

Earthen heritage in the USA: Approximation to constructive techniques

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ABSTRACT: The United States of America possesses an important architectural and archaeological heritage of built earth, both major monuments and traditional architecture. The vastness of the country and the differences in climate and territory greatly affect the variety of techniques used: cob, rammed earth, adobe, wattle and daub, earthen renderings, sod, turf, tabby, etc. In addition to the different constructive cultures found in the country resulting from autochthonous cultural influences (Native Americans with their cultural differences), those imported over time by the different peoples who have settled on North American territory (especially Spanish, French, English, African, Caribbean) and the transfer of knowledge in border territories (Mexico) are also reflected in the large variety of construction processes. The study of these techniques and their cultural transfer are of great interest not only to North American researchers but also to researchers in earthen architecture, earthen built heritage, or traditional architecture in general.

1 INTRODUCTION

This text aims to present an overview of the wealth of earthen constructive techniques in the United States of America (from now on USA), and although it does not aspire to be comprehensive, it will offer an initial overall framework of the panorama of techniques linked to the geography of the country and the different local or colonizing cultures which have created a complex map over the years.

To date there is no complete work on the techniques using earth in construction, nor is there an in-depth study on the possible variants of these techniques in the USA. As it will be seen later in the text, there are, however, many scattered local studies on the techniques in some locations, as well as publications describing the constructive techniques used by natives or by colonists from different places who often used methods of their countries of origin. There is also a considerable body of research on the channels through which these constructive techniques reached and spread through North America, as well as on treatises and manuals which covered earthen construction for rural buildings throughout the 19th century, early 20th century, the recessions of the 1930s and 1970s, as well as the postwar period.

The multiple qualitative methodology used bibliography, archives and fieldwork as sources. Fieldwork focused on cases directly documented in 25 different states, as well as cases identified in the bibliography. Case studies were grouped into four broad categories, with their various constructive techniques: earth massive construction (rammed earth, tabby, cob...), earth pieces (adobe, manual

adobe, clay lumps, sod...), earth in timber structures (half-timber, wattle and daub...), earth as secondary material (renderings, mortars, etc). In turn, each of these techniques can be divided into variants. This text presents the results of part of the fieldwork carried out cross-referenced with the bibliography, which has allowed constructive techniques in the territory and their current situation to be identified.

2 EARTHEN CONSTRUCTIVE TECHNIQUES IN THE USA

The USA is characterized for being formed by superimposition and often coexistence of several cultures that were local, native, or imported through the immigration over more than four centuries. Each migratory flow brought with it new colonists with their new uses and customs which included constructive techniques for dwellings. These numerous constructive cultures from Europe, Asia, the Caribbean, and Africa, were overlapped on the varied Native American constructive cultures of each place. The resulting blend of multiple cultures creates a rich panorama of techniques and variants in the use of earth in construction over centuries.

2.1 Earth massive construction

Massive construction is that which is executed directly on site, unlike construction by pieces which although executed on site, requires the pieces to be prepared beforehand for bonding in the wall. This group covers different techniques: rammed earth, tabby and cob.

2.1.1 *Rammed earth*

Rammed earth in historic buildings in the USA is mostly limited to the East Coast, ranging from north to south, and covers a wide range of construction periods. There have been many examples of recovery of this technique in architecture, especially from the last third of the 20th century, but they were more widely distributed throughout the country as they followed sustainability and bioarchitecture criteria.

At a historical level, the maximum increase in rammed earth construction was linked to plantation architecture or to agricultural and production needs, especially from the first half of the 19th century. This technique reached the USA mostly influenced by the treatise by François Cointeraux and its English translations (Guillaud 1997; Cellauro & Richaud 2005, 2006). The impact of construction ideas using affordable and easily accessible local materials gave rise to major experiments in construction, some of which still survive: Bremo plantation in Virginia (1815–21), by J.H. Cocke; Borough plantation (1821–24) by W.W. Anderson and the Church of the Holy Cross (1850–52) designed by E.C. Jones and supervised by W.W. Anderson, both in Statesborough, South Carolina (Golebiowski 2009). These constructions are characterized by simple rammed earth walls which were probably rendered with earth or earth and lime and later limewashed, although they are all currently rendered in cement.

This increased popularity, always linked to the world of agriculture and rural constructions in the 2nd half of the 19th century, includes the barns that can be found in the north of New York State, built on a rammed earth base (sometimes bonding agents were added) with a structure of wooden boards above (Fig. 1). An interesting example of

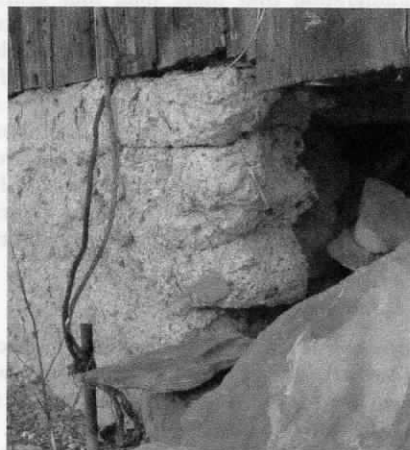


Figure 1. Rammed earth basement of a barn in the area of the Finger Lakes (New York State).

rammed earth construction, this time in Canada, is St. Thomas Church at Shanty Bay (Ontario) (1838–1841) by Edward O'Brian, of Irish origin. This is also a simple rammed earth construction which was possibly once rendered in earth mortar with limewash or lime and earth mortar and which is now rendered in cement mortar.

2.1.2 *Tabby*

Tabby is a unique technique included here as it uses formwork to build lime concrete walls, with a mix of beach sand, shells and the lime extracted by firing the shells (Sickels-Taves 1997). This is a mass constructive technique characteristic of the southeast of the USA and Caribbean, recorded from the time of early Spanish settlements on the east coast of Florida (Manucy 1963; Easton 1996: 7). This technique is found in the architecture of forts (Fig. 2) but is also often found in residential architecture especially in Georgia and Florida. This technique is used to build walls as well as barrel or groin vaults cast on formwork.

2.1.3 *Cob*

The presence of cob (piled earth without a formwork) in the USA is especially linked to Native American culture. The most important example still surviving is undoubtedly Casa Grande (Arizona). This imposing structure was built by the indigenous population in the 14th century (Houk 1996) in cob, although specialist literature has long been confused about the technique used (Matero 2000). The characteristic fissures caused by retraction from in situ drying of the earthen mass which makes up the various strata of cob is a phenomenon extensively described elsewhere (Van Beek 2007) and has been definitive in identifying the technique (Fig. 3).

2.2 *Earth pieces*

Techniques with pieces are those which build the walls or roofs with earthen pieces that are bonded which are prepared prior to execution. This family



Figure 2. Tabby wall in Pulaski Fort at Tybee Island (Georgia).



Figure 3. Cob degradation at Casa Grande (Arizona).

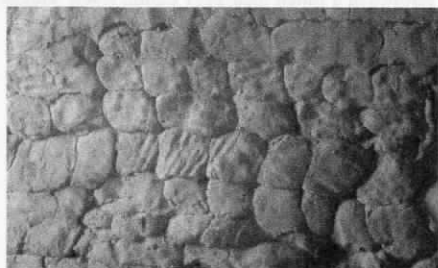


Figure 4. Fresh clay lumps bonded before drying at Barnalillo (Albuquerque, New Mexico).

includes earth loaves, clay lumps, adobe, sod and turf.

2.2.1 Manual adobe and clay lump

Constructions using hand-molded adobes dried in the open air or fresh clay lumps, as well as cob, can be considered mostly to predate the use of cast adobe introduced by the Spanish (Steen 1972; Iowa 1985: 14; Easton 1996). Major historical accounts are found in the literature on the expeditions of Spanish conquerors, such as *The Journey of Coronado (1540–42)* described by Pedro de Castañeda. The Pueblo peoples amazed the early conquerors with their multi-story constructions built using hand-molded earth loaves and executed using mud and ash mortar. The direct observations provided by Steen (Steen 1972) are also of great interest and describe the remains of walls built by Native Americans using hand-molded pieces (walls built by them using pieces in 'turtle-back' shape in Rio Grande Valley). The use of fresh clay lumps by Native North Americans can be seen in some constructions such as one of the kivas in the ruins of Kuaua Pueblo in Barnalillo (Albuquerque). In this case it is obvious that the earth was molded by hand in irregular shapes and bonded before drying (Fig. 4).

2.2.2 Adobe

It is generally agreed that the Spanish colonists introduced adobe using wooden molds into the USA (Miller 1934; Bunting 1964; Houben & Guillaud 1989; Easton 1996; Vellinga 2007). Adobe, the



Figure 5. Adobe walls and its restoration in the Church of Ruidosa (Texas).

predominant earthen technique in the country, has been used from east to west (from Brooklyn to California, passing through Four Corners and Texas) and from north to south (from Geneva in north New York State to Tumacacori on the border with Mexico) and in a wide variety of construction types (simple dwellings as well as mansions, forts, and churches) and periods, from the arrival of the Spanish through South California and Texas in the 16th and 17th centuries to the present when adobe is still produced to repair historic buildings as well as for new constructions. The most spectacular adobe constructions in the USA include the missions in Texas (Ysleta, Socorro, San Elizario), churches in New Mexico (San Miguel de Santa Fe, Ranchos de Taos, Trampas, Truchas...), the missions in South Arizona (such as San José Mission in Tumacacori or San Xavier del Bac Mission), or forts built in the 2nd half of the 19th century such as Fort Leaton (1849), Fort Davis (1854–91), and Fort Union (1851). The size, composition, and bonds also vary throughout the country. The adobe pieces vary in size and composition. The size goes from small thick pieces of adobe ($20 \times 40 \times 7$ cm) to larger thinner ones ($25 \times 50 \times 5$ cm). In most cases they are placed in header bond although when the walls do not need to be too thick, as in the case of outhouses, the bond used is stretcher and half-header. Adobes were generally bonded using clay mortar and very occasionally lime mortar. Adobe is made of earth with coarse aggregate while the rendering uses clay and large amounts of straw (Fig. 5), while the adobe used more recently or for restoration incorporates straw in the mix.

2.2.3 Sod and turf

The images of hardy settlers outside their humble sod houses in the 1880s and 1890s are well known

(Butcher 1904). Over time, those who were able to, built themselves sturdier homes in better condition in half-timber or adobe (Carlson 1981). However, the examples that can be seen in these old photographs are very interesting, and range from simple half-buried huts or almost provisional shelter to two-story dwellings of some dignity, reflected in the aesthetic desire for composition, going from colonial homes, built in a single rectangular floorplan that could be very simple with just one room, to buildings with several rooms or groups with several simple units and functional separation between the house and stables (Mead & Hunt 2006). Sod was also used in roofs to create a waterproof layer, usually on top of the structure with logs or a combination of logs and wood boards.

The use of this technique has been identified in different states and in different periods. It is worth noting its use by Native Americans to construct earth lodges, i.e., dwellings made out of log structures sometimes quite large and covered with a layer of turf insulating and waterproofing the inside of the building (Nabokov & Easton 1989). These winter lodges (contrasting with the summer teepees) were built in villages and sometimes used as buildings for meetings and ceremonies. Many archeological remains of these dwellings can be found on both banks of the Missouri river in South and North Dakota as far as Fort Berthold Reservation. Reconstructions of quite high quality have been found on some of these sites, including On-a-Slant Mandam Indian Village and Knife Indian Village).

2.3 Earth in wooden structures

This group of constructive techniques includes all techniques using wooden frameworks whose voids are filled with different types of earth, like half-timber, wattle and daub, bousillage, *poteaux en terre*...

2.3.1 Half-timber

The constructive family defined as half-timber in the USA groups in turn several constructive techniques. Strictly speaking, half-timber, where vertical, horizontal, and diagonal wooden elements create a framework of different levels of complexity and density with voids usually filled in with adobe with different bonds or with brick or stone, was brought to the USA, to the East Coast, by migrants from England, Holland, and especially Germany from 1600 (Vellinga 2007). This technique is currently found in Minnesota, Pennsylvania, Ohio, North Carolina, etc. although in most cases the panels between the wooden structures are brick (Sickels-Taves & Allsopp 2005).

There are also other types of mixed wooden and earth structures where the wooden elements are posts set at varying distances and generally filled



Figure 6. Half-timber wall made of timber posts filled in with adobes in a ranch near Fort Union (New Mexico).



Figure 7. Half-timber made of wood boards filled in with adobe at El Peñasco (New Mexico).

in with adobe. This type of structure is frequently found in areas such as New Mexico where construction with adobe is common and is associated in most cases to the needs of single-story buildings with an enclosing wall that is not too thick and where the load of the roof rests on the wooden structure. These composite walls are usually protected by earth rendering or a wooden board structure nailed directly to the wooden posts (Fig. 6).

This type of structure is also found in North Dakota, influenced by constructions by pioneers from Russia and Germany (Carlson 1981). The same is true of mixed structures built with a framework of wood boards or logs filled in with adobe (Fig. 7). These structures are generally on the upper part of the adobe wall and are used to construct the gable wall. Finally, another technique to be included in this half-timber group is that which uses a double screen structure of wooden boards fixed to vertical posts and filled in with earth.

2.3.2 Wattle and daub

Available archeological and historical research (Iowa 1985; Nabokov & Easton 1989; Rohn & Ferguson 2006) shows that Native Americans used this technique to build dwellings in different parts of the country. However, given their short-lived and ephemeral nature there are few remains to be found.

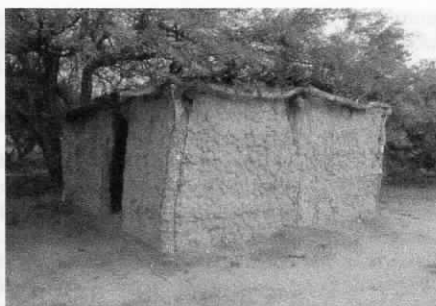


Figure 8. Reconstruction of a wattle and daub dwelling at Tumacacori (Arizona).

At present, some reconstructions such as Melhok Ki at the San José Mission in Tumacacori (Fig. 8) can be found. This small structure was rebuilt in 1997 reproducing a dwelling of the O'odham people, natives from the Sonora desert. The wattle-and-daub technique is also found in auxiliary elements of dwellings such as large chimneys or corrals.

One example of wattle and daub constructive technique is that of pit houses (Iowa 1985), dwellings built by the earliest ancestors of Native American peoples (0–700 AD). The lower part of these dwellings is underground while the upper part is a wooden-log structure covered in branches which in turn were covered with a layer of earth acting as insulation. Archeological remains of this type have been found in Mesa Verde. Unlike the earth lodges which were accessed by a side door built with logs, research shows that pit houses were accessed with a step ladder through an opening on the top.

This group should perhaps also include the constructive technique known as *jacal*, already found in Native American homes from 700–1050 AD (Houben & Guillaud 1989). This consists of a vertical structure of logs which are connected horizontally, with voids filled with cob or mud balls (Iowa 1985).

2.3.3 *Bousillage*

This constructive system consists of thinner wooden elements, squared with or without horizontal strips, and filled in with cob, and subsequently rendered in earth mortar, limewashed inside and shingle-clad on the outside (Maygarden 2006). It is precisely this wooden shingle cladding which makes it difficult to identify these structures from the exterior of the building. This technique, characteristic of Louisiana, is derived from the French constructive technique brought by French colonists, and is influenced by native culture of wattle and daub (Blokker & Knight 2013) and the culture of West African slaves (Macdonald & Morgan 2012).

2.3.4 *Mixed constructions with logs and earth*

Mixed structures built with logs and earth are widespread throughout the USA and date back to

different periods and cultural influences. In some locations it is possible to find structures with vertical posts planted in the ground at short distances (known in some areas as *poteaux en terre* due to French influence), and with voids filled in with different materials such as stone, brick, or earth (Maygarden 2006). In Louisiana, these are often likened to the *bousillage* technique but the logs are noticeably thicker and have not been carved. This section could also include the Navajo mixed constructions called *hogans*, which are log structures with an earthen cover on a wooden structure.

Finally, this group of mixed techniques with logs and earth could also include the log houses or cabins which are found throughout the country but mainly in the north. These wooden constructions can be extremely large and complex (like the hostels in Yellowstone National Park). This is especially true in less refined cabins and buildings that use uncarved logs where joints are closed or bonded with earth, wood wedges and/or mud mortar to prevent draughts. In some cases mud rendering covers the whole wall, protecting it from the elements and insulating the interior.

2.4 *Other uses for earth in construction*

2.4.1 *Renderings and mortars*

Finishes in earth or earth and straw are essential to protect adobe walls and so are always found wherever there are adobe constructions. As renderings were repaired periodically following deterioration caused by the elements, it is generally possible to find numerous superimposed layers of renderings in mud and straw sometimes limewashed inside. In places where these earth and straw renderings are still found in good condition, they are usually periodically maintained and repaired. In addition, earth renderings are also found as a protective layer or finish for stone structures, as in the case of the houses built by the native peoples in Mesa Verde in Colorado, Bandelier in New Mexico, Montezuma Castle, Navaho National Monument or Canyon de Chelly in Arizona. Some of these renderings have been painted. In some cases, structures with wooden boards or vertical logs have been discovered under these earthen renderings. Along with renderings, earthen bedding mortars are generally found in adobe constructions, and they are also commonly found with stone masonry. These mortars are generally composed of earth and fine gravel or sand and do not usually contain straw.

2.4.2 *Earth roofs*

Flat roofs of compacted earth are generally associated with adobe construction. This is the case of the architecture of Taos Pueblo in New Mexico whose uniqueness is due to its terraced adobe constructions with flat roofs, built using log structures

and a thick layer of compacted earth. In addition, as stated previously, sod roofs are a frequent feature in the log architecture of some Native American peoples and in much of the architecture of the first settlers in the central plains.

3 CONCLUSIONS

The main aim of this text is to offer a general overview of the earthen construction techniques found in the USA, reflecting the wealth of techniques and their variants and the cultural influences involved. This is without a doubt the most noteworthy aspect of this overview which interweaves culture and techniques, contributing to the outline of an extremely rich and varied heritage, virtually unknown both in its country of origin and abroad.

NOTE

This research was partly funded thanks to a Grant for stays abroad for Spanish teachers and researchers from the Spanish Ministry of Education, Culture and Sports (Salvador de Madariaga Program) awarded to Camilla Mileto for a stay at the University of Pennsylvania (Philadelphia) in the first semester of 2013.

This work is part of the research project "Restoration and rehabilitation of traditional earthen architecture in the Iberian Peninsula. Guidelines and tools for a sustainable intervention", funded by the Spanish Ministry of Science and Innovation (Ref.: BIA2014-55924-R; main researchers: Camilla Mileto and Fernando Vegas López-Manzanares).

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