Terra Europae

Earthen Architecture in the European Union

Edizioni **ETS**

Paths, tracks of explorations, research paths, sometimes tortuous, often crossed, constructed step by step. Knowledge, diversity of knowledge built over time, tacit and explicit, cultural landscapes in the world. Projects, experiments for a future that moves from relationship with the places and interpreted traditions.
The series explores architecture and design, tangible and intangible culture in places near and far, on objects and ideas, on knowledge and beliefs. Lands, knowledge, culturally, socially and environmentally sustainable innovation, scenarios of present and future challenges.

Sentiers, pistes d'exploration, parcours de recherche, parfois tortueux, souvent entrecroisées, explorés pas après pas. Savoirs, diversités des connaissances façonnées dans le temps, tacites et explicites, paysages culturels du monde. Projets, expérimentations pour un futur bâti sur la spécificité des lieux et l'interprétation des traditions.
Cette collection est une enquête sur l'architecture et le design, les cultures matérielles et immatérielles, les lieux proches et lointains, les objets et les idées, les connaissances et les croyances. Territoires, connaissances, innovations soutenables au niveau des cultures, des sociétés et de l'environnement, scénarios des défis présents et futurs.

Sentieri, tracce di esplorazioni, percorsi di ricerca, talvolta tortuosi, spesso incrociati, costruiti passo dopo passo. Saperi, diversità di conoscenze costruite nel tempo, tacite ed esplicite, paesaggi culturali del mondo. Progetti, esperimenti per un futuro che muove dal rapporto con luoghi e con tradizioni interpretate.
La collana indaga su architettura e design, su culture materiali e immateriali, su luoghi vicini e lontani, su oggetti e su idee, su saperi e credenze. Territori, conoscenze, innovazioni culturalmente, socialmente ed ambientalmente sostenibili, scenari delle sfide presenti e future.

Sentieri Saperi Progetti
Series coordination - *sous la direction de* - curata da
Giuseppe Lotti – Saverio Mecca

Cover photography by – *photo de couverture* – foto copertina: **Pierre Buch**


PROGETTI
SAPERI
SENTIERI

«O que este barro esconde e mostra é o trânsito do ser no tempo e a sua passagem pelos espaços, os sinais dos dedos, as raspaduras das unhas, as cinzas e os tições das fogueiras apagadas, os ossos próprios e alheios, os caminhos que eternamente se bifurcam e se vão distanciando e perdendo uns dos outros. Este grão que aflora à superfície é uma memória, esta depressão a marca que ficou de um corpo deitado. O cérebro perguntou e pediu, a mão respondeu e fez».

(José Saramago, *A Caverna*, 2000, Editorial Caminho, Lisboa, p. 84)

«What this clay hides and shows is the passage of a being through time and space, the marks left by fingers, the scratches left by fingernails, the ashes and charred logs of burned-out bonfires, our bones and those of others, the endlessly bifurcating paths disappearing off into the distance and merging with each other. This grain on the surface is a memory, this depression the mark left by a recumbent body. The brain asked a question and made a request, the hand answered and acted».

(José Saramago, *The Cave*, 2003, Harcourt, Orlando, p. 68)

Earthen Architecture in the European Union

Terra Europae

Edizioni ETS

TERRA INCOGNITA
EARTHEN ARCHITECTURE IN EUROPE

Education and Culture DG
Culture Programme

This publication is the result of *Terra [In]cognita – Earthen Architecture in Europe* research project, developed in the framework of Culture 2007-2013 Programme of the European Union.
This project has been funded with the support of the European Commission. This publication reflects the views only of the authors and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

Project Leader

Ecole d'Avignon, France

Partnership

Università degli Studi di Firenze, Italy

Universitat Politècnica de València (UPV), Spain

Escola Superior Gallaecia (ESG), Portugal

Conseil d'Architecture d'Urbanisme et de l'Environnement (CAUE) de Vaucluse, France

With the collaboration of

Culture Lab, Belgium

With the support of

Région Provence-Alpes-Côte d'Azur, France

www.edizioniets.com

Edizioni ETS
Piazza Carrara 16-19, I-56126 Pisa
info@edizioniets.com
www.edizioniets.com

Distribuzione PDE
ISBN 978-88-467-2957-6

CULTURE LAB ÉDITIONS
4, Elisabethlaan, B-3080 Tervuren, Belgium
ac@culturelab.be
www.culturelab.be

Dépôt légal en Belgique: D/2008/11.637/6
ISBN 978-2-9600527-9-4

Acknowledgments:
Gaia Bollini,Gianfranco Conti, Natalia Jorquera Silva, F. Chiara Robboni, Sergio Sabbadini, Eliana Baglioni, Silvia Onnis (Italy).
Juana Font Arellano, Fernando Vela Cossío, Eloy Algorri García, Alejandro Fernández Palicio, Francisco Javier López Martínez, José Manuel López Osorio, José María Sanz Zaragoza, Francisco Javier Castilla Pascual (Spain)
Alexandre Bastos, Bartolomeu Costa Cabral, Graça Jalles, Henrique Schreck, Maria Fernandes, Vera Schmidberger, Teresa Beirão (Portugal)
Dave Brickenden, Edward Byrne, Kevin McCabe, Cáit Ní Cheallacháin, Deirdre Conroy, William Cumming, Pierre-Antoine Gatier, Deirdre McDermott, John Hurd, Mary Jamin, Alain Klein, Kirsti Kovanen, Dermot Nolan, Erwan Patte, François Streiff, Linda Watson, Matthew Whelan (France).

Terra Europae

Earthen Architecture in the European Union

Authors:
Kristina Akermann, Jenny Andersson, Gérard Bavay, Georgia Bei, Mojmír Benža, Cătălin Berescu, Rasa Bertašiūtė, Peteris Blūms, Ann-Marie Braxén-Frommer, Sophie Bronchart, Pierre Buch, Miklós Buzás, Gilberto Carlos, Alexis Castro, Marie Chabenat, Louise Cooke, Mariana Correia, Maria Costi De Castrillo, Valentina Cristini, Lydie Didier, Letizia Dipasquale, Lidia García, Donika Georgieva, René Guérin, Boris Hochel, Sjap Holst, John Hurd, Rogiros Illampas, Ioannis Ioannou, Stephan Jörchel, Borut Juvanec, Teresa Kelm, Zusana Kierulfová, Saverio Mecca, Jacob Merten, Maria Mifsud, Camilla Mileto, Jaan Miljan, Patrice Morot-Sir, Barry O'Reilly, Willem Oskam, Jan Růžička, Horst Schroeder, Ričardas Skorupskas, Antonia Theodosiou, Michael Thönnes, Charles Thujils, Fernando Vegas, Miroslav Velkov, Ivana Žabičková.

Dovecote. Villamartín-de-Campos, Castile and León, Spain. (photo: Pierre Buch)

Forewords

Foreword

Jurilovca, Romania. (photo: Cătălin Berescu)

In the nineteen sixties in Europe, individuals and groups started to take an interest in earthen architecture; this movement evolved from a general need to understand, respect and perhaps return to a simpler, more vernacular expression of life.

Information and publications were scarce and in Europe the earth tradition had suffered decline through the effects of the social impact of war and with the introduction of new building materials and styles that seemed to respond to the need for improvement and modernisation of living conditions, within the reconstruction of the environment and lifestyle to which Europeans then aspired.

Things have certainly progressed and here we have in our hands "Terra Europae", earthen architecture in the European Union, an exciting and inspiring volume which demonstrates the extent to which ideas have advanced in Europe; a synthesis of the surprising and delightful historic language of earthen architecture across the continent, coupled with the renaissance of earth building traditions used in innovative and sustainable ways.

The Terra [In]cognita report helps to define European traditional styles and to recognise the development of the technology through a wide range of activities, including the introduction of a label which will draw attention to the high quality of efforts being made across the continent to both preserve, but also to re-examine the values of earth as an essential material for use in the architecture of tomorrow.

"Terra Europae", published within the activities of the Terra [In]cognita initiative brings together a widely representative group of contributors, coordinated by Ecole d'Avignon, assisted by Culture Lab and with partners from Universitat Politècnica de València, Spain, Conseil d'Architecture d'Urbanisme et de l'Environnement, France, Università degli Studi di Firenze, Italy and Escola Superior Gallaecia, Portugal. With authors from 27 European countries and overall support from Culture Programme 2007-2013 of the European Union.

Our thanks go out for this important and inspiring co-operation which valuably contributes to our understanding and appreciation of earthen architecture in the early 21st Century European context.

John Hurd
President of ICOMOS-ISCEAH-International Scientitic Committee on Earthen Architectural Heritage

Adobe wall in Kastaneri, Greece. (photo: Saverio Mecca)

Foreword

Patrice Morot-Sir, Marie Chabenat, Saverio Mecca, Fernando Vegas, Camilla Mileto, Mariana Correia, René Guérin

The book that you now hold in your hands is the fruit of work accomplished over two years. A publication that could ultimately be fairly standard, the expected, indeed conventional product resulting from a programme of European cooperation is yet in its content, quite unique: it is the first time that a snapshot of earthen architecture is presented in a synthetic and analytical form at an European Union level.

The value, the vitality and the technical nature of this heritage are embodied. The almost universal techniques and construction methods, guided by the availability of materials, by the aim of construction and then shaped by a workforce with a knowledge enlightened by practice, all demonstrates that while there is already an economic Europe, and while the attempt is being made to build a political Europe, there is already a Europe of earthen architecture.

The qualities of earthen architecture are located today at the heart of "sustainable building and living". It arose from a forgotten constructive method, ignored and discredited as an "old-fashioned" method of construction. Being able at this moment in history, to review the nature of European heritage, to take an inventory, distinguishing it from new construction and stemming from new constructive methods was a great chance.

Thus, in the beginning to map out earthen architectural heritage, we discover the vigour of the world of earthen construction, a world promoted by associations, research organisations, construction professionals, architects, producers, standard setters, residents, etc., and if there is a universality of earthen architecture in Europe, there is, conversely, a huge disparity in the manner of considering it, regenerating it, and returning it to the centre stage.

This picture of earthen architectural heritage in Europe is indeed the result of the work accomplished during the two years of the project "Terra [In]cognita". Created by a team of professionals, researchers, and ultimately friends united by a common vision of architectural heritage, by an awareness of the value of earthen architecture and a desire to return its value to the general public. This awareness was already present at the publication of the book "Discovering European Earthen Architecture" in 2008. But beyond our working group, the present publication would not have been possible without the availability and merit of the people we met during our various missions in Europe. They are all to be thanked. This book will try to convey the richness of earthen architectural, its physical, material, and objective richness. However it would be difficult to convey the wealth of meetings held all over Europe. Such meetings were occasionally very formal and organized but were also often made at random chance that guided us on the path in search of heritage sometimes hidden, sometimes forgotten, yet always present.

We have not lost sight that it is a question of architecture that structures the countryside and draws the framework of life. We have thus entrusted some territories to a professional photographer, whose sensitive eye reveals the life in the architecture, going well beyond the simple subject, even though built of earth. This vision that Pierre Buch gives us acts as a perfect counterpoint to our analytical work.

Beyond the work of the researcher, we draw a primary vision of what could be a network of earthen construction in Europe. It is certainly well past the time to build networks with the sole idea of getting together and being counted.

If it is commonplace to say that we are building today the heritage of tomorrow, this evidence is even greater for earthen architecture.

Self build earthen house in Palafrugell, Spain.
(photo: Letizia Dipasquale)

Introduction

Patrice Morot-Sir
Marie Chabenat
Alexis Castro
Mariana Correia

Supported by the Culture Programme 2007-2013 of the European Union and by the Region Provence-Alpes-Côte d'Azur, the project "Terra [in] cognita: Earthen architecture in Europe" started in November 2009 for a duration of two years.
Lead by the Ecole d'Avignon, this initiative was implemented in partnership with the Escola Superior Gallaecia (Portugal), the Universitat Politècnica de València (Spain), the Università degli Studi di Firenze (Italy) and the Conseil d'Architecture, d'Urbanisme et de l'Environnement (CAUE) of Vaucluse (France).
The project was based on two complementary aims: first, to introduce and return value to the earthen architectural heritage of Europe and, second, to establish a link between how traditional earthen architecture knowledge can contribute to current construction opportunities.

Origin and aims of the project

The ecological and constructive qualities of raw earth, as well as the availability of on-site material made it an advantageous choice for the construction of habitats. Despite the technologies developed over time, this architecture remains threatened. The European earthen heritage, little known and suffering from the loss of maintenance, as well as know-how, is reduced every day and subjected to irreversible changes. Research and scientific projects, however, are being conducted to rehabilitate the image of this art of building, and to highlight its environmental and thermal qualities. These issues, relevant to both the preservation of an exceptional heritage and the promotion of sustainable contemporary architecture, deserve greater recognition and dissemination among the professionals concerned, the authorities and the general public.
An initial project, "Terra Incognita - Conservation of European Earthen Architecture" (2006-2007), supported by the Culture 2000 Programme of the European Union (*action 3: "European Heritage Laboratories"*), had established an overview of the topic, proposing the discovery of this European heritage, as well as a methodological proposal for its conservation and preservation. However, it remained to promote initiatives aimed at raising public awareness of earthen architecture, its heritage and its current applications.
While continuing to cultivate research and expertise in earthen architecture, this new project "Terra [in]cognita" aimed to strengthen awareness, stressing in particular the possible interaction between earthen architectural heritage and contemporary architecture. The redeployment of traditional building cultures could, in fact, meet real needs in today's European society, both in terms of culture and identity, in qualitative terms (comfort, architectural aesthetics), and in terms of environmental concern.
The aim of this project then was to generate public interest in the historical cultural heritage, to return value to this way of building and to create contemporary applications. Besides, "Terra [in]cognita" revolved around two sides of the same initiative resolutely turned towards the public while strengthening European cooperation.

Main activities of the project

Initially, the project's aim was focused on dissemination, but after a thorough reflection, the project partners realized that it was fundamental to establish a more in-depth research and make a responsible contribution to knowledge.

The research project became a complex and intensive effort, complemented by the organisation and development of several activities to raise awareness and provide information. These activities were:

- A European symposium "Building with Earth. From Cultural Heritage to Contemporary Architecture" held in Marseille (4-6 May 2011), in the Chamber of the Conseil régional de Provence-Alpes-Côte d'Azur, organised in partnership with ICOMOS France ;
- A European label "Outstanding Earthen Architecture in Europe";
- A scientific exposition on earthen architecture in the European Union;
- A photography exhibition by the photographer Pierre Buch;
- A website (http://culture-terra-incognita.org).

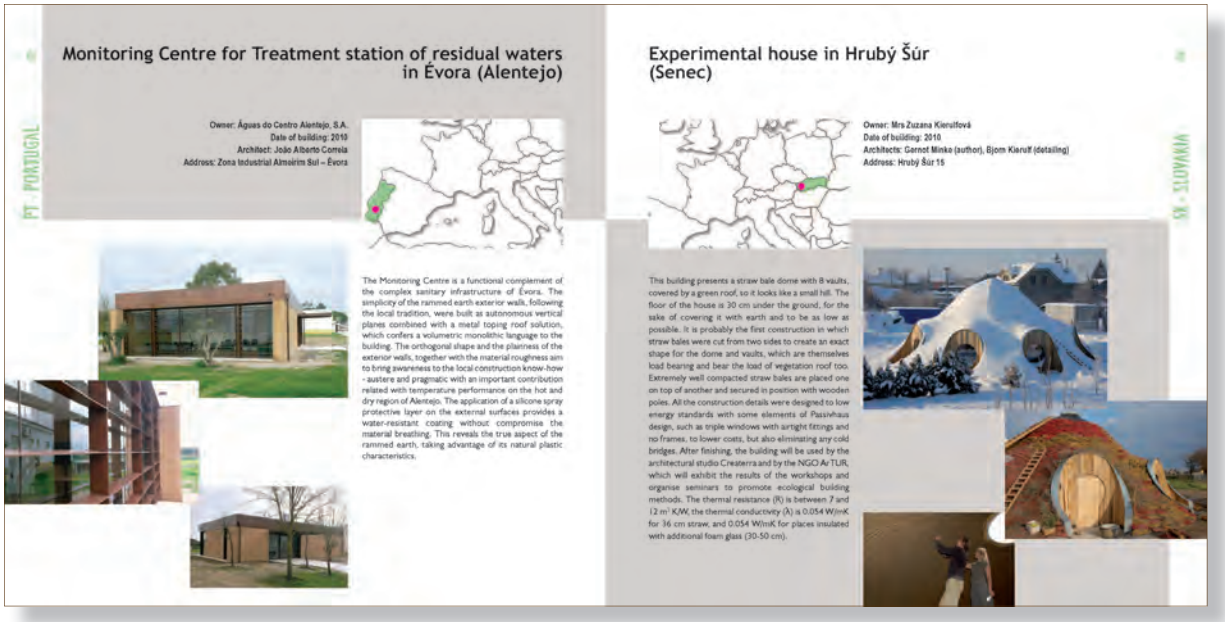
The website *www.culture-terra-incognita.org*

The creation of a formal network of specialists and institutions was added to the main activities to address, as well as the establishment of a European cartography of earthen architecture, together with the conception of a scientific publication with authors from each European Union country. The actual publication is the result of a common effort gathered by all the partners of this research project, but it also reflects the extensive contribution of 50 authors from 27 European countries - one of the major results of this publication.

From June 2010 to April 2011, scientific missions in the European Union were organised with the aim to identify and meet key people to constitute a network of earthen architecture. Authors were also identified to become potential contributors to the scientific publication.

Another result of these missions was the elaboration of a European atlas of earthen architecture. This European cartography was made according to historical and vernacular heritage (built before 1970) that is still present in the territory. The Scientific Committee of the project made sure that each countries' map would have at least three to four contributors to confirm given data. Four categories were identified to represent a wide variety of earthen building cultures: Half-timber with earth, Adobe, Rammed earth and Cob. The exception was Malta, where a fifth category was added, as earth was just identified in the interior of stone masonry walls. This atlas, although innovative, is still a work in progress, as some countries had never done research on the identification and location of earthen architecture. Thus, the editors expect that this initiative will be followed by new research where information is missing or incomplete.

Project partners are honoured to invite the readers to browse this indispensable publication that evolves from an *aesthetic approach,* earthen architecture seen by an artistic photographer, to a *scientific approach,* an inventory of earthen architecture in Europe today.



Monitoring Centre for Treatment station of residual waters in Évora (Alentejo)

PT - PORTUGAL

Owner: Águas do Centro Alentejo, S.A.
Date of building: 2010
Architect: João Alberto Correia
Address: Zona Industrial Almeirim Sul – Évora

The Monitoring Centre is a functional complement of the complex sanitary infrastructure of Évora. The simplicity of the rammed earth exterior walls, following the local tradition, were built as autonomous vertical planes combined with a metal toping roof solution, which confers a volumetric monolithic language to the building. The orthogonal shape and the plainness of the exterior walls, together with the material roughness aim to bring awareness to the local construction know-how - austere and pragmatic with an important contribution related with temperature performance on the hot and dry region of Alentejo. The application of a silicone spray protective layer on the external surfaces provides a water-resistant coating without compromise the material breathing. This reveals the true aspect of the rammed earth, taking advantage of its natural plastic characteristics.

Experimental house in Hrubý Šúr (Senec)

SK - SLOVAKIA

Owner: Mrs Zuzana Kierulfová
Date of building: 2010
Architects: Gernot Minke (author), Bjorn Kierulf (detailing)
Address: Hrubý Šúr 15

This building presents a straw bale dome with 8 vaults, covered by a green roof, so it looks like a small hill. The floor of the house is 30 cm under the ground, for the sake of covering it with earth and to be as low as possible. It is probably the first construction in which straw bales were cut from two sides to create an exact shape for the dome and vaults, which are themselves load bearing and bear the load of vegetation roof too. Extremely well compacted straw bales are placed one on top of another and secured in position with wooden poles. All the construction details were designed to low energy standards with some elements of Passivhaus design, such as triple windows with airtight fittings and no frames, to lower costs, but also eliminating any cold bridges. After finishing, the building will be used by the architectural studio Createrra and by the NGO ArTUR, which will exhibit the results of the workshops and organise seminars to promote ecological building methods. The thermal resistance (R) is between 7 and 12 m² K/W, the thermal conductivity (λ) a 0.054 W/mK for 36 cm straw, and 0.054 W/mK for places insulated with additional foam glass (30-50 cm).

A preview of the Outstanding Buildings Award catalogue

Below:
The European symposium "Building with Earth. From Cultural Heritage to Contemporary Architecture" held in Marseille, 4-6 May 2011. (photo: ICOMOS France)

Old shipyard. Canal of Castile Museum, Villaumbrales, Castile and León, Spain. (photo: Pierre Buch)

A photographer's look at earthen architecture

Traveling for quite a few years, I thought I knew a little the Earth and... earthen architecture. I lived in buildings made of cob, rammed earth, adobe, in Mali, in Mexico, in Syria... but never in Europe.

The title and theme of the project intrigued me so. It was quite a discovery. What variety! Typologies of buildings: from the tools shed to the imperial palace, from the fortified farm to the dovecote, from the winery to the Renaissance palace, from the industrial pigeon house to the minimalist villa.

Eras: from the Middle Ages until tomorrow.

Materials and techniques: from adobes embedded with pebbles, to cob saturated with straw, from the stratified section of rammed earth wall to the timber frame walls filled with wattle and daub.

Yet, it is still earth. Associated with wood, steel, stone, glass, concrete...

Always the same and never similar. Thus, I tried to capture the consistency of this infinite variety by working on the appearance of the matter, stressing its graphic beauty and its amazing ability to capture the different shades of light.

Pierre Buch

Spain

Castile and León, Villamartin-de-Campos
Dovecote

France

Normandy, Saint-André-de-Bohon
Manor of Bas-Quesney

Italy

Piedmont, Mandrogne
Village house

France

Normandy, Neuilly-la-Forêt
The Arpents farm

Spain

Castile and León, Capillas
Dovecote

Italy

Piedmont, Novi Ligure
Cascina Bellaria
Manor

Portugal

Alentejo, Beja, Aldeia do Salvado
House and artist's studio
Architect Bartolomeu Costa Cabral

Italy

Piedmont, Alessandria, Lobbi
Cascina Pagella
Farm

Italy

Piedmont, Novi Ligure
Azienda vitivinicola La Raïa
Winery
Builder Martin Rauch

Portugal

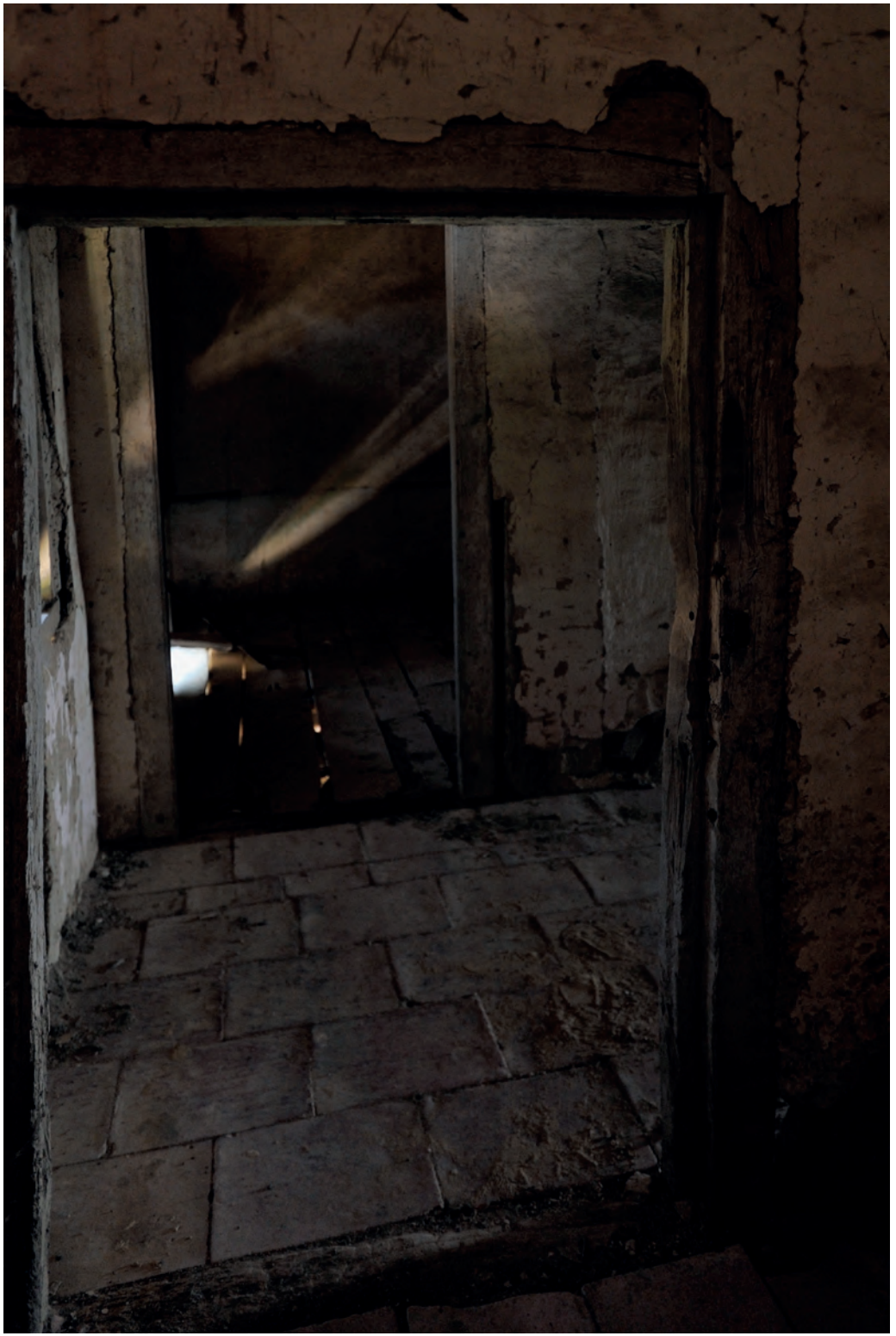
Alentejo, Monte-Novo-dos-Troviscais
Casa da Cerca, house
Architect Graça Jalles

France

Normandy, Saint-André-de-Bohon
Manor of Bas-Quesney

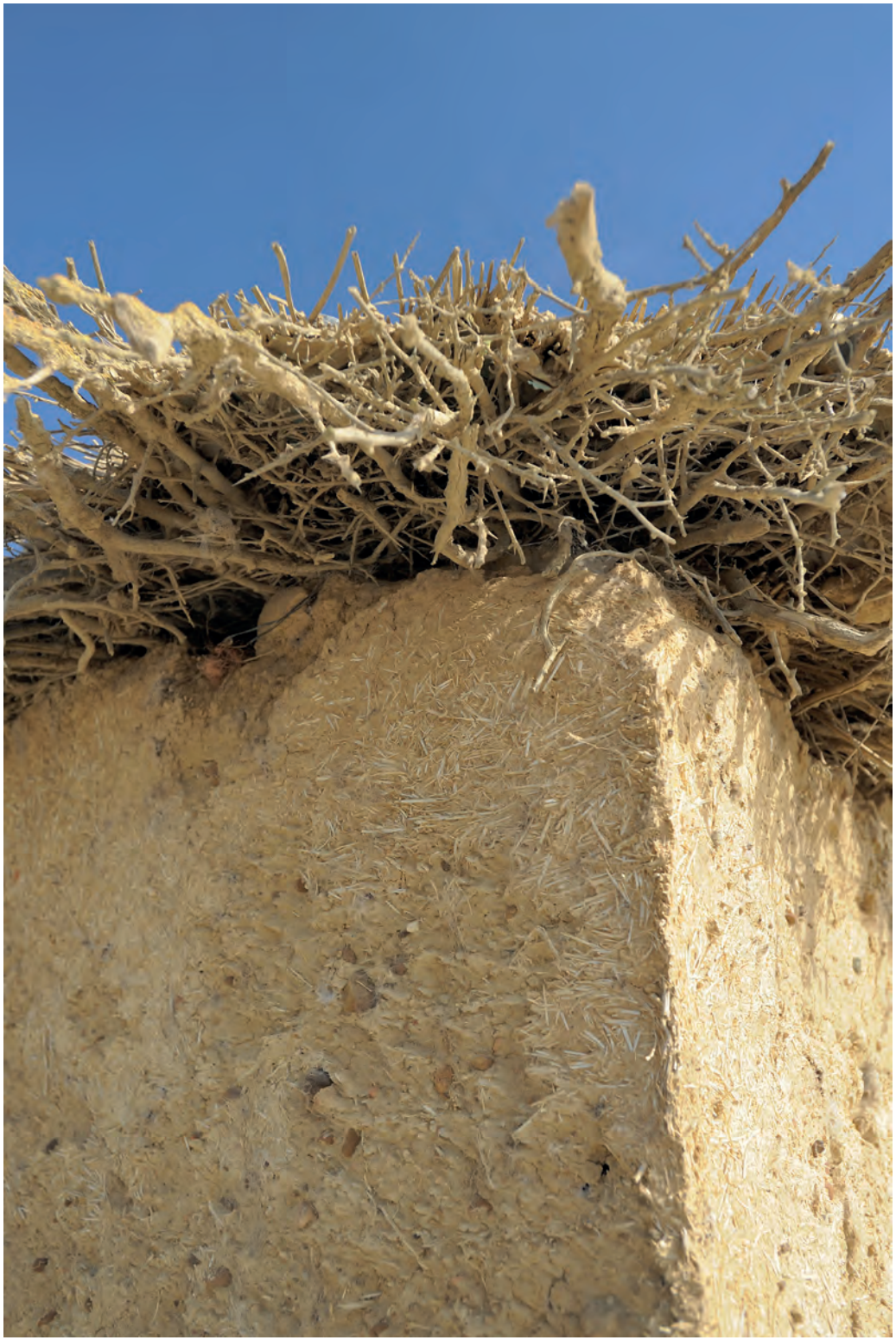
Italy

Piedmont, Novi Ligure
Azienda vitivinicola La Raïa
Winery
Builder Martin Rauch



France

Midi-Pyrénées, Juilles, Lagrange
Fortified barn



Spain

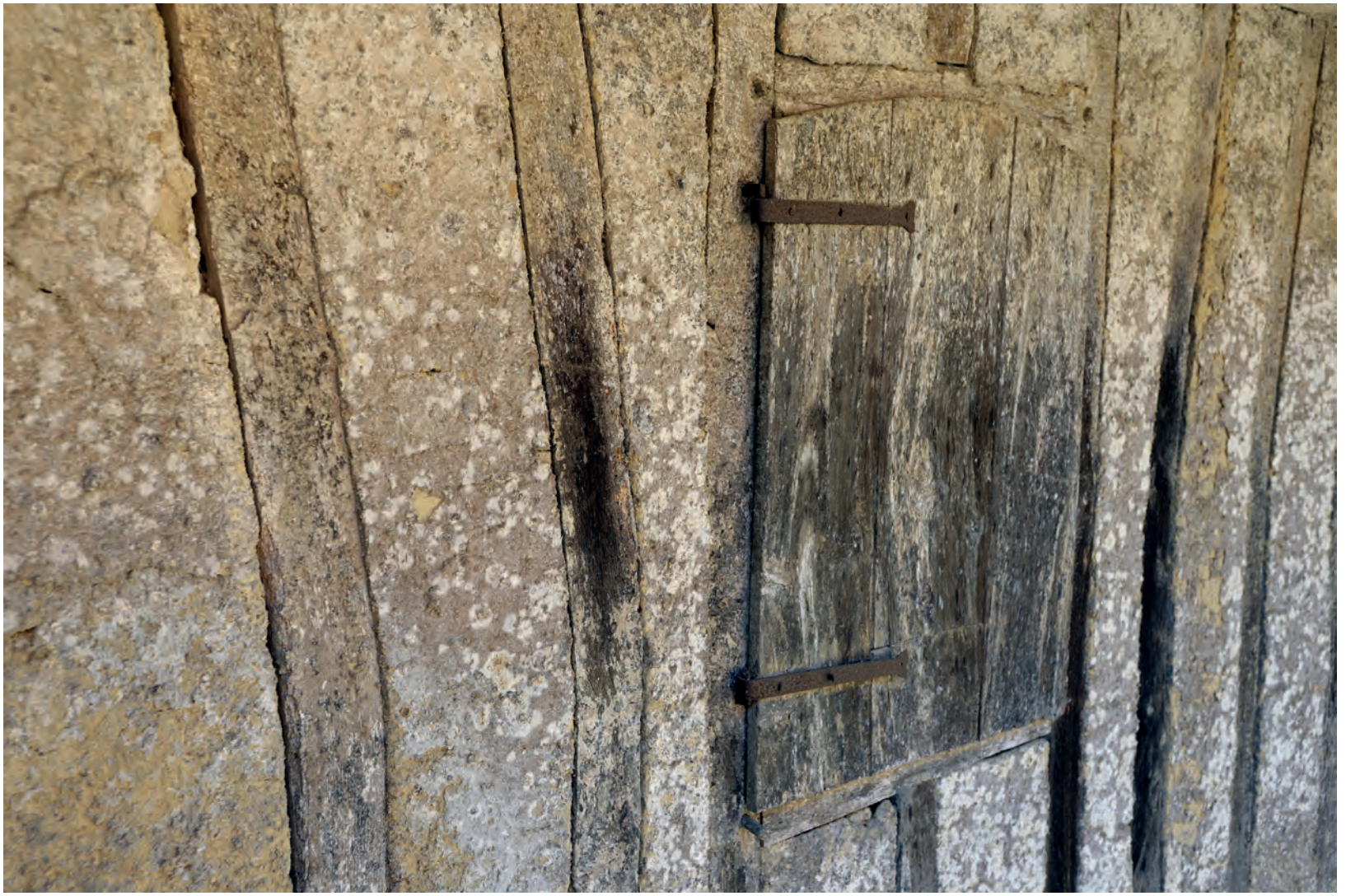
Castile and León, Villaumbrales
Village house

France

Normandy, Neuilly-la-Forêt
The Arpents farm

Portugal

Alentejo, Beja, Aldeia do Salvado
House and artist's studio
Architect Bartolomeu Costa Cabral



France

Midi-Pyrénées, Sainte-Christie-d'Armagnac
Castel

Italy

Piedmont, San-Giuliano-Nuovo
Chapel

Portugal

Alentejo, Beja, Aldeia do Salvado
House and artist's studio
Architect Bartolomeu Costa Cabral

France

Midi-Pyrénées, Castelnau-Magnoac
Gable of a barn

Fortified barn. Juilles, Lagrange,
Midi-Pyrénées, France. (photo: Pierre Buch)

Earthen architecture in Europe: a regional approach

Frilandsmuseet Open Air Museum, Denmark. (photo: Mariana Correia, Jacob Merten)

Earthen architecture in Northern Europe:
Denmark, Sweden, Finland, Estonia, Latvia and Lithuania

Patrice Morot-Sir
Ecole d'Avignon

René Guérin
Conseil d'Architecture d'Urbanisme et de l'Environnement de Vaucluse

Mariana Correia
Escola Superior Gallaecia

Geographical context

These six countries, covered by forests and lakes, share a common geographical context: they are bordered by the Baltic Sea. Thanks to the Ice Age period, soils are suitable for earthen construction, except in flatlands formed by coarse sand and gravel (for instance, this is the case of West and South-East Lithuania). However, traditional earthen architecture is not so common, due to the importance of forests providing abundant wooden resources, traditionally used for construction.

History

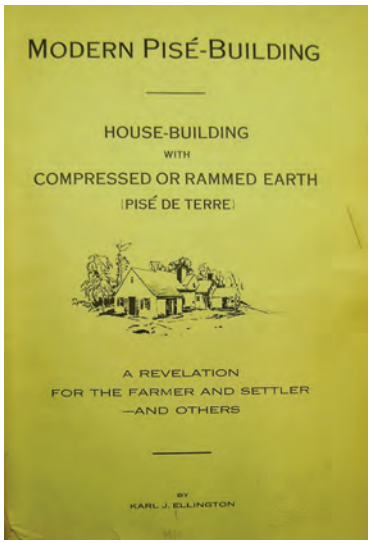
Lithuanian archaeologists discovered some wattle and daub walls, from the Prehistoric period. There is also evidence of earthen construction in Denmark from the Iron Age (Hjerl Hedes Frilandsmuseum in Vinderup) and in Sweden from the Viking Age. The earthen historical buildings still preserved nowadays were constructed after the 16th century in Finland, the 18th century in Denmark, Sweden and Latvia and the 19th century in Estonia and Lithuania. During the 19th century, influence of cob construction, originating from the UK, travelled to Denmark and then to Sweden. In 1878, the "Maamies" magazine (Countryman) published a detailed description of rammed earth. The advantages of earthen architecture were presented as follows:

"These days it does not seem necessary to verify the many benefits these buildings offer, since clay buildings have been built in many parts of South-

Adobe wall in Frilandsmuseet, Denmark.
(photo: Mariana Correia, Jacob Merten)

Villa Terra in rammed earth built in1925. Falkenberg, Sweden. (photo: Jenny Andersson)

ern and Middle Finland; the main point is that these buildings are easy to care for, long-lasting, warm (most convincingly seen during the last cold winter), forest saving, less inflammable, clean (bedbugs do not thrive on clay walls) and neat".



Modern Pisé.
Building book.

Earthen construction was taken as an alternative to wooden construction. Mainly for two reasons: saving the forest resources which became, in the 19th century, an economical resource, and building houses less susceptible to fire than wooden construction. In Finland, fires in the city centre motivated the exploration for alternatives to wooden construction. In Sweden, it was perceived that earthen construction techniques were developed to save the timber for the iron and ship building industry. Following the First World War, earthen construction was promoted and widely spread, as an alternative to wood construction. Some booklets were then published in Danish, Swedish and English to spread the know-how. As a consequence, some rammed earth houses were built in Sweden during the twenties and thirties. It is also interesting to notice that there were several historical movements of workers traveling through the northern countries during the 20th century. For instance, Estonian workers with knowledge of rammed earth construction worked in Sweden and Finland. During the Second World War, earthen construction was neglected. It was rediscovered in the 1950s and was again almost abandoned in the following decades.

Specific traditional techniques

It can be witnessed in the region, a wide range of traditional building techniques, as cob, adobe, wattle and daub, rammed earth and half-timber filled in with earth (cob or adobes) and plastered with clay. Dwelling hous-

Earthen houses in Swedish Eco-communities.
(photo: Mariana Correia, Jacob Merten)

Above: Earthen house in Swedish Eco-communities; Dejbjerg Jernalder-Skjern Museum, Denmark
On the right and in the next page: Frilandsmuseet, Denmark.
Below: Workshop in Sweden.
(photos: Mariana Correia, Jacob Merten)

es are typically built with half-timber structures filled in with wattle-and-daub, while outhouses are built with wattle or with mixed techniques (clay mortar in wood chips, stones or brick masonry). In the Baltic countries, generally, the earth used for building contains a large part of sand, and clay has a role of binder. In order to strengthen the wall and to avoid abrasion, stems of Labrador tea, heather or flax are added in the clay mixture. In many cases, in the six countries, to improve thermal insulation and avoid deformation when drying, clay mortar is mixed with straw, chopped reed, cannabis stems, little branches, pine or spruce needle leaves or horse manure. In the south of Sweden, in Skåne, the tradition of building with half-timber structures has always been strong, as the area has rich clay soils and forests are scarce. The framework was filled with different mixes of clay and straw, wattle and daub or adobe and fired

bricks, then coated with clay or lime plaster. In Denmark, the tradition in Jutland is of half-timber filled in with adobe or firebrick masonry. In Finland, most constructions in use were built with rammed earth using twigs of heather, spruce and other suitable plants as reinforcement. Cordwood masonry is found in animal shelters and for partition walls in different building types. In Finland, thousands of earth structures were built, but only around 200 are still standing; lack of maintenance, lack of concern and even some lack of construction quality are the common reasons for their disappearance. In the six countries, clay plastering was the most common protection for earth buildings. Even pig bristle, cow hair, sawdust, straw, flax are found in old earthen plasters. Clay was also used to plaster surfaces on log houses.

Today

In the all region, earthen architecture is living a dynamic 'renaissance'. Based on old techniques, architects and builders are experimenting with innovative ways of building. For instance, in Sweden, rammed earth houses have a tradition in smaller areas, also on the west coast, but non-load bearing structures such as clay-straw or clay mixed with wood chips, perlite, LECA (Light Expanded Clay Aggregate) or others are experimented in several places in the southern half of the country. Clay plaster is used, not only on earth buildings but also on timber structures, Wood Wool Cement Board (WWCB) and different kinds of masonry walls. At the same time, in Finland tens of buildings with light clay-straw or other such mixes as clay and wood chips, or clay and LECA, have been built.

Eco-communities had a strong development in Finland, Sweden and especially in Denmark. Nowadays, isolated examples of rammed earth, adobe masonry or CEB construction, as well as straw bale structures with earthen plasters can be almost always found in these communities. Earth plaster workshops are also quite common in the north of Europe, as they transmit a sense of community and belonging, but they also respond to an ecological, social and economical demand. Earthen plasters workshops are often organised around the renovation of vernacular buildings or the finishing of new straw bale structures.

Associations, professionals network have been created in Estonia, Finland and Sweden. For now, in Latvia and Lithuania the earthen building dissemination has not yet developed. A Scandinavian collaboration (NOL) with a common newsletter and annual meetings started in the early 1990's between Norway, Sweden, Finland and Denmark, inspiring national associations to be formed. The Swedish Earth Building Association (*Lerbyggeföreningen i Sverige*) was founded in 1994 and has presently around 150 members. The Scandinavian NOL is no longer active, so inter-Scandinavian contacts are now informal and irregular. The Finnish Clay Builders Association (*Saviyhdistys ry*) is working for an active network of clay and straw bale builders in Finland. The main intention is also to enlarge networking to the other Scandinavian and Baltic countries.

Church in half-timbering, Châtillon-sur-Broué, Marne, Champagne-Ardenne, France.
(photo from *Terra Incognita. Discovering/Preserving European earthen architecture*,
Argumentum/Culture Lab Editions, 2008)

Earthen architecture in Northwestern Europe:
Ireland, the United Kingdom and Northern France

Marie Chabenat*
Ecole d'Avignon
Louise Cooke
Earth Building UK
Barry O'Reilly
National Inventory of Architectural Heritage

Since prehistory the inhabitants of northern France, the United Kingdom and Ireland have built with earthen material using similar techniques of wattle and daub and cob, and less commonly, bricks or blocks of mud, peat or sod. Today this tradition is experiencing a renaissance, boosted by the interest in earthen material from an aesthetic and environmental point of view.

History

During the Neolithic, structures of earth and wood became common. This trend continued throughout the Bronze Age and the Iron Age with archaeological evidence for use of earth in a number ways, including wattle and daub, cob, sod and turves.

The cob house has existed since the Iron Age in Celtic-Gallic territories. However, in the northwest of France, this type of construction was not seen before the 16th century. Evidence survives from the Middle Ages in England (Wallingford Castle), while during the same period sod was seen in construction in Scotland. In Ireland, it is believed that the cob house was introduced by the invading Anglo-Normans in the late 12th century. Whilst ample evidence of wattle-and-daub survive in northern France and England, this technique evolved over the centuries, giving rise to the familiar forms of half-timbered houses of wattle and daub.

In the 18th century, period of the Enlightenment, monolithic earthen buildings (rammed earth), were encouraged in order to improve living conditions

Half-timber with wattle and daub, Pays d'Auge, Region of Caen, Normandy, France. (photo from *Terra Incognita. Discovering/Preserving European earthen architecture*, Argumentum/Culture Lab Editions, 2008)

*Contribution based on *Terra Incognita. Discovering/Preserving European Earthen Architecture*, Argumentum/Culture Lab Ed., 2008.

Timber-framed houses, formerly filled with wattle and daub, now with current materials: bricks or cellular concrete, Alsace, France. (photo from *Terra Incognita. Discovering/Preserving European earthen architecture*, Argumentum/Culture Lab Editions, 2008)

and housing for the peoples of this region and similarly in the rest of Europe. In England, where traditional architecture employed cob and half-timber framing, rammed earth arrived in the late 18th century but was quickly abandoned. The technique was used earlier in Great Britain under the Roman occupation (1st-5th centuries AD), with archaeological evidence interpreted in London and St Albans (*Verulamium).*

The years 1920 to 1960 were for France, the United Kingdom and Ireland, years of study and valorisation of vernacular architecture that contributed to knowledge and later to the revival of earthen architecture. In England, C. William-Ellis (1919), proposed a first monograph on *cottages in cob, mud, chalk and clay,* further developed by J. Eastwick-Field, in 1947. In Ireland, folklorist C. Ó Danachair, published in 1957, a study on traditional Irish construction techniques *(JRSAI,* 87, *Béaloideas,* 25). In 1942, the *Musée National des Arts et Traditions Populaires* launched its (worksite) *Chantier 1925* for the study of French rural architecture.

Beyond research, some of these countries recommended or implemented the use of earthen material. In England, in the 1920s, the *Ministry of Agriculture and Fisheries* supported the construction of earthen *cottages* for returning soldiers from World War I. In France, in 1941, the architect Le Corbusier designed his *Maisons Murondins,* in compressed earth block and rammed earth. In 1942, in Ireland, an (unsuccessful) proposal was made to the State to encourage the use of earth in construction, because of its widespread availability, low cost, strength and authenticity.

After World War II, France and Britain, faced with shortages of industrial materials and the need to relocate affected populations *en masse*, experienced a brief revival in earthen construction. In France, the Ministry of Reconstruction and Urbanism supported research on stabilized earthen concrete

Cob house, Cotentin, Normandy, France. (photo from *Terra Incognita. Discovering/Preserving European earthen architecture*, Argumentum/Culture Lab Editions, 2008)
Manoir du Bas-Quesney, Saint-André-de-Bohon, Manche, Normandy, France.
(photo: Région Basse-Normandie, Inventaire général du patrimoine culturel, Manuel de Rugy)
Maison des Marais, Marchésieux, Manche, Normandy, France.
(photo: Région Basse-Normandie, Inventaire général du patrimoine culturel, Manuel de Rugy)

with the experimental worksites on the farms of Bosquel (Somme), and the reconstruction of the *Cité des cheminots* in Tergnier (Aisne). But given the magnitude of the reconstruction, the reinstatement of the industrial apparatus destroyed these new prospects in most European countries.
It was not until the 1970s that this revival became a reality.

Traditional building techniques and their geographical distribution

In northern France, two principal building techniques co-exist: *cob*, found in central Brittany, Rennes basin, the marshes of the Vendée, the Grande Brière, and in Cotentin and Bessin (Lower Normandy), and *wattle and daub* which is found in Normandy (Lower and Upper), Picardie, Champagne, Alsace and the Vosges. The tradition of construction from mud brick occurs mainly in the Southwest, but there is also a northern tradition in Champagne, along the Marne valley (town of Condé, in the region of Reims).
In France, the term *wattle and daub (torchis in French)* comes directly from *torch*, which consists of preparing a mixture of heavy soil (clay) with straw from harvested grain that is stuffed between the stakes of the secondary framing studs (half-timbers). In relation to half-timbering, the regional vocabulary designating the different parts of the wood components is quite varied.
In France, two types of cob are noted: a regional variation with plenty of vegetable fibres prepared into *bigots* (soft mixed earth and fibre cut out with the spade in more or less regular sections) and stacked with a fork is used in the area of Rennes. Another variant, composed of fewer fibres and more stone or flint is used in the Vexin and the Loiret region. In Brittany and Cotentin, cob is better known by the term *masse*.
In Great Britain, the archaeological evidence of building with earth is extensive with earth-built funerary and henge monuments common throughout the UK from the Neolithic, whilst a later monument, Hadrian's Wall, built in 143AD and designated a world heritage site in 1987, is in large part earthen. The grand tradition of *cob* occupies the southern territories in Devon and Cornwall. It covers the western parts of Wales, and regions of central England. Raw (unfired) brick or *clay lump* is detectable in the South East, Essex, Norfolk





Mud house rebuilt, Effin, Kilmallock, Co. Limerick, Ireland.
Hedge built with earth and stones, Mayglass, Co. Wexford, Ireland.
Traditional mud house, Mayglass, Co. Wexford, Ireland.
Traditional house, Mayglass, Co. Wexford, Ireland.
Selfbuilt mud house, Owning, Co. Kilkenny, Ireland.
(photos: Marie Chabenat)

and Cambridgeshire. Scotland had a tradition of construction of sod or peat of which only a few examples remain. Housing of cob is also part of the Scottish tradition, which is designated by the terms *mud* or *clay walls,* easily spotted in Perthshire, Dumfriesshire, Banffshire, Inverness and the historic centres of Dundee and Edinburgh. Earth on a supporting frame is prevalent and widespread in a variety of regional variations such as wattle-and-daub and mud-and-stud.

Several regional sayings take note of the experience of traditional builders and the common sense expressed by conventional wisdom. One such saying from the region of Devon, England, states in the form of an aphorism: *All cob wants is a good hat and a good pair of shoes.*

At least 50.000 ringforts, farmsteads encircled by earthen banks, are known from every part of Ireland from the period AD500-1200. Earth and (to greater extent) stone are the two most common materials of the Irish vernacular architecture**,** wood and brick are virtually absent. Constructions made entirely or partially of earth can be found throughout the island, usually cohabiting with stone buildings but are especially prevalent in the south-eastern two-thirds. In the south of Ulster, there are a few examples of houses built entirely of mud brick. Brick of mud or peat are used equally as *hourdage* material for partitions.

Architectural typologies

In northern France, as in the rest of the country, a wide typological variety came into existence. Wattle and daub are very evident in historic urban centres (Rouen, Le Mans, Tours, Troyes, Rennes). Cob and wattle and daub are equally present on traditional farms, manors, and mansions. Here are churches in half-timber and wattle and daub, in Champagne for example (region of Reims). At the end of the 19th century, under the leadership of Minister Jules Ferry, town halls-schoolhouses were built throughout the country, sometimes with materials available on site and according to the traditional building techniques; cob was one of them.

In Great Britain, there are many earth buildings, most are distinctive to their regions, and many are rendered with earth or lime plaster. The best-known examples are the picturesque cob houses of Devon and Cornwall. Traditionally thatch was used for roofing. Single and multi-storey buildings are found throughout the UK in urban and rural settings, in addition to boundary and protective earth walls.

In Ireland, earthen buildings most often had a hipped thatched roof. Today they are often covered in a secondary pitched corrugated-iron roof. The vast majority of earthen (and indeed all vernacular) buildings are and were single-storey, although two-storey and dormered single-storey buildings are known, especially in the east.

The renewal of earthen architecture

In France and elsewhere, the involvement of the CRAterre laboratory (Grenoble) in the rediscovery of earth as a building material has played a key role in its renewal. The book *Construire en terre (1979),* the exhibition *Des architectures de terre* (Centre Pompidou, 1981), the project *Domaine de la Terre* (a public housing project near Lyons, 1983), then the creation of the DSA-

Cob Wall, Avebury, Wiltshire, United Kingdom. (photo: Louise Cooke)

Terre (higher education specializing in earthen construction, 1984) and finally the publication of the *Traité de construction en terre (Houben* and Guillaud, 1989), laid the foundation of this renewal and allowed new generations to carry the development of the techniques to their own regions.

Thus followed initiatives in Upper Normandy seeking solutions to facilitate the restoration of half-timbered and wattle and daub buildings, using wet mud, delivered in bulk or bagged; in Cotentin and Brittany, cob was celebrated and its techniques reintroduced through professional training. In Brittany also, a method of prefabricating cob blocks has been developed but is still at an experimental stage due to lack of satisfactory control. A national association of earth building professionals, AsTerre, was created in 2006 to promote and support the development of earthen construction in France.

In the United Kingdom, research and training in the field of earthen construction and the conservation of earthen heritage is particularly active (Universities of Bath, Plymouth, Nottingham, Durham, Strathclyde and York). In Plymouth, the *Centre for Earthen Construction* organized two international meetings, *Out of Earth* I and II in 1994 and 1995, to review English research and heritage of earthen architecture. *English Heritage* organized in 2000 in Torquay (Devon), the 8th International Conference on the Study and Conservation of Earthen Architecture with over 300 experts from around the world.

Over the last decade practitioners, manufacturers and distributors of earthen material are becoming more numerous in the United Kingdom and the interest is growing, although some reservations remain. A national body, Earth Building UK (EBUK), was established in 2009 with an aim to foster the conservation, understanding and development of building with earth in the United Kingdom. This is an equivalent to its French counterpart.

In Ireland, the revival of earthen architecture is not as obvious as in France or the United Kingdom. Earthen construction has, however, been the subject of limited study by a small number of researchers.

Dwelling built in mix techniques, Arnhem open air museum, Netherlands. (photo: Mariana Correia)

Earthen architecture in West Central Europe:
Netherlands, Belgium and Luxembourg

Mariana Correia
Jacob Merten
Gilberto Carlos
Escola Superior Gallaecia

Surviving earthen architecture heritage is hard to find in this region. The majority has already disappeared and some might not be apparent, as dwellings are covered with lime or cement plasters. Most times, earthen heritage is identified with vernacular architecture from the beginning of the twentieth century. However, there are still areas with an important heritage, like the Limburg-Maastricht region (comprised of 3 countries), with half-timber structures in filled with wattle and daub. This construction material was commonly used for dwellings and has a significant relevance particularly in the assembly of ancient villages and farmhouses. There is a growing interest in renovating these historical constructions using earthen building materials.

After the industrial revolution, the industry in the region established brick factories along the many existent riverbanks, due to the flat geography of the territory. This evolving development naturally contributed to the gradual replacement of the earth building construction, along with other traditional techniques, by fired brickwork, which today represents the most typical construction material in this European region.

In an effort to protect the endangered vernacular heritage, a number of important examples of characteristic rural architecture were relocated to Open-Air Museums. Scandinavia established the first open-air museums in the late nineteenth century and the concept of this type of museum has spread throughout Europe (Venborg Pedersen, 2007). The Bokrijk Open-Air Museum near Hasselt, in Belgium has more than one hundred

Arnhem open air museum, Netherlands. (photo: Jacob Merten)

Timber frame and wattle and daub, Belgium. (photo: Jacob Merten)

examples of historic structures and small landscape features. These examples represent over 500 years of history and are from all over Flanders. The Open-air Museum consults the Flemish Community Department of Heritage for recommendations for some maintenance and restoration of the structures. There are excellent examples of typical half-timber buildings with wattle and daub in fill and clay plasters that were very common and representative of the vernacular architecture of the region (Keyzer & Vlaams Openluchtmuseum, 2001). The museum of Arnhem, in the Netherlands also presents good examples of half-timber buildings with wattle and daub in fill, in particularly around Maastricht region. There is reference to old earthen architecture dwellings in the northeast of Netherlands. Some were daylabourer's huts, composed by covered pits, where poor people lived in the beginning of the twentieth century (Nederlands Openluchtmuseum, 2000). A through research should be addressed to identify in the region other earthen techniques beside wattle and daub.

Training in restoration of half-timber houses with earth in fill is developed in restoration schools and Heritage Foundations. There is a general concern to teach traditional earthen techniques and to transmit specialised knowledge of how to deal with this disappearing heritage. Workshops are also common in open-air museums and earth building companies.

This is the region, in centre and north of Europe, that presents the most

Bokrijk open air museum, Belgium. (photo: Mariana Correia, Jacob Merten)

Bokrijk open air museum, Belgium.
Arnhem open air museum, Netherlands.
(photos: Mariana Correia)

variety of new earth construction materials (straw-clay, stick-bricks, etc.). Straw-clay or clay "slip" is a contemporary earthen architecture technique that is often used throughout the region. Clay "slip" is added to straw to create a lightweight mixture that is usually used as an in fill for timber frame structures or as prefabricated blocks. This technique has a higher insulation value than most other earthen techniques. Recently, wood chips are replacing straw, which reduces the drying time and the shrinkage behaviour of the mix.

National institutions, as VIBE, the Flemish Institute for Bio-Ecology (in Belgium) and VIBA (in the Netherlands) integrate earthen architecture through research in materials and energy performance. It was recognised

Modern materials at Alexis Versele office, Belgium
Sjap Holst office, Eindhoven, Netherlands
OSKAM machinery, Netherlands.
(photos: Jacob Merten)

that at the present time, earthen architecture is approached in the region, with a more ecological and sustainable perspective. Environmental groups promote earthen architecture as economical and environmental friendly material. Used in bioclimatic design as thermal mass for walls and floors, rammed earth, adobe or compressed earth materials are advised by energy efficiency consultants.

Earth plasters have increased in their popularity, particularly in interiors of offices and households. The most known producers of plasters (Claytech, Terra Fino and Ecomat) are from this region. Earth plasters are also popular in alternative architecture circles and green building projects. It is also often used on straw bale construction.

In this region, several chains of professionals are interconnected with the earthen construction domain: from architects and engineers, to builders and producers, to machinery developers (pressers, mixers, etc.), to researchers and academics, etc. Throughout the region, there are several specialists with different expertise in earthen architecture. In general, they work isolated from each other. As one of the regions with the most prospective for innovation in earthen architecture, it becomes fundamental for experts to network, in order for the disciplinary area to fully develop its potential in the next years.

Limburg-a-d-lahn, Germany.
(photo: H. Schreckenbach)

Earthen architecture in Central Europe:
Germany and Poland

René Guérin
Conseil d'Architecture d'Urbanisme et
de l'Environnement de Vaucluse
Horst Schroeder
Stephan Jörchel
Dachverband Lehm e.V.
Teresa Kelm
Polytechnic University of Warsaw, Faculty of Architecture

Geographical context

Germany and Poland form a wide territory between the Baltic Sea and the Alps. In regard of geology, this region is divided into two important areas. North of a line between Osnabrück (Germany, Niedersachsen) and Przemyśl (Poland, Podkarpacie), is a homogeneous, almost flat territory formed by an alluvial basin, drained by important rivers such as the Elbe, Oder/Odra or Wisła, which correspond to former glacial channels (*Urstromtäler*): this whole territory is suitable for earthen building. South of this line, is a heterogeneous territory, with a large diversity of plain, hilly and mountain landscapes, presenting many different geological formations: the most part of this territory is suitable for earthen building.

Thus, traditional earthen building is present in almost the whole of Germany, and mainly in the northern and western parts of Poland (Pomorze, Dolny Śląsk, Warmia i Mazury, Wielkopolska, Pomorze Zachodnie) and also the central part of Mazowsze and Małopolska. However, there is an important difference between the two countries: in Germany, several hundred thousand traditional earthen buildings are still preserved, while in Poland earthen buildings are not so common.

History

The origins of earthen building go back to the Neolithic Period, as post and beam houses with a form of wattle and daub, from about 4000 BC, which have been replicated in several open-air museums in Germany. The origin of the first earth block buildings is uncertain. The Greeks could have introduced this building technique to the region[1], or the first users may have been the Celts. The Romans used rammed earth, as is testified by the vestiges of *Colonia Ulpia Traiana*, from the 1st century in Xanten (Germany, Nordrhein – Westfalen).

During the Middle Ages, timber framed or half-timbered buildings, filled in with wattle and daub or adobe bricks, were developed in both cities and rural areas. In Poland, the 17th century corresponds to a new step concerning building techniques: on one hand, some buildings were constructed with rammed earth, but the most part had died out by this time; on the other hand, the timber framed or half-timbered buildings, filled in with wattle and daub or adobe bricks, had become widespread substituting the log structures, due to an important increase in the price of wood. The spread of adobe brick walls in Poland goes back to the end of the 18th century, notably spurred on by the architect Piotr Aigner, author of a 1791 guide book. From 1815, in Poland, a renewal of earthen building techniques, in particular the rammed earth technique, resulted from progressive policies.

After the Second World War, in Germany as in Poland, policies for urgent rebuilding promoted the use of rammed earth or adobe due to the lack of other materials. These rebuilding programs were supported by specific publications[2]. From the 1960s on the building industry development alienated raw earth techniques, which were marginalized until their recent rediscovery.

[1] Schroeder, H. 2010, *Lehmbau: Mit Lehm ökologisch planen und bauen*, Vieweg + Teubner, Wiesbaden (Germany)
[2] Miller, T., Grigutsch, E., Schulze, K. W. 1947 (reprint: 1999), *Lehmbaufibel*, Forschungsgemeinschaft Landliches Bau und Siedlungswesen Hochschule Weimar, Weimar (Germany).

Traditional techniques

According to Dr Horst Schroeder and Stephan Jörchel (Dachverband Lehm e.V., Germany)[3], the main traditional techniques are set up as following:

- Concerning timber framed or half-timbered buildings, one of the oldest techniques is wattle and daub filling: the wooden struts are woven with a wickerwork of split willow branches; this supporting wattle is then daubed. In fill panels are also filled with a mixture of stone rubble and lean earth mortar, earthen brickwork or loose mixtures of moist clay straw or light clay.
- Cob walling corresponds to an earth mixture with a higher proportion of straw than rammed earth and contains little to no mineral substance. Earthen clumps are layered on top of each other and the irregular sides are then shaved flat with a spade to achieve an even wall surface.
- Rammed earth walls are constructed using formwork, which is filled layer by layer with a moist earth mixture. Each layer is compacted; the formwork can be removed after the earth has been compressed as the earth maintains its shape.
- Traditional adobe bricks are hand-moulded: a light malleable earth mixture is pressed or thrown into a wooden mould. The surface is drawn smooth, the mould removed and the bricks left to dry in the sun or in an oven.
- Coarse earth renders are a mixture of clay or loam and coarse aggregates; fibrous additives improve the stability and abrasion-resistance of the plaster. They are applied with a thickness of about 4 cm; coarse renders are usually painted with a finishing coat.
- Fine clay plasters are made of fine aggregates; they are applied with a thickness from 2 mm to 5 mm.

According to Teresa Kelm (Polytechnic University of Warsaw, Faculty of Architecture)[4], some specific techniques can be mentioned:

- Some cob walls are built of layers formed with wet lumps, then pressed with wooden floats or even under foot. Earthen mass is often mixed with straw to neutralize cracking during the drying process.
- Concerning rammed earth, the mixture of earth and gravel includes often up to 10 % lime; sometimes earth is mixed with peat. The mixture is beaten down in wooden forms in consecutive layers with a height from 50 cm to 100 cm. Sometimes little twigs are laid between layers for reinforcing. In many cases, the rammed earth walls are built on a high underpinning of stones or terracotta bricks, to protect them from water and moisture; sometimes, the external face is covered with a wooden siding.

Some outstanding places

Many types of earthen buildings are present in whole Germany and in the western and central part of Poland: farmhouses, barns, stables, urban or rural houses, taverns, castles, manor houses and impressive palaces…

Many medieval centres of German cities have numerous framed or half-timbered houses. The historical centre of Quedlinburg (Sachsen-Anhalt), a World Heritage site listed by UNESCO, is emblematic of the interest in this type of heritage. Limburg an der Lahn (Hessen) is also among the most famous of places.

In Poland, significant places are not common, except the little towns of Pomorze, near the Baltic Sea, such as Hel, Kartuzy or Puck. However, Poland boasts some interesting historical buildings: an ancient hospital from the 17th century in Puck, built in wooden framework filled with adobe bricks, where a local museum has been set up; Tarchomin Palace (Mazowsze), from the turn of the 17th and the 18th centuries, is probably the oldest Polish building in rammed earth still preserved.

The highest rammed earth building of the region is most likely a six-storey house located in Weilburg an der Lahn (Germany, Hessen); however, in Poland, there are also workers estates built with rammed earth of several stories, such as near Ciechanów and Pruszków in Mazowsze, or near Myślenice (Małopolska).

In the last decade significant and interesting buildings emblematic of earthen building renewal have been constructed: the Wangeliner Garden House in Buechberg (Germany, Mecklenburg-Vorpommern) was designed by the architect Günter zur Nieden; the Chapel of Reconciliation in Berlin-Mitte (Germany) was designed by the architects Peter Sassenroth and Rudolf Reitermann; the Experimental House in Pasłęk (Poland, Warmia I Mazury) was designed by the architects Teresa Kelm, Jerzy Górski and Marek Kołłątaj.

Main stakeholders in the promotion of earthen building

While in Germany there are important associations and professional networks, in Poland earthen building promotion is not yet so developed.

In Germany, Dachverband-Lehm e.V. (DVL) is an association of earthen building. DVL is a registered non-profit organisation dedicated to promot-

[3] See chapter «Earthen architecture in Germany».
[4] See chapter «Earthen architecture in Poland».

Chapel of Reconciliation in Berlin, Germany. Builder: Martin Rauch. Architects: Rudolf Reitermann, Peter Sassenroth. (photo: René Guerin)

ing building with earth at several levels. It has established building regulations for the use of earth as a building material, and developed a training programme for optimal practice in building. In addition to providing general information on building with earth, DVL also aims to support the continuing implementation of appropriate earth building practice for future generations through academic teaching and research. The Faculty of Architecture of the Bauhaus University of Weimar (Thüringen), the Technical Higher School of Aachen (Nordrhein-Westfalen) and the Building Research Institute of the University of Kassel (Hessen) are the main universities which include earthen building in their research and education programmes. There are also life-long learning centres, such as the European School of Earth Building in Ganzlin (Mecklenburg-Vorpommern) or the Knobelsdorff School in Berlin. Also many associations of promotion, which organize workshops are present in Germany, such as Artefact GmbH (International Centre for Sustainable Development) in Jessen-Glücksburg (Sachsen-Anhalt), Lehmbaukontor (Earthen Building Training) in Berlin, Lehmbaukurse (Earthen Building Training) in Biesenthal bei Birnau (Brandenburg), Lehmbau Mobil (Earthen Building Mobile) in Dortmund (Nordrhein-Westfalen), Lehmhof (Earthen House) in Lindig (Thüringen), or Moderner Lehmbau (Modern Earthen Building – Umbra GmbH) in Berlin. The Earth Museum in Gnevsdorf (Mecklenburg-Vorpommern) is the only one dedicated exclusively to this material.

In Poland, the main centre of earthen building research and education is the Faculty of Architecture of the Polytechnic University of Warsaw: within the framework of a practical workshop. This institution has built an experimental house in Pasłęk (Warmia i Mazury). Moreover, there are State Higher Vocational Schools in Nysa (Śląsk Opolski) and Zielona Góra (Ziemia Lubuska). Some associations promote earthen building, such as Architektura Ziemi in Warsaw, and sometimes organize workshops, such as Earth Hands & Houses or Naturalny Dom in Słubice (Ziemia Lubuska). For promotion towards the general public, some traditional earthen buildings were replicated in the open-air museums of Kluki (Pomorze) and Wdzydze Kiszewskie (Pomorze).

Earthen architecture in East Central Europe:
Czech Republic, Slovakia, Austria, Slovenia, Hungary and Romania

Fernando Vegas
Camilla Mileto
Valentina Cristini
Universitat Politècnica de València

Previous page: Adobe wall in Popice village, Czech Republic. (photo: Fernando vegas, camilla Mileto)

Wattle and daub wall in Szentendre open air museum, Hungary. (photo: Fernando Vegas, Camilla Mileto)

State of the Art. The large region of Pannonia, in Central Europe, possesses an extraordinary richness of different forms of earthen architecture, of a constructive variety seldom found in any other natural region in the world. In this huge plain, situated mostly in the Danube basin, and presently divided into Eastern Austria, Hungary, northeast Slovenia, Southern Slovakia, the Moravia region of the Czech Republic, Western Romania and parts of other countries such as Serbia, Croatia, Ukraine, there are manifold examples of constructive techniques that overcome in number and variety the famous range of earthen architecture techniques once developed by CRAterre-ENSAG. Earth has not only been employed from ancient to recent times to build walls with multiple simple and mixed solutions, but it has also been used to create mortars, pavements, coatings, kitchens, bread ovens, stoves, wall benches, excavated walls (in semi-buried houses), slabs between joists, isolating material (as a filling for roofs), etc[1].

Up to now, this extraordinary variety of uses for earth as a constructive material has not been as widespread as it deserves in local, national or international contexts and, therefore, is still a rather unknown architectural heritage, at least, at a European level. There are interesting and worthy exceptions to the rule, like the studies done in Hungary and the Czech Republic, but these are often published in local languages making it difficult to bring this architecture to the international position it really deserves.

[1] For a rather complete panorama of the variety of earthen building techniques in the area, see TIBOR, S., BUZAS, M., *Hagyományos falak*, Népi Kultúra, TERC, Budapest 2005. Other interesting data in NÁNDOR, G., *Az erdélyi mezöség népi építészete*, Népi Kultúra, TERC, Budapest 2005

Roma housing in rural area, Lehliu Sat, Romania. (photo: Cătălin Berescu)
Next page:
Informal house in Lehliu, Romania. (photo: Cătălin Berescu)
Stonjc village, Slovenia. (photo: Fernando Vegas, Camilla Mileto)
Bukovici village, Slovenia. (photo: Fernando Vegas, Camilla Mileto)

History. The origin of all these earthen constructive techniques goes back very probably even to Roman colonization times. There have been found remains of walls built with formwork, masonry bonding in *opus spicatum* and other details that may have inspired and/or enriched afterwards these earthen vernacular techniques. In any case, linguistic studies done around the terminology of earthen architecture reveal that most of the words used derive from Germanic roots, as in the case of Austria, or from Slavic roots, in the case of the Czech Republic, Slovakia, Slovenia, but also Hungary[2]. At first thought, this circumstance could allow us to date these constructive techniques previous to the arrival of the first Magyar emigration to the Pannonian plain, in the 7th century of our era.

Anyway, its presence as a constructive option in order to build domestic dwellings was not very representative in the middle of a world dominated by the construction of log-houses. These structures with a large consumption of wood were sometimes coated, both on the outside and the inside, with earthen renderings, the same way as the floor was made of tamped earth and the roof was thermally isolated with a layer of earth.

The true Golden Age of earthen architecture in dwellings and auxiliary rural buildings of this extensive region came from the 18th century onwards as certain factors appeared: the wood scarcity due to the increasing deforestation of the plain as a result of agricultural exploitation; the gradual publication of the "fire edicts"[3], that prohibited the building of new log-houses, requiring the existing ones to be rendered with earth and demanding the building of new kitchens and chimneys with masonry; the diffusion of earthen constructive techniques among master builders through architectural treaties; and the abolition of the serfdom system and the interdiction of cutting trees in the woods of the domains.

In the Bohemia region of the Czech Republic, outside the Pannonian plain, this process also took place in a parallel manner, though in this place of thick woods the former log-houses were substituted by half-timbered houses filled with adobe, cob or wattle and daub, the German *Fachwerk* that first spread to Bohemia through the cross-influences occurring during the Thirty Years War (1618-1648)[4].

Half-timbered architecture combined with earth is also present on the Pannonian plain but, as also happens with the rest of the great variety of

[2] SYROVA, Z., Quelques mots sur les mots utilisées dans la región danubienne et dans les langues slaves, unpublished paper

[3] See SYROVÁ, Z., SYROVÝ, J., La brique crue moulée dans les pays historiques tschèques (Bohême et Moravie-Silésie), *3emes Échanges Transdisciplinaires sur les constructions en terre crue*, Editions de l'Espérou, Montpellier 2011, p. 93-108

[4] Idem

earthen constructive techniques, it lies concealed behind the coatings and usual white-washing of the dwellings. This half-timbered architecture can be divided into two large groups according to the permanence of the auxiliary supporting character of the wooden frame. That is to say, permanent if it retains its supporting function and the earth only becomes the filling to occupy the gaps, and auxiliary if its supporting function disappears when the earthen wall is finished. Generally speaking, these buildings, frequently with angle-braces in order to offer greater stability, have better survived the floods and humidity that may have washed away the earth, sparing the wooden frame and making repair possible.

Earth with permanent wooden frames. Among half-timbered buildings with permanent supporting wooden structures, there may be walls with vertical posts and horizontal strips with vertical straw tresses, squared-pattern straw grids or continuous straw screens, generously coated at both sides with earth; walls with vertical posts and vertical strips surrounded with earthen donuts coated afterwards; walls of vertical posts with horizontal strips having thick vegetal plaits knotted to them generously coated with thick layers of earth; or half-timbered walls with fillings of wickerwork, wattle or laths also daubed or earth-coated on both sides. The above-mentioned adobe as filling of half-timbered houses to be found in Bohemia was not common on the Pannonian plain. Finally, in the middle of the 50s there still existed very primitive conical teepee-shaped daubed structures of branches used for animal shelters[5].

Earth with auxiliary half-timbered structures. Among half-timbered buildings with auxiliary supporting structures used while erecting the building, there may be walls with a simple post-and-beam wooden structure subsequently covered by a cob masonry wall; walls with frequent vertical posts rendered on both sides with a thick layer of straw and earth subsequently trimmed; or a variant of the former with horizontal branches intertwined with the vertical posts in order to increase the adherence of the earth.

Earth as a filling. Earth-coated wicker, wattle or lathwork, also used to build up distribution walls, combine themselves as a sort of double formwork in order to create structures by filling with earth. It is another example of an aux-

[5] LÁSZLÓ, D., *A magyar paraszti állatttartás építtményei*, en Ház És Ember n. 10, Szentendre 1995, p. 39-65

Adobe wall, Czech Republic; Adobe wall, Ziharec village, Slovenia; House detail at Nova vas pri Markovci villaje, Slovenia; Magyarszombata village, Hungary; Wall covering in Ziharec village, Slovenia; Wall covering in Szolnot village, Hungary. (photos: Fernando Vegas, Camilla Mileto)

iliary wooden supporting structure that will be covered by earthen walls to be filled between two panels of wicker, wattle or lathwork and subsequently daubed on both sides. This technique is particularly interesting, as archaeology has shown that the earthen-filled wall between two wattle screens was already used locally by the Romans in order to build walls and fences.

Cob. Piled earth represents one of the simplest constructive techniques with this material. It also has a great variety of forms frequently to be found in rural areas. There exists the cob masonry wall, either bonded or built with formwork, even with an *opus spicatum* variant; the cob wall is subsequently trimmed on the external surfaces with a shovel; or the earth and straw wall also subsequently trimmed with the same instrument.

Rammed earth. Rammed earth is also frequent in two versions: walls built with hanging formworks supported with trespassing stakes, as is usual in Portugal, Spain, France, Italy or Maghreb, although with a lower module; or rammed earth walls without trespassing stakes, where the low formwork that may arrive to only one plank is wrapped and supported by posts stuck in the ground at both sides of the wall. There are variants to both versions, like the insertion of little branches between modules to improve the adherence; the total lack of lateral frontiers generating frequent sloped joints; or only in the second type, the setting of the formwork always some centimetres above the former earthen layer to create small projections in the wall that may improve the adherence of the subsequent rendering. In all cases, the formwork is continuous in every corner or T-wall joint in order to avoid weakening the angles with too many joints.

Adobe. Adobe made in several types of formwork with a mixture of earth and straw is very common throughout the area. Walls are normally one foot thick and cross bonded to guarantee a better support. These walls are normally concealed under an earth rendering, as with the other techniques described, but in the case of auxiliary constructions like stalls, storehouses, huts, etc., it may appear naked as happens from time to time with *opus spicatum* cob walls, with examples of great beauty particularly in Moravia.

Other uses. Earth appears in local construction in many other forms, either very common, as mortars, wall renderings, tamped floors, kitchens, ovens or benches, or very surprising, as covering for the space between joists by surrounding each one with thick earthen rings.

Place. The use of each technique depends first on the availability of materials, not directly earth, but other elements of varying auxiliary characters. Thus, rammed earth requires almost no water at all, and so it appears in places far from water sources, while adobe and cob require water. The availability of straw from agriculture also determines the possibility of making adobes or earth and straw walls and, therefore, vineyard area buildings usually employ other techniques like rammed earth or half-timbered walls combined with wicker, wattle or lathwork. The availability of wood is also definitive,

not only for the use of auxiliary or permanent structures, but also for making formworks and moulds. For this reason, simple cob walls constituted the most common technique among the poorer people.

Position and function. Combining several building techniques in one single house after an interesting functional specialization is also very common in the area: sometimes rammed earth is used for the basement of a cob or adobe wall; rammed earth or cob walls are used to the crowning of the wall but the gable end is made of adobes or wattle and daub; adobes are possibly used to finish the crowning of the walls in order to offer a better support for the roof joists; main façades are sometimes double-sided with a fired-brick masonry wall as a protection measure against fire built simultaneously or later; etc.

Present situation. Nowadays, while restoring existing domestic architecture, very pragmatic and often unfortunate solutions are found, such as repairing renderings with wire netting to improve adherence that quickly rusts or with cement mortars that stop the wall from breathing. It is necessary to spread adequate maintenance know-how for traditional earthen architecture in order to guarantee durability and compatibility[6]. The open air museum at Szentendre (Hungary)[7] is a reference institution that has been developing an extraordinary work concerning the building and conservation techniques of earthen architecture in the whole Pannonian plain.
On the other hand, erecting again new buildings with earth has become something not common but increasingly popular in all the countries of the area. The new sensibility towards ecological and sustainable architecture has allowed a return to partially forgotten techniques or the present reinterpretation of them like building with adobes or compressed blocks, applying traditional or bought pre-dosified earthen renderings, fabricating of tamped earthen pavements, building with earthen coated straw bales, creating prefabricated earthen panels[8], etc. In almost all cases, the architectural forms of this contemporaneous earthen architecture are completely traditional, as if claiming a necessary return to earthen architecture meant to use the traditional rural architecture belonging to the collective imagination.

[6] An example is SZÜCS, M., *Föld- és vályogfalú házak építése és felújítása*, Épiésügyi Tájékoztatási Központ Kft., Budapest 2008
[7] See CSERI, M., HORVÁTH, A., SZABÓ, Z. (ed), *Skanzen. Hungarian Open Air Museum Guide*, Szentendre 2007
[8] See the work of engineer Jan Ruzicka at the University of Prague

Stubbing open air museum, Austria; Szentendre open air museum, Hungary.
(photos: Fernando Vegas, Camilla Mileto)

Earthen architecture in Southwestern Europe:
Portugal, Spain and Southern France

Mariana Correia, Jacob Merten
Escola Superior Gallaecia
Fernando Vegas, Camilla Mileto, Valentina Cristini
Universitat Politècnica de València

Previous page: Rammed earth and bricks, farm, Sainte-Agathe-la-Bouteresse, Loire, France. (photo: René Guérin)

Dovecote, stones, adobe and bricks, Nègrepelisse, Tarn-et-Garonne, France. (photo: René Guérin)

The Iberian Peninsula and the South of France are extraordinarily rich in earthen techniques, especially rammed earth, half-timber, adobe and wattle-and-daub. These traditional earthen architectural heritage examples are nowadays being studied and in some cases, restored. Simultaneously, all this historical built background serves as a basis for interesting development of newly built earthen buildings, that claim not only the continuity with local tradition, but also the ecological, practical and sustainable aspects of this building material.

In 732 AD, the arrival of the Muslims to Poitiers, France, left historical and architectural vestiges throughout the occupied territories. Muslims were the principal disseminators of rammed earth in their conquered lands (Ribeiro, 1969, p.39). Areas where they remained more than 500 years (700 in the case of Granada) have a stronger presence of earthen vernacular architecture. This is the case of rammed earth and adobe construction in the south of Portugal and the south of Spain. The etymological origin of both techniques is consistently common in both countries. The English term 'rammed earth' is 'tapia' in Spanish and 'taipa' in Portuguese, which are originated from the Arab word *'tabíya'*. The same occurs with adobe (Eng) (Sp) (Pt) that originated from the Arab word 'Tûb' or 'atôb' (Monjo Carrió, 1998, p.40). The origin of earthen architecture in Portugal, however, is Pre-historic, probably from the Middle Palaeolithic Age (Varela Gomes in Fernandes & Correia 2005, p.126). The first document to refer to rammed earth in Spain was written by Pliny in the 1st century AD. (*Naturalis Historia*), but earthen architecture may be

considered as old as the first human shelters and settlements in the country (Monjo Carrió, 1998, p.31). In France, the oldest clear testimony is from 400.000 years ago - early Palaeolithic (Varela Gomes, 2005, p.125). These remains reveal a common antiquity of earthen architecture in the region.

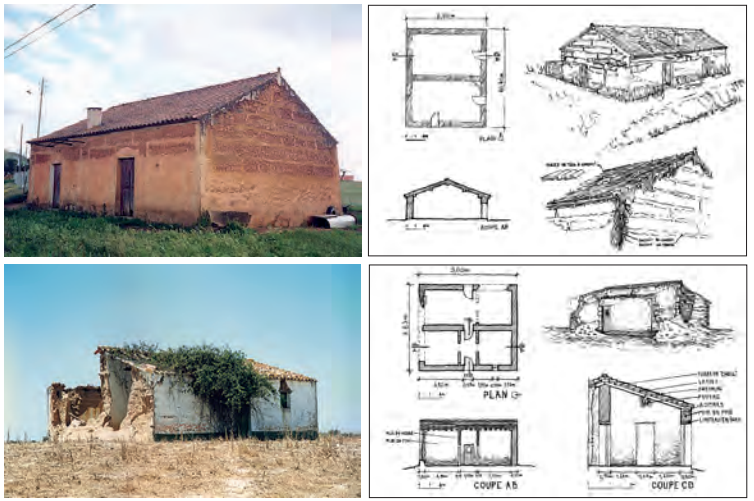
In general, the Iberian Peninsula has a similar relationship with the use of earthen materials. This is predominantly observed in the northwest of the Peninsula and the southwest of France, with the use of half-timber structures with earth in fill. In Portugal and France, the use of wattle and daub in fill for half-timber structures is more common but in Spain, an in fill in adobe is usually used. In the south of the Peninsula, adobe and rammed earth walls are very common in both countries. It is interesting to notice that in general, the same use of the earth material cross borders, which proves how important are the geographic characteristics and the building cultures of each area.

There are also particularities of each country that bring out unique characteristics. For instance, in Spain, it is more common to observe the use of several different techniques in the same traditional wall. Sometimes, new techniques emerge from this intermix, which brings a richness to Spanish earthen architecture. This is the case of the 'entramado', a wooden structure with an adobe in fill identified in the area of Castilla y León. In Portugal, several different techniques can be observed in the same building, but in general, they will be applied in different walls (e.g. exterior walls in rammed earth and interior walls in adobe or in wattle and daub). The particularities of each country also occur in terms of language. Both Spain and France have specific words for earthen architecture within each regional dialect. As Portugal has no dialects, differences are related with the use of the terms, following Muslim occupation. In the north 'taipa' is the term for wattle and daub and in the south 'taipa' means rammed earth.

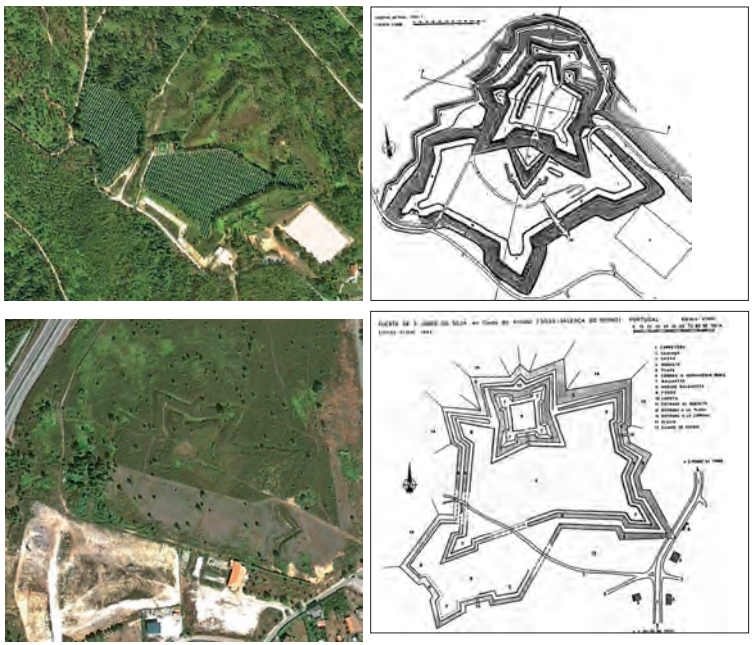
Portugal and Spain also share a wide variety of rammed earth typologies (Correia, 2007) (Cristini and Ruiz, 2009, p.285-294). Spain presents a refine use, with an extensive range of rammed earth variants with specific termi-

Rammed earth farm, Bioule, Tarn-et-Garonne, France.
Adobe masonry stable, Nègrepelisse, Tarn-et-Garonne, France.
(photos: René Guérin)

Next page:
Wattle and daub house, Saint-Sauvy, Gers, France. (photo: René Guérin)
Rammed earth house, Vales Mortos, Serpa, Portugal. (photo: Mariana Correia)
Rammed earth house, Ferragudo, Reguengos de Monsaraz, Portugal. (photo: Mariana Correia)



Rammed earth house in Telheiro, Reguengos de Monsaraz, Portugal.
Rammed earth house in Vale da Eira, Santiago do Cacém, south of Portugal.
(photos and survey drawings: Mariana Correia)



Earthen Fortress of Santiago Carrilho, Tomiño, Spain
Earthen Fortress of S. Jorge da Silva, Valença, Portugal.
(photos: Google Earth; drawings: Jaime Garrido)

nology, as 'taipa Valenciana'; 'tapia real'; 'tapia calicostrada'; 'tapia acerada'; etc. (Font, 2005, p.121-122). This is also observed by its use in civil architecture such as churches, manor houses, bullfight rings, pigeon houses, etc. In Portugal, rammed earth is more commonly observed in vernacular architecture both in urban and rural areas. Portuguese rammed earth is also very rich, but the common use of corrective materials to improve the earth mixture or the addition of other natural materials to reinforce the construction illustrates that rammed earth typologies have a more adaptive use to the environment, mason's know-how and local resources.

There is also a monumental military heritage in the centre and south of the Iberian Peninsula near the major navigable rivers, the coast, or crossing the access routes to the coast. Most of these earthen fortresses were built during the Muslim historical period (8th to 15th century) and consist of a very strong and compacted material, known as 'military rammed earth'. Portugal and Spain have a very important military earthen heritage, with some fortresses having more than 1000 years. To date, Portugal and Spain conserve hundreds of earthen military structures and fortresses. Both countries have had major works addressing the conservation of several of these historical monuments (Vegas and Mileto, 2011).

Cob is rarely used in the Iberian Peninsula and the South of France. Until now, it has only been observed in the area along the border of the Minho International River (north of Portugal and south of Galicia, Spain). In this area, several earthen fortresses were built in the 17th century, during the Restitution War (*Guerra da Restauração)* between the Portuguese and the Spanish kingdoms, resulting in Portugal's independence from Spain in 1640 (Carlos and Correia, 2009, p.425-436). These fortresses are not protected and present a high risk to disappear. The fortresses can be seen more clearly on aerial photographs.

Currently, most earthen architecture research developed in Portugal, Spain and France is undertaken by universities and their research centres. Escola Superior Gallaecia (Portugal), Universidad Politecnica de Valencia (Spain) and CRAterre-ENSAG (France) - have been working closely in European funded research in the last years. National associations and national entities are starting to take a lead. This is the case of the Portuguese Association Centro da Terra, the Spanish network Construtierra and the French association AsTerre. These networks and associations unite common national efforts for the study and documentation of the use of earth, as a building material. However, there is still not enough coordinated research and actions in the re-





Stone and adobe, Mahamud, Burgos, Spain; Rammed earth built between stone masonry pillars (Tapia mixta encadenada), Calabazanos, Palencia, Spain; Rammed earth reinforced with gypsum, Gálvez, Toledo, Spain; Earthen chimney, Vidriales, Zamora, Spain; Rammed earth renforced with gypsum, Monreal, Teruel, Spain. (photos: Juana Font)

gion. Efforts are isolated and emerge from individuals and a few institutions. A strategic and more systematic research should be embraced to avoid repetition and to respond to different aims, as well as the coordination of efforts for the development of projects that reach a major impact. This is just possible through an increasing network and commitment among institutions.

House in stone, wood and earth in Delchevo, Bulgaria. (photo: Saverio Mecca)

Earthen architecture in Southestern Europe:
Italy, Bulgaria, Greece, Cyprus and Malta

Saverio Mecca
Letizia Dipasquale
Unversità degli Studi di Firenze

State of the Art

The region of the Eastern Mediterranean, Italy, Malta, Greece, Cyprus and Bulgaria, reveals a richness of two main forms of earthen architecture. Both are related to the ancient building culture of the Middle East, the masonry (mud brick and rammed earth) and the half-timber and masonry (earthen, stone and brick) traditions. Earth was one of the main building materials used from ancient up until recent times in order to solve the main architectural problems and to produce mortars, pavements, coatings and so on.

Knowledge of the earthen architectural heritage of the region is not homogenous, besides the sub-region of Sardinia, Italy, where we can find the highest levels of identification and characterization of earthen architecture as a living heritage, or Cyprus where groups of architects are providing care to the traditional building culture, in other regions such as Bulgaria and Greece the process of rediscovery and revaluation has only started in recent years.

History

Earthen architecture in the Aegean area dates back to the Neolithic era. Its more ancient traces are well known from Cyprus (since 9000 BC) to Macedonia and Crete, and later in Italy with the colonization from the eastern Mediterranean. While in Bulgaria, picket-knit structures, coated with clay, can be traced to the Neolithic Age (6000-4000 BC), revealing the influence of a northern earthen construction culture.

During the Roman Empire period the prevalent construction technique adopted in the region was adobe masonry, save for the half-timber and earth

Adobe and wooden timber, house in the region of Gotse Delchev. (photo: Saverio Mecca)

Fortified greek walls in Gela, Sicily, Italy. (photo: Letizia Dipasquale)

tradition mostly in Macedonia and the mid-mountain regions of Greece and Bulgaria.

During the period of Ottoman rule (the end of the 14th – the second half of the 18th century) and the "National Revival" period (the end of the 18th-19th century) the traditional building techniques were consolidated and improved. This is the case of the half-timber and earthen techniques of Macedonia and South Bulgaria, especially developed for improved seismic resistance.

The need for seismically resistant structures has been an interesting factor of technical innovation and improvement of traditional building techniques in this region: in relation to the earthquakes, as in Macedonia and in south Bulgaria, and as in Calabria (Italy) at the end of the 18th century, local master masons under the Ottoman Empire or scientists after the 1793 earthquake (Calabria) developed and consolidated interesting building cultures, based on an effective interaction between timber structure and masonry (earthen bricks, fired bricks and stones) or wattle and daub.

Throughout this region the earthen building culture was extensively and continuously diffused until the middle of the 20th century, the beginning of the urbanization processes, mainly because of the local availability of raw materials and the ease of its production and application. Also in this region, the diffusion of industrialized building materials encouraged the abandonment, demolition or replacement of earthen buildings. Additionally, the adoption of national building codes and seismic regulations imposed new design procedures and limits to further uncodified traditional earthen construction techniques.

According to the main rule of distributing building techniques, earthen architecture is strongly influenced by geographical and geological and natural features respectively, the climate and the ready availability of building materials. In the regions where stone or/and wood are also widely available the simplest earth masonry technique is more easily combined with stone masonry and variably complex timber structures of earthen architecture can be found mainly in the construction of the upper floor(s), built with the wattle and daub technique.

Adobe masonry

Adobe had been the most diffused building technique in the region since an-

Traditional house in adobe (domu) in Samatzai, Sardinia, Italy. (photo: Silvia Onnis)
Adobe houses in Sambiase, Calabria. (photo: Ettore Pelaia)

cient times in Cyprus, the Aegean Islands and continental Greece, in South and Central Italy, Sardinia and to a lesser extent in Sicily.

In Cyprus, adobe was mostly used in the lowland regions (Mesaoria Plain) where the easiest construction material is clay soil. Adobe masonry was used in urban centres, villages and coastal areas, while in the hilly, mountainous areas or in villages along rivers, where stones were available, the use of adobe was predominantly limited to the upper parts of structures, supported on a stone wall, low or high, up to the first floor.

The dimensions of the earthen brick in Cyprus are 5 x 45 x 30 cm (height x length x width), while the thickness of the walls was 30-50 cm. Adobe masonry was in most cases finished with earth, gypsum or lime-based renders. The large part of adobe structures, still existing, date from the first half of the 20th century, while a few of them are from the 19th and late 18th centuries.

In almost every region of Greece adobe masonry is seismically improved by a typical "Ottoman" technique of confining with horizontal timber ties or truss, vertically spaced at 0.70 -1.00m, coordinated with the floor and the openings.

Adobe traditional houses in Pera, Cyprus. (photo: Saverio Mecca)

This building technique, diffused in all the "Ottoman" region from Albania to Azerbaijan, and finalized to reduce the propagation of a diagonal crack in the wall and the risk of collapse during seismic action (Bei, 2007), combines two different and low strength materials in an effective system to resist catastrophic damage from frequent earthquakes.

In Italy, adobe masonry or cob are more diffused in the regions such as Sardinia, Calabria and Marche where the easiest construction material is clay soil (lowlands and hills where agriculture was more diffused). Adobe masonry was used in urban centres, villages or isolated dwellings, while in the hilly, mountainous areas or in villages along rivers, stones were integrated for foundation or as in Lamezia for finishing and protecting large earthen adobe walls (civatura). Also in Italy, most adobe structures still existing, date from the first half of the 20th century, while a few of them are from the 19th and late 18th centuries.

In the central region of Bulgaria adobe masonry for houses was still popular and built until the 1960s. Normally adobe houses are plastered and cannot be easily distinguished from other masonry architecture. Although rare, adobe houses are sometimes built with two floors. In order to strengthen the construction in the masonry, wooden beams (called kushatsi) are embedded in the way they are applied in stonework.

Half timber with earth

The half-timbered building technique consisting of a wooden framework and filling (brick, adobe, wattle and clay daub or, rarely, stone) characterizes some areas of this region, such as Bulgaria and Macedonia, with high-quality architectural form and construction, revealing the influence of the Ottoman building culture. In other areas, such as Calabria, after the earthquake of 1793 scientists and architects designed with regards to seismic criteria an effective model of half-timbered houses, which were built for several years. These houses are usually rendered and white-washed and it is difficult to identify the exact filling material, except in the case of degraded plasters.

In Bulgaria (North-West and Central, Rhodope mountains, Gotse Delchev and Ivaylovgrad region), a high quality wooden framework consisting of two kinds of timber elements: main timber frame having a bearing and horizontal resistance function and secondary timber frame for supporting the in fill (adobe (called kirpich or dolma), brick or stone), or the wattle and daub system (called pletarka), or wooden laths plastered with clay and chaff (called baskii). The secondary timber frame can vary according to the in fill system, which can play a complementary structural role.

In northern Greece (regions of west Macedonia), in mid-mountain areas, usually upon the stone bearing walls, the second level is made with adobe walls and/or timber framed walls, known as tsatma, similar to wattle and daub. This second floor structure, as it is lighter than the traditional masonry type, is more effective during earthquakes. Most buildings as in Bulgaria have an architectural projection on the upper floor known as sahnissi mostly built with the tsatma technique.

The tsatma is a wooden frame of straight horizontal timber laths with the

Traditional house in Pera, Cyprus. (photo: Saverio Mecca)

Abobe with wooden timbers, Antartiko, Cyprus. (photo: Saverio Mecca)

empty spaces in between filled with different earth and masonry techniques.
In Italy the wattle and daub technique was widely used by the Villanovians and Etruscans to build elliptic or oval huts, and by the Romans who built "graticcio" walls (in Vitruvius opus graticium). The buildings were composed of a structure in wood, filled in with an earth plaster with vegetal materials, usually straw.
Today, a few examples of wattle and daub rural buildings, with a straw roof, can be found in the north of Italy (the Alpine zone, Veneto, Friuli Venezia Giulia), in rural fields. In Lazio, the "fraticci" consists of vertical posts and horizontal poles tied together with wickers, on a stone foundation, filled with tree branches of chestnut, oak or elm and interlaced canes (Beranger, 1995).
In Calabria, after the earthquake of 1783, "case baraccate" were built with a wooden frame, with vertical, horizontal and oblique chestnut or oak beams placed with a distance of roughly 1.20m to create a cross structure. A weave of wickers and reeds is bonded to the main structure with thin chestnut laths and is covered with an earth mortar. In some cases adobe fills the structure. For the interior walls the "incannicciato" technique is frequently used, a mesh of interwoven canes or branches covered by a clay plaster.
In Veneto, the traditional rural buildings, called "casoni" are composed of a wooden structure with adobe filling and a high spire roof, covered by straw and ditch reed (Bertagnin 1999). Today only three examples of these buildings, now in museums, survive.

Rammed earth

Rammed earth is consistently present in Italy: Piemonte, around Turin and above all Alessandria. Whereas Piedmontese housing made with rammed earth is usually grouped in villages, that of Tuscany is generally more disseminated. Fired bricks were used only for those building elements more susceptible to degradation, like foundations and corners, or subject to greater stress, such as arches and vaults.
In Tuscany (in the area of Val di Chiana, Val d'Elsa, San Miniato and in other inland parts of Pisa) we find rural and rustic dwellings dating back to the 13th century or 18th century (Val di Chiana). In this region rammed earth buildings are enhanced with detailed architectural elements, including buttresses in adobe, framed walls, cornices, or even ventilation openings in barns. The rammed earth enclosure wall is thick and for better reinforcement it is intercalated by pillars in adobe. Usually these rural constructions have plaster on the interior of the dwellings.

Stone and earth

In the area of Sicily and Malta we can find cases of walling where earth has been used as a complementary element, integrating the stone elements, more or less regularly, which are disposed in double leaves (walls of "pietra e tayo" and "a sacco"). These techniques were widely used in traditional Sicilian and Maltese architecture in both urban and rural contexts, because of the low cost due to the ease of building and the availability of local materials. These techniques were used continuously from the Middle Ages until the end of the 19th century.
In Malta, in traditional farmhouses and in urban buildings of Valletta and Gozo, the building technique consists of double leaves of masonry with a "mazzkan", a traditional type of in fill that was used to fill thick walls, usually made of crushed stone and soil.

Rammed earth farm. Cascina Pagella, Lobbi, Alessandria, Piedmont, Italy. (photo: Pierre Buch)

Earthen architecture in Europe: a national approach

Traditional house with thatched roof and timber slab walls with whitewashed earthen rendering in Moschendorf .
(photo: Fernando Vegas, Camilla Mileto)

Earthen architecture in Austria

Fernando Vegas
Camilla Mileto
Valentina Cristini
Universitat Politècnica de València

Traditional earthen architecture in Austria may be found above all in the eastern area of the country, not so mountainous but hilly, namely in the regions of Lower Austria, Vienna, southeast of Styria, and, in particular, in Burgenland. Indeed, the existence of traditional earth architecture in this country should not be considered as an isolated phenomenon, but rather linked to other examples of vernacular architecture close to the Danube basin and Pannonian Plain regions. This resemblance may be discovered in rural buildings of the adjacent region of Moravia (Czech Republic), southern Slovakia, Hungary and northeastern Slovenia.

In these areas, historic earthen architecture coexists with log houses, otherwise common and prevailing throughout the country. In fact, the preponderance of log buildings across the country, added to the increased difficulty of moving and rebuilding traditional earth houses, practically cancels the existence of houses built with earth in open air museums. Even in very complete collections of Austrian vernacular architecture of museums like the Freilichtmuseum Österreichischers Stübbing in the region of Styria (which is just located in the geographical border between areas of log architecture and earthen architecture), hardly reflects any existence of earthen constructions.

This is also visible in the open air museums such as Gerersdorf or Bad Tatzmannsdorf in Burgenland, a region known for having a higher concentration of earthen architecture examples. In spite of this, the museums do not show the true proportion of earthen constructions compared to log buildings present in this area.

Earth was used traditionally as an auxiliary building material even in these log houses, for making bread ovens, mortar joints between logs, coatings, renderings, as pavement for the ground floor, for filling between floor joists, thermal insulation in the roof, etc.

Earth used in walls as a structural construction material throughout the

Earth coating detail, partially detached. Logslice house in Heiligenbrünn Village.
(photo: Fernando Vegas, Camilla Mileto)



Traditional whitewashed cob house, Heiligenbrünn Village.
(photos: Fernando Vegas, Camilla Mileto)

Exterior sidewalk enclosed by timber under thatched eaves in Heiligenbrünn Village.
Rammed earth sidewalk enclosed by timber. Traditional house in Heiligenbrünn Vilage.
Reconstruction of the interior space of an earthen house, Gerersdorf Open Air Museum.
(photos: Fernando Vegas, Camilla Mileto)



Austrian Danube Basin takes form in the same building techniques and examples as in the rest of the Pannonian plain. Nevertheless, the frequent use of rammed earth walls, locally known as *Stampflehmbau* should be noted in particular.

In Austria, the location of earthen architecture frequently coincides with the presence of vineyards, where it is common to find this type of building not only in private houses but also as stores and cellars, probably due to the insulating property of earth, a material that provides constant temperatures to interior space.

In any case, today, Austrian earthen traditional architecture remains largely unknown: with thatched or tiled roof, under whitewashed earthen renderings and perfectly maintained coatings that conceal its materials, confused with rendered log houses, ignored by the open air museums..., this traditional architecture is urgently requiring care and protection of local, regional and national authorities.

On the other hand, there is in Austria an extraordinary attention and sensibility from building regulations and even from contemporary architectural trends towards earth as a new old building material, being expressive, functional, ecological and sustainable for the future. Probably in no other European Country is there a such marked divorce between local traditional architecture and contemporary architecture built with the same material.

In fact, rammed earth in Austria has been transformed from an ancient technology to an interesting and innovative raw material that is increasingly attracting attention. Today, clay has become an important material not only for an elite of alternative and ecological applications, but also for established

architects that use this versatile material and its advantageous properties (for heating and cooling, new designs, and functional potentialities, etc.). The region of Tirol, divided between Austria and Italy, has shown during recent years strong policies of this type of sustainable architecture, with important public investments in the field of this architecture (i.e. Casa Clima Project).
In Austria the pioneer of low-tech architecture applied to a high-tech approach is Martin Rauch, from Vorarlberg, with the team of "Lehm Ton Erde". He studied as a ceramist during the '70s and step by step has developed a brilliant earth constructive approach and career. In the last 10 years his research into new earth architecture techniques has spread to different experiences in Austria and generally through other countries, such as Switzerland and Germany. From public spaces (i.e. cemetery, chapel, congress hall...) to private houses, earth is always used as a lyrical and sustainable raw material. Study, design, experiments (i.e. prefabricated earthen furnace) and research are bonded, obtaining projects with high quality and durability. Though Martin Rauch refers to the existence of some examples of rammed earth historical architecture in the region of Vorarlberg, apparently, there does not seem to be any explicit link or reference between these traditional houses and the contemporaneous architecture.
Through these projects earth is used as structural material, filling, coating, finishing solution...with plasticity and always with new declinations, according to projects' function. Is it possible to use the same raw material and process, for a Kindergarten or for a bus-stop station? The answer could be affirmative and positive, analyzing "Lehm Ton Erde" concepts and works.
Austria has shown a pioneer interest in social and sustainable architecture/research, and also in speaking about education and training. In this frame Architecture Faculties have developed research programs, and among these is notable the effort of the University of Linz (Kunstuniversität Linz). "Base-habitat", set up in this University since 2005, which has a real "manifesto" of challenges and a great structure of programs-trainings, about experimental materials, climate control and sustainability in architecture. Speaking about earth architecture is important to underline "the earth work summer school", organized by this platform. This is an experience that tries to give an application-orientated knowledge in building with earth, with a series of hands-on activities.
We can affirm that Austria, like other Germanic countries, shows a deep interest in sustainable development and "green" policies. For this reason, in this country earth has a strong role, as "k-sustainable raw material", that is progressively improved and developed, through universities and, at the same time, by professionals and builders.

"Base Habitat Org-building Esplanade" in Gmunden, Upper Austria. (photo: Mark Sengstbratl)
"Base Habitat Org-hands on activities" in Gmunden, Upper Austria. (photo: Ligia Martins)
"Base Habitat Org-building Esplanade" in Gmunden, Upper Austria. (photo: Nikolina Lutz)

Building in Maisoncelles, near Beauraing
built in 2003 with a wooden frame filled with a
(ready-made) mix of clay, wood shavings
and a rammed earth wall.
(photo: Sophie Bronchart)

Earthen architecture in Belgium

Sophie Bronchart
EURECA - Consulting Office
for Energy Conservation
Gérard Bavay
ISCEAH member

Earthen architectural heritage

Following early industrialization in the 19th century, Belgium has known a quick generalization of the appeal to materials coming from industrial production (terracotta, stone and metal). This fact left deep marks on the monumental heritage. This explains why remaining examples of earthen architecture are rather scarce in Belgium and why the general public is unaware of the potential of this architecture, as well as many institutional contributors in the field of heritage conservation. However, scarce does not mean absence or insignificant residue.

Wattle and Daub and Timber frame

Wattle and daub in timber frame construction is the most frequent technique identified in particularly, in the northeast and west of the country. It is also the most visible and the best-known technique. Significant remains have been recognized in all parts of the country. This tradition resulted from the abundance of forest resources (particularly in Ardennes) and also from the importance of clay soils. In towns such as Liège, as in the whole Meuse valley, timber frame dwellings in filled with wattle and daub were reveal when the concealling plasters fell. In the countryside, the most visible timber frame appears as an efficient, as well as economical technique (as in the Pays des Collines, in Hainaut). This technique requires expertise of construction, which excludes self-building. The use of wattle and daub in timber frame construction was abandoned in the mid-nineties and in many cases, was replaced with fired bricks. In spite of its disuse, timber frame remains symbolically present in the collective imaginary, which is why much architectural heritage enjoys value given to its preservation and restoration. Timber frame is widely mentioned in the archives since the general use of seigniorial accounting in the 14th century.

Cob

On the other hand, up to the mid-seventies, heritage built in cob remained

In 2006, a rammed earth wall has built in the reception hall of the center Source O Rama in Chaudfontaine by the society Druwid (Mickaël Thonnes) with the participation of Archipel Rénovation. (photo: Michaël Thonnes)



Haute Ardenne du Nord, Belgium. XVI to XIX century. (photos: Charles Gheur)
Estinnes, adobe wall. (photo: Gérard Bavay)

Below:
Clay-straw construction in the Flemish region. Architect: Herman Remmes. Builder: Peter Willem (Bouwen met Aarde). (photo: Peter Willem)
Clay-straw construction in the Flemish region. Architect: Herman Remmes. Builder: Peter Willem (Bouwen met Aarde). (photo: Peter Willem)
Construction in 2003 built in Maisoncelles near Beauraing with a wood frame filled with a (ready-made) mix of clay and wood shavings and a rammed earth wall. Architect: Isabelle Prignot, building company: Novastar sprl. (photo: Sophie Bronchart)

ignored. Following insistent searching, numerous and sometimes monumental examples were documented (barns, houses, cowsheds, bread ovens). Witnesses questioned between 1975 and 1980 mentioned earthen techniques whose practice was lost for decades. They recalled, the addition of cow manure slurry to the clay. Lime also seems to have been added occasionally in small quantities. On a base of cinder blocks, layers of cob are applied. Each successive layer is submitted to a period of drying, levelled on both lateral faces and becomes the support for the following layer. The amount of straw mixed to the clay is small. If sheltered from the heavy rains, the result is amazingly resistant. Documentation in the archives related to construction in clay and straw is very scarce.

Other techniques

The use of unfired clay bricks is not unknown in Belgium. These are bricks that have not been fired in a kiln at a high temperature. Though rare in Hainaut, they are commonly found in interior walls and at times, can be used for vaults. Specific bricks with squared section can sometimes be found in Hesbaye. Occasionally, earth has other uses, such as: vault filling, doubling of attic floors, massive vaults... Finally, some traces of straw structures are found covered in clay plaster. These traces relate back to many remains of architectural clay found baked in the fire wastes of medieval housings. Timber frame, clay and straw mixtures and raw earth bricks can coexist under the same roof.

Network of earthen construction and rehabilitation

A new interest since 1990

Some actors in earthen construction have been identified in Belgium since 1990. A period during which several professionals, builders and architects formed an association called TerraMorpho[1], and introduced in Belgium the clay-straw building technique, developed in Germany by Franz Volhard[2].

Clay-straw is a modernized version of the cob building technique or the timber frame, which was very common in Belgium from the Middle Ages until abandoned around the mid-nineties. The principle is very similar: in filling of a load-bearing wood frame with a mixture of clay and straw. The main modification is the type of frame, prefabricated wood elements and the in



Training centre in sustainable construction, "Terre Academie", in Beauraing, Belgium. Architect: Isabelle Prignot. (photo: Sophie Bronchart)

fill material that involves coating straw in a clay slip and lightly compressing it into a formwork fastened to the load-bearing frame and that could be quickly removed. This technique is also applied to floors.

From 1990 to present, some thirty individual houses have been built in clay-straw in Belgium[3]. The choice of this technique by master-builders was motivated by the desire to build with ecological and local materials (wood – clay – straw) in order to realize a sound housing (breathing walls) available for auto-construction during the stage of in fill the frame. In 1990, the first large scale 870 square meter clay-straw building was completed for the Nos Pilifs farm, a sheltered workshop in Brussels.

Since 1993, the Druwid company is the official importer for Claytec in Benelux and has developed various contemporary earth construction projects using clay-wood chips[4], rammed earth[5], unfired clay bricks[6] and clay-straw blocks[7].

Present

For some years, the clay-straw technique seems to have been abandoned in favour of materials that allow a better energy performances. The development of ecological materials on the market (cellulose, wood fibbers, hempen wool, straw bale...) and the stricter requirements for insulation, prompted the professionals to turn to other building construction techniques showing the same assets: a sound housing built with local materials. The straw bale building technique, the most available resource on a local level, is also appropriate for self-construction and has an important development in Belgium over the past few years.

Since 2000, the appeal of clay plasters has been increasing. However, the principal plaster mixes available on the market are imported.

Today, it can be stated that in contemporary architecture in Belgium, earth is used more for inside building elements. Several craftsmen[8] carry out building restorations in cob.

Future

Several construction professional are now taking an interest in the research and development of building techniques based on clay and other local resources in order to achieve better energy performances that could be industrialized and made available in a greater number[9]. This research is lacking public support to reach a level of realisation.

[1] TerraMorpho was created by the architects Herman Remmes, Stéphan Ardui, Alexis Versele, Sjap Holst and Oswald Dellicour and the builder Peter Willem.

[2] Franz Volhard wrote the first reference book in this subject, in 1995: «Leichtlehmbau Alter Baustoff neue Technik»

[3] The project of these are by the architects Herman Remmes from the office BRIK, Alexis Versele and Stéphane Ardui in Flanders, Oswald Dellicour, Isabelle Prignot and Michel Meert. The builders were Peter Willem, Eric Pauporte, and Olivier Bale. Several self-built houses without architect nor professional contractor were built in Louvain La Neuve.

[4] In 2003, a construction was built near Beauraing, with a wood frame filled with a (ready-made) mix of clay and wood ships and a rammed earth wall, followed in 2008 by the construction of a training centre in sustainable construction, the "Terre Academie". Architect: Isabelle Prignot.

[5] In 2006 a rammed earth wall was built in centre *Source O Rama,* in Chaudfontaine by the company Druwid with the participation of Archipel Rénovation.

[6] In June 2002, an adobe dome and a clay-straw building (coordinated by Sophie Bronchart) were built during the Festival Couleur Café, in Brussel. The NGO, Ecoleem-Ecoterre, began in the nineties to produce and commercialize finishes and clay bricks, which have been used in various works by architect Alexis Versele, founder of this association.

[7] Olivier Bal developed a block of clay-straw moulded in a press from Appro techno and dried in a solar dryer in Houyet.

[8] The builders of Druwid company in Waimes, Memibo in Herstelt, Eddy Pierret in Bertogne and Olivier Bal in Beauraing are specialized in earthen restoration.

[9] Géry Despret, architect, has founded the company TERRACO GROUP currently active in research and development on earthen construction techniques.

Gotse Delchev region. (photo: Saverio Mecca)

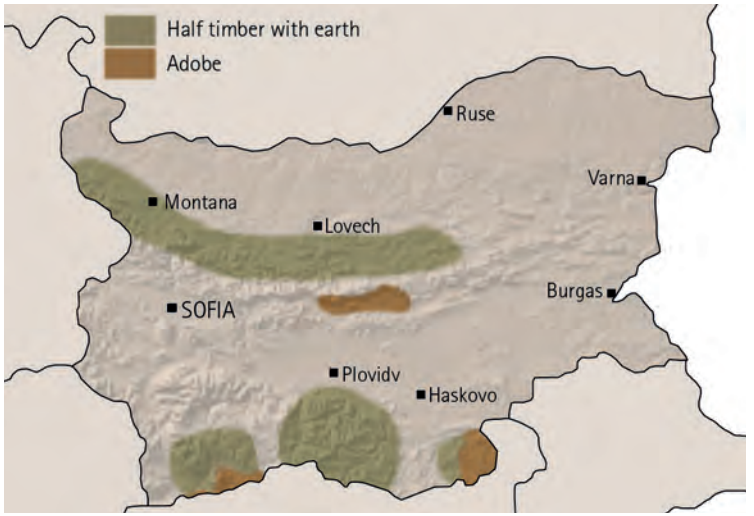
Earthen architecture in Bulgaria

Donika Georgieva
Miroslav Velkov
ICOMOS Bulgaria

The distribution of earthen architecture in Bulgaria is naturally influenced by geographical features, respectively the climate and the easy availability of building materials. In the mountain regions, where stone and wood are widely used, earthen architecture can be found mainly in the construction of the upper floor(s), often built with the wattle and daub technique. On the regions of the plains there are houses built entirely using the wattle and daub technique. Also in these regions houses made of adobe can be found.

The use of earthen architecture techniques in the territory of Bulgaria can be traced back as early as the prehistoric period (in particular the Neolithic Age – 6000-4000 BC). Several examples of ground dwellings discovered (Stara Zagora, Topolnitsa, Kremikovtsi, etc.) reveal the use of picket-knit structures, coated with clay. Studies also prove the usage of adobe bricks during the Antiquity period (until the end of the 6th century). The most widespread type of housing during the Middle Ages was the semi-dug dwelling, where evidences for the construction of the terrestrial part in wattle and daub techniques are found.

However, most structures preserved in Bulgaria, where the use of earthen architecture techniques is present, are houses from the period of the Ottoman rule (the end of the 14th – the second half of the 18th century) and from the so-called National Revival period (the end of the 18th-19th century). Therefore, these buildings, referred to in research as vernacular architecture, are the focus of this paper. The original use of the earthen architecture buildings is mainly for living. However, often different functions were added – cellar, barn and handicraft workshop – at the ground floor when the house is two-storey. Rarely some buildings were used only for the needs of the local means of livelihood (Dimitrov, eds., 1965). For example, the adobe house is not by chance spread in the region of Ivaylovgrad (South-East Bulgaria) – known in the past for its silk production.



Stone basement and adobe wall in the region of Gotse Delchev. (photo: Saverio Mecca)

The thick adobe walls provided optimal environment for the growth of silkworms.

At present, the level of conservation of earthen buildings is not satisfactory. In some bigger towns or villages, restored structures are used as museum units, but most of the houses representative of this type of architecture remain unknown and in bad physical condition.

Specific building techniques

Vernacular architecture houses in Bulgaria are made using several basic materials: stone (mainly for the ground floors), wood and brick/or adobe. According to the technique used, we may distinguish two basic types of earthen architecture dwellings.

Half-timbered house

(North-West and Central regions: Borovitsa, Prevala, Gubesh, Komshitsa, Gorna Luka, Hubavene, Lyuti dol, Zgorigrad, Teteven, Sopot, Troyan, Staro Stefanovo, Gabrovo; Rhodope mountains region: Kosovo, Shiroka laka, Levochevo, Smolyan; Gotse Delchev region: Leshten, Teshovo, Dobrotino, Sredna, Delchevo; Ivaylovgrad region: Dolno Lukovo)

The half-timbered construction is a composite structure formed by two elements: wooden framework and filling - brick, adobe, wattle and clay daub or rarely, stone. The houses are usually rendered and white-washed and it is difficult to distinguish at first sight the exact material used for the filling.

The wooden framework forms the backbone of the half-timber wall and consists of two types of timbers: main (bearing) and secondary (distribution). The main timbers have a bearing function and consist of: horizontal beams (called *tabani*), vertical posts (called *diretsi* or *mertetsi*) and diagonal braces (called *payanti*). The vertical posts are placed tightly (in 60-70 cm) and at the openings for windows and doors at a greater distance (1.00 -1.10 m). The horizontal beams have larger sizes for they bear the floor beams. The diagonal braces are placed usually in margin fields of the framework and are designed to absorb horizontal forces. The secondary timbers have only a distribution function serving for a stronger trapping of the filling (adobe, brick or stone) and are therefore significantly smaller. They are placed in different directions and at different distances depending on the filling: greater for the brick and adobe; smaller for the stone filling. Where the filling is wattle and daub, the secondary beams are missing (Peev, 1956).

The filling has no structural role. Beside the brick and the stone, the filling has three variations: (1) wattle and daub (called *pletarka*) where the fields between the timbers are filled with wattle and plastered on both sides with clay mixed with straw; (2) adobe (called *kirpich* or *dolma*) where these fields are filled with bricks of clay mixed with chaff – usually with small sizes – 22-24 cm long, 11-12 cm wide, 2.5-3 cm thick; (3) wood and clay (called *baskii*) where the framework of the building is sheathed with wooden laths plastered with clay and chaff.

Adobe house

(Central region: Tazha; Gotse Delchev region: Dragostin; Ivaylovgrad region: Siv kladenets, Mandritsa, Odrintsi)

The construction of adobe houses composes of bearing walls with a thick-

Houses built with stone and earth in Dragostin. (photos: Saverio Mecca)

Wattle and daub houses at Dragostin and Leshten. (photos: Saverio Mecca)

ness of about 50 cm made of unbaked sun-dried bricks (a mixture of sand clay and milled straw or chaff). The construction of this type of earthen architecture houses in Bulgaria was still popular and made until the 1960s. Outside, adobe houses are plastered with mortar and cannot be easily distinguished from other solid constructions. Although rare, adobe houses are sometimes built up to two floors. In order to strengthen the construction in the masonry wooden beams (called *kushatsi*) are embedded in the way they are applied in stonework.

Scientific activities, university and professional training activities, associations operating on earthen architectural heritage and new buildings

Although in the recent years the meaning of the earthen architecture as a model of sustainability is being rediscovered, the studies in this field in Bulgaria still remain limited. Nevertheless, some scientific activities directed at the architecture from the National Revival Period touch also the earthen buildings.

Trainings in conservation of cultural heritage sites are part of the architectural education at the Universities and more specialised at the National Institute for Immovable Cultural Heritage.

There are some associations operating in the field:

- In the town of Plovdiv there is a restoration center *Danchov's house*, created with the help of Chamber of Crafts in Koblenz, Germany. The house itself was conserved using old building technologies – timber-framed construction filled with adobe or wattle and daub.
- The Gaiapolis Foundation, based in Sofia, is an active non-profit organisation in the investigation, dissemination and application of different earthen building techniques (adobe, rammed earth and cob) for the construction of social housing (Gaiapolis Foundation website).

Houses built with stone, adobe
and wooden beams in the region of Gotse Delchev.
(photos: Saverio Mecca)

Adobe house Louroukina.
(photo: Saverio Mecca)

Earthen architecture in Cyprus

Rogiros Illampas
Ioannis Ioannou
Maria Costi de Castrillo
Antonia Theodosiou
University of Cyprus, Nicosia

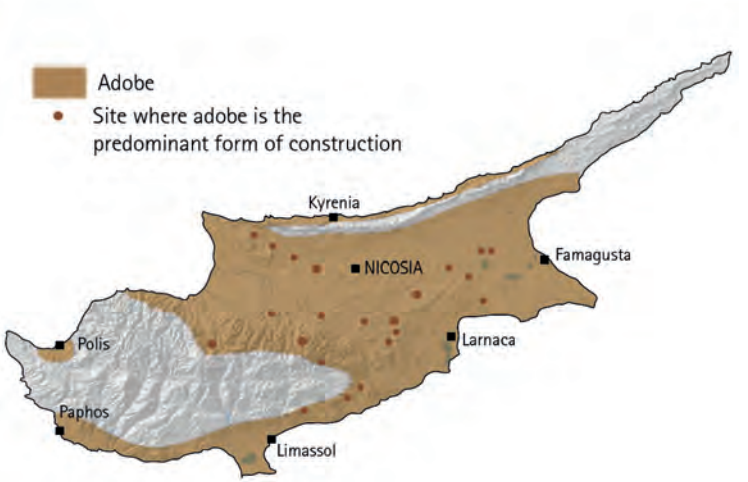
Introduction

Earthen architecture in Cyprus dates back to the Neolithic era (Demetriou et al., 2003). Its earliest traces are encountered in the Pareklishia (9000 B.C.), Choirokitia (7000-6000 B.C.) and Kalavasos-Tenta (4500 B.C.) settlements (Philokyprou, 1998; Demetriou et al., 2003). The prevalent construction technique adopted on the island was adobe masonry. This was extensively and continuously used until the 1950s mainly because of the local availability of the raw materials and the ease of its production and application.

Following the modernization of the Cyprus society, the urbanisation trends, (especially during the second half of the 20th century) and the introduction of industrialized building materials, quite a number of adobe buildings were abandoned whilst others were demolished or replaced by other structures. Furthermore, the adoption of national building codes and regulations which imposed the implementation of engineering design further precluded adobe masonry construction based on empirical techniques. Nowadays, adobe is mostly used in restoration projects. In rare cases it has also been used for the construction of contemporary structures.

Adobe was mostly used in the lowland regions of Cyprus (e.g. Mesaoria Plain) where construction materials other than soil (e.g. stone, wood) were difficult to obtain. Numerous adobe buildings were also erected in urban centres and coastal areas. In the semi-mountainous and mountainous regions, where natural building stones were available in abundance, the use of adobe was predominantly limited to the upper parts of structures.

The dimensions of the adobes used in Cyprus were 5 x 45 x 30 cm^3 (height x length x width). For their production a mixture of soil and fibres (chuff, flax straw, seaweed or goat hair) was cast into timber moulds and the final product was dried under the sun. Adobe masonry walls were always constructed on a stone foundation or on a natural rock base. The thickness of the walls was 30-50 cm. Mud-bricks were laid with the application of straw based



Traditional house in Athienou. (photo: Saverio Mecca)

Adobe masonry constructed on a stone foundation: Ayia Varvara; Nicosia; Limassol and Orounta

Use of adobe bricks in the restoration of the Museums of the Pancyprian Gymnasium, Nicosia, Cyprus.

Traditional adobe structure restored by the Cyprus Department of Antiquities, Fikardou Cyprus. This restoration project has received a Europa Nostra Award

Traditional house in Lefkadia. (photo: Saverio Mecca)

Adobe residence during its restoration

Two-storey adobe structures in the urban centre of Limassol

Traditional adobe structure in the mountainous settlement of Old Kakopetria.

earth mortar. Construction was executed in layers allowing sufficient time for the mortar to cure. This ensured adequate bonding between the bricks and enabled settling of the masonry. Additional architectural and structural elements made of wood and/or stone were always installed in earthen buildings. These included roof beams, lintels, posts, stone arches, wooden balconies and buttresses. Adobe masonry was in most cases rendered using earth, gypsum or lime-based mortars; in rare occasions, it remained uncoated.

Typology of local traditional earthen buildings

Earthen construction in Cyprus possesses a strong local architectural character, despite the fact that over the centuries it has received influences from other cultures (e.g. Byzantine, Frankish, Venetian, Neoclassical, Colonial, etc.) (Sinos, 1978). The typology of earthen buildings derives mainly from social and economic factors, since it appears to be dictated by the different mentalities and needs of the people living in the urban and rural areas (Papacharalambous, 1968; Pitta and Theodosiou, 1996). In rural settlements frugal means limited buildings to their absolute essentials in functionality and space. On the other hand, the economic prosperity and changing lifestyles of the urban areas led to the construction of dwellings with a more complex use of spaces and functions.

The setting of the structures within the built environment was essentially determined by the topography and morphology of the neighbouring area and the effort of people to utilize space to the maximum extent. The main types of earthen buildings that derive from the local vernacular architectural tradition are the following:

- The *monochoro makrynari*: this is the simplest, oldest type of Cypriot dwelling. It is a rectangular, single-roomed house, whose width is limited by the available length of the roof rafters.
- The *dichoro*: this is constructed by the parallel repetition of the makrynari, with the use of timber beams and posts or a stone arch in the middle to provide support to the roof and extend the space.
- The *trichoro*: this consists of an *iliakos* (central roofed semi-outdoor space) and rooms on either side of it.
- The two-storey structure: this is constructed by the repetition in height of a *makrynari, dichoro* or *trichoro*.
- The workshop/commercial building: this is a single-storey, open-plan space with a mezzanine floor.

It should be noted that in many cases adobe structures either occur as parts

of larger building complexes or have been altered by partial reconstruction and/or addition of extra rooms.

The majority of adobe structures surviving nowadays date from the first half of the 20th century. Few are those from the 19th and late 18th century. The restoration of earthen buildings and the preservation of their architectural character are subsidized by governmental rehabilitation schemes. They rely greatly on the efficient application of the policies established by the Departments of Antiquities and Town Planning and Housing. The maintenance of adobe structures in the countryside is negatively affected by urbanization which results in the abandonment of traditional buildings. Abandonment inevitably leads to the gradual weathering and/or collapse of adobe structures. In urban areas non-listed traditional earthen structures which fail to meet the high demands of the modern age are demolished and/or are irreversibly altered.

Urban areas where a considerable number of adobe buildings have been preserved are the historic centres of the island's major cities (Nicosia, Limassol, Larnaca, Paphos, Famagusta and Kyrenia). Characteristic examples of the local earthen architecture can also be found in the majority of Cyprus villages (e.g. Athienou, Pera Oreinis, Kato Moni, Fikardou, Old Kakopetria etc). In most cases restored buildings have retained their initial use as residences. Many though have been converted into museums, cultural and/or recreational centres.

Network of earthen construction and rehabilitation

The Departments of Antiquities and Town Planning and Housing are the main governmental bodies currently responsible for listed buildings and monuments in Cyprus. Research initiatives focusing on adobe materials and structures have recently been undertaken by the University of Cyprus (Illampas et al., 2009; 2010a-c). In the private sector, contemporary earthen construction and the rehabilitation of existing adobe buildings are being supported by individual experts that work in the field of earthen architecture and various organizations. Such organizations include the Cyprus Architectural Heritage Organization, ICOMOS Cyprus, the Cyprus Civil Engineers and Architects Associations, the Cyprus Agrotourism Association and the Cyprus Tourism Organization. Specific interest towards sustainable development and cultural heritage preservation has led to the formation of Geodomo Cyprus in 2010, a multidisciplinary association, which is dedicated solely to both traditional and contemporary earthen architecture.

Types of Cypriot traditional earthen buildings.

Typical farm house in West Bohemia (half-timbered structure filled with earth).
(photo: Žabičková Ivana, Růžička Jan)

Earthen architecture in Czech Republic

Žabičková Ivana
Faculty of Architecture of the Brno University of Technology
Růžička Jan
Faculty of Civil Engineering of the Czech Technical University, Prague

Traditional massive earthen houses can be found in particular in central and southern Moravia as a part of a broader European area of the so-called Danube-type of clay house that can be territorially defined mainly as common in Central and South Moravia, Lower Austria, South Slovakia, substantial parts of Hungary, and partially also in the adjacent regions of Romania and the Ukraine. These areas are characterized by fine grain clay that is suited for building purposes.

The rest of the country, the villages and rural areas are also covered by a large number of earthen structures using rubble masonry with burned and adobe bricks and stones with clay or lime mortar.

Bohemia (the western part of the country) also witnessed an expansion of earthen architecture, but substantially less than Moravia. Along its western border with Germany the typical house was half-timbered, with fillings made either of adobes or of burned bricks.

The territory of central and southern Moravia, where most earthen buildings are found, are flatlands, the soil is fertile and the inhabitants used to make their livings predominantly by farming. Earthen material was used also for further buildings of agricultural character, such as various chambers or vintner houses. Furthermore, stone structures were built with clay mortar and also the pointing of wooden structures was done with clay.

Danubian clay house - typical farmer house in Central Moravia
Wooden structure covered with thick clay coats on both sides, straw roof.
(photos: Žabičková Ivana, Růžička Jan)

Description of earthen architectural heritage

The earthen houses for living are usually coated with lime plaster on the outer side. At first sight, accordingly, only houses with damaged plaster enabling the earthen brickwork underneath to be seen can be identified. That is why it is not easy to ascertain the exact extent of earthen material in the respective villages or houses. This fact requires blanket screening of the communities, such as was done, e.g., in the Vyškov area within the framework of INTERREG (Project holders: Municipality Rostěnice/Zvonovice with The Earthen Archi-



Examples of historical building techniques: adobe masonry, clay rolls opus spicantum, half timbered structures with wattle and clay. (photos: Žabičková Ivana, Růžička Jan)

tecture Association, Faculty of Architecture, BUT Brno and Faculty of Industrial technologies, Púchov, TU Trenčín), or such as is underway in the Zlín region at the present day.

Earthen structures dating back some 100-250 years were built according to the prevailing habits of their time. Most of them have been later refurbished – toilets and baths were incorporated, stalls were restructured for residential or warehousing purposes. During the 20th century, i.e. the period of most massive restructuring, clay was already considered a material of poorer quality and, accordingly, it was mercilessly removed from the buildings and replaced with other materials.

Description of specific building techniques

The usage of clay as the main building material is documented in the 13th and 14th centuries. An expansion of massive earthen structures in European countries took place at the turn of the 16th and 17th century. In that period,, large fires devastated whole villages and towns in regions with prevailing traditional wooden structures. The fires would break out especially at the smoke ducts of wooden houses. In the second half of the 18th century governmental edicts prescribed measures to do away with defects and deficiencies due to excess building freedom. The fire protection measures served as a basis for future Building Rules. The so-called "Fire Patent" of Empress Maria Therese of 1751 ordered brick-built kitchens and chimneys. Every residential house had to be provided with a brick chimney within one year's time.

The construction regulations comprised in the Building Rules brought better safety and expanded the life of the buildings. They also brought a certain unification of rural architecture due to the requirement to submit plans accompanying any application for building permits to the respective authorities. Gradually this activity was taken over by municipal builders, most master bricklayers in the villages (who were on the verge of illiteracy) having provided only clumsy and primitive applications. Fire-resistant earthen structures found broad acceptance and appreciation in low-rise buildings both in the villages and the towns.

As mentioned above, along the western border with Germany clay was used for the filling of half-timbered houses, while in the mountains with prevailing wooden buildings clay served for the pointing. In other parts of the country, earthen houses were usually built with adobes, a few of the oldest houses are built with clay rolls in *opus spicatum*, and a small part of the structures are built in cob. Clay with wattle can be found quite rarely in the hill regions as fillings for wooden structures. Clay plaster is seen in traditional form on earthen houses; the modern clay plaster is used on any surface, from straw to prefabricated boards.

As above, earthen buildings of all types, with few exceptions, were closely connected with rural life, with people living predominantly on farming and related trades. The houses were inhabited by smiths, joiners, saddlers and further artisans executing their trades on the spot.

At the moment, there is a noted transition from reckless pulling down of the earthen houses towards their refurbishment and renovation. Even seriously damaged structures have been rescued, although they were previously

deemed as irreparable. The level of repairs reflects the degree of monumental protection. Cultural monuments built of clay are repaired with the aim of conserving as much as possible of the original structures, whereas earthen houses without monumental value are refurbished with respect to their environmental qualities.

The network of earthen construction and rehabilitation

The need to increase technical quality in the field of earthen structures has created professional platforms to exchange experience and knowledge. All those who are interested in this topic and who work with earth and clay - architects, academics, manufacturers, local producers and investors – are involved in this process. A number of seminars, workshops and conferences dealing with the topic provide an ideal opportunity to improve professional quality in the branch of earthen structures.

Current situation and scientific activities

First examples of modern earthen structures started in the late 1950s. A small number of experimental agricultural buildings using prefabricated earth panels for load bearing walls were built in the village Hustopece near Brno (Moravia). The systematic research in the field of earthen structures and clay materials started in 1994 at Faculty of Architecture BUT in Brno and in late 90´ at the CTU in Prague in connection with increasing interest in sustainable and ecological building, and also in renovation, reconstruction and building protection. Huge floods in Bohemia and Moravia in 1997 and 2002 showed that the amount of historical earthen buildings in the Czech Republic is much larger than supposed. This natural disaster started again interest in research of historical earthen structures.

In the middle of 90´s the new period of modern earthen structures especially those linked to the ecological and environmental approaches started. Using earthen structures and clay materials increases environmental quality of these buildings. Some of these pilot projects were significant for further development of modern earthen structures in the Czech Republic. Also research in the field of earthen structures and properties of clay materials is connected with these projects.

Scientific associations operating on earthen architectural heritage and new buildings

The official platform for exchange of information, experience and knowledge in earthen architecture and earthen structures in the Czech Republic was created by the Earthen Architecture Association (*Sdružení Hliněného Stavitelství*, better known as SHS). This non-profit organization was established in February 2004 and its aim is to support development in the field of sustainable building, natural structural materials including earthen structures and clay materials. The activities of SHS are focused on modern earthen structures but also on renovation, refurbishment, monument protection and historical techniques from the technical and cultural and historical point of view. Today the association gathers academics and students, architects, manufacturers, local producers of clay products and all others who are working with clay and earth. The National Heritage Institute is the official authority for monumental protection, reconstruction and renovation of valuable historical buildings in the Czech Republic. Its activity covers the protection of significant architectural and structural monuments, which are protected by Czech standards and law requirements.

Examples of modern earthen buildings in the Czech Republic (*from the left*):
the first modern earth building-restaurant Hlinena basta (Earthen Tower) in Pruhonice near Prague (1996, architect P. Suske), Centre for Ecological Activities in Olomouc (2007, Projektil Architects), Low-energy family house with prefabricated accumulating internal wall from rammed earth panels (2009, Aeroplan Architects, J. Ruzicka)

Traditional Architecture.
Frilandsmuseet, Lyngby.
(photo: Mariana Correia)

Earthen architecture in Denmark

Jacob Merten
Escola Superior Gallaecia
Willem Oskam
Oskam company

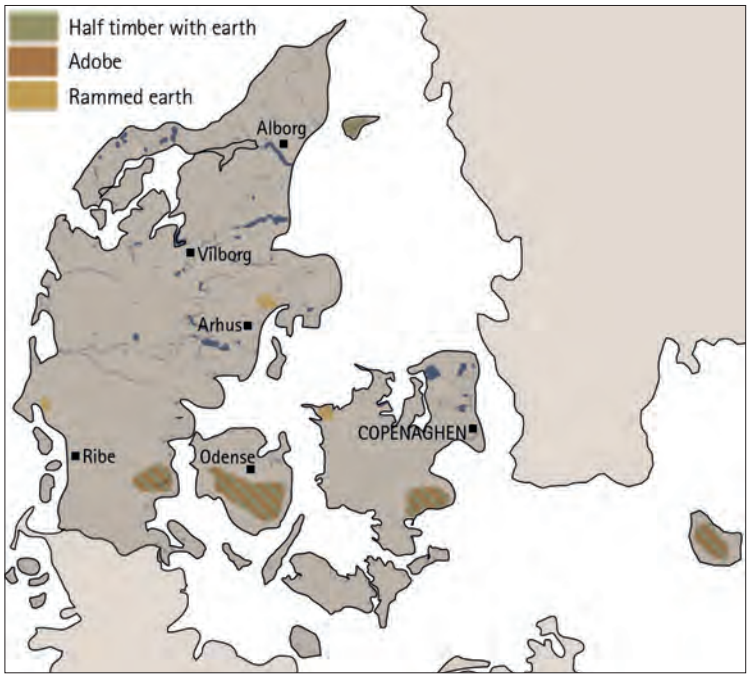
Introduction

The green building movement brought to clay building a growing renaissance, and gained a foothold, which over the past 20 years, has provided innovative work in adapting the old traditions and techniques into a worthy alternative to cement and fired brick. In Denmark, clay construction has also experienced a renaissance. Homeowners and builders alike are discovering that the aesthetics of a clay building creates an irresistible appealing warm natural ambience. Good moisture control, heat storage effect and soundproofing present a calming atmosphere.

History of Clay Building in Denmark

In Denmark, clay has been used ever since the Stone Age, along with wood, wicker, straw and peat. However, not much is known about the earliest used clay techniques. The archaeological literature, most often describes the original techniques as mud, i.e. clay that is used to fill and plaster a wicker structure of willow or similar. Although, it seems likely, that ancient cultures knew several ways of building walls and sealing them. Including the use of cob with a plaster-like surface, which must have given better shelter than the thinly plastered walls. Examples of this type of structures can be found in open-air museums throughout the country.

Timber-framed peasant houses used clay to in fill the frames, either as mud for wattle and daub or for unfired or rammed clay bricks. At the same time many houses were built with thick-bearing outer walls of clay, without supportive timbered, either in the shuttering as rammed earth, or stacked as cob. Around 1850, English merchants brought from England to Denmark, the widespread cob method. Several large houses and farms on Lolland, Falster and Zealand were built in cob, and they are still there to this day. Examples are: the old schoolhouse in Skelby, Lolland; the Rewentlow Orphanage in Ravnsborg; and several country houses around Holsteinsborg in southern Zealand are in cob. The Open-air museum in Maribo has replicated one of



Historic adobe located at OSKAM company head office in Kolind. (photo: Jacob Merten)

Detail of the exterior walls, Museum Dejbjerg Jernalder, in Skjern. (photos: Jacob Merten)

Construction site for compressed earth blocks (CEB), by OSKAM company, in Kolind.

Earth Blender and Earth Bag, OSKAM company, in Kolind. (photos: Jacob Merten)

Rewentlows village schools with thick clay walls. The Karen Blixen Museum in Rungstedlund is one of the houses that were built in the middle of 1800, after the English model.

In the early 20th century several books were published in an attempt to publicize clay buildings excellent amenities. Architect Carl Hoyer and Architect V. Moller Forgensen published a book in 1920, on stamped clay with detailed drawing and formulas. Later Sven Risom published "Lerhuse" (Clay House) in 1952 (Risom, 1952).

A survey that was made in the early 1900s by Sven Risom noted around 4,000 houses that were registered as being constructed with thick clay walls in the period of 1780-1870 (Risom, 1952).

Clay building techniques

Half timber frame with adobes in fill

In Denmark, there are still hundreds of historical earth houses from the 18th and 19th century. The houses are timber framed with adobes in fill and are known especially in Lolland, Falster and Zealand, but are also registered in Funen and Jutland.

It is not immediately apparent when entering an older house that it is in earth, as homeowners have always done what they could to hide "clay walls" Traditionally, plasters were applied to cover this walls.

Cob (wellerwände)

Architect Flemming Abrahamsson and company Fornyet Energi are the focal points of cob building in Denmark. The company disseminates books, knowledge and offers courses, but also workshops in cob. Examples of Flemming's work can be found in Dyssekilde Ecovillage, near Hundested.

Rammed earth (stampet lerjord)

Steen Moller, the community founder of Friland ecovillage built is own house in rammed earth twenty years ago. The house was built in Varde, in the western coast of the country. His building choice was due to rammed earth houses built during the fifties in the region, due to a shortage of cement at the time. However, as rammed earth walls are normally protected by plaster, these houses are very difficult to be identified.

Claystone (Lersten)

Claystone is industry-produced bricks. There are 2 main types, an unfired brickyard brick and pressed clay bricks or CEB. The unfired bricks were in the past a poor man's brick. In Denmark, both compressed blocks and factory

brick have been used in some experiments based centers. Both types can be delivered from Danish producers, and both are available in plain brick format.

Compressed Earth Blocks – CEB

In recent times, Ecovillage Andelssamfundet in Hjortshøj, near Aarhus was one of the first places in Denmark to build modern earthen architecture. FX Earth Building developed and built a housing project with non-stabilized CEBs. It was the first and largest earth-building project in Northern Europe. The company, Oskam v/f., owned and managed by Rokus Oskam in the Netherlands and by Willem Oskam in Denmark produced the CEBs and plaster for the project. The company also develops and manufactures a range of machines for the production of CEBs. They have built a number of buildings with CEB's throughout Denmark. One example is the visitor's center at the Dejbjerg Jernalder open-air museum near Skjern.

The Munkesøgård housing development in Roskilde used CEB's to build interior walls. The clay bricks absorb heat and moisture extremely well, which means it has the ability to stabilize the indoor environment better in comparison to a fired or cement brick. The company, Egen Vinding og Datter in Ringsted, produced and supplied the materials.

Clay plaster and straw bale construction

Straw bale construction is very popular in Denmark. It has been part of the ecological building tradition since the mid 1990s. The first one was built in 1998 at The Nordic Folkecenter for Renewable Energy in Northwest Jutland. Straw bale building has spread very fast through owner-builder networks and is a very popular building technique in ecovillages throughout the country. Straw bale building specialist, Lars Keller, offers frequent conferences and workshop throughout Denmark. With the popularity of straw bale construction, there has been a revival of clay plasters since they are a good protection for the bales from fire and moisture.

Self-builders were the first to use clay plaster and painstakingly applied it by hand or by using a small hand sprayer. At present, craftsmen apply clay plastering by machine. Many clients choose to plaster on both the inside and outside of the building. There are several dry-mix clay plasters that are offered by producers that give attractive and durable results.

Museum Dejbjerg Jernalder; in Skjern. (photos: Mariana Correia)

Future

Building with clay is noticeably increasing throughout Denmark, especially among the ecovillage communities. There is renewed appreciation of clay as an ecological, energy-efficient building material. Consumers and builders are looking for more efficient and economical forms of construction. In recent decades, there has been an increase in standardization and industrialization driven mainly by the environmental movement. Exchange of information and experience from all over the world, could speed up the development and contribute to sustainability in building.

Stable in rammed earth in Põlvamaa. (photo: René Guérin)

Earthen architecture in Estonia

Kristina Akermann
Jaan Miljan
Estonian University of Life Sciences

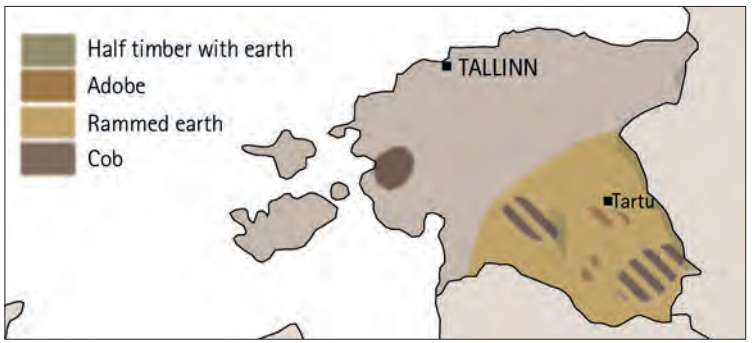
Although the most common building material in Estonia has been timber throughout history, there are thousands of buildings which are made of earth. Earth as building material and earth architecture has a centuries-old but unfortunately fading tradition in Estonia. There are still hundreds of remaining historical earthen buildings, but many of them are not maintained and are consequently in ruins.

Earthen buildings are particularly common in South-Estonia, where suitable soil is available and widely found. In Central and in North Estonia the most important local building material next to timber is limestone. This is the reason why earth did not develop as significant a role in construction as it did in South Estonia.

Earth buildings were most widespread in the 1920s after the Estonian War of Independence when large estate holdings belonging to the Baltic nobility were redistributed among the volunteers of the Estonian War of Independence. During the war the majority of forests were destroyed and timber was very expensive, therefore the Estonian government actively promoted the use of earth as building material.

Walls made of massive earth have been used mostly in rural and ancillary buildings - cowsheds, stables, barns, blacksmith shops and kilns. As earth construction became more popular and well known in Estonia, a significant number of residential buildings and even public buildings were also built.

The soil suitable for buildings had a high sand content with just enough clay in it to act as binder. It was dug out from the ground in autumn, transported near to the construction site and piled up. Piled up soil was left to erode by rain and frost during the winter making the soil tougher and more homogeneous. In the spring the eroded soil was tramped underfoot or by horses and mixed with additives. If the soil found near the construction site was too clayey, it was attenuated by adding the right quantity of sand. In order to reinforce the earth wall and enhance its strength against abrasion, stems of



Rammed earth in Põlvamaa. (photo: René Guérin)

Farm in rammed earth in Põlvamaa.
(photo: René Guérin)

Põlva Talurhva Open-Air Museum in rammed earth in Krootuse, Põlvamaa. (photo: René Guérin)

House in rammed earth in Tartu, Tartumaa.
(photo: René Guérin)

House in rammed earth in Põlva, Põlvamaa.
(photo: Marko Kikas, Saviukumaja)

Building in wattle and daub in Tartu, Tartumaa.
(photo: René Guérin)

Farm in rammed earth in Põlvamaa.
(photo: Marko Kikas, Saviukumaja)

Labrador tea, common heather and flax sheaves were added to the earth mixture. The thermal insulation of earth walls was increased by adding various porous additives such as straw, chopped reed, flax sheaves, wood shavings and pine or spruce needles.

In Estonia, there were various techniques and constructional forms for building in earth. The simplest, oldest and also the most widely occurring technique was the *cob* technique, there the earth walls were directly formed with wet earth. The earth was mixed with water-soaked straw, stems of common heather or branches of juniper and spruce. Mixed and tramped earth was stacked by pitchfork on the foundation and compacted in layers of 10 cm thick until the wall was built up to a height of 60 cm. Then the wall was left to dry for 5-6 days. After the drying period, the surface of the wall was smoothed with a spade, moistened and other layers of earth were stacked and compacted. Usually the wall widths were in the region of 50 to 60 cm. Because of the roughness of the wall surface, this type of earth wall was used primarily in production buildings.

Also, a significant number of *rammed earth* buildings have been built with movable formworks. Mixed and tramped earth was poured into formwork in layers 20-30 cm high and then compacted by ramming, forming a course the height of the formwork. After the rammed layers of earth were dried out, the formwork was removed and lifted up. Before laying a new course of layers, the upper surface of the lower course was moistened with water and air-dried branches of spruce or juniper were added between the courses.

Buildings made of unfired earthen bricks or *adobe* blocks are also present in Estonia. Even though this method was used mostly in large estate holdings, some farmhouses were also built using this technique. The main advantage

of the *adobe* wall was the minimal shrinkage after the masonry was laid, as the blocks were dried prior to use. Depending on the local climatic conditions, it took 1 to 2 weeks to dry *adobe* blocks. Also the blocks could be made at the source of the raw material or under a roof in all weathers and then moved to the building site. *Adobe* blocks were laid with an earth similar to the earth used in making the blocks.

Most of the non-load-bearing walls were made using the *wattle and daub* technique.

The main problem and disadvantage of earth buildings in Estonia is dampness - rising damp from the ground and rain. Strong stone foundations and raised plinths were therefore built to avoid moisture from the ground rising to the wall construction by means of capillary action. Pitched roofs with deep overhangs were a traditional solution to rain protection. Earth and to a lesser extent lime renders were applied to external walls. Usually the walls received also a coat of lime plaster, which was renewed annually.

According to Tõnu Keskküla, the professor emeritus of the Estonian University of Life Sciences, the history of Estonian earth architecture can be divided into 4 periods.

The first period lasted from 1850 to 1870. In that period buildings were built without foundations (and it is believed to be the reason why so few buildings remain from that period) and the houses were built mainly by using the *cob* technique.

The second period lasted from 1870 to 1900. In that period earth houses were still mostly farm houses, but now they had foundations. Window and door frames were made of wood and the houses were built using the *rammed earth* technique.

The third period lasted from 1906-1914. In that period residential houses were also built and window and door frames were made of concrete.

The fourth period lasted from 1920-1930. Earthen buildings were also built in the city, for example Tartu still has some buildings made of earth today.

After the Second World War, only a few earthen buildings were built, mainly cowsheds in collective farms.

Since the 1990s environmental consideration has become increasingly important in every aspect of life, a solution to minimize the negative environmental impact of the building industry is to find an alternative to materials with high embodied energy non-renewable resources. Earth has therefore been rediscovered as a local sustainable building material and old earth building techniques are currently enjoying a revival. More and more old historical buildings are being preserved or repaired and new methods to use earth as a building material are being developed.

Barn in rammed earth in Tatumaa. (photo: René Guérin)

Cob in Põlvamaa. (photo: René Guérin)

Most modern earth buildings in Estonia are built with lightweight clay, as the thermal insulation properties of massive earth walls are not sufficient enough to provide the levels of thermal insulation required in the Estonian climate. Lightweight clay consists of clayey soil mixed with light additives such as wood shavings and chips, flax sheaves, chopped reed or straw. Lightweight clay is slightly dampened and poured into formwork and used as in fill to timber-framed structures. The width of the light clay walls should be at least 300 mm. Sometimes lightweight clay blocks are used instead.

Building with bales of straw is becoming more and more popular all over the world and the same tendency is seen in Estonia. There have already been over 25 straw bale buildings built in Estonia in the last 10 years. Most of them are timber-framed buildings insulated with straw-bales and finished with clay or lime render, some of the houses have load bearing walls made of straw bales.

Cottages in Parainen. (photos: Patrice Morot-Sir)

Earthen architecture in Finland

Ann-Marie Braxén-Frommer
Association Savir for earthen construction

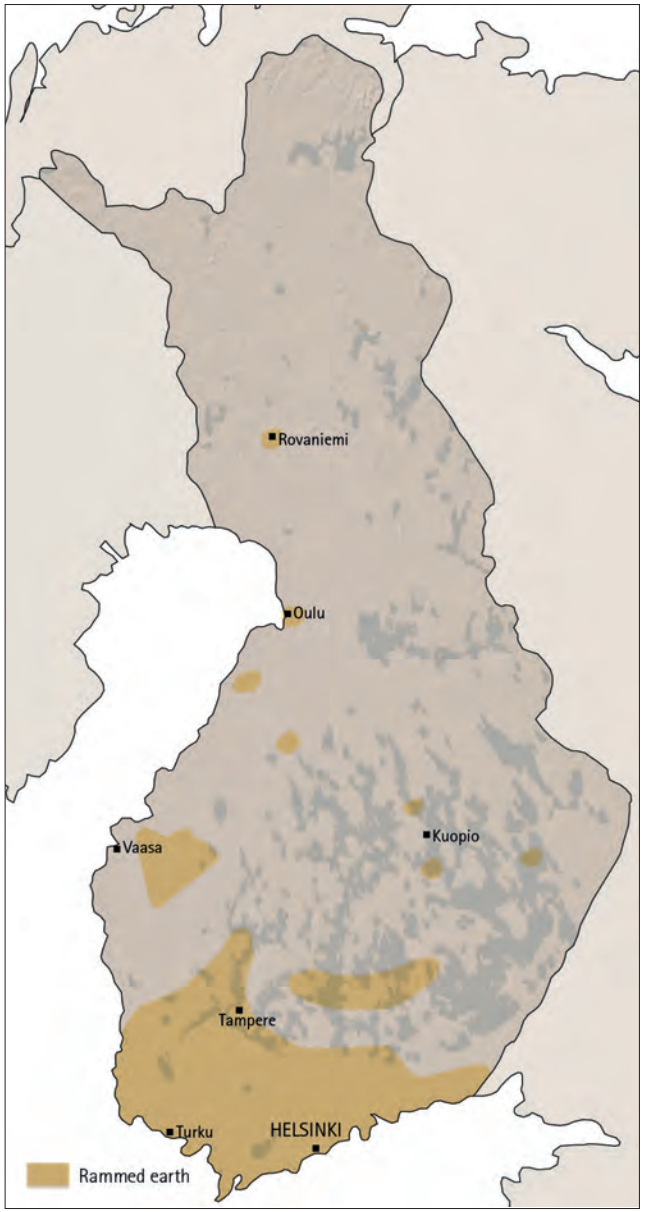
Heritage: a view into the past for a view to the future

In a country like Finland with its large forests it has always been a natural choice to use timber for building. But nevertheless earth and clay has been used for different kinds of buildings, stables, cow houses, forges, storehouses, residences and schools. Clay building techniques arrived in Finland -at that time part of Sweden- in the 16th century and were promoted as forest saving. Good quality clay was easily found in almost all parts of the country. Even building guidelines were published during different periods in magazines and building manuals. In 1878 the *"Maamies"* - magazine *(Countryman)* published a detailed working description of rammed earth. The advantages of clay were presented as follows:

"*These days it does not seem necessary to verify the many benefits these buildings offer, since clay buildings have been built in many parts of Southern and Middle Finland; the main point is that these buildings are easy to care for, long-lasting, warm (most convincingly seen during the last cold winter), forest saving, less inflammable, clean (bedbugs do not thrive on clay walls) and neat.*"

There have been hundreds of clay buildings built in Finland, though approximately two hundred are still remaining. The oldest date to the 16th century, the latest are from the 1950s. The largest and most imposing buildings stand at manors and iron works. There they had the possibility to get well acquainted with the methods and the means to do a proper job. On smaller farms and other places the results were not always of the best quality, this is evident in the loss of so many buildings. Most constructions in use were with rammed earth using twigs of heather, spruce and other suitable plants as reinforcement. Cordwood masonry is found in animal shelters and for partition walls in different building types. Only a few traces of the use of compressed earth blocks are left. The clay could be mixed with peat for reinforcement, and to improve thermal insulation, and clay mortar was used.

The remaining clay buildings give evidence of the history of building, an interesting building method and the features connected with clay as a building material.



Finland Horses stall from 1915 in Myanamaki.
Finland Workers house from 1784 in Stromfors.
Earth house in Pori.
Horses stall in Kotka.
Interior of a horses stall in Kotka.
Horses stall from 1915 in Myanamaki.
(photos: Patrice Morot-Sir)

Adobe brick from Rasio.
(photo: Patrice Morot-Sir)

The remaining buildings deserve to be taken good care of. The owners themselves have mostly cared for the conservation of the buildings and in some cases financial support has been granted. Lately the use of clay in building conservation has been taught in Universities of Applied Science, (*Turku, Ikaalinen*) thus increasing the possibilities of receiving professional help.

Clay plastering has been much in use in all kinds of buildings from manor houses to cottages as protection against drafts and to create even surfaces on log walls. Pig bristle, cow hair, sawdust, straw, flax are found in old plasters, and these are still working perfectly in reuse.

Clay building today

Hard times and shortage of building materials gave clay a better chance, for instance after 1945, as Finland faced the task of taking care of the people who left their homes in the parts of Karelia lost to the Soviet Union. Among these self-builders clay was one building technique.

At the beginning of the 1990s clay building was seen again in Finland, courses and seminars were held, at first managed by the Helsinki University of Technology. The translation of Franz Volhard´s book 'Leichtlehmbau' into Finnish was an important step, giving self-builders and professionals valuable information. In 1996 the Finnish Claybuilders Association was founded. Members and other interested people have attended courses abroad, mainly in Germany and Sweden. Slowly there has been developing a group of professional builders. Still self-building is the most common form. Tens of buildings with light clay-straw or other such mixes as clay and wood chips, or clay and leca, have been built, but at the present time straw bale building with clay plaster seems to be of greater interest. Another technique is cordwood masonry, used for instance for

Finland Cottage in Parainen.
Earth house in Vehmaa.
FInlandloght clay block villa in Raisio.
Earth house in Pori.
(photos: Patrice Morot-Sir)

round sauna buildings. Rammed earth seems to be of increasing interest. Clay as a building material for ovens and fireplaces has a tradition in Finland, and lives on.

In general, it can be said that regionally there are no earth building techniques typical for specific areas. Building is more active in the western and southern parts, but there is also the higher concentration of people. Eco villages are an increasing form of living, and straw bale building, light clay-straw and cordwood are of interest. For other than self-builders the lack of professional builders is an obstacle. Yet a growing interest in clay in its many uses for building can be seen amongst architects, engineers, bricklayers and masons. The need for building regulations like the German Lehmbauregeln has been uttered. Another obstacle is the lack of building materials, up to now there is the production of unburnt clay bricks as well as unburnt clay tiles for flooring produced in Finland.

One channel of information is through the associations for preservation of built heritage around the country, as well as local builders associations and the professional and commercial builders.

The Finnish Claybuilders Association (Saviyhdistys ry) is working for an active network of clay and straw bale builders in Finland and also with the intention to enlarge networking to the other Nordic and Baltic countries. It also has an important role as a link between builders and professionals.

Farmhouse in rammed earth, adobe and bricks
in La Salvetat-Belmontet, Tarn-et-Garonne.
(photo: René Guérin)

Earthen architecture in France

René Guerin*
Conseil d'architecture d'urbanisme
et de l'environment of Vaucluse

Lydie Didier
AsTerre Association

*Contribution based on
*Terra Incognita.
Discovering/Preserving European Earthen Architecture*,
Argumentum/Culture Lab Ed., 2008.

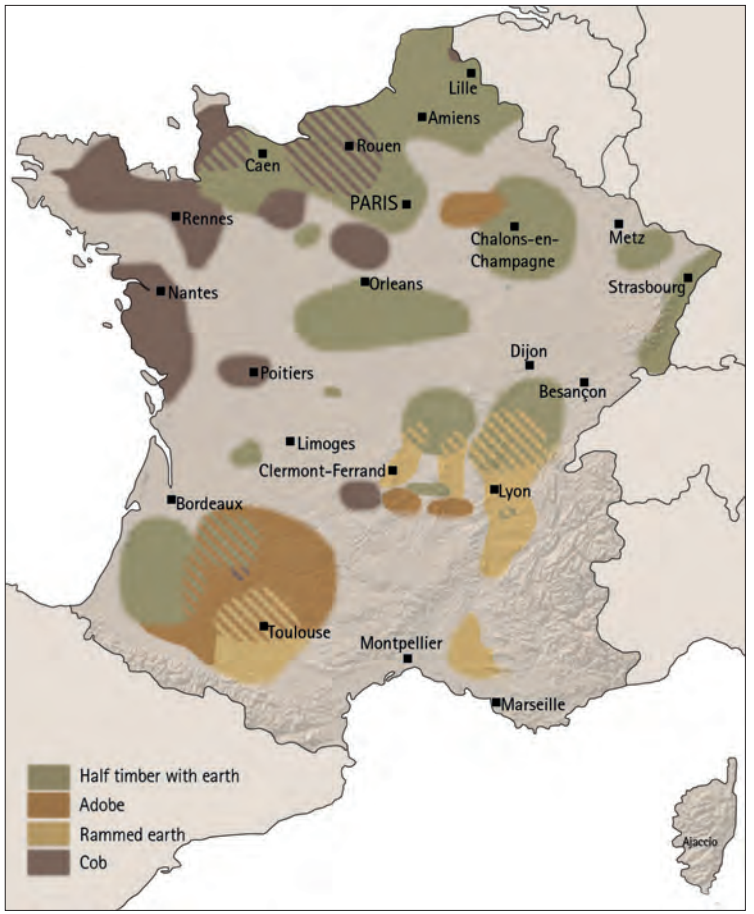
Atlas of traditional buildings

Metropolitan France presents a large geographical and geological variety which conditions earthen resources for the construction industry.

The relationship between pedology and the art of building is obvious. Put simply, cob and wattle and daub correspond to soils rich in sedimentary clays or of deterioration, to loamy soils, or to sandy clay soils, which often require the addition of vegetable fibres to limit cracking in drying. The adobe corresponds to alluvial soils (particularly earth composed of red clay, gravel and sand) with a dominant sandy fraction, while having a correctly spread out granularity. The *pisé* or rammed earth corresponds to alluvial soils and glaciofluvial deposits, very gravelly and perfectly suited to ramming.

Cultural influences have also largely conditioned the use of different techniques: cob and wattle and daub, favored by the Gauls, are of northern origin (Danubian, Germans and Celts), whereas adobe was introduced by the Greeks and rammed earth by the Romans.

Historically, though earthen construction dates from the Neolithic, buildings remains previous to the Middle Ages is rare where the techniques of *pisé* as well as half-timber combined with wattle and daub become widespread. In *La Maison Rustique*, Charles Estienne and Jean Liébaut boast in 1564 the techniques of cob, *pisé* and earthen plasters. In the 17th century, aristocrats choose earthen materials for the houses of their farm workers. In the 18th century, treaties are published on construction in the "new" *pisé*. Georges-Claude Goiffon and Abbe Rozier precede François Cointeraux whose *4e Cahier d'Ecole d'Architecture Rurale* (1791) was translated and distributed in numerous countries. Although cement gradually marginalized earthen material from the 19th century, it was used during the reconstruction following the Second World War, before its revival in the 1970s.



Rammed earth farm in Assieu, Isère.
(photo: René Guérin)

Adobe farmhouse, La Salvetat-Belmontet, Tarn-et-Garonne.
(photo: René Guérin)

Vaugirard castle (XVIIc), Champdieu, Loire.
(photo: René Guérin)

Vineyard house, adobe and bricks, Lisle-sur-Tarn, Tarn.
(photo: René Guérin)

Adobe houses, Salvagnac, Tarn.
(photo: René Guérin)

Adobe barn, Verlhac-Tescou, Tarn-et-Garonne.
(photo: René Guérin)

There is sometimes also a relation between the type of rural landscapes and the constructive typologies. In Bocage there is often wood and wattle and daub, in open-fields adobe or *pisé*.

Wattle and daub is used in Normandy, in the Loire Valley, in the north-east and southwest. In Normandy, the *éclisses* (or splints) are small sticks wedged between framing stakes. In the Pays de Bray, the clay and vegetable mixture is filled against a lost coffering formed by slats nailed to the internal facing of the skeleton. In Anjou, torches of straw and clay are tied around bars of chestnut, then wedged between framing stakes. In Champagne, the *palissons* correspond to blunt and beveled boards at each end. In Alsace, wattle and daub was sometimes formed by large packs piled and pressed down between framing stakes. In Bresse, clay is pressed into a thin layer on a weaving of thin green branches of alder.

Adobe (mud brick moulding) is mainly located in the southwest and Champagne. The *briquette* of the Southwest (standard size: 40 x 28 x 5 cm) is moulded in wooden forms, then dried on the ground, and put on the entire thickness of the wall (40 cm). It is sometimes put in rows of 5 modules in alternation with terracotta bricks. The *carreau* of Champagne (standard size: 22.5 x 10.5 x 10.5 cm) is moulded in forms with two compartments in metal or wood and metal, and then dried in piled heaps.

Rammed earth (*pisé*), sandy and clayey or gravelly soil, is used in Auvergne, Midi-Pyrénées, Rhône-Alpes and in the lower valley of the Durance. Earth is packed in layers of 6 to 8 cm between two wooden formworks called *banches*. Depending on the connection of each *banchées*, two alternatives appear: with vertical joints in the Dauphiné and the Lyonnais, with joints inclined in Auvergne and Forez. The corners can be reinforced with terracotta bricks, as in Bresse, with slag, as in the Rhone Valley, or with lime or cement, as in the Dauphiné and the Lyonnais.

Cob is mainly present in the northwest according to two types: in Brittany especially, it contains numerous vegetable fibres prepared in *bigots* (blocks) and piled with a fork; in the Loiret or the Vexin, it includes more stone or flint. The pasty mixture of clay and vegetable fibres is cut into *bigots* which are piled to form layers from 0.60 to 1.20 m in height, and up to 1 m wide at the base of the wall.

The built heritage made with earth is extremely varied: in addition to countless farms and village houses and accompanying small buildings (kilns, mills, dryers…), there are castles, churches, public buildings or factories built in *pisé* (Auvergne, Bresse, Dauphiné, Forez…), but also important historical urban centers built using timber frame and wattle and daub (Le Mans, Rouen, Tours, Troyes…), as well as *pisé* (Lyon, Montbrison…).
Most of the earthen constructions kept their original functions, including homes. When the constructions have a use value, they present a good general state. Their degradation is mainly due to neglect; numerous constructions are altered by interventions ignoring the qualities of this material.

Networks

An increasing interest is given to the preservation and the valorisation of the earthen built heritage, in particular on the initiative of the Regional Natural Parcs, the ecomuseums, the Advisers in Architecture, Urban planning and Environment or various associations.
Concerning new building, after the revival of the 1970s, efforts focused on the prefabrication of big elements (blocks of *pisé* or cob prefabricated) during the 1990s. The compressed earth block (CEB) has been standardized since 2001 (XP 13-901); the ten-year guarantee will soon be covered on the advice of the scientific and technical centre for the building industry (CSTB).
Concerning higher education, in addition to the National School of Architecture of Grenoble (Laboratory CRAterre), which delivers a specialized diploma of architecture (Post-Master), we can quote the university degree BATIR of the University of Nantes and the discovery modules of IUT 1 (University Institute of Technology) of Grenoble.
The vocational training offer, plentiful and diversified (from the short training course to the degree course), is mainly provided by members of the national federation of vocational training centres for ecoconstruction (OFECO). AsTerre, the national association of professionals for earthen construction, intervenes with support for companies, includes training organizations, architects and engineers and information organizations. Finally, the association plans the drafting of professional rules, to improve the insurability of different techniques.

Social housing "Le Village" (1998-2009), CEB walls, Cavaillon, Vaucluse. (photo: René Guérin)
Mediterranean Agronomic Institute in Montpellier, Hérault, rammed earth, stone and terracotta bricks. (photo: IAMM)
Leisure centre, rammed earth in Ramatuelle, Var. (photo: Municipality of Ramatuelle)

Medieval houses in half timber with wattle and daub, Limburg an der Lahn, Hessen. (photo: DVL H. Schreckenbach)

Earthen architecture in Germany

Horst Schroeder
Stephan Jörchel
Dachverband Lehm e.V.

The history of earthen contruction in Germany

The earliest evidence of the use of earthen building materials for settlement structures in Germany can be traced to early *post and beam houses with a form of wattle and daub* that date back to about 4000 BC. Reconstructions of these early post and beam houses can be found in various open air museums in Germany, for example in Oberdorla in Thuringia or the Museum of the Thuringian State Department for Archaeology and the Conservation of Historic Monuments in Weimar.

Over time a loadbearing construction technique developed alongside the post and beam and wattle and daub construction, which is today known in Central Germany as *Wellerlehm* and is usually left fair-faced. This method, which is similar to cob, is most widespread in rural areas of Central Germany.

The earliest known example of a loadbearing earth block construction north of the Alps is the *Heuneburg an der Donau*, which lies southwest of Ulm and dates back to circa 500 BC. It is believed to have been built, or influenced, by the Celts, i.e. long before the Roman settlement of Europe. Another interpretation is that its construction may have been influenced by knowledge brought by travelling tradesmen of Greek building culture, where the making of earth blocks for loadbearing wall constructions was already well known (Schroeder 2010).

The oldest remaining evidence of *rammed earth construction* in Germany can be found on the site of the former Roman fortified settlement of Colonia Ulpia Traiana near Xanten, which was established about 100 AD. The site was rescued from redevelopment and has since undergone complex restoration. Reconstructions of the buildings can be visited at Xanten Archaeological Park. The most well known historic rammed earth building in Germany is a six-storey residential building in Weilburg an der Lahn (Figure, Weilburg).

A second direction developed out of the Neolithic wattle and daub walls and became widespread for half-timbered constructions. Timber frame construction with earth in fill has developed over centuries in Germany and has many different stylistic and regional variations. To the present day it characterises the architectural appearance of towns and villages throughout much of Germany (Figure, Limburg). Particularly well known examples include the towns


Wattle and daub house, Wittstock, Brandenburg. (photo: René Guérin)


Lehmbaukurse house with clay plaster, Biesenthal bei Bernau, Brandenburg. (photo: René Guérin)


Six-storey building in rammed earth, Weilburg, Hessen. (photo: DVL H. Schreckenbach)


Wattle and daub detail, Limburg an der Lahn, Hessen. (photo: DVL H. Schreckenbach)

of Quedlinburg (now a UNESCO World Heritage Site) and Limburg an der Lahn. It is estimated that several hundred thousand timber frame houses still exist in Germany that are made with earth building materials. Many of these have been rendered or clad and are not immediately identifiable as timber frame and earth constructions.

Modern earthen construction in Germany

Walls made of earth

A variety of different methods are appropriate for constructing walls out of earthen materials: rammed earth, cob, adobe bricks, unfired bricks, clay panels and boarding or light clay as moist fill mixture.

Rammed earth walls

Rammed earth wall construction are used both for new-buildings as well as renovation work. Compared to monolithic or masonry constructions in other materials, rammed earth construction is relatively expensive. It is very often used for architectonic and aesthetic reasons rather than for functional reasons. Rammed earth walls are constructed using formwork (typically made of steel) which is filled layer by layer with a moist earth mixture. Each layer is mechanically compacted. The formwork can typically be removed after the earth has been compressed as the earth maintains it shape. The addition of different coloured clays and earth to successive layers produces a particularly attractive surface structure which can be left exposed without further surface treatment.

Cob walling

Cob walling is used almost exclusively for the restoration and renovation of the large heritage of rural buildings made with cob walling. The earth mixture contains a higher proportion of straw than rammed earth and contains little to no mineral substance. Formwork is not used for cob walling, instead earthen clumps are layered on top of each other and the irregular sides are then 'shaved' flat with a spade to achieve an even wall surface.

Earth block (adobe) walls

Earth blocks can be made in a number of different ways with different densities:
Hand-moulding or throwing: a light malleable earth mixture is pressed or thrown into a mould made of wood or metal. The surface is drawn smooth, the mould removed and the blocks left to dry in the sun or with an oven.
Compacted blocks: larger format blocks are made using almost dry earth mixtures filled into a mould and compacted layer by layer, either manually or mechanically. The mould is removed immediately after compression and the blocks are dried naturally or artificially.
Manual or mechanical compression: a semi-solid earth mixture is filled into a press and compressed manually or using a machine. The block is removed from the compression chamber and dried naturally or artificially.
Extrusion: a pre-mixed barely kneadable earth mixture is compressed in an extrusion press (as used for manufacturing bricks) and pressed through an extrusion nozzle of the desired block dimensions. The endless extrusion is then cut to the block size. The blocks can be left to dry naturally in the air or artificially in an oven. Blocks produced in this manner but not subsequently fired are known as 'green' or unfired bricks.
Earth blocks can be laid like any other masonry brick in coursing and bond with fully mortared joints, preferably with earthen mortar rather than cement or cement-lime mortar. Earthen mortars are a mixture of earth and sand and sometimes contain organic additives.
Earth blocks are used primarily for wall constructions (loadbearing and non-loadbearing) both for internal walls as well as external walls. They can be left

Rammed earth, Clinic Suhl. (photo: DVL H. Schreckenbach)
Xanten. (photo: C. Ziegert)

visible as facing earthen brickwork or plastered. A single or double coat of earthen plaster makes best use of the characteristics of earth.

Clay panel walls

Clay panels differ from earth blocks in size and thickness as well as the method of manufacturing. Thick panels are available as large-format blocks with or without tongue and groove joints and are laid with mortar or glued. They can be used as self-supporting blocks for interior walls without the need for a supporting structure.

Important: Due to their precise dimensions and minimal joint gap, a thin layer of fine clay render is in many cases sufficient for the surface treatment of clay panel walls.

Earth plasters

Earth is used as plaster for internal walls and ceilings as well as for external renders where walls are protected against heavy weather.

The Earth plasters can be categorised into the main groups:

Coarse earth renders are a mixture of clay or loam and coarse aggregates. Fibrous additives improve the stability and abrasion-resistance of the plaster. They can be applied by hand or using a plastering machine up to a thickness of 4cm. Pre-mixed coarse renders are available commercially as moist or dry mixtures, but they can equally be mixed from locally excavated earth. Coarse renders are usually painted with a finishing coat.

Fine clay plasters are made of clay and fine aggregates. They are usually applied by hand, seldom with a machine, with a thickness of 2-5 mm. Commercially produced fine clay plasters are available as powdered mixtures. Here too it is usual to apply a final surface coat of paint.

Coloured fine clay plasters are made of specially selected clay and earth with distinctive colourings and mixed with fine aggregates. Pigments can also be used to colour the clay mixture. These are also typically applied manually rather than with a machine, with a thickness of between 2 and 5 mm. The surface colouring is such that no further treatment or painting is required.

Brushable clay plasters are a recent addition to the range of commercially available plaster products. These are in essence a coating material in which earth and clay contribute only partially to the final surface hardening. In contrast to coloured clay plasters, these plasters contain coarse additives.

An alternative approach to wet plastering is offered by earthen plaster boarding. Pre-manufactured medium-sized boards are stuck to the backing surface much like tiles using earth mortars or adhesives.

Xanten. (photo: C. Ziegert)

Earthen in fill

In framed or half-timbered constructions, the spaces between the timber studs, rails and braces are filled with a non-structural "in fill" or "nogging" in a variety of different techniques. One of the oldest methods is known as wattle and daub: wooden struts are jammed between the timber members and woven with a wickerwork of split willow branches. This supporting "wattle" is then daubed from both sides with a clay straw mixture. This technique is used today only for renovation work.

In fill panels can also be filled with earthen brickwork or loose mixtures of moist clay straw or light clay.

Regional distribution of modern earth building techniques

Modern transport and distribution networks have rendered traditional regionally specific boundaries obsolete so that earth building methods are no longer restricted to regionally specific areas. The decision to use earth building products and techniques is instead a product of planning and design considerations.

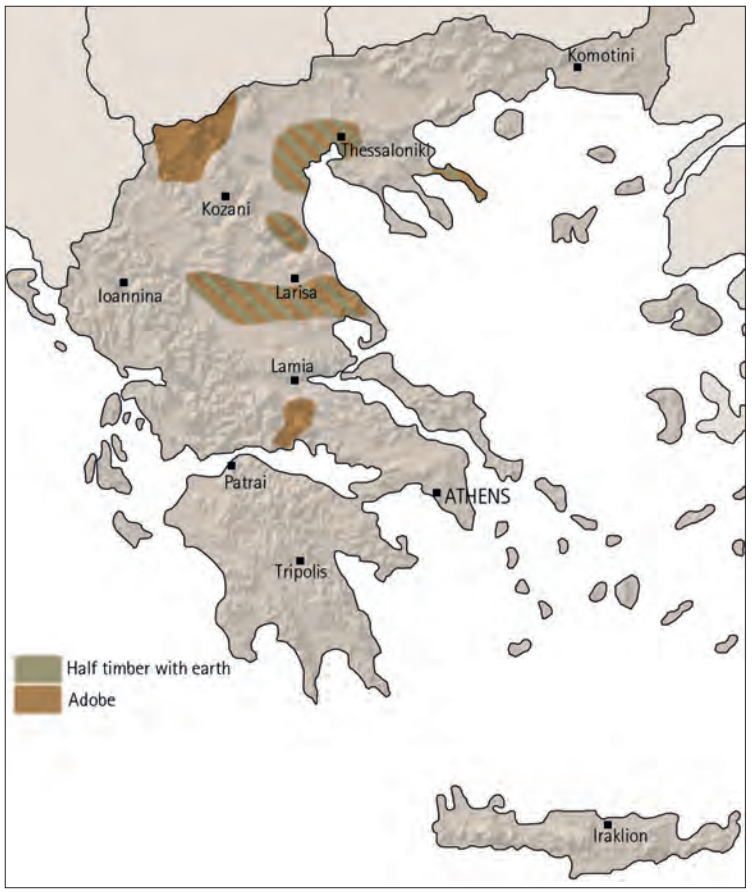
Adobe houses in Antartiko. (photo: Saverio Mecca)

Earthen architecture in Greece

Georgia Bei
Aristotle University of Thessaloniki

Identification and localization the atlas of earthen heritage

Earth is the most ancient building material in Greece. Evidences of these structures date from Neolithic period and are well known from Macedonia to Crete (Chourmousiadis, 1979) (Skafida, 1994), (Stratouli, 2004). This tradition survived in the following centuries, though the relation to the ancient forms is not always clear (Bei, 2007). Nevertheless, it represents a large part of vernacular architecture especially in the flatter part of the country, up to the mid 20th century when it was abandoned. Nowadays, most of the existed earthen buildings in Greece can be dated from the 19th to the mid 20th century and, with some contrasting exceptions, the majority are not in use or have secondary functions, such as storage rooms or stables. In almost every village in the plains there are still remains of adobe structures, most of them uninhabited or used as stables and storage places. Earthen structures are closely related to areas where soil and water (rivers and brooks) were abundant and the availability of stone was limited. Earthen buildings were found on the plains or in semi-mountainous regions. Those on the plains were totally made of *adobe* bearing walls of one, two or occasionally three storeys. For those located in the semi-mountainous regions, usually the ground floor was made of stone bearing walls and the upper was made - partly or fully - with earthen materials; adobe walls and/or mud plaster in fills in timber framed walls, the so-called *tsatma* similar to wattle and daub. As earth was lighter than stone, earthen walls were preferably constructed on the second floor of the building. This structural type was common in areas prone to frequent earthquakes (Bei, 2004).



Two storeys adobe building in Kastaneri village. (photo: Saverio Mecca)
Three storeys adobe building in Kranionas village, municipality of Kastoria.
Sahnissi made of tsatma. Ano Kranionas village, municipality of Kastoria.
Connection between ground and first floor by internal staircase leading to loggia.
Ano Kranionas village, municipality of Kastoria. (photos: Georgia Bei)

Connection between ground and first floor by external staircase.
Kato Elati village, prefecture of Trikala. (photo: Georgia Bei)
Ancient building in Antartiko. (photo: Luca Lupi)

Vernacular architectural synthesis of the earthen dwellings and their structural formation was simple and clear. The buildings on the plains had a massive building form.

In the regions of Thessaly and Central Greece the connection between the ground floor and the first floor was made by an external staircase. On the contrary, in Northern Greece (regions of West Macedonia) the connection between ground and first floor was made by an internal, usually wooden staircase. It was common to build an architectural projection on the upper floor known as *sahnissi* and this was constructed by the technique of *tsatma.* A rich tradition of earthen construction evidenced through the structural and decorative details which are present on adobe buildings in the areas of Florina and Kastoria (northwest of the country). Examples are the decorative borders at the openings of the walls, decoration of the external plaster, known as "comforting arch" made of adobe units on the top of the opening lintels, etc.

Construction techniques and materials

The structural form of an exterior adobe wall, on the ground floor, was massive. In the lower part, the stone foundations extended to a height of 40cm to 120cm, in order to protect the wall of the building from rising damp and rain splashing. Stone on the plains was difficult to find and transportation was expensive. The height of the stone masonry was decided according to the cost the owner could afford. Joints were formed by the same soil of adobe and mud mortar mixtures produced without straw or animal fibres. The *tsatma* of the first floor had a width of around 10 -12cm and consisted of a wooden frame of narrow straight laths placed horizontally every 30-40cm. The empty spaces in between were filled with bits of wood, cane, seaweed, or adobe. The walls had a top layer of mud plaster, which covered all empty voids. Adobe dwellings always had an external plaster.

List of sites of earthen architectural heritage

type	storey	region	prefecture	most characteristic towns/villages
Adobe +tsatma	1 to 3	Macedonia	Kastoria	Korestia villages: Kranionas, Ano Kranionas, Chalara, Gavros, Melas, Ano Melas, Makrochori, Mavrokampos, Agios Antonios
Adobe+ tsatma	1 to 3	Macedonia	Florina	Akritas, Antartiko, Prassino, Trigono
Adobe+ tsatma	1 to 2	Macedonia	Serres	Pentapoli, Gazoros, Nea Zichni
Tsatma on upper floor	1 to 2	Macedonia	Pieria	Paleos Panteleimonas, Ano Skotina, Palei Poroi
Adobe	1 to 2	Thessaly	Karditsa	Karditsa town (sporadically)/Palama, Sykies, Itea, Gourgovites, Myrini
Tsatma on upper floor	1 to 2	Thessaly	Magnesia	villages of Pelion
Adobe	1 to 2	Thessaly	Trikala	Kato Elati
Adobe + tsatma	1 to 2	Central Greece (Sterea Hellas)	Phofida	Charmena district in Amfissa town, Itea town (sporadically)/ Sernikaki, Chrysso, Tritea, Agia Eleftheria

Adobe masonry, in almost every region of Greece, was built as a confined bearing masonry with horizontal timber ties, which were either visible at the facade of the wall or not. The timber ties were spaced at 0,70 -1,00m inside the masonry passing at the level of the floor and/or at the openings. They could actually prevent the propagation of a diagonal crack in the wall and avoid demolition during seismic action (Bei, 2007). This characteristic – the ability of the disparate materials, each of relatively low strength - adobe and timber, to work together as a single system to resist catastrophic damage from the overwhelming forces of earthquakes – is what makes these buildings so important (Vissilia, 2010).

Problems of restoration

When modern concrete structures overran even the remotest part of the country in the 1950s, earthen construction ceased with a subsequent loss of expertise. When damages appeared on the earthen walls, the common practice was to demolish them. The repair and maintenance of the earthen vernacular heritage has relied on the use of inadequate techniques, with incompatible materials usually damaging the existing earthen walls. Consequently, these masonries were considered as inadequate structural systems. Earthen vernacular buildings are considered to be related to poor living conditions and inferior social classes. That is why they are underestimated and easily fall into ruin when not used. That decay is due to the cultural problem of the underestimation of earthen architecture and in this respect regulation and craftsmanship have important roles to play (Bei, 2006).

Perspectives

Since 1995, researchers at the University of Thessaloniki have been working towards the conservation of earthen architecture and the construction of modern earthen buildings. The program focuses on the material and structural technology of earthen walls, the stabilization, the grouting processes and the conservation of existing earthen historical buildings. In addition to that, there are some groups of practitioners with eco-friendly awareness organizing workshops, practicing known techniques of earthen construction such as cob and adobe walls. However, the local scientific community needs to be more active and involved, otherwise, if no action is taken, this heritage will not survive more than the next 10 years.

Traditional buildings in Kastaneri. (photo: Saverio Mecca)

Sahnissi (architectural projection) made of tsatma. Village Paleos Panteleimon, prefecture of Pieria.

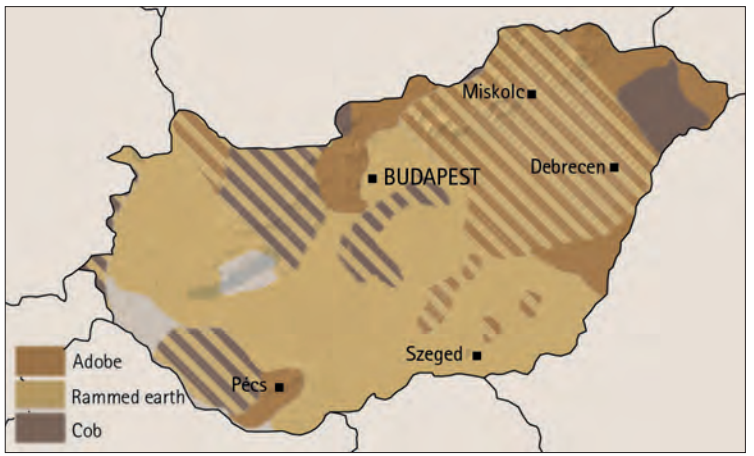
Adobe walls and Sahnissi on the upper floor. Agios Lavredios, village of Pelion, prefecture of Magnesia. (photos: Georgia Bei)

Adobe house in Baté Village. (photo: Fernando Vegas, Camilla Mileto)

Earthen architecture in Hungary

Miklós Buzás
Hungarian Open Air Museum, Szentendre

The use of earth and similar materials is extremely various in Hungarian vernacular architecture. It was indispensable even at the time when wooden construction was still prevailed. It was used in lofts above the boards as insulation material to make the area airtight and to protect it against the cold. Log walls used to be daubed with it and rammed floorings were made from earth. The closing layer of the roof covering of smaller buildings semi-buried in the ground used to be mud and in another type of roof the crest was fixed with mud. Earth used to be the building material for baking ovens, cooking-ranges, fire-benches, and open chimneys. It was generally used as a binding material (even stone-walls were mostly bound with mud) before the spread of lime-mortar and, furthermore, earth achieved fame as a material for building walls.



Earth architecture: construction tradition and techniques

Being a cheap building material, earth gained importance in Hungary only when the purchase of wood became more and more difficult and expensive. During the 18th century, decrees encouraged the construction of the more economical half-timbered houses instead of log houses made entirely of logs, even in regions with sufficient forests. The beams required for these houses had a much smaller diameter than the logs used before.

By the end of the 19th century, the Carpathian Basin became one of Europe's most diversified regions in terms of the use of earth and cob for building walls. Numerous varieties of building technologies were developed depending on the characteristics of the locally available material. The exhibition of buildings, from the end of the 19th century, in the Hungarian Open Air Museum in Szentendre, aims to represent this richness, - hardly noticeable under uniform white-washing.

Half-timbered earthen houses

When constructing half-timbered earthen houses, first the timber frame had to be made. We know different types of this structure. In our earliest examples the frame was made of posts, eventually a frame with closely set posts, while later the timber-framed wattle walled-houses on ground-sills became popular in large areas. The manors of the region of Kisalföld show frame structures with timber set on the ground. The timber is fixed to the beams with angle-braces. At the end of the 19th century, we witness the spread of frame structures even in thick walls, which carry the roof and protect the wall against rain during construction.

Straw clay wall

The best known and perhaps the most popular among earthen walls in our country is the straw clay wall. The cob wall is a type of straw clay wall and maybe the predecessor of the adobe wall. Its raw material was prepared like the straw clay. Head-size lumps were lifted with a pitchfork and rolled on straw spread out on the ground. After it had dried for a while, the lumps were placed manually. We know houses erected with straw clay walls built with the help of a cradle in South-Transdanubia. Brick-size lumps of clay were formed and two layers were put in each row between the formwork. These clay walls were constructed from clay mixed with chaff. This technique of straw clay walls built with formwork shows a strong link with rammed walls. In regions where both technologies were common, people considered straw clay walls made with a cradle older and its use died out only in the 19th century.




Rammed walls. (photo: Kisalföld c. 1930)
Half-timbered construction with cob wall. (photo: Hajdúhadház c.1940)
Rammed wall. (photo: Great Hungarian plan c.1930)
Half-timbered house with adobe wall. (photo: Hungarian Open Air Museum, Szentendre 1972)

Rammed earth walls between boards

The preparation of rammed earth walls required earth-wet clay with very negligible shrinking properties, not containing bigger pebbles than 25-30 mm. Wood formwork was set in two different ways, both in the case of straw clay and rammed earth walls. On the banks of the Danube and to the east from the river, pairs of posts were fixed in holes dug in the ground, facing each other on both sides of the wall to be built. The distance between them was about one to one and a half meters. The posts were tied together on their tops with laths or ropes and they served as support for the vertical boards. In other parts of the country, the formwork was held by stakes that passed through the wall, leaving afterwards the characteristic holes in the wall.

Rammed earth walls between wattle

A special tool was in use in the South-Transdanubian region and in the southern part of the region to the east from the river Tisza. Instead of wooden boards, they used a wooden or occasionally a metal, collapsible frame of laths to fix the cradle. The prints of the laths remain on the wall and disappear only under the daubing. The wall between wattles is similar to the rammed earth wall but its cradle is not made of boards, it is a wattle-work strengthened with stakes. After the ramming of the earth, the wickerwork was not removed. This type of wall could be built also as straw clay wall, when the lumps were placed between the two wattle-works. This method, "the Hungarian style" became well known in the time of the war against the Turkish invaders, when earthwork castles were built, but most probably it was the technology for building castle walls in much earlier times. The rammed earth wall between wattle-works was widespread also in Eastern-Europe besides the Carpathian Basin.

Adobe

Adobe walls had become the most widespread form of earth construction by the end of the 19th century. Adobes are well known in the history of universal architecture, but in Hungary we have no data before the 16th century. We encounter the terminology in written sources for the first time in 1693, but we assume that the word existed much earlier. The hand-moulded adobe is the predecessor of the industrially made building material that plays an important role in the changing practice of house building. As it happened in other parts of the world, raw materials became more and more manufactured products.

Half–timbered transitory structures

It is characteristic of the half-timbered thick earth walls that the frame was made firstfor the strengthening of the earth walls. Timbers (or sometimes brick or adobe pillars) were set up in the corners and in the middle of a long wall. After finishing the roof structure and even the roof covering as well, they started to build the wall. Each region implemented different technologies. We have data on straw clay walls from Martos and Hajdúhadháza, and rammed earth walls were preferred in the northern villages of the county of Veszprém, in Ormánság and amongst the Palóts (inhabitants of Northeastern Hungary). Cob on posts was in use in the Great Hungarian Plain, filled with cob lumps or with straw clay placed with a pitchfork.

In areas susceptible to flooding, half-timbered transitory structures daubed with earth were especially suited to survival. The lofts of these buildings of-

fered shelter for household utensils during the time of floods. When the water washed away the walls, the frame and the wattles were spared. When the building dried out completely, the walls were ready to be daubed again without further damage.

Present situation

Examples of implementations of traditional technologies combined with modern architecture may be found in increasing numbers in Hungary. More and more houses are being renovated instead of being destroyed, and new earth houses are built as a result of the growing popularity of organic architecture and of the ideas of the international environment protection. Adobes have always been used in the Great Hungarian Plain in small numbers but significant publications on the subject appeared after the eco-villages came to public notice. Such an eco-village was created in Gyűrűfű with the renovation of remaining old buildings and several more attempts were made in different parts of Hungary. Thanks to the pioneer work of Balázs Nagy, some straw clay buildings have been erected in Budapest and in its neighbourhood. He tries to create with his designs the type of modern Hungarian "peasant" house. His purpose is not the imitation of old buildings but the preservation of values, which can be used even today: natural materials, system of proportions, organic view. His own house, built in 1973, was nominated House of the Year in Hungary in 1986.

Following local customs and reviving them as an adaptation to the environment, Tibor Jankovics and his colleagues use the technology of rammed earth in their buildings in Keszthely and its neighbourhood.

The Naturbau Ltd. in Zalaegerszeg is combining the traditions of the Hungarian half-timbered earth houses and that of the German Fachwerk houses, adding the advantages of today's modern light cob technology. The walls are made either of adobes or rammed earth. Adobe walls are built faster, dry faster and may be plastered sooner.

For the establishment of new settlements, we have to mention the BioEco system from Hatvan. The developers of the system followed ecological principles. Earth houses are built with pressed earth bricks, which can be produced on the site of the construction.

Conclusion

Earthen architecture in Hungary is an extraordinary case with many different techniques and variants across the geography of the country and throughout its history. The Museum of Szentendre tries to show all this variety in order to sensitize towards the protection of our built heritage and alert against the danger of extinction of all the remaining houses through ignorant demolition and bad maintenance. The present situation of earthen architecture in Hungary suggests that there is a future for both recovering the existing traditional earthen houses and giving this technique a place in contemporary architecture for its ecological and sustainable characteristics.

"Viklis" earthen slab, Hungarian Open Air Museum. (photo: Miklós Buzás, 2004)

Rammed wall in the Hungarian Open Air Museum. (photo: Miklós Buzás, 2004)

Cob house. (photo: Pomáz,1989)

Mud house, plastered with cement.
Thatched roof being renovated, Kilmore Kay, Co. Wexford.
(photo: Marie Chabenat)

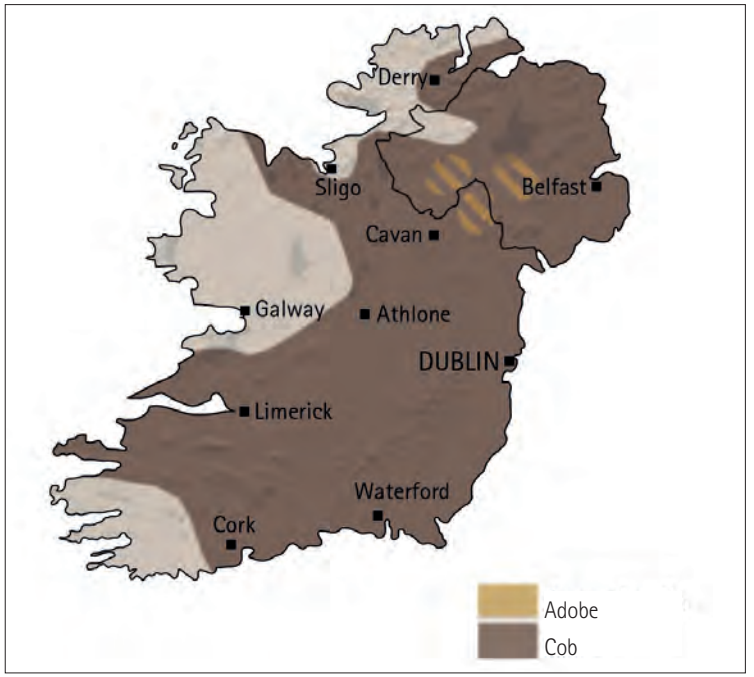
Earthen architecture in Ireland

Barry O'Reilly
National Inventory of Architectural Heritage

Stone and earth (universally termed 'mud') are the two most common vernacular building materials in Ireland, timber or brick buildings being almost entirely absent. Buildings wholly or partly of clay are found throughout the island, usually coexisting with stone-walled buildings.[1] Clay buildings are absent in most of County Donegal, much of Tyrone, west Mayo, most of Galway, north-west Clare and south-west Cork and Kerry, as well as some rugged upland pockets of bog or moorland elsewhere where there was a general shortage of deep soils suitable for the extraction of building clay (Ó Danachair,1957).

There are clear associations between clay walls and hipped roofs and, to a slightly lesser extent, houses of lobby-entry plan (which have a thick hearth wall towards the middle of the house). Structural stability is probably the main reason for these associations. Where clay buildings are gabled the gables may be of stone and internal walls of stone buildings may be of clay. There are thousands of single-storey clay buildings, but perhaps less than a hundred two-storey examples, the latter found in eastern counties.

It is assumed that clay walls were introduced by Anglo-Norman invaders from AD1169 onwards (Gailey, 1984). Travellers and colonial officials from the late sixteenth century onwards make copious mentions of clay buildings. In 1699, there were houses of wattle-work on clay walls c.1.2m high of clay and straw tempered with water (Dunton, 1950). About 1780, a clay house with a thatched roof cost a quarter to a third of that for a stone house with a slate roof (Young, 1979). In 1804, walls cost one-and-a-half times as much as the thatch and just under half the cost of the whole building (Coote, 1804). About 1814 clay houses were praised for being 'neat, [clean] and commodious…the surprising expertness with which [clay] is handled, and moulded into habitable form, makes [stone] altogether unnecessary. With a compost of moistened clay and straw, without plumb, square or level, but merely… a sprong [hay fork]…every man is capable of erecting a house for himself, compact and perpendicular' (Doyle, 1868). In the Census of Ireland, 1841, clay buildings accounted for about half of all rural houses.



Preparation of the clay material

Clay for a building was dug with spades from the subsoil (termed 'yellow clay' or 'channel') of a communal pit (within c.200m) or from the site itself (perhaps explaining why houses are often built in a hollow). Lumps were broken down and stones larger than c.25mm discarded. Water was added to the clay and the mixture kneaded to a doughy consistency with pitchforks and shovels. Otherwise the mixture was trampled with bare feet, or cattle or sheep driven through it, or horses or donkeys ridden through. It was reinforced by adding in rushes or cereal straw, hay or coarse grass, twigs or furze as the mix was turned over. Lime and cow-dung might also be added and there are traditions of using milk, buttermilk, ashes and animal blood. The mixture was

[1] In north County Dublin clay buildings account for 35% of vernacular buildings, composite clay/stone 20% and stone 45% (O'Reilly,1991).

Mud house, plastered with cement / Kilmore Kay, Co. Wexford.
The mud house of an old farm / Poulwitch, Mayglass, Co. Wexford.
Two storeys mud house, plastered with cement / Next to Kilmore Quay, Co. Wexford.
(photos: Marie Chabenat)

left for a few days to temper ('sour'), to absorb the moisture, and was turned over occasionally. More water was sprinkled on and the mixture again left to temper for a few more days until firm enough to use in construction.

Wall construction

Wall trenches c.45cm wide were dug to subsoil level and filled with stone. Generally a foundation of clay-mortared stone, usually uncoursed, was built to c.30-50cm above ground (but sometimes up to 100cm) and averaging 60-70cm thick (but more broadly 45-90cm). The top course of stonework was left irregular to key in the clay which was heaped on top with pitchforks or shovels and the material beaten down to improve adhesion. Instances of shuttering are rare but found throughout Ireland (Fairon, 1988). Instead walls were built c.1.95m high in layers ('lifts') 30-45cm high and c.5cm wider than the required thickness to allow for drying and beating down. When hardened each layer was pared to the required thickness with sharp spades, the parings being recycled into the mixture.[2] Chopped straw, rushes or twigs were sprinkled over each layer (for adhesion) which was allowed to set for one to two days, depending on weather, to harden. Seashell, animal hair, pebbles and crockery were also used (the latter two perhaps accidentally incorporated).[3] In some districts walls were formed around timber posts, though this was more common for partition walls.[4] Some buildings have composite walls: clay over 1-1.5m stone, clay upper gables to stone walls, clay walling sandwiched within stone, or stone within clay.

Walls were often tapered ('battered') and in 1802 a graduating thickness of 70cm at the base to 55cm at wall-head was recommended (M'Evoy, 1802). Battering is more evident externally, but in some districts was more often internal (Sheehy, 1970). Strong twigs or pieces of wood were often fixed into corners to strengthen these vulnerable points against movement.[5]. Rounding

[2] In parts of Armagh at least a spokeshave-like tool c.45cm long, with a handle on each side, was used (Fairon, 1988).
[3] An analysis of samples of clay from clay walls gave: fine sand (30%), small residual stones (25%), coarse sand (20%), clay (20%), straw (1%) and water, etc. (1.5%) (Hughes, Lantry and Marshall, 1995).
[4] Clay has also been noted as a packing material around the timber uprights of the internal partitions of 17th and early 18th-century houses (O'Sullivan, 1974-5)
[5] In Armagh wires were used to provide reinforcement (Fairon, 1988).

also helped prevent damage, and a large stone was placed to deflect cart-wheels and animals. Window and door openings were given rough timber lintels and jambs, sometimes lined with boards, or window openings filled with turf sods. Frames were inserted when the walls were complete. Jambs were often lined with stone (or later, brick), and fireplaces likewise. Stone pads of c.30cm square were placed in the walls to cushion the feet of the roof timbers positioned below wall heads (there being no wall-plates). A wide external overhang of thatch protected the walls. A lime/sand plaster c.10mm thick and a coat of whitewash was applied, although a plaster of clay, chopped straw, animal hair, lime or cow-dung might be used. Many clay houses have a wind-break at their entrance, a vulnerable point, and buttresses (horizontal and/or vertical) are common additions. In south Ulster some houses are entirely of 'clay lump', i.e. blocks c.10cm thick and c.30-50cm long, although it is more common in upper parts of walls, especially partitions and peat (in Ireland, 'turf') was similarly used (Evans, 1980). A large proportion of stone-walled houses predating c.1850 have clay-mortar joints.[6]

Other uses of clay

Chimney canopies partly of clay are well known. They were made of wooden uprights and willow or hazel rods to which hay rope soaked in semi-liquid clay was woven; when dry a plaster of clay was added inside and out (Ó Danachair, 1946). Floors were formed by removing the topsoil and replacing it with clay which was then trampled down (Fairon, 1988). The 'house warming' and other gatherings (house dances and masses) helped to consolidate the floor of the main room (kitchen). In the *stapple thatching* of counties Down and Dublin stone-free liquid clay was applied in layers c.5cm thick as a fixing (Buchanan, 1957, O'Reilly, 1990).

Future prospects

In 1942 a proposal was made to the State to encourage the use of clay for building because of its widespread availability and low cost, and arguing that clay buildings were superior to many modern, thin-walled houses, and that thatched clay buildings 'could remain a characteristic feature of the Irish landscape' (Gibney,1942). The proposal fell on deaf ears, perhaps explaining why modern construction in clay is almost non-existent. However, a recent project to conserve a farmstead of c.1700 has developed the skills and materials needed for the repair of old (and the construction of new) buildings of clay (Reeners, 2003). Although interest in earthen construction is currently less in Ireland than it is in the neighbouring island of Britain, training initiatives are increasing. Examples are The Hollies: Centre for Training in Practical Sustainability at Enniskeane, Co. Cork; and The Village, an eco-village at Cloughjordan, Co. Tipperary. This modest revival has been influenced by practitioners from Britain, such as Kevin McCabe, an earth builder from Devon, one of the professionals who has taught earth construction and repair. This has allowed Irish builders, such as David Brickenden from County Clare, to develop their skills and to contribute to the maintenance and repair of Ireland's earthen architectural heritage.

Contemporary mud house (self built) / Owning, Co. Kilkenny.
The mud house of an old farm / Poulwitch, Mayglass, Co. Wexford.
Farm building/ Limewashes detail / Effin, Kilmallock, Co. Limerick.
Sample of lime plasters on clay walls / Traditional Lime Company / Tullow, Co. Carlow. (photos: Marie Chabenat)

[6] An early instance was found in archaeological excavation of two 13th-century houses at Caherguillamore, Co. Limerick (Ó Ríordáin, 1942). Two houses dated c.1250-1300 and 1300-1350 and probably of mud built on a timber frame (Clery, 1988).

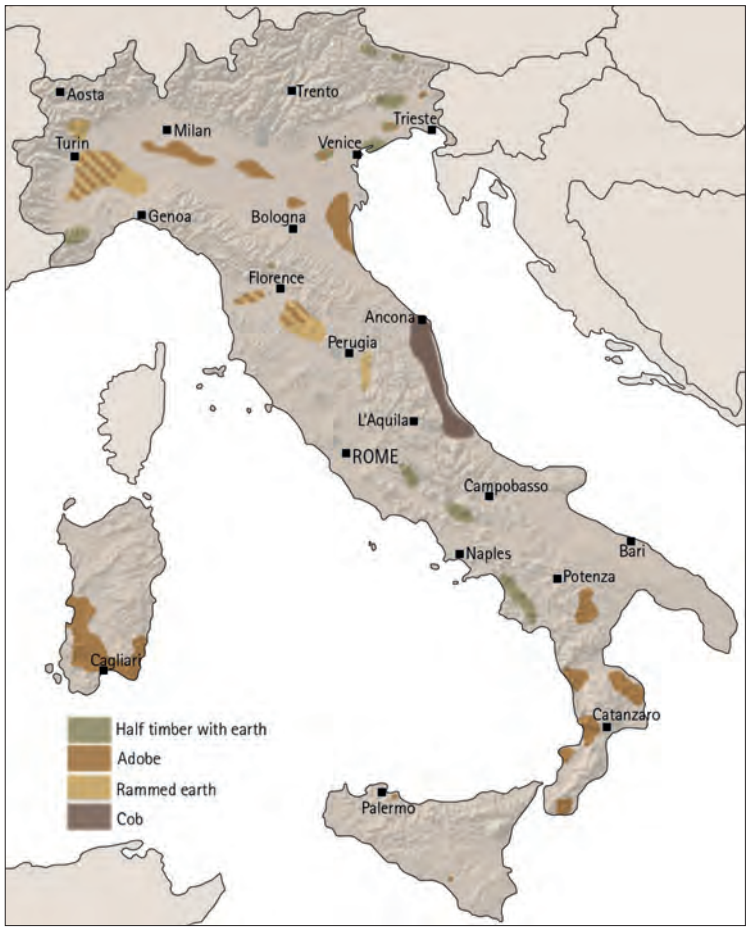
Rammed earth farmhouse, Piedmont. (photo: Isidoro Parodi)

Earthen architecture in Italy

Letizia Dipasquale
Saverio Mecca
Università degli Studi di Firenze

A culture of earthen buildings has existed in Italy since ancient times, with influences from the Middle East, North Africa, and later from the Transalpine area, the Balkans and Spain.

The earliest records of earthen buildings, belonging to the Etruscan civilization, may be dated between the 7th and 6th century BC. The use of earth developed significantly during the time of Greater Greece, when adobe was used for the construction of public buildings and fortified walls. Two examples of earthen fortification are admirable: the fortified city wall of Gela in Sicily, 3 m thick and 8 m high, composed of a stone foundation enclosing a compacted mixture of earth and rubble, and walls made with adobe squares (40 cm x 40 cm), and the rampart of Reghion (Reggio Calabria), built in the same manner, with rammed earth in the middle of two rows of bricks on the higher part. Earth as building material was used in Italy up until the mid-20th century, when sustained economic growth and changing living needs lead to the phasing-out of the constructive techniques and to the disuse of existing earthen buildings, considered as poor constructions inherited from the past. The geographer Osvaldo Baldacci, describes the distribution of earthen buildings in the 1950s, which embraces the whole country, with a predominantly rural use and some examples of urban settlements, as in Sardinia, Calabria and Piedmont.



Cascinali Pagella, Piedmont. (photo: M. Chiara Robboni)

Building techniques and materials

Adobe

In Italy, the presence of adobe constructions is most widespread in the southwest of Sardinia and in the region of Calabria. Some adobe constructions have been identified in rural areas of Lombardy, in the Piedmont, Emilia-Romagna, Tuscany, Lazio and Basilicata regions.

In the Sardinia region, adobe (*ladiri* o *làdri*) constructions are historically and currently present in the Campidano plains, a vast area of alluvial origin, dating from the Spanish occupation of the 15th century up to the middle of the 20th century. The typical building is called *domu* and consists of single-floor




Adobe wall, IV century B.C., Gela, Sicily. (photo: Letizia Dipasquale)
Adobe wall in Pimentel, Sardinia. (photo: Silvia Onnis)
Adobe wall in Lamezia, Calabria. (photo: Letizia Dipasquale)
Adobe wall section with "Civatura" rendering, Lamezia, Calabria. (photo: Ettore Pelaia)

constructions, arranged around one or more courts for agricultural activities. In Calabria traditional adobe is known as *vriesti*, *bresti* or *mattunazzu*. Earth mixed with straw or chaff is used in the Crati valley, coarse-grained earth rich in sand and gravel mixed with lime around Reggio, fine-grained earth in the Lamezia area. In Lamezia aristocratic buildings with internal courtyards and terraced houses were built with a foundation of masonry stone and adobe masonry on the uppermost floors, as well as for the interior walls. It is common to find even modest structures and large noble palaces covered with a rendering, known as *civata* or *civatura*, made with tiles and stone fragments bound by lime.

Rammed earth

Rammed earth is consistently present in Piedmont, around Turin and especially in the province of Alessandria. Here countryside farmhouses and both private and public buildings- such as schools and churches- still coexist (Bollini, 2009). Dry earth, with humidity up to 10-15%, is beaten in thin layers inside wooden formworks. The wall is built following a spiral course, in order to have a firmer construction. Also adobe is used, mostly in foundations, corners, arches, vaults, and in the inner part of the wall, difficult to achieve with formwork.

In Tuscany (in the area of Val di Chiana, Val d'Elsa, Val d'Arno, San Miniato and in other inland parts of Pisa) we find rural and rustic dwellings in rammed earth, mostly dating back to the 13th century. Earthen architecture here is not valorized yet, in fact in the urban context the presence of rammed earth is often unknown and rural buildings are frequently abandoned or used for service spaces.

Half timber with earth

The wattle and daub technique was used by the Etruscans to build elliptical or oval huts and by the Romans, who constructed buildings *a graticcio*. The buildings were composed of a structure in wood, filled in with an earthen plaster with straw.

Today, a few examples of wattle and daub rural buildings, with a straw roof, can be found in the north of Italy (the Alpine zone, Veneto, Friuli Venezia Giulia) and in Lazio, where the *fratic*ci consists of vertical posts and horizontal poles tied together with wickers, on a stone foundation, filled with chestnut, oak or elm branches and interlaced canes (Beranger, 1995).

In Calabria, after the earthquake of 1783, "case baraccate" were built with a wooden frame, with vertical, horizontal and oblique chestnut or oak beams placed at a distance of roughly 1.20m to create a cross structure. A weave of wickers and reeds is yoked to the main structure with thin chestnut laths and is covered with an earth mortar. In some cases adobe fills in the structure. For the interior walls the "incannicciato" technique is frequently used, a mesh of interwoven canes or branches covered by a clay plaster.

In Veneto, the traditional rural buildings, called "casoni", are composed of a wooden structure with adobe filling and a high spire roof, covered by straw and ditch reed (Bertagnin 1999). Today only three examples of these buildings, transformed into museums, survive.

Cob

In Italy there is a consistent presence of cob in Abruzzo, probably introduced by Christian immigrants from the Balkan territories (Galdieri 1982) and in the southern Marche region.

The Cob technique, locally denominated *massone*, consists in the mixing of the earth and straw until lumps are formed, which are then piled up and pressed together to build the walls. The earthen rural houses are called

pinciare in Abruzzo and *atterrati* in the Marche region; buildings have on the ground floor spaces for agricultural products and cattle, while the upper floor is given over to dwelling and accommodation. An over-lapping roof is often used to better protect the top of the cob walls.
In the town of Macerata, a rare example of urban settlement, *Borgo Ficana*, from about the middle of the XIX century, survives. It now consists of about sixty terraced houses, recently partially restored and employed for cultural use.

Present situation

As in other countries, in Italy a new interest in earthen constructions spread from the 1980s, thanks to the impulse from the academic world and international institutions for the safeguarding of heritage and to the initiative of local authorities. A great number of universities, most of which grouped together in the UNIVERSITERRA foundation as from 2001, a research and information network of 7 Italian universities, have developed in the last 20 years research and awareness programs for their students on building culture, structural behavior of the earthen construction and innovation in the use of the material.
Among the institutions most active today in the field of valorization of earthen architecture we may mention: in Abruzzo the *Centro di Documentazione Permanente sulle case di terra* of Casalincontrada (Chieti) founded in 1993, which has an important role in the dissemination of information, and hosts every year the *Festa della Terra* forum; in Sardinia the *Centro Studi e Ricerche sull'Architettura Regionale in Terra Cruda,* working at the Architecture Department of Cagliari University since 1997 and the *Rete dei Comuni della Terra Cruda*, a network initiated in 2000, that links those towns characterised by an earthen architectural heritage. An important result reached in Sardinia, through the collaboration between the University and the Region, is the "Manual of Rehabilitation of the historic centers of Sardinia" (2008), an in-depth analysis of building culture which provides guidelines and specific intervention on earthen heritage.
Unfortunately, this increasing attention collides with a low economic interest and legislative framework that discount earth as a building material. Very few professionals are dedicated to new architectures with earth as a material, which is used mostly as plaster, or as fill in wooden or concrete frames. Awareness towards earthen heritage is sustained by some regional laws for the valorization and rehabilitation of earthen buildings (in Abruzzo R.L. n.17/87 and 5/2001, in Piedmont R.L 16/2006) that promote the knowledge of existent heritage and give incentives for census, investigation into techniques and intervention of restoration. In 2002 a national bill ("Normative to support raw-earth buildings and raw earth as a building material") was introduced to the Chamber of Deputies of the Parliament but is still being evaluated. We trust in the increasing process of preservation and valorization of earthen architecture in Italy, and at the same time the prompt development of a specific normative to add earth as a building material to new buildings and certify its safe use.

Sa domu 'e Nannai, Museum of Popular Traditions, Samassi, Sardinia. (photo: Silvia Onnis)

Isolated adobe house near Lamezia, Calabria. (photo: Ettore Pelaia)
Massone at Morro d'alba, Ancona, Abruzzo. (photo: Eliana Baglioni)

Rammed earth dwelling for a church sexton, built in the 1st half of the 19th century, Kurland, Mežotne district. (photo: Mārīte Putniņa)

Earthen architecture in Latvia

Peteris Blūms
Architect in Riga

Geographical context

The Latvian landscape was formed during the last ice age melting process (about 10,000 years ago): sand, gravel, clay and sedimentary rocks formed hillocks. Clay of varying quality, which can be used for construction, occurs almost throughout the country. It can be collected from the very surface of the soil, which earlier was used for road construction and farming needs in rural areas.

History of building

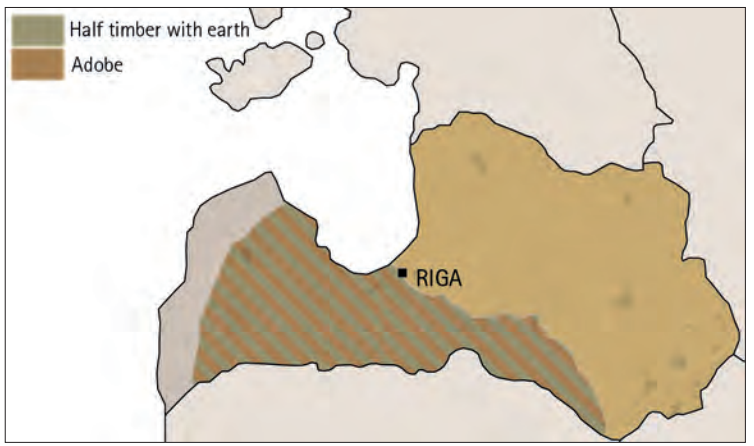
The earliest evidence of clay use in ceramic pots was found in archaeological excavations of the Neolithic era settlements, but inside buildings it was first used only for floors and fireplaces. Since the Iron Age, clay was used in log houses to insulate walls and plaster façades. Research works and excavations in medieval castles[1] of the Livonian Order[2] showed that for repairing and rebuilding them during the 16th-18th centuries, different clay materials were used such as adobe bricks, clay - earth fillings, clay plaster, fire safety insulation of wooden ceiling constructions, brick in fill of half-timbered constructions. This was most common in the southern and southwestern part of Latvia – in the territory of former Duchy of Courland[3], while in the northeastern and eastern regions of Latvia it seems it was not very popular.

Historian and ethnographer Uģis Niedre, working with historical archives over the years and through other intermediary studies on various issues of Latvian history, came to some conclusions which can be used in this review:

[1] On the Latvian land since the beginning of the13th century approximately140 stone and brick castles and forced estates were built. Today we have less than 20 left, mostly as ruins, 6 are in use.

[2] The Livonian Order - an autonomous Livonian branch of the Teutonic Order and a member of the Livonian Confederation from 1435–1561, became known after 1237.

[3] The Duchy of Courland and Semigallia (Latin: *Ducatus Curlandiæ et Semigalliæ*, Polish: *Księstwo Kurlandii i Semigalii*, German: *Herzogtum Kurland und Semgallen*, Latvian: *Kurzemes un Zemgales hercogiste*) is the name of a duchy in Latvia that existed from 1562 to 1569 as a vassal state of the Grand Duchy of Lithuania and from 1569, the Polish-Lithuanian Commonwealth. On March 28, 1795, it was annexed by the Russian Empire in the third Partition of Poland.



Rammed earth barn in Lielplatone manor, middle of the 19th century, Kurland, Jelgava district, Lielplatone parish. (photo: M. Putniņa)



Servants house (built around 1800) of Lauciene (*Nurmhusen*) manor after renovation in 2010. Talsi district, Lauciene parish. (photo: Ē. Cērpiņš)

Rammed earth barn in farmstead *Everti*, 1st half of the 19th cent. Vecumnieki district, Bārbele parish. (photo: M. Putniņa)

Cattle shed, built in 1930-ies. Rammed earth walls, concrete window framing. The facade has never been plastered or painted. Rēzekne district, Viļāni parish. (photo: P. Blūms)

- Clay constructions during the 19th century had been widespread in the territory of the Duchy of Courland (now SW and W of Latvia), but not on the Baltic Sea coast, where there were no necessary clay resources, and northern and eastern regions. Clay had been used for construction of numerous estates and farmsteads, but not in towns.
- Clay buildings in Courland were promoted by regional and estate administration by publishing and distributing practical manuals, printed in German, published since the 1830s. It is possible, that their prototypes came from Germany, because most of the local nobility were of Baltic- German origin, who maintained regular contacts with the historical homeland, and many craftsmen and construction masters were also from Germany. This kind of literature was distributed also in the northeastern parts of Latvia, but archival documents show that the construction of earthen buildings in the 19th century was not so popular there.

Lutheran church in Grīvaiši parish, built around 1700. The bell tower has been raised two times, in masonry and wooden construction. Saldus district, Grīvaiši parish.

Rammed earth dwelling house built in 1926 with the specific for Eastern latvia wooden decor around window frames. The facade before renovation. Latvia, Rēzekne district, Viļāni parish. (photo: Blūms, 2006)


The oldest known and still existing building which was constructed with the adobe bricks technique around the 1700s, is the church in Grīvaiši (Grīvaišu Lutheran Church, Saldus region). Another, no longer existing Lutheran church in Dikļi (Valmieras district, Dikļi) was built in 1630 using the rammed earth technique. An unusual example in our climatic conditions are partial but well preserved remains of a massive fence around the park of Rundale Palace, built from 1744 to 1781. Yet a number of 19th century rammed earth buildings have been identified. They are either small farm buildings (warehouses, stables, threshing houses) or buildings of significant size (pubs, cattle stockyards, servants residential building (barracks), churches, chapels, tombs, etc.) belonging to estates or communities. Archival documents show that the number of earthen - clay buildings in Courland was counted in thousands, but probably about 200 - 300 are preserved nowadays, mostly in poor condition. There is reason to believe that in the 19th century rammed earth and adobe buildings belonged to the traditional types of construction outside towns of the southern regions.

A new wave of development of earthen construction came after the establishment of the Republic of Latvia in 1918, and during the 1920s and the 1930s, a series of construction manuals were published, calling peasants to construct buildings themselves, using local resources including clay. During those years the most commonly used technique was rammed earth, with built-in timber frame elements and clay, adding coarse sand and gravel. As reinforcement, organic materials such as chopped straw, heather, pine needles, fir branches or animal manure, were used. Internal walls of agricultural buildings were generally not plastered, but white-

washed with lime. Internal walls of residential buildings and churches were plastered with lime plaster. Facades of that time were either without any exterior trim or were blanched or plastered with lime. Some buildings were built on high stone foundations, with distinct wide roof overhangs, which in our climate is the main guarantee of longevity. Since usually around buildings there formed a "cultural layer", the distance between the soil and the upper part of the stone foundation decreased, thus increasing humidity in the clay wall, which led to a very rapid destruction of the building.

Latvia suffered greatly during the two World Wars, when many roofs of buildings were damaged, emergency repairs were impossible, and for clay buildings in our climate it was fatal. During the Soviet occupation, the earthen building tradition was not renewed. In the 1950s there was a rather high popularity among individual builders for sawdust – concrete buildings, where the filler most commonly used was sawdust, but the binder – lime or cement. This building technique had come to an end by the 1980s.

The current situation

A small number of historic buildings built in clay are listed as cultural monuments, but the specific type of construction is not the main criterion of its value. Earthen buildings are not represented even in the Ethnographic Open Air museum. Watching the methods of repairs of adobe and rammed earth buildings, one can see that in most cases people have no knowledge and the works are carried out without awareness of clay constructions, appropriate repair techniques or materials. Larger losses in wall construction usually happen after repairs with brick mortar, sometimes with concrete. Constructing new or modifying existing door and window openings, owners usually do not consider the technical specifics of clay walls compared to the ceramic brick walls. Smaller wall damages usually occur if walls are repaired using much stronger lime and cement mortars. There are considerable difficulties with plastered rammed earth facades, when rather strong lime plaster is applied in too thick a layer, which after a short time starts to crack and become detached from the wall construction. In some cases reinforcement of lime plaster is carried out with barbed wire instead of iron wire, the barbed wire corrodes over time and develops cracks.

Rammed earth wall construction with fragments of broken ceramic roof tiles. Economy building of Bērzgale manor. Rēzekne district, Bērzgale parish.

Visible levels of the rammed earth wall building process. Rēzekne district, Viļāni parish.

Corner reinforcements with spruce branches in a rammed earth cattle shed, 1930-ies. Rēzekne district, Viļāni parish.

Rammed earth dwelling house built in 1926 with a later barbed wire as reinforcement for plastering with lime plaster. Rēzekne district, Viļāni parish.

Repairs of rammed earth facade, the first layer of self-made clay plaster.

Perforation of clay levelling layer on a historic facade before plastering. (photos P. Blūms)

Rammed earth dwelling house built in 1926. The facade after the removal of damaged parts of the old plaster. Rēzekne district, Viļāni parish. (photos P. Blūms)

Ecological house built with cob, Trakai district. (photo: Ričardas Skorupskas)

Earthen architecture in Lithuania

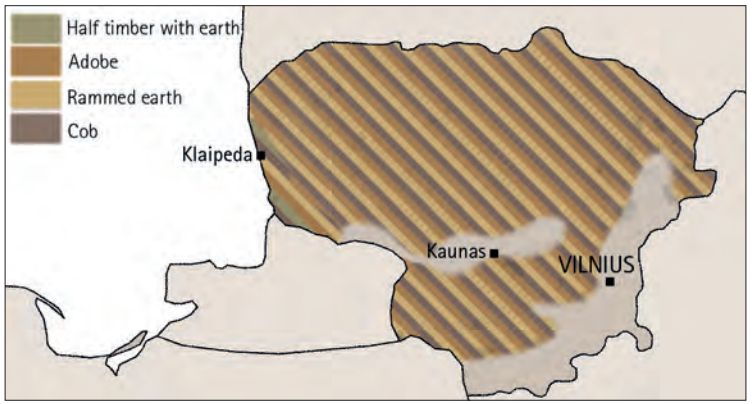
Rasa Bertašiūtė
Kaunas Technology University
Ričardas Skorupskas
Vilnius University

The origins and development of building in clay and its territorial differentiation in Lithuania is immediately related not only to the composition of material on a natural territorial basis, but also to the alternation of vegetation cover (forests as the main source of building materials) in historical perspective. The relief of the present Lithuanian territory was formed during the last ice age. The lowlands are typically solid, of inexpressive relief in large habitats of specific ground compositions. The hilly uplands are markedly separated in expressive relief with different types of ground composition spread about in no particular order. The largest area (55.2%) of the whole Lithuanian territory are the lowlands containing clay and hard loam, these parts being situated in northern Lithuanian, middle, southwest and east.

Containing many upland lakes, the hilly southeastern part of Lithuania (21,2%) has a mixed composition of loam and sandy loam and also loam and sand; loam areas suitable for clay building are scattered and very unevenly situated. The remaining part of Lithuania (23,5%), the flatlands of west Lithuania and southeast Lithuania, are mostly river beds formed from different coarse sand and solid gravel areas, which are not suitable for earthen building.

In the territory of Lithuania, clay in building was used in pre-historical times. Archeological expeditions found pisè buildings where walls were made from wattle and daub. Since ancient times clay was used as a supporting building material for sealing of foundations and walls, and also for tamping of dirt floors, stoves, chimneys, for plastering wooden walls and ceilings.

As a main building material, clay for building walls began to be widely used only in the XIX century. The main reason for this was the overstretching of forest resources in fertile clay and loam areas, which belonged to local squires, this fact being seen particularly in the second part of the XIX century. Replacing wood as a material (which had been the main building material), alternative clay building spread out and at the beginning of the XX century it became the traditional architecture in Lithuanian areas where clay was the dominant ground material.



Non-plastered out-house, made with clay, Rokiškis district.

Dwelling house made with wattle clay, Kėdainiai district, second half of XIX century.






Destroyed windmill in Šlapakiai, Joniškis district. (2003 y.)
Peon house (dwelling house for manor worker) in Maišiagala manor, Vilnius district.
Fragment of barn arch in Musninkai manor, Širvintos district.

Pisè building of Catholic church in Skaistgiris, Joniškis district.
Plastered dwelling house built with clay in the northern part of Lithuania, Gasčiūnai, Joniškis district.
Dwelling house of combined building (brick masonry and pisè) in the southwest part of Lithuania, Griežiai, Šilutė district.

Due to the availability of local building material resources, clay in the XIX century was one of the most widespread building material. In these times new effective ways of building, technologies, materials, were widely discussed as alternatives to the original architectural forms. New solutions of how to build stable, warm, economical, fireproof houses were sought; giving recommendations on how to protect separate parts of the building from degradation, decay and fire. One essential aspect was the economy and frugality of such buildings. At the end of the XIX century, clay building became not only an object of fashion, but also of practicality. The first clay buildings were built on progressive farms, manors and manor detachments and spread later to the countryside. Clay was used to build living-houses (peon houses, inns, rectories), out-houses and manufacturing houses (barns, cotes, smokehouses, windmills) and churches (Skaistgirio,1827). At the end of the XIX century, clay building became more and more popular, especially in those parts of Lithuania where there was a lack of wooden material: middle, northern and southwest parts of Lithuania. Such type of building was common among rich farmers, owning a large labor force and large infields.

In the XX century, interest in alternative clay building grew. Building of outhouses was very intensive, dividing villages into farmsteads (1920-1940). During the interwar years, clay was used more for building outhouses than for dwelling houses. According to the 1930 agricultural inventory data, housing combining buildings of clay (including wood and bricks), which is common only in the southwest part of Lithuania, numbered 9023 (or 3.07 %), and outhouse buildings 47726 (or 7.48 %). Typical clay wall technologies in Lithuania are: wattle, adobe, wattle and daub, carcass, where space in between is filled with cob or bricks, and adobe bricks.

The well thickness of dwelling houses in Lithuania is 60-70 cm, very occasionally up to 80 cm, and 40-60 cm for outhouses. To make a wattle (adobe) wall is simple and economical, up to 90 % of all buildings are made in this way. To make walls warmer and suitable for the Lithuanian climatic conditions and also less deformed when drying, clay is mixed with straw, heath,

flax or hemp hards, small branches, bristle, manure and other fibrous organic material. The clay material would be prepared nearby: the sides of excavation were wattled with switches, the bottom was paved with boards. Oak or pine rollers with wooden teeth powered by horses were used to blunge the clay.

Blunged and mixed with fillings, the clay mass was wattled up to 4-6 layers on a stone or concrete foundation, leaving holes for doors and windows. The corners of the house were sometimes reinforced with tree branches or brushwood for stability. Wooden boxes were placed in the holes for windows and doors, and reveals were sometimes laid with bricks. When the walls were ready, the roof joists were fixed. To finish the building of such houses, walls were rubbed down with special axes and plastered after a year. The plaster mix was prepared from clay, lime, sand and horse manure. To make a wall more water-proof, the wall surface was plastered with a mix of lime and ground encaustic bricks, and less commonly a mix of soil and lime-sand. Whichever technology is used, clay houses are warm, durable and long lasting, if the walls are protected from precipitation, built on a high foundation and covered with proper roofs.

Dwelling houses were mostly built with the wattle and adobe technique, out-houses (barns, granaries, garners, stack yards, storehouses) – with the wattle or mixed (clay and wood, clay and stone or bricks) technique. Walls of out-houses were often built in clay with piers.

During the period of the Soviet occupation, clay building was forgotten and most earlier built houses were destroyed during the liquidation of farmsteads, those buildings which survived appear in very bad condition. Building in clay revived after the independence, but not to the same degree as it had been during the interwar years. The first wave of clay building corresponds to the economic blockade of 1990-1994, when due to a lack of building resources, building from local-natural materials was popularized; in this way several single buildings were built. The second wave of such building (from 2006) is connected to a raised public awareness and ecological consciousness of those wishing to live in healthy environmentally friendly homes. Though clay building in Lithuania has deep traditions, it is also advanced and modern, economical and ecological. The technology of such building requires special knowledge, a large labor force, there are no standardized items, there is a lack of well-trained experts, and as a result, clay technology has not been so popular in latter-days.

Facade of modern house in Vilnius (2010). (photo: Algimantas Dailidavičius)

Modern architectural clay-type dwelling house in Vilnius. (photo: Algimantas Dailidavičius)
Ecological dwelling house built with cob, Trakai district. (photo: Ričardas Skorupskas)

Rammed earth wall for a House in Winseler. Building company: DRUWID. (photo: Michael Thönnes)

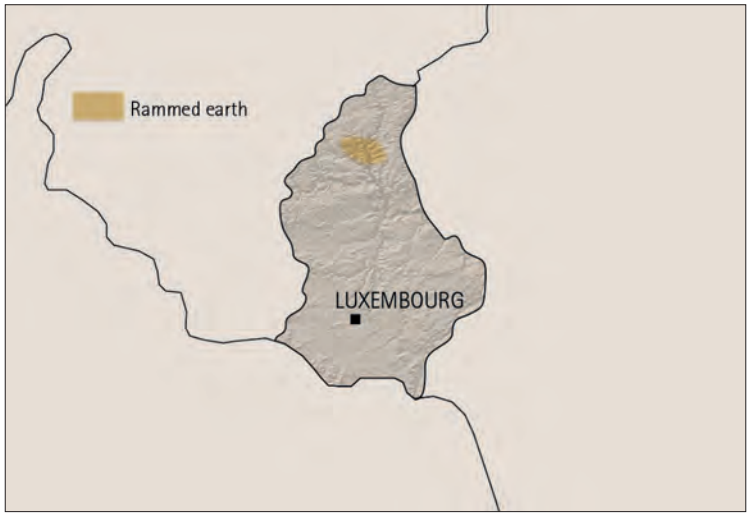
Earthen architecture in Luxemburg

Mariana Correia
Escola Superior Gallaecia
Michael Thönnes
Druwid company

Earthen heritage

Earthen architecture in Luxembourg is very residual. Several entities, such as the National Committee of ICOMOS-Luxembourg, the Department of National Sites and Monuments *(Service des Sites et Monuments Nationaux)* and the Tourism office acknowledged the lack of earthen construction in Luxembourg. The president of ICOMOS-Luxembourg sustained that there was probably earthen architecture in the past, but further research should be address. Andréa Rumpf, head of the Luxembourg Foundation for Architecture and Engineering, maintains that the lack of earthen architecture evidence is due to the fact that there is no Faculties of Architecture in the country. The absence of architectural research centres in association to universities causes difficulties in developing scientific and methodological architecture investigation.

In August 2010, in the framework of Terra (In)cognita project, Mariana Correia and Jacob Merten carried out an explorative scientific mission to Luxembourg. Several national entities and Eco-museums were contacted, but regrettably, earthen architecture was only identified in a rural wall of rammed earth. This wall was observed in the north, at Munshausen, in Duerefstrooss, Canton de Clervaux. It was also detected in the area, the common use of earthen plasters and mortars in rural heritage. These evidences prove the existence of earthen heritage; however more research should be address.



New earthen architecture

On the outskirts of Ettelbruck city, the company of Active.lu (www.active.lu) managed by Carlo Posing is currently building two semi-detached houses. These are being built with a timber-framed structure, without nails, and with traditional earthen mortars and plasters.

The Belgium office of DRUWID (www.druwid.com), located 30km from the border, has built a number of new earthen dwellings in Luxembourg. Their first project started in 1999 at Medernach, Canton de Diekirch. It was a renovation of an old farm. The new parts were built with an in fill of clay and wood chips. The interior of the dwelling was renovated in adobes and earthen plasters. A green roof contributes for the ecological approach.

A second project constructed in the Grand Duchy was built in 2006-2007. The house located in Roulingen, Canton de Wiltz. This passive designed house for handicap was built with an in fill of clay and wood chips, and plastered with earth. Another project located at Nocher-Route, Canton de Wiltz, entailed an interior renovation, with clay panels, adobe and rammed earth walls, as well as earth plasters.

Presently, there is a project under construction at Winseler, Canton de Wiltz, also in construction by the DRUWID office. A family house with an

organic concept, having a 20 m3 rammed earth wall at the centre of the dwelling. It was then surrounded by a half timber structure with earth plasters.

Since 1998, aproximately 30 houses were renovated in Luxemburg, mainly using earth plasters with colored clay. This was made in cooperation with the Luxembourg firm Oekobati Troisvierges. DRUWID also organised some international workshops on rammed earth, earth plastering and the restoration of half-timber dwellings with wattle and daub in fill. Participants came from Belgium, Luxembourg, Germany, Holland, Switzerland and Austria. The two last workshops received more than 20 people from Luxembourg. Architects, self-builders, company managers and interested people attend it, which illustrates an increase of interest and awareness of earthen architecture in Luxembourg.

Exterior of a passive designed House in Roulingen.
Rooftop Detail of a passive designed House in Roulingen.
Interior of a passive designed House in Roulingen.
Architects: DRUWID. (photos: Michael Thönnes)

Old farm renovation at Medernach. Building company: DRUWID. (photo: Michael Thönnes)

International workshop on rammed earth; organized by DRUWID company.

Old farm renovation at Medernach.
Interior renovation at a House in Nocher-Route.
Building company: DRUWID. (photos: Michael Thönnes)

Walls of Gozo with earthen mortar. (photo: Saverio Mecca)

Earthen architecture in Malta

Maria Mifsud
ICOMOS Malta

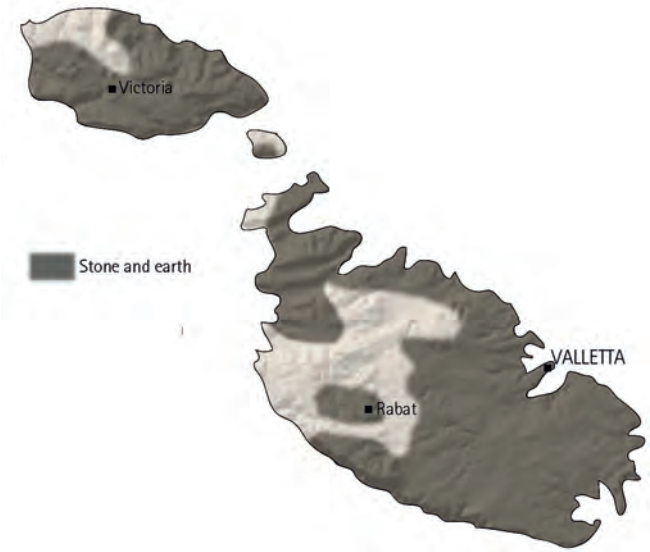
Since prehistoric times, the prime source of construction material in Malta has been stone, mainly dry stone but also associated with mud as mortar or internal core of the walls.

The main building material of Malta was always limestone – which was abundant in supply especially in older times, when the Maltese landscape was dry and rocky with only a few settlements.

The masonry elements were used for construction of rural and residential settlements as well as places believed to be places of worship, such as the prehistoric "temples". A softer limestone, the *franka*, or Globigerina Limestone, is easier to work with and cut or sculpt. However there are four main other strata of stone within the geology of the Maltese islands: the Upper and Lower Coralline Limestone, which is harder to cut, the Greensand, and the Blue Clay – the latter being unsuitable to build on and found predominantly on the Western part of Malta and the North-Eastern part of Gozo.

Limestone is used not only to cut blocks from, but "lime kilns" were also very common in Malta to produce lime building materials. This mixture is typically mixed with sand to produce a mixture or paste which is what we know as mud, or *taino*. Earthen mortars were produced using clay soil and crushed Globigerina Limestone. Typically, crushed lime, locally known as *torba*, was used as a screed for floors and levelling out. For mortar mixes, p*ozzolana* or *deffun* (ground pottery) was added in order to increase the hydraulic and waterproofing qualities of the mortar.

Many lime products are still thought and known to be the best materials in conservation and restoration practice today. Nowadays very few lime kilns still exist and function in Malta.



Aerial view of Hagar Qim in 1951. (source: National Museum of Archaeology)

Prehistoric Architecture in Malta. The Temple Period

One can find a number of remains of prehistoric architecture scattered across the islands. Megalithic architecture, such as the prehistoric tem-

Wall with earthen mortar in Malta. (photos: Maria Mifsud)

On the left: Section of a wall with earthen mortar in Gozo. (photo: Saverio Mecca)

ples of *Hagar Qim* and *Mnajdra* in the South of Malta, and *Ggantija*, in Gozo, demonstrate the use of local globigerina limestone not only in large scale blocks, but also as "plaster", or in the form of the so-called *torba*, as well as a "capping" method for prevention of water seepage, the traditional *deffun*.

When a number of prehistoric sites were excavated in the 19th and 20th centuries, they were dated by the pottery and clay materials recovered from excavations. *Torba* floors, floors with crushed limestone, and traces of mudbrick walls, were also an indication of the building materials used in one of the oldest of "phases" of unearthed sites.

Remains of a medieval rural Settlement: *Simblija*[1]

There is little documentation, if any, of settlements in Malta before the 15th century. However there lie the remains of what was a settlement around 1000 years ago: *Is-Simblija*, located just outside the limits of a small village called *Dingli* in the Western part of the island, surrounded by typical terraced farmland and countryside.

This settlement includes an old bakery, an old chapel, some small residential rooms, a room believed to function as an animal enclosure, or manger, a small piazza and the remains of the trail for cart-ruts. The construction methodology consists of double leaves of masonry also with a *mazzkan* type in fill, resulting in thick walls tucked like niches within the rock – almost like caves. *Mazzkan* is a traditional type of in fill that was used to fill

[1] The name *Simblija* is believed to derive from the corruption of the Italian word *Assemblea*, which in turn refers to the *Veneranda Assemblea di San Giovanni*, the Conventual Chaplains of the Order of St. John.

Dwejra Tower, Gozo.
Torri Mamo, Marsascala.
Sta Marija Tower in Comino.
(photos: Maria Mifsud)

thick walls – typically made of crushed stone and soil. This is also typical in traditional farmhouses in Malta.

The traditional Maltese farmhouse

Typically, the Maltese farmhouse was constructed in limestone masonry thick walls, with a *mazzkan* in fill, and roofed over using stone slabs, called *xorok*. In order to span over wider rooms, sometimes rooms used for the keeping of animals, the stone slabs would be spanned using *kileb*, which is similar in use as the corbels.

The traditional Maltese farmhouse typology not only depended on climatic factors, but also very much on the social and economic factors of the time. The farmhouse was typically built directly on rock foundations and with minimal windows on the facade, and an inwards central courtyard, thus allowing more security from passers-by. Most farmhouses also were all built on ground floor, indicating firstly the intended function of the farmhouse to cater predominantly for animal husbandry and secondly the poor economy which did not permit farmers to construct an upper floor.

As most vernacular architecture, the traditional farmhouse was also constructed in such a way to embrace the sunny climate as well as to shelter from mild winters and hot summer temperatures – hence the use of the courtyard for daylight, and the surrounding covered passageway, locally known as the *loggia*, for shelter from direct sun and rain.

Fortress Building in Malta. Military Architecture

An important aspect of military architecture lies in the recognition and knowledge of the building materials to use them in the best ways for fortresses and other buildings in the defence system, such as coastal towers that are found along the coasts of Malta, Gozo and Comino.

Most of the walls were built using predominantly Globigerina limestone, since it was faster, easier and therefore cheaper to quarry and cut, it being the softer stone. The Lower Coralline limestone, also called *Zonqor*, was used predominantly in the lower courses to act as a natural damp-proofing since this type of stone has lower capillarity and lower moisture-absorption, thus resulting in a slower rate of deterioration of the stone.

Spijk Cemetery wall, 2009. (photo: Leemwerk/Pieter Boer)

Earthen architecture in the Netherlands

Sjap Holst
Eco-Design
arTchitecture
Charles Thuijls
Earth builder, Vof LEEMWERK

History

In the hilly south part of the province of Limburg, wattle and daub was commonly used for dwellings. Several earth villages and farmhouses with hundreds of years old are located all over this region and are still inhabited. More downstream of the river Maas, the country becomes flat and many brick factories were located along the riverbanks in the provinces of Brabant, Utrecht, Gelderland and Overijssel in the centre-east part of the country. In those regions traditional earth building (wattle and daub as well as unfired brickwork) was gradually replaced by fired brickwork.

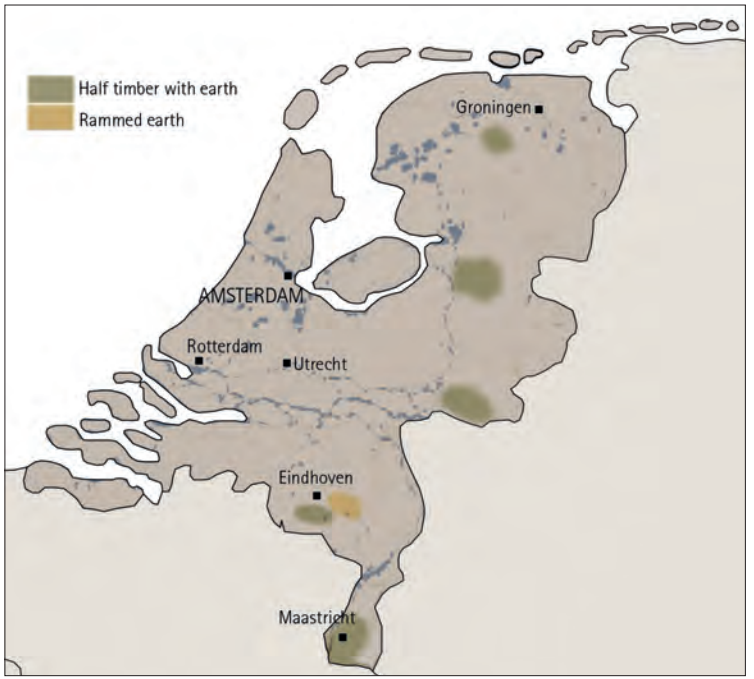
The Netherlands has several historic museums in different parts of the country, showing the heritage of past building culture in mainly wattle and daub dwellings.

During and just after the World War II, Architect Gilles Holst built some earth villas, as well as duplex houses in the provinces of Brabant and Overijssel. He acquired the earth building knowledge from the book "Building with Cob, Pisé and Stabilized Earth" (Williams-Ellis, 1920). The building technique consisted of rammed earth blocks measuring approximately 20x20x40cm and stabilized with either cement or asphalt emulsion. The earth was mixed with expanded clay granules to enhance thermal insulation properties. The wall thickness is 40 cm without any thermal insulation applied. The exterior is painted with silicate mineral paint or rendered with lime mortar. These houses are still in good shape.

Present

Nowadays, although wattle and daub technique is still applied, more modern earth building techniques are applied to build modern sustainable dwellings in accordance with the building code requirements.

Since the nineties, environmental issues in the Netherlands have become important and earth has been given a lot of credit concerning sustainabil-



Restored dwelling at Mamelis. (photo: André Schopman)



Nonke Buusjke. (photo: Sjap Holst)
Oase Pavilion, 1996-2000. (photo: Sjap Holst)
Office Fornarina, Clayplaster. (photo: Leemwerk/Pieter Boer)

ity, health and image, resulting in an earth construction revival. Numerous earth buildings were erected by owner-builders and new earth building techniques (such as straw-earth, compressed straw-earth bricks, CEBs, hybrid earth walls, light earth walls with chopped wood, Stick-Brick© and earth panels). Products like clay plasters, earth bricks and earth wall heating systems were introduced.

Professional training in earth building in the form of workshops and dedicated courses resulted in an increasing amount of skilled specialists that can design and build in a professional way.

During the last decade the decision to apply *clay* has shifted from the private customer to the architect, who integrates *clay* into the design. This leads to a shift in the application of *clay* as a mainly decorative wall finishing, to its use as part of a system, for instance, combined with wall heating. Since clay easily absorbs heat, it is a comfortable and energy efficient heating method (Technea, 2009).

Building techniques

Wattle and daub

It is probably the oldest earth building technique in the Netherlands. In the region of south Limburg dwellings with over hundreds of years old can be found. The little village museum of Nonke Buusjke, located in Schinveld, has a number of half-timbered houses from the beginning of the 20th century.

The restoration project by architect Sjap Holst with collaboration of André Schopman to restore the pathology damage to an old half-timbered barn located in Helvoirt, Molenstraat was accomplished in August 1994, using traditional techniques.

There are several open-air museums that are trying to preserve the building culture in the Netherlands. The Arnhem Open Air Museum exhibits fully restored and reconstructed wattle and daub cottages and farmhouses that were dismantled and their wooden skeletons transported to the museum and replicated in the original state of the art. The Historic Open Air Museum Eindhoven demonstrates structures from the Middle-age, traditionally restored by volunteers. Archeon Open Air Museum has full-size reconstructions of archaeological discoveries from prehistoric, Roman, and Medieval eras. The reconstructions have been recreated as authentic as possible.

Adobe

Architect Gilles Holst designed and built a number of 'adobe' (handmade 20x20x41,5cm earth blocks) structures in the Netherlands. One of the first was a cottage in Deurne, east of Eindhoven, built in 1945. The building is still surviving nowadays, but the exterior has been covered in brick strips. Between 1948 and 1951, Holst designed and built 6 villas with outbuildings in Waalre, south of Eindhoven. One of the villas had a garden pond that was created by the excavation of earth materials for the adobes. Holst even built in Almelo, eastern part of the country, in the 1950's.

Straw-earth

The straw-earth building technique consists in pouring and pressing long straw fibres, mixed with mud, into movable shuttering, fixed against a wooden skeleton. Walls with a density of 300-1000kg/m³ can be built with variable thickness.

This technique is very popular with owner-builders. A number of architects, Frans van Dillen, Ernst Israëls, Renz Peijnenborg and Sjap Holst, have designed houses, ateliers, cultural centres, pavilions, etc, from the mid 1980's

Office Tierrafino, rammed earth. (photo: Leemwerk)
Education Centre, 2001. (photo: Sjap Holst)

until present. Many of these projects are owner-built with the help of volunteers. The owner or professionals such as Carl Giskes Nederland of Leembouw or André Schopman usually render the exterior with clay.
Architects Sjap Holst, Frans van Dillen and Renz Peijnenborg have designed and built projects using compressed earth blocks. The blocks have been handmade by owners, or mechanically produced by Oskam V/F.

Stick-Brick© / hybrid walls

Hybrid walls consist of unfired industrial bricks (Stick-Bricks©), stuck together by simply wetting and stacking them in bond (without any mortar) to act as lost forms at the inside of the wall, combined with a straw earth insulation wall at the outside. It was developed by architect Sjap Holst of ECO-DESIGN.

Rammed earth

Several rammed earth projects, commissioned by municipalities, architects and individuals were accomplished.
In 1995, architect Sjap Holst/ECO-DESIGN replicated a worn-out, ancient earthen floor in a farmhouse in Pesse. The existing earth floor was recycled and mixed up with sand, stabilized with linseed oil and rammed with a Wacker compacting machine.
In Spijk, some detached walls were built on a cemetery, in 2009-2010. The designers were Louwrien Wijers and Ronald van Tienhoven and the builder was Charles Thuijls, by Leemwerk.
In Coevorden town hall there is a wall made of rammed earth, with 15m wide, 8m high and 30cm thick. This wall is located where according to excavations there used to be ramparts. The earth wall is built against an existing concrete wall. The architect was Rau and Partners, and the builder was Charles Thuijls, by Leemwerk, 2010.

Earth renderings / earth finish

Carl Giskes started about 20 years ago with his company Leembouw Nederland VOF to produce Tierrafino Clay Finish in various natural clay colours, and reintroduced the application of clay in the Netherlands. Architects were inspired to use it in public buildings and in private dwellings. Clay finishes are applicable to any smooth surface in a thickness of 3mm. As wall and ceiling finish, it is aesthetic and healthy.

Other modern earth building techniques

In 2001, architect Sjap Holst/ECO-DESIGN made a project for an educational building in Amsterdam using a heating system of ceramic load bearing walls rendered with earth plaster.
In 2002, architect Teun Verstand and builder Wim Maurits designed and built a conference building in Barchem with a wall heating system composed of thermal radiation walls, built with special compressed earth bricks, produced by Oskam V/F, and plastered with earth mortar.
In 2006, Architect Rau Amsterdam and Charles Thuijls of Leemwerk, applied earth plaster as an actual component of the total indoor climate concept of the main office of the WWF in Zeist. A thick layer of clay plaster was sprayed on the ceiling, integrating heating mats for cooling and heating. These mats consist of capillary tubes Æ 7 mm, which are attached to the subsurface and then plastered. Because of the large surface (3500m²) and the total thickness of the clay layer (45mm), the production was highly mechanized. The 90 tons of clay were supplied in big silos and directly sprayed on the ceiling.

Experimental house built in rammed earth, adobe and compressed earth blocks in Paslek. (photo: Teresa Kelm)

Earthen architecture in Poland

Teresa Kelm
Polytechnic University of Warsaw,
Faculty of Architecture

Earthen architectural heritage in Poland

A tradition of raw earth construction has existed in Poland and the areas of Slavonic culture for centuries. The oldest are post constructions filled in with clay over plaits or lists (wattle and daub) or filled with hand-made adobe and straw bricks. Over the centuries, various regional techniques were developed which, despite changing political borders, remained characteristic of the regions.

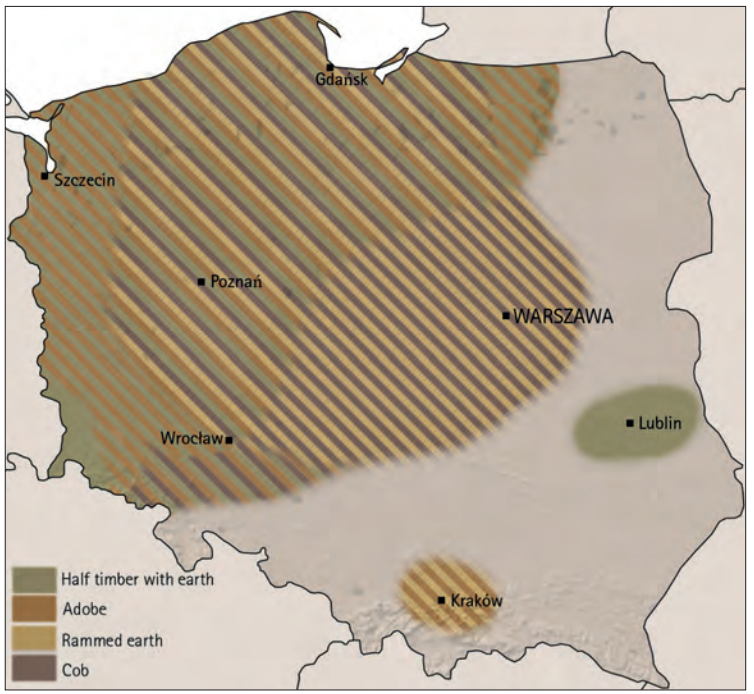
In Poland during the medieval period various types of framework structures filled in with clay or adobe bricks (colombage), were used both in urban and rural buildings.

Massive monolithic walls constructed from rammed earth in forms were not so common in the area of Poland as wattle and daub or half-timbered examples, though they were constructed at least from the XVII century onwards. This type of building is more difficult to maintain than framework objects with earthen fillings. Those buildings constructed in rammed earth or adobe bricks which are not preserved disappear forever.

Frame constructions filled in with earth

Nomenclature of framework constructions in the area of Poland is not unified. Depending on the region, some names vary to describe the "wattle-and-daub" and sort of "colombage" – wooden frames filled in with adobe or ceramic bricks. This last type is characteristic for northern and western areas and in the Polish tradition is also known as "Prussian wall". The spread of wooden frame construction, starting from XVII century, was not a result of foreign influence, as it is often explained. It was a logical result of the changes in natural conditions – continuous disappearing of forests and raising costs of wood, which caused a decrease in log type wooden structures.

Many picturesque examples of frame construction buildings may be found



Cottage, XIX c., Swarzewo, Pomorze. (photo: Teresa Kelm)

Half timber house with adobe masonry in fill (XVII c.), in Hel, Pomorze. (photo: Teresa Kelm)

Half timber barn with wattle and daub in fill (XIX c.), Nadole, Pomorze. (photo: Teresa Kelm)

Tarchomin, palace in rammed earth, XVII/XVIII c. (photo: Teresa Kelm)

Church (XVIII c) in adobe masonry, in Wytowno, Pomorze. (photo: Teresa Kelm)

Tavern (XVIII c), now museum, Różyny, Pomorze. (photo: Teresa Kelm)

Half timber cottage (XIX c) with wattle and daub in fill, in Nadole, Pomorze. (photo: Teresa Kelm)

in the regions of Gdańsk, also at Pomorze Zachodnie, Warmia and Mazury, Wielkopolska and Dolny Śląsk. Wooden frame construction, often supplemented with decorative lists, was clearly accentuated by dark painting. Spaces between structural elements were treated differently - in housing they were rendered and painted white, in farm buildings left unpainted. In houses, the internal surface of walls were covered with a sort of earthen plaster to increase thermal conditions. Many examples of such countryside objects from the turn of XVIII and XIX centuries can be found in the Kaszuby region. Only a few are subject to conservation. For example, a farm in Nadole, an open-air museum in Wdzydze, an open-air museum in Kluki, houses in the areas of Puck, Wejcherowo and Kościerzyna.

In the town of Hel at the end of the Hel Peninsula, some houses from the second half of the XVII century and beginning of the XVIII (period of Dutch settlement) were restored. Local tradition merged here with the construction culture of incoming settlers. Very characteristic of these buildings were extended decorative gable walls facing the street.

In Pomorze but also in other regions, mixed construction methods were applied: the walls of the ground floor were erected in masonry and those of the first floor in wooden framework filled with adobe. Excellent examples of such types are: a small hospital from the XVII century in Puck (now the museum of the region of Puck) and the Żuławski tavern also from the XVII century on the road from Gdańsk to Elbląg.

A large number of cottages and quite large two-storey houses in a frame construction filled with adobe bricks are situated around Słupsk. High elevations show interesting compositions of dark structural elements and white in fills. Some examples in Pomorze were reconstructed by private owners, who acquainted themselves with the problems of conservation of such buildings by visiting foreign countries such as Germany or Austria. Unfortunately, most of the existing buildings of this type, especially those of a large size, are in a bad condition and inappropriate conservation may cause their complete dilapidation in the near future.

Earthen masonry and monolithic construction

The development of techniques of monolithic earthen walls took place in the Age of Enlightenment (the end of the XVIII century). In Poland the techniques of rammed earth were rather unsophisticated, as they were

employed by people of modest means, with limitations caused by regulations imposed by the invaders who ruled over Polish territory at that time. Nevertheless, the proportions and details of such buildings, arising from tradition, were of good quality. The technology and material gave to buildings a certain solidity and expression. An example of the traditional form may be a cottage in Swarzewo near Puck, recently renovated.

Various types of buildings were constructed using rammed earth technology – houses and farms of poor or wealthier peasants, but also manor houses and even palaces. A good example is the palace in Tarchomin near Warsaw, from the turn of XVII and XVIII centuries – probably the oldest building in rammed earth that survives to date.

From the XIX century, as a result of propagandist and practical actions with the aim of activating the construction sector, the use of modernized earthen technologies progressed, particularly in the Kingdom of Poland after 1815 at a time of sudden growth in building engineering. Rammed earth constructions widely appear in Wielkopolska, Pomorze and Mazowsze. In the region of Pomorze this type of building reached 50% of the whole in the period between the two World Wars.

Traditionally a mixture of earth, gravel and lime (up to 10%), -sometimes mixed with peat- was used. The mixture was beaten down in consecutive layers in wooden forms. The height of the layers was 50 to 100 cm. Sometimes little twigs were laid between layers as a kind of reinforcement. To protect earthen walls against water, they were set on a high underpinning of stone or brickwork. The external face of the building was covered with lime and gravel render and sometimes with a wooden siding.

Monolithic walls were shaped also without forms – a kind of cob. Layers of walls were formed with wet lumps and then pressed with wooden floats or even under foot. The earthen mass was often mixed with chaff to avoid cracking during the drying process.

In the XIX century, adobe bricks and blocks shaped in forms were used for constructing walls. The buildings erected for richer owners were of two storeys, often with mansards, set on high underpinning. Apart from finishing external wall surfaces with lime and gravel render, other materials were also used for cladding, such as flat stones or ceramic bricks. Many examples of such buildings exist in Pomorze, Wielkopolska, Mazowsze and Małopolska. In this last region (south Poland) earthen techniques - rammed earth and blocks - were popular before the Second World War for constructing private houses, manor houses and schools.

Church (XVIII c), wattle and daub, Bronikowo, Pomorze Zachodnie. (photo: Teresa Kelm)

In the early period after the Second World War these techniques were applied to rebuild quickly buildings destroyed during the war. Special research was undertaken, instruction books and norms were published. Some norms, with a few modifications, are still valid now. Schools and habitable buildings in workers' housing estates with several storeys were erected. Realisation of the school in Krasinka Mała at Podkarpacie (south Poland) gave an opportunity for organizing some publicity. This building consists of a ground floor and usable garret, and has regional character with walls constructed in earth rammed in layers. This school, after conservation in the 90s, is in perfect condition.

The buildings erected in workers' housing estates had three or four storeys. They were in various areas: near Ciechanów, Pruszków (Mazowsze), near Myślenice (Małopolska).

The house in Pruszków was built at the turn of the 50s and 60s and is used up to the present date without any major repairs.

Despite the positive results achieved during this time, earthen building technologies have been pushed out by big industry.

In Poland, the problem of saving regional building relics – various wasting objects in hundreds of villages and towns – has not been solved yet. This problem refers also to the heritage of architecture erected in raw earth. Conservation is not sufficiently financially supported by the government or by other organizations.

Rammed earth contemporary house, architect Alexandre Bastos. (photo: Mariana Correia)

Earthen architecture in Portugal

Mariana Correia
Escola Superior Gallaecia
Jacob Merten
Escola Superior Gallaecia

Earthen heritage

Portugal has a relevant earthen heritage spread through almost a half of the country's territory. Traditional building techniques, as rammed earth, adobe, wattle and daub, and cob are expressed through vernacular, civil and military heritage. Local building cultures vary greatly through Portuguese territory.

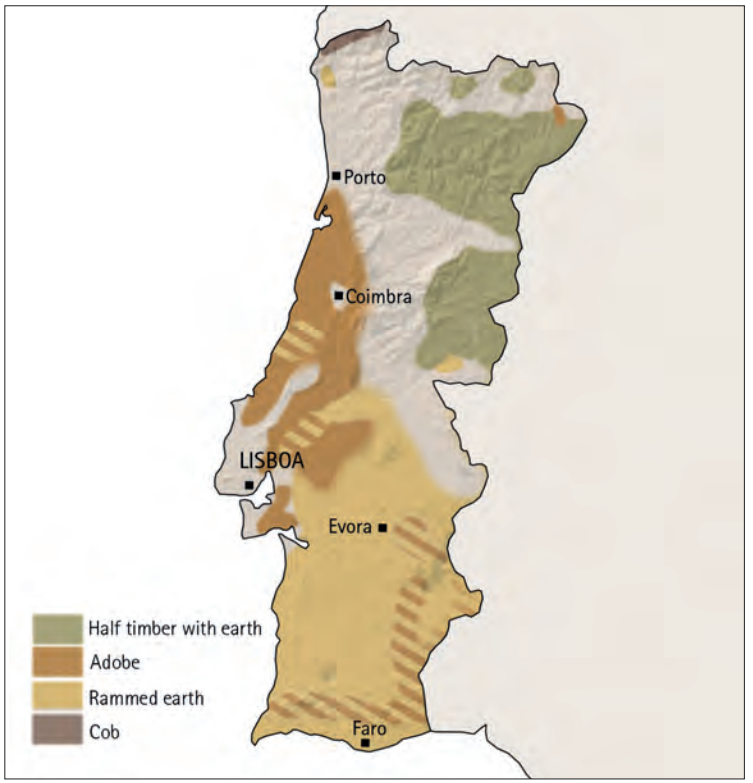
Rammed earth (*Taipa*)

Rammed earth was used until the fifties in most of Alentejo region, and in some parts of Algarve and Ribatejo regions (e.g. Abrantes and Santarém). The wide variety of rammed earth building typologies, observed through the all country, exemplified the diversity associated to the local knowledge, the adaptation to the environment and to the context of the existent resources. Most buildings are located in the south, however in the northwest of the country, in Lanheses, near Viana do Castelo, several rammed earth dwellings from the XIX and XX century have been also identified.

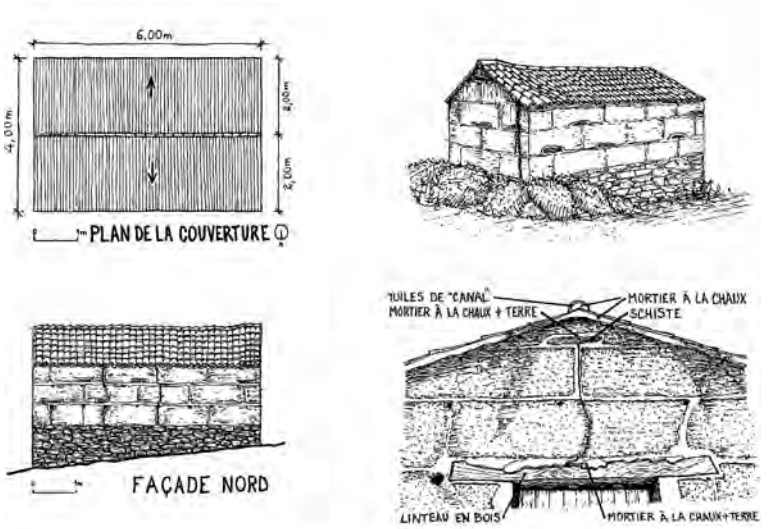
In the south of the country were located several earthen fortresses built in military rammed earth (*taipa militar*). It is a material composed by lime, *pozzolana* and natural aggregates in different proportions, which constituted a strong defensive structure. Among several others, the fortresses of Paderne and Salir in Algarve or Juromenha and Alcácer do Sal in Alentejo are still standing, at least 800 years following their construction, during the Islamic period (VIII to XIII centuries).

Adobe (*adobe*)

Dimensions and shapes of adobes vary between regions, acquiring a unique diversity in form, composition, colour and texture. Adobe was commonly used in Portugal, until the sixties and seventies in flood zones, in areas presenting a clayish soil. That is the case of the valleys of Tagus and Sado, the Gândara and Bairrada region, but also in Ribatejo (e.g. Almeirim, Coruche and Benavente). It can be also observed in the inner walls of many houses in Alentejo. In the northeast of Portugal, it was recently identified[1] the use of adobe in specific areas of Vimioso, such as Caçarelhos and Aldeia de Angueira, but also in Miranda do Douro, at Fonte da Aldeia. On the central coast, from Aveiro to Nazaré, in the presence of a sandier soil with a lower presence of clay, lime used to be added to the mixture. For instance, in Fermentelos, municipality of Águeda, the material presented such a strong bond that it was used in the construction of water wells for agricultural irrigation.



[1] by Vera Schmidberger



Rammed earth house at Aldeia das Amoreiras. (drawings: Mariana Correia)

House in Vale da Eira, Santiago do Cacém, south of Portugal. (photo: Mariana Correia)

Earthen fortress of Paderne, Algarve (photo: Mariana Correia, 1999)

Wattle and Daub (*Tabique*)

In Portugal, there was an extensive and diverse use of wattle and daub as a building culture. Wattle and daub was a variant, consisting in applied daub earth that, simultaneously, acted as an in fill of the openings of the wooden structure. It was also used to cover or plaster the structure. In the north of the country, it can still be observed roof tiles, slate shingles or corrugated metal covering the wattle and daub exterior walls.

The material can be identified throughout the country, most often in the central interior of Portugal, around Covilhã, Guarda, Fundão and Alpedrinha. There are also cases of its use in the northern interior of Portugal, where the upper floors of several traditional stone masonry houses, were completed in wattle and daub. In the south, it is observed in the dwelling's interior.

Cob (*terra empilhada*)

Cob was recently identified in the Alto Minho region, in earthen military fortresses from the XVII century. These military assets located in the municipality of Valença, on the border with Galicia, were from the Restoration War period. These earthen fortresses and the cob material are in rapid degradation, making it difficult for the fortresses to be identified, as the clay binder is almost absent. To date, the identification in Portugal of cob architectural structures is rare. Due to its building characteristics, it is suspected that cob was a common technique in use during the proto-historic period in the northern Portuguese territory. This possibility was still not consistently verified.

Architecture and production today

Portuguese contemporary earthen architecture expresses distinct architectural languages, for varied uses and programmes (habitation, markets, schools, rural tourisms, hotels, etc.). Since the eighties, more than 200 new buildings were erected throughout Algarve (Albufeira, Silves, Lagos, etc.), the Alentejo interior (Beja, Évora, Cuba, etc.), but mostly in the Alentejo coast (São Luis, Aljezur, Odemira, etc.). In the last decade, rammed earth has been considerably applied in contemporary building. Adobe and compressed earth blocks (CEB) have a less consistent use. The increase of architect's project's and earthen contemporary architecture in the country has been impressive[2].

The production of CEB's had a growing use in the Algarve coast. The best-known companies that produce and build in CEB are Terra Crua, in Aljezur, and Arquiterra, in Albufeira. Regarding adobe production, the mechanised manufacture grew until 2005 through the companies Construdobe and later Terradobe. At present, the production sector of mechanized adobe is stagnated. Due to the increasing demand for green materials, it can be envisioned a return to the mechanical production in the near future.

Dissemination of knowledge

Since 2002, ESG/ Escola Superior Gallaecia and Foundation Convento da Orada have organised six national seminars 'Earthen Architecture in Portu-

[2] Architects such as Alexandre Bastos, Bartolomeu Costa Cabral, Carlos Vitorino, Eduardo Carvalho, Filipe Almeida, Francisco Freire, Graça Jalles, Guilherme Quintino, Henrique Schreck, João Correia, José Alegria, Luis Gama, Maria da Luz Seixas, Martin Groebe, Miguel Oliveira, Miguel Peixinho, Ricardo Cruz, Rui Graça, Susana Sequeira, Teresa Beirão, Vera Schmidberger, Victor Mestre, among several others.

gal'. The ATP seminar has been dedicated to different interdisciplinary fields: Architecture and Engineering at the University of Aveiro (2007); Architecture and Archaeology at CEAUCP-University of Coimbra (2010). The 7thATP seminar will be held in October 2013, in Vila Nova de Cerveira, dedicated to vernacular architecture. The National Association Centro da Terra joined the organisation in 2003 with the coordination of the practical workshops.
The publication, in five years, of eleven books regarding earthen architecture by Argumentum Publisher, several co-edited by Escola Superior Gallaecia, had an important role for a wider dissemination of scientific knowledge. The first publication in 2005 was "Earth Architecture in Portugal", gathering 54 authors from different disciplines. This was a relevant contribution from the National Association Centro da Terra (CdT) aiming to study, document and disseminate earthen architecture and contributing for its awareness. Additionally, CdT organised, throughout the country, several workshops in different municipalities and universities, which also raised interest in the field.

Scientific Research and Strategic Cooperation

The consistent growth of Masters and PhDs in earthen architecture was possible due to the inclusion of earthen architecture lectures on post-graduate degrees of Heritage, Archaeology and Sustainability, throughout the all country. Additionally, several professors in different universities supported dissertation's research in earthen architecture[3].
Escola Superior Gallaecia has developed consistent research with projects financed through European (Houses and Cities built of Earth; Terra Incognita I, Terra Incognita II); Iberian (CADIVAFOR) and National (CATPAP) R&DT programmes. Gallaecia also supported PROTERRA Iberian-American research project (CYTED) through the coordination of Terminology and PROTERRA website. Chair UNESCO in Earthen Architecture was awarded to the school in 2005[4].

Outreach

In the last decade, there has been a growing interest in Portugal concerning earthen architecture. This awareness is due to the increase of earthen contemporary architecture, the growth of scientific research and publications in the field, but especially the dissemination of earthen architecture both at national and international levels. The engagement of several entities (universities, associations, municipalities, etc.) generated a clear advance in this disciplinary area. However, just outreach strategies among institutions will expand and consolidate the quality of knowledge and more effective outcomes to preserve this endangered heritage.

ETAR, Center of monitorisation in Évora, architect João Correia.
New house in Aljezur, architect Henrique Schreck.
New house in S. Luís, Odemira, architect: Graça Jalles.
CEB house in Aljezur, architect: Guilherme Quintino. (photos: Mariana Correia)

[3] Maria Fernandes, Humberto Varum, Paulina Faria and Mariana Correia had an important input expanding student research, at a national level.
[4] At an international level, Escola Superior Gallaecia co-organised the Mediterranean Experts Workshop with UNICA, CRAterre-ENSAG and GCI. This event was promoted following MEDITERRA 2009, also co-organised by Gallaecia.

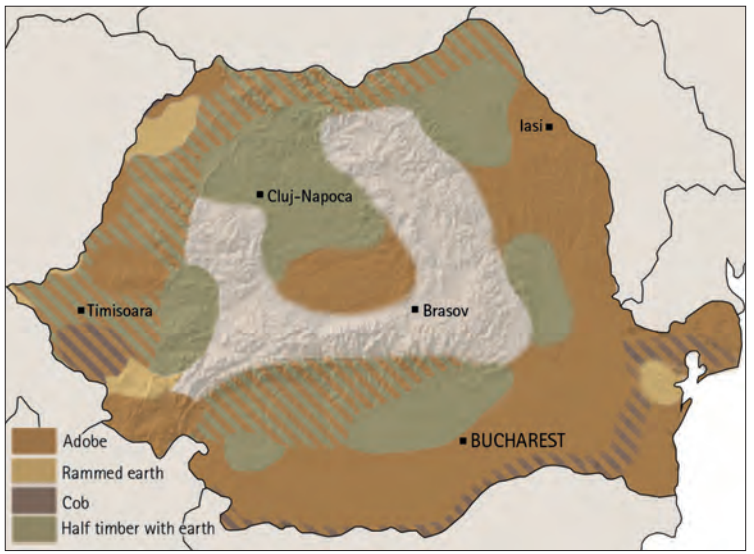
Adobe houses in Dolosman. (photo: Cătălin Berescu)

Earthen architecture in Romania

Cătălin Berescu
Frontal association

The Romanian territory is almost equally divided between plains, hills and mountains and the geographical distribution of earthen architecture follows this general division, from a larger concentration of earthen buildings in the fields, to a lower one in the hills and mountains. Nevertheless, despite a more visible presence of adobe buildings in Moldova and Dobruja, earthen architecture can be found in different forms spread across the country. The vast forests and wild natural areas created throughout history supported until recent times a predominantly wood culture, however, earth was always a material that had its part in any construction. Romania has an extreme continental climate and a traditional architecture that was very well adapted to a geographical setting dominated by hills and valleys and by a way of life in close connection to the forest. Houses made of adobe bricks, sometimes of cob, are common to the large plains that appeared in the last 150 years as a result of massive deforestation. In around two thirds of the 3,000 communes of Romania one can still find many genuine earth houses, whilst elsewhere earth is used for secondary constructions or finishing.

The vast majority of earthen buildings belong to vernacular architecture but most of the listed heritage, as the recently updated List of Monuments[1] shows, consists mainly of ancient fortifications and Neolithic villages. Among the latter, the Cucuteni culture is one of the first and most well documented in Europe. Earthen fortifications form the main part of the patrimony and there are documents indicating that the Voievodal Palace of Bucharest in the XV century was partially made of cob. Examples of rural architecture can be found in the Village Museums around the country (Bucharest, Rîmnicu Vîlcea, Sibiu, Pitești, etc.) but rarely *in situ*. These ethnographic museums are designed as a collection of representative households from the surrounding territories and often contain houses



Contemporary adobe architecture in Bradulet. (photo: Ileana Mavrodin)

[1] Monitorul Oficial nr. 670 din 01.10.2010

Storage room in a traditional house in Jurilovca

Oven in a courtyard in Lehliu

House under renovation in Dobrogea region

Maierus village in the mountains

Roma dwelling in Lehliu

Abandoned traditional house in Jurilovca. (photos: Cătălin Berescu)

made of earth or using earth for plastering and other finishing works. Besides this, there is another form of protection resulting from urban regulations that establish protected areas of urban tissue with a high density of monuments or a specific character. Occasionally, this includes some examples of XIX century urban mansions made with earth. The measure is not applied to villages, where the major part of the earthen architecture still exists. Nevertheless, due to the extraordinary spread of earthen buildings it is easy to consider that most of the vernacular earthen heritage is still in use, i.e. inhabited by local dwellers. Many of these pieces are fast losing their original character due to an accelerated process of modernization or on account of extensive abandonment.

Earthen architecture in Romania is relatively widespread across the territories and historic areas but earthen constructions are more visible in Moldova and Dobruja. For example, around 60 - 70% of the houses in the historic region of Moldova are built of adobe, some counties, like Botoşani reaching 85%, whilst the *municipum* with the same name has 52% of the houses made of "light materials" as mentioned in the local statistics. A programme to replace 233 schools made of adobe was started in 2007 in the region of Moldova, another for 91 schools in Dobruja and 47 in Transylvania and Banat.

Based on the fact that it is hard not to find a village without adobe buildings, and most of them poor households, there is a stigma of poverty strongly associated with this type of construction. The poor image of earthen architecture is common not only among the general public but also among specialists. Most owners are trying to get rid of earthen buildings rather then conserve them, and earthen buildings and techniques are only briefly mentioned in architectural research papers or books. The mistrust is also built on the lack a of legal framework that is based on some summary technical norms from the 50s, considered obsolete and not actually in current use by structural engineers. The trend to reject

new earthen constructions was tempered by the obligations to follow the requirements for a standard concrete structure filled with adobe bricks. Also, due to more information on the benefits of adobe walls, some wealthier urban dwellers would accept an earthen building as a leisure facility (secondary residence, restaurant, etc.) but still strongly reject the idea of having crude earth in their permanent residencies. However, in the rural environment, building with earth is very much alive and there is a relatively strong economy based on adobe brick production, up to seven times cheaper then modern brick.

The oldest and most widespread technique in the hilly areas is the wattle and daub system (*paiantă*). Its Neolithic existence was confirmed by several studies (Godea, Ionescu, Moisescu). There are several churches built in this technique, specific to the entire sub-Carpathian area, and also in the high plains of Moldova or in Oltenia. Pisè, or rammed earth can be also found in hundreds of localities, mostly in north-Moldova, the buildings being frequently finished with wooden planks in vertical stripes, making it hard to distinguish between houses made entirely of wood and houses made of a wooden skeleton filled with bricks, adobe bricks or cob, then protected by painted wooden planks. Strong rural communities preserved until recently a highly valued custom of mutual help named "clacă", not only during harvesting but also for building houses for young couples. In Dobruja, the *ceamur* house (from the Turkish *çamur*), the local name of cob, was built in this way and, due to a particularly harsh climate, besides the thick walls the ceiling was also very well insulated with reed covered by a thick layer of cob. The most widespread technique is that of adobe bricks, named chirpici (from the Turkish *kerpiç*) or *văiugă* in Banat or *ceamur* in Dobruja, sun dried and layered as regular masonry blocks. A building realised in this manner generally has foundations made of stones, a wooden roof and has only one floor. Where there is also a wooden structure to support the adobe it is called *paiantă*. Compressed blocks are rare and not used anymore; there is an old press in Braşov and one in Botoşani. There is also quite a common material that is not far from crude earth – the gypsy brick (*cărămidă ţigănească*), produced by Roma communities, of clay and sand, burnt in an improvised furnace at a relatively low temperature. The material is a low-quality brick still popular in the countryside due to its low price.

Contemporary adobe houses in Dolosman. (photos: Cătălin Berescu)
Last below:
"The Green House": Summer house built in cob. Architect: Ileana Mavrodin. (photo: Ileana Mavrodin)

Traditional house in Diakovec village. (photo: Fernando Vegas, Camilla Mileto)

Earthen architecture in Slovakia

Zuzana Kierulfová
Boris Hochel
ArTUR NGO - Sustainable Architecture
Mojmír Benža
Slovak Academy of Science

Introduction

The landscape of Slovakia is formed by the flatland of the Danube River in the south and the Carpathian mountains in the north. The whole area of the flatlands was rich with clay and earth and this material was therefore widely used with different building techniques: wattle and daub, rammed technique, adobe or cob. Building with adobes and rammed earth was the most common technique. Less usual was wattle and daub, mostly used for the gables of houses.

Types and techniques

Earthen techniques were used for building peasant houses, barns and corn stores. All peasant earthen houses were usually plastered with earth plaster and painted with lime wash both on the interior and exterior. In southern areas the houses were usually covered by thatched roofs. Earth floors in old houses were also very typical. Often before festivities the floor was maintained by sweeping and applying an earth slip mixed with cow dung.

In some areas, mostly in middle Slovakia, with accessible mineral rocks and stones, people used to build stone houses with earth mortar and earth plaster. Mountainous areas had enough green trees with straight wood suitable for log houses. Moreover, areas with earth resources used earth plaster applied over wood on the interior, or just in the gaps between the logs. On the outside they sometimes used lime plaster, or clay plaster with lime wash. The plaster was fixed to the wood by small wooden chips, sticking out from the beams, and thus preventing plaster from falling down, or by diagonal planks fixed to logs with gaps between them.

In Slovakia, earth used as building material is usually grey, yellowish or brownish.

Different types of earthen techniques observed in Slovakia. (photos: Boris Hochel, Zuzana Kierulfová and Inez Búci)

Above: Agricultural buildings: granary and barn. Clay plaster has been washed off.
Left side below:
Cultural monument - Hutterite House/ Museum of Hutterite crafts in Vel'ké Leváre.
Right side below:
Cultural monument in Šala / earthen peasant house with special roof construction supported by external façade wooden posts.
(photos: Boris Hochel, Zuzana Kierulfová and Inez Búci)

Building earthen tradition and heritage

In Slovakia there is a central institution for monument protection (*Pamiatkový úrad Slovenskej republiky*). There are about 150 monuments, built with different earthen techniques, protected for their earthen building materials or for the typology, origin or other extraordinary features.

The biggest area of several protected earthen houses is Hutterite Yard, built in the 17th century in Vel'ke Levare, which is protected for its architecture and typology special to the Hutterites, who moved and settled in West Slovakia[1].

Other old earthen houses, more typical for Slovak culture, can still be found on the Danube flatland and below the Carpathian Mountains. They are usually very small peasant houses, which had a typical narrow and long floor plan perpendicular to the roads or rivers and with saddle roof and gable façade. The side façade with entrance from the yard was often protected by overhangs sometimes supported with wooden posts, or later masonry columns. Some earthen houses had special accent at the entrance – an arched wall sticking out of the facade.

The oldest houses had only two rooms: entrance and living room. Later a storage area was added and the stove was moved from the room to the entrance. The living room became cleaner, more representative and the clay floor in this room was substituted by a wooden one, placed on wooden beams lying on ash. In this period, the house had three spaces: an access from the entrance with open "black" kitchen to the main room on one side and storage on the other side. Some areas with wider yards had their summer kitchen and storage opposite the house. Many houses had an outside or inside wooden ladder or steep clay stairs to the attic but with separate entrance. The attic was used for storing hay and straw for animals. Earthen houses in vineyard areas below the Carpathian Mountains had a large stone cellar underneath for wine production.

Present situation and research

With the spread of fired brick production at the beginning of the last century, earthen building techniques began to be considered as a material for the poor. Additionally to this prejudice, in the distant and near past it happened that some areas with earthen houses were unfortunately flooded. The houses were destroyed by water damage especially in the south of Slovakia. After such disasters, people tended to believe that clay was not a reliable building material in general.

Later in the middle of the 20th century, earth usage totally disappeared, which was also connected to the political system and its unsupportive policy to crafts in general. At the end of the 20th century, when the Czech and Slovak republics split, Czechoslovak norms were slowly exchanged with new norms, and earth was no longer mentioned in norms and building codes as a building material.

However, in the 1990s some strength tests were carried out on rammed earth walls at the Slovak Academy of Science. The results were used by only one company, which aimed to establish a business, but unfortunately society was not ready to accept earthen constructions, and therefore only a few houses were built. Another attempt, was the buying a license for a

[1] Hutterite houses have big roofs, which originated from late Gothic South German framed houses. Bigger community houses have three floors: ground floor with shared kitchen, dining and big room for workshop for their developed crafts. First and second floor were divided into small but solid rooms for community members or families. The space was divided by wattle and daub partitions, which were lime washed. Partitions were part of the complicated roof structure. The roof used to be covered with a straw roof, with a very special technique. Roof tiles made of straw dipped in earth slip, dried and then smoothed again with a wooden level after fixing it to the wooden roof construction. Like this the roof was solid, insulating and better protected against fire.

"Novotny's" system which was rammed earth combined with cement stabilization on the side while ramming. It was made by pouring cement in a specially created space of the mould for ramming. Both companies still exist, but earthen construction is no more than a side business, from which they are not able to make their livings. In the Faculty of Architecture at the Slovak Technical University in Bratislava, some teachers organized workshops at that time, inspired also by the activities of Gernot Minke at Kassel University. The school for restoration and protection of cultural monuments in Banská Štiavnica, on one hand kept up some knowledge about earth, but on the other hand worked and preferred lime, which was more commonly used for finishes in protected houses. Civic association, Academia Istropolitana Nova, was established to offer specialized postgraduate education about vernacular architecture, cultural heritage and its renovation, but they do not specialize or focus on earthen building techniques. At the beginning of the 21st Century, there were established several NGOs mostly founded by young educated people who wanted to live a healthier life and saw the importance of re-connecting to crafts and self-sufficient living and of preserving the values of inherited architecture. NGOs such as, *Pospolitost' pre harmonický* život (Zaježka), Hoblina t.c., and later NGO ArTUR – Sustainable Architecture, NGO Jablonka and NGO Sosna organized workshops for "learning by doing" – building straw-bale houses plastered with earth – a technique adopted from other, mostly western countries.

In 2010, an experimental building – a load bearing straw bale dome surrounded by 8 vaults - was built near Senec. The building was used as a case study for international workshops organized by NGO ArTUR. The designer of the dome building was Gernot Minke, with the assistance of the local architectural studio Createrra.

In Slovakia we are happy to see a growing interest for earthen building material especially because of the work of NGO Artur – Sustainable Architecture, which is promoting the use of natural materials, exhibiting at building fairs, organizing seminars, workshops, conferences, and publishing articles[2].

Slovakia is a small country with only 5 million inhabitants, therefore the market for new productions in the country itself might not be great, while the neighboring countries such as Austria and the Czech Republic have their sale representatives in Slovakia already. The financial conditions are almost comparable and transportation distance is relatively short, so it would not be easy to compete. This is why production of earth plaster is not yet present in Slovakia.

However, there are older brick factories, which keep their traditional process of production and are therefore able to offer earthen bricks. . There are several architects who design houses with natural materials, using clay in different ways. There is an initiative by members of NGO ArTUR to prepare norms for earthen building material in cooperation with the Czech Republic.

There was an extensive survey on earthen techniques accomplished in the 1980s by SAV – the Slovak Academy of Science, by Mr. Benža from the department of ethnology. The survey took 10 years and resulted in a detailed map of villages and earthen techniques. The goal of the survey was to choose afterwards the typical houses to be presented in the open-air folk museum of Slovakia in Martin. .

[2] For example a family house in Stupava was built from light wooden construction and the inner surface of the external walls was built with unburned earth bricks in a dry method, without mortar. Each 3rd layer was fixed to wooden construction with horizontal planks. Then the wall was plastered with interior earth plaster. Unburned bricks were used also in the ceiling under the wood fiber board and wooden finish to improve accumulating mass and soundproof qualities.

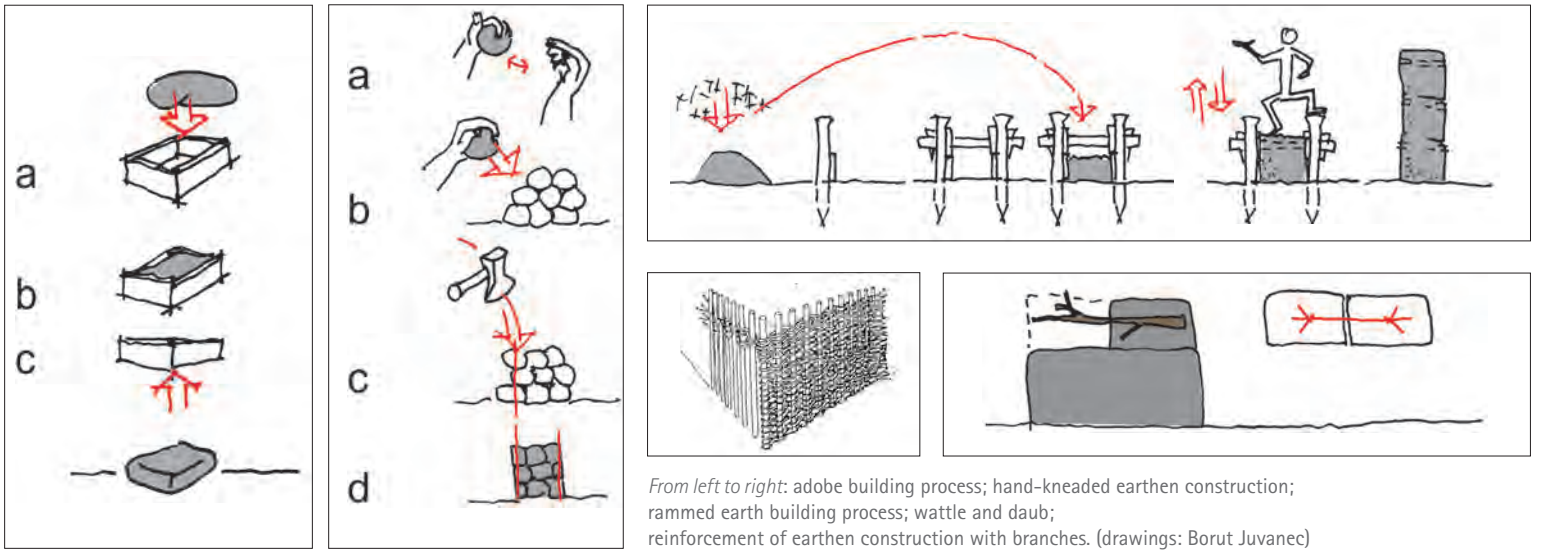
'Klet', the cellar in Slovenske gorice: timber construction, sealed with earth. (photo: Borut Juvanec)

Earthen architecture in Slovenia

Borut Juvanec
Ljubljana University, Faculty of Architecture

Slovenia is not a very large country geographically but it is rich in culture, including architecture in all the three basic materials: stone, wood and clay.
Slovenia is a green country, with plenty of water in streams, rivers, lakes, waterfalls and even a small glacier.
Architecture is not the result of only one material; in the Alps stone and wood are mostly found, in the central part stone, bricks and wood, in the south mainly wood with clay plaster, on the Karst stone with clay tiles (instead of the stone plates of former times) and the northeastern architecture consists mainly of clay and wood (Juvanec, 2010).
Clay is the common material in the plains around the River Mura, layered of course.
There are many types of settlement: from narrow, condensed villages (almost towns) on the Karst and in the Alps, to concentrated villages in the centre and extended villages along the roads in the northeast. Slovenia has known colonization from the 11th century (in the northeast in the 15th), characterised by very narrow parcels of land, only a few meters broad but several hundred meters long. Houses followed this system but the original house shape of the region is an 'L' shape, which enables an inner 'working' yard, protected and overseen from two directions (Juvanec, 2009).
North of the villages of Filovci (the name translates as *village of clay*) and Strehovci (*village of roofs*) and in Lendavske Gorice, Ujtomas in Hungarian, on the border, there are some dense settlements of houses used for wine production. This is a special 'part-time' use of houses, like transhumance in the Alps. The houses are called 'wine cellars' (*klet*), but most of them are normal ground floor houses, without rooms in the basement or below ground level. If a cellar exists, as an underground room, the staircase from the kitchen is hewn directly into the clay or sandstone, including the steps. The pit in the ground, form where the earth was taken, was generally used for a wine cellar or crop storage.

Clay architecture in the Slovene northeast has the clear imprint of history: Hungarian supremacy for the period up to the Second World War, a relatively poor economy for centuries and the availability of local materials.
The quality of earthen architecture in Slovenia is surprisingly good, in those objects in use, of course. Houses of cob, rammed earth and adobe, as well as wooden constructions with daub may be up to three or four hundreds years old. One of them, a cob 'cellar' near Bogojina, was built in 1802, with the reinforcement of juniper branches. It was carefully deconstructed and immediately rebuilt in 1910: today it is in perfect condition (2010) and used as it was built.
The newest houses built in rammed earth were completed in the 1970s.
Earth was the sole construction known: for residential as well as auxiliary buildings - except for drying houses for corn (*koruznjak*), which were made exclusively in wood. The oldest principle, wattle and daub, was used for less important parts of houses: pig sties, parts for storing firewood or toilets - all at the rear of the house.
Earthen architecture, as well as timber constructions with daub, was the traditional form of rural architecture for centuries.



From left to right: adobe building process; hand-kneaded earthen construction; rammed earth building process; wattle and daub; reinforcement of earthen construction with branches. (drawings: Borut Juvanec)

However, most of the auxiliary buildings used for viniculture on the hills still exist. The most important is dense housing at the edge of villages, or not far from the homes. This type of wine cellar can be found north of Vienna (on the border with the Czech Republic), north of Pecs in Hungary (Oliver,1997) and in the northeast of Slovenia: Trnavski breg, Filovski breg and Filovski gaj, Strehovski breg and Lendavske gorice/Ujtomas.

Architecture in rammed earth

The word *beaten* (Slovene: *butanje*,), evidently domesticated and widespread in Slovenia, already indicates that this method of building is established and widespread in the northeast of the country (Ptujsko polje, Prekmurje, Goricko). Ramming simplifies work, where the clay mixed with sand and water is poured between wooden boards, which are held together, and the clay rammed.

Reinforcement is also needed with ramming. The commonest material for this is straw: anything 4-10 cm long. It may not be longer because of the potential transmission of moisture. Small stones or gravel can be used with earth in rammed constructions to strengthen the wall.

While construction is the men's work, maintenance (and thus 'coating' mainly by hand) is in the care of the women of the house.

The walls are normally 40-50 cm thick. The clay, which is mixed with pieces of straw, is placed between wooden boards, and then rammed: compressed by foot or with mallets, wooden clubs on long arms.

The rammed construction can be seen, when decay sets in. Some houses in Bukovci. Some rammed earth compositions are still in perfect condition, thanks to the owners, Bukovci. (photos: Borut Juvanec)

A rammed wall is a composite of horizontal bands that follow the panelling (the normal height is two boards of 25 cm, together 50 cm), and the boards are normally around four metres long, which corresponds to the length of sawn planks.

Since they ram the walls round and round, the upper edge is already dry when the next layer is added: the horizontal contacts are thus visible, while vertical joints are coated with liquid clay. After loading, these joints tend to open, but only when the wall is completely dry.

A wall made from rammed clay, which is daubed and maintained, cannot be distinguished externally from other walls. Problems appear only when the daub falls off. The joints between the horizontal layers are visible, as well as the vertical joints because of the limited length of the wooden panelling. These joints can be smeared with more liquid clay but, in terms of quality, this achieves neither the hardness nor the durability of the rest of the wall.

Thatched roofing is perfect for earthen architecture: it is lightweight, and has the same wooden construction.

A clay wall is less problematic. Only careful handling is required and the wall is re-coated each year. This ensures protection of the wall itself and, during the coating, possible cracks that appear during maintenance work are also sealed.

The final act of coating the wall is whitewashing. This is not just an aesthetic feature, it is confirmation of the work performed. This is not connected to the church, although it is done by Easter. This is an older, pre-Christian celebration of spring, when the house had to be prepared for new life with the coming of summer.

Earth, reinforced with straw flocks (fibres), no more than 7cm long, is a more or less compact material but only when it has a proper compacted consistency, without any holes. The only holes are planned and placed in the structure as a trace of the frame construction. They can later be used for the construction of scaffolding, for the required regular maintenance of the earthen wall.

Use, vernacular architecture and the rehabilitation of earthen objects

Earthen architecture is a facet of northeast Slovenia: many objects can be found. The problem lies in its identification, because earthen architecture is covered with clay plaster and cannot be identified individually from several different techniques.

This is living architecture, in use – mostly as private property. Local people have even established and own some folk museums.

There is no official, governmental organization for its preservation, and there are no records, inventories or evaluation of this type of building culture.

Wooden construction wine cellar.
The cellar is under the living room, called the 'hisa'(Penova kleit, Filovski gaj)
(photos: Borut Juvanec)

The only professional works can be seen at the Faculty of Architecture of the University of Ljubljana (Moskon 1975, Juvanec 1985, 2000 - 2010, Zbasnik 2000, Kresal 2002, D Zupancic 2009, Brojan 2011).

There is a lack of research projects for preserving and renovating all types of earthen architecture. International research projects would be an ideal opportunity for preserving this earthen architecture for future generations.

The use of contemporary materials is essential in new design; and not just in design, in architecture, too.

Elements of clay, technologically modified, are used for new composite boards in the most recent high-tech architecture. A very thin layer of clay, combined with other layers (for stability, insulation, protection, etc.) can be a very successful, human and pleasant surface cover for buildings.

Non-structural daubed earth wall in a store structure, Calatañazor, Soria, Castilla y León.
(photo: Valentina Cristini with José Ramón Ruiz Checa)

Earthen architecture in Spain

Fernando Vegas
Camilla Mileto
Valentina Cristini
Universitat Politècnica de València

Introduction

Earthen architecture has undeniable value within the culture of construction materials of the Iberian Peninsula, both for its remote origins and level of preservation and the way it adapts itself perfectly to the environment.
The fact that many of these techniques are still valid and that they have survived practically unaltered for so many centuries, is full proof of their capacity to handle technical and constructive problems.

Types and features of earthen architecture

There are many factors in Spain that have lead either to the perfection or to the abandonment of the several constructive techniques over the centuries. Among the main factors, we have the availability of natural resources and the productive social and economic systems. However, as water has always been a cause of vulnerability for these earthen structures, the long search for resistance against water damage has created a whole repertoire of formal, material and dimensional answers.

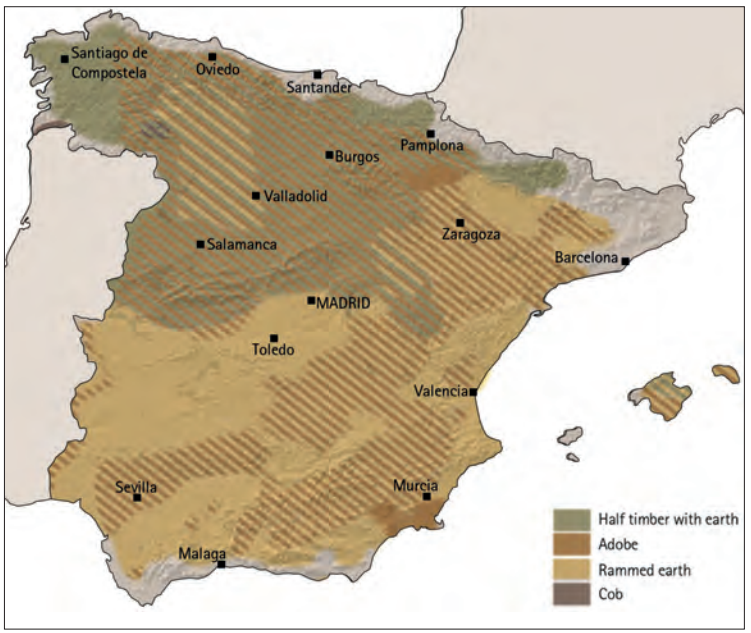
Adobe

Adobe can usually be found both in homes and in auxiliary buildings for animals and storage. We find these in Meseta Norte (region of Tierra de Campos) and along the regions of the basins of the rivers Guadalquivir, Ebro, Turia (Andalucía, Aragón, Cataluña, Comunidad Valenciana), Júcar (Cuenca, Albacete). In Comunidad Valenciana its specific use is known in the adobe houses of the orchards and wetlands (*barracas*).

Rammed earth walls

In Spain we usually have three basic types of rammed earth wall, with the following features.

Simple rammed earth wall: the simplest technique, which uses tamped soil within the formwork. The soil is previously prepared by airing and slight dampening.



Improved rammed earth wall: the soil used is enriched by adding different sized gravels or rocks, so as to obtain a more compact mass. Very frequently lime is added in order to guarantee a better consistency and duration of the face.

Reinforced rammed earth wall: the soil is reinforced with other constructive elements to give the modules more consistency in its grip to the eventual render. These additions are put on the outside of the margin of the formwork before tamping each earth layer.

Improved rammed earth wall

Rammed earth wall with lime render (tapia acerada). This is a rammed earth wall with a protective lime render, a mortar garnishing made out of lime and sand. This mix gives the external parts a new look and represents a reinforce-



Adobe wall detail, Piqueras del Castillo, Cuenca, Castilla la Mancha.
Example of rammed earth with black gypsum waved layers, peasant house, Villamar, Teruel, Aragón.
Example of rammed earth wall reinforced by bricks (so called tapia valenciana); S. Jaime church, Castellon, Comunidad Valenciana.
(photos: Valentina Cristini with José Ramón Ruiz Checa)

ment of the faces. (Andalucía, Castilla la Mancha, Baleares, Castilla y Leon, Cataluña).

Rammed earth wall with gypsum layers (tapia con brencas). This is a rammed earth wall which presents some reinforcements shaped like a crescent moon on the inferior part of the formwork. They can be found especially in Aragón (the most western part of the Comunidad Valenciana), in rural houses, walls and storage rooms and, sometimes, they may also be found in Murcia and Castilla y León.

Rammed earth wall reinforced with lime strata (tapia calicostrada). This is a type of rammed earth wall, which presents a regular strata of lime among the layers of soil. It is mostly found in Andalucía, Castilla la Mancha, Castilla y León and Murcia. It is much more common in military architecture than in residential. Important examples of buildings where this technique is used are the Alhambra in Granada, the Alcázar in Sevilla or in city walls of Niebla, Huelva, etc.

Reinforced rammed earth wall

Rammed earth walls with stones or bricks. These are rammed earth walls that boast different kinds of reinforcement elements mixed with the soil layers. It is possible to find both rough stones and ashlars or bricks (in this latter example it is usually called *tapia valenciana*).

Mixed rammed earth walls. This is a type of rammed earth wall that has structural reinforcements that take most of the loads withstood by the wall. These reinforcements are usually called buttresses. The rammed earth walls with adobe buttresses are of the same type as those with brick buttresses, replacing the material for adobes (Castilla y León, Extremadura, Andalucía, Aragón). The rammed earth walls with gypsum buttresses are made of gypsum reinforced with rubble or rough stones (region of Rincón de Ademuz (Comunidad Valenciana) and the village of Albarracín).

Half-timber with adobe filling

This construction technique can be found in almost all of the Iberian Peninsula, but especially in the central region of the mountain chain towards the north, meaning in País Vasco, Navarra, La Rioja, Asturias, Galicia, Extremadura, Castilla la Mancha and Castilla y León. This type of construction is almost certainly to be found in stables, storage rooms, houses and in areas that are rich in forests (wood for sawing).

Wattle and daub

These solutions can be found in the third part of the northern peninsula (País Vasco, Navarra, Riojas, Asturias, Galicia), but also in areas of the Extremadura and more precisely in Castilla, the surroundings of Soria and Aragón. Generally, these structures are found as internal partition walls, which are not directly exposed to the climatic conditions.

Present situation and perspectives

Currently, in Spain, the main lines of academic investigation are promoted by CIAT (the Center of Traditional Architectural Investigation), lead by the Polytechnic University of Madrid, and there are also specific lines of investigation promoted by members of other autonomous universities (Barcelona, Valencia, Valladolid, Granada, Sevilla, Zaragoza, etc.). The organization of the Construtierra network stands out and presents the common efforts for the documentation and promotion of the soil as construction material (with the

collaboration of the Universities of Madrid, Palencia, Valladolid, Alcalá de Henares...).

Also some associations have been born in order to promote important actions of cooperation for the development and encouragement of the constructive quality. Among them, the most famous is Habitat Tierra, founded in Madrid with its head office also in Peru, or Proterra a multilateral and international group for technical cooperation that promotes the investigation and development of soil construction.

On the other hand, referring to associations that aim towards professional development, we have to take into consideration, without any doubt, the pioneer experience of the Center of Studies of Navapalos. Also business concerns such as Adobera del Norte, Cannabric, Terrablock or Bioterre Promotions, have a great influence on the market. As for promotion, there are magazines such as Ecohabitar or Ecoconstruction.

Generally, compressed earth brick production (in Spanish BTC) is a tangible reality in the peninsula, represented by Amayuelas, a small village in the province of Palencia, which aims towards total ecology and soil and BTC construction materials.

At the same time, in Spain, an important work of maintenance and conservation is in progress related to earthen architecture, with first-rate interventions both vernacular and monumental (fortresses and citadels from the province of Castellón, Murcia, Granada, Córdoba). Professionals show interest in the study of historical constructive techniques and its reproduction and are also turning their attention towards the conservation of the surface patina and materiality.

Conclusions

In Spain, the relationship between contemporaneous and traditional vernacular architecture has a real potential that should be explored and developed. This complex repertoire could really be an excellent field of experimental investigations that could deepen the close relationship between traditional constructive techniques and the criteria of energetic efficiency. On the other hand, the process of normative regulation, partly completed and partly still in progress, guarantees the quality of current earthen architecture. The lack of a systematic network that could embrace all the different projects and contexts weakens and devalues important initiatives that do not get the opportunity to have a major impact, but their mark remains at best at an exclusively regional level, and only within the reach of specialists.

Example of rammed earth wall in rural house, Jijoca, Teruel, Aragón.
A dovecote (*palomar*) in Tierra de Campos (Castilla y León). (photos: Juana Font)

Example of reinforced earth wall with lime and stones, Bofilla tower, Bétera, Valencia, Comunidad Valenciana. (photo: Fernando Vegas with Camilla Mileto)
Example of tapia calicastrada wall, city wall of Niebla, Huelva, Andalucía. (photo: Valentina Cristini)

House in Steninge, built in the 1940's. Architect: Hakon Ahlberg. (photo:Mariana Correia, Jacob Merten)

Earthen architecture in Sweden

Jenny Andersson
Architect and Clay Builder

Introduction

How common is the use of earth-building techniques in the north of Europe? Actually, remains from the Viking Age show that wattle and daub structures were probably used for dwellings, and adobe masonry is considered to be one of the oldest techniques in the country. In many parts of Sweden, there are good geological conditions for using earth for building as the Ice Ages have created and transported rich and pure clays to many areas. Therefore, clay plaster and other earth techniques can be found throughout Sweden. However, rammed earth and clay in fill in formwork are more common to be found nowadays than adobe and wattle and daub.

Modern History

In modern history, earth has been used during periods of lack of other building materials. For instance, in the 18th century, huge amounts of wood was used in the iron and ship building industry, leading to a worry that Sweden would be short of forests. Architect Lars Allan Palmgren mentioned in his published thesis, "Swedish Earth Buildings 1750-1950", how the tradition of using earth was spread, starting with Rutger Macklean, who brought home the cob technique from Germany and erected the first building in 1786. Also, after World War II, when the building industry was not yet back in business and the demand for dwellings was urgent, earth building became of common use for a certain period of time.

In Skåne, south of Sweden, the tradition of building with timber frames has always been strong, as the area has rich clay soils and forests are scarce. The framework was filled with different mixes of clay and straw, wattle and daub or adobe and fired bricks, then coated with clay plaster or lime plaster.

Clay plaster has been common all over the country and it is the best-known use of earth in construction. Other known techniques used in Sweden are cob, rammed earth and cast walls, i.e. a wooden formwork filled with a mix of clay and stones or other spare material. Also, it is applied as earth mortar for chimneys and fireplaces and insulation between floors.

Further north, there is no lack of timber and log cabins are common. The log joints were traditionally packed with mosses against draft and this is where clay plaster was found to do a great job, both to avoid draft and to get a flat surface for painting and later, wallpaper.

New built rammed earth house in Steninge. Architect: Hans Rendahl, builder: Hans Bulthuis. (photo: Jenny Andersson)

Present

At present, many different earth-building techniques can be found in Sweden and none of them seems more popular than the others. Clay plasters on straw buildings are generally popular in Eco-villages and more common on the west coast. Rammed earth houses have a tradition in smaller areas, also on the west coast, but non-load bearing structures such as clay-straw mixes or clay mixed with wood chips, perlite, LECA (Light Expanded Clay Aggregate) or others are found in several places in the southern half of the country. Clay plaster is used, not only on earth buildings but also on timber structures, Wood Wool Cement Board (WWCB) and different kinds of masonry walls. Plastering is by far the most widespread technique and probably used by several self-builders and craftsmen lacking contact with the general earth-building network, which makes the exact expansion difficult to estimate.

Networking

A Scandinavian collaboration (NOL) with a common newsletter and annual meetings started in the early 1990's between Norway, Sweden, Finland and Denmark, inspiring national associations to be formed. The Swedish Earth Building Association (Lerbyggeföreningen i Sverige) was founded in 1994 and has presently around 150 members. It promotes and supports earth as a building material, mainly gathering self-builders, but as there is no other organisation for professionals, those will also be found there. Members of the Association have over the years held a large number of short courses to spread the knowledge of building with earth. The Scandinavian NOL is no longer active so inter-Scandinavian contacts are now informal and irregular.

Detail of Earth experimental shelter in Nääs ; architect: Jan Hedberg.
Earth experimental shelter in Nääs ; architect: Jan Hedberg.

Earth constrution Workshop in Vekhyttan, group photo.
Earth constrution Workshop in Vekhyttan. (photos: Mariana Correia, Jacob Merten)

Clay plastering on log wall at the Dacapo training in Mariestad.
Baskemölla Eco Village, Rammed earth house under construction. (photos: Jenny Andersson)

Some members regularly attend the TERRA conferences and other gatherings abroad and some occasionally do earth work outside Sweden. However this remains a limited contact network.

Training

In 2005 three Swedish earth builders attended a three-week training course for professionals organised by Dachverband Lehm, the German Earth Building Organisation. They were awarded formal certificates as earth builders. The following year, a similar but shorter training course was organised in Sweden. The courses are held at the School of Crafts in Mariestad, Dacapo,

and run biannually. The aim is to train builders that want to work professionally with earth but also to inform conservation officers, architects and other professionals about earth as a building material.

Groups with Interest in Earth

Eco-villages and Self-Builders

In eco-villages, where members build their own houses plot by plot, there are always several earth-building techniques present. Information and Schedules regarding Earth Building Association workshops is spread through their networks and a new group of enthusiasts gathered each time. In this context, some ecovillages should be mentioned, such as Baskemölla, Ubbhult, Kampetorp, Skärkäll and the Steiner influenced area of Järna.

Self-builders are generally people with a serious interest in the environment, looking for ecological and low carbon impact alternatives and often with more time than money. They appreciate the user-friendly earth which also is cheap to acquire and often can be found locally.

Universities and Academics

When it comes to academic interest there are regularly post-graduate students, for example architects and engineers, that want to approach this building material in their diploma work. At a higher level, two architects can be mentioned: Lars Allan Palmgren, mentioned above, with his research on historical earth building and Eva-Rut Lindberg with her thesis "Earth Building in Sweden and Countries with Similar Climate", which is, at present, one of few Swedish texts describing the various earth building techniques in a modern way. Both are connected to the Royal Institute of Technology (KTH) in Stockholm.

Lund University (LTH) in the south of Sweden is traditionally focusing on third world housing with some publications on earth building in this context and Chalmers University of Technology (CTH) in Gothenburg encourages students doing work on straw bale building, which often include earth details.

Historians and Conservators

Institutions and organisations engaged in restoration and rehabilitation will inevitably gather information also on historical earth building, and be in contact with builders in the conservation/restoration area, who can be familiar with clay plaster and maybe some other earth techniques. Worth mentioning is Byggnadsvård Nääs outside Gothenburg, the Dacapo School of Crafts in Mariestad and Skansen, the open-air museum of Stockholm. All run with public funding.

Christian Community Church, in Järna; architect: Walter Druml, earth works: Johannes Riesterer. (photo: Mariana Correia, Jacob Merten)

Commercial Builders

When it comes to professionals that can be called Earth Builders, there are barely a handful of them in Sweden. The three builders responsible for the Mariestad training are also three of the most active builders and possess a wide knowledge on earth building, often leading workshops presenting different techniques. However, only one of them is running a large scale business with employed staff. A local builder, in an area where rammed earth houses have been erected on and off since the 1920's, is running a scheme with planning permission for 7 rammed earth houses (of which 3 are concluded in 2011). This is presently Sweden's largest earth building project.

There are a couple more builders working in conservation with an extended knowledge in earth (mainly earth plaster and wattle and daub), but they are only executing earthwork sporadically.

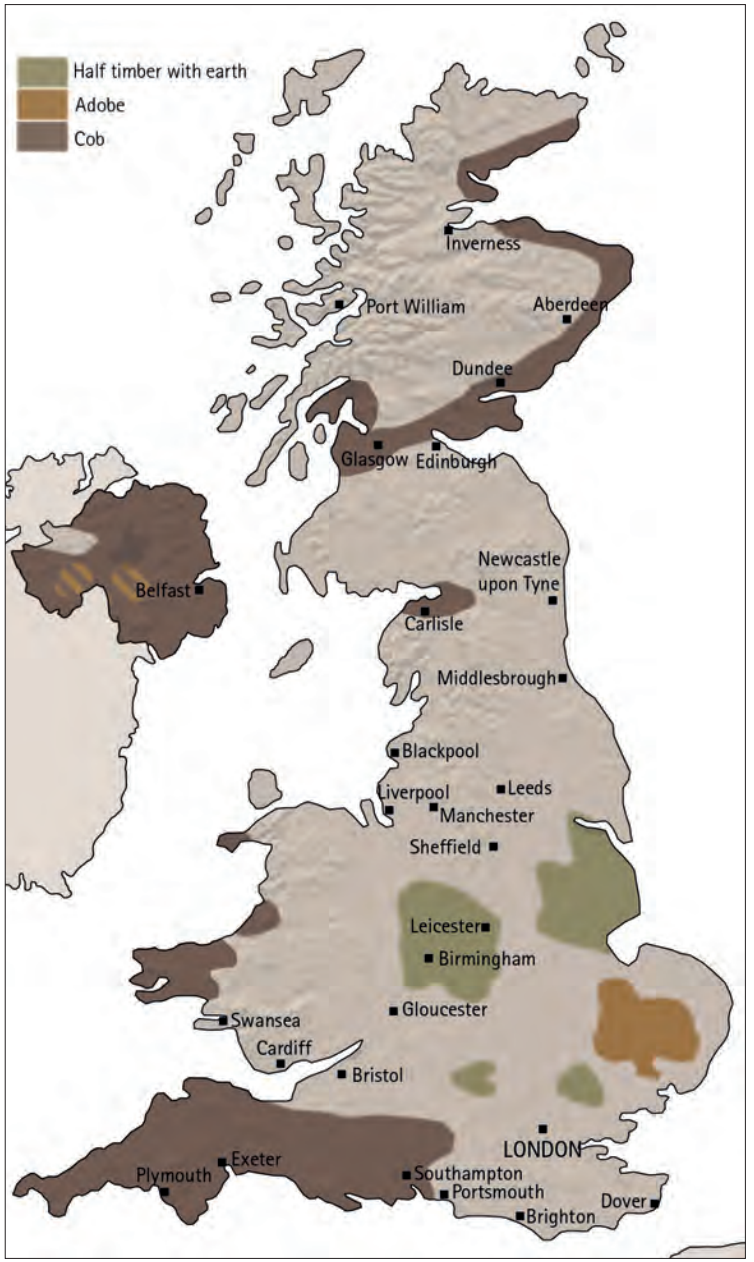
Future

There is a growing interest in earth building in Sweden today. The awareness for this building material has expanded from being known by 'ecological interested people' and historians, to being known and asked for by contemporary families looking for a sound and locally produced material, appealing to the senses. Sweden is still at a level of relying on highly engaged enthusiasts, but is working hard to stress the professional side of earth building and to turn it into a modern building material amongst others. This is a work that must include architects, producers, salesmen and builders.

Silbury Hill, Avebury, Wiltshire, UK. (photo: Louise Cooke)

Earthen architecture in the United Kingdom

Louise Cooke
Earth Building UK



Earth building in the UK

In the UK, practitioners, researchers and institutions are involved in building with earth with a small number of projects completed each year. These include small personal projects, conservation of historic buildings, owner-builder constructions, and larger, research or experimental projects. The current state of earth building in the UK is unquantified, and this very broad summary highlights the current context and a number of developments.

Earth building in the UK is split into that undertaken in heritage contexts and that concerned with the use of earth in new buildings as a natural material with low embodied energy. However these two areas are joined, with many practitioners involved in both conservation and new construction. This is particularly true for the research on soil properties, effectiveness of materials, and methods of monitoring performance over time.

The regional basis established in Terra Britannica (Hurd and Gourley, 2000) remains important. In the South-West, cob predominates, whilst in the Eastern part of the country clay lump is common. There are numerous other areas that use earth on a supporting framework (wattle and daub, mud and stud). As in the rest of the world, since the 18th century, vernacular practices were challenged by so called "conventional" building materials. A number of modern rammed earth projects in regions with no historical precedence have been undertaken more recently.

The UK has a number of organisations and practitioners involved in the repair and conservation of buildings, and use of earth for new construction. In addition to undertaking projects, a majority of practitioners also plan and deliver training courses in a diverse range of skills associated with earth building, including wattle-and-daub, cob, rammed earth, earth finishes and earth plasters. Many of those involved champion their own online resources in addition to numerous conventional publications, offering a broad range of information on methods and techniques of using earth as a building material.

Abandoned wattle and daub village pub. Suffolk, UK.
Cob building, East Budleigh, Devon, UK.
Modern cob building, Jackie Abey and Jill Smallcombe, Eden Visitor Centre, Cornwall, UK.
(photos: Louise Cooke)

A brief survey of practitioners in the UK shows the diversity and large number of people involved. Mention is made here of just a few individuals whose work has had a significant impact. Kevin McCabe is a cob practitioner in Ottery St. Mary, Devon, who has constructed a number of buildings over the last 20 years, including his own iconic home, and is currently undertaking work on a Zero-carbon Cob House. Jackie Abey and Jill Smallcombe, also based in Devon, explore the artistic and sculptural possibilities of building with earth, with a number of high-status artistic and community projects. In addition, they run a successful hands-on education project, '3 little pigs' aimed at primary school children.

In Fife, Scotland, Tom Morton (Arc Architects) and Rebecca Little (Little and Davie Construction) have pioneered conservation research and the use of earth for new building projects. The restoration of the mud walled Logie Schoolhouse for the National Trust for Scotland achieved international acclaim. Rowland Keable (Ram-Cast CIC) has been involved in a number of high profile projects using rammed earth across the UK over the last 20 years. These include the Eden Project Centre (1999) and WISE building at CAT (see below).

The UK has a number of suppliers located throughout the country, including Mike Wye & Associates Ltd, based in Buckland Filleigh, Devon and Ty Mawr, in mid Wales. Products available include lime and related materials, clay plasters, earth and clay paints, cob blocks and bricks, and clay boards. Some practitioners such as Adam Weismann and Katy Bryce have diversified to become product manufacturers and suppliers (Clayworks).

Numerous UK universities undertake research in relation to conservation and the use of earth in new construction. These include the universities of Bath, Plymouth, Nottingham, Durham, Strathclyde and York. The Centre for Alternative Technology in Machynlleth in Mid Wales is also home to the Wales Institute for Sustainable Education (WISE), a building which utilises rammed earth and hemp lime. These universities teach different aspects of earth building at undergraduate and postgraduate level, often in partnership with UK-based practitioners and other universities. Within universities, research funding tends to focus on partnership projects, researching material properties, and new materials for industrial use. For example the Buildings Research Establishment, (BRE) Centre for Innovative Construction Materials,

in the Faculty of Engineering and Design at the University of Bath has been active in developing approaches to the use of rammed earth (Walker et al 2005) and unfired clay masonry.

The UK has a number of earth building interest groups concerned with the promotion of earth building and production of technical guidance. These have a strong regional emphasis. For example, the Devon Earth Building Association (DEBA) was formed in 1991 to sustain and support the building with earth (cob) in the South West. The East Anglia Earth Buildings Group (EARTHA) was formed in 1994, to provide advice on clay and clay lump buildings in Eastern England. Their interests are in both conservation and new construction. Both of these organisations represent the shared passions of a number of motivated individuals, Larry Keefe and Ray Harrison (DEBA) and Dirk Bouwens (EARTHA).

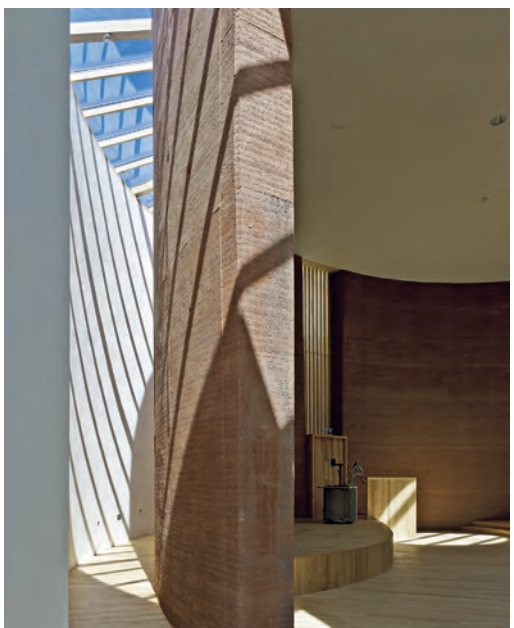
In addition, a national body, Earth Building UK (EBUK), was established in 2009 with an aim to foster the conservation, understanding and development of building with earth in the United Kingdom. EBUK brings together builders, academics, researchers, architects, engineers, conservators and manufacturers to work in areas of common interest at a national and local level. EBUK has identified a need to survey and quantify earth building in the UK as one of their key activities.

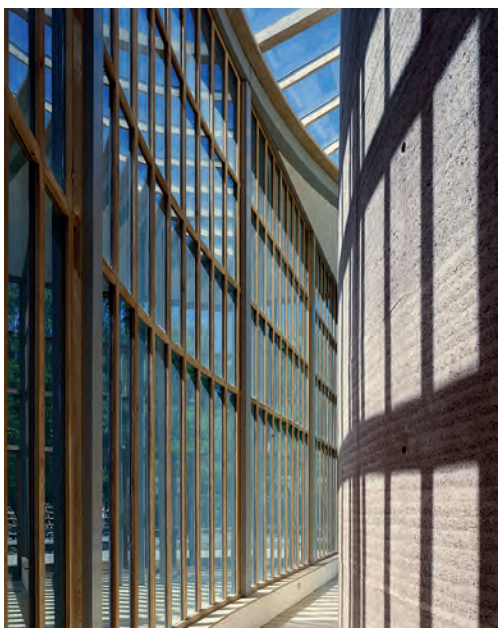
National initiatives supported from a variety of different funding sources, such as the heritage building skills bursary scheme, are intended to address skills within the traditional crafts and built heritage sector. The current planning requirements for conservation and ecological use of materials in new construction are a good background for development into the 21st century. A number of high-status projects continue to inspire the use of earth for artistic and aesthetic reasons, alongside environmental aspirations.

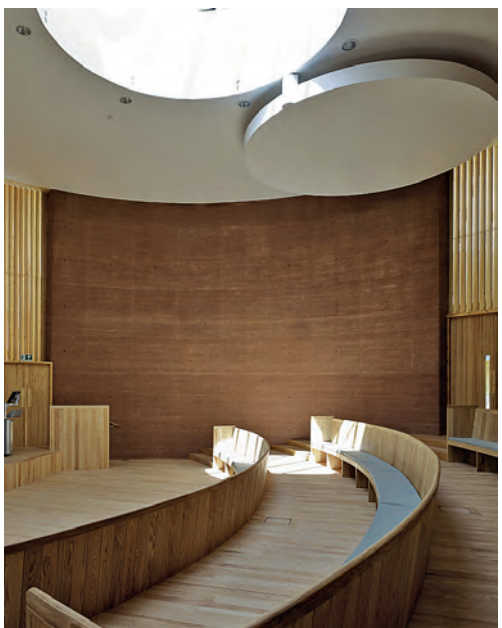
Modern cob building, Jackie Abey and Jill Smallcombe, Eden Visitor Centre, Cornwall, UK. (photos: Louise Cooke)

Below: Wales Institute for Sustainable Education (WISE), Centre for Alternative Technology, Machynlleth, Powys, UK. (photos: CAT)

In this tentative context, earth may once more to be seen as a material of choice for the mass market rather than specialist applications. Large corporate bodies, such as, engineers Ove Arup and Partners are involved in research, Hanson and Ibstock are producing green (unfired) bricks for the mass market and the BRE has included rammed earth with the Green Guide to Specification. In the UK, earth building is diverse and vibrant, with passionate individuals presenting a consistent and persuasive argument for the use of earth in conservation and new build projects.







Azienda vitivinicola la Raia (winery). Builder: Martin Rauch.
Novi Ligure, Piedmont, Italy. (photo: Pierre Buch)

Synthesis

Earthen plaster, Amusco, Spain. (photo: Natalia Jorquera)

Earthen techniques in Europe

Camilla Mileto
Fernando Vegas
Valentina Cristini
Lidia García
Universitat Politecnica de València

Drawings by:
Lidia García, Valentina Cristini, Sabján Tibor

Europe has an extraordinary richness in traditional earthen techniques. An attempt of classification based upon the use and bonding systems follows divided into walls (adobe, half-timber, cob, rammed earth, daubed walls, lumps, CEB, earth bags, coated straw bales), floors, pavements, roofs (excavated, gardened, coating layers, bedding layers), mortars (beddings, coatings). Just not to forget any related variant, some hybrid techniques like gypsum or lime with masonry in formwork, that retain the formwork but almost belong to the masonry field, have been included in rammed earth. We may point out the big number of mixed techniques where earth is combined with other materials like wood, brick or stone, other bounding products such as lime or gypsum, vegetal fibres like wattle, laths, wicker, straw, etc. The different function that wood assumes in some mixed techniques, definitive or auxiliary, has allowed to classify them into half-timber, when it retains it structural function and earth in several forms becomes just a filling; daubed walls, when the act of coating a vegetal screen between posts prevails; and cob or another techniques, when the wood structure has only an auxiliary function while building the wall, being structurally absorbed by the earthen wall once finished. Much in the same way, this classification include the new earthen constructive techniques and related ones, reinterpretation of the tradition, like the modern adobe or CEB, the new cob earth-straw walls, earthen coated straw bale walls, etc.

CLASSIFICATION OF THE TECHNIQUES

A. WALLS

1. Adobe
- 1.1. Adobe masonry wall
- 1.2. Adobe masonry with wattle or reed bedding layers
- 1.3. Adobe masonry with brick reinforcement
- 1.4. Adobe masonry with timber boards protection
- 1.5. Adobe masonry with stone slabs reinforcement

2. Half-timber
- 2.1. Half-timber with horizontal adobe in fill
- 2.2. Half-timber with herringbone adobe in fill
- 2.3. Half-timber with cob in fill
- 2.4. Half-timber with donut-like in fill
- 2.5. Half-timber with angle braces and donut-like in fill
- 2.6. Half-timber with earth in fill between two lath screens
- 2.7. Half-timber with adobe in fill and tile protection
- 2.8. Half-timber with earth in fill between two wicker screens
- 2.9. Half-timber with earth in fill between two wattle screens

3. Cob
- 3.1. Cob
- 3.2. Cob built with between forms
- 3.3. Cob built with wattle formwork fixed by vertical posts
- 3.4. Cob with auxiliary post-and-beam structure

3.5. Tooled cob
3.6. Cob with adobe masonry layers
3.7. Tooled cob with auxiliary post-and-beam structure
3.8. Tooled cob with auxiliary structure of post-and-beam with close studding
3.9. Tooled cob with auxiliary structure of log post-and-beam with wattle

4. Rammed earth

4.1. Rammed earth built with single or double board formwork
4.2. Rammed earth with single or double boards formwork fixed by vertical posts
4.3. Rammed earth built between forms
4.4. Rammed earth reinforced with layers of lime mortar
4.5. Rammed earth reinforced with layers of brick masonry bonded with lime mortar
4.6. Rammed earth reinforced with layers of adobe masonry bonded with lime mortar
4.7. Rammed earth reinforced with gypsum mortar
4.8. Rammed earth reinforced with gypsum mortar, forming waves
4.9. Rammed earth reinforced with gypsum mortar and gypsum pillars
4.10. Rammed earth reinforced with gypsum mortar waves and bricks on outer surface
4.11. Rammed earth reinforced with gypsum mortar waves and stones on outer surface
4.12. Rammed earth reinforced with bricks on outer surface
4.13. Rammed earth reinforced with stones on outer surface
4.14. Rammed earth with an ashlar masonry basement
4.15. Rammed earth with masonry pillars
4.16. Rammed earth with stone and lime mortar in fill
4.17. Rammed earth built between brick masonry pillars
4.18. Formed masonry with gypsum mortar
4.19. Formed masonry with lime mortar

5. Daubed walls

5.1. Post-and-beam structure with wattle-and-daub in fill
5.2. Post-and-beam with angle braces and wattle-and-daub in fill I
5.3. Post-and-beam with angle braces and wattle-and-daub in fill II
5.4. Daubed straw screens between posts
5.5. Daubed straw knotted plaits between posts
5.6. Daubed straw tresses between posts

6. Lump

6.1. Lump wall

7. CEB (Compressed Earth Blocks)

7.1. CEB simple wall
7.2. CEB with corners reinforced

8. Earth bags

9. Straw-bale structure with earthen plaster

B. FLOORS

1. Donut-like earthen filling
2. Tamped earth pavement

C. ROOFS

1. Underground dwellings
2. Gardened roofs
3. Insulating earth layer for wooden roof
4. Bedding mortar for roof tiles
5. Crest for vegetal roofs

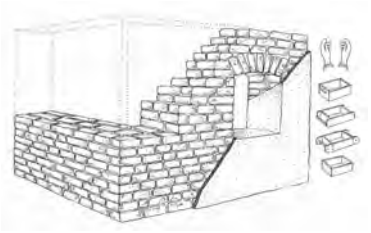
D. MORTAR

1. Bedding mortar for log houses
2. Bedding mortar for adobe masonry walls
3. Earthen bedding mortar for masonry wall
4. Earthen plaster for log houses
5. Lath and earthen plaster on wooden houses
6. Earthen plaster for earthen walls
7. Plaster with fibres for earthen walls
8. Lime plaster for earthen walls
9. Earthen plaster with mesh for earthen walls
10. Stone masonry wall with earthen filling and earthen plaster
11. Decorative elements

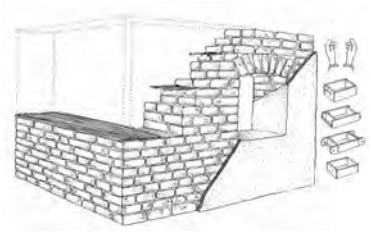
E. AUXILIAR

1. Baking ovens
2. Chimneys

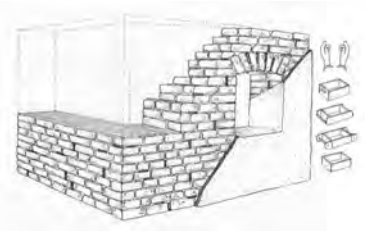
1. Adobe



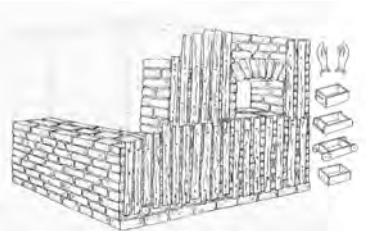
1.1. Adobe masonry wall



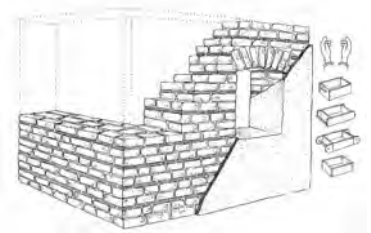
1.2. Adobe masonry with wattle or reed bedding layers



1.3. Adobe masonry with brick reinforcement

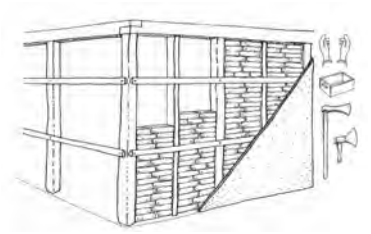


1.4. Adobe masonry with timber boards protection

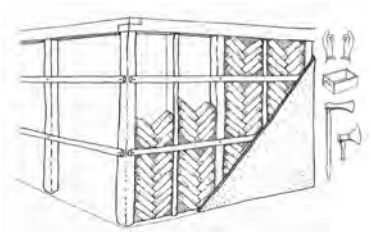


1.5. Adobe masonry with stone slabs reinforcement

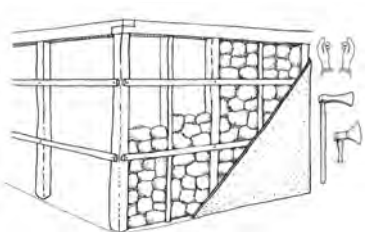
2. Half timber



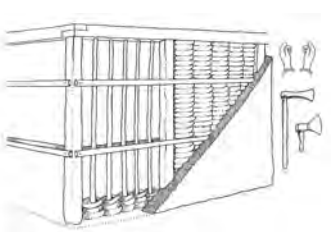
2.1. Half-timber with horizontal adobe in fill



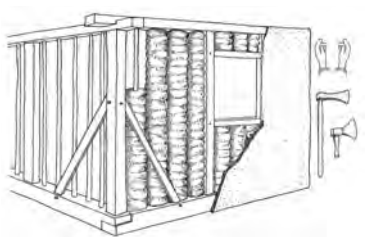
2.2. Half-timber with herringbone adobe in fill



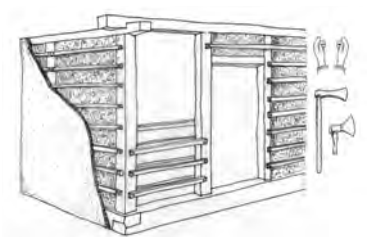
2.3. Half-timber with cob in fill



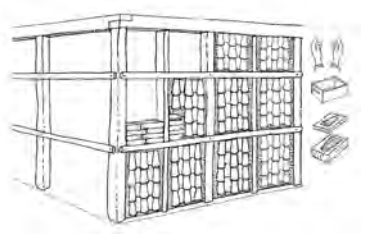
2.4. Half-timber with donut-like in fill



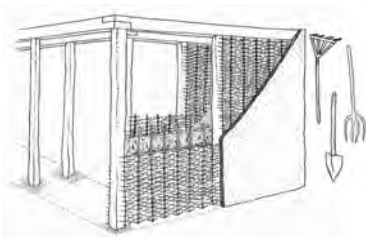
2.5. Half-timber with angle braces and donut-like in fill



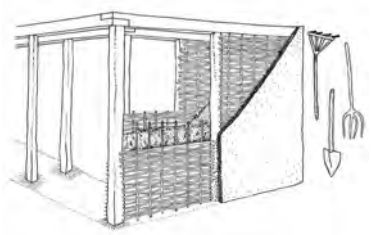
2.6. Half-timber with earth in fill between two lath screens



2.7. Half-timber with adobe in fill and tile protection

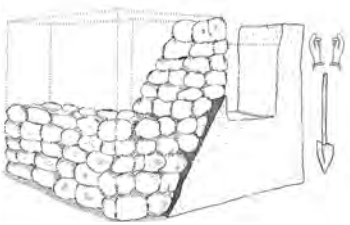


2.8. Half-timber with earth in fill between two wicker screens

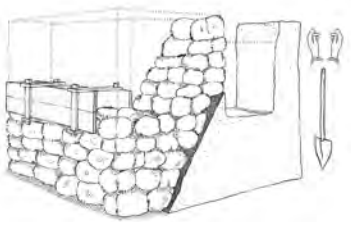


2.9. Half-timber with earth in fill between two wattle screens

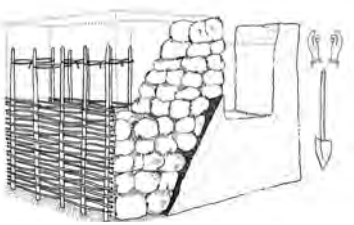
3. Cob



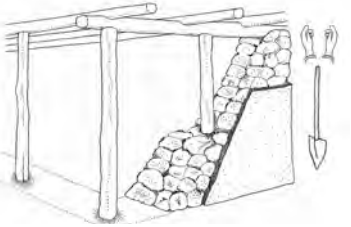
3.1. Cob



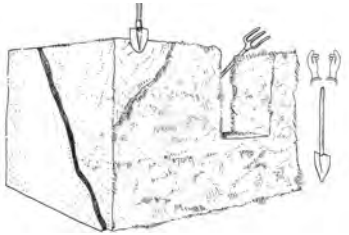
3.2. Cob built with between forms



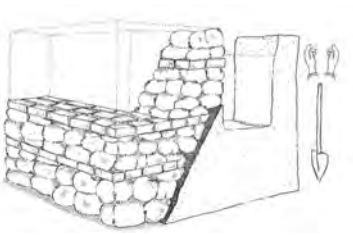
3.3. Cob built with wattle formwork fixed by vertical posts



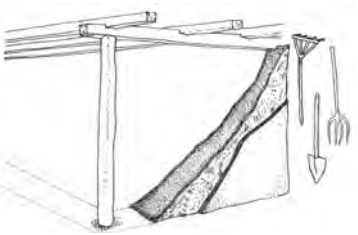
3.4. Cob with auxiliary post-and-beam structure



3.5. Tooled cob

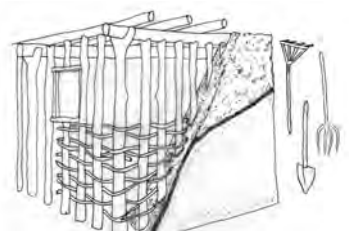


3.6. Cob with adobe masonry layers



3.7. Tooled cob with auxiliary post-and-beam structure

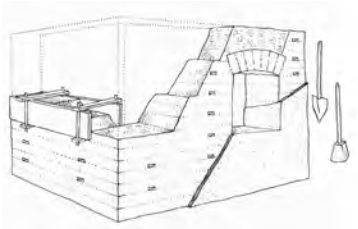
3.8. Tooled cob with auxiliary structure of post-and-beam with close studding



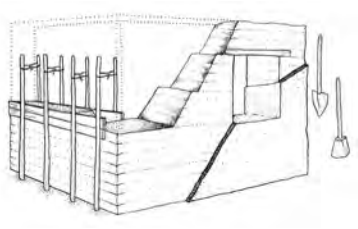
3.9. Tooled cob with auxiliary structure of log post-and-beam with wattle

WALLS

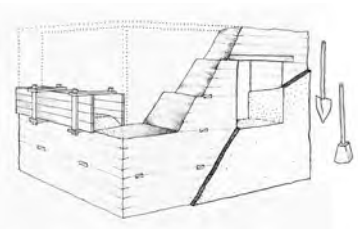
4. Rammed earth



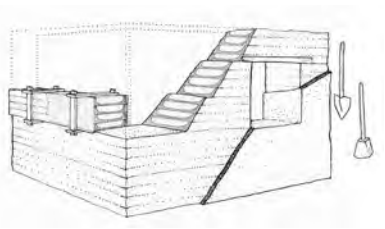
4.1. Rammed earth built with single or double board formwork



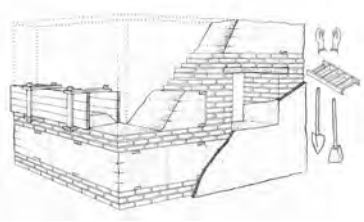
4.2. Rammed earth with single or double boards formwork fixed by vertical posts



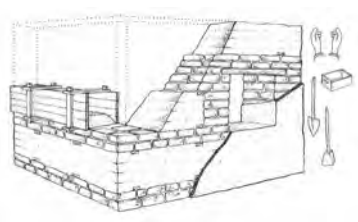
4.3. Rammed earth built between forms



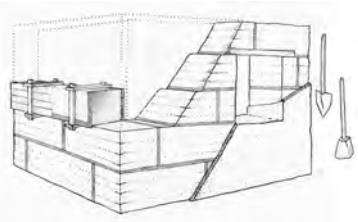
4.4. Rammed earth reinforced with layers of lime mortar



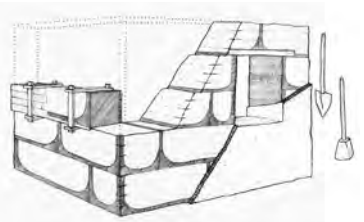
4.5. Rammed earth reinforced with layers of brick masonry bonded with lime mortar



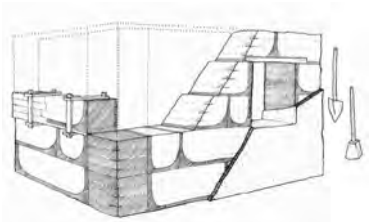
4.6. Rammed earth reinforced with layers of adobe masonry bonded with lime mortar



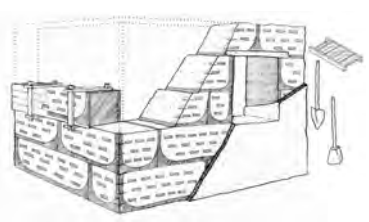
4.7. Rammed earth reinforced with gypsum mortar



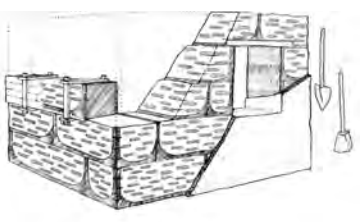
4.8. Rammed earth reinforced with gypsum mortar, forming waves



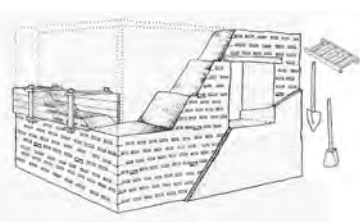
4.9. Rammed earth reinforced with gypsum mortar and gypsum pillars



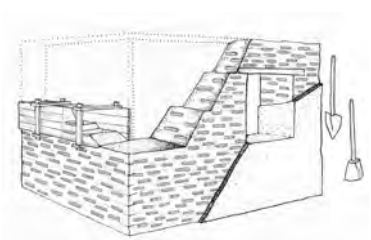
4.10. Rammed earth reinforced with gypsum mortar waves and bricks on outer surface



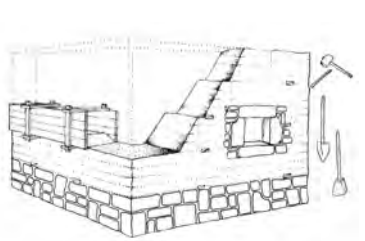
4.11. Rammed earth reinforced with gypsum mortar waves and stones on outer surface



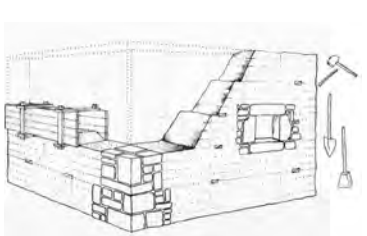
4.12. Rammed earth reinforced with bricks on outer surface



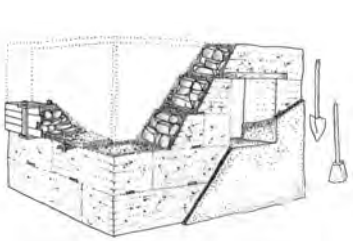
4.13. Rammed earth reinforced with stones on outer surface



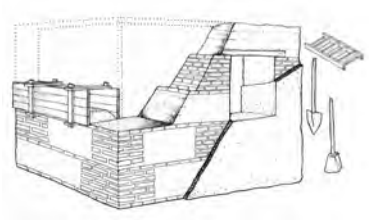
4.14. Rammed earth with an ashlar masonry basement



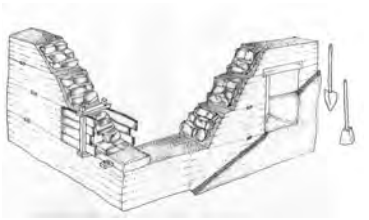
4.15. Rammed earth with masonry pillars



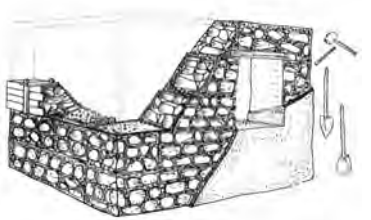
4.16. Rammed earth with stone and lime mortar in fill



4.17. Rammed earth built between brick masonry pillars

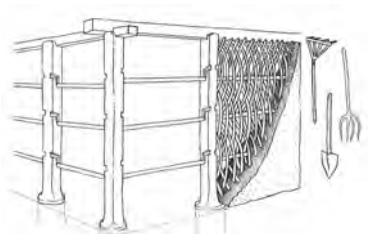


4.18. Formed masonry with gypsum mortar

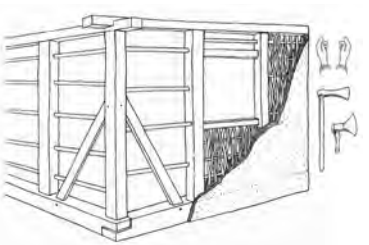


4.19. Formed masonry with lime mortar

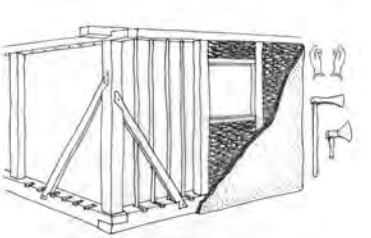
5. Daubed walls



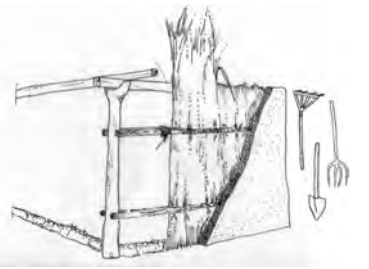
5.1. Post-and-beam structure with wattle-and-daub in fill



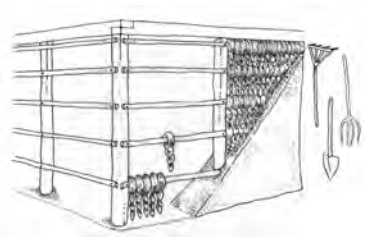
5.2. Post-and-beam with angle braces and wattle-and-daub in fill I



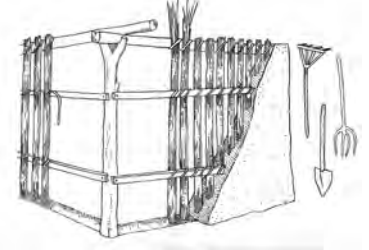
5.3. Post-and-beam with angle braces and wattle-and-daub in fill II



5.4. Daubed straw screens between posts

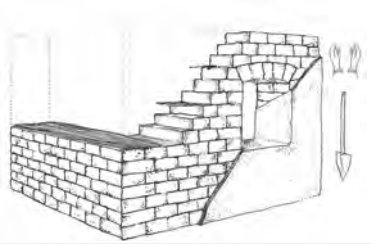


5.5. Daubed straw knotted plaits between posts



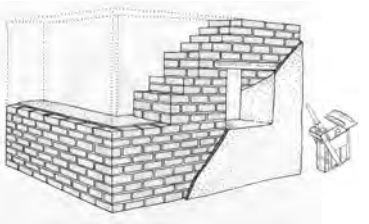
5.6. Daubed straw tresses between posts

6. Lump

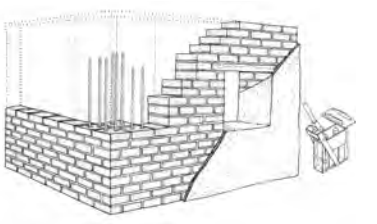


6.1. Lump wall

7. CEB (Compressed Earth Blocks)



7.1. CEB simple wall

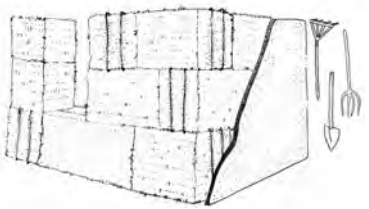


7.2. CEB with corners reinforced

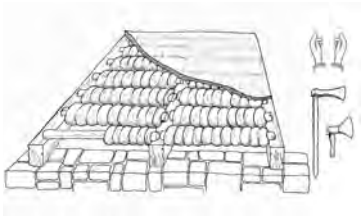
WALLS

8. Earth bags

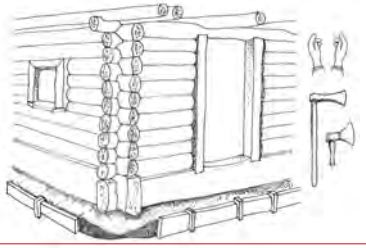
9. Straw-bale structure with earthen plaster



FLOORS



1. Donut-like earthen filling



2. Tamped earth pavement

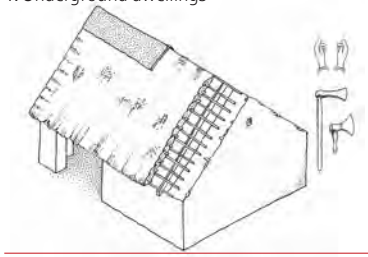
ROOFS

1. Underground dwellings

2. Gardened roofs

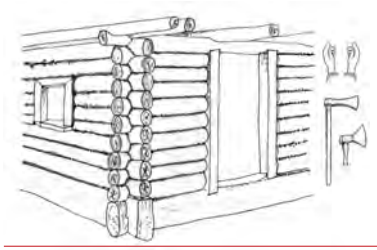
3. Insulating earth layer for wooden roof

4. Bedding mortar for roof tiles

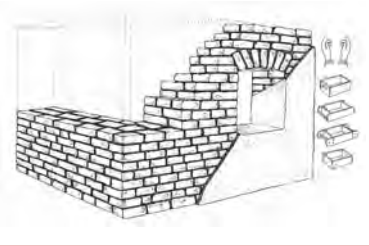


5. Crest for vegetal roofs

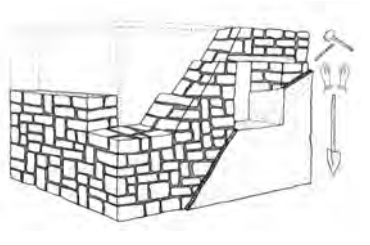
MORTAR



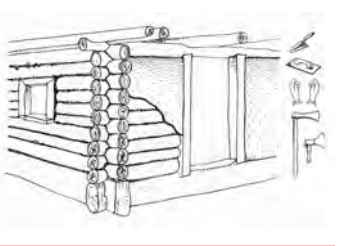
1. Bedding mortar for log houses



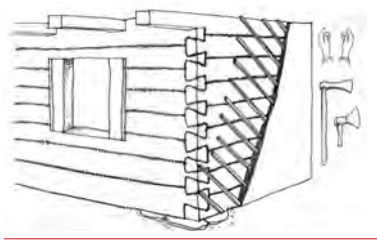
2. Bedding mortar for adobe masonry walls



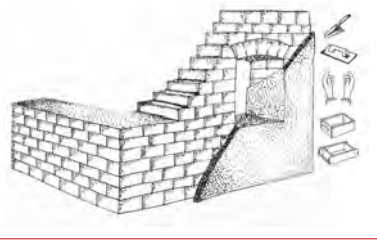
3. Earthen bedding mortar for masonry wall



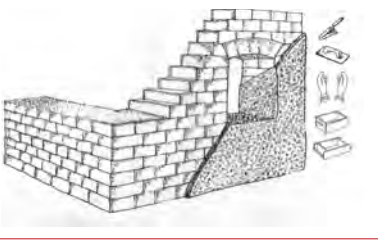
4. Earthen plaster for log houses



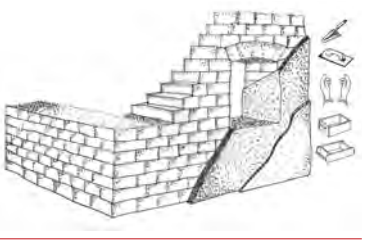
5. Lath and earthen plaster on wooden houses



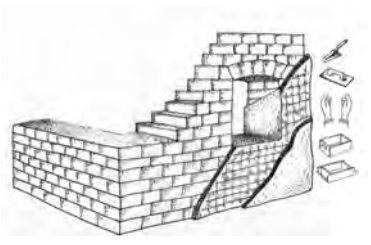
6. Earthen plaster for earthen walls



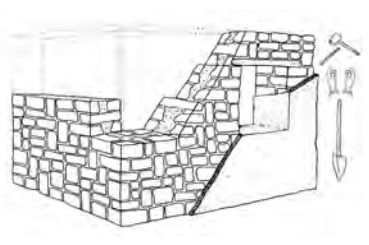
7. Plaster with fibres for earthen walls



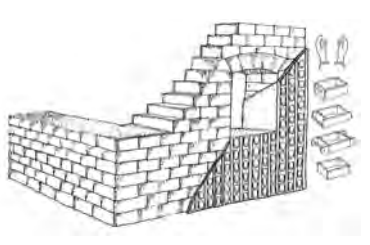
8. Lime plaster for earthen walls



9. Earthen plaster with mesh for earthen walls

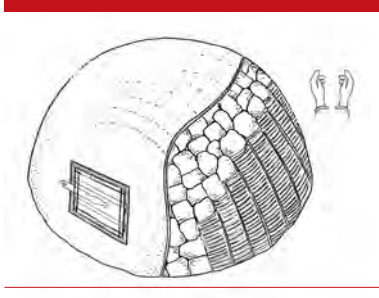


10. Stone masonry wall with earthen filling and earthen plaster

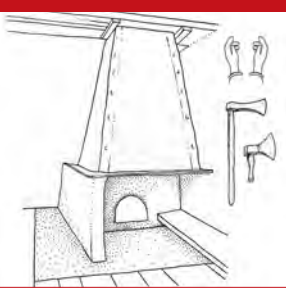


11. Decorative elements

AUXILIAR



1. Baking ovens



2. Chimneys

2011 map of earthen heritage in the European Union

Pigeon buiding, called "Palomar", Amayuelas de Abajo, Spain. (photo: Natalia Jorquera)

Conclusion

Mariana Correia, Marie Chabenat, Valentina Cristini, Letizia Dipasquale, René Guérin, Jacob Merten, Saverio Mecca, Camilla Mileto, Patrice Morot-Sir, Fernando Vegas

Terra [In]cognita project contributed with an overview of the state of art of earthen architecture in the European Union. The principal aims of the research project were restructured for a profounder and richer impact and a real contribution to knowledge. Therefore, the project was organised in three complementary stages of work: a Scientific axis; an Educational and Dissemination axis; and a Networking axis.

Scientific axis

To integrate scientific procedures in the research project was fundamental to define a more accurate methodology of work, with more consistent and systematic outcomes. This was possible due to different undertakings:

Scientific missions

The institutional partners undertook scientific missions to the 27 European Union countries. Their assignments were:

- The definition of an earthen architecture state of art, in terms of available expertise regarding earthen heritage and contemporary architecture, conservation and related training, education and academic research, professionals and producers, etc.
- To identify accurate earthen heritage data in order to establish an up-to-date cartography of each country.
- To identify key-contacts (experts and institutions), contributing to earthen architecture awareness. The missions were assisted by a comprehensive questionnaire developed to systematise findings. Scientific missions had a definitive impact networking experts (e.g. Belgium and Romania) to unite efforts in a national and European level.

Scientific publication

The *TERRA EUROPAE - Earthen Architecture in the European Union* is a scientific publication dedicated to selected outcomes of the two years of research. The book's content starts with a photography overview, followed by 27 articles from 50 authors from all European Union countries, overviews of 7 European regions and to complement this extensive and inclusive publication, a 2011 map of earthen heritage in the European Union. An intensive and valued teamwork generated maps and texts from the selected regions and countries. The outcomes were systematically and consistently combined to create a relevant overview of the state-of-art of earthen architecture in Europe.

European atlas of earthen architecture

As a result of the scientific missions, an accurate cartography was developed. The European atlas brought more clarity to earthen architecture presence in several geographic areas, where it had never been acknowledged. It also established that there is earthen heritage in all the European Union countries.

Educational and Dissemination axis

Improving educational knowledge, raising awareness and providing information regarding earthen architecture in each European country, defined this axis.

European symposium

Project findings were presented on the 4th and 5th of May 2011, in Marseille (Conseil Régional de Provence-Alpes-Côte d'Azur), France, during the European symposium organised by Terra [In]cognita partners and ICOMOS-France. The first day was dedicated to earthen architecture in Europe and the second day was committed to earthen heritage preservation. 37 experts and researchers discussed from heritage and its conservation to material innovation and its contemporary application. The symposium received 160 participants, representing 23 countries, from which 17 were European Union countries. Digital proceedings of the symposium were also prepared and distributed during the event.

Website

The website (http://culture-terra-incognita.org) has become an important tool for contact, a platform for communication and contribution of all the

findings: availability of photos from each European country (under 'Photo Gallery'); down-load of the scientific exposition; access to questionnaires; reports per country of each scientific mission (key-people identified; key institutions identified; key-people contacted; sites identified; sites visited; contributors to cartography; notes), information concerning the European symposium; data regarding European Label; etc.

European label

The Award for 'Outstanding Earthen Architecture in Europe' was a distinctive recognition of earthen architectural quality. Three categories were established:

- Buildings with archaeological, historical or architectural interest;
- Buildings subjected to a remarkable and relevant intervention (restoration, rehabilitation or extension);
- Buildings built after 1970.

The initiative received a considerable number of candidacies from 15 European countries. An international jury of 9 members appointed by ICOMOS-ISCEAH (International Scientific Committee on Earthen Architectural Heritage) and the different project partners awarded the label to 42 European buildings. The award initiative brought an insightful perspective of the existent earthen heritage, significant earthen heritage interventions and earthen contemporary architecture.

Scientific exposition

An important contribution was made by a scientific exposition with an educational and academic purpose. The exposition was developed based on the findings of each European region. Additionally, an important illustration overview of the variety of European earthen building cultures enhanced the exposition. This synopsis was most relevant to understand the contribution of each region to the diversity of earthen architecture in Europe. The exposition is available for free download, on the Terra [in]cognita project website.

Photography exhibition

The exhibition was the outcome of a photography campaign on earthen architecture made by the Belgian photographer, Pierre Buch, who travelled through Normandy and the South-West of France, Andalusia and Castile in Spain, Alentejo in Portugal and Piedmont in Italy. The selected images are the subject of an itinerant exhibition focusing on public awareness.

Booklets for general dissemination

Two booklets were published: a photography catalogue named *'A photographer's look at earthen architecture' (Terre en vues: Regard d'un photographe sur l'architecture de terre)* - an overview of Pierre Buch's photography exhibition; and the label catalogue dedicated to the 42 awarded buildings, recognised as Outstanding Buildings for their architectural quality.

Networking axis

To strengthen the existing partnership and to extend it to a national and European platform for knowledge exchange were the main aims for this axis. On the 6th of May, following the Symposium, a formal reunion was organised by the project partners to create a European network on earthen architecture. The 80 participants, originated from 18 European countries, recognized the importance of launching a European Federation or Association. This could well sustain the work of research and reflection undertaken by the project, and ensure in the long term, an exchange of knowledge and experience in preservation and new construction, as well as earthen architecture standards and regulations. This structure will encourage an intensification of professional and scientific exchange, and the sharing of technical expertise and joint projects dedicated to earthen architecture.

Overall Contribution

The project not only resulted in an exchange of information, but also brought together specialists who, until then, believed there was just a few interested in earthen architecture in their country. The project contributed to create awareness for their country's heritage and an inspiration to start research, to go beyond and to discover an unrevealed earthen heritage.

The research project also provided the opportunity to identify European institutional partners for future research and consultancy, for professional projects or networking. It brought acknowledgment of other experts, academics and professionals involved in the field and a real interest for national collaboration and European networking. This will result in more coordinated efforts to establish research projects and continued scientific research responding to actual challenges.

It is undeniably that the outcome that Terra [In]cognita research project brought was an important contribution to knowledge. This was possible due to the general commitment of the project partners; due to their perseverance to carry through the project and to present more results than the initial aimed and especially, due to their demand for higher quality and exceptional results. The involvement of all the authors, key-contacts and key-institutions made this project a reality with relevant findings. We thank all for their contribution, it definitely made a difference.

Bibliography

Austria

AA.VV. 2008,„"Archaism" in *WBW, werk, bauen+wohnen*, nº3, Zurich.

Fally J.,2008, *Drunt im Burgenland, welcome to Pannonia*, Europrint Ed., Deutschkreutz.

Gernot M., 2004, Friedemann M., *Manual de construcción con paja, fardos de paja*, Fin de siglo Ed., Staufen bei Freiburg.

Otto K. 2001, Martin Rauch: *Rammed Earth / Lehm und Architektur / Terra cruda* (English and German Edition), Birkäuser, Basel.

Pöttler V.H.1985, *Österreichisches freilichtmuseum*, Österreichisches Freilichtmuseum Ed., Graz.

Pöttler V. H. 1997, *Bäuerliche fahrzeuge und arbeitsgeräte*, Österreichisches Freilichtmuseum Ed., Graz.

Pöttler V. H. 1992, *Erlebte baukultur*, Österreichisches Freilichtmuseum Ed., Graz, 1992.

website: www.lehmtonerde.at; www.basehabitat.org

Belgium

Bavay, G. 1983, "L'architecture en terre en Hainaut. Typologie et économie", *Recueil d'études d'histoire hainuyère offertes à M. M.-A. Arnould*, pp. 371-402.

Bavay, G. 2007, "Trente années d'investigations sur la bauge en Wallonie (Belgique). La bauge dans le contexte des architectures de terre. Historiographie et tendances", *L'architecture en bauge en Europe, Actes du Colloque européen organisé par le Parc naturel régional des marais du Cotentin et du Bessin, Isigny-sur-Mer, 12-14 October 2006*, pp. 93-115.

Bavay, G. 2008, "Autour de la bauge. Héritage et devenir du patrimoine architectural en terre crue en Hainaut", *Congrès de la Fédération des cercles d'histoire, d'archéologie et de folklore de Belgique*, unpublished.

Houbrechts, D. 2008, "Le logis en pan-de-bois dans les villes du bassin de la Meuse moyenne (1450-1650)", *Dossiers de la Commission royale des Monuments, Sites et Fouilles,* 12, Liège.

Bulgaria

Dimitrov, D., Yordanov, Y., Kozhuharov, G., Miatev, K. Stoykov, G., Tonev, L. & Hristov, H. (eds) 1965, *Short history of the Bulgarian Architecture*, Bulgarian Academy of Science, Sofia.

Peev, Hristo 1956, *Studies on the Bulgarian Revival architecture,* Ed. Science and Art, Sofia.

Gaiapolis Foundation 1998, Available at: http://gaiapolis.hit.bg.

Cyprus

Demetriou, T., Pattichis, A., Constantinides, A. & Papadouris, G. 2006, *Restoration and Maintenance of Traditional Settlements,* Cyprus Civil Engineers and Architects Association, Nicosia.

Illampas, R., Ioannou, I. & Charmpis, D.C. 2009, *Adobe: "*An Environmentally Friendly Construction Material", *4th International Conference on Sustainable Development and Planning IV,* Limassol, Cyprus, 13-15 May.

Illampas, R., Ioannou, I. & Charmpis, D.C. 2010, "A Study of the Deterioration and Rehabilitation of Adobe Structures", *Proceedings of the 8th International Symposium on the Conservation of Monuments in the Mediterranean Basin, 31 May-2 June,* Patras.

Illampas, R., Ioannou, I. & Charmpis, D.C. 2010, "Destructive and Non-Destructive Testing of Hand-Made Adobe Bricks", *Proceedings of the 13th International Congress and Exhibition on Structural Faults and Repairs, 15-17 June*, Edinburgh.

Illampas, R., Ioannou, I. & Charmpis, D.C. 2010, "An Assessment of the Compressive Strength of Adobe Brick Assemblages", *Proceedings of the 9th HSTAM International Congress on Mechanics*, Limassol, Cyprus, 12-14 July.

Papacharalambous, G. Ch. 1968, *The Traditional Cyprus House*. Cyprus Research Centre, Nicosia.

Pitta, A. & Theodosiou A. 1996, *Dwelling Architecture in the Akamas Area*, Leventis Foundation, Nicosia.

Philokyprou, M. 1998, *Building Materials and Structures of Cyprus Architecture: From the Neolithic Period to the Late Chalcolithic Period*, PhD Study, University of Cyprus - Department of History and Archeology.

Sinos, S. 1976, *A Review of Cyprus Vernacular Architecture*, Athens Press, Nicosia.

Czech Republic

Frolec, V. 1974, *Lidová architektura na Moravě a ve Slezsku*, nakladatelství Blok.

Havlíček, V & Souček K. 1958, *Stavby z nepálené hlíny*, Státní zemědělské nakladatelství, Praha.

Karasová, A. 2009, *Rekonstrukce hliněných staveb v regionu Haná*, dissertation work, Brno.

Mencl, V. 1980, *Lidová architektura v Československu*, Academia, Praha.

Suske, P. 1991, *Hlinené domy novej generácie*, nakladatelství Alfa, Bratislava.

Žabičková, I. 2002, *Hliněné stavby*, Era, Brno.

Žabičková, I.& Čermáková, E. 2008, "Earthen Buildings and Geomagnetic Fields". *Learning from Earthen Architecture in Climate Change*, Cyprus International University, Lefkosa, pp. 271-275.

Žabičková, I., Kabourková, E. & Karasová, A. 2009, *Hliněné stavby včera a dnes*, Brno, SHS, o.s., pp. 1-34

Žabičková, I., Karasová, A.& Šmardová, K. 2009, *Stavět z hlíny jak a proč*. Brno, SHS, o.s., pp. 1-42.

Žabičková, I. 2009, *Přestavby hliněných budov*. Brno, SHS, o.s., pp. 1-38.

Žabičková, I. & Holá, B. Hlinarch 2010, *Profesionální kvalifikace v oboru hliněných omítek*. Atelier otvorových výplní, roč. 14, č. 5/ 2010, pp. 26-27.

Žabičková, I.& Dunajová, A. 2010, *Revitalizace hliněných staveb na přelomu tisíciletí. Národopisná revue*, roč. XX, č. 2/ 2010, pp. 84-96.

website: www.hlina, www.hlina info/en.htlm

Denmark

Byggeriets, U.,Tegnestuen, V. & Bygge-og B. 1993, *Lerjord som byggemateriale : vejledning,* Byggecentrum,nHørsholm.

Dickson, T. 2009, *Dansk design*, Murdoch, London.

Guy, S. 2005, *Sustainable architectures: cultures and natures in Europe and North America*. Spon Press, New York.

Høyer, C. 1920, *Billige Boliger af stampet Ler*, Odense.

Risom, S. 1952, *Lerhuse, stampede og soltørrede, praktisk Vejledning med kortfattet historisk Oversigt, ved Sven Risom*, A. Busck, Kjøbenhavn.

Risom, S. 1959, *Nordiske ler-jords-huse ledsaget af en sammenlignende studie i lerbyggeskikkens udbredelse i Europa, Asien, Afrika og Amerika*. Rosenkilde og Bagger.

Risom, S. 1965, *Supplement til bogen: "Nordiske lerhuse".* Frederiksborg amts historiske Samfund, Hillerød.

Thøgersen, F. 1993, *Byggematerialet lerjord,* Lyngby.

Vejlby, Ulf. 1991, *Bindingsværkshuset : renovering, fugtskader, isolering.* Skovlænge, Søllested.

Estonia

Keskküla, T. 2001, *Eesti savihoonete ehitamise ajalugu*, EPMÜ teadustööde kogumik, 214.

Keskküla, T. (täiendanud) 1991, *Juhatused sawihoonete ehitamiseks*, Põllutööministeeriumi Maakorralduse Peawalitsuse Tehnika Osakond.

Pertma, J. 1923, *Saviehitused,* Põllutööministeeriumi Maakorralduse Peawalitsuse Tehnika, 0. 1922, *Juhatused sawihoonete ehitamiseks.*

Sepp, A. 1935, *Savihooned.*

Finland

Kajaste,T. & Kuivalainen, T. 2005, *Vanhojen savirappausten konservointi,* Opinnäytetyö, EVTEK-ammattikorkeakoulu, Espoo.

Kaila, P. 1997, *Talotohtori,* WSOY.

Kätevyyden, K.1962,Savirakenne, WSOY.

Lundsten, B, Achcar, L & Westermarck, M.1994, "Selvitys savirakentamisesta. Raportti koerakentamisesta kevytsavitekniikalla", *Teknillinen korkeakoulu, arkkitehtiosaston julkaisuja*, 1994/8, Espoo.

Maamies-Lehti No 20 & 21, 1878. Rakennuksista saviruukki-seinillä.

Ranki, T. 2007, *Savirakennukset ja niiden korjaaminen*, Turku.

Salonen, M. 2001, *Kevytsavirakentaminen, koetalo Raision asuntomessuilla. Insinöörityö, Turun Ammattikorkeakoulu*, Turku.

Samsten, L. 2005, *Savilaastit ja savirappaus. Opinnäytetyö, Turun Ammattikorkeakoulu*, Turku.

Sipilä, M. & Anttila R.1960, *Maatalouden rakennukset*, WSOY.

Villanen, L. 2006, *Hirsirakennusten savirappaus. Opinnäytetyö, Ikaalisten käsi- ja taideteollisuusoppilaitos,* Ikaalinen.

Volhard,F. suomeksi toimittanut Westermarck, M. 1994, Savirakentaminen - kevytsavitekniikka. RAK, Helsinki.

Westermarck, M., Heuru, E-R. & Lundsten, B. 1998, "Luonnonmukaiset rakennusaineet". *Teknillinen korkeakoulu, arkkitehtiosaston julkaisuja* 1998/46. Rakennustieto, Helsinki.

France

Anger, R. & Fontaine, L. 2005, *Grains de bâtisseurs*, CRATerre éditions, Grenoble.

Anger, R. & Fontaine, L. 2009, *Bâtir en terre – Du grain de sable à l'architecture*, Editions Belin / Cité des Sciences et de l'Industrie, Paris.

Bardagot, A.M., Doat, P., Houben, H., Guillaud,H. & Odul, P. 1991, *L'intelligence de l'Europe et le développement de l'habitat économique en terre des années vingt à nos jours*, Ministère de la Recherche et de la Technologie, Département des Sciences de l'Homme et de la Société, CRATerre-EAG, Grenoble.

Belmans, D., Dayre, M., Doat, P., Guillaud,H. & Houben, H. 1982, *Recommandations pour la conception des bâtiments du quartier en terre de l'Isle d'Abeau*, Editions AGRA-EAG, Grenoble.

Cointeraux, F. 1790, *Même maison sortant de la main de l'ouvrier*, Ecole d'architecture rurale, fac-similé BNF, Paris.

Cointeraux, F. 1791, *Ecole d'architecture rurale. Quatrième cahier dans lequel on traite du nouveau pisé inventé par l'auteur, de la construction en terre et de ses outils*, fac-similé BNF, Paris.

Dethier, J. 1981, 1986, *Architecture de terre ou l'avenir d'une tradition millénaire*, Centre Georges Pompidou, Paris.

Doat, P., Hays, A., Houben, H., Matuk, S. & Vitoux, F. 1985, 1991, *Construire en terre*, CRATerre-EAG, Editions Alternatives, Paris.

Guillaud, H. 1981, 1997, *Pour une Histoire des Architectures de Terre – Premiers repères*, CRATerre-EAG, Grenoble.

Guillaud, H. 1990, *La terre crue : des matériaux, des techniques et des savoir-faire au service de nouvelles applications architecturales*, Cahiers techniques 2135, 2135-1, 2135-2, 2135-3, Encyclopédie du bâtiment, Editions Techniques – Editions Eyrolles, Paris.

Houben, H. & Guillaud, H. 1989, *Traité de Construction en Terre*, CRATerre-EAG, Editions Parenthèses, Marseille.

Jeannet, J., Pollet, G. & Scarato, P. 1986, *Le pisé – Patrimoine, restauration, techniques d'avenir*, Editions Créer, Nonette.

Germany

AA.VV. 2004, *LEHM 2004: Conference proceedings*, Dachverband Lehm e.V., Weimar.

AA.VV. 2008, *LEHM 2008: Conference proceedings*, Dachverband Lehm e.V., Weimar.

Güntzel, J. 1986, *Zur Geschichte des Lehmbaus in Deutschland*, Dissertation FB Architektur, GH Kassel.

Röhlen, U., Ziegert, C. 2010, *Lehmbau-Praxis - Planung und Ausführung*, Bauwerk Verlag, Berlin

Schreckenbach, H. 2004, *Building with Earth: Consumer information*, Dachverband Lehm e.V., Weimar.

Schroeder, H. 2010, *Lehmbau - Mit Lehm ökologisch planen und bauen*, Vieweg+Teubner Verlag, Wiesbaden

Ziegert, C. 2003, *Lehmwellerbau - Konstruktion, Schäden und Sanierung; Berichte aus dem Konstruktiven Ingenieurbau*, Technische Universität Berlin, Heft 37, Berlin, Fraunhofer IRB Verlag Stuttgart

websites: www.dachverband-lehm.de; www.uni-terra.org

Greece
Bei, G. 2004, *Earth masonry: Experimental investigation of mechanical and physical characteristics of structural units and walls from Compressed Earth Bricks*, Ph.D. Civil Engineer Dept., Aristotle University of Thessaloniki, Greece.
Chourousiadis, G. 1979, The noelithic Dimini, *Society of Thessalian Studies ed.*, Volos, (in Greek).
Bei, G. 2006, 'Earth building conservation. Does it produce a high quality building environment?', *Proceedings of the International Conference Conservation in Changing Societies, Heritage and Development*, Raymond Lemaire International Centre for Conservation, Leuven, Belgium, pp.425-430.
Bei, G. 2007, 'Earth bricks construction technology in historic and socio-economic frame. Contemporary conditions of their use', *1st National Conference on the History of Structures. 11-13 October 2007, ed.* Dept of Architecture, University of Thrace, Ksanthi el. Ed. 06/2009.
Skafida, E. 1994, Building Materials. Technology of the mud houses in Neolithic Thessaly. A ethno-archaiological approach, *La Thessalie, Quienze annees de recherché archeologiques, 1975-1990, Biilans et perspectives, Actes du Colloque International,* Lyon, Avril 17-22, 77-188.
Stratouli, G. 2004, Neolith Avgi of Kastoria. A village 7500 years ago, *Journal of Archaeology and Arts*, June, 110-116.
Vissilia, A-M., Villi, M 2010, Adobe and Timber Ties as main Construction Materials for an Historic Greek Dwelling, *International Journal of Architectural Heritage,* 4:295-319, Taylor & Francis Group.

Hungary
Cseri M. & Buzás M. 1995, "The reconstruction of earth buildings in the Hungarian Open Air Museum at Szentendre", *Out of Earth* nº II, Ed. Linda Watson, Rex Harries, University of Plymouth, Plymouth.
Dora Wiebenson, Sisa J. 1998, *The Architecture of Historic Hungary*, Massechusetts Institute of Technology Ed.,USA.
Sabján T. & Buzás M. 2003,*Hagyományos falak*, Terc Kiadó, Budapest.
website: www.skanzen.hu

Ireland
Buchanan, R.H. 1957, "Stapple thatch", *Ulster Folklife* 3, pp. 13-19.
Clery, R. 1988, "Lough Gur ten years on", *The Lough Gur and District Historical Society. Journal*, 4, pp. 8-10.
Coote, C. 1804, *A statistical survey of County Armagh*
Doyle, M.1868, *Notes and gleanings relating to County Wexford in its past and present conditions*, Dublin.
Dunton, J.1950, "Teague Land or a merry ramble to the wild Irish", MacLysaght, E., *Irish life in the seventeenth century*, Cork, pp. 344-367.
Evans, E.E.1980, "Gleanings from County Cavan", *Ulster Folklife*, 26 pp. 54-59.
Fairon, P. 1988, "The mud-wall house", *Dúiche Néill: Journal of the ONeill County Historical Society*, 1:3, pp. 40-53.
Gailey, A. 1984, *Rural houses of the North of Ireland*, John Donald, Edinburgh.
Gibney, F. 1942, *Clay building memorandum.*
Hughes, E., Lantry, P. & Marshall, O. 1995, *Thatched roofs and clay walls.* Second year civil engineering study, UCD.
M'Evoy, J. 1802, *Statistical Survey of the County of Tyrone*, Dublin.
Ó Danachair, C.1946, "Hearth and chimney in the Irish house", *Béaloideas* 16, pp. 91-109.
Ó Danachair, C.1957, "Materials and methods in Irish traditional building", *JRSAI*, 87.
Ó Danachair, C.1957, "Some distribution patterns in Irish folk tradition", *Béaloideas*, 25,pp. 108-123.
O'Reilly, B.1990, "Stapple thatch in County Dublin", *Sinsear* 6, pp. 13-19.
O'Reilly, B.1991, "The vernacular architecture of north Co. Dublin", *Archaeology Ireland*, 5:2, pp. 24-26.
Ó Ríordáin, S.1942, "Medieval dwellings at Caherguillamore", Co. Limerick, *JRSAI*, 72, pp. 37-63.
O'Sullivan, John C.1974-5, "Wickerwork partition in an Athlone house", *Journal of the Old Athlone Society*, 1:4, pp. 232-233.
Reeners, R.2003, *A Wexford farmstead: the conservation of an XVIIIth Century farmstead at Mayglass*, Kilkenny.
Sheehy, M.1964-70, "Architecture in Offaly", *JCKAS*, 14, pp. 23-28.
Young, A., *Tour in Ireland 1776-1779*, vol. 1, pp. 214- 217.

Italy
Achenza, M. 2005, ´A National law for earthen architecture in Italy´, in proceedings of *Difficulties and expectances in Living in Earthen Cities – kerpic05* ITU Istanbul, Türkiye.
Achenza, M.,Correia, M., Cadinu, M. & Serra, A. (eds) 2006, *Houses and Cities built with earth – conservation, significance and urban quality*, Editora Argumentum, Lisboa.
Achenza, M., Correia, M. & Guiillaud, H.(eds) 2009, *Mediterra 2009, 1st Mediterranean conference on earth architecture*, Edicom Edizioni, Monfalcone (Gorizia).
Bertagnin, M. 1999, *Architetture di terra in Italia, Tipologie, tecnologie e culture costruttive*, Edicom Edizioni, Monfalcone (Gorizia).
Bollini, G. (ed.) 2002, *La ricerca universitaria sull'architettura di terra*, Universiterra1, Edicom, Monfalcone.
Bollini, G. 2006, *Costruire in terra cruda oggi*, Edicom, Monfalcone.
Cavalcanti, O. & Chimirri, R. 1999, *Di fango, di paglia... Architettura in terra cruda in Calabria*, Rubbettino, Soveria Mannelli (CZ).
Forlani M. C. (ed.) 2002, *Costruzione e uso della terra*, Milano, Maggioli Editore.
Galdieri, E. 1982, *Le meraviglie dell'architettura in terra cruda*, Laterza, Rome-Bari.
Sanna, A. & Achenza, M. (ed.) 1999, *Abitare la terra,* CUEC Editrice, Cagliari.
Saracco, M. 2002, *Architettura in terra cruda. Il caso delle Marche*, Alinea Ed., Firenze.
Scudo, G. & Bonati, N. (eds) 1994, *Architettura in Terra: memoria e innovazione*, CLUP, Milano.
Scudo, G. & Sabbadini, S. 1997, *Le Regioni della terra*, Maggioli Editore, Rimini.

Latvia
Dalbiņš M. 1930, *Mazābūvskola* (Riga).
Navickas J. 2002, *Influence of sapropol on the samples of unburned clay* – Proceedings of the International Scientific Conferencce "Safe and Economical Agricultural technologies" (Priekuli, 25 and 26 July, 2002) p. 189-191.
Sahmenko G., Strozs M., *The use of straw-clay material* – Riga Technical University, Faculty of Civil Engineering (Institute of Materials and Structures).
Zariņš D. 1927 – 1931, *Būvmācība, 1. un 2. dala. Būvju konstruktīvie darbi* – Riga.

Lithuania
Balkevičius, V., Christauskas, J., Gailius, A., Špokauskas, A., & Siaurys, V. 2007, ´Analysis of some properties of model system from low-melting illite clay and fibrous mineral wool waste´, in *Material Science-Poland, no. 25 (1)*, pp. 209–217.
Gimbutas, L. 1929, ´Statybinės medžiagos ir trobesių dalys´, in *Žemės ūkio statyba*, Kaunas.
Gurskis, V., Juodis, J., Ramukevičius, D. 2004, *Molio namas, skiedrų stogas*, Ūkininko patarėjas, Kaunas.
Januševičius, P. 1917, *Namai: jų svarba, vieta, padėjimas, stilius, medega, statymas, papuošimas, išvaizda ir planai*, Kaunas.
Kaip ir iš ko galima statyti pigius tvermingus ūkio pastatus 1910, Vilnius.
Kasperiūnaitė, D. & Navickas, J. 2006, ´Nedegto molio savybės´[Properties of unburnt clay], in *Vandens inžinerija: Šiuolaikiniai tyrimo metodai ir technologijos*, Birštonas, pp.120-123.
Krassowskiego, J. 1839, *Sposob stawiania budowli gospodarskich z wczosu I gliny I pokrycia onych dachem niepalnym*, Wilno.
Navickas, J. 2002, ´Influence of sapropol on the samples of unburned clay´, in *Proceedings of the International Scientific Conferencce "Safe and Economical Agricultural technologies"*, 25 and 26 July, Priekuli, Latvia, pp.189-191.
Reisonas, K. 1928, *Molio statyba*, Kaunas.

Luxembourg
Krier, T. & Koltz, J.P., 1975, *Les châteaux historiques du Luxembourg: à l'occasion de l'année européenne du patrimoine architectural*, Saint-Paul, Luxembourg.
Stanislaw, B. & Bienkowska-Bogdan, A., 1992, *Approche typologique de l'architecture rurale au Grand-Duché de Luxembourg*, Ministère des affaires culturelles, Publications nationales, Luxembourg.

Malta
Fsadni, M. 1999, *The Girna – The Maltese Corbelled Stone Hut,* Dominican Publication, Malta.
Jaccarini, C. 1998, *IR-RAZZETT – The Maltese Farmhouse,* P.E.G. Ltd. San Gwann, Malta.
Saliba, P. C., Magro Conti J. and Borg C. 2003, *A Study of Landscape and Irrigation Systems at Is-Simblija limits of Dingli, Malta, and a Conservation Project.* Malta.
Spiteri, S. 2008, *The Art of Fortress Building In Hospitaller Malta.* BDL Publications, Malta.
Trump, D. 2004 (*2nd Ed.*), *MALTA – Prehistory and Temples,* Poligrafici Calderara S.p.A. Bologna, Italy.

Netherlands
Historic Open Air Museum Eindhoven, Boutenslaan 161. Available at: http://www.homeindhoven.nl
Nonk Buusjke, Schinveld, Heringsweg 5a. Available at: http://www.nonkebuusjke.nl
Open Air Museum Arnhem. Available at: http://www.openluchtmuseum.nl
Archeon Historic Open Air Museum, Alphen aan den Rijn. Available at: http://www.archeon.nl/
Technea, 2009, Available at: www.technea.nl/home/cat=182/nea.nl (Accessed 29/11/2009)

Poland
Hughes, J-J., Jez, J. & Zurakowska, M. 2009, *History, materials and social aspects of building from unfired earth in Poland*, Proceedings of the 11th International Conference on Non-conventional Materials and Technologies (NOCMAT 2009 - 6-9 September 2009, Bath, UK).
Kelm, T. 1996, *Architektura ziemi - tradycja i współczesność*, Wydawnictwo Murator, Warszawa.
Kelm T., Długosz-Nowicka D. 2011, *Budowa domu z surowej ziemi – idea i realizacja*, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa

Portugal
Carlos, G. & Correia, M. 2009, 'Military Topographies: Earth Fortresses Between Borders', *MEDITERRA 2009 Proceedings,* EdicomEdizioni, Gorizia, pp.425-436.
CCRC 1992, *Arquitecturas de Terra,* Actas do Seminário, Comissão de Coordenação da Região Centro, Alliance Française de Coimbra e Museu Monográfico de Conímbriga, Conímbriga.
Correia, M. 2007, *Taipa no Alentejo / Rammed Earth in Alentejo*, Editora Argumentum, Lisbon.
Correia, M., Fernandes, M. & Jorge, F. (eds) 2005, *Terra em Seminário*. Actas do 4º Seminário Ibero-Americano de Construção com Terra e 3º Seminário de Arquitectura de Terra em Portugal, Editora Argumentum e Escola Superior Gallaecia, Lisbon.
Correia, M. & Oliveira Jorge, V. (eds) 2006, *TERRA: Forma de Construir. Arquitectura – Antropologia – Arqueologia*. Actas da 10ª Mesa Redonda de Primavera, Editora Argumentum e Escola Superior Gallaecia, Lisbon.
DGEMN 1993, *Proceedings of Terra 93*, Comunicações da 7ª Conferência Internacional sobre o Estudo e Conservação da Arquitectura de Terra, 24 a 29 de Outubro 1993, Direcção Geral dos Edifícios e Monumentos Nacionais, Lisbon.
Fernandes, M. & Correia, M. (eds) 2005, *Arquitectura de Terra em Portugal / Earth Architecture in Portugal*, Editora Argumentum, Lisbon.
Fernandes, M., Correia, M. &Lopes, M. (eds) 2010, *Terra em Seminário 2010.* Actas do 6º Seminário de Arquitectura de Terra em Portugal e 9º Seminário Ibero-Americano de Arquitectura e Construção com Terra, Editora Argumentum, Lisbon.
Neves, C., Varum, H., Fernandes, M. & Correia, M. (eds.) 2007, *Terra em Seminário 2007*. Actas do 5º Seminário de Arquitectura de Terra em Portugal e do TerraBrasil 2006, Editora Argumentum, Lisbon.
Ribeiro, O., 1969, *Geografia e Civilização*, Livros Horizonte, Lisboa.

Romania
Godea, I. 2007, *Arhitectura la români, de la obîrșii la Cozia*, Ed. Primus, Oradea.
Ionașcu, I 1959, *Bucureștii de odinioară*, Ed. Științifică, București.
Ionescu, G. 1981, *Arhitectura pe teritoriul României de-a lungul veacurilor*, Ed. Academiei RSR, București.
Ionescu, G. 1986, *Arhitectura românească*, Ed. Tehnică, București.
Moisescu A. 2001, *Arhitectura românească veche*, Ed. Meridiane, Bucharest.
Panasiu, I.G. 2006, *Tipuri de locuințe rurale în banatul românesc din perioada dominației* habsburgice, Comunicare prezentată la Simpozionul A.R.A., avaible at: *http://www.simpara.ro/ara7/a7_02_13.htm.*
Popoiu, P 2010, *Antropologia Dobrogei / Dobruja Anthropology*, Ed. Universitaria, Craiova.

Slovakia
AA.VV., from NPaKC,1999, *Folk Architecture in Slovakia*,Academic Electronic Press.
Thurzo, I.,2004, *Ľudová architektúra na Slovensku*,Albert Marenčin / Vydavateľstvo, PT Ed.

AA.VV., 2009, *Catalogue: Srdce Z Hliny, Ludová architektúra v Euroregione Váh-Dunaj-Ipel*, arTUR Ed., Bratislava, 2009.
Benža M., 1981, *Researche - Earth Building Techniques of Residential Houses in the beginning of 20th Century in Slovakia, a map.*
Kresánek P., 2009, *Slovakia, Illustrated Encyclopaedia of Monuments,* Simplicissimus vydavatel'stvo, Vel'ké Leváre: Hutterite Yard, p.76.
Mencl V., 1980, *Lidová architektura v Ceskoslovensku*, Academia Ed., Praha.
Syrová Z., 1991, Architecture rurale en terre en Tchécoslovaquie, *in Bulletin d'information du CRATerre*, nº9, Grenoble.
www.ozartur.sk
www.bielekarpaty.sk, 2007, *L'udová architektúra (article based on text by Nešporová, T., Pozdišovský, Š., Kužela, L.: Vývoj osídlenia, l'udová architektúra a pamiatky. In: Kuča et al. (eds): Chránenál krajinná oblast' Biele Bílé Karpaty, 1992)*

Slovenia

Egenter, N. 1992, *Architectural Anthropology*, Structura Mundi Lausanne.
Fister, P. 1986, *Umetnost stavbarstva na Slovenskem,* Cankarjeva zalozba Ljubljana.
Guillaud, H. et al. 2008, *Terra Incognita*, Argumentum Lisboa.
Juvanec, B. 2004, *Vernak. arhitektura, kompleksnost preprostosti*, *AR, UL*,Ljubljana.
Juvanec, B 2005: *Jewell of Architecture: Yemen,* UL FA, Ljubljana.
Juvanec, B. 2009, Corbelling of the Mediterranean, in *Earthen Domes et Habitat*, Edizioni ETS Pisa.
Juvanec, B. 2010, *Architecture of Slovenia 2, Northeast*, UL i2 Ljubljana.
Martin Galindo, J. L. 2007, *La arquitectura vernacula*, Disputacion de Badajoz, Badajoz.
Mileto, C. & Vegas, F. 2008, *Homo faber*, Mancomunidad, Ademuz.
Moskon, D. 1975, *Gradbena raziskava ilovnatega naboja,* UL FAGG Ljubljana.
Oliver, P. 1997, *Encyclopedia of Vernacular Architecture*, Cambridge University Press, Cambridge.
Vegas, F. & Mileto, C. 2007, *Renovar conservando*, Municipio Rincon Ademuz.
Vellinga, M. 2008, *Vernacular Architecture in the 21st Century,* Cambridge University Press, Cambridge.
Zbasnik S., M. 2005, Tradicionalna gradnja z ilovico, *AR 2005/1,* UL Faculty of Arch., Ljubljana.
Zbasnik S., M. 2006, Sodobna gradnja z ilovico, *AR 2006/1,* UL Faculty of Arch., Ljubljana.
Zupancic, D. 2009, Economy and common Sense, *Mediterra 2009*, Cagliari, Edicom Edizioni, Monfalcone.

Spain

AA.VV. 2006, *Arquitectura de Tierra y materiales cerámicos, Técnicas de la Restauración y conservación*, (Máster de Restauración y rehabilitación del Patrimonio), Vicerrectorado de postgrado, Universidad de Alcalá.
AA.VV. 1986, *Informes de la construcción*, Instituto Eduardo Torroja Ed., 1986, cap. "La Tierra, material de construcción", vol.37, n.377, n.385, n. 386.
Alcalde Crespo, G. 1994, *Palencia, barro, madera, piedra*, Ed. EST, Palencia.
Caamaño Suárez, M. 1998, *A casa Popular*, Cadernos do pobo Gallego n.8.
Cristini, V. & Ruiz, J. 2009, 'Taipa Valenciana: Caratteristiche di Muri in Terra Cruda rinforzati con Mattoni', in *MEDITERRA 2009 Proceedings.* EdicomEdizioni, Gorizia, pp.285-294
De Hoz Honrubia, J., Maldonado Ramos L. & Vela Cossío F. 2003, *Diccionario de construcción tradicional: tierra*, Nerea, Madrid.
Flores López, C. *Tesoros de España, Pueblos y Lugares*, Aguilar Ed., Madrid.
Font, J. 2005, 'Earth construction in Spain and Portugal. Differences and Similarities', *Arquitectura de Terra em Portugal – Earth Architecture in Portugal*, Editora Argumentum, Lisboa, pp.119-123
Font Mequita F. & Hidalgo i Chulio P. 2009, *Arquitecturas de tapia*, Coat Ed., Castellon.
González Limón M.T. 1996, "Adobes y Tapiales", Degradación y conservación del patrimonio arquitectónico, Ed. Complutense, Madrid, pp.127-138.
Guarner González, I. 1994, Restauración de la muralla de Niebla; Huelva, in Actas de "Jornadas sobre la restauración y conservación de monumentos", Ministerio de Cultura –ICRBC Ed., Madrid.
Keable, J. 1996, Rammed Earth Structure. A code of Practice, Intermediate Technology Publications, London.
Monjo Carrió, J. 1998. 'La evolución histórica de la arquitectura de tierra en España', *Arquitectura de Tierra, Encuentros internacionales Centro de Investigación Navapalos,* Serie monografica del Ministerio de Fomento, Madrid, pp.31-44.
Olcese Segarra, M.1993, Arquitecturas de tierra: tapial y adobe, COAV Ed., Valladolid.
Palacios Mendoza, V.1994, I*nventario de Arquitectura Rural Alavesa*, Diputación Foral de Alava, Vitoria.
Pliny, 2002, *Naturalis Historia.* XXXV, 169, Ed. Cátedra.
Roldán Morales, F.P. 1983, *Palomares de barro de tierra de campos*, Caja Ahorro de Valladolid Ed., Valladolid.

Sweden

Ellington, K. 1920, *Billiga bostäder av pressad jord : (Pisé de terre)*, Stockholm.
Ellington, K. 1924, *Modern Pisé-Building. House-building with compressed or rammed earth*, (English version).
Lindberg, Eva-Rut, and Tekniska högskolan i Stockholm. 2002, *Gjort av jord : lerjord som byggmaterial i Sverige och länder med likartat klimat*, Stockholm.
Palmgren, L., & Kungliga tekniska högskolan. 2003, *Svenska jordhus med lera eller kalk 1750-1950 : om olika svenska jordhusmetoder - när, varför och hur de uppfördes.* Arkitekturskolan avd. för konstruktionslära KTH, Stockholm.
Wallner, S. & Chalmers Tekniska Högskola 2004, *Stigfinnare innovativt byggande för en hållbar utveckling*, Arkitektursektionen Chalmers, Göteborg.

United Kingdom

Brunskill, R. 1981, *Traditional Buildings of Britain: an introduction to vernacular architecture*, Orion, London.
Egeland, P. 1988, *Cob and Thatch*, Devon Books, Exeter.
Hurd, J. & Gourley, B. 2000, *Terra Britannica: a celebration of earthen structures in Great Britain and Ireland,* James and James, London.
Walker, B and McGregor, C. 1996, Earth Structures and Construction in Scotland, Historic Scotland Technical Advice Note 6, Historic Scotlandù, Edinburgh.
Pearson, G. 1992, *Conservation of Chalk and Clay Buildings*, Donhead, London.
Walker, P., Keable, R., Martin, J. & Maniatidis, V. 2005, *Rammed Earth: Design and Construction Guidelines,* Building Research Establishment, Watford.
Weismann, A and Bryce, K. 2006. *Building with Cob.* Foxhole, Green Books, Devon.
Williams-Ellis, C. 1920, *Cottage Building in Cob, Pisé, Chalk, and Clay, a renaissance*, Country Life, London.

House and artist's studio. Architect: Bartolomeu Costa Cabral.
Aldeia do Salvado, Beja, Alentejo, Portugal. (photo: Pierre Buch)

Contents

Forewords 9

Foreword 11
John Hurd

Foreword
Patrice Morot-Sir, Marie Chabenat, Saverio Mecca, Fernando Vegas, Camilla Mileto, Mariana Correia, René Guérin 13

Introduction
Patrice Morot-Sir, Marie Chabenat, Alexis Castro, Mariana Correia 15

A photographer's look at earthen architecture 19
Pierre Buch

Earthen architecture in Europe: a regional approach 41

Earthen architecture in the Northern Europe: Denmark, Sweden, Finland, Estonia, Latvia and Lithuania 43
Patrice Morot-Sir, René Guérin, Mariana Correia

Earthen architecture in Northwestern Europe: Ireland, the United Kingdom and Northern France 49
Marie Chabenat, Louise Cooke, Barry O'Reilly

Earthen architecture in West Central Europe: Netherlands, Belgium and Luxembourg 55
Mariana Correia, Jacob Merten, Gilberto Carlos

Earthen architecture in Central Europe: Germany and Poland 61
René Guérin, Horst Schroeder, Stephan Jörchel, Teresa Kelm

Earthen architecture in East Central Europe: Czech Republic, Slovakia, Austria, Slovenia, Hungary and Romania 65
Fernando Vegas, Camilla Mileto, Valentina Cristini

Earthen architecture in Southwestern Europe: Portugal, Spain and Southern France 71
Mariana Correia, Jacob Merten, Fernando Vegas, Camilla Mileto, Valentina Cristini

Earthen architecture in Southeastern Europe: Italy, Bulgaria, Greece, Cyprus and Malta 77
Saverio Mecca, Letizia Dipasquale

Earthen architecture in Europe: a national approach **83**

Earthen architecture in Austria **85**
Fernando Vegas, Camilla Mileto, Valentina Cristini

Earthen architecture in Belgium **89**
Sophie Bronchart, Gérard Bavay

Earthen architecture in Bulgaria **93**
Donika Georgieva, Miroslav Velkov

Earthen architecture in Cyprus **97**
Rogiros Illampas, Ioannis Ioannou, Maria Costi de Castrillo, Antonia Theodosiou

Earthen architecture in Czech Republic **101**
Ivana Žabičková, Jan Růžička

Earthen architecture in Denmark **105**
Jacob Merten, Willem Oskam

Earthen architecture in Estonia **109**
Kristina Akermann, Jaan Miljan

Earthen architecture in Finland **113**
Ann-Marie Braxén-Frommer

Earthen architecture in France **117**
René Guerin, Lydie Didier

Earthen architecture in Germany **121**
Horst Schroeder, Stephan Jörchel

Earthen architecture in Greece **125**
Georgia Bei

Earthen architecture in Hungary **129**
Miklós Buzás

Earthen architecture in Ireland **133**
Barry O'Reilly

Earthen architecture in Italy **137**
Letizia Dipasquale, Saverio Mecca

Earthen architecture in Latvia **141**
Peteris Blūms

Earthen architecture in Lithuania **145**
Rasa Bertašiūtė, Ričardas Skorupskas

Earthen architecture in Luxembourg **149**
Mariana Correia, Michael Thönnes

Earthen architecture in Malta **153**
Maria Mifsud

Earthen architecture in the Netherlands **157**
Sjap Holst, Charles Thuijls

Earthen architecture in Poland **161**
Teresa Kelm

Earthen architecture in Portugal **165**
Mariana Correia, Jacob Merten

Earthen architecture in Romania **169**
Cătălin Berescu

Earthen architecture in Slovakia **173**
Zuzana Kierulfová, Boris Hochel, Mojmír Benža

Earthen architecture in Slovenia **177**
Borut Juvanec

Earthen architecture in Spain **181**
Fernando Vegas, Camilla Mileto, Valentina Cristini

Earthen architecture in Sweden **185**
Jenny Andersson

Earthen architecture in the United Kingdom **189**
Louise Cooke

Synthesis **193**

Earthen techniques in Europe **195**
Fernando Vegas, Camilla Mileto, Valentina Cristini, Lidia García

Conclusion **205**
Mariana Correia, Marie Chabenat, Valentina Cristini,
Letizia Dipasquale, René Guérin, Jacob Merten,
Saverio Mecca, Camilla Mileto, Patrice Morot-Sir, Fernando Vegas

Bibliography 207

Finito di stampare nel mese di luglio 2011
in Pisa dalle Edizioni ETS
Piazza Carrara, 16-19, I-56126 Pisa
info@edizioniets.com
www.edizioniets.com

Giuseppe Lotti & Ilaria Bedeschi (a cura di – *sous la direction de*), *Elles Peuvent. Progetti per gli artigiani della Valle del Drâa in Marocco Projets pour les artisans de la Vallée du Drâa au Maroc*, pp. 96.

Lino Centi & Giuseppe Lotti (a cura di), *Design ± Infinito. Percorsi del progetto critico*, pp. 96.

Saverio Mecca & Letizia Dipasquale (a cura di – edit by), *Earthen Domes et Habitats. Villages of Northern Syria. An architectural tradition shared by East and West*, pp. 480.

Saverio Mecca, Letizia Dipasquale, Luisa Rovero, Ugo Tonietti & Vittoria Volpi (a cura di), *Chefchaouen, Architettura e cultura costruttiva*, pp. 216.

Saverio Mecca, Silvia Briccoli Bati, Maria Cristina Forlani & Maria Luisa Germanà (a cura di – edit by), *Earth/Lands. Earthen architectures in Southern Italy / Architetture in terra nell'Italia del Sud*, pp. 304.

Giuseppe Lotti, *Territori & connessioni. Design come attore della dialettica tra locale e globale*, pp. 124.

Giuseppe Lotti, Khadija Kabbaj & Ilaria Serpente (a cura di – *sous la direction de*), *A quatre mains et plus. Design per la ceramica della regione di Tanger-Tétouan in Marocco Design et poterie dans la région de Tanger-Tétouan au Maroc*, pp. 132.

Mariana Correia, Letizia Dipasquale & Saverio Mecca (edit by), *Terra Europae. Earthen architecture in the European Union*, pp. 216.

Terra Europae - Earthen Architecture in the European Union is a scientific publication, resulting from an intensive and valued teamwork of 50 authors that generated exclusive maps and texts from different regions and countries of the European Union. The outcomes were systematically and consistently combined to create a relevant overview of the state-of-art of earthen architecture in Europe.

The publication opens with a photography summary of earthen historical heritage and contemporary architecture in Europe today. It presents an overview of 7 European regions, complemented by 27 articles from all European Union countries. To complete this broad publication, and as a result of the scientific missions, a comprehensive cartography of European earthen heritage is offered.

This book is the result of a common effort gathered by Ecole d'Avignon (France), Escola Superior Gallaecia (Portugal), Universitat Politècnica de València (Spain), Università degli Studi di Firenze (Italy) and CAUE-Conseil d'Architecture, d'Urbanisme et de l'Environnement of Vaucluse (France). European partners in the Culture 2007-2013 programme, through the Terra [In]cognita research project developed between 2009 and 2011.

The project gathered experts that contributed to create an awareness of their country's heritage and brought inspiration to launch research, to go beyond and to discover the unrevealed European earthen heritage and contemporary earthen architecture.

€ 25.00

ISBN 978-884672957-6