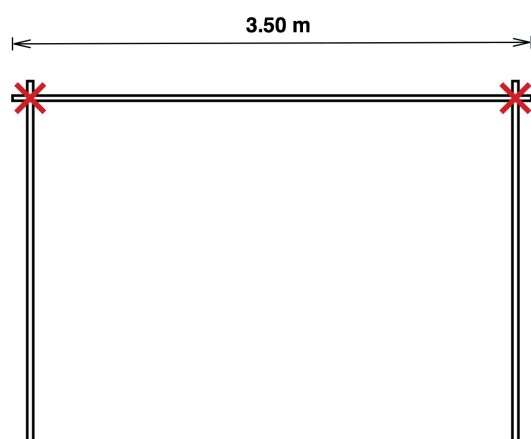
Instructions/recommendations:

- Overlap the four 2.90m bamboo poles in turn to make a reciprocal frame (roof frame) with a central square of 0.80 x 0.80m.
- The central square measures approximately 0.80m on centre
- Cross lash the poles together
- Pole overlap is approximately 50mm (2in.)

Note: The **reciprocal frame** can be defined as a structure made up of mutually supporting poles placed in a closed circuit. In this shelter 4 poles are overlapped in turn to create a **self-supporting** reciprocal frame roof. (As each pole supports the next in a reciprocal manner no internal support structure is required).

Two options are available for the next two steps. Both of them present advantages and provide the same result.
 ➔ Option 1 provides a support frame to help hold up the roof frame while lashing takes place.
 Option 2 provides more stability to the roof frame while lifting up one side of the structure.

Option 1 - Step 2: assembling the ridge pole on top of the two support poles to create the support frame



Materials:

- 1 ridge pole (length: 3.50m)
- 2 support poles (length: 2.45m)
- 2 lashings (length: 2.00m)

Tools:

- handsaw, machete, measuring tape

Instructions/recommendations:

- Lay the 3.50m bamboo ridge pole on top of two bamboo support poles
- Cross lash the joints
- Support frame overlap is approximately 100mm (4in.)

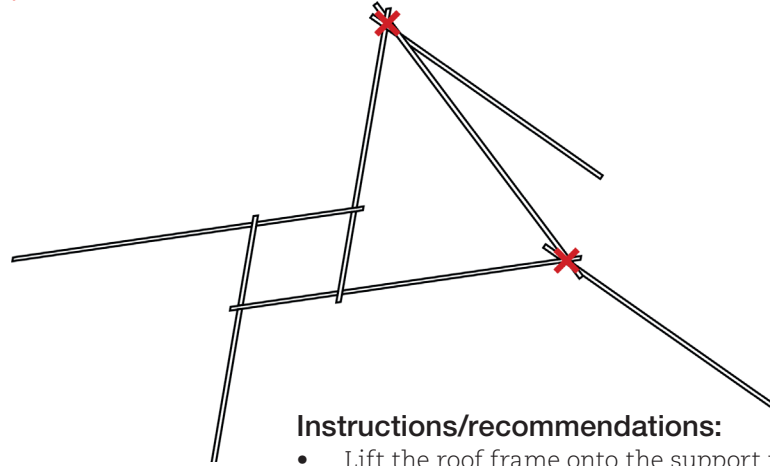
Option 1 - Step 3: assembling the roof frame on top of the support frame

Materials:

- 1 roof frame
- 1 support frame
- 2 lashings (length: 2.00m)

Tool:

- machete



Instructions/recommendations:

- Lift the roof frame onto the support frame
- Cross lash together
- Support poles are located inside the top of the roof frame and the ridge pole

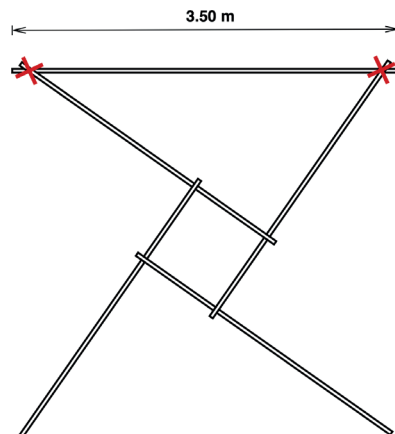
Option 2 - Step 2: assembling the roof frame on top of the ridge pole

Materials:

- 1 roof frame
- 1 ridge pole (length: 3.50m)
- 2 lashings (length: 2.00m)

Tools:

- handsaw, machete, measuring tape



Instructions/recommendations:

- Place the bamboo ridge pole on the ground
- Mark on the ridge pole where the support poles will be positioned - leave approx. 100mm (4in.) on both sides of the ridge pole
- Lay the roof frame on top of the ridge pole
- Cross lash the joints
- Overlap is approximately 50mm (2in.)

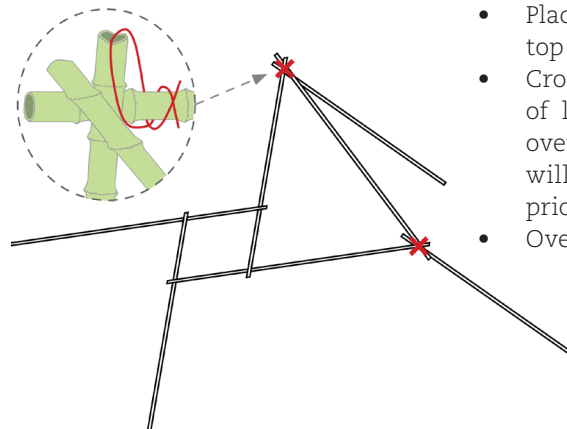
Option 2 - Step 3: assembling the roof frame on top of the support poles

Materials:

- 1 roof frame with ridge pole
- 2 support poles (length: 2.45m)
- 2 lashings (length: 2.00m)

Tools:

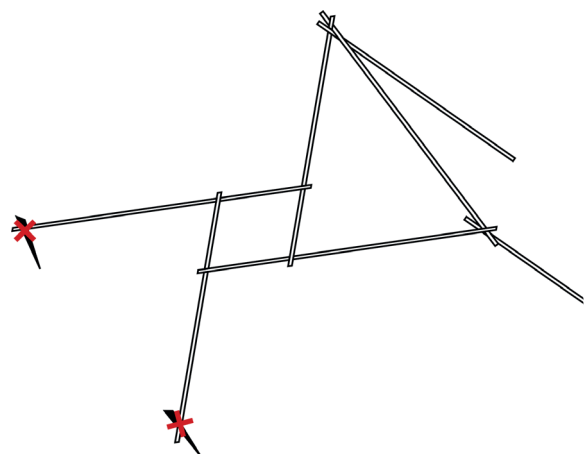
- handsaw, machete, measuring tape



Instructions/recommendations:

- Lift the ridge pole and roof frame
- Place the support poles inside the top of the roof frame and ridge pole
- Cross lash together - a single loop of lashing twine from ridge pole over the top of each support pole will hold the structure in position prior to final lashing together
- Overlap is approx. 100mm (4in.)

Step 4: anchoring the base of the roof frame to the ground

**Materials:**

- 2 wooden or bamboo stakes (length: 0.45m)
- 2 lashings (length: 2.00m)

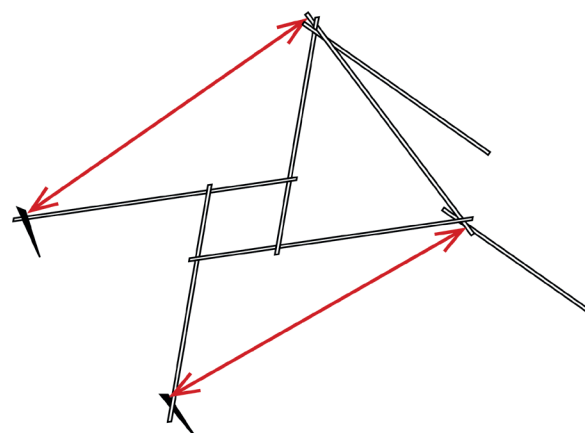
Tools:

- sledge hammer, machete, measuring tape

Instructions/recommendations:

- Anchor the base of the roof frame to the ground by cross lashing it to two large wooden stakes
- The stakes should be placed at a 90° angle with the bamboo to ensure a good anchorage and lashing
- The stakes are located at each end of the bamboos
- Overlap should be at least 100mm (4in.)

Step 5: attaching two sides ropes between stakes and ridge pole

**Materials:**

- 2 ropes (length: 4.00m)

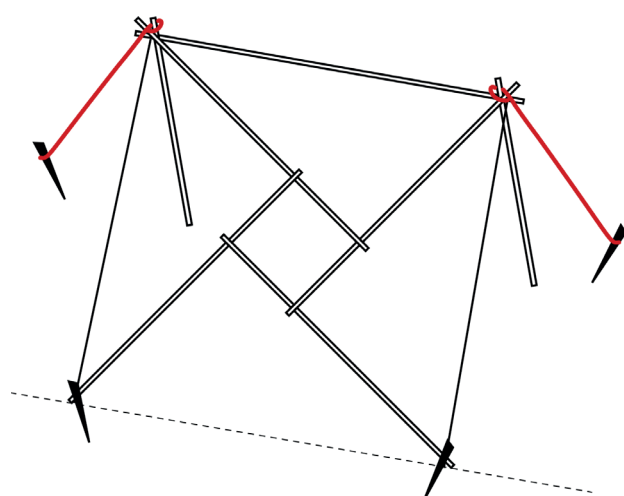
Tool:

- machete

Instructions/recommendations:

- Attach each side rope to the top of each stake and the ridge pole --> this is used to create the side of the shelter
- Do not tighten the side ropes yet
- It is possible to replace the ropes by bamboo (length: 3.50m) --> this will increase the strength of the frame, through reducing the stress, by up to 25%

Step 6: anchoring the support frame to the ground

**Materials:**

- 2 wooden or bamboo stakes (length: 0.45m)
- 2 ropes (length: 4.00m)

Tools:

- sledge hammer, machete

Instructions/recommendations:

- Loop the guy ropes over the top of the two support poles
- Peg out to the sides of the shelter
- The stakes should be placed at a 90° angle with the rope to ensure a good anchorage and lashing
- The side ropes can now be tightened



The shelter frame is now complete. The next steps are dedicated to covering the shelter with the two tarpaulins and making the entrance door, which can be located at the front or side of the shelter.

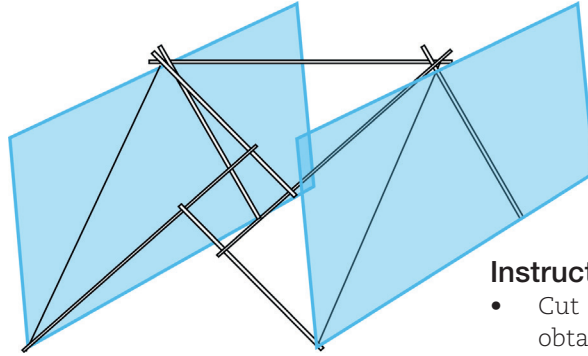
Step 7: cutting of one tarpaulin in the middle lengthwise

Material:

- 1 tarpaulin (4 x 6m)

Tools:

- machete or shears



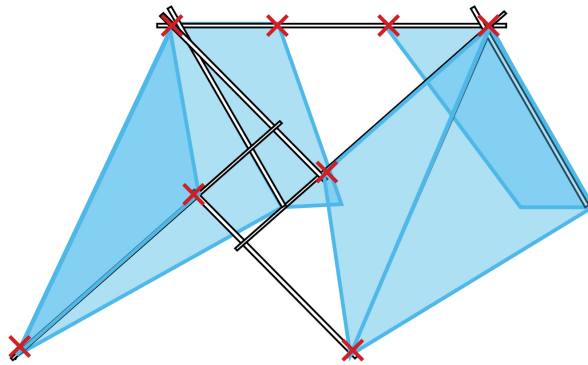
Instructions/recommendations:

- Cut the tarpaulin lengthwise to obtain two pieces of 2 x 6 m
- Position each piece of tarpaulin to each side of the shelter

Step 8: attaching the tarpaulin to the sides of the shelter

Materials:

- 2 sides tarpaulins (pieces of tarpaulin previously cut 2 x 6 m)
- 8 lashings (length: 2.00m)



Instructions/recommendations:

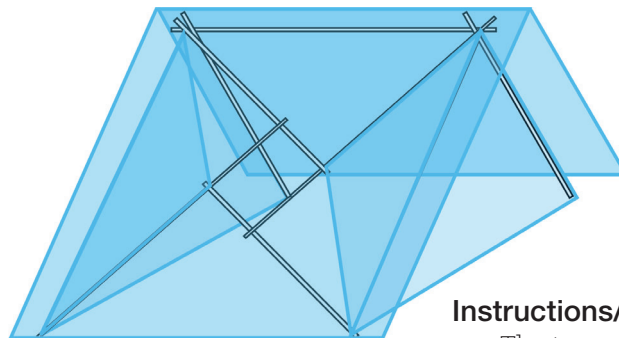
- Fold the tarpaulin over the roof frame
- Attach the tarpaulin to the central part of the roof frame
- Attach the tarpaulin at different places (4-5 in total for each piece of tarpaulin): base of the roof frame, bottom and top of the support pole and the ridge pole

Note: the door is situated at the front of the shelter, but it can also be located at the side. In this case, one half of the tarpaulin covers a side wall. The second half of tarpaulin is attached to the roof frame and ground leaving an open flap that is closed by attaching to the support pole.

Step 9: covering the shelter top with a tarpaulin

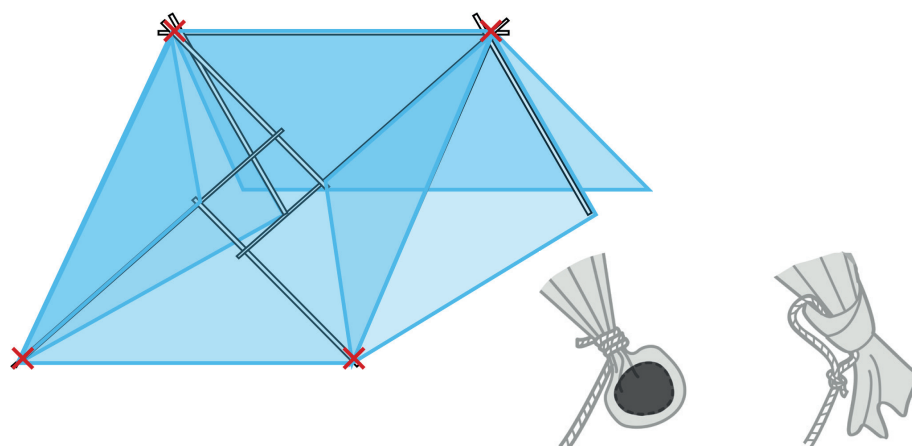
Materials:

- 1 tarpaulin (4 x 6m)
- 4-6 lashings (length: 2.00m)



Instructions/recommendations:

- The tarpaulin is placed on top of the roof frame and overlaps each side
- The overlap is 30cm (12in.) to enable the fastening of the tarpaulin

**Instructions/recommendations:**

- The tarpaulin is attached to the four corners of the shelter frame using lashing or bamboo strips
- The extra part of the tarpaulin can be placed differently depending on the time of the day: folded on and securely attached to the support poles at night, or attached with bamboo poles and ropes to make an eaves during the day



The shelter is now complete

Possible improvements to the standard shelter

In order to improve the resistance and comfort of the standard shelter, it is possible to carry out a few tasks after the assembly of the shelter.

Here are a few:

- Looping the guy ropes over the top of the tarpaulin and securely attaching to the stakes
- At the bottom of the roof frame, placing 2 stakes on each end of the bamboo (4 stakes instead of 2 in step 4)
- Securing the base of the tarpaulin to the ground by placing stones at the base of the tarpaulin or digging a trench and burying the tarpaulin
- Placing a bamboo/palm leaves mat on top of the roof frame to lower the temperature inside the shelter
- Lifting the roof frame off the ground to build an elevated bamboo shelter (see next chapter)



2.

Elevated bamboo shelter model

1. Summary information

Materials: IFRC shelter kit and bamboo poles

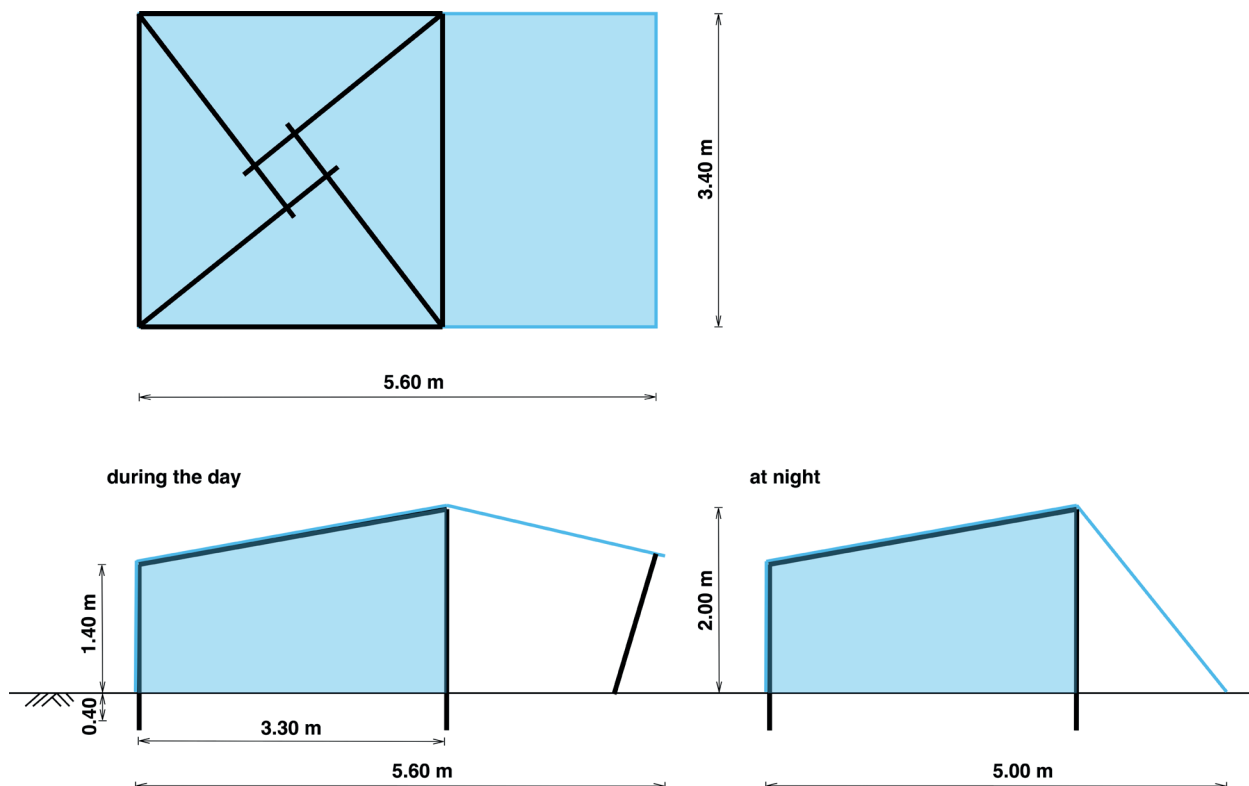
Material source: available in Emergency Items Catalogue and locally procured

Time to build: 2 hours for basic structure + additional hours for improvements

Construction team: 3 people

Shelter description: this emergency shelter has a rectangular shape, pitched roof. Covered floor area: 3.40 x 5.60m (19m²). The frame has plastic sheeting (tarpaulin) for both roof and wall covering, and one entrance at the front.

2. Plans



3. Materials and tools, including bill of quantities (BoQ)

The table of quantities below is for the materials required to build the elevated shelter model. It does not take into account issues such as which lengths of bamboo are available and allowances for spoilage in transport and delivery.

The materials for the structure and stakes should be locally sourced. The other materials and tools are available in the Emergency Items Catalogue (EIC).

Item	Specifications	Q	EIC Code / source	Alternatives/ comments
IFRC SHELTER KIT				
Tarpaulin	Size: 4 x 6m Woven plastic, white/white	2	HSHETARPW406	IFRC standard
IFRC shelter tool kit	Tools and fixings	1	KRELSHEK01	IFRC standard
STRUCTURE				
Bamboo (roof frame)	Length: 2.90m Diameter: 45mm (range 30-60) Dry, mature, treated	4	Locally sourced	Green bamboo (reduced resistance)
Bamboo (ridge pole)	Length: 3.50m Diameter: 45mm (range 30-60) Dry, mature, treated	4	Locally sourced	Green bamboo (reduced resistance)
Bamboo (main support pole)	Length: 2.40m Diameter: 45mm (range 30-80) Dry, mature, treated	2	Locally sourced	Green bamboo (reduced resistance)
Bamboo (short support pole)	Length: 1.80m Diameter: 45mm (range 30-80) Dry, mature, treated	2	Locally sourced	Green bamboo (reduced resistance)
Bamboo (for entrance) (optional)	Length: 2.00m Diameter: 45mm (range 30-60) Dry, mature, treated	2	Locally sourced	Ropes tied to trees or existing poles
ADDITIONAL ANCHORING & FIXING				
Lashings (for frame and tarpaulins)	Length: 2.00m (total length: 60m) Diameter: 2-4mm Sisal/hemp, twisted	30	Locally sourced	Bamboo strip, coconut fibre, wire, rubber strip
Stake (optional)	Length: 450mm, diameter: 40-50mm, wood	4	Locally sourced	Bamboo
ADDITIONAL ANCHORING & FIXING				
Measuring tape	Length: 5m, 19mm tape, metric and inch, rolling case	1	EMEATAPMRO52	
Chisel (optional)	For wood, 20mm flat with handle	1	ETOOCHISWF20	Machete, handsaw
Drill brace (optional)	Hand operated, with 13mm chuck	1	EMACDRILHBRA	
Drill bit (optional)	For wood, round tail diameter 12mm	1	ETOODRILWR12	

4. Installation guidelines

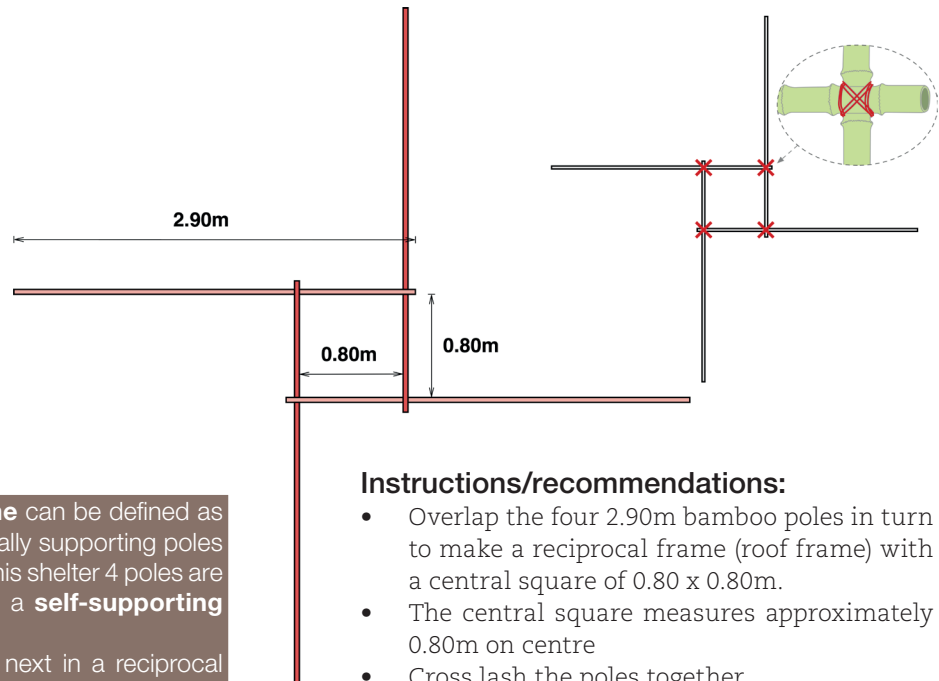
Step 1: assembling the bamboo poles to create the roof frame

Materials:

- 4 poles (length: 2.90m)
- 4 lashings (length: 2.00m)

Tools:

- handsaw, machete, measuring tape



Note: The **reciprocal frame** can be defined as a structure made up of mutually supporting poles placed in a closed circuit. In this shelter 4 poles are overlapped in turn to create a **self-supporting** reciprocal frame roof. (As each pole supports the next in a reciprocal manner no internal support structure is required).

Instructions/recommendations:

- Overlap the four 2.90m bamboo poles in turn to make a reciprocal frame (roof frame) with a central square of 0.80 x 0.80m.
- The central square measures approximately 0.80m on centre
- Cross lash the poles together
- Pole overlap is approximately 50mm (2in.)

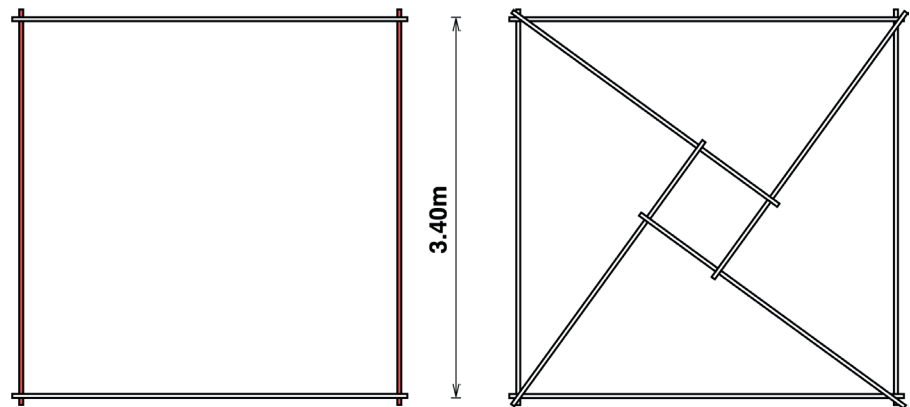
Step 2: position the roof frame on top of a ridge-pole square

Materials:

- 4 ridge poles (length: 3.50m)
- 1 roof frame
- 4 lashings (length: 2.00m)

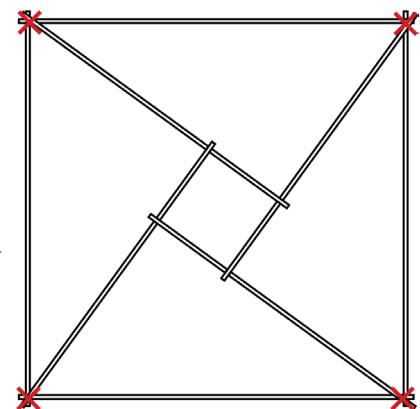
Tools:

- handsaw, machete, measuring tape

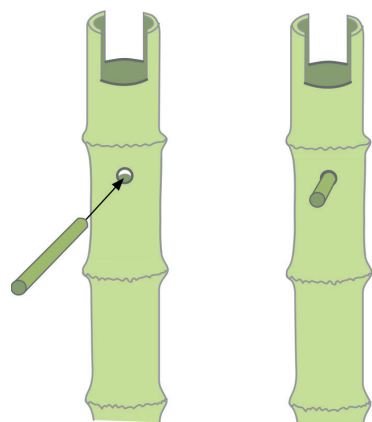


Instructions/recommendations:

- Overlap the four ridge poles to make a 3.40 x 3.40m square. Opposite poles should be on the same side (on top or underneath) their adjacent poles
- Place the roof frame on top of the ridge poles
- Cross lash the ridge poles and the roof frame
- Roof frame and ridge poles overlap is 50-100mm (2-4in.)



Step 3: prepare the support poles by cutting slots in top of each of them and placing dowels



Instructions/recommendations:

- Cut slots in top of support poles to take ridge poles
- Cut 4 dowels (12mm-diameter) made of bamboo or wood
- Drill one 12mm-diameter hole in each support pole under a knot to place the dowel

Materials:

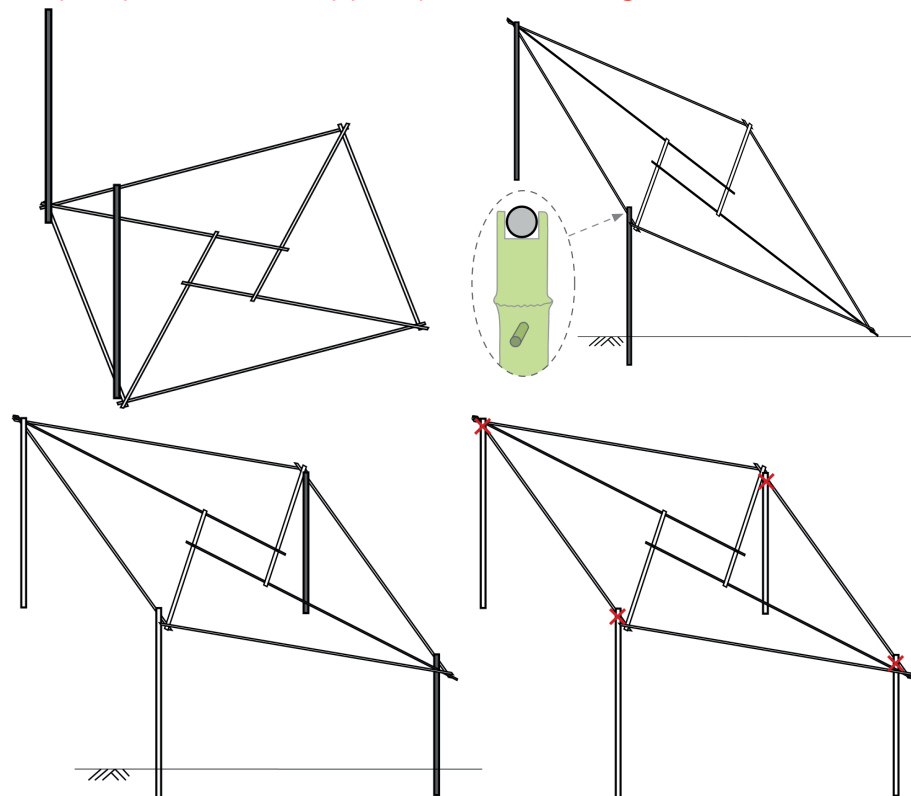
- 2 main support poles (length: 2.40m)
- 2 lower support poles (length: 1.80m)
- 4 dowels of bamboo

Tools:

- handsaw, machete, measuring tape (optional: wood chisel, drill brace, hammer)

Note: if tools (handsaw, machete, drill brace) are not available for cutting slots in top of poles and dowels, then ridge poles can simply be cross-lashed to the support poles (as in the standard shelter model).

Step 4: position the support poles into the ground



Materials:

- 2 main support poles (length: 2.40m)
- 2 lower support poles (length: 1.80m)
- 1 roof frame
- 4 lashings (length: 2.00m)

Tools:

- hoe, shovel, machete, measuring tape

Instructions/recommendations:

- Mark position of main support poles on ground
- Sink main support poles to a depth of 0.40m (16in.)
- Lift ridge pole frame onto the main support poles
- Lift the lower part of the ridge pole frame to the required height and mark position of lower support poles on ground
- Sink lower support poles to a depth of 0.40m (16in.)
- Place the ridge pole frame on top of the lower support poles
- Lash the roof frame to the support poles



The elevated shelter frame is now complete.

The next steps are dedicated to covering the shelter with the two tarpaulins and making the entrance door, which can be located at the front or side of the shelter.

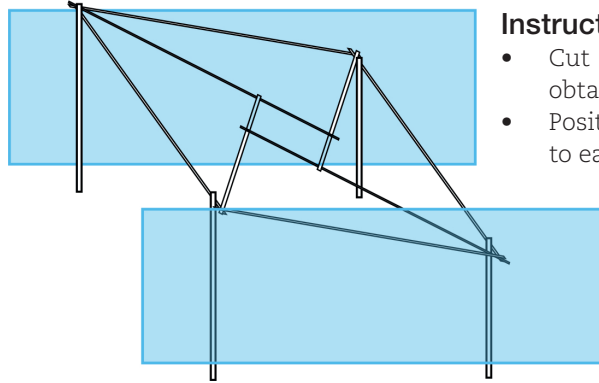
Step 5: cutting of one tarpaulin in the middle lengthwise

Material:

- 1 tarpaulin 4 x 6 m

Tools:

- machete or shears



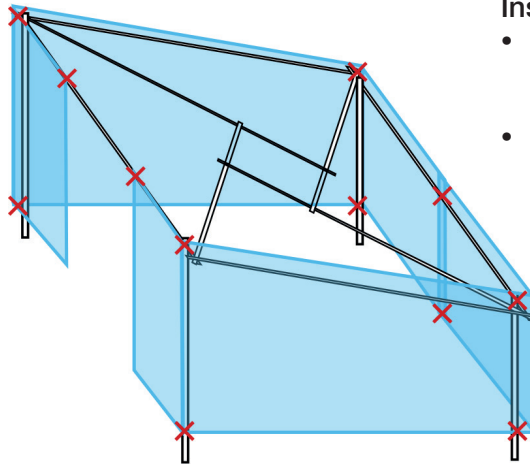
Instructions/recommendations:

- Cut the tarpaulin lengthwise to obtain two pieces of 2 x 6 m
- Position each piece of tarpaulin to each side of the shelter

Step 6: attaching the tarpaulin to the sides of the shelter

Materials:

- 2 sides tarpaulins (pieces of tarpaulin previously cut 2 x 6 m)
- 12 lashings (length: 2.00m)



Instructions/recommendations:

- Fold the tarpaulin over the sides of the shelter frame, making sure that all short sides are covered
- Attach the tarpaulin to the ridge poles and support poles at different places (6 in total for each piece of tarpaulin): each corner of tarpaulin, each corner of the shelter and bottom of the support poles

Note: the door is situated at the front of the shelter, but it can also be located at the side. In this case, one half of the tarpaulin covers a side wall. The second half of tarpaulin is attached to the roof frame and ground leaving an open flap that is closed by attaching to the support pole.

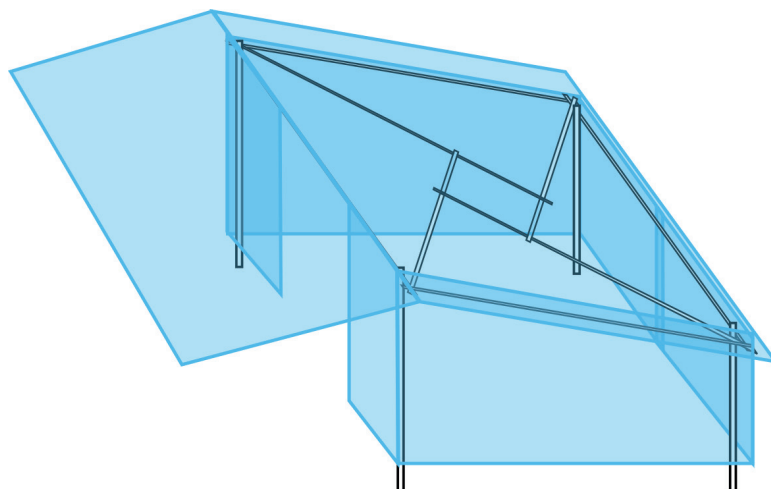
Step 7: covering the shelter top with a tarpaulin

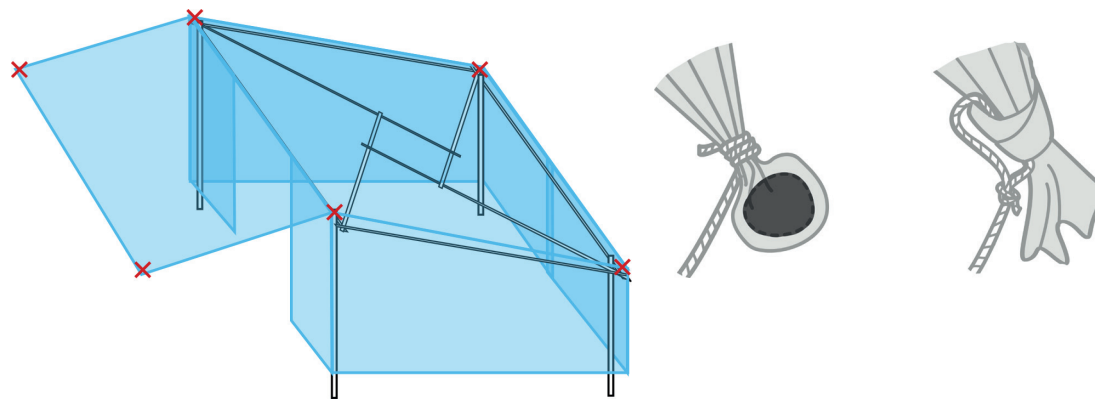
Materials:

- 1 tarpaulin 4 x 6 m
- 6 lashings (length: 2.00m)
- 2 ropes (optional)
- 2 stakes (optional)
- 2 stones (optional)

Tool:

- hammer



**Instructions/recommendations:**

- The tarpaulin is placed on top of the roof frame and overlaps each side
- The overlap is 20-30cm (8-12in.) to enable the fastening of the tarpaulin
- The tarpaulin is attached to the four corners of the shelter frame using lashing or bamboo strips
- The extra part of the tarpaulin (front of the shelter) can be placed differently depending on the time of the day: folded on and securely attached to the support poles at night, or attached with ropes and/or bamboo poles and to make an eaves during the day



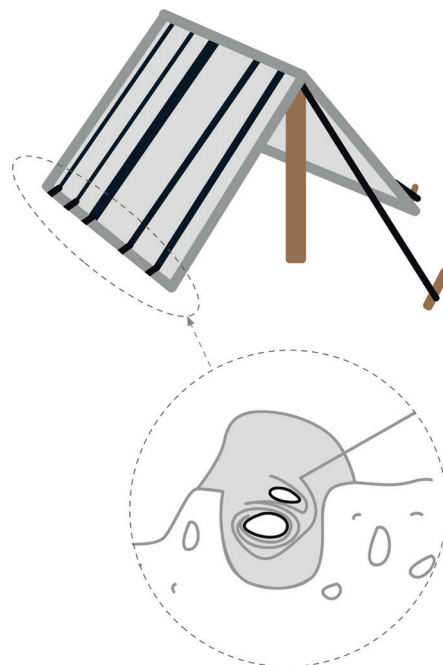
The shelter is now complete

Possible improvements to the elevated shelter

In order to improve the resistance and comfort of the elevated shelter, it is possible to carry out a few tasks after the assembly of the shelter.

Here are a few:

- Securing the base of the tarpaulin to the ground by placing stones at the base of the tarpaulin or digging a trench and burying the tarpaulin
- A bamboo/palm leaves mat can be placed on top of the roof frame to lower the temperature inside the shelter
- Anchoring the support poles to the ground, by digging deeper holes approximately 0.60m (2ft) instead of 0.40m (16in.)



3.

Bamboo roof frame model

1. Summary information

Materials: IFRC shelter kit and bamboo poles

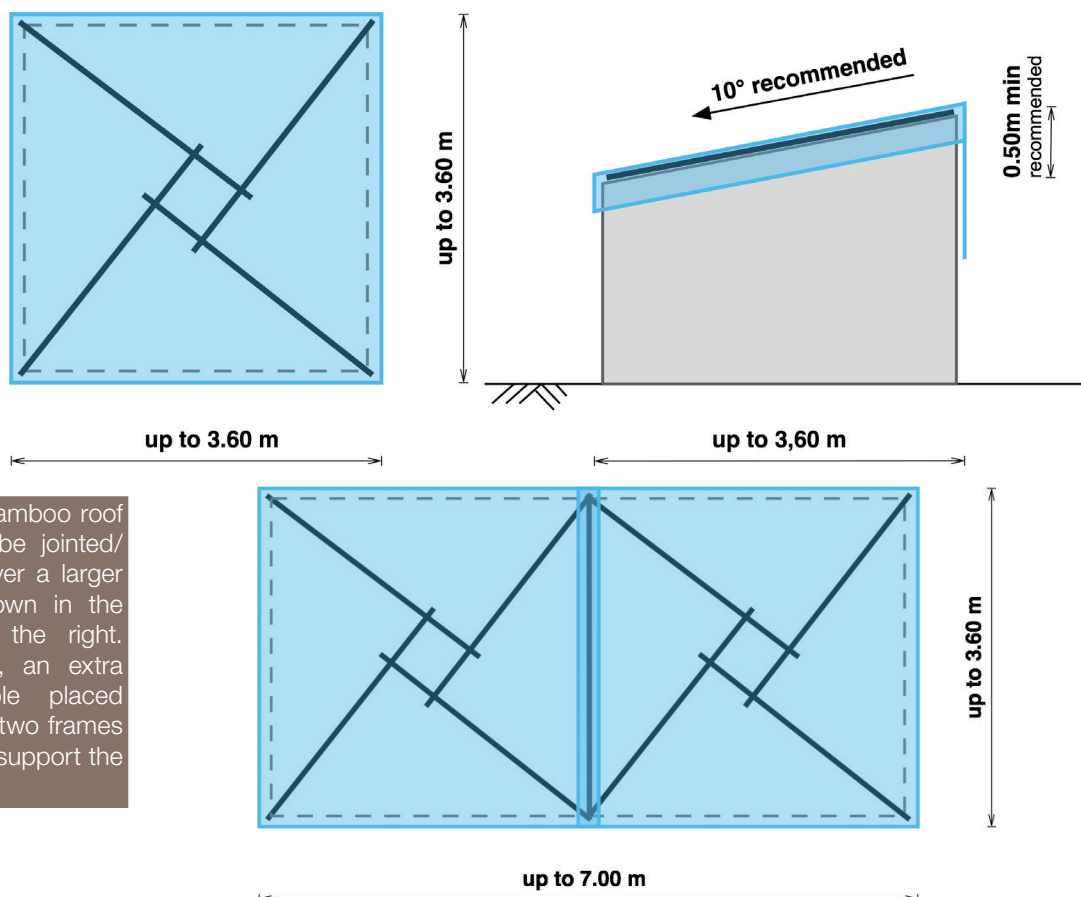
Material source: available in Emergency Items Catalogue, locally procured and/or salvaged

Time to build: less than 1 hour for basic structure + additional hours for improvements

Construction team: 3 people

Shelter description: this roof frame is used to cover a damaged roof. Covered floor area: up to 3.60 x 3.60m (13 m²). The frame has plastic sheeting (tarpaulin) for the roof.

2. Plans



Note: Two bamboo roof frames can be jointed/paired to cover a larger area, as shown in the drawing on the right. In this case, an extra bamboo pole placed between the two frames is needed to support the tarpaulin.

3. Materials and tools, including bill of quantities (BoQ)

The table of quantities below is for the materials required to build one roof frame. It does not take into account issues such as which lengths of bamboo are available and allowances for spoilage in transport and delivery.

The materials for the roof frame should be locally sourced or be salvaged materials. The other materials and tools are available in the Emergency Items Catalogue (EIC).

Item	Specifications	Q	EIC Code / source	Alternatives/ comments
IFRC SHELTER KIT				
Tarpaulin	Size: 4 x 6m Woven plastic, white/white	1	HSHETARPW406	IFRC standard
IFRC shelter tool kit	Tools and fixings	1	KRELSHEK01	IFRC standard
STRUCTURE				
Bamboo (roof frame)	Length: 3.00m Diameter: 45mm (range 30-60) Dry, mature, treated	4	Locally sourced	Green bamboo (reduced resistance)
ADDITIONAL ANCHORING & FIXING				
Lashings (for frame and tarpaulins)	Length: 2.00m (total length: 28m) Diameter: 2-4mm Sisal/hemp, twisted	12-14	Locally sourced	Bamboo strip, coconut fibre, wire, rubber strip
ADDITIONAL ANCHORING & FIXING				
Measuring tape	Length: 5m, 19mm tape, metric and inch, rolling case	1	EMEATAPMRO52	

4. Installation guidelines

Steps to take prior to the construction of a roof frame:

- Assess the damaged roof and building – make sure the structure is sturdy to receive a temporary roof, make sure to remove all roof elements that are not well attached to the structure
- Measure the roof area to be covered and verify if building a bamboo roof frame is the best solution to repair the roof – surface to cover adequate with roof frame surface (max: 3.60 x 3.60m) and a low roof incline (5 to 10° recommended roof pitch).

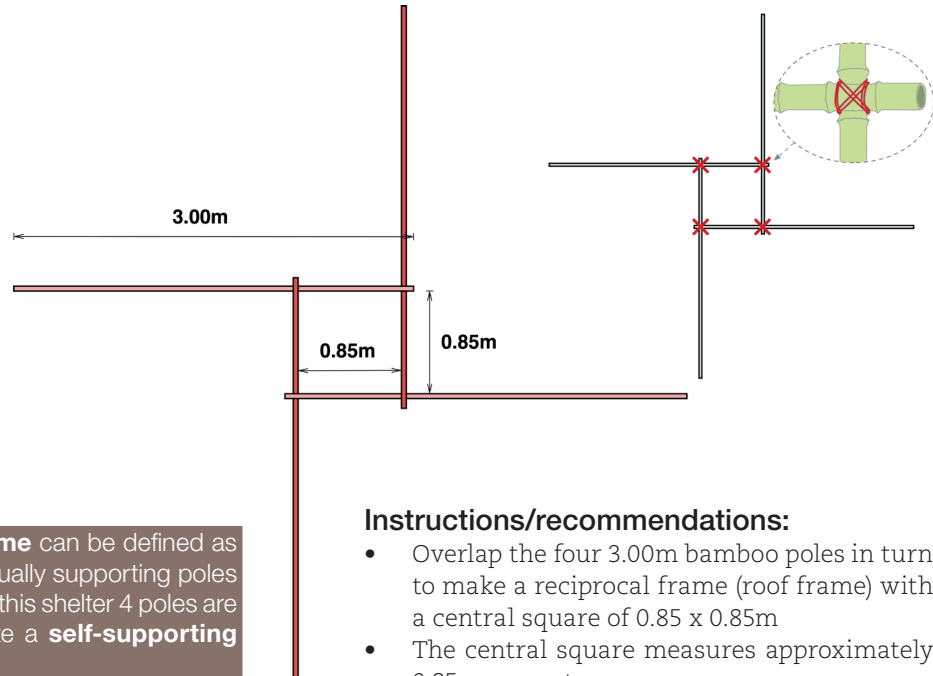
Step 1: assembling the bamboo poles to create the roof frame

Materials:

- 4 poles (length: 3.00m)
- 4 lashings (length: 2.00m)

Tools:

- handsaw, machete, measuring tape



Note: The **reciprocal frame** can be defined as a structure made up of mutually supporting poles placed in a closed circuit. In this shelter 4 poles are overlapped in turn to create a **self-supporting** reciprocal frame roof.

(As each pole supports the next in a reciprocal manner no internal support structure is required).

Instructions/recommendations:

- Overlap the four 3.00m bamboo poles in turn to make a reciprocal frame (roof frame) with a central square of 0.85 x 0.85m
- The central square measures approximately 0.85m on centre
- Cross lash the poles together
- Pole overlap is approximately 50mm (2in.)

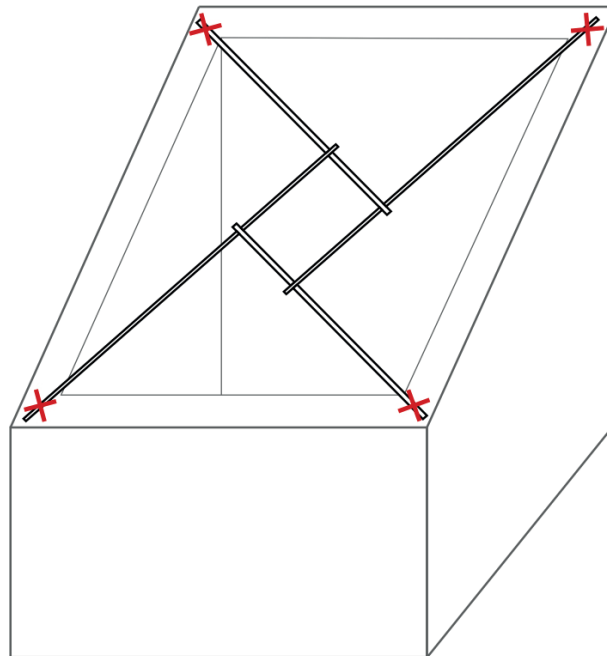
Step 2: anchoring the roof frame to the structure

Materials:

- 6 lashings (length: 2.00m / longer depending on type of structure)

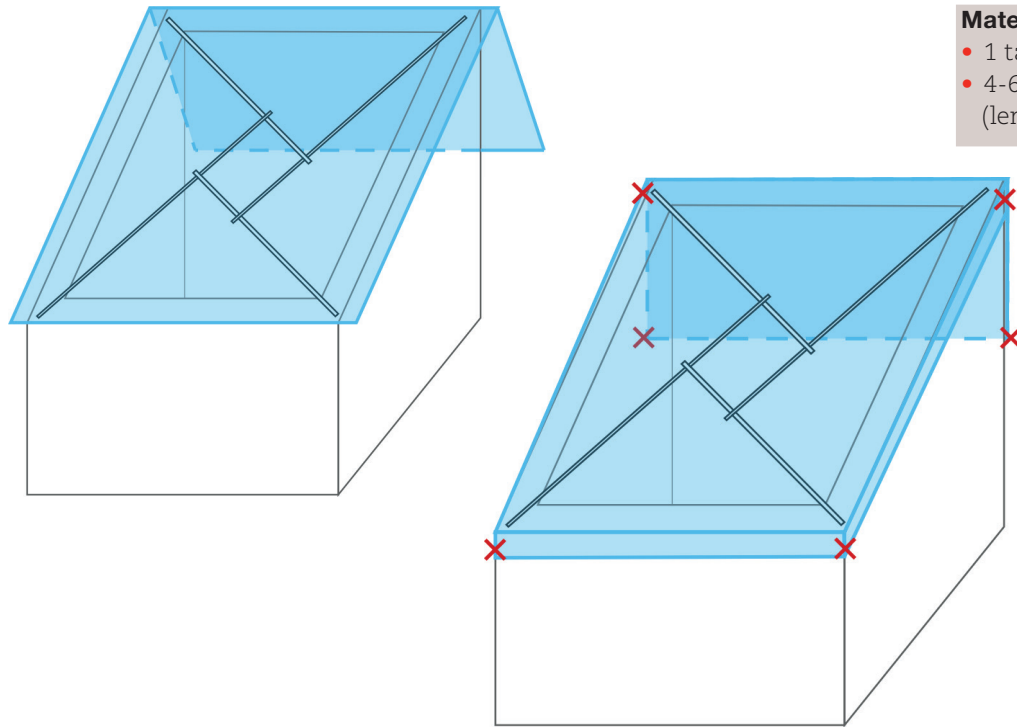
Tools:

- machete

**Instructions/recommendations:**

- Place the roof frame over the structure
- The roof frame should not overhang the structure
- Anchor the four bamboo poles to each corner of the structure

Step 3: covering the roof frame with a tarpaulin


Materials:

- 1 tarpaulin 4 x 6 m
- 4-6 lashings (length: 2.00m)

Instructions/recommendations:

- The tarpaulin is placed on top of the roof frame and overlaps each side
- The overlap on the shortest side of the tarpaulin is 20-30cm (8-12in.) to enable the fastening of the tarpaulin
- The longest side can be equally shared on each side
- The four corners of the tarpaulin are attached to the structure using lashings or bamboo strips.



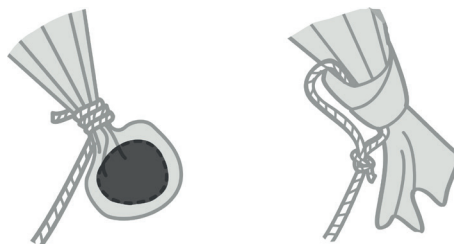
The roof repairs are now complete.

Possible improvements to the roof frame

In order to improve the resistance of the roof frame, it is possible to carry out a few tasks after the repair of the roof.

Here are a few:

- Looping the rope over the stone placed inside the corner of the tarpaulin and securely attaching to the structure or wooden stakes


If the walls are made of sand bags:

- Anchor the roof frame by passing the rope under at least 3 rows of sand bags
- Wrap the edges of the tarpaulin below one row of sand bags
- One row of sand bags can also be placed over the tarpaulin on the gable ends to improve the anchoring of the tarpaulin

For more information on this IFRC publication, please contact:

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