



Rammed Earth Construction Nowadays - Comparing Methodologies and Design Between Portugal and USA

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Article disponible dans les actes du colloque Terra 2016:

JOFFROY, Thierry, GUILLAUD, Hubert, SADOZAÏ, Chamsia (dir.) 2018, *Terra Lyon 2016: Articles sélectionnés pour publication en ligne / articles selected for on-line publication / artículos seleccionados para publicación en línea*. Villefontaine : CRAterre. ISBN 979-10-96446-12-4.

Summary

The future of earthen construction depends on the way it is adapted to our comfort needs, to the new standards and building codes. Based on site visits and interviews, this study is a comparative overview of several rammed earth recent works, in Portugal and in the USA. The main goal is to compare different strategies of rammed earth construction, regarding distinct cultures, climate and resources, technical background and methodologies, taking into consideration all the agents involved within the process. A detailed analysis of contemporary rammed earth masterworks was performed in both countries and a very distinct approach was found regarding design and constructive solutions. New strategies have been developed for innovation, combining traditional techniques with modern construction systems and new materials, changing the earthen construction paradigm. Nevertheless, earthen materials are still seen as an alternative and experimental resource, fulfilling some clients' expectations and builders' ambition to make different architecture.

Introduction

This article results from a research project on contemporary earthen construction focusing on two techniques: adobe and rammed earth. A period of ten months stay in the Southwest of the USA, and an ongoing study in the Southwest coast of Portugal (the Alentejo region), were the starting point for this reflection. The USA situation has the major focus in this presentation, as the Portuguese case was already discussed in a previous paper (Marques et al. 2014). After a deep contact with these two realities, followed by a systematic analysis, innovative solutions to design and function.

Among the techniques that use earth as raw material, rammed earth is very common, approached differently according to climate, geography, resources and culture. In both southwest regions of Portugal and the USA, the economical context, combined with the dry and hot climate, has promoted the intense use of soil for construction. In the USA, some remains of indigenous and pre-colonial earth construction techniques can be found, reminiscent of wattle and daub or cob. However, it was only in the 16th century that the Spaniards brought their techniques of adobe and rammed earth, with strong Roman and Arab heritage, from the Iberian Peninsula.

Besides the general misconceptions about earthen construction, still considered weak and of poor quality, it has been gaining new perspectives worldwide, in the last two decades. Rammed earth is a vernacular technique brought with a great success into contemporary construction, allowing a sustainable approach and a unique visual expression. With good behaviour regarding thermal and acoustic parameters, rammed earth can be used both in new construction and in architectural rehabilitation, with a contemporary design, respecting local and traditional styles. The long legacy and enormous contemporary potential, makes it a relevant topic of study.

1. THE CURRENT SITUATION IN PORTUGAL AND IN THE USA

1.1. Background

Casa Grande is one of the most important pre-colonial ruins in the USA (Arizona) and came to notice after 650 years of abandonment and weathering (Fig.1). The main building had three stories made in a type of cob and rammed earth techniques without

using formwork and it is still standing up, which shows how resistant and durable these techniques can be. Despite this evidence and all the cultural influences brought from colonization and emigration periods, what caught the public attention, in the mid 19th century was *“the first book, devoted entirely to earth construction, that has been published in the USA. This book is the American translation, in 1821 by Henry Holland, from the Rural School of Architecture of François Cointeraux (1791)”*¹(Ricaud 2014, 12). Holland’s publication is considered² the promoter of the first wave of interest in earthen construction in the USA, subsequent to other waves up to the present, showing that such techniques have not conquered yet a clear position on the construction world. With the industrial revolution, earthen construction techniques have been just an economic alternative to conventional construction. Since then, architecture exists on the spectrum of expensive but unique craftsmanship, to the standardization of design. The high level of industrialization, particularly in the USA, lead to an extreme point where concrete, wood frame or metal structures allowed a fastest and cheapest process to build.



Fig.1 – Casa Grande ruins, Arizona, USA (Credits: Lima, 2015)

In the contemporary History, some moments of crisis (war, oil and energy crises) reduced the rhythm of resource consumption and encouraged the use of approachable traditional techniques and sustainable habits. The Great Depression was the second important moment for earthen architecture development in the USA because *“it induced shortages of money and building materials, and an abundance of cheap available labor”* (Easton 2007, 15). In consequence, the “New Deal” program gave to the people the opportunity to obtain work and dwellings. Part of it, the Homesteads Project *“would encourage basic ‘American values’ and restore dignity to the common people”* (Easton 2007, 16). Seven experimental and affordable houses, a project by Thomas Hibben, in Gardendale (Alabama), were made in rammed earth. However, this fact was hidden and the buildings were all plastered in case they failed (which did not happen), and they are still inhabited today.

The ongoing wave, specially stronger after the 2008 economic crash, is based on the global sustainability tendency and the attempt to save resources. In Portugal, because of its late industrialization, rammed earth stayed in use until the middle of 20th century but diminishing along with the introduction of concrete and other new materials (Fig.2). The technique was reintroduced between the 1980’s and 1990’s *“led by architects but rooted in traditional knowledge of the old masters ‘taipeiros’*” (Marques et al. 2014, 3), with no role

¹ free translation from original French version

² according to David Easton (2007, 13)

performed by governmental or public initiative. Paradoxically, in both countries the most common contemporary rammed earth clients are most of the time from a wealthy upper class *“in the context of an eco-friendly trend, being a life choice (...) or a high standard tourism investment, which requires technical expertise”* (Marques et al. 2014, 5).



Fig.2 – Traditional technique, Aljezur, Portugal (Credits: Marques, 2014)

1.2. Building Codes

One of the largest differences between Portugal and the USA is related to building codes applied to earthen construction. While in Portugal still is a lack of specific regulations for earthen construction and its feasibility has to be totally assumed by engineers' and architects' experience; in the USA, beyond the technical responsibility, fragmented references from individual state codes can be found in the current International Building Code. This fact does not help to achieve consistency in earthen practices, since there are substantial differences, for instance, between Arizona, New Mexico, Texas and California, which are not about their specific issues, such as earthquakes, but have to do with each State, its economic and cultural context. In order to help owner builders, New Mexico Building Code includes tables with wall ratios and drawing details, making it more prescriptive and supportive of a cultural identity, compared with Pima County (Tucson, AZ). Tucson has a different business approach, following the legal procedures like other construction types. And California has even more regulations, with the result that almost only the wealthy people can afford rammed earth, *“In California there is a political and a structural major battle all the time. To get a permit there, it can take years!”*³. More restrictive codes end up demanding steel reinforcement in rammed earth load bearing walls and concrete bond beam, instead of the traditional wood bond beam, more flexible in earthquakes. However, placing reinforcement in rammed earth walls is somewhat problematic because *“rammed earth cannot be vertically reinforced with steel reinforcing bars like concrete block, it remains vulnerable to earthquakes”* (Vint 2005, 91). Simultaneously, cement plasters or stucco are required on new constructions, prohibiting exposed unstabilized walls, regardless all the bad examples in the past, where rigid and low permeability performance of the plasters lead to the degradation of the core earth wall.

³ Bob Barnes, interview conducted by the author in May, 2015

1.3. Context and typology

The use of earthen materials has always been driven by at least two major reasons: cultural and economic, to which we can today add an increasing ecological concern. These greater motivations to chose earth as a building material are based on several factors to take into account such as weather conditions, location and site topography (Fig.3), availability of soil and its characteristics, typology and program requirements, project design and availability of expertise hand labor and/or guidance.



Fig.3 – Troviscais House, Odemira, Portugal (Credits: Marques, 2014)

In both Southwest regions of Portugal and of the USA, rammed earth seems to be the most used earthen technique nowadays and not only climatic reasons explain this major presence of rammed earth since there are so many cases attesting its use in cold and humid climates (North of America and Europe). In the USA it is possible to find several rammed earth building typologies, driven by economical and social circumstances: owner-builder housing (if allowed by regulations), low-cost dwellings sometimes related to educational official programs and hands-on experience workshops organized by nonprofit associations, urban landscape (public art or lot walls), luxurious houses and private/public equipment (Fig.4). On the other side, in Portugal, due to its context, there are more private housing or touristic initiatives (new or restoration), along with some educational programs and recent public art works that used rammed earth as a manifesto (Fig.5).



Fig.4 – Low Compound House, Scottsdale, Arizona, USA (Credits: Eddie Jones, 1997)



Fig.5 – MUD, Viseu- Portugal, 2015 (Credits: NunoVasconcelos, 2015)

Until now, there were very few programs on both sides of the Atlantic for apprenticeship, perhaps due to a lack of interest and disclosure. These programs do not open regularly and cover a small community of recipients, being its long-term continuation not assured, neither the monitoring of the building's life cycle (Fig.6). The major educational and official projects in the USA aimed to support local communities with low cost housing and equipment or historical preservation programs. They are specially driven by the University of Arizona, University of New Mexico with YCC - Youth Conservation Corps Program, Northern New Mexico College and Cornerstones Community partnerships. In Portugal in the 1990's, in one of the rare public equipment projects made in rammed earth, São Luís Market, in Odemira, there was the opportunity to train some students in earth building construction. Recently there has been some positive development in the educational area, since the country is now part of an European project (PIRATE - Provides Instruction and Resources for Assessment and Training in Earth building) that aims "to establish the new standards of competence needed by the growing market of sustainable building with earth material" (Pirate 2012).



Fig.6 – Rammed earth wall by students with Mike Sims (Credits: Lima, 2015)

1.4. Constructive methods

Between Portugal and the United States, what differs the most is clearly the rammed earth methodologies and technique. The constructive method relies on a still traditional system in Portugal and in a more standardized scheme in the USA, having great consequences in the final appearance of the walls and building as a whole.

Regardless of the well-known type of structure that rammed earth is based on - monolithic structure, it is interesting to point out the close similarities between Portuguese rammed earth technique of composed courses and a typical masonry system. Although the growing use of continuous horizontal formwork, there is still a permanence of traditional methods, with crafted and small-scale formwork. The wall is built horizontally with the first course being completed before the second starts on a reverse way. Every lift is compacted firmly leading to a uniform panel. It is still common to use mortar with lime and sand for the joints between courses, which will reduce the possibility of cracking and will help to fix the finish plaster. Surprisingly, this last technique is totally unknown in the USA, where instead insulation foam is used to fill specific joints, such as expansion voids.

The reappearance of rammed earth in the United States in the late 19th century triggered a faster development of building practices, using bigger structures managed with heavier machinery, changing timing and organization on the work site. In this case, mostly vertical forms are used and, depending on the budget, there is a choice between a movable modular height form or a static form with total high. This last choice may require special care to assemble and disassemble the heavy forms made of steel or plywood (Fig.7). Since the North American technique does not use mortar for joints, each form will work as a whole independent panel tied up to the adjacent one and to the bond beams with keyways. To avoid horizontal cold joints in the same panels or sections, there is a special concern to end the ramming process on the same day. In this context, rammed earth became an expensive solution compared with the common concrete block and wood frame systems. As architect Eddie Jones said in our interview *“if you’re poor, dirt walls are cheap, if you are rich you are not going to build by yourself, and it will be an expensive wall. I can do a cast-in-place concrete wall for the same price I can do a rammed earth wall for. And the rammed earth technology, at least in Phoenix, has advanced so far it’s almost too good. It looks like a piece of cake, literally like you can eat it! It is so beautiful and perfectly uniform!”*⁴. The quality of the final work will depend on the efficiency of the formwork system, while the building design will determine the best system to rise up the wall. In the USA recent constructions, the rammed earth walls have been associated to a concrete post and beam structure, that makes possible a free plan, where rammed panels are combined with glass, having no longer the traditional closed box structure. In this country several systems (from freestanding panel to panel-to-panel) are being used to achieve this shape. These techniques have gotten to a point that innovation is constant, becoming even more a hybrid system with less earth and more concrete basis.

⁴ Jones, interview conducted by the author in May, 2015



Fig.7 – SEWWC forms panorama sirewall (Credits: <http://sirewall.com/>)

1.5. Design and function

The new rammed earth systems are being used in the contemporary architecture, with strong authorship features, since there are no limits to build with. These solutions allow a wider freedom in creating walls with aesthetic value comparable to a fine art object: *“blurred boundaries - earthen walls and a glass, all reaching to the sky”* (Holl and Pallasmaa 2002, 117). The constructive value of the wall is reduced for a creative will of free sculpture shape (Fig.8). However, without a modular pattern, a more complex wall design, sinuous and with exceptional dimensions, will increase costs and hamper level of execution. In the USA, rammed earth load bearing walls are frequently on a range of 18 inches (45,72 cm) to 2 feet (61 cm) thick, providing great thermal mass. Due to its structural limitations, buildings have usually one floor with *“a maximum wall thickness-to-height ratio of 1:10, adequate cross-walls, and continuous bond beam is needed to provide adequate resistance to lateral forces”* (Vint 2005, 91). Openings vary from simple and defined windows in the Portuguese case, to the large glass panels in the North American case. Framing can be completely omitted allowing glass panels to sit in the opening, sealing the joints with elastomeric putty. As thermal advantages are not the determinant reason for choosing rammed earth, a large amount of glass surface in the facade (with a lower R-value for thermal insulation and naturally facing South) gives the panoramic views. Windows can be very traditional though, with metal or plain wood frames laid on sandstone or concrete sills (sometimes coming from the stem wall). According to the North American regulations openings in stabilized rammed earth walls, when they have *“less than twenty-four inches in width shall not require a lintel or semi-circular arched opening”* (CID-RLD - New Mexico Code 2009, art.14.7.4.18). Lintels can be in wood or steel plate, with the last one observing the aesthetics of minimal design (Fig.9).



Fig.8 – Outpost House, Paradise Valley, Arizona, USA (Credits: Eddie Jones)



Fig.9 – La Tierra Nueva Residence, New Mexico, USA (Credits: Graham Hogan)

The North American roof system is in general a light system of corrugated metal over insulation panels and wood trusses supported by concrete bond beams at the top of the rammed earth bearing walls. In traditional buildings, these roofs have enough overhangs to protect the walls from the rain. Recently there are many examples where rammed earth is exposed with just a metal flashing or concrete cap at the top, reducing at maximum the concept of volumes, with linear edges for transition of materials and plans (Fig.10). However it is visible, for instance in the office of the architect Rick Joy (a set of separated volumes, built in 1995-1998), how design and perhaps the type of soil determined the decay of the walls. On his following project, the 2004 Tucson Mountain House, Rick Joy invested in visible overhangs over the earthen walls and assumed the expression of the footer in concrete to step up the bearing value of the rammed earth wall. The footer reminds us the traditional stone base, protection from the water and other biological presence. In these cases, as in others in the vast North American production, the transition between the stem and the rammed wall is often highlighted with an indent.



Fig.10 – PERA Building, Santa Fe, New Mexico, USA (Credits: Lima, 2015)

In Portugal, rammed earth walls were traditionally hidden from exterior with a thick layer of plaster, as a finishing protection from weathering. This type of finishing is still in use, but recent buildings are exposing earth on the entire surface of the walls, for aesthetic reasons, using lime or cement for compound stabilization. According to Peter Walker, the compound for rammed earth should have an ideal percentage between 45 to 80% of sand, 10 to 30% of silts and 5 to 20% of clay (Ponte 2012, 127). The portion of clay may vary depending on the cement content if the compound is stabilized. The traditional North American mixture of soil has approximately 10% clay, with medium and sharp aggregates, stabilized with 6% to 10% of cement, which allows totally exposed walls. In order to get a painting effect on the wall with a high quality finish, formworks are carefully planned in an extremely time consuming process and every lift with 4 to 8 inches for ramming is designed to incorporate most of the time natural pigments. As a highly efficient solution to deal with extreme temperatures, some walls have insulation panels in between two rammed earth panels, or in other cases they have the insulation panels on one side, which is then covered by a final plaster. Whatever is the final coat, or intermediate solution to comply with comfort standards, rammed earth inspires architect's desire to minimal and pristine shapes as if only the walls texture could fill the space.

Conclusion

Rammed Earth, although an unusual construction system for large scale typologies, is becoming highly appreciated for its sculptured mass and unique beauty in every single work. Large scale rammed earth structures for public and private equipment are being built, such as the recent project of an Hospital on an Indian Reservation, in Oklahoma, that will be carried on by Sims General Construction. Today several media forms have been spreading images of these fascinating structures or minimal house spaces associated with idyllic scenarios, which contributes for the contemporary image of this vernacular technique.

Two major movements can be identified within the earthen construction evolution. One of the movements, found in the North American Southwest, approaches a high-tech system that makes the construction extremely expensive and less accessible, without fearing cement contribution. The other tendency, found in the Portuguese Southwest, keeps a traditional profile, with a low cost level. These differences have to do with country's scale, construction market and available resources. Despite global standards, regional codes and many scientific results, on both countries there is still a long path to promote more recommendations and standards to face warranty demands, to inspire and educate the public in general and also to instruct and prepare a specialized corp of technicians. This is part of a long process that could give to rammed earth a more prominent position in the construction scenario.

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This paper is cofinanced by FCT; COMPETE 2020, Portugal 2020 and Fundo Europeu de Desenvolvimento Regional.