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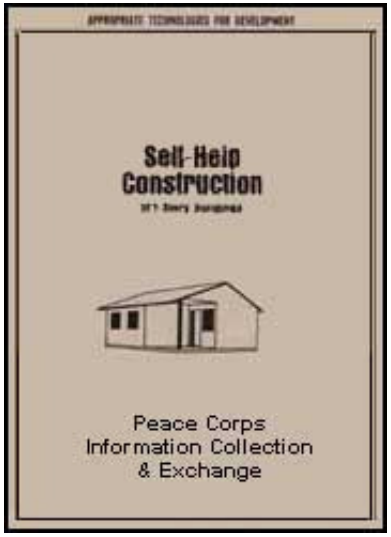


Self-Help Construction of 1-Story Building (Peace Corps, 1977, 235 p.)

- Construction with bamboo
  - *(introduction...)*
  - Bamboo for foundations
  - Bamboo for frames
  - Bamboo for floors
  - Bamboo for walls
  - Bamboo for doors and windows
  - Bamboo for roofs
  - Bamboo reinforcement of concrete

Preservation of bamboo

Self-Help Construction of 1-Story Building (Peace Corps, 1977, 235 p.)

Construction with bamboo

BAMBOO

Bamboo is an excellent building material for several reasons:

- it has a very high strength-to-weight ratio -- very sturdy for such a light-weight material;
- it is easily handled, with little waste and no bark to remove;
- it adapts to a variety of uses; a few bamboo

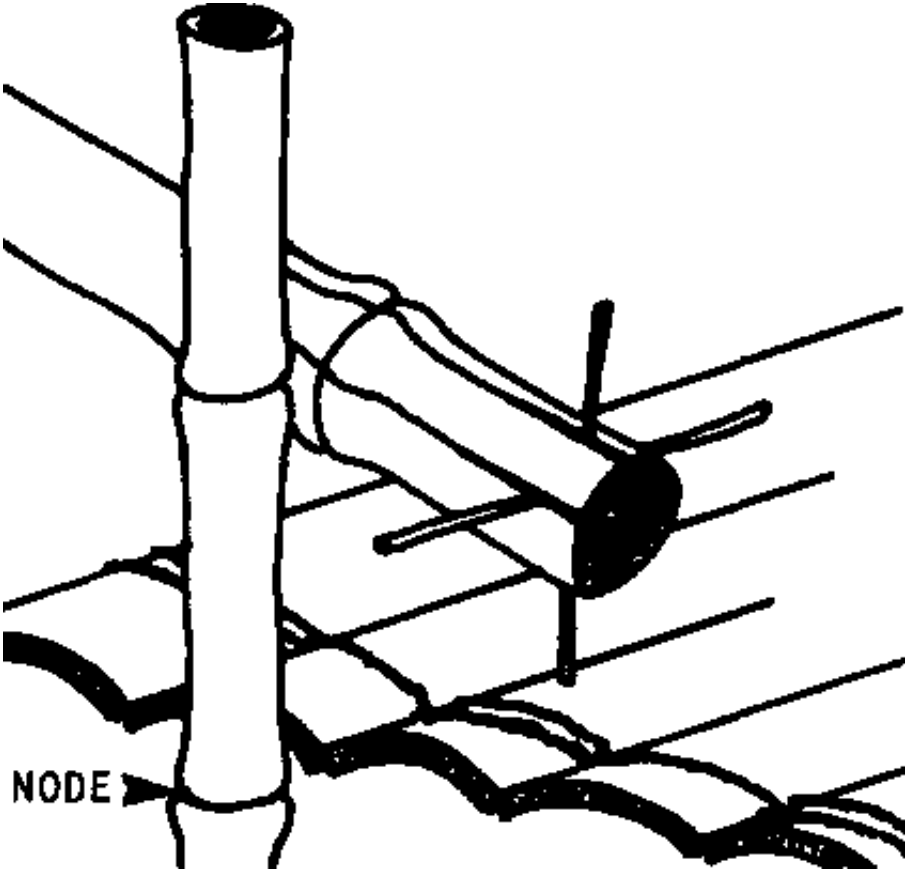
plants in the backyard will provide enough bamboo for a fence, a pigpen, extra rooms, or a house;

- **after construction, bamboo can be used for other income-generating crafts such as baskets, mats, and so on.**

About the only parts of a building that cannot be made from bamboo are fireplaces and chimneys. However, bamboo is rarely used as the only construction material for a whole building. Usually it is combined with other materials: wood, clay, lime, cement, iron, palm leaves, thatch, and so on.

There are many bamboo species. They differ in thickness, strength, flexibility, and resistance to insects and decay. Each is useful in only a few parts of a

building. For example, a species that makes good supporting columns cannot be used to make screen matting for a window. The general characteristics of different species are discussed below. But when in doubt about a specific bamboo supply, the best thing to do is check local practice and/or seek advice from a local contractor.



Uneven dimensions

To balance its advantages, bamboo has many drawbacks as a construction material:

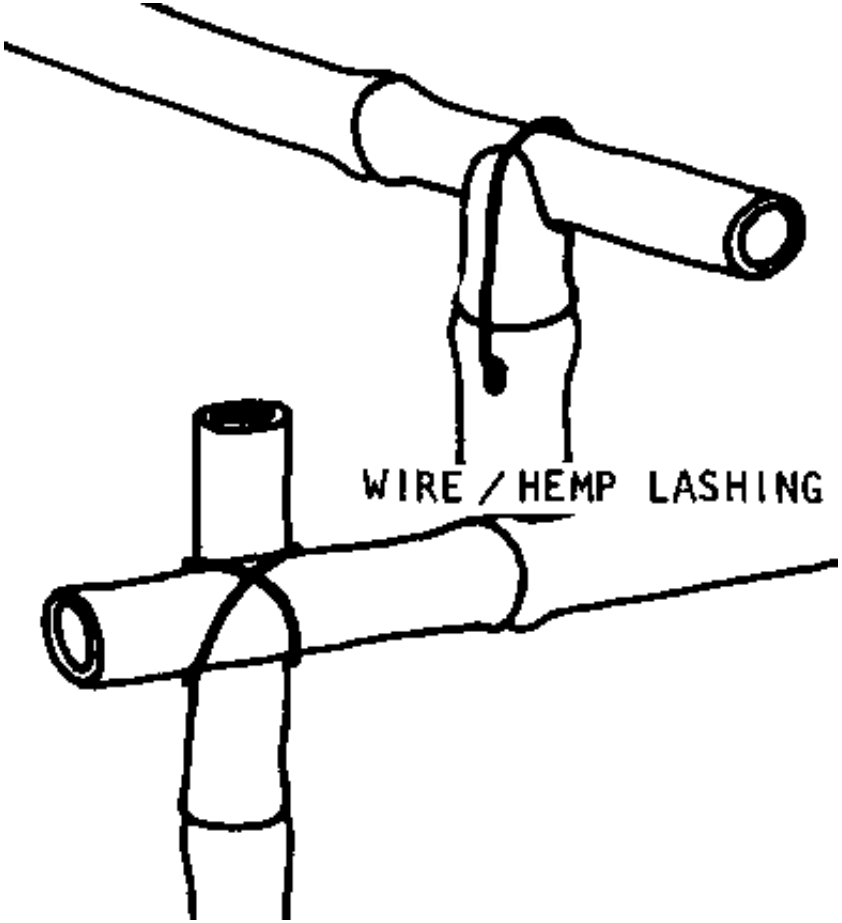
- **Uneven Dimensions. It is usually necessary to have a large supply in order to weed out pieces that are too thin, too crooked, broken, or otherwise useless.**

- **Uneven surfaces. Variations in the diameter of the shaft (called a culm), in the prominence of the nodes, and in the rate of tapering at the end of the culm all make certain applications difficult. On the other hand, long culms can often be cut up and the tips used for one purpose while the shafts are used for another.**

- **Brittleness. In almost all cases bamboo cannot be nailed. Most bonds are made with wire or**

hemp lashings. A few thick-walled species can be bored to insert pegs.

- **Low durability. Bamboo is susceptible to insects (especially beetles and termites) and to rot. Both insect decay and rot can be chemically retarded, and some species are more resistant than others. But even in the best cases, bamboo cannot last much more than 5 years in weight-bearing parts of a building.**

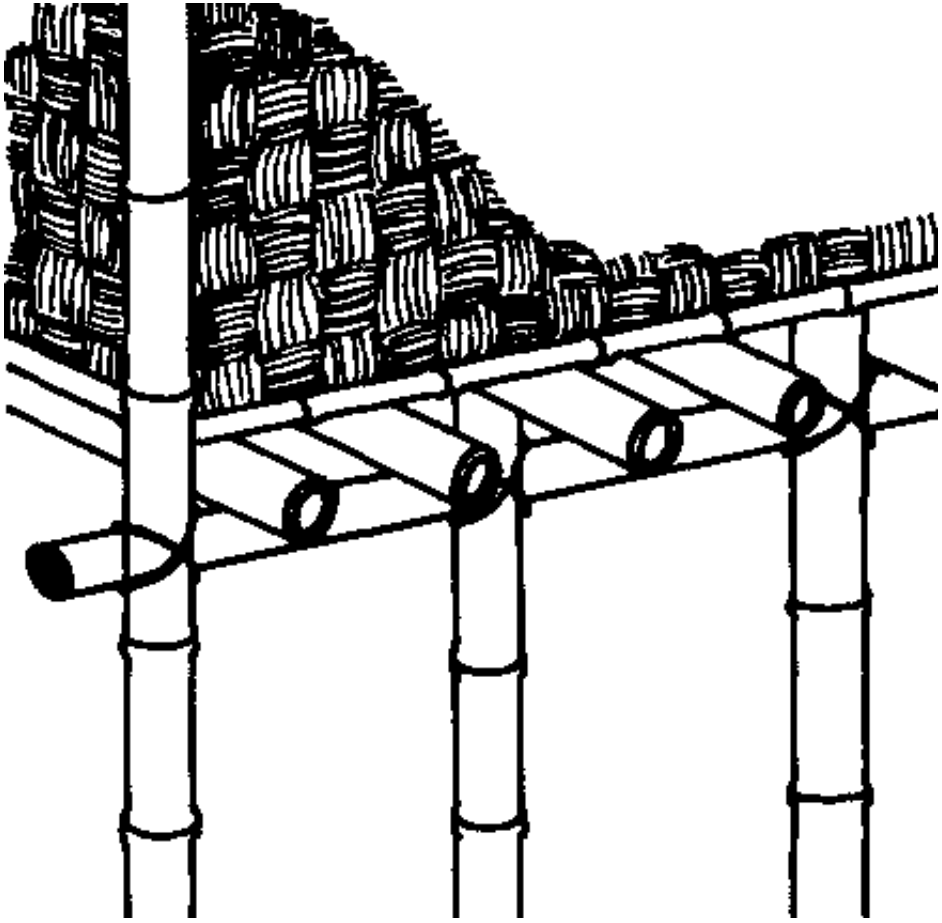

WIRE / HEMP LASHING

Wire/hemp lashing

Bamboo for foundations

Bamboo is basically an above-ground material. Unless it is treated with a preservative, it will last only 2-3 years underground.

However, bamboo will serve as a supporting post: for a house on stilts, for example. Use the largest diameter culms (at least 1220cm) with closely spaced nodes for stiffness. If only smaller shafts are available, they can be bound into columns.



Bamboo for foundations

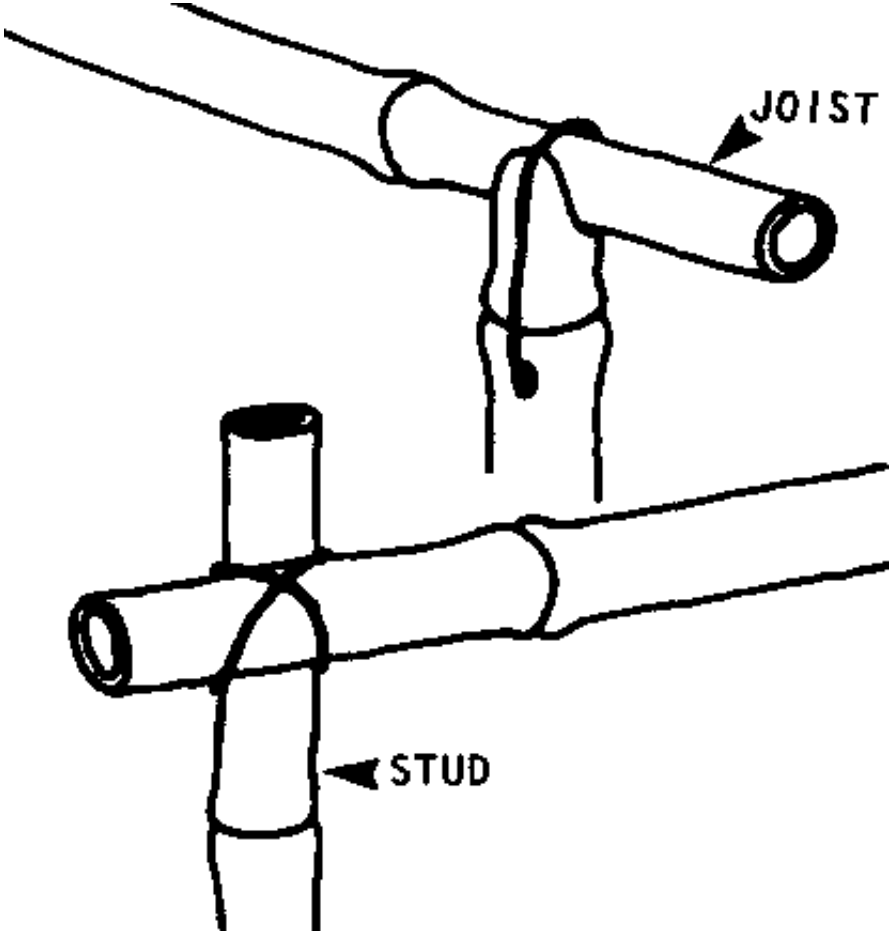
Bamboo for frames

In earthquake areas, bamboo's flexibility makes it a good choice for construction of a frame for floors, walls, and roofs. Such a frame may then be finished by weaving bamboo to form the solid parts of the building, or by using other materials such as clay, mud, or thatch.

Use only whole culms. Cut off and discard the upper, tapered ends of each culm so that all shafts used will have uniform thickness and strength.

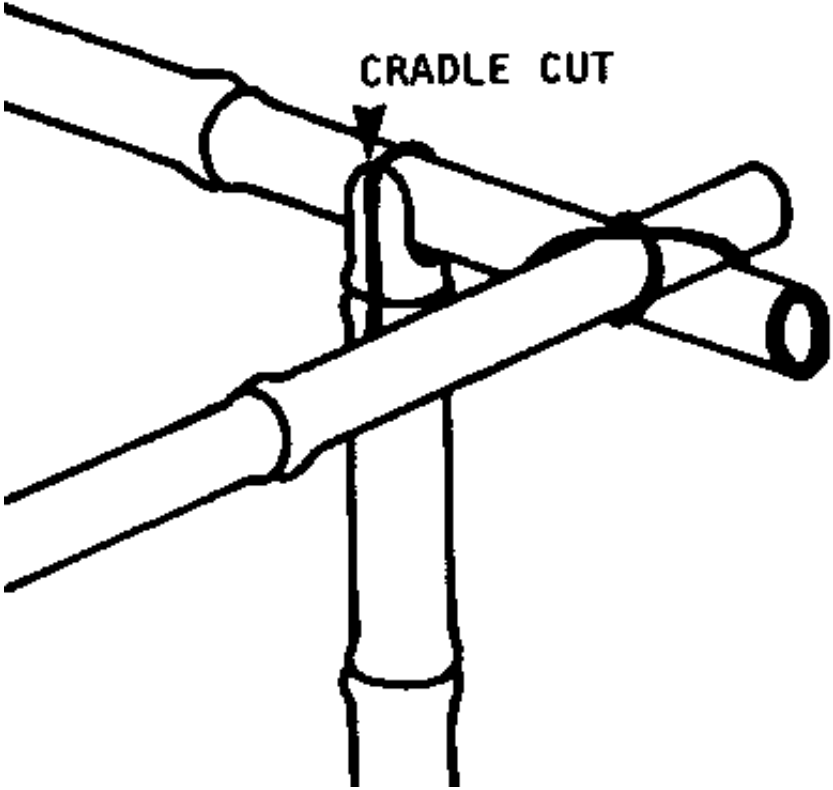
The design of a bamboo frame is simple:

Begin with corner posts firmly planted in the corners set out at the site. Next, attach joists (horizontal culms that will support the floor and roof). Then attach studs (vertical culms that will form the wall frame).


JOIST
STUD

Attach studs

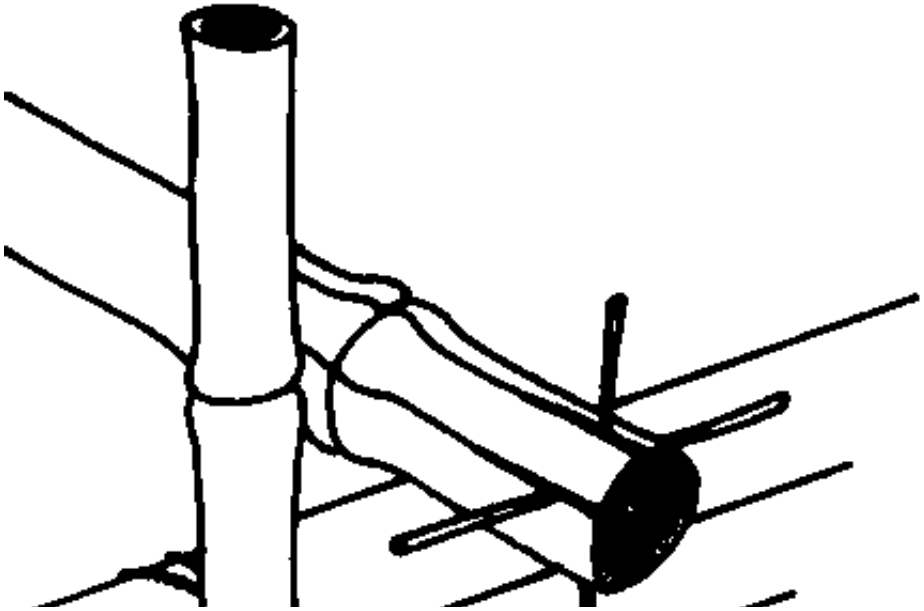
Since bamboo cannot be cut to make perfectly measured joints, the shafts must be lashed with vines, bark' or wire. The only cut that can be made is a notch or cradle-like cut that can be used at the upper end of posts to support a horizontal piece.



Cradle cut

Bamboo for floors

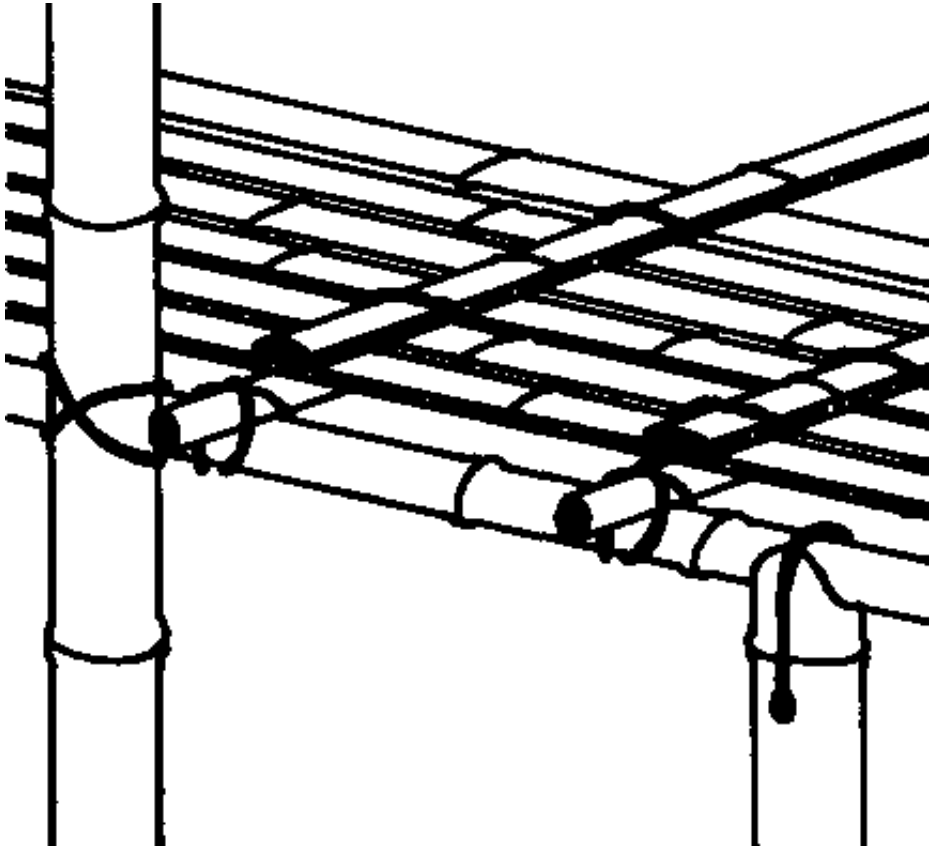
The culm of certain species can be split open and flattened out, making a "board". Among other uses, these boards can be laid directly on a hard earth surface to make a floor. Clay is the best soil for this purpose. It should be evenly graded (for proper drainage) before the boards are pounded into place.



BAMBOO BOARDS MADE BY SPLITTING
LARGE CULM AS SHOWN

Bamboo boards made by splitting large culm as shown

Another type of bamboo floor is raised 1.5-2 meters so that the space underneath may be used for storage of equipment or animals. Thick culms are used as column supports; thinner culms are flattened for the floor; and woven mats are used as floor covering.

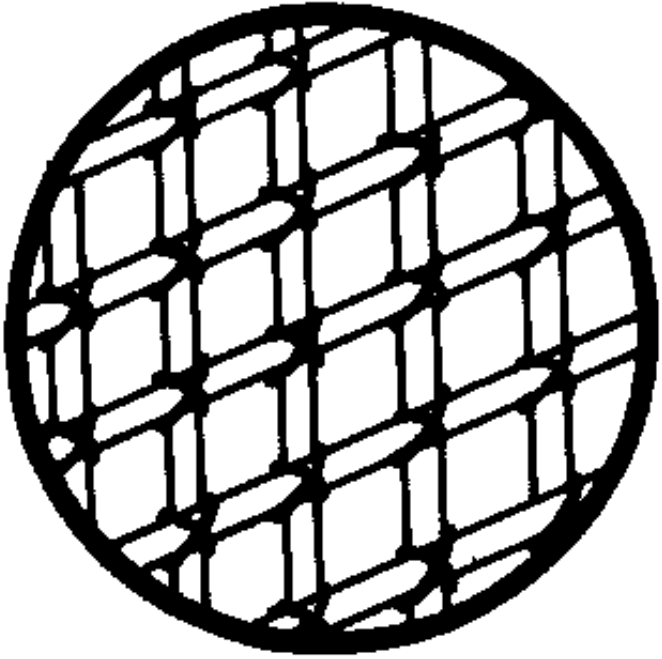


Another type of bamboo floor

Bamboo for walls

Here are two common ways to use bamboo for walls:

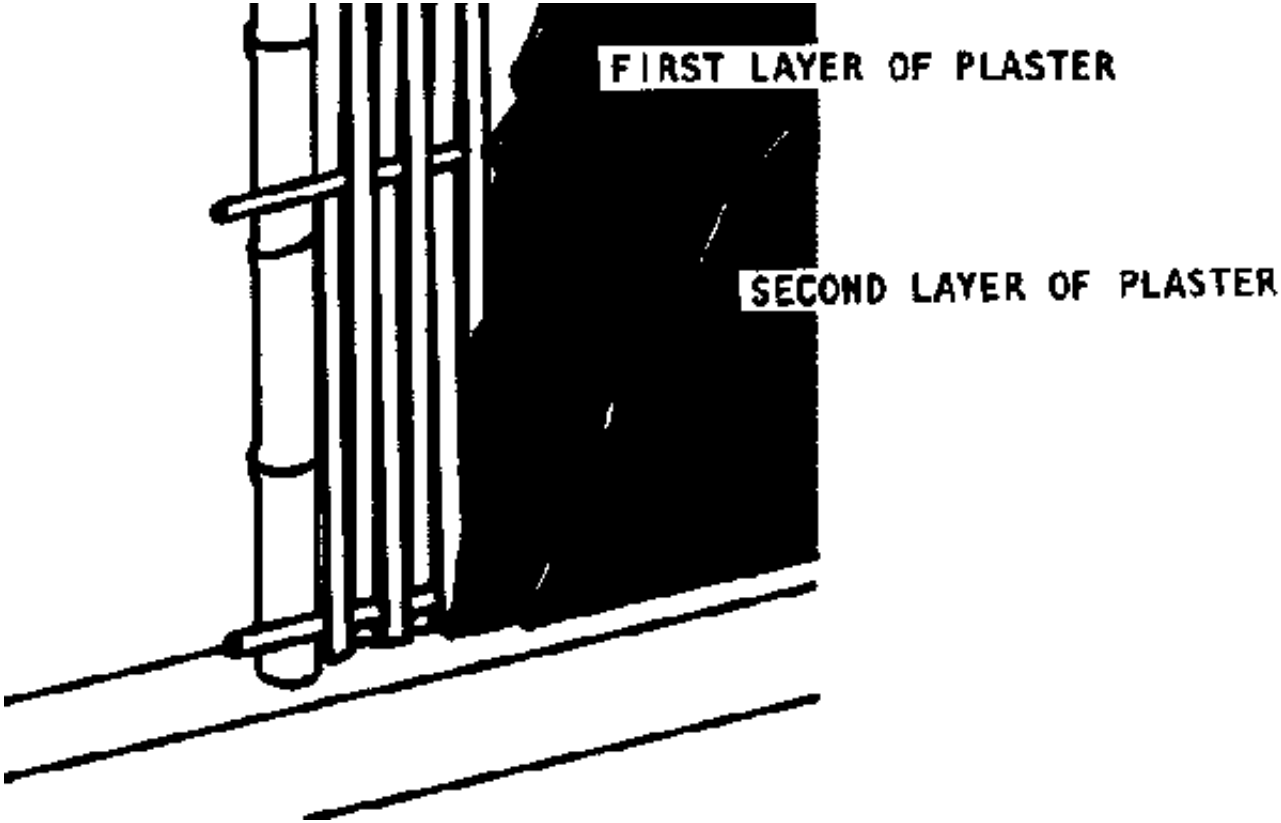
- **Wide bamboo shafts are lashed horizontally to both sides of vertical hardwood posts. Occasionally thick bamboo posts are used instead of hardwood posts. The spaces between the bamboo shafts may be filled with mud, mud and stones, thatch, or more bamboo.**



The spaces between the bamboo

- **Sprung Strip Construction. Vertical bamboo shafts are woven around three horizontal poles. The frame is then covered with plaster on one or**

both sides.



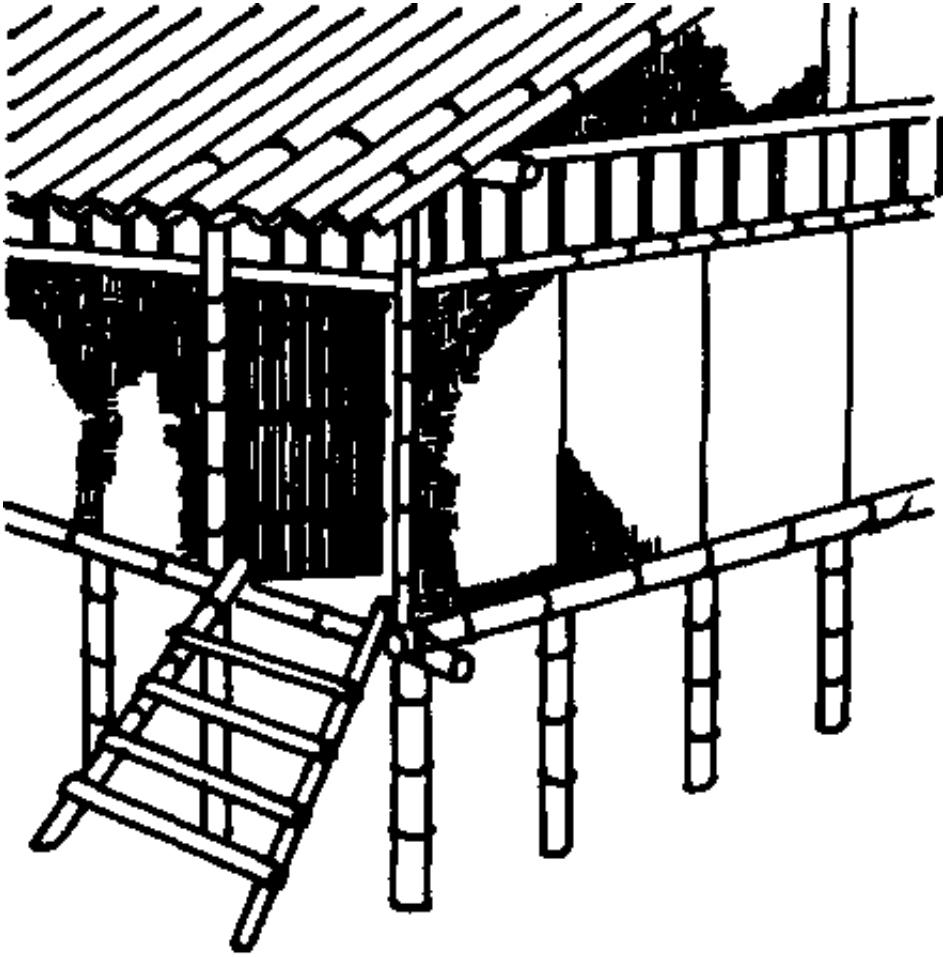
The frame is covered with plaster

Partitions may be made exactly as walls are but with lighter, portable frames. Use the lightest species available. Crack and flatten the shafts; then weave them into mats that can be suspended.

Bamboo for doors and windows

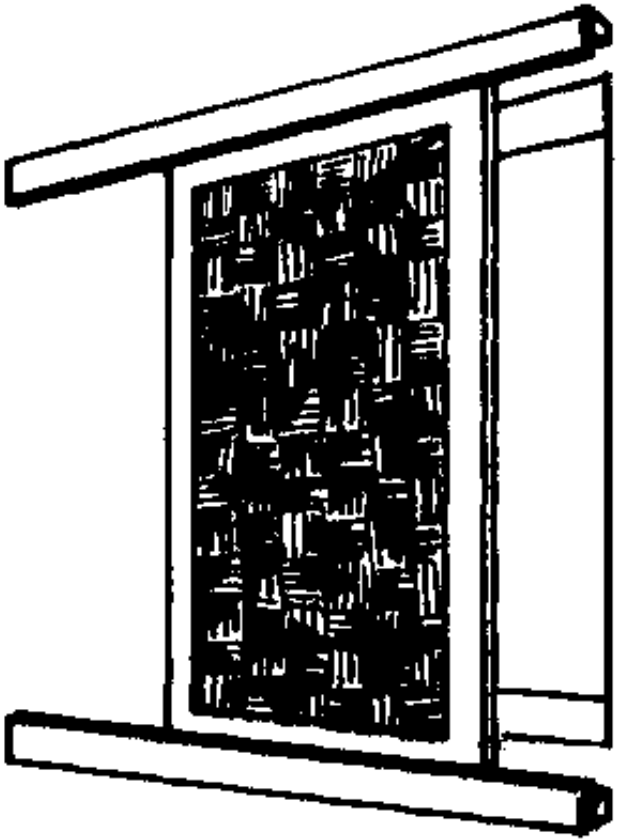
For practical reasons, doors and windows are kept to a minimum in bamboo housing. Doors tend to be made of:

- **wood; or,**
- **bamboo matting woven on a bamboo frame; or,**
- **bamboo "bars" put up in a gate-like fashion.**



Bamboo for doors

Windows are usually unscreened and covered with bamboo matting or a palm leaf. They can also be made out of a row of shafts tightly pressed and bound together by pieces of wood: this kind of window, when raised, acts as a shade.



Bamboo for windows

Bamboo for roofs

Bamboo is used for the frame of the roof. The roof covering can be of several materials:

- **grass thatch;**
- **corrugated metal or asbestos;**
- **tile;**
- **bamboo tiles made from halved culms.**

Bamboo reinforcement of concrete

Bamboo can be used to increase the strength of concrete by 2 to 3 times. To be effective, the shafts must be "seasoned" - dried out and shrunk for a month or more and then split in half.

The placement of the shafts is the same as the placement of iron reinforcement rods (see the section

on reinforcing concrete, page 137).

Preservation of bamboo

The following simple steps will lengthen the useful life of bamboo:

- **Cut the shafts at the base and store them upright in clumps in a dry, sheltered place. Never store bamboo out in the open or expose it to rain or dampness: it may rot or be eaten by insects.**
- **Dust the ends of each shaft with a mixture of 1:20 DDT to talc (or other, safer insecticides where available and effective).**
- **Use pegs to keep the ends off the ground.**
- **After 4-8 weeks of drying, trim all twigs and**

leaves off the shafts and dust the newly cut surfaces.

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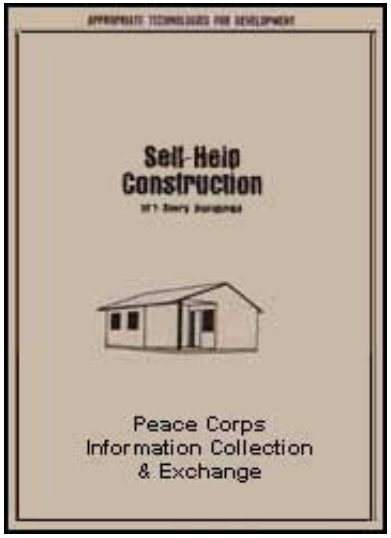


Shelter

Self-Help Construction of 1-Story Building (Peace Corps, 1977, 235 p.)

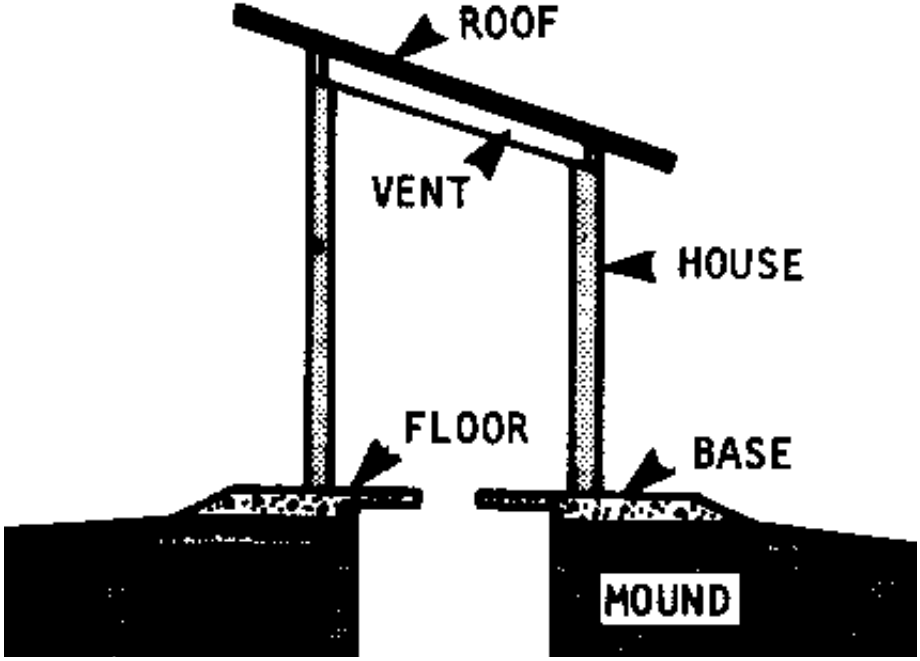
Latrines

Latrines

Latrines are vital for community health. They keep local water used for drinking or growing crops free from diseases spread through human feces; and they discourage transmission of diseases by flies that breed in excrement.

In many areas, community acceptance of latrines as an integral part of any home, school, or clinic project may be more important than any other construction ideas in this manual.

Basically, a latrine consists of: a pit dug in the ground for the storage of excrement; a base built over the nit with a small hole in it so that a person can stand over the pit; and a shelter to provide privacy, protect against weather, and to keep flies from breeding in the pit.



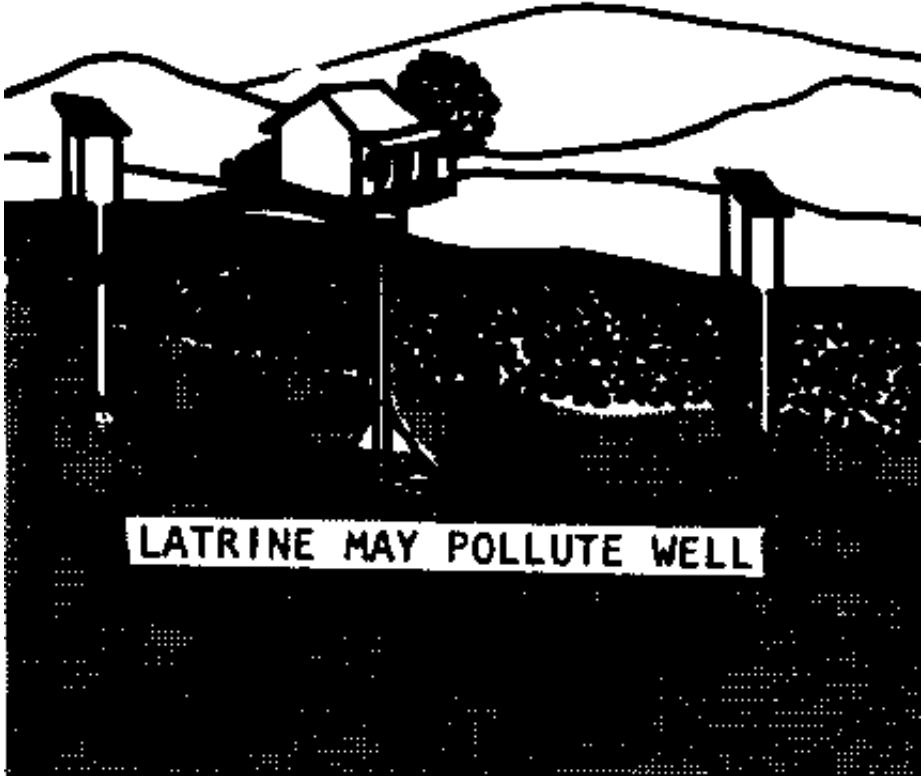
Latrines

Location of latrines

Two principal requirements should govern the choice of a latrine's location:

*** It should be close enough to the school, clinic, or home to be reached easily; but far enough away to keep the main building free of odors and potential contamination. 30 meters is the distance recommended by many experts.**

*** It should be situated so that it will not contaminate ground or surface water that may enter springs, wells, or fields. Satisfying this requirement can sometimes be complex.**



Location of latrines

The most important considerations to keep in mind are:

- **the latrine should be high enough so it will not be flooded during the rainy season;**

- **the latrine should be downhill from any nearby wells or springs; if this is impossible - of if the land is flat - the latrine must be at least 15 meters away from wells or springs (7.5 meters in sandy soil);**

- **in regions with fissured rocks or limestone foundations (which can carry pollution great distances), get expert advice!**

Pit

At the chosen location, begin by digging a pit, either round or square, about 1 meter across, and from 1-3 meters deep. The table below shows recommended depths for a latrine for a family of 5. The same depths

may be used for latrines in public buildings such as schools or clinics provided there will be 1 latrine for every 15 people who use the building regularly.

On the table, "wet pit type" refers to pits which penetrate the water table in the ground and are constantly wet. "Dry pit type" refers to pits that are 3 meters or more above the highest underground water level.

If the soil is soft and tends to cave in during the digging, line the pit with stone, brick, wood, or bamboo to keep the sides of the pit strong. Even when the soil is firm, it's a good idea to line the upper few feet.

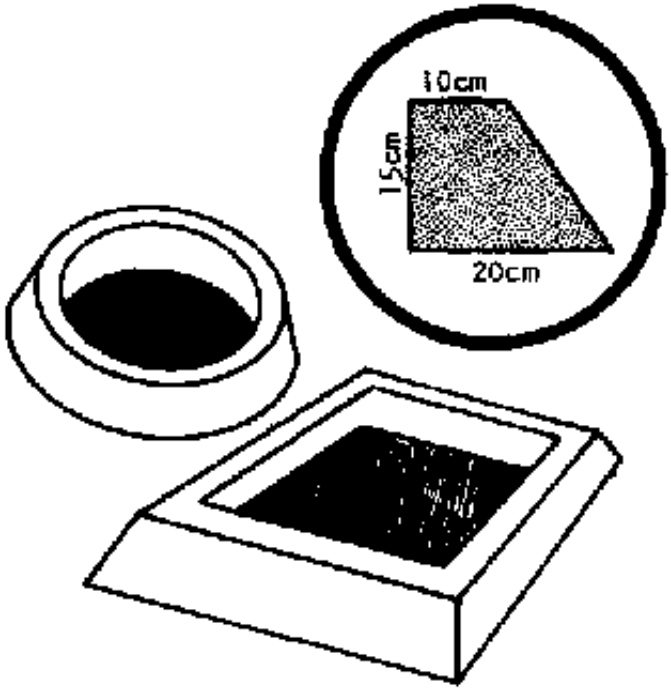
PIT TYPE	YEARS OF SERVICE	PERSONAL CLEANSING MATERIAL	
		WATER	SOLID
		RECOMMENDED DEPTH, Meters	RECOMMENDED DEPTH, Meters
WET	4	0.74	1.13
	8	1.47	2.26
	15	2.74	4.23
DRY	4	1.13	1.70
	8	2.26	3.38
	15	4.23	----

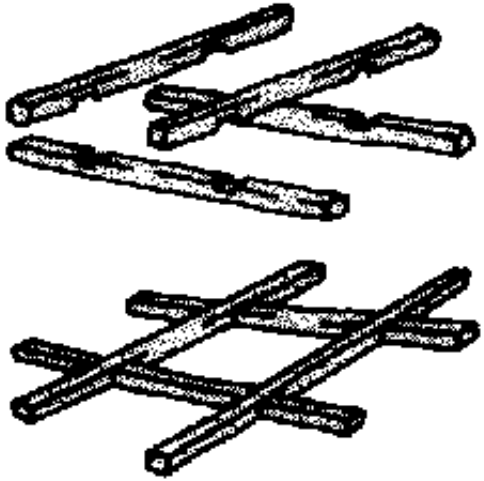
Recommended depths for holes with 1 square meter area

Base

The base is essentially a foundation for the floor. It also helps to prevent hookworm larvae and burrowing rodents from entering the pit.

The best materials for the base are concrete from a 1:2:3 mixture, or stabilized earth with 5-6% cement content. Heavy hewn logs treated for insect resistance may also be used as shown.





Base

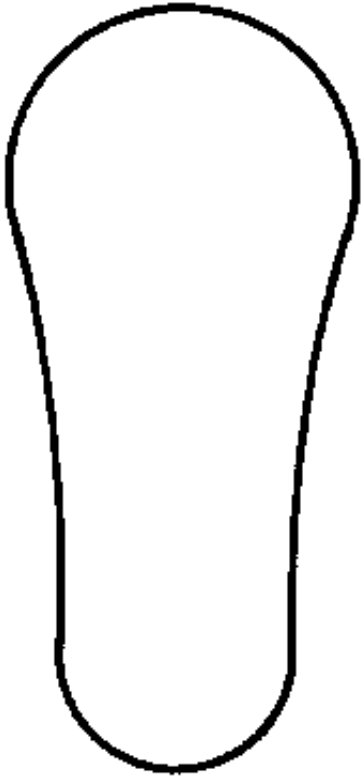
Floor

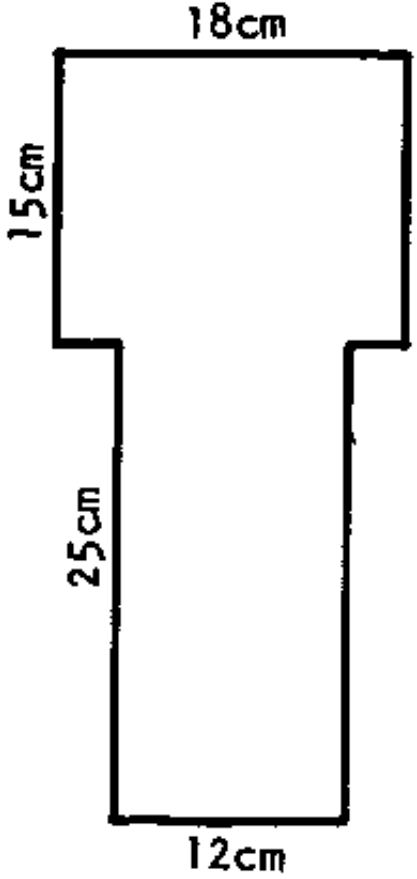
Following construction of the base, a mound of hard-

packed earth or dry fill should be built up until it is level with the top of the base (at least 15cm above ground level), and it covers the floor area planned for the shelter.

Above this mound must be placed a floor with a built-in hole about 40cm long and 12-18cm wide. Do not make the hole wider than 18cm or children may fall through it!

The shape of the hole can vary according to local preference. Two common shapes are shown.



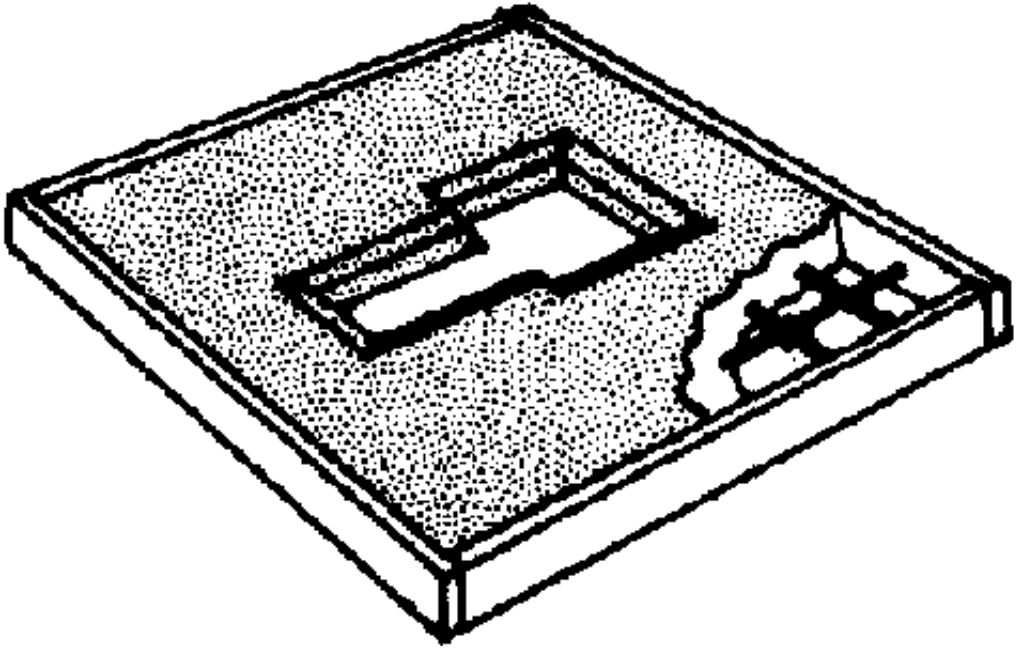


Shapes

The floor may be built of several materials. Reinforced concrete is best. Build a form about 100cm x 100cm and 6cm deep. Then cut a piece of wood 6cm high and the size and shape of the hole desired. This piece will act as the mold for the hole in the concrete slab. If you slope its sides slightly instead of making them straight up and down, it will be easier to remove from the concrete after the concrete has set.

Place the wood piece inside the 100cm x 100cm form where you want the hole to be. Then place reinforcement rods (bamboo or iron) in a grid across the formwork.

Mix, pour and cure the concrete as you would for any concrete floor (see pages 154-156), After curing, place the concrete slab over the mound and base so that the hole is centered over the pit opening.

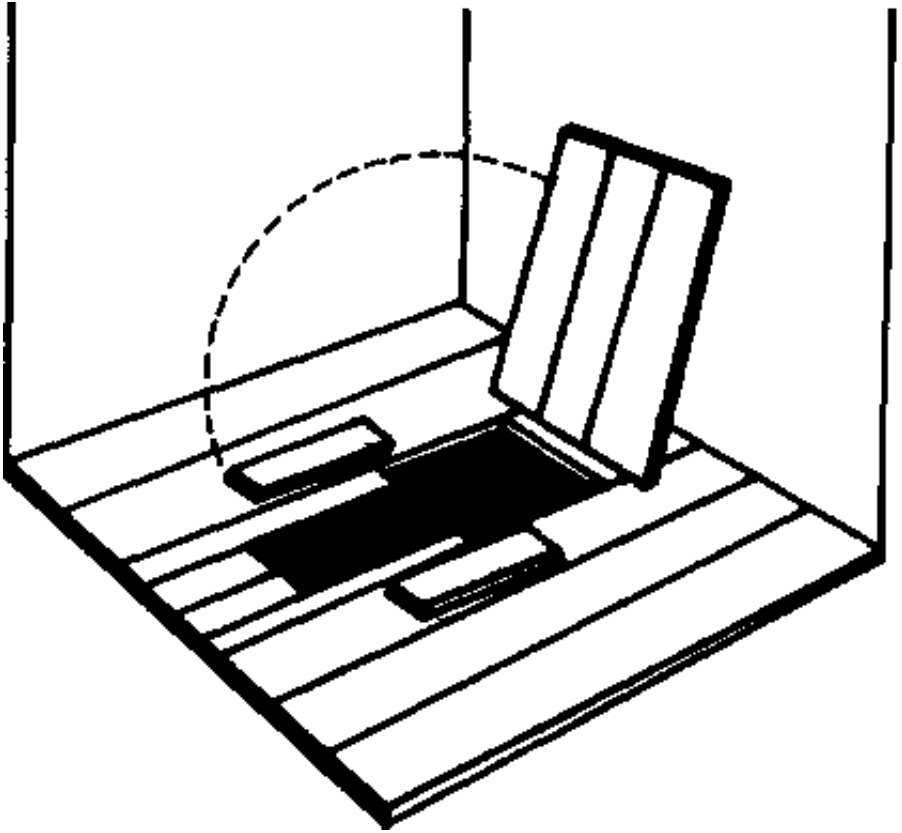


Place the wood piece

Other materials appropriate for building latrine floors include reinforced brick mortar, wood, and logs with earth.

It may be desirable to add raised foot rests, approximately 30cm long and 10cm wide as shown.

In addition, a simple wood cover can greatly reduce odors and keep flies away from the pit.



Other materials appropriate for building latrine floors

Shelter

The latrine shelter serves several purposes:

- **protection from wind and rain;**
- **privacy;**
- **protection of the pit from direct light (darkness keeps flies and other disease-carrying insects and rodents from breeding in the pit).**

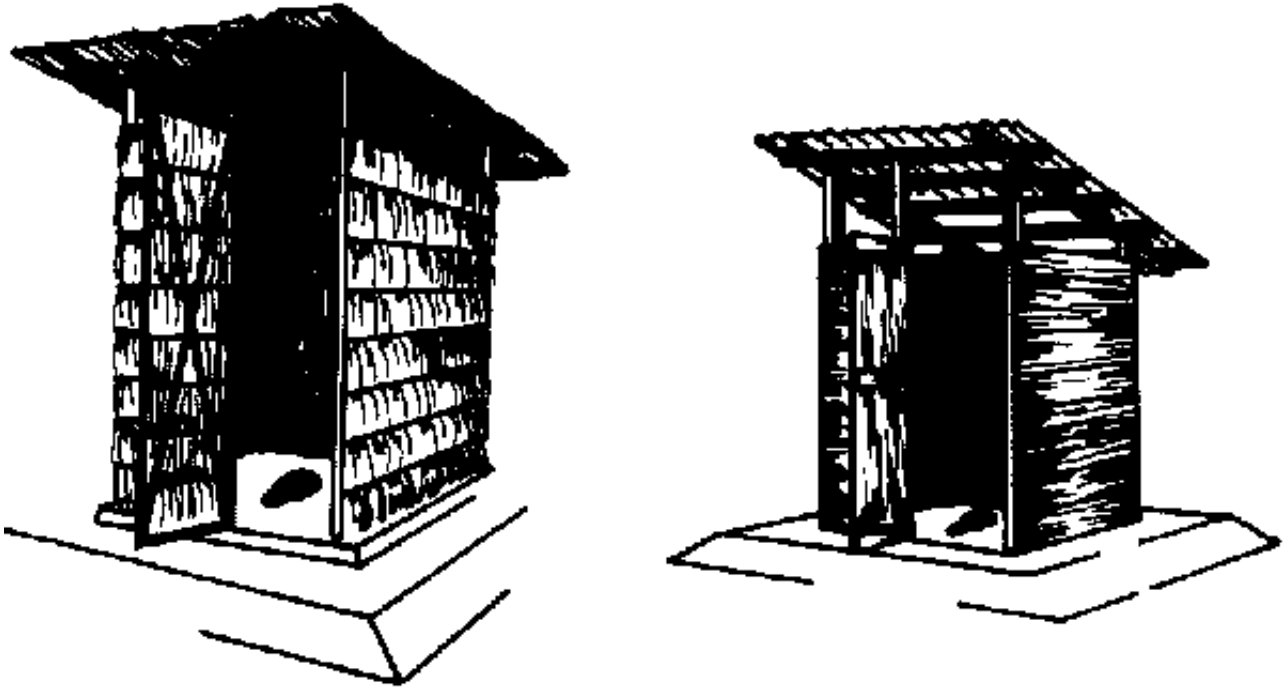
In general, the shelter should be about 1 meter wide, 1.5 meters long, and 1.5 meters high.

It should have a shed roof with a large overhang [about 60l00cm). The roof should be 10-15cm above the walls for ventilation to diffuse any odors which might build up.

If acceptable socially, it is beat to cut all vegetation within 2 meters of the shelter, especially if food is grown nearby. This will prevent contamination of the ground surface resulting from any possible misuse of the latrine.

The illustrations above show two types of latrine shelter. The actual construction of latrine shelters follows the normal procedures for any building.

One final note: The latrine design described in this manual is only one of the many possible designs. See the sources listed in the bibliography (page 227) for information on other designs.



Shelter

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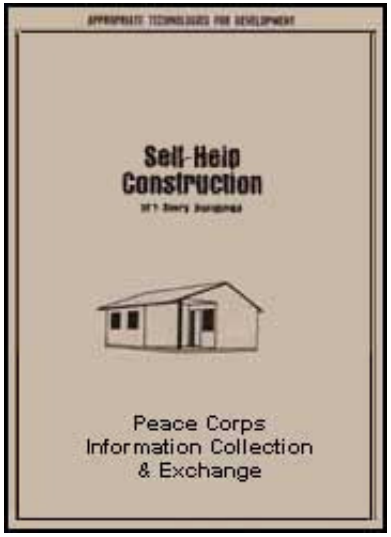


- **Self-Help Construction of 1-Story Building (Peace Corps, 1977, 235 p.)**
  - **Construction in earthquake areas**
    - ***(introduction...)***
    - **Selection and preparation of the site**
    - **Selection of building materials**
    - **Reinforcement of buildings**

Self-Help Construction of 1-Story Building (Peace Corps, 1977, 235 p.)

Construction in earthquake areas

Construction in earthquake areas

In areas where earthquakes or tremors are likely, there are a number of ways to reduce the danger of structural damage and to increase the safety of those who use a building. Special care should be taken in:

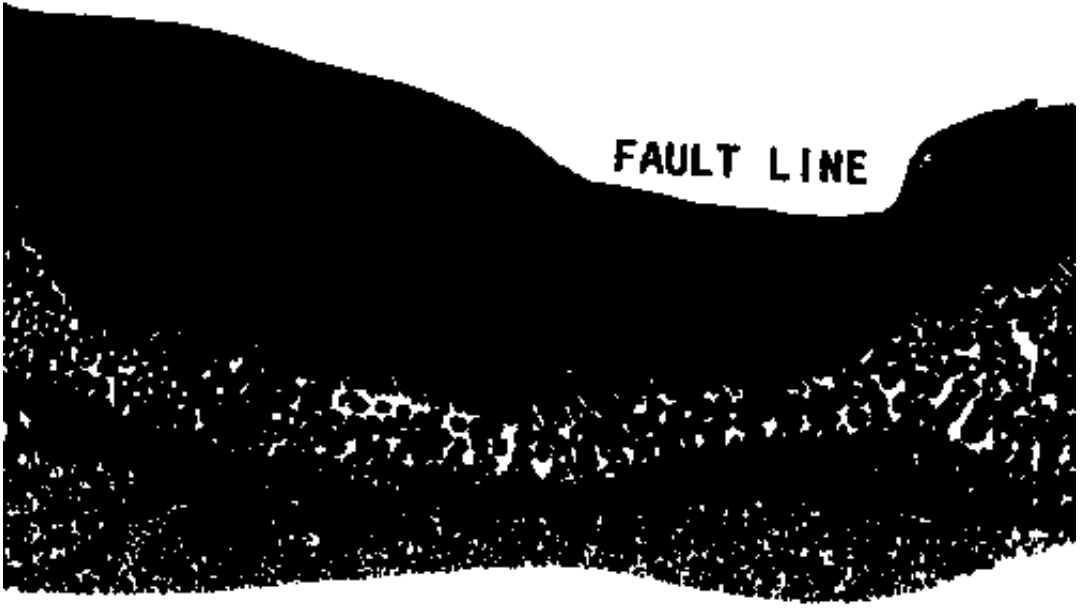
- **the selection and preparation of the site and the building position;**
- **the selection of building materials;**
- **the use of special techniques for reinforcing foundations, floors, walls, and roofs.**

Selection and preparation of the site

One of the simplest precautions against earthquake destruction is to choose a site as far as possible from the fault line. The fault line is the line along which two

blocks of earth meet and slide against each other. Earthquakes occur when two such blocks of earth move suddenly.

In areas where a serious earthquake has occurred recently, people near the fault line will know where it is. Fault lines may also be found by looking for places where geological formations such as dry river beds or veins of rock appear to have suddenly split and shifted. The location of such shifts will be on the fault line.



Selection and preparation of the site

Other suggestions for the selection of a site in earthquake areas include the following:

- Flat terrain is best; avoid sharply sloping ground if possible; ground slippage occurs most

often on hills.

- If the land has some slope to it, level the entire site around the building so that the foundation and walls are the same height throughout. Stepped foundations and walls of unequal height are less stable.

- Do not build on "filled-in" earth: it can't be as stable as ground that has settled naturally over time.

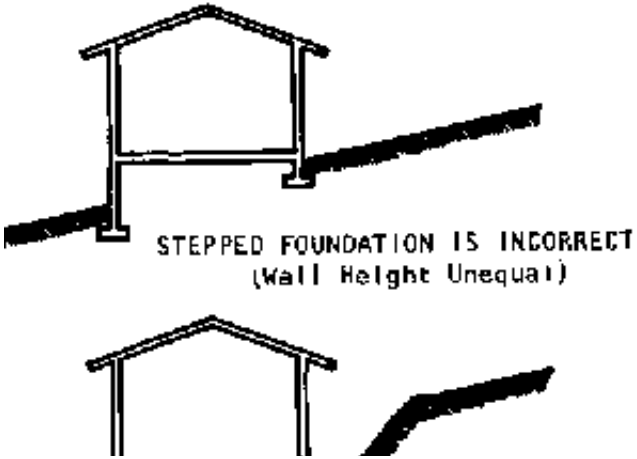
- Align the building so that its length is parallel to the nearest fault line. This will help the structure go "with" and not "against" a tremor.

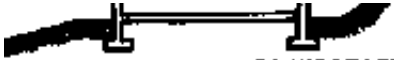
- Choose a site as far from other buildings as possible. The minimum distance between 1story

structures should be equal to their height.

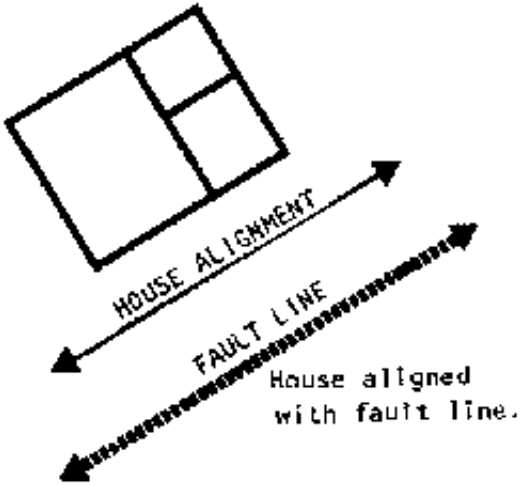
- If a new building must be built less than the minimum distance from another building, any separation is better than none. Never interconnect the walls of two buildings.

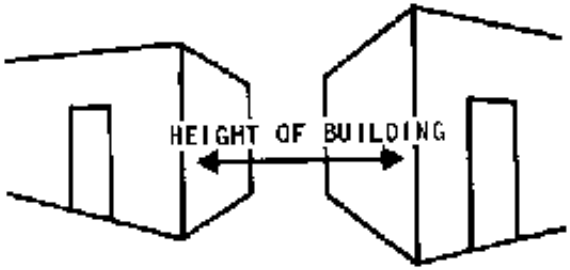
- Use rectangular or circular shapes for buildings in earthquake areas. Avoid "L-shaped" buildings.





LEVEL FOUNDATION IS CORRECT
(Wall Height Equal)





Foundation

INCORRECT: Walls Connected

CORRECT: Buildings Separate

Any separation is better than none

Selection of building materials

Generally, the safest materials in earthquake areas are the lightest and most flexible.

In foundations concrete footings reinforced with iron or bamboo, and concrete or block foundation walls are good. Avoid rock foundation walls because the large amounts of mortar used to bind the rocks are easily weakened in earthquakes.

For walls, where climate permits, bamboo and wood are the best because their flexibility keeps them from cracking or collapsing, and because they are less dangerous if they do fall. Walls made from bricks or blocks of any material are fine but should be made as light and as thin as possible. Rammed earth walls and rock walls are unstable and dangerous in earthquakes:

they should be avoided.

Roofe are safest when made of bamboos and grasses (thatch). Woodbeam supported roofs are also fine, provided the material they support is light, such as shingles or corrugated metal. Adobe and tile roofs should be avoided.

Reinforcement of buildings

There are many ways of reinforcing buildings to resist earthquakes. The most important and least expensive techniques are listed here. But if earthquakes are a major problem in the local area, the field worker or community should consult experienced local contractors for advice.

All of the techniques listed here can help save a building

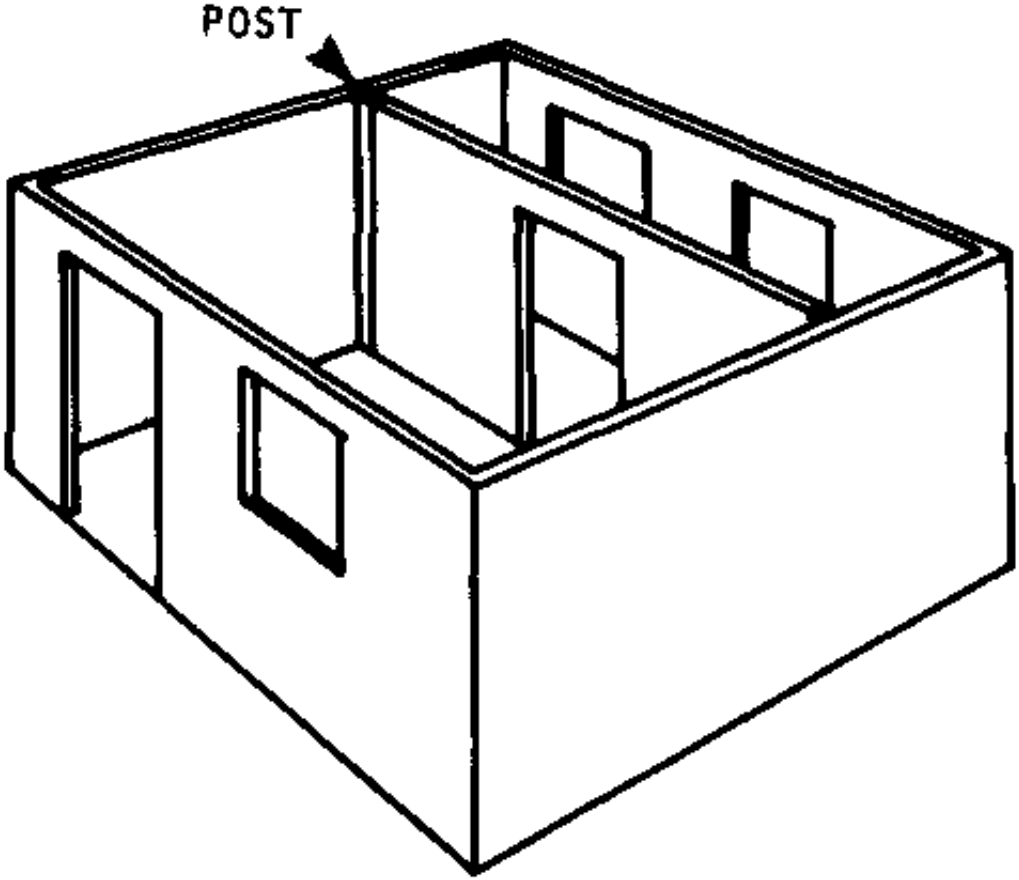
in an earthquake, whether they are used alone or in any combination. They cannot guarantee that a building will survive a severe earthquake intact. But even in the worst case, they will give people more time to get outside safely, before the building collapses.

To strengthen foundations and floors, reinforce them with bamboo or iron rods.

To strengthen walls:

- **place windows and doors on opposite walls;**
- **place inside doors as close to the middle of interior walls as possible;**

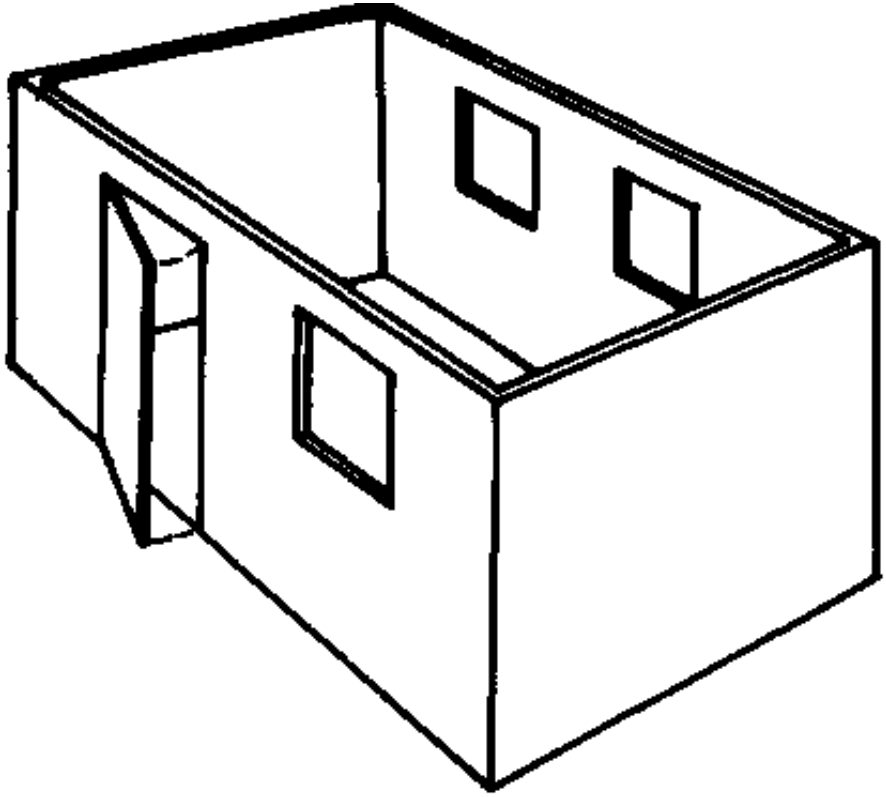
- **place timber posts at the ends of interior walls (see the section on window and door frames, page 96, for details of construction);**



Post

- **mount exterior doors so they open to the outside (this permits faster escape during a quake);**

- **allow at least 1 meter of wall space between openings and corners;**

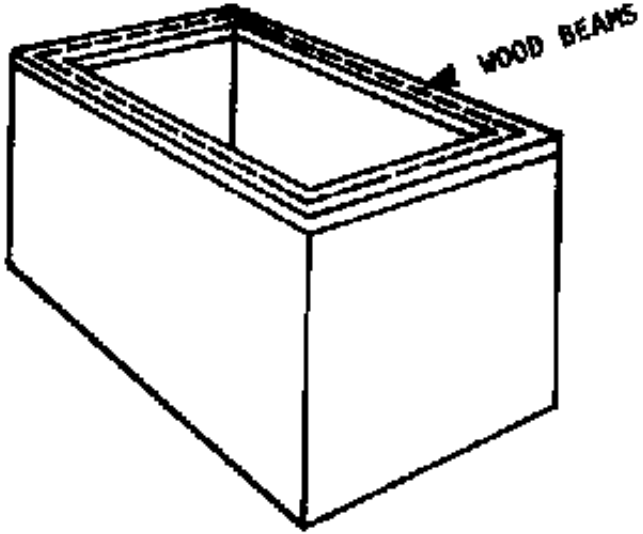


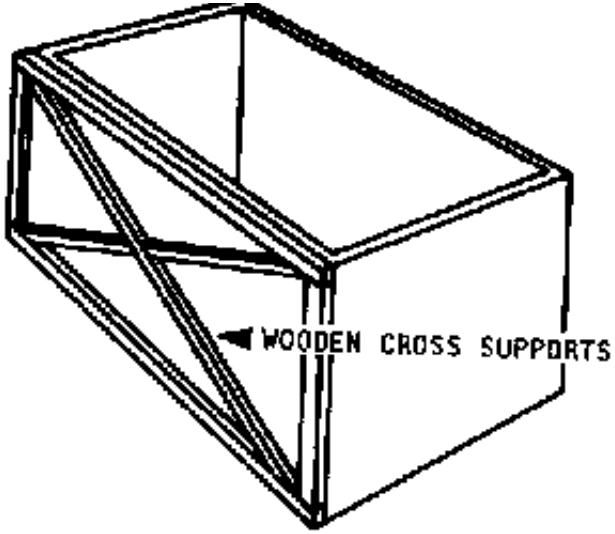
Mount exterior doors

- **connect all walls with interlocking wooden**

beams at the tops of the walls, and preferably at the floor and lintel levels too;

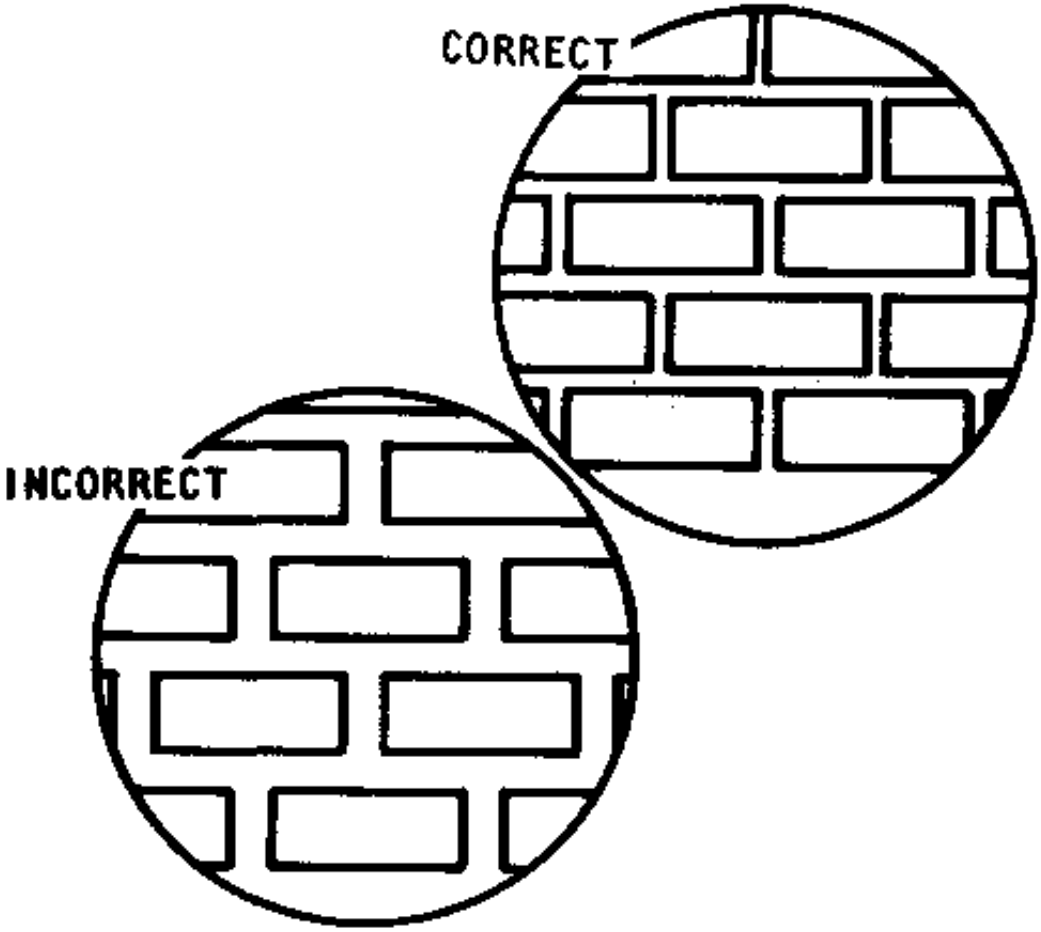
- **reinforce wooden frame walls with cross-supports;**





Wooden cross supports

- **use a 'tight" bond between brick or block courses; too much mortar will weaken the wall.**


CORRECT
INCORRECT

No use too much mortar