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Various Types of Earth Buildings

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Abstract

Earth architecture is a vernacular architecture. Earth architecture is included various types of buildings. This paper is described various types of earth buildings in the world. Rammed earth buildings, Cob, Adobe, Wattle and Daub, Poured earth are various types of earth buildings. The paper has shown the significant of earth buildings and earth architecture in vernacular architecture. Earth Architecture is a study devoted to the architectural uses of earth in shaping the environment of humankind, a subject closely related to human ecology. Earth Architecture includes contemporary as well as historical and vernacular examples drawn from many cultures and periods. Structural built of earth presently house an estimated 1.5 billion people about 30 percent of the world's population (Keefe 2005). Archaeologists have found evidence of mud brick buildings constructed as early as ten thousand years ago in the Middle East and North Africa, where impressive buildings up to ten stories high have been recorded in an unbroken architectural tradition that continuous today.

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1. Adobe Brick Building

For wall construction, there has always been a comparison between adobe bricks and rammed earth. One of the major requirements for adobe bricks is climate. Some regular periods of dry weather is essential for the could to dry and the bricks to be structured firmly. This supports the common belief that adobe bricks are limited to arid lands only; however, this is not correct. Any area where climate supports a full week without rain is suitable. Adobe bricks (Figure 1) have also offered simple structural solutions for structures such as vaults, arches and domes, which are impossible to construct with rammed earth. A variety of soil can be used to manufacture adobe bricks. Based on the quality of bricks needed and the capital available for investment in the manufacturing tools, the manufacturing operation is established with different levels. Stabilizing agents such as bricks, mud and mortar are used for manufacturing adobe bricks. The factors on which the type of stabilizing agent is decided are cost and effectiveness. Other additives like asphalt emulsion, lime and Portland cement have also been used in mud bricks and walls. Vernacular builders in some cultures have also used many organic compounds that involve manure, straw, blood and plant juices. The number of advantages in using adobe brick walls is far more than the number of disadvantages associated with it. Some major advantages are low sound-transmission levels

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through walls, solidity and security. Such walls are also considered in selecting the heating, ventilating and cooling systems. Adobe bricks are found to be fireproof and the investment of energy in basic materials is also very low. The major disadvantage of using adobe bricks; however, is their extra wall thickness that considerably decreases the ratio between the total building space and the usable interior space.

2. Rammed Earth Building

The man-made equivalent for sedimentary rocks is rammed earth. For more than many thousand years, builders are making use of simple tools to compact soil in order to produce rock-hard structures. This has created some very beautiful and well-known wonders in the construction industry. Examples of such great architectures include the Alhambra in Spain, the great Kasbahs of Morocco and the long stretches of the Great Wall of China. China has evidences of some of the most previous works built from rammed earth, where archaeologists discovered walls made of rammed earth back from the Longshan Culture of the Late Neolithic period (between 2600 and 1900 B.C.E), the period between the Stone Age and the Bronze Age, a period when many cities in China were established. This technology of building structures using rammed earth later spread throughout the Middle East. The Phoenician trading empire was the one that introduced the technology in Europe and helped in laying the foundations of the rammed earth city of Carthage. A famous Roman historian called Gaius Plinius Secundus stated that Carthaginians taught this technology to Romans, and Romans disseminated the technology throughout other territories. He also provided evidences of a fortification built out of rammed earth by Hannibal 250 years ago and also mentioned rammed earth walls in Spain in his studies. The Romans spread the technology to southern France through the Rhone River valley, where they built the capital city, Gaul, which is called Lyon today. In the city of Lyon, substantial evidences of agricultural buildings and houses made of rammed earth are still visible today. Native Americans were practicing the technology much before the arrival of Europeans in America. Another notable rammed earth structure that began construction in 100 C.E., in Teotihuacan, Mexico, is the famous Pyramid of the Sun. This structure was built using 2 million tons of rammed earth along with stone and rises to an impressive height of 207 feet. The first time rammed earth European traditions arrived in Americas was from Spain. The oldest remains of a European structure in America are a restructured earth house belonging to the first formal European settlement and the city of La Isabella in the Dominican Republic. Christopher Columbus founded this on his second voyage to America in the year 1493. The technology of rammed earth further spread into the southern United States and South America with the Spanish conquest. In the mid-19th century, Chinese immigrants that had arrived to participate in the gold rush in California brought this technology to the western coast of the United States. In Dutch flat in California, a small store that was constructed of rammed earth in the year 1877 by Chinese immigrants still remains. During the same time as the gold rush was raging in the West, French immigrants that arrived in the southern United States were constructing plantation houses, churches, slave quarters and schools out of rammed earth. Other notable examples of rammed earth construction are the historic campus of the Southwest School of Art and Craft in Sumter, South Carolina built in 1850. While rammed earth was building its emphasis in the United States, Australians, on the other hand, were beginning to establish towns by compacting the soil of the Central Australian desert. Many French-making countries renamed rammed earth walls “Pise”. Although when the rammed earth technology began is still not clear, researches conclude that it evolved from “puffed” mud wall construction. This is defined as a prehistoric mud type wall that was developed separately worldwide but is still currently used. Rammed earth walls that are placed with forms are similar to the construction using adobe bricks; however, the concept is totally different.

Rammed earth walls, in comparison to adobe bricks, are built in more damp, humid climates where building adobe bricks are practically impossible. In countries like North Africa and Australia, rammed earth has been considered a viable option although using adobe bricks in these arid-climate countries is not ruled out. Rammed earth is also widely used in France, Eastern Seaboard of the United States during the 19th Century, especially at the time of the unavailability of manufactured materials. E. Gilman wrote an early manual on constructing rammed earth walls in 1839; the manual was called "The Economical Euilder". The manual mentioned the construction of rammed earth walls as highly sound and economical. The construction of rammed earth walls includes aggregate portions of silt, sand and clay and adding this mixture to the soil. This makes use of forms, usually of wood, that are placed and secured into damp earth. After drying for few days, the forms are removed and the wall structure is complete, except for curing. Once at this stage, the wall requires no further building except for furnishing it and performing some cosmetic treatments, etc. this is perhaps the most notable feature of rammed earth construction. Forms used can range from very simple small, wooden slip forms, secured with rope or wire, to patented manufactured forming systems used in concrete. The soil used is the same as that used in building adobe brick walls. The most suitable soil type; however, is the one that has small gravel aggregate, sand, silt and clay. Some qualities of the wall such as durability and waterproof qualities are based on the content of the clay in it, which is approximate 15-18%. For soils sued for rammed earth walls, higher clay content is preferred, while adobe bricks that are built using high clay content have a tendency to crack on drying. The moisture content in rammed earth initially is much lower and therefore, rammed earth walls are less subject to shrinkage on drying. A different form of rammed earth wall (Figure 2) construction that does not make use of forms is in Iran, called "chine" construction. This method makes use of damp mud and shapes it with hand. The wall comprises many successive layers, each 18-24 in. in thickness and 18-24 in. in height. The lower level has to dry completely before another layer can be placed on top of it. This technique is similar to the one used in "coil" pottery. However, this construction method is believed to not construct more strengthened wall structures like in case of adobe bricks and rammed earth using forms. In Iran, this type of wall is most often used for garden walls rather than structural building walls. Perhaps this indicates their lack of confidence in the structural qualities of this type of wall design. Other examples of such architecture can also be found in the Western Hemisphere at Casa Grande, Arizona and Casa Grandes, Chihuahua, Mexico, dating back almost a thousand years.

3. Cob

The simplest of all earth-building technologies is called Cob. This technology makes use of very few tools and no formwork or internal structure and consists of piling and molding mud to create walls. The cob mix is similar to that of mud brick, however, it is stiffer and has higher straw content, which helps the mud hold its form as it is piled. Mud is shaped using trowel or hand and is placed directly in top of a structure at a height of approximately 18 inches around the perimeter of the building footprint. This is done by using a cob fork or a pitchfork - a traditional tool found in the United Kingdom – that are specifically designed for use in cob construction.

Each layer in this construction is called a lift and must be dried completely for the next layer to be placed on top of it. Windows and doors are made as the wall grows and to increase the openings, wood or stone lintels are added after the wall is built completely. Because of the processes involved in building them, cob structures are highly sculptural. Openings in cob construction can be aligned using a pairing iron that helps in creating cleaner walls and edges. Because of its simple nature, cob construction has become very common in the whole world. Native Americans piled mud to create large multi-story dwellings. The ruins of Casa Grande, built using cob construction between 1200 and 1450 by the Hohokam culture near

Phoenix, Arizona, became the first prehistoric cultural site to be protected in the United States. The multi-story Taos Pueblo in New Mexico that was constructed using cob construction between 1000 and 1450 is the oldest continuously occupied dwelling in North America and still even today a thriving village. In northern Yemen, Zabur, as cob is called there, is a sophisticated tradition; multi-story dwelling and fortifications of piled mud flourished from the thirteenth to the nineteenth century. In Ireland, Scotland, Wales, Northern Ireland and England, many typologies from humble farmhouses to stately manors, as well as the birthplace of sixteenth century writer and explorer Sir Walter Raleigh were constructed of cob. With British colonization the use of cob spread to Australia, New Zealand, and North America. In New Zealand, English colonists constructed more than 8000 cob houses.

4. Wattle and Daub

All this has made cob construction to be part of the present world in which we live. In the United Kingdom the long, curving cob wall in Associated Architects' Cabtun House demonstrates how well suited this seismological design. In Heringer and Roswag's design for a children's school in Bangladesh, the sculptural potential of cob is explored in the caves carved out of the wall where students can study, play, or sleep. Wattle and daub is perhaps the oldest earth-building technologies in the world. Even before humankind had started to create societies based on farming, hunter-gatherer societies seemed shelter that could be made with ready materials that were available to a nomadic lifestyle. Tree branches were the most common construction material at that time to build the structural framework and mud plastered into the nest of interwoven branches to ensure protection from sun and other unfavorable weather conditions. In excavations of the oldest known settlements, such as Jericho and Catalhoyul, wattle and daub structures overpower the more permanent structures constructed using mud brick or rammed earth. The Wattle and daub technique consists of two parts. A wattle is a woven structure of small plant elements held together in a stiff frame. Common materials used to create wattle are reeds, bamboo, branches and twigs. Daub or mud adheres to the irregularities and overhangs of the organic matrix. This mud mixture is similar to the one used for mud brick but with smaller aggregate, and dung is often the organic binder. The daub in then smeared on to the wattle by hand until the entire surface is covered. When dry, either the finish surface can be a smooth final coat of daub, or it can be whitewashed with lime. Unlike other earth building systems, wattle and daub is very thin; however, it lacks the thermal mass properties rendered to the structure by rammed earth or adobe brick. However, the woven structure is highly earthquake resistant because it is extremely flexible. This is the reason why wattle and daub is used in seismic zones throughout the world such as South America and Indonesia. In addition to this, many Native American cultures of North America also employ wattle and daub as the primary construction method, and the United Kingdom is still home to a sophisticated array of examples of the technique. Indigenous and European Australian too used wattle and daub and it also flourishes throughout Europe and Asia.

5. Poured Earth

Each of the four earth construction techniques mentioned here comprise pouring earth into frameworks and allowing it to dry. In case of wattle used for an exterior or an interior wall, the resulting gap is filled with mud. However, rammed earth construction requires laborious tamping where the resulting shape is achieved when the mud is completely dry. Based on the traditions prevalent in a region, the framework can serve as the primary structural support to the building. The Juana Briones Houses, built in 1845 near San Francisco, California, is a unique example of this construction type that is also called encajonado. This term is Spanish in origin that describes the process of stuffing mud into a framework of the lath. In the United Kingdom, many houses were built during the late eighteenth and early nineteenth centuries by using a mixture of chalk, straw and soil and pouring the mix into formwork. Once the material dried, the

formwork was removed to expose the brilliant white walls. This is similar to Marwan Al-Sayed's use of gypsum in a poured earth wall in Phoenix, Arizona; the color renders the quality of lightness to the massive poured earth walls while reflecting the desert sun. Nader Khalili's super adobe, in which flexible sacks of earth are stacked to create quick, low-cost disaster housing, is a radical take on poured earth traditions.

6. Conclusion

The current paper is shown a review on various types of earth buildings. According to information, rammed earth houses are high performance buildings in earth buildings that they are developed in various countries.

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