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MUD ARCHITECTURE

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ABSTRACT

Man has always built with natural materials, building with mud/earth; the most natural of all building materials poses a special challenge. Architecture today is discriminated by cold hard, machine made building materials. While all previous attempts to replace these with a more plastic, environmental friendly material have resulted in a region of the structural of technical dimension of the architecture, building with mud offers unique possibility of a synthesis. As an exploration into the possibilities of mud as building material is especially relevant in country like India. The advantages and possibilities of mud construction are endless. Conceptually the material can be used to combine traditional elements in contemporary contest. A greater understanding of the possibilities of the material and the great strides it has made with respect to application and use will enable a constructive redefining of its suitability for different types of construction. Construction with mud is the answer to many of our waxing housing problems and presents an exciting and down to earth alternative to the perpetuation of the concrete jungle.

1. INTRODUCTION

Architecture involves use of various different construction materials that require a unique construction technique. But most of these construction techniques are energy intensive techniques. All the natural resources are depleting which has made it mandatory that we choose materials and construction systems which require less energy for its execution. Mud construction system is less energy intensive and very effective in different climatic conditions. Earth is one of man's oldest building materials and most ancient civilizations used it in some form. It was easily available, cheap, and strong and required only simple technology. In Egypt the grain stores of Ramasseum built in adobe in 1300BC still exist; the Great Wall of China has sections built in rammed earth over 2000 years ago. Iran, India, Nepal, Yemen all have examples of ancient cities and large buildings built in various forms of earthen construction. It is significant that the oldest surviving examples of this building form are in the most arid areas of the world. The strength of unsterilized earth walls comes from the bonding effect of dried clay. If this becomes wet the strength is lost and indeed the wall will erode or even fail completely. Different countries have different approaches to this problem. From the earliest times men built dwellings that were closest at hand: out of fibers, leaves, stone or unbaked-sundried-mud. But the onset of the industrial revolution, bricks of baked clay and mass-produced materials such as cement, steel and glass gradually supplanted the basic element of traditional construction. The development of transportation made it possible to bring

building materials from far away; while the use of modern components and specialized use of construction techniques brought about the less of craftsmanship and art that had given each locale its sense of place. But it is the fact that unbaked mud is still the most viable building material for one third of world's population-predominantly the poor who remain on the side-lines of money economy that depends on manufactured materials. Furthermore building with mud has become an important factor in planning new development. Following the recent energy crisis, technological progress has been made in certain countries, and the enthusiasm of architects and land developers has added in the spread of these new techniques. Today we are able to choose between conventional 'international architecture' and a more 'down to earth' approach that combines reasonable cost with traditional cultural motifs in a modern way.

2. WHY MUD CAN BE USED AS A BUILDING MATERIAL?

Mud, a mixture of earth and water, is economical, practical, functional and attractive. It is easy to work with, and it takes decoration as well. Mud is especially useful in humid and hot climates. Mud is a natural building material that is found in abundance, especially where other
building materials such as bricks, stone or wood are scarce due to affordability and or availability. The mud architecture is a great resource that focuses on architecture constructed of mud brick, rammed earth, compressed earth block and other methods of earthen construction. The proliferation of concept to use mud and improved techniques in order to raise the level of living in the population is a very welcome idea. This can go a long way not only in the form of changing the look of population centers, rural as well as urban, but also in solving environmental problems and problems related to energy and other finite resources. Various reasons for using mud as a construction material is described below:

Energy Consumption

In mud construction, minimum fossil fuel energy is consumed and is naturally abundant throughout the world, where as in brick construction fossil energy is consumed for manufacturing process and transportation.

Recycling

Recycling of modern materials for building construction is expensive. Recycling of soil does not need fossil fuel and labour requirement is also less. The characteristic of recycled soil for construction remains the same whereas in modern building material it acquires inferior character after recycling.

Abundance

The abundance availability of soil in large areas helps the economically weaker section of the society to afford the mud construction. It is easily adaptable and the technology can be transferred easily.

Housing demand

A huge deficit of housing demand in urban and rural areas linked with limited resources on all fronts make it absolutely essential that the housing solution have o be best effective, through optimal and efficient use of all resources of land and building material.

3. USABILITY OF DIFFERENT TYPES OF SOIL

Soil suitable for the construction can be taken from the site itself. The top layer soil should e removed; it will be full of organic matter. Dig a pit and see that there are different layers of soil. Excavate the sand and clay for construction purpose. After finishing the work organic soil can be replaced. All soil types are not suitable for construction. Sometimes two or more types can be combined to make a good mixture. *Gravel:* alone is of no use for mud wall building - the tiny lumps of stone have nothing to bind them together. *Sand:* similar to gravel, it is of no use for wall making by itself - but if mixed with clay, i.e. sandy clays or clayey sands, it is the ideal mud wall building soil. *Silt:* by itself is also no good for building walls. It will hold together but is not strong. Furthermore, it will not compact so it is also of no

use for pressed blocks or rammed earthwork. *Clay:* can be rammed or compressed but in drying out they often shrink. During the monsoon they get damp and expand again and crack form. *Laterite:* is also a type of clay, which contains red iron or aluminium material. It is strong and stable and is cut out of the ground in blocks and hardens further when stacked and exposed to the air. It is of course a first class building material and we usually think of it as a stone. It is wise to follow local traditional opinions about clays and laterites. There is some clay which has proved to be unsatisfactory as building material and over many centuries local people have learned to avoid these particular unsuitable clays. *Organic Soils:* are mainly useless for wall building. A reliable rule is that if a soil as good for growing plants in, it is not good for building walls with. *Mixtures:* Find out which soils are contained in the mixture and then the usability depends on the proportion of the various types of soil listed above. Always look at the old buildings in your district and see for yourself the types of soil that have been used, durability, or shortcomings of these old buildings.
Proper soil testing should be done before selecting the material for the purpose. Better still is
to go round nearby area and see and ask about the mud that other people have already used for building their houses. Simple in-situ tests can be done by the person itself to check the suitability of material in his ground. Such as cigar test, biscuit test, hand wash test etc.

4. MANIFESTATION OF MUD

Depending on the characteristics of the mud available, availability of supporting materials and technology used, different manifestations of mud are used. These include Adobe or Sun-dried bricks, Cob, Rammed earth, Pressed brick, Wattle and Daub etc. ***Cob***: The word cob comes from Old English root meaning "a lump of rounded mass". It's a traditional building technique using hand formed lumps if earth mixed with sand and straw. Cob is easy to learn and inexpensive to build. It dries to hardness similar to lean concrete. This ancient technology doesn't contribute to deforestation, pollution or mining, nor depend on manufactured
materials or power tools. Cob is non-toxic and completely recyclable. Regular working windows
are embedded in the cob along with their lintels while the layers are building up. If fixed window is needed we can use any kind of glass embedded into the cob. Cob houses have been known to last for centuries.

Adobe: Adobe is a natural building material made from sand, clay, water and some kind of fibrous or organic material (sticks, straw and or manure),which the builders shapes into bricks using frames and dry in sun. Adobe buildings are similar to cob and mud brick buildings. Adobe structures are extremely durable, and account for some of the oldest existing building in the world. In hot climates, compared with wooden buildings offer significant advantage due to their greater thermal mass, but they are known to be particularly susceptible to earthquake damage. Buildings made up of sun-dried earth are common in the West Asia, Northern Africa, West Africa, South America, Spain, Eastern Europe and East Anglia.

TABLE 1: energy required to produce different building materials

Building materials	Quantity	Unit Energy (kWh)
Cement	Sack	50
Concrete	Cubic meter	400-500
Fired brick	Cubic meter	1000
Adobe	Cubic meter	5

Rammed earth: Rammed earth is a technique used in the building of walls using the raw materials of earth, chalk, lime and gravel. It is an ancient building method that has seen a revival in recent years as people seek more sustainable building materials and natural building methods. Rammed earth walls are simple to construct, incombustible to water damage. Traditionally, rammed earth buildings are found in every continent except Antartica, from the temperate and wet regions of Northern Europe to semi-dry deserts, mountain areas and the tropics.

FIGURE 1: Hinderland house Australia made of rammed earth walls

The compressive strength of rammed earth can be up to 4.3 MPa. This is less than that of a similar thickness of concrete, but more than strong enough for use in domestic buildings. Indeed, properly built rammed earth can withstand loads for thousands of years, as many still-standing ancient structures around the world attest. Rammed earth using re-bar, wood or bamboo reinforcement can prevent failure caused by earthquakes or heavy storms.

Wattle and Daub : Wattle and daub is a building material used for making walls, in which a woven lattice of wooden strips called wattle is daubed with a sticky material usually made of some combination of wet soil, clay, sand,animal dung ang straw. It is an important construction
materialin many parts of the world. The wattle is made by weaving thin branches or slats between upright stakes. The wattle may be made in place to form the whole of a wall. Daub is generally created from a mixture of certain ingradients from three categories: binders, aggregates and reinforcement. Binders hold the mix together and can include clay, lime, chalk dust and limestone dust. Aggregates give the mix its bulk and dimensional stablity through mateials such as earth, sand, crushed chalk and crushed stone. Reinforcement is provided by staw hair, hay or other fiberous material and helps to hold mix together as well as to control shrinkage and provide flexibility. The daub may be mixed by hand or by treading either by humans or livestock it is then applied to the wattle and allowed to dry and oftenthen whitewashed to increase its resistance to rain.

Compressed Earth Blocks: the soil, raw or stabilized , is slightly moistened, poured into a steeel press and then compressed either with a manual or motorized press. It is developed from traditional rammed earth. The input of soil stabilization allowed building higher with thinner walls, which have a much better compressive strength and water resistance.

TABLE 2 : comparative analysis of energy consumption and carbon dioxide emission of four types of building material

Product and thickness	Number of units (per squar meter)	Energy conception (MJ per square meter)	Carbon dioxide emission (kg per square meter)
CSEB	40	110	16
WIRE CUT BRICK	87	539	39
COUNTRY FIRED BRICK	112	1657	126
CONCRETE BLOCK	20	235	26

(Source: Maini, 2005)

FIG 2 : ecoresort at Banglore and earth quake resistant building at Gujarath

Earthbag construction: This method was developed from the bunkers made by the military the basic construction method begins by digging a trench. Rows of woven bags (or tubes) are filled with available inorganic material after the foundation is laid, each successive layer will have one or more strands of barbed wire placed on top. The weight of this earth-filled bag pushes down on the barbed wire strands, locking the bag in place on the row below. The most popular type of bag is made of woven polypropylene. Organic/natural materials such as hemp, burlap or other naturalfiber bags (like "gunny sacks") can be used.

5. STABILIZER

Some types of soil like gravel, sand, silt on their own is not stable stabilizers can be added to make them stable. Cement, is a modern contemporary stabilizer. It is good in most circumstances but there is always the question of availability, cost, and the excessive use of energy in its production, etc. Lime, on the other hand, is made from the same basic material as cement, but is thousands of years old, can be manufactured almost anywhere, on the spot, for a fraction the energy and cost of cement and is a first class stabilizer for mud. Slaked or un-slaked lime is both acceptable but slaked lime will give less trouble to the workers

hands and feet. The quantity of stabilizer depends on the quality of your soil mix. A lot of sand or a lot of clay means a lot of stabilizer. Lime can be used between 2% and 6%. Traditional building has used many other rural stabilizers such as cow dung, straw, gum Arabic and other gums and resins, sugar and molasses, tannic acid and their wastes, oil etc.

6. MORTAR

The soil which was used for building walls can also be used as mortar. Too much of clay should be avoided otherwise it will result in shrinkage cracks. Sieve the soil when dry so that gravel and pebbles are all removed for a smooth mortar. If stabilizers such as lime or cement were used in the making of the blocks, it is also required in the mortar. In fact twice as much stabilizer must be used in the mortar.

7. PLASTER

The finish of adobe, rammed earth and cob walls is often bit rough and the need for plaster is felt. The mortar between the blocks should be left rough to act as a key to hold the plaster, which may be of mud, or mud and any stabilizer such as cow dung, lime or cement etc. pressed earth blocks are very smooth and is difficult to apply plaster on them. It is better to apply two or three coats of whitewash or thin slurry of sieved earth with lime or cement mixed with it. Coloring matter may of course be added if required.

8. CONCLUSION

Building with earth is definitely an appropriate and cost and energy efficient technology that has a great future. By using appropriate structural techniques and stabilization methods mud buildings can be used in almost all climates. In this type of construction locally available materials are used and good amount of money can be saved. Poor people can afford such a type of house building; in this context mud architecture can be considered as an alternate housing technology.

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