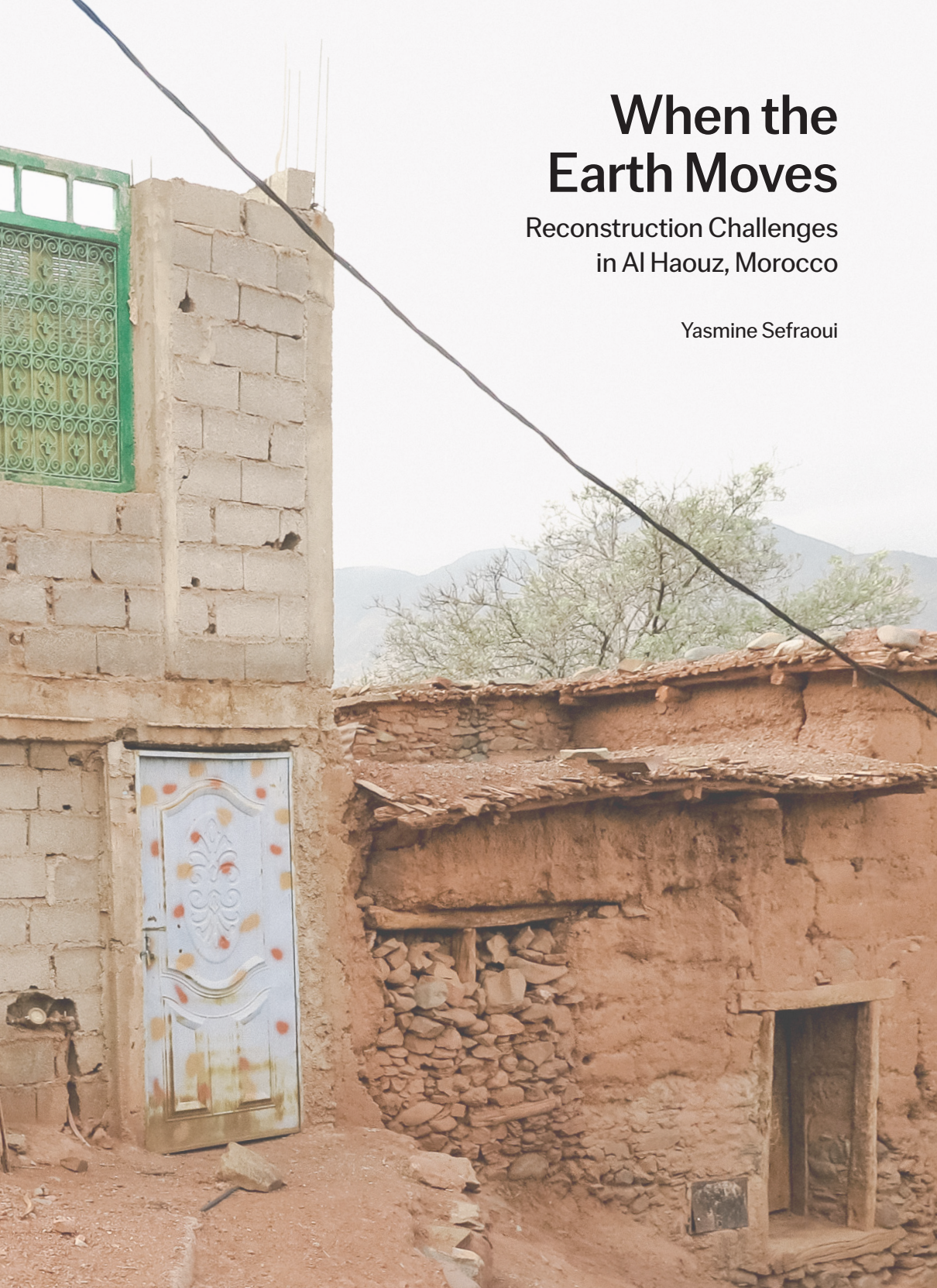


When the Earth Moves

Reconstruction Challenges
in Al Haouz, Morocco

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When the Earth Moves

Enoncé theorique 2024
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Reconstruction Challenges in Al Haouz, Morocco

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Introduction

¹ The earthquake caused the death of more than 3,000 people, injured several thousand, and destroyed nearly 19,000 homes. Approximately 60,000 other buildings were damaged. In total, over 500,000 people were displaced, according to Islamic Relief Suisse, *Tremblement de Terre d'Al Haouz au Maroc*.

On the night of September 8, 2023, an earthquake struck the province of *Al Haouz*, Morocco, causing considerable loss of life and material damage.¹ The areas closest to the epicenter are predominantly rural, mountainous regions inhabited by Amazigh communities. These regions are characterized by vernacular earthen constructions made from local materials such as earth, stones and wood, that reflect a long-standing adaptation to the region's climate and social organization. Reconstruction projects, however, largely favor the use of concrete, neglecting traditional architecture. This shift risks erasing not only the architectural heritage of earthen construction but also its practical benefits, such as its low environmental impact and ability to adapt to the local climate.

This research seeks to understand the reasons behind this choice, by addressing a central question:

*In the context of post-earthquake reconstruction in Al Haouz, what are the main obstacles to building with earth?*²

The study examines the historical, social, technical, environmental, and normative factors contributing to the marginalization of earthen construction in Morocco. The analysis of post-earthquake reconstruction efforts in the Al Haouz region offers a valuable lens for exploring these themes. Crises such as earthquakes can act as pivotal moments, prompting either a reevaluation of established practices, or the dominance of standardized methods justified by the urgency of the situation.

The research methodology includes a literature review on the identified themes, field visits to the Al Haouz region and the southeastern regions of Morocco, and discussions with experts. It begins by introducing earth as a building material, exploring its characteristics and applications. It then contextualizes the Al Haouz region and the earthquake. Finally, it examines the challenges encountered when building with earth, drawing on interactions and insights from my fieldwork. Additional theoretical contributions essential to the argument are provided in the *Appendix*, along with extracts from discussions conducted during the research. These exchanges and fieldwork provide a bridge between theoretical research and tangible realities, enriching the study with diverse perspectives.



Earth

A Building Material

Origins and Properties of Earth

² CRATerre, "Centre international de la construction en terre."

³ Fontaine and Anger, *Bâtir en terre*, 101.

⁴ Thermal inertia can be defined as the ability of a material to store heat and gradually release it.

⁵ The sorption capacity is a material's ability to absorb and adsorb moisture, helping regulate humidity by storing and releasing water vapor.

⁶ Röhlen and Ziegert, *Construire en terre crue*, 14.

Earth is one of the oldest building materials in human history. It is estimated one third of the world's population lives in earthen homes today.² Before it is a building material, however, earth is simply what lies beneath our feet. It comes from soil, a universal and accessible resource that is essential for life. While it is one of the most abundant materials on the planet, its extraction must be done thoughtfully. Excessive use risks depleting local resources and disrupting ecosystems. This is especially important since earth is not a renewable material, as it forms through the slow degradation of parent rock via physical, chemical, and biological processes—a cycle that far exceeds a human timescale. However, when minimally altered, earth can be reintegrated into the ground at the end of its use, maintaining a closed cycle, from earth to earth. This means that, unlike many other materials, earth does not create permanent waste if its natural composition is preserved.³ One of the most notable properties of earth as a building material is its high thermal inertia and its ability to regulate humidity.⁴ The sorption capacity of earth for water vapor exceeds that of other construction materials.⁵ This is due to the large specific surface area of clay particles, which allows them to bind more water molecules than materials with lower surface areas. This property also enables earth to absorb odors and harmful substances.⁶

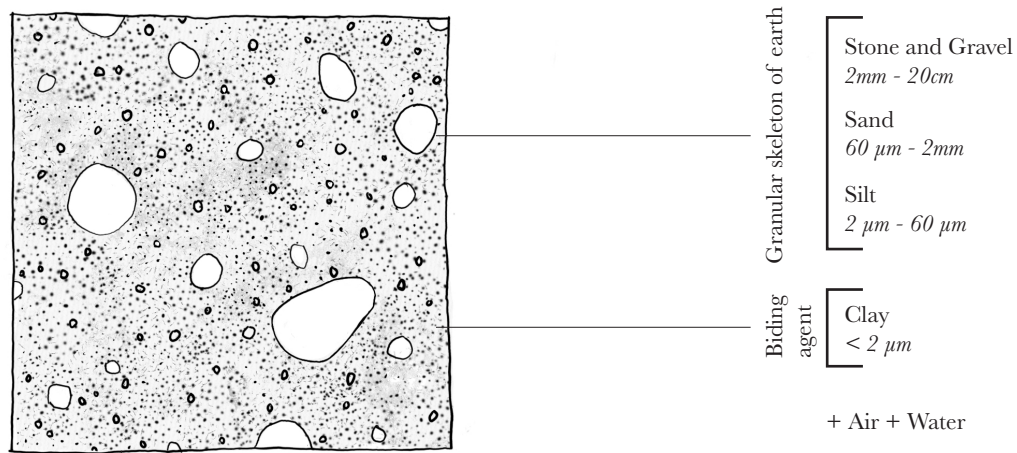
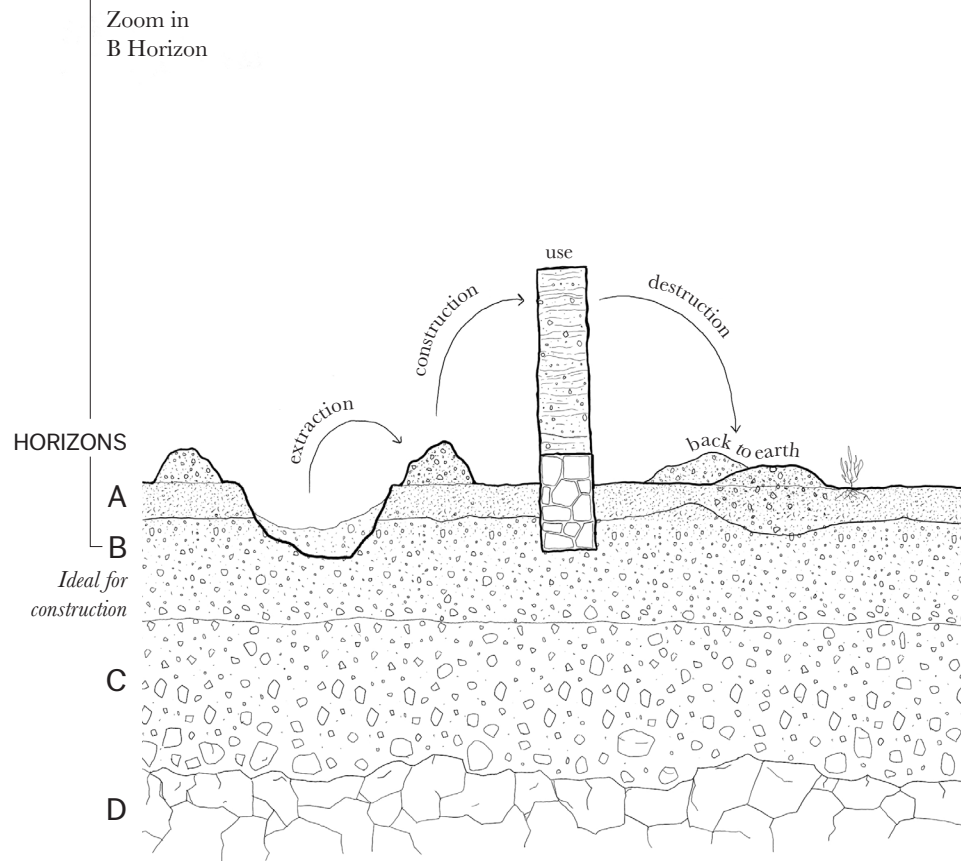


Fig. 1
Earth Composition
and Life Cycle.
Based on Fontaine
and Anger, *Bâtir en
terre*.

⁷ Fontaine and
Anger, *Bâtir en terre*,
102, 152.

Gravel, stone, sand, and silt, are fragments of rocks that differ mainly by their size and shape, which can range from rounded to angular. Clay, however, is fundamentally different due to its microscopic size and distinctive form: its particles are flat, resembling tiny sheets. This property gives them the unique ability to bond with other grains. Clay — along with the water between its particles — acts as a natural binding agent, much like the cement in concrete. Concrete consists of a granular skeleton held together by a binder. In this context, earth-based materials belong to the family of concretes, specifically earthen concrete. By contrast, what is commonly referred to as *concrete* today is actually cement concrete.⁷





Traditional Construction Techniques

Fig. 2
Clay nest constructed by a solitary potter wasp or leafcutter bee, incorporating pink flower petals to seal the brood cells. *Kasbah Timidarte, Afra, October 18, 2024.*

8 Fontaine and Anger, *Bâtir en terre*, 9; Doat et al., *Construire en terre*, 10.

9 In French, rammed earth is known as *pisé*. The term adobe comes from the Egyptian word *thobe*, meaning “brick.”

10 Fontaine and Anger, *Bâtir en terre*, 30; Röhlen and Ziegert, *Construire en terre crue*, 167.

11 Fontaine and Anger, *Bâtir en terre*, 31.

Earth exists in various forms, varying in color, texture and proportion of its components, each ending itself to specific construction techniques. The construction techniques are diverse and depend largely on the water status of the material during application, which can range from dry to humid, plastic, liquid, or viscous states. The various construction techniques also vary according to whether the soil is compacted, rammed, or filled.⁸ In Morocco, there are two main traditional techniques used for construction: *rammed earth* and *adobe*.⁹

Rammed earth consists of compacting moist, nearly dry, pulverized soil in layers to produce dense and solid walls. The composition of the earth must balance the primary components in optimal proportions to ensure structural strength. This is the only technique that accommodates earth containing stones and gravel, making mountain or ravine soils particularly suitable.¹⁰ The earth used for rammed earth contains minimal water. A simple field test can determine the optimal moisture content: A ball of soil is formed and dropped from a height of 1 meter. If it breaks into three to four pieces, the moisture content is ideal. If it disintegrates completely, the soil is too dry, and if it remains intact, the soil is too wet.¹¹

Adobe is a type of raw earthen brick. The technique consists of mixing earth with water and plant fibers to produce earthen bricks that are shaped or molded while in a plastic state and left to air-dry.¹² The soil used for adobe contains fewer stones and gravel than the one used for rammed earth and is easier to work by hand.¹³ Compared to other earthen construction techniques, masonry using bricks is known for its rapid execution, comparable to that of industrial materials.

The following test can be conducted to assess the suitability of the earth for adobe production: A cigar-shaped ribbon of soil is formed and stretched as far as possible. If the ribbon breaks between 5 and 15 cm, the soil is ideal. If it breaks before 5 cm, it contains too much sand, and if it stretches beyond 15 cm, it has excessive clay content.¹⁴

¹² The term 'plastic state' refers to a mixture characterized by a modeling clay-like texture, which allows it to be easily shaped or molded.

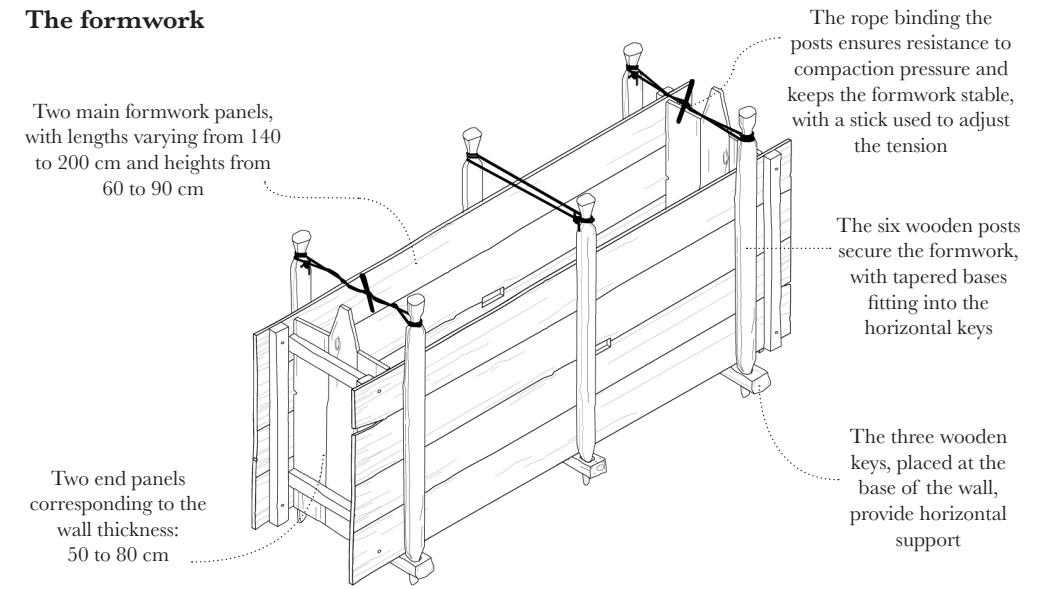
¹³ Fontaine and Anger, *Bâtir en terre*, 105.

¹⁴ Doat. et al., *Construire en terre*, 111.

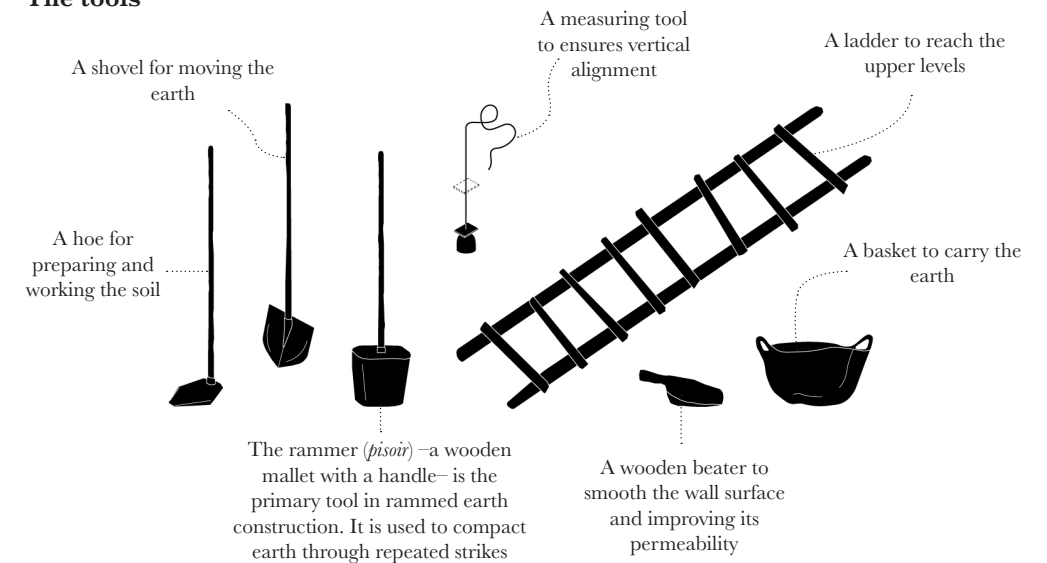
Rammed earth

Called *Tabout* or *Louh*

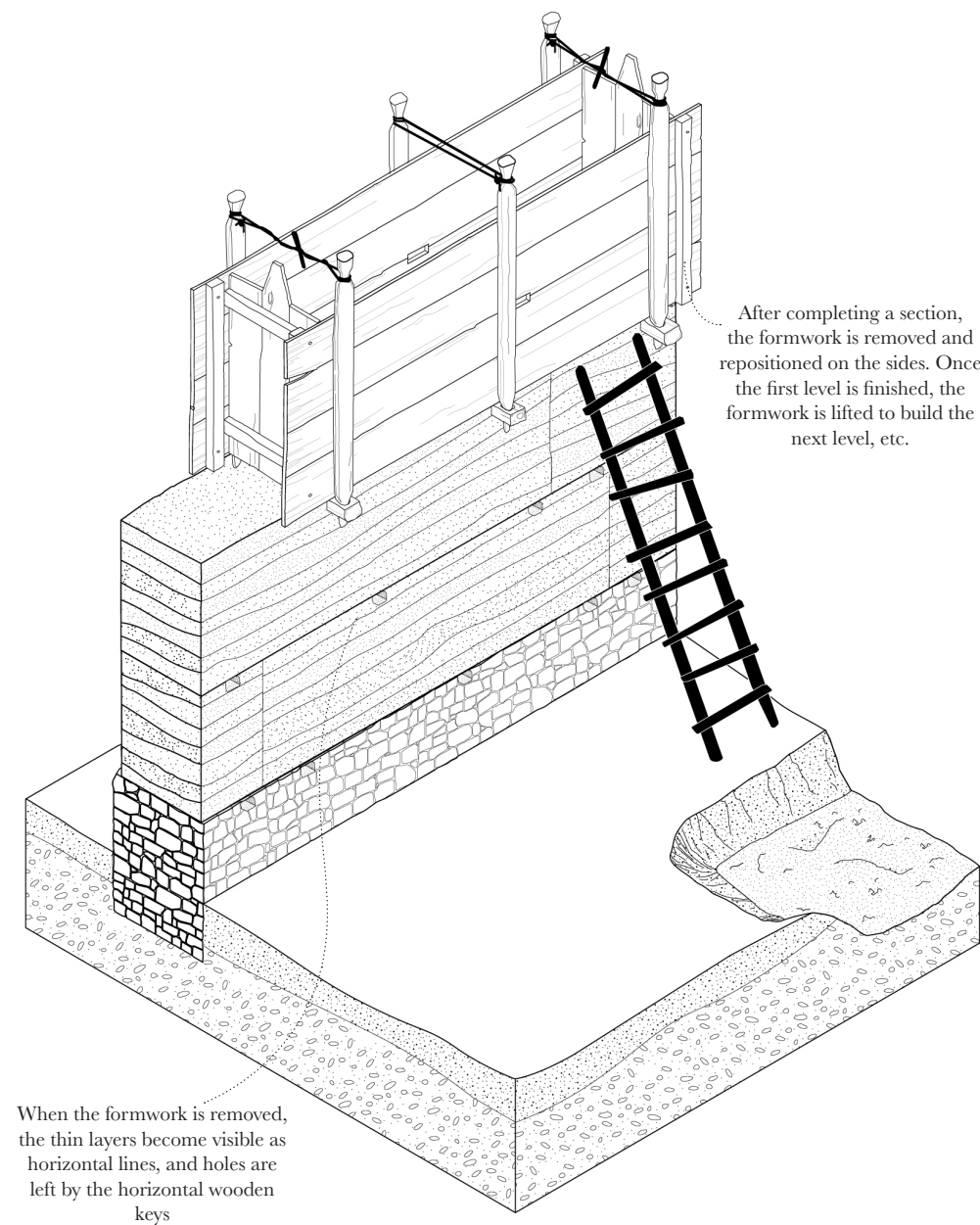
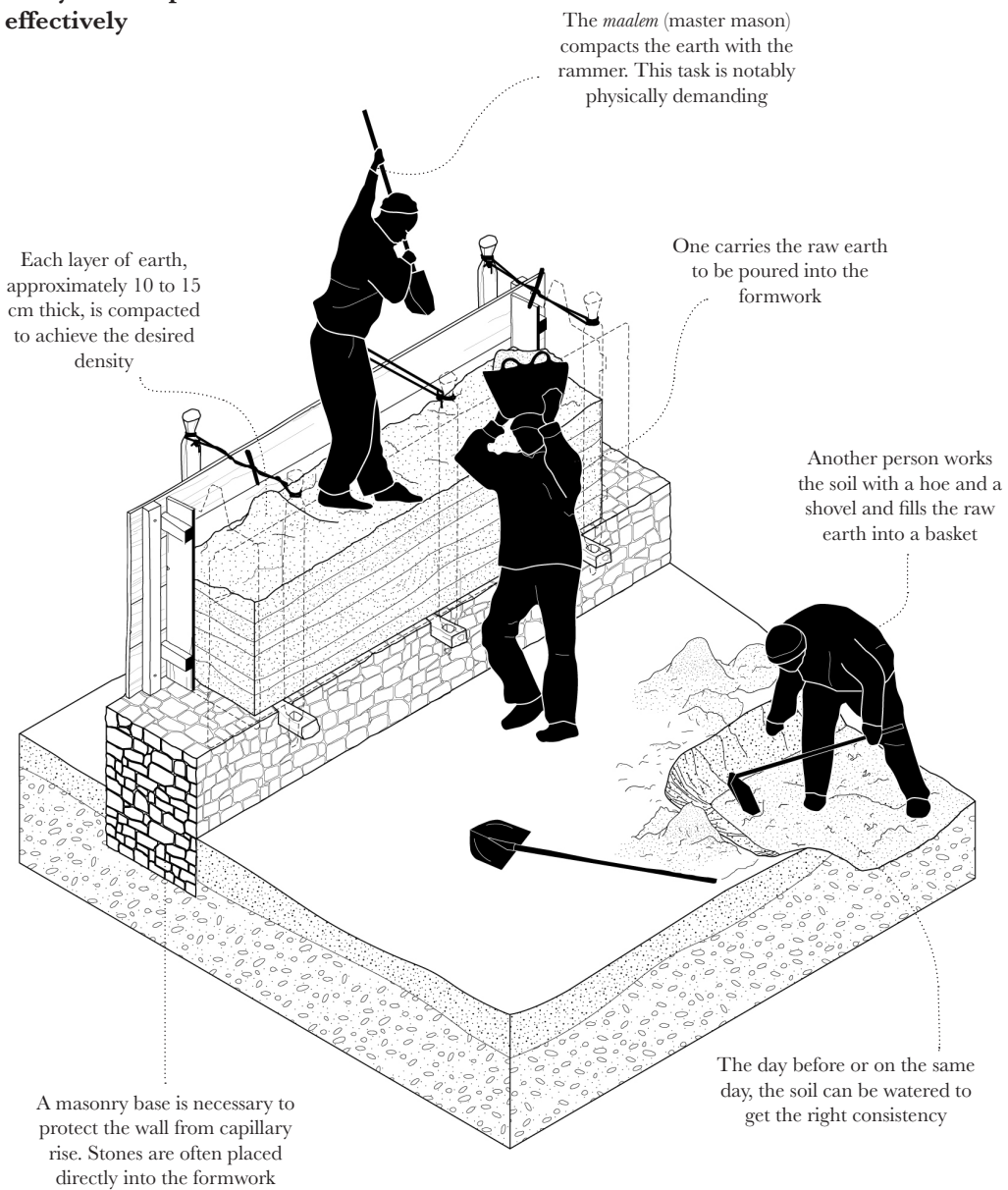
The formwork



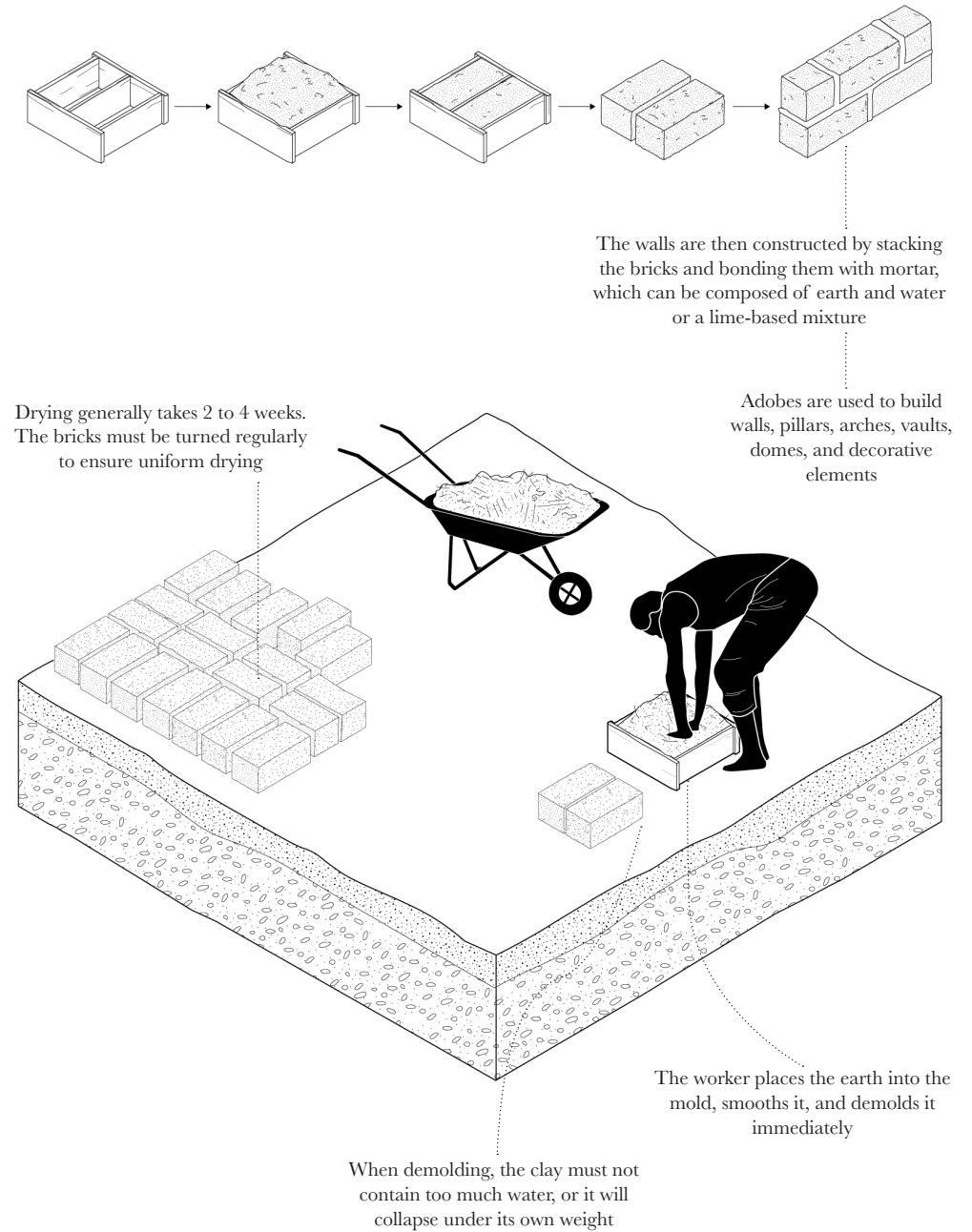
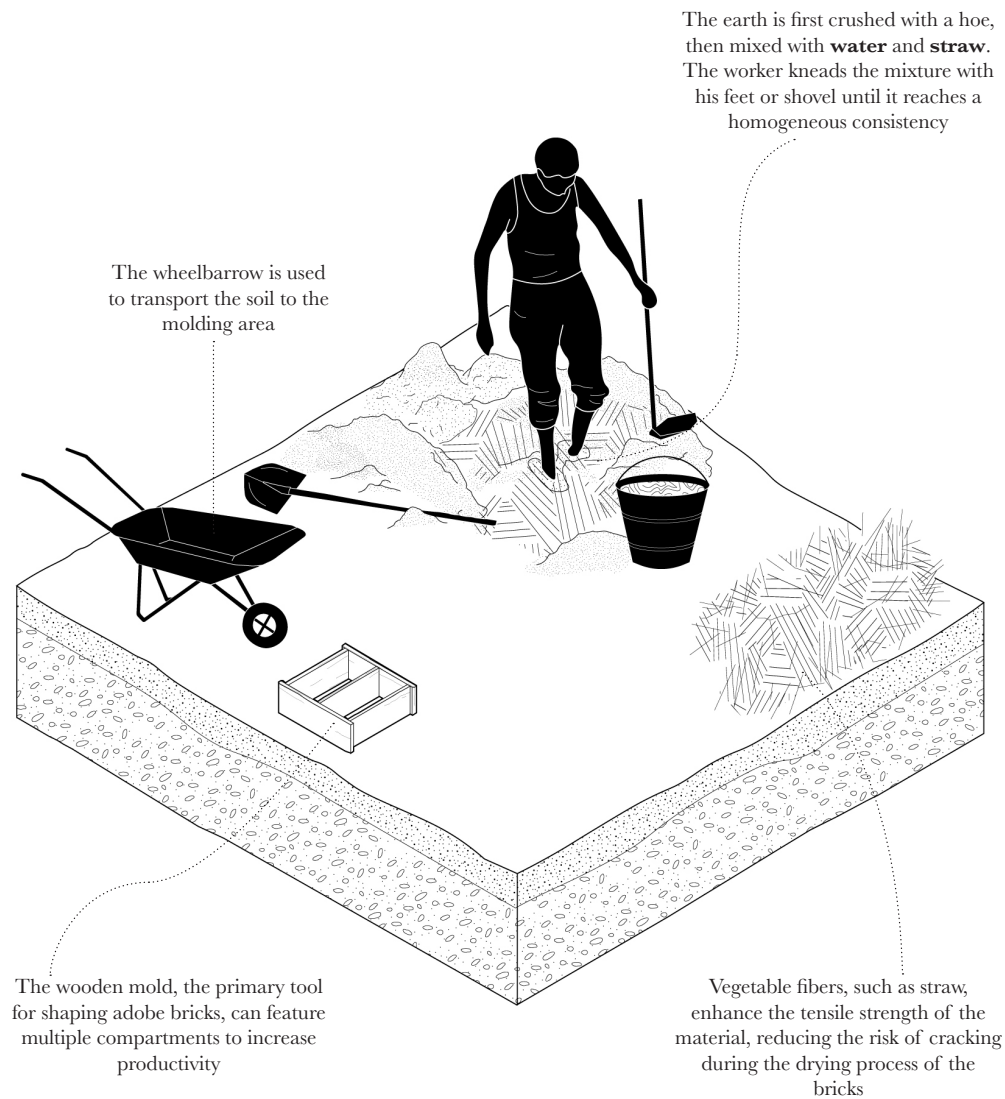
The tools



A minimum of three workers is required to carry out the process effectively



Adobe Called *Tob*



Al Haouz

The Earthquake



Al Haouz



15 The High Atlas is a major mountain range in Morocco, spanning around 700 kilometers and divided into the Western, Central, and Eastern High Atlas.

16 Benkirane, "Penser la reconstruction du Haut Atlas."

17 Costa and Batista, "Architecture traditionnelle dans les zones de montagne."

18 Coquillard, "Amazigh."

The Al Haouz province, located in the Western High Atlas Mountains within the Marrakech-Safi region, is characterized by diverse topography, soil types, hydrological resources, and socio-economic systems.¹⁵ The province comprises various human settlements, known as *douars*, ranging from small clusters of houses to larger communities. They are distributed across three ecological zones: high mountains, piedmont, and plains.¹⁶

The organization of these douars reflect adaptations to local resources and cultural practices, with architectural solutions consistently relying on earth, stone, and wood, integrating into the landscape.¹⁷ However, the Atlas Mountains are undergoing significant transformations. Rising temperatures and declining rainfall are profoundly affecting the region, while forests, once abundant, continue to shrink due to a combination of climate change and human activity. At the same time, more and more villages are being abandoned.¹⁸

Reconstruction in Ouirgane

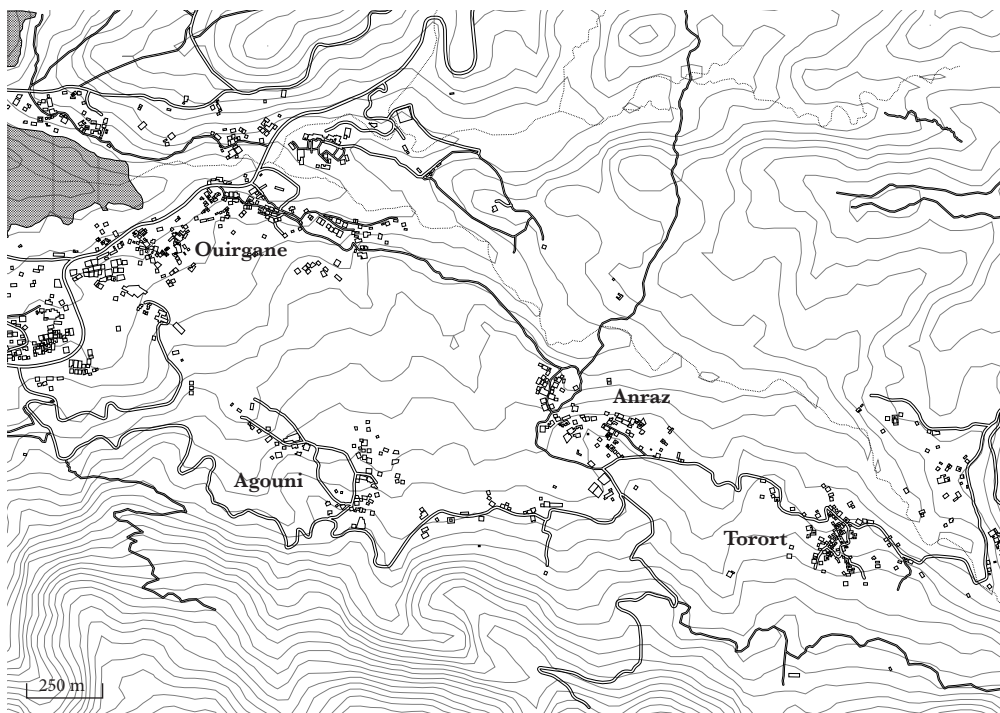
As part of my research, I visited the rural commune of Ouirgane, in the Al Haouz province, situated at an altitude of 955 meters. Ouirgane plays an important role in the local economy through tourism, on which part of the population depends. However, the September 8, 2023 earthquake severely impacted the commune.

During my visit, I was accompanied by Mohammed, a local resident and guide from Ouirgane, who shared with me his experience of the difficulties faced in the aftermath of the earthquake. As we walked through Ouirgane and the surrounding villages — *Anraz*, *Torort* and *Agouni* — the scars of the earthquake were still evident, with collapsed walls, abandoned houses and traces of interrupted lives.

Many of the reconstruction projects I have seen in the region are still in their early stages and rely mainly on reinforced concrete and concrete blocks, in contrast to the traditional earthen dwellings that blended in perfectly with the landscape.

Through the villages, everyone we met offered us tea, a gesture of hospitality even in the midst of difficulty. Some spoke with quiet frustration about the slow progress and the hardship they were enduring, caught between the urgency to rebuild and the scarcity of resources at their disposal. Beyond the visible damage, what stands out most is the hardship and resilience of people determined to rebuild their lives after heavy losses and a year of relentless effort.

Fig. 3
Plan of Ouirgane
and its surrounding
villages.



Amazigh Roots

¹⁹ While the 2014 census indicates that 27% of Moroccans speak Tamazight, some sources estimate this figure to be as high as 50%.

²⁰ Pouessel, "Du village au 'village global': émergence et construction d'une revendication autochtone berbère au Maroc."

²¹ Rancé, "Le combat des Berbères.", 57.

²² Pouessel, "Du village au 'village global.'"

²³ Also called *Neo-Tifinagh* or *Tifinagh-Ircam*, as it is derived from the ancient North African script, the Tifinagh.

²⁴ Fadma Aït Mous, "Les enjeux de l'amazighité au Maroc."

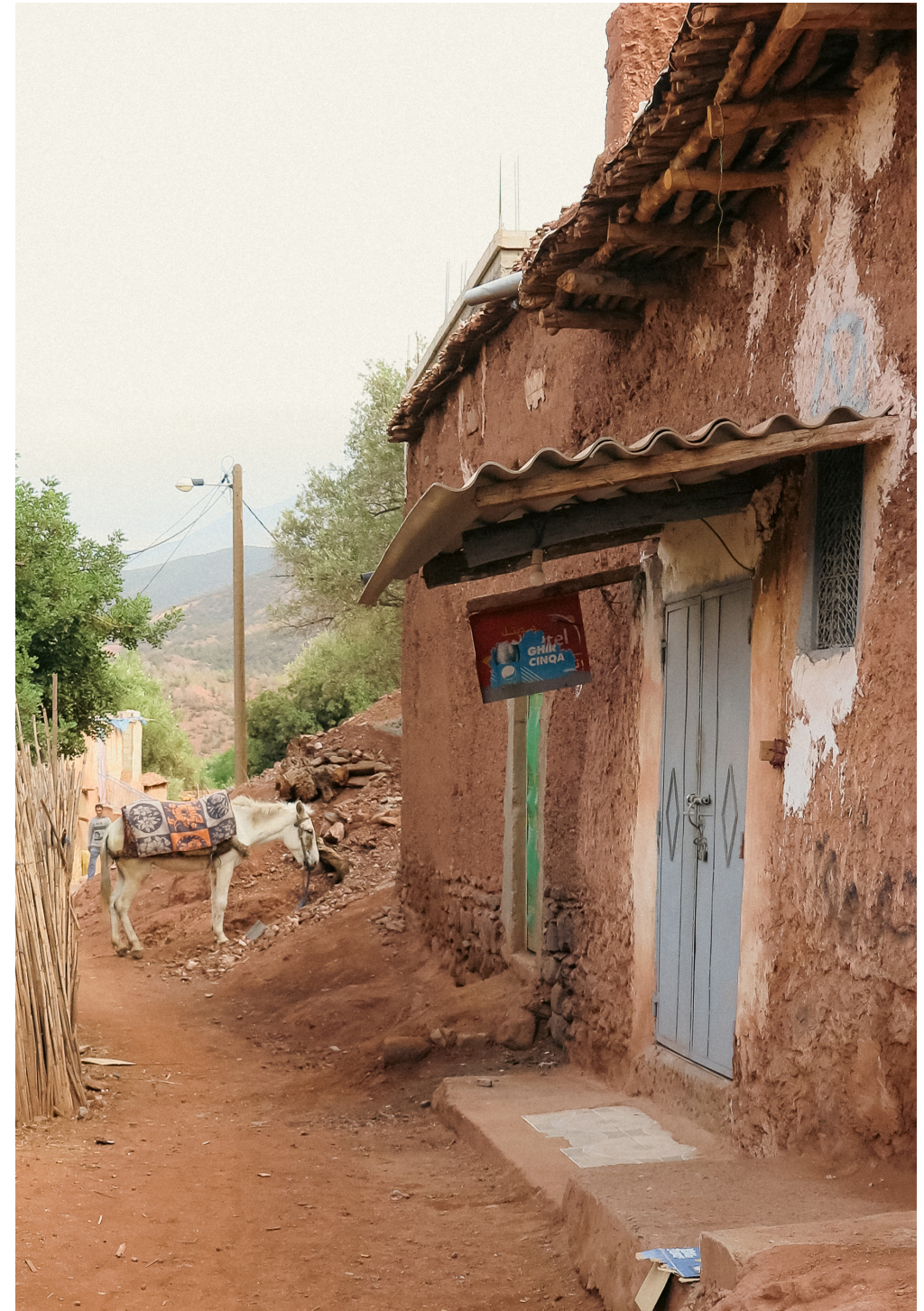
²⁵ United Nations, "Concluding observations on the combined nineteenth to twenty-first periodic reports of Morocco.", 6.

Most of the population in Al Haouz is *Amazigh*. The language includes three main dialects: *Tarifit* in the north, *Tamazight* in the Middle and High Atlas, and *Tachelhit* in the south.¹⁹ The *Imazighen*, considered Morocco's first inhabitants, are often referred to as Berbers — a term that may have originated from the Greco-Roman 'barbarians' and considered pejorative. By contrast, Amazigh means 'free man'.²⁰

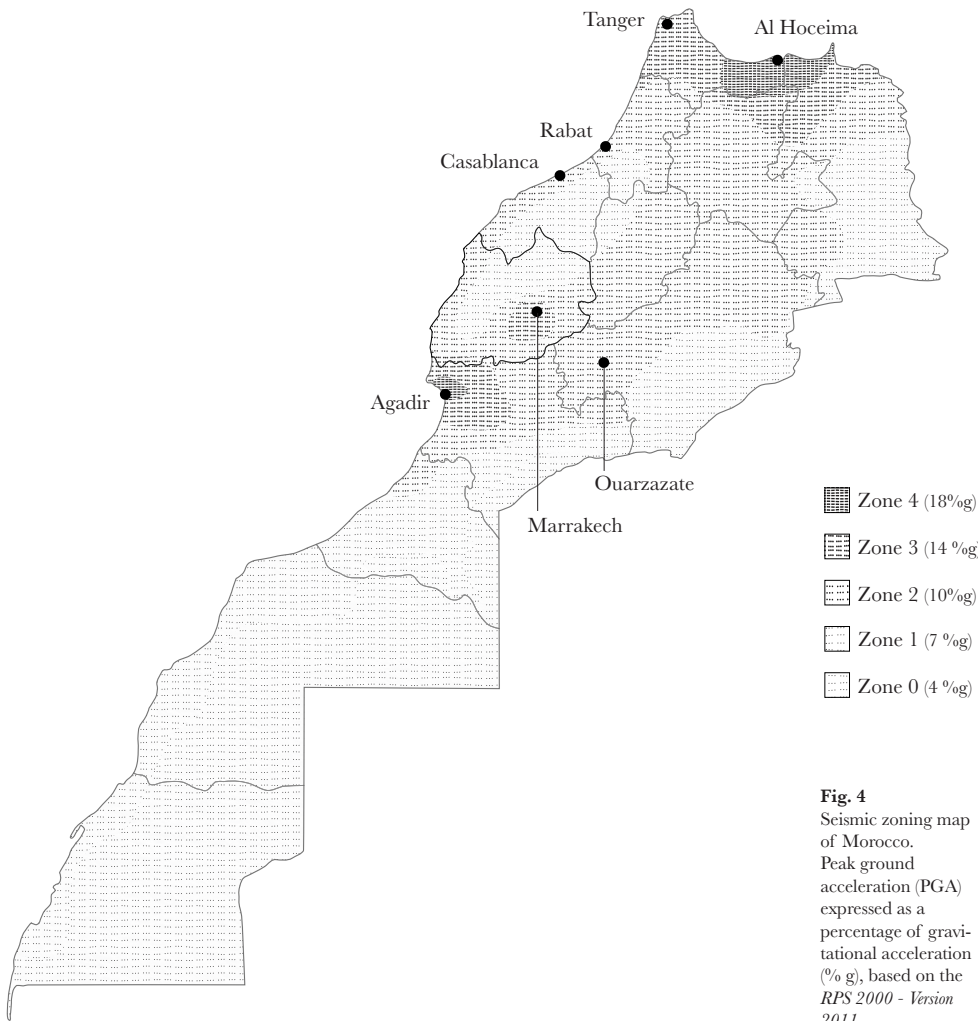
The Amazigh people have historically faced marginalization. In 1930, the *Berber Dahir*, enacted by French colonial authorities, aimed to preserve their legal autonomy by maintaining customary law. However, this decree sparked strong opposition, particularly from nationalists, who viewed it as an attempt at de-Arabization and de-Islamization.²¹ Following independence in 1956, Morocco adopted an Arab-Muslim nationalism, framing Amazigh identity as an obstacle to national unity. In the 1970s, a policy of Arabization was implemented to suppress the Amazigh language and culture.²² Despite this, Amazigh intellectuals and activists rose to demand recognition of their identity, leading to significant progress. In 2011, Tamazight was officially recognized as a state language, and its transcription using the *Tifinagh* alphabet is now visible in public spaces.²³ Efforts have also been made to gradually promote Amazigh culture and language in schools and media.²⁴

Nonetheless, challenges persist. Amazigh communities still face structural discrimination, especially in employment, education, and healthcare, and collective Amazigh lands continue to be seized for state or private projects.²⁵

In the context of post-earthquake reconstruction in an Amazigh region, this historical and social backdrop becomes essential. The cultural and technical heritage of the Amazigh, especially in earthen construction, offers valuable insights often overlooked in modern policies. These traditions align with heritage preservation, environmental sustainability, and climate adaptation. In contrast, the widespread use of standardized concrete houses not only erases cultural and architectural heritage but also exacerbates environmental degradation, and fails to adapt to local needs and climatic conditions.



Seismic Activity in Morocco



Seismic activity in Morocco is caused by the convergence of the African and Eurasian plates, resulting in predominantly moderate seismic activity with occasional high-intensity events.²⁶ The country has experienced several destructive earthquakes throughout its history, including the 1960 Agadir earthquake which destroyed most of the city and claimed the lives of one-third of its inhabitants.²⁷

The earthquake of September 8, 2023 is the largest recorded by the country's seismic stations in over a century, with a moment magnitude (M_w) of 6.8. Most of the victims were in the Al Haouz and Taroudant regions.²⁸ This region was classed in a *moderate* seismic risk zone (zones 2 and 3 in *Fig. 3*) but this is currently being amended following the earthquake. The moderate seismic risk in Morocco is amplified by the structural vulnerability of buildings, which is a key factor in the extent of human and material losses.²⁹

²⁶ Ministry of Housing and Urban Policy, *RPS 2000*.

²⁷ Bcquiraj et al., *Rapport de la mission de reconnaissance SGE*.

²⁸ Ibid.

²⁹ TelQuel, "Séisme: pourquoi le Maroc est particulièrement vulnérable."

The Earthquake Management



After an earthquake, the response generally unfolds in distinct phases to address immediate and long-term needs. The acute phase, occurring immediately after the event, includes search and rescue operations, emergency aid, and securing damaged structures to prevent risks from aftershocks. In Al Haouz, these efforts were affected by landslides blocking roads, requiring heavy equipment to restore access to the villages. After the acute phase, the next step involves a damage assessment phase to evaluate the safety and habitability of structures. In Al Haouz, many residents were forced to vacate at-risk homes and move into tents or temporary containers. Some families, however, continued to use their damaged homes during the day while sleeping in tents at night, accepting certain risks. Finally, the rehabilitation and reconstruction phases, which can take months or years, focus on restoring or rebuilding housing.³⁰

For reconstruction, the Moroccan government provided financial aid: 2,500 dirhams per month for one year (later extended by five months), plus 80,000 dirhams for partially destroyed houses, and 140,000 dirhams for fully destroyed homes.³¹ The funds are distributed through a public agency, *Al Omrane*, which oversees the call for reconstruction projects. Payments are made in installments of 20,000 dirhams, linked to each stage of construction progress.³²

³⁰ Beqiraj et al., *Rapport de la mission de reconnaissance SGB*.

³¹ On-site observations revealed that some affected households did not receive any aid.

³² At the time of writing, 10 Dirhams $\approx$ 1 Swiss franc

This aid is intended to allow beneficiaries to *"benefit from the technical support of the relevant services to finalize the necessary measures for the initiation and monitoring of reconstruction operations, particularly through architectural plans that meet the specificities and standards of the region."*³³

The beneficiaries of this aid are, therefore, obliged to follow the plans supplied by the engineering offices, which, according to my field visits, consist of standardized models of reinforced concrete and cement or concrete blocks. In addition to state aid, numerous associations and collaborative initiatives have made significant and extensive contributions to providing support.³⁴

Reconstruction in remote mountain areas closest to the epicenter has been slow and complex due to isolation, difficult access, and the lack of formal land documentation. Indeed, unlike urban zones, where land and ownership are well-documented and processes more streamlined, these rural regions operate autonomously. Families typically negotiate and agree among themselves to allocate plots for construction. This approach often results in delays and back-and-forth discussions, as a topographer must first determine and delineate the boundaries of their plots for the reconstruction process. The presence of debris further complicates this task, making it challenging to identify and agree upon property limits.³⁵ Moreover, the lack of proper infrastructure in these remote areas adds to the difficulty and time required to clear rubble. In some of the more inaccessible villages, this task is nearly impossible, leaving families with little choice but to relocate.

Faced with limited resources, many families have opted for self-construction using government aid. This choice stems not only from a lack of qualified masons but also from the need to cover daily expenses after sustaining heavy losses. While self-construction reduces labor costs, it often means longer construction times and potential quality problems due to a lack of expertise.

³³ Kingdom of Morocco, "Communiqué de Presse."

³⁴ Such as Association *Labina Post-Séisme*, Association *Tamounte Ouirgane*, and the *ReBuild* program by UM6P.

³⁵ These informations are based on insights gathered through various discussions.

Since the earthquake, most people are leaving their homes here ... There are no roads for trucks to bring in machines or materials.

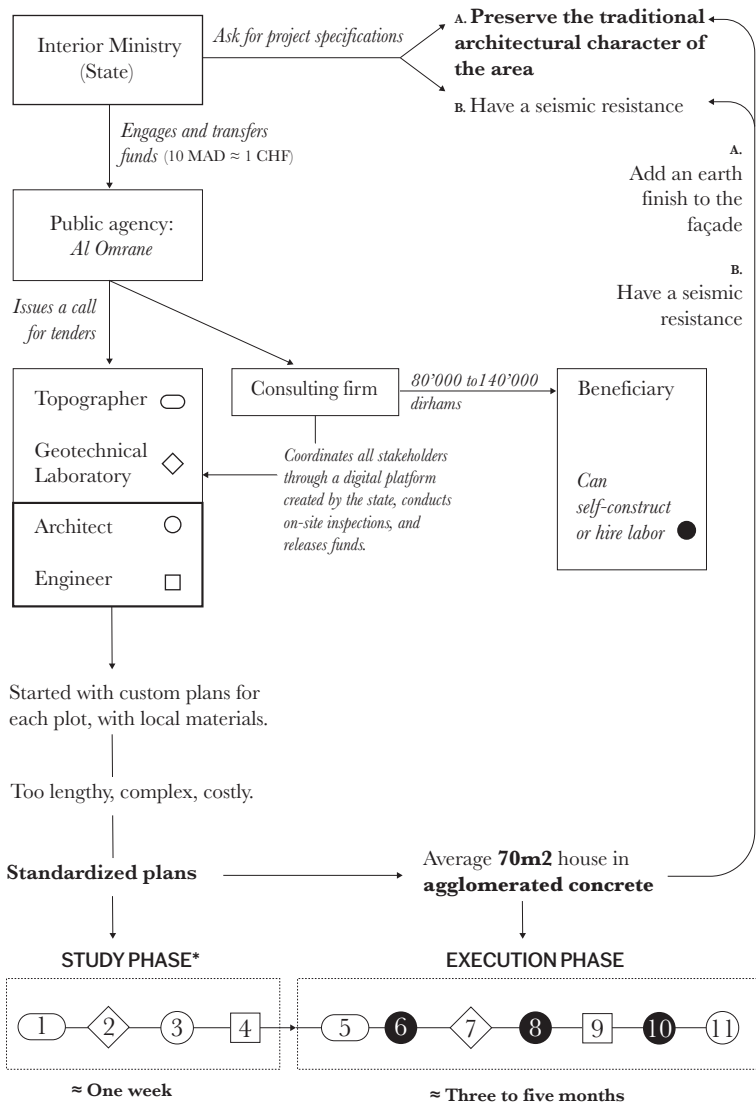
So, they are forced to find another piece of land for construction. It's not possible here, how do you clear all the soil, wood, stones?

Where would you take it?

So, they abandon it and move elsewhere in the same village ... Most of the houses are empty, yes. This house, for example, wasn't affected. Neither were these two, but the others are abandoned. It's a shame, isn't it? ... They're living in tents and waiting to finish their house. Look at this house, it's over 500 years old and it's still standing.

— Mohammed, local resident and guide from Ouirgane, Anraz, October 14, 2024.

Saif-Eddine, head of a consulting firm overseeing the reconstruction of over 1,500 houses, explained to me the typical government-led reconstruction process, which is summarized in the following diagram.



- ① The topographer conducts the initial land survey to determine boundaries, elevations, and physical features. Delivers a topographic map with X, Y, Z coordinates to the consulting firm.
- ② The geotechnical laboratory analyzes soil composition with surveys, verifies stability, and confirms if the land is suitable for construction. Deliver a report.
- ③ The architect designs building plans based on surveys and constraints identified by the laboratory.
- ④ The engineer sizes load-bearing elements (foundations, walls, slabs) based on geotechnical results and seismic safety regulations.
- ⑤ During the **execution phase**, the topographer parks the lot and positions the building on the site. Ensures the construction respects property boundaries to avoid disputes with neighbors.
- ⑥ The builder, who can be the beneficiary himself, digs foundations and prepares for inspection.
- ⑦ The geotechnical laboratory approves excavation levels by inspecting the site. Confirms to the consulting firm that the foundation reaches stable, load-bearing soil to guarantee stability. — Releases the first tranche of 20,000 dirhams to start work.
- ⑧ The builder installs rebar for foundations according to the plans.
- ⑨ The consulting firm and engineer inspect rebars, approves concrete pouring for foundations and slabs. — Another tranche of aid is released after approval.
- ⑩ The builder continues with structural elements. — 3rd tranche of 20'000 dirhams released after inspection.
- ⑪ Final inspection for project completion: The architect and consulting firm verify that the partition walls match the approved design. — Release of the final tranche of aid for finishes, utility connections (electricity and water), and issuance of the habitat permit.

*Exceptional building permit granted despite non-compliance with certain regulations, due to urgency.

Seismic Construction Regulations



³⁶ Ministry of Housing and Urban Policy, *RPS 2000*.

³⁷ *Décret n° 2-12-666 du 17 rejeb 1434*

³⁸ Naji, *Architectures du bien commun*, 188-189.

³⁹ In zones with maximum seismic accelerations of 4 and 3, earthen dwellings are limited to one level, while in zones 2, 1, and 0, they can have up to two levels.

Earthquake-resistant building regulations were introduced in 2000 with the *Règlement de la construction parasismique* (RPS 2000), later revised in 2011. It aims to define seismic forces on buildings and establish minimum design and construction standards to ensure their stability during earthquakes.³⁶ Yet, these regulations do not apply to constructions using traditional techniques and materials.

On May 28, 2013, however, a decree approved earthquake-resistant regulations for earthen construction, marking a significant shift in Morocco's approach to traditional building techniques.³⁷ Before this, the "*Moroccan urban planning code prevent[ed] the use of vernacular techniques for a long time, which [were] often banned outright from projects to avoid, during the authorization process, any reservations that might delay the start of operations.*"³⁸

This decree introduced two distinct sections:

The *Seismic Regulations for Self-Construction in Earth* (RPACTerre 2011), which focuses on self-construction without the need for architects or engineers, and the *Seismic Regulations for Construction in Earth* (RPCTerre 2011), which applies to projects that are professionally supervised.

These regulations provide a clear framework, allowing construction permits for load-bearing walls built with earthen materials or stone masonry bonded with earthen mortar.

They specify authorized techniques and structural requirements, including wall thickness, maximum percentages of façade openings, and building height limits.³⁹



Construction Resistance and Vulnerabilities

A common misconception regarding earth construction is that it's not sturdy enough to withstand events like earthquakes and floods. Hassan Fathy, an Egyptian architect known for his work on traditional and sustainable construction methods, addressed this issue during a visit to a village affected by floods. He pointed out that the real problem often lies in poor construction practices, rather than the materials themselves. *"I went to see the devastated village, which turned out to have been built with mud bricks but constructed without proper skills. The houses had walls only one brick thick at ground level, and it was obviously impossible to expect them to withstand a torrent. The walls crumbled, and the houses collapsed. However, this was not an argument against the use of mud bricks in that location. With sufficiently thick walls and stone foundations, the mud-brick houses could have withstood even Noah's flood."*⁴⁰

⁴⁰ Fathy, *Construire avec le peuple*, 41.

Earthen buildings have historically demonstrated their resistance. In Ouirgane, some earthen houses over 400 years old withstood the earthquake, highlighting the potential of these techniques.⁴¹

⁴¹ Mohammed, discussion with the author, October 2024.

However, challenges arise when these traditional methods are poorly implemented or combined with incompatible materials. Some post-seismic reports have analyzed the types of damage observed in various structures, and whether built using traditional or modern techniques, all constructions show specific vulnerabilities. The following examples provide an overview without delving into technical specifics, based on the *Reconnaissance Mission Report* from the *Swiss Society for Earthquake Engineering and Structural Dynamics* (SGEB).⁴²

⁴² Beqiraj et al., *Rapport de la mission de reconnaissance SGEB*.

For earthen constructions, weaknesses include Vertical cracks at the intersections of perpendicular walls, often caused by inadequate anchoring. Junctions between different materials, such as adobe, rammed earth, or stone, also frequently serve as points of failure. Furthermore, the lack of vertical stabilization has led to out-of-plane wall collapses, particularly for façades parallel to the direction of floor joists.

Hybrid structures, combining reinforced concrete and masonry, have also shown significant vulnerabilities. Mylène Devaux, a professor specializing in seismic engineering, explained during an interview, *"the main issue we observed, ... concerns structures with a kind of reinforced concrete frame combined with masonry, a pseudo-confined infill of average quality."*⁴³ One contributing factor is the variability in material quality, particularly cement bricks, which are often artisanally produced with suboptimal proportions of components. As she mentioned, *"given the observed damage, the quality seems insufficient."* Another significant issue lies in horizontal connections. Hourdi slabs, which are commonly used, often lack proper anchorage with the walls, increasing the risks of deformation or collapse.

Additionally, frequent modifications to buildings, such as adding floors or extensions with incompatible materials, exacerbate structural vulnerabilities.⁴⁴ Devaux shared, *"sometimes you'll see masonry made of natural stone with questionable mortar quality, and then they decide to expand and add reinforced concrete, which leads to very different structural behaviors. This significantly increases vulnerability."* While often driven by practical needs, these transformations introduce structural irregularities that exacerbate seismic vulnerabilities.

Analyses have therefore shown that structural failures, whether in earthen or concrete buildings, often result from poor implementation. When traditional techniques are applied correctly, they can provide remarkable resilience. As Devaux concluded, *"yes, you can build with earth, but again, you need to respect lightweight floors, ensure proper anchorage lengths. In this regard, I imagine that following the standard published by the Moroccan government is perfectly valid."* Conversely, mixing incompatible materials or using low-quality materials raises the risk of collapse.

⁴³ Devaux,
Interview with the
author, November
2024.

In the case of cement bricks, it is relatively easy to compromise their quality by adjusting the proportions of components to reduce costs, which diminishes their strength.

Ultimately, a traditional earthen building is not inherently fragile if it is well-constructed, just as a concrete building can be vulnerable if poorly executed. The crucial factor lies in the quality of the material, but more importantly, in its rigorous implementation.



Rebuilding with Earth

The Challenges

A Field Perspective

I traveled in Ouirgane and its surroundings to examine the reconstruction efforts following the earthquake. To deepen my understanding of earthen construction in Morocco, I continued my journey southeast, through the region of Ouarzazate and the Drâa Valley, known for its rich heritage of earthen architecture. This experience allowed me to engage with both local residents and experts, who shared their expertise, and perspectives on the reconstruction process and the use of earth in construction. These interactions, coupled with readings, highlighted the numerous challenges associated with earth as a construction material in Morocco.

From shifting social perceptions to regulatory constraints and practical limitations, these factors underscore the complexities of working with earth, despite its considerable potential and its place in Morocco's heritage. The aim here is to outline some of the challenges encountered in the context of post-earthquake reconstruction, in order to better understand the possibilities of reintroducing earthen construction practices.



Fig. 6
Route of my travel
(outbound) from
October 14 to 18,
2024.



Stigma Surrounding Earth

It's a mentality.
Living in a concrete house shows that you're rich.
Living in an earth house means you're poor.
It's a false idea, but it exists.

— CERKAS Technical Expert,
Kaourit Kasbah, Ouarzazate, October 17, 2024.

The perception of earthen architecture in Morocco is shaped by historical, social, and economic factors. Western construction methods were promoted during the colonial era as symbols of progress, relegating local practices to static heritage. This dichotomy, rooted in colonial narratives, persists today as a post-colonial legacy marked by distrust toward local materials and traditional forms.⁴⁴ (see p.121, *Fig.15* in *Preservation Policies through Time*) Earth is consequently often dismissed as a material tied to poverty and backwardness, contrasting with the widespread association of concrete with wealth and modernity.

Oussama Moukmir, a specialist in Moroccan local techniques, highlights the paradox of earthen heritage: in countries with a strong earthen tradition, earth is often perceived as a material for the poor, while in nations without such a heritage, it is seen as a material for the rich.⁴⁵ This perception is exacerbated by the abandonment of earthen buildings, which, when left to deteriorate, age poorly, collapse, and discredit the material. While heritage offers an opportunity to learn from the past and provides constructive solutions, it also carries a downside. This duality sheds light on the double-edged nature of patrimonialization.⁴⁶

Salima Naji, architect and anthropologist known for her work on preserving Morocco's earthen architecture, points out in her book *Architectures du bien commun* that the stigma surrounding earth goes deeper than a simple material preference: *"This shame associated with the material also reflects a deeper shame of their origins: there is a desire to erase anything that represents the modesty of their rural backgrounds. This negative self-image, felt by some individuals from agrarian societies, leads to a drive to erase what is experienced as the burden of their origins. 'Raw earth is good for animals, not for houses'. ... This aspiration for modernity through its artifacts has reached the point where many local architectural forms are being destroyed and are on the verge of disappearing."*⁴⁷

This perception of earth as an inferior material is linked to broader social and economic dynamics, notably the phenomenon of traditional rural villages being abandoned in favor of new centers. This is further amplified by the Moroccan government's promotion of *emerging rural centers*. These initiatives aim to create urban hubs within rural areas, seeking to mitigate the effects of rural exodus and enhance local living conditions. These policies, which address valid aspirations for better infrastructure and services, have unintended consequences.⁴⁸ As one local explained, *"People, they leave, and they build there; it's a sign of wealth."*

⁴⁴ Naji, *Architectures du bien commun*, 36.

⁴⁵ While this is an interesting perspective, some countries with an earthen heritage, like France, do not exhibit the same level of rejection, possibly due to differing colonial history.

⁴⁶ Moukmir, Interview by Atelier Gémigné.

⁴⁷ Naji, *Architectures du bien commun*, 40.

⁴⁸ This is based on insights gathered during discussions with local residents and experts during my fieldwork.

As a result, the old douars are gradually being deserted, and their abandonment is accelerating their deterioration, reinforcing the negative perception of traditional materials such as earth. Meanwhile, new concrete constructions, perceived as modern and a marker of social advancement, continue to dominate.

However, alternative approaches are possible. For example, investing in the rehabilitation of earthen homes or incorporating local materials in new constructions could address some of the practical challenges associated with traditional architecture while retaining its cultural and environmental value. However, such alternatives require significant commitment from stakeholders and a supportive social, technical, and economic framework.

The architect's role can challenge these perceptions and revalorize earthen construction. As Fathy wrote, *"The architect has the unique power to revive the peasant's faith in his own culture if, as an authorized critic, he shows what is admirable in local forms, and goes so far as to use them himself, then the peasants will immediately begin to regard their products with pride. What was previously ignored or even despised will now become a source of just pride for the villagers."*⁴⁹

By supporting local materials and techniques, architects can challenge public perceptions and question the stigma associated with traditional practices.

Yet, architects cannot, on their own, reshape deeply rooted societal perceptions. Their ability to effect change depends on the resources available to them, the socio-economic and political context, and the level of institutional support. In Morocco, some architects are increasingly engaging in initiatives aimed at revitalizing local craftsmanship and materials, which indicates a shift in perspective. However, as Khalil Morad El Ghilali, a Moroccan architect, explained during a discussion; practicing architecture and working with earth in Morocco demands considerable resilience due to numerous obstacles such as the dominance of the concrete industry, building regulations that favor industrial materials, the dispossession of knowledge and a normative framework that continues to marginalize traditional construction techniques.⁵⁰

⁴⁹ Fathy, *Construire avec le peuple*, 87.

⁵⁰ Khalil Morad El Ghilali is the founder of *Atelier be.* in Rabat, Morocco, which specializes in construction with local materials and explores themes of climate, ecology, and technology.



Fig. 7 and 8
The Qsar of Ait Ben
Haddou (UNESCO
World Heritage Site)
facing the *modern*
concrete center,
October 16, 2024.





Systemic Constraints

⁵¹ The CERKAS is the Center for the Restoration and Rehabilitation of Architectural Heritage in the Atlas and Sub-Atlas Zones.

Unfortunately, earthen construction is still not recognized as a building material. There are a lot of gaps in the law ... For our cultural center project, it was special because we wanted to build with earth and not use concrete.

I submitted my file, but to move forward, we had to find the CERKAS⁵¹ to assist us and validate the project. Thanks to them, we were able to get the authorization. In Morocco, the urban agency reviews project applications to ensure they meet the conditions. But these conditions are designed for concrete. For earth, they simply don't exist.

— Halim Sbaï, local and president of Joudour Sahara Music School, *Joudour Sahara Cultural Center* (project under construction with architect Aziza Chaoui), M'hamid el Ghizlane, October 18, 2024.

Since May 2014, the RPCCT and the RPACT have provided a legal framework for seismic-resistant earthen construction (see p.47, *Seismic Construction Regulations*), making it possible to obtain building permits using this material. While these regulations represent a step toward legitimizing local techniques, they come with design restrictions, which can discourage architects and clients. Additionally, since earthen projects are not yet widely adopted, these regulations remain little known, even among the administrations responsible for oversight. This lack of familiarity slows down their implementation and complicates their broader application.⁵²

Despite these regulatory advancements, Morocco's economy, heavily influenced by industrialized materials, favors solutions like concrete, which aligns with fiscal systems and normative practices. In contrast, earthen construction relies on local craftsmanship and short supply chains, which are poorly suited to conventional economic frameworks based on standardized purchases and formal transactions.⁵³ This contrast underscores a broader conflict, where current systems favor large industrial groups at the expense of local and artisanal initiatives. As Pierre Frey notes in his book *Learning from Vernacular*, "*The development of traditional societies faces an active form of unfair competition. The clash between the logic of a traditional society and the modern world is, in reality, a clash with a specific and dominant expression of Western modernity: a generalized market economy driven by the systematic pursuit of maximum profit and governed by legal frameworks that systematically favor the interests of dominant market players.*"⁵⁴

To navigate these obstacles, projects such as the *Joudour Sahara Cultural Center* project quoted at the beginning of this section, rely on private funding and specific partnership. These initiatives are therefore difficult to replicate, as they operate beyond Morocco's usual legal framework. Meanwhile, concrete remains the most 'accessible' and straightforward solution, reinforcing its dominance in the construction market.

In the context of post-earthquake reconstruction in Al Haouz, the preference for concrete is particularly evident. The state-owned public agency *Al Omrane*, issues calls for proposals for reconstruction projects. While the state has established guidelines aimed at preserving the region's artisanal identity and ensuring seismic resistance, selected projects predominantly favor concrete (see p.44, *Fig. 5* in *The Earthquake Management*).

⁵⁵ Saif-Eddine, discussion with the author, November 2024.

⁵² El Ghilali, discussion with the author, October 2024.

⁵³ Moukmir, Interview by Atelier Géméné.

⁵⁴ Frey, *Learning from Vernacular*, 41.

Preservation efforts are typically limited to applying earthen finishes to facades, and in the urgency of reconstruction, certain regulations have been relaxed or bypassed to expedite the work.⁵⁵

These choices raise several questions: What criteria guide the state agency in selecting reconstruction projects? How are standards prioritized in such situations? Who decides on the necessary compromises, and for what purpose? These decisions appear to be driven more by urgency and budgetary constraints than by a genuine commitment to heritage preservation or solutions adapted to local needs. While this research does not aim to provide definitive answers to these questions, it is essential to highlight them. They reveal tensions between normative requirements, an economic system that disfavors local materials and craftsmanship, contextual constraints, and the divergent priorities of the various stakeholders involved. While the current approach centralizes decision-making at the state level, it often overlooks the needs of local populations and the specificities of their environment. An approach more centered on individuals and families as primary decision-makers, rather than one centralized on the state, could allow for reconstruction better suited to local specificities and the actual needs of the population.





Standardization and Local Living Practices

Look, the house of that man there collapsed. Now, he's digging the foundations. There's another one here, half of it stayed up, and the other half collapsed. [He switches to speaking with a man in Tamazight.] He has 4 kids, his wife, and his parents. Before, they had 100m², and fortunately, they managed to get 70m² now. Most families only receive 50 or 55m². You see, many people live with their extended families; how are they supposed to live in just 50m²? ... No, they can't [build multiple floors]. With the government aid, everyone can only afford to build one floor. Look around. Most of them are still living in tents.

— Mohammed, local resident and guide from Ouirgane, Torort, October 14, 2024.

The standardized architectural solutions proposed for reconstruction fail to consider the specific lifestyles of rural and mountainous regions like the High Atlas. In Al Haouz, houses are traditionally adapted to the territory's constraints and the local population's needs. The houses are typically structured to accommodate one or two levels of living space alongside dependencies for livestock and fodder storage. This organization not only houses extended families but also supports the agricultural and pastoral activities that underpin the local economy.⁵⁶ Architectural logic in the region used to be guided by the availability of materials, for example, the beam span was dictated by the size of local trees.⁵⁷ Over the past decades, cement bricks and concrete have been increasingly incorporated into homes as families expand their dwellings, based on their evolving needs and financial means. This has resulted in hybrid architectures, where traditional knowledge and industrial materials coexist, reflecting changing needs, a loss of traditional skills, and an adaptation to modern contexts. Yet, as discussed earlier (see p.49, *Construction Resistance and Vulnerabilities*), this blending of different materials increases seismic vulnerability, as the structural behavior of these materials is often incompatible.

However, state-funded reconstruction projects impose standardized designs driven by urgency and budgetary constraints, which struggle to incorporate the local specificities. Saif-Eddine, leading a consulting firm, explained that adjustments are sometimes made to these standard plans to better align with local habits: smaller bedrooms to allow for larger communal spaces, external staircases, or other necessary adaptations. Yet, financial limitations often prevent the inclusion of essential functional spaces, such as stables, located on the ground floor, which are vital for families who rely on them for their livelihood. Saif-Eddine explained that the responsibility is left to the beneficiaries, who must later adapt and complete their homes as their means allow.⁵⁸ Author Ivan Illich offers a critical perspective on the relationship between dwellings and living practices, stating that "*customs and dwelling mean almost the same thing (...) the cartesian, three-dimensional, homogeneous space that architects conceive of, and the vernacular space that use brings into being, are entirely distinct categories.*"⁵⁹

⁵⁶ Benkirane, "Penser la reconstruction du Haut Atlas."

⁵⁷ Naji, *Architectures du bien commun*, 23.

⁶⁰ Benkirane, "Penser la reconstruction du Haut Atlas."

⁵⁸ Saif-Eddine, discussion with the author, November 2024.

⁵⁹ Illich, *In the Mirror of the Past*, quoted in *Learning from Vernacular*, 75.

This observation resonates with the challenges faced in reconstruction projects, where standardized plans and norms often fail to account for the relationship between space and the lived practices they are intended to serve.

Additionally, while state intervention relies on formal procedures like cadastral mapping, land boundaries in this region are often established orally between families or marked by physical landmarks, without written documentation. In this context, post-earthquake interventions require numerous back-and-forth negotiations with residents, making administrative procedures particularly complex and time-consuming.

Forced to conform to norms and administrative procedures previously absent from these territories, the region is undergoing a gradual transformation, altering its local ways of life.⁶⁰ This situation raises questions about the capacity of institutional systems to recognize and integrate alternative land tenure frameworks without compromising the safety and legality requirements imposed by state regulations.



Fig. 9
Village along the
road to Telouet.
October 16, 2024.





Labor and the Marginalization of Know-How

⁶¹ At the time of writing, 10 Dirhams $\approx$ 1 Swiss franc.

I was a mason before ... It's not for me, it's too exhausting. You work all day to earn 100 dirhams.⁶¹ There are companies that take all the money, and they give you almost nothing. So why would I stay working for people who take advantage of me? I'm lucky to speak French, so I prefer to do something else and be close to my family.

— Former mason turned guide, Telouet, October 16, 2024.

This statement highlights the persistent precariousness of the mason's profession. The work is exhausting and underpaid, and artisans are often exploited by intermediaries. Workers endure the consequences of policies that prioritize immediate profitability over working conditions and the recognition of artisanal know-how. This is accompanied by a marked preference for standardized industrial materials, often associated with corrupt practices. Unlike traditional materials such as earth and stone, which require skilled labor and are difficult to alter or misuse, industrial materials are easier to manipulate and quantify, enabling cost reductions and embezzlement. This allows companies to generate surpluses that are redistributed among stakeholders. As Naji explains, local materials, since they cannot be tampered with, make it difficult for companies to cut the wages of qualified workers. According to her, in Morocco, *"a major construction site results in 10 to 30% of funds being embezzled."*⁶²

The choice of one material over another is not merely technical decisions but has far-reaching economic and social implications. Building with earth supports artisans, preserves craftsmanship, and fosters more equitable economic systems, in contrast to the concentration of wealth enabled by industrialized construction.

The widespread adoption of industrial materials has contributed to the marginalization of artisanal skills. Artisans specializing in these techniques are less and less in demand, confined to isolated projects or specific commissions.⁶³ Historically, the role of the *maalem* (master artisan) was central to traditional construction and the transmission of knowledge.⁶⁴ Indeed, buildings were mostly constructed by local labor, whether through self-construction or by calling upon a third party, referred to as *maalem*. *"[He] traveled from village to village while the inhabitants came to participate in the construction site."*⁶⁵ This transmission of knowledge, this sharing on the construction site itself, has almost entirely disappeared in favor of industrial standardization. The market economy prioritizes speed and standardization, making the transmission of knowledge a fragile and vulnerable process. Yet, as illustrated by Fathy through an exchange with an artisan, providing employment could revitalize this sector: *"If I brought you ten boys, would you teach them the trade?" Ismaïl shook his head. "I didn't learn in a school. If you want to revive the trade, well, give us work, and then you will see not ten students but twenty apprentices."*⁶⁶

Although this situation in Fathy's book dates back several decades, it remains unfortunately comparable to the current reality.

The marginalization of skills cannot be reduced to a simple consequence of modernization or corruption. It reflects political and economic choices. Public policies must integrate support mechanisms for local artisans, encouraging construction projects that value earth and sustainable materials. Training new artisans and raising awareness among companies and clients are key steps toward revitalizing traditional know-how.

Fig. 10

A worker starting a stone wall with earth mortar. The blue string on the right of the photo is used to mark the line of the wall, ensuring it is straight.
Telouet,
October 16, 2024.



⁶² Naji, *Architectures du bien commun*, 54.

⁶³ Atelier Géméné, *De terre et d'eau*.

⁶⁴ *Maalem* is iterally translated as *the one who knows* or *the one who teaches*.

⁶⁵ Naji, *Architectures du bien commun*, 51.

⁶⁶ Fathy, *Construire avec le peuple*, 66.



Temporal Dynamics

You know, building with earth is not easy. Just one or two meters, and it takes you the whole day. Back then, people had the patience to do it. Nowadays, for example, I don't have that patience ... Anyone here in Talouet, people don't have the patience; it takes a lot of time. To build your house in earth, it takes four to five months, whereas with concrete, just one to one and a half month.

— Former mason turned guide, Telouet, October 16, 2024.

The opinion of this former mason reflects a common perception that earth construction is slow and incompatible with today's demands for efficiency and speed. However, this opinion deserves to be questioned.

To begin with, the speed of construction largely depends on the techniques used (adobe, rammed earth, poured concrete, concrete blocks, etc.) and the desired quality standards. For example, while rammed earth or adobe walls can support loads immediately after completion, reinforced concrete requires curing pauses, which can extend timelines.⁶⁷

Earthen materials also have specific constraints, such as their sensitivity to climatic conditions. Drying times are longer in winter, and walls must be protected from rain to prevent degradation before consolidation.⁶⁸ Yet, local knowledge integrates these constraints through planning adapted to seasonal cycles.

Concrete, associated with progress, has benefited from decades of standardization and industrialization, while the skills related to earth construction have been marginalized. This has led to a shortage of expertise and institutional reluctance, fostering the perception that earth is slower or more complex. In reality, these barriers are the result of political and economic choices rather than inherent material limitations.

In this context of crisis and urgency, standardized solutions are therefore prioritized, as they are easier to implement. However, this could also be an opportunity to question these ill-suited practices while integrating transitional solutions to address the urgent needs of displaced populations. During my visit to villages near Ouirgane, I observed that many residents lived in tents. Mohammed shared; *"I visited some people the other day, and everything was soaked—their clothes, blankets, everything. I lived in a tent for just a month and a half, and it made me sick. ... Thankfully, in the center of Ouirgane, along the roadside, some associations provided containers, so it's manageable. But here, nothing"*⁶⁹

While temporary structures, such as containers or prefabricated shelters, can offer an immediate response, their deployment should be seen as part of an overall reconstruction strategy.

⁶⁷ Moukmir, Interview by Atelier Géméné.

⁶⁸ The drying time varies depending on the construction technique. Doat et al., *Construire en terre*, 38.

⁶⁹ Mohammed, discussion with the author, October 2024.

Urgency in post-earthquake reconstruction often justifies rapid and standardized approaches, but these solutions, while aiming for immediate efficiency, can often be counterproductive and poorly adapted to local needs.

During a conference discussing post-earthquake reconstruction, a representative from an association explained this issue through an example: *"During our visits, we came across a village in the High Atlas, Tidili Mountain, that experienced an earthquake in 1974 ... Directives were issued to rebuild for these people in Aït Ourix, on the plain. Buildings were constructed for them, and they lived there for six months before returning their keys and moving back to their original douar in the mountains. As fate would have it, in 2023 another earthquake hit their village, destroying their homes ... When I asked them, 'Why did you return when you had been given houses?' they told me that after four months, people began falling ill. So, they returned to rebuild where their houses had been destroyed."*⁷⁰

This experience underscores the limitations of reconstruction efforts driven solely by quick, uniform solutions that disregard local realities. It compromises not only the durability of the constructions but also the well-being of local populations.

Taking the time to observe, listen, and co-create with local populations does not mean unnecessarily delaying projects but rather adopting a thoughtful and contextualized approach. In Al Haouz, ensuring the relevance of reconstruction efforts requires careful consideration of the local context and specific constraints, which cannot be addressed through one-size-fits-all solutions. Rethinking the timeline of reconstruction projects allows us to move beyond the sole pursuit of speed and incorporate human, environmental, and social dimensions aligned with the expectations and living practices of the affected communities.

Contextual architecture has, over centuries, successfully adapted to the specificities of its region. Patrick Bouchain, architect, notes that; *"its strength, as well as its fragility, lies in the fact that it is rooted in permanence rather than in the event."*⁷¹ Gradually erasing this heritage under the pressure of crises would mean sacrificing what is enduring in favor of transient solutions, thereby jeopardizing an architecture inherently tied to the territory and its evolution.

⁷⁰ Representative from Anouar association, "Penser la reconstruction du Haut Atlas."

⁷¹ Bouchain, "Preface", in Frey, *Learning from Vernacular*.



The Importance of Maintenance

Abandoning a site causes deterioration ... Regular maintenance is essential. An earthen construction is alive; it breathes. There's always a flaw, and it needs to be fixed.

— CERKAS Technical Expert,
Taourirt Kasbah, Ouarzazate, October 17, 2024.

Unlike concrete, earthen constructions need to be inhabited to endure. If abandoned, they quickly deteriorate, reinforcing a false perception of fragility. Their durability primarily depends on proper maintenance, which can be both simple and effective. In many regions, residents regularly sweep their courtyards and, using a mop soaked in a mixture of limewash and clay (locally called *biyada*), they apply a thin coating to the stairs and the top of walls every few days. The coating seals small cracks, preventing surface delamination and ensures the structural integrity of the building without the need for major interventions. The abundance of earthen materials simplifies these tasks, as the coating is made of the same material as the walls, essentially integrating maintenance into ordinary household cleaning.⁷² When earthen homes are abandoned, they lack the regular maintenance essential for their preservation.

As the most vulnerable part of earthen construction, roof care is particularly critical. As Mohammed explained, *"the problem with earth houses is the roof. You need to build a very good roof so that water doesn't get inside... As soon as we finish the wall, we add wood, bamboo, or reeds, and then cover it with earth. Nowadays, we add a layer of plastic under the earth, so water doesn't get in."*⁷³ Some now reinforce this technique with a thin concrete slab to prevent water infiltration. Water seeping through a poorly sealed roof can cause structural damage: walls swell and eventually collapse, which reinforces the misconception that earthen buildings are outdated.⁷⁴ In reality, these failures are due to a lack of maintenance rather than any inherent defect in earth materials. Traditional earthen construction represents a different approach to housing than those built with industrial materials. It cultivates a richer relationship between the dwelling and its occupants, where ongoing maintenance, viewed as an act of care, is an integral part of the building's life cycle.

72 Zerhouni and Guillaud, *L'Architecture de terre au Maroc*, 78.

73 Mohammed, discussion with the author, October 2024.

74 Naji, *Architectures du bien commun*, 42-43.

Fig. 11
Sand and earth
blending together in
an abandoned Qsar,
M'hamid El
Ghizlaine, October
18, 2024.







Unsuitability to Local Climate

This is my sister's house. She received the aid and built the house out of cement bricks, but now she regrets it. Sometimes they sleep on the roof terrace at night, because when it's hot, you can't go inside. The concrete slab absorbs all the sun's heat and releases it into the room.

— Mohammed, local resident and guide from Ouirgane, Agouni, October 14, 2024.

The climate of the Al Haouz region is characterized by hot, dry summers and cooler winters, particularly in higher altitudes, where temperatures can drop below 0°C. The region also features high diurnal temperature variations. Rainfall is scarce and irregular, mostly concentrated in winter and spring.⁷⁵ These conditions require constructions capable of maintaining comfortable indoor temperatures — staying cool during the day and retaining warmth at night.

Historically, the dwellings in this region have incorporated local materials such as raw earth, stone, and wooden frameworks. These architectural choices represent a progressive adaptation to the environmental and social realities of the area. Earth, in particular, stands out for its thermal and hygroscopic properties. It absorbs excess moisture, releases it later on, and significantly slows down thermal exchanges due to its density and the thickness of the walls. These qualities, coupled with a thoughtful architectural strategy, help maintain cool interiors in summer and comfortable temperatures in winter. During my visit to the Kasbah Taourirt in Ouarzazate, now the headquarters of the *Center for the Restoration and Rehabilitation of Architectural Heritage in the Atlas and Sub-Atlas Zones* (CERKAS), a technical expert explained: *"Look at this wall; it's 65 to 70 cm thick. When the cold comes from outside, it takes 12 to 16 hours to reach the inside, and the same with heat."*⁷⁶

Despite these advantages, post-earthquake reconstruction largely relies on reinforced concrete structures, hollow concrete blocks and cement bricks, with walls barely reaching 20 centimeters in thickness. These constructions are poorly suited for thermal and hygroscopic regulation without external additions such as thermal insulation or air conditioning. Yet, due to budget constraints, none of these measures are included in the reconstruction efforts, leaving residents to endure uncomfortable living conditions. Here, concrete, often presented as a symbol of modernity and progress, reveals its inadequacy. In his book *Béton: arme de construction massive du capitalisme*, author Anselm Jappe rightly critiques this dependence on artificial additions in concrete constructions. *"The thermal deficiencies of reinforced concrete buildings have given rise to two other marvels of contemporary life: thermal insulation, such as fiberglass, and air conditioning—one of humanity's most useless and harmful inventions, unknown when we still knew how to build."*⁷⁷

⁷⁵ Based on insights from discussions and meteorological data for the Al Haouz region.

⁷⁶ CERKAS Technical Expert, discussion with the author, October 2024.

⁷⁷ Jappe, *Béton*, 100.

The widespread use of industrialized materials eclipses a contextual architecture that, over the centuries, has responded to the region's particular climatic and geographical features. Using local materials is not only a sustainable and appropriate alternative, but also a necessity to prevent the growing impact of global warming. Continuing with this construction approach could make this already vulnerable region difficult to inhabit in the long term.



Construction Costs

The problem is, people don't have enough money for this, because it's expensive, but they also have to bring sand from the "machine". Before, most people used river sand, but now they're required to get this sand delivered by truck from further away, near *Amizmiz*. One truckload costs 3,000 dirhams, which is a lot. Then there's the cement, like this one ... This [pile of rebar], this alone costs a lot of money. Each brick, just to get it here, costs 10 dirhams, so imagine how many bricks you'll need for your house. Plus, the cement, plus the sand.

— Mohammed, local resident and guide from Ouirgane, Agouni, October 14, 2024.

The price of building materials is a recurring issue in post-earthquake reconstruction discussions. Depending on who you talk to (craftsmen, engineers or local residents) opinions differ on the relative cost of local materials versus industrialized materials.

Saif-Eddine, working at the consulting firm, points out that local materials sometimes seem cheaper, as they are often used in contexts that escape regulatory standards: *"Why do they say it's cheaper? Because they're built in the traditional way, on site, without conforming to standards or regulations. So yes, in that sense, it's cheaper. But as soon as you try to combine it with modern materials like reinforced concrete, it becomes more expensive."*⁷⁸ This observation highlights a regulatory framework that is unfavorable to local materials, which are often marginalized by standards designed for industrialized materials. Saif-Eddine further explains that the main cost factors for constructions using local materials are the skilled labor which is more expensive, and the longer construction time. For example, he explains that a brick wall can be built in one day by a worker paid 150 dirhams, whereas an equivalent rammed earth wall requires 4 to 5 days of work by a specialized artisan charging between 250 and 300 dirhams per day. Thus, constructing a wall in concrete blocks can cost three times less labor than an equivalent stone or rammed earth wall.⁷⁹ This cost differential partially explains why local materials are perceived as expensive, despite often being available on-site.

However, some architects demonstrate that involving specialized artisans in specific projects using local materials can still meet budgetary and time constraints imposed by reconstruction. Although such initiatives sometimes require training to compensate for the loss of certain traditional skills, they help revalue these trades and restore a central place for local craftsmanship. As Naji points out: *"We need to train people, assist extensively, encourage, and remain very present on the worksite to maintain a standard of quality that has been lost."*⁸⁰

These two perspectives—one favoring large-scale efficiency, the other emphasizing contextual adaptation—represent distinct approaches to reconstruction. Large-scale initiatives often rely on standardized solutions driven by strict time and budget constraints, which can overshadow local needs and specificities.

⁷⁸ Saif-Eddine, discussion with the author, November 2024.

⁷⁹ According to on-site observations, traditional houses in many regions are often constructed by the inhabitants themselves, significantly reducing labor costs. The *RPACT* explicitly encourages self-construction, though its application remains limited.

⁸⁰ Naji, *Architectures du bien commun*, 72.

⁸¹ Fathy, *Construire avec le peuple*, 67.

⁸² Ibid., 68.

⁸³ Ibid., 73.

⁸⁴ Naji, *Architectures du bien commun*, 53.

⁸⁵ Heringer, *Form Follows Love*, 48.

Fathy, citing a government architect, illustrates the limits of such methods: *"We have one million houses to build, we have little money and little time. Please be realistic. How could we possibly send architects to discuss with one million families?"*⁸¹ He explains that *"The result is hideous and inhuman; one million families are crowded into inadequate boxes without having a single say in the project, and no matter how scientific the approach to matching families and housing units, the majority are doomed to dissatisfaction."*⁸² These words resonate with the realities observed during post-earthquake reconstruction and in my own conversations, where standardized models, justified by budget and time constraints, often come at the expense of solutions tailored to local specificities.

For Fathy, the solution does not lie in imposed uniformity but in a return to participatory, family-centered construction. He argues that each family, when involved in building its own home, can address its specific needs and maintain a direct link to local know-how.⁸³

Logistical constraints further complicate matters, exacerbating inequalities in access to materials. Although local resources (such as river sand) are available on site, they are often prohibited in state-supervised projects, forcing residents to use industrially processed materials like quarry sand, which must be delivered from farther away. As Mohammed explained, this raises costs significantly. Such restrictions exclude abundant local resources and lead to increased financial and environmental burdens. Dependence on conventional materials can also lower quality, as some companies may adjust concrete mix ratios to cut costs, potentially compromising structural durability and safety, particularly in seismic zones.⁸⁴

Architect Anna Heringer emphasizes the urgent need to rethink these practices, proposing that environmental impact be taken into account when calculating costs: *"It is crucial that the price of a material also reflects its capacity to be reused—and by that, I mean genuinely reused, not merely recycled. The environmental impact at the end of a building's lifecycle, when its waste is treated, must also be included. Materials and processes relying on nonrenewable resources and emitting CO₂ should be heavily taxed, while human energy—the labor involved in constructing buildings—should benefit from tax relief and subsidies. The most important and creative energy, that of human beings, must once again become affordable."*⁸⁵

Once viewed as a 'material for the poor', earth is now paradoxically seen as too expensive, frequently associated with exclusive projects. This shift reveals the contradictions of a normative and industrial system that hinders the use of abundant, well-adapted local materials. Ultimately, the issue of cost transcends a simple price comparison: it calls for reexamining construction strategies and reassessing how traditional know-how can be integrated into current practices.





Conclusion

Before beginning my research, I had a firm opinion on the matter. For me, rebuilding with earth in a region with a strong heritage of earthen architecture seemed like the 'right' decision. My assumption was that concrete, with its heavy ecological footprint, unsuitability for the local climate and potential to erase heritage, had no place here. However, onsite and after deeper research, things have proven to be more complex. Not only does earthen construction bear a deep social stigma in Morocco, but it also faces considerable hurdles in the form of regulatory frameworks, administrative processes, and a dominant concrete industry. Additionally, barriers such as time constraints and the erosion of traditional know-how further complicate its implementation. In crisis situations, speed understandably takes precedence over deliberation, and my aim is not to condemn the standard approach. Rather, I wish to emphasize that the present reconstruction model stems from decades of modernization and diverse external influences.

Through this research, I traveled to the country of my origins and gained a deeper understanding of its complexities and heritage. Observing the situation a year after the earthquake, was unexpectedly difficult, but it was also a very instructive and enriching experience fostering various exchanges. I am fully aware that my observations and research represent only a small fraction of reality, and as such, this work should not be regarded as exhaustive.

Now that my research has reached its conclusion, I stand by my initial conviction that that rebuilding Al Haouz with concrete is ill-suited, for all the reasons outlined in this study. Still, I recognize just how intricate and multi-layered the situation is.

Despite the challenges, I remain optimistic. Through conversations and fieldwork, I encountered encouraging initiatives that address the obstacles of building with earth, such as architects advocating for earthen construction practices and communities eager to revive traditional know-how.

However, one aspect not explored in this work is the impact of climate change in Morocco. Recent floods, becoming more frequent, have weakened some earthen constructions, just as the earthquake did. This calls for increased efforts to enhance the resilience of these constructions. In that sense, integrating contemporary solutions with traditional techniques may be a viable option, not only strengthening these constructions but also fostering broader acceptance of earth as a material.

As Naji states, *"true modernity is about embracing one's heritage while introducing the necessary innovations and comforts, without erasing the experiences inherited from our ancestors, that we carry within ourselves."*⁸⁶

⁸⁶ Naji, *Architectures du bien commun*, 50.

Appendix



Climate and the Construction Sector

Clear evidence of the rapid and widespread impact of human activity on the Earth System has led many scientists to propose that the Earth has entered a new geological epoch, *the Anthropocene*. It is defined as a period in which human influence has become the dominant force shaping planetary systems, causing unprecedented changes in atmospheric composition and global ecosystems. The Anthropocene is marked by unprecedented increases in CO₂ levels and global temperatures far surpassing natural rates observed over the past 800,000 years.⁸⁷

These disruptions have culminated in a global climate crisis, affecting nature and living beings with increasing frequency and severity. Global agreements, such as *the Paris Agreement*, aim to limit global warming to well below 2°C, with an ideal target of 1.5°C, mainly by progressively reducing greenhouse gas emissions to achieve net zero by 2050.⁸⁸

However, these goals remain far from reality, as the 1.5°C threshold has already been temporarily exceeded, and such occurrences are becoming more frequent.⁸⁹ Reducing greenhouse gas emissions (including CO₂, methane, and nitrous oxide) is therefore essential, since they are the main driver of global warming. CO₂ emissions can be measured in various ways, nonetheless, the general trend is clear: developed countries emit far more than developing ones. The emissions are distributed across various sectors, with construction being one of the largest contributors.

⁸⁷ IPCC, "Summary for Policymakers," in *Global Warming of 1.5°C*, ed. Masson-Delmotte et al., 54.

⁸⁸ Office fédéral de l'environnement (OFEV), "L'Accord de Paris."

⁸⁹ The year 2024 is the hottest on record and the first to exceed the 1.5°C above-average threshold, according to the Copernicus Observatory.

This sector accounts for 37% of global CO₂ emissions, including the energy used by buildings (heating, cooling) and the production of materials like cement and steel.⁹⁰ The consequences of global warming are not evenly distributed, often affecting those who emit the least.⁹¹ In Morocco, about 40% of the population depends on agriculture for their livelihoods, making these communities particularly vulnerable to droughts and climate change.⁹²

The Concrete Problem

As mentioned, the construction sector is one of the largest contributors to global greenhouse gas emissions. Cement production, a key component of concrete, alone accounts for approximately 8% of global CO₂ emissions (with clinker, the primary component, responsible for 90% of these emissions).⁹³ Additionally, concrete buildings often require air conditioning or thermal insulation systems to compensate for their poor thermal regulation, leading to further energy consumption and increased emissions. Beyond CO₂ emissions, concrete also has harmful effects on natural environments. The massive extraction of sand and gravel, essential for its production, disrupts ecosystems and local habitats. Moreover, the use of concrete results in soil sterilization, compromising its fertility and capacity to store CO₂.⁹⁴

Although certain forms of concrete have been used since Antiquity, these impacts were once negligible due to the low volume of construction. As one analysis highlights: *"The harmfulness is primarily a problem of quantity and threshold."*⁹⁵ Today, however, concrete is omnipresent. When used in its reinforced form, it presents another significant challenge: planned obsolescence. Its main weakness lies in the corrosion of steel or iron reinforcements, leading to cracks and material breakdown. With an estimated lifespan of around 50 years (or requiring costly and complex maintenance), this raises concerns about waste management and recycling systems.⁹⁶ In Morocco, *"The absence of a recycling stream for cement concrete leads to increasing amounts of waste accumulating near urban areas. In this context, adopting new construction methods becomes a necessity."*⁹⁷ Despite its well-documented drawbacks, concrete remains the backbone of global construction, with approximately 80% of contemporary buildings constructed using cement-based mixtures.⁹⁸

90 UNEP, 2021
*Global Status Report
for Buildings and
Construction.*

91 IPCC, "Summary
for Policymakers", 9.

92 AgriMaroc.ma,
"Le secteur agricole
au Maroc."

93 World Economic
Forum, "Cement is a
big problem for the
environment."

94 Jappe, *Béton*, 100.

95 Ibid, 85.
Between 1950 and
2019, global cement
production rose from
less than 200 million
tons to 4.4 billion
tons per year.

96 Ibid., 99, 102.

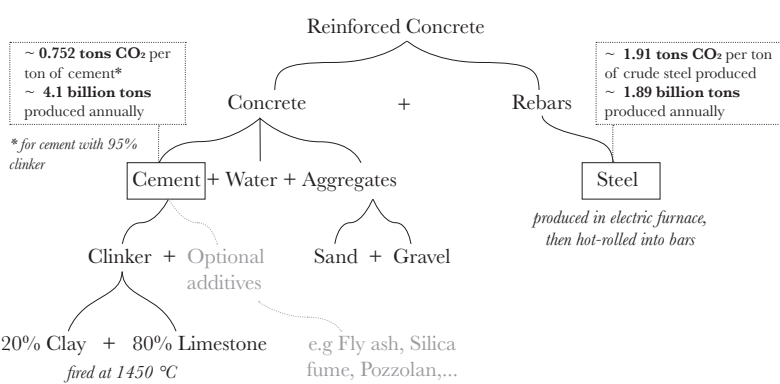
97 Naji, *Architectures
du bien commun*, 184.

98 Bengana,
Baechtold, and
Maréchal, *Béton,
enquête en sables
mouvants*, 20.

99 The
high-temperature
heating required for
clinker production
relies mainly on fossil
fuels.

In light of these findings, it is urgent to rethink our construction practices and reduce our societies dependence on fossil fuels to address the challenges of the climate crisis, or at least to adapt to them.⁹⁹ One viable alternative is to turn towards local construction materials with a low environmental impact, such as earth.

Fig. 12
Reinforced Concrete
Composition and
Emissions.
Based on World Steel
Association,
"Sustainability Indi-
cators 2023 Report.";
Infociments,
"Réussir la construc-
tion décarbonée."



Main Architectural Typologies of Heritage

Morocco has a significant heritage of earthen construction, a building tradition that has been practiced for centuries. Among the various forms of earthen construction in Morocco, three typologies stand out for their historical and monumental character, benefiting from specific preservation efforts:

Qsar, pl. *Qsour*

Qsour are fortified villages surrounded by defensive walls, often featuring guard towers and between one to four entrances, depending on the site's importance. These complexes include public spaces such as the entrance square, often accompanied by a guard's house, a meeting hall, and communal facilities like a mosque or hammam. From the main square, primary alleys lead to narrower secondary pathways, providing access to private areas and individual houses. Qsour were designed to protect communities and their resources in environments shaped by local conflicts and instability.¹⁰⁰

¹⁰⁰ Mohamed Boussalh, in *De terre et d'eau*.

¹⁰¹ Ibid. This term is used incorrectly. In fact, the concept of Kasbah, invented during the French Protectorate period, encompasses a number of different realities: qsar, qsour, seigneurial residence, and fortified houses.

*Kasbah*¹⁰¹

The Kasbah is a square or rectangular fortress in shape, with towers at each corner. They emerged in the 18th and 19th centuries, reflecting the growing influence of economically powerful families who distanced themselves from collective living in qsour. These families built kasbahs in strategically advantageous locations, such as near rivers, fertile lands, or on elevated terrain. Kasbahs often symbolize authority and social inequality.

As Naji points out, *"they bear the memory of authority and social inequality, representing injustice or collaboration, especially when families gained prominence during colonial times."*¹⁰² Despite external similarities to Qsour, the Kasbah differ significantly in spatial organization and social hierarchy.¹⁰³

Agadir, pl. Igudar — Collective Granaries

Igudar are communal structures that serve as storage spaces for the wealth and harvests of local populations, including agricultural products such as seeds, dates, and oils, as well as valuable goods like jewelry and weapons. *"Protected by a guardian chosen and paid by the group, it embodies the common good."*¹⁰⁴ Each village had its own granary, typically located in elevated areas for protection. *"Unlike kasbahs, which reflect the rise of prominent families whose power is often displayed through the wealth of their decorations, these fortresses prioritized functionality and resource conservation, embodying an "economy of means"."*¹⁰⁵

The materials used for construction varied depending on their geographical location and the period. For instance, Igudar found in the Anti-Atlas mountains were built using argan wood and oleander. In contrast, for those constructed in the plains, rammed earth was the preferred technique.¹⁰⁶

¹⁰² Naji, *Architectures du bien commun*, 64.

¹⁰³ Zerhouni and Guillaud, *L'Architecture de terre au Maroc*, 110.

¹⁰⁴ Naji, *Architectures du bien commun*, 78.

¹⁰⁵ Ibid., 79.

¹⁰⁶ Arab News, "Les greniers collectifs ou igoudar: un trésor architectural marocain en perdition."

Fig. 13
The Kasbah of Têlouet, residence of the Glaoua and Pasha El Glaoui, who maintained a close relationship with colonial France. It was affected by the earthquake, leaving behind ruins. October 16, 2024.

Fig. 14 (see next page)
The Ait Ben Haddou Qsar, a UNESCO World Heritage site, benefiting from conservation and protection efforts. October 16, 2024.





Preservation Policies through Time

Protectorate

The notion of heritage is rooted in social and cultural constructs. As author Karim Mechta explains, "*specifically, as a fragment of what is characterized as culture, and more particularly as part of the products of a culture or civilization, the principle of recognizing something as heritage involves social subjects.*"¹⁰⁷ This reflection emphasizes that heritage is not an immutable reality but rather the product of social and cultural construction.

In Morocco, the preservation of architectural heritage began during the French Protectorate (1912–1956). The establishment of the Service of Antiquities, Fine Arts, and Historical Monuments in 1912, and the promulgation of various dahirs (royal decrees) that institutionalized conservation practices. These legal texts protected historical monuments and, with the 1945 dahir, introduced the concept of preserving old towns and regional architectures.¹⁰⁸

However, this policy reflected a segregationist vision. Lyautey, the Resident General, advocated for "*the complete separation of European and indigenous settlements for political, economic, sanitary, municipal, and aesthetic reasons.*"¹⁰⁹ This policy created a dichotomy between the 'new cities' designed for the European population and the Moroccan elite, and the medinas and historical villages, which were regarded as frozen in an unchanging temporality to satisfy an orientalist curiosity.

¹⁰⁷ Mechta, *Maghreb, Architecture et Urbanisme*, 15.

¹⁰⁸ Adili-Toutain, "Historique de la sauvegarde par la législation."

¹⁰⁹ Résidence Générale de la République française, *La renaissance du Maroc. Dix ans de protectorat*, quoted in "Historique de la sauvegarde par la législation."

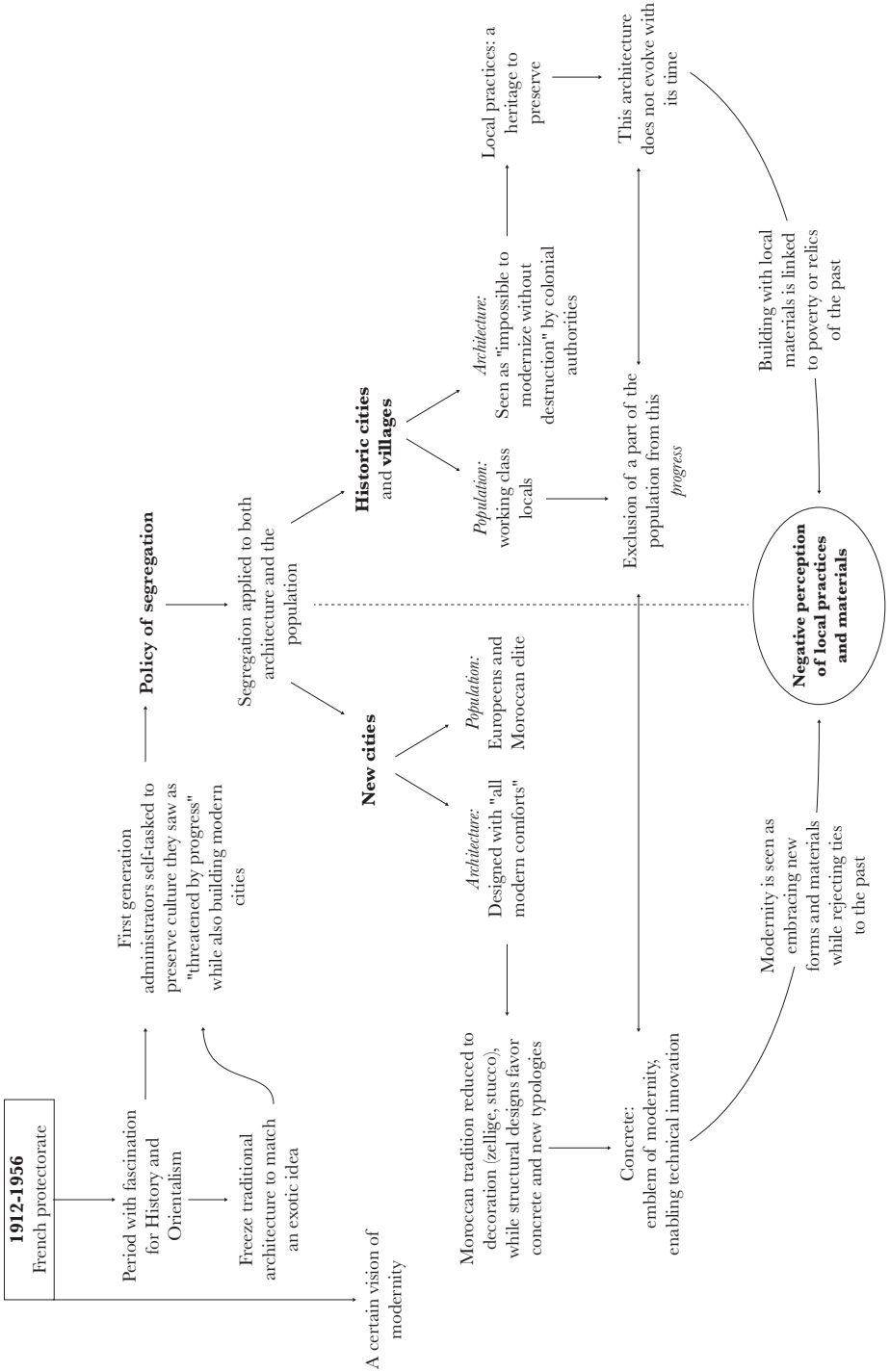
Yet, this perception oversimplifies reality. In truth, medinas such as Fez have evolved over the centuries, including during the Protectorate period, when modifications were introduced to adapt to contemporary needs. This raises questions about the authenticity of heritage, which can sometimes be constructed or mythologized.¹¹⁰ However, Naji points that this fixation excluded local practices from modern dynamics, confining them to a 'static heritage' status without evolutionary potential.

I would like to note that the context outlined here is part of a rich and complex history, explored through numerous historical, sociological, and anthropological studies that trace its evolution. While this context helps shed light on certain aspects of my work, it does not claim to reflect the entirety of research conducted on the subject, which encompasses a diversity of interpretations. As Monique Eleb and Jean-Louis Cohen highlight in a book tracing the urban evolution of Casablanca, *"a narrative reduced to two protagonists has been constructed, favoring the frontal opposition between administrative measures of the Protectorate and the spontaneous organizational modes of the recently urbanized Muslim populations."*¹¹¹ In an effort to remain concise and relevant, this research adopts necessary simplifications to structure the analysis around architectural heritage. These simplifications, however, should not be taken as an exhaustive vision of this period but rather as a lens through which to better understand heritage dynamics within aspecific historical and social context.

110 Girard and Jelidi, "La patrimonialisation de l'architecture produite sous le Protectorat français au Maroc."

111 Eleb and Cohen, *Casablanca: Mythes et figures d'une aventure urbaine*, 11.

Fig.15
Link between preservation policies during the Protectorate and the perception of local architecture and materials. Simplified diagram based on the book *Architectures du bien commun* by Salima Naji.



Post-Independence

At the independence of Morocco (1956), the question of heritage was relegated to the background, and it was only with the creation of the *Ministry of Cultural Affairs* in 1974 that it was reintegrated into public policies. Several Moroccan sites, such as the medinas of Fez, Marrakech, and Essaouira, as well as the Qsar of Aït Ben Haddou, are now listed as UNESCO World Heritage sites, reflecting a growing awareness of the importance of preserving heritage.

However, some critiques, such as those by Naji, denounce a disproportionate focus on iconic monuments, often at the expense of modest architectures, which hold functional and cultural value. This 'aestheticization of heritage' prioritizes visual appeal and risks marginalizing architectonic forms within contemporary heritage policies.¹¹²

Today, architectural heritage management relies on a collaboration between public institutions (Ministry of Housing and Ministry of Culture) and private associations. A central actor in this field is the *Center for the Restoration and Rehabilitation of Architectural Heritage in the Atlas and Sub-Atlas Zones* (CERKAS).¹¹³ It supports restoration projects for qsour, kasbahs, and other earthen and stone architecture forms. It works on classified sites (National Heritage sites or UNESCO sites) or at the request of village councils.

The management of architectural heritage in Morocco has long been marked by the marginalization of traditional materials, especially earth. However, attempts to reintroduce earth as a contemporary building material took place, notably in the 1960s with projects such as the Daoudiate neighborhood in Marrakech. This initiative used stabilized earthen concrete in an industrialized manner to address the housing crisis.¹¹⁴ Despite the cessation of social earth construction projects in the 1990s, these initiatives highlighted the potential of local materials. Today, there is a renewed interest in earth construction, particularly through tourism projects that valorize traditional architectural heritage and align with sustainable development efforts.

112 Naji, *Architectures du bien commun*, 14, 22.

113 Fondé in 1989 by the Moroccan Ministry of Culture in collaboration with UNESCO.

114 Rouizem Labied, *Réinventer la terre crue: expérimentations au Maroc depuis 1960*, 10.







People and Conversations

In the context of this research, I had the opportunity to speak with a number of people who have provided me with valuable information, for which I am grateful. Here are the main participants, some named, others kept anonymous:

July 18, 2024.

Omar Sefraoui — Cousin, and construction entrepreneur based in Casablanca, specializing in thermal insulation. He develops solutions using local materials such as hemp and raw earth. He taught me about the technical aspects and properties of these materials, as well as insights into Morocco's earthen construction industry.

October 14, 2024.

Mohammed — Guide and resident of Ouirgane. During an extensive 5-hour walk through the surrounding villages of Ouirgane, he patiently explained the challenges faced by the region after the earthquake.

October 14-15, 2024.

Kenza Fenjiro — Member of the *Tamounte Ouirgane Association*, which is based in Ouirgane and primarily works to support children's education. The association is also currently involved in the reconstruction of a number of projects (including schools and houses) following the earthquake. Kenza welcomed me in Ouirgane and explained with passion the association's commitment and the collaboration among various stakeholders to aid in the reconstruction process.

October 16, 2024.

Former mason reconverted to guide — Shared his experiences as a former mason during my visit to Telouet.

CERKAS Technical Expert — At the CERKAS headquarters in *Kasbah Taourirt*, Ouarzazate, this technical expert in local construction shared extensive knowledge about the CERKAS's conservation efforts and the practices of earthen construction in Morocco.

October 17, 2024.

Extracts from an Interview with Mylène Devaux,
November 4, 2024.

Halim Sbaï — President of *Joudour Sahara Music School*, cultural actor and environmental activist. From Ouarzazate to M'hamid El Ghizlaine, he introduced me to Morocco's architectural earthen heritage and described some environmental challenges the country faces, such as the gradual decline of oases due to drought and overexploitation of the groundwater.

October 17-18,
2024.

Khalil Morad El Ghilali — Architect and founder of Atelier be. in Rabat, Morocco. Interested by themes like climate, ecology and local materials, he is engaged in reintroducing local practices into Moroccan architecture and in post-earthquake reconstruction projects. During a telephone conversation, he shared his experiences with genuine interest.

October 25, 2024.

Mylène Devaux — Civil Engineering professor at the *Haute École d'Ingénierie et d'Architecture de Fribourg*, specializing in seismic engineering. Mylène contributed to the *Reconnaissance Mission Report* for the Al Haouz Earthquake, in collaboration with the *Swiss Society for Earthquake Engineering and Structural Dynamics*. In an interview, she addressed my questions regarding the resistance and vulnerabilities of constructions in the region and expressed her commitment to helping those affected by the earthquake.

November 4, 2024.

Saif-Eddine — Manager of a consulting firm responsible for the reconstruction of about 1,500 houses after the earthquake. During a telephone conversation, he explained in detail the entire reconstruction process managed by his agency, as well as the roles of the various stakeholders involved.

November 5, 2024.

Ismail El Kasmi — Architect based in Morocco. Interested in traditional architecture practices, especially in the High Atlas region, he kindly shared his experiences through a video call.

November 27,
2024.

The following pages contain extracts from the interview with Mylène Devaux and selected segments of the discussions with Mohammed while in Ouirgane.

MD: The main issue we observed—and you may have noticed this too—concerns structures with a kind of reinforced concrete frame combined with masonry, a pseudo-confined infill of average quality. These are the ones that mostly failed.

YS: When you talk about masonry, are you referring to cement or clay bricks?

MD: I saw very few clay bricks. It's mostly cement bricks, with granularity that doesn't optimize their strength. In talking with locals, we asked how these bricks were made. They told us, "we mix one bucket of sand for two buckets of water", or something like that. They mix it, mold the bricks, let them dry in the sun, and move them around occasionally. Once this process is complete, the bricks are ready for use. It could yield good results, but given the observed damage, the quality seems insufficient... Reinforced concrete was a concrete of poor quality, with very little reinforcement and poorly reinforced.

...

YS: So, based on your observations, the damage mostly came from those structures ?

MD: Yes, and also because they often modify the constructions in a somewhat improvised manner. Sometimes you'll see masonry made of natural stone with questionable mortar quality, and then they decide to expand and add reinforced concrete, which leads to very different structural behaviors. This significantly increases vulnerability.

YS: Yes, I saw buildings expanded with a ground floor in rammed earth, a second floor in cement bricks, and a third in fired clay bricks. It was quite special.

MD: It's terrible, yes. And in such cases, the differences in material strengths drastically affect the structure's behavior. Then there are mass-related issues. For example, rammed earth constructions can hold if they're one or two stories, as traditional floors are relatively light. Rammed earth itself is quite heavy, but it's stable, thick, and works well. However, if you add [*unclear term, likely referring to modern elements*], suddenly the mass increases, leading to dislocations. If everything is done traditionally, it's fine. It's really the mix that's problematic.

YS: Someone I spoke to didn't receive any aid and rebuilt his house himself. He focused on making it sturdy, with a belt and reinforced concrete pillars, and rammed earth infill for thermal comfort. But I've read that vertical reinforcements aren't necessarily compatible with rammed earth. Is that right?

MD: Yes, the problem is that those vertical reinforcements are relatively flexible, whereas rammed earth isn't flexible at all. The question then becomes how much deformation will occur and whether it could lead to these elements' destruction. But I don't think it's a good idea. I think it comes from a lack of knowledge.

...

YS: If you were to summarize in simple terms, what would be the main rules to ensure a building withstands an earthquake?

MD: First, mixing materials is inherently not ideal. However, you can definitely build with a system combining reinforced concrete frames and confined masonry. But the masonry needs to be of good quality, and the concrete elements must also be high-quality. I'd say there's a lot of room for improvement in these areas. Then, you can also build with masonry, but you must build properly and not too tall. You need a slightly different design approach. And yes, you can build with earth, but again, you need to respect lightweight floors, ensure proper anchorage lengths. In this regard, I imagine that following the standard published by the Moroccan government is perfectly valid.

...



Extracts from discussions with Mohammed,
October 14, 2024.

Mohammed: [Speaks to a lady in Tamazight]
Do you know what she's saying? There is a man who came into the village to see all the poor people, and he said that he had a large construction company. He was asking, "how many meters do you have, etc." so they signed a paper and he took 20,000 dirhams from each person and left with the money. A big thief. Maybe 5 people here, 6 in the other villages. He stole a lot of money and put it in his pocket. The people are unhappy, they stay in tents for a long time, so they believed that he could help them; they gave him an advance and trusted him.

...

Mohammed: This house didn't hold up, so the family now lives in tents, you see? They're waiting—they've already started digging. But the problem here is that the state didn't grant them as much land to build on. They get a smaller area. Look, the man had a big house, and now he's only allowed about 70 m². So he's already started digging and they're waiting for the architect to come and check.

YS: And those stones over there, what are they for?

Mohammed: They're going to use them for the foundations. Because if they fill all that with concrete, cement and sand, it costs a lot of money.

...

Mohammed: When I see this, it hurts me. You know why? Because during the earthquake, we came here to save people, and we found dead bodies. Look at this poor man—he can't find any labor. He's all alone. This is his house. Look at how he mixes the cement and everything. It's a very hard work. Even when he receives government aid, what is he supposed to do with it? He lays the bricks, a truck delivers the materials along with the money, and then he has to find donkeys and mules to haul the rest of the supplies here.

YS: It's really difficult to find labor here?

Mohammed: Yes, there isn't any available; it's tough, everyone is working! He's a mason, so he knows what he's doing. He follows the plan, and there's an engineer supervising him.

As soon as he finishes that stage, he calls the engineer, who comes to check if everything's correct and then releases the second tranche of funds. [Talks to the man in Tamazight]

He said that if he hadn't received the aid, he wouldn't have been able to find the money for the materials, etc. But if he had the money, he would have refused the government aid; therefore he wouldn't have had to wait like this. Instead, he dug all of this by himself in two weeks. The reinforcement alone cost him 15,000 dirhams, all just for the foundations. They give you a little money, and then you're forced to do it this way.

...

Mohammed: Look, the walls are made with that sprayed concrete. I already did all the concrete work on the outside, so that when it rains, water doesn't seep into the earthen wall. I added an iron mesh to hold together the sand, cement, and earth, making it solid.

YS: And apparently it's mandatory to apply an earthen coating on the outside?

Mohammed: Yes, afterwards—like *tadelakt*. It's an earthen mix with straw and a sort of paint. I will do that later so that it looks like the house it's made of earth.

...



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