CRS
CATHOLIC RELIEF SERVICES

SAFER AND HEALTHIER HOMES

LOW-COST AND SUSTAINABLE HOUSE DESIGN AND CONSTRUCTION

MANUAL VERSION 2022

Since 1943, Catholic Relief Services has held the privilege of serving the poor and disadvantaged overseas. Without regard to race, creed or nationality, CRS provides emergency relief in the wake of disasters. CRS works to uphold human dignity and promote better standards of living through development projects in fields such as agriculture, education, health, microfinance, peacebuilding, and water and sanitation. CRS also works throughout the United States to expand the knowledge and action of Catholics and others interested in issues of international peace and justice. Our programs and resources respond to the U.S. Conference of Catholic Bishops' call to live in solidarity as one human family.

Cover image by Cristina García Escobar, 2022

Acknowledgements

The content of the different sections will be defined considering the valuable input of a variety of agents, including the Ministry of Health, the Ministry of Land, Housing, and Urban Development, CRS, CARE, Oxford Brookes University, TEVETA, as well as other actors.

Glossary

ACPC	Area Civil Protection Committee
SBA	Sugarcane Bagasse Ash
CD	Chronic Disease
CARE	CARE International UK
CEB	Compressed Earth Block
CGI	Corrugated Galvanized Iron sheet
CRS	Catholic Relief Services
DPM	Damp-proof membrane
DRR	Disaster Risk Reduction
GoM	Government of Malawi
HSA	Health Surveillance Assistant
LRI	Low Respiratory Infection
MoH	Ministry of Health
MoLHUP	Ministry of Land, Housing, and Urban Planning
NCD	Non-communicable Disease
OBU	Oxford Brookes University
SHCG	Safer House Construction Guidelines
SHH	Safer and Healthier Homes Manual
SSB	Stabilised Soil Block
TA	Traditional Authority
TEVETA	Technical, Entrepreneurial, Vocational Education and Training Authority
VCPC	Village Civil Protection Committee
WASH	Water, Sanitation and Hygiene

Table of Contents

Foreword

The purpose of this curriculum is to enhance best construction practices in low-cost housing, considering safer construction and environmental, health, and well-being aspects, through shelter design, construction materials, and construction techniques, mitigating risks related to physical and mental health, psychosocial well-being, and environmental issues, as well as integrating disaster risk reduction measures to support the self-recovery process of the communities affected by disasters and extend impact to the wider community.

Rains and floods pose a continuous threat to Malawi districts every year. In 2015, the vast amount of households affected by severe rains and floods prompted a Sate of Emergency and CRS, along with local partners, targeted support of shelter solutions to displaced people in the Phalombe, Zomba and Machinga districts.

After the floods subsided, evidence showed that despite weeks of immersion in water and driving rain, many houses survived with little or no damage, including those constructed using blocks, render and mortar made of earth. This indicated that the Malawian traditional homes had specific design features that were adapted to the local weather conditions.

Departing from that knowledge, CRS and partners facilitated a process with local communities and builders to identify and build upon best practices and to develop a house design that provided a demonstration of these details and techniques. The aim is to provide strong, durable and dignified homes with affordable local materials, to achieve social, cultural and economic sustainability

The purpose of this manual is to guide the construction of the afore mentioned house model. It is aimed at householders, artisans and site supervisors in the Malawian context, with the hope of extending impact to the wider community.

This manual has the *Safer House Construction Guidelines* as one of the main references, as well as previous manuals from CRS, and the humanitarian sector.

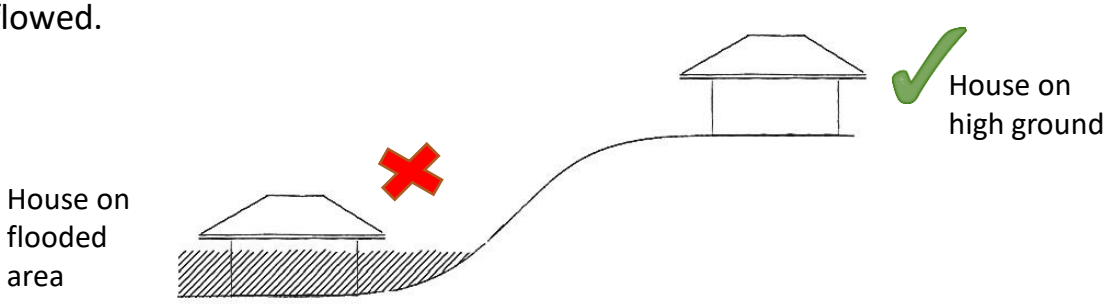
1 Site Selection

1.1. SITE SELECTION

Resilience begins by choosing a safe place to build, learning from past experiences. A few key recommendations on how to choose a site are:

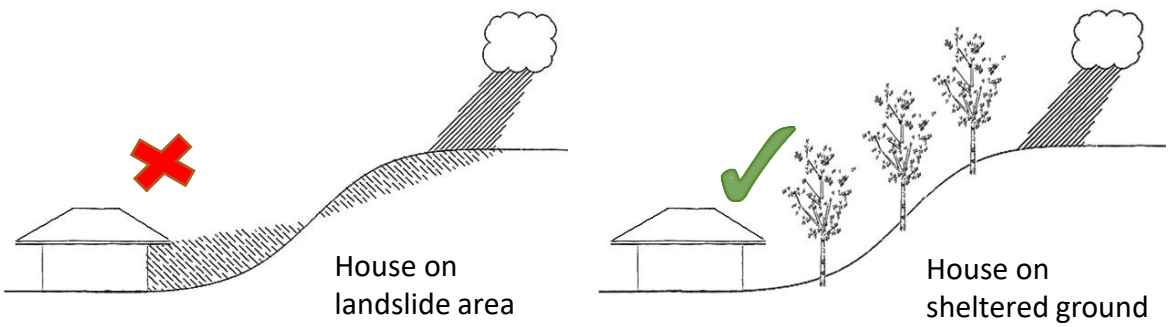
Avoid flood risk areas

Think about where the floods came to in the past and where the water flowed.



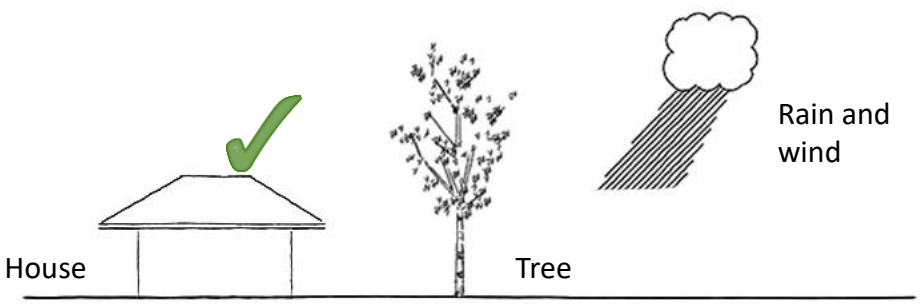
Be careful when building near slopes

Think about what may happen when it rains, especially landslides.



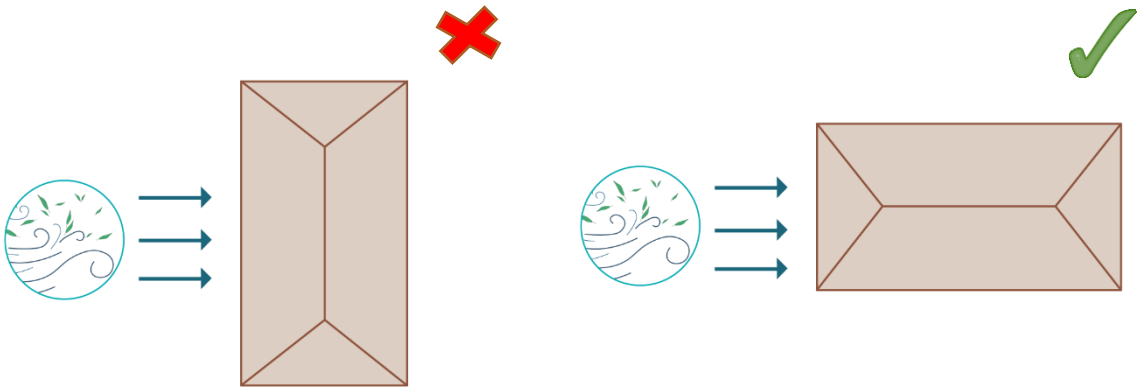
Natural Shelter

Think about the direction of the wind and rain and find a sheltered site.



1.2. ORIENTATION

When possible, position the short side of the house towards the direction of the prevailing winds. This will help to avoid having wind pressure in a larger area of the roof.



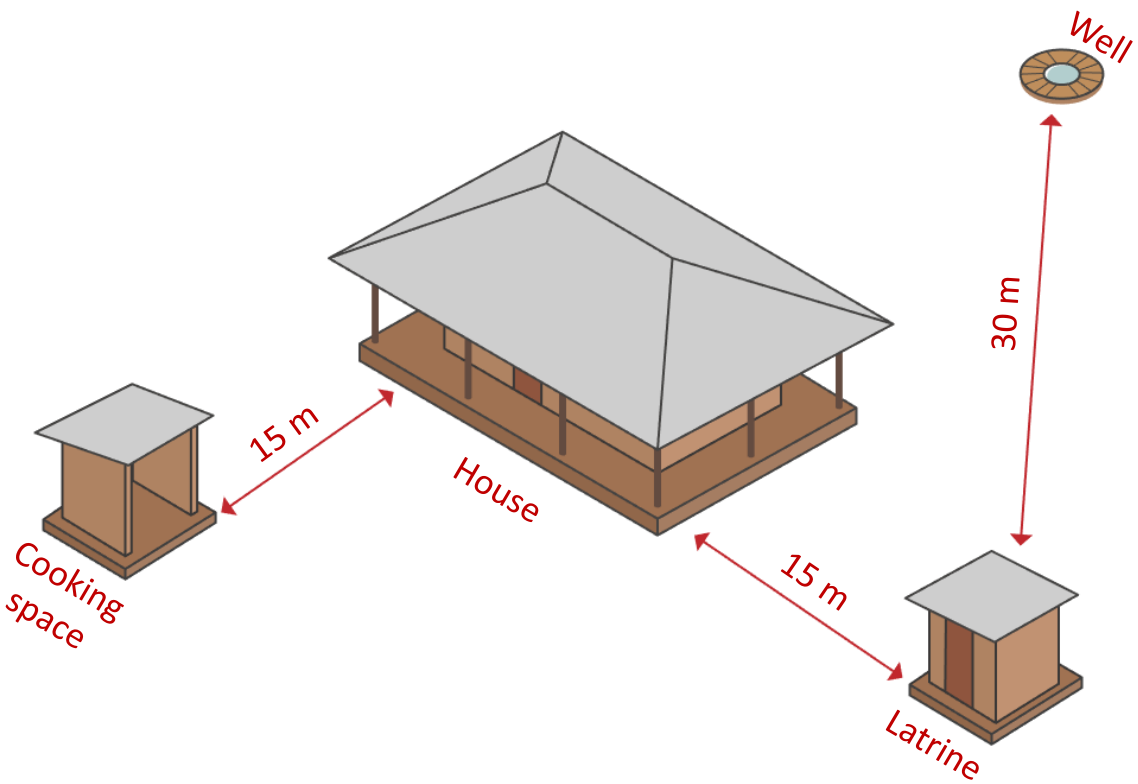
2 Site Design

2.1 LOCATION WITHIN PLOT AND DISTANCES

2.1.1 Distance between latrine, well and house

Determining a good location for the latrine in relation to the water source and the house is very important to prevent diseases and flies. Key considerations for placing kitchen and latrine facilities are:

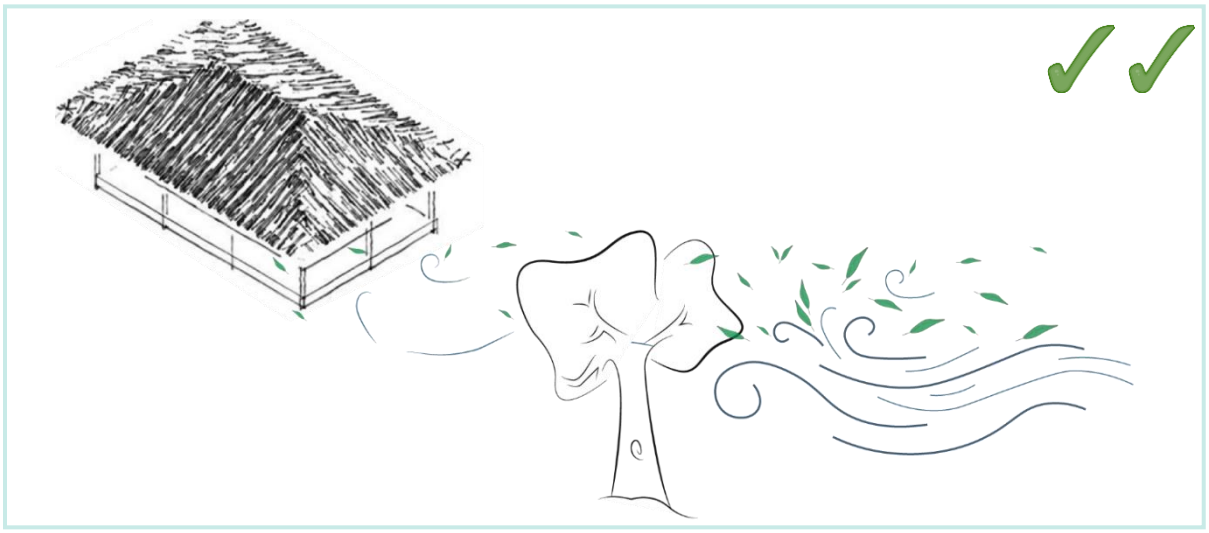
- Latrine should be separated from the house and kitchen by at least 15m
- Avoid wind direction flowing from latrine to house and kitchen
- Latrine should be placed at least 30m away from water source (well)



2.1 LOCATION WITHIN PLOT AND DISTANCES

2.1.2 Distance from trees

Try to keep an adequate distance from the house to prevent damage in case of falling. Some of the main benefits of trees around the house are shade, windbreaks, reduce the rain flow.



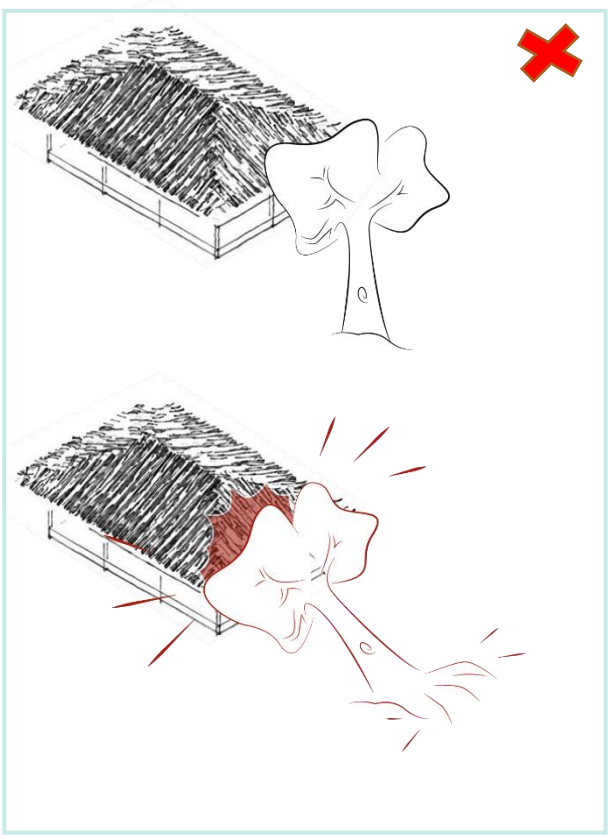
DRR MESSAGE

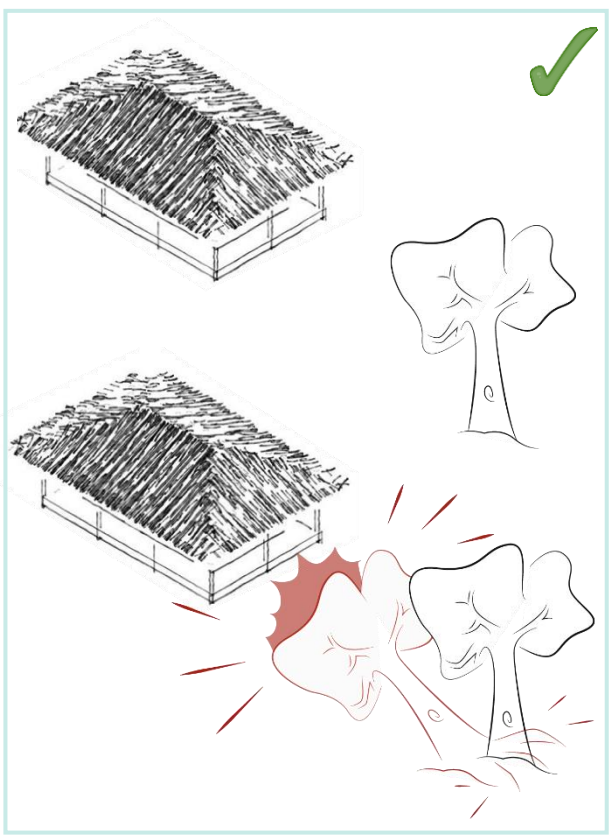
Trees and bushes around the house are encouraged as windbreaks. Consider planting trees or building at a proper distance from existing ones.

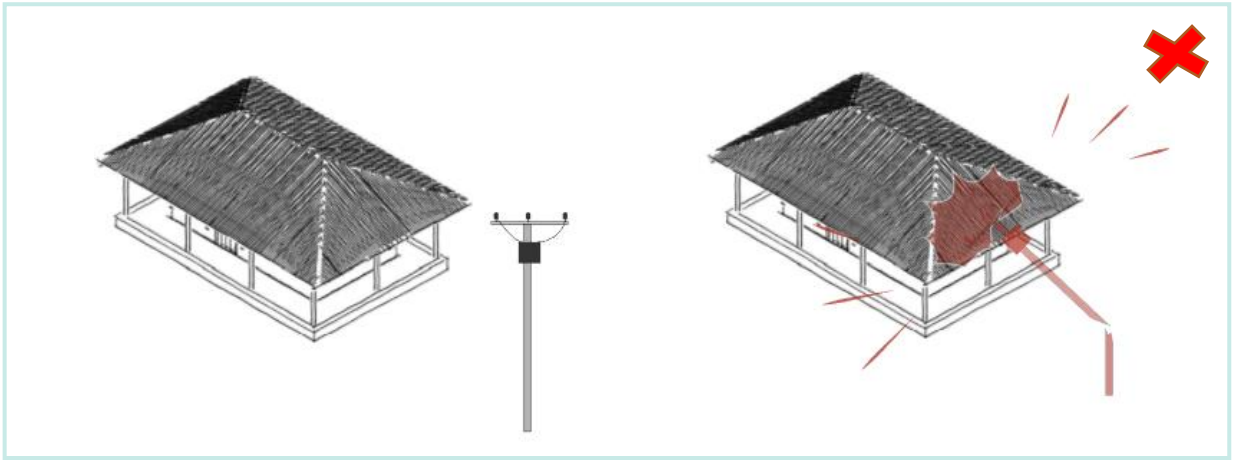
2.1 LOCATION WITHIN PLOT AND DISTANCES

2.1.3 Distance from trees

Try to keep an adequate distance from the house to prevent damage in case of falling.



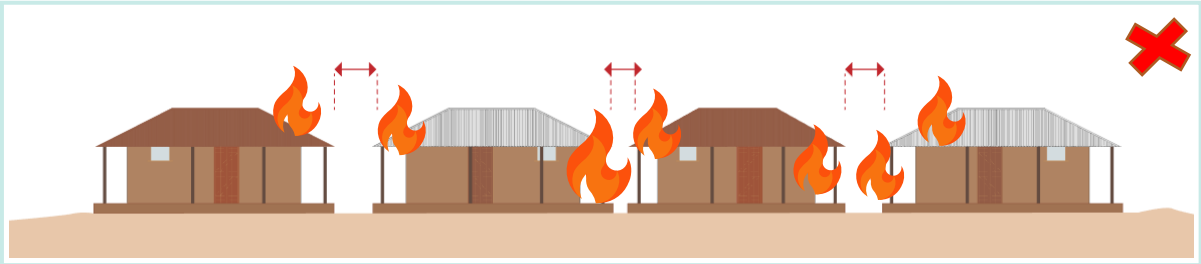


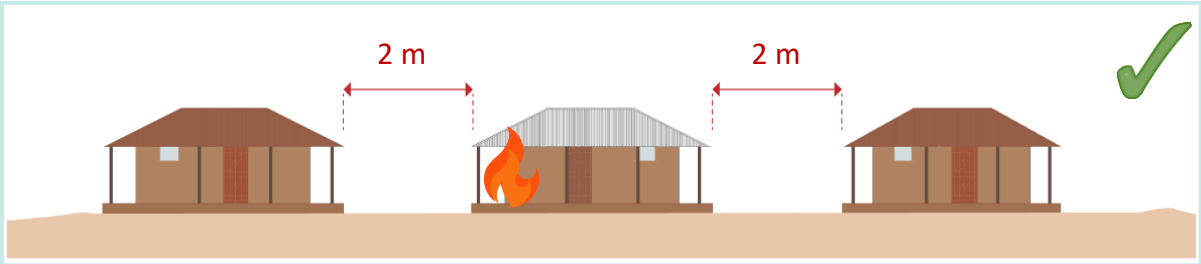


2.1 LOCATION WITHIN PLOT AND DISTANCES

2.1.4 Distance from other buildings

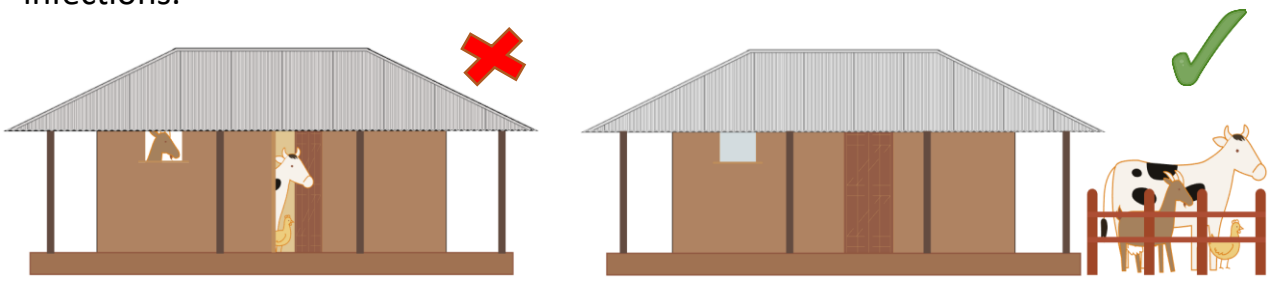
Keep an appropriate distance from other buildings to allow for better ventilation and prevent firebreaks from spreading around the village.





2.1.5 Distance from domestic animals

Don't keep animals inside the house, make space outside for them to avoid infections.



HEALTH ALERT

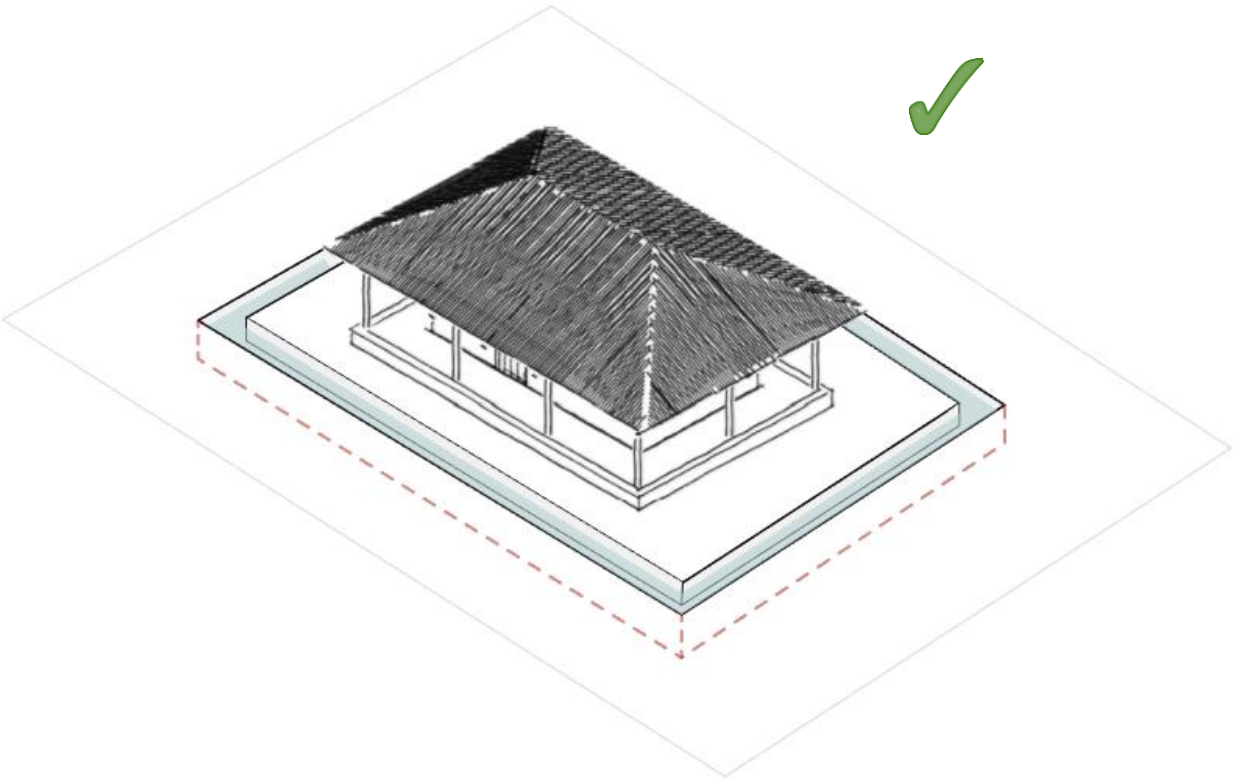
Trachoma is a bacterial infection that affects your eyes, and it can cause blindness. It can be transmitted through animals, flies or direct contact with a person infected with trachoma.

2.2 DRAINAGE

2.2.1 Drainage around house

Build a **drainage channel** around the house of about **30cm deep** to prevent flooding in the area next to the house.

If the house is surrounded by other houses, the drainage channels can be combined to create a larger drainage network in the village.



DRR MESSAGE

Drainage channels have an important impact during rainy seasons, since this can help keep the water flowing away from the house. **Keep the drainage channel clean**, otherwise the water will not be allowed to drain.

2.2 KEYHOLE GARDEN

2.2.1 Select the area

Choose and area that is levelled and not prone to flooding for the keyhole garden.

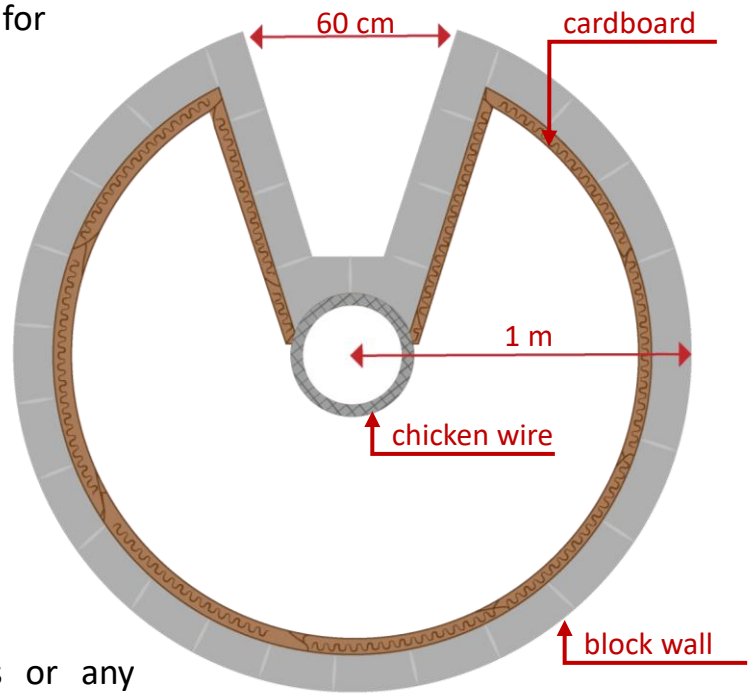
2.2.2 Setting out

Hold a 1 m string in the center of the garden and mark the perimeter of the wall using the other end of the string as a compass.

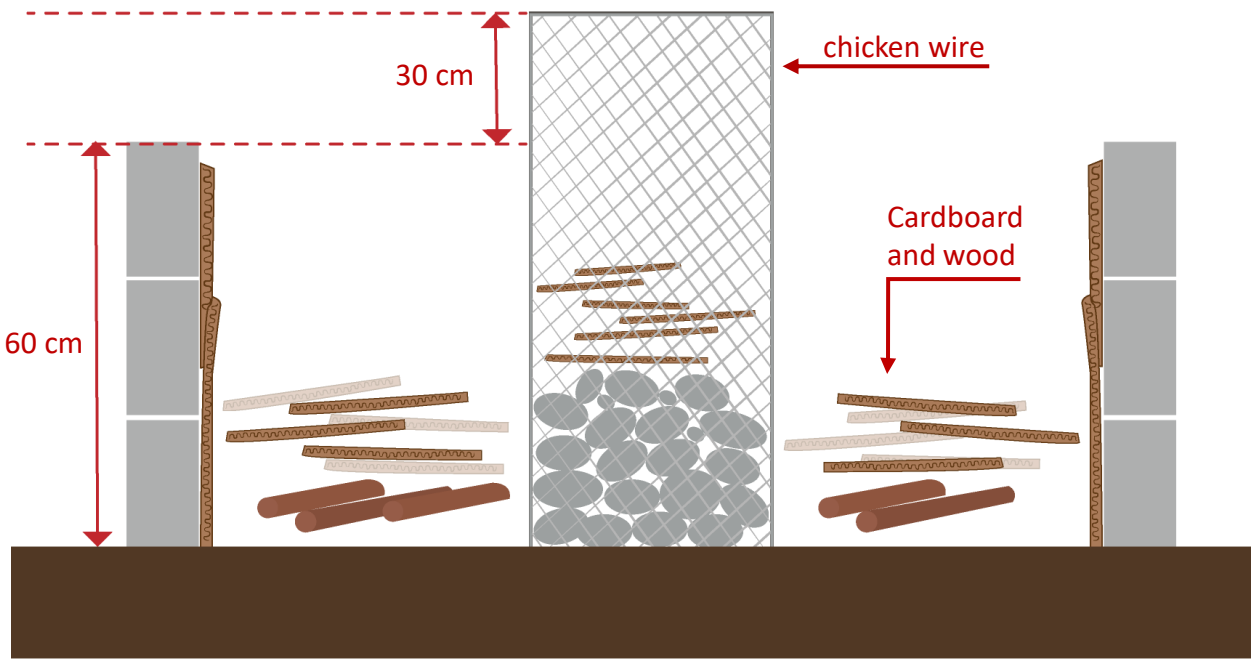
Leave an opening of 60 cm in the perimeter wall that narrows as it reaches the center of the garden.

2.2.3 Build the perimeter wall

For the wall, blocks, stones or any other material that is water-resistant can be used. The perimeter wall height can be around 60 cm to 90 cm.



Top view of keyhole garden in construction.



Section of keyhole garden in construction.

2.2 KEYHOLE GARDEN

2.2.4 Compost bin

At the center of the garden a compost cage made of a permeable material should be placed. This material can be chicken wire, bamboos stakes or anything that allows water to flow through. It should be 30cm above the top of the garden.

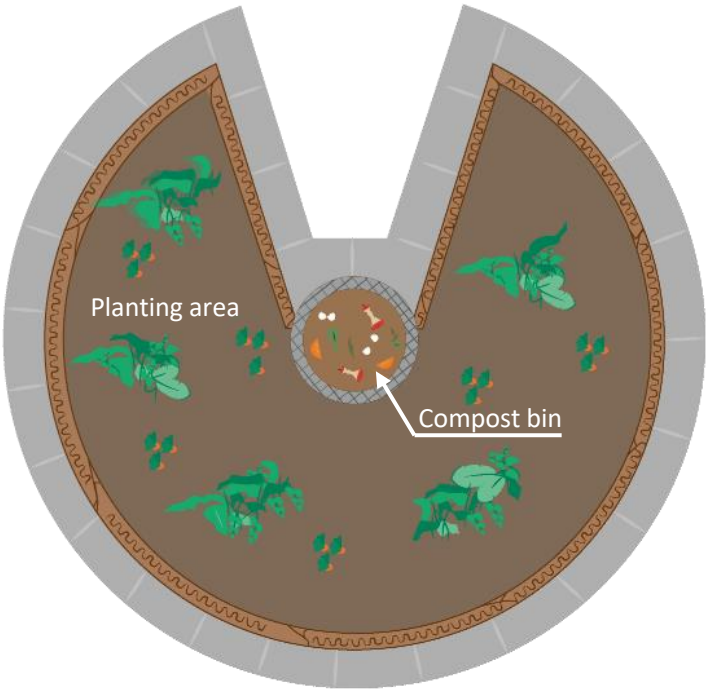
2.2.5 Bottom layer

Line the walls and bottom layer of the garden with cardboard and other compostable material.

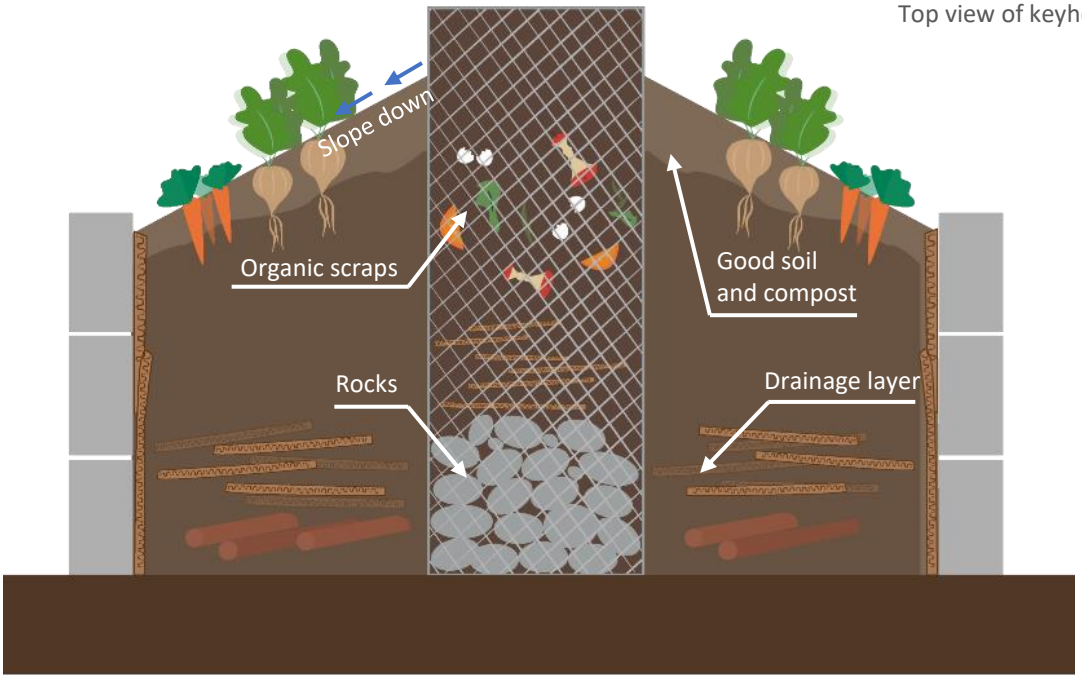
Additional layers of organic matter such as leaves can be placed.

The top layer should be made of good soil and compost, and it should slope down from the center compost bin to the perimeter wall.

Wet the layers as you place them.



Top view of keyhole garden.



Section of keyhole garden.

3 House Design

1) Privacy

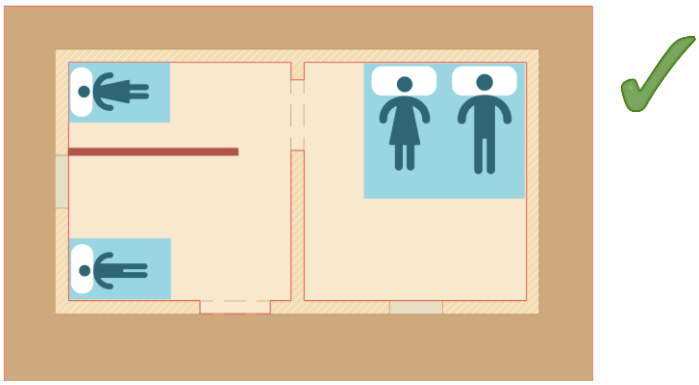
3) Appropriate space

2) Ventilation

3.1 HOUSE LAYOUT

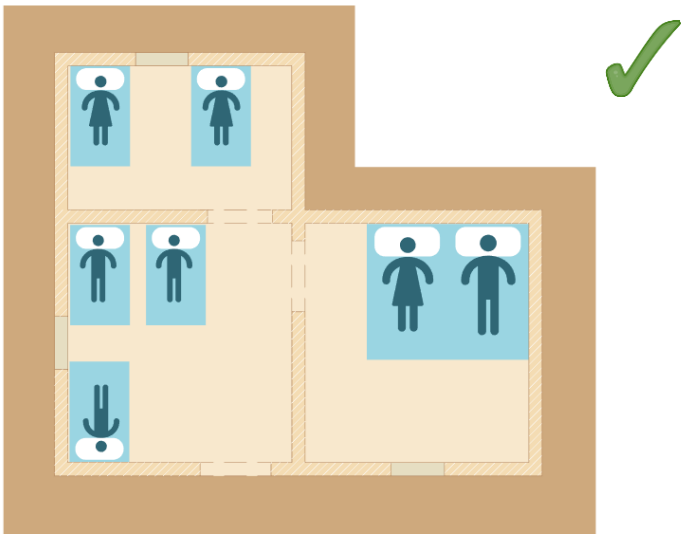
3.1.1 Privacy

There should be separations between men and women inside the house to provide privacy.



3.1.1 Room size

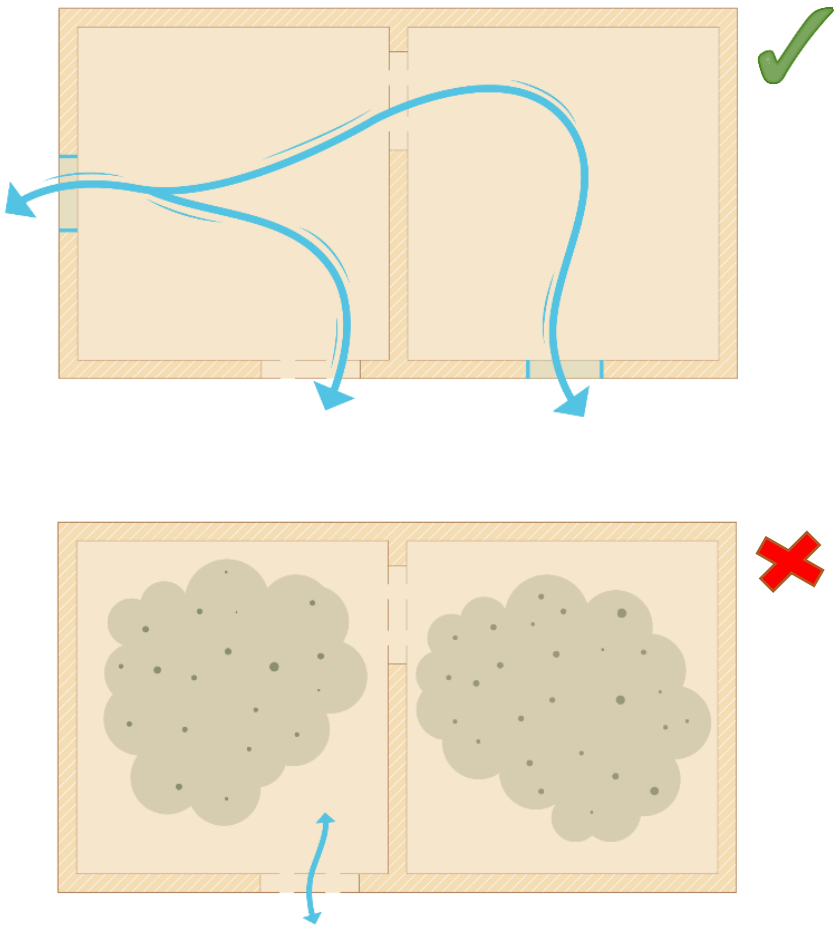
Make sure the rooms are large enough for the number of people living there to avoid overcrowding. As a reference, **3.5 m^2 per person** (SPHERE).



3.2 HOUSE VENTILATION

3.2.1 Windows

Place windows on opposite sides of the house and open them frequently for a good ventilation. As a rule of thumb, the total m2 of opening should be 10% of the floor area. Don’t shut window openings.



HEALTH ALERT

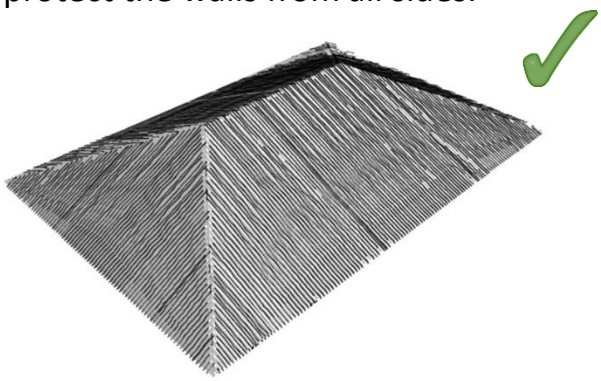
Good ventilation improves the indoor air quality and helps to reduce respiratory infections, vector-borne diseases, and chronic diseases.

Overcrowding affects negatively the indoor air quality and mental health.

3.3 ROOF DESIGN

3.3.1 Hip roof

The inclined angles of the **hip shape roof help to resist the uplift pull of strong winds,** while the shape avoids gable ends and allows to have a veranda around the house to protect the walls from all sides.

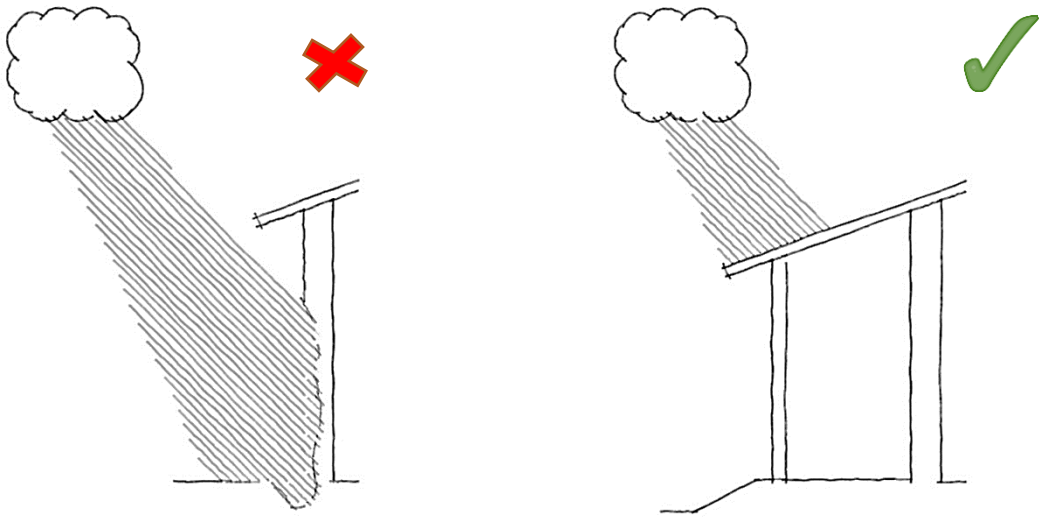


DRR MESSAGE

A hip roof can reduce the hazards of strong winds, this shape protects the house from all four sides and prevents wind from uplift pull.

2.3.2 Roof overhang

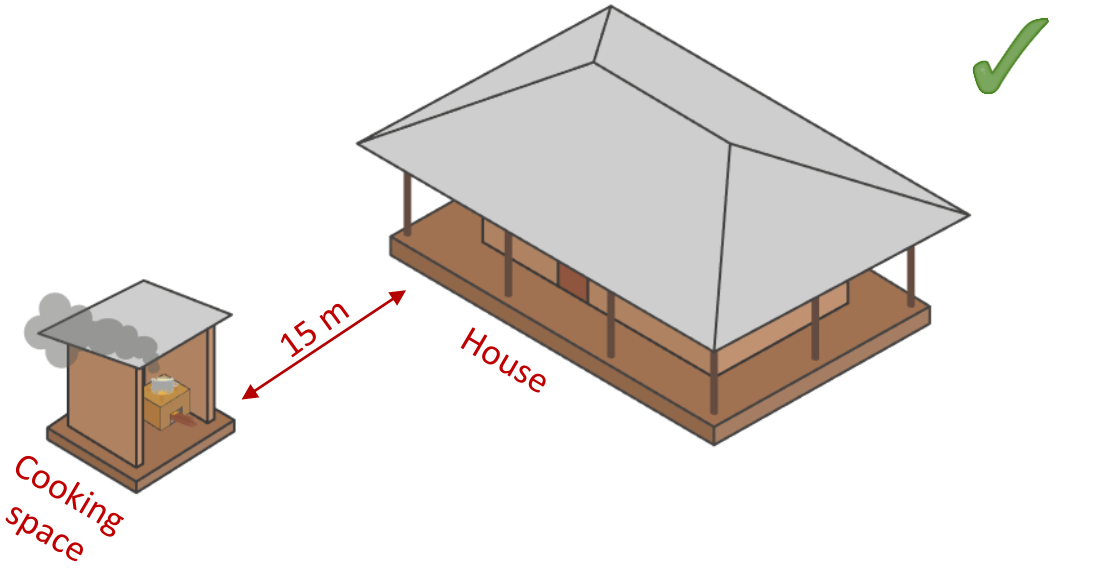
The roof is extended outside of the veranda. This **overhang protects the walls from the rain**, avoiding water damage to the earth blocks.

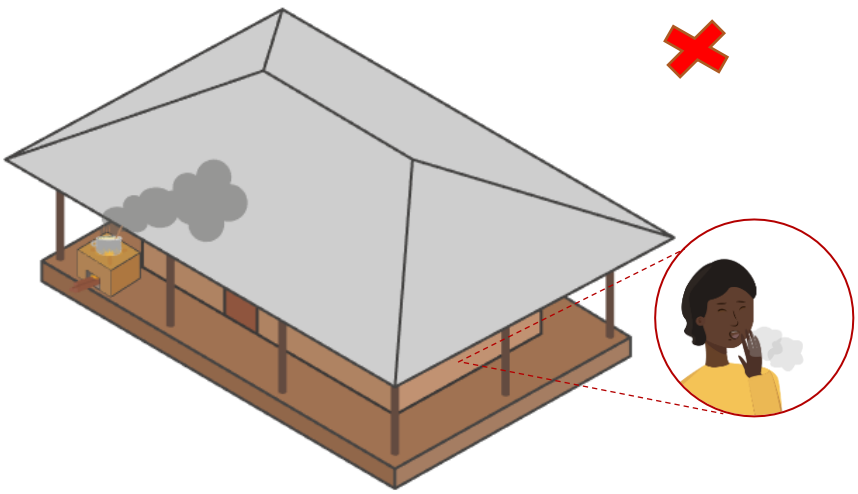


3.3 COOKING

3.3.1 Cooking area

It is preferable to have the cooking area outside to prevent firebreaks and smoke spreading in the house. Avoid cooking inside with the windows closed. If you are cooking inside, make sure the windows are open and paying attention the whole time.





HEALTH ALERT

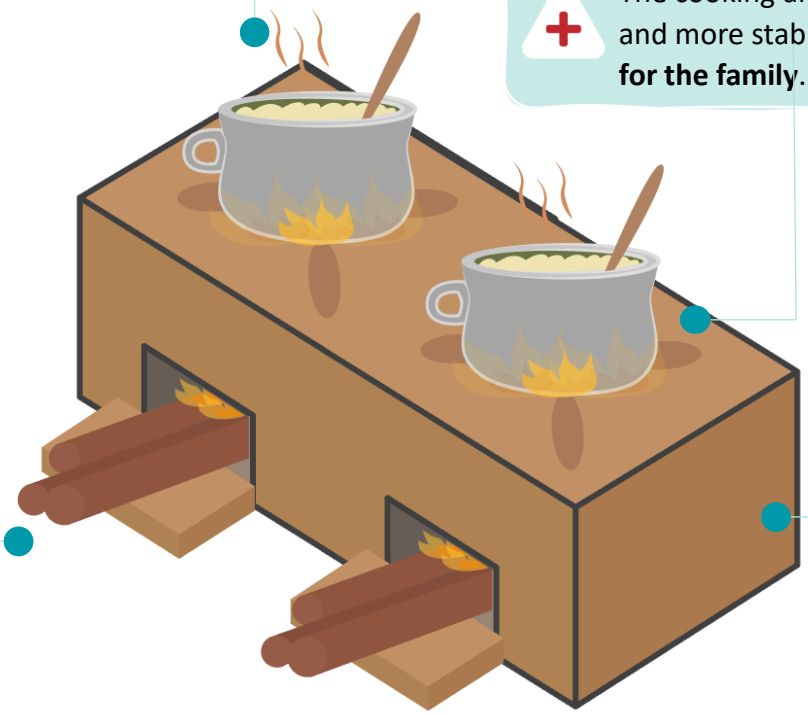
Cooking pollution severely affects the respiratory system. Household Air Pollution from cooking with polluting fuels inside the house affects specially women and children.

3.3.2 Mud brick stove

A mud brick stove is easier to use, requires less firewood, produces less smoke, and it is safer for children. It can easily be built with unburnt bricks, which makes it affordable and minimizes pollution. See Annex XX for step-by-step construction of the mud brick stove.

The production of less smoke **reduces the impact on the respiratory system**.

The cooking area is protected and more stable, making it **safer for the family**.



The use of less firewood can **reduce deforestation and be more affordable**.

Can be made of earth blocks, avoiding burning procedures **minimizes deforestation**.

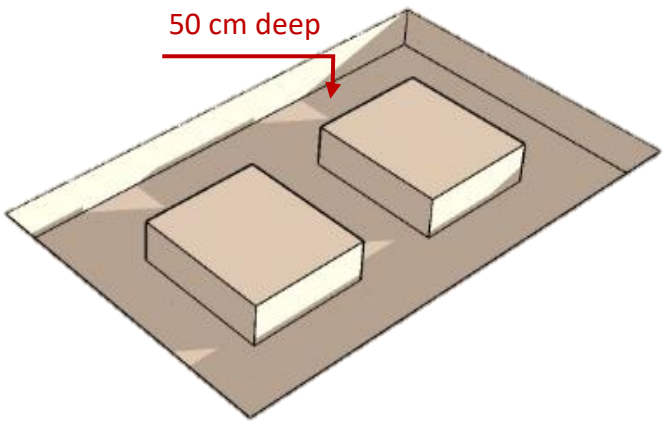
4 Construction Details

4.1 FOUNDATIONS

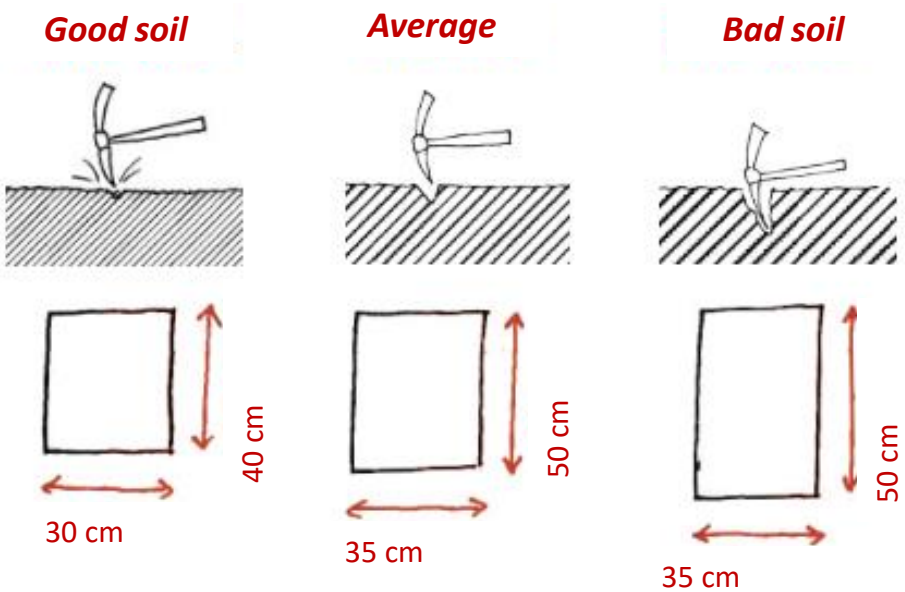
The foundation is the structure that supports the weight of the house. They must be under all shelter walls. Hence, foundation trenches are dug in the perimeter of the shelter, and in the middle, to receive the outer and inner walls.

4.1.1 Trench digging

1) **Identify the type of soil** you have if it is good, average or bad soil.
2) **Remove the topsoil** and clean the area.
3) Dig until you **reach firm soil**. The depth should be according to the type of soil. It must be **minimum 40 cm depth** and the width can be usually 3 times the plinth wall thickness.



Foundation trench for house.



4.1.2 Courses

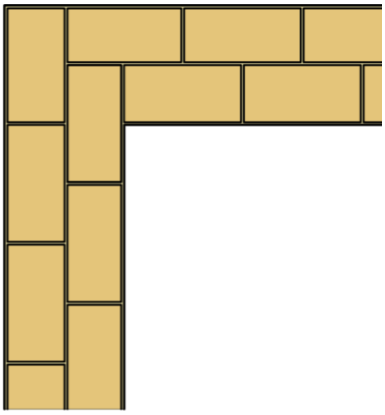
1) **The first course of the foundations is 2 blocks wide** and consists of sleepers.

2) **The second course is 2 blocks wide** and consists of headers.

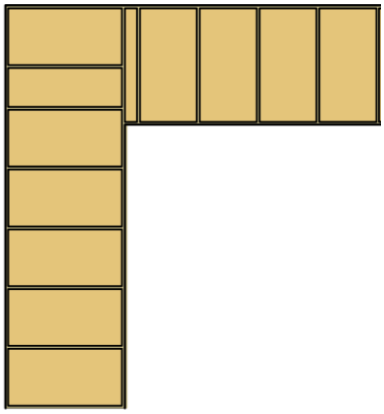
3) From the third course up to plinth height (30 cm above ground level) the courses are **single block** as sleepers.

NOTE: this may vary according to the material chosen for the foundation and type of soil.

Course 1: sleepers

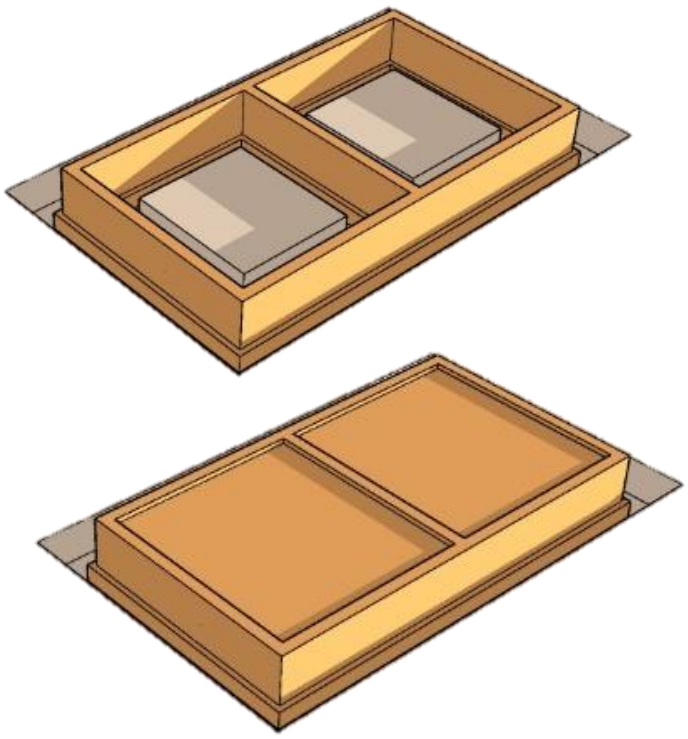


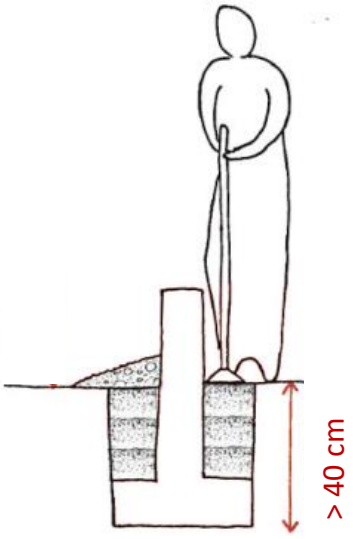
Course 2: headers



4.1.3 Compaction around foundations

Compact layers of 15 cm around the foundations until you reach the desired height.



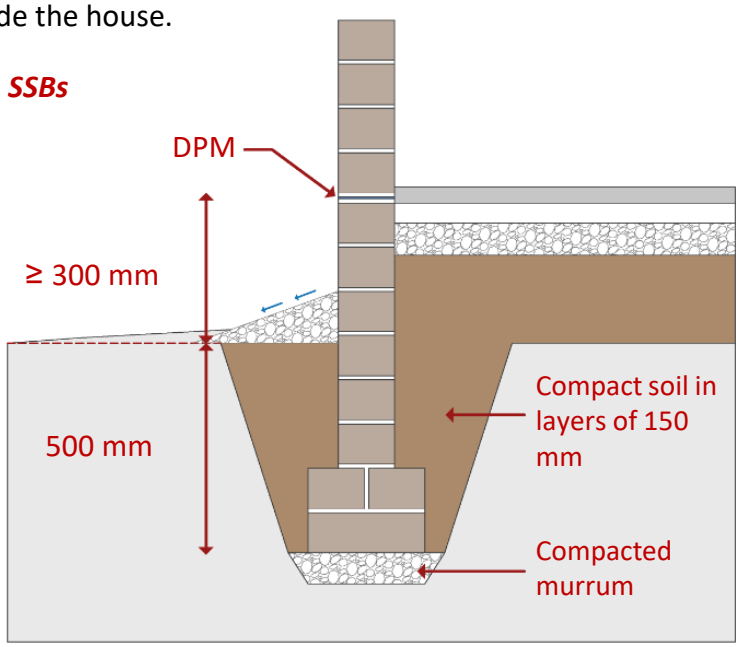


Foundations before and after compacting earth.

4.1.4 Foundations with **SSBs**

SSBs are a good material for use underground, since they are stabilized blocks. A damp-proof membrane (DPM) will be required at plinth height to prevent moisture from rising to the walls and inside the house.

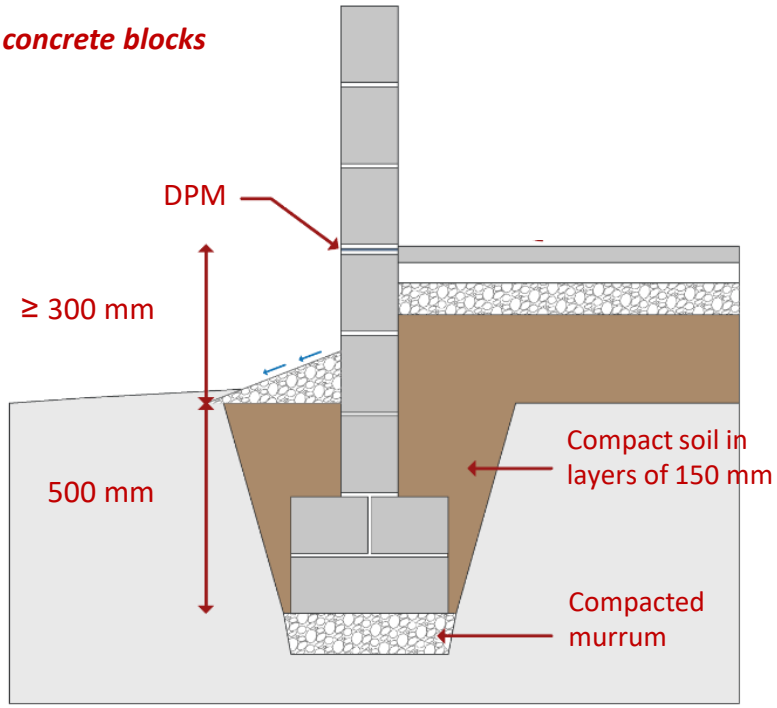
Foundations with SSBs



4.1.5 Foundations with **concrete blocks**

Concrete blocks are also a good material for use underground, since they can withstand humidity. A damp-proof membrane (DPM) will be required at plinth height to prevent moisture from rising to the walls and inside the house.

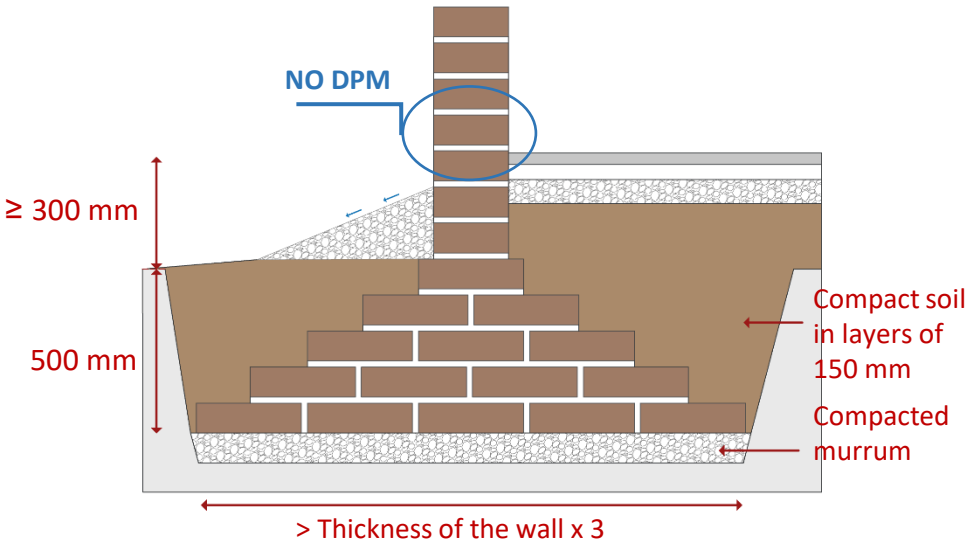
Foundations with concrete blocks



4.1.6 Foundations with **adobe blocks**

Adobe blocks can easily deteriorate with humidity underground, for this reason, if the foundations are going to be built with adobe, the width of the foundations must be at least 3 times the thickness of the wall. The external part will protect the rest of the foundation from water.

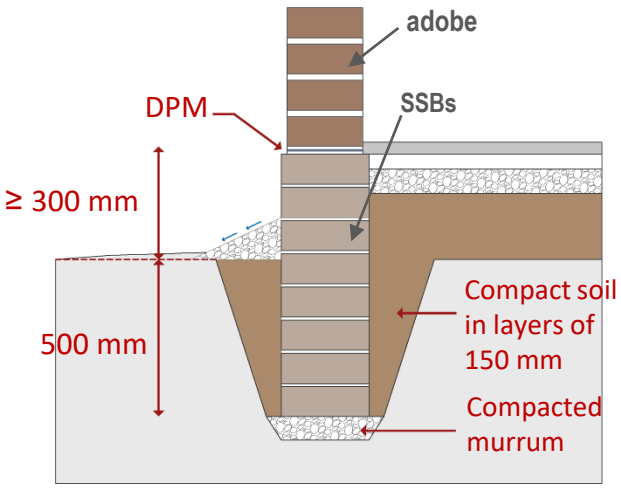
Option A: Foundations with adobe blocks



DRR MESSAGE

When building the foundations as **Option A:** Foundations with adobe blocks, **DO NOT use** a DPM. This will make water concentrate in the foundations and cause severe damage.

Option B: Foundations with SSBs and adobe wall

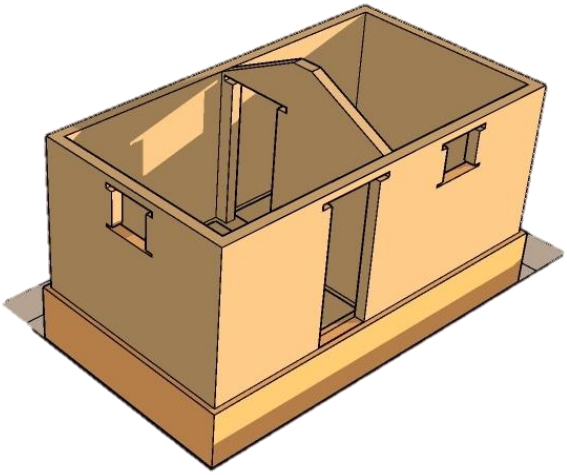


Since SSBs are good for use underground, a mix of materials can be done. Build the foundations with SSBs, when reaching the plinth height prevent moisture from rising to the wall by placing a DPM and then start building the wall with adobe blocks.

4.2 WALLS

4.2.1 Keep walls horizontally and vertically levelled

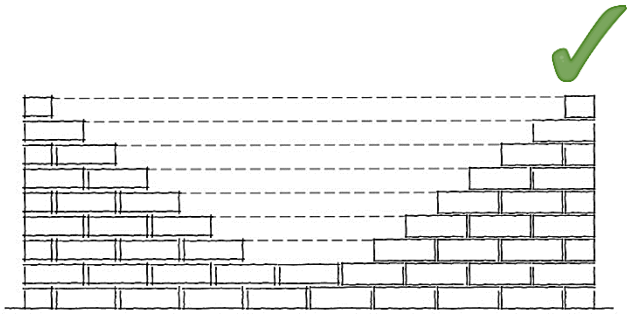
Use a gauge rod or spirit level to ensure walls are levelled. Go to Section *7. Skills : Bricklaying* for details.

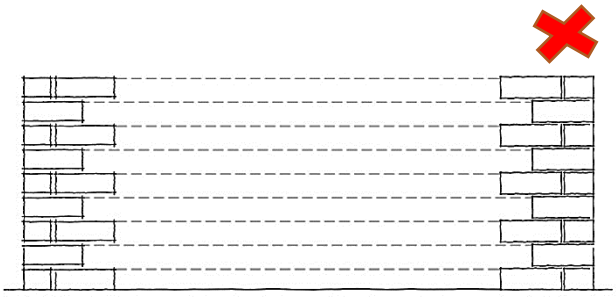


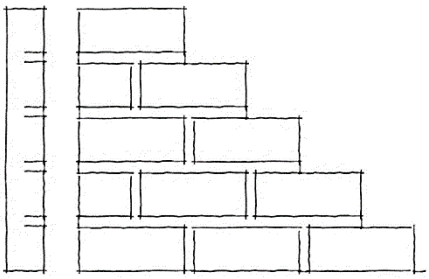
4.2.2 Use the right mix for mortar

The mortar must be the same quality of soil as used for the brick production. All joints must be fully filled with mortar 1 – 2 cm thick joints.

Go to Section *6. Materials : Mortar* for details.





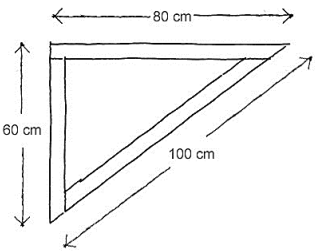


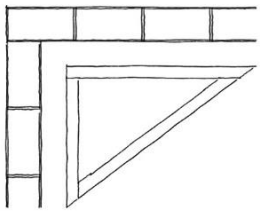
Check for plumb walls.

4.2.3 Pay attention to corners

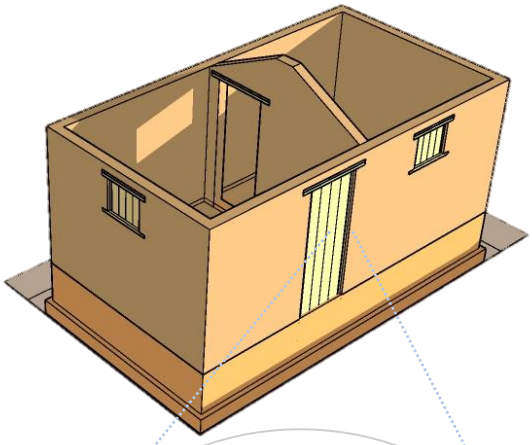
The corners should be built as steps, not toothed.

All wall corners should be right angles and must be constantly checked with a wooden triangle model.





4.3 WINDOWS AND DOORS



4.3.1 Lintels

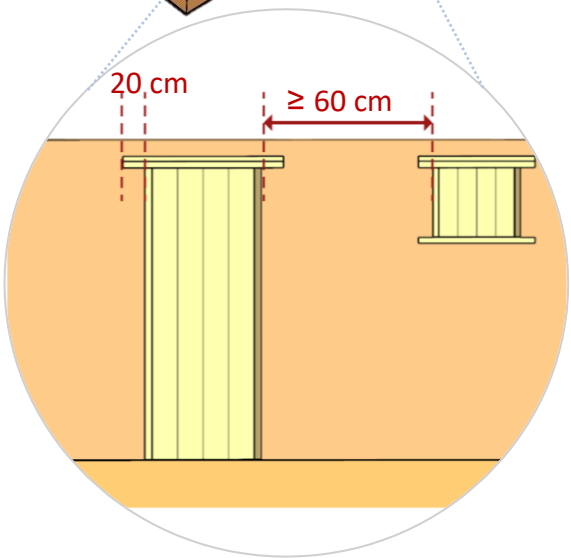
All openings must have suitable lintels to support the structure. Use 2 poles of minimum 3" (7.5cm) thick for each lintel.

The strongest timber should be selected for the lintel above the internal wall opening, as it supports the most load and does not have a door frame underneath.

See 7. Skills : Carpentry for details.

4.3.2 Distance between openings

Doors and windows must be separated at least 60 cm from corners and other openings.



4.3.3 Size of openings

Door and window openings should not be greater than 120 cm.

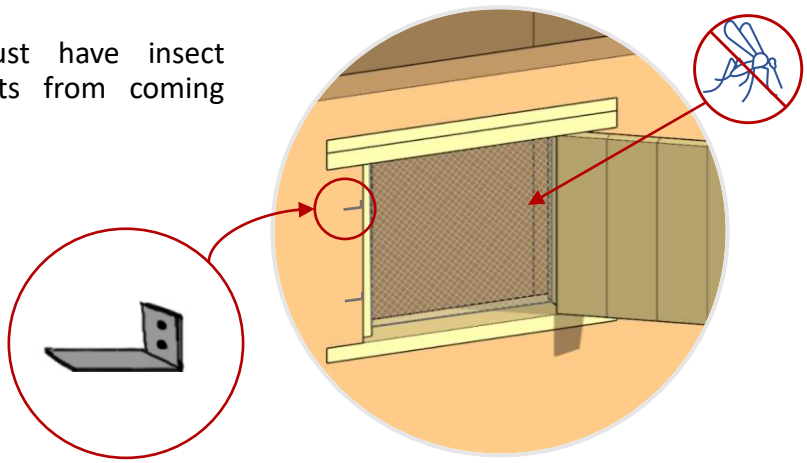
The total area of openings must be less than 50% of the total wall area.

4.3.4 Insect screens

Windows and doors must have insect screens to prevent insects from coming inside the house.

4.3.5 Fix frames to wall

Fix metal ties/lags to either side of window and door frame, to provide an anchor into brickwork.



HEALTH ALERT

Insect screens on the windows can prevent mosquitos and other insects from entering your home, and so, protect your family from malaria and other vector-borne diseases.

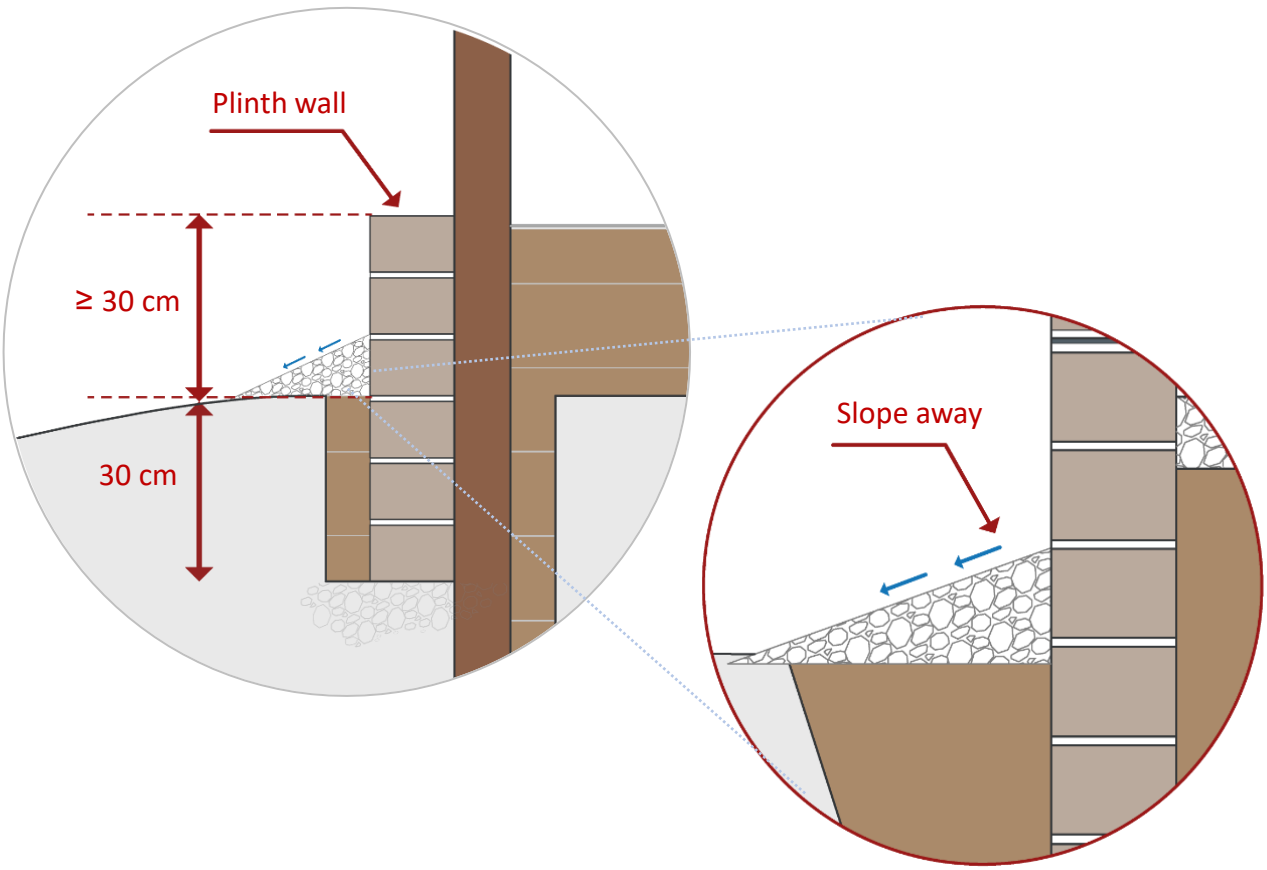
4.4 PLINTH

4.4.1 Raised plinth

The plinth height should be at least 300 mm or the height of the highest flood record in the area.

DRR MESSAGE

The ***plinth must be raised*** up at least 300 mm or to the Highest Floor Level of the area.



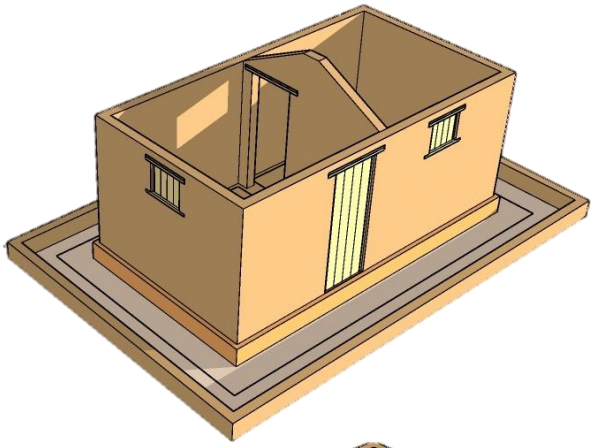
4.2.2 Slope away

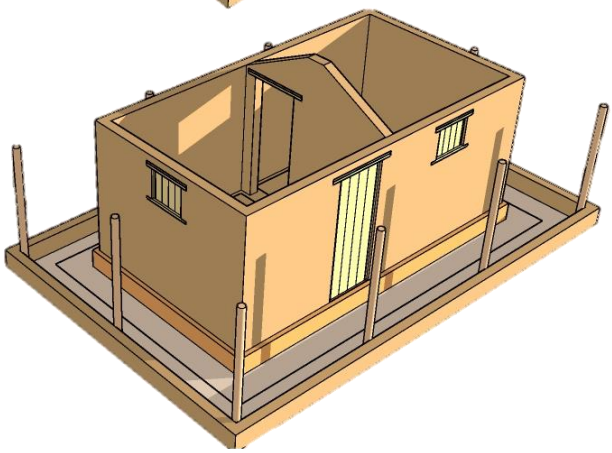
Compact murrum around the plinth with a slope that drives water away from the foundations. The ground should slope away from the building at a gradient of 1:10.

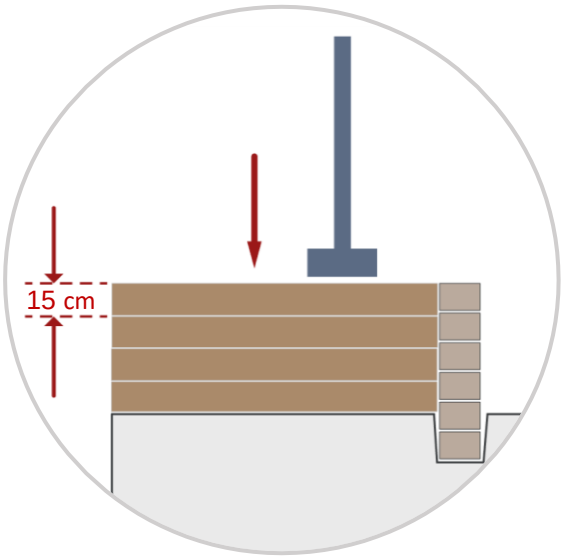
4.5 VERANDA

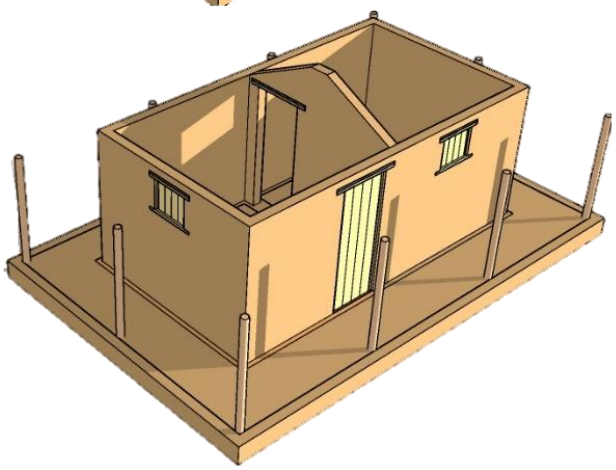
4.5.1 Foundations for veranda

1) **Foundation trench** for veranda of at least 20cm deep and wide enough for one block thick foundation.
2) The **height of the foundation wall** should be at least 30cm above ground level.
3) Use **wooden posts treated** by heat treatment or anti-termite treatment and laid minimum 50cm below ground level.
4) Fill ground level between both plinths with **compacted earth** in layers of 15cm.









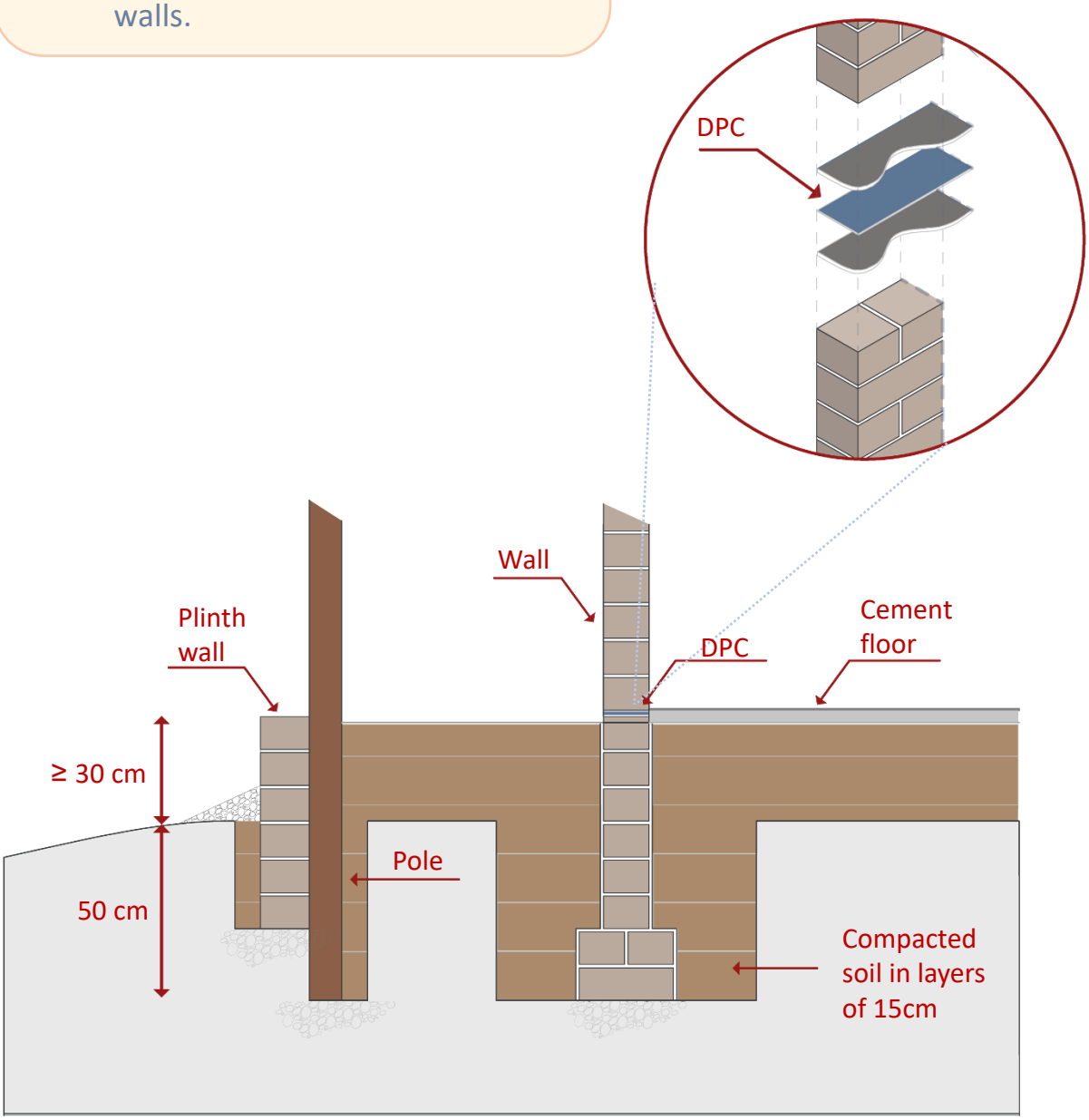
DRR MESSAGE

The wooden poles must be treated to prevent pests such as termites, this will have an important impact on their durability.

FOUNDATIONS, PLINTH AND VERANDA DIAGRAM

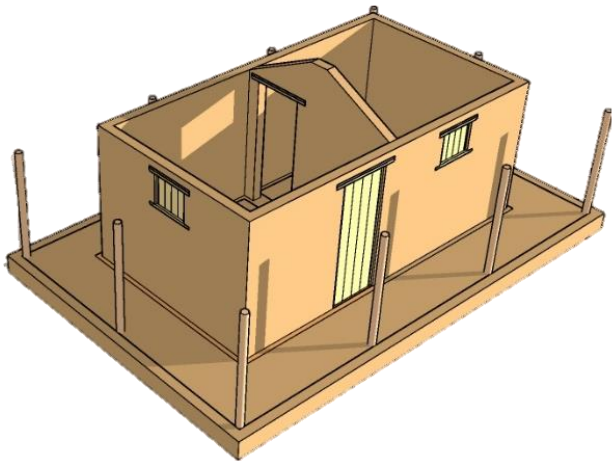
DRR MESSAGE

Place a ***damp-proof course (DPC)*** above foundations to prevent moisture from raising to the walls.

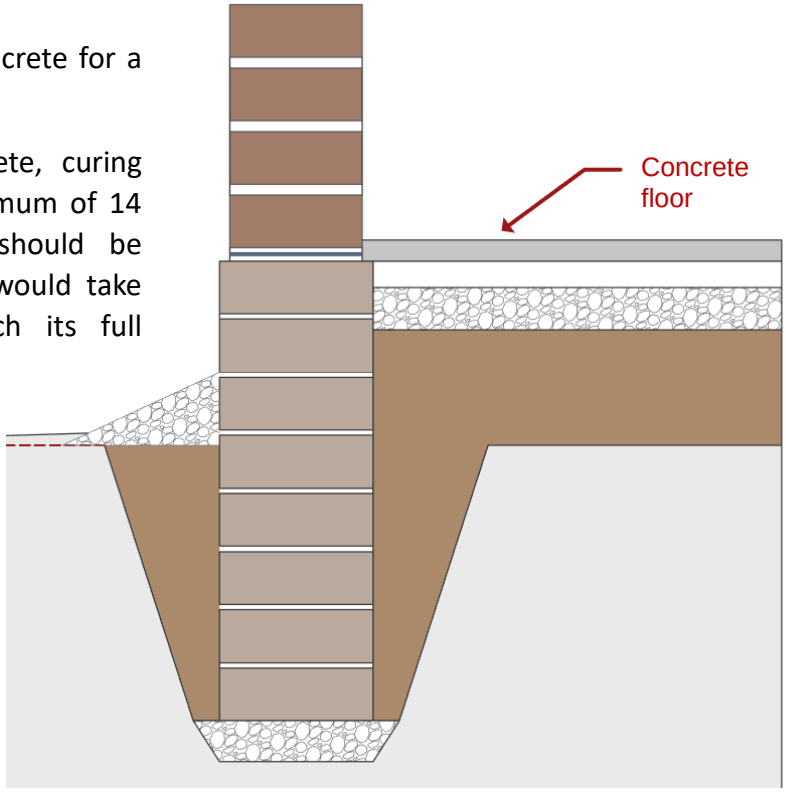


4.6 FLOOR

4.6.1 Concrete floor



1) Make a wooden frame for the concrete layer, use a square to make sure the corners are at 90° angles.
2) Prepare the concrete mix according to table on Section: 6. Materials and Skills – Concrete.
3) Pour the concrete while spreading it throughout the area using shovels and rakers.
4) Screed the top of the concrete for a uniform surface.
5) After pouring the concrete, curing must be done for a minimum of 14 days and the surface should be always wet, normally it would take 28 days for it to reach its full strength.



HEALTH ALERT

Insect screens on the windows can prevent mosquitos and other insects from entering your home, and so, protect your family from malaria and other vector-borne diseases.

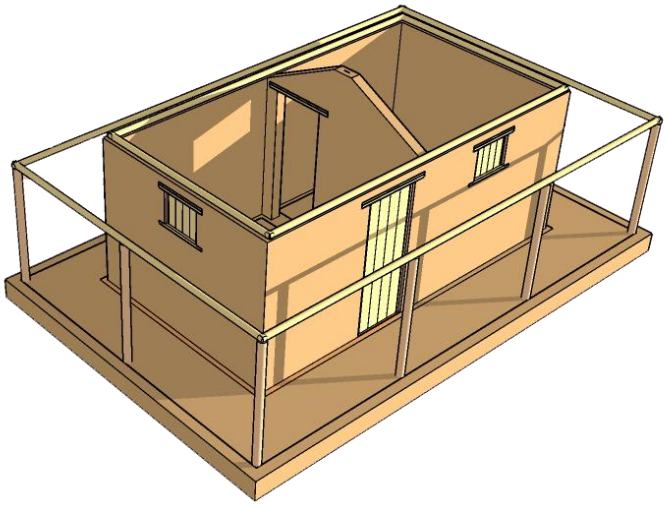
4.6 WALL PLATE

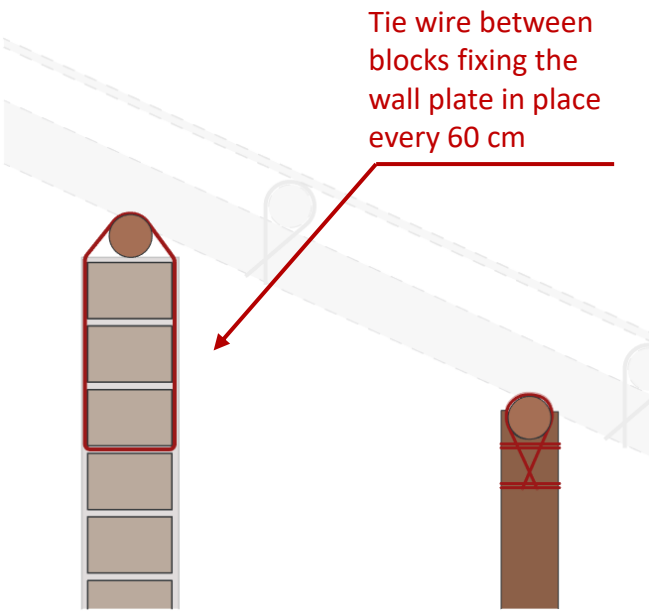
4.6.1 Fixing wall plates

Post connections should be fitted and nailed securely to posts and wall plates should be fixed to the walls with tie wire.

Make a hole to feed the wire through the wall and then up to internal wall.

Ensure ties are in place at intervals of 60 cm, at corners, and junctions to windows and doors.





4.6.2 Poles treatment

Timber wall plates must be treated for termites with anti-termite treatment or by heat treatment for pest control.

4.6.3 Keep wall plates levelled

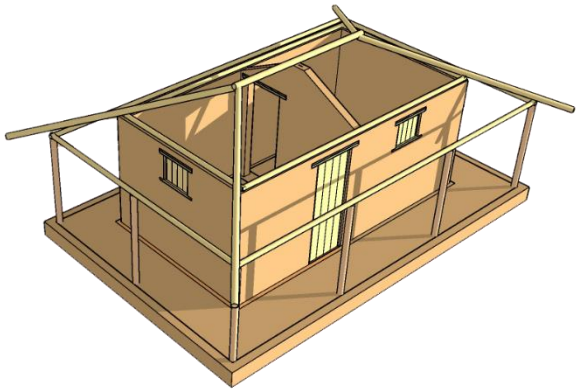
When fitting wall plates, remember to set them parallel to each other.

Use a tape measure to check the distance between both ends of the wall plates is the same.

DRR MESSAGE

Wall plate must be fixed on top of the wall with a galvanised tie wire to strengthen the resistance of the roof during high winds, since this will be the connection between the roof and the walls.

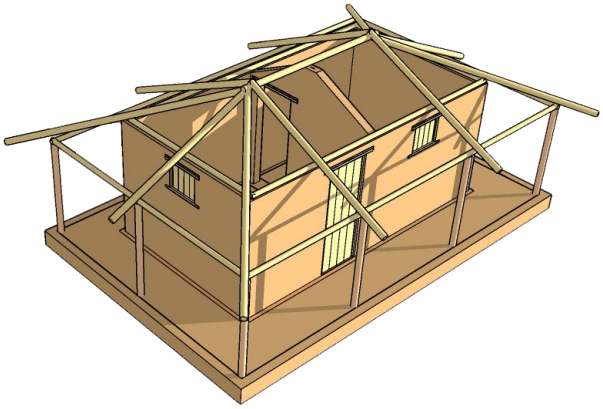
4.7 ROOF



4.7.1 Fitting ridge and hip beams

Select the strongest piece of timber for the ridge beam.

The ridge beam to be supported at the top of the internal wall and fixed in position by tie wire.

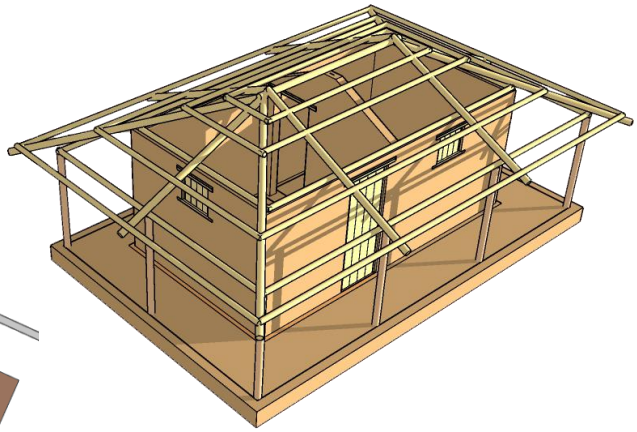


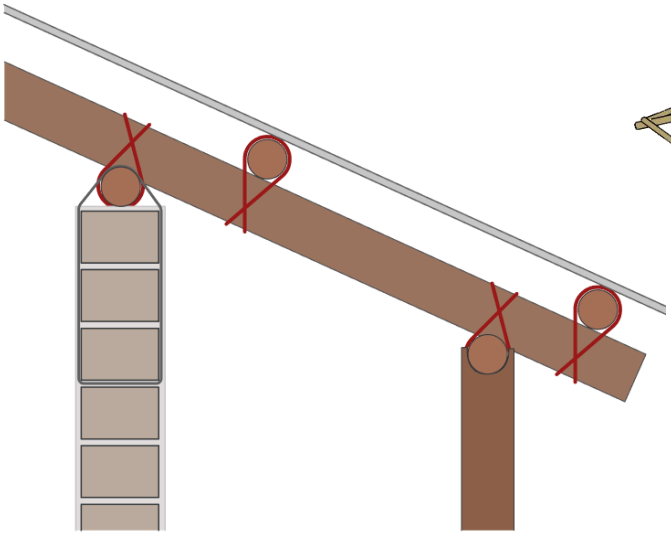
4.7.2 Fitting rafters

Spacing of the rafters will depend on the size of the timber or bamboo. For pieces of around 100 mm diameter, a spacing of 2.70 m is recommended.

4.7.3 Fitting battens

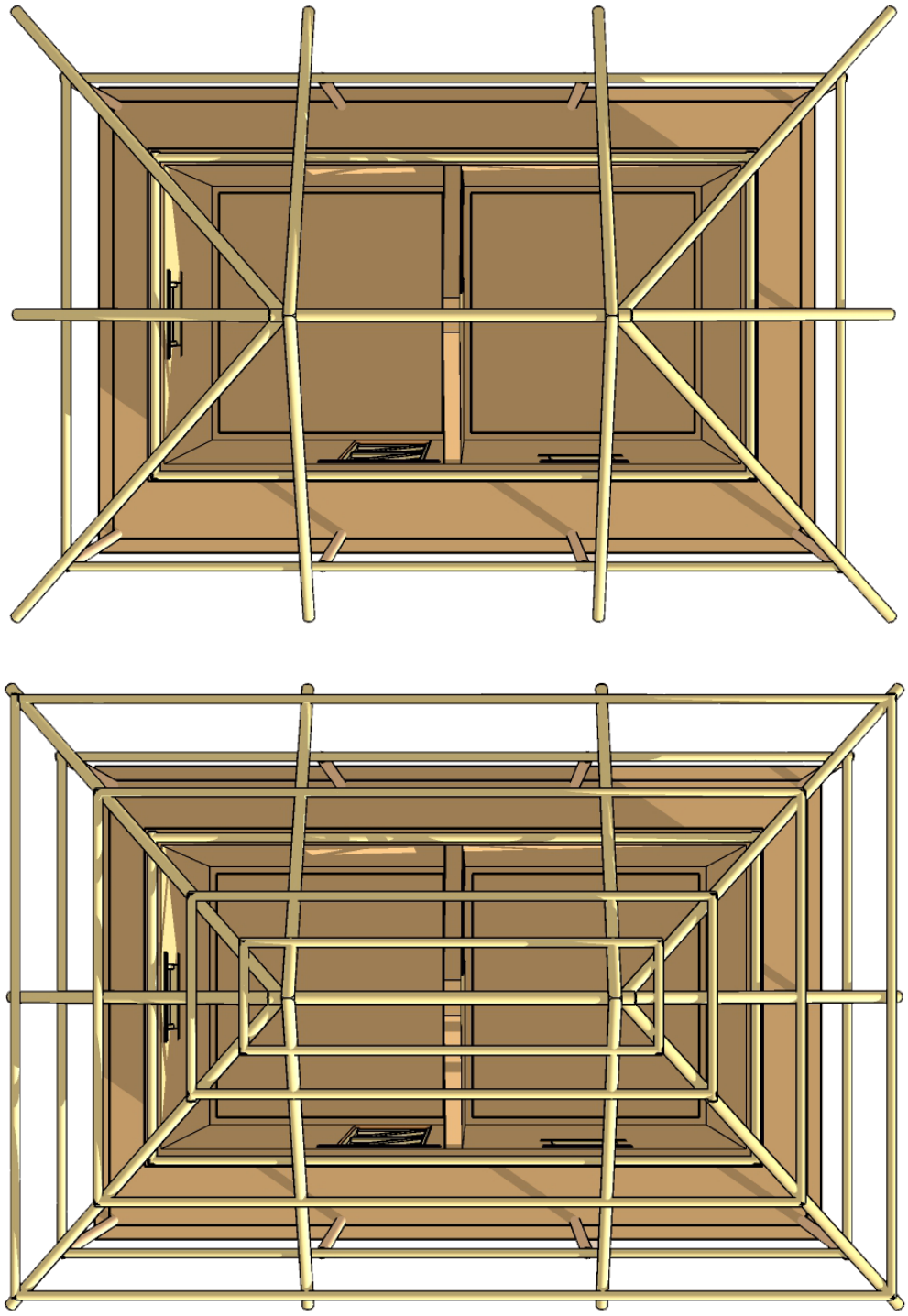
Battens of 75 mm diameter are spaced at 1m.





DRR MESSAGE

The rafters must be fixed to the wall plate and the battens to the rafters to strengthen the resistance of the roof during high winds.

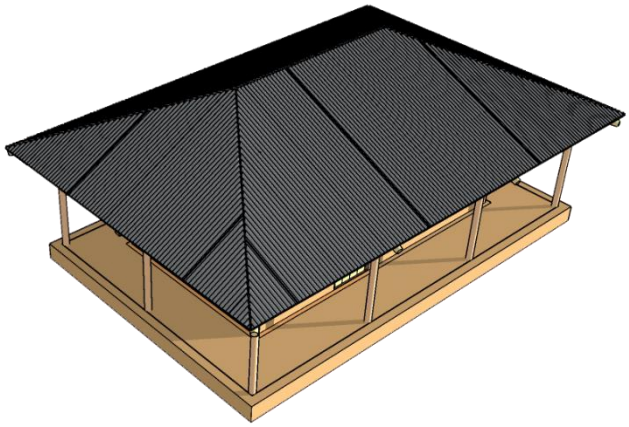


Top view of roof structure.

4.7.4 Fixing CGI sheets

Fix the CGI sheets to the battens with springhead nails. The nails should always be placed at the crest (top of corrugation) to avoid water infiltration.

Springheads nails must be fixed through everyother CGI ridge, at eaves and ridge of roof, to prevent uplift from wind. Sheets should be fixed with 3 nails to intermediate battens.

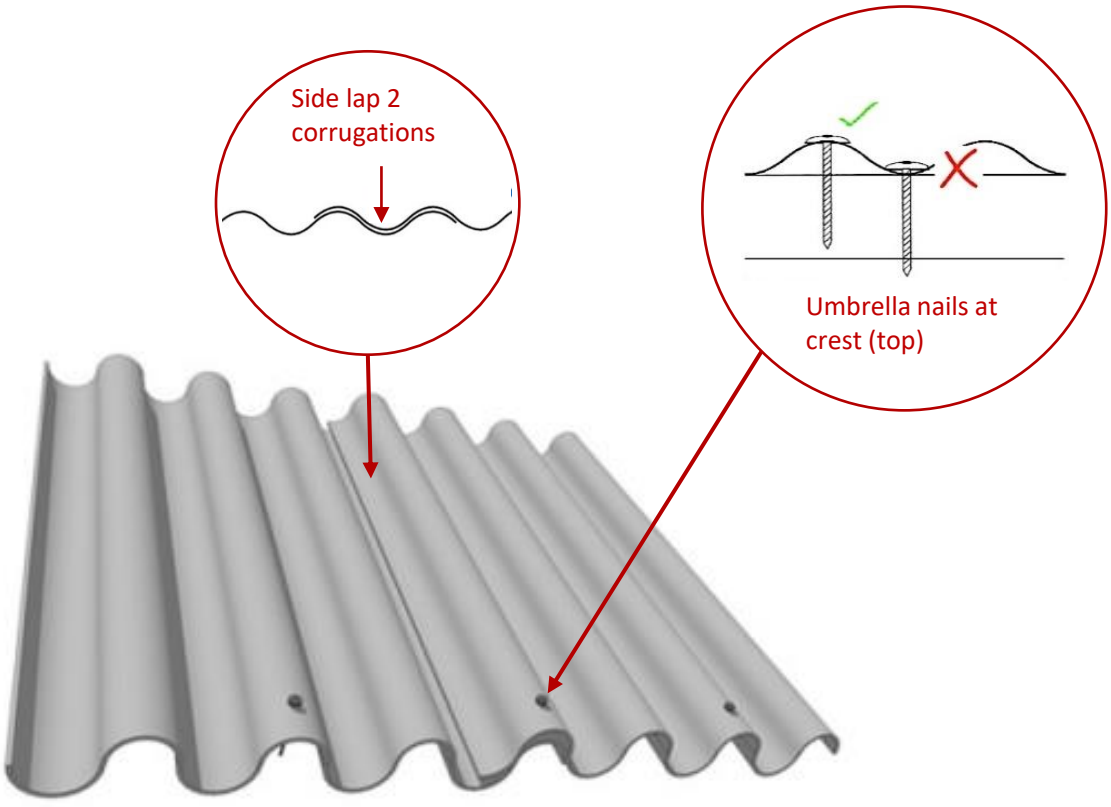


CGI roof.

4.7.5 Overlapping CGI sheets

There should be a 12 cm horizontal overlap (2 corrugations approximately).

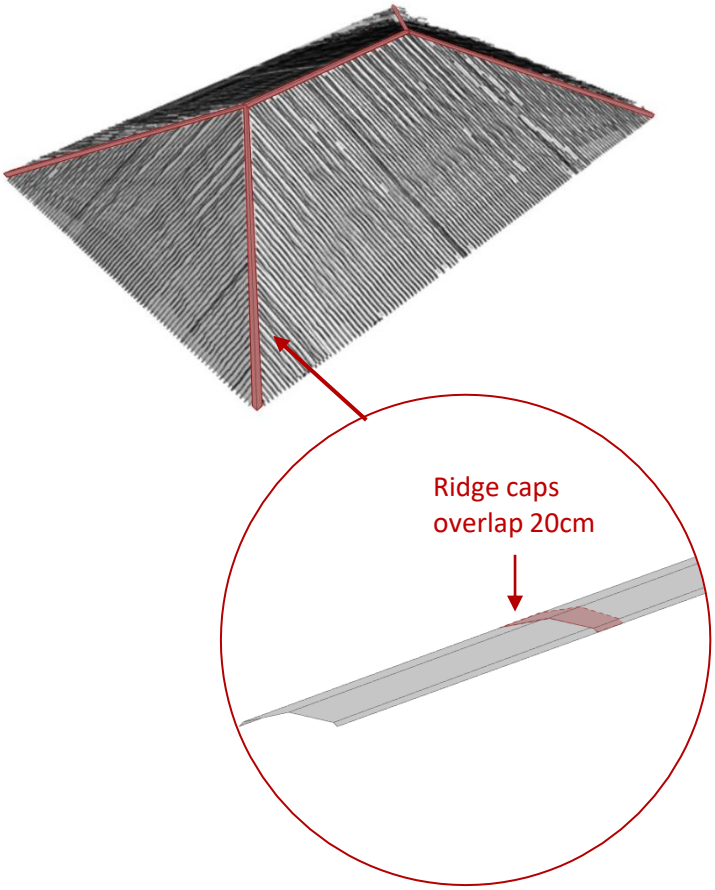
For end overlap between sheets, there should be a minimum of 15cm.



Right way to overlap CGI sheets.

4.7.6 Ridge caps

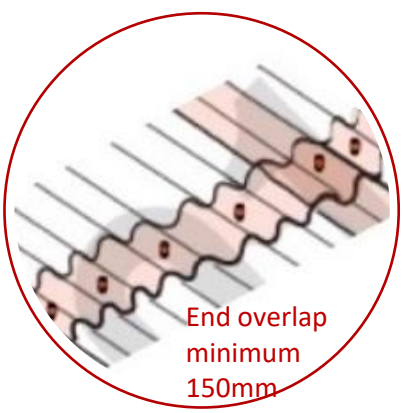
For the galvanized ridge caps, the overlap should be of 20cm. Place them on top of the ridge beam and hips.

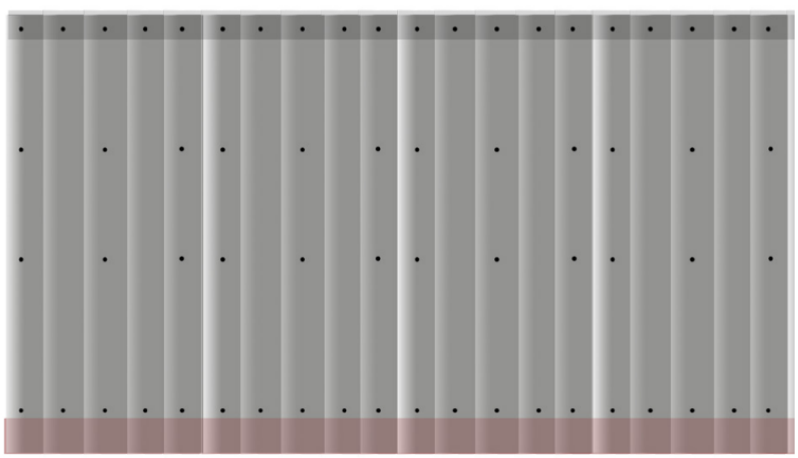


4.7.7 Closed eaves

Pay special attention to eaves, they should be fully closed or with a wire gauze to avoid the presence of insects.

When fixing ridge caps and CGI sheets, ensure they are well placed, without leaving gaps.





HEALTH ALERT

Ensure all eaves are fully closed to prevent mosquitos and other insects from entering the house.

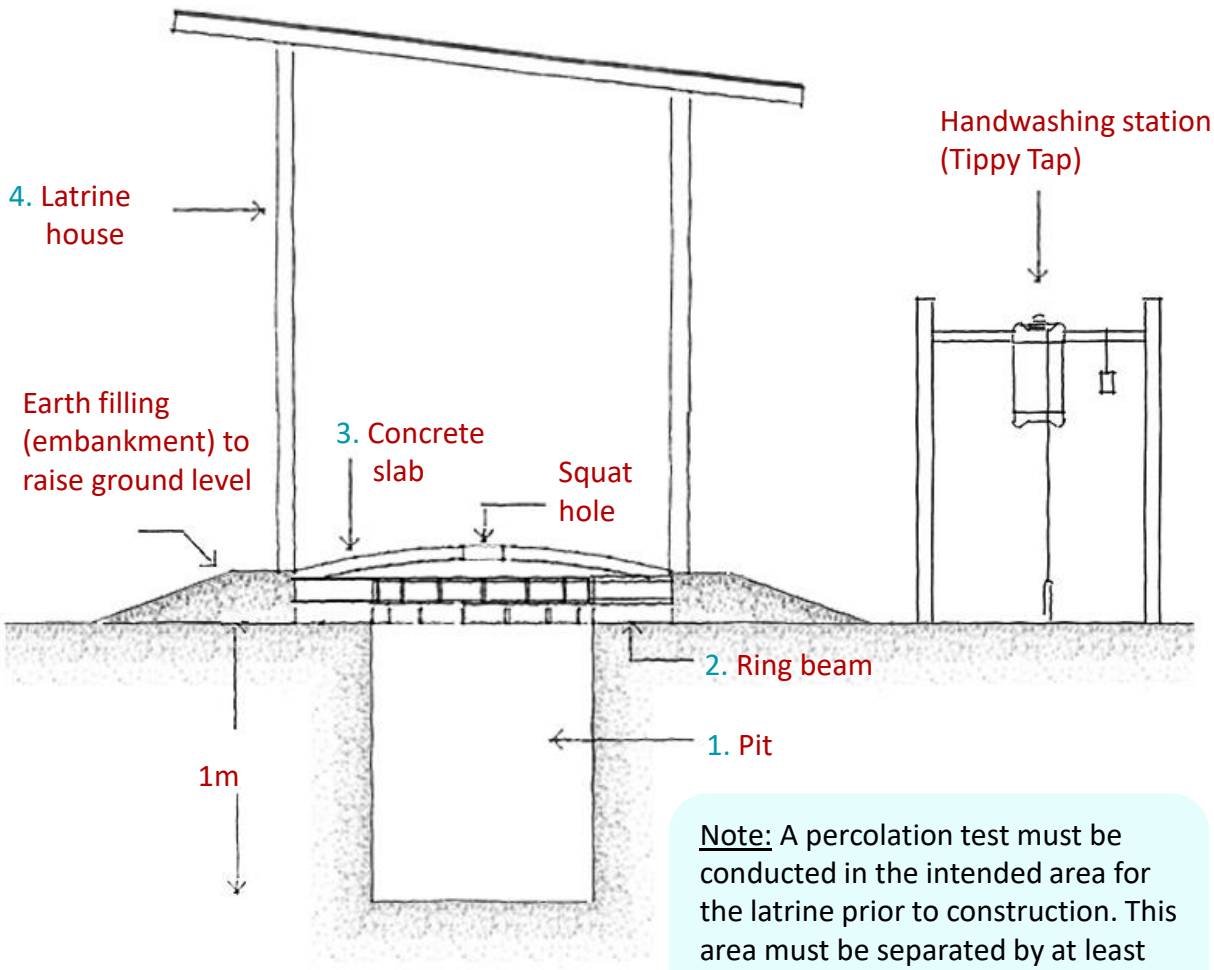
5 WASH

5.1 ARBOLOO DESIGN

Sanitation solutions will vary depending on budget and available materials. The arborloo is a simple pit latrine that is low cost, affordable and easy to build and maintain. It consists of four elements:

1. The pit
2. The ring beam
3. The concrete slab
4. The toilet house

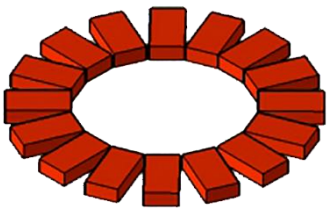
In addition, a handwashing station must be placed outside the latrine house to allow for proper hygiene practices.



Arboloo latrine section

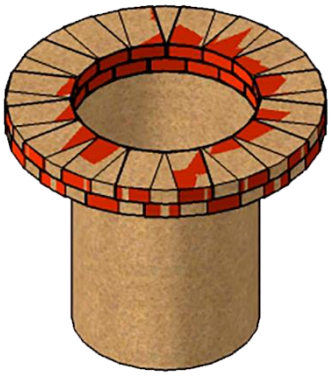
Note: A percolation test must be conducted in the intended area for the latrine prior to construction. This area must be separated by at least 15m from the house.

5.1.1 Construction process



1) On level ground, make a circle of at least 80 cm diameter and place burnt bricks around it.

2) Fill the spaces between bricks with mortar made of soil and water, then add another layer of bricks set perpendicularly to the first and also fill all spaces with mortar.

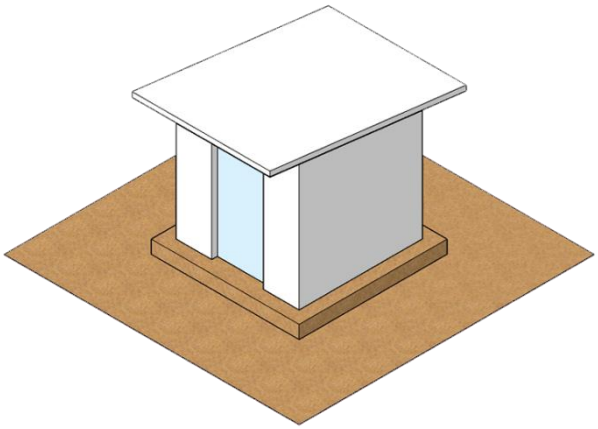


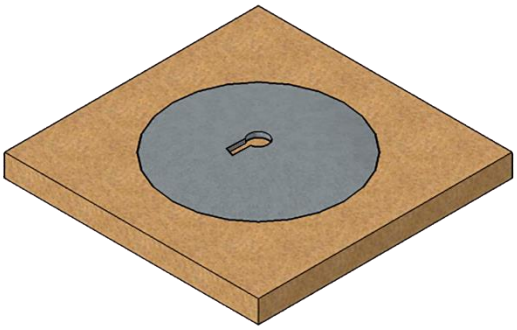
3) Dig the pit inside the ring beam. It must be between 1m and 1.5m deep. Add a sack full of dry leaves at the bottom of the pit to help the contents of the pit to compost.

4) Place the concrete slab on top of the ring beam.

5) Place the soil dug out from the pit around the beam ring and ram it hard to form an embankment. This will secure the ring beam and prevent water from getting into the pit.

6) Build the latrine house.



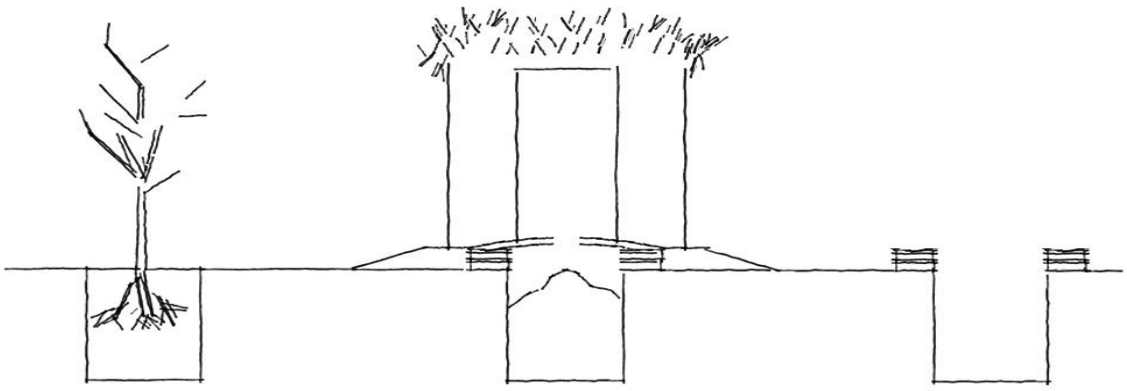


5.1.2 How to use the arboloo

- After every use, a mix of dry soil, wood ash and leaves must be thrown into the pit. This will help to make good compost in the pit.
- No other materials (trash) must be thrown into the pit.
- Use the Arborloo until the pit is nearly full. The time to fill the Arborloo will depend on the size of the pit and the number of users, but in general it will be between 6 to 12 months.

5.1.2 What to do when the pit is full

- When the pit is nearly full, the latrine house must be taken apart and the ring beam and concrete slab moved to a new location where another pit will be dug. Then construct a new latrine house around it and start using it.
- The old pit must be covered with leaves and a thick layer of good soil (at least 15 cm thick).
- The old pit can be used in two ways:
    - A tree can be planted in it (preferably during the rainy season).
    - The contents of the pit can be used as compost for a vegetable garden. In this case the contents must be left to compost for an additional 12 months after being filled.



Old pit with planted tree | Current pit almost full | New pit

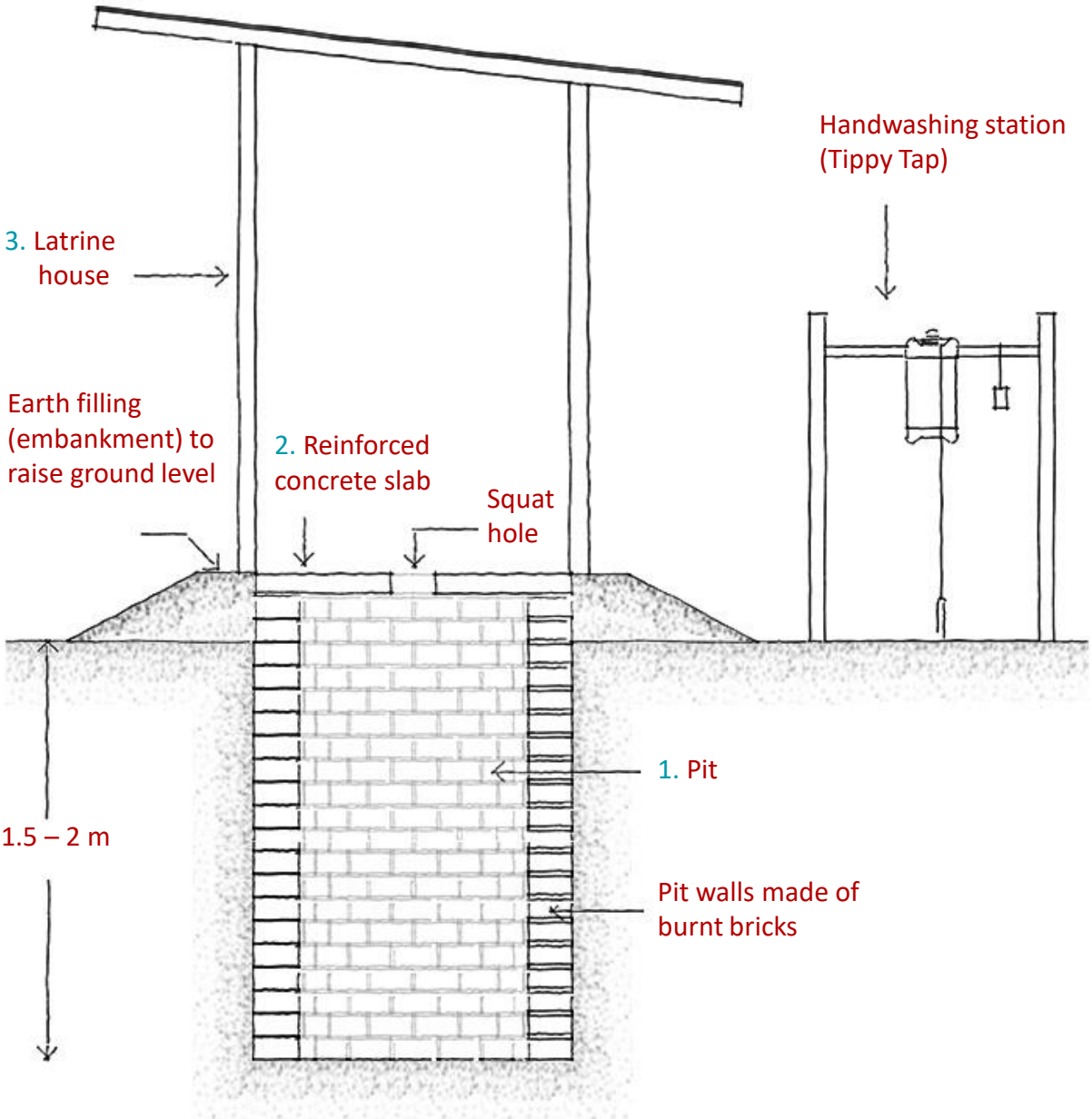
Stages of the arboloo

5.1 PIT LATRINE

Another sanitation option is a pit latrine, which has a deep pit 1.5m-2m with walls lined with burnt bricks. It consists of the following elements:

1. The pit
2. The concrete slab
3. The toilet house

In addition, a handwashing station must be placed outside the latrine house to allow for proper hygiene practices.



Pit latrine section

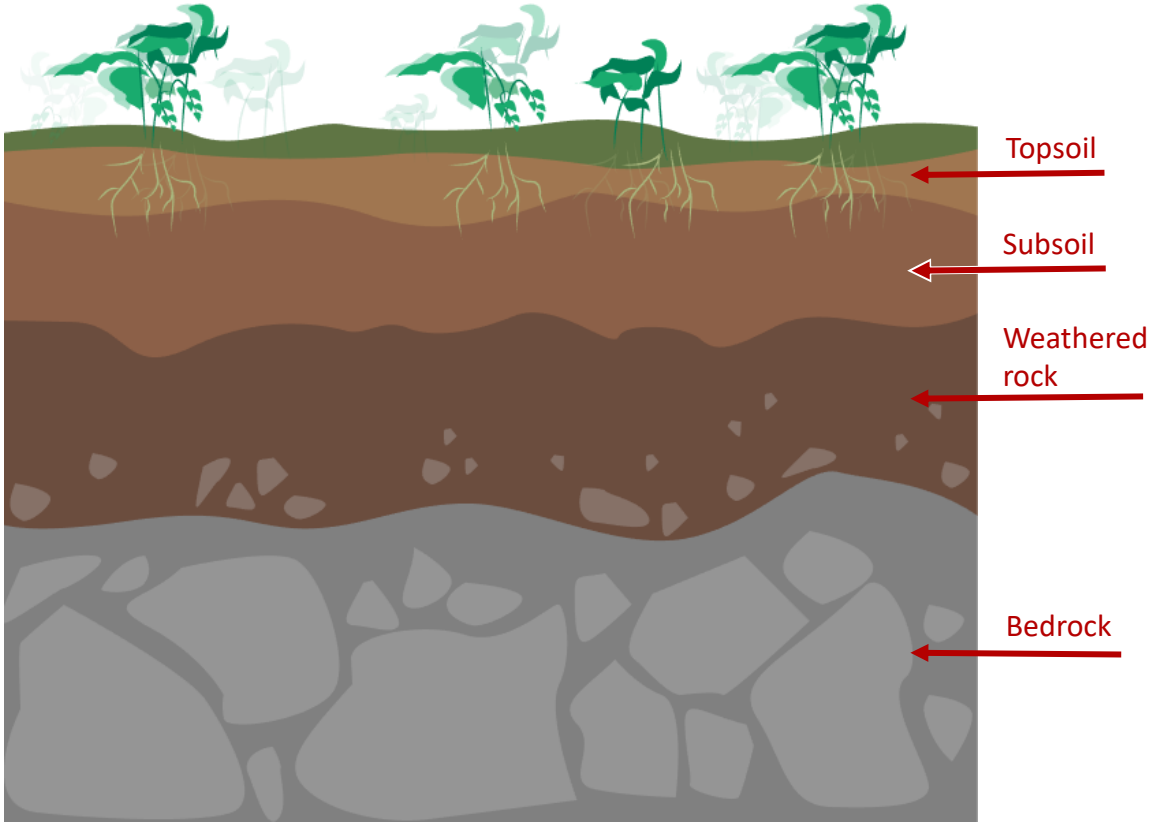
6 Materials and Skills

CONTENT

6.1 EARTH CONSTRUCTION

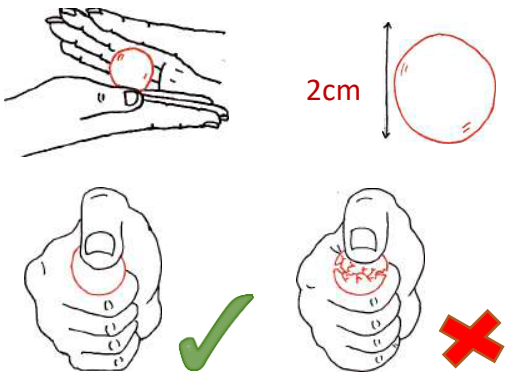
6.1.1 Soil selection and tests

To produce good quality earth blocks, the soil must be selected from the subsoil, without roots or any other materials. Soil tests must be conducted to determine the best quality soil to be used.



Test of the ball

To identify the existence of clay in the soil.

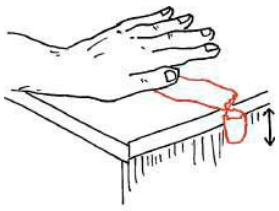


1. Take a bit of soil from the site and add some water, to make a small ball of 2cm diameter approx.
2. Let it rest for at least 24 hours, and then press it with your hand. If the ball doesn't break, the soil is adequate. If it breaks, the soil has not enough clay.

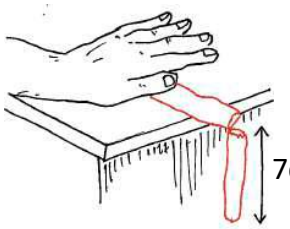
Test of the cigar

To identify the quantity of clay in the soil.

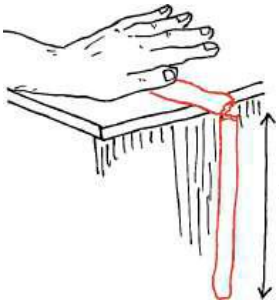
1. Remove gravel, add water and let it rest for at least 12h.
2. Make a cigar and push it from a table slowly.
3. Measure the length of the part that falls down.
4. Repeat three times and take the average measure to find the best proportion.



✖ The soil does not have enough clay.



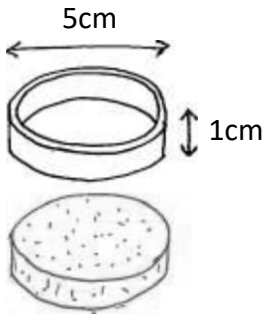
✓ The soil has a good proportion of clay.



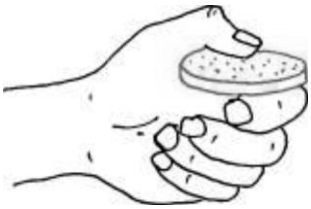
✖ The soil has too much clay.

Test of the pill

To identify the behavior of the clay in the soil and the nature of it, if it shrinks and expands or not.



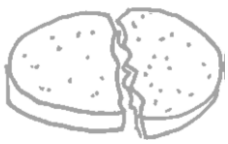
1. With the same mix of the previous test, make two pills with a piece of PVC or similar.



2. Once dried observe what happens when you try to break the pills with two fingers.

A. Some shrinkage and easy to reduce to powder, the soil is SILTY.

B. No shrinkage and easy to reduce to powder, the soil is SANDY.



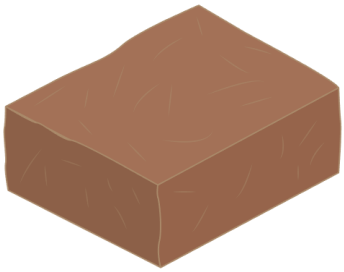
C. Important shrinkage and very difficult to reduce to powder, the soil is CLAY.

The best for earth block construction is less than 1mm shrinkage and difficult to reduce to powder.

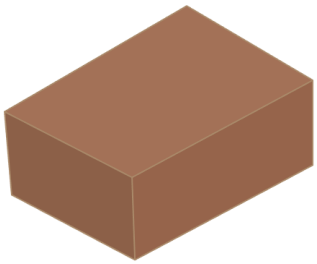
Important: Depending on the nature of the clay, results may be different and still a good soil to build with. The best thing to test the soil is to make earth blocks and observe what happens once dried (appearance, cracks, resistance). If there is no time, these tests will help to choose the best soil.

6.1.2 Types of earth blocks

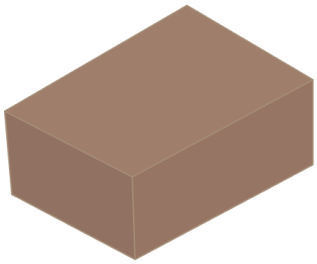
Advantages and disadvantages of adobe blocks, compressed earth blocks (CEBs), and Stabilised Soil Blocks (SSBs).



Adobe blocks



Compressed earth blocks (CEBs)



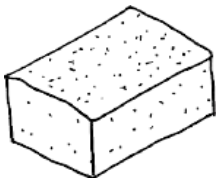
Stabilised Soil Blocks (SSBs)

	Adobe blocks	Compressed Earth Blocks CEBs	Stabilised Soil Blocks SSBs
Materials	Soil, sand, fibers, water	Soil, sand, water	Soil, sand, cement, water
Water - resistance	Bad	Bad	Good
Underground use	Bad	Bad	Good
Durability	Good	Good	Good
Maintenance	Protect the walls from moisture by repairing any fractures in the plaster.	Protect the walls from moisture by repairing any fractures in the plaster.	
Tools	Wood mold, handmade	Press machine	Press machine
Cost	Low	Low	Medium

6.1.3 Adobe blocks

Materials and steps to make adobe blocks.

Materials



1 Adobe Block

=

Clay soil, dry and without organic material

+

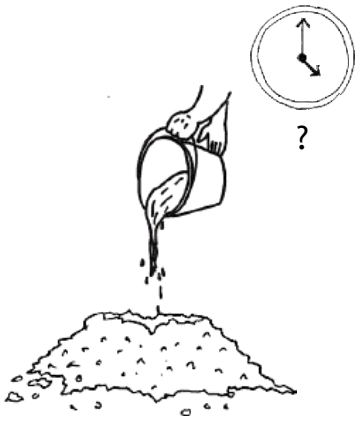
Sandy soil

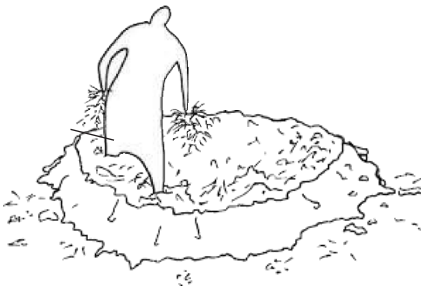
Fiber, dry

+

Water

Preparing the soil



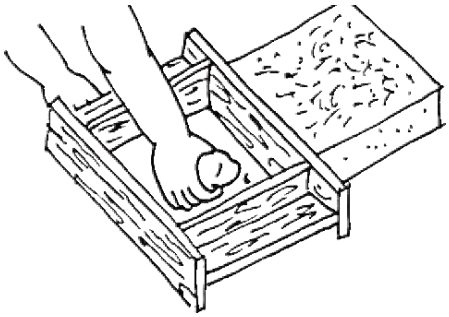


1. Sieve the soil to remove gravel and organic material.

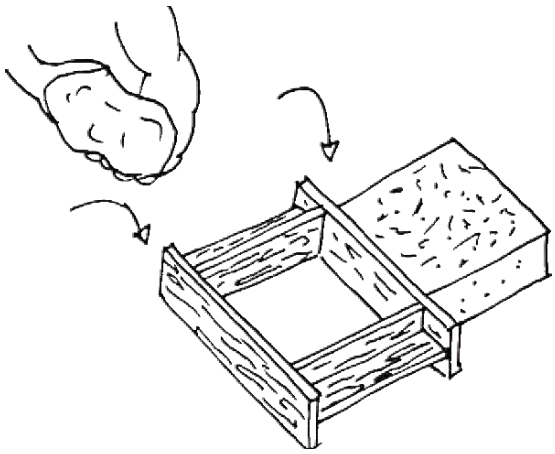
2. Mix the soil with the water and let rest. The time will depend on the soil nature. Consider asking local artisans, they must know!

3. Then mix with the fiber, which must be in 5cm pieces. You can use your feet or animals to do this.

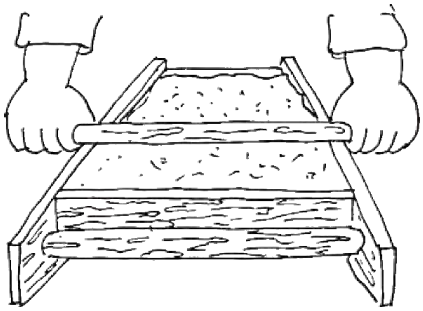
Making the adobe blocks



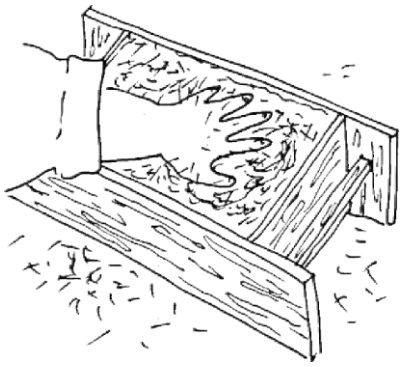
1. Clean the mold and put some sand on the walls so that the soil does not stick.



2. Throw the mix inside the mold, pressing firmly on the corners, making sure there are no air balls.

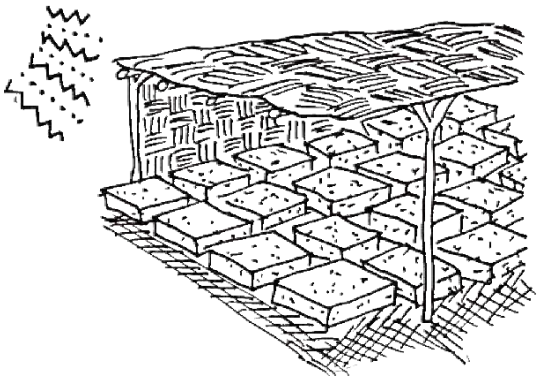


3. Level the surface with a wet wood or metal stick.

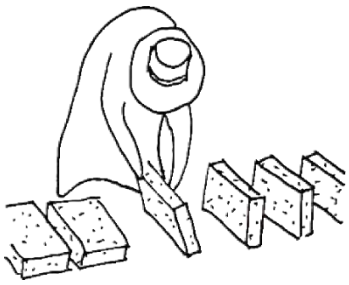


4. Add some straw or sand on the surface and unmold carefully trying not to deform the earth block.

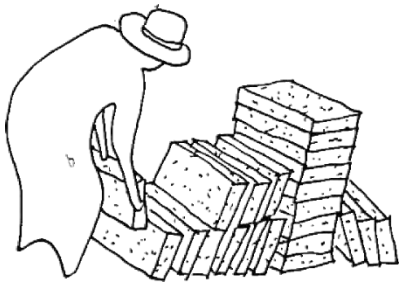
Drying and storing adobe blocks



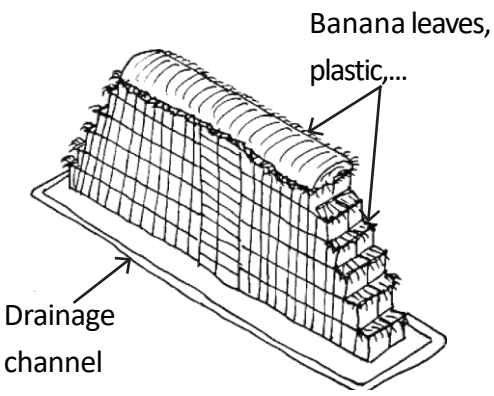
1. Use a horizontal, clean surface without any organic material or salts to dry the earth blocks. It must be covered during rainy season and protected from direct sunshine.



2. After three days place the earth blocks on their side to let them dry evenly.



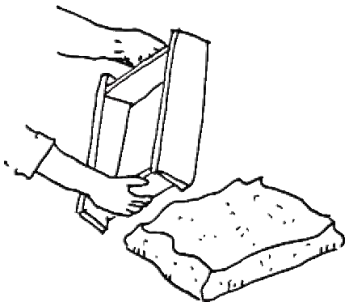
3. After one week you can pile them up.



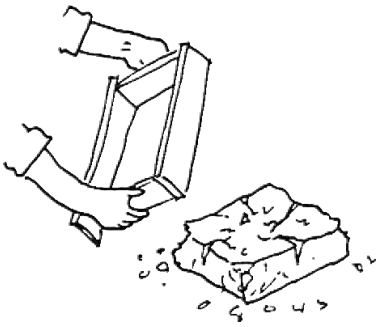
4. To store the earth blocks, you must pile them up carefully to avoid losses and have them covered to protect from rain and direct sunshine.

Testing the adobe blocks

Just after unmolding



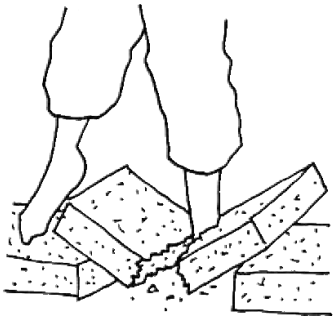
NO !



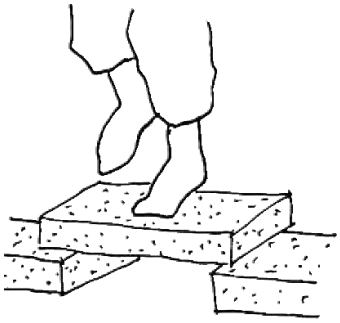
NO !

No empty space is accepted in the corners, and the base must not increase more than 5%. If so, you must tamper better the corners or reduce the quantity of water in the mix.

After 4 weeks

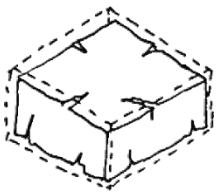


NO !



YES !

Once the earth blocks are dried, put one block above two others with an empty space underneath. A person of approx.. 70 Kg must step on it for at least 1 minute. If the earth block doesn't break, it is suitable for construction.



NO !

If there are cracks of more than 5 cm deep, change the proportions of soil and fiber, or protect from direct sunshine while drying.

6.1 EARTH CONSTRUCTION

6.2 BAMBOO CONSTRUCTION

WHY BAMBOO?

Bamboo **grows quickly** and can be used for construction from 3-5 years old. Compared to 10 years for blue gum.

The use of bamboo for construction will **reduce deforestation**.

Bamboo plantations are a great **barrier against high winds and flooding**, since it acts as a protective wall that slows down the winds and water rising.

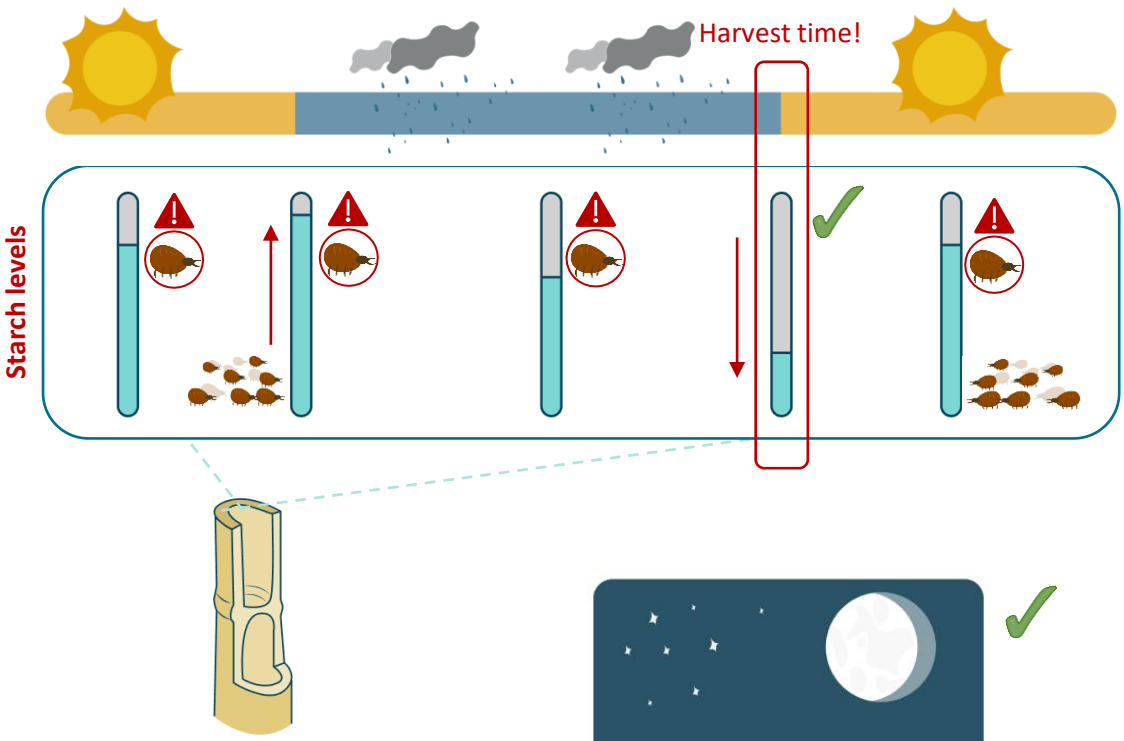
The roots of the bamboos help to stabilize the soil, binding it together and therefore **preventing erosion**.

Bamboo is easy to grow, **resistant,** and it is an **affordable material** for construction.

6.2.1 Bamboo harvest

Bamboo has large amounts of starch (sugars) which attract parasites and insects such as termites that can damage the bamboo. When the levels of starch are low, the bamboo is more resistant to these insects.

The levels of starch vary depending on the season. The moment with the highest levels of starch is at the end of the dry season, and the moment with the lowest is **at the end of the rainy season / beginning of the dry season.**



Harvest bamboo

- **At the end of the rainy season / beginning of the dry season**.
- **At night, between 12pm and 6am,** when most of the starch is in the roots.

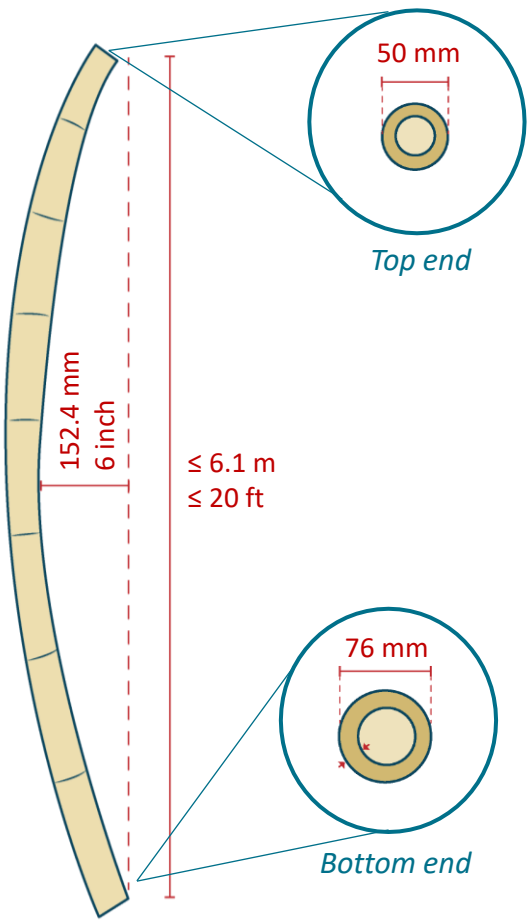
6.2 BAMBOO CONSTRUCTION

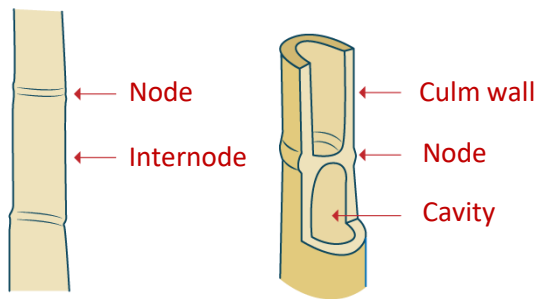
6.2.2 Quality of bamboo

Different species of bamboo can be used for construction. In Africa, one of the most common species for construction is *Bambusa balcooa*. The main characteristics of the bamboo material for construction should be carefully considered when choosing the bamboos:

Length	About 6.1 m
Bottom diameter	76 mm minimum
Bottom wall thickness	¾ inch or 18mm minimum
Top diameter	50 mm minimum
Insect damage	Insect free
Cracks	No cracks
Age	3-5 years old
Straightness	Maximum 6-inch bend across a pole ≤ 20 ft

Reference: Shelter/NFI Sector Technical Guidance: Bamboo Selection, Storage and Handling, 2019.





Parts of bamboo

Storage

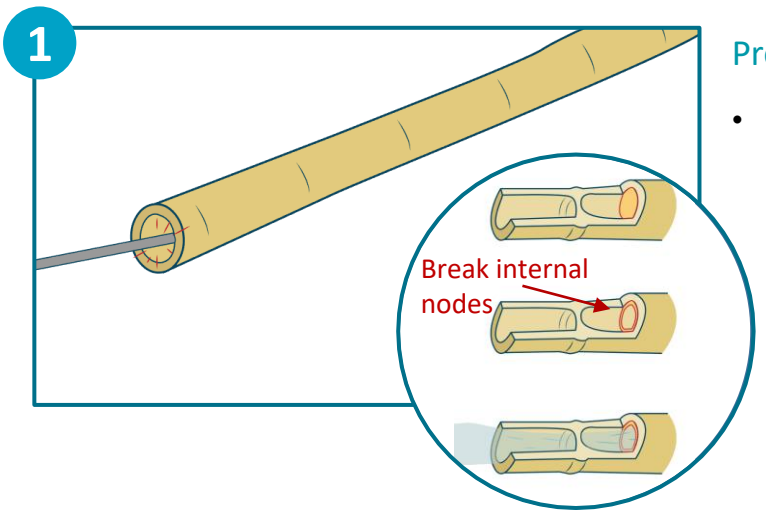
- **Dry:** keep the bamboo in a dry area, elevated 30cm above ground level.
- **Protect** it from the rain and the sun.
- **Ventilation:** ensure the bamboo stock is well ventilated.

6.2.3 Bamboo treatment

Bamboos need to be treated before using for construction, since this increases their strength significantly and their duration. Bamboo culms **must be treated immediately after harvesting**.

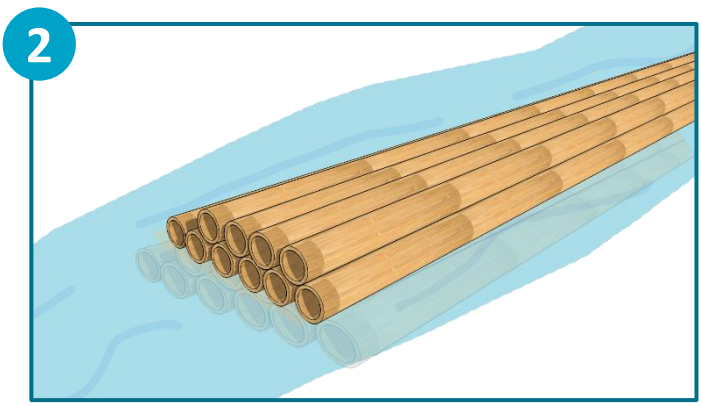
Treatment	Description
Water	Bamboos are soaked in either running salt water or water ponds from a few weeks to a few months to leach out the starch, sugar and other water-soluble contents.
Borax and Boric Acid	Mix boric acid and borax in a proportion of 1:1.5 per 100 liters of water. The bamboo culms should be submerged for around 6 weeks.

Reference: All About Bamboo: Comprehensive Resource for All Your Bamboo Related Queries.



Prepare the water and the bamboo

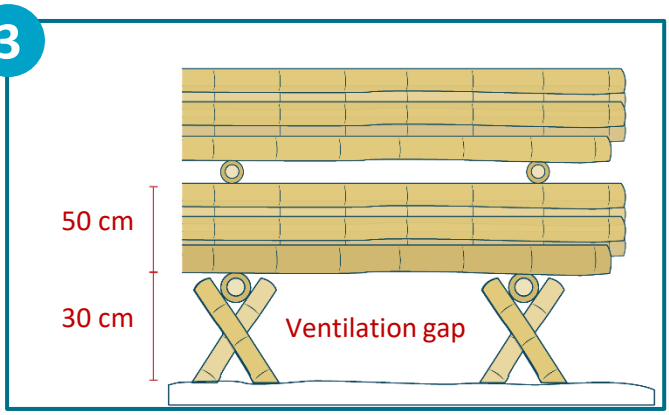
- **Break nodes**: break the nodes on the inside for water to get through the whole bamboo culm, so the starch inside is reduced.



Prepare the water and the bamboo

- **Pond / Running water:** should be large enough to cover the bamboo culms completely.
- **Break nodes**: break the nodes on the inside for water to get through the whole bamboo culm.
- **Soak**: during about 6 weeks.

3

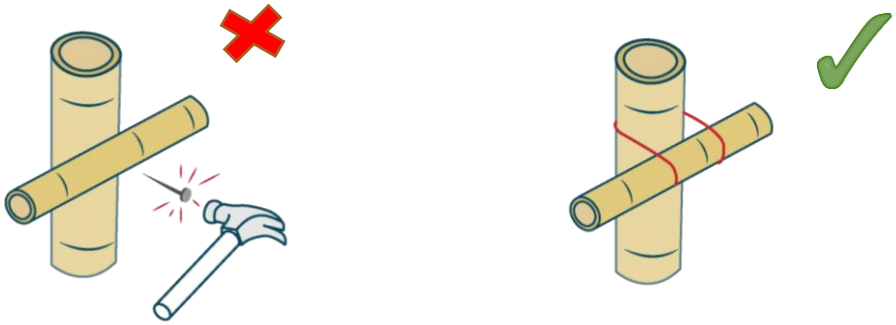


Dry properly

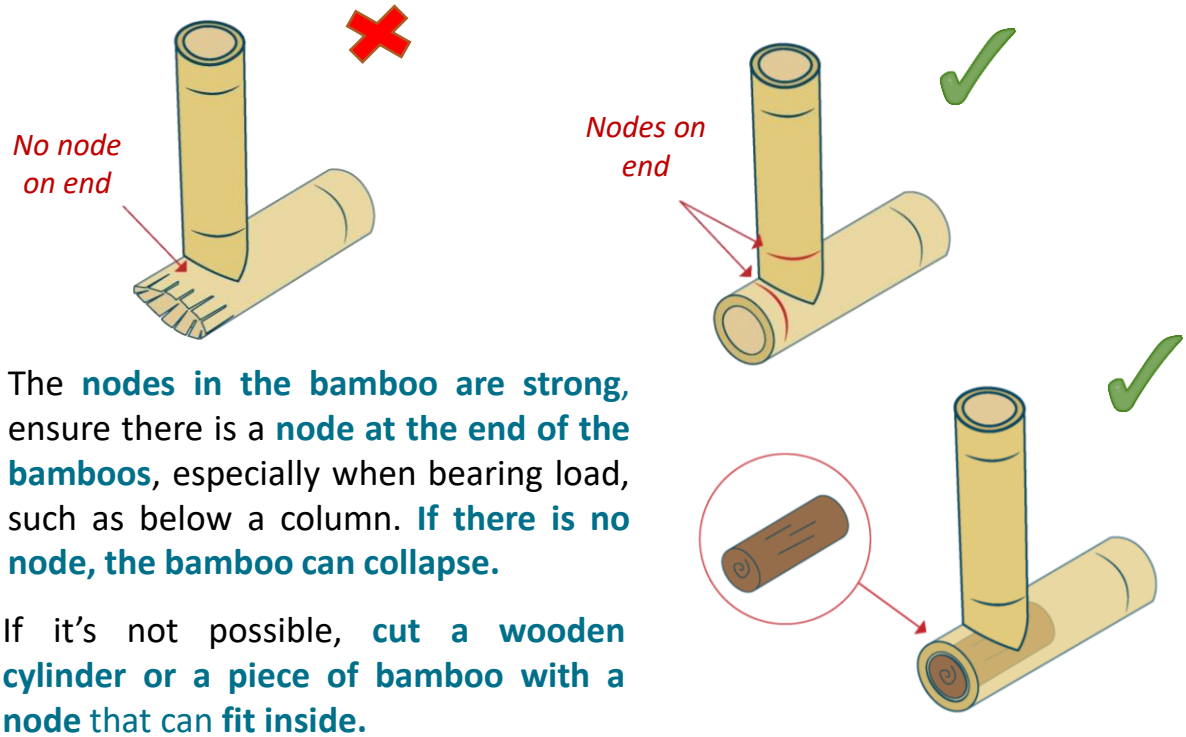
- **Storage:** above ground level (30cm) and allow for cross ventilation between bamboo stocks.
- **Protect**: from rain and direct sunlight.
- **Dry**: for a period of 6 to 12 weeks.

6.2.4 Bamboo principles

Don't use green bamboo for construction. **ALWAYS use properly dried bamboo**. The green bamboo will shrink, and this will make the shelter weak.



Avoid using conventional wood nails, they can split the bamboo. **Use nylon, steel or vegetal cords**.



The **nodes in the bamboo are strong,** ensure there is a **node at the end of the bamboos**, especially when bearing load, such as below a column. **If there is no node, the bamboo can collapse.**

If it's not possible, **cut a wooden cylinder or a piece of bamboo with a node** that can **fit inside.**

Reference: Guadua Bambu.

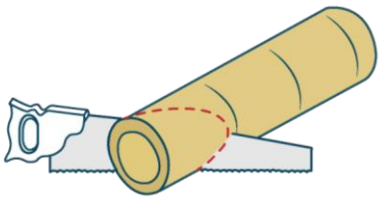
6.2.5 Workmanship

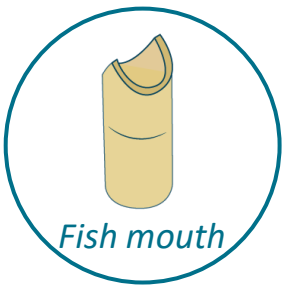
Bamboo cuts and tools

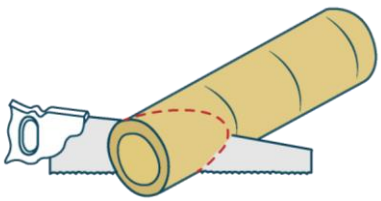
Claw hammer

Tape Measure

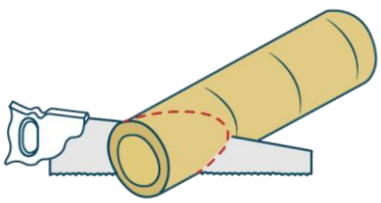
Hand Saw

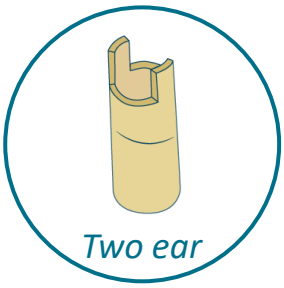


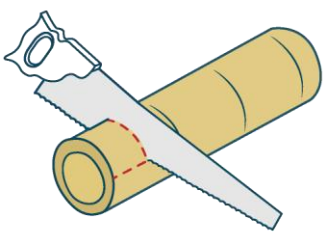


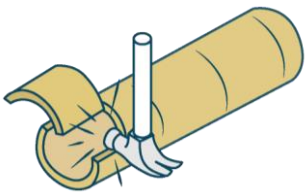


X 2



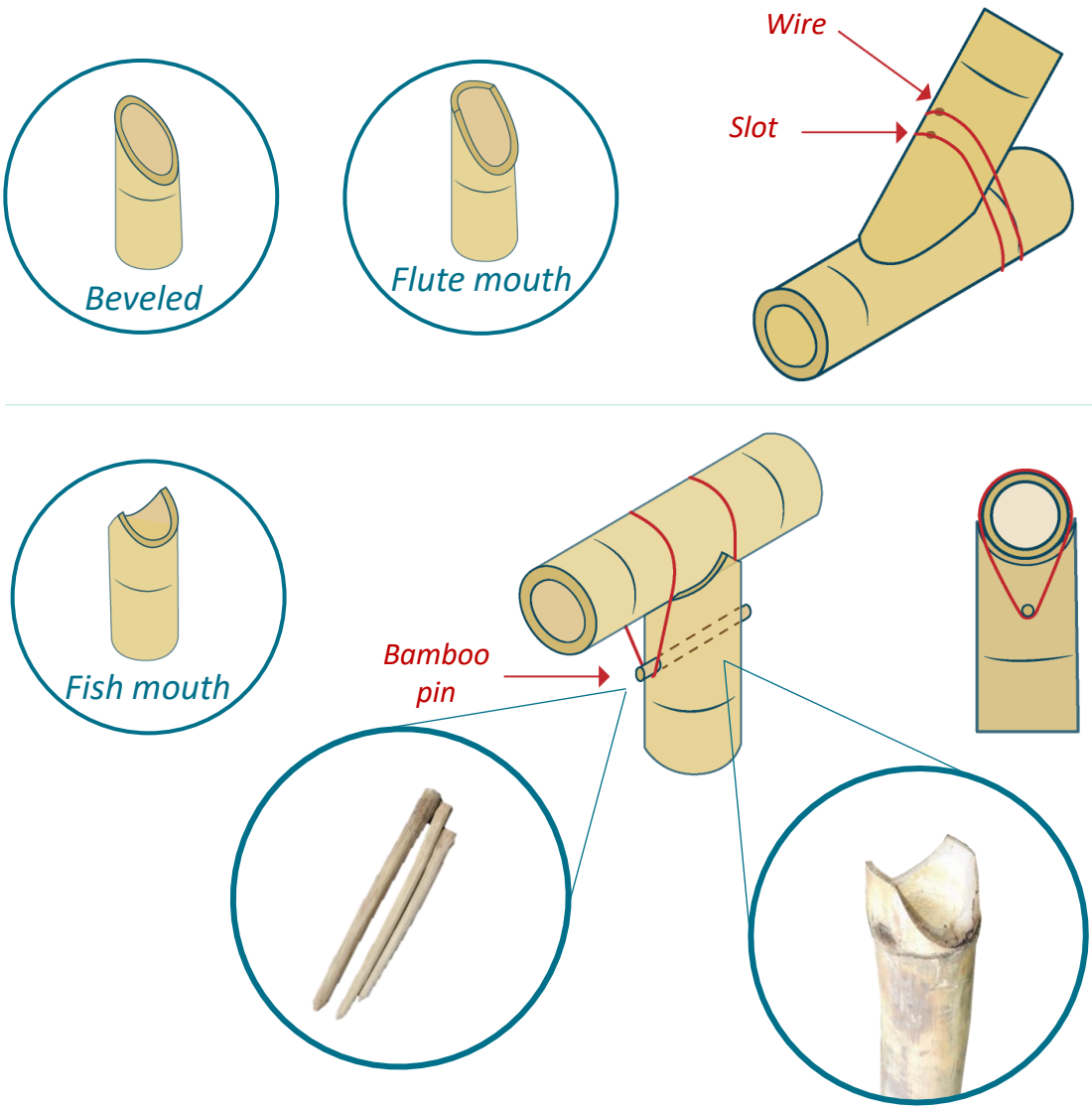






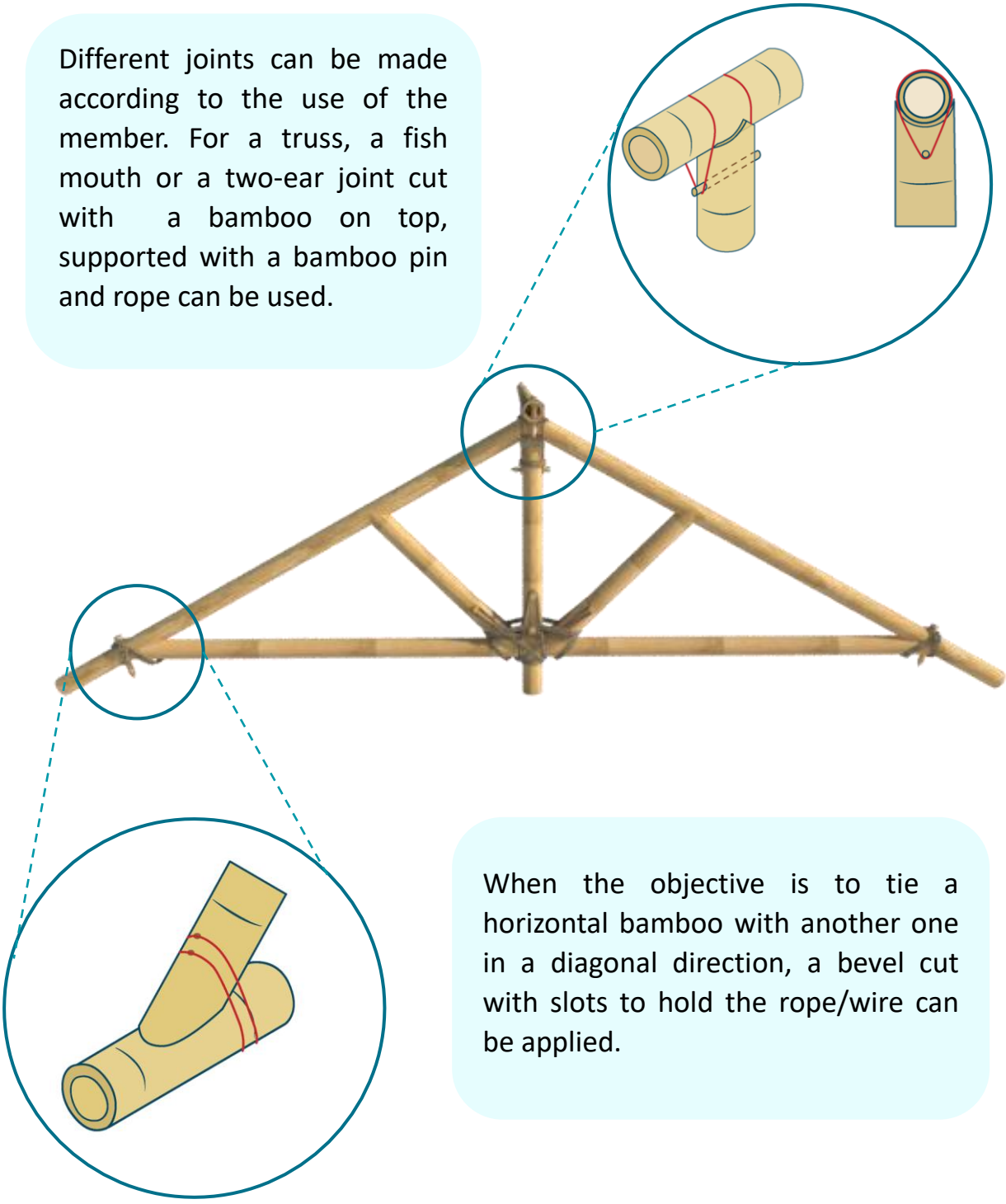
Reference: Hidalgo Lopez, Oscar. Manual de Construcción con Bambú.

6.2.6 Bamboo joints



Reference: Guadua Bambu.

Different joints can be made according to the use of the member. For a truss, a fish mouth or a two-ear joint cut with a bamboo on top, supported with a bamboo pin and rope can be used.



When the objective is to tie a horizontal bamboo with another one in a diagonal direction, a bevel cut with slots to hold the rope/wire can be applied.

Reference: Guadua Bambu.

6.3 CONCRETE

6.3.1 Material quality

The quality of the materials should be checked, the date of manufacture should not be older than 3 months. Cement older than 6 months is not adequate for use.

No lumps should be present. The cement should feel silky and cool to touch.

The gravel / stone aggregate should be cubic, with sharp edges, and not flaky or elongated. It should be granite or similar. If the gravel has rounded edges, it should be crushed before use to get sharp edges.

6.3.2 Correct ratio of mix

The adequate mix must be used according to the use:

Application	Cement	Sand	Gravel/Stone
Foundations	1	3	6
General use	1	2.5	5
Reinforced	1	2	4

6.3.3 Pouring concrete

1) Pour the concrete from a distance of no more than 1.5m to avoid segregation. While pouring, other should be spreading it throughout the area using shovels and rakers.

2) Vibrate the pour until no bubbles are left, but be careful not to over vibrate it, because this could cause segregation.

3) Screed the top of the concrete for a uniform surface.

6.3.4 Curing

1) After pouring the concrete, curing must be done for a minimum of 14 days and the surface should be always wet, normally it would take 28 days for it to reach its full strength.

2) “Moist curing” must be done for the first 7 days; it consists of spraying water with a hose 5-10 times per day. In case curing with a hose cannot be done, an alternative is watering the concrete and covering it with plastic sheeting of 4mm thick to retain moisture. This process must be repeated daily for the first 7 days.

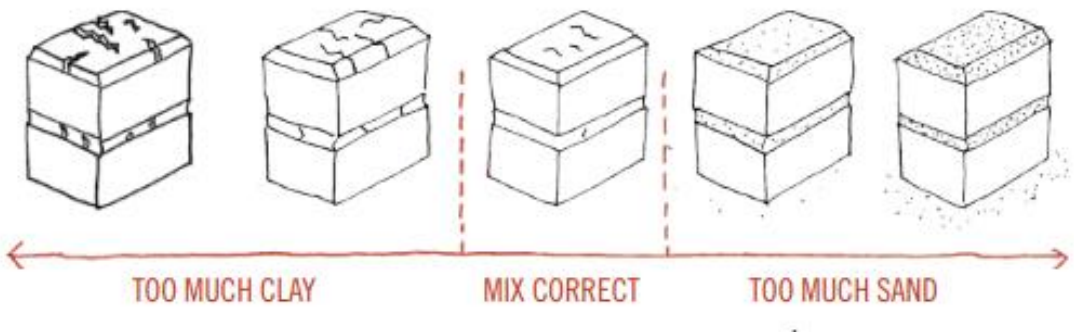
6.4 MORTAR AND RENDERING

6.4.1 Mud mortar

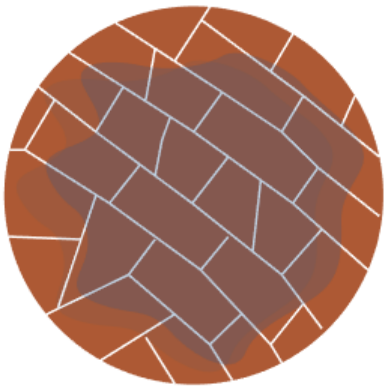
1. To determine the best proportion of soil and sand, make different mixes of soil and sand and put them in samples of two mud blocks.

2. Wait until they are completely dry and see the results. The best mix will be very slightly cracked, to ensure the best joining between the two blocks.

3. Try to lift up the two blocks by taking the one on the top. If they remain together, it means that the binding capacity of the mortar is good.

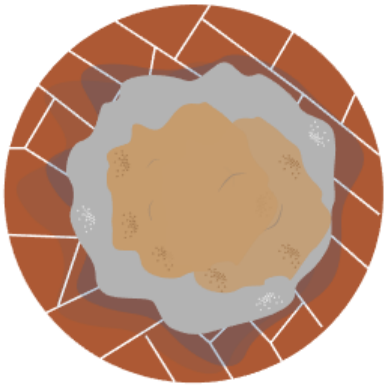


6.4.2 Cement mortar



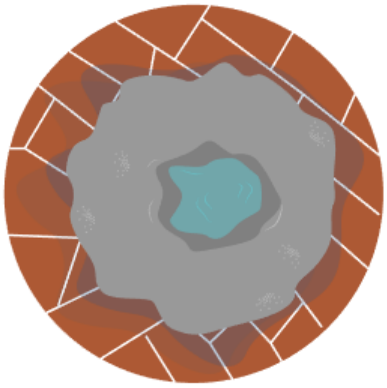
1. Make a preparation area on the ground using broken blocks and grout them together.

An approximate preparation area would be 1500 mm diameter. This is to ensure that each mix is clean and regulated i.e. no impurities from the ground. The preparation area must be wetted before use.



2. Put the accurate measures of sand and cement (and any other material required) onto the preparation area. Mix the dry materials together until there is a mix of all the materials.

Application	Cement	Sand
Brick work	1	4
Render	1	3
Screed	1	2

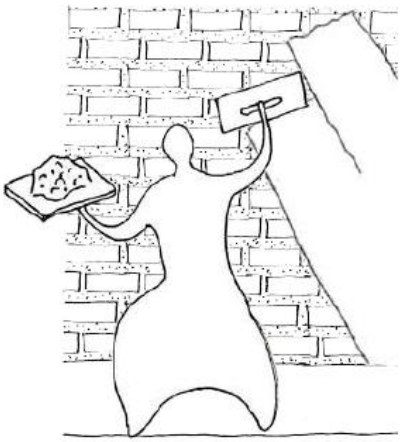


3. Create a well in the middle of the dry mix, add clean water, and begin blending in the water to make the mortar.

Once the mix is ready, cover it with a damp cloth to prevent the mortar from drying. Use within ½ hours.

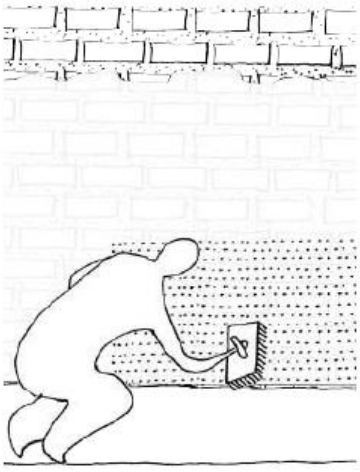
6.4.3 Rendering / plastering

The plastering should be done after complete drying of the walls, 1 month after the construction. It provides protection to the walls from rain and winds, improving the lifetime of the wall.



1. Remove dust and wet the wall.

2. The base layer serves to level the wall and prepare it for the final coat. Apply the mortar with a trowel from the base to the top of the wall. The thickness of this layer will be 8mm to 20mm.



3. Immediately after the base layer is applied and before it dries, small holes are made with help of a wire brush to improve cohesion with the next layer.

4. This layer is done when the first layer is completely dry, and the thickness will be 1-3mm. For this layer it is important to find the best dosage possible after making the plaster tests.

5. Even out uniformly the surface with a float or a sponge.

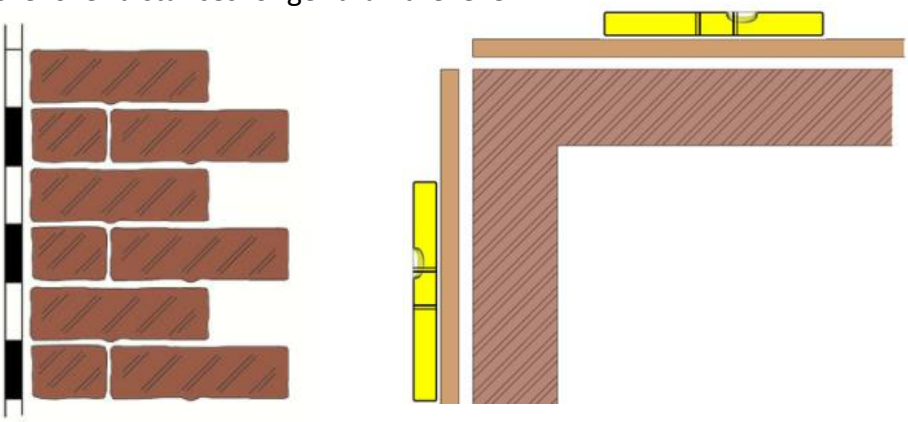
6.5 BRICKLAYING

6.5.1 Keep bonds even

Ensure the bonds are even, if necessary, cut blocks to keep them even. This will make the wall more resistant

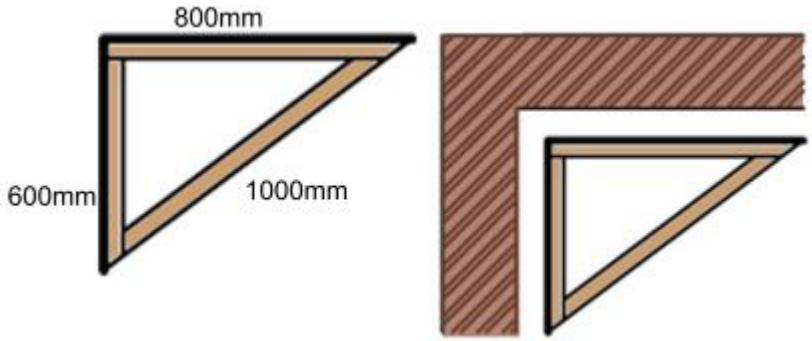
6.5.2 Check courses are even

Use a gauge rod to keep courses even. Use a straight piece of wood to check plumb and level over distances longer than the level.

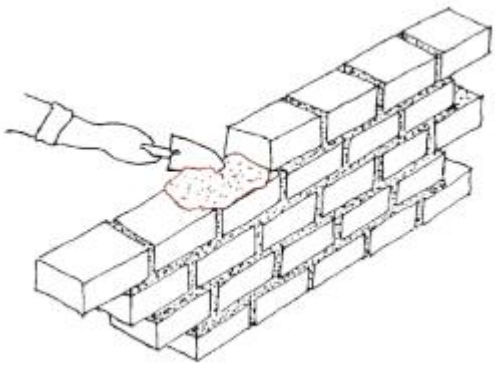


6.5.3 Check corner angle

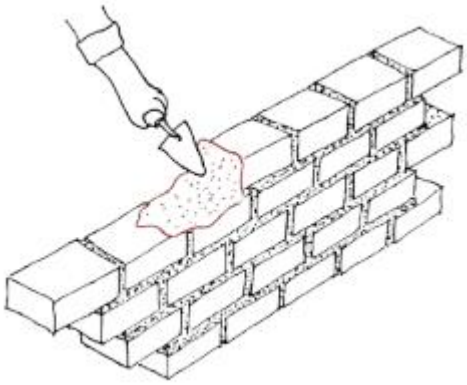
The corners should be built as steps, not toothed. All wall corners should be right angles and must be constantly checked with a wooden triangle model.



6.5.4 Laying blocks

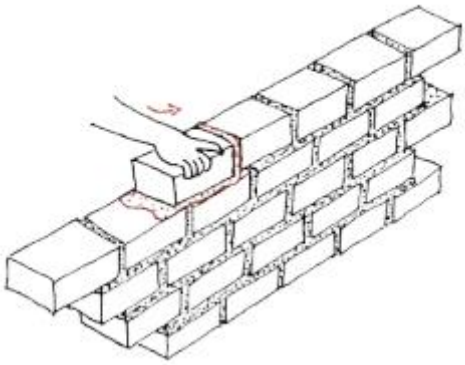


1) Lay enough mortar (not excessive). The mortar bed should be 10mm – 15mm.

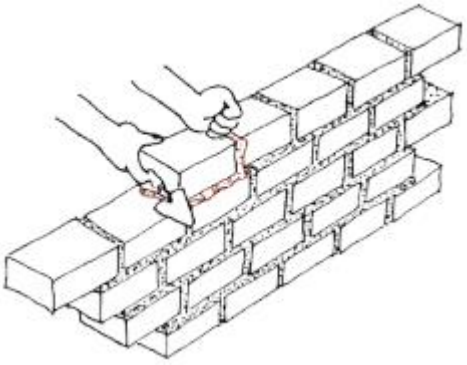


2) Spread the mortar evenly including the vertical face.

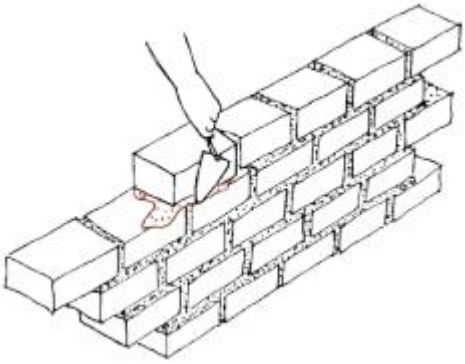
3) Wet the blocks before using.



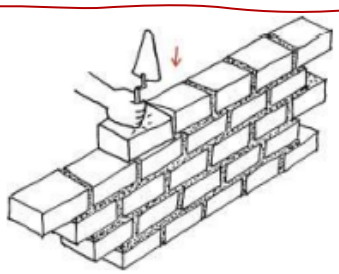
4) Place the brick applying pressure evenly.



5) Position and fix the brick correctly without tapping.

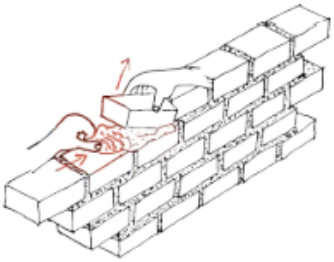


6) Remove the excess mortar.



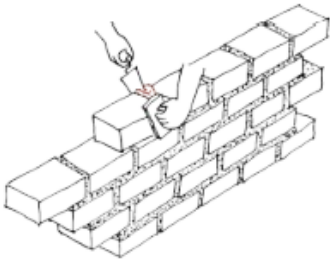
NO !

Do not strike the brick with a hard tool to put in place.



NO !

Do not lift the brick and push some mortar under it to fill the gaps.

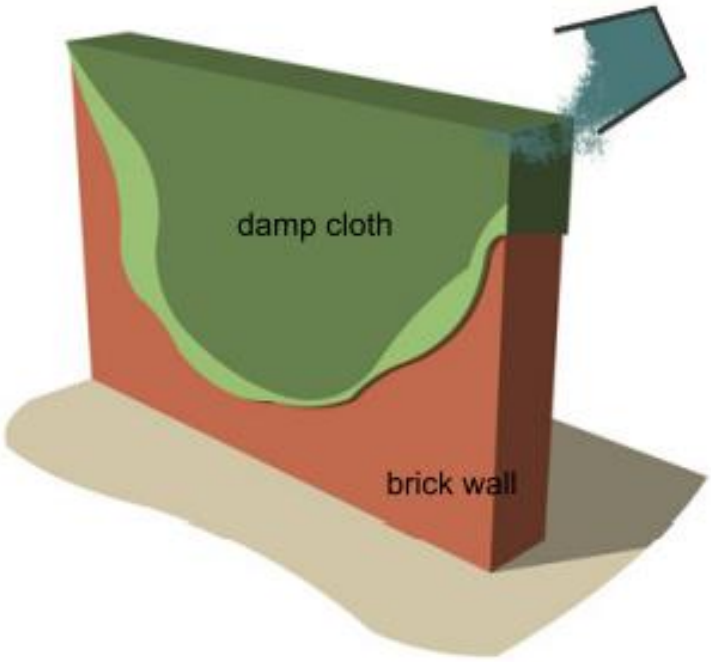


NO !

Do not fill the vertical joints after lying the bricks.

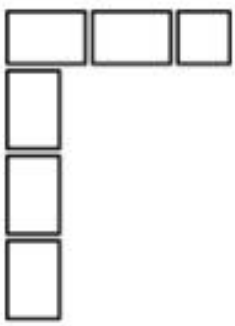
6.5.5 Keep damp

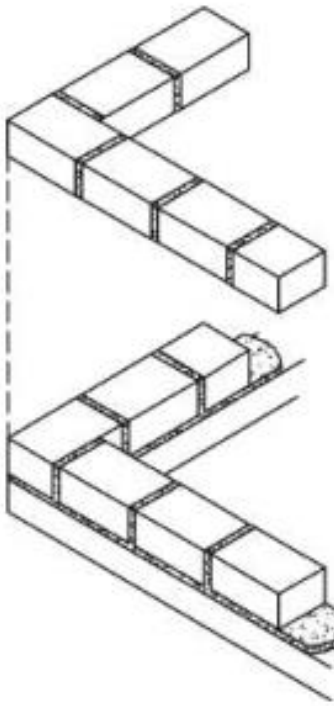
Cover walls with wet material to keep blocks damp, allowing mortar to dry slowly and create stronger connections.



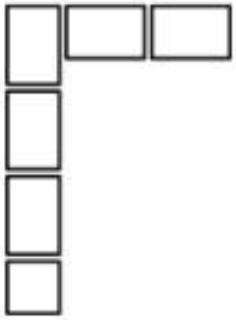
Stretcher bond

1st course

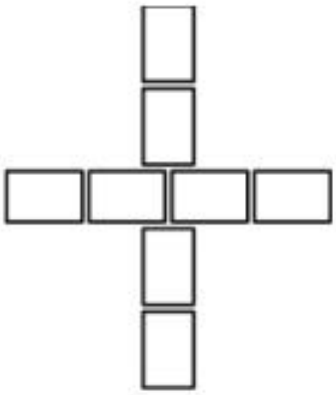


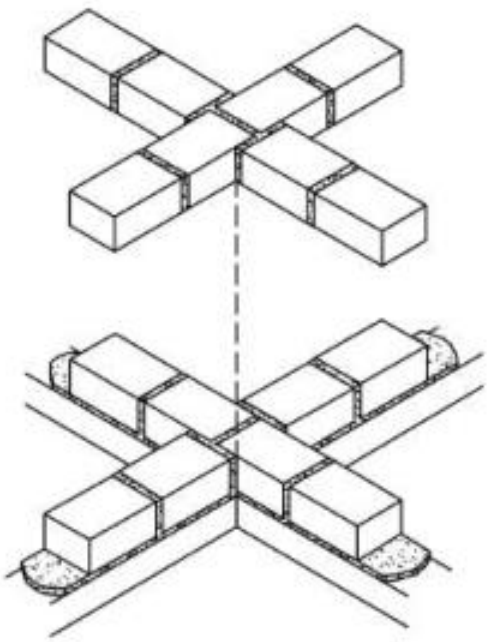


2nd course

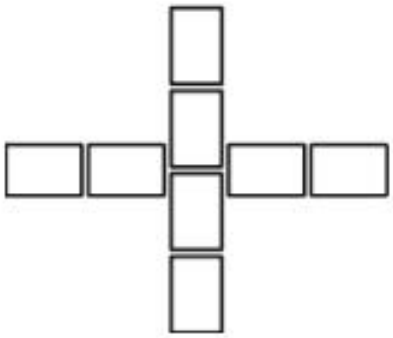


1st course



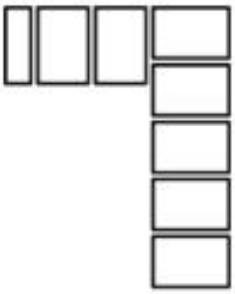


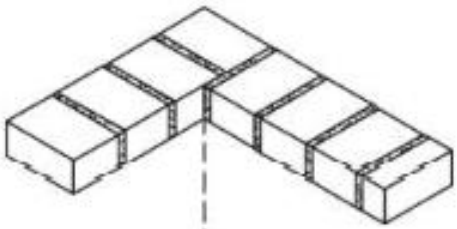
2nd course

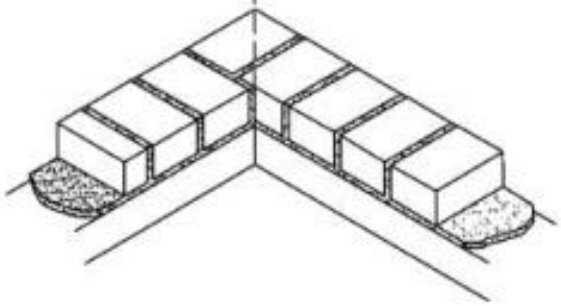


Headed bond

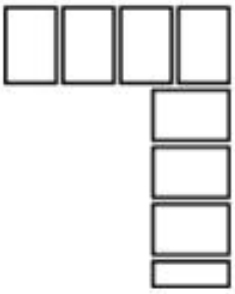
1st course



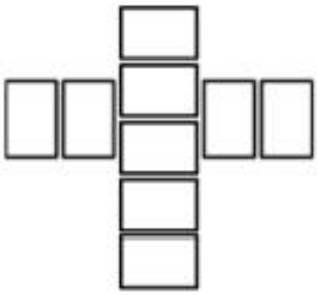


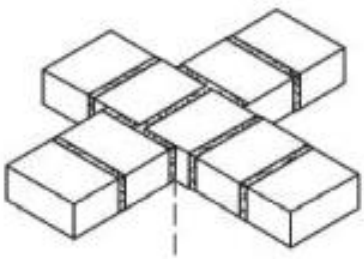


2nd course

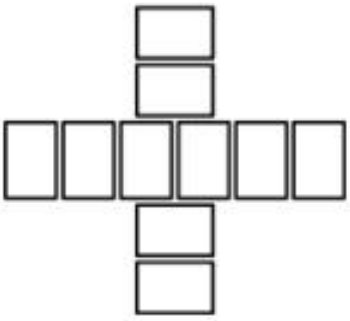


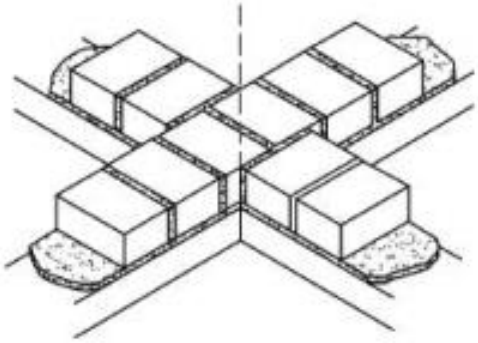
1st course





2nd course

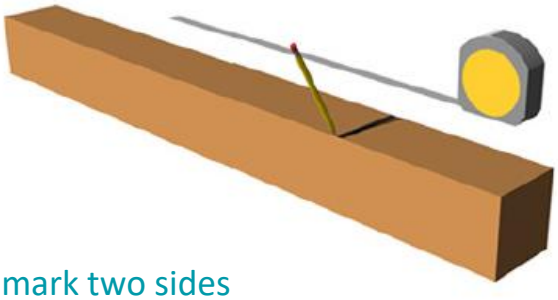




6.6 CARPENTRY

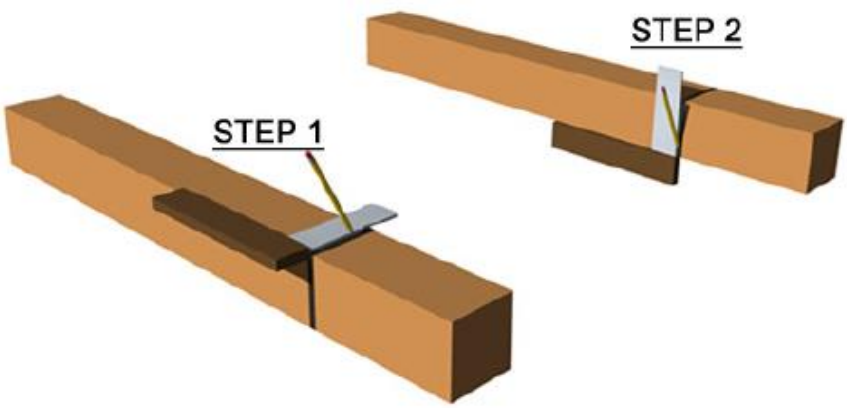
6.6.1 Cutting timber to the right length

Measure accurately and make a mark, measure again to verify, and cut. *"Measure twice, cut once"*



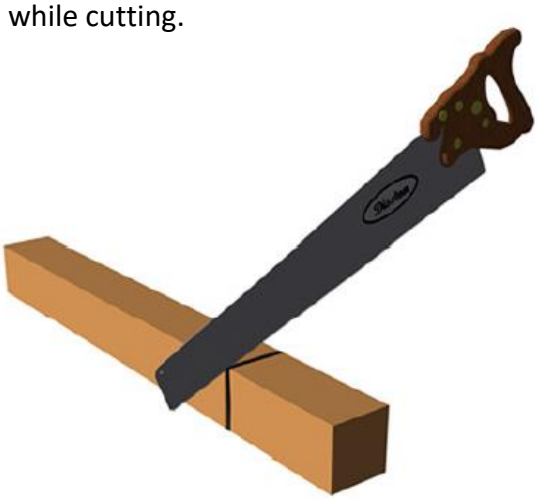
6.6.2 Always use a square to mark two sides

By using a square, you can be sure both marks are correct and even.



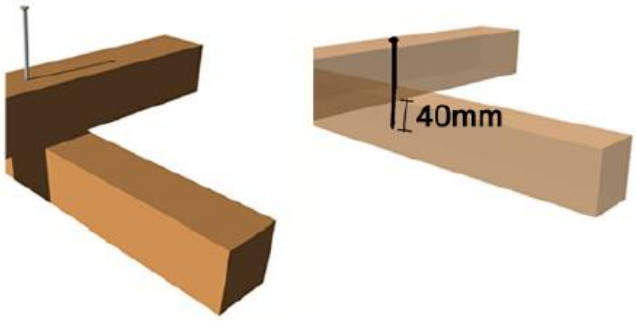
6.6.3 Sawing timber square

Start cutting at the edge of the timber where the two lines (pencil) meet. Then follow both lines while cutting.

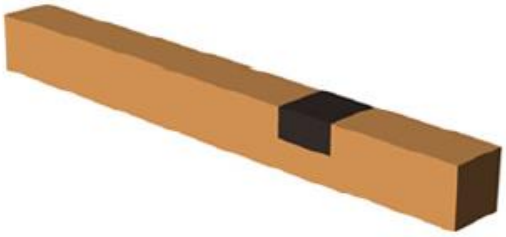


6.6.4 Nails to be minimum 40mm into the wood

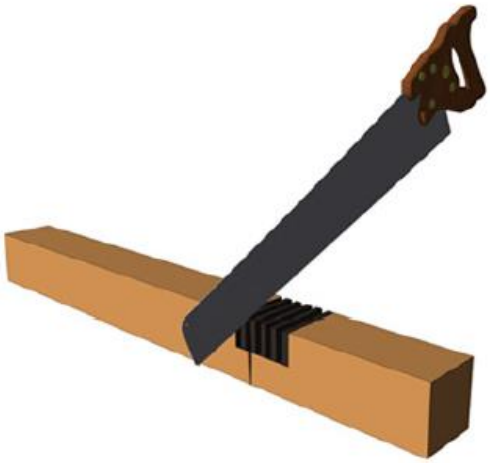
Nails need to be at least 40 mm (1 ½") to make a good connection with the timber.



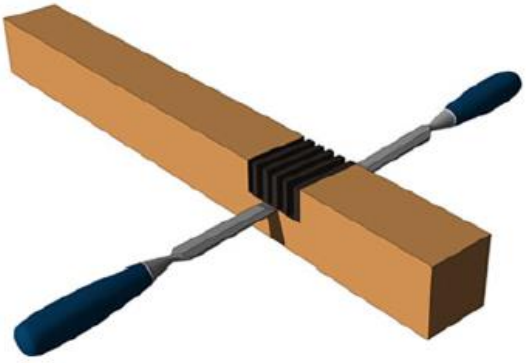
6.6.5 Cutting notches in timber correctly



1) Using a tape measure and square mark the position of the notch.



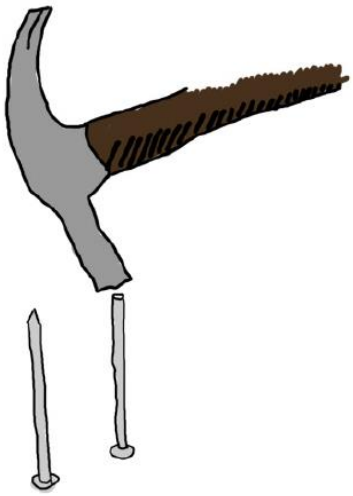
2) Make several saw cuts along the area to be notched out.



3) Using a chisel remove the timber from the notch working from both sides to avoid splitting.

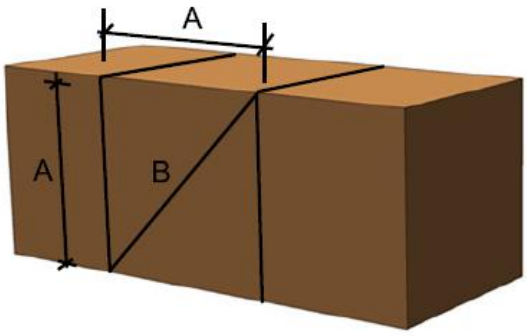
6.6.6 Blunting nails

The risk of splitting can be reduced by blunting the nail, by hitting the point of the nail with a hammer.



6.6.7 Marking a 45 degree angle for a cut

Make two marks equal to the depth of the timber (A=A). Mark the diagonal (B). This makes a 45 degree angle.



7 References

Safer and Healthier Homes Manual

Catholic Relief Services | 228 W. Lexington Street, Baltimore, MD 21201, USA | crs.org | crsespanol.org
Country Program Offices| Lilongwe Central Office, Manobec Complex, Mchinji Roundabout, P/B B-319, Malawi | Blantyre Office, Mount Pleasant No. 399, P/B 142, Malawi.
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