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Peruvian earthen architecture: Reflections on traditional constructive techniques

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ABSTRACT: This study, carried out by the authors from a research developed in 2011, presents a series of reflections on Peruvian earthen constructive systems. Undoubtedly, these solutions are the result of a perfect combination of adaptation to local climate, seismic resistance and low cost of production. There is certain continuity between the Pre-Inca constructive skills and those of the following civilizations (Inca or Viceroyalty). The "Constructive Grammar" does not change drastically through the centuries. Earthen architecture is always the protagonist, according to the availability of autochthonous raw materials, such as reeds, cactus gel and carob timber.

1 INTRODUCTION

1.1 *The area of study*

Peruvian earthen architecture is present in two wide areas of the country: traces of earthen architecture in various archaeological sites can be found along the Pacific coast (in particular from Lambayeque up to Arequipa), and an omnipresence of adobe architecture in the area known as La Sierra, a region that occupies the central third of the country, characterized by its Andean climate.

The study focuses on these two areas, with the aim of collating information on various constructive earthen techniques, combining features of archaeological sites with sample of/examples of vernacular architecture (Fig. 1).

Figure 1. Map of areas/provinces with earthen architecture, visited during the research. (Authors: Cristini & Ruiz Checa).

1.2 *The research method and the addressed visits*

Visiting the different archaeological sites has enabled us to understand a range of constructive techniques, including those relating to the people that began occupying the Peruvian coastal area (Alvariño Guzmán 2001), and at the same time, other constructive traditions that were developed in the less accessible pre-Andean territory (Velarte 1978). In total, 7 provinces of the Country have been selected, and more of 10,000 kms have been covered in two months (including the Province of Lambayeque, Ica, La Libertad, Ancash, Lima, Arequipa, and Cusco). More than 15 archaeological sites have been visited after speaking with different earthen architecture specialists and key-contacts.

More specifically, in the north of the country, the authors visited the archaeological sites of Huaca del Sol and Huaca de la Luna (Moche Civilization, 100–700 a. C.), and Chan Chan, (Chimú Civilization, 900–1470 a. C.), both close to the northern city of Trujillo (Rodríguez Suy Suy 1971, Campana Delgado 2001). Archaeological sites visits were completed by talks and discussions with experts and technicians, in particular in the ancient sites of Chotuna (Moche Civilization).

In Lima and its surroundings, it was possible to get to know in detail the Lima Civilization (550 a. C.) especially in the areas of Huaca Pucllana, Huaca Huallamarca and Pachacamac (Cardenas Martín 1998). In the outskirts of the city, it was possible to study the site of Caral (Shady Solís et al. 2008), which together with Ventarron and Collud form the "golden triangle" of primordial Pre-Columbian Cultures (5000–1800 b.C.).

On the other hand, the visits to the southern provinces centered on the surrounding of Nazca

(Cahuachi and Paredones, examples of Nazca Civilization 100–700 a. C.) and on Arequipa city (Tejada Schmidt, 1937). In the interior mountain area, visits were mainly made to the various Inca archaeological sites, including Pisaac, Ollantaytambo, Macchu Pichu, Qenco Quzco, Sacsayhuaman (Inca Civilization 1470–1533 a. C-Esquivel Fernández 2010).

1.3 *The success of a raw material: adobe*

During the various visits it was possible to classify the construction materials, typologies and geometries, the latter of which are frequently related to their earthquake resistance properties. Regarding this last point, the employment of different shapes is noteworthy: cross, circular or zig-zag floor layout. Also is frequent the use of sloping structures for earthquake resistance, whit a constructive process similar to a foundation walls with trenches. In terms of the materials used, the employment of a multitude of rich types of adobes (Fig. 2) or lump combinations is significant, among which we should mention: lumps (cut/justlined), flat convex adobes, "loaf" shape adobes, "molar" shaped adobes, conical adobes and prismatic adobes (with/without pattern).

With regards to the lumps, these, along with the adobes with a prismatic shape, are typical of the Ventarrón-Collud Civilization (Aprox. 5000–1800 b.C.). Their dimensions change substantially from one region to another, but in all cases they are characterized by dimensions which are greater than the standards found in European archaeological sites.

Figure 2. Examples of "molar" shaped adobes, "loaf" shaped adobes, prismatic or conical adobes. Museo Antonini, Nazca. (Authors: Cristini & Ruiz Checa).

Figure 3. Detail of *librillo* bonds, with sloping walls profiles in *Huaca Pucllana,* archaeological site, Lima (Authors: Cristini & Ruiz Checa).

Thus it is possible to observe the presence of modules more than 50 cm long, and almost 20 cm high. These pieces are manufactured in response to the use of archaic patterns and the easy molded manual process. It's interesting to highlight that on some models the producers' marks are visible, like trading stamps. These pieces most likely correspond to different production workshops, as has been proven in adobe studied in Northern provinces (such as La Libertad/Trujillo). Adobe is also the main raw material found in the archeological sites surrounding Lima. In this case the bonding is characterized by header/stretcher bonds or *librillo* bonds (a soldier brickwork with a few centimeters of looseness between the pieces-Fig. 3), forming sloping walls, built using a process similar to a basic trench system (Cardenas Martín 1998).

Other, perhaps less elaborate pieces are made in loaf, molar and conical shapes. These can be found in the more recent Chimú, Moche or Nazca civilizations. In this case, the trapezoidal section of the building constructive elements responds even more specifically to earthquake movements.

2 THE LOGIC OF THE GEOMETRY: THE TRAPEZE

2.1 *A "trapeze shaped constructive culture"*

Throughout the visits to the different archaeological sites and the rural contexts it has been possible to identify different bond systems and constructive solutions, which in the majority of the cases, answer to the aforementioned rules. In fact, the constructive "fingerprints" left by the different civilizations reveal frequent trends. The load bearing walls are always made of earth, and are trapezoidal in shape. This can be observed both on a large and a small scale; from the very configuration of the adobe modules, to the design of the openings and wall sections.

Undoubtedly, the trapezoidal geometry is omnipresent all over the country and throughout the different Civilizations, both on a symbolic and constructive level (Hartkop 1985). The trapezoidal shaping has been used both by the Pre Inca conquerors (between the 6th and 14th centuries), and by the Inca civilization itself (after 15th Century).

In this way, the trapezoidal section walls are built using elements that follow the same geometric tracing. Even the openings, such as the doors or windows, or the niches repeat this geometrical "obsession" (Fig. 6).

This "trapeze-shaped culture", which is clearly visible in façades and in the inner parts of the structures or foundations, always responds to a sloping geometry (Tejada Schmidt 1937).

Whether the basis of these foundations are large ashlar masonries bonded with by mortar (Andes Mountain System/ Sacred valley-Samanez Argumedo 1983) or adobe in its simplest form (desert or coastal regions), they always follow the same design. Frequently the bases of the walls which were built in the Colonial era come from older sloped Pre-Columbian foundations, always displaying a certain inclination in terms of the vertical line (Figs. 5–7). The trenches corresponding to these bases are often filled with compacted earth and homogeneously sized ashlars. Furthermore the depth of these trenches is not greater than the thickness of the walls they receive, thus always making good use of rocky outcrops.

Figure 4. Examples of trapezoidal units (adobe) in Chotuna archaeological site, Chiclayo Province (Authors: Cristini & Ruiz Checa).

Figure 5. Example of sloping wall, in *Huaca Arcoiris* archaeological site, *Trujillo* Province. (Authors: Cristini & Ruiz Checa).

Figure 6. Examples of trapezoidal opening in rammed earth stores; Huchuy Qosco archaeological site, Cusco Province (Cristini Ruiz Checa).

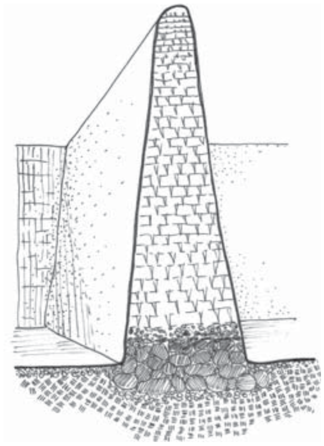

Figure 7. Examples of trapezoidal sloping walls, frequent in *Trujillo* and *Chiclayo* Provinces (Authors: Cristini & Ruiz Checa).

3 THE HYBRIDIZATION IN DOMESTIC ARCHITECTURE: MIXED EARTH TECHNIQUES

3.1 *Earth with autochthonous raw materials*

There is certain continuity between the Pre-Inca constructive skills and those of the following civilizations (Inca or Viceroyalty). The "Constructive Grammar" does not change drastically through the centuries (Fig. 8).

Earth is the most widespread raw material, whether it is used on its own or with other materials, the combination of which can include: earth

Figure 8. Example of constructive continuity: contemporary earthen architecture in Colca Valley, Arequipa Province. (Authors: Cristini & Ruiz Checa).

and sand, earth and straw, earth and reeds (*quincha*), earth and cactus gel, earth and *guarango* (a type of carob tree).

From this framework it is interesting to highlight the latter three alternatives, as they are the least known and least studied combinations in Europe: *quincha*, the mixture of earth and cactus gel, and the combination of earth with *guarango* timber.

3.2 *Quincha wall system*

A *quincha* structure, also known as a light half-timber structure with wicker screens (Fig. 9), is an autochthonous constructive technique which has proven to be an effective solution in case of earthquakes.

This is fundamentally owing to the great elasticity granted by a half timber structure (Fig. 10), which absorbs the vibrations and allows them to be dissipated.

On the other hand, other interesting factors worth considering include its lightness (Fig. 11), the ease of assembly and the reduction of load in the hypothetical case of collapse. Moreover it's important to highlight the good thermal performance of this wall.

It is used in all the regions of the country, both in rural and urban settings, and is particularly useful when employed in dividing walls or partition systems.

3.3 *Extract of San Pedro Cactus*

The second combination, as previously mentioned, is a constructive mixture made from an extract of the San Pedro cactus (*Echinopsis Pachanoi*, syn. *Trichocereus Pachanoi*) and earth. This combination provides the earth mortar with impermeable properties (ideal for using in covers due to its great waterproofing ability).

The gel is extracted after a careful process of cactus maceration (taking 15 days-Fig. 12), after

Figure 9. Detail of a *quincha* dividing wall, M. Antonini, Nazca (Authors: Cristini & Ruiz Checa).

Figure 10. Examples of quincha dividing wall, Lima city centre. (Authors: Cristini & Ruiz Checa).

Figure 11. Details of the wicker screens, filled with earth, in a *quincha* wall, Lima (Authors: Cristini & Ruiz Checa).

Figure 12. Detail of San Pedro cactus maceration, *Echinopsis Pachanoi*, syn. *Trichocereus Pachanoi*, (Cristini & Ruiz Checa).

which the water is leaked slowly and the extracted substance is hardened.

It is subsequently added to the sand and earth mixture, creating a water-repellent mortar, which is still used nowadays in protective layers for horizontal housings covers (Fig. 13).

3.4 *Guarango timber structure*

Finally, in the Northern area of the Country another autochthonous binomial constructive technique, based on earth and *guarango* timber, can be found (Fig. 14).

This timber comes from a robust species of carob tree, with a broad and dense crown that can reach up to 12 m high and which is better known for its fruit, a species of locust-bean.

It boasts a really resistant wood that rarely suffers attacks from wood bugs, and thus there is a long tradition of its use in Peruvian vernacular architecture.

These timber trunks combined with earth can be found in vertical structures (posts or pillars, Fig. 15) or in horizontal systems (ceilings or covers), based on daubed earth and straw layers, extended over the wood surface and subsequently whitewashed.

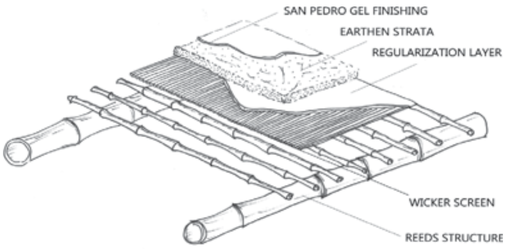

Figure 13. Constructive layers in horizontal housings covers.

Figure 14. *Guarango* tree and a covering structure, made with this timber. (Authors: Cristini & Ruiz Checa).

Figure 15. Example of contemporary house in Tucume, Chiclayo Province. A *Guarango* structure, with daubed earth and straw layers, lately whitewashed. (Cristini & Ruiz Checa).

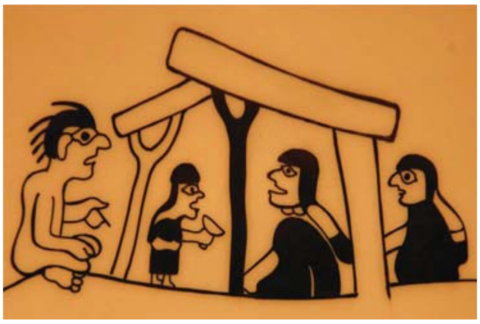

Figure 16. Example of Pre-Inca graffiti in Tucume archaeological site, Chiclayo Province, in which is visible a *guarango* timber structure. (Authors: Cristini & Ruiz Checa).

4 CONCLUSIONS

The direct contact with seven different Peruvian provinces and the visits to more than 15 archaeological and rural sites, have permitted a direct understanding of the evolution of earthen constructive techniques in the country.

All this is thanks to the discovery of a wide range of technical combinations, evident throughout a vast geographical area and an extensive time period: from 5000 BC to the Colonial era, and covering more than 10,000 km of land.

Objectively, the presented study is just an initial approximation, open to possible future research.

But aside from the introductory nature of this analysis, it's possible to note how Peruvian earthen architecture displays incredible coherence in its evolution, overlapping in time and above all reflecting strong technical/formal continuity (Fig. 16).

Different lines of investigation (Blondet, & Torrealva & Vargas Neumann) are being carried out in different departments of the *Pontificia Universidad Católica de Peru* (PUCP) that make the preservation and the maintenance of these constructive solutions possible, through contemporary experimentation and improvements in traditional methods (Sánchez Puerta 2010, Cabreras Arias 2010, Gallegos Gallegos 2010, etc…) with adobe experimentation, cactus gel or *guarango* timber.

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