

A REPORT
CONCERNING THE
MAHARASHTRA
EARTHQUAKE

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OCTOBER 1993

THE DESIGNS & TECHNIQUES IN THIS
REPORT ARE HELPING RE-HOUSE PEOPLE
IN MAHARASHTRA TODAY.

IT HAS BEEN COMPILED AT THE REQUEST
OF, AND WITH THE HELP OF, OXFAM - TO
HELP THE PEOPLE OF MAHARASHTRA
MAINTAIN THEIR HERITAGE, WHILE BUILDING
HOMES, SCHOOLS & OTHER BUILDINGS TO
WITHSTAND EARTHQUAKES.

HOUSING is one of the things that is recognised by many nations as one of the **HUMAN' RIGHTS**.

'HOUSING' does **NOT** merely mean a building — but a place where a family can **LOVE** — in **PEACE, SAFETY & DIGNITY**

This also means **SECURITY** and **PRIVACY** for the family.

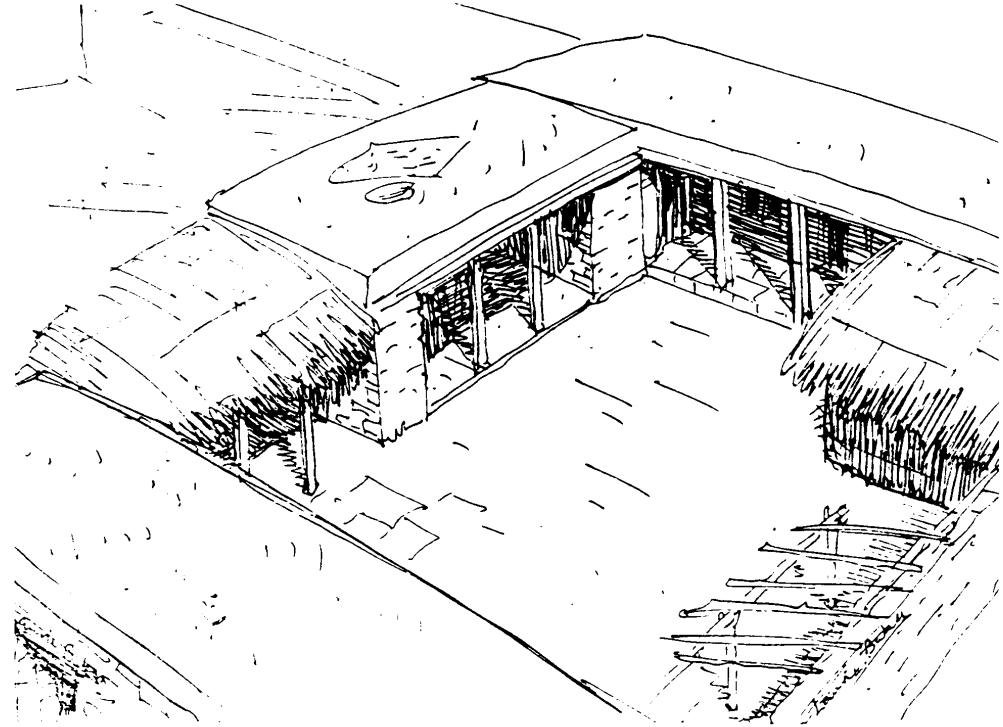
It also implies access to the means of **EARNING** a **LOVELIHOOD**, and a base from which a family and its members can **DEVELOP**.

VILLAGE HOUSING all over India shows very clearly that the family **COMPOUND** is every bit as important as the house inside it

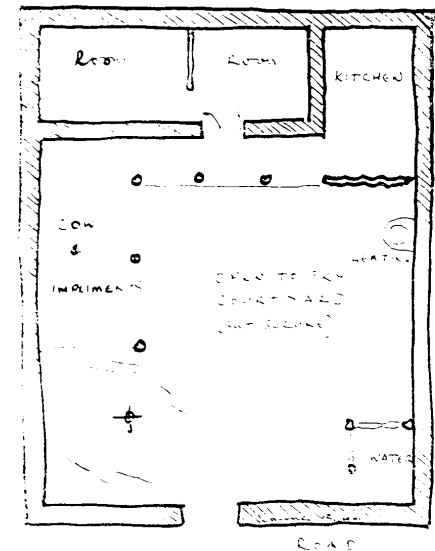
IN THE WEST A NEW FASHION IS TO DEVELOP "NEIGHBOURHOODS"—CLUSTERS OF HOUSES AROUND A NON-TRAFFIC VILLAGE GREEN. LITTLE DO PEOPLE REALISE THAT THIS IS THE ESTABLISHED INDIAN RURAL PATTERN OF "**TOWN PLANNING**".

"NEIGHBOURHOODS" ARE QUITE DIFFERENT FROM PARKS OR RECREATION GROUNDS. HERE PEOPLE CHAT, DRAW WATER, PARK THEIR BULLOCKS & BULLOCK CARTS, CHILDREN PLAY, GOATS AND HENS ARE FREE-RANGE.

SURELY THIS **LONG-STANDING**, WELL PROVEN SYSTEM OF RURAL PLANNING SHOULD NOT BE OVERLOOKED IN THE REBUILDING OF MAHARASHTRA.



OVER HUNDREDS OF YEARS A SUITABLE HOME PLAN HAS EVOLVED. THE MAIN LIVING AREA IS AN OPEN COURTYARD. IT IS ENCLOSED BY A HIGH WALL FOR PRIVACY AND SECURITY. ROOMS LIE ALONG THE PERIMETER OF THE YARD — THE COMPOUND WALL BEING THE BACK WALL OF ROOMS, VERANDAHS & WORK AREAS & CATTLE SHEDS. THERE IS NOTHING WRONG WITH THESE DESIGNS. **THEY JUST NEED TO BE BUILT TO WITHSTAND EARTHQUAKES.**



IN THIS REPORT I WILL SHOW JUST SOME OF THE SIMPLE WAYS THIS CAN BE DONE.

QUAKE ZONE BUILDINGS SHOULD BE LIGHT-WEIGHT

There are 2 main reasons for this assertion

1/ Walls give way & heavy stone or timber roofs fall & kill people.

But even a so-called 'light weight roof' (e.g. sheeting) falling from a height of 8-10 feet can cause a lot of harm.

Also in India, thin roofing causes big insulation problems. (In hot weather - unbearable!)

The real remedy is to make the roof support independent from the normal wall system. (The normal walls too must be constructed properly so that they do NOT disintegrate)

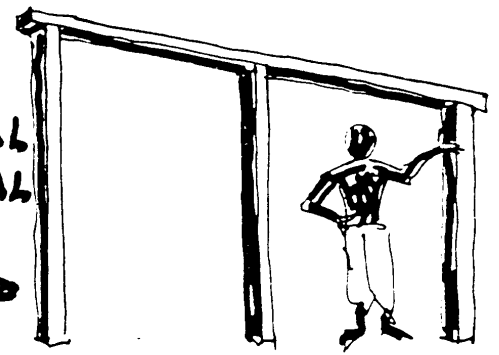
2/ The other reason given is that on sand or or black cotton soil buildings should "float" - almost like a ship on water.

In fact - the ideal earth quake proof building would be like a submarine! It can float, roll over, is designed to take great external pressure - but of course such 'Hi Tec' ideas, even if acceptable, would be phenomenal in cost!

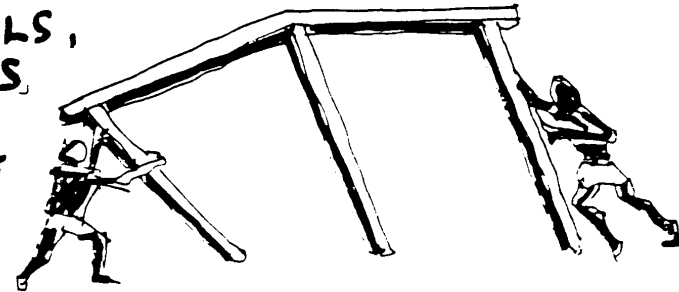
Far more important than weight is a proper, scientific use of 3-D diagonal bracing for floors, walls & roof.

Local plentifully available building material in Marathwada is not light-weight, but properly used there is nothing undesirable or wrong in its use for reconstructing villages & houses.

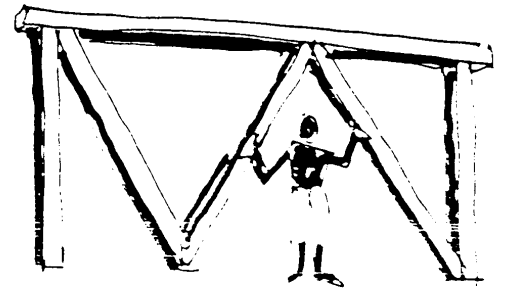
MAKE SQUARED VERTICAL POSTS & HORIZONTAL BEAMS LIKE THIS



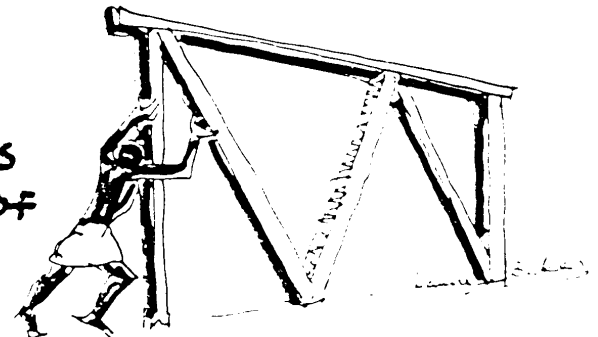
AND STRONG WINDS, ANIMALS, EARTHQUAKES, CAN KNOCK THEM "OUT OF SQUARE"



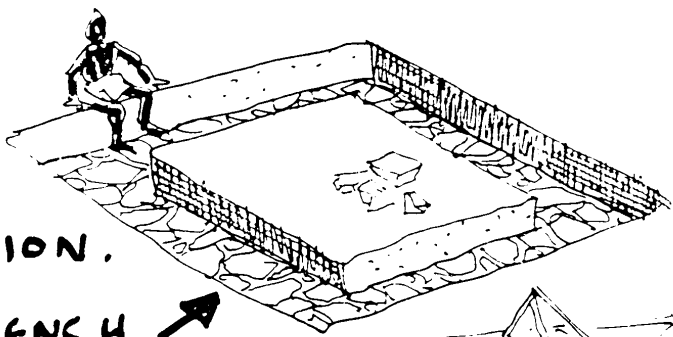
TRIANGULAR STRUCTURES LIKE THIS CAN NOT BE PUSHED "OUT OF TRUE"



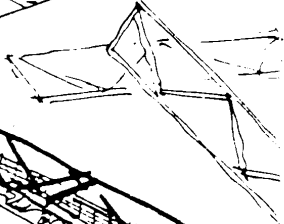
THIS IS ONE OF THE MAJOR BASIC PRINCIPLES TO BE MADE USE OF IN EARTHQUAKE ZONES



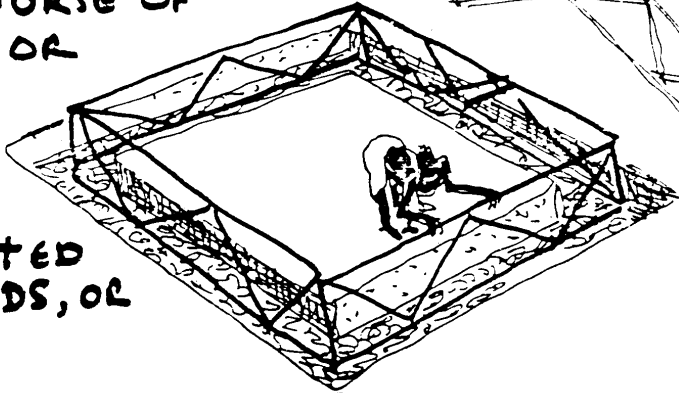
THIS IS THE
'TRIANGLE'
PRINCIPLE
APPLIED TO
A FOUNDATION.



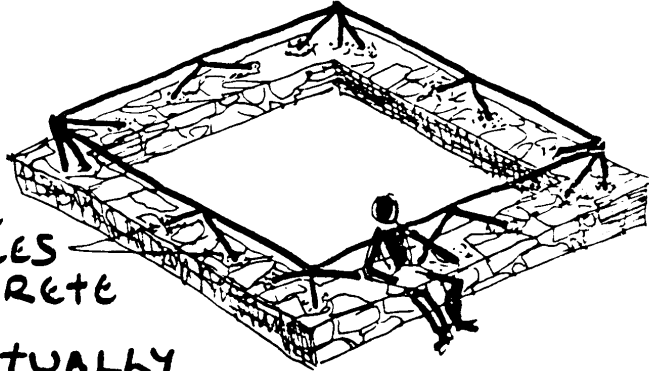
DIG THE TRENCH. →
PUT IN A COURSE OF
CONCRETE OR
STONE



PLACE A
'FENCE' OF
TRIANGULATED
STEEL (RODS, OR
PIPING)

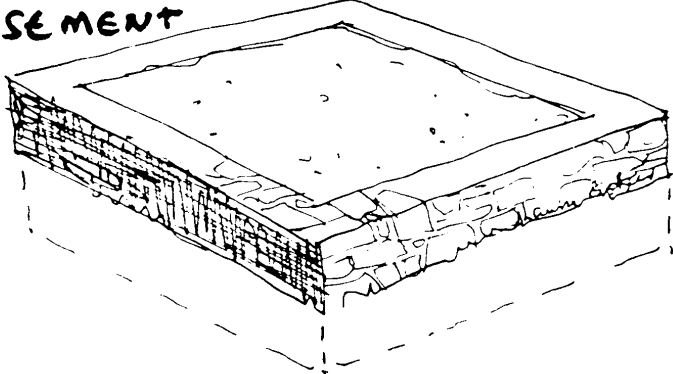


BUILD UP
THE STONE
WALL,
FILLING IN
ROUND THE
STEEL PIECES
WITH CONCRETE



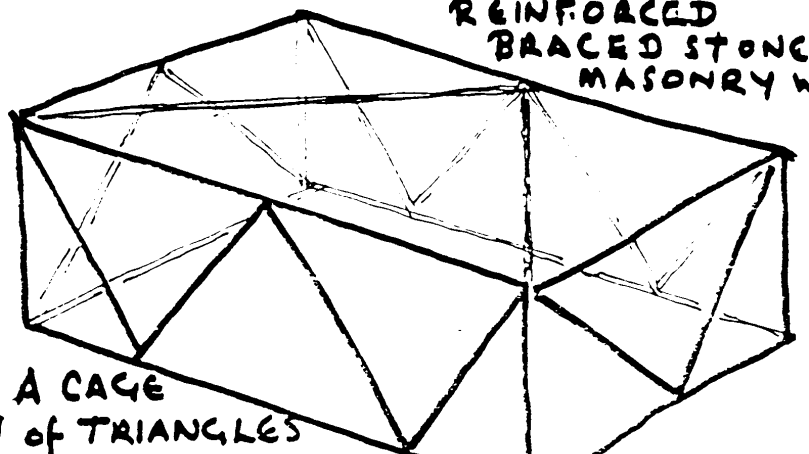
AND EVENTUALLY
YOU WILL HAVE A NORMAL
LOOKING BASEMENT

BUT
IT IS
QUAKE
PROOF



REINFORCED
BRACED STONE
MASONRY WALLS.

A CAGE
of TRIANGLES



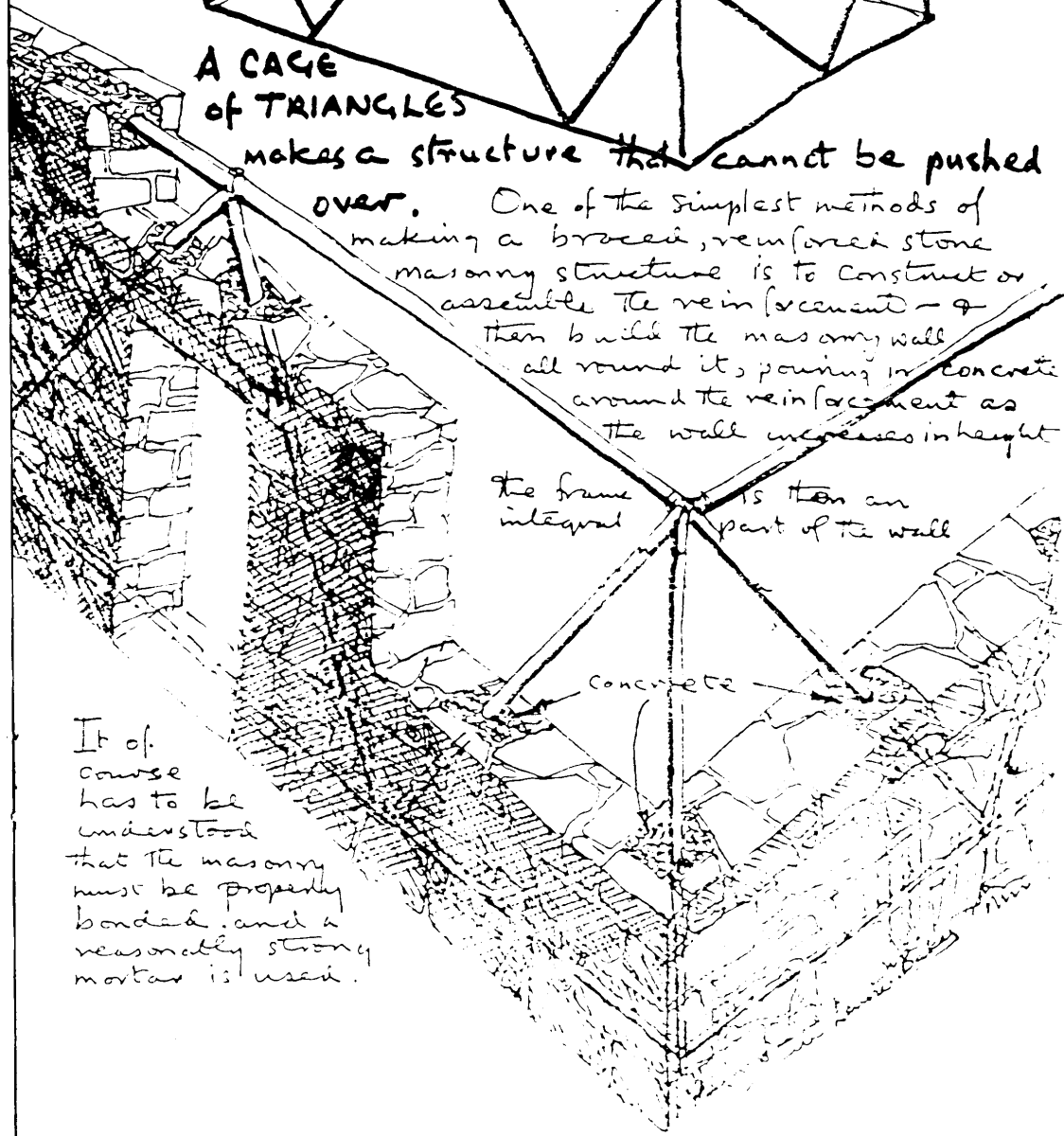
makes a structure that cannot be pushed
over.

One of the simplest methods of making a braced, reinforced stone masonry structure is to construct or assemble the reinforcement and then build the masonry wall all round it, pouring in concrete around the reinforcement as the wall increases in height.

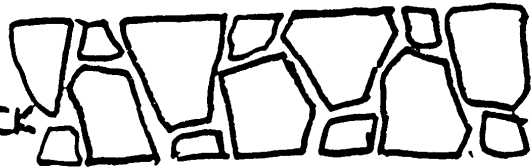
The frame is then an integral part of the wall

concrete

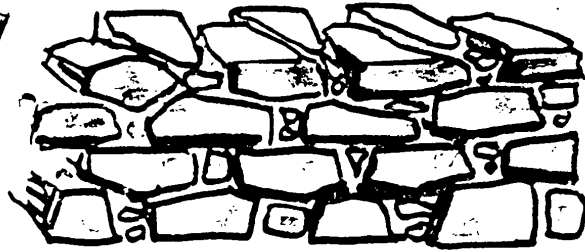
It of course has to be understood that the masonry must be properly bonded, and a reasonably strong mortar is used.



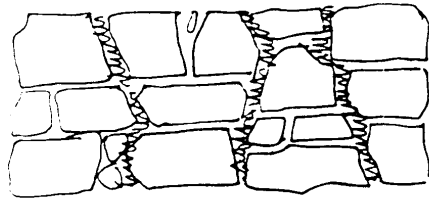
STONES
MUST INTERLOCK



LIKE THIS ✓



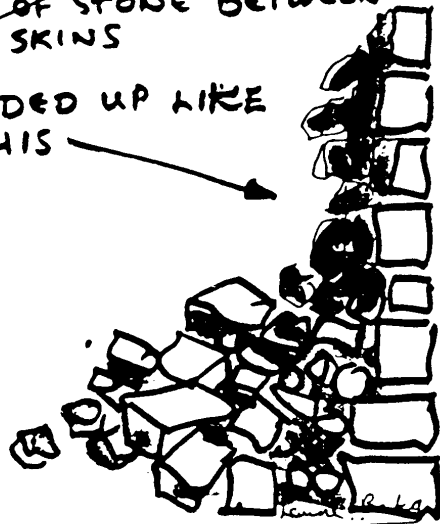
NOT LIKE THIS ✗
WHERE VERTICAL
CRACKS CAN
EASILY DEVELOP



THROUGHOUT THE AREA
WALLS THAT WERE BADLY
BUILT LIKE THIS WITH
NOTHING BUT A LOT OF
BITS OF STONE BETWEEN
2 SKINS



ENDED UP LIKE
THIS



Many of its survivors now
HATE STONE.

Stones killed parents and
friends: Stone killed their
children.

They naturally revolted at
the thought of reusing
good building stone to
rebuild their new homes.

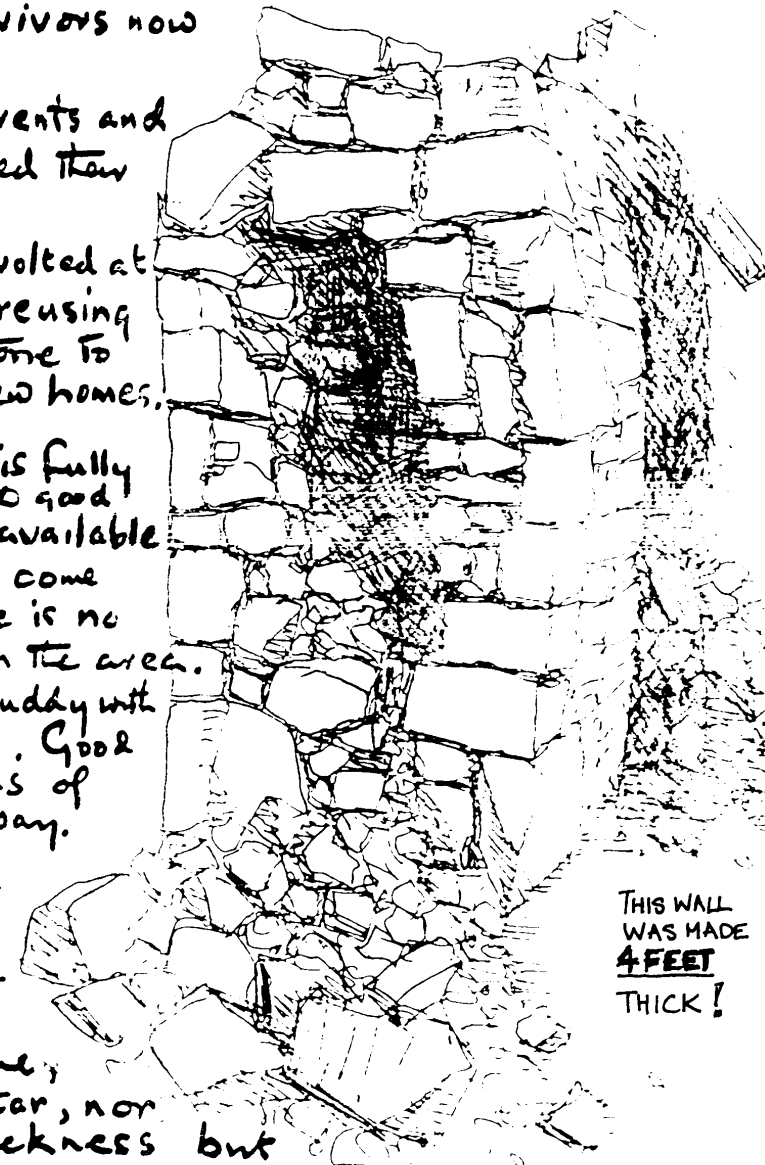
This revulsion is fully
understood. But good
bricks are not available.
Steel & cement come
from afar. There is no
proper sand in the area.

River sand is muddy with
black cotton soil. Good
sand is hundreds of
kilometers away.

People MUST be
shown that
collapse of stone
walls was not
because of the
quality of stone,
nor poor mortar, nor
adequate thickness but

ENTIRELY DUE TO TOTAL ABSENCE OF THE ART
AND PRINCIPLES OF BONDING.

STONE KILLED - BUT ONLY
BECAUSE IT WAS IMPROPERLY USED.



THIS WALL
WAS MADE
4 FEET
THICK!

ENCLOSING the compound is an Essential.

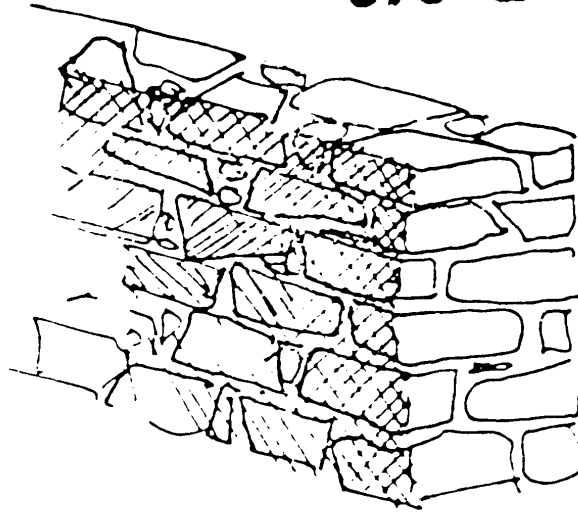
It may be by a hedge, a live fence, fencing, palings, wire, etc. Some of these may provide safety, but not privacy.

In these villages the ideal enclosure has been a solid wall, built from LOCALLY AVAILABLE material — STONE in one area and LATERITE in another.

Unfortunately it has often been built by the occupants themselves, without their knowing the required principles of stone masonry construction. Without BONDING (see elsewhere) many of these walls fell down in the earthquake.

There are simple methods of building these walls so that they will NOT fall down, & slightly more complex methods making use of reinforcement.

PROPER BONDING OF STONE IS LIKE THIS



IF IT IS PROPERLY DONE IT CAN EVEN BE A "DRY WALL" BUT USUALLY MORTAR IS USED

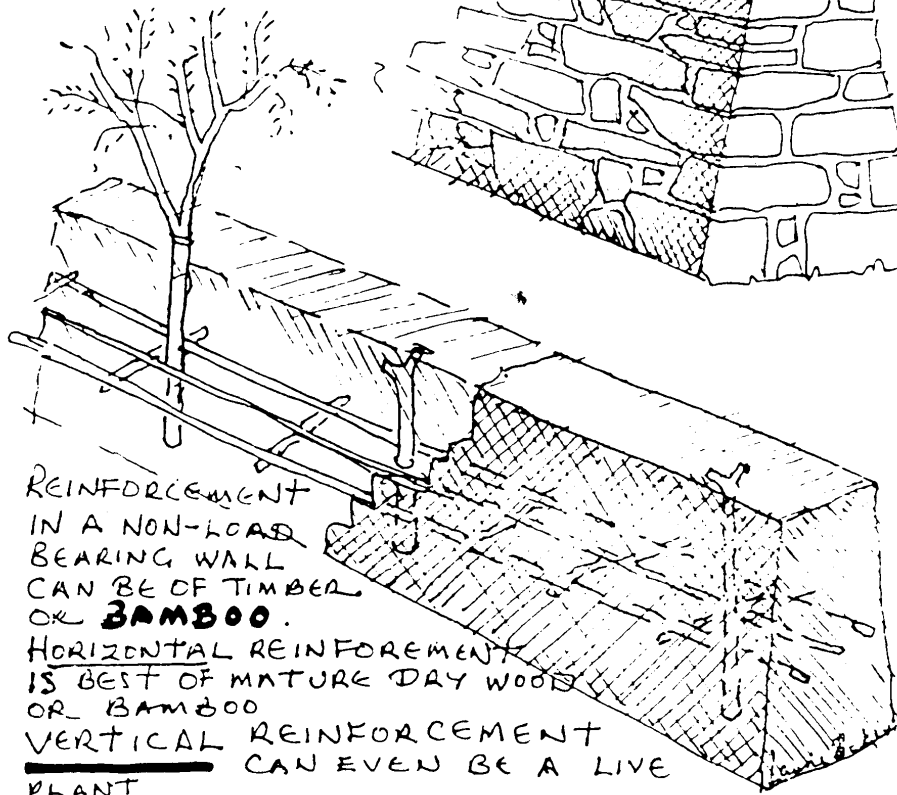
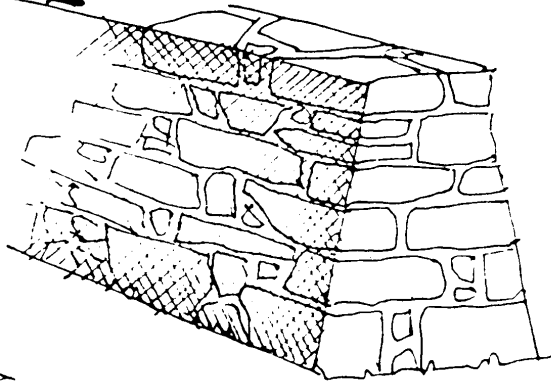
(BUT FOR STABILITY ONE MUST NOT RELY ON MORTAR)

BONDING IS LIKE THE CLASPING OF HANDS



A 'BATTERED' WALL

IS LESS LIKELY TO
FALL DOWN —
BUT BONDING IS STILL
NECESSARY.



REINFORCEMENT
IN A NON-LOAD
BEARING WALL
CAN BE OF TIMBER
OR **BAMBOO**.

HORIZONTAL REINFORCEMENT
IS BEST OF MATURE DRY WOOD
OR BAMBOO

VERTICAL REINFORCEMENT
 CAN EVEN BE A LIVE
PLANT

STEEL IS NOT THE ONLY FORM OF REINFORCEMENT.

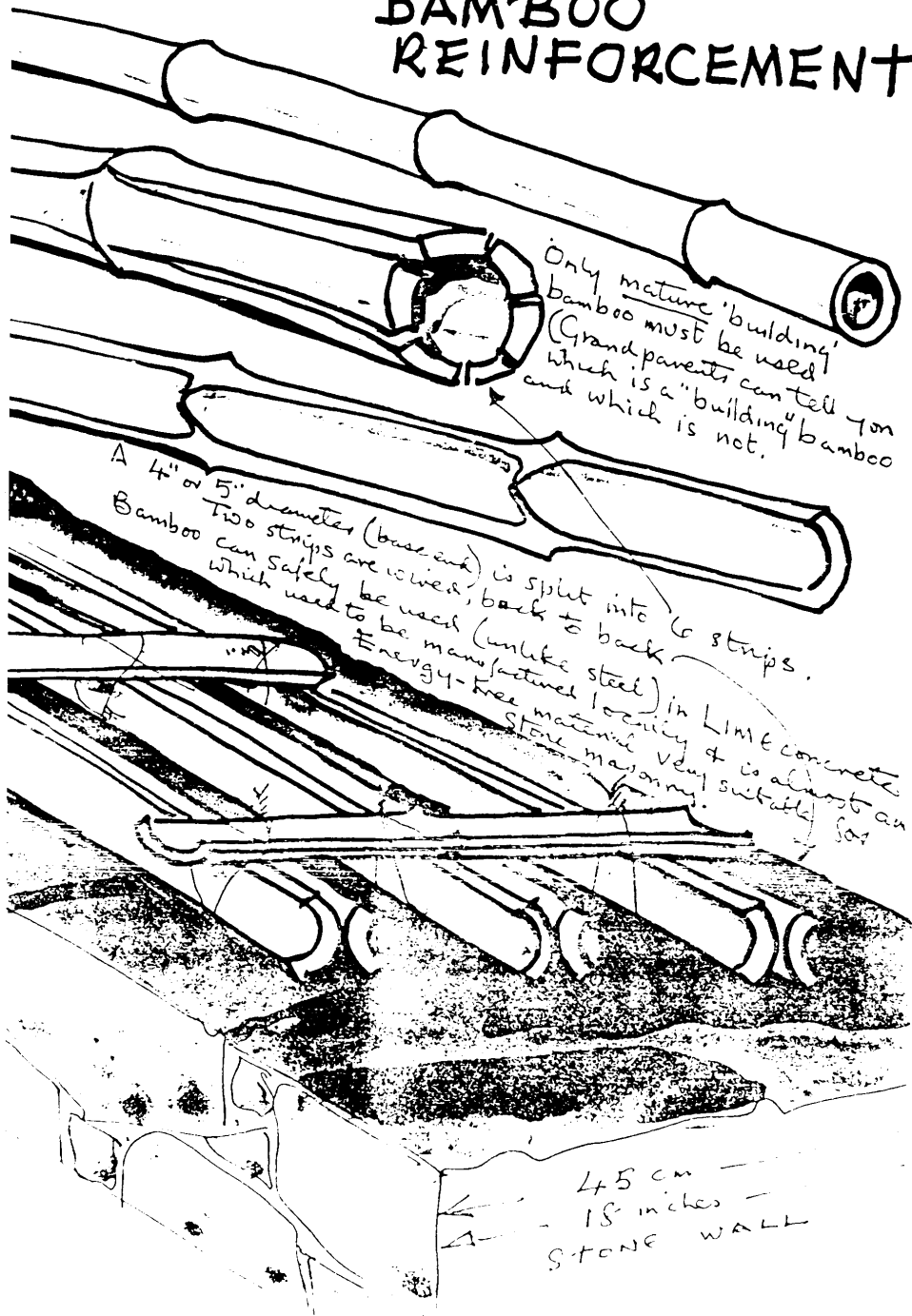


BAMBOO

A mature 'building' bamboo can be split lengthwise & used for reinforcement (its tensile strength is similar to that of some steels!). India's North East States continue to build extensively with bamboo because they are earthquake zones & bamboo remains when reinforced concrete falls.

There is extensive research & experience of the use of bamboo reinforcement in reinforced concrete.

BAMBOO REINFORCEMENT.



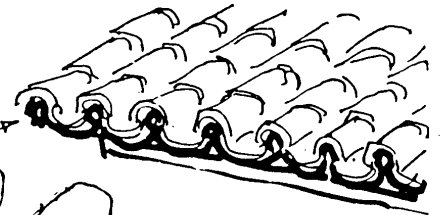
Only mature 'building' bamboo must be used (Grandparents can tell you which is a "building" bamboo and which is not.)

A 4" or 5" diameter (base end) is split into 6 strips. Two strips are used back to back (unlike steel) in lime concrete. Bamboo can safely be used (unlike steel) in lime concrete which used to be manufactured using stone masonry suitable for Energy-free material. Lime concrete is almost an Energy-free material.

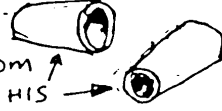
45 cm -
18 inches -
STONE WALL

LIGHT WEIGHT, GOOD INSULATION, 'POT' ROOFING

The potter who makes your country pantile can make you slightly conical, open at top & bottom tile 'pots' like this

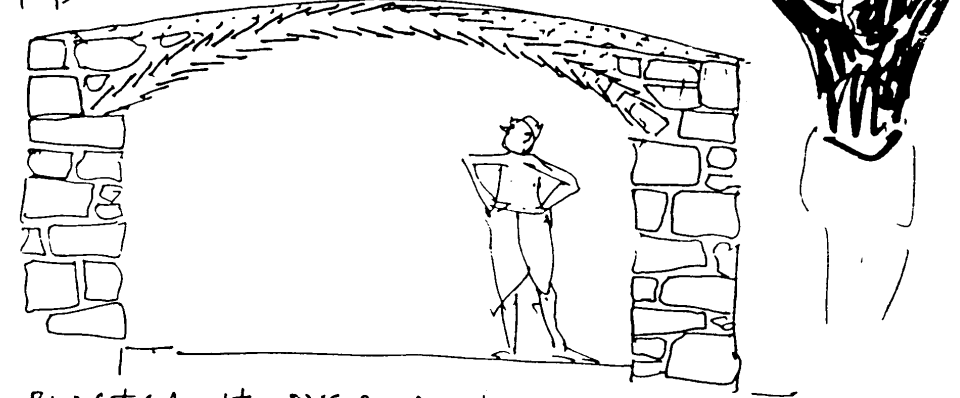
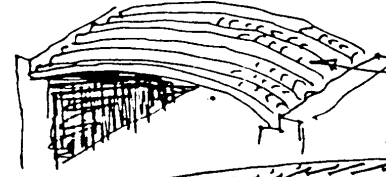


You can nest them together until you have a long row of them, up to ten feet long (or more)



Like this and you will see that they gently curve like an arch

Put rows of them side by side and you have a light weight roof



Plaster it over & it is waterproof. If your stone (or laterite) (or brick) wall has been built correctly, it, the pots, will not come down in an earthquake.

(Even if they do - they will not hurt you like the stone, or concrete, or heavy timber roof does.)