IFRC bamboo frame for emergency shelters and emergency roofs
Technical sheets
The Fundamental Principles of the International Red Cross and Red Crescent Movement

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**Impartiality** It makes no discrimination as to nationality, race, religious beliefs, class or political opinions. It endeavours to relieve the suffering of individuals, being guided solely by their needs, and to give priority to the most urgent cases of distress.

**Neutrality** In order to enjoy the confidence of all, the Movement may not take sides in hostilities or engage at any time in controversies of a political, racial, religious or ideological nature.

**Independence** The Movement is independent. The National Societies, while auxiliaries in the humanitarian services of their governments and subject to the laws of their respective countries, must always maintain their autonomy so that they may be able at all times to act in accordance with the principles of the Movement.

**Voluntary service** It is a voluntary relief movement not prompted in any manner by desire for gain.

**Unity** There can be only one Red Cross or Red Crescent Society in any one country. It must be open to all. It must carry on its humanitarian work throughout its territory.

**Universality** The International Red Cross and Red Crescent Movement, in which all societies have equal status and share equal responsibilities and duties in helping each other, is worldwide.
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.

Neither the International Federation of Red Cross and Red Crescent Societies nor affiliated companies, assume any liability for damages, loss or claims, of any nature, including the death or injury of persons or property damage, associated with the use of or reliance upon information contained in this document.
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Acknowledgements

Project coordinated by Corinne Tréherne (Shelter & Settlements Unit IFRC)

Lead author: Emeline Decoray
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

![Diagram of bamboo shelter model]

**During the day**
- Length: 5.15 m
- Width: 3.40 m
- Height: 1.89 m

**At night**
- Length: 5.15 m
- Width: 4.20 m
- Height: 2.60 m
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).

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<th>EIC Code / source</th>
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</table>
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.)

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)

Tools:
• 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

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 bamboo
- Overlap should be at least 100mm (4in.)

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

Tools:
- sledge hammer, machete, measuring tape

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

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%

Materials:
- 2 ropes (length: 4.00m)

Tool:
- machete

Step 6: anchoring the support frame to the ground

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

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

Tools:
- sledge hammer, machete

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.
1 tarpaulin (4 x 6m)

**Tools:**
- machete or shears

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### Step 7: cutting of one tarpaulin in the middle lengthwise

**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

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### 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.

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### 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.

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).
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

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Elevated bamboo shelter model

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![Elevated bamboo shelter model diagram](image-url)
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).

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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).

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) 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).

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

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).
International Federation of Red Cross and Red Crescent Societies

IFRC bamboo frame for emergency shelters and emergency roofs

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

Tools:
- handsaw, machete, measuring tape

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.)

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).

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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