MANUAL DE CONSTRUÇÃO DE SECADOR SOLAR E SUPORTE PARA PAINEL FOTOVOLTAICO DE BAIXO CUSTO E BAIXO IMPACTO AMBIENTAL

Low cost and low environmental impact solar crops dryer and photovoltaic panel mounting construction manuals

Manuales de construcción de secador solar y soporte para panel fotovoltaico de bajo costo e bajo impacto ambiental

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PREFACE

This manual is part of the Project “Technology-based climate change impact mitigation in small coffee farms in Jamaica and Mexico” funded by Fulbright Commission from 2016 to 2018. The project was led by Dr. João Onofre P. Pinto (coordinator) - Universidade Federal de Mato Grosso do Sul / Brazil, Dr. Enrique J. C. Barriga - Pontifical Catholic University / Ecuador, Dr. Rachael Garrett - Boston University / USA, Ms. Sharon N. G. Nelson - Technological University / Jamaica, and Dr. Erick de la Barrera - National Autonomous University of Mexico / Mexico.

In this project, we have developed two models of photovoltaic panels mounting structure and one of solar crop dryer using mainly bamboo and soil. They are easy to build, and final users - the rural producers - can build them themselves. The design of the solar crop dryer is an adaptation from the model developed by researchers from Cenicafé, Colombia (OLIVEROS et al., 2008).

Seeking the most suitable application in rural areas, we targeted maximizing the ease of transportation and assembly and the uvse of simple components generally found in the majority of agricultural product stores. The proposal prioritized the care with weather exposure of the pieces of bamboo since chemical treatments were not used to be aligned with standards of organic production as well. All structures performed well when exposed to the rain and the sun.

The construction manuals are available in Portuguese, English and Spanish. Access them for free at: https://repositorio.ufms.br/handle/123456789/3421

If you have any questions or are setting up a workshop to build these products and need help, please contact us:

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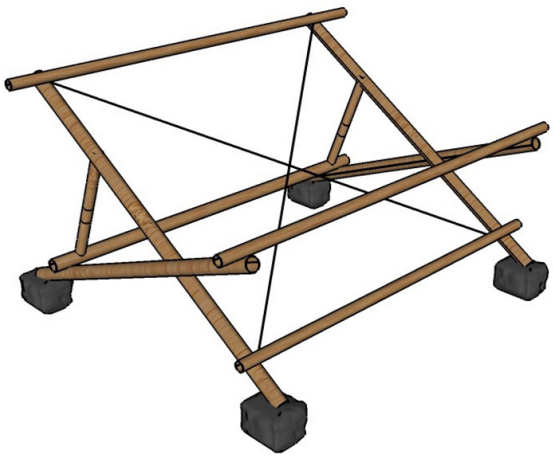
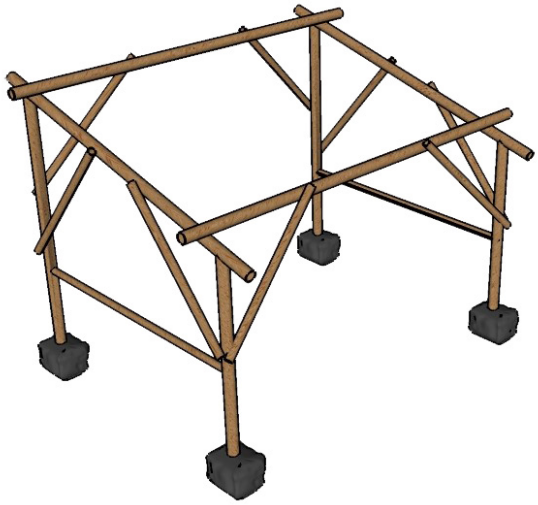
PARTE 2

BAMBOO MOUNTING STRUCTURE FOR PHOTOVOLTAIC PANEL: FOLDABLE AND FIXED





GETTING TO KNOW THE BAMBOO MOUNTING STRUCTURE FOR PHOTOVOLTAIC PANELS...

In this manual, two types of mounting structures for photovoltaic panels are presented: foldable and fixed:

- The foldable is compact (easy transportation) and allows tilt adjustment, even after it is mounted.
- The fixed is easy to build (more intuitive) and uses less variety of materials than the foldable model.

The foldable mounting structure consists of:

- Foundation: fabric formwork filled with soil-cement to anchor the light system to the ground;
- Structure: resembles a beach chair, which folds to become portable;
- Capacity: supports up to two 3' wide photovoltaic panels;
- Slope: flexible adjustment (winter-summer), using bamboo stems. The dimensions adopted in this manual result in an inclination of 15 degrees.

The fixed mounting structure consists of:

- Foundation: fabric formwork filled with soil-cement to anchors the light system to the ground;
- Legs: like four legs of an inclined table, braced;
- Capacity: supports up to two 3' wide photovoltaic panels;
- Slope: it is not flexible, i.e., once the length of the legs is defined, the slope cannot be changed. The dimensions adopted in this manual result in an inclination of 15 degrees.

Search Internet sites to see what inclination will work best for you needs.

BEFORE STARTING...

1. Use bamboos stems that are ripe (opaque surface, with mosses and lichens, but not rotten), dry, straight and free from attack by insects and fungi.

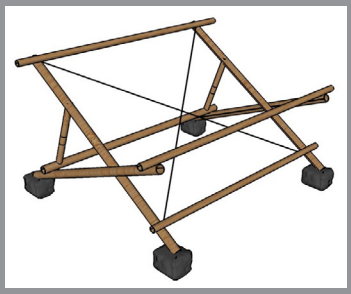
2. Gather materials and tools (see next page).

3. If possible, work on a large table to help cut and pre-assemble parts.

4. Do not hammer nails into the bamboo. All holes must be made on the stems with electric drill and drill bits.

5. Wear proper PPE (personal protective equipment): gloves, safety glasses and safety shoes.

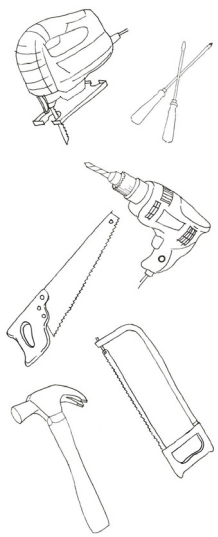
2.1. FOLDABLE MOUNTING STRUCTURE



Materials to build foldable mounting structure

item	quantity	purpose
Steel wire rope clamp	4 un.	to fasten the steel wire to the hook and eye turnbuckle
Rubber sealing washer (1/4” internal diameter)	20 un.	to seal holes in bamboo poles
Annealed wire	1 lb	to anchor the mounting structures to the ground
Washer (1/4”)	20 un.	to fasten the bamboo stems
Threaded bar (1/4”, 3’ length)	4 un.	to fasten the bamboo stems
Steel wire (1/8”)	18’	to brace the mounting structure
Solar panel mid clamp	2 un.	to fasten the photovoltaic panels to the mounting structure
Solar panel mounting Z bracket	4 un.	to fasten the photovoltaic panels to the mounting structure
Cement	55 lb	to make the mounting structure bases
Hook and eye turnbuckle	2 un.	to stretch the steel cable
Nylon bricklayer line	40’	to sew the shade cloth
Self-drilling screws (1/4” x 1.1/2”)	6 un.	to fasten the photovoltaic panels to the mounting structure
Nuts (1/4”)	40 un.	to fasten the bamboo stems (20 to be used as lock nuts)
Shade cloth (13’ width)	3’	to make the mounting structure bases

Tools to build foldable mounting structure



item	purpose
Pliers	general use
Bow saw	to cut the bamboo into stems
Bucket	to make the mounting structure bases
Long high-speed drill bit (5/16”)	to drill various bamboo stems simultaneously
Hand held pole hole digger	to make the mounting structure bases
Combined key set	to tighten nuts
Hand tamper	to make the mounting structure bases
Hoe	to make the mounting structure bases
Crayons	to mark the bamboo stems
High-speed drill bit set	to drill bamboo stems
Hole saw set	to drill wide holes in bamboo stems
Carpenter’s pencil	general use
Hammer	general use
Root slayer shovel	to make the mounting structure bases
Electric drill/screw driver	general use
Scissors	to cut shade cloth
Measuring tape (16’)	general use

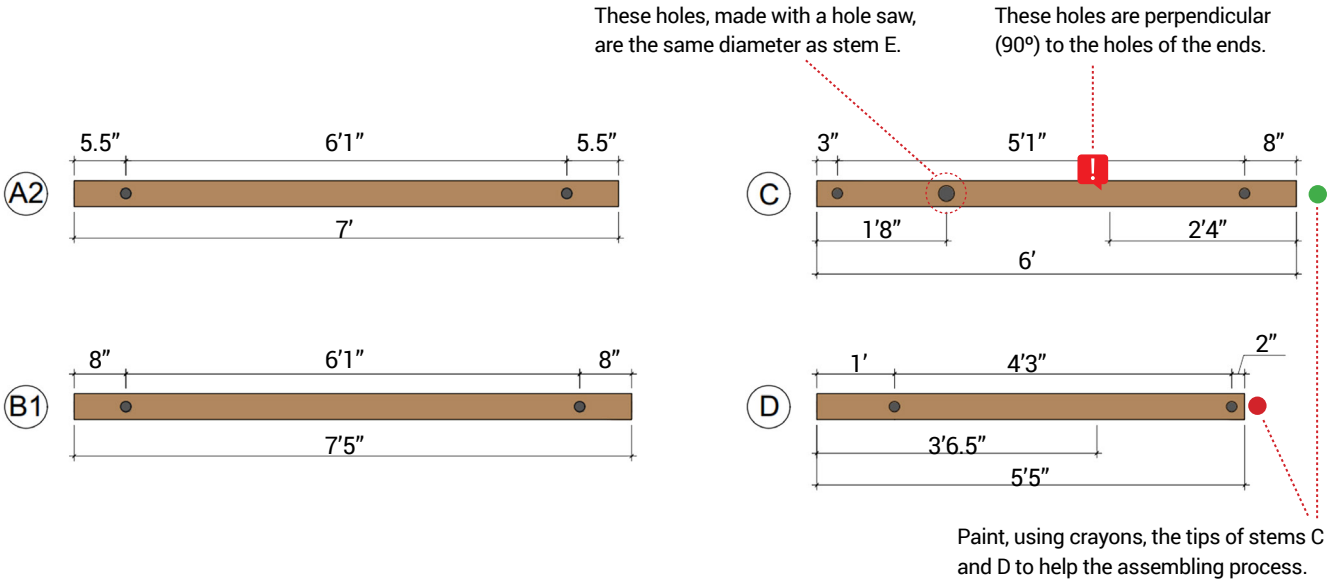
STEP 1: cut the bamboos to produce the mounting structure stems.

stem	quantity	length (inches and ft)	diameter (inches)	wall thickness (inches)
A1	1	7’5”	4” to 5”	0.4” to 0.6”
A2	1	7’	4” to 5”	0.4” to 0.6”
B1	1	7’5”	4” to 5”	0.4” to 0.6”
B2	1	7’	4” to 5”	0.4” to 0.6”
C	2	6’	4” to 5”	0.6”
D	2	5’5”	4” to 5”	0.4” to 0.6”
E	2	2’2”	2”	0.4” to 0.6”

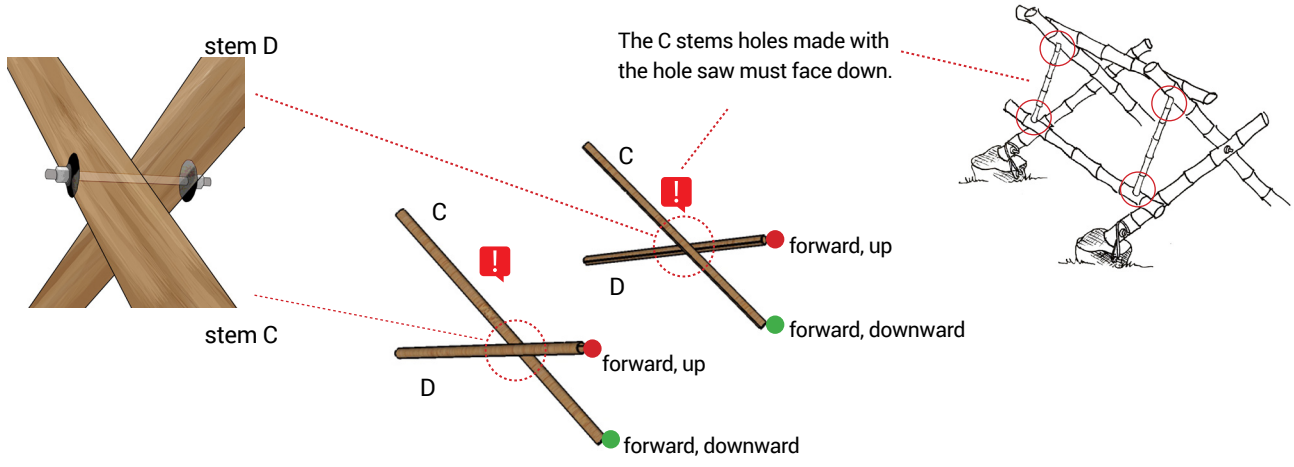
Preserve the bamboo node at the ends or make lids using the bamboo itself (see step 13). This helps to give more resistance and durability to the mounting structure.

C stems should be made of very thick-walled bamboos, as they will support more load than the others.

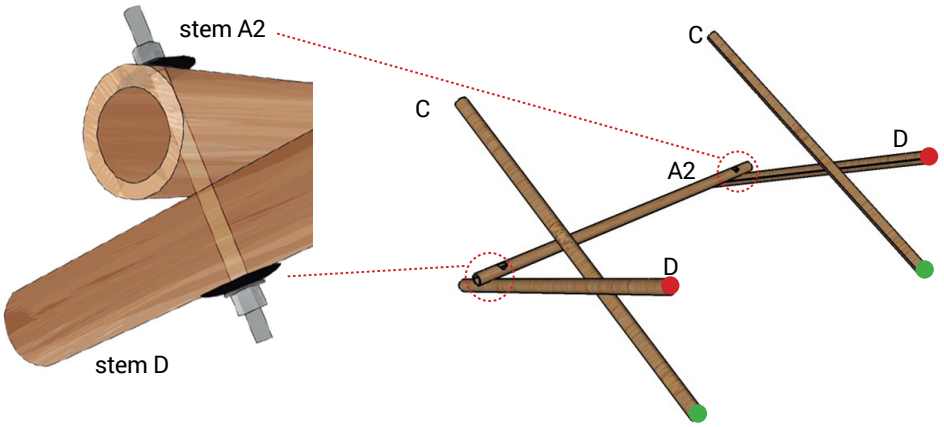
STEP 2: drill the stems A2, B1, C and D with a 5/16” long drill. Do not drill the stems A1 and B2 yet.



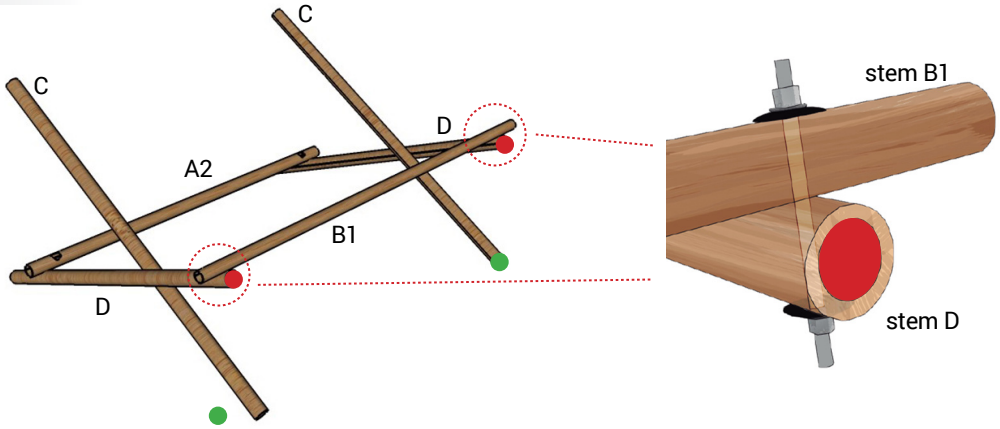
STEP 3: attach the stems C (inside) and D (outside) to make an “X”. Fasten with threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



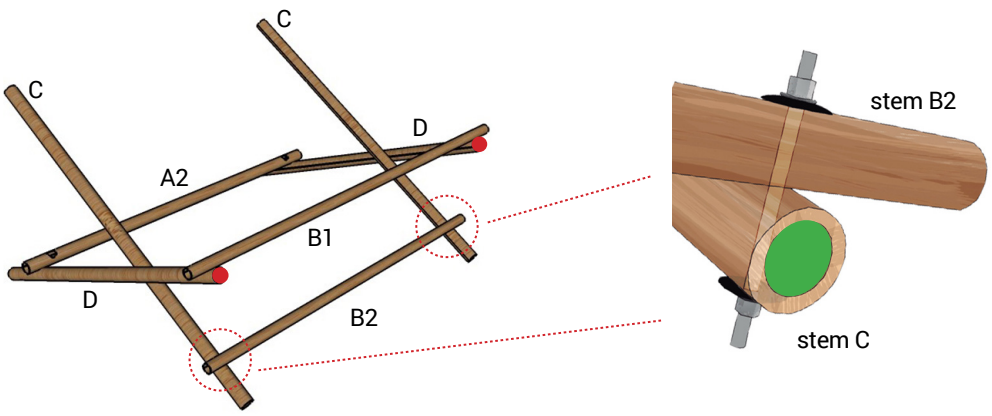
STEP 4: support stem A2 on stems D, forming a “U”. Fasten them with threaded bars, nuts, lock nuts, washers and rubber sealing washers. The mounting structure does not yet stand on its own. So, in order not to get confused, use the painted tips to position it correctly.



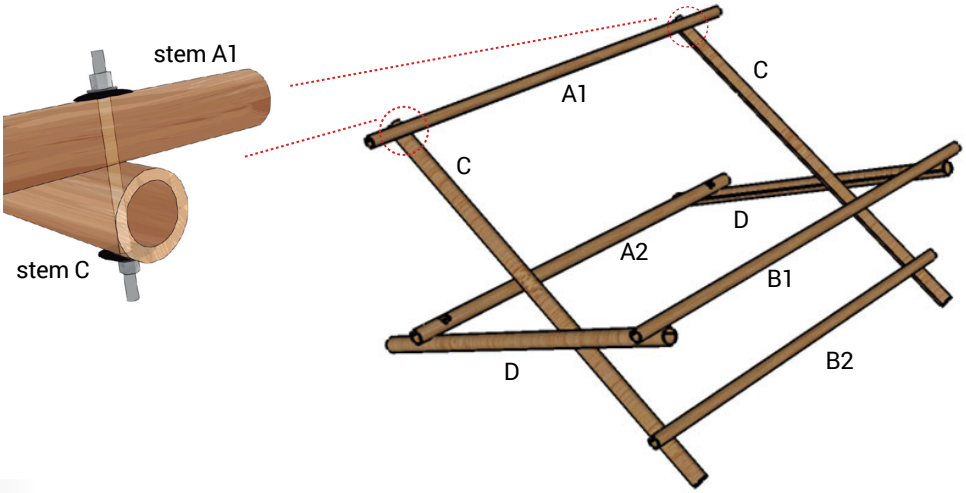
STEP 5: support stem B1 on stems D. Fasten them with threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



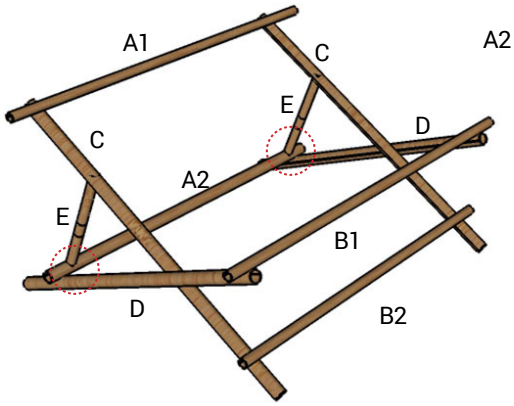
STEP 6: drill stem B2. Measure the position of the hole to match the holes in the C stems. Fasten with threaded bars, nuts, lock nuts, washers, and rubber sealing washers.

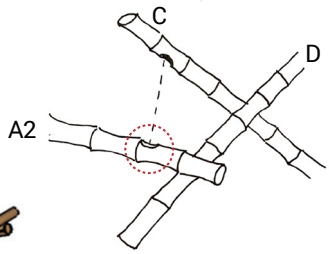


STEP 7: repeat Step 6 with stem A1. Measure the position of the hole to match the holes in the C stems. Fasten with threaded bars, nuts, lock nuts, washers, and rubber sealing washers.

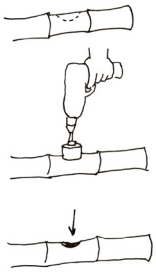


STEP 8: fit the stems E into the holes made in C.





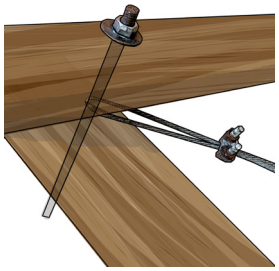
Draw the diameter of stem E on A2.



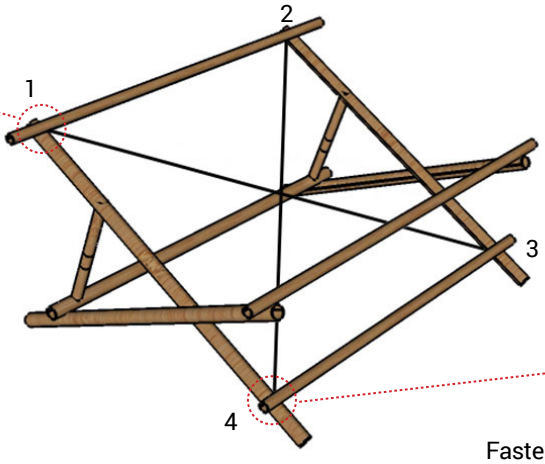
Drill using hole saw.

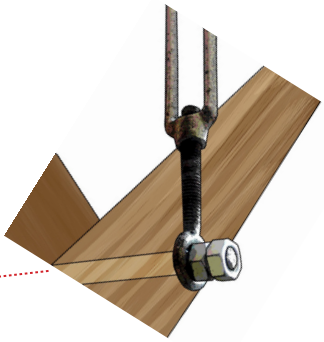
Make a drain (hole underneath stem A2) to avoid rainwater retention.

STEP 9: brace the structure with steel cables connecting point 1 to 3, and point 2 to 4. Use hook and eye turnbuckles and steel wire rope clamps. Tighten the cable until the support is steady..



Pass the steel wire between the bamboo stems.



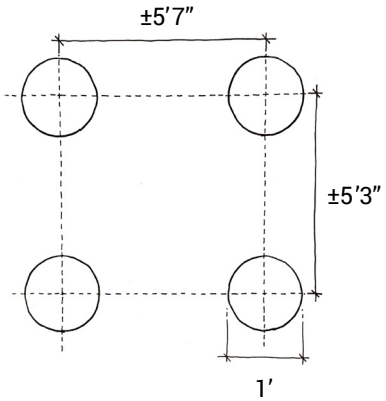


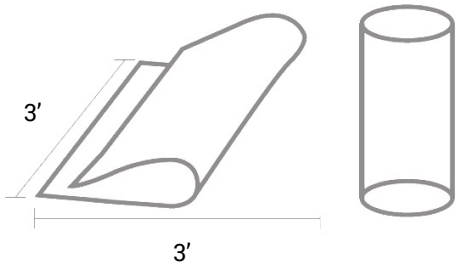
Fasten the hook and eye turnbuckles to the threaded bar.

Congratulations!

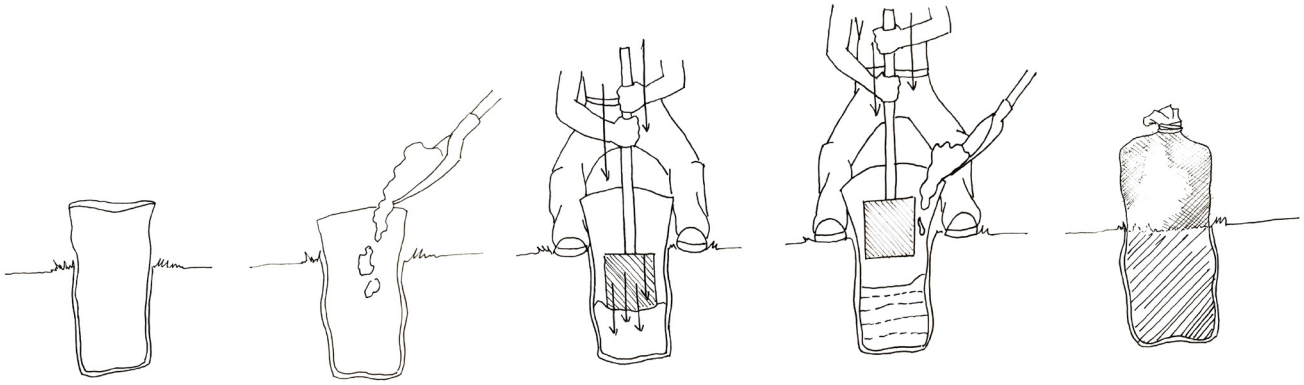
The first part of the mounting structure is ready! Now it is time to anchor it...

STEP 10: mark the position of the mounting structure feet on the floor. Dig holes with 1′ diameter and 1′ depth. Cut the shade cloth (3′x3′), make a “needle” with a piece of wire and sew one side to the other with nylon bricklayer line, forming a tube. Position the tubes in the digged holes.

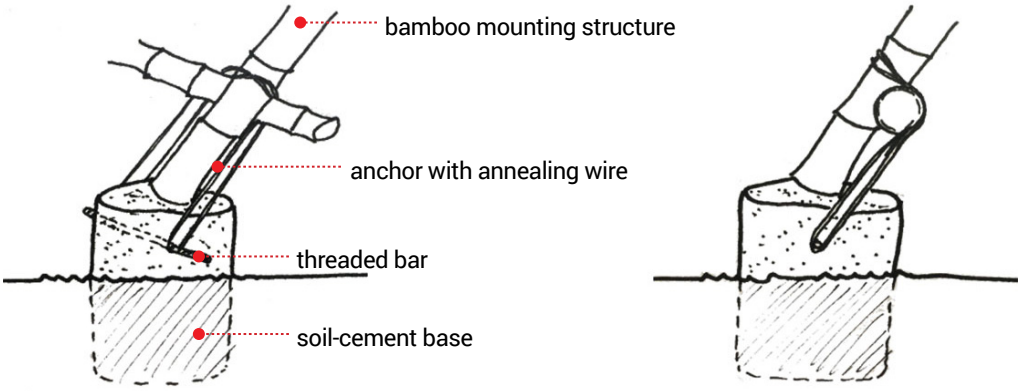




STEP 11: prepare a soil-cement mixture (1 part of cement and 12 parts of soil) and moisten it until you get the consistency of moist sand. With the shade cloth tubes inside of the holes, put the mixture in successive layers inside the tubes, ramming it well, up to 3/4 of the tubes volume, and then tie the edge of the tubes.



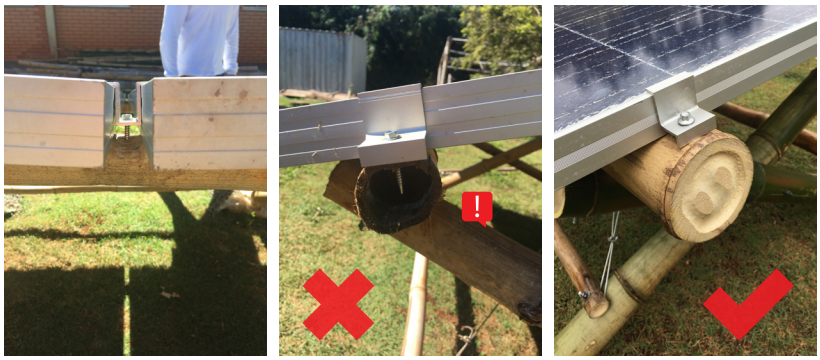
STEP 12: pass a threaded bar through each of the 4 bases. Position the mounting structure on the 4 bases and tie them using annealed wire.



STEP 13: attach the photovoltaic panels to the mounting structure.

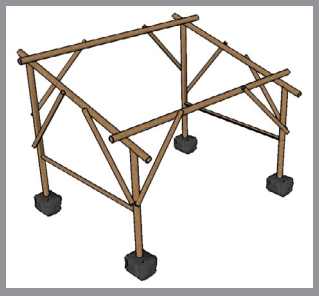
Use the solar panel mid clamp between the panels, and the solar panel mounting Z bracket on the edges, fastening them to the bamboo stems with self-drilling screws.

Look for possible points of rainwater retention and make drains (holes underneath the stems).



Also, it is time to put the bamboo lids on if
any end has become apparent. Use a tip with a node. The tip diameter must be equal to the inner diameter of the stem to be sealed. Fasten using screws.

2.2 FIXED MOUNTING STRUCTURE



Materials for fixed mounting structure

item	quantity	purpose
Rubber sealing washer (1/4” internal diameter)	56 un.	to seal holes in bamboo stems
Rubber sealing washer (5/16” internal diameter)	4 un.	to seal holes in bamboo stems
Annealed wire	1 lb	to anchor the mounting structures to the ground
Washer (1/4”)	56 un.	to fasten the bamboo stems
Washer (5/16”)	4 un.	to fasten the bamboo stem C to A and B
Threaded bar (1/4”, 3’ length)	4 un.	to fasten the bamboo stems
Threaded bar (5/16”, 3’ length)	2 un.	to fasten the bamboo stem C to A and B
Solar panel mid clamp	2 un.	to fasten the photovoltaic panels to the mounting structure
Solar panel mounting Z bracket	4 un.	to fasten the photovoltaic panels to the mounting structure
Cement	55 lb	to make the mounting structure bases
Nylon bricklayer line	40’	to sew the shade cloth
Self-drilling screw (1/4” x 1.1/2”)	6 un.	to fasten the photovoltaic panels to the mounting structure
Nut (1/4”)	112 un.	to fasten the bamboo stems (56 to be used as lock nuts)
Nut (5/16”)	8 un.	to fasten the bamboo stem C to A and B (4 to be used as lock nuts)
Shade cloth (13’ width)	3’	to make the mounting structure bases

Tools to build fixed mounting structure

item	purpose
Pliers	general use
Bow saw	to cut the bamboo into stems
Bucket	to make the mounting structure bases
Long high-speed drill bit (5/16”)	to drill various bamboo stems simultaneously
Hand held pole hole digger	to make the mounting structure bases
Combined key set	to tighten nuts
Hand tamper	to make the mounting structure bases
Hoe	to make the mounting structure bases
Crayons	to mark the bamboo stems
High-speed drill bit set	to drill bamboo stems
Hole saw set	to drill wide holes in bamboo stems
Carpenter’s pencil	general use
Hammer	general use
Root slayer shovel	to make the mounting structure bases
Electric drill/screw driver	general use
Jig saw (optional)	to cut “fish mouth” shape in bamboo stems
Scissors	to cut shade cloth
Measuring tape (16’)	general use

STEP 1: cut the bamboos to produce the mounting structure stems.

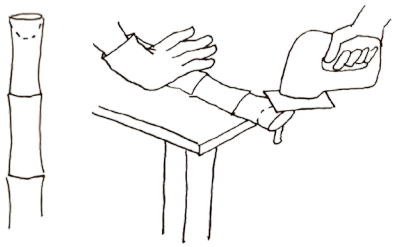
stem	quantidade	quantity	length (inches and ft)	wall thickness (inches)
A	2	3’3”	4” to 5”	0.4” to 0.6”
B	2	4’5”	4” to 5”	0.4” to 0.6”
C	2	5’7”	4” to 5”	0.4” to 0.6”
D	2	4’7”	1.2” to 2”	at least 0.2”
E	2	3’	1.2” to 2”	at least 0.2”
F	2	3’	1.2” to 2”	at least 0.2”
G	1	7’5”	4” to 5”	0.4” to 0.6”
H	1	7’5”	4” to 5”	0.4” to 0.6”
I	2	3’	1.2” to 2”	at least 0.2”
J	2	3’	1.2” to 2”	at least 0.2”

Preserve the bamboo node at the ends or make lids using the bamboo itself (see step 13). This helps to give more resistance and durability to the mounting structure.

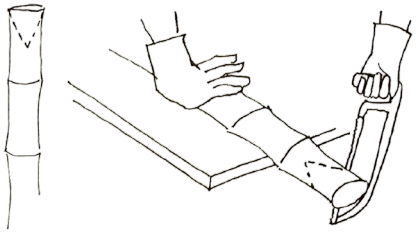
STEP 2: prepare the tips of the stems A and B to fit the stems C. Also prepare the 5/16” threaded bars for these connections.

a. Cut the end of the bamboo stems in a “fish mouth” shape (using jigsaw) or in a “V” shape (using bow saw).

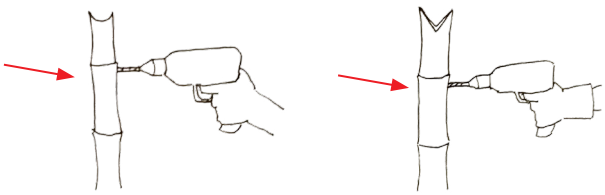
“fish mouth” shape cut



“V” shape cut

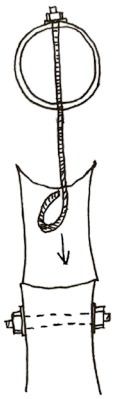


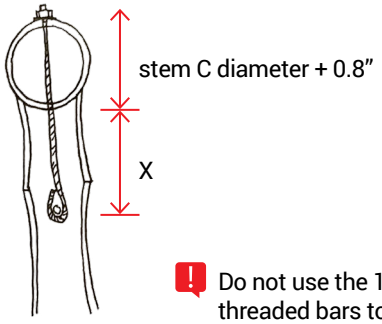
b. Drill a hole through the bamboo, just below the first node.



below the first node

c. Bend 4 pieces of 5/16” threaded bar into a “J” shape. The “J” shape threaded bar length comprises the distances between the end of the bamboo stem and the first node (X), plus the C diameter, plus 0.8” (for nut, lock nut, rubber sealing washer, and washer). It is recommended to cut the threaded bar after fastened so that there is no waste.

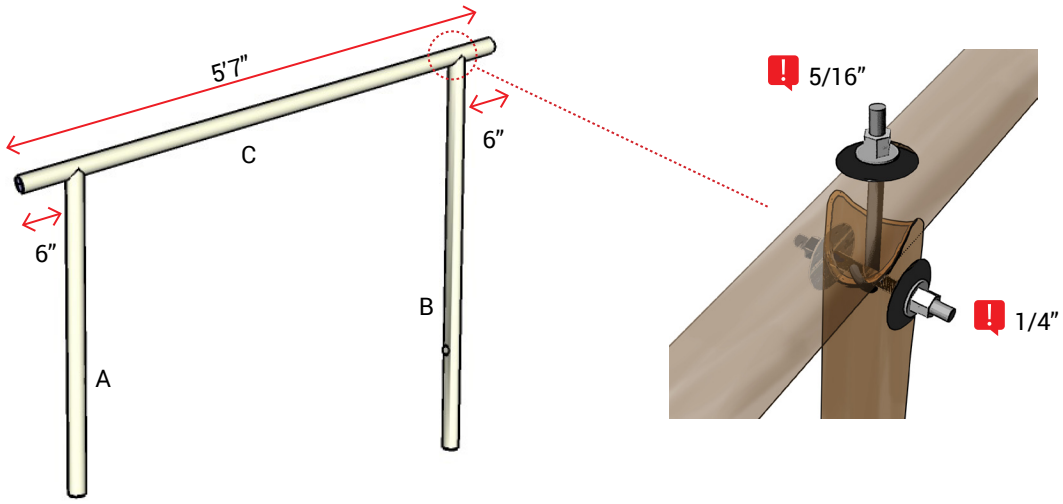




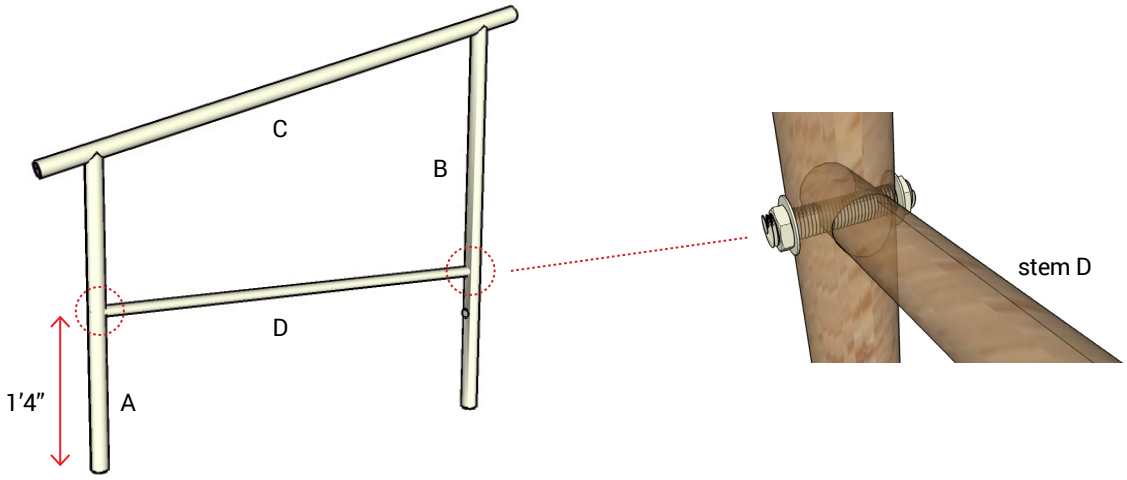
Do not use the 1/4” threaded bars to make the “J” shape bars, as they do not resist bending and they break easily.

d. Pass a 1/4” bar through the loop and fasten it to C stem with nuts, lock nuts, rubber sealing washers, and washers.

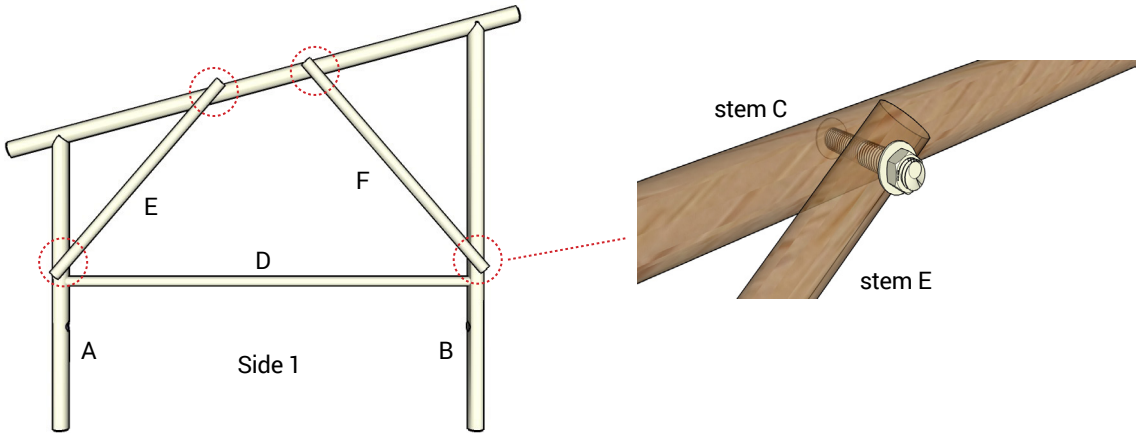
STEP 3: drill the stem C. Mount an inverted “U” connecting it with A and B stems. Fasten them with 1/4” threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



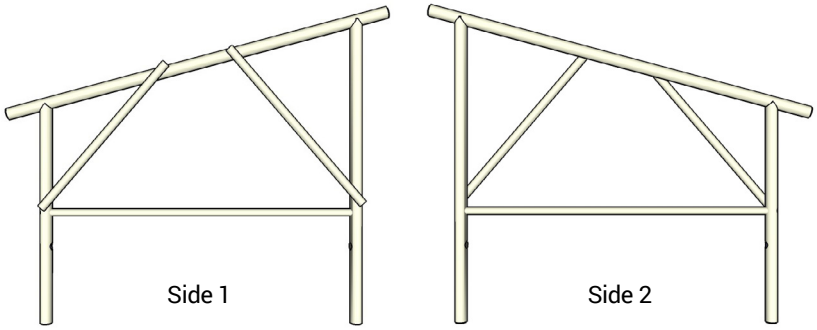
STEP 4: drill stem A and B with a hole saw, with same diameter as D. Fit stem D in A and B and fasten with 1/4" threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



STEP 5: attach stems E and F to C. These stems brace the "U" formed by A, C and B. Use 1/4" threaded bars, nuts, lock nuts, washers, and rubber sealing washers. The SIDE 1 is ready.

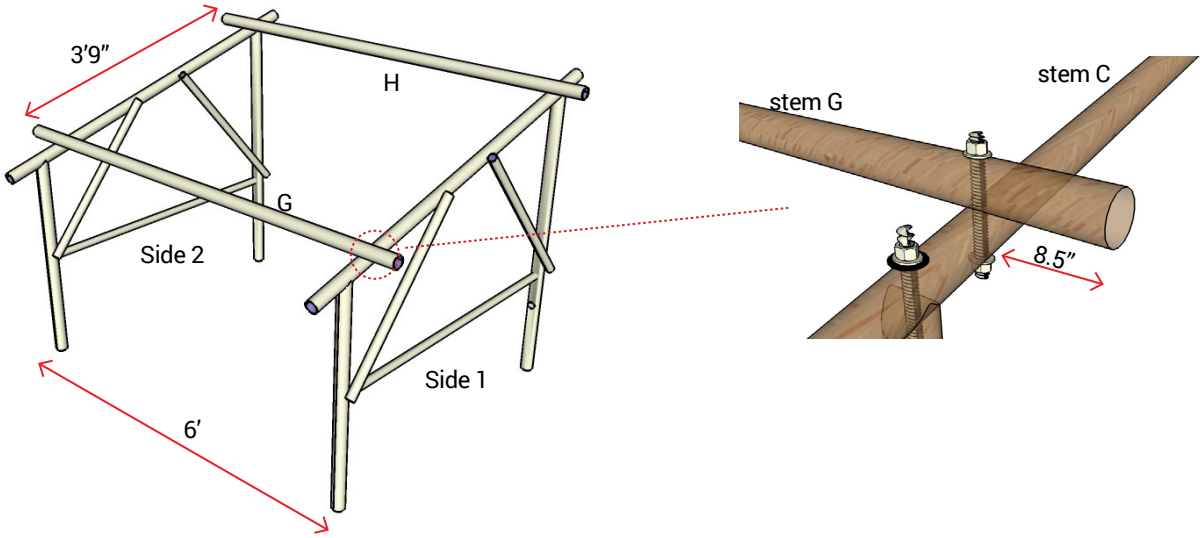


STEP 6: make SIDE 2 the same way.

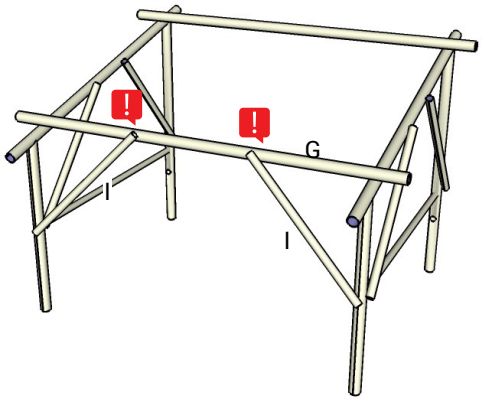


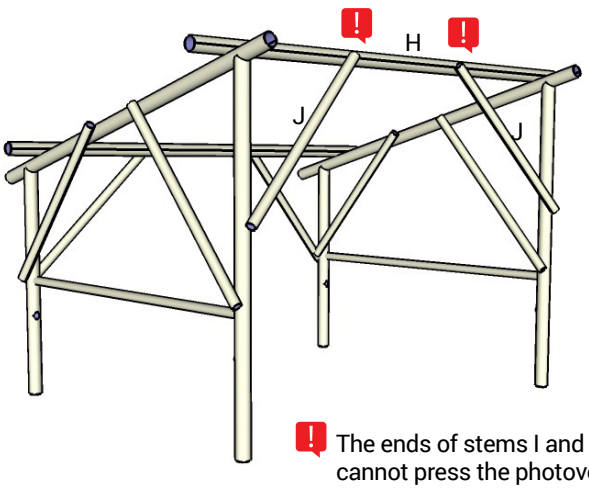
SIDE 1 and SIDE 2 must have the same height.

STEP 7: attach stems G and H to C, connecting SIDE 1 and SIDE 2. The distance between G and H must be 3'9". Use 1/4" threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



STEP 8: use stems I and J to brace the structure. Use 1/4" threaded bars, nuts, lock nuts, washers, and rubber sealing washers.



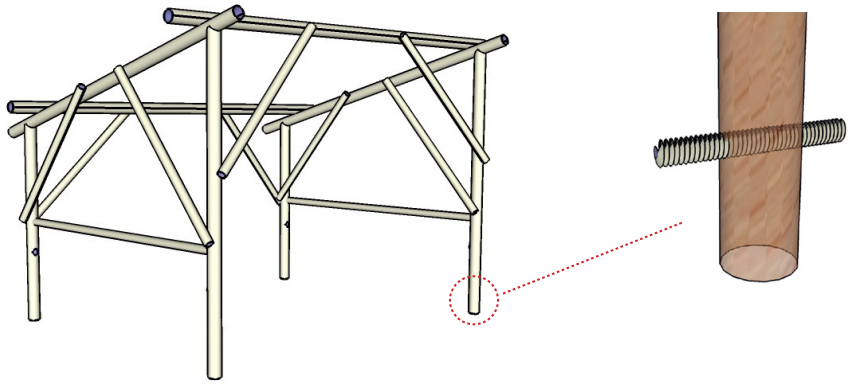


The ends of stems I and J cannot press the photovoltaic panels from below.

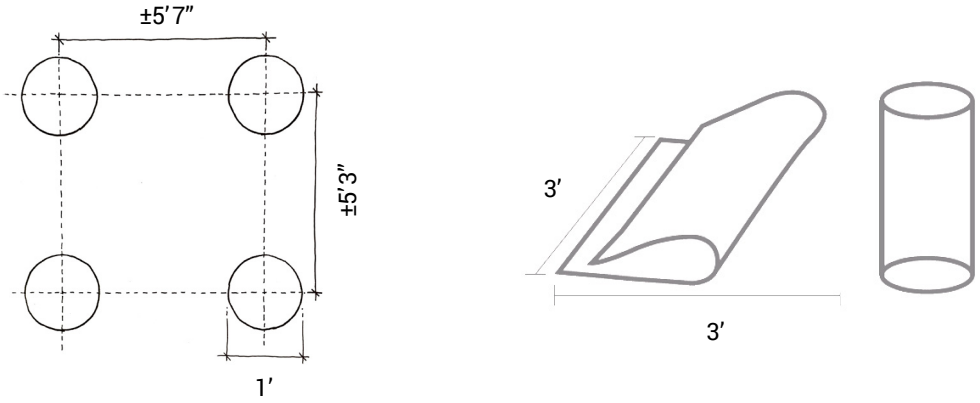
Congratulations!

The first part of the mounting structure is ready!
Now it time to anchor it...

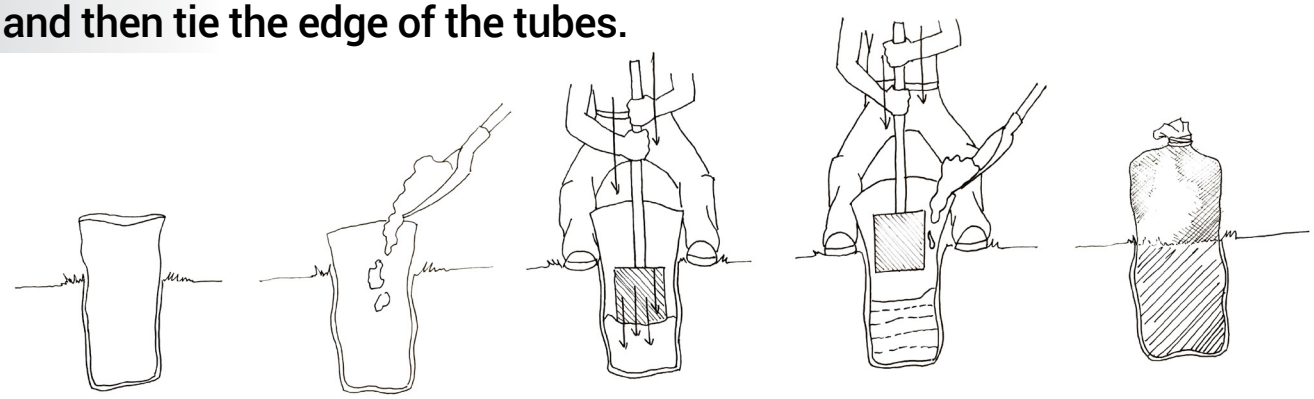
STEP 9: drill holes above the first node of the 4 feet (stems A and B) of the mounting structure, and pass a piece of threaded bar through them for anchoring, above a node.



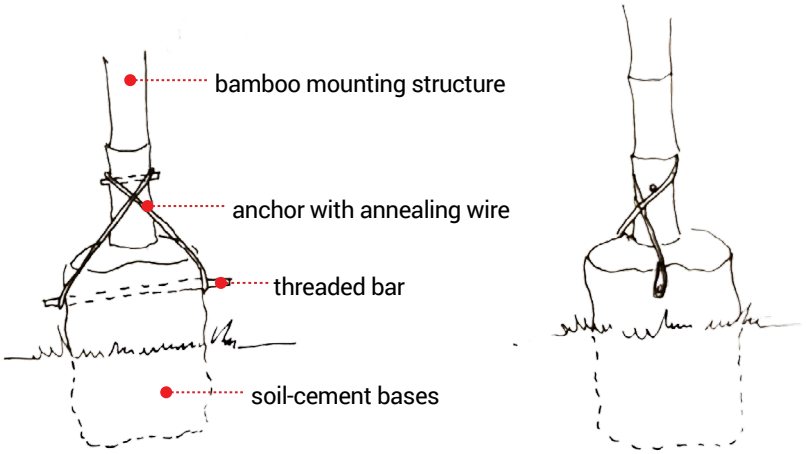
STEP 10: mark the position of the mounting structure feet on the floor. Dig holes with 1' diameter and 1' depth. Cut the shade cloth (3'x3'), make a "needle" with a piece of wire and sew one side to the other with nylon bricklayer line, forming a tube. Position the tubes in the digged holes.



STEP 11: prepare a soil-cement mixture (1 part of cement and 12 parts of soil) and moisten it until you get the consistency of moist sand. With the shade cloth tubes inside of the holes, put the mixture in successive layers inside the tubes, ramming well, up to 3/4 of the tubes volume, and then tie the edge of the tubes.



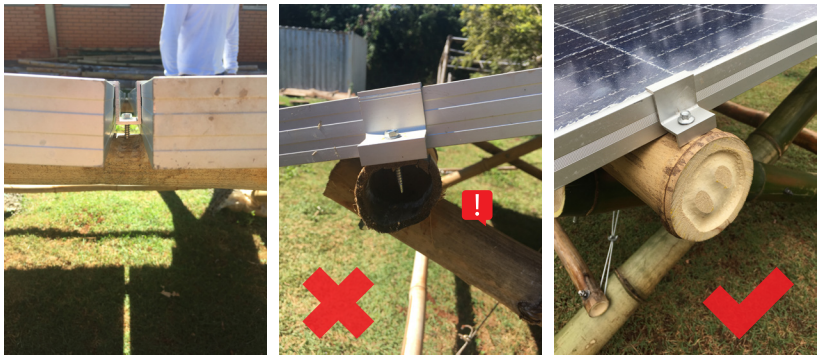
STEP 12: pass a threaded bar through each of the 4 bases. Position the mounting structure on the 4 bases and tie them using annealed wire.



STEP 13: attach the photovoltaic panels to the mounting structure.

Use the solar panel mid clamp between the panels, and the solar panel mounting Z bracket on the edges, fastening them to the bamboo stems with self-drilling screws.

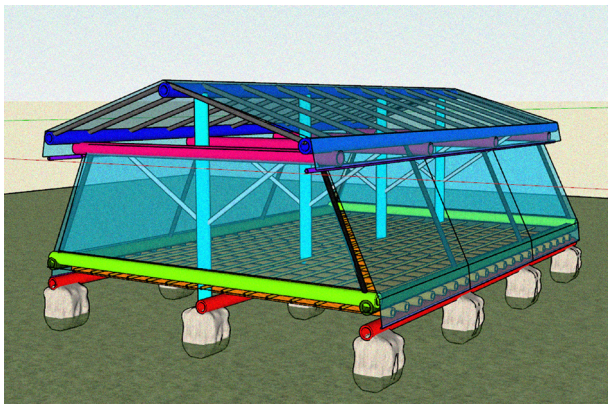
Look for possible points of rainwater retention and make drains (holes underneath the stems).



Also, it is time to put the bamboo lids on if
any end has become apparent. Use a tip with a node. The tip diameter must be equal to the inner diameter of the stem to be sealed. Fasten using screws.

PARTE 5

BAMBOO SOLAR CROP DRYER



GETTING TO KNOW THE SOLAR CROP DRYER...

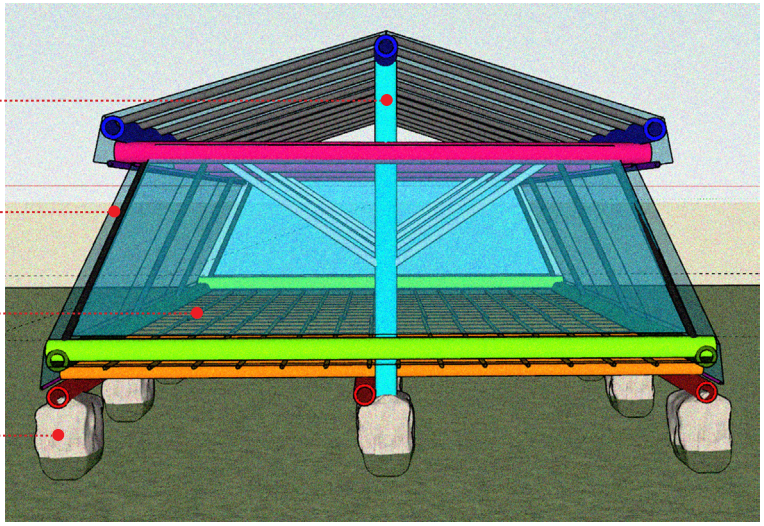
This solar crop dryer consists of 4 parts:

FOUNDATION: bags with soil-cement mixture for anchoring the dryer to the ground.

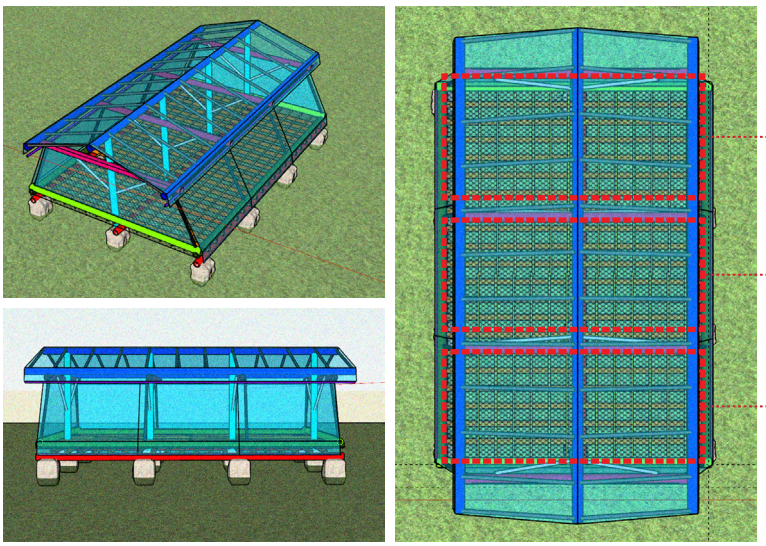
TABLE: ventilated surface for drying crops.

DOORS: plastic opening to access and manipulate the crops.

STRUCTURE: bamboo crosses to give form to the plastic roof.



In sunny weather, hot and humid air inside the dryer comes out through the top oppenings, as it is lighter than the cold air. This allows the cooler and drier air to enter from underneath, passing through the table and crops. That is how the solar crop dryer works.



The design of the solar crop dryer is for 6'7" x 13'2" modules. In this manual, the guidelines are for a solar crop dryer with 3 modules (13'2" x 19'9"). The decision regarding the number of modules depends on the needs of your production are.
It can be built even in remote areas of difficult access, since all the necessary industrialized materials
are either light and can be easily transported or are replaceable with materials that can be obtained on any rural property.

BEFORE STARTING...

1. Use bamboos that are ripe (opaque surface, with mosses and lichens, but not rotten), dry, and free from attack by insects and *fungi*.
2. Gather materials and tools.
3. If possible, work on a large table to facilitate cutting and pre-assembling parts.
4. Do not hammer nails into the bamboo. All holes must be made on bamboo with electric drill and drill bits.
5. Wear proper PPE (personal protective equipment): gloves, safety glasses and safety shoes.

If you have a large crew to build the solar dryer, divide them into 3 teams to tackle different tasks:

A

- template
- digging holes
- foundation

(steps 1, 2, and 5)

Suggestion: at least 3 people.

B

- bamboo cutting
- crosses
- roof structure

(steps 4, 6, 11, and 14)

Suggestion: at least 4 people.

C

sewing foundation bags

- table surface
- plastic cutting and gluing

(steps 3, 10, 13, 15, and 18)

Suggestion: at least 2 people.

D

table structure

- side bracings
- roof and doors

(steps 7, 8, 9, 12, 16, and 17)

Each step requires at least 2 people. However, some steps require more people to make the execution easier.

BAMBOO STEMS

Dendrocalamus asper (giant bamboo)

items	quantity	lenght (ft and inches)	diameter (inches)	wall thickness (inches)	color in the drawing
Rafters	30	6’7”	1.2”	-	dark grey
Longitudinal edge	2	21’	6”	0.6”	dark green
Transversal edge	2	14’	6”	0.6”	light green
Diagonal of the cross	8	4’7”	2” to 6”	0.4”	light gray
Lower platform of the table (transversal)	21	14’	4”	0.6”	orange
Upper platform of the table (longitudinal)	48	10’6”	1”	-	yellow
Pillar of the cross	4	9’	6”	0.6”	light blue
Door stem	12	7’	1.2”	-	light pink
Plastic roof tensioning stem	6	6’7”	1.2”	-	purple
Side bracing	8	5’3”	1.2”	-	black
Roof beam	3	23’5”	6”	0.6”	dark blue
Beam of the cross	4	12’2”	6”	0.6”	dark pink
Table beam	3	21’	6”	0.6”	red

* when there is no thickness specification, adopt the maximum possible.
* cut all stems with an extra 4” for adjustments.

Preserve the nodes.

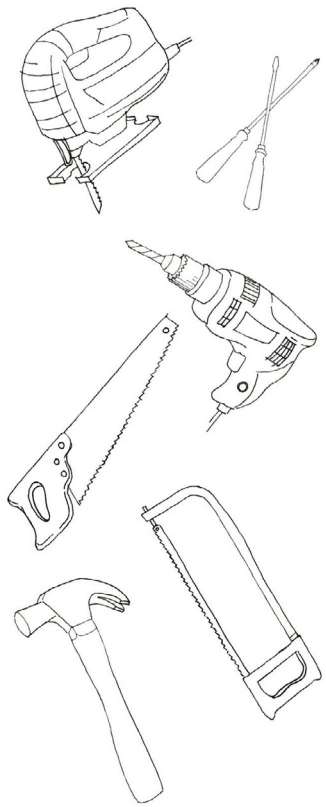
Look for straight stems.

Use thick wall bamboo.

Materials to build a 3-module solar crop dryer

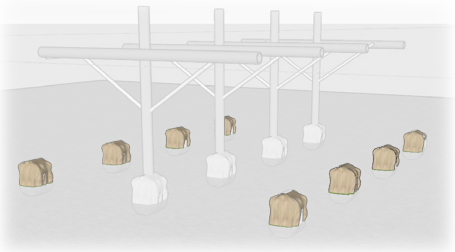
materials	quantity	purpose
Plastic zip tie (16”, 100 units pack)	3 un.	To fasten table platform and chicken wire (this amount of zip tie can be substituted by 6 lb of annealed wire)
Plastic zip tie (6”, 100 units pack)	2 un.	
Contact adhesive (gallon of 3.8 liters)	3 un.	Roof plastic, doors, sides and table
Rubber sealing washer (5/16”)	92 un.	To seal the bamboo holes for threaded bars or screws
Rubber sealing washer (1/4”)	92 un.	To seal the bamboo holes for threaded bars or screws
Annealed wire	6 lbs	table beams, roof beams, bottom table platform
Washer (5/16”)	92 un.	To fasten bamboo stems with threaded bar
Washer (1/4”)	92 un.	To fasten bamboo stems with screw
Threaded bar (5/16”, 3’ length)	21 un.	To fasten bamboo stems
Cement (94lbs)	4 bags	soil-cement mixture of the solar dryer bases
UV resistant polypropylene cord (1/8”, 250’)	1 un.	Plastic roof stretching
Wooden stake (2” x 2” x 36”)	14 un.	Template
Sandpaper for wood (grain 80)	10 sheets	clean edges, tips and barbs of bamboo
Wood screw (2”)	76 un.	To fasten the diagonals of the crosses and roof rafters
Wood screw (3.15”)	32 un.	To fasten the doors, roof stretching stem and side bracings
Awning plastic (white, 7’ width)	5’	edge of the roof plastic (2 strips of 25’ x 8”)
Transparent plastic for greenhouse (25’ width)	40’	to cover the solar dryer (see cutting plan in the step 13)
Nuts (5/16”)	184 un.	To fasten bamboo stems (half is lock nuts)
Nail (2” x 11 Gauge)	50 un.	Template
Wooden plank (8” x 10’)	4 un.	Template
Wooden plank (8” x 13’)	4 un.	Template
Fabric – canvas or denim, it can be used fabric (60” width)	23’	gluing and finishing between plastic, bamboo and mesh (cut in 6” strips)
Chicken wire or other steel wire or UV resistant plastic mesh (5’ width)	60’	to cover the table (see cutting plan in step 10)
Nylon mesh (5’ width)	60’	to cover the table (see cutting plan in step 10)
Shade cloth (13’ width)	32’	to make the foundation bags (see cutting in step 3)
Asphalt paint (32oz)	1 un.	Buried crosses pillars protection

Tools to build a 3-module solar crop dryer

tools and equipments	quantity	
Pliers	1	
Bow saw	1	
Bucket	1	
Long high-speed drill bit (3/8”)	1	
Hand held pole hole digger	1	
Combined key (1/2”)	2	
Screwdriver	1	
Phillips screwdriver	1	
Hoe	1	
Carpentry square	1	
Stiletto knife	1	
Machete	1	
Electric drill	1	
Rasp	1	
High-speed drill bit set	1	
Wood hole saw set	1	
Carpenter’s pencil	1	
Sharpening file	1	
Nylon bricklayers line	1	
Level hose	1	
Hammer	1	
Level	1	
Root slayer shovel	1	
Paint brush	1	
Jig saw (this tool is useful for making “fish mouth” cuts, but v cuts can be used, which can be done with a bow saw)	1	
Scissors	1	
End cutters	1	
Measuring tape (25’)	1	

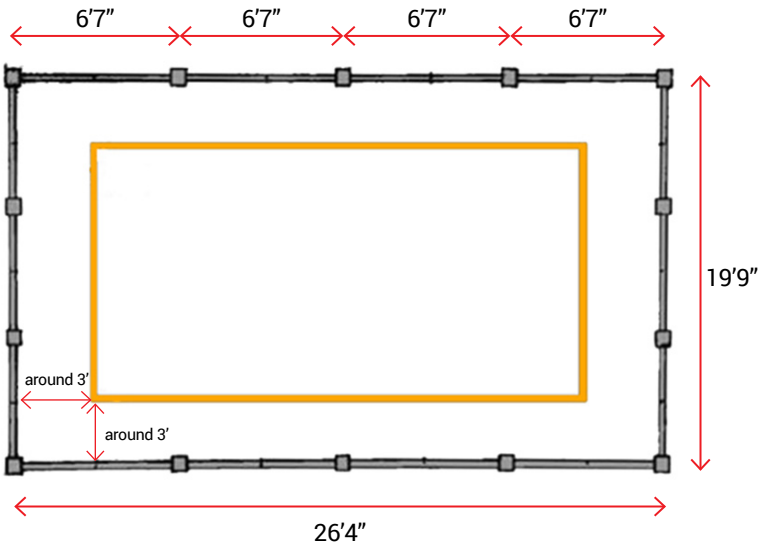
This is the minimum quantity, but it will vary depending on the size of the team. Read the manual and review it.

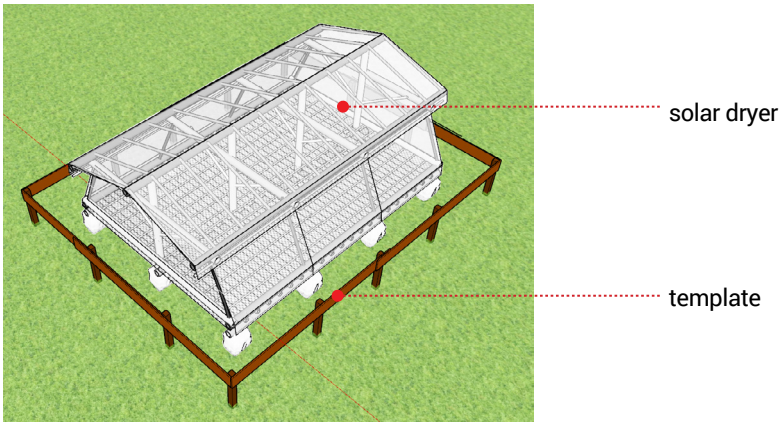
STEP 1. POSITIONING



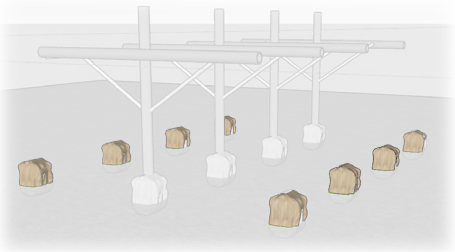
Mark the area of the solar dryer (13’2” x 19’9”) where there is no shade. The smaller side should face prevailing wind.

Make a template with the wooden stakes and planks, with extra 3’ on each side.

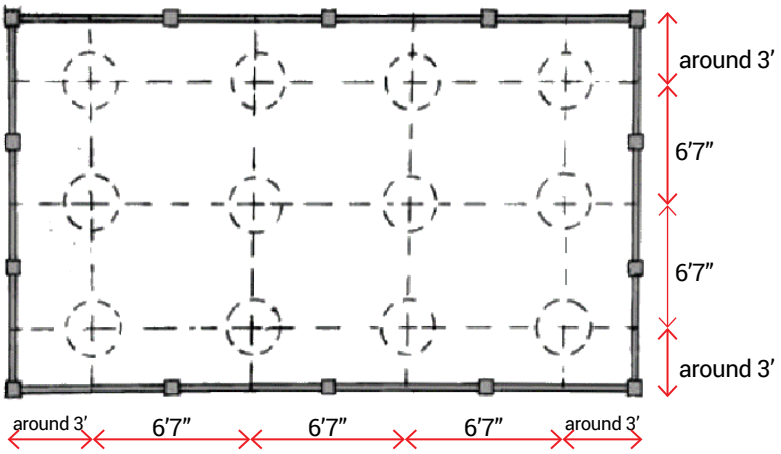




STEP 2. DIGGING

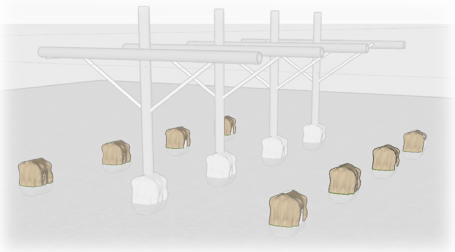


In the template, mark the axes of the foundations with the nylon bricklayers line.

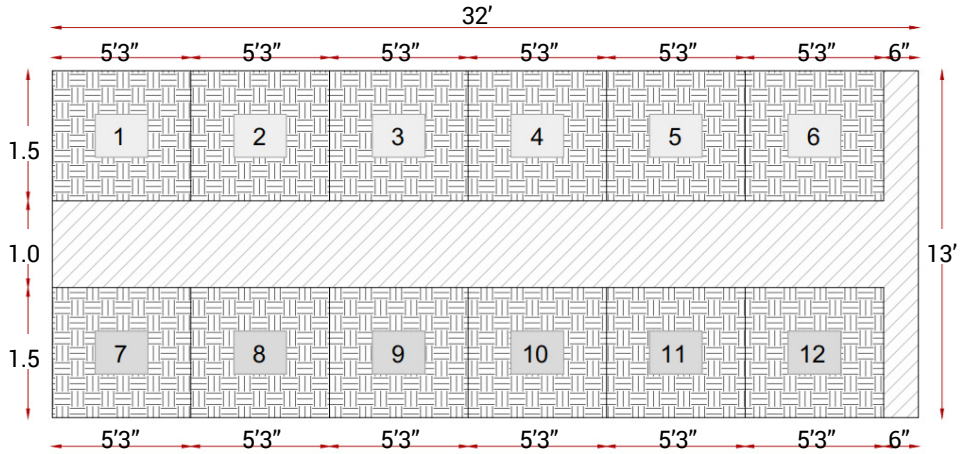


Using hand held post hole digger and shovel, dig holes 2' depth and 1'8" diameter.

STEP 3. FOUNDATION



For the foundations, cut the shade cloth, in 12 rectangles.

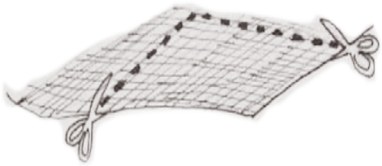


Pieces for the bags

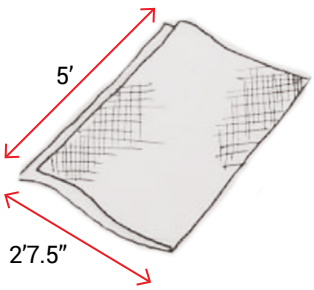
Leftover cloth

The cutting plan can change depending on the available shade cloth width.

Make bags with the shade cloth.

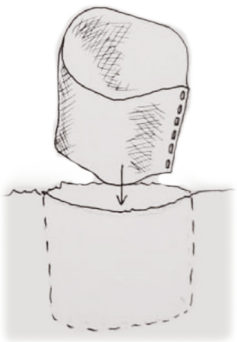


Cut 12 pieces of 5′x5′3″.



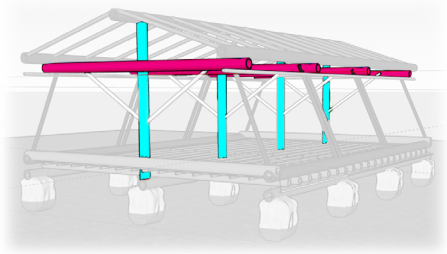
Fold them in half.

Sew the sides and bottom to form a bag. Each bag should have 1′8″ diameter.

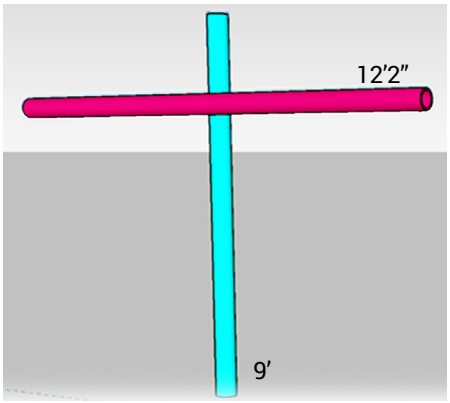


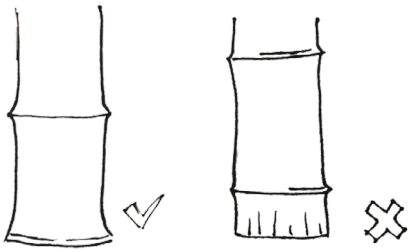
Put the bags in the holes.

STEP 4. CROSSES



Select bamboo pieces to produce the 4 crosses.

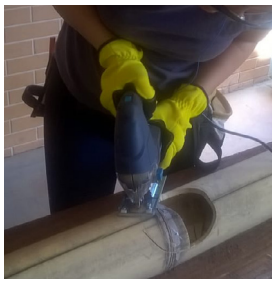




All ends of the cross pillars must have the nodes preserved.

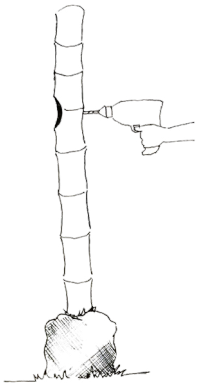
Place the beam on the pillar and mark the oval shape on the pillar to fit.

Use pencil to draw the beam profile on the pillar.

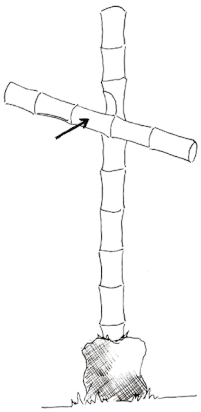


With the jigsaw, make the cut on the pillar.

Fasten the beam of the cross to the pillar.



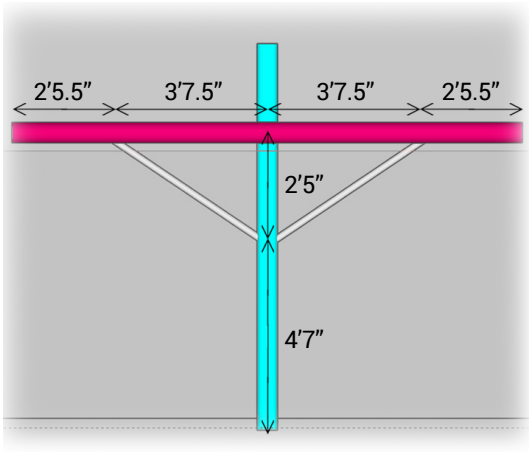
Drill the pillar.



Position the beam on the pillar.

Fasten with threaded bars, nuts, lock nuts, rubber sealing washers and washers.

Fasten the diagonals to the beam and the pillar of the cross to brace it.

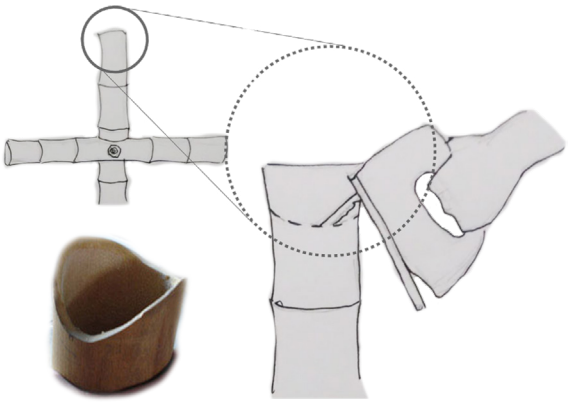


Level the cross, mark the length of the diagonals, cut and fasten. This fastening can be done with screws or threaded bars, depending on the diameter of the stems.

Diagonals fastened with screws.

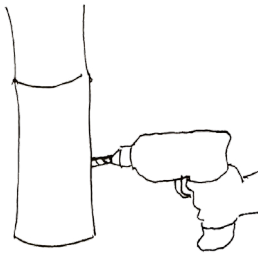
Diagonals fastened with threaded bars.

At the top of the pillar, make the "fish mouth" shape cut to fit the roof beam. Search Internet websites for details on how to make this type of cut.

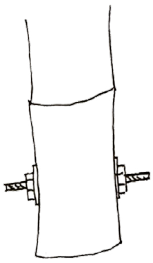


In the same way as the oval cut in the pillar, reproduce the profile of the roof beam at the top of the pillar.

Create an anchor for the crosses and position them in the central holes.

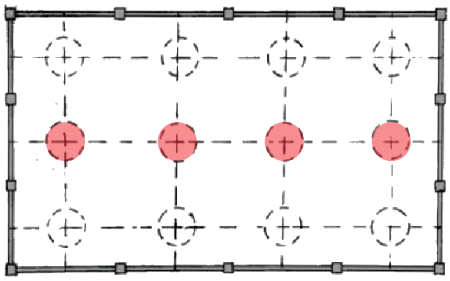


Drill the base of the pillar, right above the node.



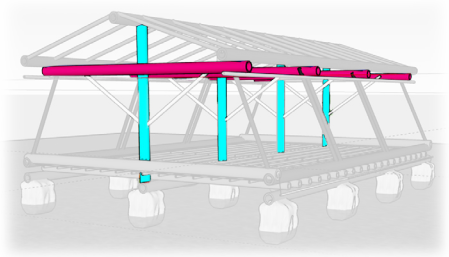
Pass a piece of threaded bar through the base of each pillar. Waterproof 3' of the base of each pillar with asphalt paint, following the manufacturer's instructions.

Example of cross with 2 bamboo anchor bars, however threaded bars will do a better job. Remember to put first the bag in the hole, and then the cross in the bag!



Place the bags and the 4 crosses in the central holes. Then, level, upright and prop them.

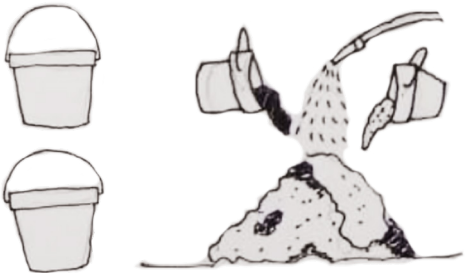
STEP 5. FOUNDATION



Prepare a soil-cement mixture (1 part of cement and 12 parts of soil) and moisten it until you get the consistency of moist sand.

12 buckets of soil

1 bucket of cement



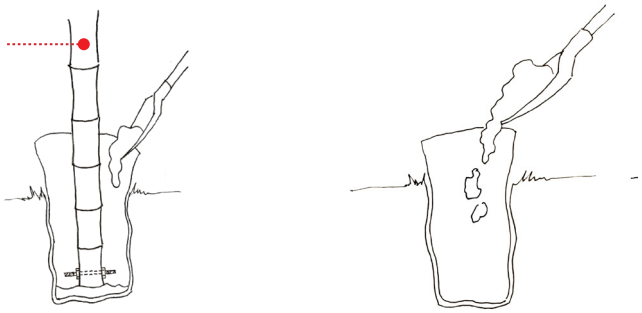
Make the foundation.

4 central foundations

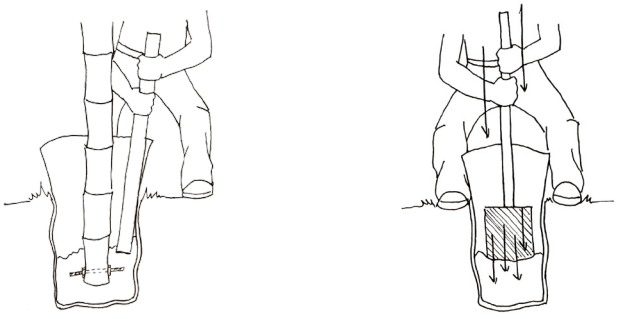
8 lateral foundations

pillar of the cross

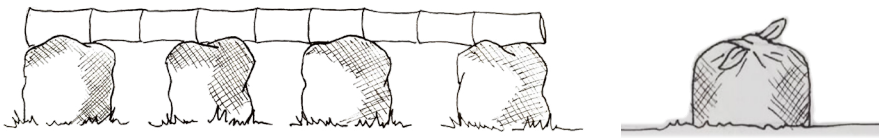
Fill the first 8" of the hole with the mixture.



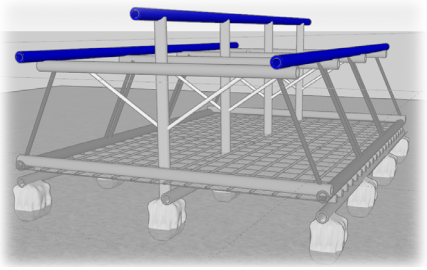
Ram and add more layers. When you reach 12" above the ground level, start leveling with the other foundations. This minimum 12" heigh above ground helps protect the bamboo from splashing rain.



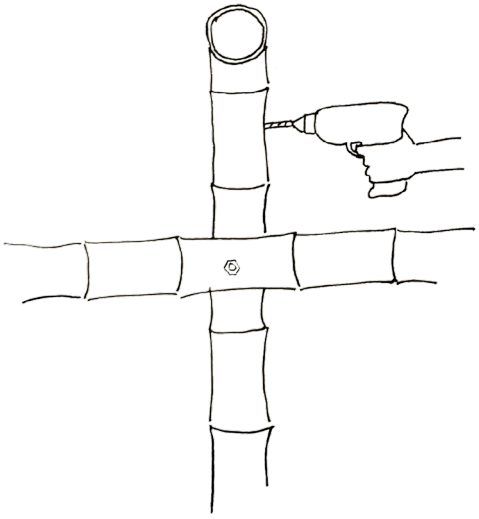
Level all foundations to receive the beams. Finishing the foundations doesn't have to be done now. It can be done during step 7.



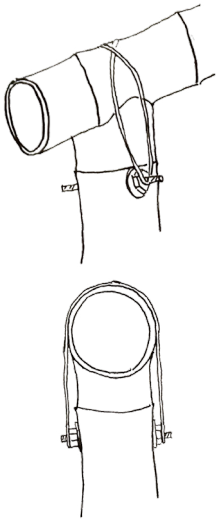
STEP 6. ROOF BEAMS



Fasten the roof beam over the crosses. Do not leave anything sharp that could pierce the plastic of the roof.

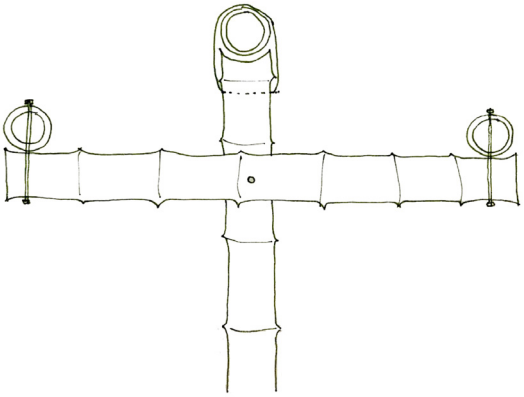


Position the beam. Drill a hole just below the pillar first node.

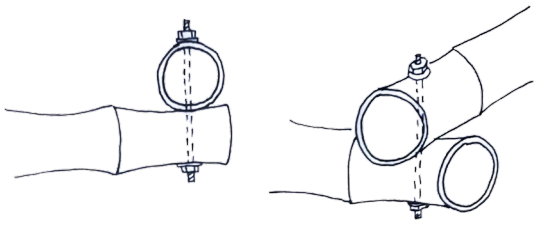


Pass a threaded bar through the pillar and fasten it with nuts, lock nuts, rubber sealing washers and washers. Tie with wire.

Fasten the remaining two roof beams to the beams of the crosses.

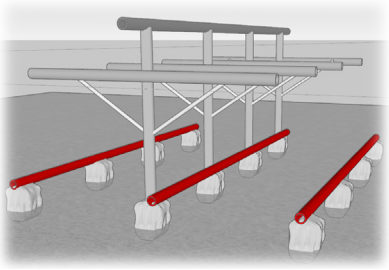


Level the beams, making cuts on if necessary. This adjustment is important so that the plastic of the cover rests without wrinkles on the structure.

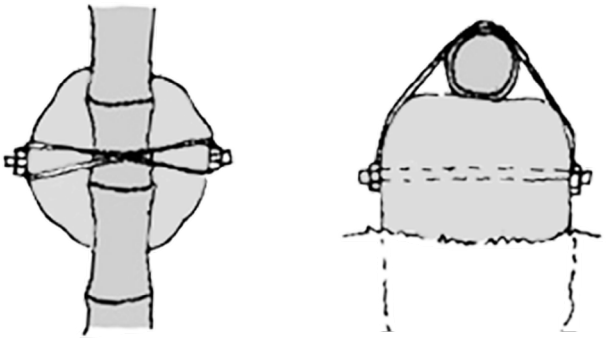


Fasten with threaded bars, nuts, lock nuts, rubber sealing washers and washers.

STEP 7. TABLE BEAMS



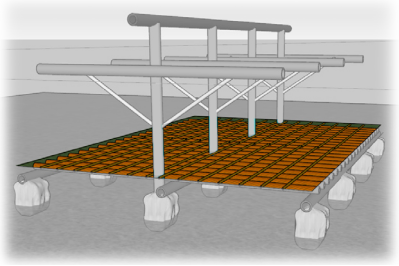
Position the table beams over the foundations.



As the bamboo has diameter variation, height adjustments in the foundations may be necessary to obtain a good leveling. Align the pieces. Pass threaded bars through the foundations and tie them to the bamboo beams using annealed wire.

The central beam must be fastened to the cross pillars using threaded bars, nuts, lock nuts, rubber sealing washers and washers.

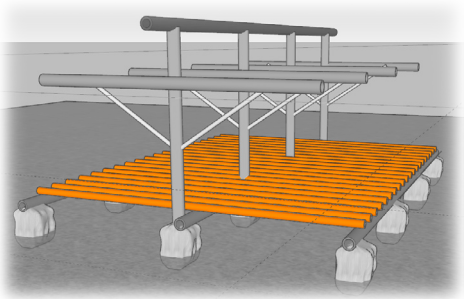
STEP 8. PLATFORM



Position the 21 pieces of the table platform (bottom) and tie them to the table beams. There are 7 pieces per module.

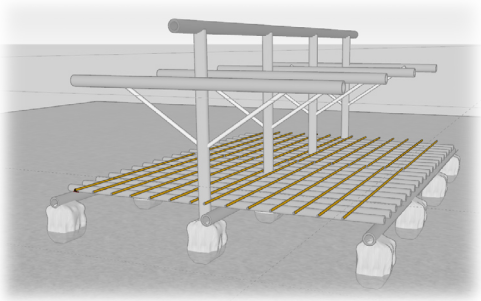
Distribute the pieces between the pillars (every 1') on the table beams.

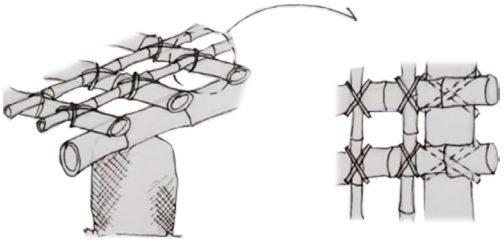
Tie using annealed wire, forming Xs.



The edge pieces must be on the inner face of the pillars.

Distribute the pieces of the upper platform every 6" (24 pieces). Each piece is composed by 2 stems.

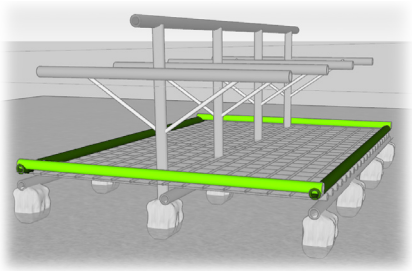




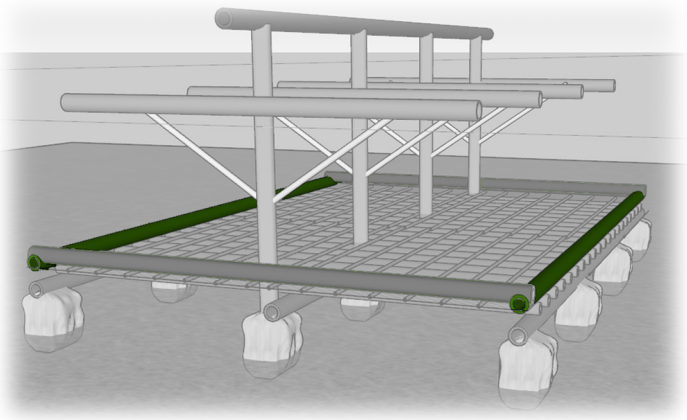
Tie with annelead wire.

Splice to reach 19'9" using with annealed wire or zip tie. Start positioning stems from the middle to the edges.

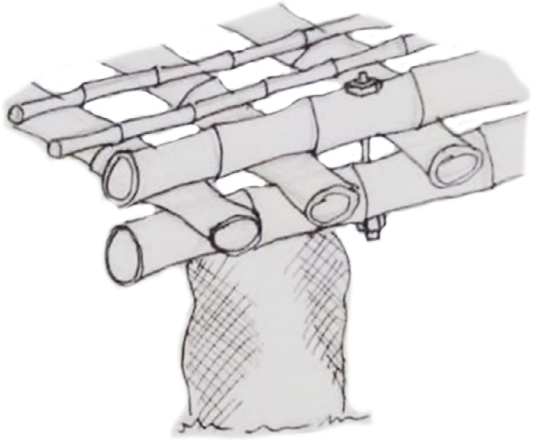
STEP 9. EDGES



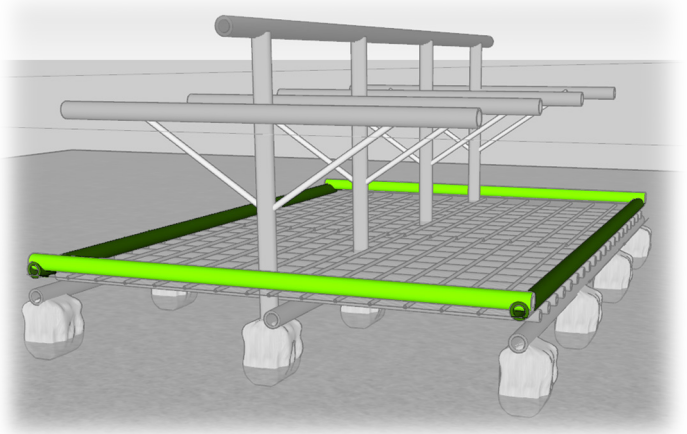
Place the edges on the plataform.



Start with the longitudinal edges, which are the longest stems (dark green).



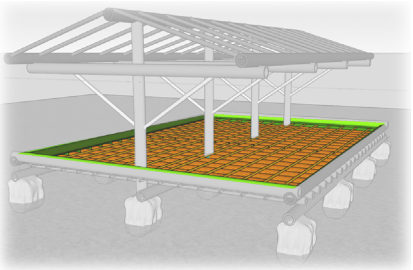
Every 6'7" fasten the longitudinal edge to the table beam with threaded bars, nuts, lock nuts, rubber sealing washers, and washers. Leave the ends of the longitudinal edge to fasten them to the ends of the short edges.



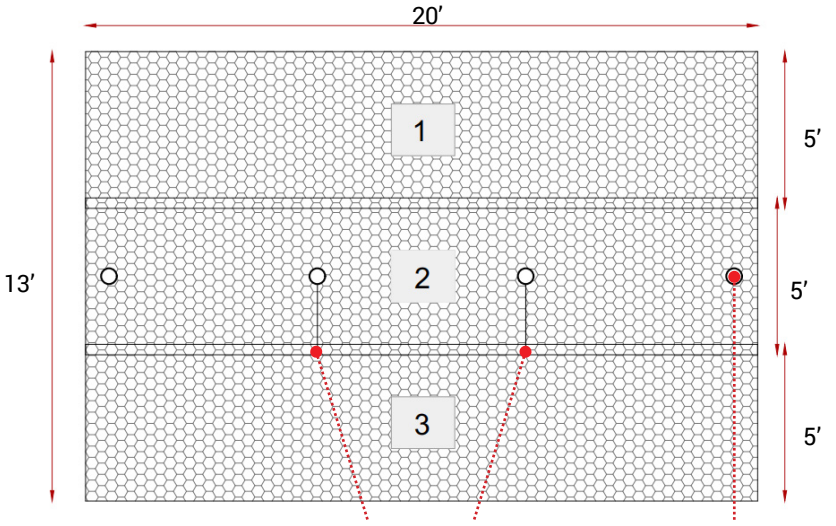
Fasten the transverse edges, which are the shortest stem (light green), fitting them over the longitudinal ones.

Cut the stem to fit and fasten to the longitudinal edge at the corners. In the middle, fasten the stem to the table beam. Use threaded bars, nuts, lock nuts, rubber sealing washers, and washers.

STEP 10. TABLE



Cut the chicken wire. It will support the load of crops that will be placed on the table. Place the chicken wire pieces on
the platform as shown below.



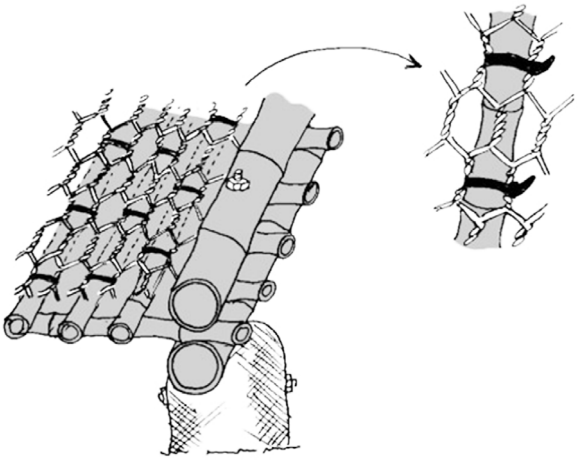
The cutting plan may vary if the available chicken wire width is different than 5'.

Cut the chicken wire, "embrace" the pillars of the crosses, and tie them back together with zip tie or annealed wire.

pillars of the crosses

Tie the chicken wire to the platform stems.

Attach the chicken wire, stretching it well.

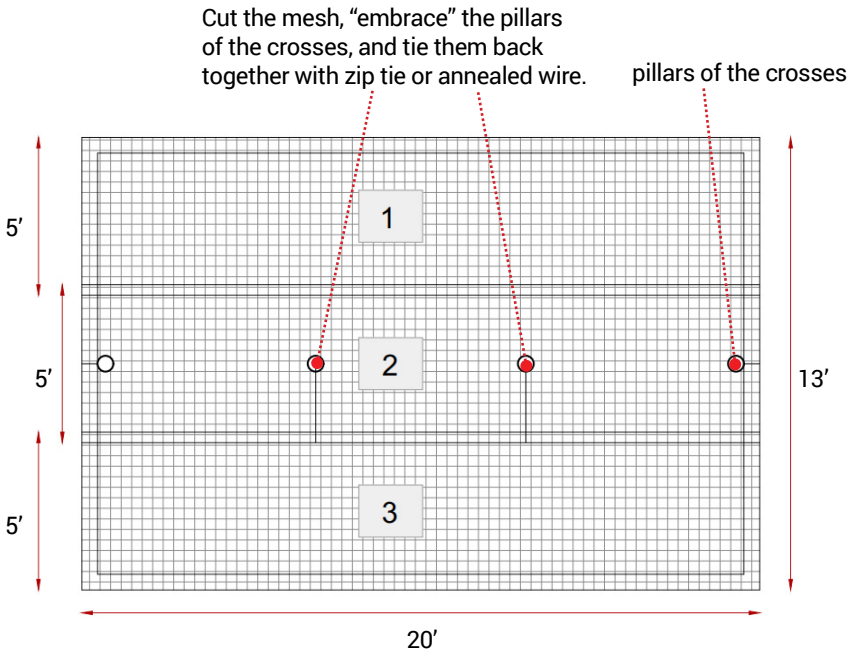


Use annealed wire and/or zip tie.

The wire has to cover the entire table, but the edges.

When climbing the table to perform any work step, use wooden planks to avoid deforming the chicken wire.

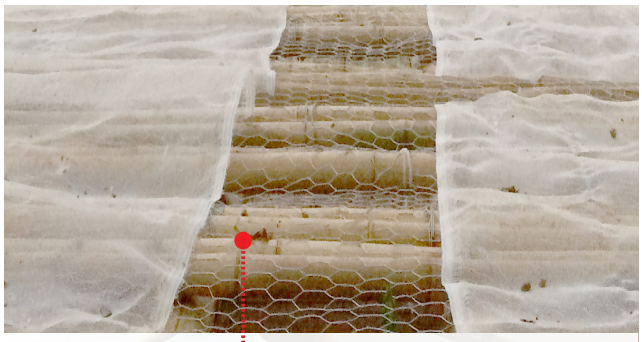
Cut the nylon mesh. Place the mesh on the chicken wire, as shown below.



The cutting plan may vary if the available nylon mesh width is different than 5’.

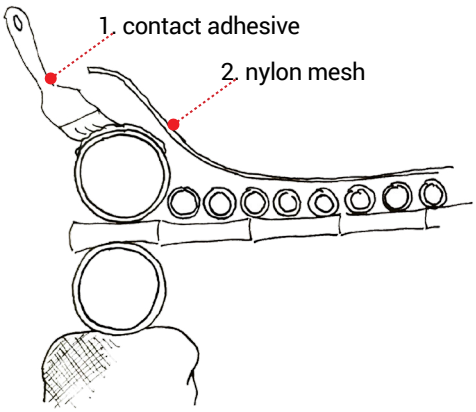
Opt for overlapping the pieces of the mesh, avoiding cutting exceeding parts.

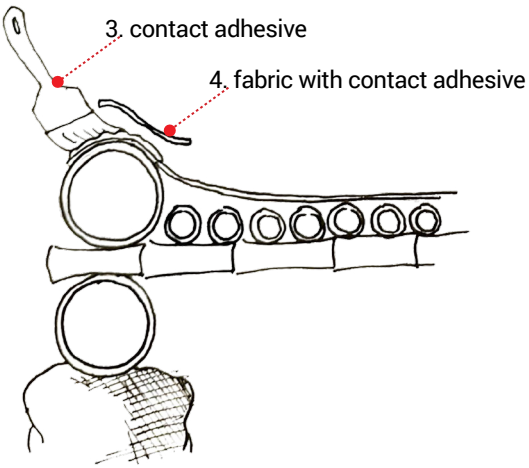
Place the nylon mesh over the chicken wire.



Splice the pieces of nylon mesh:
1. Spread adhesive on the bottom fabric (6”);
2. Position the mesh over the fabric;
3. Spread adhesive on the top fabric (6”);
4. Glue the fabrics, pressing them against each other.
Wait for the drying time before gluing (follow the manufacturer’s instructions).

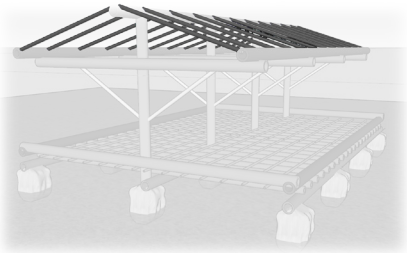
Do not leave burrs on the nylon mesh.



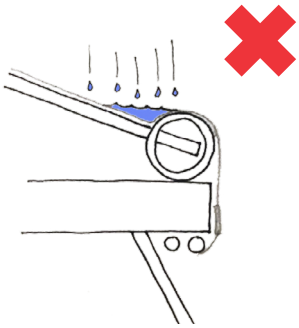


Glue using contact adhesive and fabric:
1. on the bamboo, spread the contact adhesive;
2. position the nylon mesh;
3. if necessary, add more contact adhesive;
4. on the fabric, spread contact adhesive and glue the fabric over the nylon mesh.
Wait for the drying time before gluing (follow the manufacturer’s instructions).

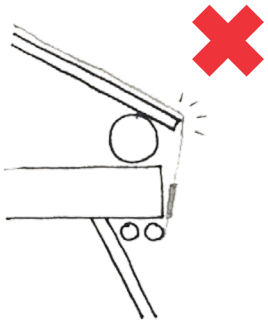
STEP 11. RAFTERS



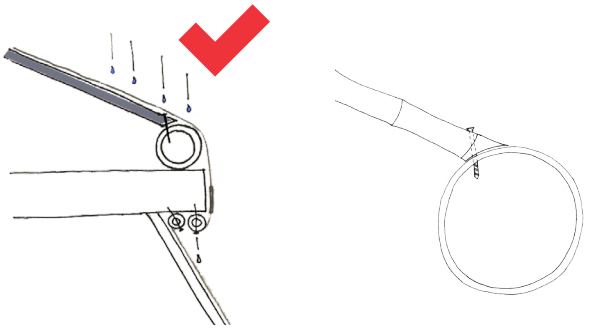
Fasten the rafters to the roof beams with screws, rubber sealing washers, and washers every 1’8”.



Do not leave hollows that may retain water.



Do not leave tips that can pierce the plastic.



Rigth after a node, make an angled cut at the end of the rafter to fasten it to the beam.

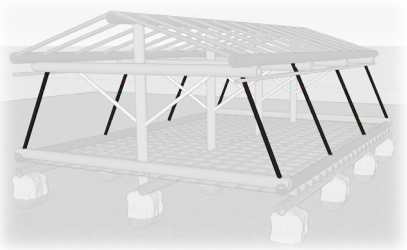
Eliminate tips, sharp edges, and burrs throughout the structure.

Use sandpaper and rasp on the roughness of the nodes.

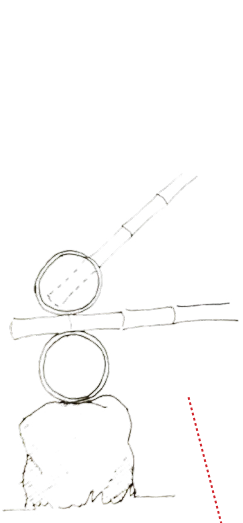
Wrap the ends of bamboo stems with plastic scraps.

No tip or metal should be in contact with the plastic.

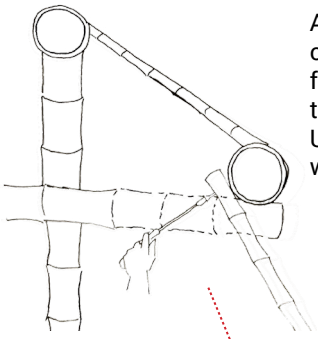
STEP 12. BRACING



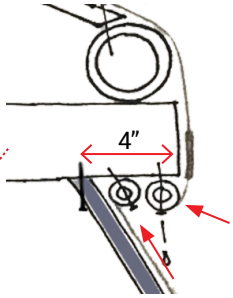
With screws, fasten the side bracing stems on the beam of the cross and the longitudinal edge.



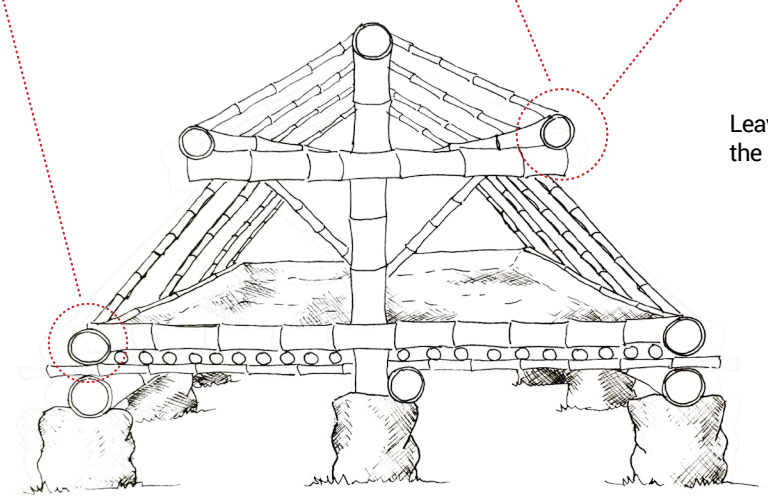
Drill the longitudinal edge with the hole saw and fit the side bracing.



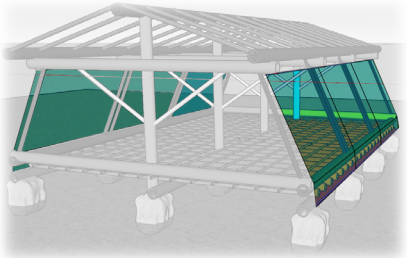
At the top, the fastening can be either way: screwing from the sides or from below the beam of the cross. Use screws, rubber sealing washers and washers.



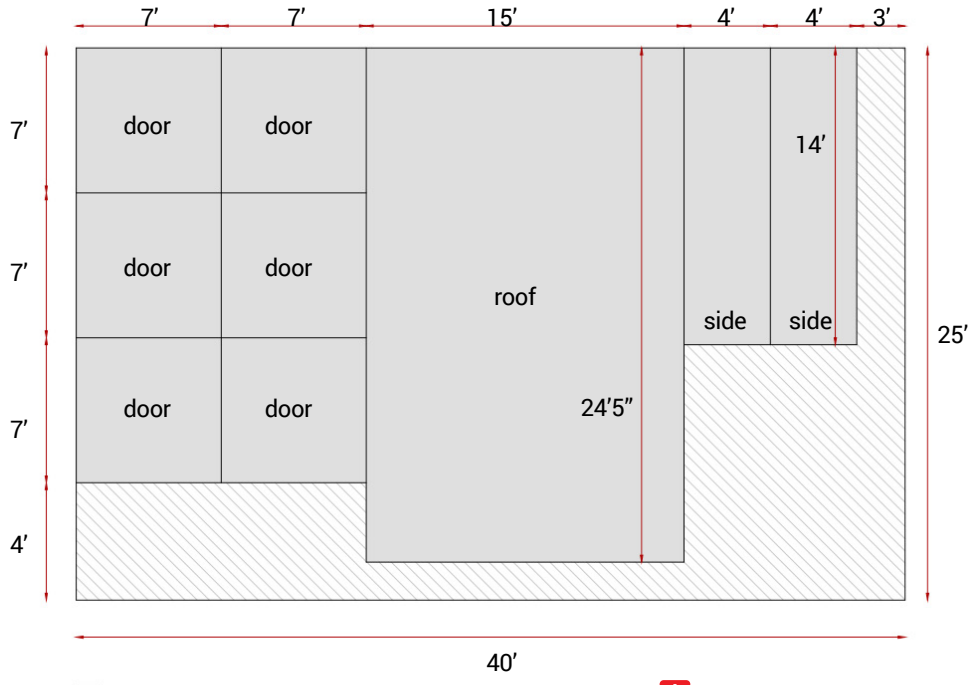
Leave 4" to fit the door and the roof stretching stem.



STEP 13. GLUING

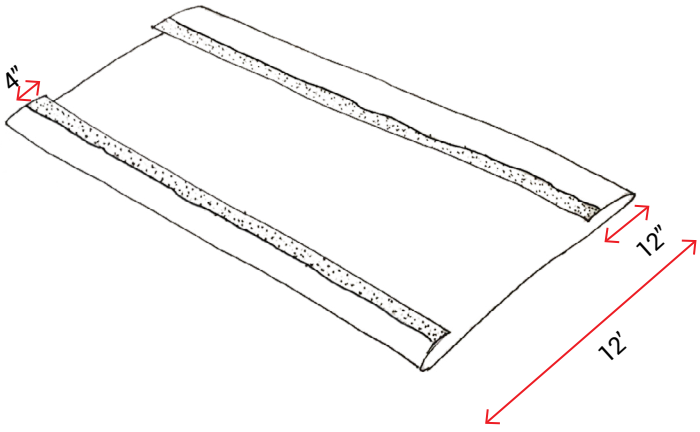


Cut the transparent plastic for the roof.



Prepare the roof plastic.

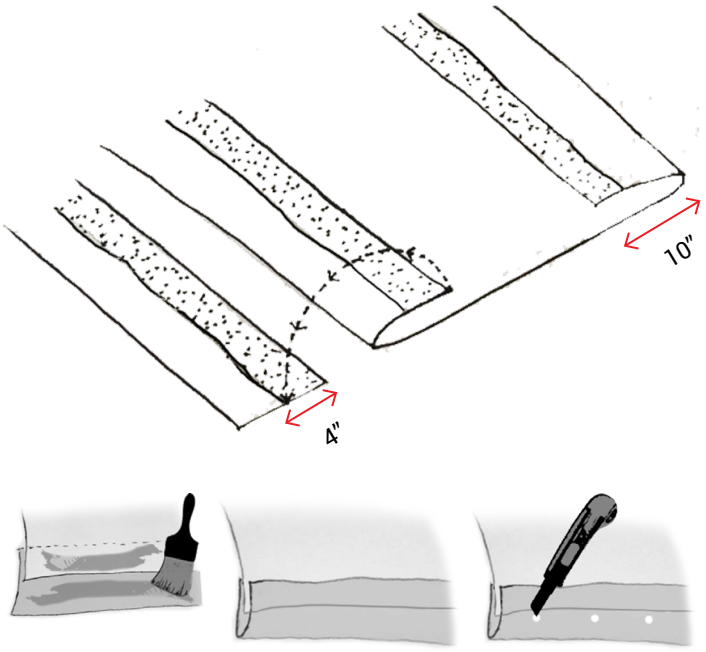
Open the 15′ x 24′5″ plastic and fold the longer sides. Spread contact adhesive in a 4″ strip on the underside of the plastic.



Open a 25′ strip awning plastic.
Spread contact adhesive in a 4″ strip of the awning plastic.
Unfold the roof plastic over the awning plastic strip and glue them.

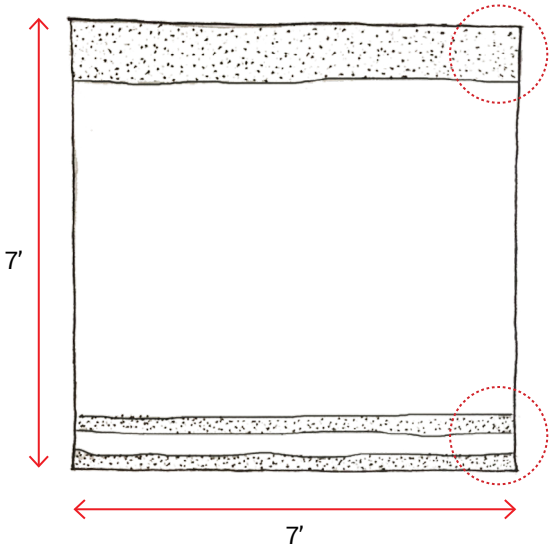
Spread contact adhesive in the remaining 4″ of awning plastic strip.
Spread contact adhesive in a 4″ strip on the top side of the roof plastic.
Fold the awning plastic over the roof plastic and glue them.
Wait for the drying time before gluing (follow the manufacturer's instructions).

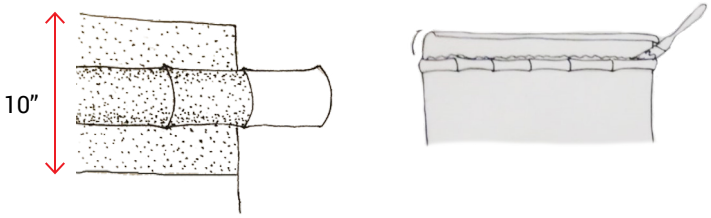
Punch every 4″.



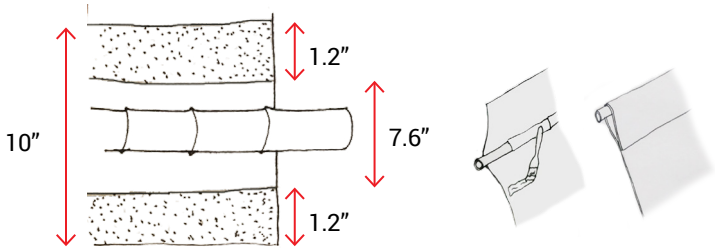
Make 6 plastic doors of 7′ x 7′.

Mark a 12″ strip at the top and bottom.



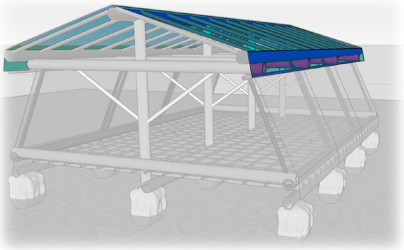


To make the top of the door:
• spread contact adhesive on a 10″ strip of the door plastic;
• spread contact adhesive on the door stem;
• glue them.
Wait for the drying time before gluing (follow the manufacturer's instructions).

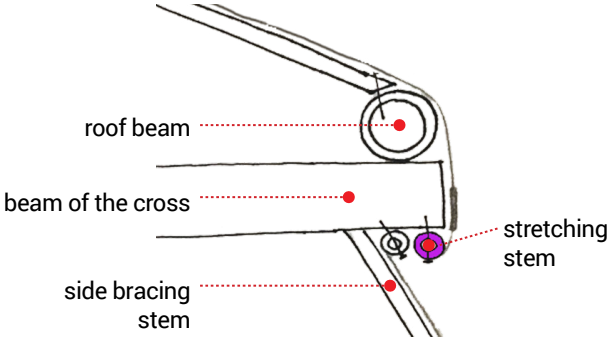


To make the bottom of the door:
• Spread contact adhesive on 1.2″ strips of the door bottom;
• Glue one side to the other, forming a tube. Note that the inside part of the tube will not be glued;
• Pass the door stem through the tube.
Wait for the drying time before gluing (follow the manufacturer's instructions).

STEP 14. ROOF

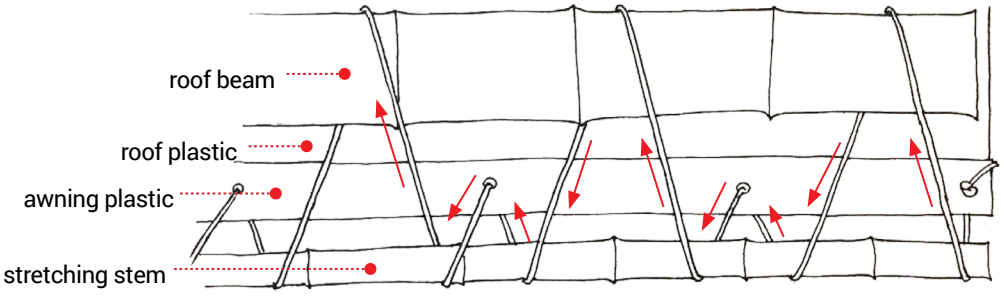


Fasten the 6 stretching stems of the roof to the ends of the beams of the crosses. They will help to stretch tight the roof plastic. Use screws, rubber sealing washers, and washers.



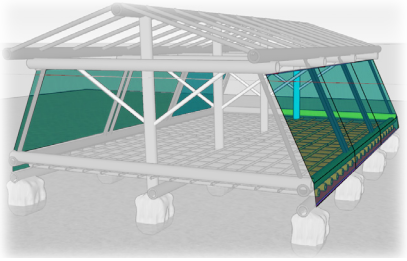
Position the roof plastic and prepare the polypropylene cord. Put yourself under the cover for a better view of the lashing.

To stretch tight the roof, make a sewing-like process as shown.

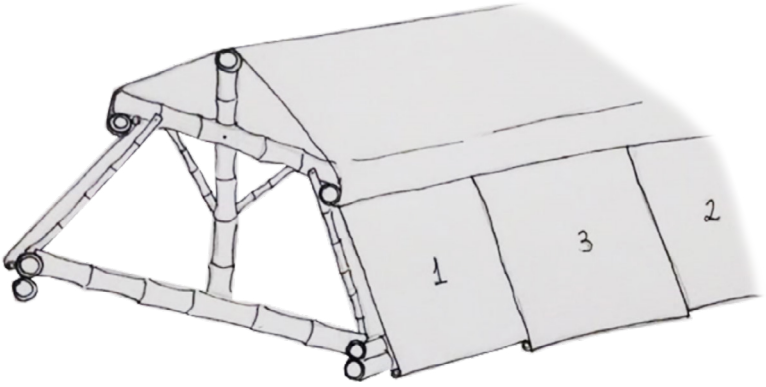


Leave the plastic loose while sewing. Stretch tight both sides simultaneously, always checking the position of the roof plastic.

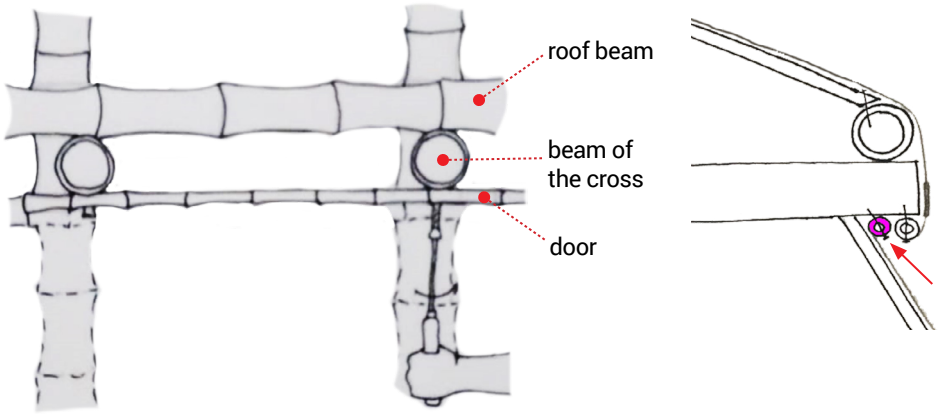
STEP 15. DOORS



Start attaching doors at the ends of the dryer (1 and 2), and then the middle door (3). For more than 3 modules, attach the doors alternately.

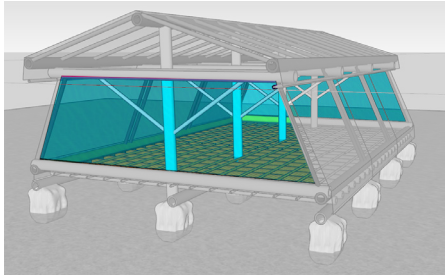


Fasten the doors under the beams of the crosses, next to the side bracing stems. Use screws, rubber sealing washers, and washers.



The doors are roll-up and can be held up on the roof while handling crops on the table.

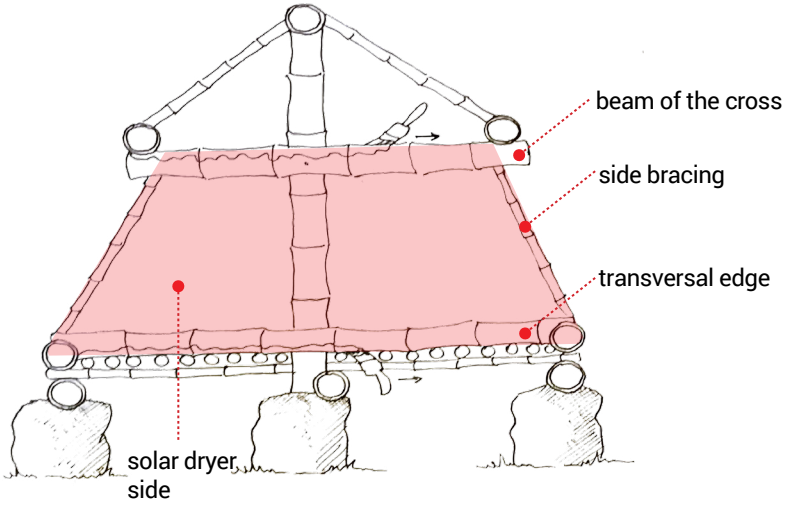
STEP 16. SIDES



Now, the plastic will be glued differently. It will be by layers as follow: **bamboo + adhesive + transparent plastic + adhesive + fabric reinforcement.**

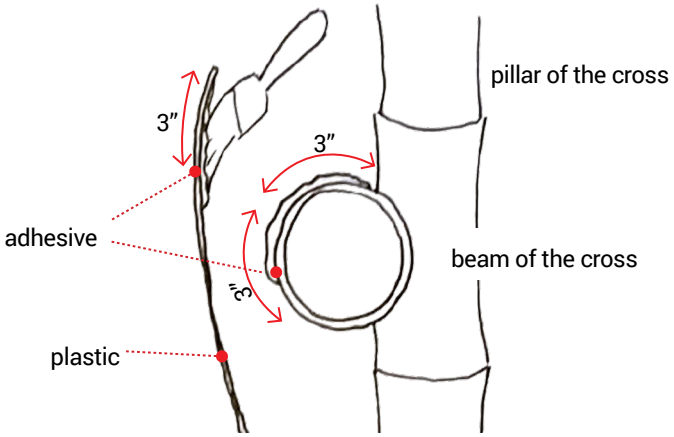
Start by gluing the plastic to the beam of the cross, then to the transversal edge, and finally, to the side bracings.

Cut the plastic in the shape of the side.



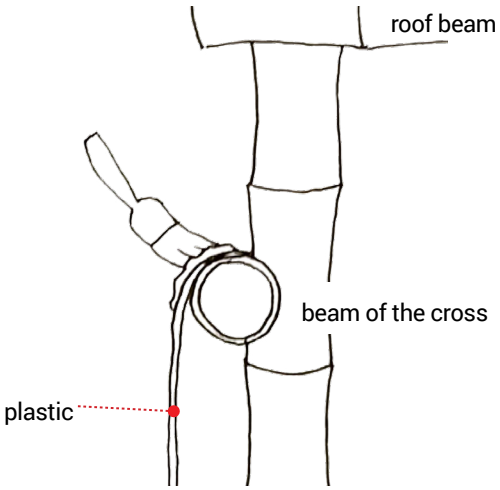
Spread adhesive in a 6" strip of the cross beam, border of the cross, and side bracings.

Spread adhesive on the plastic in a strip of only 3".



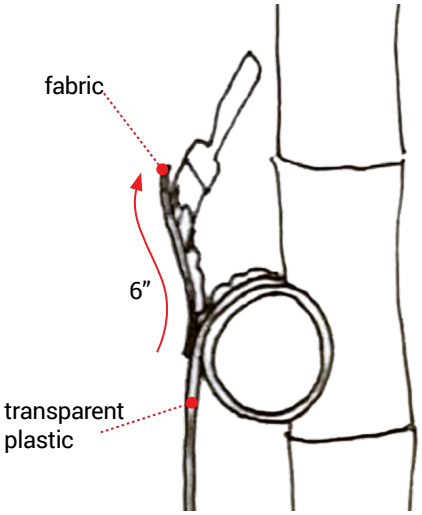
After gluing the plastic over 3" of the strip with adhesive of the cross beam, spread adhesive on a 3" strip of the back of the plastic.

The 6" fabric strip will be glued to 3" strip of the beam of the cross and 3" of the plastic with adhesive.



Spread contact adhesive on the 6" fabric band.
Glue the fabric over the plastic (3" strip) and the beam of the cross (3" strip).
Wait for the drying time before gluing (follow the manufacturer's instructions).

Repeat this process with the transversal edge.



Do not leave the plastic loose.
Stretch it while gluing.

The upper oppenings on the sides are the exits for hot and humid air.

Congratulations!
The solar crop dryer is ready!

REFERÊNCIAS
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