

# Earth Architecture: Earth as a Building Material

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**Abstract:** *This paper is concise discussion on how earth can be used as a construction material and how feasible it is in providing affordable housing to low income group and economically weaker section of our society. In modern time we are face a huge shortage of conventional building materials such as “OPC - Ordinary Portland Cement” and Steel for reinforcement. These two materials have large significance in construction industry are not only very costly but also have very diverse effect on our surroundings. Due to the height demand of ordinary Portland cement and steel there price are rising every day due to which it has become very difficult to provide affordable housing to the weaker section of the society. And not only in terms of cost has the constant use of this conventional material been causing severe damage to our society. There for earth can be a great asset to us. Which not only reduces the cost of construction as it is available in abundance around us? But also help us preserve our environment due to its organic properties.*

**Keywords:** Earth construction, affordability, low cost housing, economically weaker section, low income group, sustainability

## 1. Introduction

To provide a single dwelling unite we require various different types of construction materials and unique techniques due to which there is always a hefty load on supply chains. And normally there is huge shortage of materials due to their height demand and short supply which causes hike in their prices. Due to these constant material shortage and hike in there price it is becoming difficult to provide affordable housing to weaker sections day by day. To get rid of this problem we have to search for the alternatives of these conventional materials. Ideally materials used in low cost housing or affordable housing should be locally available and manufactured. In our surrounding earth is available in abundance and has been in use for several years. There are traces of earth construction and use of adobe blocks from the earliest of the civilization known to us. Such as Mesopotamian, dated from 10, 000 BC and Assyrian from 5, 000 BC. In archaeological survey traces of rammed earth foundation and sundried bricks are found respectively. There are some historic monuments made totally out of earth like temple of Remses II at Gaurna Egypt fig.1 and Citadel of Bam at Iran (Johan Vyncke1, 2018) fig.2.

The conventional construction materials like Ordinary Portland Cement are manufactured in factories which involve different raw materials which are carried to the plant by the means of transportation which makes the manufacturing more expansive and use of fossil fuels make the process environmentally unfriendly. Whereas earth provides a great alternative to these conventional material with out to having any much negative impact over surroundings.



Figure 1: Temple of Remses II



Figure 2: Citadel of bam

## 2. Sustainability of earth as a material

Any building which is called sustainable is not just because of its design and layout but also for the kind of materials has been used for its construction and the type of construction techniques which has been adopted during its construction. The sustainable development is amalgamation of all three factors design, material and construction techniques due to which we succeed to reduce environmental impacts. Choice of material plays an very important role in sustainability of any building (Burele, 2016). Through which we aim to:

- Transportation related environmental impact.
- To reduce embodied energy associated with manufacturing of material



And earth succeeds in achieving both the above aims due to its presence in abundance around us and nontoxic nature due to which it is highly environment friendly. And mostly earth used in construction is excavated from the site or nearby site only there for pollution exerted through transport is minimal and no heavy machinery or special raw materials require for stabilization of earth which cost of manufacturing and embodied energy associated with it are also minimal. These factors make earth construction sustainable in nature (Burele, 2016).

In current time earth has been advanced a few times as a maintainable construction material. As of late new current

methods have developed to improve execution of earth, for example, compacted earth blocks (ECB), rammed earth and cast earth. These cutting edge practices of earth development has been generally spread around the globe for instance Australia, France, USA and India. Furthermore, number of particular establishments in earth development has come into the presence till now like CRATERRE in France, DVL in Germany, and Auroville in India.

**3. Different use of earth as a building material**

These has been utilized generally as a walling material, nonetheless, different uses like, flooring and footing should likewise be possible with earth, contingent upon the methods and prerequisites around then of work. . Earth can be widely used as for different purpose by mixing with different stabilizing materials (El - Kabban, 2013)

	Rammed earth	Mud	Clay Straw	Light clay	Loam filling	Earth mortar	Earth blocks	Earth panels
Flooring	•				•			
Wall bearing	•	•				•	•	
Wall freestanding	•	•	•	•		•	•	•
Roof / ceiling			•	•	•		•	•
Dry construction							•	•
plaster			•	•				

**4. Use of earth as a modern building material:**

Manifestation of earth depends up on the kind of earth available in the region as characteristics of earth vary from place to place and characteristics of available supporting materials and technologies used. Some of the common use of earth are Adobe or Sun dried bricks, cob, Rammed earth, Pressed brick, Wattle and Daub etc.

**4.1 Adobe**

It is a natural binding material made by mixing earth with sand, water and some kind of fibrous material like thatch, straw and manure. This mixture is then filled in moulds. And after they get set are left exposed in sun to get dry. Buildings made with adobe are similar to cob and mud brick buildings. These buildings made by using adobe are very durable. Some of the oldest existing buildings are entirely made by using adobe blocks. In countries like India and West African countries adobe construction are very effective in terms of thermal insulation due to their greater thermal mass than that of wooden structures which are widely used in western countries. But the biggest drawbacks regarding adobe construction is they are very susceptible of earthquakes. Adobe blocks are common in practice in West Asia, Northern Africa, West Africa, South America, Spain, Eastern Europe and East Anglia.

**4.2 Rammed earth**

- It is kind of unbaked earthen development basically used to fabricate walls by their different applications is

in establishment, floors and rooftops. Also, presently a days has been utilized for furniture, garden adornments and different elements.

- Lose moist soil mixed with chalk, lime, sand and gravels are filled in temporary form work and compacted by the means of manual or pneumatic rammer layers by layers (100 to 150 mm deep). After mixture gets settled well the form work is removed.
- The distinctive layers can be seen in this kind of construction adding different color dies can result in interesting patterns on the walls.

**4.2.1 Prefabricated rammed earth:**

In recent years with advancement in technology prefabricated rammed earth techniques have been developed. Due to limited demand of the techniques there are very less practitioners of this technique. Prefabrication allows us high quality manufacturing of rammed earth elements which helps construction to achieve high extent of precession. As all the details of prefabrication carried out in presence of experts in specially set up plants the building cost of the construction get increases. It also requires transportation and machinery for lifting elements. (S, 2013, p.6) But the time taken to carry forward out the construction work is quite efficient and finishing to the final work is also very good for example rammed earth wall construction at Eden project, Cornwall fig.3 and Hinder land house Australia made of rammed earth wall fig.4 and fig.5.



**Figure 3:** A rammed earth wall, fig.4 Hinderland house An Australia made of

**Eden project, cornwal. Rammed earth wall.**



**Figure 5:** Hinderland house An Australia made of rammed earth

#### 4.2.2 Rammed earth in Saint Katherine

The city of Saint Katherine is a very unique city with a special local context and identity. A building designed for the training center for training for building craft was totally made up of rammed earth Fig.6. The project was implemented by EECA and funded by the EU (South Sinai Regional Development Program SSRDP).

This project was the first building which introduced rammed earth construction to the city. The aim of the project was to experiment the find an appropriate

alternative to the conventional building materials. Whereas rammed earth is the perfect technique which cheaper and more sustainable alternative of the conventional building materials which has to be transported to the city from nearest city, Al - Arshi, 200 km. away. Desert clay or Tafla has been used as a raw material. Which was obtained by the location near by. and the mix design was done with the help of a material scientist's office in Cairo. The cost for the Un - stabilized rammed earth was only 10% of fire brick wall, whereas cement stabilized rammed earth cost 45% of fire brick wall (El - Kabbany, 2013).



**Figure 6:** Training center for training for building craft

Due to the lack of equipment's and technical resources to the local people and builders who has been trained during the construction period of building has been facilitated with establishment of private entities like local contractors who

took initiative and started their own businesses. Whereas the demand of such houses has increased among the locals and they have started to ask whether if they can have their own houses built with the similar technique. The shuttering

required for ramming has to be manufactured locally because conventional shuttering cannot bear the load exerted by ramming.

### 4.3 Compressed Earth Blocks

For attaining desired outcome the mix design of earth blocks are as important as for concrete construction. However there are significant disadvantage of earth construction. For the best outcome earth used should be keenly monitored for their performance via standard testing during the production process so that blocks get desired strength for construction. For CEB, mixture of earth, cement, and water are in most common practice. The ratio of this mixture differs greatly in literature studies varying from 0.02 to 0.50, and from 0.5 to 3.9 respectively. These

variations might be because of the use of different kind of soil (A. R. A. Agib).

The role of cement in this mixture is to act as a stabilizer, which creates the network of hydrated calcium silicate (CSH). Higher is the cement content denser would be the CSH network which results in the increase of compressive strength of the earthen block. Sufficient amount of water is to be added to the mixture to hydrate the cement and increase the strength of the mixture but too high water content decreases its compressive strength and leads to cracks and shrinkage. Sand can also be used to reduce clay from the soil.



**Figure 7:** El - Haj Yousif experimental school, south Sudan

El - Haj Yousif experimental school is entirely made out of compressed earth blocks.

- In extreme weather condition mixture with stabilizer show great workability.
- Experiments done in Sudan with blocks prepared by stabilizing earth with lime and un - stabilized earth show tremendous variation in their performance against extreme weather conditions.
- Where as in field test at El - Haj Yousif experimental (fig.7) school in south Sudan wall built with cement stabilized Compressed Earth Blocks show good resistance to the extreme weather conditions.

## 5. Earthen Plasters

Earth plasters are used in form of mixture such as earth and cow dung, or earth and wheat straws. Or some minerals could also be added with earth such as bitumen to improve its water resistance property and hardness. This plaster without any additives can also perform well but require good skills and care with regular maintenance. With increase in demand of low cost mass housing and increasing interest of people towards conservation of heritage and techniques the need of materials which are both efficient and economical increasing day by day.

As earth is available around the world in abundance and distinctive properties they are highly compatible with traditional materials and building techniques and have distinct advantage with their traditional counterparts.

There are several kinds of earth based plasters traditionally existing such as Earth and Lime plaster; straw fiber bound plasters and earth and surkhi plaster. But in modern time there have been some experiments taken place with addition of some different stabilizing materials such as gypsum, bitumen and cement.

### 5.1 Some modern plasters

#### 5.1.1 Clay cement bound plaster

Clay – strength of these plaster are high but elasticity of clay cement bound plaster is not good. The plasters are characteristics sensitive to thermal and mechanical movements of the building and easy to crack. Therefore, they shouldn't be used as internal and external plaster in low strength wall material (wall material weight per volume less than  $1000 \text{ kg/m}^3$ ) and in building sections with expected motion or moving building systems. Because of those properties, they are applied in building with limitation. They are preferred as external plaster of exterior walls of basements on or under ground level and as ceiling plaster of reinforced concrete floors open to outdoor conditions (Minke, 2012).

#### 5.1.2 Clay and gypsum bound plaster

Addition of gypsum to the mortar it increases its setting time. After setting of plaster it possess negligible amount of humidity which also helps in prevention of cracks. This plaster is flexible in nature but have very low strength. But it has good resistance to heat and humidity but are highly water soluble and smooth in nature. Due to which these are not recommended on exterior walls.

### 5.1.3 Clay bitumen bound plaster:

Bitumen is added to this plaster to enhance its water resistance. Adding Bitumen to the clay has also improved its hardening.

## 6. Conclusion

From the above study and review of the earth architecture we can conclude that how much helpful earth can be in conceiving sustainability considering its various aspects and how important it is to introduce some of these techniques to common citizens to achieve sustainable environment in modern times. Following are some of the inferences made through our study:

- As earth is ecofriendly in nature it can contribute to the sustainable architecture.
- Considering the modern aspect of the architecture the modern techniques developed for the construction of earthen building should be delivered to common public through proper and formal skill training.
- As it is totally based on local availability of materials and resources it also helps in supporting local economy.
- Promoting earth architecture will be extremely helpful in developing low cost and affordable housing for low income group and economically weaker section.
- Professionals like architects and engineers must promote these construction techniques and materials in order to preserve ecology and environment.

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