Earth Architecture : Building Future With Ancient Technique

Satish Kumar Lohar[1], Dhananjay Deshmukh[2]
[1, 2] Dept of Architecture
[1, 2] Tulsiramji Gaikwad-Patil College of Architecture, Nagpur

Abstract- *This paper is focusing particularly on the innovations done in last few years in the field of earth construction that can lead to its better use as a building material. This research deals with earth as a building material, and provides a survey of its application and construction technique which is widely used that is rammed earth while explaining its specific qualities and the possibilities of optimizing them.*

Many assume that it's only used for housing in poor rural areas but there are examples of bungalows, offices, apartments and institutions that are made of earth. It's also assume that earth is a fragile, ephemeral material, while in reality some of the oldest extent buildings on the planet are made of earth.

Mud (wet, soft earth) is a natural material which after exploration can be used just the way other contemporary materials are used. If there are advantages about certain material then there are limitations and disadvantages too, that can be solved by studies, experiments and application of that material in different ways. Just because mud was used traditionally doesn't mean it cannot be used today in contemporary architecture.

For using earth as building material, rammed earth is best construction technique. This is the technique which is very often used and rapidly innovating with time as compare to other techniques.

Keywords- Construction Technique, earth, building material, traditional techniques, contemporary techniques.

I. INTRODUCTION

1.1 Aim

- To discover efficient earth construction technique.

1.2 Objective

- To understand ideology of earth materials.
- To study the various earth construction techniques.
- To analyze the contemporary earth architecture in respect to its construction.
- To review the possible innovative earth construction methods and study the minor details that can help improve its use.
- To review the appropriateness of the earth as building material in present scenario.

1.3 Need

- To get knowledge about the material and promote earth architecture.
- To create awareness about earth construction.
- To learn the potentials of earth building process.(Designing, construction, maintenance, reuse).

1.4 Limitations

- This paper is only about the study of rammed earth construction technique.

1.5 Methodology

- Understanding traditional earth construction techniques (internet, books and people).
- Gathering secondary data (internet, books, previous thesis done by others).
- Identifying problems related to earth architecture through articles.
- Completion of data, chapter writing and deriving conclusion.

II. LITERATURE STUDY

2.1Introduction

- Many assume that earth is only used for housing in rural areas but there are examples of bungalow, offices, apartments and institutions that are made up of earth.

- It's also assumed that earth is a fragile, ephemeral material, while in reality some of the oldest extent buildings on this planet are made up of earth.
- Earth is a natural material which after exploration can be used just the way other contemporary material are used.
- Just because earth was used traditionally doesn't mean it can't be used today in contemporary architecture, it has risen from those mud toys to mud huts and now to institutions, bungalows and multistory.

2.2History of earth construction

- Down through the ages, people have been using raw earth for building their living spaces.
- Every single continent, and nearly every country, possesses a rich heritage of earthen buildings.
- From the roof of the world in Tibet, of the Andes Mountains in Peru, to the Nile's shore in Egypt or the fertile valleys in china, many are the examples of earth as a building material.
- Earth construction techniques have been known for over 9000 years.
- Mud brick(adobe) houses dating from 8000 to 6000 bc have been discovered in Russian Turkestan.
- Rammed earth foundations dating from ca. 5000bc have been discovered in Assyria.
- Earth was used as the building material in all ancient cultures, not only for homes, but for religious building as well.
- In India, the oldest earthen building is tabo monastery, in spiti valley- Himachal Pradesh.
- It was also built with adobe and has withstood Himalayan winters since 996ad.

2.3Earth as a building Material

- Earth comes from the disintegration of the parent rock.
- This rock disintegrates into mineral particles with varying dimensions ranging from pebbles to clayey dust.

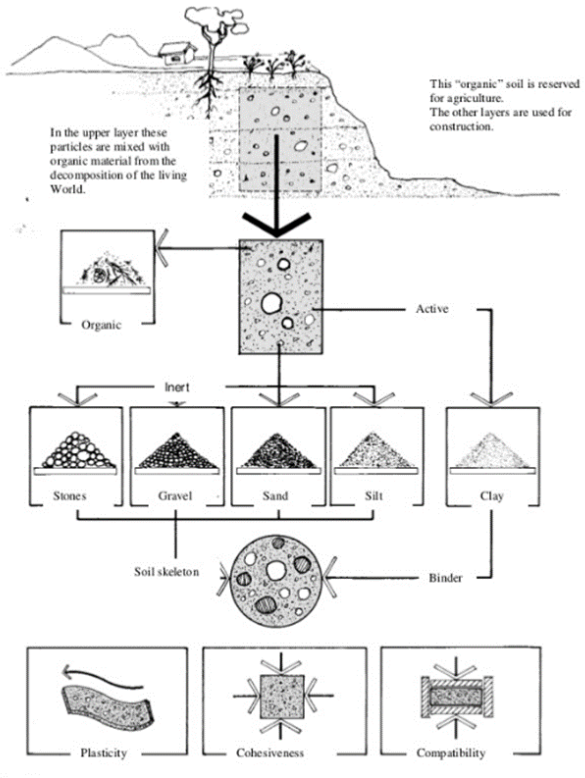


Fig 1: Earth as Building Material

2.4Traditional earth construction techniques

- These are the different types of earth construction techniques with different climatic conditions.
- But basically they categorized into how they are used.
- Types are as follows:

1) Dugout7) Stacked(Cob)
2) Cut blocks 8) Molded(Adobe)
3) Filled in 9) Extruded
4) Covered 10) Daubed
5) Compressed blocks rammed 11) Formed (straw clay)
6) Shaped 12) Poured

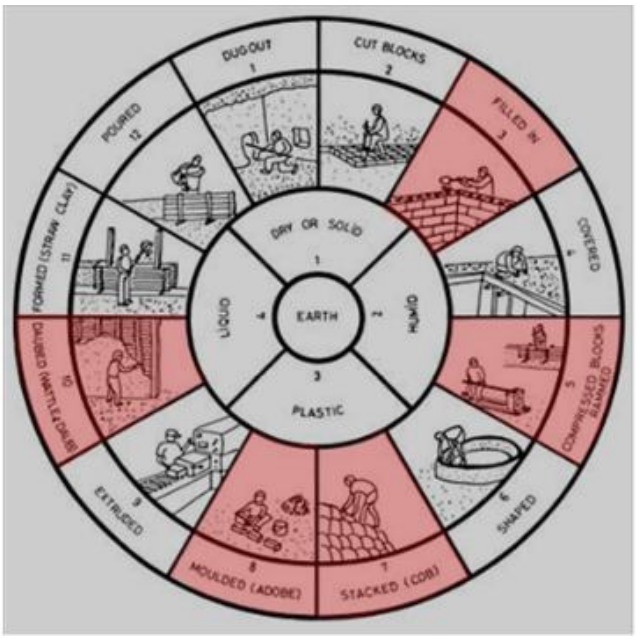


Fig 2 : Traditional Techniques

2.5 Contemporary earth construction techniques

- The techniques mentioned now included overall all the techniques of earth construction.
- Nowadays out of all those only few of them are used with their innovative applications and manufacturing.

1) Cob
2) Adobe
3) Wattle and daub
4) compressed stabilized earth block
5) Rammed earth

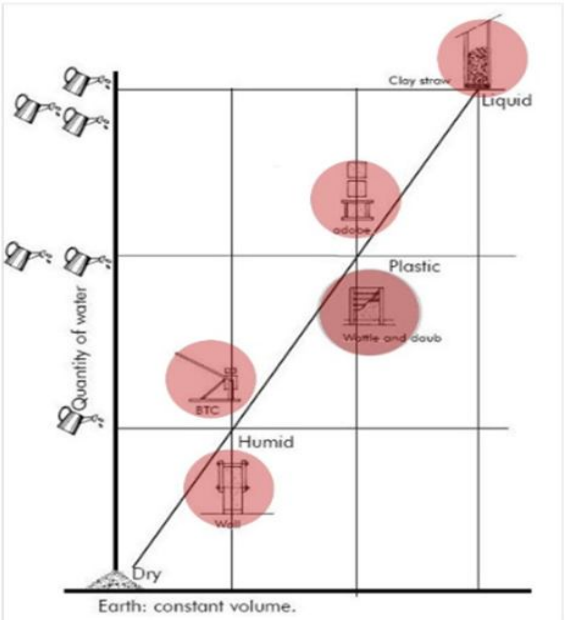


Fig 3 : Contemporary Techniques

IIII. INNOVATIONS IN EARTH ARCHITECTURE

- The research tells about the solution of problem associated with the earth architecture and it's divided into four parts according to the various stages of building process.

1) Designing
2) construction
3) maintenance
4) reuse

- Now, there are innovation, detailing and some necessary precautions that can overcome those problems, limitations and make earth construction as a viable system for building.

3.1 Designing

Factors to be seen before choosing earth as a construction material

1) Availability of raw materials- in the proximity of 20 kms is considered viable
2) Climate- mostly everywhere on each an every continent except Antarctica because of unavailability of raw materials.
3) Local labor- training min. Of 12 to 15 people is must for good earth construction.
4) Getting knowledge about the material thoroughly through books and resource people.

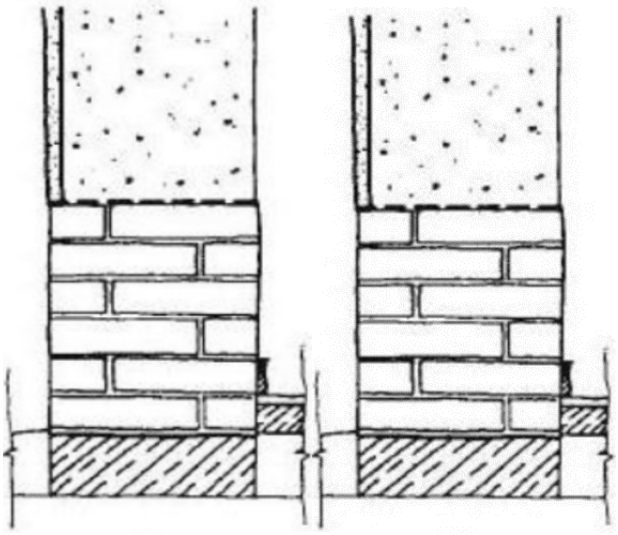
Factors to be kept in mind while designing earth building that can overcome the surface and structural defects :

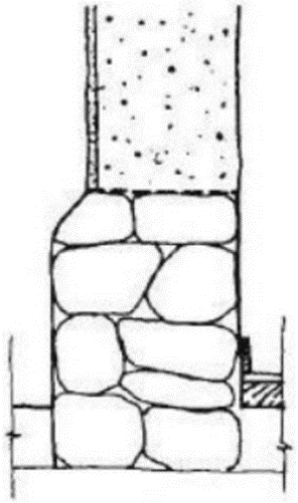
1) Wall thickness
2) Spanning members
3) Which technique to be used for construction
4) Number of story's
5) Corner junctions
6) Joineries and detailing to avoid water and termite penetration
7) Water is a major agent of decay for earth walls. Therefore, codes and other publications generally recommend not placing plumbing within earthen features

Protection from rain

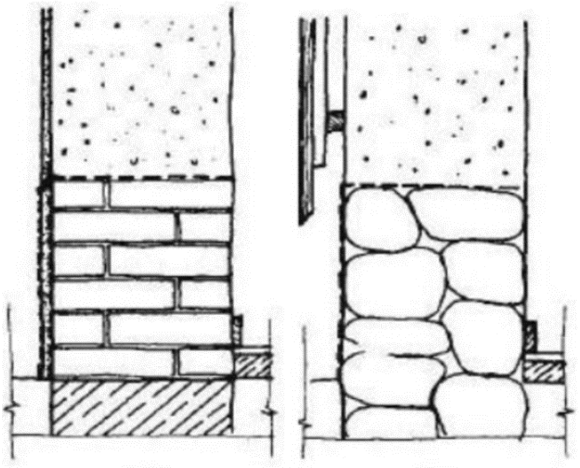
1) One method of preventing rain from coming into contact with a loam wall is to provide it with a roof overhang.

2) A sufficiently high plinth (30 to 50 cm) can protect from splashing rain.
3) Solution a and b may be acceptable in areas with little rain.
4) Solution c is common, whereas d and f show perfect designs for combating this problem.





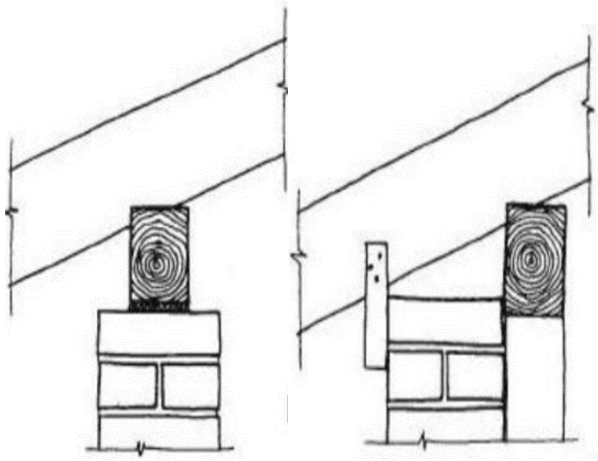
(A) (B)(C)



(D) (E)

Protection from shrinkage and cracks

1) In a, an elastic sealant has been introduced between the beam and wall in order to provide sufficient tolerance for this shrinkage.
2) In b, the structural system is separated from the wall, thereby allowing a greater vertical movement of the timber structure.



(A) (B)

3.2 Construction

- When it comes to earth construction techniques RAMMED EARTH is widely used earth construction techniques.
- The compressive strength of rammed earth is a maximum of 4.3 MPa (620 psi).This is less than that of concrete but more than sufficiently strong for domestic edifices.
- This techniques is suitable for most of the climatic conditions throughout the world. That's the only

reason it is the most preferable earth construction technique.

Process of construction:

1) After being excavated, the soil is thoroughly sieved, to break the lumps and make it lighter.
2) Big rocks should remove but some stones could be kept.
3) If the natural soil is too dry, it should moistened and mixed so as to get a uniform humid mix.
4) This method has developed from cob wall so as to standardize he thickness of the wall.
5) It is also an attempt to increase the strength of the wall by ramming it.

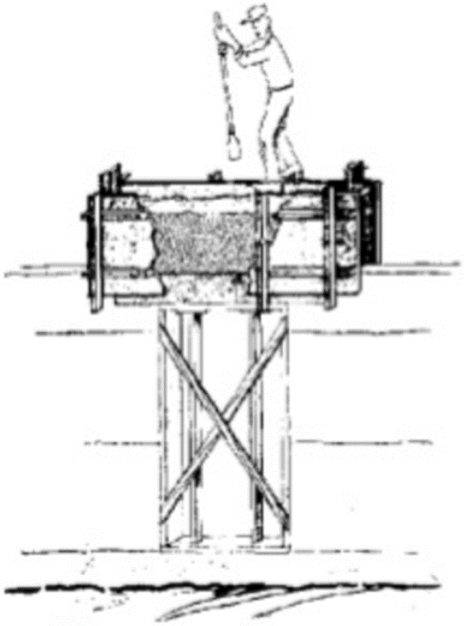


Fig 4 : Rammed EarthTechniques

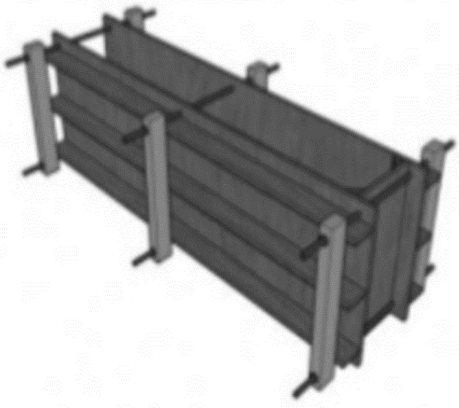


Fig5 : Rammed Earth Mold

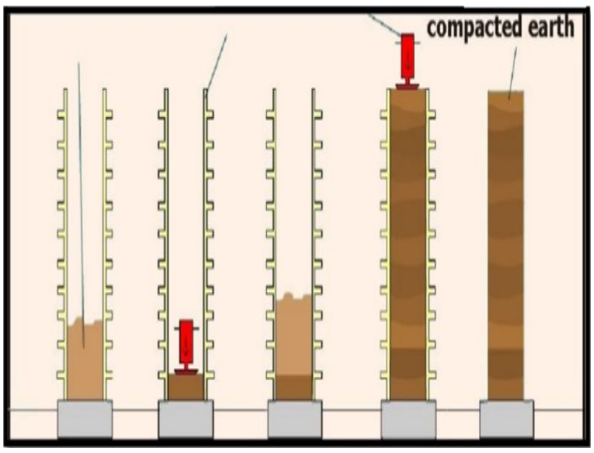


Fig 6 :Compaction Process

Solution for the Problems while constructing rammed earth:

1) Seismic activity, or any overhang force, causes cracking within the wall that leads in low tensile strength.

- Problem areas can be targeted.
- Steel rebar can be placed into the form and bound to the earth during the ramming process. This can occur at corners and over wall openings to provide stability and tensile strength.
- Instead of rebar, lintels of various materials or even arches can also be used over openings.

2) Extra compaction leads to failure of the wall during construction.

- The specific construction of rammed earth consists of “lifts” or layers of earth poured into formwork at a depth of eight inches and then compacted to five inches. This creates a striated earthen wall.
- Care is taken so that larger stones are moved away from the form. The edges are rammed first, and then the center until no further impressions result from blows from the temper.
- There are machines developed for ramming the walls.

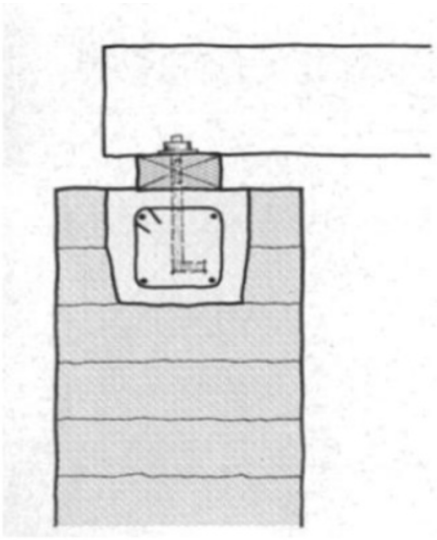


Fig 7 :Lifts

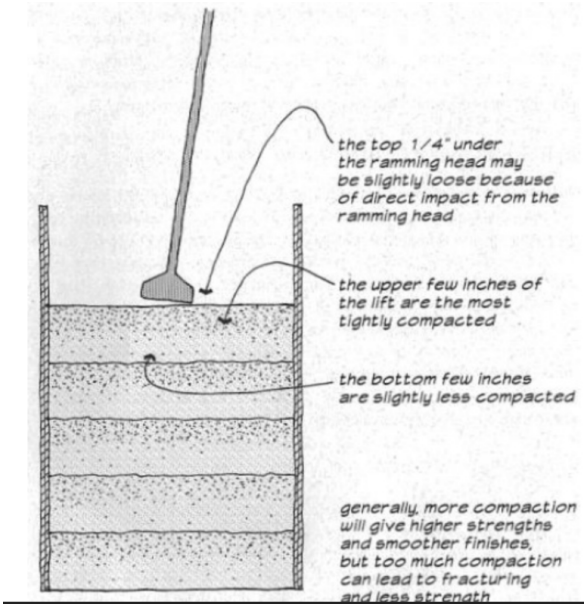


Fig 8 : Ramming Process

Fig 9 : Advanced Ramming Equipment

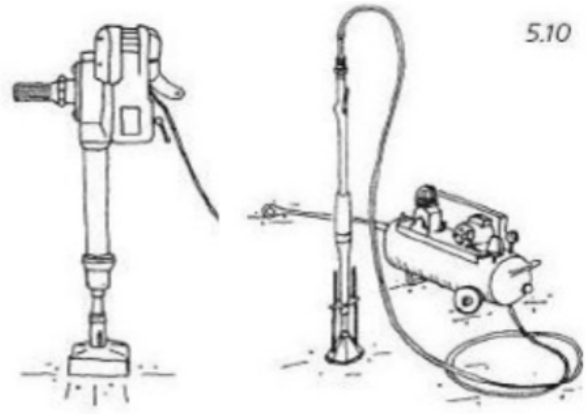


Fig 10 :Advanced RammingEquipment

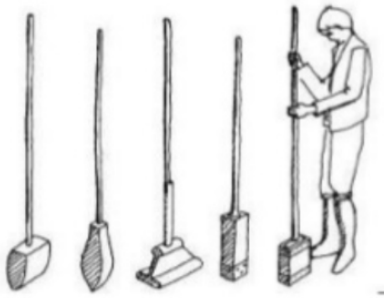


Fig 11 : Traditional Equipment

3) Much of the general concern with rammed earth, though, is its susceptibility to water. If the wall absorbs water, the bonds between particles lessen and crushing strength is reduced. Driving rain loosens smaller particles, which create larger holes and cracks within the wall.

- Common design techniques, such as deep over hangs (usually one-third the height of the wall), van begin to protect the wall.
- The addition of stabilizer will help with the water absorption. But as far as water damage goes, surface treatment can provide the best protection for rammed earth wall. Breathable finishes should be used to allow for water evaporation. DPC should be added always to solve water problems.
- Traditionally, stucco or plaster has been used and then painted over the rammed earth walls. Also, a lime wash (whitewash), bitumen with paint, emulsion paint, or oil-based paint can protect the surface. Still, with the desire to express the earthen quality of rammed earth, polymer emulsion (PVA) has more recently been used to seal the wall and protect it from wind and rain, left transparent for aesthetics.

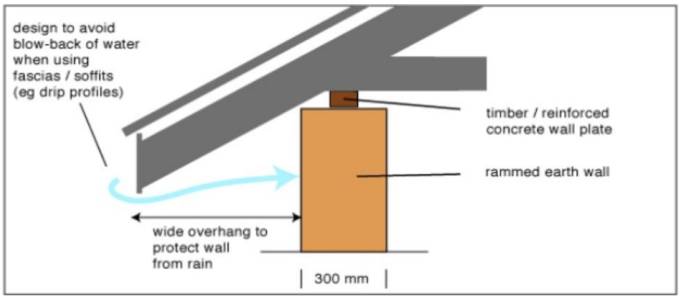


Fig 12 : Protection From Water(a)

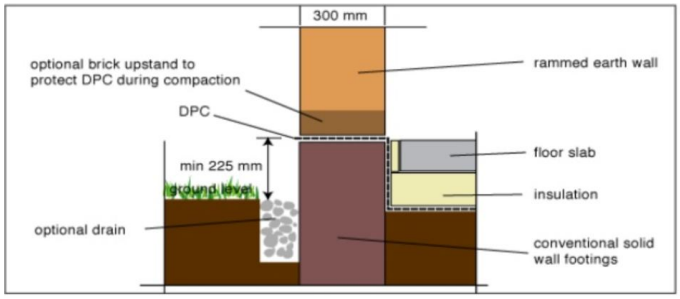


Fig 13 : Protection From water(b)

4) Problem of swelling and shrinkage of wall.

- This problem was solved by using a layer of lime mortar above each course before laying a new one.
- A lime mortar cures over several weeks and remains plastic until the loam has stopped shrinking; sometimes even the side joint between sections of the course is made with mortar at an incline.

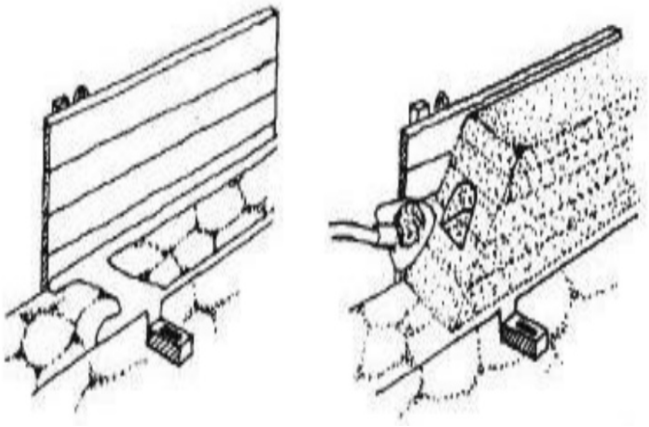


Fig 14 : Prevention From Swelling And Shrinkage(a)

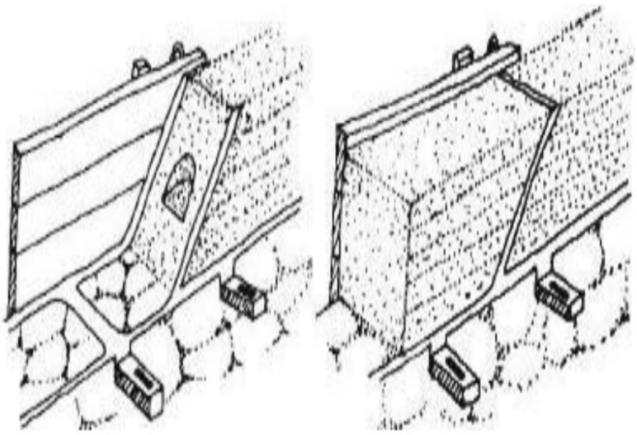


Fig 15 : Prevention From Swelling And Shrinkage(b)

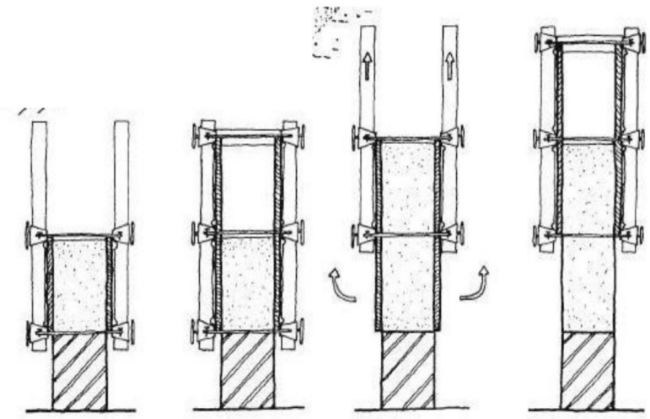


Fig 16 : Prevention From Swelling And Shrinkage(c)

5) With traditional formwork, the boards on both sides are held apart and kept together by spacers. These spacers pierce the wall, causing opening that must be filled in after removal of formwork.

- A system with very thin tensile spacers (4 x 6 mm) penetrating the wall has been developed.
- Formwork for curved walls also possible.
- With special formwork, rounded corners and curved walls can also be formed.

6) Formworks without intermediary spacers which are braced on both sides require a lot of space and hinder site movement.

- In order to completely eliminate this disadvantage, spacer-free system have been developed.
- One-storey height panels. With widths od up to 2.4, in continuous ramming process. This technique avoids horizontal joints, and the

vertical joints that occur are closed only after shrinkage is complete.

- For lateral stability, the vertical joints are made in a tongue-in-groove pattern.

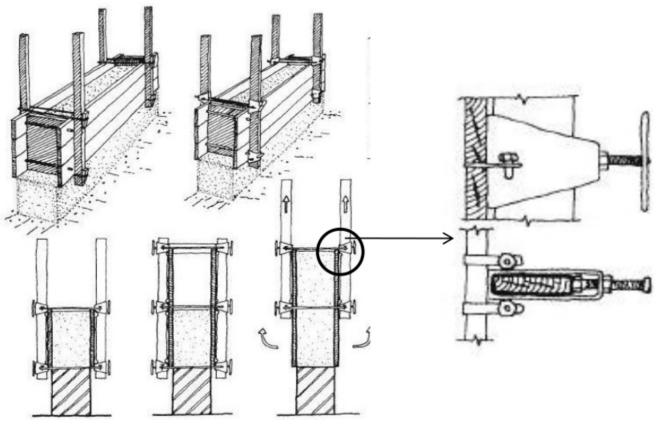


Fig 17 : Formwork(a)

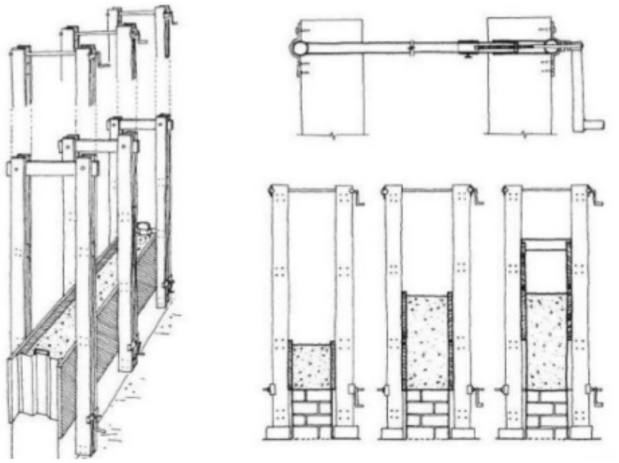


Fig 18 : Formwork(b)

7) Curved walls are not possible. Corner junctions are difficult to be made. Insulation for climatic variations. Patterns on walls.

- Some potential methods for making loam walls with improved thermal insulations are being developed are as follows :

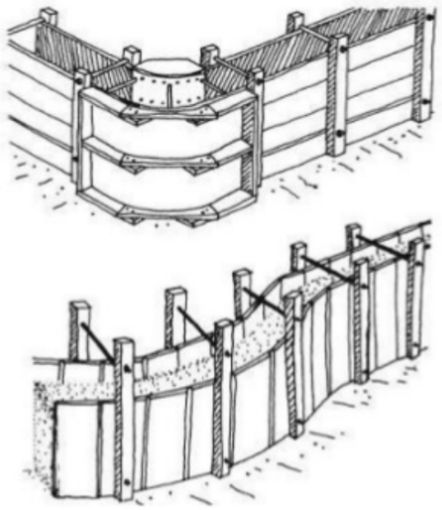


Fig 19 : Formwork For Curve shape wall

3.3 Maintenance

- With the right quality control measures in place, 75 years service life for an service life for an adobe or wattle and daub buildings is a very safe estimation.
- Sympathetic appropriate design has a significant role in minimizing maintenance.
- A well designed building with good detailing will require fair less maintenance than one designed with other materials in mind.
- Flat roofs, small overhangs and a general failure to provide protection from rainfall needs to be carefully considered.
- Loam surfaces can be dealt with by painting them with casein, lime-casein, linseed oil or other coatings, which make them non abrasive.
- One of the main quality requirements is therefore in protecting the walls from water.
- The entire earth wall needs to be protected using a watertight roof with generous overhangs.
- An appropriate coat of plaster will also give extra protection to the earth wall.
- There should also be a damp proof membrane included in each plinth for moisture protection.

3.4 Reuse

- Loam is always reusable.
- Unbaked loam can be recycled an indefinite number of times over an extremely long period.
- Old dry loam can be reused after soaking in water, so loam never becomes a waste material that harms the environment**.**
- According to Lal (1995, pl22), the major advantage of the stabilised soil block verses the burnt bricks is

the significant saving in energy (about70%) ad such blocks are cheaper by 20 to 40% compared to burnt bricks and the building is demolished can be reused and the broken bricks merge with the existing soil.

IV. CONCLUSION

- Hence we can conclude that, rammed earth is the best earth constriction techniques for the building construction.
- Not only for the dry climatic conditions but also where Rainfall is good we can use this technique.

V. ACKNOWLEDGMENT

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