VERNACULAR AND EARTHEN ARCHITECTURE: CONSERVATION AND SUSTAINABILITY
Vernacular and Earthen Architecture: Conservation and Sustainability

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Cover photo: Half-timber in Villanueva de la Vera (Cáceres, Spain). Foto by Vegas & Mileto.
# Table of contents

**Preface**  
xiii

**Organization and committees**  
xv

**Conference support**  
xix

**Collaboration**  
xxi

**Plenary lectures**

- Markers of earthen construction modern revival  
  *H. Guillaud*  
  3

- The geography of earth building  
  *M. Lowie*  
  9

**Vernacular earthen architecture**

- A sustainable repair process for heritage buildings in historic Jeddah  
  *A.A. Ados & M. Y. Alawi*  
  17

- Santal mud dwellings: Materials, construction and space typology  
  *I. Ahmed*  
  23

- The study and analysis of the adaptation of earthen constructions in Hadhramaut (Yemen)  
  *A.A. Alawi*  
  29

- Vernacular houses of Stretonikeia: Architectural typology, materials and techniques  
  *O.B. Ayan & U. D. Gine*  
  35

- Ksar Taghit: Earthen architecture between authenticity and changes  
  *T. Bachir Cherif & M. Aiche*  
  41

- Supplemented rammed earth in the northwestern regions of Valencia  
  *L. Bulaguer Garzón, L. García-Soriano & L. Villacampa Crespo*  
  47

- Earth construction in prehistoric settlements of southern Portugal  
  *P. Bruno*  
  53

- Vernacular construction techniques and earth employ in Arg-e-Bam (Iran)  
  *C. Cacciavillani, S. Rinaldi & M. Severini*  
  59

- Vernacular heritage in Mendoza (Cuyo region, Argentina)  
  *S.A. Cirrini*  
  65

- Comparative evolution of vernacular mudbrick houses in the Nile Delta and Qurna (Luxor)  
  *M. Correas Amador & C. Simpson*  
  71

- Tapiobrick: A digital platform on brick-supplemented rammed earth walls  
  *V. Cristini & J.R. Ruiz Checa*  
  79

- The ancient caves from El Alguacilcejo. Vernacular habitat and landscape of Gran Canaria, Spain  
  *I. Díaz-Ramos & J. Manzano-Cabrera*  
  83

- Interpretation of sustainable desert architecture in Ghadames city, Libya  
  *A. El-Abbadi & H. Altan*  
  89
Thermal performance and comfort of vernacular earthen buildings in Egypt and Portugal
J. Fernandes, M. Debaïch, R. Matens, S.M. Silva, L. Broganza & H. Ger militia

Earthen construction in Ourense, Galicia (Spain)
A. Fernández-Palicio

Earthen vernacular architecture in Cuneo’s territories (Piedmont, Italy)
F. Fratini, S. Roscic, M. Mottone & L. Royero

Vernacular earthen architecture and its restoration in the region of La Manchauela in Albacete (Spain)
L. Garcia-Soriano

Earthen elements in the Iberian Peninsula: Cataloging and preliminary study
L. Garcia-Soriano, L. Villacampa-Crespo & F.J. Gómez-Patroclato

Vernacular architecture in El Khobab, Morocco; Evolution of the Igrem
T. Gil Piquéras, P. Rodríguez-Namayo & A. Pérez-Vila

Examination of structural decay processes in adobe vernacular architecture in Spain
F.J. Gómez-Patroclato, L. Garcia-Soriano & L. Balguer-Garzón

Mid-century earthen architecture in Aotearoa New Zealand—a new vernacular?
M. Hall

Stone, clay and turf in architectural construction
B. Javnoce

Transforming Kasena houses and indigenous building technology in Burkina Faso
H. Kobayashi, T. Shinzui, M. Ito & S. Nakao

Earth and gypsum: From theory to practice in Spanish vernacular architecture
V. La Spina

Earthen roofs in the region of Murcia, Spain: La Azohía
F.J. López-Martínez & V. La Spina

Material and typological characterization of the Igrem n’Aft Makhat (Morocco)
J.M. López-Osorio, S. Batani Senbak & L. Martinez Bernal

Mud architecture: Sustaining communities in cold desert regions of Northern India
A.K. Meel & G. Nanda

Earthen heritage in the USA: Approximation to constructive techniques
C. Mileo & F. Vega López-Menzenares

SOSTierra Project. Initial results
C. Mileo, F. Vega López-Menzenares, L. Garcia-Soriano & V. Cristini

A method of cataloguing for the earthen architectural heritage in Santo Domingo neighborhood in Tuxtla Gutierrez, Chiapas, Mexico
A. Parra Zebadúa & M. Genis Vinyals

Study and appreciation of earthen architecture in Valencia’s southern farmland
A. Pérez-Vila

Mestizo and hybrid typologies. Vernacular rural housing in Colombia
Y. Pulgarín

Mexico’s central area earthen architecture. Rammed earth construction: Use and technique
D. Romero Olguín

Domestic wineries in the Urz-Vidriales countryside (Spain)
M. Ruiz-Bediña & A. Herrera Peral

Scottish earthen building materials
M. Saez-Martínez & A. Leslie
Thinking about historic resources: A proposed guidance document

Historic cob structures in Moravia
Z. Syrová & J. Syrový

A study of pit houses with soil-covered roofs in a humid climate in Japan
T. Tsukidate

Traditional earthen architecture in Aragon, Spain
L. Villacampa Crespo, J. M. Sánchez Zaragoza & L. García-Soriano

The use of natural materials and ancient building techniques: The case for rammed earth construction
E. R. Wagner

Wind and dwellings in the villages of Rincón de Ademuz, Valencia (Spain)
W. Ji

Rehabilitation of vernacular earthen architecture

Thermal insulation for a sustainable rehabilitation of traditional buildings
M. Achenza

Thermal assessment of the behavior of retrofitted rammed earth in central Catalonia
G. Barbeta, M. M. Pareto, M. A. Chamorro & M. Sábat

Using machine-dismantled cotton seed hulls in the making of light earth blocks
A. González & S. Cabrera

The systemic approach in the intervention on earthen architecture
J. L. González Moreno-Narrowo, M. Genís Vinyals, R. Onecha Pérez & A. Casals Balagé

Kasbah Taourirt: Conserving earthen heritage in Morocco
B. Mares, C. Cancino & M. Boussab

Consumption study and energy optimization of a typical Valencian house
A. Martínez, R. Rojo & S. Torno

Maps, actors & local policies around earth buildings in Auvergne Rhône-Alpes
G. Pascalou, M. Chambodot, L. Genis, P. Guitiérrez, E. Mille, B. Rakotomananj. J. Avins-Bariot & D. Studer

Rammed earth buildings to meet Italian thermal regulation: Monitoring and sample tests
R. Punzi & G. Piccioletto

A pilot project, a tool for conserving the historic city of Cuenca, Ecuador
B. Rakotomananj, E. Sevillaano Guitiérrez & E. Carnevale

Vernacular change in Brazil southeast region
M. A. P. Resende, S. L. A. Braga, J. L. R. Vale & M. V. S. Peixoto

Investigating the preservation of vernacular earthen buildings of Louroujina (Akincular) in North Cyprus
R. Sari & H. Al-tan

Camping Segoviana's earthen heritage and conservation clues from Isère
E. Sevillaano Guitiérrez & E. Camaresalas Párez

Transformation in the Kasena’s large earthen compound houses in Burkina Faso
T. Shimizu, S. Nakao, H. Kobayashi & M. Jio
Contemporary earthen architecture

Hassan Fathy’s humane considerations in design and the significance of New Gourna
A.G. Abdel Towab

A temporary pavilion as a way to experiment with mud. The case of Roly Poly
L. Balbod Quesada & A.J. Jiménez Quesada

A home with roots. Construction process of an adobe contemporaneum house
P. Bel-Anzub

A minus carbon eco-cycle earthen refugee shelter: A feasibility study
M. Dabateh

Net Zero Energy straw bale & rammed earth design; cold climate case study
R. Davidson

Natural clay plasters: Checking regulations to characterization tests
A. González-Serrano, R. Rodríguez-Garcia, L. Molina & M. Ponce

Terra nova—earthen architecture and modernity
F.M. Lorusso & S. Mecca

The school of Bausneere, the process of international cooperation
J.V. Maravilla Moreno & X. Ferragud Adan

CEB Factory for seismic resistant earthen architecture design in Nepal
F. Maso Ros

CEB production in social insertion workshops. An experience in Algemesí (Spain)
J. Nacher Martínez, J.V. Maravilla Moreno, X. Ferragud Adan & F.I. Gómez-Patrocinio

A case study project of reinterpretation of local traditional techniques
J.R. Ruiz Checa & V. Cristini

Restoration of monumental earthen architecture

Restoration method on the southern wall of the Medieval access road to the Generalife
I. Bestué Cardiel, F.I. López Martínez & J.C. Molina Gaitán

The keep of the Alcázar of Carmona (Sevilla, Spain). Materials for the restoration of rammed earth walls
P.J. Blasco-López, J. Caniello, A. Grucaia, J.J. Martín-del-Río & E.I. Alejandre

Rammed earth and formworks in Medieval fortifications in Castilla-La Mancha, Spain
F.J. Castilla, D. Gallego, J. Molero, C. Peña & D. Sanz

The Islamic wall of Mula (Spain): 3D reconstruction, restoration and musealization
P.E. Collado Espejo, J. García León, V. La Spina & J. Fernández Del Toro

The use of lime, an example of good practices in the conservation of cultural heritage built on earth
R. Fernández Baca Cusares, M. García de Casasola Gómez, E. Ontiveros Ortega, B. Castellano Bravo & P. Santana Martin

Earth in historical fortifications. Pedro de Lenczow’s method
L. Gimeno Romero, L. Cortés Meseguer & S. Torno Estave

PREFORTI project: The preventive conservation of historic rammed-earth
M.L. Gutiérrez-Carrillo, I. Bestué Cardiel, J.C. Molina Gaitán & J.A. Martínez López

3D modeling for the interpretation of watchtowers between capes of San Antonio and La Nao (Alicante, Spain)
F. Juan-Vidal & P. Rodríguez-Navarro
Earthbank architecture, appreciation and landscape: The oasis of Ferklia (Morocco)
E. Juan-Vidal & T. Gil Piquerás

New technology for analysis of the chapel of Santa María, Conchuela, Mexico
R. López de Juambelz, A.S. Rodríguez Cepeido & M.A. Sorroche Cuerva

Implementing a GIS for cataloguing Medieval defensive earth architecture
E. Márquez, M.L. Gutiérrez-Carrillo & J. Gurría

The defense of the technique of rammed earth made by Giovanni Battista Antonelli in 1560
P. Rodríguez-Navarro

An approach to earthen fortifications in villages of La Serranía (Valencia, Spain)
F. Roger

The first rammed earth wall in America. Earth in 16th-century Dominican architecture
M.A. Sorroche Cuerva

The preservation of the Nubian earthen architecture
G. Torra i Campos, I. García Alonso, M. Crescenzi & O. Hatab el Rasoul Ahmed

Constructive analysis of the rammed earth walls in the Petrás Castle (Valencia, Spain)
F. Vegas López-Munzanares, C. Milet, E.J. Gómez-Patrón & A. Pérez Villa

Seismic Retrofitting Project: On-site retrofitting techniques workshops
K.H. Wong, C. Cantino, J.C. Menendez & L. Villacorta Santamato

Lessons from vernacular heritage for a sustainable contemporary architecture

Conservation of vernacular architecture, the case of the old town of Nablus/Palestine
E.M. Ameid

The habitat of the nomadic shepherds in the Jbel Zagho, Morocco
J. Asencio Junco, G. Cudero Baigneur, P. Izango Navas, M.A. Porras Díaz & S. Pino Martín

Vernacular nomadic architecture in the Mgoun Valley, High Atlas (Morocco)
J. Asencio Junco, J. Ingelmoy Moyano & J. Ramírez Bandera

Casa de los Cintires: Constructive analysis of a traditional house in northern Valencia
L. Balañégar Garzón & S. Traver

S. Jerónimo de Cotalba. Strategies for the preservation of the monastic complex
J.M. Barrera Puigdollers & N. Maturredona Desantes

Life cycle assessment for the earthen heritage center (Pabillonis, Sardinia)
A. Bonoli, S. Rizzo, M. Tomasi & A. Vado

The Tiburtino II district in Rome (Italy). Proposals for preserving the modern architecture
C. Corecchia, T. De Gemmara & M.G. Rizzi

Vernacular tradition and modernity. New scenarios in urban living
R. Chiniari

Sustainable proposal for the conservation of Castillojo de Monteagudo (Murcia, Spain)
P.F. Collado Espejo & M.J. Serrano Latorre

Perceptions of earth in the age of global architecture
J. Dahmen

Is it useless rubble or recyclable building material?
B. del Cueto

Understanding the vernacular heritage to design sustainable habitats in Asni, Morocco
L. Dipasquale & D. Giorgi
A survey of Danish earthen heritage for sustainable building
B.T. Eybye & I. Vestergaard

Lessons of sustainability from the survey of the Valencian barroca
Y. Hernández Navarro & P. de Dato

Restoration of the church of the Immaculate Conception in El Llano, Alajuela, Costa Rica
I. Hernández Salazar

When the neo-vernacular architecture inspires the contemporary conception
S. Kersema & S. Chouiche

Characteristics of earthen architecture in Ağlasun
V.B. Kurulušu, E. Ç. Asrav, N. Şahin Güzhan & G. Bilgin Altmız

The painted facades and the urban landscape of Bisceglie, Italy. Notes of history and restoration
A. La Noite

Set of nine cave houses in La Algueña, Alicante (Spain). Renewal proposal
A. Martínez Antón, G. López Patino, V. Blanca Giménez & F. Aranda Navarro

The influence of rice cultivation in the architecture of Sueca’s village (Valencia, Spain)
C. Masó Vendrell

In situ monitoring and characterisation of earthen envelopes: A review
M.A. Mellado Mascareñas, P.J. Castilla Pascual, I. Oteiza & F. Martín-Consuegra

Study of the situation of traditional constructive techniques and materials in Spain
C. Mileto, F. Vegas López-Manzanares, V. Cristini & M.S. García Sáez

Vernacular housing and transformations at the Cordillera de Santa (Bolivia)
P. Moreno, C. Pérez de Guzmán & S. Santiago

Built heritage as catalysts of environmental sustainability: A pragmatic paradigm for Anthropocene
A.P. Olukoya Obafemi

Adobe vernacular heritage in Mexicali, Mexico
D. Olivera, L. Mendoza & L. Guerrero

Balconies in traditional urban architecture through typology and solar radiation
P. Privitera

The Chilean adobe as a seismic vernacular technology, the study of the “Norte Chico” area
A. Rivera Vidal

Tracking down constructive techniques: Farmhouses preliminary studies
F. Romero Iglesias, M. Martínez Leledó & V. Cristini

Water-related built heritage in Campania, Italy. Knowledge for conservation of a sustainable vernacular architecture
V. Russo, S. Poliello, G. Conteola & L. Romano

From vernacular to contemporary: Kitwa (Tanzania) and Albreda (The Gambia) tourist information centres
N. Sánchez Muñoz & S. Moriset

Passive design principles in vernacular architecture of Castilla-La Mancha, Spain
A.B. Serrano Lanzarote, M. Navarro Escudero, L. Ramírez Pareja & C. Mateo Cecilia

Local pre-industrial communities in Tuscany and the exploitation of water
D. Ulivieri

Contemporary earthen architecture in the northern temperate climate
I. Vestergaard & B.T. Eybye
Sustainability of rammed earth building tradition in Tepeyahualco, Mexico
M.A. Vizcarra & L.F. Guerrero

Structural analysis of vernacular architecture

Structural assessment of earthen walls using damage tests and models
A. Alonso Durá, A. Martínez Bogueru & F.J. Gómez-Patrón

Planning for acceptable contemporary earth construction in South Africa
G. Bosman

Main church of the Cartuja de Vall de Christi, Altura (Spain). Analysis of the interventions
A. Carballal García

Thermal orthophotos and vernacular architecture: Surveying half-timber walls in Béjar, Spain
M. Diodato, S. Torno Esteve & L. Balaguer Garzón

The influence of ambient conditions into rammed earth compressive strength
B. González-Sánchez, J.R. Rosell Amigó & A. Navarro Ezquerro

Acoustic test on adobe and rammed earth walls
P. Guillaum Marzal

Experimental study of adobe walls with geogrid reinforced mud plaster
S. Invernizzi, M. Mattone, P. Vachey & M. Gentile

A preliminary study of CIPS as a consolidant for earthen cultural materials
I. Loo, C. Kiy, S. Collis, A. Jamieson & G. Price

Low-cost adobe structures with bamboo additives and bamboo frames: Strength tests
M. Paradiso, V. Bizzeti, E. Perrot, A. Farigu & O. Lotti

Experimental analysis of compressive mechanical behavior of adobe masonry
J.D. Rodríguez Mariscal & M. Solís Muñiz

Stabilisation of earthen surfaces using carob (Carobinae silique L.)
J. Romero & G. Barbeta

Advanced study of the mechanical properties of compressed earth block
G. Ruiz, X.X. Zhang, L. Garito, I. Cañés & W.A. Fouad

Seismic analysis of Portuguese adobe buildings
L. Sarchi, R. Monteiro & H. Varum

Improved 2nd order holder: Method for heat transfer calculation for walls
L. Soio Frances, B. Serrano Lanzarote, L. Ortega Madrigal & J.M. Piuzzo Ofj

Schematic analysis of traditional Vietnamese houses under the influence of Han culture
W.J. Wang

Author index
The use of lime, an example of good practices in the conservation of cultural heritage built on earth

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ABSTRACT: The Andalusian Institute of Historical Heritage (IAPH) is a public agency of the Ministry of Culture of the Andalusian Regional Government, accredited as a member of the Andalusian Knowledge System since 2011. The IAPH launched a research project on the use of lime and its applications in conservation with the aim of establishing criteria for the use of materials compatible with traditional and historical masonry. The methodological document that is proposed is structured in two parts: the first one focuses on the definition of heritage, identifying the scope and formulating procedures based on a tested methodology. The second part deals with the generation of requisites for the conservation of cultural assets which are amenable to standardization, in compliance with standards and recommendations.

1 INTRODUCTION

In the last decades, we have witnessed a demand, heightened by the economic crisis, for the responsible use of natural and cultural resources. In this context, there has been a change in the orientation of work in heritage, whose goal is to achieve sustainability, from the economic, social and environmental point of view, at the centre of the debate on cultural policies. This means a search for the improvement of the quality of interventions and a commitment to control, maintenance and preventive conservation as guarantees of the durability of the actions carried out.

The Charter of Krakow (2000) recognizes the critical nature of the intervention processes, asserting that any intervention on the well-being of a property “implies decisions, selections and responsibilities related to internal heritage, including those parts that do not have a specific meaning today, but may have in the future”.

The concept of conservation and all those employed in the sector of cultural assets (restoration, rehabilitation, etc.) refer us to a broader concept that is related to the idea of “intervening heritage”. In order to ensure quality in cultural heritage interventions and to meet the objectives of safeguarding, preserving their values and identity attributes, we will place our trust in the development of a methodology and of some intervention instruments, using the general objectives, principles and criteria set out in the international charters, texts and documents of reference and in the corresponding legislation on heritage as a starting point.

The tool established in the Charter of Krakow is the project, which Law 14/2007 of November 26th of the Historical Heritage of Andalusia specifies in the Conservation Project as the technical instrument that should govern interventions in movable and immovable assets which are inscribed in the General Catalogue of Andalusian Historical Heritage. Minimum contents that guarantee the quality of these processes are defined thus: the study of the asset and its cultural values, the diagnosis of its state, the description of the methodology to be used, the proposal of action from the theoretical, technical and economic point of view, and the impact on protected values. Finally, the law also establishes the obligation to develop a maintenance program.

The Conservation Project structure endorses the axiom of “knowing to intervene”, a principle that underlies the methodology of the IAPH in the intervention of cultural heritage; a methodology of a critical-scientific nature that is based on a deep knowledge of the asset and its integral consideration through the formation of interdisciplinary teams.

In view of said situation, the IAPH, as an agent of the Andalusian knowledge system, assumes the challenge of setting guidelines and defining action protocols that cover all stages of the process of conservation of cultural assets. As a first action, it is proposed to standardize the use of traditional lime in heritage interventions, a project that is part of the Program for Standardization of Preliminary Studies and Quality Control applied to intervention in immovable assets, which the IAPH has been developing since 1995 (AAVV 1998, AAVV 2003,
AAVV2006) and currently constitutes one of its strategic lines. To this research activity is added its experience in intervention in cultural assets, in accordance with good practices for the preservation of heritage, working on the permanent search for a procedural model of value that translates into protocols capable of responding in the most effective way possible to the nature of the processes undertake and their associated problems.

2. STANDARDIZATION OF CONSERVATION OF ARCHITECTURE IN EARTH

The standardization project carried out by the IAPHE proposes as the first action the definition of technical suitability documents for heritage conservation, defining three documents associated with the three phases that structure the development of conservation projects.

<table>
<thead>
<tr>
<th>CONSOLIDATION PROJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRELIMINARY STUDIES</td>
</tr>
<tr>
<td>AND COMMISSIONING</td>
</tr>
<tr>
<td>STANDARDIZED SUITABILITY DOCUMENTS</td>
</tr>
<tr>
<td>Characterization</td>
</tr>
</tbody>
</table>

Each process should be defined based on methodologies already consolidated in different disciplinary fields, flexible and feasible from the point of view of project execution; which will allow us to adequately solve the problems of conservation, which are sometimes complex, that currently affect our Cultural Heritage and, specifically, that are built using earth. In addition, time will be endorsed as a compatible and sustainable material.

The scope of this work is related to how the Andalusian Heritage Law defines the intervention criteria in Article 20 of Title II on Conservation and Restoration:

1. The performance of interventions on assets registered in the CGPHA will seek by all means of science and technology their conservation, restoration and rehabilitation.

2. Restorations will respect the contributions of all existing epochs, as well as patterns. They should constitute a proper value of the asset. The elimination of some of them will only be authorized, if appropriate, and provided that it is justified that the element that is to be suppressed is degrading the asset and its elimination is necessary to allow the proper conservation of the asset and a better historical and cultural interpretation of said asset. The parts suppressed shall be duly documented.

3. The materials used in conservation, restoration and rehabilitation must be compatible with those of the asset. In their selection, criteria of reversibility will be followed, with the obligation of offering sufficiently contrasted behaviours and results. The construction methods and materials to be used must be compatible with the construction tradition of the asset.

4. In the case of immovable property, the actions referred to in paragraph 3 shall avoid attempts at reconstruction, unless in its repositioning some original parts of the asset are used or the necessary documentary information is available and its authenticity can be proved. If additional materials or parts are added, the additions should be recognisable and should avoid mimetic confusions.

2.1 Importance of preliminary studies in earth constructions

The monitoring of all the processes to be developed in the Knowledge Phase, known as Preliminary Studies (see Fig. 1), is of interest because of the information about the building that can be obtained. Related to techniques-construction phases, use, restoration interventions, structural pathologies, materials analysis, etc. Results that should be useful in order to know the cultural values and authenticity of the Cultural Asset, the diagnosis of the state of conservation of the materials, the conservation needs of the building, conservation measures most suitable to apply and finally, the requirements of the asset maintenance plan.

Figure 1. Process map of the knowledge phase or preliminary studies.
At the moment when we speak of actions of conservation traditional earth-based architecture it refers, unfortunately in the majority of cases, to the more initial levels of protection that are reduced to its cataloguing. When projects are carried out, it is worth noting that, considering the complexity of the conservation of the materiality of this construction masonry, the characterization of the original materials should not be systematically considered in the Knowledge Phase or Preliminary Studies. It is necessary to take into account that the characterization of the materialization of earth-based architecture is based on two groups of interest: the construction techniques used and the memory of the traditional activities that they use.

These aspects are already included in the various Letters of Restoration, for example Clavicomos of 1992 (extension Charter of Venice 1964) and Charter of Krakow 2000 which establish as basic principles of conservation:

- Scientific research prior to the intervention and conservation of the original materials; In the case of degradation problems, more appropriate and compatible materials can be used.
- Interventions responding to contemporary use must be carried out by introducing techniques and materials that maintain a balance of expression, appearance, texture and shape with the original structure.
- And finally, being a typology of local or regional character integrated in the resources of the territory, its conservation must be approached respecting the landscape, enabling the conservation of traditional wisdom in the design and construction, strengthening and protecting their craft and traditional construction techniques. Their conservation should be supported by continuity of use and maintenance.

The challenge for the forthcoming years is to address integral interventions that contemplate the development of the different phases that make up a conservation project of excellence, using standardized protocols that in some way contribute to its protection.

Due to the cultural complexity of this type of architecture which involves patrimonial dimensions, both tangible and intangible, research in order to assess, diagnose and propose adequate solutions for its conservation and protection must be supported by multidisciplinarity.

The greatest difficulty arises in how to preserve the materiality of this type of architecture and work on this matter is very scarce, for example. (Elect et al. 2015).

Construction typologies, their forms of arrangement, union or assembly, among others, follow a logic in which they have been able to optimize available resources, establishing precise limits of action that are known and inherited. It is necessary to take into account that much of the knowledge of these activities has been lost at present and/or is found in few territories at world level, hence the importance of the Knowledge Phase and specifically the characterization of materials in conservation of this type of architecture (Guerrero et al. 2012).

2.2 Fundamentals of study methodology

The peculiarities of this masonry are due to the typology of the material used for its construction: earth and additives, which are generally used for stabilization and improvement. The investigation of earth as a construction material has been widely developed in the 20th century, related to the stabilization of land for its application in public works (for example roads). The earth is a mixture of clay, silt and sand, and occasionally, it may also contain small amounts of gravel and stones blocks. Its requirements as a construction material are mainly related to its granulometry and clay content, as these parameters define the optimal characteristics of earth for use in walls or adobes. Controlling the contents in clay fraction is due to the susceptibility to water present by these mineralogical components, which can cause important disturbances in their structure by swelling and/or retraction. These aspects will condition the compaction and density (optimal values 1.7 and 2.3 g/cm³); parameters that define the stability of this architectural masonry (Houben & Guillaud 1989).

The regulation applied to this type of materials is scarce, the first norm at national level was applied to this type of buildings in 2008: Blocks of compressed earth for walls and partitions. Definitions, specifications and testing methods. UNE 41410, Madrid, 2008. Issued by the sub-committee AEN/CTN 41 SC 10 "Building with raw earth" by AENOR. Most of the existing standards, even at the international level, do not cover the properties of earth as a building material as a whole. It is therefore necessary to standardize the tests applied to earth constructions, both for pieces and for monolithic walls, in order to be able to carry out an adequate comparative analysis between the different existing construction techniques (Cid et al. 2011).

The research on this subject is scarce if it is compared it with other typologies of materials, as far as the characterization of original materials is concerned, as well as research in the line of conservation (Maldonado & Vela-Cossío 2011), with some standing out (Ontiveros et al. 1995, Ontiveros et al. 1996, Aguilar Fletes et al. 1998, Ontiveros et al. 1999, Barbeta 2002, Concaives da Silva Braga 2011). Based on this background, we propose the methodology on the characterization of materials indicated in Figures 2 and 3.

Methodology that is based on the following aspects:

437
certain parameters on their behavior as a construction material.

- Elaboration of general models of behavior that allow us to predict the response of the soil to the stresses to which they are subjected.

In summary, there is a lack of experimentation concerning the scientific-technical methods of the parameters that identify earth from a construction point of view. This affects the set-up of tests to improve the stabilization of this material for its application in construction and restoration (pore test, particle size test and its contradiction with plasticity curves), the lack of correspondence between laboratory and in situ studies on site, the absence of an integral and consensus method to obtain the parameters that define the chemical components of the earth, its durability and stabilization consistent with the chemistry of clays, as well as correspondence between the technological analysis of the implementation process and the architectural parameters of the project (Barbetta 2002).

The panorama described demonstrates the lack of regulations to be applied in restoration works currently in terms of quality control, which makes the need to carry out Preliminary Studies to any intervention carried out in this type of buildings since the criteria used so far are very variable (Miele et al. 2011).

2.3 Lime and earth

As discussed above; the conservation projects of architecture on earth are based on the conservation of the original materials, respect for the identity and the search for sustainable local development. These issues have to do with an adequate conservation with respect to the materiality of this construction masonry using the traditional activities as a strength to take into account in these patrimonial construction types (see Fig. 4).

Earth and lime are materials that have gone hand in hand since the earliest times in the history of construction, as evidenced by the countless examples of lime-stabilized earth masonry that we find in our cultural resources today.

Figure 3. Methodology of laboratory phase.

- Direct observation of the behavior of the soils and/or earth masonry by means of instrumentation and field tests, determining the most significant parameters from a construction point of view.
- Conducting laboratory tests, reproducing natural phenomena and analyzing the influence of

Figure 4. Objectives of the research on lime in conservation of cultural heritage.
Traditional architecture is sustainable since its inception, given that it uses the available resources of the natural environment and the territory in which it is located: construction materials, tools, utensils, preferably located in the vicinity of the construction to reduce costs. It also facilitates the conservation and regeneration of the territory, because it uses the materials it needs, allows the environment and vegetation to be cleaned (obtaining wood, river rocks, stone, etc.). These principles of traditional architecture are in line with what is now known as sustainable architecture and the recovery of Good Practices in construction, to be applied in the Conservation of Cultural Heritage.

On the other hand, in the most scientific area, the improvements that lime contributes to earth as a building material are already known (Houben & Guillaud 1989), which are:

- the drying effect of lime on the earth during the transformation process from quicklime to hydrated lime
- the change of cations, Ca for Na, K as a chemical process of interest since it causes the soil particles to flocculate and agglomerate.
- The other hand, silica and free alumina in the earth react with lime and form calcium silicates and aluminates (pozzolanic reactions) that increase their hardness and in general the mechanical resistance of the masonry, together with the carbonation process that takes place when lime reacts with the CO₂ in the air.

In Spain there is a wide tradition of the use of aerial limes or plasters for stabilization and improvement of soils. Andalusia has a rich cultural heritage, where the use of aerial lime has played an important role, given that it is an area with important geological resources. This traditional activity of lime processing lasted until the middle of the 20th century, preserving itself in exceptional cases until today. An example of this exceptionality is the Comarca de Morón de la Frontera, in Seville, which is located in the subbetic area of the Béticas mountain range, has abundant outcrops of carbonate rocks, including oolitic limestones, which have been mined since ancient times for different uses in construction. Its use for the production of lime is connected with the activities of an artisan and industrial nature and more directly with its traditional architecture, mostly built on earth.

The peculiarities of this activity which is currently being developed in the region of Morón de la Frontera (Seville) justify its inclusion in the Inventory of Popular Architecture of Andalusia that is currently included in the Database of Immovable Assets of the Ministry of Culture. In 2008 it was registered in the General Catalogue of Historical Heritage of Andalusia as an Asset of Cultural Interest (BIC). The Caleras de Sierra de Morón de la Frontera (Seville) a place of Ethnological interest, protection of immovable assets associated with intangible activity: settlements, houses, lime kilns, areas linked to the activity and old extraction area (historic quarry). Finally in 2010, this activity was included in the second phase of the Intangible Atlas of Andalusia (Carreras & Olivi 2014). Its peculiarities earned it recognition in November 2011, on behalf of UNESCO, being included in the List of programs, projects and activities for the Safeguarding of Heritage and declared to be Intangible Heritage of Humanity in the Good Practices section. In 2013 it was included in the Spanish Network of Industrial Tourism.

The advance in knowledge about traditional production lime, elaborated in the region of Morón de la Frontera, Seville, will contribute to the technological advance through the design of products that will favour good practices in the matter of the Conservation of Cultural Assets and will have a significant effect on economic recovery at territorial level. At present, innovation and technological diffusion must be understood as processes whose management and development require the existence of suitable environments, or sets of interrelated elements, that generate a system with a certain spatial projection at national or regional level. (Gómez Uranga and Borja Álvarez, 1996). For this reason a structured and convergent network has been created, made up of scientific, technological and productive environments; environments which will contribute to a range of topics, from cooperation to knowledge development, technology and know-how, together with the creation of goods and services, which will have a direct impact on society, enhancing economic development and well-being.

It is of interest to determine the properties of lime for use as mortars, painting and consolidation of traditional construction masonry, with a view to its application in restoration works, which at present are not sufficiently promoted at market level. At present, research on lime, its application in the preservation of traditional masonry, is more oriented towards case studies, understanding that its application must be determined by forms of local production, linked to a territory and justified by its necessity and quality.

The implementation of lime and its viability as a material for conservation demands that the advance of the research experienced in the last decades serves to create products that show an appropriate behaviour on the building. The level of research currently allows us to adequately position ourselves before this problem and to form the aspects in which it is necessary to influence and develop. It is important to define the requirements of these products for use in restoration.

However, the problem of the use of lime in construction not only arises with the materials, their nomenclature or their design (Rosell 2012). The use
of time requires a traditional way of working that is associated with the craft, at a pace of execution that respected the construction processes and maturation of materials and with a work schedule drawn up with much foresight. Traditionally the construction processes were slow which allowed the work to settle slowly, while the walls were being erected. The loss of water and the incorporation of CO2 were produced as the work aged and increased the rigidity of the materials through carbonation, all at a pace compatible with the construction process.

For this reason the conservation of traditional materials must be approached from the perspective of knowledge, quality control, minimal intervention, direct action on agents of deterioration, together with adequate preventive conservation measures.

3 CONCLUSIONS

The IAPH’s objectives for the coming years are the drafting of technical documents associated with the different phases of intervention in heritage. The first document will be a technical document on the suitability of lime for use in the conservation of cultural property.

The ultimate goal of this task is to improve the quality of cultural heritage interventions. The sustainable use of the heritage resources of Andalusia must be based on the efficiency and sustainability of traditional activities, as a tool that contributes to social and economic development, revitalizing activities currently in danger of disappearing and that make the territory unique. These strategies must be supported by research, development and innovation. For this reason, and because of its compatibility with historic masonry, artisanal lime has been selected.

Lime products are in line with the fundamentals that define the conservation of cultural assets: protecting traditional techniques, documenting their use and respecting the characteristics of the historical materials they are intended to restore or protect.

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Vernacular architecture in general and earthen architecture in particular, with their rich variety of forms worldwide, are custodians of the material culture and identity of the peoples who built them. In addition, they are widely recognized as ancestral examples of sustainability in all their variants and interpretations, and the architecture of the present ought to learn from these when designing the sustainable architecture of the future. The conservation of these architectures—seemingly simple yet full of wisdom—is to be undertaken now given their intrinsic value and their status as genuine examples of sustainability to be learnt from and interpreted in contemporary architecture.

Vernacular and earthen architecture: Conservation and Sustainability will be a valuable source of information for academics and professionals in the fields of Environmental Science, Civil Engineering, Construction and Building Engineering and Architecture.