Organization of the United Nations for Education, Science and Culture

Panasonic supports sustainable development through Education and conservation of UNESCO World Heritage

Heritage World

CRAterre

Instituto Nacional de Patrimonio Cultural

MATERIAL PEDAGOGICAL

GUIDELINES FOR CONSERVATION OF HERITAGE PROPERTIES OF LAND IN CUENCA

Organization of the United Nations for Education, Science and Culture

Heritage World

Panasonic supports sustainable development through Education and conservation of UNESCO World Heritage

CRAterre

Instituto Nacional de Patrimonio Cultural

AUTHORS

ADDRESS

Bakonirina Rakotomamonjy

AUTHORS

Elisabetta Carnevale

Bakonirina Rakotomamonjy

Enrique Sevillano Gutiérrez

María de Lourdes Abad Rodas

CONTRIBUTORS

Ana Abad Rodas

Álvaro Maldonado Valverde

Germán Pérez Solís

Verónica Rosales Mitte

Luis Felipe Solano Guevara

Christian Tamayo Jara

ACKNOWLEDGMENTS

Cuenca Municipal Government

Maria Cecilia Achig

Patricio Cevallos

Romain Anger and Laetitia Fontaine

David Gandreau

Hubert Guillaud

Thierry Joffroy

Arnaud Misse

Sébastien Moriset

Printed in Cuenca, Ecuador

First edition, October 2015 - 100 copies

IMAGE SOURCES AND ILLUSTRATIONS

Arnaud Misse, AM

André Roseira, AR

Bakonirina Rakotomamonjy, BR

César Piedra, CP

Diana Piedra, DP

Elisabetta Carnevale, EC

Architects DSA Terre ENSAG, Grenoble (Suilan Hau, Alina Je-ronimo, Etienne Samin), EN

Enrique Sevillano Gutiérrez, ES

Frank Stabel, FS

Franz Volhard, FV

Gustavo Lloret, GL

Manolo Salgado Carpio, MS

María de Lourdes Abad Rodas, LA

María Cecilia Achig, MCA

Mariana Gómez, MG

Raed Gindeya, RG

Sébastien Moriset, SM

Students of City and Heritage, University of Azuay, UA

Verónica Rosales, VR

- Junta de Andalucía, 2007, Architecture Guide, Cuenca, Ecuador.

- Carazas, Rivero, 2002, Bahareque, Guide *to parasis-mica construction.*

- Babanedjar, Bois-Soulier, Cornet, Terki, 2007, Construire avec les Adobes, Les ateliers de bâtisseurs, la matière en grains, de la géologie à l'architecture, CRATerre.

- Houben Hugo, Guillaud Hubert, Dayre Michel, Bard Pierre-Yves, Perrier Guy, Dath Fabienne, Dethier Jean, 2006, Traité de construction en terre, Parenthèses, CRATerre.

Cover image: Building in the El Vado neighborhood. (AR)

Back cover image: Adobe brick making, transmission of building culture. (ES)

TABLE OF CONTENTS

PRESENTATION

The publication "Guidelines for the conservation of heritage earthen buildings in Cuenca" was produced within the framework of the UNESCO-promoted project "Mobilization of women and youth in the transmission of traditional techniques for the preservation of earthen architecture", 2015, in the Historic Center of the city of Cuenca, in Ecuador.

The project was developed through a collaboration between UNESCO World Heritage Centre, Latin America and the Caribbean Unit, and CRAterre (France), and the National Institute of Cultural Heritage of Ecuador, a leading institution in the field. It also has the support of the Cuenca Municipal Government and the Faculty of Architecture and Urbanism of the University of Cuenca, and the Panasonic Foundation.

This document stems from the desire to curb the harmful practices that are affecting the earthen architectural heritage of Cuenca's Historic Center, in order to preserve what remains of its exceptional traditional character—a unique and fragile World Heritage Site. The factors contributing to its deterioration are numerous and the dynamics of change are powerful; each building lost represents a step toward the disappearance of this treasure.

The preservation of these splendid ancient structures does not conflict with the modernization of life and the improvement of the comfort of their inhabitants. However, certain ethical rules must be followed.

to avoid the destruction of the cultural values that these buildings possess.

This publication proposes best practices for the conservation of Cuenca's heritage and provides guidance on the most appropriate maintenance and conservation techniques for earthen architecture. Modern materials, often imported, frequently compromise the visual integrity of the Historic Center, are generally poorly suited to earthen structures, and are therefore potentially very destructive. The construction traditions preserved by master masons over time have proven to possess unique qualities.

These guidelines constitute a pedagogical proposal that deserves to be expanded and deepened by all actors involved in the conservation of the land heritage of Cuenca in the near future.

The publication aims to:

- Reduce the loss of heritage values by providing information to policymakers, owners and technicians on current regulations and good conservation practices.

- To help owners, tenants, and technicians to make the right decisions for the conservation, transformation and enhancement of real estate.

- Improve the quality of assistance by providing technical recommendations for maintenance, preservation or restoration actions.

- To inform the community about those municipal services intended to support the conservation of heritage buildings in the City.

The document is addressed to all those who wish to carry out works in the Historic Center of Cuenca, an exceptional architectural heritage of Ecuador and the world, but also to other people and institutions with an interest in the conservation of earth-built heritage:

- Owners and residents.

- Institutions (central state, municipalities, regions, rural communities, local authorities, directorates of Historical and Heritage Areas, Public Works, Housing Commission and others).

- Construction professionals (independent architects and engineers, technicians, construction companies, craftsmen, master builders, bricklayers).

The rich architectural heritage of the Historic Center of Cuenca is characterized by the predominance of earth, present through different techniques: adobe, wattle and daub, plaster, roofs; it also has rich decorations.

We hope to awaken the reader's attention to those details that make up the unity of the historic city and represent a know-how that needs to be revitalized.

Party wall made of adobe. (AR)

1. A TOUR OF THE ARCHITECTURE OF THE HISTORIC CENTER

View of a street in the Historic Center of Cuenca (EC)

THE COLONIAL PERIOD

The houses of the colonial period were organized according to the traditional typology of the Andalusian house, with a patio, back patio and garden, surrounded by portals of wooden pillars or brick pilasters on the ground floor.

Even in the smallest houses, where it also served as a garden, the patio was an essential element, from which the different spaces could be accessed.

The most modest dwellings, for example in the El Vado neighborhood, had between one and five rooms and, in general, also a shop, which functioned as a workplace and as a residence for families with few

resources.

Traditional architecture, originally adapted to an agricultural society, allocated a large area within the dwellings to the storage of agricultural or artisanal products.

The homes of people with fewer resources were of simple construction, without ornamentation, with a single-pitched roof and a single room.

When combined with other properties, they formed complexes with similar characteristics.

MATERIALS AND TECHNIQUES

In general, construction was done on earth (adobe and wattle and daub), with large sections of wall with small openings and low walls.

Building plan from that period (House of the Inns)
(Regional Government of Andalusia, 2007, Architecture Guide, Cuenca, Ecuador)

BLUE HOUSE

GRAN COLOMBIA 10-29 AND PADRE AGUIRRE

ASSET VALUE

Var (B)

STRUCTURAL SYSTEM

Load-bearing adobe walls
Wooden structure

USES

Commercial, offices

SPECIAL FEATURES

Curved eaves (horizontal reed wainscoting, rope ties and wrought iron nails)
Indigo blue woodwork (traditional application with methylene blue, effective moth killer)

Blue House (AR)

HOUSE OF THE POTS

GRAN COLOMBIA 17-42

ASSET VALUE

Emergent

STRUCTURAL SYSTEM

Load-bearing walls of adobe and wattle and daub
Wooden structure

USES

Cultural

SPECIAL FEATURES

First courtyard floor made of river stones
Clay ceilings and eaves

House of the Inns (UA)

FIRST REPUBLICAN PERIOD 1822-1875

The changes that originated from Independence were not immediately reflected in architecture.

The modest dwellings retained the characteristics of the colonial period.

However, in their properties, wealthy families sought to establish differences through superficial treatments on the facades, showcasing the benefits acquired since Independence.

For example, the popular republican houses on Mariscal Sucre and Hermano Miguel streets use classical orders as purely decorative elements: pilasters and columns embedded in the walls that rise without foundations and even without structural support, give the impression of floating on the facades.

The levels used in doors, windows, cornices, eaves and roofs are maintained homogeneously.

MATERIALS AND TECHNIQUES

The master masons continued to build mostly with the traditional materials and techniques of the colonial era: adobe, wattle and daub, tiles and wood.

Typical floor plan of the period (Colonial Hostel)
(Regional Government of Andalusia, 2007, Architecture Guide, Cuenca, Ecuador)

COLONIAL HOSTEL

PADRE AGUIRRE STREETS 9-99 AND GRAN COLOMBIA.

ASSET VALUE

Stick)

STRUCTURAL SYSTEM

Load-bearing adobe walls, *0.60m thick (interior) - 1.20m thick (exterior)*

Interior partition walls made of brick , *0.15m thick*

Wooden structure

USE

Commercial

SPECIAL FEATURES

Wrought iron balconies

Hostal Colonial (AR)

HOTEL SANTA LUCÍA

ANTONIO BORRERO STREET 8-44 AND SIMÓN BOLÍVAR

ASSET VALUE

Stick)

STRUCTURAL SYSTEM

Load-bearing adobe walls, *1.20m thick*

Wooden structure

USE

Commercial

SPECIAL FEATURES

Thick cornice with overhang

Window and door framing

Wrought iron balconies

Hotel Santa Lucia (AR)

FRENCH NEOCLASSICAL 1875-1935

The growth of exports of cinchona bark and toquilla straw hats led to a shift in materials and styles in Cuenca. The rejection of colonial culture and the admiration for European styles, especially French Neoclassicism, in a local reinterpretation, are reflected in the buildings of this period. During this time, the construction of many houses was directed by the owner.

In the case of new architecture, with two or more floors, only the first floor was used for storage and the rest for living rooms and bedrooms.

The layout remained traditional, with rooms arranged around courtyards; therefore, the bathroom and kitchen were located under an overhang overlooking the garden or in the corridor of the outermost courtyard. Houses that lacked sanitary facilities improvised them outside or under the steps.

In other cases, colonial houses were given facades "in the French style", completely replacing the previous ones with new materials or adorning them with cornices, wrought iron lines, window frames, blind walls and high relief work.

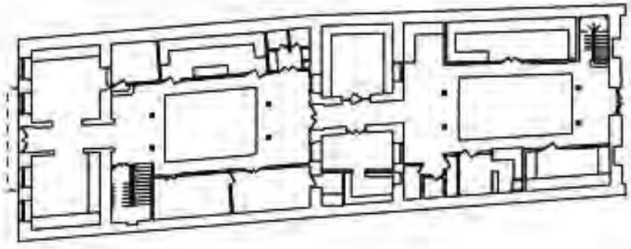
At the beginning of this period, the new houses were out of context and the owners sought only to stand out above the rest of the population, but over time a process of harmonious integration into the Historic Center began.

The neighborhoods specializing in different trades, such as El Chorro, Las Herrerías, and Los Panaderos, maintained their simple, single-story architecture, with a great formal contrast to the new facades but with a great integration in terms of materials and colors, with adobe, tile, and wood.

MATERIALS AND TECHNIQUES

New imported materials began to be used; windows were no longer made solely of solid wood, but lightweight frames with glass imported from Belgium were added. Eucalyptus replaced native species in beams, pillars, and planking. Reed replaced suro for constructing ceilings and roofs. The use of marble, extracted from local quarries, became widespread.

Building plan from that era (Coconut House)
(Regional Government of Andalusia, 2007, Architecture Guide, Cuenca, Ecuador)



COCONUT HOUSE

SIMÓN BOLÍVAR STREET 12-60 AND JUAN MONTALVO

ASSET VALUE

Stick)

STRUCTURAL SYSTEM

Load-bearing adobe walls
Wooden structure

USE

Cultural

PARTICULARITY

Lintels decorated with high reliefs in plaster, lime or brick

Facade of Casa del Coco (Junta de Andalucía, 2007, Architecture Guide, Cuenca, Ecuador) and patio (UA)

PASSAGE KILLS

SIMÓN BOLÍVAR STREET 8-28 AND LUIS CORDERO

ASSET VALUE

Stick)

STRUCTURAL SYSTEM

Load-bearing adobe walls
Wooden structure

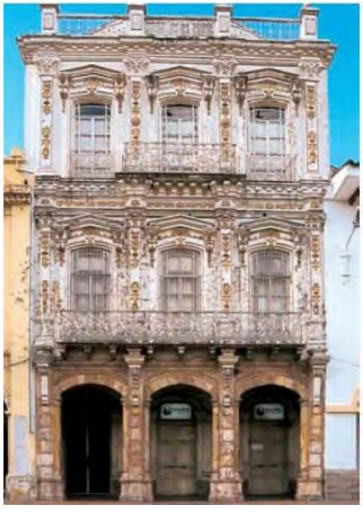
USE

Cultural

SPECIAL FEATURES

Glass imported from Belgium; balusters and polychrome brass for ceilings from France

Facade of the Hortensia Mata Passage (Regional Government of Andalusia, 2007, Architecture Guide, Cuenca, Ecuador)



ART DECO 1930-1940

Art Deco was reflected in a large number of facades, while preserving the traditional interior layouts.

This influence is found in several areas, especially around the San Francisco square, at the beginning of Calle Larga and in the vicinity of the Monastery of the Conceptas.

In the first buildings of this style, classical elements – columns, pediments – were not used; instead, steps were built for facade finishes, friezes, and lintels for doors and windows.

The reinterpretation of Art Deco required the removal of the front eaves of the buildings, which were replaced by a facade finish that concealed the sloping tile roof, giving the building its own identity.

The facades, symmetrical and flat, use geometric decorative elements on different stepped planes, in high and low relief.

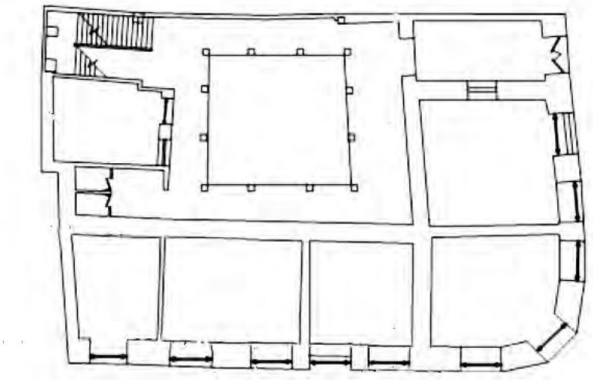
During that period, the designers and builders were generally the bricklayers along with the owners.

MATERIALS AND TECHNIQUES

In some cases, only the facade was replaced using brick and lime and sand mortar, preserving the earthen walls inside; the new houses were built entirely with brick.

Reinforced concrete was used for balconies and small eaves; decorated and colorful cement tiles were widely used to form mosaics.

Building plan from that period (San Augustín Building)
(Regional Government of Andalusia, 2007, Architecture Guide, Cuenca, Ecuador)



TARQUI HOUSE 7-80

TARQUI STREETS 7-80 AND SUCRE

ASSET VALUE

Var (B)

STRUCTURAL SYSTEM

Load-bearing adobe walls

Wattle and daub

USE

Residential

SPECIAL FEATURES

Stepped finish

Wrought iron balcony

Facade. (Source: University of Azuay. 2013. The built heritage in Cuenca. Architectural photogrammetry)

TARQUI HOUSE 6-116

TARQUI STREETS 6-116 AND LARGA STREET

ASSET VALUE

Var (B)

STRUCTURAL SYSTEM

Load-bearing adobe walls

Wattle and daub

USE

Residential

SPECIAL FEATURES

Art Deco Windows

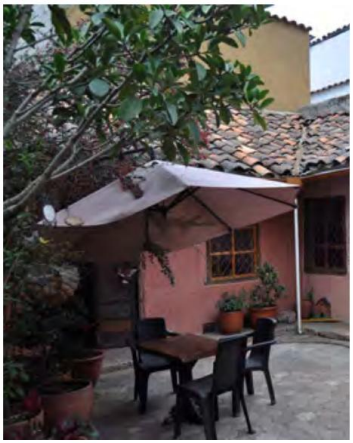
Wrought iron balcony

Facade. (Source: University of Azuay. 2013. The built heritage in Cuenca. Architectural photogrammetry)

The typical architecture of Cuenca features courtyards and backyards, around which the various rooms and buildings are arranged. These spaces often include covered galleries on different floors.

EC and ES images





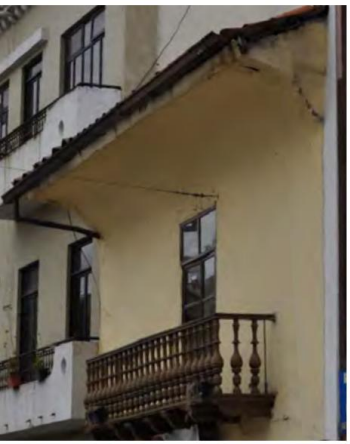


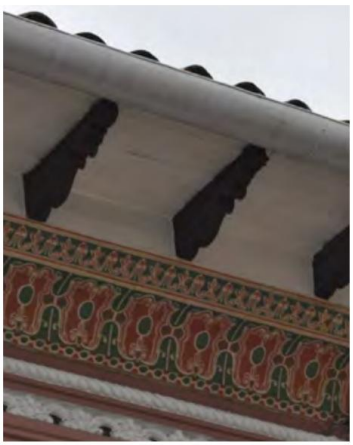

In Cuenca's architecture, the eaves are a fundamental element found in numerous historical buildings. Sometimes they have a curved design.

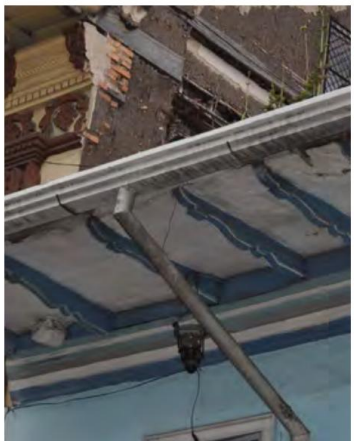
EC and ES images

EAVES CURVED

EAVES WITH CORBELS CARVED WOOD





The continuous balustrade is a typical element of French Neoclassical architecture in Cuenca. It consists of a facade that extends to cover the eaves. Since there are no eaves, rainwater is collected at the junction of the roof and the raised facade wall.

EC,ES,UA,AR Images

1818

CONTINUOUS BALUSTRADE







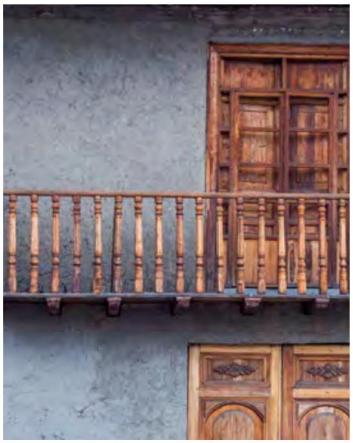

BALCONIES ARE VERY COMMON ELEMENTS; WE CAN FIND THEM IN VARIOUS TYPES AND MATERIALS.

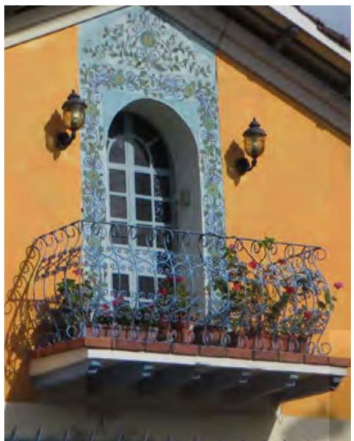
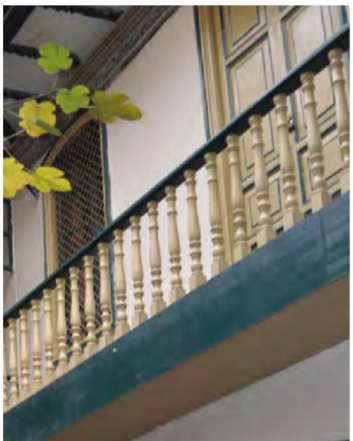
EC,ES,UA,AR Images

BALCONIES WROUGHT IRON

WOODEN BALCONIES



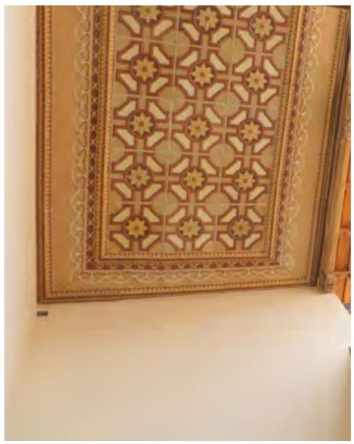
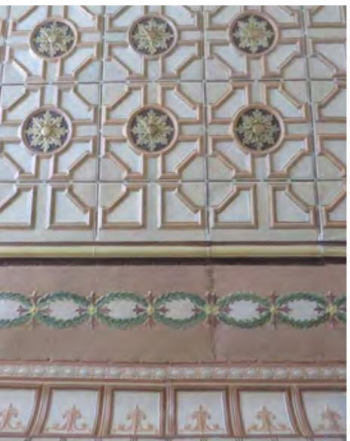



Decorated ceilings are a characteristic feature of many buildings in the historic center. They can be found made of both wood and brass.

EC,ES,UA,AR Images

20 CEILINGS OF WOOD OR BRASS


In many buildings, the dividing walls have no plaster or coverings; therefore, they reveal the raw earth.

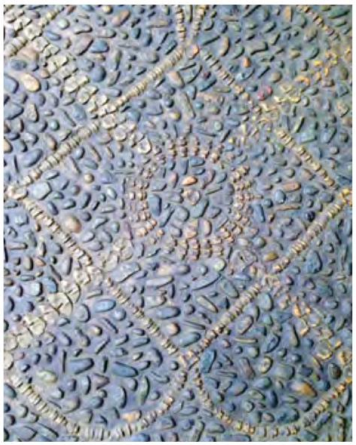
PARTY WALLS OF ADOBE OR WATTLE AND DAUB

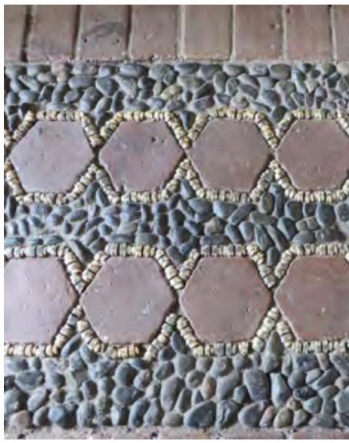



THIS TYPE OF PAVEMENT IS MADE UP OF DECORATIVE MOSAICS MADE WITH BRICK, ROUND STONE AND ANIMAL VERTEBRAE AND IS CHARACTERISTIC OF THE COLONIAL ERA.

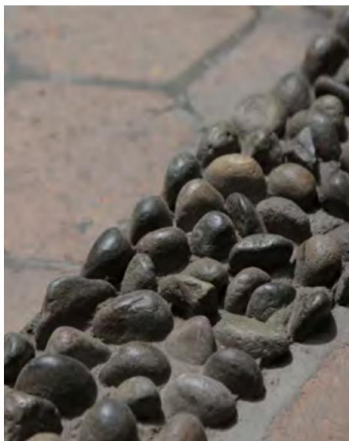
EC,ES,UA,AR Images

ENMORRILLADOS







All soils can be used as building material, except those that are highly organic or have a predominant presence of expansive clays.

Building lands are very diverse, and it is essential to know their main characteristics in order to use them wisely.

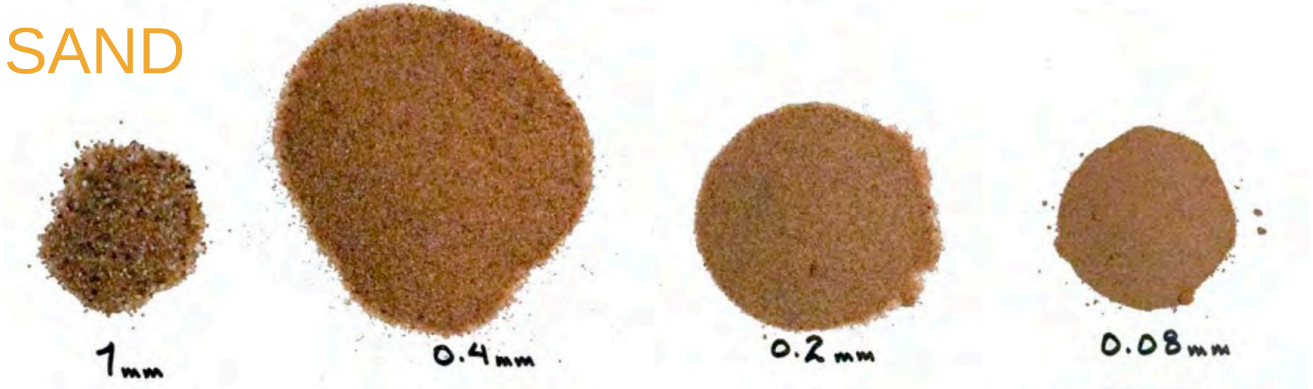
This chapter presents some key steps for identifying the characteristics of different soils.

Different types of earth at the Grains d'Isère earth architecture festival, Grenoble, France. (MG)

2. KNOW THE EARTH

GRAVEL

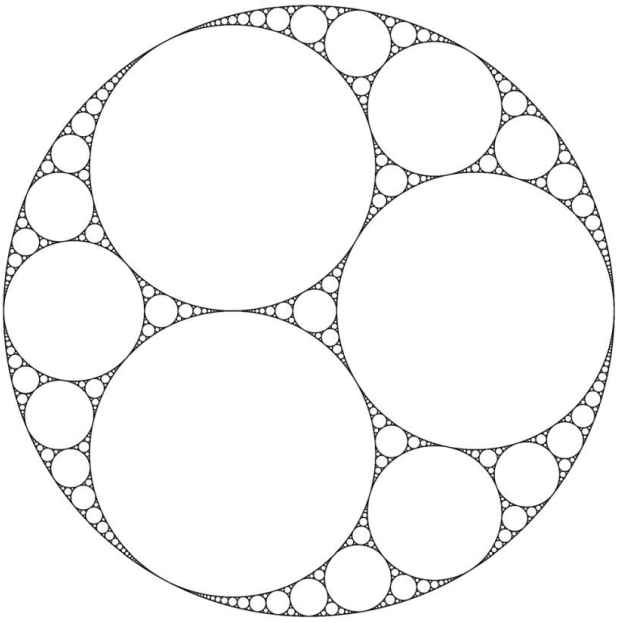
SAND



LIME AND CLAY

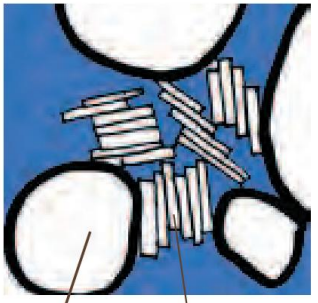
Gravel and sand can be separated using a series of sieves. Clay and silt, the finest particles, cannot be separated by sieving and require laboratory methods for their breakdown and quantification through sediment analysis.

(Image granulometry: EN)



Good building soil has particles of all sizes, so as not to leave gaps and to be more resistant.

(Image: Wikimedia)



Clay gives the earth its cohesion, uniting the particles of gravel, sand and silt thanks to its ability to trap water between its layers, which allows the different particles to "stick" together.

Image: Babanedjar, Bois-Soulier, Cornet, Terki, Construire avec les Adobes, Les ateliers de bâtisseurs, la matière en grains, de la géologie à l'architecture, CRATerre, 2007.

THE EARTH

Soil comes from the decomposition of rocks and is made up of mineral and/or organic elements.

Suitable land for construction is generally located underground, free of organic matter, large stones, and roots.

The most important properties of soils for construction are:

- at the time of selection: granulometric composition, plasticity and shrinkage

- at the time of execution: humidity and degree of compaction.

GRANULOMETRIC COMPOSITION

The earth is made up of particles that can be grouped according to their dimensions: gravel, sand, silt and clay, which also have different sizes, behaviors and characteristics.

The grains that can be seen with the naked eye are gravel and sand. The rest of the soil consists of fine particles: silt—an inert grain like gravel and sand—and clay. Clays can be of various types and, in general, are made up of filaments and multiple flat surfaces (like a mille-feuille) that can store water in their interstices, resulting in cohesion, a characteristic that allows construction with earth.

The granulometric composition of a soil and the quality of its clay are what allow us to determine in which applications we can use each type of soil.

	Diameter	Characteristics of the particles
GRAVEL	2-20 mm	Inert, resistant and without cohesion.
SAND	0.06 - 2 mm	Inert and non-cohesive.
SILT	0.002 – 0.06 mm	Without cohesion, the resistance of the sand.
CLAY	< 0.002 mm	It has strong cohesion. It expands in the presence of water. Its physical and chemical properties vary depending on its origin.

To accurately determine the particle size distribution of soil, laboratory tests are necessary. However, to obtain general information about the type of soil we have and its potential uses, some field tests or trials, which we will discuss below, are sufficient.

VISUAL ANALYSIS

We can identify some characteristics of the lands simply by observing them:

- Light and bright colors are characteristic of inorganic soils

- Dark brown, olive green or black colors are characteristic of organic soils; we should avoid soils with organic matter for construction.

The presence of gravel can be determined with the naked eye. The presence of clay can be assessed through its luster. To observe the luster, it is necessary to:

1. Take a little very fine material and knead with water until you form a compact ball the size of your hand.
2. Cut the ball in half
3. Observe the cut surfaces:
- If they are shiny, the soil is generally clayey.
- if they have little shine, the soil is often silty
- If they are opaque, the soil is probably sandy.

TOUCH TEST

1. By rubbing dry soil between your hands, you can identify the types of particles present in it:
- the sand feels rough when rubbed between the hands;
- the slime covers the fingers with soft particles, like talcum powder.

2. To check for the presence of clay, moisten a small amount of soil and mold it into a ball. The easier it is to form the ball, the more clay there is in the material.

3. Next, we smear our hands with damp soil. When we wash them, we observe whether the soil comes off easily or not.

- If it drains easily, it's a sign that the soil contains little clay.

- If it is difficult to wash off and leaves a film the color of the earth impregnated on our hands, that means our soil contains quite a lot of clay.

(Images: EC)

BOTTLE TEST

To visualize the proportion of different particles present in a given soil (gravel, sand, silt and clay) we can perform the bottle test using the following steps:

• Place a portion of dry, crumbled soil in a smooth, transparent, cylindrical glass, up to about 1/4 of its height

• Add water until the container is almost full, always leaving enough air to stir the mixture.

• Add a pinch of salt, which helps to break down the clay particles (do not add too much as it can have the opposite effect).

• Cover the glass and shake the mixture vigorously so that the soil disperses in the water
• Let it rest for one hour and then shake vigorously again

• Place the container on a horizontal surface for 24 hours.

Each component of the soil settles at different times, forming distinct layers that can be observed with the naked eye. Gravel and sand settle first, being the heaviest particles, followed by silt and finally clay.

If the soil contains organic matter, it floats on the surface of the water.

If the water remains cloudy, it indicates that the soil being studied contains highly active or expansive clays, which swell in reaction with water and either do not settle or take a very long time to do so. In that case, further tests are necessary to determine the type of clay and whether it is suitable for construction.

hands.

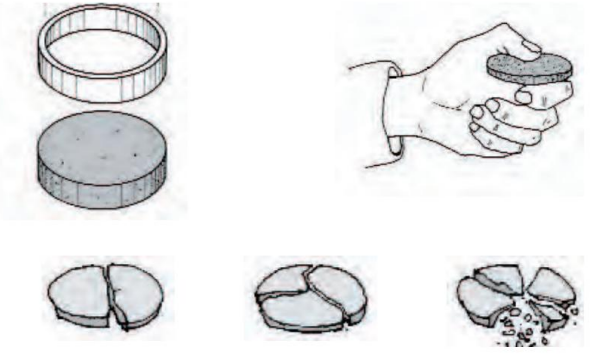
DRY STRENGTH TEST

This test identifies the type of soil based on its resistance to abrasion and fracture:

1. Mold two or three tablets of well-moistened soil, about 1 cm thick and 2 to 3 cm in diameter.
2. Leave the tablets to dry completely for a few days (preferably in the sun) or dry them in an oven
3. Lightly scratch the surface of the tablet with your fingernail to check if its particles come off easily or not, indicating its abrasion resistance.

of the earth

4. Try to break each clay pellet by holding it between your index finger and thumb. Generally, it's not possible to break a pellet of very clayey soil with just these two fingers. A pellet of this type of soil only breaks by bending and with the use of both hands.

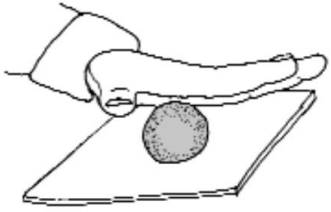


Types of test results. Top image:
Different breaks (Carazas, Rivero, 2002, p. 9)
Bottom image: Different grounding pads (EC)

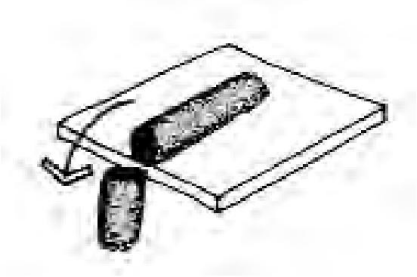
CYLINDER TEST

This test provides information about the cohesion of the soil we are studying. To carry it out, the following steps must be followed:

1. Prepare the soil in a plastic state (in this state it is possible to form a ball with the soil without it crumbling due to lack of water or falling apart due to having too much). Let the soil rest for one hour before carrying out the test, so that the clay has the necessary time to react with the water.



2. On a table, form a cylinder 3 cm in diameter and at least 20 cm long.



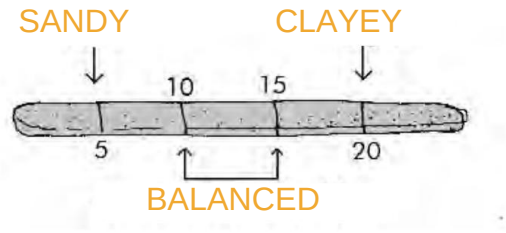
3. Slowly push the cylinder into the vacuum.
4. Measure the length of the cylinder fragment that falls.
5. Perform the test a minimum of 3 times and calculate the average.

If the measurement of the part that falls off is:

- up to 5 cm: the soil is too sandy and needs to be amended with more clayey soil.

- between 7 and 15 cm: the soil is suitable for construction, and can be used for multiple techniques.

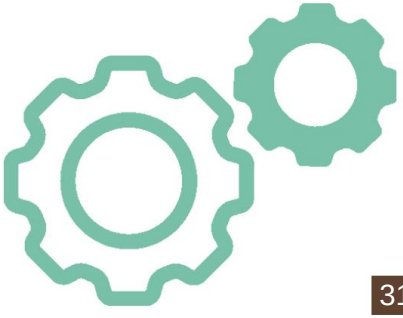
- more than 20 cm: the soil is too clayey and needs to be amended with less clayey soil, sand or fibers.



Cylinder test

(Image: Carazas, Rivero, 2002, p. 9)

Atelier-Greenhouse, built in rammed earth
Machachi, Ecuador, 2006
Architects: Al bordE – Pascual Gangotena
(Image: On the edge)



SELECT THE SOIL

Any soil, except for highly organic soils or those with a predominance of expansive clays, can be used as a building material. We will not use topsoil or soils with high organic content, but rather those found below the topsoil layer.

However, there are limitations regarding the use of certain soils. For example, excessively clayey soils are difficult to mix and compact due to their high cohesion, as they tend to exhibit very high shrinkage when drying, resulting in cracked and poorly finished surfaces.

It is common practice to prioritize using soil from the construction site and to use only one type of soil. In each location, techniques have been developed that are appropriate to the type of soil available and according to local needs.

However, when a type of soil does not allow us to use it for what we need it for, it is possible to mix it with others to achieve better results.

The mixing of different soil types is carried out, for example, when the soil of the place is very clayey or very sandy and when the incorporation of different proportions of another or other soils improves the properties of the original soil and allows us to use it for the desired use.

Other materials are often added to the soil to make it usable and improve its performance: fibers in different proportions, binders other than clay such as lime or gypsum, sand and other inert aggregates, manure, etc.

TYPE OF LAND	APPROPRIATE CONSTRUCTION TECHNIQUE
Sandy	Tapia, compressed earth block (CEB), plasters.
Limosa	More difficult to use, but possible with the use of a binder (lime, clay soil).
Clayey with gravel, sand, or silt	Adobe, rammed earth or compressed earth block (CEB), plasters.
Clayey	With the addition of fibers and/or sand: adobe, mud, wattle and daub.

House Between Walls (adobe wall),
Tumbaco, Quito, Ecuador, 2008
Architects: Al Borde (David Barragán and Pascual Gangotena)
(Image: RG)

(Image: EN)

dry consistency

plastic consistency

consistency
liquid plastic

LAND AND WATER

The consistency of the soil changes as water is added. There are four states in terms of the consistency of the soil and water mixture: dry, moist, plastic, and liquid.

For each state, the land can be worked in different ways, allowing the use of various construction systems:

- In a DRY state, the soil crumbles.
- In a MOIST state, soil can be compacted by blows and pressure. With this consistency and the appropriate type of soil, walls can be built or compressed earth blocks (CEBs) can be manufactured.

- In its PLASTIC state, earth can be molded. Adobe bricks, hand-built walls or "cob," wattle and daub can be made.
plasters.
- In LIQUID state it can be poured, pumped, sprayed and used as paint (earth concrete, sprayed earth, earth paints).

To change from one state to another, a quantity of water must be added that varies depending on the type of terrain:
Sandy soil: very little water is needed to change the consistency.

Clay soil: a large amount of water is needed to change the consistency.

The more cohesive the clay, the greater the soil's water absorption capacity.

PLASTICITY

Depending on the amount of water it contains, the earth can behave as a liquid, as a solid, as a viscous or plastic substance.

RETRACTION

The amount and type of clay present in the soil are responsible for shrinkage and expansion movements that are observed when there is a variation in moisture.
In earthen walls, these movements of the clay can cause cracks and generate internal and/or surface damage. This damage allows water to penetrate and leads to the development of problems that contribute to the loss of material strength and the degradation of the wall.

MOISTURE AND COMPACTION

Earth as a building material can be used:

- Soaked in water, forming a plastic mass or mud, or a wet mixture;

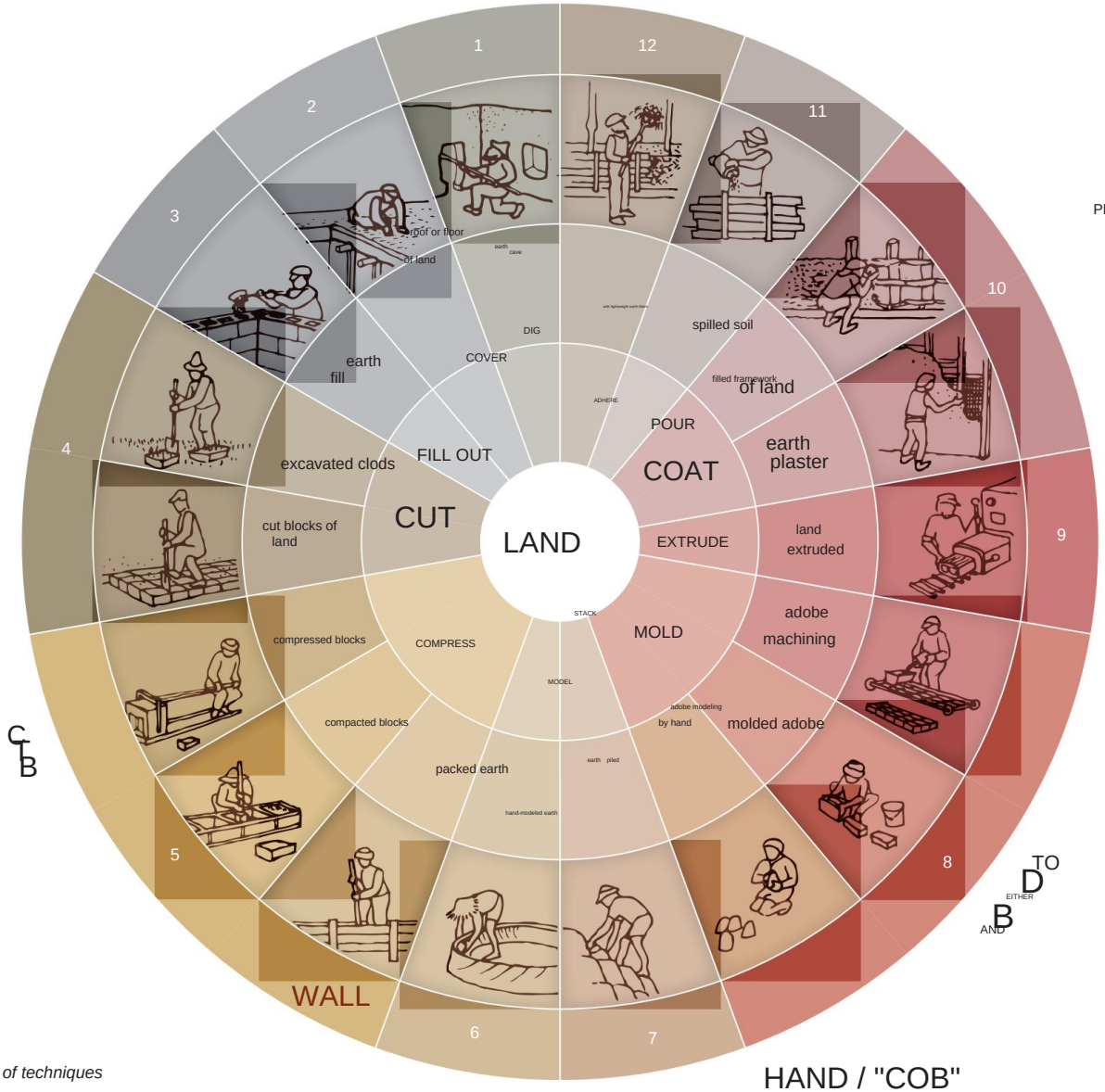
- Compacted or pressed. When soil is compacted, its strength is directly related to its degree of compaction. For each type of soil and each level of compaction, there is an optimum moisture content for compaction. At its optimum moisture content, the soil has less porosity, resulting in a more durable and mechanically resistant material.

Worldwide, we find multiple techniques that take advantage of each type of available soil and adapt to the climatic conditions of each place.

In Cuenca, the predominant earth construction techniques are adobe and wattle and daub. It is also found in plasterwork and as part of traditional roofs beneath the tiles.

Adobe
Image: FS

3.
BEGINNING UNDER CONSTRUCTION WITH LAND; LEGAL FRAMEWORK



Wheel of techniques
of earthen architecture.
CRAterre. (AM)

HAND / "COB"
WALL OF

Private residence "Lienzo de Barro"
Quito, Ecuador, 2013,
Chaquiñan Architecture
(Image: Chaquiñan Arquitectura)

ADOBE

Among all earth construction techniques, adobe is the one that allows the use of the greatest variety of soils, which explains its widespread use.

Adobe is a sun-dried, unfired brick made from a plastic mixture of earth and, in many cases, sand and/or natural aggregates to control cracking (straw, other plant fibers, animal hair). The mixture must be prepared in advance so that the clays activate and any natural aggregates can release their cellulose, resulting in a higher-quality mixture.

Adobe bricks are made by pouring this mixture into molds of the desired size, pressing it down by hand, especially at the corners, to eliminate any gaps. They are then left to dry in the sun, turning them over once they begin to dry so that all sides can air dry, and finally standing them upright to complete the drying process.

Once dry, adobe is used as interlocking masonry for self-supporting walls, load-bearing walls, arches, vaults, and domes. The adobe bricks are joined together with mortar, generally made from a mixture very similar to that of the adobe itself, although almost always without straw.

TYPES OF SOIL

To make adobe bricks, it is recommended to use sandy-clay soil with little silt.

If the soil has a lot of clay, the risk of cracking when it dries increases; if it has too much sand or silt, it may lack sufficient internal cohesion and fall apart easily, in addition to decreasing its compressive strength.

According to the Peruvian standard NTE E 080, 2000, suitable soil should contain: clay – 10% to 20%

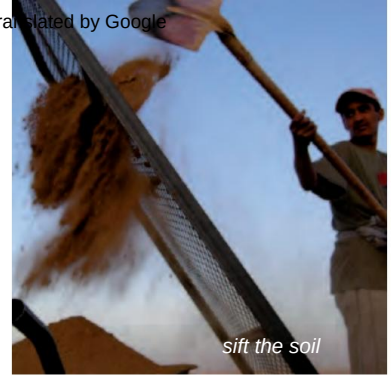
silt – 15% to 25%
sand – 55% to 70%

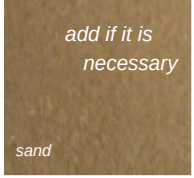
ADDITIVES

The usual additives used are:
- Vegetable fibers and/or animal hair (to prevent cracking due to drying).

- Sand (to prevent cracking due to drying when the soil is very clayey).

It is also possible to add binders such as lime and gypsum to improve their compressive strength or their stability against moisture.





PRODUCTION

1. PREPARATION OF THE SOIL AND AGGREGATES

The soil, preferably dry and free of stones, debris, and vegetation, can be sieved through a 5 mm mesh if it contains larger grains. A roller or mechanical clod breaker can be used to obtain a larger volume of soil.

Once dry, the straw is chopped into pieces of approximately 15 cm and stored in bags.

2. PREPARATION OF THE MIXTURE OF SOIL, WATER AND AGGREGATES

Soil and aggregates are mixed with plenty of water on the floor or in a pit 30 cm deep.
They can step on people or animals or perform the mixing using mechanical means.

The mixture is left to rest, with water added and stirring once or twice a day, for 2-3 days and up to two weeks. This process is called "sleeping" or "rotting" the clay, and its purpose is to hydrate the clays, dissolve lumps, and obtain a more plastic and uniform material.

3. MANUFACTURING OF ADOBE BRICKS

The adobe bricks are made directly on a firm, open-air surface. The mold is kept wet to prevent the mud from sticking. The mud is placed by hand into the mold, filling corners and sides completely, with light manual pressure, without tamping.

It is leveled with a ruler or by hand and unmolded upwards, all quickly but neatly. Rows are arranged, leaving a space every meter for walking.

3.1 MOLDS

The most widespread technique uses rectangular wooden molds of one or two units.

- Molds for small-scale artisanal manufacturing: of 1, 2, 4 and 6 whole units and half units, for rectangular and also square adobes; in seismic zones they can be reinforced with reeds placed inside.

The molds are placed on the floor or on a table.

- Molds for large-scale manufacturing: fixed or mobile grills from 6 to 60 or 70 units.

Mechanical molding can also be used, employing animal-powered or electric extruders. Only fiber-free mixtures can be used in the extrusion process.

mold

dry

store (Images: IN, THE, EC)

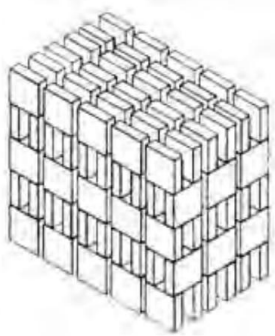
CONSTRUCTION TECHNIQUE

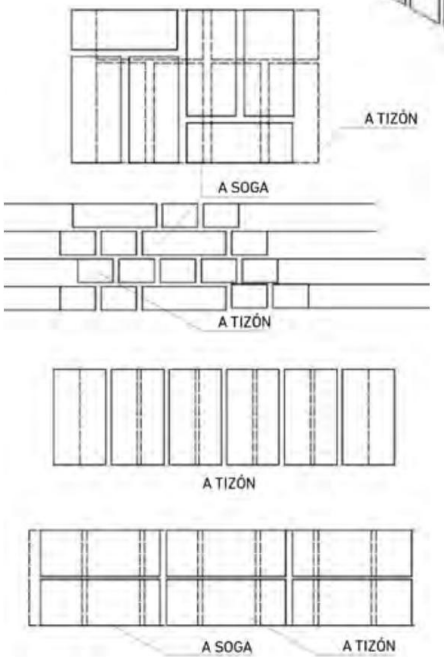
Adobe walls are constructed using a mud mortar, generally without fibers. It is important to minimize the thickness of both horizontal and vertical joints to prevent cracking after the mortar dries and to increase the walls' compressive strength. In the city of Cuenca, adobe walls can reach 1 or 1.2 meters in thickness.

We can find adobe bricks of different proportions: square adobe bricks, adobe bricks with a 2:1 ratio, and adobe bricks with a 3:2 ratio. Each type of adobe brick has different bonding patterns that must be respected to avoid compromising the wall's stability and compressive strength. The adobe brick ratio commonly used in Cuenca is 2:1. For this ratio, there are different bonding patterns found in the buildings of the Historic Center, as we can see in the drawing on the right.

For improved structural performance, horizontal timber framing is used inside the walls as intermediate stiffeners to absorb stress, particularly in the event of an earthquake. Collar beams are also essential for the structural stability of these walls.

Pre- and post-drying storage techniques (DP)





Types of adobe bonding. (DP)

Quinta López Cordero (bahareque)
Jacarín, Cañar, Ecuador, 2011
(Image: Felipe Cobos)

WATTLE AND PEATHER

In traditional Cuenca wattle and daub construction, the structural system is made with wood and reeds, and the earth serves as a covering and sometimes as a filling.

Reeds, wood, and guadua (or bamboo) can be biologically attacked by insects and fungi. For proper use and durability, a natural or artificial drying process should be carried out to remove moisture and reduce it to between 14% and 20%. It is also necessary to remove the bark from wood and reeds and clean the interior of guadua canes, as these elements can be easily attacked by moths.

The wall is composed of: - Main structure
- Auxiliary structure
- Stuffed
- Cladding.

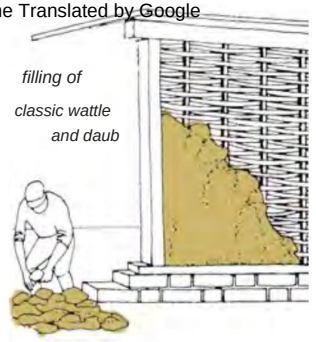
MASTER STRUCTURE

The main structure supports the mechanical stresses.

These are typically wooden frames whose elements are joined by mortise and tenon joints to allow for movement within the structure without damage. The main structure includes bracing, diagonal elements that prevent the walls from deforming.

Vertical or horizontal wooden slats are fixed to the main porticos, depending on the orientation of the auxiliary structure that will be attached to them.

Top image: To use guadua cane for wattle and daub construction, the inner layer of the cane, which can be attacked by moths, must be removed. (EC)
Bottom image: Filling a wattle and daub wall made of guadua cane and wood. Otorongo House. (EC)



AUXILIARY STRUCTURE

The function of the auxiliary structure is to support and consolidate the filling in the wall and the cladding.
This auxiliary structure is usually made of reed in traditional constructions, but it can also be made of guadua cane or small wooden slats.

STUFFED

The infill can be of various types, and sometimes wattle and daub walls are left hollow. The classic infill for wattle and daub in Cuenca is a mixture of earth and fibers, forming a lightweight, vapor-permeable, and elastic blend that responds to the structure's movements. The infill acts like a skin: it provides a degree of thermal insulation and regulates moisture exchange. It must be stable under varying weather conditions and compatible with the structure.

It can be applied as wrapping, filling, braiding, stuffing or by mechanical projection.

TYPE OF SOIL
Since the soil in these systems does not have a structural function, we can use more types of soil. The appropriate composition should contain:

SAND | A minimum of 50% sand is recommended to keep the mixture stable.

SILT | It is suggested that the silt content not exceed 30% because silt can change volume in the presence of water and lacks cohesion, unlike clay. A wall with excess silt can deteriorate with moisture.

CLAY | Too much clay cracks the covering when it dries, and too little clay doesn't allow it to adhere to the structure; therefore, ideally, you should look for soil with 20% clay, always bearing in mind that not all clays are the same and that this percentage is a guideline.

ADDITION OF FIBERS

To achieve a wrap with greater mechanical resistance, durability, impermeability and a better finish, fibers can be added.

The fibers improve the adhesion of the soil to the supporting structure and prevent cracking of highly clayey soils as they dry. The fibers generate two effects: - Thermal improvement: the hollow fibers in the mud create voids that lighten the
material and improve its thermal insulation.

- Structural and strength improvement: the fibers improve strength and prevent cracking under significant elastic deformation. A lightweight filler helps in seismic events.

The fibers must be prepared beforehand and some mixtures need to rest “sleeping” with the clay, so that the clay expands and the fibers integrate.

Vernacular construction in wattle and daub, France

Lupe's house made of metal wattle and daub, Chili

Architect Patricio Arias

(Left page, Images: FV, EN; Drawings: Traité de Construction en Terre, p.186.)

The most commonly used fibers are:

HILL STRAW | Full fiber with a diameter of a few millimeters. Currently, to protect the moorlands, cutting the straw is no longer permitted; therefore, it is necessary to use other types of fibers such as those described below.

WHEAT STRAW | A fairly rigid hollow fiber with a diameter of approximately 5 mm. It does not mix easily with clay and, being difficult to work with, is not commonly used. It is a good alternative for mixtures with clays that expand significantly with water, as it prevents swelling.

BARLEY STRAW | The stalk is less rigid and has lower resistance than wheat. It is used because it mixes more easily with mud and is easier to apply.

COATING

The fill is usually a porous material, susceptible to erosion from rain and frost. Its density is low due to the use of fibers in the mixture. For external protection of the fill or to give a finish to wattle and daub without fill, the following can be used:

LINING

Solid cladding that is attached to the structure and is independent of the filling.

PLASTER

It is a plaster, stucco, or other coating applied in a plastic state that must achieve mechanical adhesion to the filler and/or the supporting structure. The base of the

The wattle and daub walls in Cuenca are typically coated with a mixture of earth and straw in a plastic state. The earth used must contain clay and fine particles such as sand and silt to ensure stability. A finish can be added on top of this mixture, using materials and techniques that are not aggressive to the earth, such as a plaster (a mixture of horse manure and kaolin-type white clay) or lime mortar.

Beforehand, all the components to which the mixture will adhere (wood, bamboo, matting, or filler) must be moistened to facilitate adhesion and prevent shrinkage. Nails or other objects can also be used to help secure the mixture. If it is not desired to leave the main wooden structure exposed, the wood is roughened using an adze to create a surface that will allow the plaster or render to adhere.

For the plastering, it is suggested to apply several layers:

FIRST LAYER | It can be about 2.5 cm thick.
The mixture may contain a lot of fiber, which must be long to attach to the auxiliary structure.

SECOND LAYER | It should not exceed 1.0 cm. The fibers should be shorter and the finish as smooth as possible to facilitate the application of the finishing layer.

THIRD LAYER | It should be almost liquid like a slurry.
It seals cracks and micro-cracks, providing the final finish. Short natural fibers are used, which give a fine texture and reduce shrinkage. A natural waterproofing agent and color can be applied over it.

CONSTRUCTION ERRORS TO AVOID

ADOBE

DESIGN ERRORS

- Height/thickness ratio (slenderness): the height of the walls must be less than 7 times their thickness.
- Door and window openings that are too wide, too numerous, or too close to the corners.

- Little embedment of the lintels.

- Lack of upper tie-down chain or intermediate chains if the building is tall.

EXECUTION ERRORS

- Insufficient horizontal bonding between the adobe bricks, especially when laid on a header bond. Continuous vertical joints in several courses.

- Inadequate and/or deficient fastenings at wall junctions with continuous vertical joints throughout the wall, causing high instability under horizontal roof loads or during earthquakes.

WATTLE AND PEATHER

DESIGN ERRORS -

Eccentricity of the loads, with deformation of the structure.

- Exposure to prevailing rainfall.

EXECUTION ERRORS - Poor quality of materials.

- Construction defects (joints and part sections).

- Use of reed or cane without proper manufacturing, which is susceptible to moth attack.

Little embedment of the lintels (LA)

There is no vertical lock (CP)

Wall exposed to prevailing rainfall (ES)

LEGAL FRAMEWORK

EXTRACT FROM NEC-SE-HOUSING STANDARD PART 2 (6.7. LOAD-BEARING EARTH WALLS)

It is important to have sufficient walls on the ground floor, aiming for a continuous system without any detached walls. Vertical continuity in the design must be achieved to prevent the accumulation of seismic forces on the ground floor. A floor or roof system that integrates the walls, such as collar beams (made of wood or similar material), is also necessary.

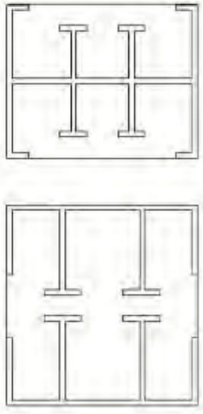
The law refers to Peruvian Standard E.080 for the following indications:

SHAPE AND DIMENSIONS OF ADOBE

a) For rectangular adobe bricks, the length should be approximately twice their width.
b) The ratio between length and height must be 4 to 1.
c) If possible, the height should be greater than 8cm.

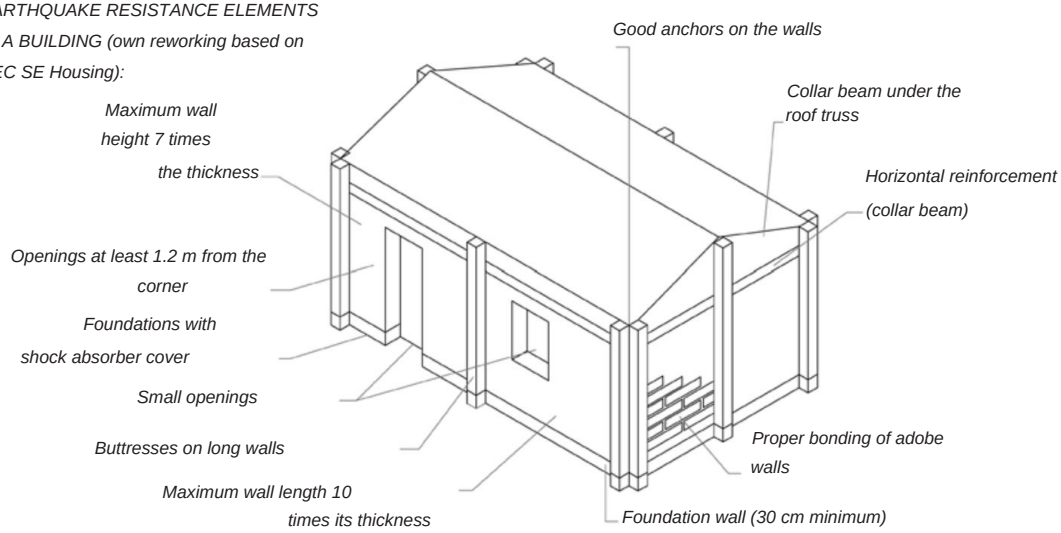
MOISTURE PROTECTION

- Adequate foundations and footings
- Eaves
- Drainage systems



Correct distributions of the walls in plan (NEC SE HOUSING STANDARD PART 2 (6.7)

EARTHQUAKE RESISTANCE ELEMENTS IN A BUILDING (own reworking based on NEC SE Housing):



All structures, including those made of earth, are exposed to the passage of time and suffer degradation caused by natural or human factors. However, there are actions that can be taken to prevent the deterioration of earthen architecture and ensure its proper maintenance and preservation.

These guidelines, while not exhaustive, aim to encourage residents to deepen their understanding of the condition of their homes, so that they can prevent further damage either on their own or by resorting to competent professionals.

Otorongo House Project
Cuenca, Ecuador
(Image: EC)

4. DAMAGE AND CONSERVATION OF EARTH BUILDINGS

ETHICAL PRINCIPLES OF CONSERVATION

The cause of pathologies is not always found at the point where they appear; to prevent them from causing greater problems, it is necessary to intervene at their source.
causes.

That is why one should not intervene directly in a building, but only after observing the property and understanding its functioning and its deterioration processes.

Interventions in heritage buildings are acceptable when they do not alter their authenticity. The authenticity of a building concerns its form and design, its materials, its use and function, traditions and techniques, location and orientation, its spirit and atmosphere.

In this regard, and as indicated in the document “Management of the UNESCO/ICOMOS World Cultural Heritage/
ICCROM”:

“For an urban area, it might be appropriate to examine the structures and spatial organization plans, as well as the traditions and socio-economic and environmental structures of the communities that currently live there, and that allow it to express its value. Thus, a balance between physical conservation and contemporary development must be ensured.”

Source: http://whc.unesco.org/fr/gerer-le-patrimoine-mondial-culturel

What are the principles we must respect first and foremost?

RESPECT FOR ARCHITECTURE

The aesthetic values of traditional architecture must be preserved. This earthen architecture is the first trace of heritage recognition.

from Cuenca.

The preservation of this architectural value implies respect for the many architectural details (balconies, balustrades, wrought iron, woodwork, colors, moldings, corbels, ceilings, exposed party walls, textures) of the materials and traditional techniques.

All interventions must be as discreet as possible.

REVERSIBILITY

All interventions in heritage buildings must be reversible. This requires the use of materials and techniques that allow the building to be returned to its original condition.

In the conservation process, ethics and technique must go hand in hand.

FACTORS OF DETERIORATION: NATURAL AND HUMAN

To understand the deterioration processes that caused the present damage, it is important to know the main causes of deterioration that may have led to the disorders.

A deterioration factor rarely acts in isolation. Several sources of deterioration must always be considered in combination, as they accumulate in a chain of damaging impacts or a domino effect.

We can separate two groups of causes that often act together:

- Natural causes (rain, wind, earthquake).
- Human causes (abandonment, introduction of new materials, poor interventions).

Human factors typically accelerate the deterioration processes caused by natural factors. For example, a lack of maintenance of a drainage system can trigger a cascade of destructive events, beginning with the erosion of wall foundations due to rainwater accumulation. If this situation persists, the loss of strength at the base of the wall due to a lack of cohesion can lead to its collapse.

Other factors contributing to degradation caused by human activity include design or construction errors in buildings. These errors affect the building's durability and can lead to significant damage.

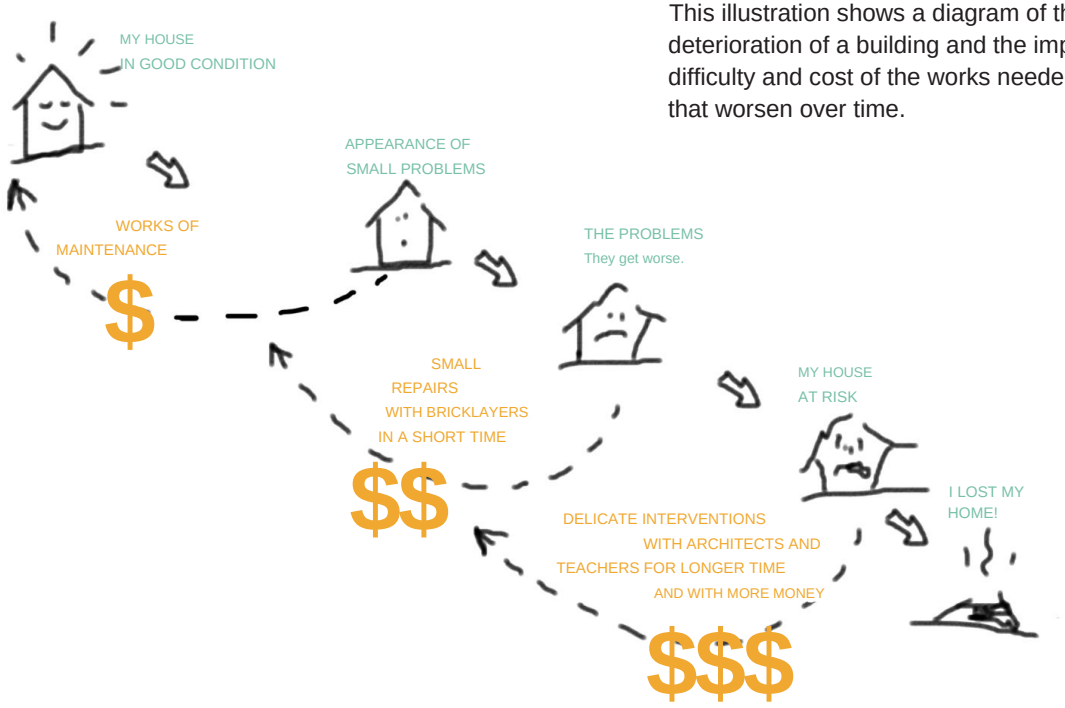
Ruined building in the Historic Center (ES)

COST OF MAINTENANCE OF A PROPERTY

Daily maintenance is a key factor in preventing the appearance of damage and disorders that can jeopardize the stability of a property.

Performing simple maintenance operations will be much cheaper than letting time pass and allowing problems to worsen.

This illustration shows a diagram of the progression of the deterioration of a building and the impact in terms of difficulty and cost of the works needed to solve the problems that worsen over time.



PROBLEMS ARISING FROM HUMIDITY

DAMP STAINS
SALTS EFFLORESCENCE
EROSION AT THE BASE OF THE WALL
BULGEMENT OF THE WALLS
PLANTS, MOSSES AND FUNGI
PLASTER DETACHMENT

Water is essential for building with earth, but it becomes an enemy of these constructions when it appears in excess during the useful life of the buildings.

Soil is a capillary material, meaning it absorbs moisture and only allows it to evaporate when the amount is small and prolonged. Moisture trapped in walls becomes dangerous when leaks are significant because the clay, which normally ensures the material's strength, loses its cohesive properties and the damp material softens.

The damage caused by moisture can be severe or serious if measures are not taken in time, since moisture saturation or the repetition of wetting and drying cycles generates weakening of the material (fragility, erosion, instability, crumbling).

Humidity can weaken earthen constructions when they lose their mechanical properties, potentially leading to structural deformation and even the collapse of a building.

Problems arising from humidity have various causes: - Exposure to rain or splashes from
earthen walls.

- Absence or insufficient drainage capacity in the vicinity of buildings.

- Raising the level of the streets causing greater water retention at the base of the buildings.
- Accumulation of water inside the walls due to watertight plaster and capillary action of water.

- Leaks in water installations that are embedded in or in direct contact with earth walls.

- Damage to the roof structure.

Damage due to moisture usually occurs at the bottom of walls, where water can stagnate and splash.

Seepage and capillary absorption of water from the ground by the wall have more serious effects when the ground around the building is watertight, for example, if against the wall there is a sidewalk or street made of concrete, asphalt or tiles

Waterproof because they prevent water from infiltrating the ground, allowing it to pass into the wall through its base by capillary action. Similarly, groundwater trapped beneath the waterproof layer of the pavement can only evaporate by passing through the base of the wall, rising up the wall, and exiting from its surface, if the latter does not have waterproof coverings.

Waterproof coatings on raw earth walls (ceramics, cement mortar or closed-pore paints such as oil enamel) prevent water from escaping the wall by evaporation, causing condensation inside the wall and signs of dampness (deformations, detachment, etc.).

Watertight floors inside the building (concrete floors, linoleum, watertight tiles) worsen the absorption of water through the base of the wall by capillary action.

It is also necessary to avoid storing objects or materials that retain moisture at the base of the wall (for example, piles of sand or rubble) as they prevent the wall from drying out and cause serious problems.

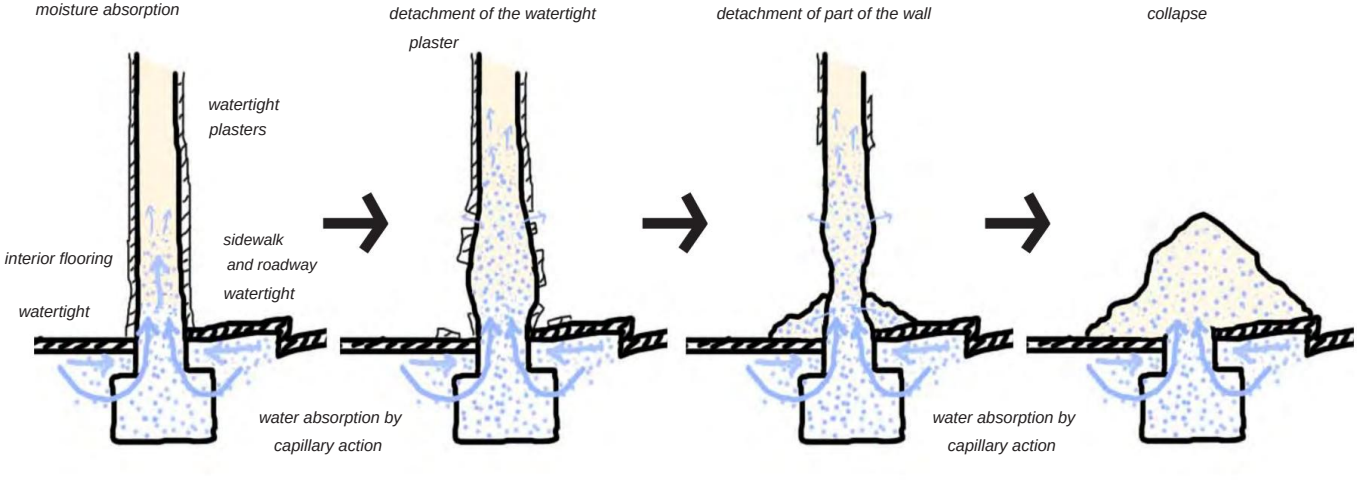
Moss or parasitic vegetation on walls indicates a high level of humidity, possibly due to poor drainage at the base of the wall. It is important to control the presence of vegetation at the base of building walls.

We can also find problems at the top of the walls, resulting from leaks in the roof, in other specific areas in kitchens, bathrooms and where pipes or downpipes pass.

The direct impact of raindrops on walls causes negligible erosion, especially if they have foundations and generous eaves. However, rainwater can often be trapped in retention areas within the building, created as a result of the transport of materials by the water itself or errors in the construction of the slopes.

Water can also pool inside buildings when poorly maintained roofs leak. Much of that water seeps into earthen walls. Infiltration can occur in minutes.

Moisture absorption scheme in an earth wall surrounded by impermeable surfaces (ES)



WHY DOES THE PROBLEM OCCUR?

DEFECTIVE PIPES WITHIN WALLS

Sometimes the cause of a damp problem is a faulty pipe inside a wall. This can cause very serious damage because we only become aware of the problem when the damp reaches the surface of the wall, once it is already completely saturated.

It is important to avoid placing pipes or downpipes inside earthen walls.

A faulty downpipe inside the wall is causing a water leak. (LA)

HOW CAN I INTERVENE?

SUBSTITUTION of defective pipes

In the case of faulty water installations inside the walls, we will first have to seal the pipe to stop water from entering the wall.

Once sealed, we should leave it inside the wall if it's not badly damaged; otherwise, we'll need to replace the damaged section, taking into account how it fits with the rest of the wall. Then we can install a new pipe outside the wall.

Replacement of defective piping at the Carvallo House (LA)

WHY DOES THE PROBLEM OCCUR?

LEVEL ELEVATION STREET

After many renovations of a street with its asphalt and sidewalks, it can happen that the street level is higher than the level of the building and even higher than the foundations of the earth wall.

In that case, the foundation wall does not fulfill its function of protecting the base of the wall from the absorption of moisture by capillary action, and the wall is in a very vulnerable state at its most important and most demanded point: the base.

Street level rise (ES)

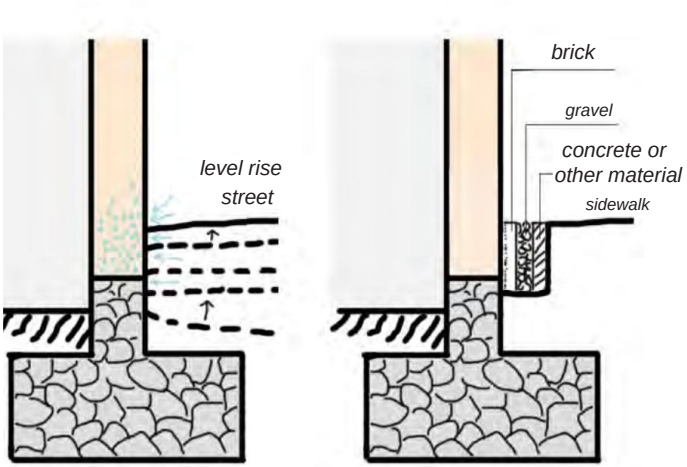
HOW CAN I INTERVENE?

INTERVENTION IN THE BASE OF THE WALL

- The ideal solution would be to lower the level of the sidewalk.

- When this is not possible, another solution may be: 1. Shoring up the wall if necessary.
2. Remove the concrete or cement in the part next to the earth wall, in a strip at least 15 cm wide, and going down to the level of the foundation.
3. Place a fired brick vertically next to the earthen wall, using mud or lime mortar.
4. Fill the strip with gravel, with a thickness of 5cm, up to the level of the sidewalk.
5. Pour concrete or other material back onto the sidewalk.

Possible solution to this problem (ES)



WHY DOES THE PROBLEM OCCUR?

LACK OF FOUNDATIONS

The lack of foundations in earthen walls encourages the appearance of dampness in the lower part of the walls due to capillary action. Over time, this dampness deteriorates the wall. The presence of dampness is particularly dangerous when it occurs at the base of the walls.

Due to the vertical load they bear, damp walls begin to swell laterally, eventually collapsing under their own weight. In the event of an earthquake, such a wall will most likely collapse.

Lack of foundations with signs of erosion at the base (ES)

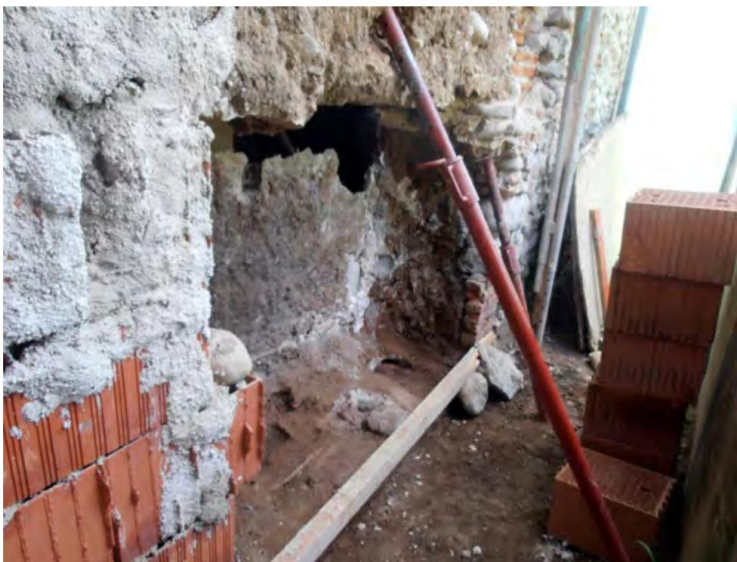
HOW CAN I INTERVENE?

CREATION of FOUNDATION

To address a wall with dampness problems due to a lack of foundations, the following steps can be taken:

1. Shoring up the wall, floors and/or roof.
2. Replace the adobe with stone or fired brick set in lime or cement mortar. This replacement is done in short sections, ranging from 50 cm to 1 m in length. We will begin by replacing half the thickness of the wall on the exterior side.
3. Replace the other half of the wall thickness on the inside side, always in sections and taking into account the bond.
4. If the wall is very thin, replace it at once by shoring up the top part.

Creation of a foundation wall with hollow brick (ES)



WHY DOES THE PROBLEM OCCUR?

WATERTIGHT PLASTER

Cement-based plasters (sand-cement or earth-cement) prevent moisture from evaporating from the walls. This causes a high level of humidity inside the wall and reduces the cohesion of the soil; the wall weakens and loses its load-bearing capacity. If the humidity level is high, the wall can collapse.

Moisture trapped in the wall beneath the watertight plaster tends to evaporate, especially in hot weather. Unable to escape the wall, the water condenses on the surface between the plaster and the wall, causing the earthen wall to weaken and crumble, and the plaster to detach.

HOW CAN I INTERVENE?

SUBSTITUTION WATERPROOF PLASTER

If we have an impermeable plaster, the solution is to remove it and replace it with a plaster that allows the wall to evacuate internal moisture, for example a mud and straw plaster, a lime plaster or a gypsum plaster.

A traditional solution in Cuenca is the plastering of mud and straw:
- First layer of mud and straw, 2-3 cm thick.
(depends on the original layer)
- Plaster finish, 3mm thick, with an average proportion of: 1 part of very fine kaolin-type soil and 1 part of shredded horse manure.

Adobe wall with detachment of the watertight plaster (LA)

The same wall after plaster repair (AR)

WHY DOES THE PROBLEM OCCUR?

DESIGN ERRORS IN DRAINS AND SILLS

Design errors can cause rainwater to leak into an earthen wall, leading to dampness, weakening, and detachment of part of the wall.

A poorly designed windowsill, which does not allow water to drip to the ground before reaching the wall, can cause water leaks in the wall.

It is also possible to have defective pipes or downpipes installed outside the walls, in which case the consequences will be the same: loss of material in the wall and its weakening.

Water infiltration under the sill (SM)

Defective downpipe (ES)

HOW CAN I INTERVENE?

REPLACEMENT OF DRAIN OR SILL

In case of dampness due to a poorly designed windowsill, we can put a sheet of metal (zinc) that channels the water away.

In case of dampness due to a poorly designed drain, we will have to replace the pipe with one that reaches the floor, filling the degraded parts of the wall with a mixture of earth and straw and replastering it with a non-watertight mortar.

Extended windowsill with metal element (ES)

Downpipe outside the wall (IS)

WHY DOES THE PROBLEM OCCUR?

SHORT EAVES OR LEAKS

The presence of short eaves or deficiencies in the roof increases the probability that rainwater will penetrate the wall, generating undermining and erosion of the materials, which facilitates the presence of cracks and decreases the resistance of the structural system.

HOW CAN I INTERVENE?

INTERVENTIONS IN SHORT EAVES AND LEAKS

If the dampness problem is due to an overhang that is too short, we need to lengthen the overhang with new rafters parallel to the existing ones, attached to them with metal bolts. The rafters must have a similar cross-section to those of the structure. We finish the work by installing a zinc gutter along the edge of the new overhang.

If the cause of the dampness problem is leaks, it is necessary to repair the roof at the affected points by replacing broken tiles, doubling up any damaged wooden structural elements, and giving the roof general maintenance.

Water infiltration from the roof (DP)

Extension of the eaves with new joists (LA)

WHY DOES THE PROBLEM OCCUR?

5858

FLATTENING DUE TO LOCALIZED HUMIDITY

Partial collapse of adobe or wattle and daub walls caused by water infiltration is common. The moisture weakens the base of the wall, causing the affected section to separate from the rest and begin to sink.

These cases may require replacing the wet area of the wall with new masonry or new wattle and daub elements.

Cracks caused by crushing of part of the wall due to localized dampness in a bathroom (ES)

HOW CAN I INTERVENE?

ZONE REPLACEMENT WALL DAMPNESS

A possible solution when there is complete disintegration of the adobe bricks:

1. Sometimes it is necessary to shore up to temporarily support the weight located at the top of the damaged area with lintels of sufficient rigidity.

It is also possible to construct an arch to support the loads above the damaged area if the building is not a heritage site. Arches eliminate the need for shoring, as they can be built in short sections supported by the wall damaged by damp, which will later be replaced.

2. After that, the new masonry is placed, bonded in all directions, horizontal and vertical.

Replacement of wall affected by localized dampness (ES)

WHY DOES THE PROBLEM OCCUR?

FLOORS, MOSSES, TREES

Mosses and parasitic plants that appear on walls are an indicator of a high level of humidity in the area where they are found, possibly due to poor drainage at the base of the wall, lack of foundations or leaks.

On the other hand, if vegetation is planted at the base of the wall, and even more so if it is watered regularly, this prevents the base of the wall from drying out, causing moisture problems. Tree roots can also contribute to the deformation or destruction of walls.

Adobe wall with a defective roof, showing dampness and plants, before and after the intervention, Casa Otorongo. (EC, ES)

HOW CAN I INTERVENE?

INTERVENTION IN PRESENCE OF PLANTS

If plants are growing inside the wall, they must be removed and the underlying moisture problem that allowed them to thrive must be addressed. If the damage is severe, the wall must be shored up before any work begins.
If the wall has lost a significant section, it will be necessary to fill it with a mixture of mud and straw and once dry apply a non-watertight plaster and finish (plaster, lime plaster).

If vegetation is planted at the base of the wall and this causes moisture problems, it is preferable to remove these plants and then repair the wall.

Adobe wall after intervention with mud and straw plaster, stucco and lime, Otorongo House. (EC, ES)

STRUCTURAL DAMAGE

CRACKS AND FISSURES
LATERAL BUCKLING
COLLAPSES
SETTLEMENTS
BULGES
DEFORMATIONS
LOSS OF RESISTANCE

Structural damage can have various causes, among which the following stand out:

- Problems in the terrain due to localized moisture or expansiveness of the clays present in the soil.
- Poor design or execution of structural elements.
- Poor interventions.
- Overloading, misuse of buildings.
- Biotic agents such as the moth.
- Earthquakes, vibrations, shocks.

Some of the effects generated by these problems are the following:

CRACKS AND FISSURES

Cracks and fissures are elongated openings that occur in a solid body, dividing it. Fissures are small, generally superficial cuts. Cracks are deeper fissures that usually affect the entire thickness of the wall.

They have very diverse causes, as we will see in the following pages. They generally originate at the edges or perimeter and extend horizontally, vertically, or at an angle.

LATERAL BUCKLING

Buckling is an instability phenomenon that can occur in slender compressed elements (for example, very tall walls with little thickness and no buttresses). The phenomenon of buckling in walls manifests itself through displacements in the horizontal direction. Slender, heavily loaded walls flex like a playing card squeezed between two fingers and tend to lose their stability.

Foundation settlement cracks (upper crack) (LA)

COLLAPSES

A collapse is a tilting or loss of plumbness of a wall. This occurs due to horizontal forces that deform the affected wall, preventing it from returning to its original position. Furthermore, the weight of the wall itself, plus the weight of the roof acting on the deformed area, also generates a force that maintains the deformation over time (the collapse).

SETTLEMENTS

This phenomenon occurs when the ground fails for various reasons and stops supporting the weight of the buildings, when the foundations are insufficient, or when new floors are built that overload them.

Collapse of the upper floor of a building. (EC)

BULGES

Bulges in walls are usually caused by a loss of strength in them, generally due to poor construction or subsequent overloading.

DEFORMATIONS AND LOSS OF STRENGTH

They arise as a result of poor initial sizing of wooden structures, overloads, moth infestation, or humidity.

A vertical crack indicates that the two walls are separating. (ES)

WHY DOES THE PROBLEM OCCUR?

COLLAPSES

Collapses are dangerous and require the attention of specialists. They can be caused by soil settlement, poor design, or faulty construction of walls.

Collapses due to soil settlement usually occur in clay soils with steep slopes and in areas that retain rainwater, where the weakened soil cannot support the load of the building and settles.
This causes the wall to collapse and often creates cracks that separate it from the rest of the building.
When walls are too slender and are not supported by perpendicular walls, or when they have been built without verifying verticality, collapses can also occur.

Collapse due to soil settlement (with trapped water) in Madagascar, (YE)

HOW CAN I INTERVENE?

INTERVENTIONS ON WALLS WITH COLLAPSE

In case of a wall collapse:

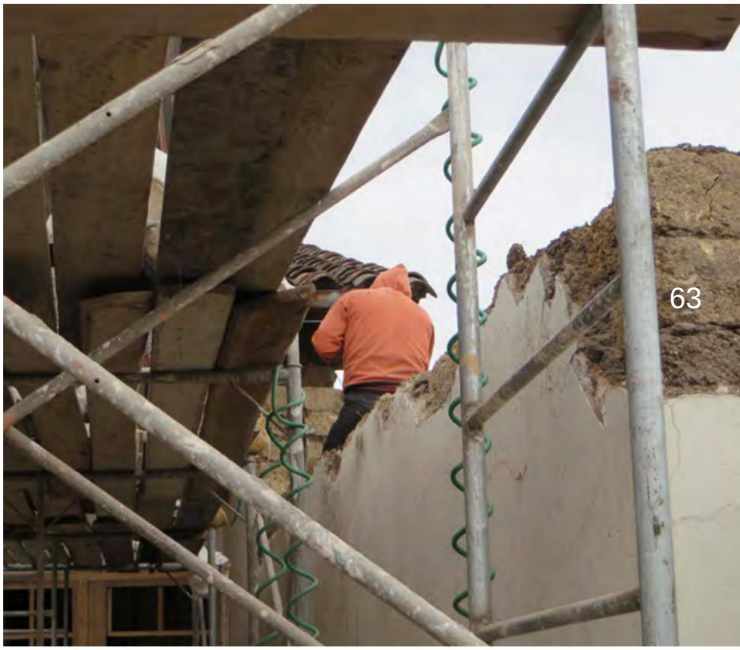
1. First, we need to do shoring where necessary.

2. To solve the problem, we must address its cause. If the collapse is due to dampness, in many cases we will need to dry the floor with proper drainage. We may even need to amend or replace the flooring using lime until it stabilizes.

3. Next, we can address the wall. When a wall loses its verticality, it requires a static analysis to verify the load distribution. This analysis would lead to different types of solutions:
- use of tensioners and wrenches,
- construction of buttresses,
- replacement of the damaged wall.

If the cause of the collapse is still active, we must dismantle the wall. If it is not active and the collapse has stabilized, we must assess whether to demolish the wall based on the collapse measurement.

- Less than 10%: acceptable.
- Between 10% and 20%: significant collapse, we have the option of intervening in the wall (with keys, tensioners or buttresses) or dismantling it.
- Greater than 20%: it is necessary to dismantle the wall.



If the damaged wall needs replacing, we proceed in sections and rebuild it afterward. We can reuse the adobe bricks.

The new wall must be self-supporting but also securely connected to the existing structure. The wall's stability will be ensured by the use of buttresses and by effectively anchoring the floors to it.

The connection with the old walls is fundamental and is ensured through the use of:
- wooden keys (see previous point)
- interlocking of new masonry with old masonry
- sill beams

Wall with collapse and intervention: dismantling of the upper part of the wall and tying the wall to a perpendicular wall using a wooden collar beam. Carvallo House (LA left / ES top and right)

WHY DOES THE PROBLEM OCCUR?

CRACKS AND FISSURES CAUSED BY MULTIPLE

A crack or fissure indicates a deformation of the structure. Not all cracks and fissures pose a threat.

Capillary cracks are not significant and only affect the plaster. They are cracks less than 3 mm thick.

Superficial cracks generally do not affect the building's stability. These cracks are around 5 mm thick. It is necessary to monitor whether these cracks evolve over time in order to address the underlying causes.

DEEP CRACKS

They affect all or a large part of a wall's cross-section, which can present a risk. These cracks are more than 8 mm thick. It is necessary to check if they are stable or active.

Cracks and fissures appear for various reasons:

- soil settlement
- humidity
- deficient structures
- lack of connection between two walls
- overloads
- earthquakes
- vibrations
- collisions
- Effects of expansion and contraction due to temperature
- disparate movements of building elements, exceeding the resistance limit of the material.

HOW CAN I INTERVENE?

MONITORING AND STABILIZATION

To measure the level of danger, we first need to know if the crack continues to evolve (active crack) or if it is stable after a long time.

To determine whether a crack is active or inactive, it is recommended to measure it at regular intervals over several months (monitoring).

One or more markers or "palm pegs" can be placed in the crack; these are surface elements positioned over the fissures. Their shape is as shown in the image on the right, their length is around 20 cm, and their thickness is approximately 1 cm.

For interior walls, plaster is preferable, while for exterior walls, sand and cement mortar is ideal. To apply these materials, it is necessary to remove existing coverings, roughen the masonry to a thickness of 1 cm, and dampen the wall surface.

If the witness breaks over time, it is a sign that the crack is alive and continues to widen.

Addressing the crack without first eliminating its cause solves nothing. We need to understand why the crack appeared and analyze the problem within its context. The cause may lie far from the crack, for example, at the base of the building.

We then need to identify and locate the cause of

the crack and eliminate the problem at its source, making sure not to displace it to another part of the building. After the intervention, we must ensure that the crack has stabilized by placing a new indicator and observing it. Stabilization may take several weeks.
manas after the elimination of its cause.

If the rift is dead or once we have stabilized -
Once the problem that caused it has been identified, then it is possible to intervene in it.

WOODEN KEYS

Adobe walls can lose their bonding due to effects -
to a crack. Continuity can be restored -
tuida for example through the use of wooden “keys” (see image in the center on the right).

To join two walls with a key we have to: 1. Clean the crack to remove the dust.
2. Insert some wooden keys inside the masonry -
teria, adhering them with earth mortar at least 15 cm deep on both sides.

METAL TENSIONERS

As a complement to the insertion of made keys -
Therefore, a good solution is the use of metal tensioners.
To be effective, the tensioners must connect the wall in question to another perpendicular wall. To distribute the tension within the wall, they must be anchored to the two perpendicular walls using wooden plates.

Top image: Gypsum core sample for crack monitoring (SM);

Central image: Wooden key for tying two walls (DP);

Intervention with a metal key in a vertical crack. (ES)

WHY DOES THE PROBLEM OCCUR?

SETTLEMENT CRACKS

FROM THE GROUND

Almost every foundation bed is subject to settlement, which does not usually cause damage when there has been good design. Settlement is not always uniform. If the foundation settlement differs between different parts of the building, this can lead to effects that compromise its stability:

- Level discontinuity between floors.

- Cracks in the walls, predominantly vertical.

Cracks can threaten structural safety.
The injuries may be due to the presence of:
A) Different heights or masses of the different parts of the building. This occurs, for example, if one part has many more openings than another, as it will settle less.
B) Soil weakened by the presence of water from rain or leaks at a certain point. At that point, the weakened soil cannot support the weight of the building, settling and causing cracks, slumps, and even collapses.
Settlement cracks can take two forms:

PARABOLIC CRACKS

They appear in the weakest parts (lintels and parapets). They usually manifest when there is a failure in the foundation, which gives way to a parabolic crack. These cracks almost never represent a risk to the stability of the building.

VERTICAL CRACKS

They can seriously threaten the stability of the structure. If an earthquake is added to this situation, the probability of the building collapsing is very high.

HOW CAN I INTERVENE?

INTERVENTION IN SETTLEMENT CRACKS

This is a structural problem: it is advisable to seek help from a structural engineer.

First, it is necessary to reinforce the structure.
If cracks appear due to settling caused by moisture at a point, the area should be cleaned and drainage should be carried out at a distance of at least 1 m from the wall.
Once the moisture problem is solved, we can tie the two sides of the crack together using wooden or metal keys as we have already seen.

In the case of live parabolic cracks, it will be necessary to reinforce the foundation in short sections and by shoring it up.

Vertical settlement cracks, Sigsig Cemetery (LA)

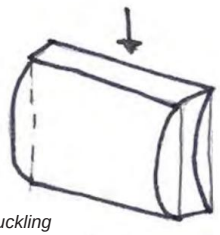
WHY DOES THE PROBLEM OCCUR?

LATERAL BUCKLING IN SLENDER WALLS

In excessively long or tall walls of little thickness (slender walls), lateral buckling can occur.

These cases are easily recognizable by the horizontal or vertical curvature they exhibit, which is more pronounced in the middle of their length or height, depending on the case.

Sometimes the buckling of a slender wall is due to the removal of another wall that provided it with lateral support.



Buckling phenomenon

Buckling due to leakage Rainwater dripped onto a wattle and daub wall. "Good Shepherd" Convent (MCA)

HOW CAN I INTERVENE?

SIDE SUPPORT

When there is lateral buckling or excessive slenderness, adequate lateral support must be provided to the wall.

Such support may consist of:
- New perpendicular walls.
- Buttresses.

Stiffening beams can also be added at ceiling level, which must have a high moment of inertia. This can be achieved by constructing triangulated wooden trusses or coupled beams of the same material.

Buttresses on a long adobe wall, Ugarte House, Cuenca, architect Max Cabrera. (EC)

WHY DOES THE PROBLEM OCCUR?

BULGES BY CRUSHING

6868

Sometimes we find walls, especially adobe walls, with problems of:

- Bulges.
- Disintegration of the adobe bricks and/or mortar.

These problems, especially if they occur together, may be due to wall crushing, caused by:

- Interventions in old buildings with increases in height (more frequently).
- Water seepage through adobe walls.
- Poor initial quality of the mortar.
- Aging of the mortar and/or the adobe bricks.
- Poor initial quality of the adobe (more rarely).

Wall deformation due to water infiltration (MCA)

HOW CAN I INTERVENE?

DISASSEMBLY

If crushing problems appear in the wall, we have to proceed with its dismantling because it is a serious structural problem in which the wall has lost load-bearing capacity.

We can reuse the recovered material to create new and improved adobe bricks, for example with a better proportion of clay, sand and silt or with plant fibers.

To avoid problems of this type, it is important not to increase the height of consolidated earthen buildings.

Repair of the deteriorated part of an adobe wall (EC)

WHY DOES THE PROBLEM OCCUR?

MOTH OR DEFORMATION OF THE WOODEN STRUCTURE

The wooden structure of the roofs or wattle and daub walls can be affected by woodworm, a common problem. It can also be warped and show signs of buckling, for example.

This can happen in the roof structure, in the lintels, in the beams of the floors or in the wattle and daub walls.

Both problems can have serious consequences for the stability of the structure.

Wattle and daub structure deteriorated by moths (LA)

HOW CAN I INTERVENE?

INTERVENTION IN DAMAGED STRUCTURE

We can reinforce a damaged wooden structure by adding new pieces alongside or beneath the damaged ones, leaving the damaged pieces unload-bearing or working in conjunction with the new element. If the old elements are in very poor condition, we can also replace them. The required support length must be at least 30 cm for beams, lintels, rafters, or other load-bearing elements.

If the problem arises in a wattle and daub wall, the damaged wooden sections can be replaced with sound ones, which will be secured to the existing sound section by tying them together. If replacement is not possible, new sections will be placed parallel to the old ones.

Accompanying a deteriorated pair with a new element (LA)

HUMAN ACTION AND BAD PRACTICES

Human beings participate directly in the destruction of heritage, often due to a lack of knowledge.
Human actions often cause structural or moisture problems, which we have already seen previously.

It is necessary to control these actions in order not to add risk factors to the conservation of buildings, since the passage of time, settlements and atmospheric agents already make preventive maintenance necessary in constructions.

Some causes of building deterioration due to human causes are:

LACK OF MAINTENANCE

Sometimes, buildings of heritage value are observed to be in a fairly advanced state of disrepair. Preventive maintenance of the buildings in Cuenca's Historic Center should be promoted to mitigate adverse effects and prevent further damage over time. This should be achieved through public awareness campaigns, training, and improved access to materials and qualified professionals.

ABANDONMENT OF PROPERTIES

The abandonment of properties occurs for various reasons such as inheritance problems, complexity of interventions, lack of resources for conservation, difficulties ability to adapt buildings to the demands of contemporary life, etc.

Inheritance disputes are typical examples of property neglect. Numerous families who have inherited large apartment buildings, once single-family homes but now oversized by today's standards, cannot agree on how to enjoy or sell the property; time runs out for these old buildings, which sometimes end up collapsing.

DAMAGING INTERVENTIONS WITH BUILDINGS

Transformations of spaces carried out with flawed criteria, altering the structure of buildings and jeopardizing their stability, are a serious problem. This occurs, for example, when alterations are made to the original typology to adapt them to new commercial activities.

Furthermore, the Historic Center of Cuenca is highly sought after by real estate developers for projects that promise large profits in a short period. However, heritage is often seen as an obstacle; consequently, it is sometimes deliberately destroyed or allowed to deteriorate rapidly. An abandoned and unmaintained building can collapse in a short time.

INADEQUATE FACILITIES

Incorrect installation of various utility networks, such as water and electricity, can lead to structural instability. For example, a meter box installed on a facade, especially near a corner, can cause structural instability. Wiring should be run through the plaster layer of the walls, taking care to avoid penetrating the load-bearing wall. Once installed, the wall can be resealed with mud and straw mortar, never with cement.

Water installations are also potentially harmful. It is recommended to always place them outside the walls to prevent water accumulation and to keep them under close supervision.

USE OF INADEQUATE MATERIALS

The introduction of new materials, such as cement plasters, and the lack of knowledge about earth as a building material, often cause problems in the fragile balance of heritage earth architecture, concentrating loads and humidity in specific points and generating great damage to the buildings.

GENTRIFICATION

The historic city of Cuenca attracts a large number of tourists and other people with greater purchasing power than the local population to buy homes. This strong demand causes an increase in the price of

The land and buildings are becoming increasingly scarce, so many local families are deciding to sell, and few are able to buy or rent in the city center. This is causing the historic city to become increasingly depopulated, and many buildings to lose their tenants.

Furthermore, we see that tourists occupy their homes only for a short period of the year; in this way, the spirit of the Historic Centre of Cuenca is gradually changing.

LACK OF AWARENESS AND INFORMATION

Sometimes, especially in private buildings, inadequate actions are observed due to a lack of knowledge of traditional building culture.

It is necessary to act by emphasizing good practices to avoid the problems created by bad interventions.

This is key to reducing the deterioration of heritage sites caused by human activity. Therefore, in the following pages, we present an example of informational brochures designed to raise public awareness about best practices and common problems such as dampness.

WHY DOES THE PROBLEM OCCUR?

HOW CAN I INTERVENE?

LACK OF KNOWLEDGE

INFORMATION

Extracts from an information leaflet intended for citizens (own elaboration):

IT'S CAREFUL WITH WATER AND HU

HUMIDITY, NATURAL ENEMIES OF FROM ALL THE HOUSES...

SHORT WINGS

An overhang that is too short can allow rainwater to penetrate.

ON THE WALL.
WE CAN LENGTHEN IT BY JOINING NEW, LONGER PAIRS TO THE EXISTING PAIRS, AND PLACING A CHANNEL AT THE EDGE OF THE NEW EAVES.

LEAKS

Leaks increase the likelihood of LET THE RAINWATER PENETRATE THE WALL AND IN THE WOODEN STRUCTURE, DEVELOPING CRACKS, REDUCING THE STRENGTH OF THE WALL AND ROTTING THE WOOD.

BLOCKED CHANNEL

IF THE DRAINAGE CHANNEL IS

When obstructed, rainwater cannot drain and overflows onto the wall, causing dampness and detachment .

It is important to clean the channels often, so as problems.

MORE SERIOUS.

CONTINUOUS BALUSTRADE WITH LEAKAGE FROM THE CANAL

THE CONTINUOUS BALUSTRADE IS

REPUBLICAN ARCHITECTURE OF CUENCA.

IF THE GUTTERS ARE NOT CLEANED OFTEN, THEY

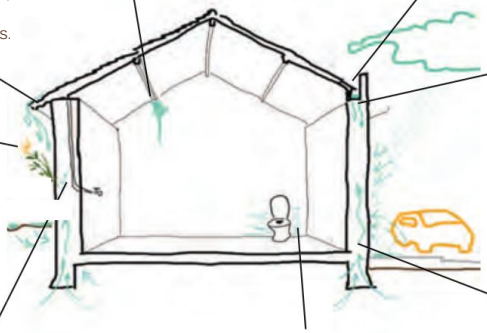
THE WALLS AND THE WOODEN BEAMS.

IT MUST BE REPAIRED AS NECESSARY TO REPAIR

FLOORS

The plants that appear on the walls indicate that there is a lot of humidity due to bad drainage, to a

Leaks, due to faulty pipes inside the wall...



PIPES DEFECTIVE

A PIPE DEFECTIVE INSIDE FROM THE WALL CAN CAUSE VERY DAMAGE SERIOUS, BECAUSE WE WE WILL FIND OUT ABOUT PROBLEM ONLY WHEN THE WALL IS WET UP TO THE SURFACE.

HUMIDITY IN BATHROOMS

In damp areas of the house, it is necessary to protect the mud walls with ceramic tiles. First, we fix bricks to the wall, placed on their edges, using mud mortar (not cement!).

THE BRICK JOINTS ARE MADE WITH CEMENT MORTAR, AND THE CERAMIC IS FIXED ON TOP OF THE BRICKS WITH THAT SAME MORTAR.

LACK OF FOUNDATION

The lack of foundation, the rise in street levels or interior floors, favor dampness at the base of the walls.

OVER TIME, THIS DETERIORATES THE WALL, WHICH BEGINS TO SWELL AND EVEN COLLAPSES.
IT IS NECESSARY TO PLACE A NEXT TO THE WALL MATERIAL THAT PROTECTS IT, SUCH AS BRICK.

Plants growing on walls
indicate high humidity
due to poor drainage, leaks, or
faulty pipes inside the wall.

THE WALLS AND THE WOODEN BEAMS.
IF THERE ARE LEAKS, IT IS NECESSARY TO REPAIR
THEM BY REMAKING THE MORTAR, INCORPORATING
METAL CHANNELS OR WATERPROOFING THE
CHANNELS WITH AN ASPHALT PRODUCT.

PIPES : EFFECTIVE

A PIPE
DEFECTIVE INSIDE
FROM THE WALL CAN
CAUSE VERY DAMAGE
SERIOUS, BECAUSE WE
WE WILL FIND OUT about
PROBLEM ONLY WHEN
THE WALL IS WET UP TO
THE SURFACE.

HUMIDITY IN BATHROOMS

In damp areas of the house, it is necessary to protect
the mud walls with ceramic tiles. First, we fix bricks to the
wall, placed on their edges, using mud mortar (not cement!).

THE BRICK JOINTS ARE MADE WITH CEMENT
MORTAR, AND THE CERAMIC IS FIXED ON TOP OF
THE BRICKS WITH THAT SAME MORTAR.

LACK OF FOUNDATION

The lack of foundation, the rise in street levels or interior
floors, favor dampness at the base of the walls.

OVER TIME, THIS DETERIORATES THE WALL, WHICH
BEGINS TO SWELL AND EVEN COLLAPSES.
IT IS NECESSARY TO PLACE A NEXT TO THE WALL
MATERIAL THAT PROTECTS IT, SUCH AS BRICK.

WHY DOES THE PROBLEM OCCUR?

HOW CAN I INTERVENE?

BAD PRACTICES

SENSITIZATION

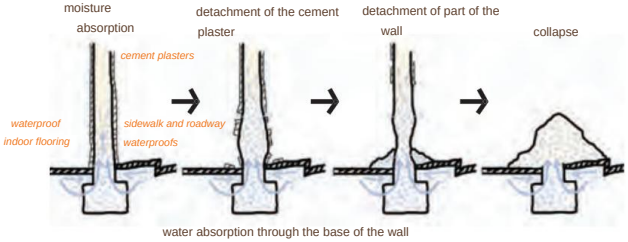
...AND I DON'T PERFORM INTERVENTIONS THAT MAY BE BAD P FOR THE HOUSE AND FOR OUR SAFETY!

PLASTER OR PAINTING

CEMENT PLASTER AND THE
PLASTIC PAINTS PREVENT MOISTURE
FROM EVAPORATING FROM THE WALLS
AND WEAKEN THEM UNTIL THEY FALL
APART.
IF AN EARTH WALL HAS A CEMENT
PLASTER, WE HAVE TO REPLACE IT WITH
ANOTHER ONE THAT ALLOWS THE WALL TO
BREATHE, SUCH AS A MUD AND
STRAW, LIME OR GYPSUM PLASTER.

The best paints are those that allow water
vapor to pass through: water-based paints, earth-
based paints, paints with lime...

IN CASE OF AN EARTHQUAKE,
THERE IS A GREATER RISK OF
COLLAPSE WHEN THERE
ARE POOR INTERVENTIONS OR
LACK OF MAINTENANCE.



water absorption through the base of the wall

PARTY WALLS

A MUD HOUSE IN THE CITY
SHARE WALLS WITH NEIGHBORS.

SOMETIMES EACH OWNER
INTERVENES ON THEIR OWN IN THE
PARTY WALL, WITHOUT INFORMING THE
NEIGHBOR AND BREAKING THE WALL.
THIS IS DANGEROUS AND AFFECTS THE
SAFETY OF HOMES.

ADD STRUCTURES MADE OF NEW MATERIALS

ADDING STRUCTURES MADE
OF NEW MATERIALS, SUCH AS STEEL
OR REINFORCED CONCRETE, CREATES
SEPARATION BETWEEN WALLS.

IN CASE OF AN EARTHQUAKE, THE NEW
STRUCTURES HIT LIKE A
HAMMER TO THE EARTH WALLS, WHICH
FALL DOWN MORE EASILY.

NEW DOORS AND WINDOWS

You cannot open new doors or windows
without consulting a specialist,
because it can be very
dangerous for the safety of the house.

FILLED HOLES WITH CEMENT MORTAR

OPENINGS MADE IN WALLS SHOULD NOT BE
REPAIRED WITH CEMENT AND SAND
MORTAR, TO AVOID DAMAGING THE WALLS.

WE NEED TO USE A MORTAR OF CLAY AND
STRAW, AND ONCE DRY PROCEED TO
FINISH.

FLOOR ELEVATION OR WATERPROOF FLOORS

WATERPROOF FLOORS (CEMENT...)
SHOULD BE AVOIDED.
They should not be left below ground
level either.
ADOBE AND WATTLE AND DAUB WALLS.

SEISMIC RISK

In places where earthquakes are not very frequent, such as Cuenca, there is a great deal of concern about improving construction conditions immediately after an earthquake, but as time passes, the damage is forgotten and after a few months construction resumes in the same careless manner.

However, some simple interventions can greatly improve the building's resistance to earthquakes, especially when the building has damage that weakens it.

SYMMETRY

Simple and symmetrical constructions are preferable because they eliminate the risk of torsion, a frequent cause of building collapse. Seismic risk mitigation efforts must preserve these qualities if they already exist or attempt to create them.

SMALL SLENDERS

Very slender walls are susceptible to damage from the normal structural load of the building and, even more so, in the event of an earthquake.

Adobe walls should have a maximum slenderness ratio of 1:7 between wall thickness and height. If slenderness ratios greater than 1:7 are found, it is recommended to reduce the height of the walls.

SMALL OPENINGS (DOORS AND WINDOWS)

The resistance of walls to stress

The load-bearing capacity is determined by its mass. Any weakening of the cross-section becomes dangerous. The intervention must avoid or correct the presence of large spans, especially when slender pilasters appear alongside them.

TIES AND STRENGTHENING FLOORS AND ROOF

In the event of an earthquake, both the floors and the roof act as load-bearing elements for the walls they rest on, resisting the horizontal thrusts of the earthquake. It is therefore important to tie them properly and stiffen them in their horizontal plane.

TYING THE WALLS WITH BEAMS/JOISTS

Earthquake resistance is greatly improved by linking the different resistant elements together with continuous chains that link the walls to each other and to the floor and roof system.

The tie beam can be made of reinforced concrete, steel or wood, with the latter being preferable because it is more flexible and works more in accordance with the earth walls.

EQUALITY OF RESISTANCES

The walls of the building should have equal resistance in both directions of the building: this greatly improves earthquake resistance.

Adobe is often found combined with other materials such as reinforced concrete, brick masonry, or cement plaster; all of which are much more rigid than adobe. This is generally the result of architectural modifications to the original adobe construction. In the event of earthquakes, cracks appear in the contact zone between the two materials, especially in relatively thick walls.

Adding structures made of new materials, such as steel or reinforced concrete, is dangerous. The violent earthquakes in the city of Bam, Iran (2003), demonstrate the fragility of composite structures. The diversity of materials generates different behaviors, which favor collapses, ruptures, and subsidence.

Homogeneous structures, made solely of earth, are much more resistant when they are well built and maintained.

We need to try to replace the materials. If this isn't possible, we must create a separation joint, wide enough so that the walls can work independently during an earthquake.

HORIZONTAL DECK THRUST

Roofs, especially heavy or gable roofs, can cause unforeseen horizontal thrusts on the top of the walls when the trusses are not properly constructed.

This is very dangerous in the event of an earthquake because the vertical acceleration caused by it can cause an increase in the horizontal thrust of the roof on the walls, with the consequent collapse of the roof inside the house.

Before undertaking major interventions that go beyond maintenance, it is very useful to carry out a diagnosis to understand the value of the building, identify the elements that should be preserved, and understand the degradation processes.

Image of Cuenca, (EC)

5. TECHNICAL DIAGNOSIS

THE TECHNICAL DIAGNOSIS

A technical diagnosis allows one to understand the condition of a property and find the appropriate solutions for its preservation.

The diagnosis must:

1. Understand the history of the property and identify its heritage value.
2. Explain the condition of the property and its evolution.
3. Present all existing pathologies.
4. Describe the deterioration processes and identify the causes that led to the damage.
5. Provide technical recommendations and, if necessary, emergency interventions. Sometimes it is enough to shore up a lintel, add some tiles, or dig a drain to save a threatened wall.

Before analyzing the property in detail, the initial visit must assess the level of deterioration and risk of structural collapse. This stage identifies at-risk areas that need to be stabilized (for example, with shoring) or closed off to prevent access.

A fundamental step in diagnosing an earthen building is understanding the paths and flow of water. Observing the path of rainwater and seepage is much easier when it rains.

The diagnosis must include basic questions: - In which direction does rainwater flow?
- Where does it stagnate?
- Which areas receive the highest concentrations of water?

A drawing of the walls and roof, even if synthetic, allows one to understand the structure and the distribution of loads as well as to indicate any existing damage.

It is important to understand the order in which the structures were built and to indicate the successive interventions throughout the building's history. This allows, for example, the differentiation between "natural" cracks resulting from the juxtaposition of parts at different times, and cracks due to structural deformations.

At this stage, old photographs can be very useful to understand the evolution of the building, as well as dialogue with the former inhabitants, a source of valuable information.

It is important to prioritize damages according to their level of threat. We need to differentiate between: - old damages
and recent damages.
- damages “ordinary or from normal use” (e.g. dirt, erosion of surfaces), as opposed to what is accidental.

Each pathology is generated by a set of deteriorating factors that must be understood as a whole. Research into the causes of pathologies is very important and should be carried out by qualified professionals.

experts. The factors of deterioration are several, and in many cases they act together or one after the other (domino effect).

RECORD TEMPLATE
TECHNICAL DIAGNOSTIC

We propose an example of a technical diagnostic sheet that can be useful to understand the condition of a property, observing all its parts, and formulating a hypothesis about the causes and dynamics that have generated the current state of the property.

This stage is fundamental to finding the appropriate solutions for its conservation.

1. GENERAL IDENTIFICATION

1.1 LOCATION

Cadastral Key:

Zone Sector Block Property P. Horiz.

Street:

Civic Number

1.2 USES AND FUNCTIONS

Current Predominant Use(s):

1.

2.

2. ASSESSMENT FIELDS

Pre-registration assessment: VHIAR 1 ☐ VHIAR 2 ☐ VHIAR 3 ☐ ☐ Worthless ☐

Registration Assessment: AND ☐ STICK. ☐ VAR B. ☐ TO. ☐ SV. ☐ N. ☐

3. BUILDING CONDITION REPORT

The building is located in:

Good condition ☐ Significant ailments ☐ It cannot be clearly defined ☐

Mild conditions ☐ Severe conditions ☐

Element	Visible	Material	Visible Damage	Feature	Record
Facades towards the streets			Presence of cracks	Diagonal	*To record visible damage according to its characteristics, mark with an "x" in this box.*
				Horizontal	
				At the junction of walls	
			Presence of moisture	Upper part	
				Lower part	
			Change in the shape of wall	Inclination	
				Bulging	
			Visible detachments		
			Presence of stains		
Doors, windows, railing (woodworking)			Change of form	Torsion	
				Buckling	
			Visible wear		
			Rip		
			Moth		
			Alteration of junctions		
			Cracks		
			Decay		

Element	Visible	Material	Visible Damage	Feature	Record
Doors, windows, balustrades (metalwork)			Deformation	Torsion	
				Buckling	
			Presence of breakage(s)		
			Presence of moths		
			Visible alteration of joints		
			Presence of cracks		
			Presence of corrosion		
Walls			Presence of cracks	Diagonal	
				Horizontal	
				At the junction of walls	
			Presence of moisture	Upper part	
				Lower part	
			Change in the shape of the wall	Inclination	
				Bulging	
Columns			Change of form	Visible tilt	
				Torsion	
				Buckling	
			Presence of breakage(s)		
			Presence of moths		
			Visible alteration of joints		
			Presence of cracks		
			Presence of rot		

Element	Visible	Material	Visible Damage	Feature	Record
Beams			Change of form	Visible tilt	
				Torsion	
				Buckling	
			Presence of breakage(s)		
			Presence of moths		
			Visible alteration of joints		
			Presence of cracks		
			Presence of rot		
Deck			Presence of leaks		
			Sinking		
			Missing material		
			Condition of canals and downpipes	Defective joint	
				Obstruction	
				Rip	
			Invasive vegetation		
Floor (finishes + structure)			Visible subsidence		
			Strong vibration while walking		
			Presence of cracks		
Ceiling			Visible detachment		
			Presence of stains		
			Presence of cracks		

Element	Visible	Material	Visible Damage	Feature	Record
Stairs			Change of form	Visible tilt	
				Torsion	
				Buckling	
			Step wear		
			Presence of breakage		
			Presence of moths		
			Visible alteration of joints		
			Presence of cracks		
			Presence of rot		
Finishes			Plasters	Landslide	
				Cracks	
			Paint	Stains	
				Bleaching	
Facilities			Presence of water leaks		
			Pipe blockage		
			Presence of exposed cables		
			Defective splices (joints)		

4. AUTHENTICITY AND INTEGRITY

Valuable architectural elements that have been preserved	
Harmful Additives	
Beneficial modifications	

5. COMMENTS AND OBSERVATIONS

In this section we can hypothesize about how the damage occurred: its causes and the natural or human factors that led to the current state of the property.

This is very important because eliminating the causes of problems is a priority, instead of

Attempting to solve existing damage without eliminating its causes, as seen in many bad interventions.

6. THREATS AND URGENT MEASURES

Main threats to building construction	Urgent measures to save the building
It's important to prioritize damage according to its level of threat in order to act in time. Sometimes simply shoring up a lintel, adding some tiles, or digging a drain is enough to save a wall.	

Numerous residents, professionals, and institutions are committed to the conservation of Cuenca's land heritage. This chapter presents a small selection of conservation projects carried out with different approaches and methods.

It is necessary to highlight and communicate other exemplary conservation projects.
The network “Friends of Earthen Architecture of Cuenca” can be a good exchange space for all people interested in the conservation of Cuenca's earthen heritage.

Otorongo House (Image: EC)

6. EXAMPLES INTERVENTION

INTERVENING ON AN EARTH BUILDING

What to preserve? What to demolish? It is important to preserve everything that is still in good condition. This also applies to construction details, such as decorations or types of windows.

For example, when part of a wall is crumbling but the rest of the structure is not weakened, it is sufficient to rebuild the damaged part. If we have to rebuild, it is important that the reconstruction uses the same technique or at least the original material.

MODERN MATERIALS

Traditional materials and techniques require regular maintenance. For reasons of thermal comfort, sustainability, and respect for architectural values, it is best to follow ancestral construction techniques to carry out this maintenance.

That doesn't mean that cement or other materials for sale should be rejected, but we need to be careful and use them judiciously because their use can be destructive in the long run.

Some modern solutions are not appropriate for land-based properties, for example:
- Cement-based plasters, which do not allow water to evaporate and cause dampness problems. - Chemically stabilized plasters, which detach from earthen walls.

IDENTIFY PRIORITIES

The lack of resources makes the decision to carry out a conservation intervention difficult, as the resources are not enough to solve all the problems of the property.

We need to identify priorities and make the best use of resources. The information gathered in the technical assessment will then be useful for making these decisions. A list of interventions must be defined and ordered according to priority.

Cement-based plasters, which do not allow water to evaporate, cause moisture problems in the wall. (LA)

BROTHER MIGUEL 5-40

8686

CARVALLO HOUSE

The heritage building located in the traditional La Merced neighborhood has significant environmental value. The land on which the building stands was once part of a larger property known as the Carvallo garages.

The building was constructed during the 1940s, with adjoining walls of adobe, interior walls of wattle and daub, and facade walls of brick and wattle and daub.
The building has two floors facing Hermano Miguel Street and three floors inside the garages. It is organized around a side patio and corridors. Notable features include the woodwork of the doors, pillars, windows, and handrails, as well as the use of cement tiles.

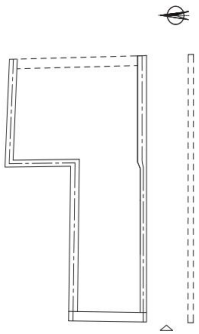
In the 1960s, the ceiling height was reduced by replacing the ceilings; wattle and daub walls were removed, and modern materials of the time were used. On the facade, the mud plaster was replaced with a cement and sand mortar.

INTERVENTION

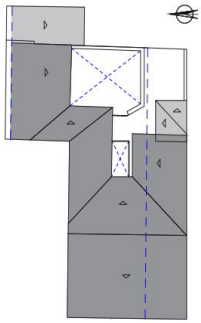
The main objective is to maintain the residential vocation of the property and its original typology.
The restoration of the wattle and daub walls was achieved, the height of the ceilings was recovered, the additions were removed, and new electricity, drinking water, and sewage installations were provided.

The priorities of the intervention were to stop the damage from leaks in walls, roofs and floors, as well as to reinforce the general structure of the building.

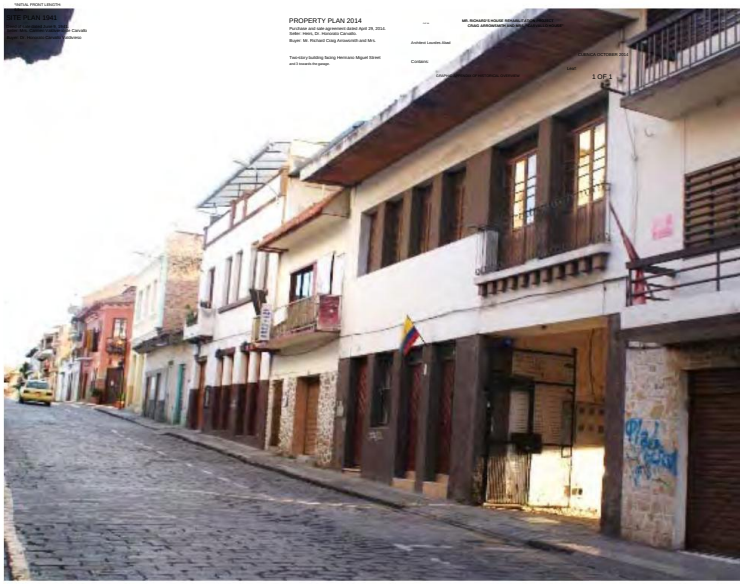
All photographs in this example are from LA



Site plan, 1941 (LA)



Property plan, 2014 (LA)



Wattle and daub walls

Adobe wall with dismantled collapse (lower image)

Metal wattle and daub (bathrooms)

Wattle and daub

PATHOLOGIES AND INTERVENTIONS

ADOBE WALLS

- Collapse of the rear enclosure wall, due to a slenderness greater than 7, without anchoring elements or a crowning chain.

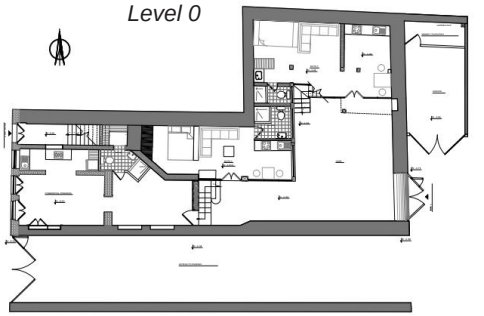
- Cracks in wall axis E due to lack of interlocking between adobe bricks.
- Cracks in wall axis E, in the area where it meets the brick front facade wall due to differences in materials.
- Wall at garage access: dampness at base and top was corrected.

The adobe wall, which is leaning, is very slender and lacks tie beams at its top. Therefore, its height was reduced and eucalyptus tie beams were installed. The material from this wall was reused in the wattle and daub walls and plastering.

WATTLE AND DAUB WALLS

- The reeds and mud mortar have come loose from the walls that enclose the roofs.
- Pillar base rot.

The removed wattle and daub walls were rebuilt using a wooden framework of beams and eucalyptus strips. To expedite the work, guadua cane, cut into 3- to 5-cm strips spaced 1 cm apart to improve mud adhesion, was used. One-inch nails were used to secure it. A single 3-cm layer of mud and straw mortar was then applied. The wood and cane had been previously treated against termites.



FLOORS

- The wooden beam structure of the brick terrace shows dampness and rot on the adobe wall.

The two layers of brick and the support strips were removed, the condition of the beams was checked, and those that were rotten at their ends were reinforced. Parallel beams were then installed and secured with bolts to minimize damage to the adobe walls.

The first layer of brick was then laid, followed by a sheet of asphalt for waterproofing, and then the second layer of brick.

The floor beams in the garage access as well as the wattle and daub walls were reinforced with braces anchored to the wall through eucalyptus support beams, to distribute the load.
The eucalyptus decking was maintained; only in the bedroom area was a new floor laid with 4x5cm eucalyptus strips and boards, achieving a better structure than the initial decking, while also achieving better sound insulation from the noise caused by the entry of vehicles.

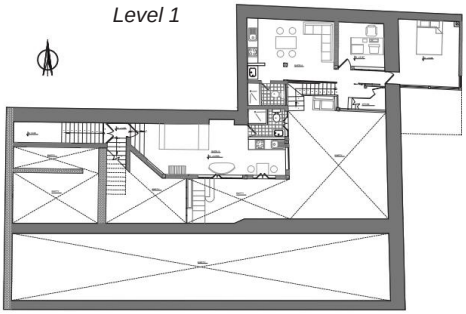
DECK

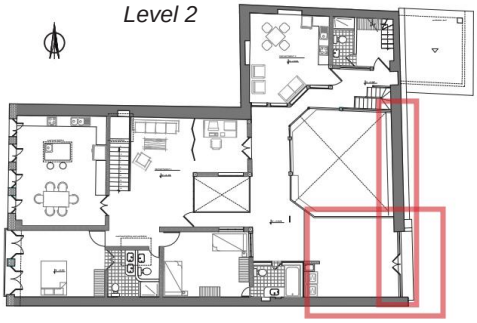
- The tiled roof has three areas with water leaks.

- The reed fencing is detached in some areas.

- The glass roof structure shows rot next to the drainage channels.

Terrace floor: structure, finish. Tie beam between walls.





House plans (LA)

SYMBOLISM

Item seized

The original system of reed and mud lath on which the tiles rest is maintained; only the wooden structure was reinforced and the location of the tiles was verified.

PLASTERED

- In the wet areas the plaster is detached.
- There are cracks in the joint between the mud mortar plaster and the new cement and sand mortars.
- In the plinths, around the patio, the mud mortar was replaced by waterproof cement mortar and cavities and detachments can be observed.

In damp areas and where cement and sand mortars existed, the plaster was removed. Before applying the new plaster, we waited for the wall to dry and then reapplied the mud and straw mortar.

CONSTRUCTION TIME AND BUDGET

The intervention began in April 2015 and is expected to last until September of the same year and has a budget of $130,000.

ORIGINAL USE

The original use of the "Casa Carvallo" property was as a family residence, with an area for a medical office on the ground floor. Initially, the property was home to a large family consisting of the parents, 10 children, and employees, with 11 rooms designated as bedrooms.

POST-PROCEDURE USE

The present project proposes to maintain the original vocation and use as a family residential space, adapted to the needs of the present.

The proposal is to adapt the property for two complete apartments, two small suites, and to maintain the medical office as a commercial space.

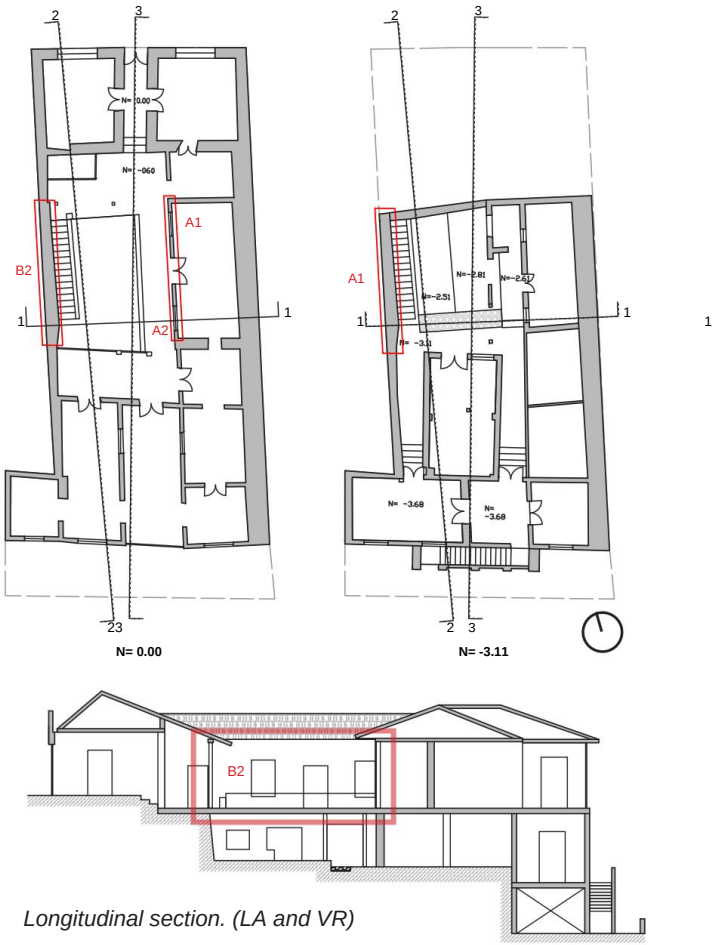
APPROACH

The aim is to conserve the building, through the maintenance and consolidation of the structure, its formal expression, its typology and the enhancement of its materiality.

PRESIDENT CÓRDOVA 14-35 AND COLONEL TALBOT

909 OTORONGO HOUSE

Casa Otorongo, in the El Vado neighborhood, is a mixed construction of adobe, wattle and daub, and wood, consisting of three bays and a central courtyard. A demonstration project for maintenance with limited resources was carried out within the framework of the 2015 UNESCO project "Mobilizing women and youth in the transmission of traditional techniques for the preservation of earthen architecture." Interventions were limited to areas requiring urgent action for structural protection and consolidation. During the project, a pilot training program was developed for seven artisans, working with expert master craftspeople and architects, and for 50 architects and technicians from heritage conservation institutions or independent professionals.



Longitudinal section. (LA and VR)

The project's objective is to demonstrate that it is feasible to preserve earthen architecture while working with a limited budget, as well as to revalue the culture of earthen construction.

CONSTRUCTION TIME

10 days

BUDGET

$2,500 (labor and materials)

POST-PROCEDURE USE

The building will remain a residence; the front wing will be used for commerce and art exhibitions, along with the courtyard. The goal is to create a space for community engagement through art.

PATHOLOGIES AND INTERVENTIONS

PARTY ADOBE WALL IN COURTYARD *A1. Detachment of plaster and growth of vegetation inside the wall* >> Removal of vegetation, repair of the mud and straw plaster, plastering and lime finish

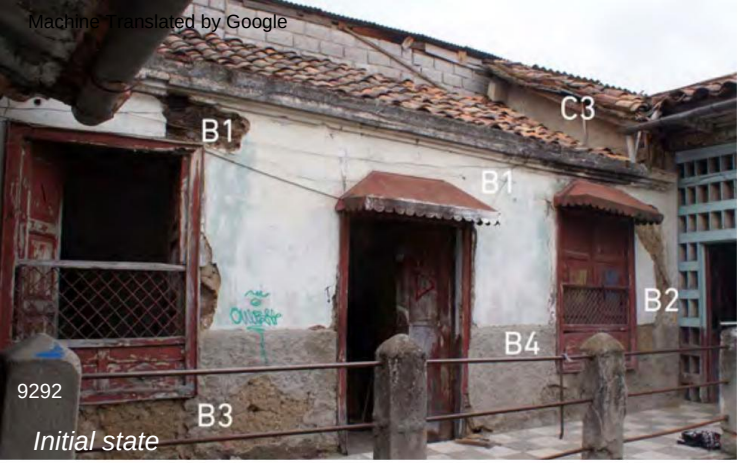
A2. Erosion of the wall header due to improper installation of an embedded downpipe. >> Implementation of an external downpipe, underpinning with adobe and mud mortar in the eroded area.

A3. Protection of the wall by means of two deteriorated courses of bricks >> Repair of the courses of bricks

A4. Cement block wall of the adjacent property deteriorated >> Leveling of the surface and maintenance with lime base (cat's coat).

A5. Base of the wall not protected from water >> Creation of a protective layer in masonry bricks.

Initial state



Initial state

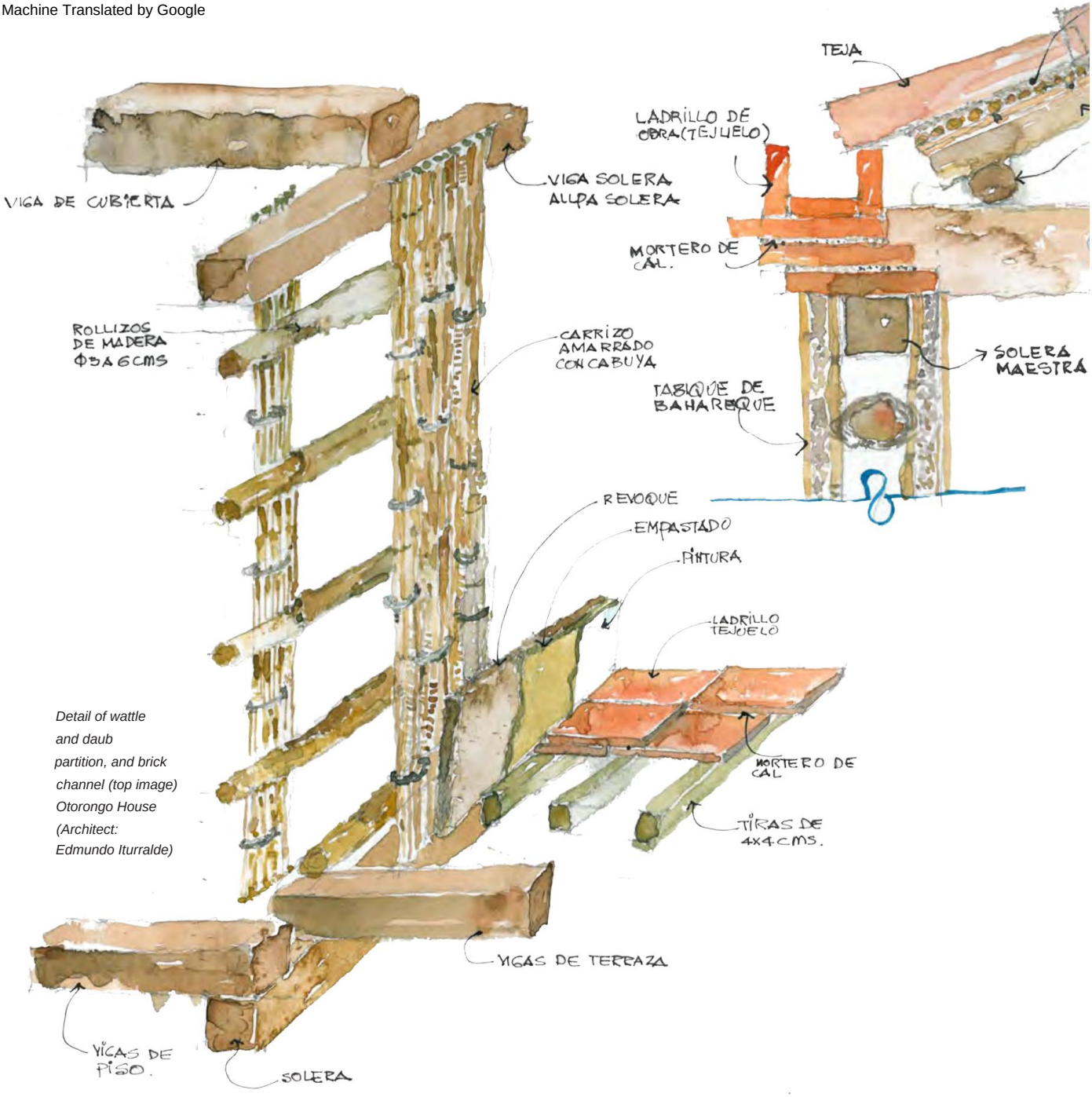
MIXED CONSTRUCTION WALL ADOBE + WATTLE AND DAUB

B1. Rotten wooden lintels and partially rotten sill >> Replacement of lintels and partial replacement of sill.

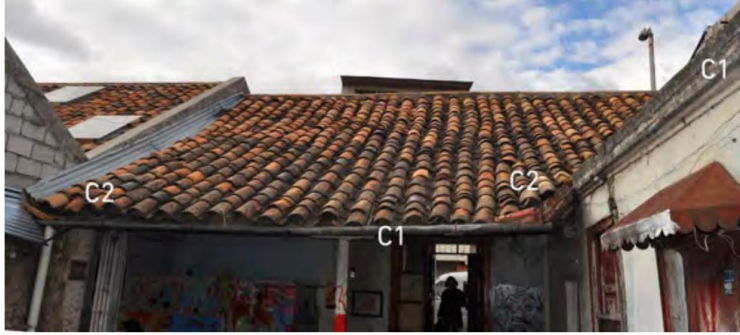
B2. Cracks due to difference in technique with lack of adobe/ wattle and daub bonding and moisture from the channel >> Bonding of the walls and closing of the crack with mud and straw mortar.

B3. Part of the rotten wattle and daub wall >> Dismantling and repair of part of the wattle and daub wall, with replacement of a wooden column and introduction of a new wooden column.

B4. Watertight and deteriorated plaster >> Replacement of the watertight plaster with mud and straw plaster and stucco (mixture of whitish earth and horse manure).



Detail of wattle and daub partition, and brick channel (top image) Otorongo House (Architect: Edmundo Iturralde)



9494 ROOF AND DRAINAGE CHANNELS

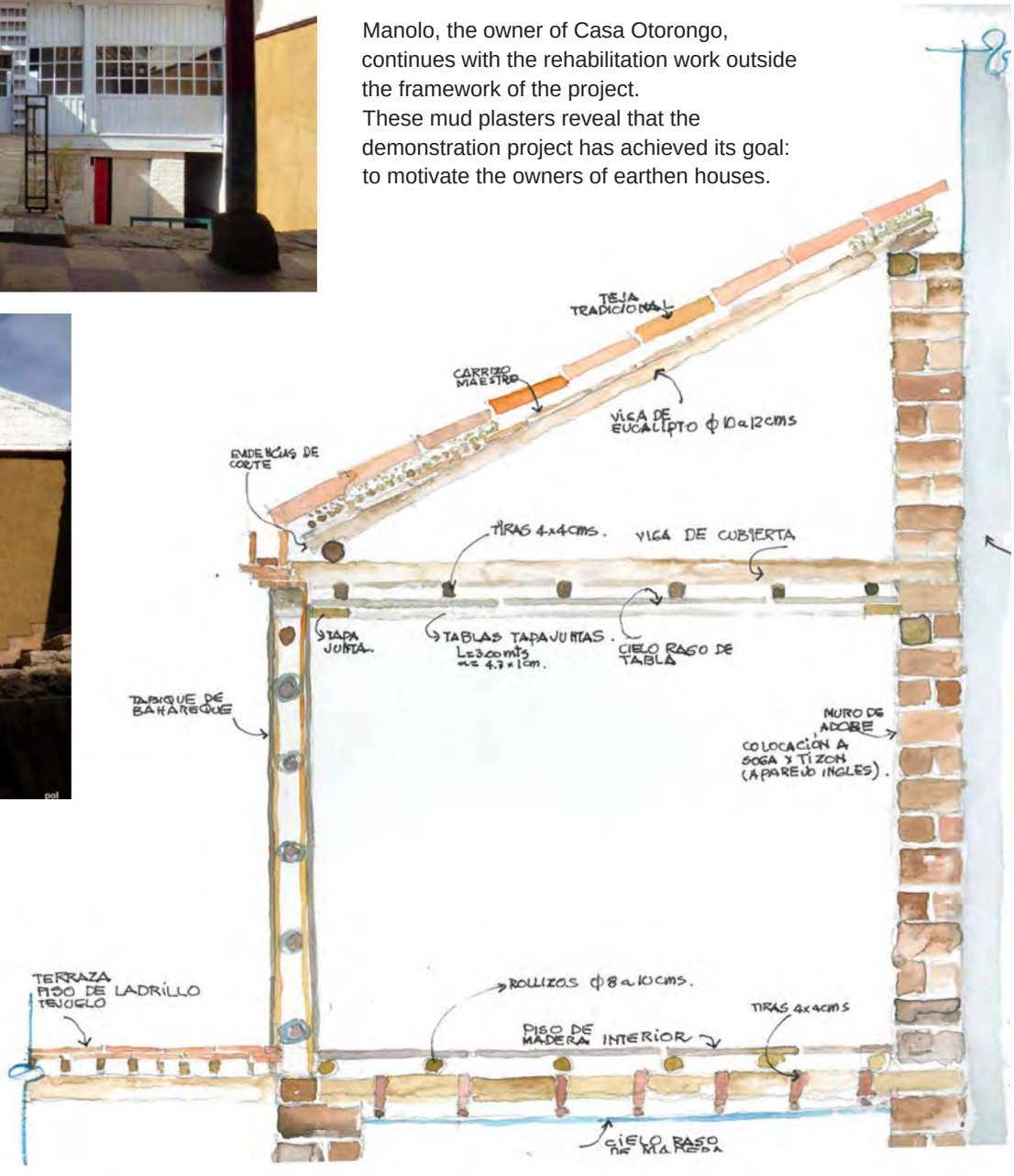
C1. Leaking brick channel in the wattle and daub wall and defective zinc channels in the gallery and in the roof of the rear bay >> Construction of brick cornice and replacement of the channels.

C2. Wear due to humidity on the left and right ends of the gallery roof >> Repair of the missing corbel and the deteriorated part of the roof, with reed and mud.

C3. Terminal pair of the rear bay cover rotten (initial state on previous page) >> Pair replacement.

TO BE CONTINUED...

Manolo, the owner of Casa Otorongo, continues with the rehabilitation work outside the framework of the project.
These mud plasters reveal that the demonstration project has achieved its goal: to motivate the owners of earthen houses.



Images: MS

Detail
West-facing court
(image below)
Otorongo House
(Architect:
Edmundo Iturralde)

PARTY WALL OF BAHAREQUE *D1.*

Tiles placed with bastard mortar of cement and lime >> Removal of the tiles and the mortar.

D2. Wattle and daub wall with dampness, mud detachment and rotting of wooden elements >> Dismantling and repair of the lower part of the wattle and daub wall.

OTHER MINOR JOBS

E1. Cement plasters >> Replacement with mud and straw plasters and stucco.

E2. Cement mortar covering gaps in walls >> Removal and repair with mud and straw mixture.

E3. Cement joints in stone wall >> Removal of joints

E4. Degraded arch
>> Repair with earth and straw mortar

LITERATURE

AA.VV., 2011. Earth construction techniques. Bauru: FEB-UNESP / PROTERRA. São Paulo, Brazil.

Abad Rodas, ML, & Tómmerbak, M., 2009. Cuenca, in: City and republican architecture of Ecuador, 1850-1950. Publications Center, PUCE. Quito, Ecuador.

Technological Development Corporation, 2012. Damage assessment and solutions for raw earth constructions. Field manual. Chile.

Fontaine, L., & Anger, R., 2009. Bâtir en terre: Du grain de sable à l'architecture. Belin, Paris.

Junta de Andalucía, 2007. Architecture Guide, Cuenca, Ecuador.

Ministry of Urban Development and Housing of Ecuador, 2014. Ecuadorian Construction Standard. Houses up to 2 stories with spans up to 5 meters. Ecuador.

Piedra, C., 2008. Solutions to damage in heritage buildings constructed with traditional technologies. Master's Thesis in Conservation of Monuments and Sites. Faculty of Architecture. University of Cuenca. Ecuador.

PIEDRA C., DC, 2008. Pathologies and their causes in raw and cooked earth walls in heritage buildings. Master's Thesis in Conservation of Monuments and Sites. Faculty of Architecture. University of Cuenca. Ecuador.

UNESCO, 2012. The historic center of Santa Ana de los Cuatro Ríos de Cuenca, Ecuador, Ms María de Lourdes Abad Rodas, in: Earthen Architecture in today's world: Proceedings of the UNESCO International Colloquium on the Conservation of World Heritage Earthen Architecture, 17-18 December 2012

University of Cuenca, Faculty of Architecture, vlirCPM Project, 2014. Final Report for the Municipality of Cuenca. “Maintenance Campaign applied to the heritage buildings of San Roque”. Ecuador.

University of Azuay, 2013. The built heritage in Cuenca. Architectural photogrammetry. Ecuador.

SERVICES AND INSTITUTIONS

Some institutions can help you in the different stages of your projects: preparing permits, technical and financial advice, selecting materials, execution and monitoring of the work.

NATIONAL INSTITUTE OF CULTURAL HERITAGE INPC REGIONAL 6 AZUAY

Free technical advice

House of the Doves
Benigno Malo Street 6-40
(between Presidente Córdova and Juan Jaramillo)
Cuenca, Ecuador

Monday to Friday
from 08:00 to 16:30

Municipality of Cuenca ADVISORY AND CONTROL DEPARTMENT FROM THE DIRECTORATE OF HISTORICAL AREAS

Free technical advice

Pasaje León Building, First Floor
President Cordova
(between General Torres and Father Aguirre)
Cuenca, Ecuador

Monday to Friday, from
3:00 PM to 5:00 PM