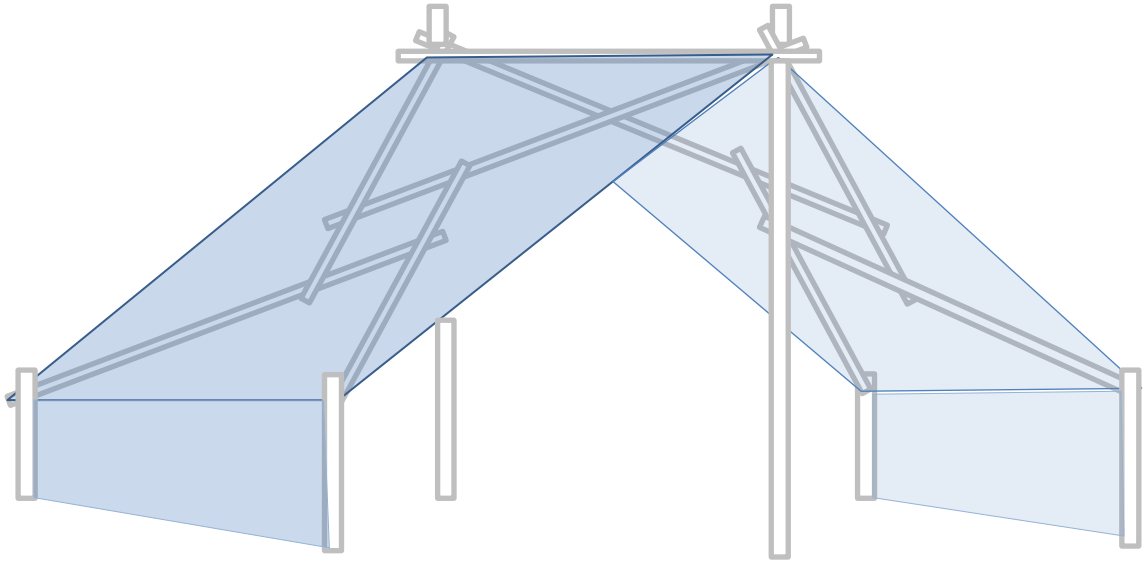
Bamboo Workshop Nepal Report:

A new type of relief shelter



Introducing reciprocal frame shelter kits for disaster relief.

ReciproBoo www.reciproboo.org

Thanks to the Bikalpa team Nepal www.bikalpa.org for helping to organise this bamboo workshop; without their hard work and enthusiasm this would not have been possible. Also to staff at IBMS college Chakaput for providing the venue and catering facilities.

Thanks also to Sunita Sharma and Manoj Manandhar, Oxfam Nepal and Ramesh Ghimirey and Sanjeev Hada, IFRC Nepal for their guidance and advice.

A special thanks to Zobyr Hashmi for his professional engineering input.

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Introduction

This joint bamboo workshop was organised by ReciproBoo and Bikalpa at IMBS college, Chakaput, Kathmandu, Nepal from 30th April to 3rd May 2013. On the final day the shelters built were demonstrated to representatives of Red Cross, Oxfam, IOM, OCHA, SCDRR and local engineers.

The workshop set out to investigate the use of a new construction concept, the reciprocal frame, for constructing bamboo relief shelters. A key objective was to determine whether the steel ReciproBoo shelter could be translated into its bamboo equivalent.

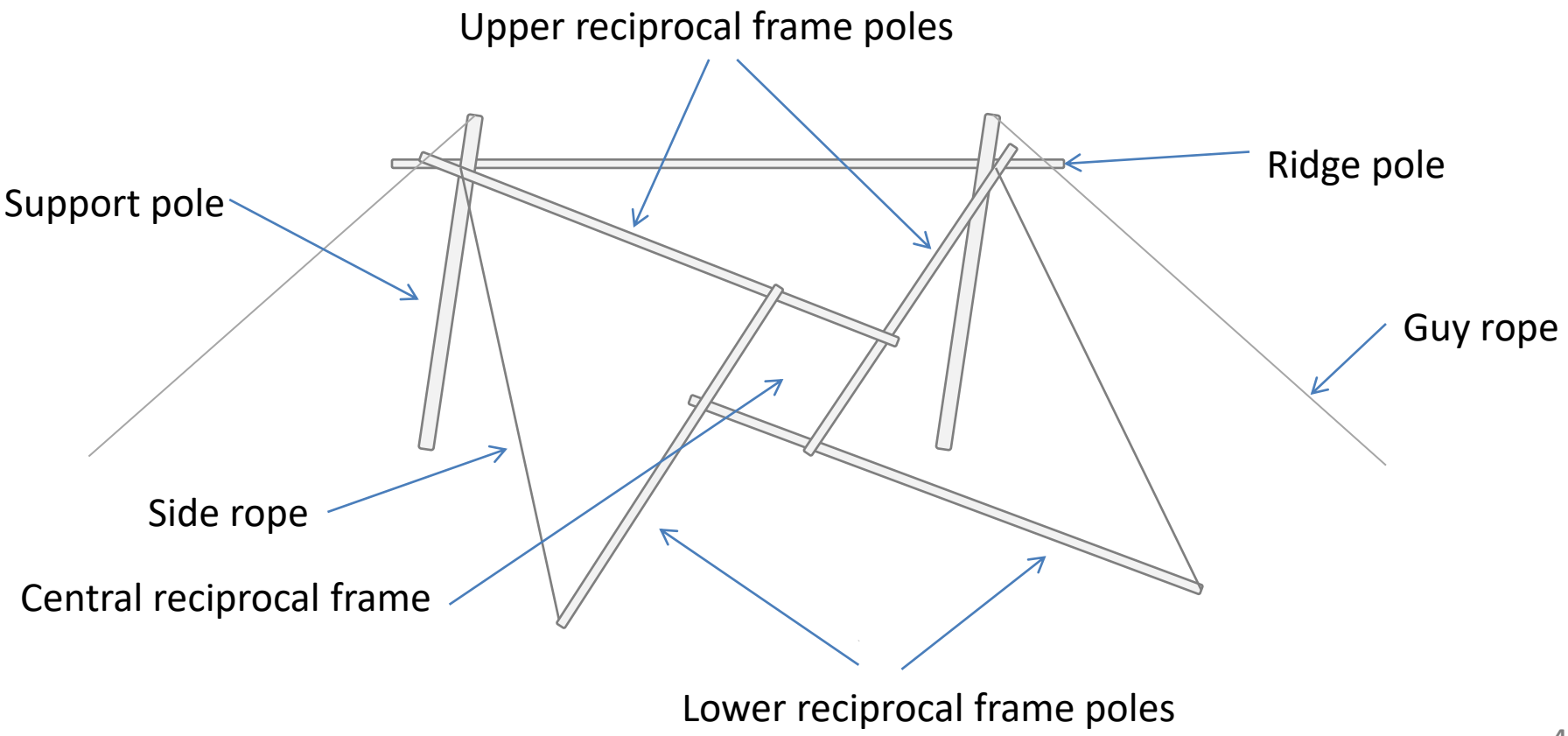
Both fresh cut green bamboo as found in disaster situations and dry bamboo for use in shelter kits were used to construct the different types of shelter.

These shelters are simple to construct and require only basic cross lashing skills. The self-supporting reciprocal frame roofs use 33% less bamboo than conventional roofs. Their exceptional strength and ability to support heavy cladding makes them much cooler than tents in the tropics, and better insulated in a cold climate. They can be easily repaired, worked on and upgraded to more permanent shelters.

This report describes the construction of five relief shelter options and records specifications and costs. It is hoped that these findings for this new shelter will be of interest to aid agencies, persons working in the shelter sector, and other individuals concerned with disaster relief.

Abbreviations and terms used

RSK = ReciproBoo Shelter Kit
Double RSK = Double ReciproBoo Shelter Kit
DERSK = Double Elevated ReciproBoo Shelter Kit



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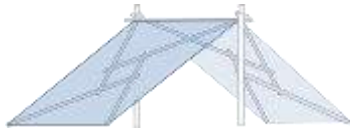
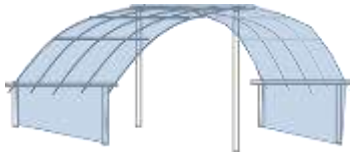
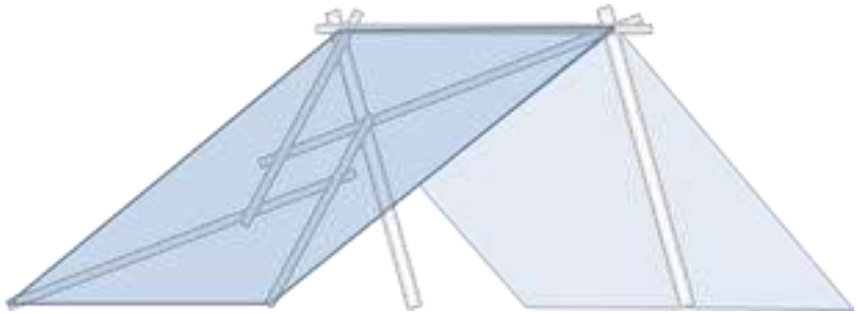


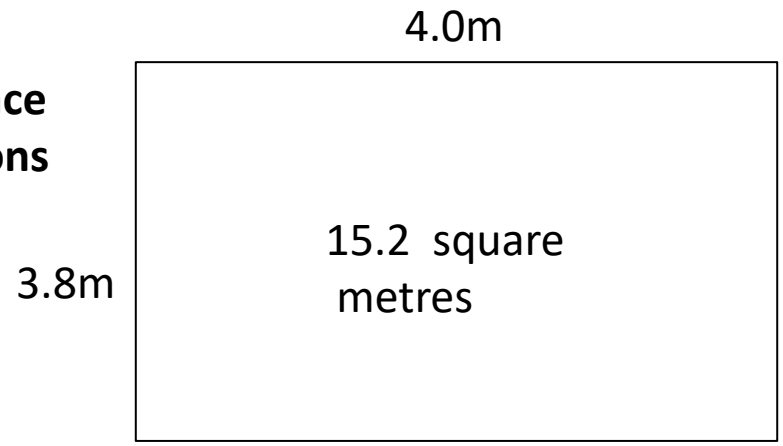


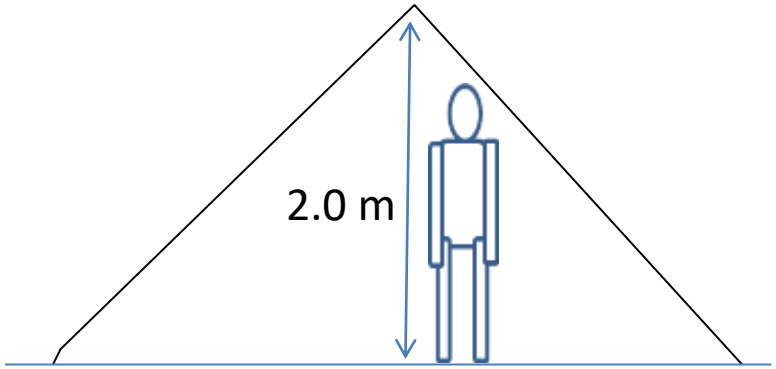
7 bamboo pole kit

2 x 2.5m
4 x 3m
1 x 4m



Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$9.60
Tarpaulin:	$15
Total RSK:	**$24.60**

ReciproBoo Shelter Kit (RSK)

Overview

Intended for emergency phase one, this shelter is the basic framing kit for tarpaulins. It is simple to construct within minutes and requires only basic cross lashing skills. The self-supporting reciprocal frame roof uses **33% less bamboo than conventional roofs**.

Its ability to support heavy cladding makes it much cooler than a tent in the tropics, and better insulated and warmer in a cold climate.

If bamboo resources are available it can be easily upgraded to the elevated or double shelter options.

Using green bamboo

This shelter was the first to be built by the workshop using green bamboo. The green bamboo was cut on the previous day at Sundarijal (15Km from Kathmandu).

It should be noted that the workshop team had no previous experience of bamboo construction.

The intention was to simulate a disaster situation where fresh cut bamboo is being used.

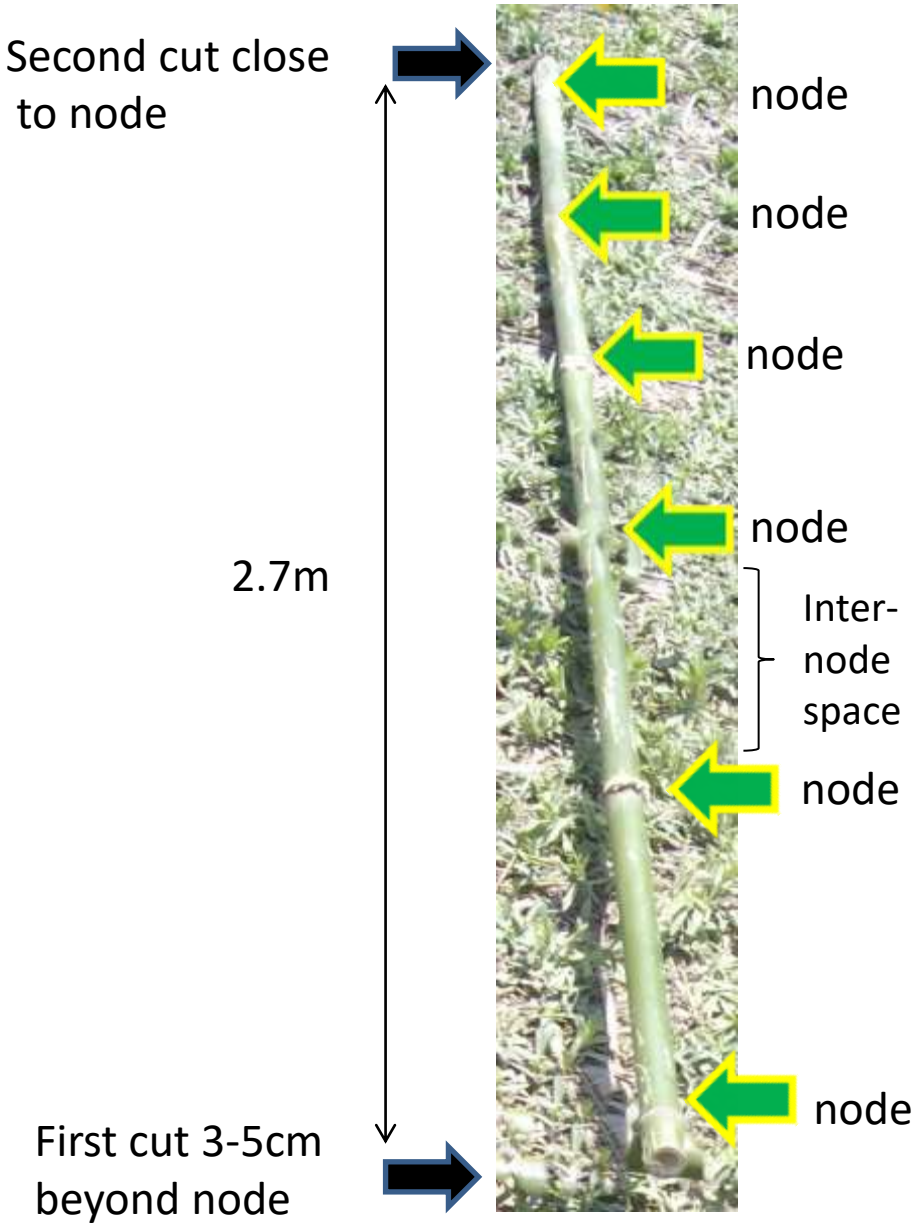
Detailed construction steps can be found in Appendix 3.

Dimensions

The first shelters built were based on the steel version of the RSK: frame poles 2.7m, ridge pole 3.6m and support poles 2.0m. This was in anticipation of creating end walls for the shelter using two tarpaulins 6 x 4m. Later the dimensions were rounded to 3.0, 4.0 and 2.5m to provide a larger standard dry bamboo shelter. If two end walls are not required this larger shelter could be adopted as the standard shelter size.

Selection of frame poles

Poles from 3 to 5cm diameter were found to be suitable. The thin ends were cut approximately 3cm distant from a node for maximum strength. The measurement of 2.7m was taken from this end and the final cut made close to the nearest node.



ReciproBoo Shelter Kit (RSK)

Selection of ridge pole

Heavier pole chosen (diameter 3.5 to 5cm)

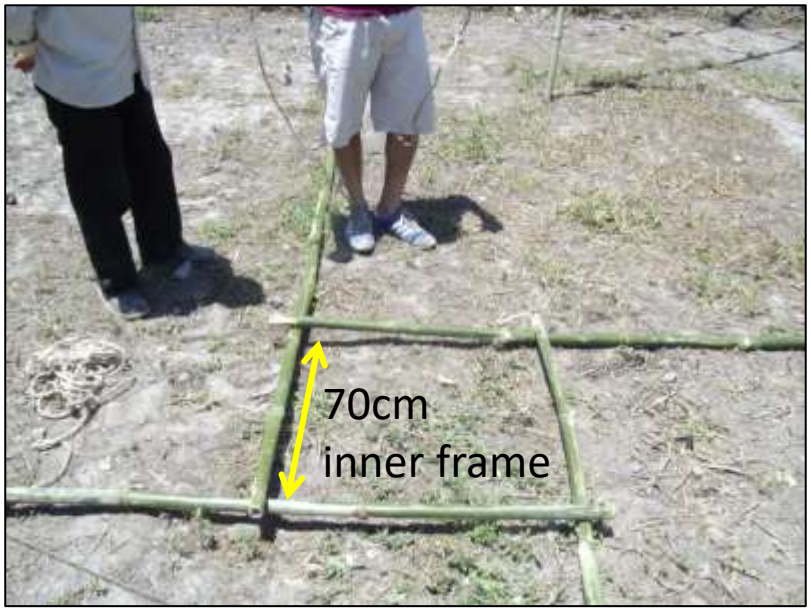
Selection of support poles

Heaviest poles chosen (diameter 4.5 to 5cm)

Crossover points on frame

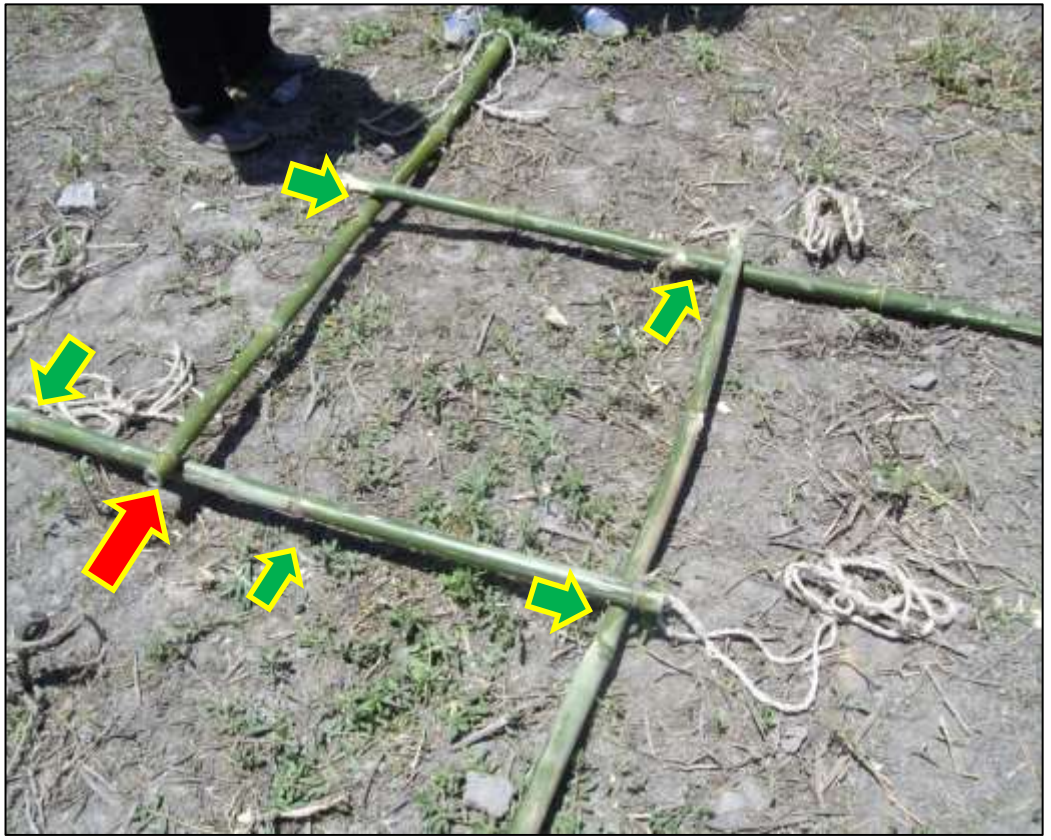
This was set to 80cm (as for the steel frame).
A bamboo baton cut to the inner frame width of 70cm made alignment of the frame easier.

The overlap was approximately 5cm, although it was agreed that this could be less for future frames as the node prevented the lashings slipping outwards.

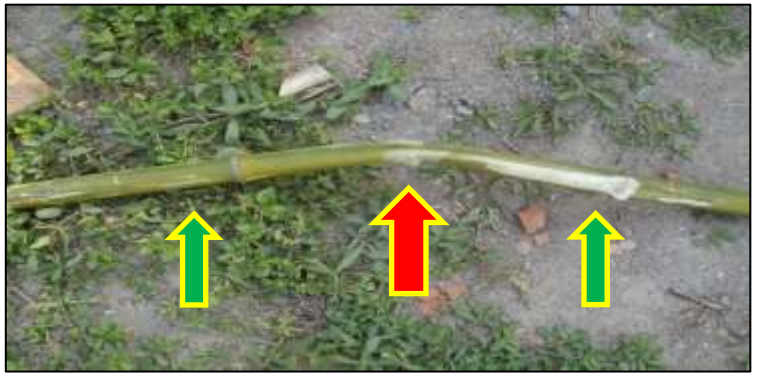


Crossover points (cont)

If possible, position the crossover points of the frame near a node for strength. Nodes closest to crossover points are marked by green arrows on this frame. The inter-node crossover point denoted by the red arrow is the weakest point on the frame.
Consideration should be given to making the crossover points close to a node with green bamboo.



Pulling down on a frame caused this green bamboo pole to crack at the centre of the inter-node space. This was easily replaced or splinted with a second piece of bamboo. Dry bamboo was found to be much stronger and could support heavy loads with ease.



Lashing the frame

The 3m lengths of jute twine worked well. The shiny surface of the green bamboo resulted in some slippage of the frame joints with movement over time (see wire below).

Consideration could be given to scraping this shiny surface over the contact area to make it rough and less slippery like dry bamboo. A short horizontal loop across the lashing as used for the steel frame improved compression on the joint.

Using wire

Steel wire was also useful for lashing together the frame. In particular with green bamboo it could "bite into" the soft outer skin of the bamboo. We used it folded double prior to lashing with jute to fix the frame and reduce slippage.

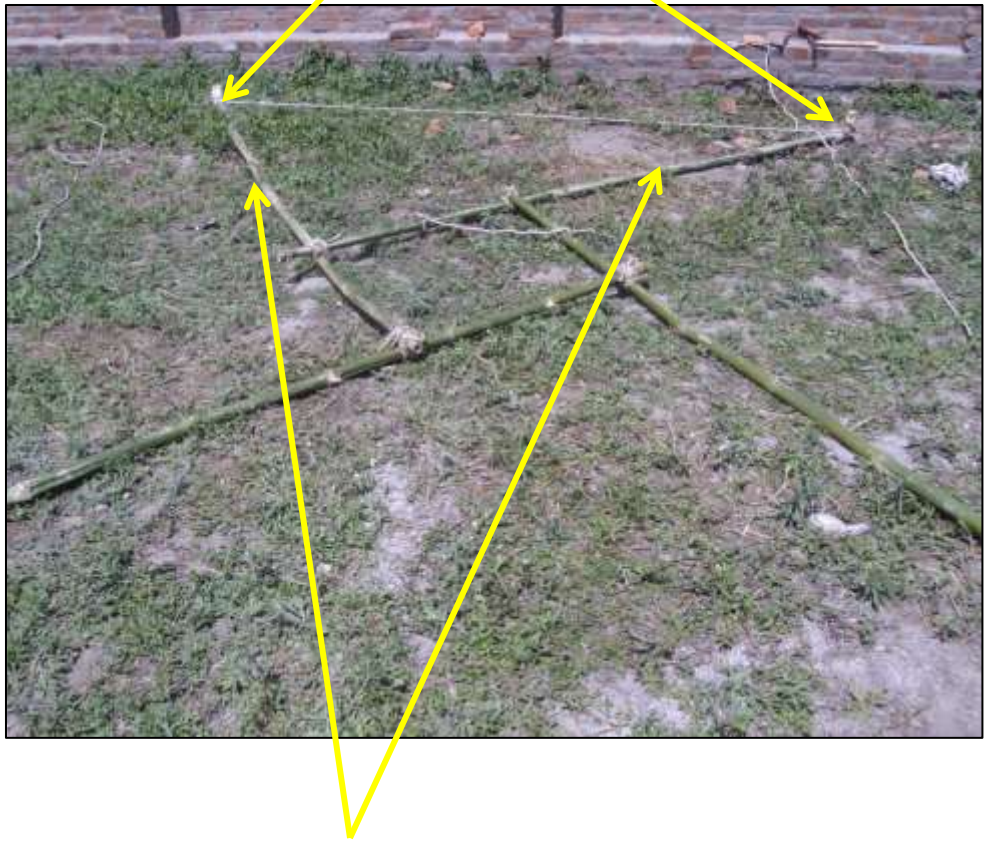
Laying out the frame

Choose the two strongest/ thickest poles for the base of the roof as these support the maximum weight. This is more important for the more flexible green bamboo than the more rigid dry bamboo.

Use a bamboo stake to anchor the ends of the base poles to the ground.

This is a good point at which to check that the central frame is set square.

Fix the ends of the base poles to the ground with 2 stakes



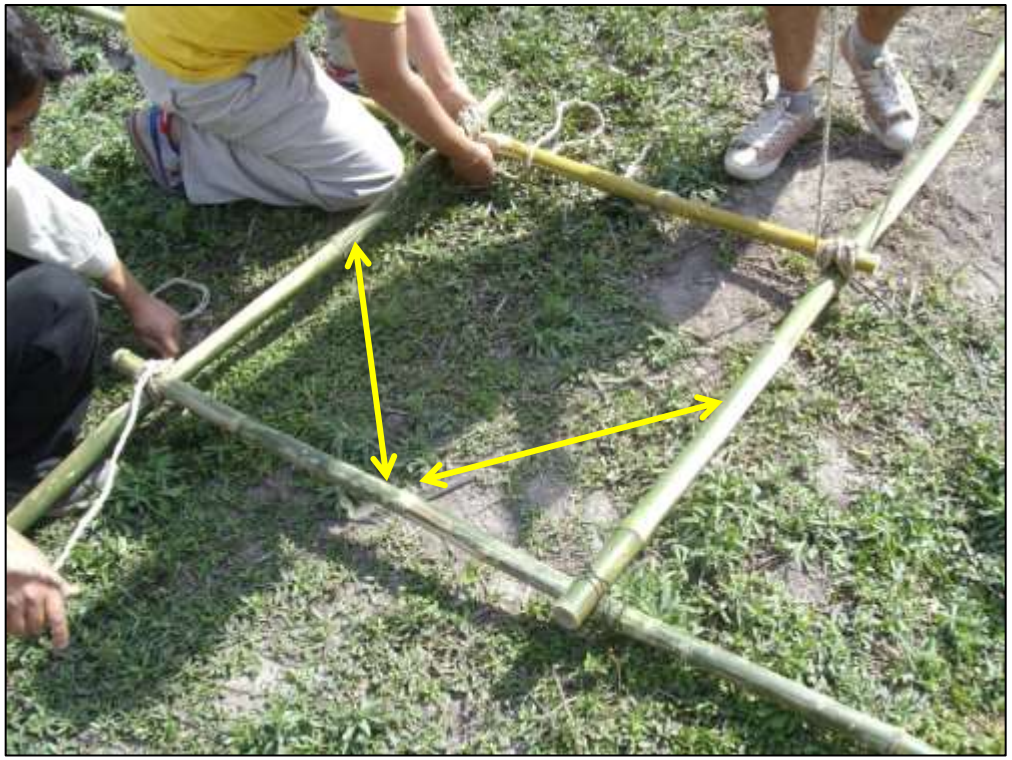
Thicker /stronger base poles

Setting the frame square

Tying 2 short ropes between the centre of two adjacent frame members will keep the frame square.

As shear forces are applied to the frame and the tension on one rope reduces, the tension on the other increases preventing further deformation. Study of this movement will show that if the two ropes are on opposite sides of the frame that this deformation is not prevented.

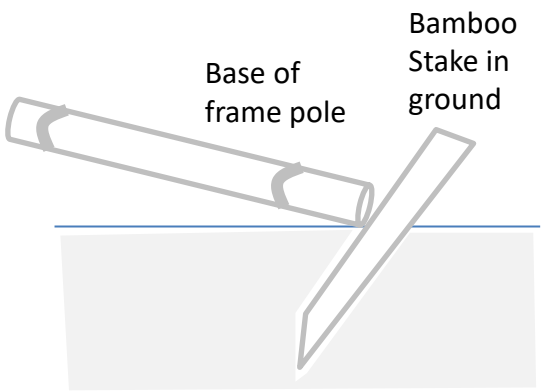
Using two small lengths of bamboo in position of the ropes and lashed to the underside of the frame would also prevent deformation.

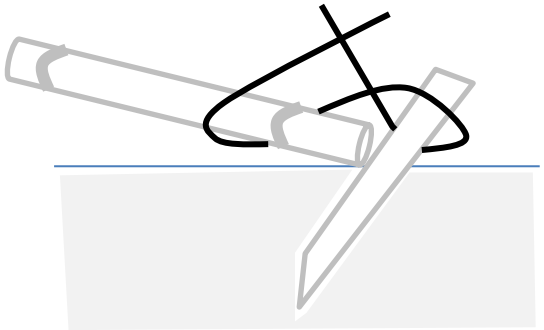


Anchoring the frame

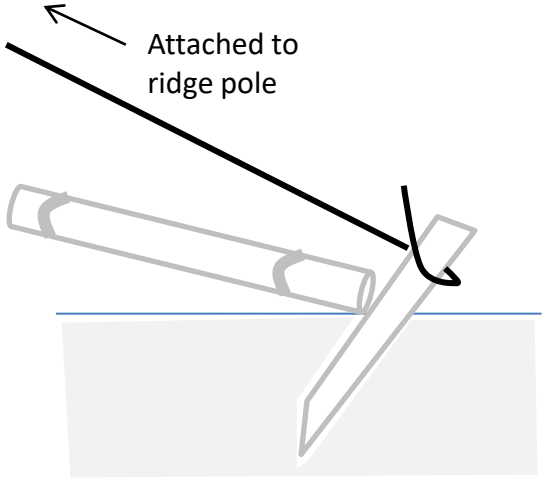
Unlike the steel shelter the roof frame does not require a base rope. Instead two bamboo stakes anchor the base of the two lower frame poles to the ground.

One rope is used to secure the end of the frame to the stake. A second (side) rope is attached to the stake and the ridge pole.





First rope attaches frame pole to bamboo stake



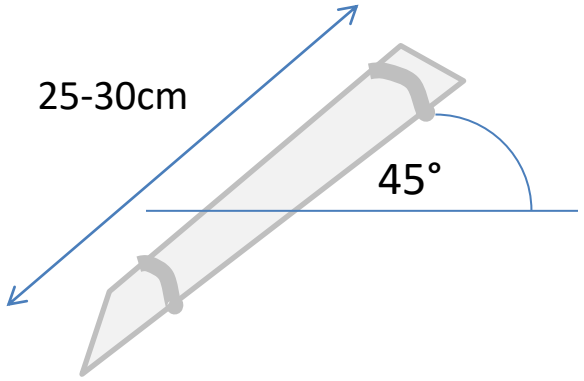
Second (side) rope from ridge pole attaches to bamboo stake

Attaching the side ropes

The two side ropes were tied between the bamboo anchor stake and the ridge pole. This is different to the steel frame. Although this single anchor point was used by the workshop, consideration needs to be given to the later attachment of tarpaulins. It may be better to have the base of the roof frame attached to a separate stake to that of the tarpaulin, so that all the stress is not on a single stake.

Bamboo stakes /pegs

The bamboo stakes were made from either 3cm whole bamboo or 5cm split bamboo and set at about 45 degrees to the ground. A minimum of 4 are required; two for the base of roof frame and two for the guy ropes.



Lifting the roof frame options

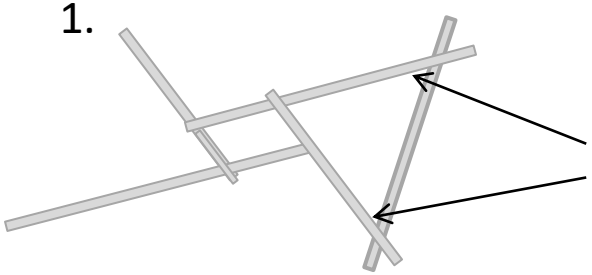
Option 1: Lashing roof frame to ridge pole then elevating on support poles.

This ensured good stability of the roof frame before lifting but was more difficult to support when lashing the ridge pole to the two support poles.

Option 2: Lashing the two support poles to the ridge pole first then using this as a prop to support the roof frame.

This was much easier as the prop held the roof frame in position for lashing. It is important to first mark the points where the frame poles overlap the ridge pole on the ground so that the support poles are lashed in the correct location on the ridge pole.

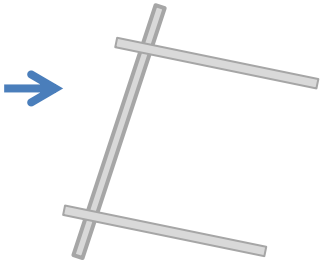
1.



Lay the frame on top of ridge pole. Mark on the ridge pole where the final positions of the support poles will be located.

2.

Take this ridge pole and lash the two support poles to it at the marked points



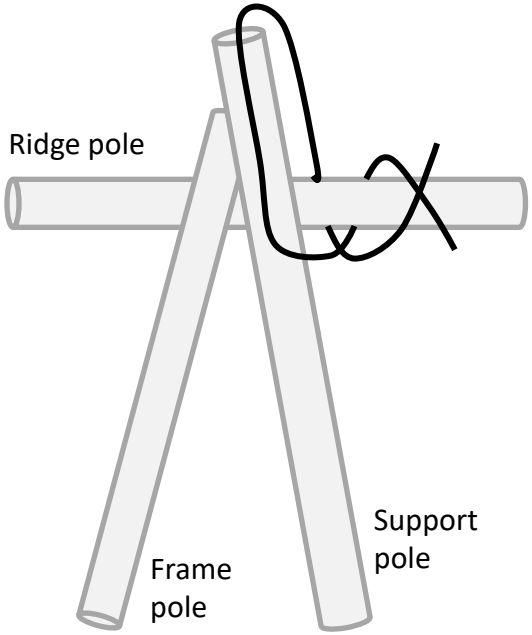
Use this as a prop for the roof frame.

Supporting the ridge pole

A simple loop of twine over the top of the support pole and then lashed to the ridge pole, prevented any slippage of the ridge pole down the support pole. Cutting a small groove in the support pole may be useful. If the ridge pole is lashed to the support pole just above a node this also prevents slippage.

Attaching a short length of bamboo beneath the support pole was not necessary.

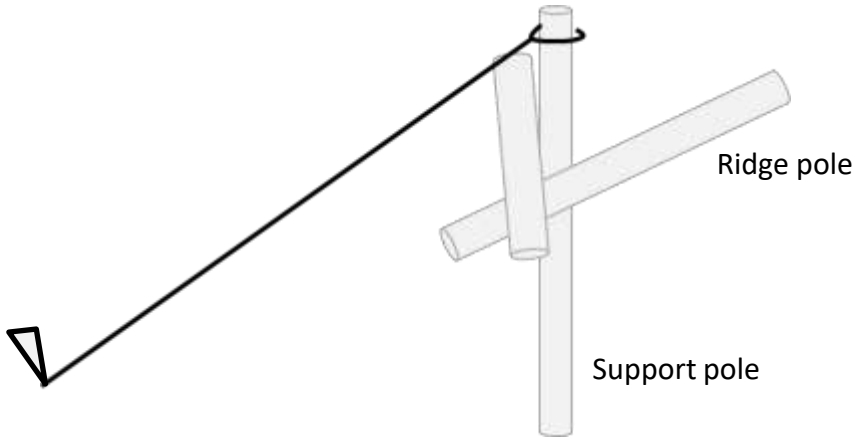
If this is used a half section of bamboo would attach better than a full round profile.



Attaching the 2 guy ropes

Each guy rope is attached to the top of a support pole and extended to each side where it is fixed to a bamboo peg or stake. It is important that the support pole is located inside the crossover point of the ridge pole and the top of frame pole.

The cotton rope used for these guys lost tension during the day and we used polypropylene rope instead. Non synthetic natural fibre rope would have been preferable and less expensive for this purpose.



ReciproBoo Shelter Kit (RSK)

Using dry bamboo

This shelter also uses only 7 bamboo poles and would be ideal for distributing with a tarpaulin as a shelter kit.

The bamboo was sourced locally in Kathmandu; its strength and rigidity was comparable to the steel RSK.

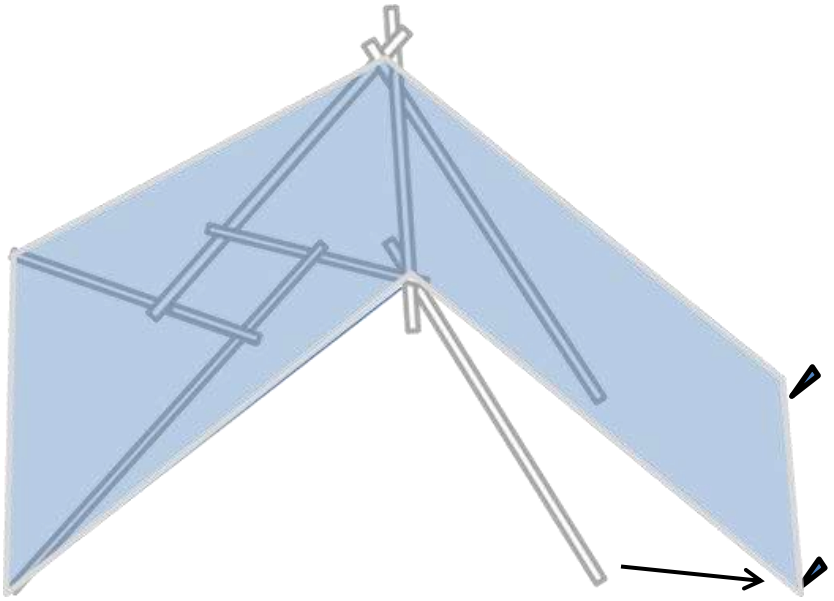
The rougher surface meant that lashings did not slip like the green bamboo and it was not felt necessary to use any wire for this shelter.

With this shelter all upgrade options are available: elevated, double shelter and double elevated shelter. If these dimensions had been used for the double elevated shelter an even larger shelter could have been built. This could be an option for a future workshop.

Tarpaulins

The tarpaulins we had were too small for this larger shelter. Ideally a larger 6 x 4 metre tarpaulin could be extended on the side of the shelter without a reciprocal frame roof as shown below.

The protruding ends of the central frame were covered with pads of cloth to prevent friction damage to the tarpaulin. In Nepal they also use strips of rubber made from cycle or car tyre inner tubes for this purpose.



Repairs

Bamboo damage was easy to repair.
Here a cracked pole is splinted using a half section length of bamboo lashed across the crack with twine.

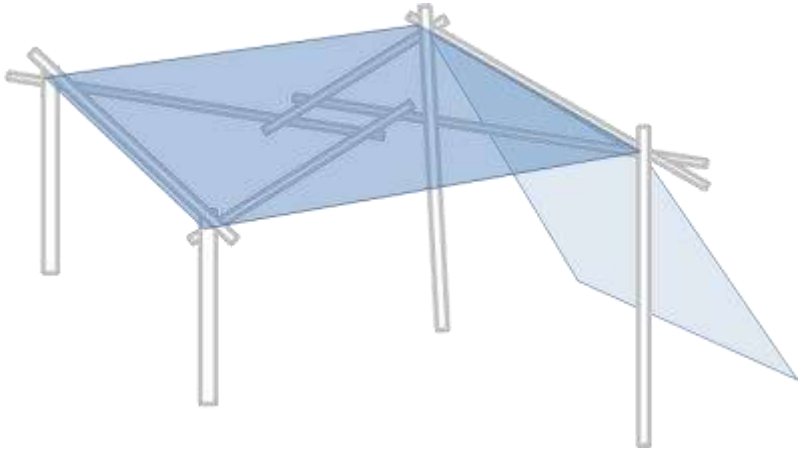
Comparison with the steel shelter

The rigidity of the dry bamboo used meant that at times it performed better than its steel counterpart.

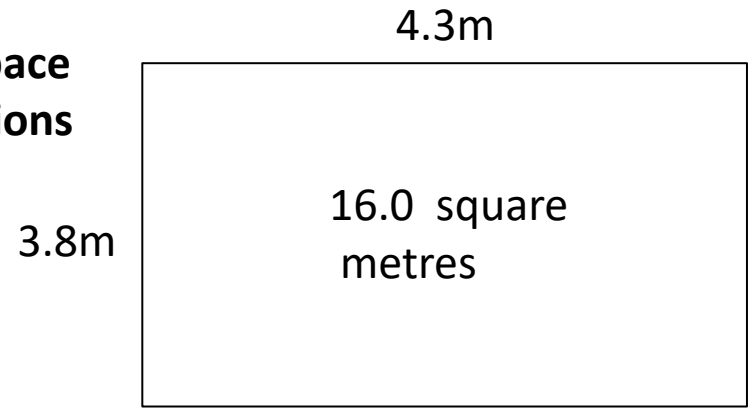
However the fresh cut green bamboo is more flexible and not as strong ; so larger poles , about 4cm diameter, would be better if node position is being ignored.

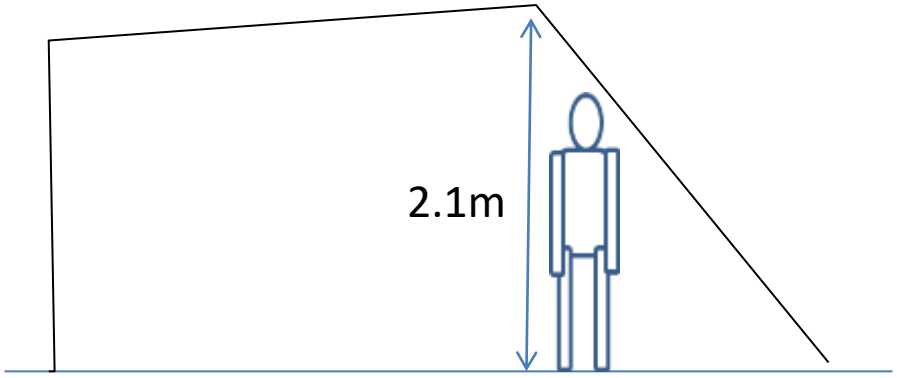
10 bamboo pole kit

4 x 2.5m
4 x 3m
2 x 4m



Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$12.40
Tarpaulin:	$15
Total RSK:	**$27.40**

Elevated ReciproBoo Shelter Kit (RSK)

Overview

This shelter requires only 3 more poles to considerably increase the headroom over the entire floor space.

It is particularly suitable in urban disaster situations where use can be made of any low wall, or available masonry.

As the roof is slowly elevated from 30 degrees it becomes increasing stable with gravity forces acting perpendicular to the frame joints. However, it is advisable to have a small incline to facilitate water run off.

The team built one elevated shelter using green bamboo using a combination of bamboo posts and an existing wall.

Elevated ReciproBoo Shelter Kit (RSK)

Workshop findings

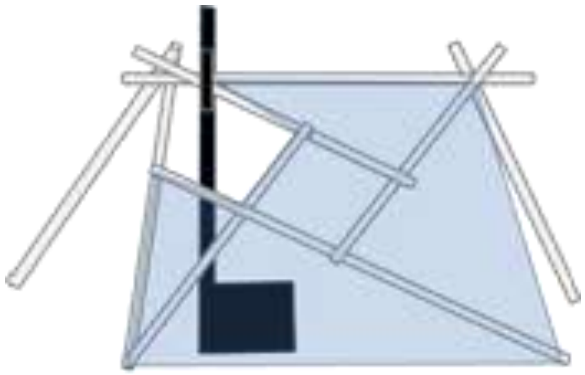
Elevating the basic shelter made a huge difference to the living space.
Two bamboo posts sunk 30cm into the ground provided the stability required to use the available wall. If the wall had not been used a single ridge pole between the two posts and two guy ropes would have provided good support.

The workshop shelter was propped against the wall with the two support poles inclined at an angle. It would have been better to fix the two support poles vertically in the ground and extend the tarpaulin outwards to increase the floor space.

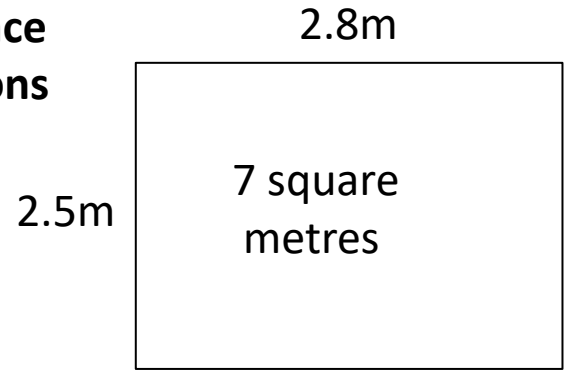
This shelter is particularly adaptable to irregular shaped spaces found in urban disasters where setting up a tent may not be possible.

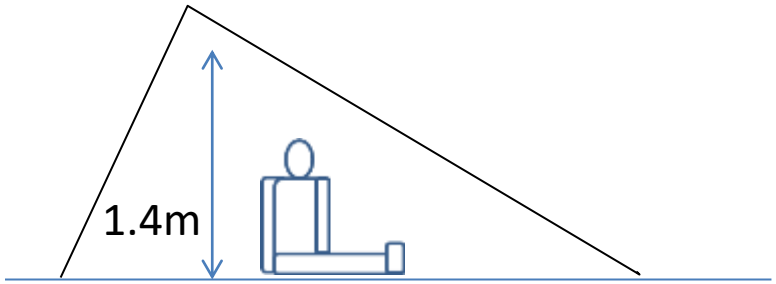
8 bamboo pole kit

2 x 1.8m
3 x 2.5m
2 x 3m
1 x 3.5m



Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$9.40
Tarpaulin:	$15
Total RSK:	**$24.40**

Overview

This compact shelter can be heavily clad with snow or available materials for insulation.

One particular attribute is the creation of a **natural roof aperture** near the entrance for a stove flue to pass.

It demonstrates the flexibility of the reciprocal frame shelter; shortening one or more of the roof frame poles changes the shelter significantly. In this case one of the central frame poles has been extended to meet an additional side ridge pole.

Like all the other shelters this one can be elevated to create head space as required.

Tarpaulin covers

The shelter offers some interesting options for survival at altitude or in a very cold climate.

The rigid frame entrance on one side makes this a particularly strong and flexible shelter.

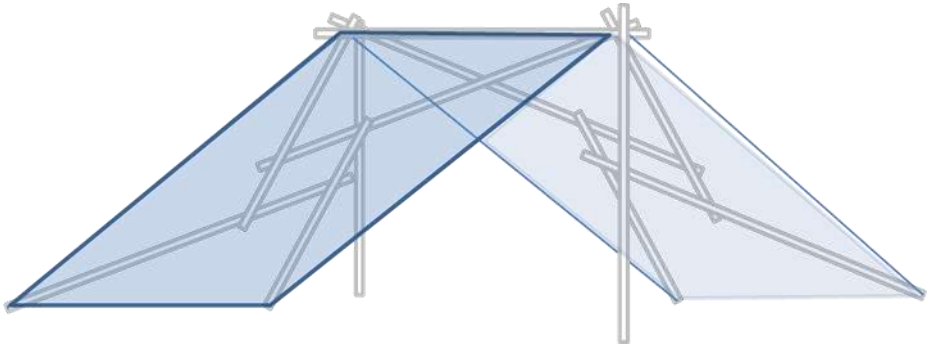
The numerous ways of attaching the tarpaulin to the frame could make the structure suitable for heating and these will be further assessed at the next workshop.

Double ReciproBoo Shelter Kit (double RSK)

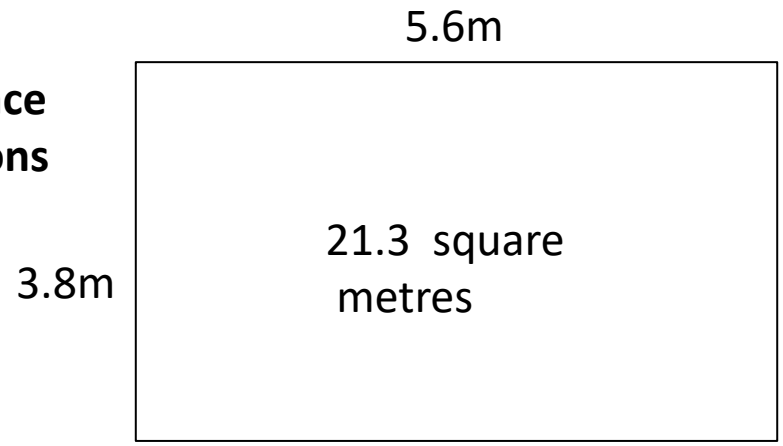
Emergency shelter: day 1 of disaster

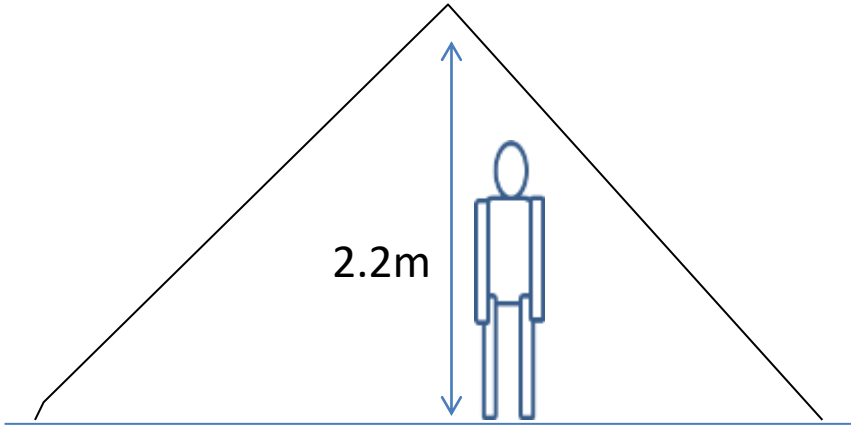
11 bamboo pole kit

10 x 3m
1 x 4m



Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$15.60
Tarpaulin:	$15
Total double RSK:	**$30.60**

Double ReciproBoo Shelter Kit (DRSK)

Overview

This shelter can be used as a first response option if bamboo resources are available.

It provides an **additional 6 square metres of floor space** for the addition of only 4 more bamboo poles. In addition, the **increase of 20cm headroom** makes a considerable difference to standing space.

Beneficiaries have the option of elevating one side to further increase headspace or upgrading to the full double elevated shelter.

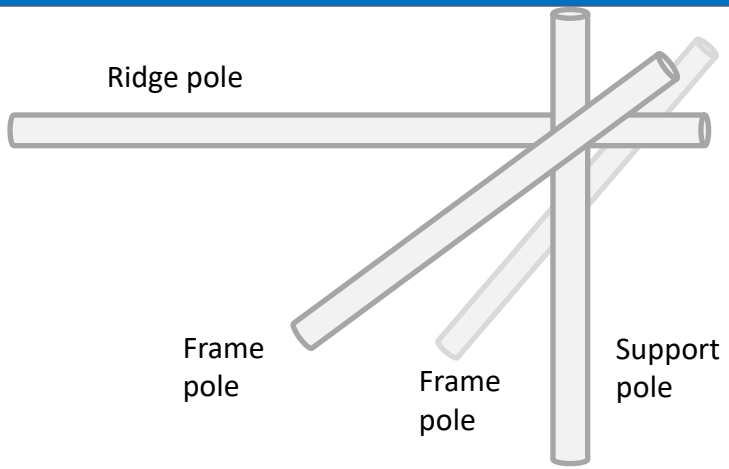
The team built one double emergency shelter in green bamboo.

Double ReciproBoo Shelter Kit (DRSK)

Construction points

The first roof frame is built and placed on top of the ridge pole in its final position.
The support poles are placed inside the crossover point of ridge and roof frame poles and their position marked on the ground. At the same time the position of the support pole on the ridge pole is marked.

The support poles are then lashed to the ridge pole and the support poles sunk in the ground.
The first roof frame is lifted onto the ridge pole and secured. The second roof frame is lifted onto the ridge pole and secured. Both the roof frames are then anchored in the ground, the side ropes attached and the guy ropes secured.



Both roof frame poles are located outside the support pole

Double ReciproBoo Shelter Kit (DRSK)

Options

The side ropes can be replaced with bamboo ridge poles if available. Recent Galway University research http://bit.ly/YGh8Lt showed that this step could reduce maximum stress by 24% and significantly increase the strength of the structure.

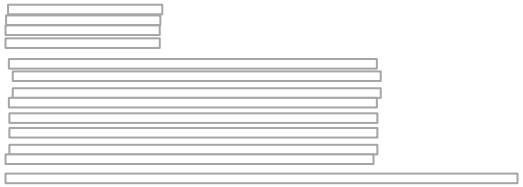
The shelter can easily be elevated on one or both sides to increase the headroom and if additional bamboo poles are available the shelter can easily be upgraded to the fully elevated double shelter.

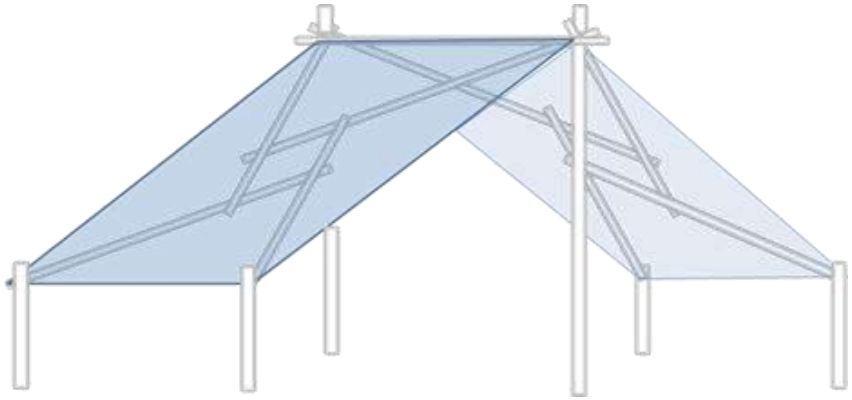
Here the double steel frame shelter is being set up with its equivalent double bamboo frame shelter in the background

Double Elevated ReciproBoo Shelter Kit (DERSK) days 1 to 7 post disaster

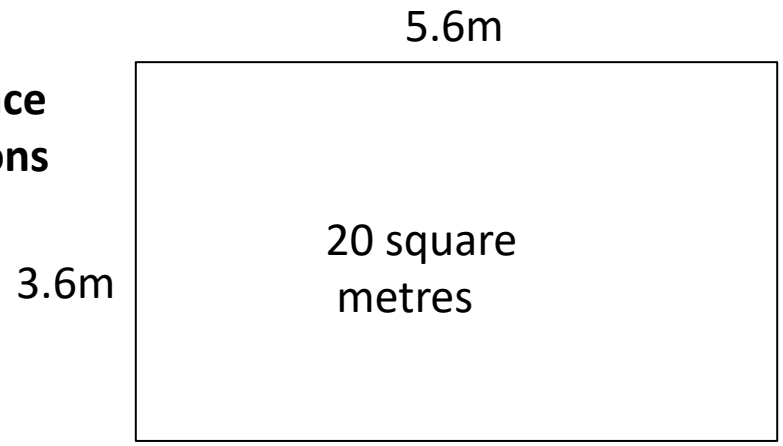
15 bamboo pole kit

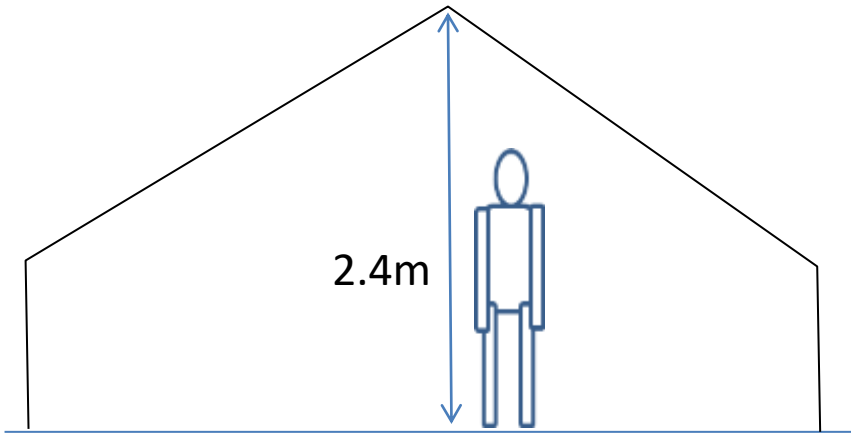
4 x 1.5m
10 x 3m
1 x 4m





Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$17.70
Tarpaulin:	$15
Total DERSK:	**$32.70**

Double Elevated ReciproBoo Shelter Kit (DERSK)

Overview

This double shelter was inspired by the Oxfam shelters built in large numbers at Koshi river disaster in 2008. It attracted the most interest by visiting engineers as it highlighted the strength and flexibility of the reciprocal frame roof.

The Koshi shelters were of a similar design and dimensions to the shelter we built at the workshop but the main difference was the construction of the roof. Whereas the Koshi shelter had a traditional curved split bamboo arrangement the ReciproBoo roof used two spans of reciprocal frames to support tarpaulins.

This shelter has some special advantages that become clear in the following account of the workshop.


Traditional shelter
(Koshi river disaster)

Double Elevated ReciproBoo Shelter Kit (DERSK)

Construction

This was the same as the double shelter except instead of anchoring to the ground, the corners were lifted onto 4 posts.

A small “V” was cut in the top of the central support posts to take the ridge pole. Although this worked well it was felt that the original cross over joint with loop support, used for the double shelter, could also have been used.

Ropes were tied between the side posts to support the tarpaulin but bamboo side poles would have been better.

Consideration should be given to attaching guy ropes to the main support posts and each corner post.

Tying a sliding knot

Sliding the knot up to a node to secure it

Double Elevated ReciproBoo Shelter Kit (DERSK)

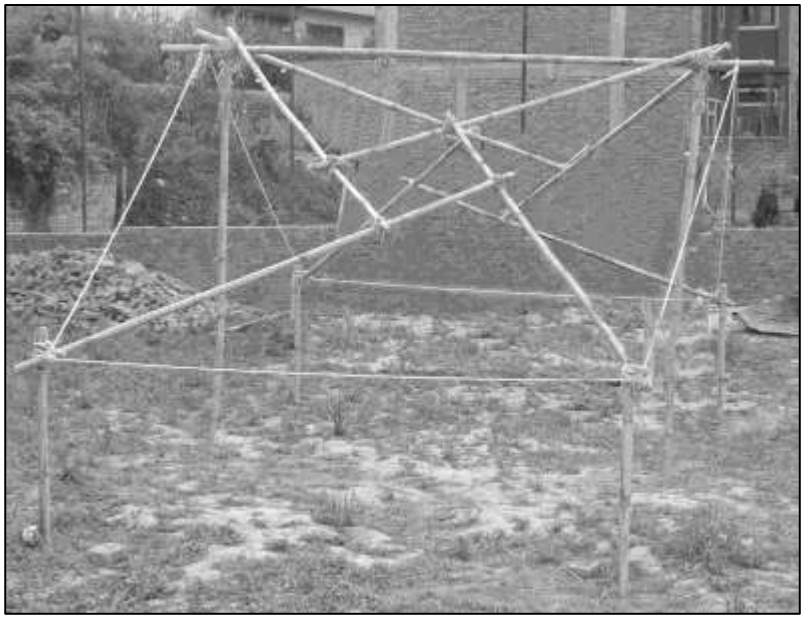
Workshop observations

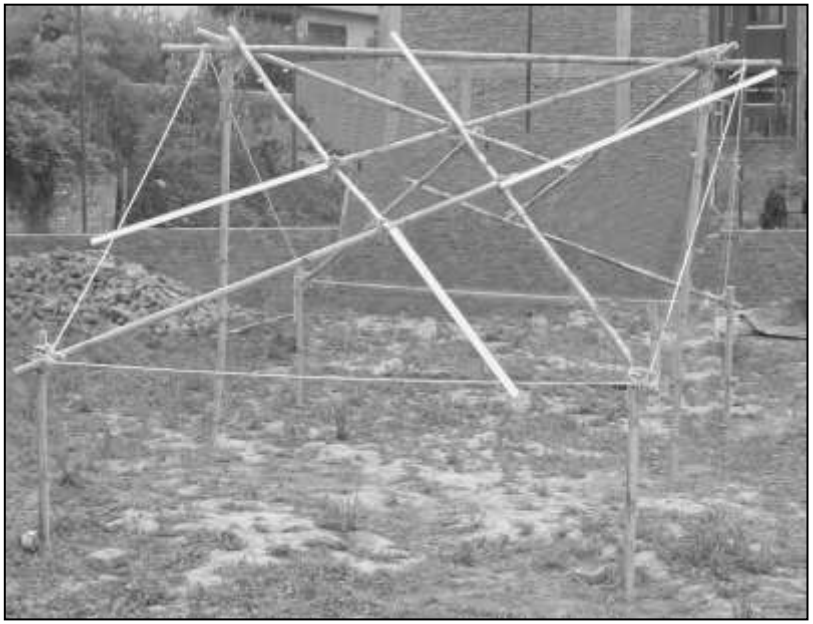
The shelter was easy to build and the resulting living space impressive. The large roof space created a well ventilated shelter.

As green bamboo is cheaper per metre than the rope we used it would be preferable to replace side ropes with poles if available.

Covering the ends of the frame with rubber strips or padded cloth would prevent friction between frame and tarpaulins. Consideration could also be given to fixing the tarpaulin to the frame ends at these points, especially if covering the tarpaulin with cladding.

Engineers attending discussed the option of extending central frame poles to meet side ridge poles as shown in this superimposed photo. It was thought this would add further support for the tarpaulin.



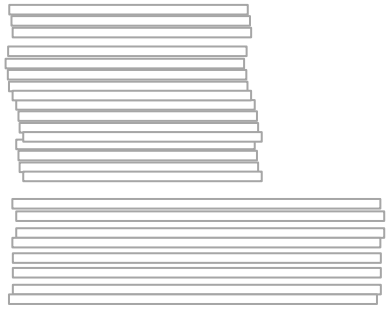


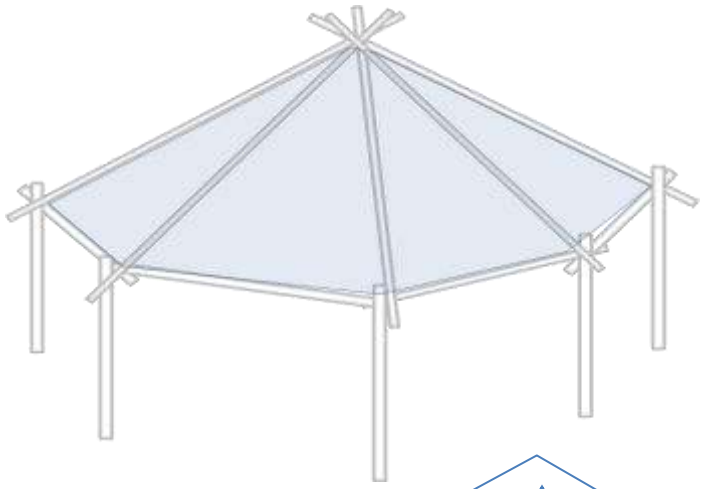
ReciproBoo Shelter — Large 8 pole reciprocal frame transitional shelter

24 bamboo pole kit

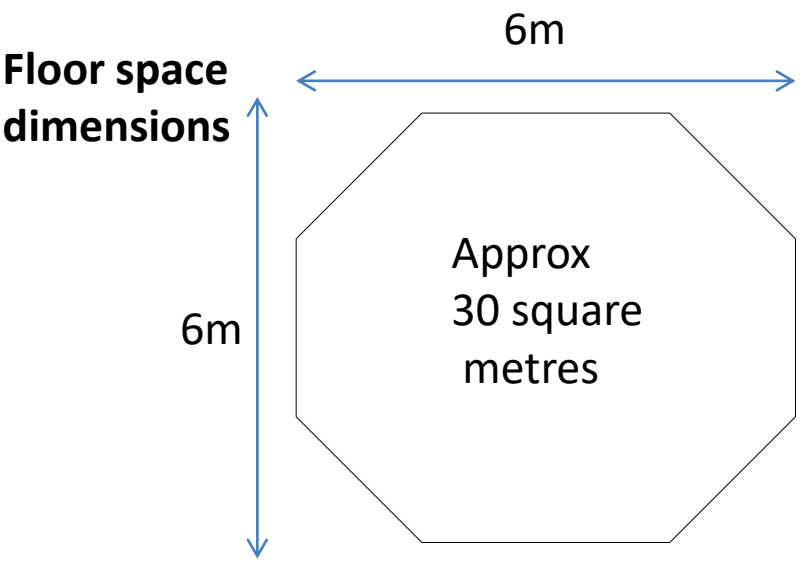
16 x 2.5m

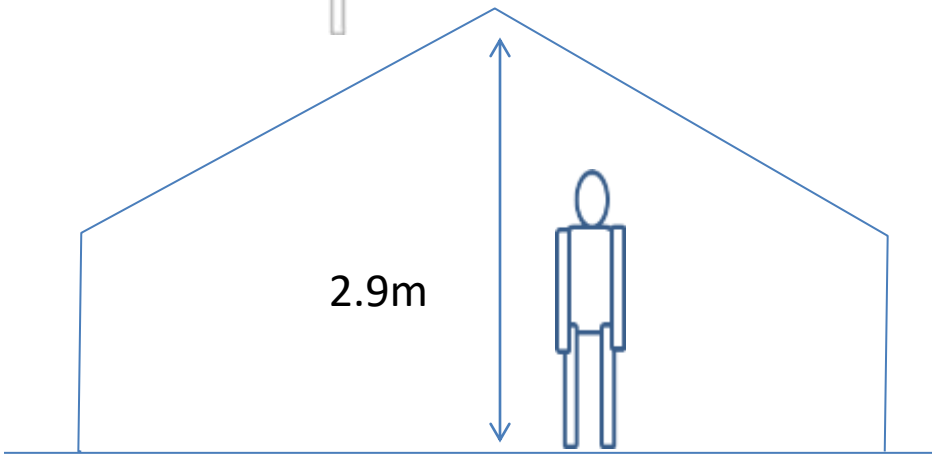
8 x 3.5m





Floor space dimensions





Cost (USD)

Frame (bamboo poles; ropes, lashings)	$21.40
Tarpaulins:	$30
Total RSK:	**$51.40**

Eight pole reciprocal frame roof shelter

Overview

This large shelter was built for demonstration purposes to show the benefits of a self-supporting reciprocal frame roof.

The roof was assembled on the ground and lashed together before being lifted onto 8 support posts.

In this demonstration the support posts were low to facilitate working but posts of 2.5 metre length would normally be used. Ropes were also used instead of bamboo side ridge poles for demonstration purposes.

This type of shelter could be used where a large covered area is required such as community space, distribution depots or classrooms. It is modular and easily adapted to available space and terrain.

Eight pole reciprocal frame roof shelter

Construction

To build this roof with a greater incline requires the use of a central support pole during construction (see this website for details http://bit.ly/14AVXf6)

This central support pole is removed after the roof frame has been lashed together, leaving a self-supporting reciprocal frame roof.

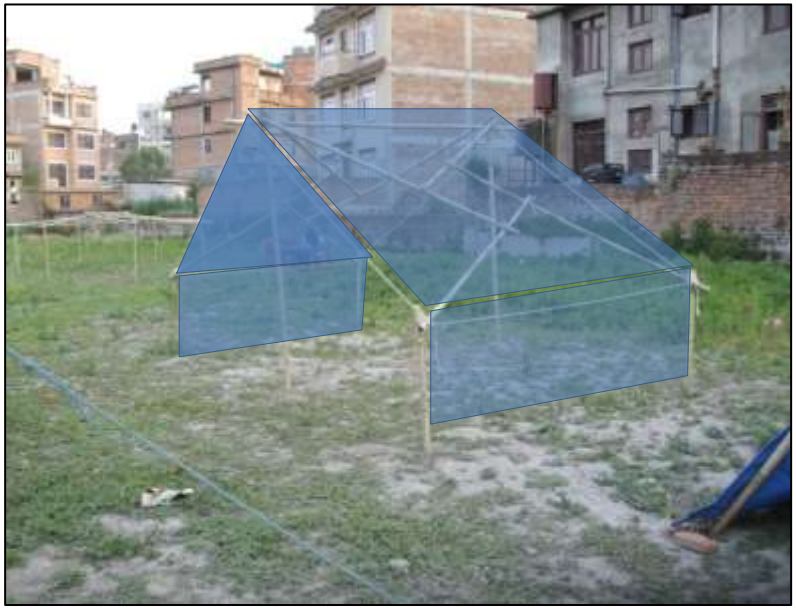
This type of roof not only uses much less bamboo than traditional roofs, it requires no special skills to construct, exerts less spreading forces at its supports and is entirely modular. The central aperture can also be used to increase ventilation if required.

Nepal shelter

In a disaster situation such as the Koshi River floods in 2008 the Nepali people response is to build a traditional shelter using bamboo. This well proven shelter provides a well ventilated dignified living space and uses widely known basic skills for construction.


Traditional shelters

The double elevated ReciproBoo Shelter Kit (DE-RSK) built at this workshop produced a shelter similar in appearance and dimensions but very different in the method of construction. Whereas the traditional shelter roof consists of curved sections of split bamboo and purlins this new shelter had only rigid reciprocal frame bamboo poles.



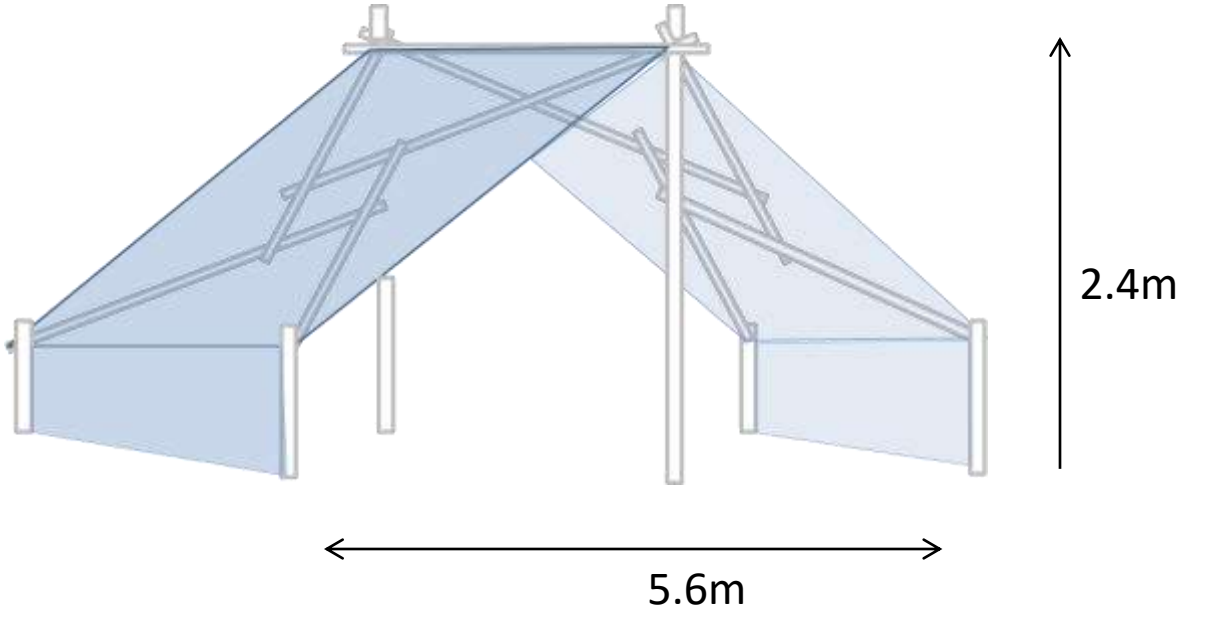
It is worth comparing these two shelters in some detail.

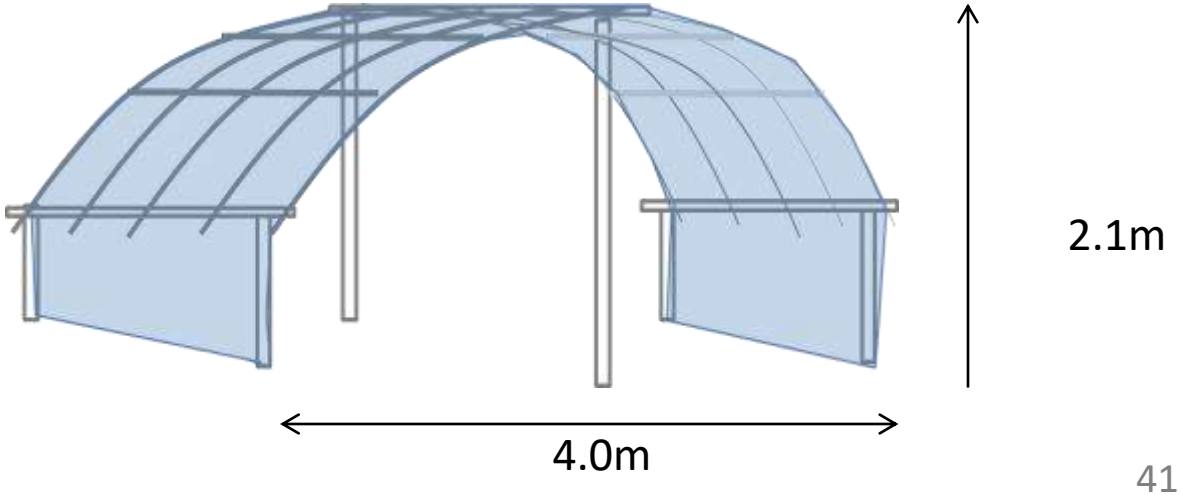
Dimensions

The DERSK is noticeably wider and higher than the traditional shelter.

This is due to the ability of reciprocal frames to span large areas using minimal materials.

The shelter we built used the shorter 2.7m poles for the roof, but the longer 3 metre poles would have made an even larger shelter.





Materials used

By making use of split bamboo the Nepal traditional shelter uses approximately the same amount of bamboo as the DERSK.
However, the DERSK is stronger and can support the weight of cladding. It has a greater roof span and is better ventilated (see later).


Koshi River shelters

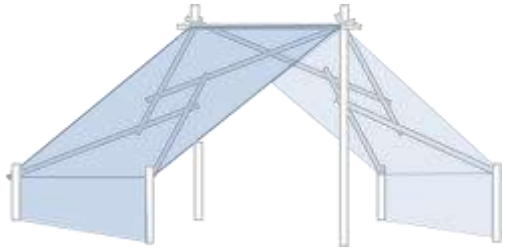
It must also be remembered that in disasters large sections of the community cannot build these traditional shelters and revert to poorly constructed units as shown here at Koshi river.

People in a disaster also tend to resort to this multiple rafter / purlin arrangement as shown here in Pakistan. It is when compared to this type of structure that DERSK uses 33% less bamboo.


Pakistan shelters

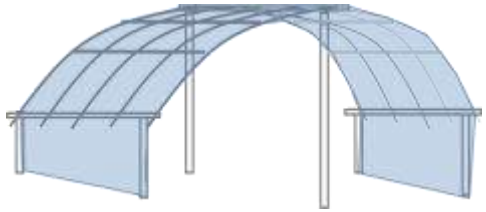
Cost

Buying retail the DERSK costs 1,560 Nepal Rupees (US $ 17.70). This equates to less than US $10 wholesale and even less for green bamboo.



A well made traditional shelter using split bamboo will cost about the same. However, as indicated, the conventional “A” frame shelters cost 33% more per square metre of covered floor space.

Recycling

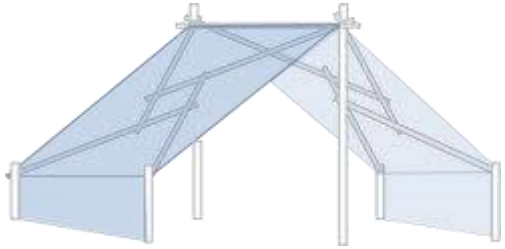


All the bamboo poles in the DERSK can be used again in the construction of a permanent shelter.

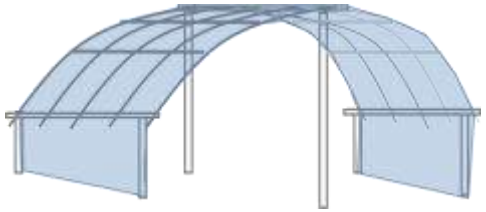
The split bamboo used for the roof of the traditional shelter is unlikely to be used again for construction of a more permanent shelter

Kit options

The DERSK can be made into a portable 15 bamboo pole kit held together with rope. There are only 3 sizes of bamboo pole making mass assembly straightforward.

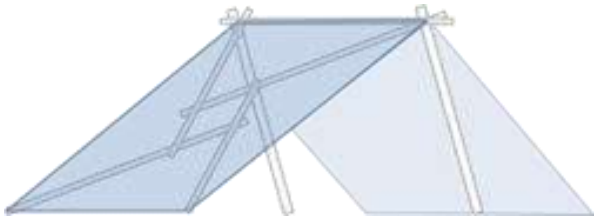


Due to the long lengths of split bamboo required the conventional shelter is practically impossible to make in kit form. This traditional shelter requires 12 bamboo poles and 8 split bamboo hoops.



In contrast the 7 pole basic RSK could be rapidly deployed in an urban disaster situation as could be encountered in Nepal.

However the question has to be asked; do Nepal aid agencies want to preposition kits or can adequate transport logistics make this unnecessary?



Discussion

Ease of construction

The DERSK is easier to construct, requiring only basic cross-lashing skills. The roof joints are lashed together on the ground making it easier to work on. The traditional shelter is more difficult to work on as the split bamboo needs to be attached working overhead. Some skill is needed for splitting the bamboo hoops.

The straight section end walls of the DERSK make it easier to build end walls to the shelter than the curved sections of the traditional shelter.

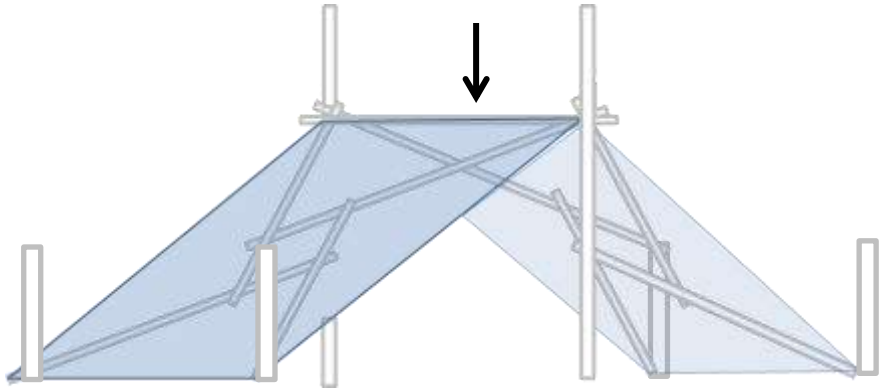
It should be noted that the simple skills required for erecting the basic RSK may be achievable by all members of the family who can then upgrade to the larger shelters later.

Traditional shelter

Discussion

Strength of shelter

The DERSK appears to be a much stronger shelter by virtue of its reciprocal frame roof which can support heavy loading. However it has not been tested in the field long term and the only experimental data we have is comparing it to the steel RSK (see research http://bit.ly/YGh8Lt)



Lowering the roof is simple in severe weather

It does have a unique advantage over other shelters in that it can quickly be lowered to a storm profile which makes it stronger in severe winds.

The steel shelter in lowered storm profile.
A similar shelter option could work with bamboo.

The traditional shelter, as used in the Koshi river disaster, is well proven in the field and all its strengths and weaknesses are well known to aid agencies.

Discussion

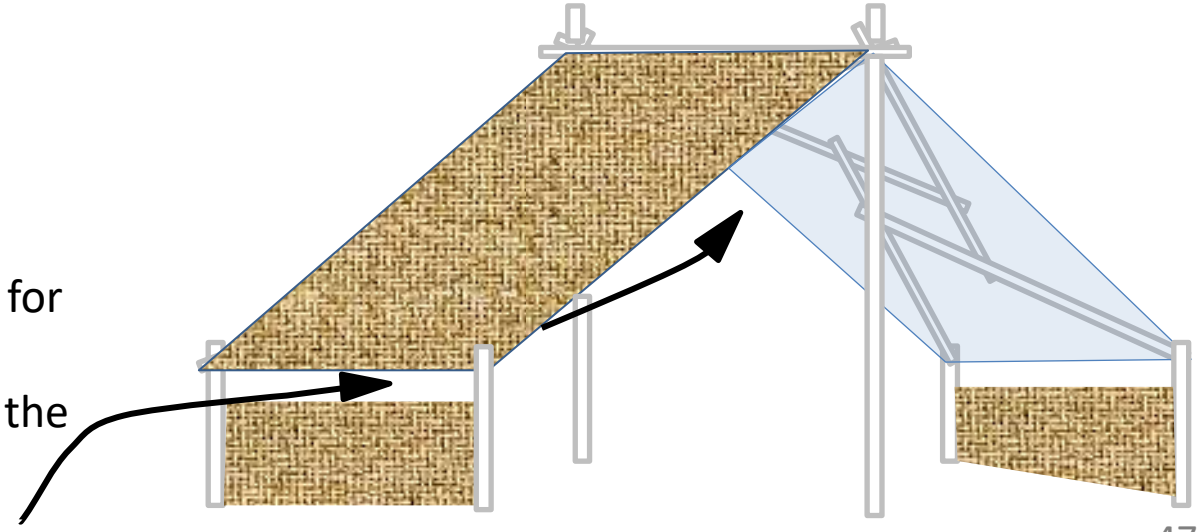
Strength of shelter

There is a desire by beneficiaries to improve the shelters and make them more secure and cooler by adding thatch.

It was intended to demonstrate this ability of the reciprocal frame roof to support this type of insulation at the workshop, but time was not available and it will have to be done at the next workshop

Ventilation

An advantage over the traditional shelter is that it could allow a gap for ventilation high on the walls. This would be difficult to achieve with the curved bamboo sections in the traditional roof.



Discussion

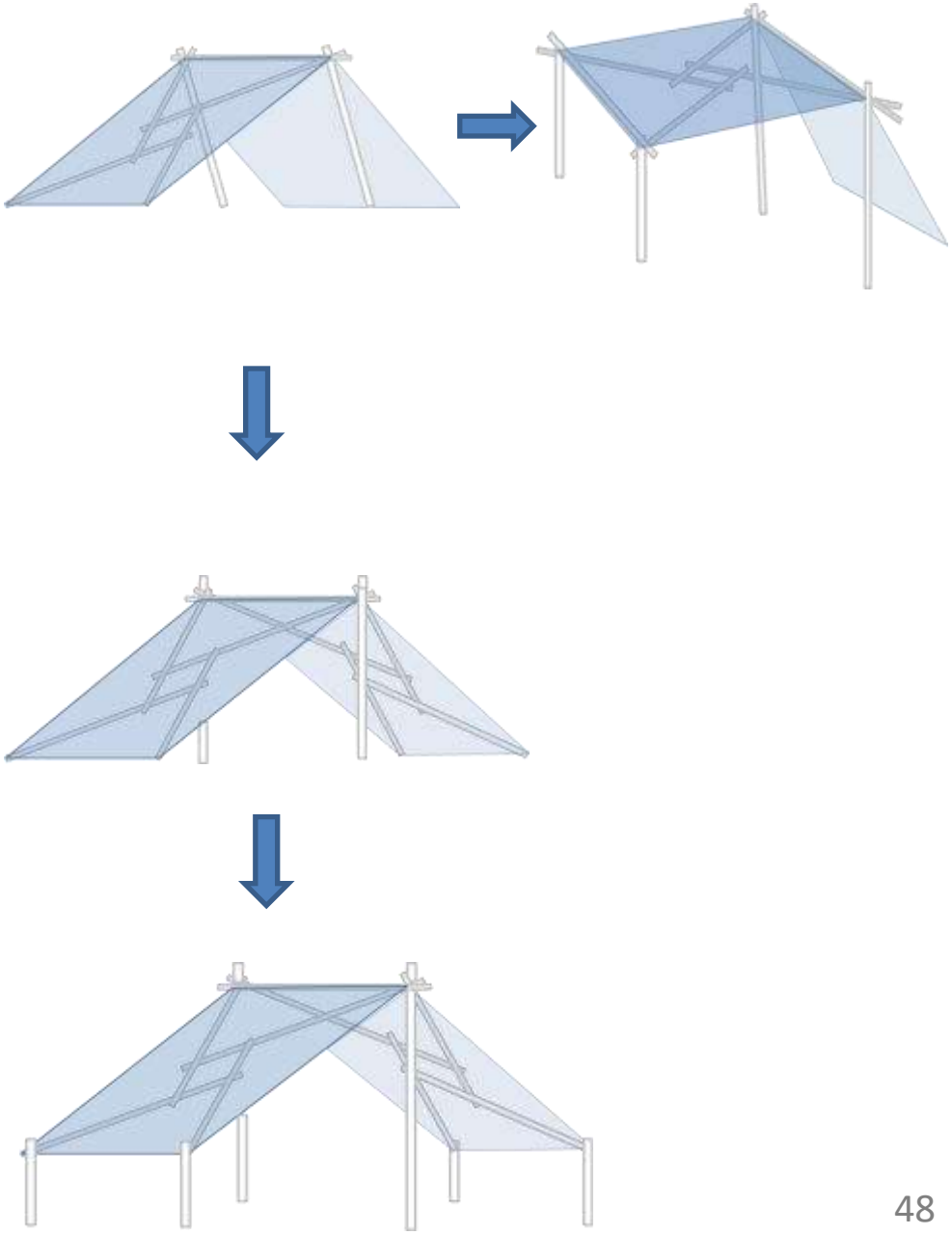
Using the new concept shelters

As for the workshop team it is envisaged that this simple concept will also be rapidly adopted by the local community after a single demonstration.

If kits are being distributed some simple paint markings on the 4 roof poles will ensure a reciprocal frame every time (page 56).

In large scale disasters where bamboo transportation is limited a simple 3 step approach could be considered, from basic RSK to double RSK to DERSK.

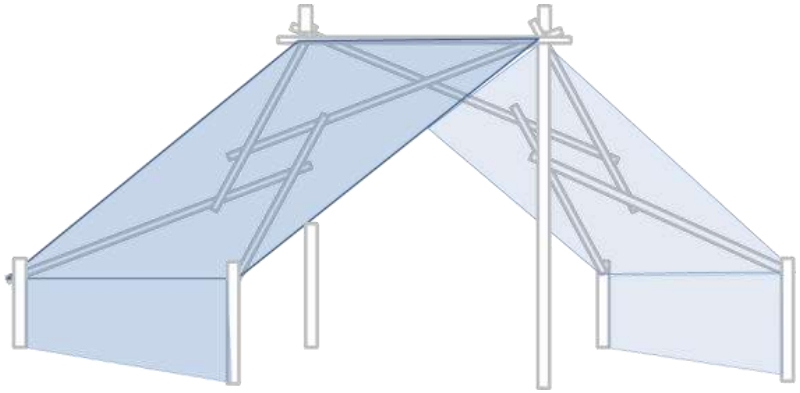
The basic RSK has particular advantages over conventional shelters in urban disasters where it can adapt to use existing walls and masonry in any space, slope or terrain.



Discussion

Conclusions

The DERSK shelter offers:



- ✓ A stronger roof structure
- ✓ Increased floor space due to larger span
- ✓ Higher better ventilated roof space
- ✓ An option to clad the roof making it cooler
- ✓ All straight bamboo components easily repaired
- ✓ Ease of disassembly to move if required

Using the bamboo shelter:

- ❑ If fresh cut green bamboo is used for this shelter it is suggested that 4cm diameter frame poles are used to achieve the required strength.

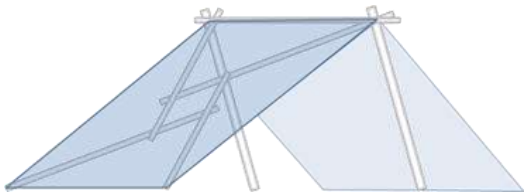
- ❑ The necessity to protect the tarpaulin by padding the protruding edges of the frame should also be considered with this shelter.

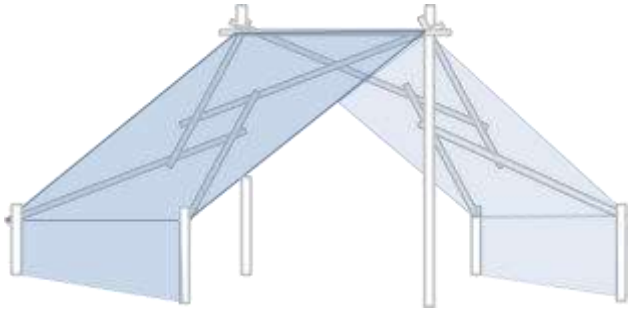
Discussion

Future proposals: Nepal

A joint workshop

- ReciproBoo, Bikalpa, Nepal aid agencies and other parties.
- Build a traditional shelter and compare directly with the DERSK
- Strength testing / are side ridge poles needed long term?
- Confirm exceptional weight bearing using cladding.
- Upgrade green bamboo specification if required.
- Determine single or double anchor points for side ropes.
- Complete tarpaulin attachments to frame.
- Build full scale 8 pole shelter if needed.



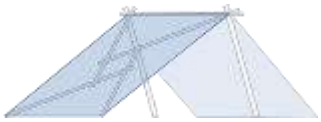


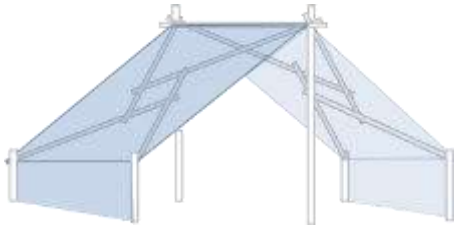
Field deployment of shelters

- Work with local government and aid agencies to see how these types of shelter kit can improve disaster preparedness.
- Consider a pilot scheme to assess this type of shelter deployment.
- Consider stockpiling shelter kits that can be rapidly mobilised when needed. A resource of prepared dry bamboo for construction would be invaluable.

Discussion

Future proposals: other countries





Joint in country workshop

- Identify suitability of local bamboo for this type of shelter.
- Identify locally available lashings and ropes for shelter.
- Compare traditional shelter construction methods used in country and assess needs for this type of shelter.
- Complete the unfinished work in Nepal: side poles/cladding/tarpaulin attachment etc.

Disaster preparedness

- Work with local government and aid agencies to see how these types of shelter kit can improve disaster preparedness.
- Consider a pilot scheme to assess this type of shelter deployment.
- Consider stockpiling shelter kits that can be rapidly mobilised when needed.

Contact details

If you have any suggestions for introducing this shelter construction concept to a country please contact Shaun Halbert at shaunvet@hotmail.co.uk or phone +44(0)7890401558

Bamboo

Used locally for construction, believed to be B.Vulgaris species

Two forms of the bamboo were used for the workshop:

1. **Green bamboo**

   Fresh cut from Sundarijal region 15Km north east of Kathmandu.
   This was cut to full length, approximately 12 metres and side branches trimmed on site.
   Maximum diameter 7cm tapering to zero.
   The intention was to simulate the type of bamboo that is cut in response to a disaster situation.

Green bamboo

2. **Dry bamboo**

   Purchased locally Kathmandu.
   Pre-cut to 6 metre lengths.
   Maximum diameter 5cms tapering to 2.5cm

Dry bamboo

Lashing materials

1. Jute twine

Purchased in 3m lengths from any local store.
Used locally for lashing bamboo.

Jute twine

2. Wire

Standard steel wire readily available local stores.

Steel wire

3. Rubber strips

Samples examined were too friable for lashings so not used. Apparently strips of tyre inner-tubes could be used for covering ends of poles to prevent tarpaulin damage.

Ropes

1. Cotton ropes

Braided, approximately 0.8mm diameter. Local hardware stores.

2. Synthetic plastic / polypropylene rope/ twine

Readily available but not used as difficult to attach to bamboo. Could possibly be used for guy ropes.

Tarpaulins

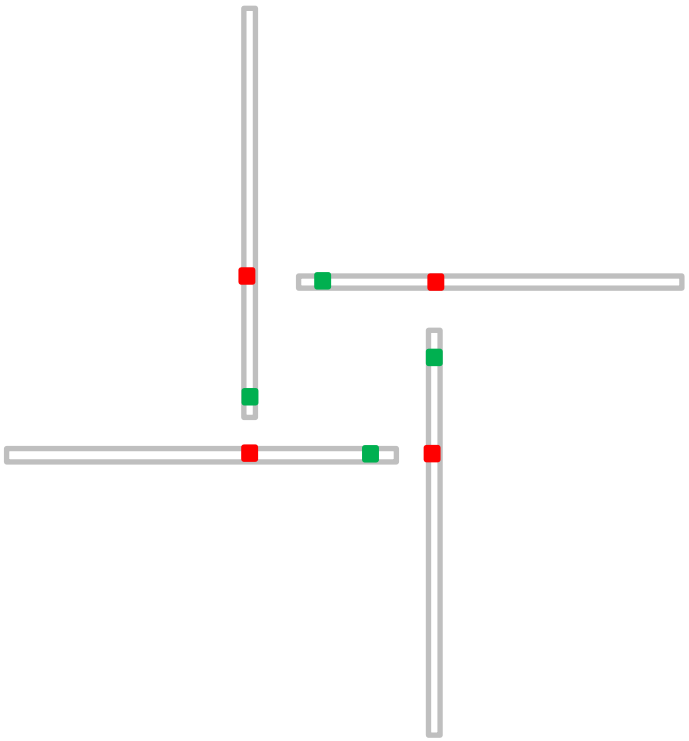
Available local hardware stores but of variable quality. Laminated tarps available but expensive. Blue plastic sheeting available in 2 metre wide rolls but of poor quality. All these tarpaulins are unlikely to have been treated with a fire retardant and so constitute a fire risk.
Red Cross and Oxfam kindly loaned the tarps used.

Appendix 2. Tools

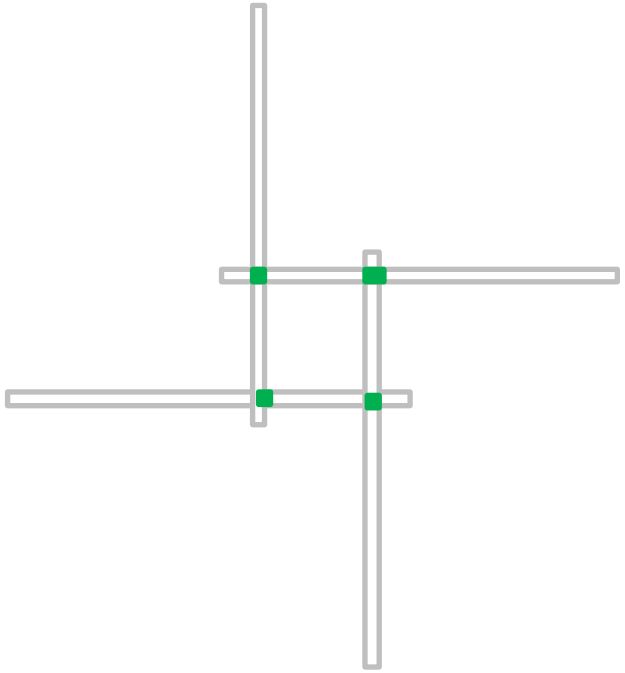
1. Hacksaw x 3
2. Machete x 1
3. Knife x 1
4. Pliers x 1
5. Pick x 1
6. Tape measure x 1

Reciproboo Shelter Kit (RSK) assembly

Step 1

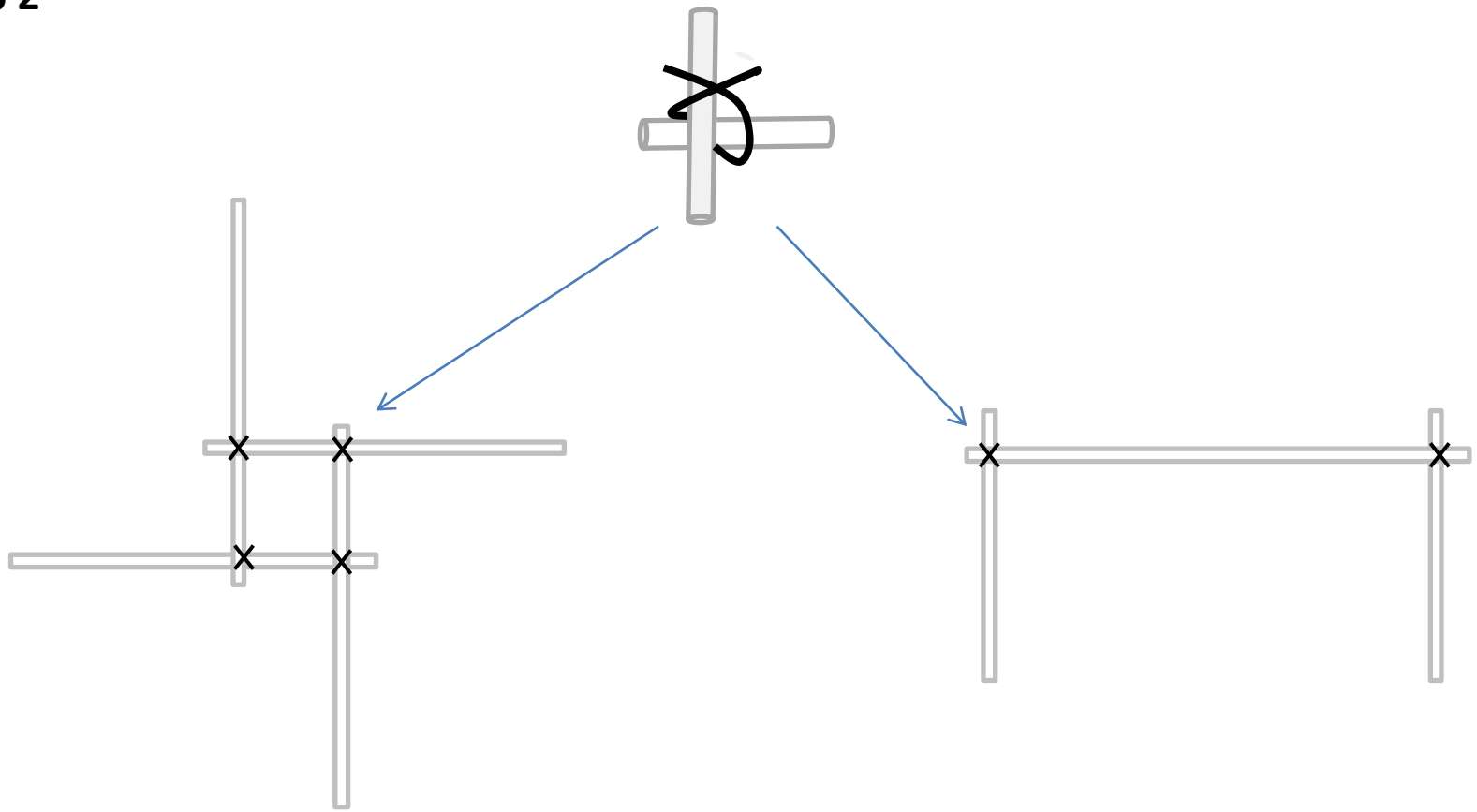


Lay the 4 marked bamboo poles on the ground as shown.



Overlap the 4 bamboo poles so that the green mark covers the red mark. This ensures a reciprocal frame.

Step 2



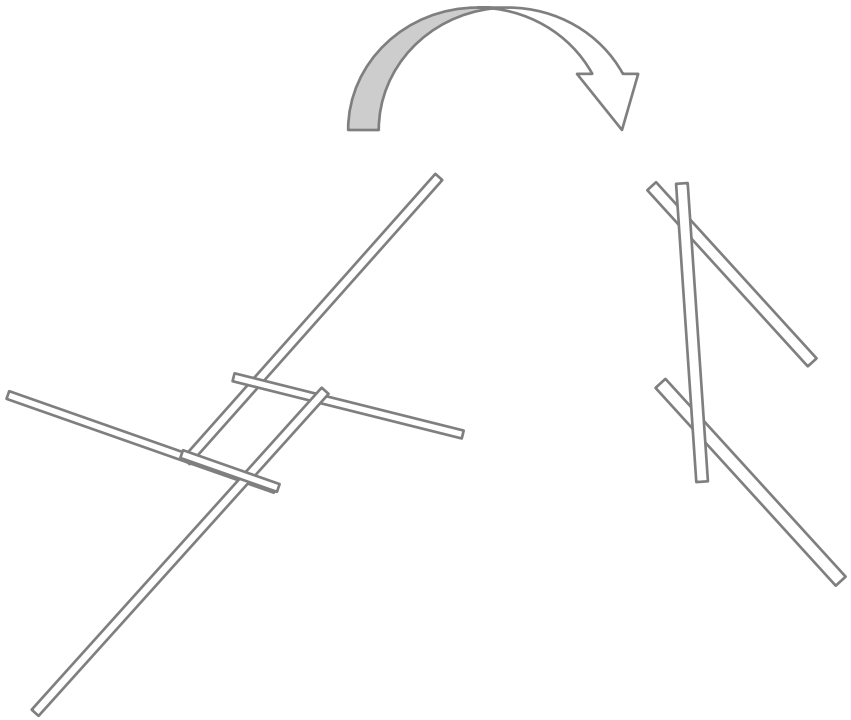
Cross lash the 4 joints.

This is the roof.

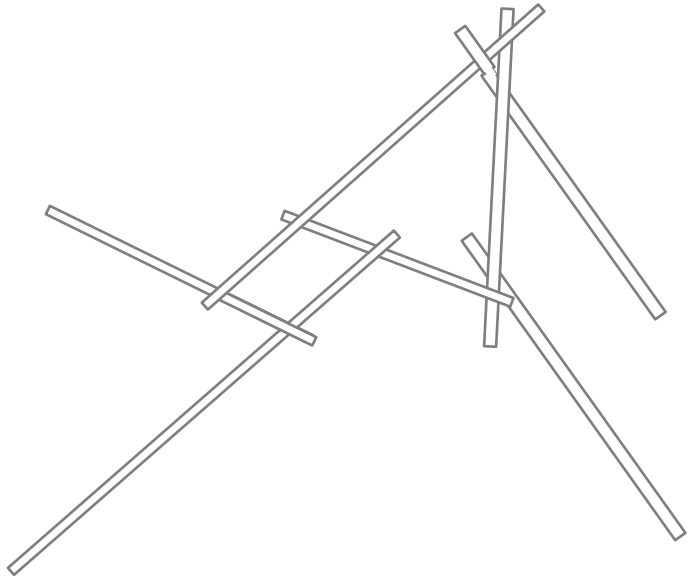
Lay the longest pole on top of the two short poles as above and cross lash the joints.

This is the support frame.

Step 3



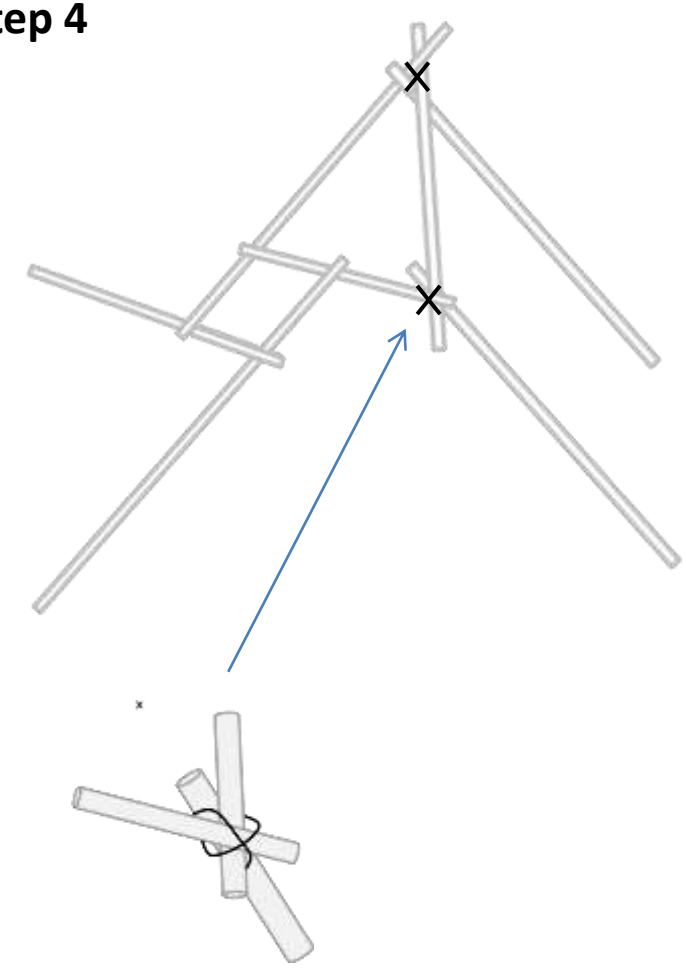
Lift roof onto the support frame.



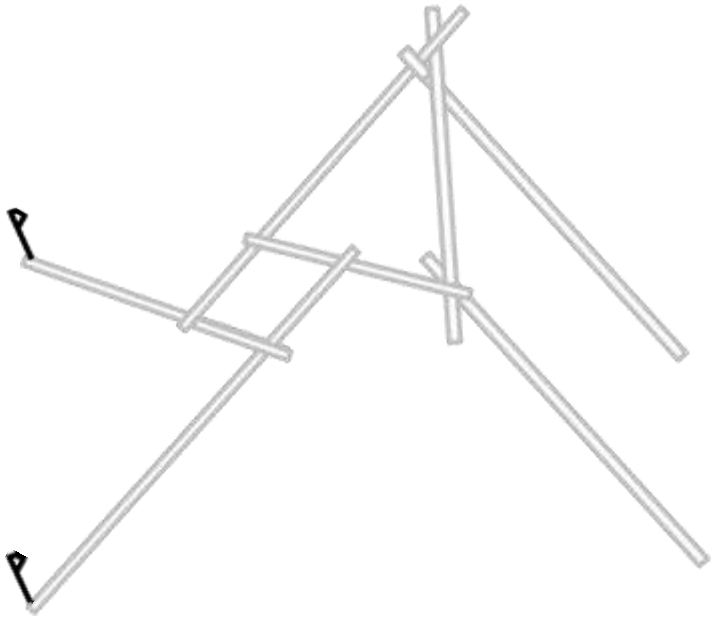
Position the roof poles outside the support frame as shown.

Reciproboo Shelter Kit (RSK) assembly

Step 4

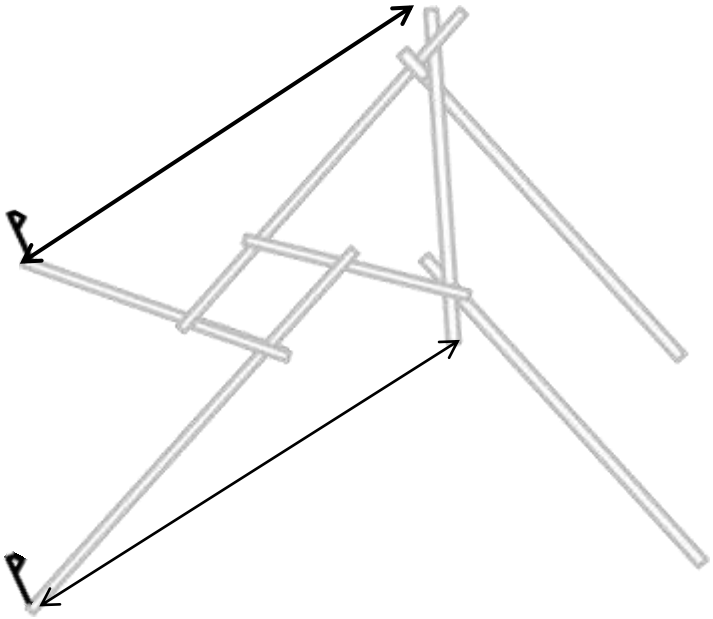


Cross lash the roof to the support frame.

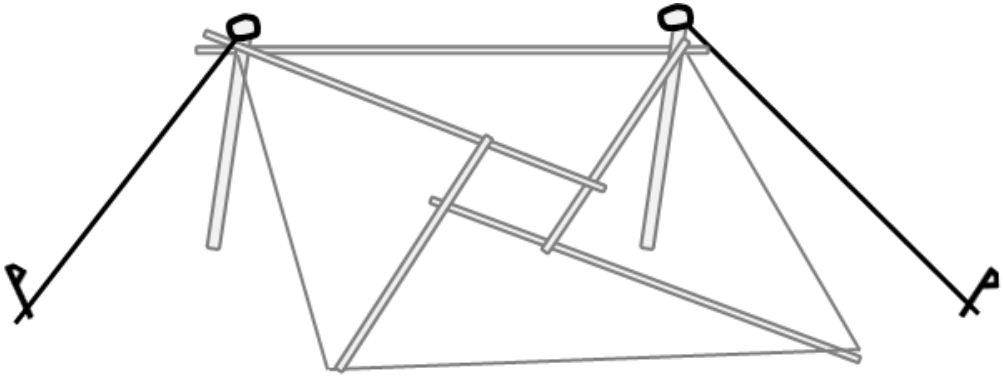


Fix the lower ends of roof frame to the ground using a stake and rope.

Step 5



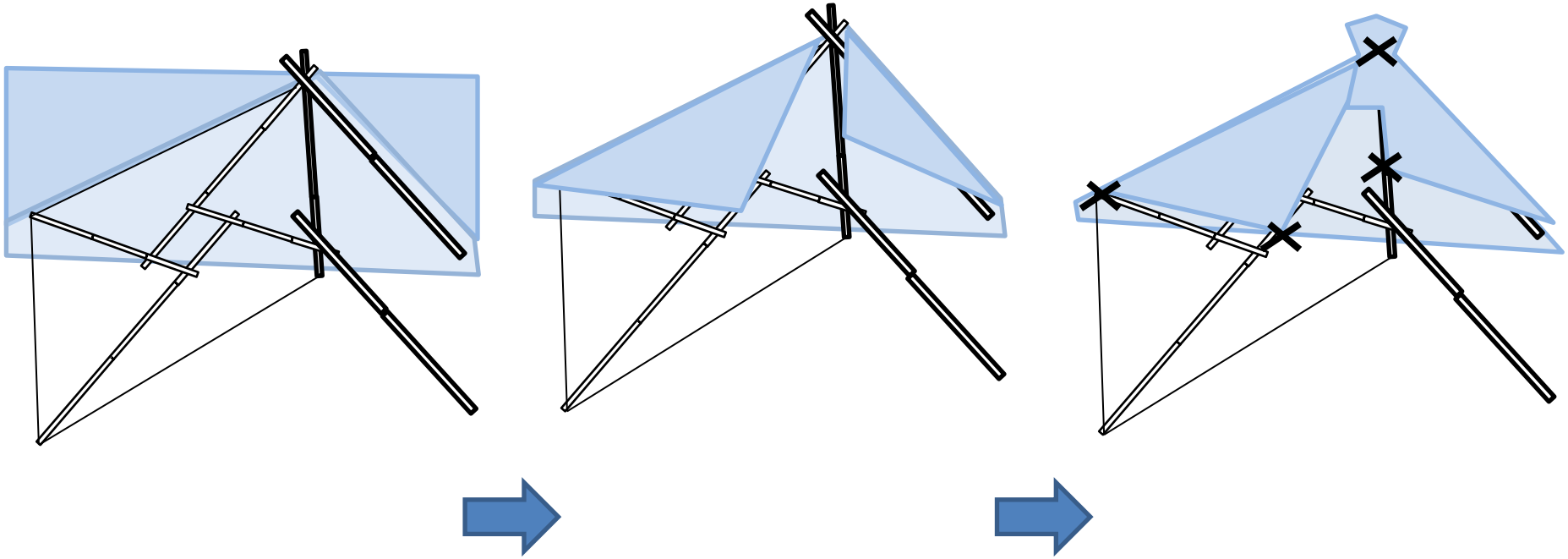
Tie a side rope between the stake and the end of the ridge pole on each side.



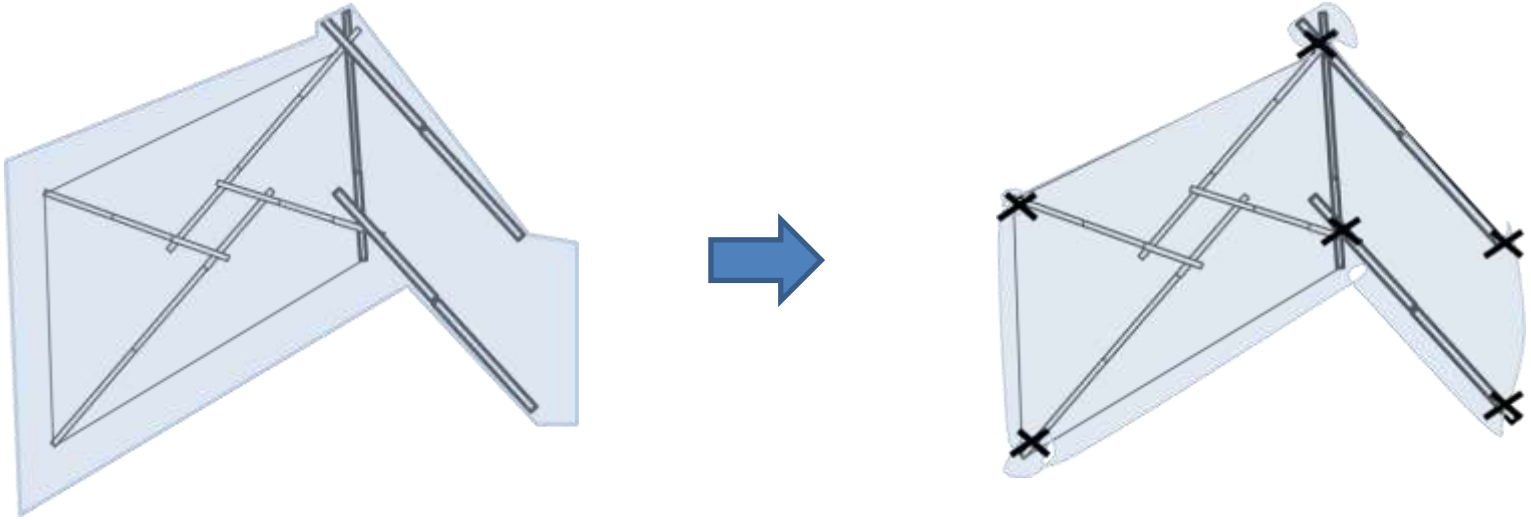
Attach guy ropes to the top of support poles and stake out to sides.

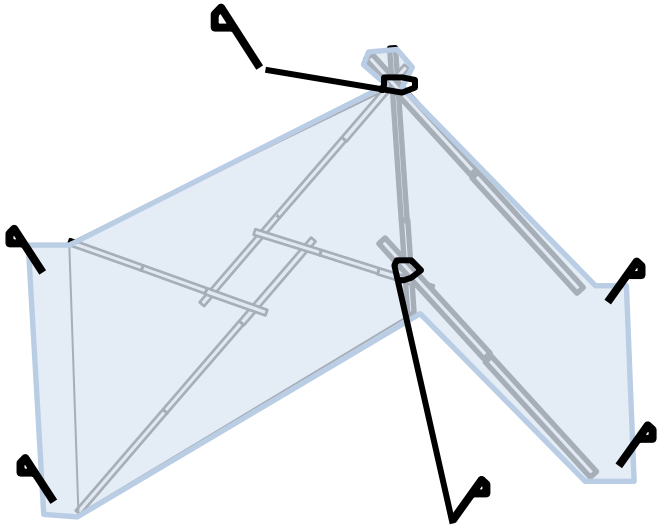
Step 6

If sides are to be built a 6 x 4m tarpaulin is cut in two and attached to the frame as follows:



Step 7 The main tarpaulin is then pulled over the frame and secured.





The side guy ropes are re-attached and anchored to the ground to complete the shelter.

Appendix 4

Cost of shelters

	ReciproBoo Shelter Kit (RSK) Retail $US	Elevated RSK Retail $US	Cold weather RSK Retail $US	Double RSK Retail $US	Double elevated ReciproBoo shelter (DERSK) Retail $US	8 pole transitional shelter Retail $US
Bamboo	6.00	8.50	5.80	9.70	11.40	19.30
Rope	2.90	2.90	2.30	4.50	4.90	Bamboo ridge poles used instead of rope
Lashings	0.70	1.10	0.90	1.10	1.40	2.90
Total cost of frame kit	9.60	12.50	9.00	15.30	17.70	22.20
Tarpaulin	15.00	15.00	15.00	15.00	15.00	30.00
Total cost of shelter	24.60	27.50	24.00	30.30	32.70	52.20

Costs are for dry bamboo, cotton rope and jute lashings purchased retail on streets of Kathmandu. It is anticipated costs can be reduced by at least a third if purchasing the items bulk wholesale.