International Journal of Research in Engineering, Science and Management
Volume-1, Issue-10, October-2018
www.ijresm.com | ISSN (Online): 2581-5792

Earth Architecture

Mradul Khatod[1], Mohd. Simroz Khan[2]
[1]*Student, Department of Architecture, SDPS Women's College, Indore, India*
[2]*Assistant Professor, Department of Architecture, SDPS Women's College, Indore, India*

***Abstract*—This paper deals with a research on Earth Construction Techniques. Various aspect of Earth as a building material. Research contains the analysis of various types of soil that can be used for construction according to their strength, suitability and availability.**

The research also highlights the resistance of Earth construction as per case studies and literature review. And majorly focused on adaptability of earth construction methods on high notes.

***Index Terms*—Earth Architecture, Conditions of soil. Kinds of Stabilizers, Techniques of earth construction**

I. Introduction

Earth, the medium through which we can connect ourselves from the nature. Earth is the widely available material that has been used from decades. Like all materials this is also has its own limitations, but these is not of much problem as there are many research going on for the improvement of soil as a building material.

Earth usually requires some sort of processing for use in construction. It may be combined with water to make mud, straw may be added, some form of stabilizing material such as lime or cement may be used to harden the earth, and the earth may be compacted to increase strength. There are various set examples in our history through which we can take inspirations.

II. Objective

- To understand the advantages and limitations of earth as a building material
- Its properties and testing procedures
- How it can be improved through stabilization
- The main design and building requirements
- The most relevant constructions techniques that are used in the industry today.

III. Methodology

To achieve the objectives of the study the following methodology is proposed:

- Detailed literature review related to Earth Architecture is carried out.
- Detailed case studies related to Earth Architecture
- Analysis will be carried out through different built examples

IV. Construction Techniques

- *Rammed Earth:* Rammed earth is a method of building walls whereby a selected mixture of earth, sand and aggregate is compacted in layers between forms. Each layer is approximately 15 cm (6 in) deep. As each form is filled, another form is placed above it, and the process begins again. This is continued until the desired wall height is achieved. A wider range of soils are suitable when a small amount (approx. 6%) of cement is added to the mix. The result, known as 'stabilized rammed earth', is an extremely durable and attractive masonry product with numerous benefits.
- *Cob:* "Cob" (the English term for mud wall construction) is direct shaping of plastic earth to build walls, and uses no forms, bricks, nor structural framework. As a natural Building material, it is a combination of about 75-85% of sand/ aggregate, 15-12% clay, mixed with straw and water. The rough surface is trimmed up and usually rendered, which leads to a soft, undulating look of wall. Any type of clay can be used but be careful not to use silt which can sometimes appear like clay.
- *Adobe blocks:* Adobe bricks (mud bricks) are made of earth with a fairly high content and straw. If produced manually the earth mix is cast in open moulds onto the ground and then left to dry out. Adobe bricks are only sun dried, not kiln fired. When used for construction they laid up into a wall using an earth mortar. Before drying out, the finished wall is smoothed down. Often a clay render is applied as a surface coating.
- *Compressed Earth Blocks:* They are primarily made from damp soil compressed at high pressure to form blocks. Compressed earth blocks used a mechanical press to form blocks out of an appropriate mix of fairy dry inorganic subsoil.
- *Poured Earth:* This technique involves mixing water with the earth until it can be poured it into molds without creating voids – typically about cake-mix consistency. The mix is placed into molds set up directly in place on the wall, and once it has set the mold is removed.

The mix used in this technique has much higher moisture content than rammed earth, so the shrinkage is potentially much higher. This means that the soil mix has to be carefully

controlled to avoid unsightly and structurally damaging cracks opening up as the material dries. Sometimes the molds are set up in a castle-like pattern, and the intervening gaps are filled with a second pour after some shrinkage has taken place with the setting of the first pour.

V. Kinds of Stabilizers

- *Sand and clay:* If the soil is too much sandy/clayey then add clay/ sand accordingly
- *Portland cement:* It must be very thoroughly mixed with & soil clods should be broken down.
- *Lime:* Lime breaks the lumps down and makes the soil easier to mix.
- *Combinations of lime and cement:* Lime won't react enough with soil to water proof it or make it strong, add cement.
- *Asphalt:* Asphalts do a good job of water proofing and they keep the soil from losing strength when wet.
- *Straw:* When your soil is a little too clayey and you have no other way, then you use straw.
- *Fly-ash and lime combinations:* They almost as good as port land cement. It can be used on both sandy and clayey soils.
- *Cow urine:* It enhances the property of mud and enables good curing of soil.
- *Wood ashes:* Certain wood ashes can actually be harmful instead of stabilizing the soil, so you will to try it out on your soil.
- *Coconut oil:* It is a waterproofing agent, probably increase the wet strength of the soil.
- *Resins:* They can make very good waterproofing agent, ask the manufacturers how to apply it.
- *Cow dung:* The 1:4 ratio of cow dung/soil had the highest compressive strength and the highest resistant to erosion.

VI. Conditions to Soil

Nearly any soil can be made into a better building material with the addition of the correct stabilizer. According to the suitability of soil the stabilizers are mixed. There are various kinds of stabilizers mix with the soil for improving their stability.

TABLE I
Sandy Soil

Name of soil	Suitability for Earth Homes	Stabilizers
Silty-sands	Usually suitable if stabilized. If almost a "clean" sand it may be necessary to add more fines	Portland cement is best. Asphalt emulsions may work clayey fines
Clayey sands	Usually very suitable for all types of earth houses If almost clean, may add some clayey fines	Lime is best. Portland cement will work if soil mixes easily
Clean sands	Not suitable for earth houses unless mixed with fines	Clayey fines

TABLE II
Silty Clay Soil

Name of soil	Suitability for Earth Homes	Stabilizers
Very fine sands, silty fine sands, clayey fine sands, clayey silts	Usually suitable for all types, particularly adobe if stabilized	Portland cement most suitable. Asphalt emulsions also work as do most water proofers
Silts, very	Should not be used if possible. Stabilize heavily if necessary to use	Portland cement, asphalt emulsions if soil is not too sticky
Gravelly clay, sandy clay, silty clay	Will usually require stabilizers most suitable for rammed earth and pressed blocks	Lime Sand Gravel
Clays, fat clays	Should never be used for earth houses	-
Organic silts, organic silty clays	Should never be used for earth houses	-

TABLE III
Gravel Soil

Name of soil	Suitability for Earth Homes	Stabilizers
Silty gravels, sand-silt gravel mixtures	Usually suitable if it is first stabilized. If almost a "clean" gravel it may be necessary to first add more fines	Portland cement most suitable. Asphalt emulsions may also work.
Clayey gravels, gravel sand-clay mixtures	May be very suitable for all types of earth houses. If almost clean, it may be necessary to add some fines	Lime most suitable. Portland cement may work if soil mixes easily
Clean gravel	Not suitable for earth houses. Can be mixed with fines (silt or clay) to make suitable soils for earth houses	-

VII. Case Study

A. Office Building, New Delhi, India

Architect and supervisor: Gernot Minke, Kassel, Germany
Collaborator: R. Muthu Kumar, New Delhi, India Energy concept: N.K. Bansal, New Delhi, India Completion: 1991
Area: 115 m^2
Foundation and plinth: Burned bricks
Vertical walls and domes: Stabilized soil blocks
Vaults: Handmade stabilized adobes
Surface treatment: Cow dung-mud mortar with water repellent
Skylights: Acrylic glass with openings for natural ventilation

This office building was constructed in order to prove that domed and vaulted rooms built of earth blocks are conducive to a better indoor climate and can be more economical than traditional buildings with flat concrete roofs.

The project was built as part of a research and development project. The building provides office and laboratory space for a research group with a usable area of 115 m^2. The central hall

acts as a multi-purpose room for seminars, meetings and exhibitions. The three domes were built of soil blocks.

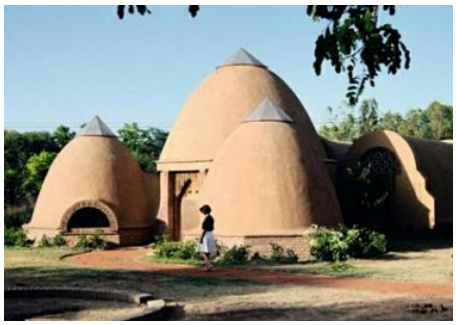

Fig. 1. Office building

B. Eco-Friendly House, Kolhapur, Maharashtra, India

Designed by: Mr. Rahul Deshpande (Eco Spiritualist and Rural Reconstructor)

It is a double storey house where they have used Mud as a mortar and as a plaster. Flooring is also a Mud flooring that is beneficial to health. Have Mud roof tiles which is excellent ventilator and requires no fans. They have save 31000 of cement and 4500 kg's of steel.

Fig. 2. Eco-friendly house

VIII. Conclusion

It is said that simplicity is prosperity. Earth as a form of nature has lot of advantages. Its simplicity and ecofriendly nature gives us a way to create anything from it. Its dual nature of cooling and heating and because of its various properties, it gain its importance in construction industry. Today many Architect's, Architectural firms, Rural constructors, Institutions, Construction industry were trying to elaborate and spread the use of Earth as building material. Government also trying to incorporate Earth as a building material as well as in renovation of our historical monuments.

The time involved in the construction is more/less depending on the materials and techniques of construction. The building of masonry walls from adobes, from sun-dried, unfired earth blocks, will continue to be a dominant technique simply because such techniques can be used by masons in all parts of the world without special training. Adobe domes and vaults are an economically and structurally valuable alternative to the usual flat or slightly inclined roofs of sheet metal, asbestos cement or reinforced cement concrete. They will certainly be used with greater frequency once an understanding of their potential becomes more widespread.

The rammed earth technique is favorable for moderate and warm climates, and is also economical, especially if used with adequate equipment and mechanized technology.

References

[1] www.solidearth.co.nz
[2] www.archinomy.com.
[3] https:/whc.unesco.org/en/earthen-architecture
[4] https:/www.earthhomesnow.com
[5] https:/www.sciencelearn.org.nz/resources/957-soil properties
[6] https:/www.tutorialspoint.com/geography
[7] www.cobcources.com
[8] Agris.fao.org
[9] www.nzdl.org
[10] www.fao.org
[11] www.getty.edu
[12] Building with earth 2016
[13] Geotechnical Manual
[14] A Handbook for Building Homes of Earth [Peace Corps]