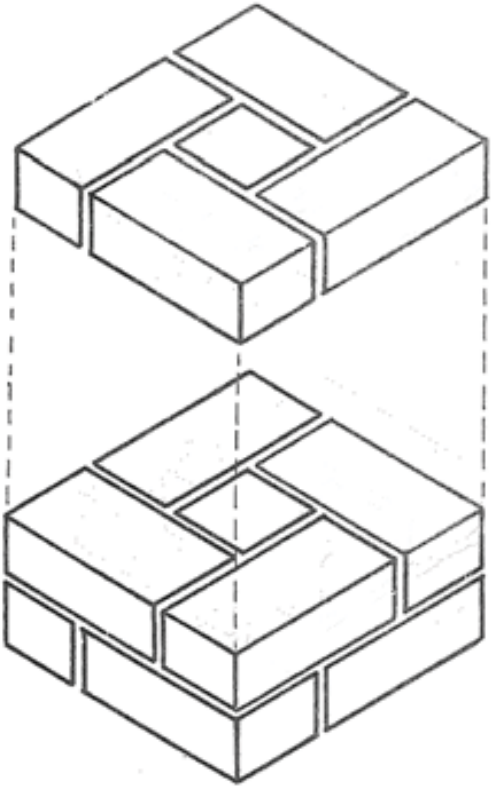


BLOCKS AND STABILISED MOULED EARTH BLOCKS MEB & SMEB

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

skat Swiss Resource Centre and Consultancies for Development

PROECCO

00

TABLES OF CONTENTS

INTRODUCTION

Beyond the fact that Mouled Earth Blocks are assembled onto walls using standard bricklaying and masonry techniques, building with MEB sends the designer and builder directly back to the rules of «good practice» for designing and building with earth.

These essential rules respond to two categories of problems to solve :
• Structural problems: and, the poor tensile and shearing strength of earth as a building ma- terial. In respecting these principles, it is essential to choose between appropriate structural designs and construction details.
• Problems of water and humidity: to be respected : protecting the top and the base of the Walls («a good hat and good shoes»), allowing the earth building material to breathe and incorporating suitable details into the design principles.

Before building, implantation site should prevent following problems :
- water stagnation;
- flooding;
- rain water flowing down the ground.

01

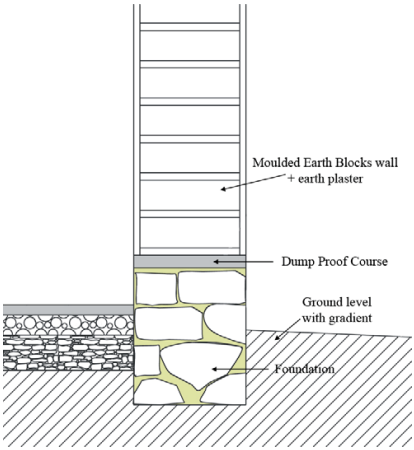
FOUNDATION

REMINDER: The foundations permit equal distribution of the weight of walls and roof into the ground. They should be strong, resistant to compression, and should ensure total wall stability.

Standards for MEB buildings' foundations are similar to those for other brick walls.
The basic principle of building with earth is to keep the wall out of contact with the ground, in order to protect the walls from water and damp ac- tion. Therefore, waterproof materials (concrete, stone, burnt bricks or sandcrete block masonry, highly stabilized compacted soil or compressed bricks for dry and well-drained sites) should be used to stop capillarity.

The following should be taken into consideration for a good foundation design :

- Drainage: a properly designed peripheral drainage that will keep the soil dry around the foundatio;.
- Gradient: a gradient, outside the building, to divert rain waters away from the wall. Pervious materials must be used for it to allowgood evaporation of moisture in the soil;
- DPC (Dump Proof Course): a good damp proof course between the foundation and the base course (bitumen, water repellent cement) in order to prevent moisture to soak slowly from the foundation into the earth wall.



02

BASE WALL

MATERIALS

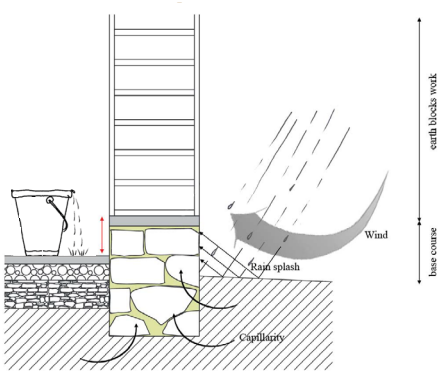
The materials used for the base should be able to carry the weight of the building and resist humidity. Such materials include :

- stones;
- fired brick;
- hollow concrete blocks.

If the above materials are not accessible, highly stabilized earth blocks can be used if they are well protected against any contact with water and moisture, and if the surrounding is dry, well drained and protected from

Caution ! To use stabilized moulded earth blocks in base wall, their good production and quality of the prefabricated materials have to be gua- ranteed : a good mastery of the technique is essential.

The role of the base wall is to protect the rest of the wall from humidity.

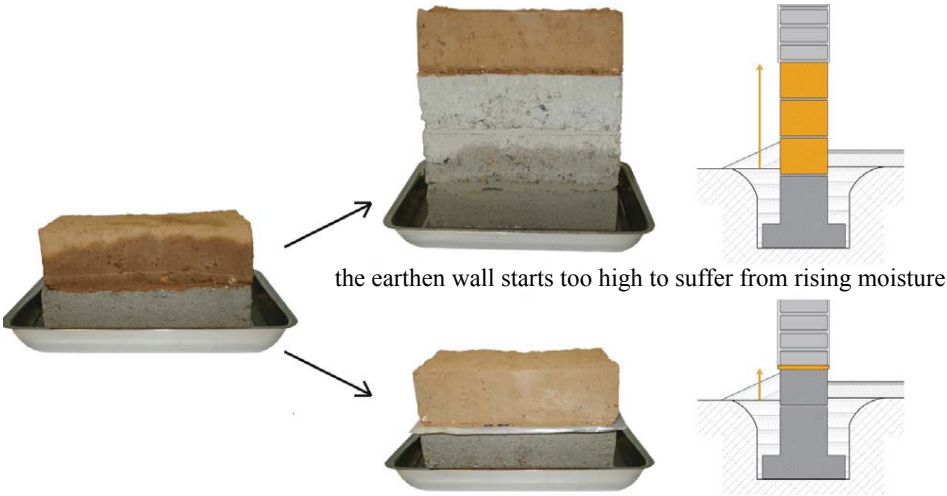


HIEGHT

The base of the wall should be high enough to avoid the eroding effect of splashing water and capillary action on brickwork.
Whatever the nature of foundation is, the base wall must be raised up sufficiently:

- To about 20 cm (8") minimum above the natural ground level if there is a capillary barrier to stop rising damp by the base wall (and if the risk of stagnant water beyond is excluded).
- To about 40 cm (1'4") or more (above the level of rising damp observed on the surrounding buildings) if there is any capillary barrier, as the function of the basement wall is to allow the humidity to evaporate before reaching the earth wall, more vulnerable.

Layers of hollow concrete blocks, stone or fired bricks, offers a good protection for a MEB wall. Stabilized moulded earth blocks can also be used, only if their good production and quality of the prefabricated ma- terials can be guaranteed: a good mastery of the technique is essential.



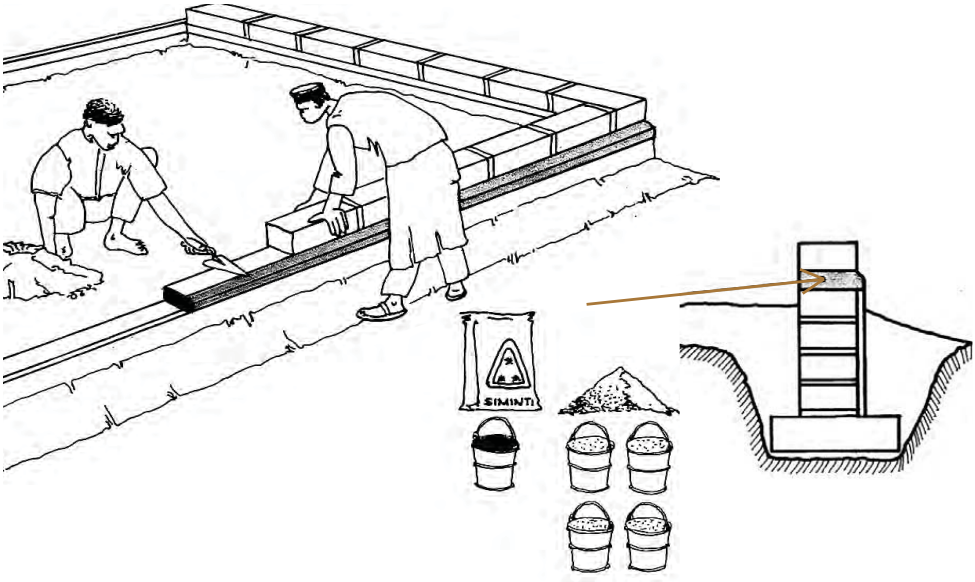
the earthen wall starts too high to suffer from rising moisture

Dump Proof Course stop rising damp

DUMP PROOF COURSE

Anyway, dump proof course (cement plastering, coal tar plastering, use of plastic sheets, etc.) should be provided in base wall to prevent dam- pness rising easily into the building.

To be effective, the capillary barrier is laid down on top of the basement wall, one course minimum above the internal slab level, otherwise water can rise by capillary action through the soil towards the wall.
Plastering or the waterproof film has on every wall (external and internal), and always at the same level, on the same course.



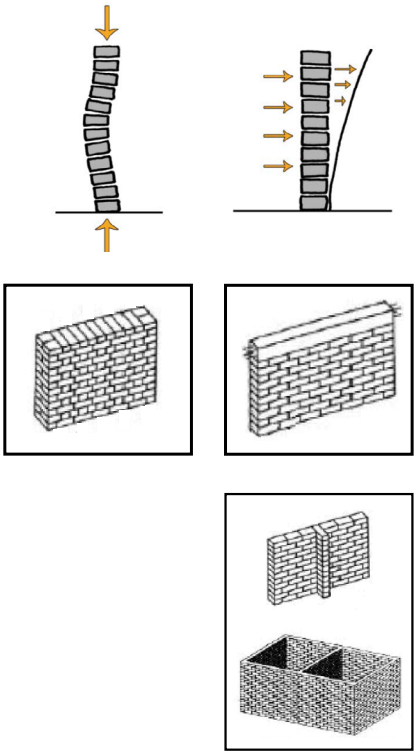
03

WALL-BLOCK WORK

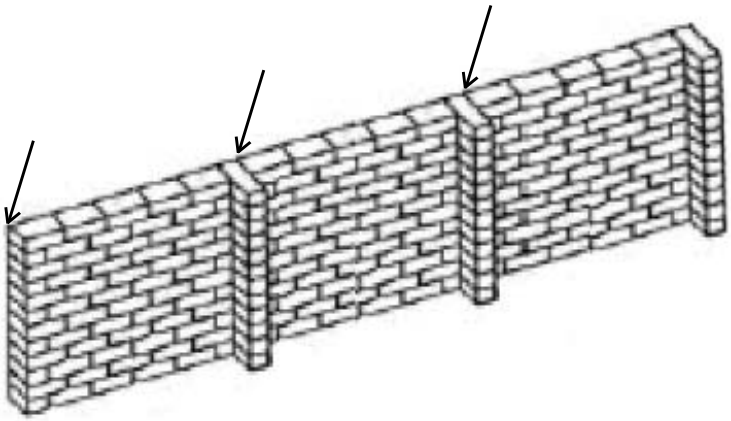
Earth block work permits to construct thin or thick walls, serving as support or partition.
The earth works well in compression but resists badly to the forces of traction (opposing forces), bending or shearing.

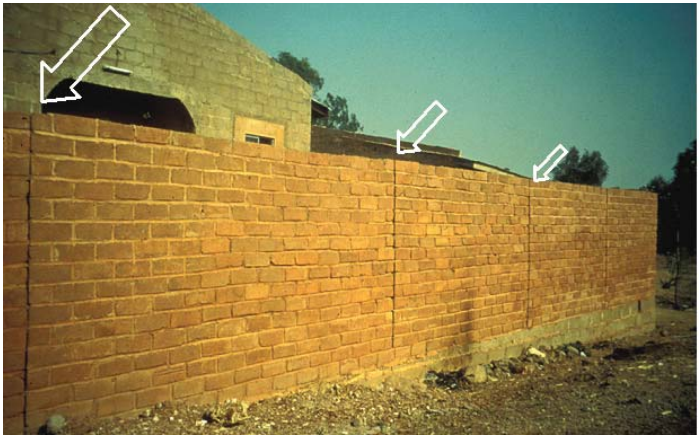
The dimensions of the earth walls must follow some rules :
• The relation thickness / height of the wall must be lower than 1/10 (for example : 20cm thick for 2m hight is allowed, but 20 cm thick with 2,20m hight is not allowed). Beyond of that the wall loses its stability);

If the width /height ratio exceeds 1/10, three solutions:
• Increasing the tickness of the wall;
• Add a peripheral tie-beam before exceeding the 1:10 ratio (for example at maximum 2 meters height for a 20 cm wide wall);
• Add buttress walls to prevent the wall tips over.



The maximal distance between sidewalls or vertical joints on a same wall is 5 meters (16'8"). If long walls are needed, they should be divided into smaller sections, providing expansion joints and buttresses.



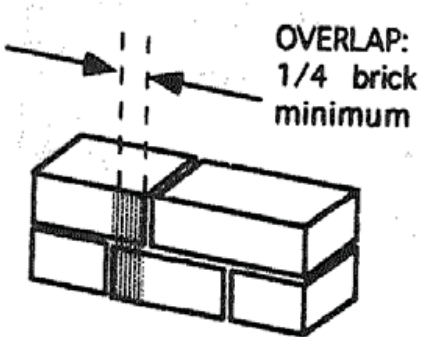


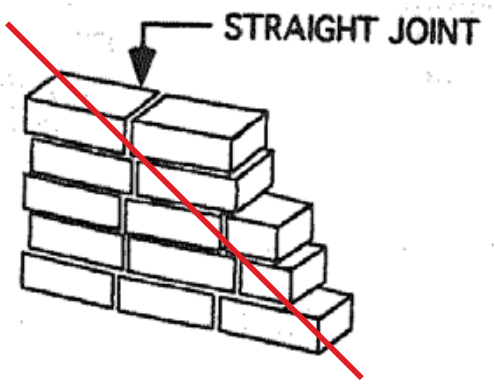
03

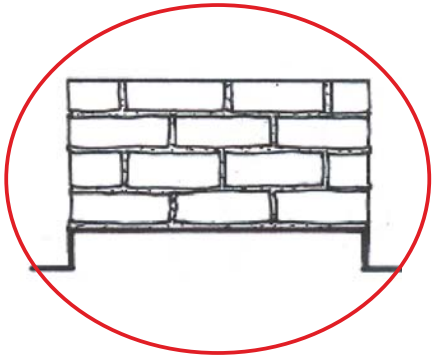
03.1 - BLOCK COURSING

Poor coursing can result in uneven settlement and cracking. Stability is achieved with good bonds at corners junction and separating walls that help tie them together.
It is necessary to respect 2 rules :

- The width of the mortar joints, both horizontal and vertical, should be even and a maximum of 1 to 3cm (about 2 cm thick, for the passage of fingers for masonry);
- The minimum overlap between two bricks should be ¼ of the length of a full brick (No vertical straight joints in the wall);





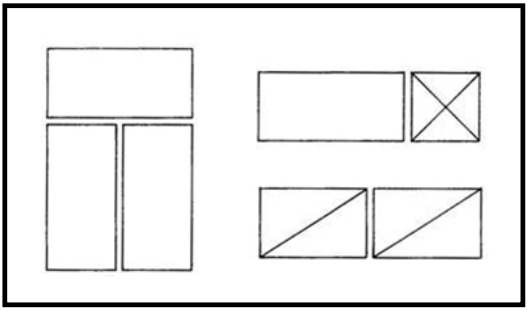


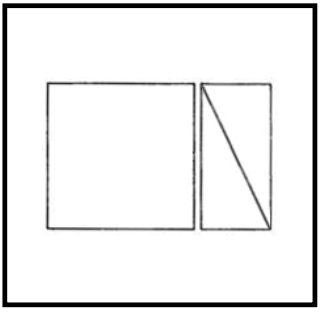
HORIZONTAL COURSING PRINCIPLES

Moulded Earth Blocks have the advantage of being easily resized on site if necessary. This advantage ensures always a proper brick bonding.
Nevertheless, you can consider producing bricks of specified sizes or several bricks of complementary sizes if you need, for example, to obtain a particular wall thickness or to ease brick bonding.

- Your needs in dimesnions should be studied in advance designing phase;
- Molds of the right size have to be manufactured to produce the blocks.

Bricks are drawn to check the bonding and dimensions are calculated according to the size of the "brick+mortar joint".
Then, the speed of laying bricks is increased: blocks do not have to be resized one by one.



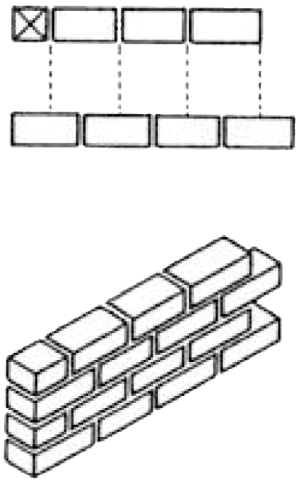


03

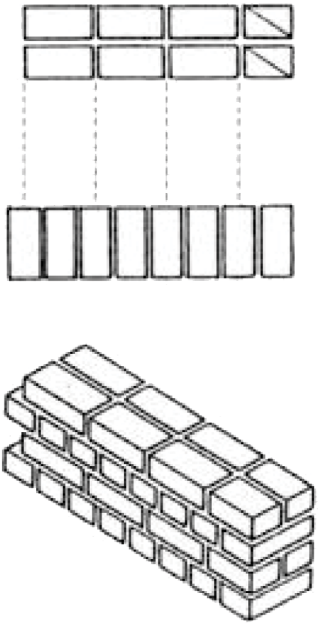
03.2 - BONDING PATTERNS

STRAIGHT WALL

HALF BRICK WALL THICKNESS

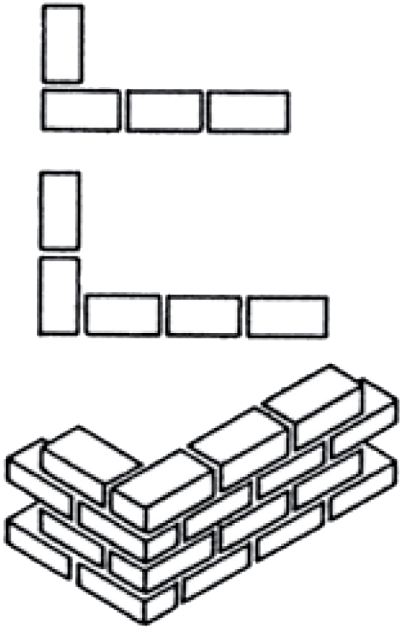


ONE BRICK WALL THICKNESS

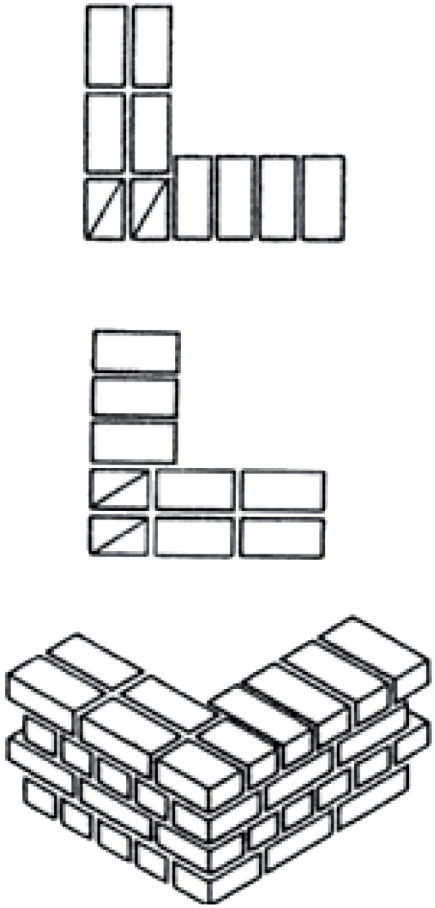


L-SHAPE

HALF BRICK WALL THICKNESS

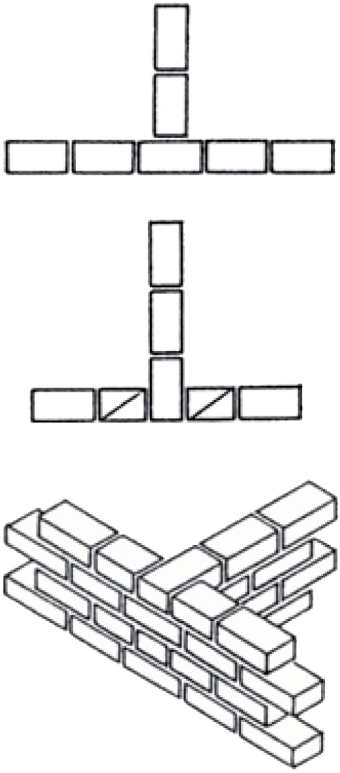


ONE BRICK WALL THICKNESS

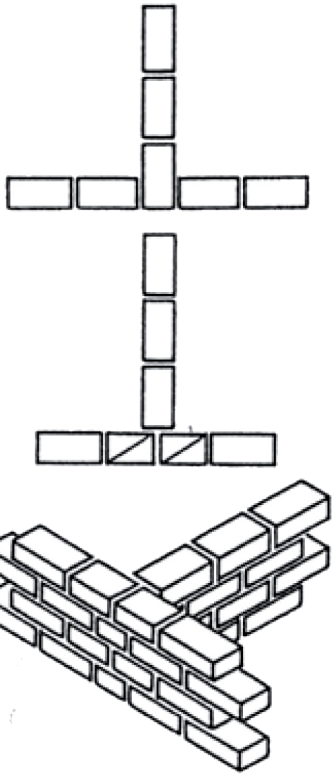


T-SHAPE

HALF BRICK WALL THICKNESS

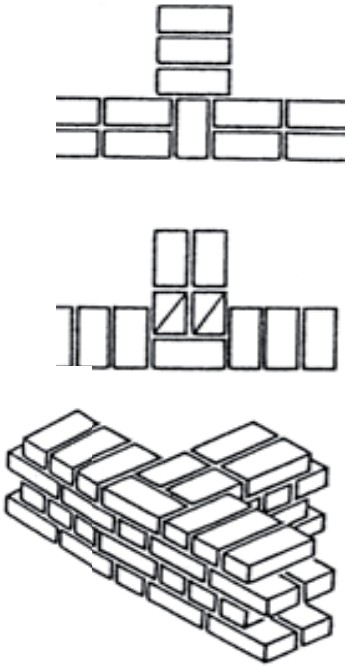


option 1



option 2

FULL BRICK WALL THICKNESS



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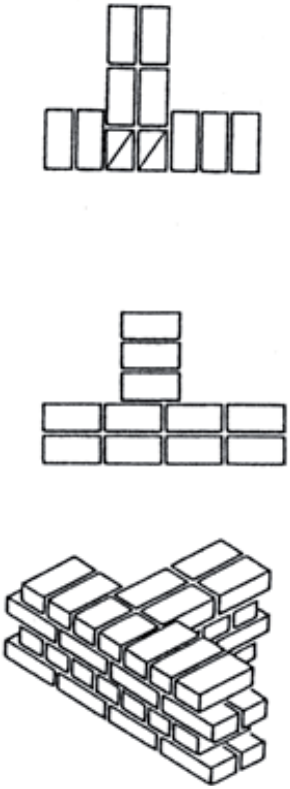
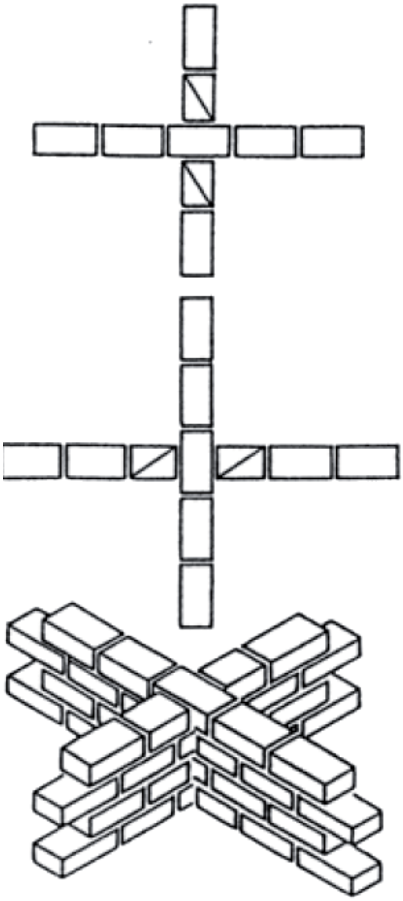


option 2

X-SHAPE

HALF BRICK WALL THICKNESS



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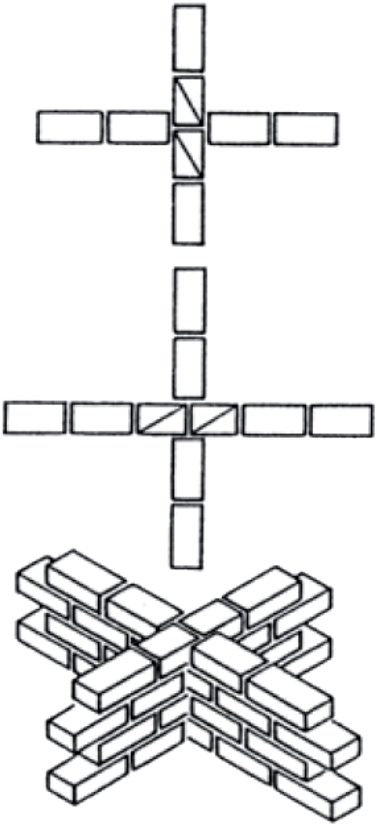
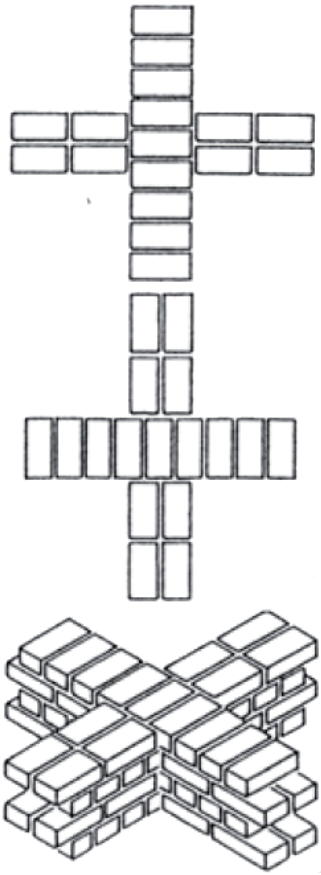


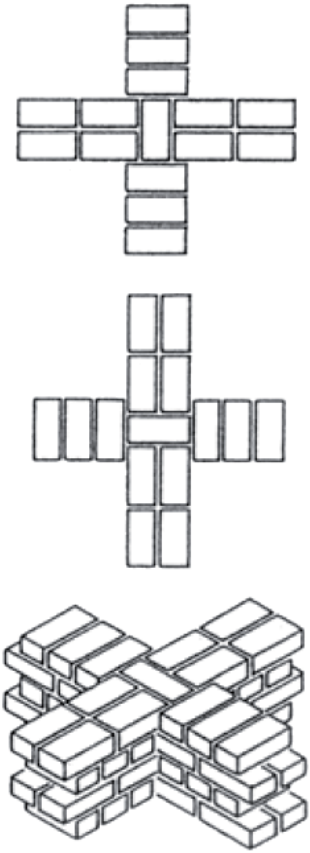
option 2

X-SHAPE

FULL BRICK WALL THICKNESS



option 1



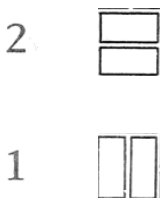
option 2

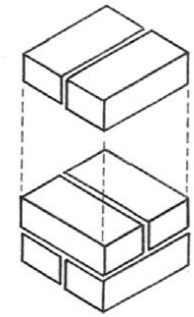
PILLARS

Bonding patterns for small section pillars generally require full blocks and use a rotating patterns.

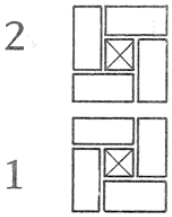
Bonding patterns for large section pillars require the use of full blocks plus a half block in the center.

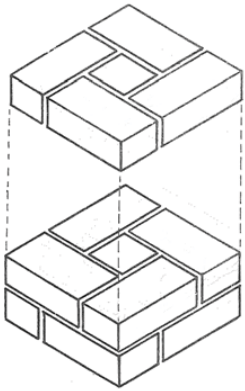
1 FULL BRICK X 1 FULL BRICK





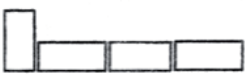
1,5 FULL BRICK X 1,5 FULL BRICK

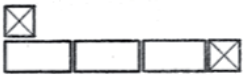


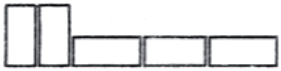


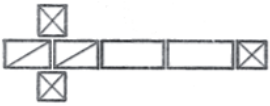
BUTRESSES

Straight walls :
To ensure good stability and support pointed loads, buttresses can be used for fine walls.



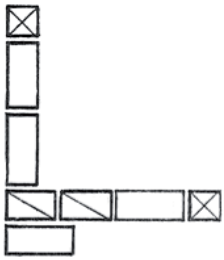


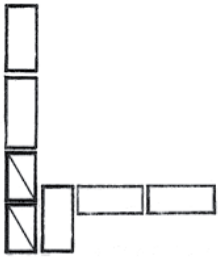


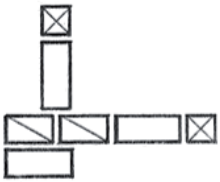


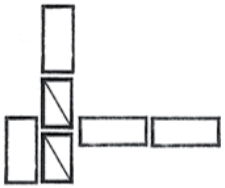
BUTRESSES

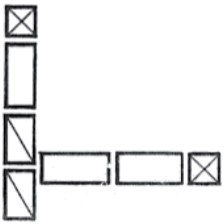
Corners:

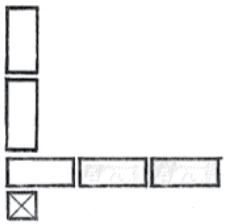










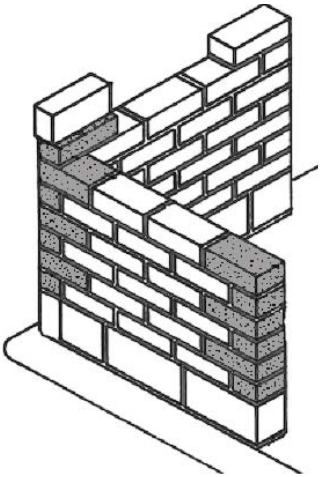


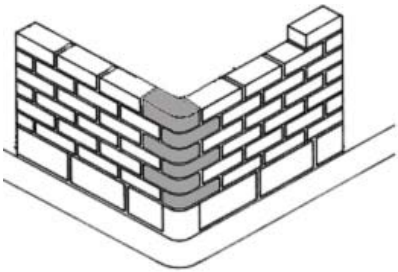
03

03.3 - IMPROVED WALLS

Corners of buildings tend to be more fragile. Because of their greater exposure to multi-directional friction and rain, they are more prone to erosion.

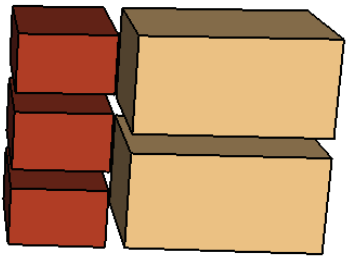
These vulnerable parts are situated at the building corners, around the openings (doors and windows) and at any angle such as building recesses or buttresses.
These weaker points can then be reinforced by toothing the masonry with stronger materials such as stabilized adobes or baked bricks, more resistant to water and erosion.
If using stabilized adobes, it is possible to produce elements with rounded corners, less likely to erode than sharp angles..

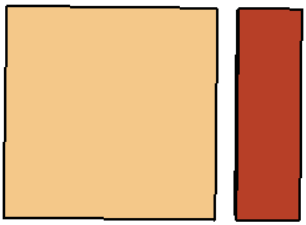


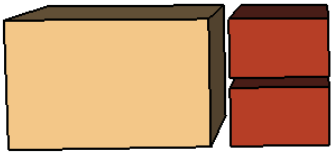


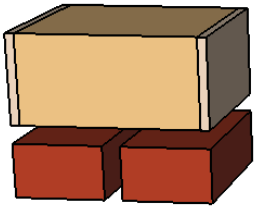
When planning to mix in the same building different elements, dimensioning work is essential to produce blocks with compatible sizes and to ensure a correct bonding between earth moulded blocks and the other selected elements (stabilized earth blocks, fires bricks, ...).

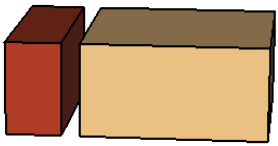
For example mud bricks with fired bricks in the corners: eath blocks toproduce have to be dimensioned depending on the size of bricks available in the market.



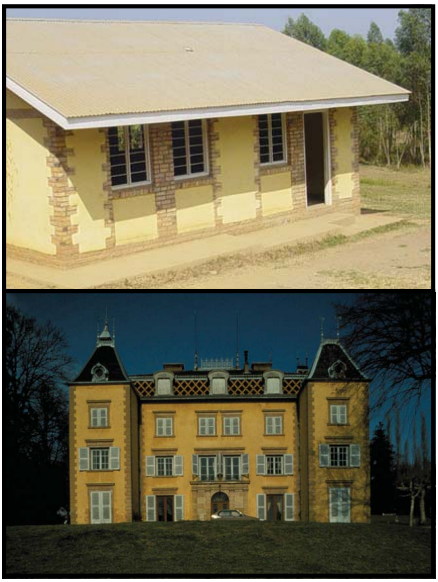


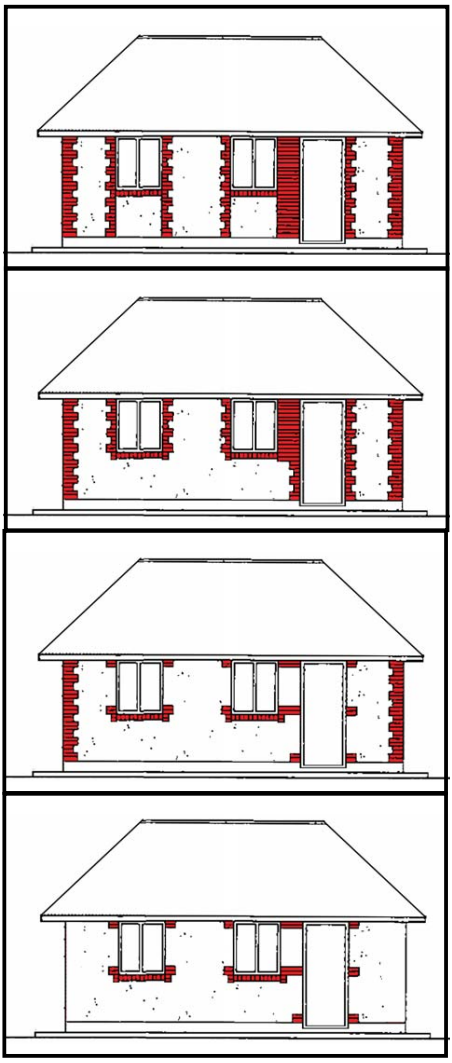






When planning to mix in the same building different According to economic means or material availability, you can strengthen all of these vulnerable areas by reinforcing all outgoing corners (window and door surrounds, building corners and buttresses) or only the most stressed points: anchorage of windows and doors and window sills.





03

03.4 - IMPLEMENTATION

MORTAR

A good mortar should have good mechanical strength and should have a compressive strength and resistance to erosion as close as possible to those of the masonry element.

Mortar used for Moulded Earth Blocks masonry will be made of earth. Tests have to be done to determine the best mortar mix : soil ratio.

Procedure:
• Lay on soil brick on another using different mortar mixes, with increasing sand content. (examples of possible mixes: only soil, 8 soils / 2 sand, 6 soil / 4 sand, 5 soil / 5 sand, 4 soil / 6 sand)
• Wait until the complete drying.

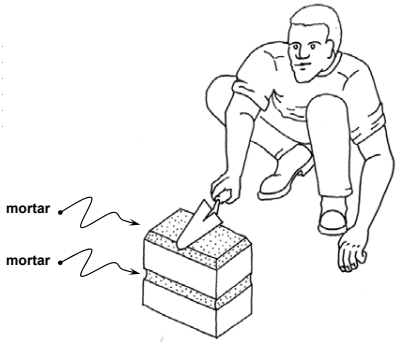
Result:
Choose the mortar mix that is the hardest and has the fewest cracks; and which gives the best adhesion between the two bricks.

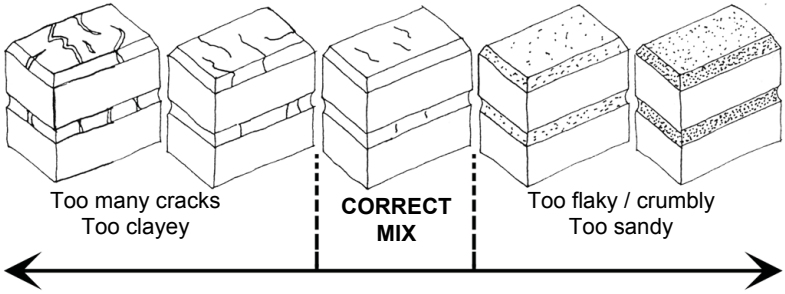
If quoins are added to improve the walls, they should be masoned with different mortar, which has closest characteristics with added items:

• stabilized earth for Stabilized Moulded Earth Blocks

• for fires bricks, there are three options:

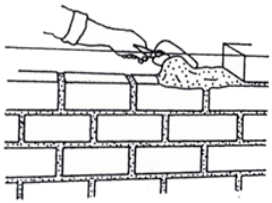
- earth mortar, repointed with an hybrid mortar: 1 part cement / 3 volumes of lime / 12 volumes of sand (with possible adjustment of the proportions depending on the quality of the lime)
- low dose coement mortar (150 kg /m3).



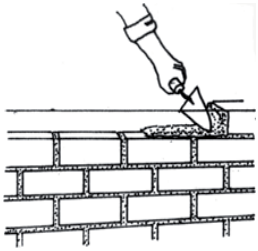


BLOCK LAYING

• Before laying the first course, it is recommended to lay the blocks dry in order to check thier right position and have joints of uniform thickness. This dry laying also helps to think about block bonding solutions of actual and future block layers to implement (first, second and other specific layers);
• Do not rise up more than 5 layers of bricks per day; this may have some effect on the settling of the mortar and affect the stability of the walls.

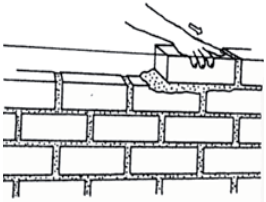


Lay enough mortar
(not excessive)

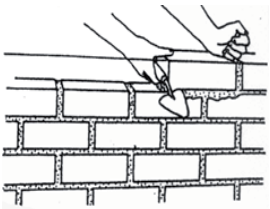


Spread the mortar evenly including the vertical face

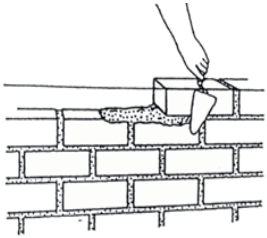
Wet bricks before using
A dry block will absorb the water of the mortar; therefore the mortar will not harden correctly.



Place the brick applying pressure evenly



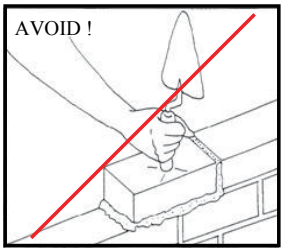
Position and fix the brick correctly without tapping



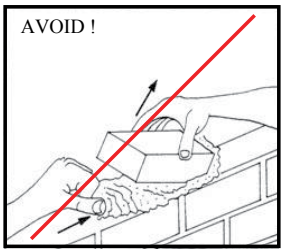
Remove the excess mortar

BLOCK LAYING

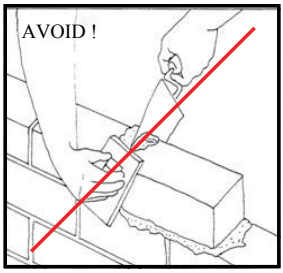
Do not strike the brick with a hard tool to put it in place. If there is too much mortar or if the mortar is too hard to push the brick down by hand, remove the brick and reduce the mortar.



Do not lift the brick and push some mortar under it to fi ll the gaps, it is better to replace the mortar completely in enough quantities



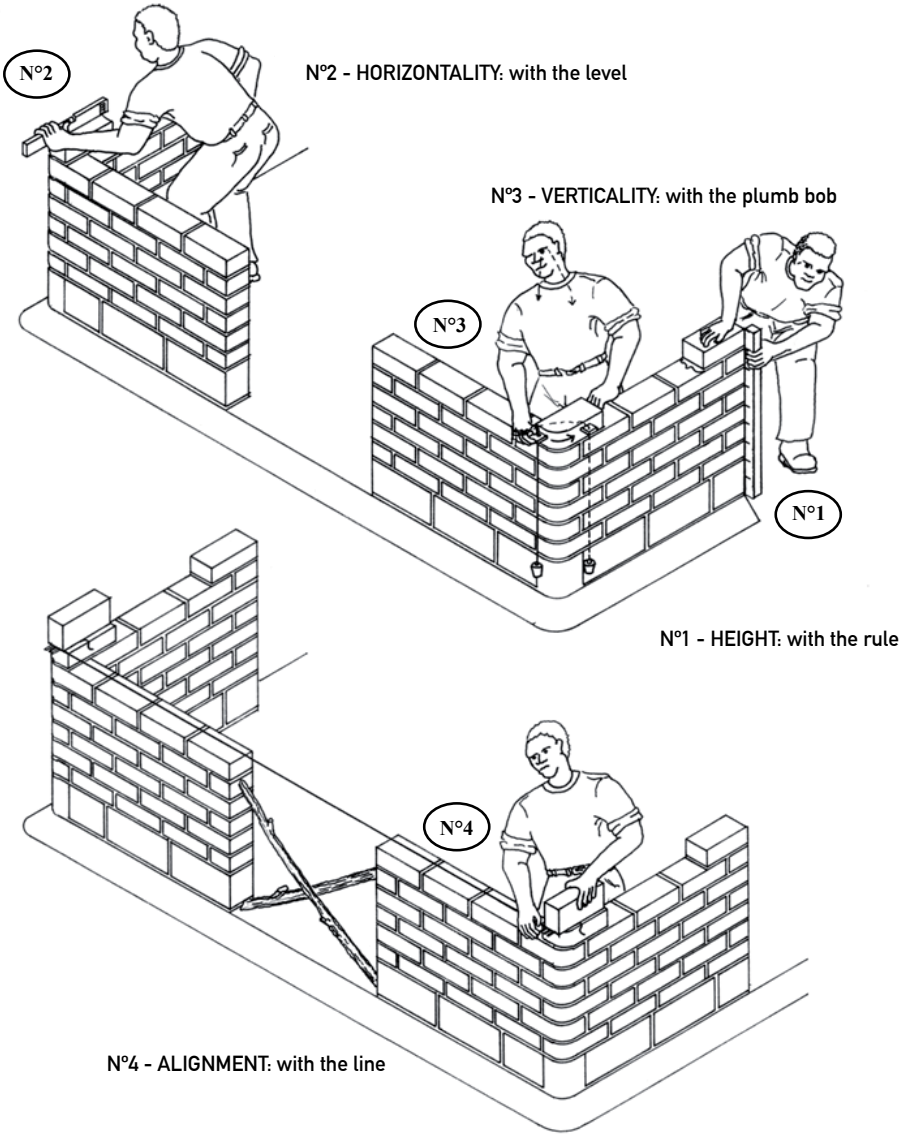
Do not fi ll the vertical joints after laying the bricks :
- Waste of time;
- Risk smearing the bricks;
- Risk of partial filling;



According to context, adobe constructions are often covered with coating. In this case, it is reccommended to slightly rake out the mortar joints on the facade (before drying of the joints) to provide a better gripping surface to the coating.

MANSONRY WITH DIFFERENT GUIDES

For each layer, start by laying the corner block, and check:



04

OPENINGS

The openings (windows, doors…) represent a weak point in the structure of the building.

It is often from the openings that appear many cracks. Therefore it is neces- sary to look after their solidity.

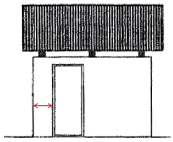
04

04.1 - DIMENSIONS

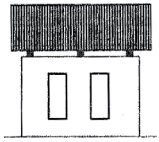
It is necessary to respect some rules in the construction of openings :
- Do not make openings too close one from another (minimum 1 meter) (3'4");
- Do not place the openings less than 1 meter from an angle of the building;
- Well anchorage the lintel in the wall: support it on a minimum of 25 cm (8") inside the wall on each side of the opening.

It is necessary to avoid :
- Too large openings (more than 1.20 meters) (4');
- Too many openings on a same wall or openings badly equilibrated in the wall.

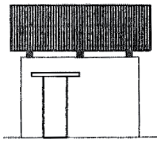
CORRECT PRACTICE



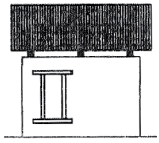
Openings are placed at least 1 meter far from the corner



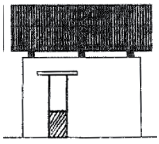
Regular distribution



Good overlap of the lintel on the jambs (min 25 cm)



Strengthening of the jambs and sills



Straight joints in the wall under the window

04

04.2 - LINTELS

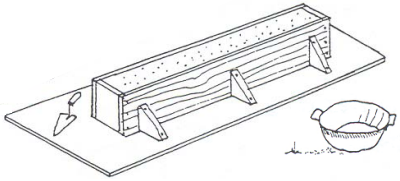
Lintels are placed over openings to carry wall and roof loads.

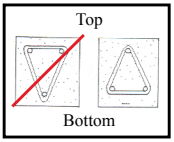
Can be used :
• Wood lintels;
• Prefabricated concrete lintels: before molding a lintel, calculate its weight to ensure that workers can lift it without risk. The rebars (reinforcement) should always be placed at the bottom of the lintel. It is then op- portune to put a mark on top of the lintel during prefabrication, to avoid mistakes during implementation and implement the lintel with bars on the bottom part.
(Wood or concrete lintel is installed with the same mortar as used for bricks laying.)
• Prefabricated Stabilized Moulded Earth Blocks lintel: Because bricks have little tensile strength, they can't be used for straight lintels on their own. They must be used with other materials such as steel and cement. U-shape brick can be used to precast reinfor- ced concrete lintels. The length of these lintels shouldn't be more than 4 + 2 bricks, 4 bricks being the width of the opening.

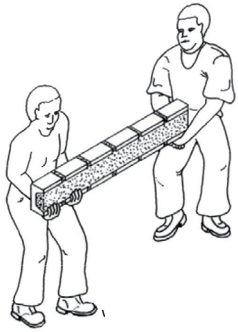
• Arches: As the prefabricated lintel with SMEB, arch lintel in earth block has the advantage of keeping a structural homogeneity of the wall and facilitating application of a plasteron the wall. Arch lintel with MEB avoid to the use of wood and is very inexpensive.

WOOD LINTELS

PREFABRICTAED LINTELS

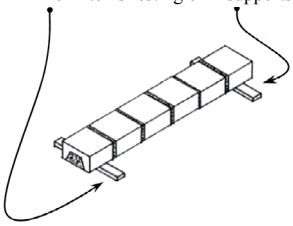






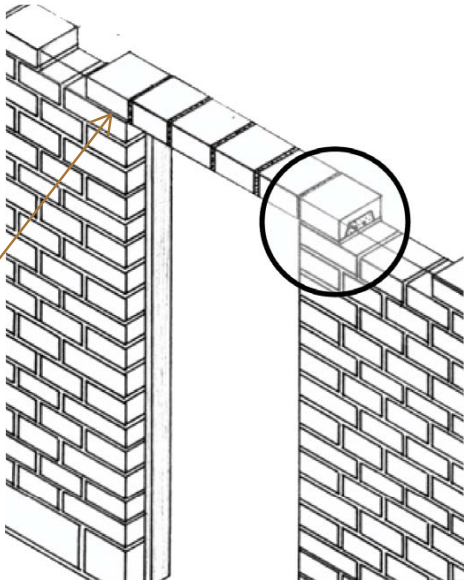
Transport :
Do not hold the bricks when lifting up, but hold the concrete part
The concrete should always rest either at the bottom or on the side.

Stocking:
• The rods are placed at the bottom
• The lintel is resting on 2 supports



Transport :
Do not hold the bricks when lifting up, but hold the concrete part
The concrete should always rest either at the bottom or on the side.

WARNING !
Leave a 5 mm gap without mortar between the frame and the lintel to allow the lintel to go down when the masonry will settle down.
(Shrinkage due to settling of the mortar and loading)



ARCHES

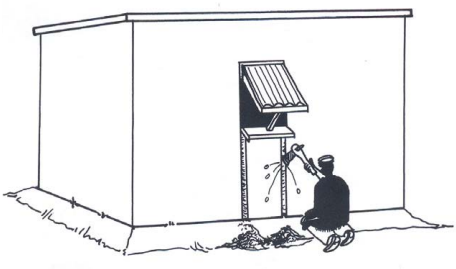
04

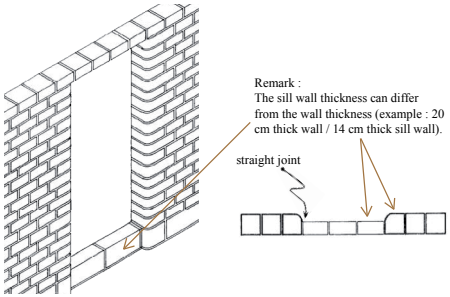
04.3 - SILL WALL

The jambs are very solicited by the loads transmitted from the lintel by the sides of the opening, while the sill supports little weight. To avoid the cracks under the sill, it is possible to create straight joints under the opening.

They can be realized either during the construction or after the construction, while jointing or pointing with a tool.

It is also possible to increase the length of the sill or put some reinforcement underneath.
Building the sill wall at the end offers 2 advantages :
- Easy circulation of materials and equipment on site, as all windows serve as doors;
- The possibility to create 2 straight joints and therefore avoids cracks between the main wall and the sill wall.





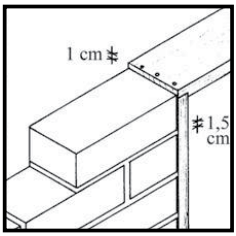
04

04.4 - ANCHORING

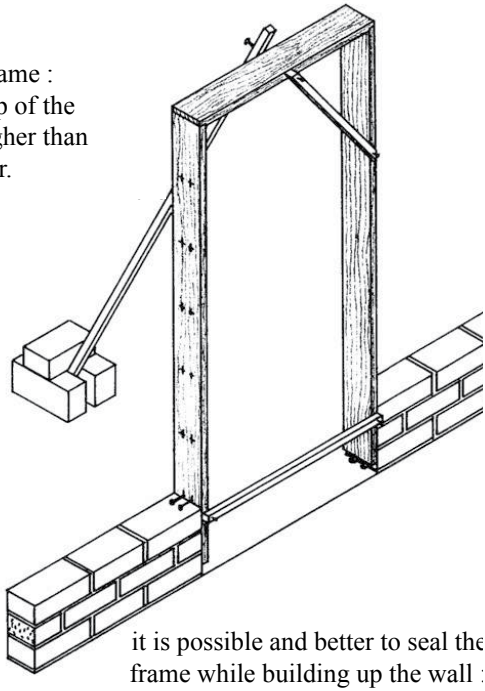
The vibrations and shocks resulting from the manipulation of the doors and windows can cause some cracks in the walls.
It is therefore necessary to anchor well the joineries in the masonry.

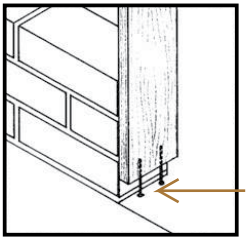
There are several possible solutions for the anchorage :
• Put in place the door and window frames before building up the walls, and fix them with nails or wire at the level of a mortar joint;
• Put in place in the same way the frames before constructing the walls, but fix them in the masonry with special U shape blocks permitting to sink concrete for a better anchorage;
• Integrate some wood in the masonry aound the windows, also makes it possible to nail or screw thereafter frames.

PUT IN DOOR AND WINDOW FRAMES BEFORE BUILDING UP THE WALLS

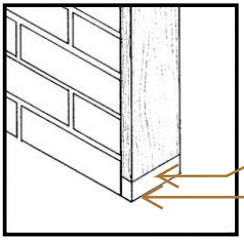


Position of the frame :
Make sure the top of the frame is 2 cm higher than the last bricklayer.





At the base :
In case of wood frame, wood is not in contact with the ground to prevent moisture or termite attack.



it is possible and better to seal the frame while building up the wall : 2 nails every 3 layers, inserted in the mortar joints.

PUT IN THE SAME WAY THE FRAMES BEFORE CONSTRUCTING THE WALLS

INTEGRATE SOME WOOD

Sealing frames during brick work. Align the position of anchoring and U-shape blocks

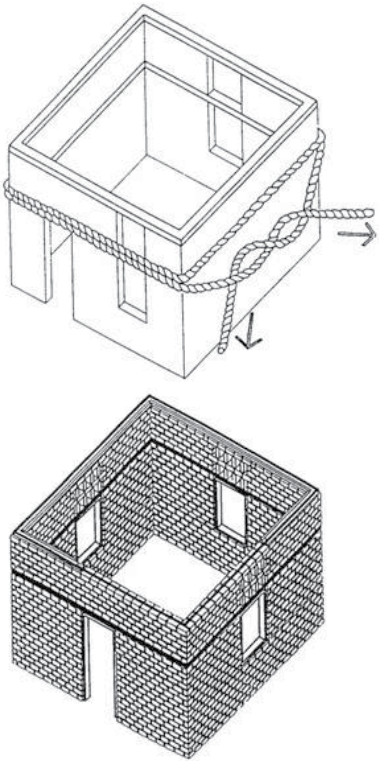
05

RING-BEAM

A reinforced concrete or wood bond beam is built at the top of a CEB wall to tie all of the walls together, level the walls, provide an anchor point for the roof or act as continuous lintel for the openings.

The main role of the ring beam is to link the walls, to tighten the building in all directions.
To assure its function, and to resist the strengths of traction, the ring beam must be rigid and unalterable and without discontinuity all around the building.

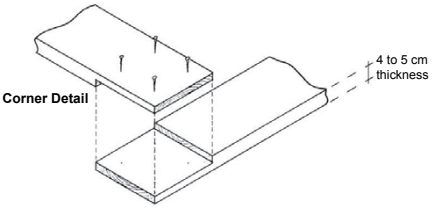
Important :
The ring beam is positioned under the last layers of blocks. Therefore, the ring beam is loaded with the top layers of blocks, and avoids any movement of pieces of walls (the height of the wall over the ring beam should be of 3 layers minimum).



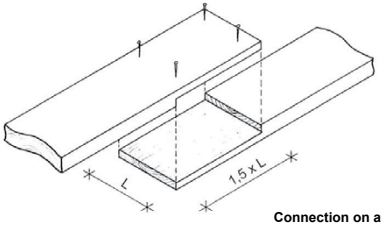
WOODEN RING BEAN

Ring beam must without discontinuity all around the building. Before installing, wood should be well treated against insect attack.

Since earth does not adhere to the wood, it must then apply the plaster on the wall in two distinct parts: one under the ring beam and another one above, without plaster on the wooden ring beam.



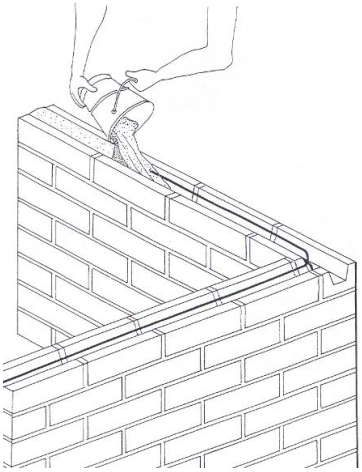
Corner Detail

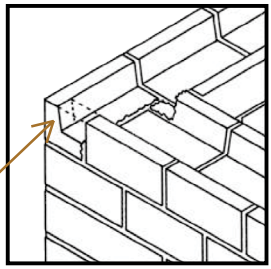


Connection on a vertically continuous wall

U-SHAPE BICKS, USED AS LOST FRAMEWORK

Advantages of U-shape bricks :
- Quantity of concrete is reduced;
- Walls remain clean with continuity of material (blocks), allowing then to apply the plaster over the entire height of the wall;
- No formwork is needed saving time and materials (wood);
- Brick laying can continue immediately after pouring the concrete.





In the corners :
- gently break the U-shape blocks,
- fill up the cavity with a soil mortar.

06

ROOF / WALL BOND

Strong winds can pull out the roof and disunite the walls. To reduce the risks of distortion and uprising of the roof, it is necessary to bond the roof to the wall.

The selected anchorage solutions should be very strong and well dimensioned.
Anchoring the roof to the exterior walls, and also possibly to interior walls, is necessary. Preferably, anchor to the ring beam (in wood, steel, or concrete) rather than to isolated supports.

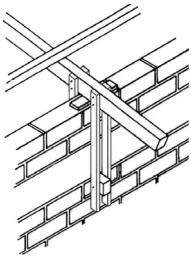
06

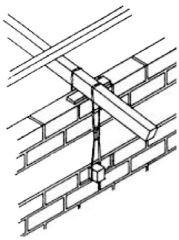
06.1 - ROOF ANCHORAGE

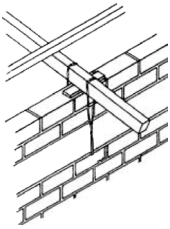
EXTERNAL ROOF ANCHORAGE

The roof truss is fixed to the timber section built in under the ring beam with 4 battens.

The anchorage can also be achieved by using steel cables that connect the roof truss to the timber section built in under the ring beam.



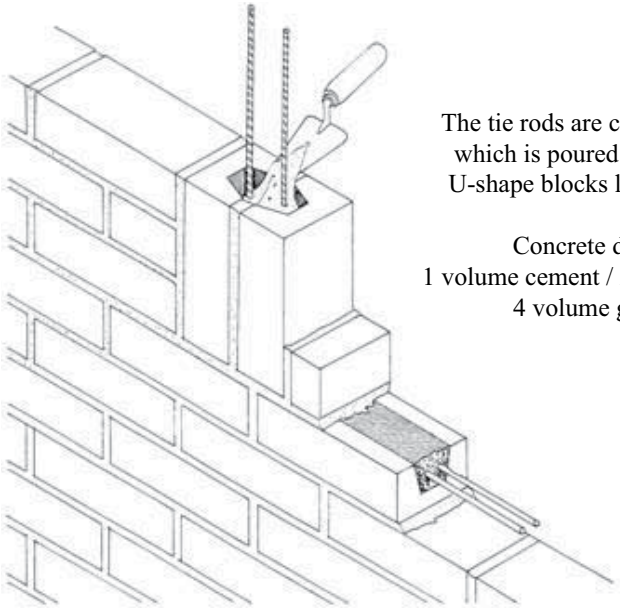




HIDDEN ANCHORAGE

To anchor the roof to the ring beam, iron rods (1/4") should be cast in the ring beam and brought up to the trusses. The height of the wall over the ring beam should be of 3 layers minimum. This connection can be done by passing iron rods :

• through vertical U-shape frog bricks filled with concrete.



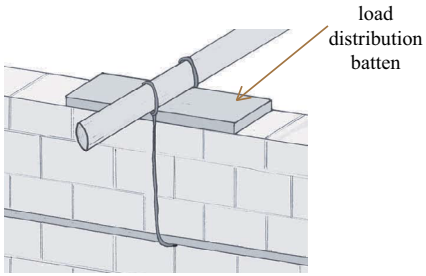
The tie rods are cast in concrete which is poured between two U-shape blocks laid vertically.

Concrete dosage :
1 volume cement / 2 volume Sand / 4 volume gravels.

06

06.2 - ROOF SUPPORT

A batten distributing the load of the trusses is positioned above the wall to avoid loads concentration and cracks on the wall.

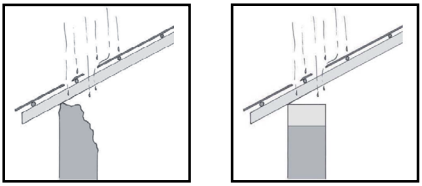


06

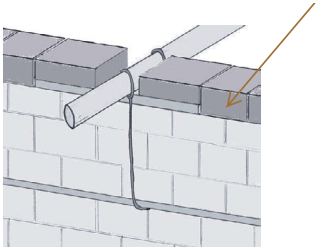
06.3 - TOP OF THE WALL

Top of the wall is a delicate point of the building: water infiltrations or effects of condensation under the roof covering can cause damages and erosion of the wall.

A solution could be to lay a waterproof material on the top of the wall, as Stabilized Moulded Earth Blocks. The water proof course must be as homogeneus as possible with the rest of the wall, so as to avoid the same issue between this course and the wall below.

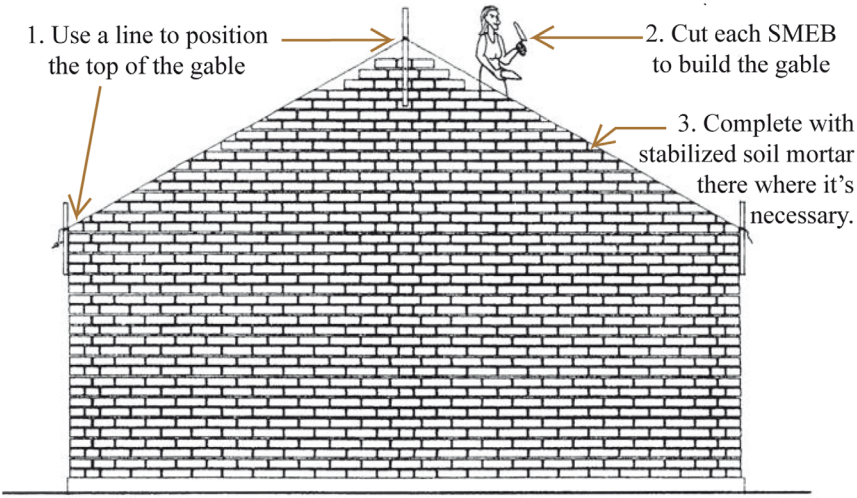


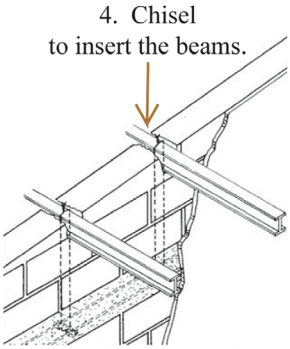
The final course course of the blocks between trusses should be made out of stabilized earth blocks (or fired bricks).



GABLE WALLS

For gable walls, the same principle is applied: Satbilized Moulded Earth Blocks with a stabilized soil mortar.





5. Tie and seal the beams with the same mortar.

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