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The Architecture on Land and its Construction Techniques, Millenary Tradition that is Reborn

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Abstract

In the context of sustainable development, the use of materials of low environmental impact in the activities inherent to the construction of houses plays an important role when it comes to reducing waste pollution. The alternative materials to be used in the various construction processes, besides being totally renewable, they must be reusable, available locally and have little or no energy expenditure in its extraction, preparation and application. The Bio resources or Eco materials meet these requirements, of which land as ancestral material used in millenary construction techniques, it becomes the most feasible alternative for its use as a construction material to replace the conventional ones. The main objective is the literary review of articles published in reliable databases, whose research topic was based on the analysis and use of land and natural materials for application in housing construction. The articles were categorized, analyzed and integrated into a synthesized structure to extract the important aspects in the thematic introduction, the constructive techniques, the results of the processes carried out and finally, the conclusions on the constructive implementation of the elements studied. In this way it offers information of interest to people who want to delve into the subject investigated.

Keywords: Architecture, Construction techniques, Bahareque, Adobe

1 Introduction

The early man originally made due with treetops, caves (like today's lower animals) and then tents. Further evolution, time, and increase in technology led to increased sophistication of procuring shelter [1]. The use of natural materials for the construction of shelters is as old as humanity itself, some of the research carried out confirm that one third of humanity still lives in constructions made with this type of materials, with earth being the predominant material. Earth has been tried and tested by natural construction material for thousands of years [2], the oldest use of this material is evidenced by archaeological excavations of the first permanent dwellings in Southwest Asia, dating back to 10,000 BCE [3], its positive qualities – carbon neutrality, local availability, excellent thermal performance – are, however, offset by its unpredictable structural performance [4].

Vernacular architecture is a type of architecture which is not found on advanced methods of architecture, in contrast, it is based on empirical methods that are aimed at providing requirements of local residents and reflecting local traditions [5], due to the fact that earth buildings not only are economical and energy efficient, but also are sustainable and eco-friendly [6], former builders mainly used animal energy and unprocessed local materials for construction purpose [7], mixing sufficient material can be a back breaking process unless assistance can be given by animals or machinery [8]. These factors and attributes are espoused as criteria for the choice of these building materials for building operations, especially in the housing sector, not only in Third-World countries, but globally [1]. Earth is the material of construction used with greater antiquity by humanity, and is the base of one of the technologies that better adapt to the environment and to contemporary forms to conceive the sustainable construction [9].

Although the passage of the centuries have covered many of these early sites of human occupation, the use of this material has not been lost, it arises from knowledge that was refined over the course of time, from the construction of huts and modern homes, until palaces, residential complexes and whole cities [10] this is why we have to say that the earth as an architectural material has been part of the construction since the beginning of its days [11].

The architecture on land together with its construction techniques are intimately linked and are part of the landscapes and scenarios of our history. Also, its empathy with the landscape is so close that a natural and endearing symbiosis forms, a perfect harmony and fusion, until becoming a rich and varied heritage ambit [12]. Earth construction is widespread in various geographical, climate and chronological contexts [13], there are about 500,000 earth buildings in the UK, mostly constructed before the 20th century and are still occupied [14], in India,

the walls of 55% of homes are still constructed from raw earth [15]. This type of construction is a variation of a shared construction tradition that has existed throughout history in many parts of the world, from ancient Rome to almost the present-Day [16].

In recent years, the construction of land has generated great interest worldwide in use of natural materials and are considered sustainable constructions, that is why a series of studies and experiments on this subject have emerged in several countries of the world [17]. The will of reducing environmental and social impact of building industry has led to a renewed interest in earth construction [7]. The building sector is currently innovating, in order to use more environmentally friendly materials and ensure the comfort of users [18]. It's for this reason that the earth building systems have evolved in vernacular architecture as a material that people could source easily for the construction of viable shelters in the locations where they choose to settle [19].

At the beginning of the 19th century, it was referred to vernacular architecture to buildings considered 'typical' of each place, these were studied through descriptions or narratives of travelers, missionaries or colonizing officers of that time [20], they who evoked the majesty of built heritage. Unfortunately the neglect of this type of construction and the little interest in history makes us relegate our past. Currently it has been possible to demonstrate that, from the mechanics of materials that deals with the behavior of solid bodies and has as main objective to determine the tensions and deformation [21], the participation of the civil engineering in the restoration of the cultural patrimony is basic. Nevertheless, it is common that it is a poorly resolved area because the historical aspects in many cases have been forgotten [22]. The built heritage, besides being cultural emblematic of the different nations has evidences of long-lived characteristics of a material, that is not only economical but also friendly to the environment due to its low energy cost in the processes of extraction, transformation and application. Earth building heritage is therefore a precious testimony of low-environmental impact construction [7].

2 Construction Techniques

Raw earth building techniques are spreading out, under the promise of being environmentally friendly, thermally comfortable, easy to maintain and aesthetically interesting. They use local, non-industrialized material and, besides avoiding waste production, some techniques even allow reusing domestic and construction rubbish, making good use of this abundant deject [23]. Within the vast range of possibilities and forms to use the raw land in construction, the earth can be molded in the form of mud bricks or handmade clay balls and placed fresh; it can be projected on panels, formed by frameworks of cane, branches, wood, strings or strips of leather; and also it can be compacted in rammed wall or tamped floors [24].

Let's see some of the most common ancestral and modern techniques

2.1 Adobe (Raw Earth brick)

It is not possible to date the beginning of adobe construction; however, it is known that this type of construction appears in a period between 6000 and 10,000 BC [25], in addition to its historical implementation, the technique of adobe, is a very simple way to use the earth as construction material, just add water to the soil, some kind of natural fiber to make a mixture and mold it with the help of a mold called adorer. Currently, the traditional technique of adobe has been retaken and studies have been done to improve its original characteristics, this has produced what we know as technified adobe brick, it was given that name because we used machinery semi mechanized or mechanized to produce it and at the same time substances or materials that improve their original characteristics are added [26]

Figure 1. Adobes manufacture.

2.2 Tapia Pisada (Rammed earth walls)

The constructive technique called Tapia Pisada differs from other ancestral construction techniques because in most cases, freshly extracted soil whose moisture is natural or added as needed is used. Building in rammed earth (Tapial) consists in compacting moistened earth inside a framework to erect walls [27], the framework constitutes a key element within the definition of this technique, where traditional rammed earth walls are mainly built by means of a crawling formwork made of timber [28]. A traditional rammed earth wall is formed by several large-dimension blocks composed by compacted layers of earth. The framework is supported directly on the wall and is moved horizontally after completion of each block. After the helping of a lift, the framework is moved upwards and mounted with mismatched vertical joints, and then the process is repeated until the desired height of the wall is achieved [27].

Figure 2. Construction rammed earth wall– Marruecos

2.3 Bahareque (walls made with wooden frame and mud)

Within the variety of ancestral techniques that use the earth as construction material is the Bahareque [17], technique that it is helped with a wooden framework or reeds that make up the main structure of the house, to then apply the mixture directly to the wall. The mixture is made in this ancestral construction technique similar to that used in the elaboration of adobe bricks and may contain vegetable fibers of different sizes that are usually pastures or cereal vegetable waste among others. At the level of the structural response of earth constructions. It is known that the framework structures such as the bahareque, are structures of supporting wall type, such as adobe and rammed earth wall constructions, resist without problems the vertical weight [29].

Figure 3. Bahareque wall construction, Villa de los Santos
Source: Alcibiades Cortez

2.4 Cob (walls made with clay or mud balls)

The simplest of all earth-building technologies is called Cob. This technology makes use of very few tools and no framework or internal structure is used, and

consists of piling and molding mud to create walls [30]. It consists in stacking clods, made of a mix of plastic earth, in order to build a monolithic wall [7], each layer of applied clay is left to dry around 12 hours to then receive the following process The surface of the applied earth mixture layer must contain concave and convex points in order to help fix the upper layer.

Figure 4. Constructive technique Cob
Source: Tierra al Sur Arquitectura Construccion

2.5 Super adobe (Bags earth)

The Superadobe is an ecological construction technique designed by architect Nader Khalili, for the construction of houses on the Moon and Mars, calling itself at that time "velcro adobe" [31]. The building is quite simple. It is made by filling polypropylene plastic bags with earth. Straw, sawdust and construction waste may be added if available. The filled bags are then compressed mechanically or manually. This process takes place until the walls reach approximately two meters high. From this point on, the walls are placed in a decreasing diameter, so that they will close into a spiral, to form the roof [23]. For the attachment of the bags, with each other, you can extend to barbed wire to help prevent the displacement of the same.

Figure 5. Rammed earth bags
Source: Comencemos una Ecoaldea

2.6 CEB (Compressed Earth Block)

This constructive technique includes the elaboration of blocks in earth with addition of arid and cementing materials, the elaboration of the blocks is done with the help of a machine whose mechanism of action can be manual or mechanized making one or several blocks at a time. The compressed earth block (CEB) is easy to produce and its use is a technique of greater efficiency and speed; so that its structural performance has greater stability is mixed with a part cement and sand. Tests are carried out to determine the limits of consistency and granulometry. The blocks can be manufactured with different geometries from solid blocks to improve the structural union [9].

Figure 6. Elaboration of Blocks in Compressed Earth
Source: Tierra al Sur Arquitectura Construccion

3 Results of investigations

Research aimed at improving the mechanical properties of the land encourage its use as a building material, making it a feasible option as an alternative material for its implementation in housing construction. The analyzes carried out in adobes collected in diverse sites and some of them elaborated around one hundred ago years, results for resistance to compression between 15,3 a 27,3 kg/cm2 [32].

The average amount of clay in the adobe is 54%, much higher than the amount of clay in the soil used by the rammed earth wall, the which is 23%; As for sands, the average for adobe is 37% and for the tapial the 66% and, the gravels in the adobe reaches on average 7% and for the tapial the 10% [33]. The moisture content in rammed earth initially is much lower and therefore, rammed earth walls are less subject to shrinkage on drying [30]. The compacted adobe present better mechanical characteristics than traditional adobe, Nevertheless, it requires studies and experimentations to improve its quality [34]. The optimum design for the elabo-

ration of Compressed Earth Blocks is obtained from the earth mixture (82,75%), sand (6,20%) and cement (11,03%), to then compact it. The material must be sifted before mixing and stabilized. The machine used for compaction is known as press or block; the best known is the CINVARAM [9].

For the mixtures used in the Cob technique, the silts, sands and gravels were identified as the granular skeleton that provides strength to the material, well-graded soils were preferred since their packing structure allowed good space filling properties that increased cob density, and therefore its mechanical strength, clay was identified as the binder that brings cohesion to the material, if clay content was too low, cob material crumbled, Nevertheless, clay content also governs the drying shrinkage of the cob mixture. If clay content was too high, large shrinkage cracks weakened the material [7].

In the constructive technique Bahareque, the research presented showed that the Bahareque construction method has the potential to produce building envelopes with low heat transfer coefficients, the Bahareque technique presents a potential energy demand reductions of 52% and 35% when compared to concrete block and clay brick construction respectively. These results are important because the growing demand for parts manufactured for construction, handling and machine development has generated research that ignores the use of traditional materials [35]. This result indicates that the Bahareque technique has the potential to reduce both material and energy demands. What the research presented here showed that alternative construction materials have the potential to be used in highly energy efficient building envelopes, and, moreover, that the material and energy demand of existing techniques can be improved even further [36].

Any house format can be built in super adobe, however, the circular format gives a structural feature to the building. Doorways and window apertures can be made by forming arches with the bags or by incorporating ten per cent of cement to the soil at the lintels. This measure also can be applied when the soil available has excessive sand in its composition [23].

4. Conclusions

In recent years, land constructions have generated great interest worldwide to use natural materials and be considered sustainable constructions, which is why a series of studies and experiments on this subject have emerged in several countries of the world. But the constructive techniques that use the earth as constructive material do not possess the same normative rigor as that used in other materials and construction processes [17].

The investigation of adobe as a constructive element among the construction sectors that promote land architecture as an economic and sustainable choice for housing, it becomes a feasible and environmental alternative for its implementation

since it is an element that is manufactured with raw earth, totally recyclable material, and requires very little energy to be elaborated [10].

It was observed that the height of the walls was the characteristic presenting the highest variation among the buildings, whose importance can be assumed to be high for the seismic performance of traditional rammed earth constructions [27]. The analysis and tests in the laboratory of resistance of materials made to the raw earth, together with mechanized compaction systems, make possible the development of optimal mixing designs and compaction processes for the use of the material as a main element in the construction technique rammed earth wall (tapial).

To the construction of Bahareque walls, it is recommended the mud mixture with 10 percent of cement, because it had the lowest values of water absorption, that is to say, it is the most waterproof [17]. There are many variations of the vernacular cob construction process resulting from the adaptation of the technique to local environments the earth could have been adapted to the cob process. For example the addition of fibers was often used to limit shrinkage cracks and made it possible the use of clayey earth [37].

The fundamental material for the construction with the technique of the super adobe is undoubtedly the earth, so it is vitally important to study its characteristics well. Its optimal dosage will be the one that allows us enough stability and resistance. Generally, earth is composed of clay, silt (pulverized rock dust), fine and coarse sands, and gravel [38]. For the compressed earth blocks, the use of mechanical presses means an improvement in the quality of the pieces obtained, from the formal and mechanical point of view, what facilitates its placement on the workplace. The use of "portable" machinery allows a use of the land obtained from the excavation of the work itself. With motorized hydraulic machinery you can get blocks with sufficient initial resistance to be placed on site immediately after manufacturing [39].

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