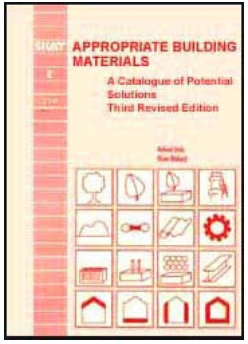
Home"" """"> ar.cn.de.en.es.fr.id.it.ph.po.ru.sw



Appropriate Building Materials: a Catalogue of Potential Solutions (SKAT, 1988, 430 p.)

Examples of wall materials

Stone masonry blocks walls

KEYWORDS:

Special properties	Improvement of random rubble masonry
Economical aspects	Medium to high costs
Stability	Very good

Stability	Very good
Skills required	Masonry skills
Equipment required	Steel formwork, plate vibrator, masonry tools
Resistance to earthquake	Medium to good
Resistance to hurricane	Very good
Resistance to rain	Very good
Resistance to insects	Very good
Climatic suitability	All climates
Stage of experience	Increasing use on the Indian Sub-continent

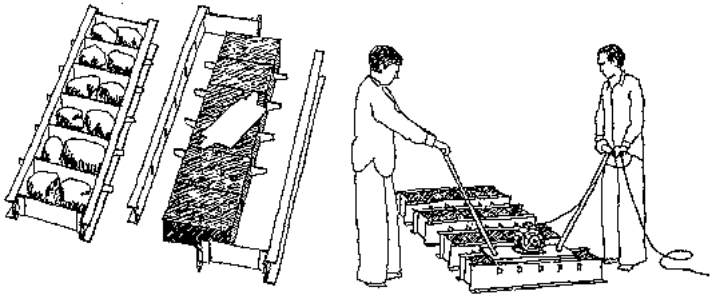
SHORT DESCRIPTION:

- **The drawbacks of random rubble masonry, common in many hilly areas, are the excessive use of stones, mortar and labour, also its non-uniformity and the risk of water penetration. By precasting the stones into uniform concrete blocks these drawbacks are eliminated.**

- **The technique, developed in India, basically involves steel moulds, a plate vibrator and trowels. A concrete casting platform and the inner surfaces of 4 or 5 battery moulds are oiled. The moulds are arranged side by side on the platform. Into each mould 2 or 3 stones are placed, with the flattest side of each stone resting on the casting platform. Gaps between stones or between stones and mould should be at least 15 mm.**

- **A concrete mix of 1: 5: 8 (1 cement: 5 sand: 8 graded course aggregate of 10 mm and less) is filled into the moulds, compacted with the plate vibrator, and finished with a trowel. The blocks are demoulded 5 to 10 minutes later (depending on the climatic conditions), water cured for two weeks and kept dry for another two weeks.**

- **The bottom face with the exposed stone texture forms the external face during construction. The blocks, typically 29 x 19 x 14 cm (l x b x h), are used in conventional masonry construction, permitting single brick thick walls (20 cm) for 3-storeyed buildings. Special blocks with recesses for reinforcement can be used, thus also achieving earthquake resistance Further information: Bibl. 22.01.**



Filling the moulds; Demoulding; Compacting the blocks with a plate vibrator

The precast stone elements consume slightly more cement in the production and laying of the blocks, than random rubble masonry, but waterproofing is achieved without or with far less plastering. Thinner load-bearing walls are possible and the construction time is greatly reduced. Even earthquake resistance can be achieved, which must be rated higher than the costs of construction.

Rammed earth walls

KEYWORDS:

Special properties	Good impact resistance and durability
Economical aspects	Low cost
Stability	Good

Stability	Good
Skills required	Experience in earth construction
Equipment required	Formwork, rammer
Resistance to earthquake	Low to medium
Resistance to hurricane	Good
Resistance to rain	Medium
Resistance to insects	Medium
Climatic suitability	Hot dry climates, upland climates
Stage of experience	Traditional

SHORT DESCRIPTION:

- **This method of construction has been used for centuries in various parts of the world and is commonly known by its French name "Pise".**

- **Earth is filled into formwork in layers of up to 10 cm and thoroughly compacted to a thickness of 6 - 7 cm with a ramming tool. When the formwork is full, it is dismantled and moved (usually horizontally) to the next position, fixing it firmly over a previously completed row. In this way the building goes up gradually, layer by layer, row by row.**

- **Other than patching up cracks, holes and damaged edges immediately after removing the formwork, no surface treatment is normally required.**

- **To a large extent, the choice of formwork and ramming device influences the speed, cost and quality of construction, so that experience and/or several trials with alternative equipment is necessary. As far as possible, the use of stabitizing agents (eg cement, time, etc.) should be avoided, as they complicate the whole procedure. However, this is only possible with optimum soil qualities and good building design.**

• Rammed earth is a natural material, constructed with only a small fraction of the energy input required for other materials to produce structures of similar strength and durability. It also causes no wastage or pollution, and when demolished, soils that contain no stabilizer can be reused over again. Further information: Bibl. 02.06, 02.19, 02.28, 02.32.

Soil

• The most appropriate soil for rammed earth construction contains: 50 to 75 % fine gravel and sand; 15 to 30 % silt (pulverized sand) and 10 to 20 % clay (cohesive particles).

Formwork

• The formwork must be more rigid than standard concrete shuttering, because of the high outward pressure of compacted earth;

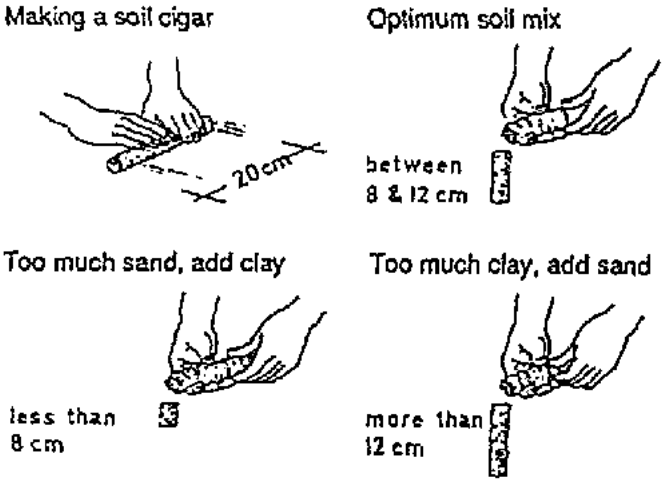
• it must be light and easy to dismantle and assemble, so that the work does not become too tiring and time-consuming;

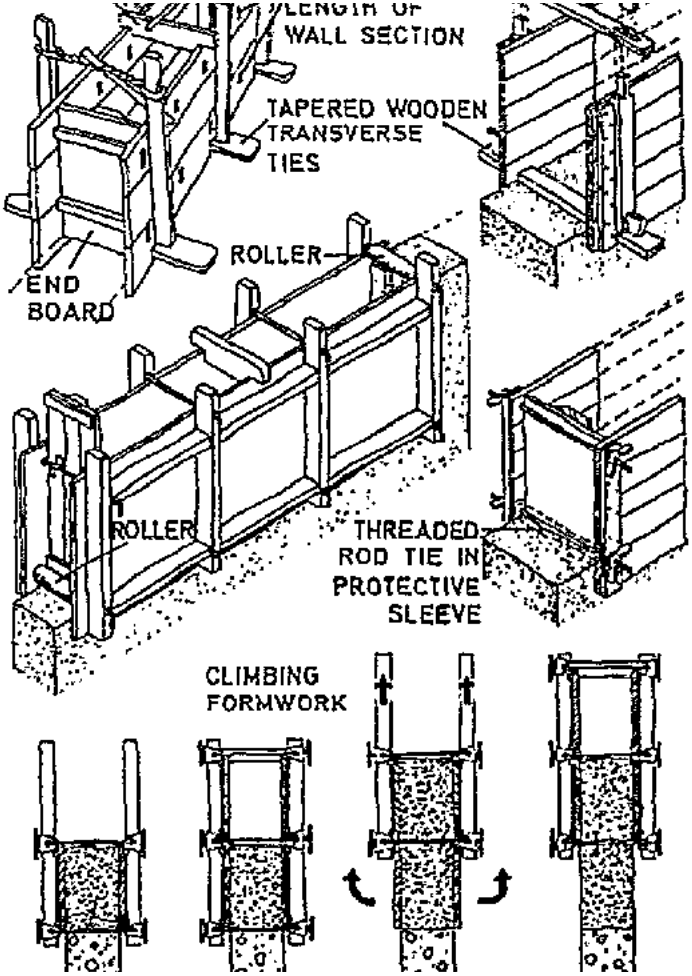
• it should be the largest size that can be reasonably handled, in order to reduce the number of moves;

• and it should permit the wall thickness to be varied.

• Different types of formwork are illustrated. The formwork is normally moved horizontally after each section is completed. In order to avoid the horizontal cracks that tend to develop between successive rows of rammed earth (since each row dries out separately), a climbing formwork was developed at the Kassel College of Technology, Federal Republic of Germany (Bibl. 02.28, Vol. 2).

- **The length of formwork can range between 150 and 300 cm, the height between 50 and 100 cm. As the ratio of wall thickness to wall height should be between 1: 8 and 1: 12 (the latter requiring good quality control), rammed earth walls can be as thin as 30cm. However, foreman to stand between the two sides of the form to compact the soil, a minimum of 40 cm is recommended.**




WALL SECTION
TAPERED WOODEN TRANSVERSE TIES
ROLLER
END BOARD
ROLLER
THREADED ROD TIE IN PROTECTIVE SLEEVE
CLIMBING FORMWORK

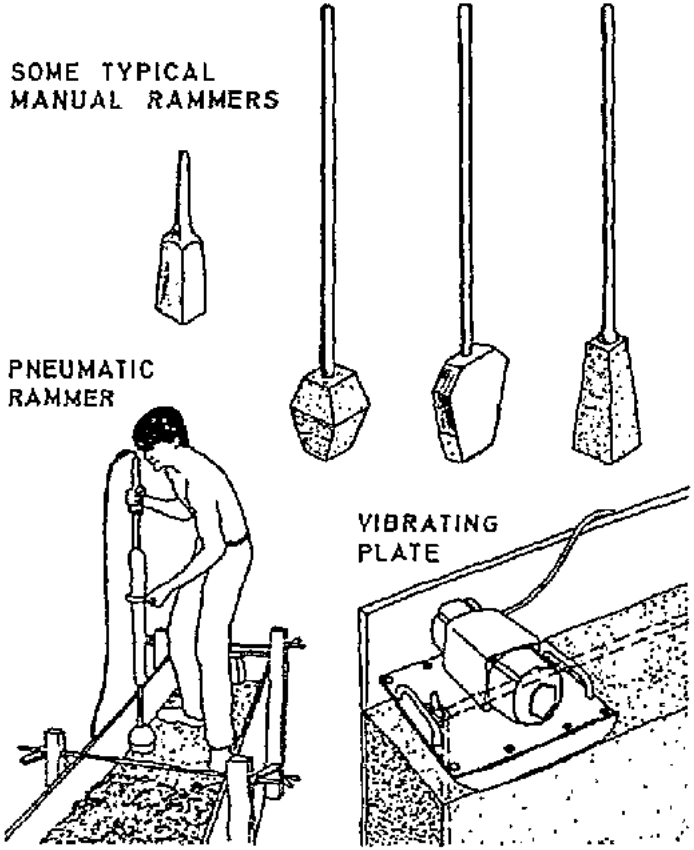
Test to determine optimum sand and clay content

Rammers

- **Manual rammers consist of a wooden or steel rod with a heavy wooden or metal striking head. The heavier it is, the better the compaction, but the more tiring for the user.**

- **Pneumatic rammers imitate the manual rammers, but achieve much higher impact frequencies, thus reducing construction time. The main drawback is their high cost.**

- **An alternative is a small vibrating plate, developed at the Kassel College of Technology. An electric motor with an eccentric rotating mass transmits vibrations to the plate, thus causing the machine to move. An automatic switch makes it move back and forth in the formwork, without manual guidance.**



FIGURE

Construction

- **A stone, burnt brick or concrete foundation and base course (at least 30 cm above ground level and exactly as wide as the earth wall) are required to start with. The top surface must be horizontal (requiring steps on sloping sites) and should never project beyond the external face of the Barth wall. A damp proof course between the footing and wall is recommended in moist environments.**

- **The sides of the formwork should overlap the wall section below by at least 10 cm to stand firmly. The work should always begin at a corner.**

- **The soil is filled in the formwork in layers of not more than 10 cm. The person who rams the soil stands on it or on the top edges of the formwork, and strikes the soil systematically, first along the sides and then in the centre. The operation is completed, when the sound of each stroke of the rammer changes from a dull to a solid clear sound. Once the formwork is moved to the next section, the previous section should be covered with an appropriate material (grass, leaves, cloth, plastic sheets) for protection against rain, wind or direct sunshine.**

- **Care must be taken to stagger the joints between each row (just as in masonry work) and wall junctions should be made to interlock connecting walls. Wall anchors and reinforcements (eg at corners) made of metal scrips or rods, strong twigs, split bamboo or rope, can be placed in these junctions and building corners during compaction.**

Openings

- **These should be well planned so that their sides correspond to the ends of formwork sections, their height is in line with the top of the last layer, and the ring beam substitutes the lintel. It is also possible to insert the window and door frames within the formwork and attach anchors, so that the frames are rigidly fixed to the wall. Small openings can also be easily cut into the finished wall by means of a pise saw (a length of barbed wire with handles at each end) used by two men.**

Surface Treatment

It is important for the durability of the wall that broken edges, cracks and holes are filled and compacted, immediately after removing the formwork, as the patching material does not bond with partially dried up walls.

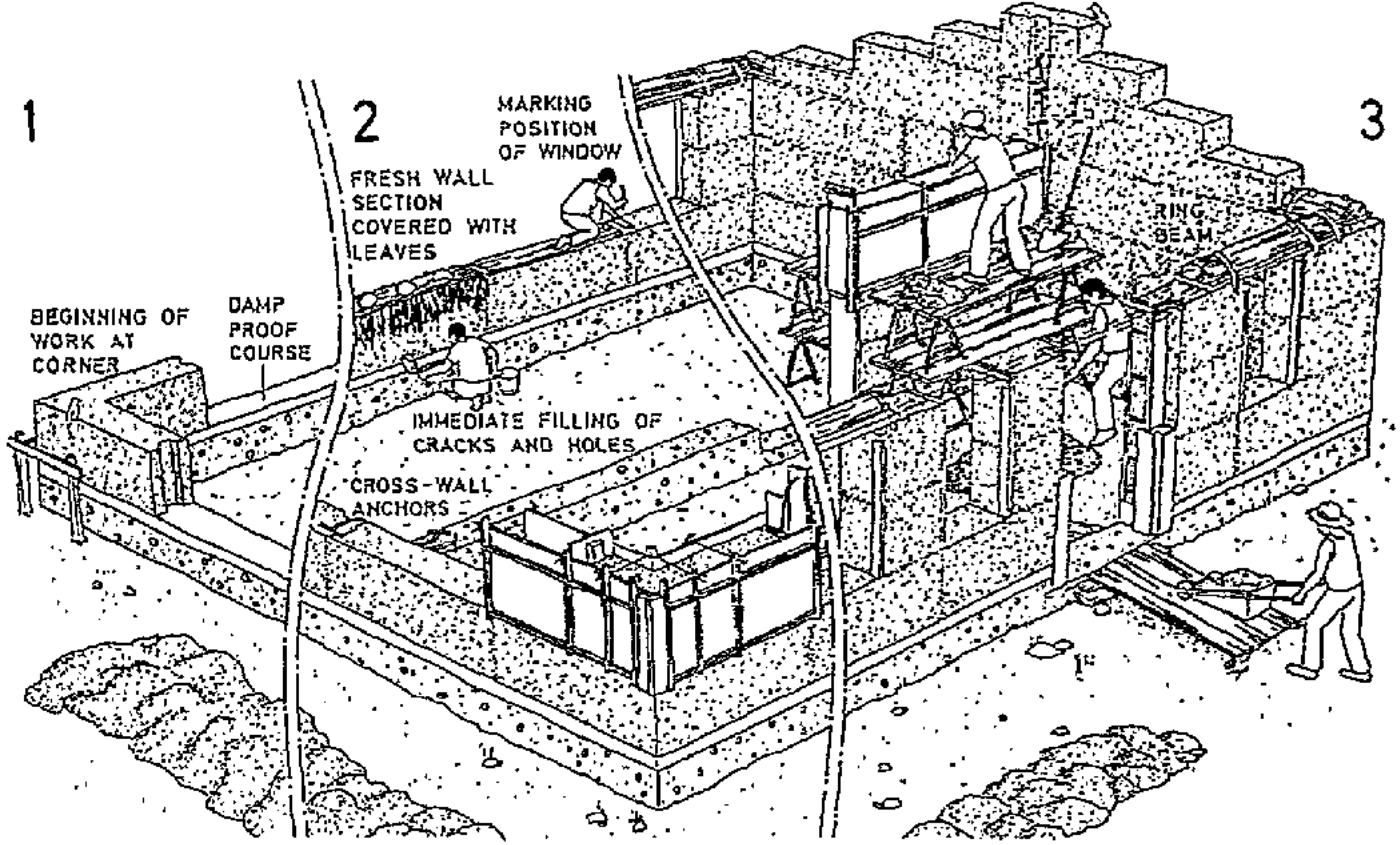
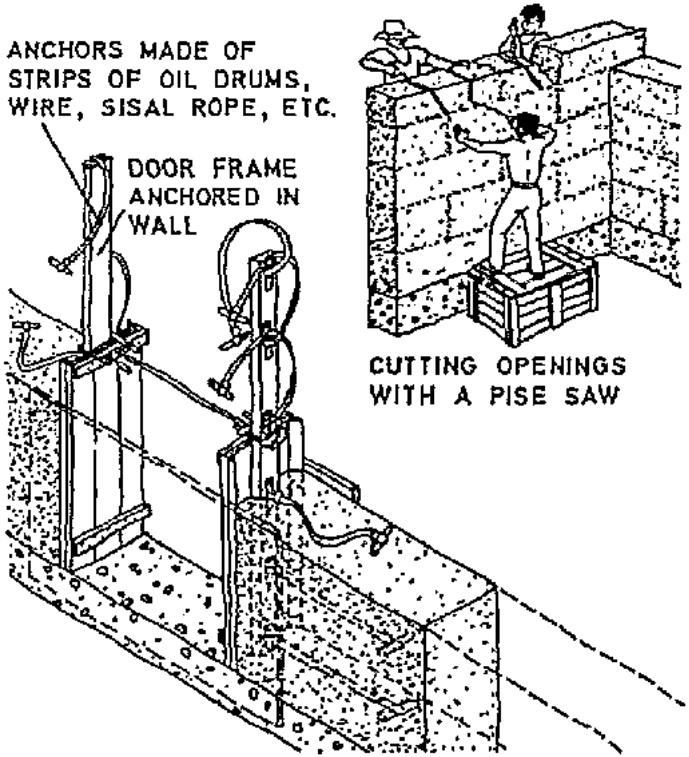


Illustration adapted from Vorhauer, 1979 (Bibl. 22.09)



FIGURE

Compressed soil blocks walls

KEYWORDS:

Special properties	Comparable to burnt clay brick walls

Special properties	Comparable to burnt clay brick walls
Economical aspects	Low cost
Stability	Good
Skills required	Semi-skilled workers
Equipment required	Manual block press
Resistance to earthquake	Good
Resistance to hurricane	Good
Resistance to rain	Medium, depends on stabilization
Resistance to insects	Medium
Climatic suitability	All except very wet climates
Stage of experience	Widely used in many countries

SHORT DESCRIPTION:

- **A suitable soil, with a good grain size distribution and a clay content of 10 to 25 %, can be compacted in a slightly moistened state to produce strong, dimensionally stable blocks.**

- **In order to increase their durability, a binder and/or waterproofing agent is added to the soil. Common binders are cement, lime and bitumen, and their proportions vary according to the quality of soil (see Earth, Soil, Laterite and Soil Stabilizers).**

- **The advantages of building with stabilized soil blocks compared with most other soil construction techniques are:**

- **higher compressive strength and greater water resistance;**

- **ability to carry away by hand immediately after production;**

- **small drying and storage space requirement, as the block can be stacked immediately or on the day after production;**

- **easy transportation of dried blocks with low breakage rate;**

- **possibility of building walls with a higher height to thickness ratio;**

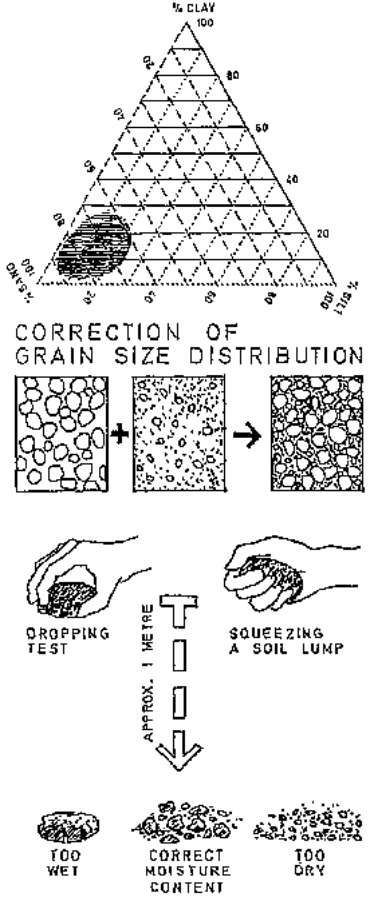
- **savings in cost, material and energy, as no external rendering is needed on well stabilized compressed blocks;**

- **lower cost of production and energy input than for equivalent volume of burnt clay bricks or concrete blocks, which are alternatives to stabilized compressed soil blocks.**

Soil Selection

- **The most appropriate soils for stabilized block production have sand contents of about 75 %, and minimum clay content of 10 %. The shaded area in the chart gives the impression that very few soil types fall within this group, but in reality their availability is almost universal. It is excavated after removing 10 - 15 cm of the topsoil in order to exclude organic matter.**

- **To achieve satisfactory results, however, a series of field tests are essential. Wherever laboratory facilities are available, they should be made use of, as field tests are not sufficiently accurate.**


% CLAY
100
80
60
40
20
% SAND
% SILT
CORRECTION OF
GRAIN SIZE DISTRIBUTION
DROPPING
TEST
SQUEEZING
A SOIL LUMP
APPROX. 1 METRE
TOO
WET
CORRECT
MOISTURE
CONTENT
TOO
DRY

FIGURE

Soil Preparation

- **Soils are rarely found in the state required for block production. In most cases, they need to be ground and screened through a 5 mm wire mesh.**

- **Mixing should take place close to the block mould and all additives thoroughly blended in the dry state. Unlike mixing concrete, the predetermined quantity of water must be sprinkled for even distribution.**

- **Each mix must be checked by squeezing a lump in one hand and allowing it to drop on a hard surface from about 1 metre height. If the lump remains together, it is too moist; if it disintegrates completely, it is too dry. The correct moisture content will not moisten the hand, but will make a firm lump which breaks apart into several smaller pieces when dropped. When using cement as the binder, only so much material should be prepared, as can be used up in about 20 minutes.**

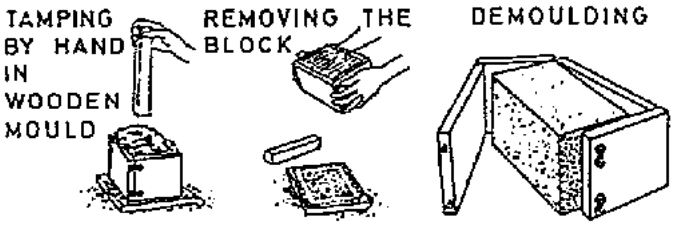
Making the Blocks

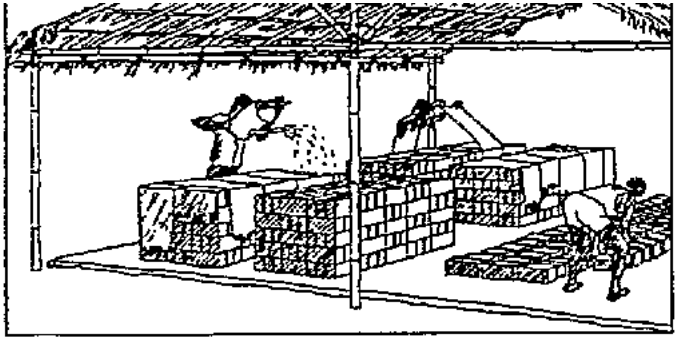
- **Compaction of the soil mix in a mould can be done dynamically (ie sudden impact by tamping) or statically (ie gradual compression). Static pressure is obtained by blockmaking machines, which has become the most common method.**

- **The simplest, but slowest and most tiring method of block production is by tamping the soil in a mould (usually with hinged or detachable parts).**

- **More efficiently, a block press is used, in which the soil mix is compressed to 60 %, or even 50 %, of its original volume. The machines are either manually operated or motorized, but the procedure always involves filling the mould(s), compacting the soil (sometimes after pre-compaction), demoulding the block and removal to the drying area (see ANNEX: Machines and Equipment). On average, a team of 3 people is generally**

needed to operate the machine and remove the blocks. They must be assisted by a team of 4 - 6 workers, who excavate and prepare the soil at the same pace as the blocks are produced.





FIGURE

Drying and Curing

- **Unlike traditional unstabilized, hand-moulded mud blocks, which have to be left to dry where they are made, compressed soil blocks are carried to a shaded curing area. Weakly compacted blocks are laid in rows on the ground and stacked a day later, while denser blocks can be stacked up to 5 layers immediately.**

- **If bitumen stabilizer is used, drying can be completed within 5 days, whereas cement requires about 15 days and lime 25 days. With both cement and lime, the blocks must be kept moist for the first 5 days by daily sprinkling.**

LOK BRIK System (Bibl. 22.04)

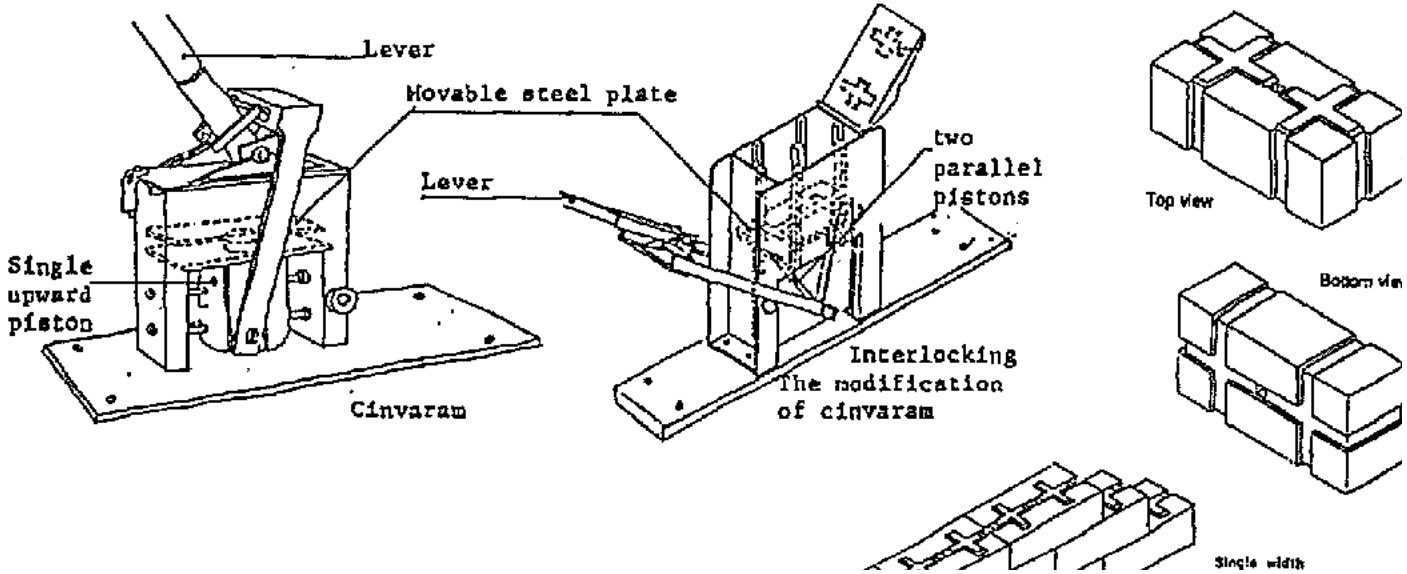
- **This system, developed by Dr. A. Bruce Etherington of AIT, Bangkok, is a variation of standard compressed soil block constructions, by which the walls can be built with great accuracy and speed, even with unskilled labour.**

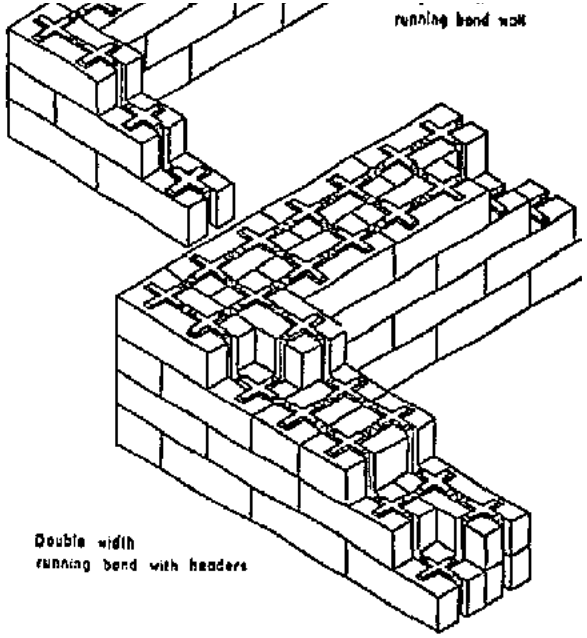
- **The interlocking soil-cement bricks are made in a modified CINVA-Ram brickmaking**

machine (see ANNEX), which has two parallel upward thrust pistons (to ensure more accurate dimensions of the finished block) and a system of positive and negative frogs (to form recesses or protruding parts).

- **No mortar is needed for laying the bricks, but vertical holes are provided, into which grout (thin fluid mortar) is poured. Vertical steel reinforcement can also be inserted wherever necessary, making the construction earthquake resistant.**

- **Apart from costs saved in material and labour, the uniformity and accuracy of construction gives it an appealing finish, so that no rendering is needed and further costs are saved.**





FIGURE

Bamboo reinforced earth walls

KEYWORDS:

Special properties	High earthquake resistance
Economical aspects	Low cost
Stability	Good
Skills required	Traditional earth construction skills

Equipment required	Bamboo cutting tools, formwork, tamper
Resistance to earthquake	Good
Resistance to hurricane	Good
Resistance to rain	Low
Resistance to insects	Low
Climatic suitability	All except very humid climates
Stage of experience	Experimental and traditional techniques

SHORT DESCRIPTION:

• Rammed earth walls generally have low earthquake resistance, but with bamboo reinforcements this problem can be overcome.

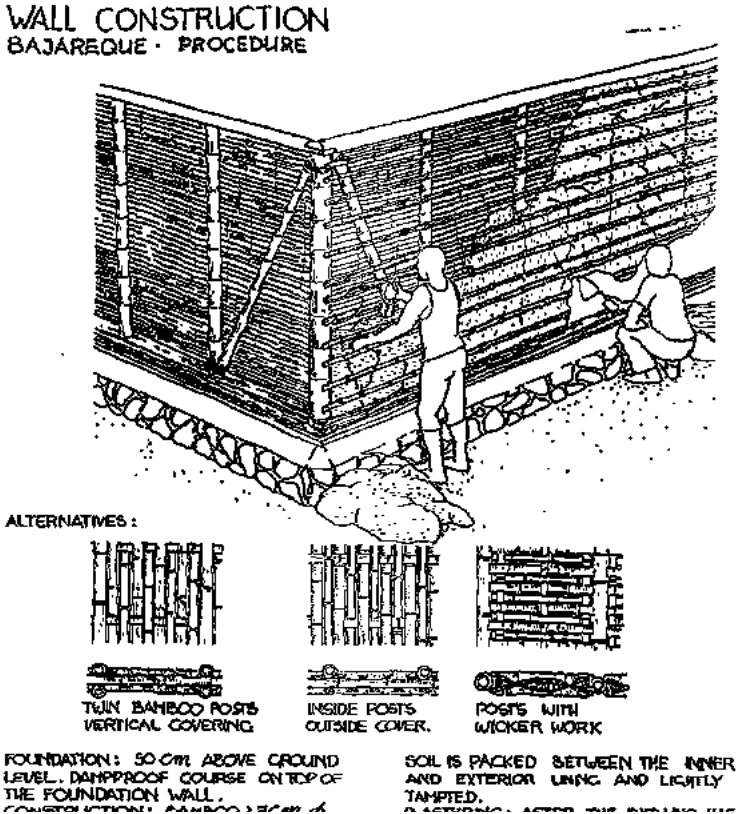
• The examples on the following pages (taken from Bibl. 22.09) show traditional methods, generally known as wattle and daub (or "bajareque" in Latinamerica), and an innovative construction developed by Prof. Gernot Minke of Kassel College of Technology (Federal Republic of Germany) and implemented in a village in Guatemala (in cooperation with the University Francisco Marroquin and CEMAT, Guatemala).

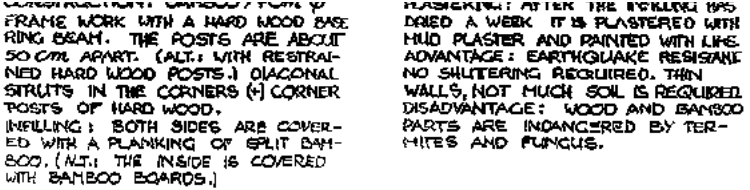
• The traditional examples can also be built with low quality timbers, but bamboo provides straight components (for uniform constructions) and higher tensile strengths.

• The example from Guatemala combines the advantages of rammed earth construction (high density walls) and tensile strength of bamboo. The walls comprise a number of independent vertical sections, which are held together at the top by a bamboo ring beam. During an earthquake each section can respond to seismic forces individually, thus avoiding differential stresses within the whole wall, which can subsequently collapse. The

roof rests on timber supports which are structurally separated from the walls, so that any wall movements will not cause to roof to collapse.

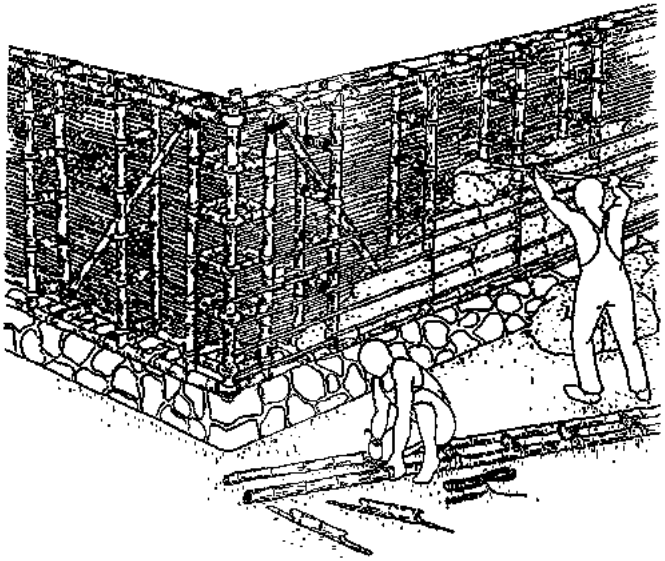
- **Treatment of the bamboo is essential to avoid biological destruction.**




CONSTRUCTION: CANOSO FORM OF
FRAME WORK WITH A HARD WOOD BASE
RING BEAM. THE POSTS ARE ABOUT
50 cm APART. (ALT.: WITH RESTRAI-
NED HARD WOOD POSTS.) DIAGONAL
STRUTS IN THE CORNERS (+) CORNER
POSTS OF HARD WOOD.
INFILLING: BOTH SIDES ARE COVER-
ED WITH A PLANKING OF SPLIT BAM-
BOO. (ALT.: THE INSIDE IS COVERED
WITH BAMBOO BOARDS.)
PLASTERING: AFTER THE WORKED HAS
DRIED A WEEK IT IS PLASTERED WITH
MUD PLASTER AND PAINTED WITH LIME.
ADVANTAGE: EARTHQUAKE RESISTANT
NO SHUTTERING REQUIRED. THIN
WALLS, NOT MUCH SOIL IS REQUIRED.
DISADVANTAGE: WOOD AND BAMBOO
PARTS ARE ENDANGERED BY TER-
MITES AND FUNGUS.

FIGURE

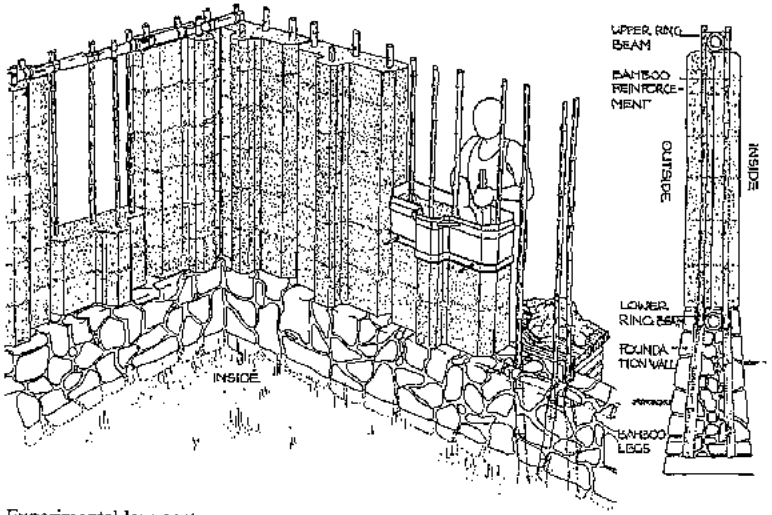
WALL CONSTRUCTION
LADDER BAJAREQUE - PROCEDURE



FOUNDATION: 50 cm. ABOVE GROUND LEVEL. DAMPPROOF COURSE ON TOP OF THE FOUNDATION WALL.
CONSTRUCTION: THE LADDERS ARE PREFABRICATED OUT OF GREEN BAMBOO $\phi > 4$ cm.
THE OUTSIDE BAMBOO SPLIT COVERING IS NAILED OR FASTENED TO THE LADDERS IN SUCCESSIVE LAYERS AS THE SOIL IS FILLED.
THE CORNERS ARE BRACED DIAGONALLY.

IN EARTH-QUAKE AREAS IT IS RECOMMANDED THAT THE BASE FRAME LYING ON THE FOUNDATION WALL BE SECURED BY A COURSE OF LIME SOIL MORTAR.
ADVANTAGES: THE WALL IS THICKER THAN NORMAL BAJAREQUE (CLIMATE) EARTH-QUAKE RESISTANT. THIN ϕ.
DISADVANTAGE: ONE NEEDS MORE BAMBOO AND SOIL.

FIGURE



Experimental low-cost earthquake resistant house in Guatemala (top: Bibl. 22.09; bottom: Bibl. 22.05)

FIGURE

Experimental low-cost earthquake resistant house in Guatemala (top: Bibl. 22.09; bottom: Bibl. 22.05)

Burnt clay brick walls

KEYWORDS:

Special properties	Improved method of bricklaying
Economical aspects	Medium costs
Stability	Very good
Skills required	Masonry skills
Equipment required	Simple frames and string holders
Resistance to earthquake	Good
Resistance to hurricane	Very good
Resistance to rain	Very good
Resistance to insects	Very good
Climatic stability	All climates
Stage of experience	Increasing applications in India

SHORT DESCRIPTION:

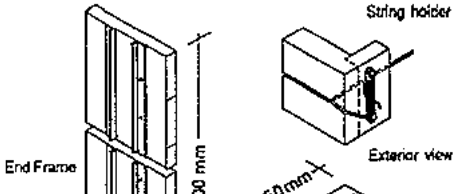
- **This example, developed at the CBRI, Roorkee, India, shows how simple devices and a well organized work place can not only increase the speed of construction (field trials resulted in a 30 percent increase), but also greatly improve the accuracy and quality of brickwork. All that is needed is a set of end-frames for different wall thicknesses and heights, string holders that can be used with any straight, vertical member, of rectangular cross-section (eg concrete columns), boards to hold the mortar, a few accessories, and a well worked out plan of action.**

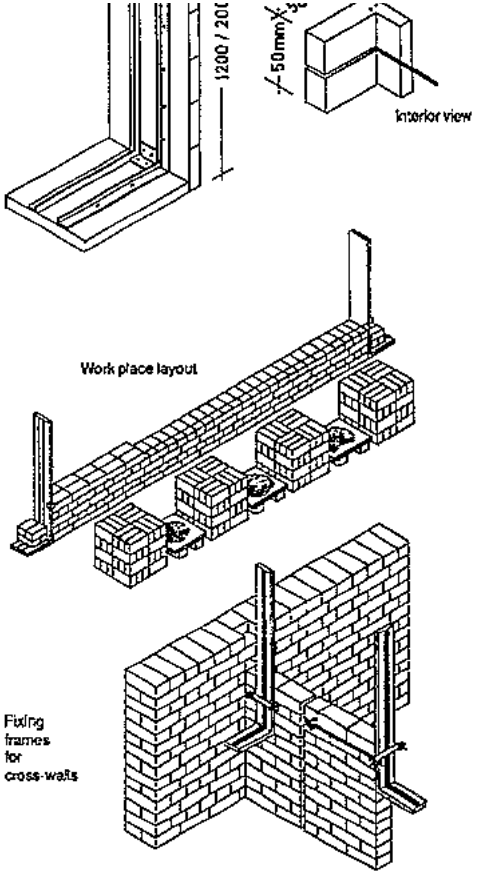
- **The mortar used for laying the bricks and for plastering must satisfy a number of requirements: it must be easy to spread, remain plastic as long as it is being applied, but then harden rapidly to resist deformation.**

- **Mortars basically consist of sand and a suitable binder, in most cases ordinary portland cement, in proportions varying from 1: 3 to 1: 12 (cement: sand), depending on the strengths required. However, the use of OPC alone makes a harsh mortar, which achieves undesirably high strengths. Hence it is advisable to add lime, which makes a more workable mortar, prevents cracking and achieves strengths that correspond to those of the bricks.**

- **The high costs of OPC can be reduced by replacing 30 % of it by a suitable pozzolana (see section on Pozzolanas). Further information: Bibl. 22.03.**

Bricklaying With Higher Efficiency




1200 / 20
50mm
interior view
Work place layout
Fixing
frames
for
cross-walls

FIGURE

- **With a few end-frames (as illustrated) the usual, time- consuming process of plumbing and stringing the wall is avoided. Each end-frame consists of two wooden planks held at right angles by a welded steel frame. The widths of the boards correspond to the wall thickness, ie half, one, or one and a half brick length.**

- **Simple L-shaped wooden string holders, which are held in place by the tension of the string, are slid along the edge of the frame as required. Accurate marks on the frame, corresponding to the height of the brick plus mortar joint, eliminate the need for measurements at each layer.**

- **Higher efficiency is also achieved by improving the layout of the work place. The principal idea is to place stacks of bricks and mortar boards in alternate succession parallel to the wall under construction, at a distance of 50 - 60 cm for the mason to move along. The bricks are placed on edge for the bricklayer to grip easily. The mortar is placed on the boards, substituting the traditional metal pans, which the masons normally hold in one hand. Bricks and mortar are continuously supplied from the other side by helpers.**

- **The mortar is picked up on a trowel and unloaded on the wall while moving along it for a distance of about 1 m. Then 8 - 10 bricks are placed in line with the string, each time filling the vertical joints with mortar. The procedure is then repeated for the next metre and so on. For each new layer the string holders are just pushed up to the next mark.**

- **The string holders can also be used independently for filler brick walls in framed buildings by fixing them directly on the reinforced columns. The method is equally applicable for work on scaffolding.**

Concrete hollow block walls

KEYWORDS:

Special properties	Strong, light walls; rapid construction
Economical aspects	Medium to high costs
Stability	Very good
Skills required	Masonry skills
Equipment required	Blockmaking equipment, masonry tools
Resistance to earthquake	Very good
Resistance to hurricane	Very good
Resistance to rain	Very good
Resistance to insects	Very good
Climatic stability	All climates
Stage of experience	Widely used method

SHORT DESCRIPTION:

- **The use of concrete hollow blocks has several advantages:**

- **they can be made much larger than solid bricks, and if lightweight aggregate is used, can be very light, without forfeiting much of their load-bearing capacity;**

- **they can be made to any shape and size, and remain dimensionally stable;**

- **they require far less mortar than solid bricks (because of the cavities and less proportion of joints, due to the large size), and construction of walls is easier and quicker;**

- **the cavities can be filled with reinforcement and concrete, achieving high earthquake resistance;**

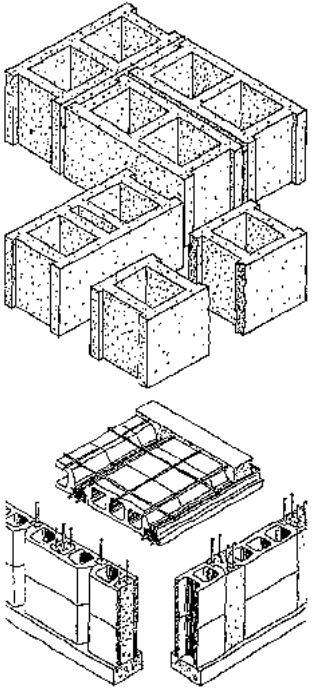
- **the air-space provides good thermal insulation, which is of advantage in highland and**

cooler regions (alternatively, the cavities can be filled with thermal insulation material);

- **the cavities can also be used as ducts for electrical installation and plumbing.**

- **The concrete hollow blocks can be made in simple hand moulds and vibrator (for production on the building site) or in expensive, stationary or "egg-laying" machines (for mass production). Further information: Bibl. 22.07, 22.08.**

Standard Hollow Blocks



FIGURE

- **Concrete hollow blocks generally have two cavities and the length is twice the width plus l cm (thickness of joint).**

- **In order to be able to divide the block into two identical halves, a narrow cavity in the centre is needed. Division of blocks is done with a few knocks along the centre line with the edge of a hammer.**

The Zipbloc System (Bibl. 22.08)

- **This system is based on a special type of hollow block (53 x 25 x 14 cm), which can be used for different types of walls, as well as for ceiling and roof construction.**

- **For wall constructions, the blocks are assembled vertically with a little mortar. The gaps between these vertical units are filled with concrete 1: 3: 6 (1 cement: 3 sand: 6 aggregate). Reinforcing steel is placed in the vertical cavities and also filled with concrete. In most cases, it is sufficient to fill only one cavity. Door and window frames are eliminated, as the shape of the block provides the necessary jamb for fixing shutters.**

- **For ceilings and roofs, inverted T-beams of required length are precast and placed on the walls at 60 cm centres and propped at mid-span. The concrete hollow blocks are placed to span two beams (as illustrated). On top of this a welded steel mat is provided (for temperature stresses) and screed is cast in-situ.**

Bamboo walls

KEYWORDS:

Special properties	Light, flexible; great variety of constructions
Economical aspects	Low cost
Stability	Low to medium
Skills required	Traditional bamboo construction skills
Equipment required	Tools for cutting and splitting bamboo
Resistance to earthquake	Good
Resistance to hurricane	Low
Resistance to rain	Low

Resistance to insects	Low
Climatic stability	Warm humid climates
Stage of experience	Traditional

SHORT DESCRIPTION:

• In bamboo-growing regions the climate is generally warm and humid, requiring construction materials of low thermal storage capacity and designs which permit good cross-ventilation. Bamboo constructions ideally satisfy these requirements, which is why they have long been used for housing in warm humid climates.

• Plain bamboo walls cannot be made air-tight or waterproof, so that cross-ventilation is a natural feature, providing indoor comfort and removing moisture.

• The flexibility and high tensile strength makes bamboo walls highly earthquake resistant, and in case of collapse, their low weight causes less damage to people and property; reconstruction is relatively quick and easy.

• Special skills are required to handle bamboo, but these are traditionally available in most bamboo-growing regions.

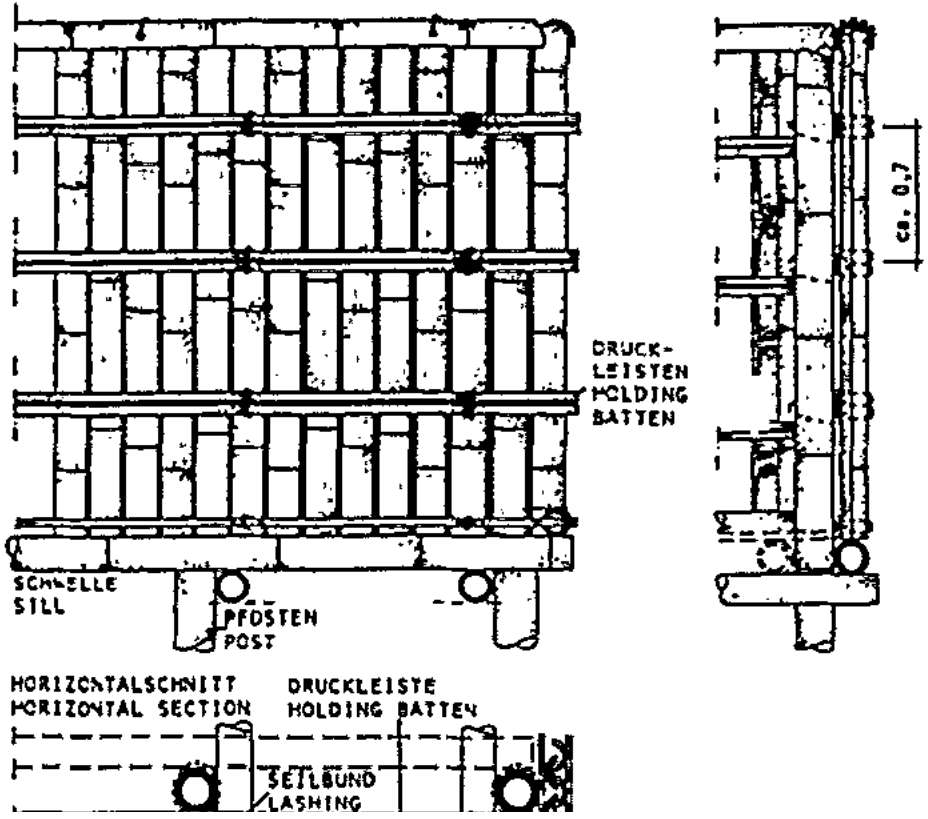
• The main drawbacks are the relatively low durability (due to biological hazards), the low resistance to hurricanes and fire, therefore protective measures are essential (see section on PROTECTIVE MEASURES).

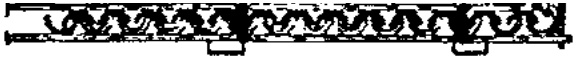
Further information: Bibl. 13.02, 13.04, 13.05, 13.09, 13.10, 13.12.

Halved bamboo culms arranged vertically Bamboo batt

like Spanish roof tiles

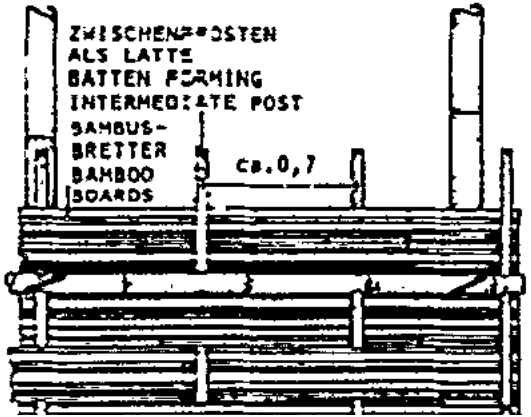
into eight seg

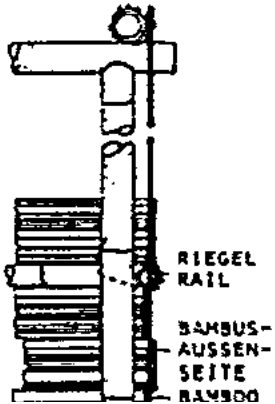


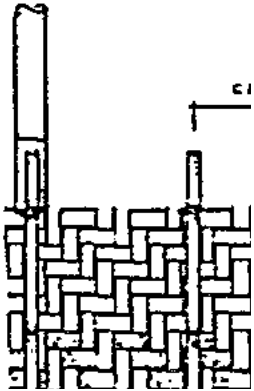


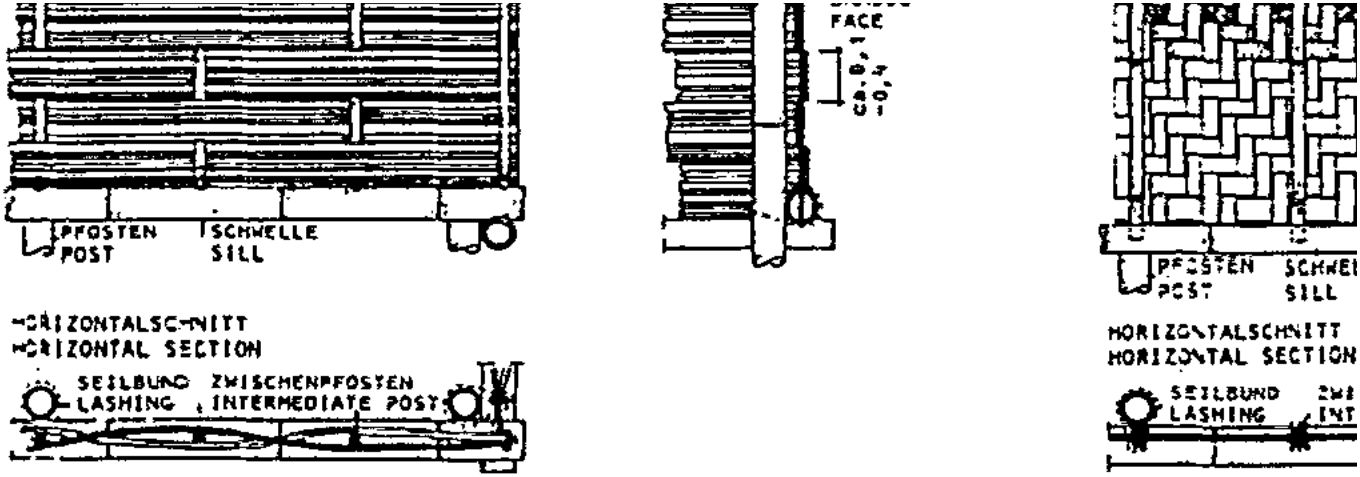
Bamboo boards (split and flattened culms) interwoven with the frame

Panels of wov or tied to the









Examples of Traditional Bamboo Wall Construction (Bibl. 13.02): Halved bamboo culms arranged vertically like Spanish roof tiles; Bamboo boards (split and flattened culms) interwoven with the frame; Bamboo battens (made from culms split into eight segments) nailed to a light frame; Panels of woven bamboo strips nailed and/ or tied to the bamboo frame

Timber panel walls

KEYWORDS:

Special properties	Suitable for prefabrication, quick assembly
Economical aspects	Medium costs
Stability	Good

Skills required	Carpentry skills
Equipment required	Carpentry tools
Resistance to earthquake	Good
Resistance to hurricane	Low to medium
Resistance to rain	Low to medium
Resistance to insects	Low
Climatic stability	Warm humid climates
Stage of experience	Standard construction

SHORT DESCRIPTION:

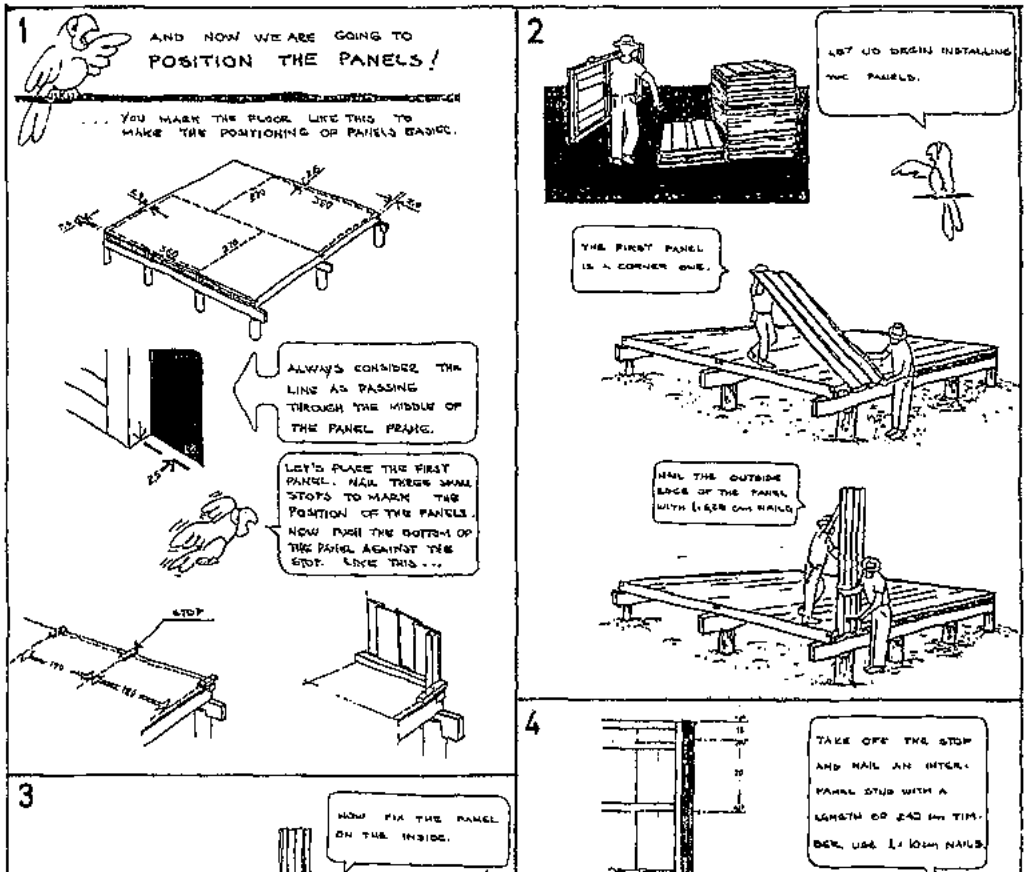
- **With a well coordinated, modular design, only a few types of wall panels need to be prefabricated, and the less the number of different components, the quicker and cheaper is the process of prefabrication.**

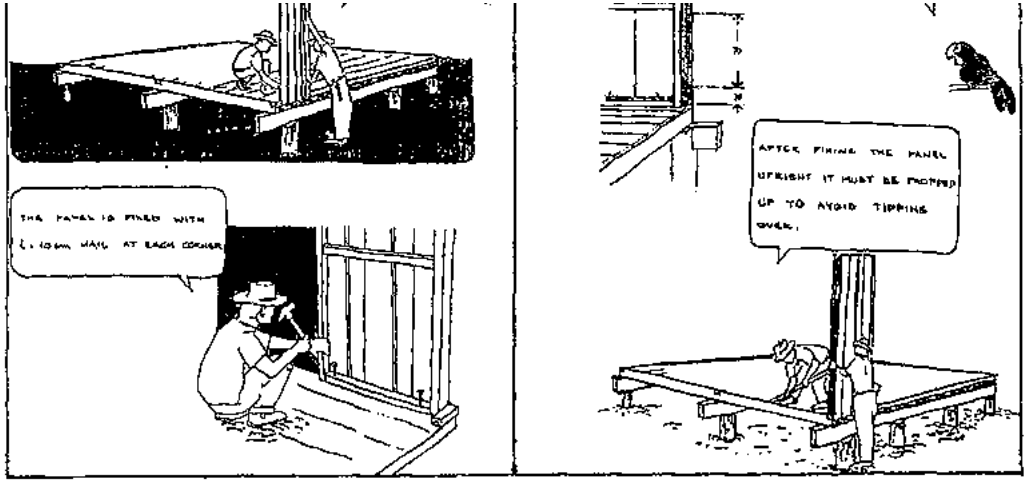
- **Well seasoned timber should be used in order to prevent moisture movements and distortions which could make assembly difficult and cause dangerous stresses in the course of time.**

- **Protective measures against biological agents, hurricanes and fire are essential (see section on PROTECTIVE MEASURES).**

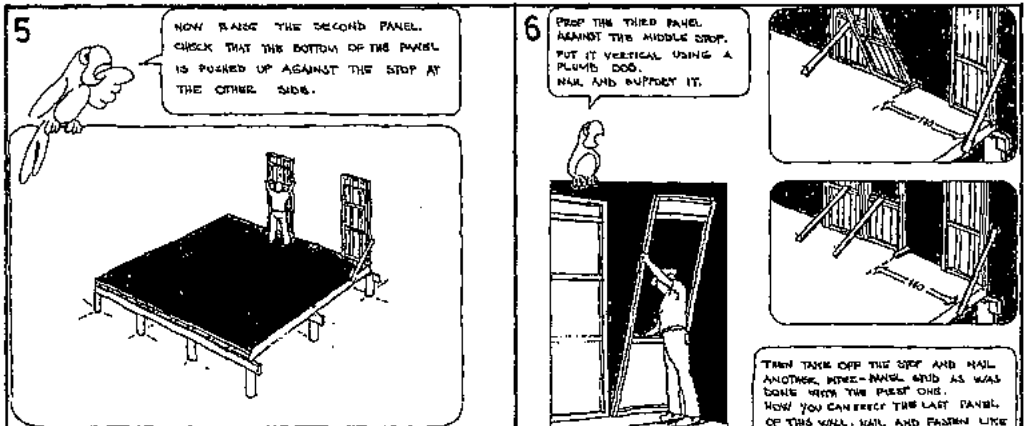
- **The illustrations on the next three pages are taken from the excellently illustrated UNIDO Manual on Wooden House Construction, which was prepared by the Instituto de Pesquisas Tecnologicas (IPI), Sao Paulo, Brazil, for a self-help community building project at Coroados, Manaus, under a contract with the Housing Society for the Amazon State (SHAM).**

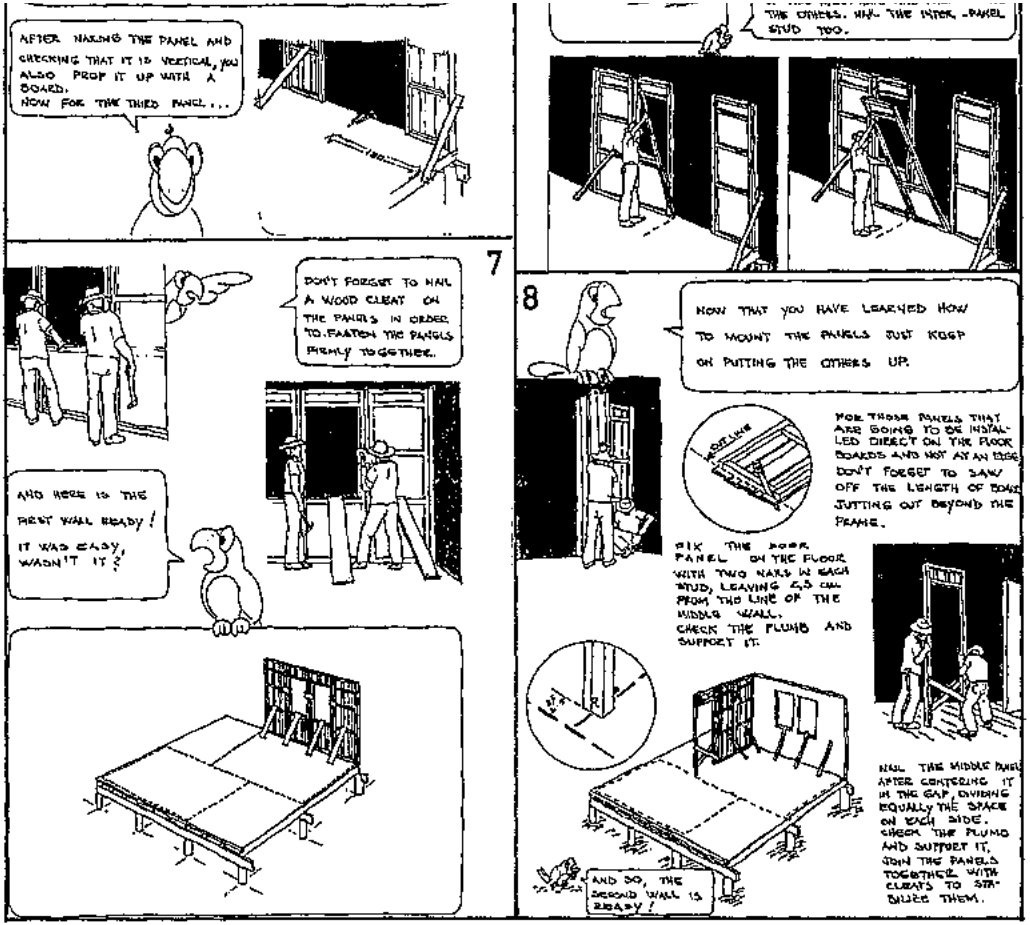
Further information: Instituto de Pesquisas Tecnologicas (IPI) do Estado de Sao Paulo, S.A., P.O. Box 7141, 05508 Sao Paulo, Brazil; Bibl. 14.22.



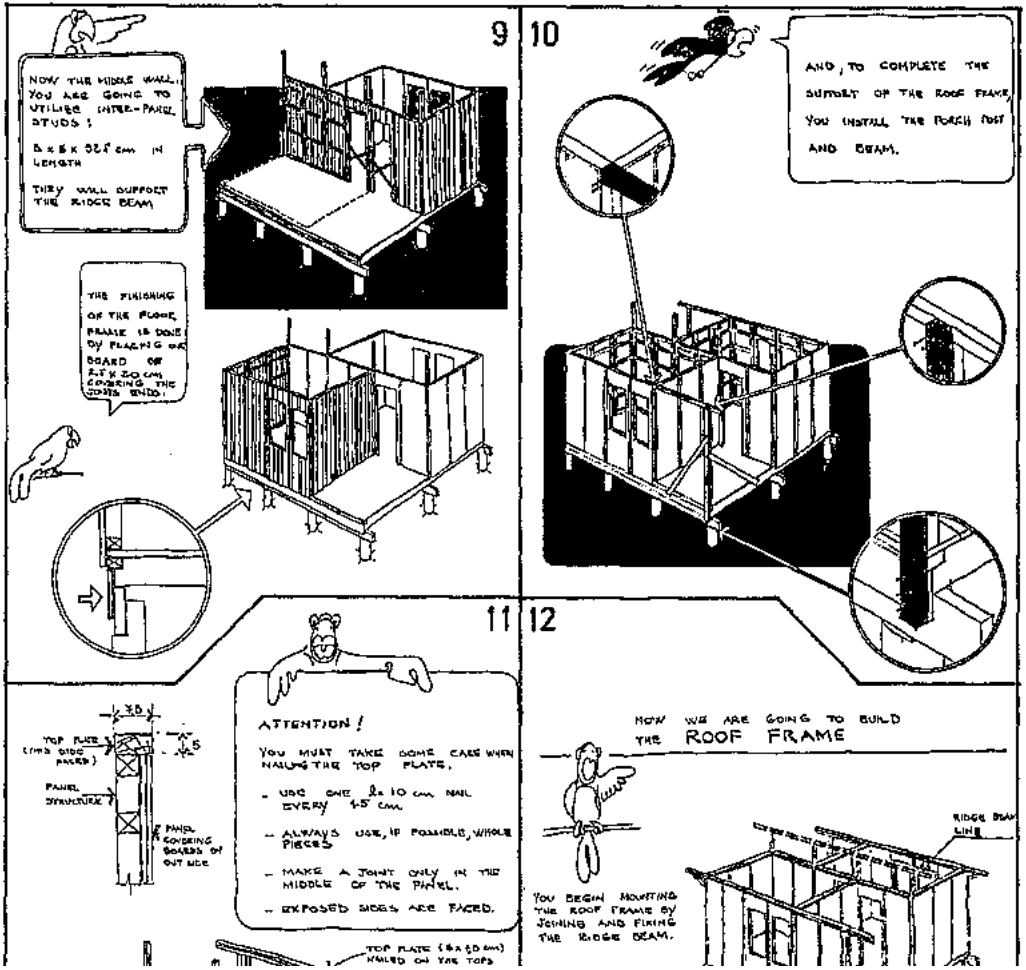

THE PANEL IS FIXED WITH
AFTER FIXING THE PANEL
UPRIGHT IT MUST BE PROPPED
UP TO AVOID TIPPING
OVER.

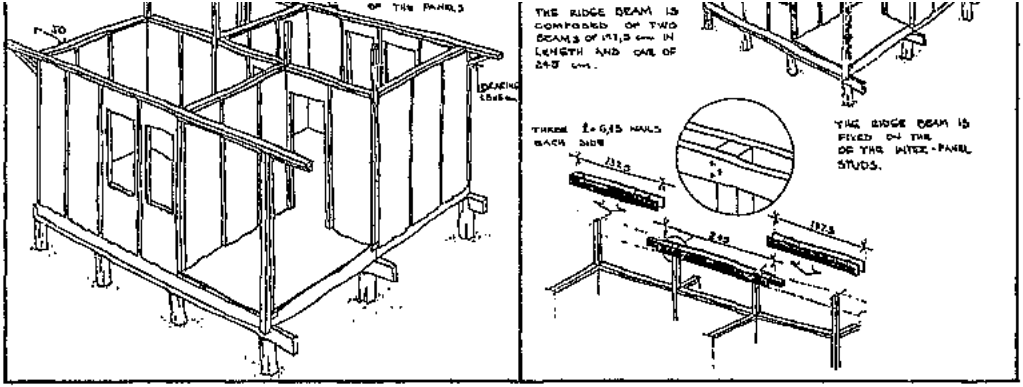
FIGURE


5
NOW PLACE THE SECOND PANEL.
CHECK THAT THE BOTTOM OF THE PANEL
IS PUSHED UP AGAINST THE STOP AT
THE OTHER SIDE.
6
PROP THE THIRD PANEL
AGAINST THE MIDDLE STOP.
PUT IT VERTICAL USING A
PLUMB BOB.
NAIL AND SUPPORT IT.
THEN TAKE OFF THE PROP AND NAIL
ANOTHER NINE-PANEL STUD AS WAS
DONE WITH THE FIRST ONE.
NOW YOU CAN ERECT THE LAST PANEL
OF THIS WALL, NAIL AND FASTEN LIKE


AFTER NAILING THE PANEL AND CHECKING THAT IT IS VERTICAL, YOU ALSO PROP IT UP WITH A BOARD.
NOW FOR THE THIRD PANEL...
7
DON'T FORGET TO NAIL A WOOD CLEAT ON THE PANELS IN ORDER TO FASTEN THE PANELS FIRMLY TOGETHER.
AND HERE IS THE REST WALL READY!
IT WAS EASY, WASN'T IT?
THE OTHERS. NAIL THE INTER-PANEL STUD TOO.
8
NOW THAT YOU HAVE LEARNED HOW TO MOUNT THE PANELS JUST KEEP ON PUTTING THE OTHERS UP.
FOR THOSE PANELS THAT ARE GOING TO BE INSTALLED DIRECT ON THE FLOOR BOARDS AND NOT AT AN EDGE DON'T FORGET TO SAW OFF THE LENGTH OF BOARD JUTTING OUT BEYOND THE FRAME.
FIX THE DOOR PANEL ON THE FLOOR WITH TWO NAILS IN EACH STUD, LEAVING 4.5 cm FROM THE LINE OF THE MIDDLE WALL. CHECK THE PLUMB AND SUPPORT IT.
NAIL THE MIDDLE PANEL AFTER CENTERING IT IN THE GAP, DIVIDING EQUALLY THE SPACE ON EACH SIDE. CHECK THE PLUMB AND SUPPORT IT. JOIN THE PANELS TOGETHER WITH CLEATS TO STABILIZE THEM.
AND SO, THE SECOND WALL IS READY!

FIGURE


9
NOW THE MIDDLE WALL: YOU ARE GOING TO UTILISE INTER-PANEL STUDS !
5 x 5 x 322 cm IN LENGTH
THEY WILL SUPPORT THE RIDGE BEAM
THE FINISHING OF THE FLOOR FRAME IS DONE BY PLACING ONE BOARD OF 2.5 X 20 cm COVERING THE JOISTS ENDS.
10
AND, TO COMPLETE THE SUPPORT OF THE ROOF FRAME, YOU INSTALL THE PORCH POST AND BEAM.
11
ATTENTION !
YOU MUST TAKE SOME CARE WHEN NAILING THE TOP PLATE.
- USE ONE 2 x 10 cm NAIL EVERY 45 cm.
- ALWAYS USE, IF POSSIBLE, WHOLE PIECES
- MAKE A JOINT ONLY IN THE MIDDLE OF THE PANEL.
- EXPOSED SIDES ARE FACED.
10
5
TOP PLATE (TWO SIDES PAIRED)
PANEL STRUCTURE
PANEL COVERING BOARDS ON OUT SIDE
TOP PLATE (5 x 10 cm) NAILED ON THE TOPS
12
NOW WE ARE GOING TO BUILD THE ROOF FRAME
RIDGE BEAM LINE
YOU BEGIN MOUNTING THE ROOF FRAME BY JOINING AND FIXING THE RIDGE BEAM.



FIGURE

Sulphur concrete walls

KEYWORDS:

Special properties	Cheaper alternative to cement concrete walls
Economical aspects	Low to medium costs
Stability	Very good
Skills required	Experience in use of sulphur
Equipment required	Concrete mixer with heater
Resistance to earthquake	Very good
Resistance to hurricane	Very good
Resistance to rain	Very good
Resistance to insects	Very good
Climatic stability	All climates

Climate stability	All climates
Stage of experience	Experimental

SHORT DESCRIPTION:

• The ingredients of sulphur concrete are elemental sulphur, send end a plasticizer. Sulphur concrete remains unaffected by impurities, such as salts, which are harmful to reinforced cement concrete.

• The most appropriate use of sulphur concrete for walls is to make hollow blocks, especially interlocking blocks, which can be assembled with great speed and accuracy.

• Block production requires some skill and experience in the use of sulphur, as the molten sulphur hardens quickly. Because of the short curing time, only few moulds are required. Any broken blocks can be remelted and recycled.

• The illustrations overleaf show a practical example of interlocking sulphur concrete block walls in Dubai, United Arab Emirates. The blocks were based on the LOK BLOK system developed by Professor Bruce Etherington (see LOK BILD System) and adapted to sulphur concrete by Bernard Lefebvre.

Further information: Alvaro Ortega, Research Consultant, 3460 Peel Street, Apt. 811, Montreal P.Q., Canada; Bibl. 18.06, 18.07.

Sulphur Concrete Block Walls in Dubai, United Arab Emirates (Photos: A. Ortega)

• The interlocking blocks are quickly assembled without mortar.

• The smooth, non-absorbing marble-like surfaces eliminate the need for plastering or painting, and can easily be cleaned by washing with plain water.

- **Depending on the aggregates, different coloured blocks can be made, producing attractive wall surfaces.**

Walls from agro-waste

KEYWORDS:

Special properties	Promising use of local waste materials
Economical aspects	Low cost
Stability	Good
Skills required	Average construction skills
Equipment required	Wooden hand mould, masonry equipment
Resistance to earthquake	Good
Resistance to hurricane	Good
Resistance to rain	Depends on stabilization
Resistance to insects	Medium
Climatic stability	All except very wet climates
Stage of experience	Experimental

SHORT DESCRIPTION:

- **The system described here, developed at the Forest Products Research and Development Institute, Philippines, uses hollow soil-cement blocks, which contain a certain amount of beach sand and agricultural wastes, such as rice husks, sawdust, wood chips and coconuttrunk particles.**

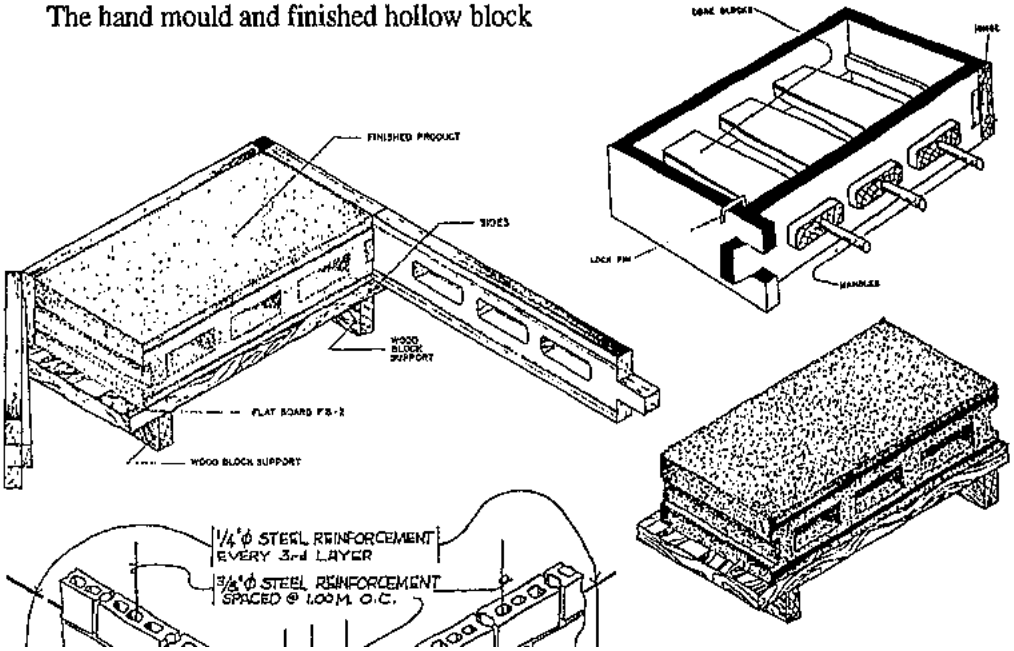
- **The blocks (10 x 20 x 40 cm with 3 rectangular holes) are made in wooden hand moulds.**

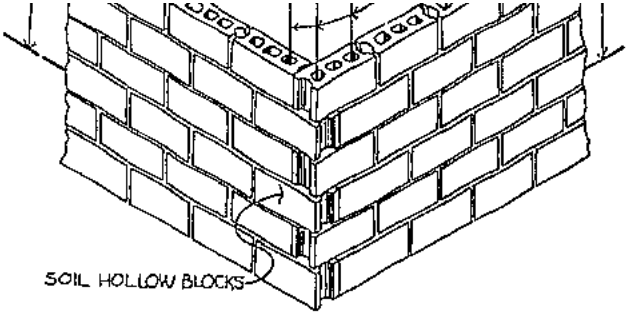
The raw mixture, with a moisture content similar to that for common soil cement blocks, is filled into the mould, tamped and levelled, after which the blocks can be demoulded and placed on their narrow sides for moist curing (about 10 days).

- **Wall construction is the same as for concrete hollow blocks, and extremely rigid constructions are achieved by filling the cavities with steel reinforcement and concrete.**

Further information: Forest Products Research and Development Institute, Los Banos, Laguna, Philippines; Bibl. 19.11.

The hand mould and finished hollow block





Construction and reinforcement of hollow block walls

The hand mould and finished hollow block; Construction and reinforcement of hollow block walls