STANDARDS FOR THE CONSERVATION AND RECOVERY OF EARTHEN HERITAGE, PERU AND CHILE

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Theme 8: Charters, Standards and Guidelines for Heritage and Construction
Keywords: Standards, earthquake, heritage, conservation

Abstract

This paper presents relevant criteria used in two important official Standards that guide intervention to earthen built heritage in Peru and Chile: 1) the revision of Peruvian Standard NTP E-080 and presentation of Seismic Resistant Conservation Principles for Earthen Heritage; and 2) the Chilean Standard for Structural Intervention in Earthen Heritage Construction. Both cases arise for the first time in either country. In Latin America, these principles or standards cover a huge gap in the regulations for the design of the maintenance and repair of heritage buildings damaged by earthquakes.

A new and indispensable element has been the integration of risk management techniques to disasters, through international declarations and charters for heritage conservation. It foresees the inclusion of social organization in national plans for disaster, as well as the treatment for earthen built heritage, during the three stages: Mitigation Emergency and Recovery. Unlike what was commonly done in the past, it is of paramount importance to stop any attempts at heritage demolition, damaged during the emergency phase of an earthquake.

Therefore, the importance of a pre-demolition or intervention study and the condition of the heritage building is emphasized, to assess the significance of its cultural values and to deeply identify its structural stability. Regulations highlight the vulnerability of earthen material and its tendency to sudden collapse threatening the lives of the occupants or visitors. It also emphasizes the desirability of using criteria based on performance design, which means installing permanent reinforcement to control the movement in damaged heritage structures. However, the use of such reinforcement must meet three conditions: 1) Minimal intervention, to preserve its heritage significance; 2) Compatibility with earthen material, to prevent deterioration due to the reinforcement itself; and finally, 3) Reversibility, to modify or withdraw the reinforcement when better solutions are available.

1. INTRODUCTION

Regulations aim for global sustainability. Regulations work to improve technology and social organization, so that the environment can recover at the same rate that it is affected by human activity. Regulations attempt to develop solutions for durability.

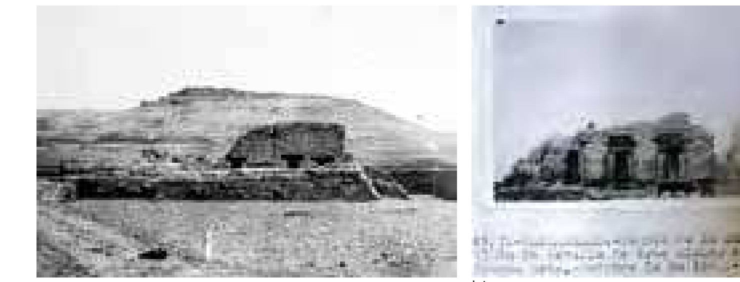
The material advantages of earthen construction are known, such as low pollution, energy savings, low thermal and acoustic conductance, sensory compatibility (visual and touch) with nature and the rural landscape, economy, self-built construction, and easy access to earth as a building material in harmony with the environment. Disadvantages are also known, like the vulnerability of earthen buildings to disasters such as earthquakes or floods, the difficulty of spreading the technology to protect them, and social organization to mitigate the damage and loss of life against these disasters.

Treatment against natural disasters or risk management has three phases: the emergency, the recovery and the mitigation. These can be associated with short-, medium- and long-term actions, respectively. The last phase is the one that involves prevention and preparedness efforts, wherein society should be organized by all means for the next of these recurring disasters, through regulations.

2. PROTECTION OF EARTHEN CONSTRUCTION IN SEISMIC-PRONE AREAS

Earthquakes are natural disasters that produce loss of life and extensive natural damage, especially in the American costal area of the Pacific Ocean. This area is part of the Circum-Pacific circle, where about 95% of the seismic energy in the world is

Fig.1 Collapsed houses during the earthquakes of Pisco, Peru, 2007 and Maule, Chile, 2010 (credits: J. Vargas-Neumann, 2007 y 2010)



a) b)

Fig.2 a) Ruins of the Temples of the Moon and Sun (back); and b) Detail (credits: Archive J.C. Tello, 1940)

released as a result of an ongoing process of continental drift associated with the inner make-up of the planet and its dynamic equilibrium.

Some of the countries most affected by these disasters have studied the behavior of earthen construction, either houses or buildings of cultural significance. Experimental studies and post-earthquake observation are the major source of information to mitigate damage from these phenomena and to develop new repair technologies and more stable construction. The study, research and design of the material, existing technologies and their further development are a relevant part of mitigation tasks. Regulations are the technical foundation to build better. Dissemination and technological transfer is an essential, but a rather complex task. Peru was a leader in this area of concern for several decades. Therefore, here are presented the outstanding achievements and regulatory efforts of Peru (ININVI, 1977; MTC, 2000), and more recently, of Chile.

3. EFFECTS OF EARTHQUAKES ON ADOBE BUILDINGS

The main structural elements of earthen built housing are the walls. Columns, arches, vaults and domes built of earth have collapsed over time due to the action of earthquakes. They are no longer part of the construction typology in American seismic prone areas, but they are found in other areas of the seismic world, and are the causes of fatal accidents.

Earthen structural elements have limitations to seismic safety as the material is heavy, offers little resistance and is fragile. This limits earthen architectural design as well. Peruvian architecture has been influenced by seismic history. The remaining earthen houses from the Colonial era have dense walls, which are very wide with few and small openings.

Increasing soil scarcity in urban areas produces earthen housing with thinner walls and large windows, imitating the architectural models of more resistant materials, such as brick. Nowadays, earthen houses are built very vulnerably.

Roofs of earthen masonry disappeared as a result of earthquakes during the time of the Spanish colony (1532-1821). There are still some remnants in churches. Lighter roofs, along with reed and quincha materials, have replaced them. For ceilings and walls, a type of quincha was developed, which started in the 17th century, and flourished in the Republican period (from 1821 onwards). Quincha is a mixed technique of wood, reed, vegetal fibers and earth, and the oldest traces have been found in Caral, Peru dating to 5,000 years ago (Vargas, Iwaki, & Rubiños, 2011).

The quality of the soil on which the earthen buildings or other vulnerable materials are sited is also a significant factor in their destruction due to earthquakes. Firm soils transmit seismic waves to constructions almost without modification, but soft soils significantly amplify the movement of the foundation soil. This dynamic amplification is a determining factor for the amount of destruction. The Peruvian Standard prohibits earthen buildings on loose, soft, filled and organic soils.

4. EARTHQUAKE DESTRUCTION OF EARTHEN-BUILT HERITAGE

Many testimonies of seismic destruction of earthen archaeological heritage are located throughout the coast and highlands of Peru. A prominent example that has been studied is Pachacamac, especially its Acllawasi Temple, located near Lima. Pachacamac's north-south and east-west roads connected to Qhapac Ñan are shaped by stone walls set with earthen mortar, which have been destroyed by earthquakes since Colonial times. Recently reconstructed, they clearly reveal that the technology of earth and stone masonry set with earthen mortar is inadequate to contain fillers or soil deposits in seismic prone areas.

A good example is the Acllawasi Temple, built by the Incas initially in stone around 1450. It was seriously damaged by earthquakes, and rebuilt with local materials (adobe and wood and reed ceilings) by the same Incas. Photos and drawings from the Julio C. Tello Archive show the remaining vestiges of the temple after the earthquake of 1940, and these account for the inexorable seismic destruction of almost five centuries. Julio C. Tello rebuilt the temple from 1941 until 1945, and four subsequent earthquakes have damaged it again. Today, it is no longer possible to visit the temple for security reasons. The seismic damage of cultural heritage is permanent, cumulative and tends to collapse the structures up to the point where their historical value disappears.

a) b)

Fig.3 Tests of adobe modules on vibrating table a) Unreinforced module; and b) Reinforced module (credits: Joop den Uyl, file PUCP, 1982)

5. DESIGN CRITERIA FOR EARTHQUAKE-RESISTANT CONSTRUCTION

There are three major design criteria to provide security for earthen buildings:

- Criteria based on resistance;
- Criteria based on stability;
- Criteria based on performance or behavior.

Traditional earthen construction designs have been based on strength and stability. Thick walls are more resistant and stable. The width of walls is, therefore, an important variable. Historical buildings or ruins that have survived earthquakes, although very damaged, are robust, less slender and with small openings. Also, wall density, or the ratio of wall area to covered area in each of the directions of study, is another important variable.

Earthquakes produce dynamic soil movements as sequences of combined and complex waves. Soil movement induces movement in buildings, which, at peak times, are very large, usually quite higher than those supported by the materials. Strong earthquakes crack earthen walls due to their low resistance, and these will gradually become divided into unstable pieces. Based on resistance and stability criteria, too bulky and expensive construction would have to be considered in order to avoid collapse. In general, earthen buildings are insufficient to withstand strong earthquakes and, therefore, are hazardous to life safety.

Modern design criteria for performance consider the most efficient way to control movement and to provide greater security. This consists of the use of reinforcement materials with greater traction. The use of reinforcements must conform to an acquired knowledge, including laboratory experimentation and mechanical testing, as well as the invaluable experience of observation after each earthquake.

The compatibility between the proposed reinforcement and earthen materials is indispensable. Introduced reinforcement, by its hardness, elasticity, texture and strength, helps control the movement of cracked structural elements so as to avoid partial and total collapses without local damage to structural earthen elements. Historic construction requires additional minimum reinforcement, aimed at achieving an intervention that impact, as little as possible, the cultural heritage and also respects authenticity. While design criteria for performance is now universally used for all fragile materials in modern construction standards, it should be noted that 5,000 years ago in the culture of Caral, reinforcement was also used for earthen construction, such as plant fibers and the use of mixed earthen technologies combined with wood and reed (Vargas et al., 2011).

Fig.4 Module reinforced with synthetic mesh or geogrid with total reinforcement and coating of half of the module (credits: File PUCP, 2007)

6. RESEARCH TO MITIGATE SEISMIC DISASTERS

Since the 1970s, the Engineering Department of the Pontifical Catholic University of Peru (PUCP) has been concerned with the study of the stability of earthen construction in seismic prone areas. The first work was aimed at determining the mechanical properties of adobe masonry walls by static experiments, and the search for efficient reinforcements. In the 1970s, a rotating platform was used to statically test full-scale housing and various reinforcing materials, such as reed, wood and wire (Vargas, 1978; Blondet, 2004). The most efficient reinforcement at this stage was vertical reed meshes, tied to horizontal layers of crushed cane (Vargas, Blondet, Tarque, & Velásquez, 2005).

To better understand the influence of material properties on the resistance of adobe masonry, a project with funding from USAID was developed in 1983 (Vargas, Bariola, Blondet, & Mehta, 1984). The main conclusions were that since the mortar is responsible for the integration of the masonry, clay is the most important component of the soil used to build with earth, as it provides the link between mortar and adobes. Yet clay also shrinks when drying, causing cracks in the mortar. Adding straw or coarse sand to the mortar can control these cracks.

In the 1980s, the first seismic experiments were conducted on adobe house modules using a unidirectional vibrating table (Ottazzi, Yep, Blondet, Villa García, & Ginocchio, 1989). The housing modules used had no ceiling and were tested with and without internal reed reinforcement, in accordance with the *National Building Regulation* (MTC, 2000).

Fig.5 Avoid strengthening with reinforced concrete beams and columns, because they aid in collapse instead of protecting adobe walls, as in this example of the church of San Luis de Canete, damaged during the Pisco earthquake in 2007 (credits: J. Vargas-Neumann, 2007)

The main conclusion drawn was that when faced with a severe earthquake, unreinforced structures collapse (Fig.3a). The interior reinforcement of horizontal and vertical reed plus an upper wooden collar beam prevents separation of the walls and maintains some integrity during repeated severe unidirectional earthquakes (Fig.3b), providing the option for future repairs.

Later, another line of research began to develop more efficient reinforcement systems to avoid sudden failures using industrial materials. Synthetic geogrid reinforcing has proven to be very effective. The geogrid must completely cover both sides of the walls and to be fixed to the upper collar beam of the walls.

7. REINFORCED EARTH, A NEW SEISMIC -RESISTANT MATERIAL

As a result of research and post-earthquake observation, it is possible to improve the seismic resistance of earthen constructions, if compatible and traction resistant reinforcements are added. This new material is reinforced earth, which endows structures a large deformation capacity. During an earthquake, although reinforced earth walls present some cracks, they maintain their deformation capability and continue withstanding gravity and seismic loads, safeguarding lives and allowing for their future repair.

8. REQUIREMENT FOR REGULATIONS AND GUIDELINES

To ensure the safety of reinforced earthen work, regulations are required. In the case of heritage buildings, where the cultural value must be preserved, conservation guidelines are also required as it is difficult to establish standards with minimum specifications, which may not be met anyway, because these buildings already existed.

9. SOCIAL EARTHEN-CONSTRUCTION STANDARDS IN PERU

Based on the studies described, since 1977 (Vargas et al., 2005), Peru has a standard for earthen building, which was revised in 1985 and 1999. It is currently under revision again with a new rural and urban vernacular emphasis.

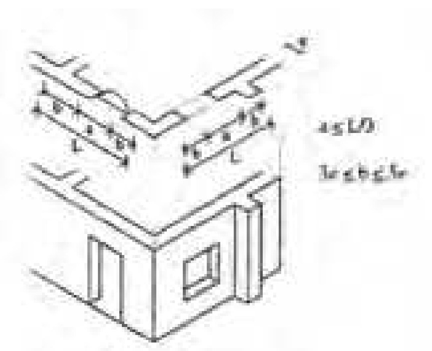


Fig.6 Specifications for wall openings; the relief of the buttresses must be equal to "b" (credits: Norma NTE Adobe, 1999)

The 1985 version was used as the earthen building chapter in Guidelines for Earthquake-Resistant Non-Engineered Construction (IAEE, 1986), which influenced the production of other national standards, such as in India and Nepal. Other countries have also had their regulations inspired directly by the Peruvian Standard (Morocco and Chile). It has influenced also the *Recomendaciones para la Elaboración de Normas Técnicas de Edificaciones de Adobe, Tapial, Ladrillos y Bloques de Suelo-Cemento* from the Habiterra thematic network (CYTED, 1995), including Nicaragua, Ecuador, Brazil and other Latin American countries.

Earthquake Resistant Design (EQRD) standards are legal policies containing technical provisos for structural design of buildings in seismic prone areas. For weak and fragile earthen buildings, the philosophy of EQRD must accept the occurrence of cracking in moderate quakes, while ensuring the protection of the lives of the occupants, and preventing the occurrence of collapse during moderate and strong earthquakes by installing essential reinforcements. The current Peruvian Standard (MTC, 2000) specifies that adobe buildings are to be designed by rational methods based on the principles of mechanics with elastic behavior criteria. However, it also recommends wall reinforcements to improve seismic behavior.

Seismic thrust is represented by a basal lateral force H = SUCP, where C is the percentage of weight to be applied laterally to simulate the seismic force, and depends on the seismic area. In high seismicity areas, C is equal to 0.20. S, the soil factor, is 1.00, if the soil is good (rocky or firm soil), and 1.20 when the soil is intermediate. The use factor, U, is 1.00 for housing and 1.20 for other buildings, such as schools, medical centers, or public buildings. The weight, P, should include the dead load plus 50% of the live load.

Observations of damage from past earthquakes indicate that adobe buildings located on soft soils have significantly greater damage than those located on firm soil. The S coefficient increases to 1.35 for intermediate soil, and construction on soft soil is not proscribed. In the area of greatest seismic activity, the construction of two-story adobe buildings is not endorsed; this is appropriate only in areas of lower seismic hazard. It is recommended that the second floor be built with lighter materials, such as *quincha*, as was also the direction of the Viceroyalty Royal Ordinance after the great earthquake that destroyed Lima and Callao in 1746.

A symmetrical plan is recommended with adequate wall density in two perpendicular directions, small and centered openings. Walls together should be connected together using reinforcements. The foundation must be built with stone masonry. The foundation level must be met by cutting and never by infill.

The *Peruvian Standard* specifies the allowable stresses for adobe masonry. It also specifies that the walls should be well connected. The vertical bracing can be cross walls, buttresses or reinforced concrete columns. The upper collar beams, made of wood or reinforced concrete, are the horizontal reinforcement and must be applied to all walls. However, the current revision to the Standard does not recommend reinforced concrete columns or beams because of their difference in hardness and rigidity with earth.

The walls must comply with certain geometric conditions to ensure good seismic behavior. The maximum length between wall bracing should be 12 times the thickness of the wall, and the openings must be central and small.

Currently, it is known through experimental verification that synthetic meshes are the best reinforcement alternate. This reinforcement was included in the Peruvian norm after the earthquake of 2007, as it has proven to be efficient. Reinforcement requirements depend on the slenderness of the walls. The Standard permits unreinforced construction of slenderness walls less than 6. However, the current review of the Standard recommends reinforcing all earthen walls and limits slenderness to 8 or 10 depending on the seismic area. This is based on laboratory and field experience, which revealed sudden life-threatening flaws for occupants (Vargas, Torrealva, & Blondet, 2007).

10. GUIDELINES FOR HERITAGE BUILDINGS IN CALIFORNIA, USA

In order to understand life-safety issues for occupants of historic buildings of earthen masonry, the Getty Conservation Institute (GCI) with advice from Peru conducted a research program, known as the Getty Seismic Adobe Project (GSAP), which determined recommendations for performance criteria. The types of reinforcement developed in California from 1990 to 1996 (Tolles, Kimbro, & Ginell, 2003) provided some kind of ductility, as well as local and global stability. Slender walls require more aggressive reinforcement solutions and these can become irreversible. The main tools selected were:

- Upper wooden collar beam, as recommended by the Peruvian Standard;
- Horizontal upper and/or lower ties of plastic or steel;
- Vertical ties near the corners and openings of synthetic material;
- Central nuclei of synthetic material in the walls (non-reversible solution).

11. PRINCIPLES FOR SEISMIC RESISTANT CONSERVATION OF EARTHEN-BUILT HERITAGE IN PERU

The Specialized Committee in charge of reviewing and updating the current Standard E-080 Adobe decided to include under the section of existing structures, a chapter for the intervention on buildings of cultural value. This chapter required principles for the preservation of heritage buildings. The proposed principles were unanimously agreed upon, and will soon be part of the National Building Regulations of Peru.

Under the Venice Charter (ICOMOS, 1964), when traditional techniques prove inadequate (e.g. against the cumulative destruction from disasters, such as earthquakes), the consolidation of a monument can be achieved by the use of modern techniques for building conservation, whose effectiveness has been demonstrated by scientific data and experience. The application of these was initially aimed at architectural heritage, but it also extends to aspects of archaeological sites of architectural value, according to the Lausanne Charter (ICOMOS, 1990).

The vulnerability of materials, such as earth, forces conservation compromises, when disasters like earthquakes create vulnerable situations on earthen structures in seismic prone areas. The cycle of damage-restoration-damage associated with earthquakes and earthen heritage has occurred for many centuries. Newly documented during the last century is the starting point for technological change in the prevention of heritage built in seismic prone areas. In Peru, the need to develop adequate principles to preserve heritage was understood. Conservation charters were generated in the West, whereas the principles were generated in the East. These did not consider the fact that the world is geographically divided into seismic and non-seismic areas. Some architectural heritage principles assert urgent protection measures to prevent the imminent collapse of the structures, for example, following the damage caused by an earthquake, as mentioned in the Charter Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage (ICOMOS, 2003). However, today it is considered necessary to act before the occurrence of earthquakes, with a preventive culture, and not acting only in emergency, after the earthquakes have created irreparable damage.

Every intervention should be based on proper studies and assessments, not only on durability against weathering and natural deterioration, but also on the resilience against disasters from seismic activity. Problems should be solved according to local and particular conditions, respecting aesthetic, historic, scientific (physical integrity, materials, technology, stability) and social values of the structure itself or of the historic site. Any proposed intervention should aim to:

- Preserve and prevent deterioration of the building;
- Maintain traditional techniques and materials of special value;
- Ensure the safety of the occupants;
- Keep the intervention to a minimum to ensure authenticity;
- Be technically reversible and compatible with the original material;
- Allow further necessary conservation actions;
- Facilitate future access to information incorporated in the structure.

The decision to use "traditional" or "innovative" techniques should be weighed on a case-by-case basis, always giving preference to techniques that produce as minor an invasive effect as possible, and those that are more compatible with the values of cultural heritage, never forgetting to meet the requirements imposed by the seismic safety and the durability.

Minimum intervention on the fabric of earthen or of earthen-based historic structures is the ideal. Notwithstanding this fact, the minimum intervention aimed at ensuring the preservation of structures damaged by earthquakes may require its partial disassembly and subsequent reassembly, aiming at its proper preservation and the employment of necessary reinforcement. The anastylosis methodologies of intervention can be an option, by using a solution of earthen mortars or addition of liquid earth (sieved earth) as an integrative material, seeking the maximum use of the original earth or similar earth. As for additives, the use of chemicals or industrial binders should be avoided. These have no real evidence of durability, or may, in time, have a behavior that will generate discontinuities or subsequent deterioration.

To better understand these principles, defined as minimal intervention, is the set of actions necessary to prevent further deterioration to a historic building, such as reversible reinforcement, temporary or permanent, which can be substituted by a better solution without causing significant damage to the historic structure at a later date. Compatible reinforcement, even in advanced stages of deterioration of the fabric, helps controlling the movement of the original structure, without further damage.

12. CONCLUSION

Chilean engineers developed advanced building regulations for all materials except for earthen construction. The weakness of the material and the amount of life lost from earthquakes in vulnerable earthen houses and churches were certainties that advised against promoting any further construction with earthen materials. However, Chilean families were raised in adobe or quincha houses, and many of the ancient buildings built of those materials now constitute valuable cultural heritage.

The earthquake of February 2010, which hit mainly the central part of the country, destroyed much of this heritage. The community reacted looking for the legal means to obtain permits and licenses to repair and rebuild its lost cultural value. The Institute of Construction organized a Commission for Heritage Construction, which created a Committee for the Chilean Standard of Structural Intervention in Earthen

Building Heritage, in order to develop the first legislation that would allow a legal conduit for the reconstruction of damaged heritage. The absence of earthen seismic resistant construction experience, research, builders and masons skilled to perform the great task of restoring historic churches, manor houses, museums and public buildings built of this material resulted in the decision of using the experience developed in Peru.

The inclusion of Peruvian engineering by the Committee of the Standard allowed the quick development of a legislative draft, which was submitted to the Ministry of Housing and Urban Development (MINVU). After a period of discussion, MINVU collected observations and issued the official version. The document clarifies that it is not aimed at promoting new buildings, but rather the reconstruction of the existing earthen heritage. Adobe, rammed-earth, *quincha*, and stone masonry with earthen mortar are the techniques covered in the document.

Characteristic values of the allowable stresses for adobe masonry are encompassed, as well as the design, by analysis methods and traditional calculation. These include reinforcement recommendations with materials resistant to traction and compatible with the earthen material, such as the synthetic mesh developed at the Pontifical Catholic University of Peru. The main chapters of the Standard are intervention, structural and economic criteria, structural design (design philosophy); diagnosis of the monument; registry of the building (description); analysis and verification of the design and the geometry; mechanical properties of the material, design and calculation basis; structural intervention plan, restoration, reinforcement system, implementation and maintenance.

References

Blondet, M. (2004). *Estudio de la Vulnerabilidad de Viviendas Informales Construidas en la Región Sierra*. Lima: SENCICO/PUCP.

CYTED (1995). Recomendaciones para la elaboración de Normas Técnicas de Edificaciones de Adobe, Tapial, Ladrillos y Bloques de suelo cemento. *Red Temática XIV.A: HABITERRA. Sistematización del Uso de la Tierra en Viviendas de Interés Social*. La Paz.

IAEE (1986). *Guidelines for Earthquake Resistant Non-Engineered Construction*. Tokyo: Asociación Internacional de Ingeniería Sísmica.

ICOMOS (1990). *Charter for the Protection and Management of the Archaeological Heritage. The Lausanne Charter*. Available at: http://www.icomos.org/charters/arch_e.pdf.

ICOMOS (1964). *International Charter for the Conservation and Restoration of Monuments and Sites (The Venice Charter)*. Available at: http://www.icomos.org/charters/venice_e.pdf.

ICOMOS (2003). *ICOMOS Charter - Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage*. Available at: http://www.icomos.org/charters/structures_e.pdf.

ININVI (1977). *Adobe: Norma Técnica de Edificación E-080*. Lima, Peru: Ministerio de Vivienda y Construcción Instituto Nacional de Investigación y Normalización de la Vivienda.

MTC (2000). *Reglamento Nacional de Construcciones. Adobe: Norma Técnica de Edificación E-080*. Lima, Peru: MTC/SENCICO.

Ottazzi, G., Yep, J., Blondet, M., Villa García, G., & Ginocchio, F. (1989). *Ensayos de Simulación Sísmica de Viviendas de Adobe*. Lima, Peru: PUCP.

Tolles, L., Kimbro, E., & Ginell, W. (2003). *Planning and Engineering Guidelines for the Seismic Retrofitting of Historical Adobe Structures*. Los Angeles, USA: Getty Conservation Institute Scientific Program Reports.

Vargas, J. (1978). Recomendaciones para el diseño y construcción de viviendas de adobe. Estudio experimental. *Simposio Internacional sobre el Terremoto del 4 de febrero de 1976, y Proceso de Reconstrucción*. Antigua Guatemala, Guatemala.

Vargas, J., Bariola, J., Blondet, M. & Mehta, K. (1984). *Resistencia Sísmica de la Mampostería de Adobe*. DI-84-01. Lima, Peru: PUCP. Proyecto financiado por USAID.

Vargas, J., Blondet, M., Tarque, N., & Velásquez, J. (2005). La tierra armada: 35 años de investigación en la PUCP. S*eminario Internacional de Arquitectura, Construcción y Conservación de Edificaciones en Tierra en Áreas Sísmicas*. Lima, Peru.

Vargas, J., Iwaki, C., & Rubiños, A. (2011). *Evaluación Estructural del Edificio Piramidal La Galería. Proyecto Especial Arqueológico Caral-Supe, Lima, Peru* . Fondo el Embajador de EEUU.

Vargas, J., Torrealva, D., & Blondet, M. (2007). *Building hygienic and earthquake- resistant adobe houses using geomesh reinforcement*. Lima, Peru: Fondo Editorial, Catholic University of Peru.

PREVENTIVE CONSERVATION: A CONCEPT SUITED TO THE CONSERVATION OF EARTHEN-ARCHITECTURAL HERITAGE?

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Theme 8: Charters, Standards and Guidelines for Heritage and Construction
Keywords: traditional practices, risk, management

Abstract

The concept of preventive conservation (PC) is relatively old, as the term was already in use as early as the end of the 19th century. As the definition implies, the theory of preventive conservation was developed mainly in the context of work on movable heritage. Yet the concept appears to be equally applicable to built heritage, and more specifically to earthen-architectural heritage whose basic raw material is usually fragile by nature and in some circumstances, can decay relatively fast.

Though earthen architecture is varied, one of its characteristics is that for each typology, there is always a specific way of ensuring durability or minimizing the risk of damage. This is achieved by implementing a variety of measures that depend on the physical, economic and social context of the site. What is interesting is that all of these measures are aimed at protecting and extending the life expectancy of the structures in question, thus linking them to the concept of preventive conservation.

This leads to the conclusion that preventive conservation is by its very nature a concept well adapted to earthen structures. Taking into account climate change, which brings about unusual situations, reinforces the suitability of the concept, which allows us to anticipate natural disaster.

This paper examines the suitability and limits of applying the concept of PC in the conservation of earthen architecture through theoretical analysis and practical examples. It concludes with recommendations for its adoption, taking into account intrinsic specificities, and both the tangible and intangible values of the heritage being considered for conservation.

1. INTRODUCTION

The concept of preventive conservation is relatively old, having been in use as early as the 19th century. Yet it has not been widely utilized by practitioners. It was only in recent times, after the acceptance of the failure of the more commonly used methods of 'remedial conservation' that the concept reappeared in the 1970s, gained ground in the 1980s, and acquired recognition as a specific discipline in the early 1990s.

The concept was widely disseminated, mainly through the efforts of ICCROM (International Centre for the Study of the Preservation and Restoration of Cultural Property ICCROM (de Guichen, 1999) posited that preventive conservation should be defined as follows: *"The full range of actions designed to safeguard or increase the life expectancy of a collection or an object."*

As this definition implies, the theory of preventive conservation was mainly developed in the context of work on cultural material, primarily by ICCROM, but also by other organizations, such as the Association of Art, Archaeology Restorers with University Education (ARAAFU) or the International Institute for the Conservation of Historic and Artistic Works (IIC).

However, at the beginning of the 1990s, North American professionals enlarged the field of application to historic buildings and housing artifacts, by adopting the New Orleans Charter (APTI/AIC, 1990-1993). This initiative did not move further, though the concept of 'risk management', which is nowadays quite widely considered, is similar, but in general is limited to disasters.

By the mid 1990s, a partnership with ICCROM (1) led CRAterre to explore the possibility of applying the concept of preventive conservation to the conservation of the Palais Royaux d'Abomey in Bénin. The results of this experience being quite promising, CRAterre decided to continue this exploration. This was the start of a series of field activities throughout the world in which preventive conservation was considered as a priority for the definition of conservation strategies and, further, for their implementation. The following is the result of this exploration, and the current state of our reflection on this question.