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Domestic and Productive Earthen Architecture Conserved In Situ in Archaeological Sites of the Iberian Peninsula

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Abstract: For past societies on the Iberian Peninsula, one of the most prolific architectures was earthen construction, with a wealth of typologies and solutions derived from the legacy of local construction and materials. However, its study within the field of archaeology has been limited. The challenges posed by conservation, archaeological identification and social recognition have traditionally limited the dissemination of this type of architecture. Its low profile is perceived as fragile once the original protections collapse. The ethnological information preserved and linked to past ways of life and societies is crucial to the interpretation of the cultural development handed down over generations by different communities and now transmitted to the general public through archaeological sites. This research aims to provide an overview of the main earthen vestiges from domestic, productive and funerary architecture dating from the prehistoric, protohistoric, Roman and medieval periods. For this, a bibliographical review and data collection through fieldwork were conducted for numerous case studies. These included the classification of materials, compositions and construction techniques, creating an integrated comprehensive database with information on geography, measurements and the general state of conservation.

Keywords: archaeological sites; vernacular heritage; traditional construction; adobe; rammed earth; cob; conservation; local knowledge

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1. Introduction

In their transition to sedentary lifestyles, past societies relied most heavily on the use of earth as a construction material. This material, which was easy to source and handle, could be found in abundance in any type of habitat. This inspired a series of processes of observation, experimentation and improvement of permanent and durable constructions, knowledge of which was handed down over generations. These constructions were produced by the people for the people [1], without architects [2], prioritize economy, the efficient use of resources, functionality and resistance to aesthetics [3].

Overall, the climate and geology of the Iberian Peninsula made it an ideal location for earthen architecture to thrive over almost the whole territory, as can be deduced from evidence from different periods: prehistory [4,5]; protohistory, also boosted by orientalizing influences [6]; the Roman period [7,8]; and the Middle Ages [9]. Since the late 19th century, the search for ethnological and historical information that it can provide and its interpretation as a non-renewable document for sustainability [10] have all promoted growing interest in the processes of documenting and interpreting the technique [11]. It has also prompted the production of different studies and general classifications of techniques, excavations and interpretations since the end of the 20th century [12,13]. These have been developed in keeping with international research [14–16], although the establishment of up-to-date databases has been infrequent, even from the public administration.

Archaeology has made it possible to access the different physical remains conserved and to identify the architecture and construction techniques used. There are four major

primary groups—mixed structures (Figure 1a), cob (Figure 1b), adobe (Figure 1c) and rammed earth) (Figure 1d)—which also prompt reflection on form and function. However, the highly variable state of conservation of this type of heritage makes this classification a complex task. This is due to both its nature and the wide range of subvariants of construction processes and traditions rooted in different territories or, hypothetically, in specific societies and cultures. Although monumental and defensive structures are more widely studied and recognized by society, this construction style is not limited to the building envelope, and it also covers aspects such as fixed furniture, production systems and burial rituals in the domestic space. While shown to be highly variable compared to other types of architecture, relatively few cases have been identified to date.

(**a**) (**b**) (**c**) (**d**)

Figure 1. Groups of earthen architecture constructions identified in the study area: (**a**) modern reconstruction of a half-timber wall with braided reed in Numancia (Garray, Soria); (**b**) cob wall in the archaeological site of the Roman villa La Olmeda (Pedrosa de la Vega, Palencia); (**c**) adobe wall preserved in the Roman houses of Bílbilis (Calatayud, Zaragoza); (**d**) rammed earth wall in Ampurias (La Escala, Girona).

In the case of envelopes, although until now roofs have only appeared in a state of collapse, they have been classified based on the diameters of plant imprints burnt into fragments following fire damage. In addition, stone plinths have usually been conserved in walls and, in some of the best-case scenarios, so have one or two floors of earthen elevation. Such is the case, for example, with Cancho Roano, Contrebia Belaisca, Bílbilis and Casas del Turuñuelo. Most frequently, these are less than one metre from the springing (plinth or ground level) [17].

Numerous examples of domestic elements have been classified, with self-construction and adaptation to the space resulting in unique characteristics and layouts. These can be classified into main groups, depending on use, and include benches (Coll del Moro (Gandesa) [18] and Castellet de Banyoles (Tivissa) [19]; shelves for vessels (Cabezo Redondo (Villena) [20]; hearths (Tossal de Manises (Alicante) [21]; platforms (Cerro de San Vicente (Salamanca) [22]; water deposits (Plaza de Moros (Villatobas) [23]; ponds and kilns (Lépida Celsa (Velilla de Ebro) [24]; and workshops and paving.

Many funerary element typologies have also been documented. These include simple graves (Cerro Santuario (Baza)) [25]; central pillars (Túgi (Galera)) [26]; perimeter walls (Doña Blanca, (El Puerto de Santa María)); outer rings (El Castillo, (Castejón)) [27]; and structures such as those with corbel vaults (Castejón de Arguedas (Arguedas)) [28], with roofs usually found in a state of full collapse.

In addition to kilns for domestic use, the economic activities of the different societies—such as pottery or ironwork—have left behind a specific earthen construction heritage sharing similar problems. While frequent in different societies and historical periods, one particularly notable example is that of the technologies introduced in the Late Iron Age by the inhabitants of the Eastern Mediterranean. These survived until Roman times and beyond, gradually transitioning to a form of hierarchized production that was in contrast with the domestic production of the Bronze Age [29].

In response to the need for high temperatures to transform materials, specific pieces and elements were developed for production kilns. One of the most widely studied innovations is that of kilns with vertical flues, which usually include a combustion chamber below, horizontal compartmentation or a grate and a firing chamber above these. Numerous variants can be found within this typology: with a system supporting a grate, with a central pillar (with axial prolongation or freestanding [30], seen in kilns 2 and 1 in S3-Camposoto (San Fernando), respectively); with perpendicular side walls or rows of walls (La Jericó (Herrera del Pisuerga) [31]) (Figure 2d); or with low radial walls. Differently shaped systems have also been documented: U systems with a compartmented combustion chamber (El Olmo and Mas del Moreno) [32] (Figure 2a); omega systems; circular or oval (in the Roman villa El Ruedo (Almedinilla)) [33]; and quadrangular or rectangular (El Monastil (Elda)) [34]. The construction process often took advantage of the natural earth stratum when selecting the location for the combustion chamber and used a wide variety of pieces. This is the case of the corbel vaults built with plano-convex adobe bricks in kiln 1 in Torrealta (San Fernando) [29]; the steps at the base of the praefornium in La Milagrosa (San Fernando) [35]; and grates with radial adobe bars in Pajar del Artillo (Santiponce) [36].

(**a**) (**b**) (**c**) (**d**)

Figure 2. Earthen productive architecture in the study area: (**a**) two-chamber kiln in adobe partially preserved in the production complex of Mas de Moreno-El Olmo (Foz-Calanda, Teruel); (**b**) Roman kiln with a central pillar, grate and cupola at Clos Miquel (Sant Miquel de Fluvià, Girona); (**c**) adobe hearth and flooring in dwellings in Cerro de la Mota (Medina del Campo, Valladolid); (**d**) single chamber adobe kiln with supporting structures hardened through exposure to high temperatures in La Jericó (Herrera del Pisuerga, Palencia).

However, not all this variety is suitably valorized or physically represented with visible structures. Given the vital importance of physical documents as tools for transmission to the wider public, this lack of visibility negatively affects the dissemination and social recognition of this type of architecture, compared with that of the use of carved stone masonry in varying degrees. By ensuring maximum representation of examples of structures conserved in situ in different states of preservation or replacement, their importance and increased value can be highlighted within these enclaves, where they can be maintained and transmitted as part of a cycle of cultural use.

This broad approach to these techniques, employing general concepts whilst steering clear of the detailed and independent study of specific territorial cases, limits a general overview to the search for chronological parallels. This could lead to a more comprehensive joint examination highlighting a richer selection of characteristics. However, as far back as the 1990s, some publications already favoured the presentation of collections of samples, including metrics [37,38], where scope and antiquity make it possible to update a selection of sites still visitable in their original contexts. This collective discussion of techniques, tools and measurements is still relevant in the academic field of archaeology and architecture, lacking consensus on hypothetical connections with specific societies, in stark contrast with the consequent spontaneous need for timely construction solutions.

The main objective of this study Is a clear, painstaking examination of the state of the art and different aspects of earthen structures on the Iberian Peninsula. For this, a database is created following the bibliographical review and data collection in fieldwork for the case studies conserved in situ in archaeological settings. This should boost the analysis and cross-referencing of geographical information systems to detect the patterns and density of case studies while serving as the basis for subsequent vulnerability and risk studies. This general overview has led to debates on a series of statistical observations and reflections on the materials and techniques employed, classified by typology or historical period, while also revealing the main issues or case studies to be addressed during the cultural transfer.

2. Methodology

The methodology selected consists of two main phases: the search and selection of the case studies and the statistical management of data.

2.1. Case Studies

The starting point is the identification of case study locations based on various indirect sources, including national archives (Archive of the Spanish Cultural Heritage Institute (IPCE) of the Ministry of Culture); national archaeological collections (Excavaciones Arqueológicas de España, EAE; Noticiario Arqueológico Hispánico, NAH); regional collections (Serie de Trabajos Varios del Museo de Prehistoria de Valencia, MUPREVA; Anuario Arqueológico de Andalucía, AAA); and other sources, such as repositories (Calaix-GENCAT; the SOS-Tierra research project; publications of the Archaeological Museum of Alicante, MARQ); and dossiers, reports or articles on the territory. The dispersion of the information throughout the Iberian Peninsula has resulted in a more extensive compilation of publications and journal articles, accounting for 46% of the total. Remaining sources are found in lower percentages: 17% came from the IPCE, 13% from national collections, 12% from regional repositories, 10% from regional series of studies and the remaining 5% from research projects and museums (Table 1).

Table 1. Dispersion of sources consulted and case studies of interest identified.

Source	n	%	Source	n	%
MUPREVA	9	5%	Publications	79	46%
MARQ	2	1%	SOSTierra Research Project	7	4%
IPCE-Map library	10	6%	Calaix	20	12%
IPCE-Projects	17	10%	AAA-Anuario Arqueológico de Andalucía	8	5%
IPCE-Photo library	2	1%	EAE-Excavaciones Arqueológicas de España	9	5%
IPCE-Inventory	0	0%	NAH-Noticiario Arqueológico Hispánico	14	8%

As the research requires examination of remains conserved in situ, geographical limitations were a conditioning factor in regions such as Galicia, Principado de Asturias

and Cantabria. Earthen constructions are extensively documented in these areas [39,40], but the predominance of half-timbered techniques greatly limits preservation. Given the organic nature of timber, which did not survive in situ, no cases of half-timber were found, which in turn limited verification tasks to the elements observed in calcined and collapsed fragments. No reliable conclusions have been reached on the absence of other construction techniques in these spaces, possibly due to material and climate issues (abundance of forest masses and high average rainfall) [41]. The social issues (scope of societies) offer a comparison of Celtiberian and Iberian expansion, the latter widely found in the Spanish Levant, with a well-documented culture of adobe and cob [13].

It Is Impossible to establish clear limits for the case study timeframe given the limited number of domestic cases and the inclusion of techniques, such as rammed earth, which appear to be more recent [42]. However, the greater popularity of cases of Iberian origin and the difficulties in characterizing techniques, such as cob compared to adobe, suggest increased representation of the protohistoric period.

Efforts have been made, when examining typologies, to prioritize structures that are vernacular, domestic, productive and funerary and are at greater risk of loss or invisibilization. The high quality of construction of earthen monumental and defensive architecture, inherently larger and thicker, enjoys a privileged position in terms of the social recognition, impact and priority of intervention, which facilitates its survival.

Care has been taken to minimize errors in classifying terminology due to the misuse of synonyms [43], and, whenever possible, a macrovisual review has been provided in cases of ambiguous historical descriptions. The most common confusions involve misuse of the terms *adobe*, *tapia* and *tapial* (adobe, rammed earth and formwork, respectively) generally used to describe *amasado* (cob).

Based on the above, 170 case studies in different states of conservation and context were preselected (Figure 3) (Appendix A), aiming to represent all the provinces within the territory and recognizing the limitations mentioned above. Field visits were made to 121 of these based on their individual characteristics, collecting data to update information, rapidly changing with this type of heritage at times of unfinished musealization.

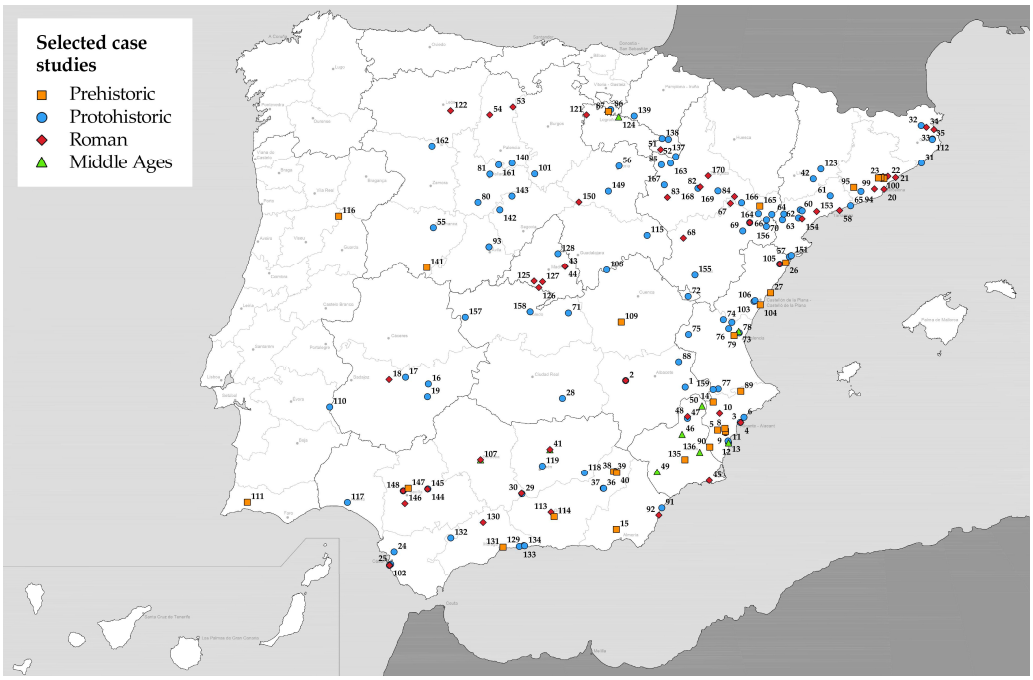


Figure 3. Distribution of selected case studies on the Iberian Peninsula and main structures' period.

2.2. Characteristics and Statistical Management of Information

Information was collected and organized through fiches with a hierarchized sequence to allow the visual interpretation of general and specific characteristics [44]. This article focuses particularly on the urbanistic and territorial situation, featuring typology, use, ownership, urban location, historical period of the structures and geographical location. Given that these conditioning factors can affect the survival of these structures in varying degrees, they were taken into account in the data collection process.

In addition, an urban location can affect the conservation and valorization process, showing the contrast between musealized sites in urban settings and abandoned sites in isolated and non-urbanized natural spaces. Natural events, such as flooding, tend to be occasional and irregular, with the potential to cause different effects on flat surfaces or in settings with evacuation systems vulnerable to overflow caused by torrential rain. This also affects society, as access to human and economic resources reflected in maintenance and cultural and tourist operations can all vary. Observing the locations where these archaeological sites are usually found and their symbiosis with their surroundings is vital to understanding interventions.

Furthermore, assigning typologies can showcase the volume of disseminated finds, which originally served a specific function. Used as the basis for future risk and conservation studies, it can also aid reflection on natural problems, for example, in settings where seismic movements can be minimized by structural geometry and bracing. On social issues, they either help or hinder the general public's access to information about a broader range of constructions incorporating these materials and techniques.

Ownership may also be a factor of interest when cross-referencing the state of conservation of different case studies. The budget guaranteed by the public administration can facilitate access to resources for the conservation and enhancement of the enclaves, although this continues to be a latent problem in the sector. Given the lack of additional support measures, sites such as Illa de Banyets (El Camepello, Alicante), acquired at a later stage, have lost a high volume of earthen construction since being uncovered.

In addition, the original function of these archaeological remains has given way to a new typology, used for documentation and research (aimed at the specialist public) or for cultural or exhibition purposes (aimed at the general public). During the intermediate phases of excavation, these two uses are often compromised, despite the increased number of initiatives offering guided tours after the different annual excavation campaigns. Different forms of damage can also be observed, depending on their specific predominance.

Ultimately, any examination of the use of the different earthen construction techniques in past societies also requires the approximate dating of any finds. Current knowledge and tools can be applied to those with earlier dating, which are susceptible to review. In this way, a general overview of the situation on the Iberian Peninsula can be deduced from the compilation of periods identified by a series of professionals in charge of the different enclaves.

The text also examines the architectural situation, featuring the identification of the material by element, construction technique, metrics, stabilizing agents, complementary use with other systems and specific features of the structure, when these values are known.

In this regard, depending on the structures conserved, earth can be found in different spots within the same site. Whereas, in monumental and defensive construction, the demand for greater resistance or wealth of construction of many societies resulted in a predominant use of carved stone, in the domestic and production spheres, earth was a key element. Stone masonry was usually limited to use for plinths or additions to load-bearing walls in order to ensure minimum damage to sensitive areas, thus saving on materials that were more expensive to extract and handle.

As regards construction techniques, the classification divides these into four main groups: half-timber techniques, cob, adobe and rammed earth. According to extensive research from the first international classifications [45], a large number of subvariants with these well-established techniques can currently be found on the Iberian Peninsula. However, the territorial misuse of synonyms in the 20th century [43] has resulted in issues that have hindered classification tasks and are still ongoing.

Therefore, some interesting decisions have recently been made to homogenize the terminology [46,47], establishing separate uses for the words *adobe* and *tapial* (formwork) to refer to *amasado* (cob). This also applies to the use of components and terms with negative connotations, such as *arena* (sand), *arcilla* (clay) or *barro* (mud) when referring to earth. Even so, the difficulties of preservation and display in situ can lead to the underrepresentation of this wide range of techniques, meaning that only a small fraction of these can be observed.

Each of these techniques is analyzed independently based on characteristics such as the thickness of construction elements or bricks, bonding or execution systems.

Nevertheless, earthen constructions display several weak points, particularly in the base and upper section, as the material is frequently combined with other types of structures, and only the lower section is conserved following the collapse of the roof. Thanks to the wide range of solutions employed, these elements help improve the quality of the construction and the response to rising damp and major flooding episodes. Identifying the frequency of recurrence of these may be relevant to the classification of these systems.

A general overview, resulting from the use of GIS and statistical management software and filtered by theme of interest, reveals the recurring presence of different cases, through heatmaps, analysis and visual examination. Thus, case density is obtained from the heatmaps for construction techniques using QGIS software and a 70km radius. The results are complemented by interpretations obtained from Real Statistics, software developed by C. Zaiontz, carrying out a Kernel density estimation (KDE) of random variables with a bandwidth of 0.8, overcoming the limitations of histograms for aspects, such as recorded metrics, to test the probability of their appearance in specific ranges or periods. This can be relevant when proposing a response to the question of metrics and their implications, as different experts still consider this variable to Be of interest when finally establishing intersocietal correlations.

3. Results

Case studies have been identified from a series of perspectives, offering a context, a general and detailed framework of the enclave and construction techniques. The geographical distribution of the territory studied has been analyzed, observing dispersion, whilst analyzing the historic, urbanistic, typological, use, architectural and construction characteristics according to the bibliography consulted and a macrovisual review. Microscopic studies have also been considered in the course of these processes.

3.1. Historical, Urbanistic, Typological and Use Characteristics

3.1.1. Geographical Distribution

Geographical distribution was observed from the total number of case studies, including the 170 preselected ones, and considering all communities except Galicia, Principado de Asturias and Cantabria, mentioned above. While this dispersion appears to be logical, with a tendency to show higher case study percentages in certain communities, some territories display a characteristic accumulation of documented remains. Although these include the Ebro valley and the south of Alicante, this may not necessarily be due to strategic issues of proximity to the sea, commercial ports or major rivers.

Case studies worth noting include the vast territory of Andalucía, with 19% of cases; the Levant, with 19% in Catalonia, 18% in Comunidad Valenciana, 11% in Aragón and 5% in Región de Murcia; and a lower representation inland, with 10% in Castilla y León, 6% in Castilla-La Mancha, 4% in Comunidad de Madrid, 3% in Comunidad Foral de Navarra, 2%

in Extremadura, 1% in the Basque Country and 1% of cases in the La Rioja. Cases are also found in the south, east and north of Portugal as well as in 3 different districts (Bragança, Evora and Faro), making up 2% of the total.

3.1.2. Urban Location

According to the sample, 69% of case studies are in isolated locations, while 21% are in built-up and unbuilt areas and have an infrastructure for water evacuation, as in the cases of the Roman villa El Ruedo (Almedinilla) (Figure 4b), Tossal de Manises (Alicante) and Casa del Mitreo (Mérida). 10% of cases are in built-up plots, occupying the ground or basement floors of the construction (Domus Avinyó (Barcelona)) (Figure 4d). They are also found in historic town centres or below pedestrian level, as in El Molinete (Cartagena) (Figure 4c). Although archaeological finds are often uncovered during the construction of infrastructures, this architectural typology has mainly been conserved in natural surroundings far from urban nuclei.

(**a**) (**b**) (**c**) (**d**)

Figure 4. Variability of urban location of the different case studies: (**a**) isolated and irregular location in Plaza de Moros (Villatobas, Toledo); (**b**) unbuilt urbanized context in the kiln of El Ruedo (Almedinilla, Córdoba); (**c**) covered urban context below pedestrian level in El Molinete (Cartagena, Murcia); (**d**) interior insertion in building of Domus Avinyó (Barcelona).

3.1.3. Typology

Non-defensive earthen architecture in archaeological sites shows viewers a variety of constructions dedicated to domestic life (Figure 5a) (Figure 5b), pottery production (Figure 5c) and death rituals (Figure 5d). In the sample obtained, 41% of the structures, such as walls or fragments of roof, are linked to the dwelling envelope. Furthermore, 25% are linked to production activity, including kilns; 33% are associated with domestic elements, as in the case of fixed furniture; 5% are linked to funeral architecture, found in different types of burial sites; and 3% correspond to a completely religious typology. Finally, despite not being a subject of study, 2% of cases also incorporate at least one structure above ground, which could be linked to defensive typology. It should be noted that earthen residential architecture and earthen productive architecture are both present in 4% of sites, while in 21% of sites, productive architecture can be found in isolation. As with the rest of the factors, these figures are very broad-ranging in relation to the current condition of these enclaves, and the discovery of new sectors could alter the number of case studies.

(**a**) (**b**) (**c**) (**d**)

Figure 5. Typological variability of different case studies: (**a**) earthen walls in a dwelling in La Celadilla (Ademuz, Valencia); (**b**) fixed earthen domestic shelves for vessels in Cabezo Redondo (Villena, Alicante); (**c**) earthen productive structures in El Monastil (Elda, Alicante); (**d**) earthen funerary structures in Cerro Santuario (Baza, Granada).

3.1.4. Ownership

In contrast, attempts have been made to identify general ownership of the different case studies. In this respect, the results obtained show that 64% of cases are publicly owned, like Contrebia Belaisca (Botorrita, Zaragoza) (Figure 6a), compared to 21%, which are privately owned, like the site of Tos Pelat (Moncada) (Figure 6b). In 16% of cases, this information could not be confirmed.

(**a**) (**b**)

Figure 6. Variable ownership of the different case studies: (**a**) public, Contrebia Belaisca (Botorrita, Zaragoza); (**b**) private, Tos Pelat (Moncada, Valencia).

3.1.5. Use

For most of the cases of the sample valorized, except those where the remains found have been either deliberately or accidentally destroyed [48], research and exhibition purposes should be assessed. This ensures occasional scientific use while protecting cultural transmission of the knowledge they hold. However, not all archaeological sites offer optimum conditions for conservation or valorization, and, for a number of reasons, there are high levels of re-burial, which lessen loss, abandonment and even destruction.

Thus, 51% of cases are visible for cultural and exhibition use (Figure 7a); 24% are not visible and are buried; 4% are not visible as the excavation is underway (Figure 7b); 12% have been temporarily abandoned (Figure 7c); and 10% have been destroyed (Figure 7d) or dismantled due to geographical location or the lack of measures for supporting the earthen structures.

(**a**) (**b**) (**c**) (**d**)

Figure 7. Variability of use in the different case studies: (**a**) cultural and display use of the site at Casa del Mitreo (Mérida, Badajoz); (**b**) site closed to the general public due to the excavation of Casas del Turuñuelo (Guareña, Badajoz); (**c**) site abandoned following excavation, Tossal del Moro (Pinyeres, Tarragona); (**d**) destroyed adobe walls in Puntal dels Llops (Olocau, Valencia).

3.1.6. Historical Period

Based on the selected sample, 4% of structures can be dated to prehistory (Figure 8a), 53% to protohistory (Figure 8b), 29% to Roman times (Figure 8c) and 6% to the Middle Ages (Figure 8d). More precise dating processes show that 6% of cases can be dated to the Bronze Age, 7% to the Late Bronze Age, and 18% to Iron Age I and II. Although the medieval era has been selected to include rammed earth case studies, most structures can be dated to protohistory, followed by the Roman period, which largely continued these construction traditions. Therefore, the lower representation of this medieval period does not necessarily equate to a lower number of case studies, and it is merely the result of bibliography and typology. However, correlations can be established between the techniques identified and their frequency. The lack of prehistoric cases conserved could be due to their greater antiquity and, thus, the greater probabilities of collapse. A more widespread use of timber and earth for load-bearing structures also makes situ conservation practically impossible.

(**a**) (**b**) (**c**) (**d**)

Figure 8. Variability of historical periods in case studies: (**a**) re-buried prehistoric cob wall in Caramoro I (Elche, Alicante); (**b**) protohistoric adobe furniture in Coll del Moro (Gandesa, Tarragona); (**c**) adobe structures in the insulae of Lepida Celsa (Velilla de Ebro, Zaragoza); (**d**) medieval rammed earth wall over Roman remains in Los Torrejones (Yecla, Murcia).

These percentages, referring to all case studies, have been compiled and observed for the different construction techniques. It should be noted that the profuse adobe structures in

isolated locations can be outnumbered by cob and rammed earth, although, proportionally, these are in the minority in built-up settings.

Notable inequalities can also be found in the remaining factors, such as the notable presence of cob in residential structures, as it is more likely to be found in domestic furniture than in the walls themselves. Furthermore, an abundant use of adobe has also been documented in most productive elements, although it is also found in the natural terrain excavated. However, rammed earth has almost been relegated to residential and structural use. This is only to be expected, as it is harder to execute, less adaptable when used on joints and smaller construction elements as well as elements thought to have been added at later stages.

As regards ownership, while all systems display a balanced public–private ratio, according to the research, ownership remains unknown in higher percentages in the cob case studies documented. In terms of use, a similar pattern can be observed, with 50% of the buried case study typologies compared to approximately 50% of the musealized ones. Nevertheless, a significantly higher number of cases of cob construction is believed to have been lost In relation to the overall figures for the technique, while most examples of rammed earth have survived (Table 2).

Table 2. Proportions of historical, urbanistic, typological and use characteristics in case studies.

Characteristics	**Earthen Construction Technique**							
Urban Location	**All Techniques**		**Cob**		**Adobe**		**Rammed Earth**	
Isolated	117	68.8%	21	12.4%	101	59.4%	17	10.0%
Urbanized plot	36	21.2%	8	4.7%	33	19.4%	4	2.3%
Built plot	17	10.0%	3	1.7%	15	8.8%	3	1.8%
Typology	**All Techniques**		**Cob**		**Adobe**		**Rammed Earth**	
Residential	69	40.6%	12	7.0%	53	31.2%	14	8.2%
Domestic	56	32.9%	14	8.2%	36	21.2%	7	4.1%
Productive	42	24.7%	6	3.5%	38	22.4%	0	0.0%
Funerary	8	4.7%	0	0.0%	8	4.7%	0	0.0%
Religious	5	2.9%	0	0.0%	2	1.2%	3	1.8%
Defensive	4	2.4%	0	0.0%	4	2.4%	0	0.0%
Ownership	**All Techniques**		**Cob**		**Adobe**		**Rammed Earth**	
Public	109	64.1%	17	10.0%	95	55.9%	18	10.5%
Private	35	20.6%	5	2.9%	33	19.4%	4	2.4%
Unknown	28	16.5%	10	5.9%	23	13.5%	2	1.2%
Use	**All Techniques**		**Cob**		**Adobe**		**Rammed Earth**	
Exhibition/cultural	86	50.6%	13	7.6%	76	44.7%	14	8.2%
Closed (under excavation)	6	3.5%	0	0.0%	6	3.5%	0	0.0%
Closed (buried)	40	23.5%	8	4.7%	37	21.8%	10	5.8%
Abandoned	21	12.4%	6	3.5%	17	10.0%	0	0.0%
Destroyed	17	10.0%	5	2.9%	13	7.6%	0	0.0%
Historical Period	**All Techniques**		**Cob**		**Adobe**		**Rammed Earth**	
Prehistoric	28	16.5%	13	7.6%	17	10.0%	1	0.6%
Protohistoric	97	57.0%	15	8.8%	92	54.1%	11	6.4%
Roman	47	27.6%	4	2.4%	45	26.4%	8	4.7%
Middle Ages	9	5.3%	0	0.0%	7	4.1%	4	2.3%

Sites can display different techniques in a single location (elements $\geq$ sites). Percentages are shown for the total number of sites (170).

3.2. Architectural and Construction Characteristics

The general and detailed architectural classification of the structures found is key to identifying the most frequent systems and subvariants. In addition, the location of the earthen material, the monolithic or built construction system, its measurements, the presence or absence of stabilizing agents and the combinations with other materials and techniques can potentially determine different responses. Thus, a more precise representation of the different behaviours, degradations and intervention methodologies is obtained. In turn, ensuring maximum precision in sample classification can help form a solid database for further research.

3.2.1. Presence of Earth

The sample studied shows a distribution of 67% of cases using earth-on-wall elevations raised on plinths in different materials and 12% at the base of the wall, due to the absence of a plinth, which is more common in internal compartmentations. Additionally, 49% correspond to domestic elements (Figure 9a), usually at ground level and with little elevation; 29% to production structures, especially pottery kilns (Figure 9b); 7% to funerary elements; 59% to paving (Figure 9c); and 36% to protective renderings of the load-bearing structure (Figure 9d). These are usually irregular in appearance as this is the first layer to be sacrificed.

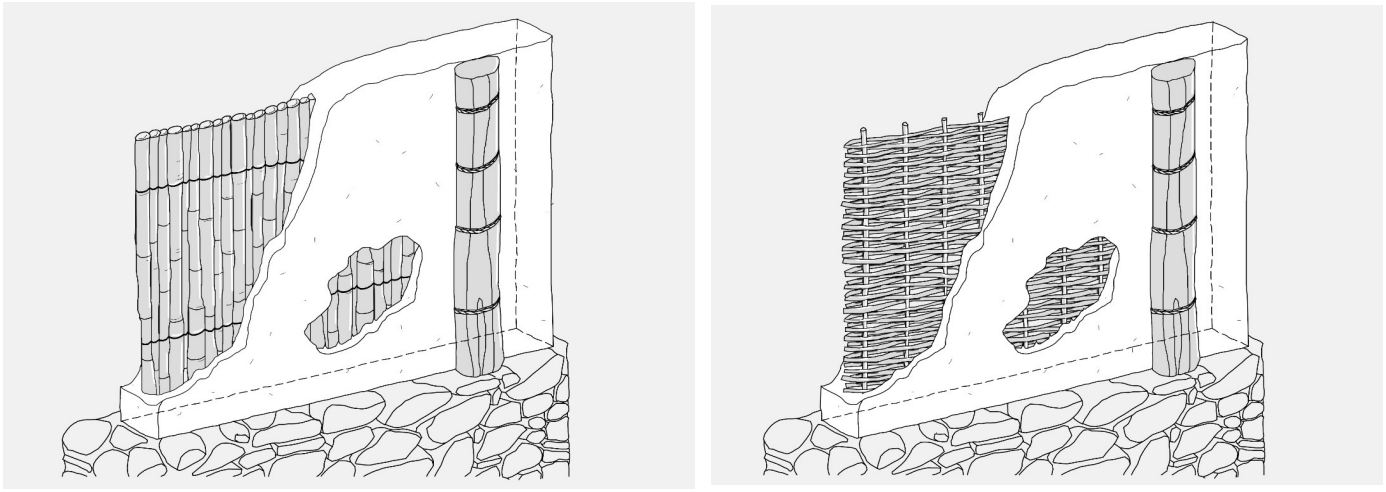
(**a**) (**b**) (**c**) (**d**)

Figure 9. Locations of earthen structures in case studies: (**a**) adobe bench with no plinth in Mas Castellar (Pontós, Girona); (**b**) low walls, pillars and renderings with adobe in the production complexes of Torrealta and Camposoto (San Fernando, Cádiz); (**c**) adobe paving in Cerro de San Vicente (Salamanca); (**d**) gaps in earthen rendering in structures in Lloma de Betxí (Paterna, Valencia).

3.2.2. Construction Techniques

The different construction techniques identified in the case studies belong to the four major families identified in recent years, both within and outside the peninsula.

The structures resulting from the mix of water and earth covering the timber substructure, also used as internal supporting reinforcement, are considered examples of mixed techniques (*torchis* or *técnicas mixtas*). This technique was widely observed on the Iberian Peninsula from as early as the Neolithic [49], and was also found in Roman times [50]. It survives to this day thanks to half-timber, although the only archaeological remains found conserved in situ are collapsed fragments. Therefore, all the cases observed are interpretative reconstructions used to disseminate and identify some of the usual subvariants. This is the case with woven reed (Figure 10a) and braided reed (Figure 10b), found in 4% of the case studies, with thicknesses of around 27 cm, as seen in Castellón Alto (Galera, Granada) and Numancia (Garray, Soria).

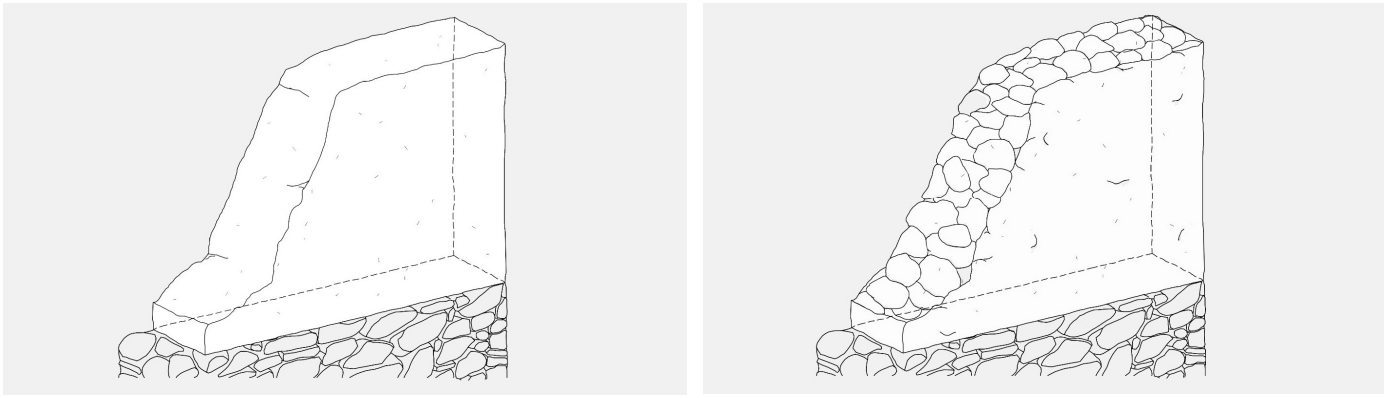


(**a**) (**b**)

Figure 10. Interpretative variants of case studies: (**a**) enclosure of woven reed in Castellón Alto (Galera, Granada); (**b**) internal compartmentation of braided reed in Numancia (Garray, Soria).

Furthermore, the construction technique of cob (*bauge* or *amasado/pared de mano*) used plastic applications of simple earth to form monolithic walls, which, despite often appearing as piles of units, were individual homogeneous masses [51]. This technique was predominant in the 3rd and 2nd millennia, along with mixed techniques [52]. In this case, layers of earth, naturally stabilized with plant fibres or anthropically with lime, were applied in heaps, usually in easy-to-manipulate spherical shapes. Walls could be made either with or without formwork, being later smoothed off using forks, planes and other tools. In this classification, this group includes elements linked to domestic fixed furniture, such as hearths, kilns, shelves for vessels and benches all built in the same way.

The identification of cob in archaeological sites has been widely debated in the field, as it has been traditionally considered adobe or rammed earth. Thus, this has contributed to both the protohistoric standardization of adobe and its underrepresentation in the sample. Nineteen percent of all the sites feature some form of cob structure, including La Olmeda (Pedrosa de la Vega, Palencia) (Figure 11a) and Caramoro I (Elche, Alicante) (Figure 11b). Walls around 37–45 cm thick are found, as well as ones that are 25–30 cm thick for interior compartmentations and 60–80 cm thick in the case of domestic structures. Moreover, the paving category was filtered, and 48% of cases were identified as compacted earth and 16% as clay.



(**a**) (**b**)

Figure 11. Interpretative variants in case studies: (**a**) enclosure of a simple cob wall in La Olmeda Roman villa (Pedrosa de la Vega, Palencia); (**b**) cob ball wall enclosure in the site of Caramoro I (Elche, Alicante).

Adobe (*brique crue* or *adobe*) is the most widely documented variant in the group of earthen walls. It is normally made with raw earth units mixed with straw and coarse sand to improve resistance and durability. It is serially manufactured with moulds and pieces dried in the open air, suggesting a possible quick execution process, although moulds were not necessarily involved in many of the variants documented. Although terminological issues have obscured discussion of the origins of the term, there is conclusive evidence of its existence in the Late Bronze Age and Early Iron Age [6], when it was linked to orientalizing influences in the south and southeast of the Iberian Peninsula. Subsequently, from the second half of the 6th century BC, it spread across the peninsula and has been documented in some settlements predating the Phoenicians [13]. Among the different case studies selected and reliably dated to these periods, only Cerro de la Mota (Medina del Campo, Valladolid) has conserved and musealized remains in situ.

Given the extremely variable placement of units, in keeping with the high number of variants, solutions can be achieved that can satisfy construction requirements in terms of resistance and thickness. Load-bearing walls, for example, tend to use stretcher and header bonds for good adhesion and resistance, as seen in El Turuñuelo (Guareña, Badajoz) [53]. Header configurations are found in walls of one foot in Puntal dels Llops (Olocau, Valencia) [54]; double stretcher configurations are found in Cancho Roano (Zalamea de la Serena, Badajoz) [55]; and to a lesser extent, square ones, with a better seismic response, are found in Mas Castellar (Pontós, Girona) [56]. When thinner constructions are sought, stretcher configurations can be seen, as in the case of the upper floors or the partition walls of Tossal de Sant Miquel (Lliria, Valencia) [57]; in the funerary sphere, in El Castillo (Castejón, Navarra) [58]; or in shiner bond, as in La Celadilla (Ademuz, Valencia). These thicknesses can also be achieved with stretcher configurations in smaller modules (15–20 cm wide), as in Puntal dels Llops (Olocau, Valencia) [59].

The system is also found in other contexts, including paving, in Castellet de Banyoles (Tivissa, Tarragona) [60] or smaller domestic elements, such as benches with stretcher configurations in Coll del Moro (Gandesa, Tarragona) [18], kilns in La Jericó (Herra del Pisuerga, Palencia) [31] or in Mas del Moreno (Foz-Calanda, Teruel) [32], platforms like those in Cerro de San Vicente (Salamanca) [22] or hearths or water deposits. In some enclaves, although information is not conclusive, research suggests the possible construction of corbel domes in the dwellings in El Turuñuelo (Guareña, Badajoz), using lightweight modules that were easier to manipulate [61]. It was also used for coating in Alto de la Cruz (Cortes, Navarra) [62] and was more common in productive architecture, as seen in kiln 3 in Torrealta, kiln 4 in Camposoto (San Fernando, Cádiz) [29] and in La Cabrera (Torredonjimeno, Jaén) [63].

Finally, these pieces have successfully adapted special geometries for concrete elements, usually structural ones in productive settings. A notable example is that of large plano-convex elements documented as a system to support combustion chambers in Pajar del Artillo (Santiponce, Sevilla) [36]. Other pseudotriangular structures are found, such as kiln 4 in Torrealta (San Fernando, Cádiz), as well as tegulae inserts, as in the production sector in El Ruedo (Almedinilla, Córdoba) [33].

Adobe has historically been the most widely recognized construction system, with at least one structure in 88% of the case studies. Moreover, the measurements collected provide an overview of the different construction scenarios, using probability to identify those most frequently repeated in specific periods. This is particularly complex in the case of adobe, given its variability (Figure 12) and numerous conditioning factors, including mould size, type of execution, construction culture, spontaneity and simple needs to cope with construction issues. In order to combine the metrics documented by the different specialists (Appendix B), the probable measurement ranges for adobe bricks put forward by the KDE have been observed: prehistoric (44/52 × 26/30 × 7/10 cm), protohistoric (36/43 × 19/25 × 10/12 cm) and Roman (40/51 × 29/40 × 10/11 cm) (Figure 13).

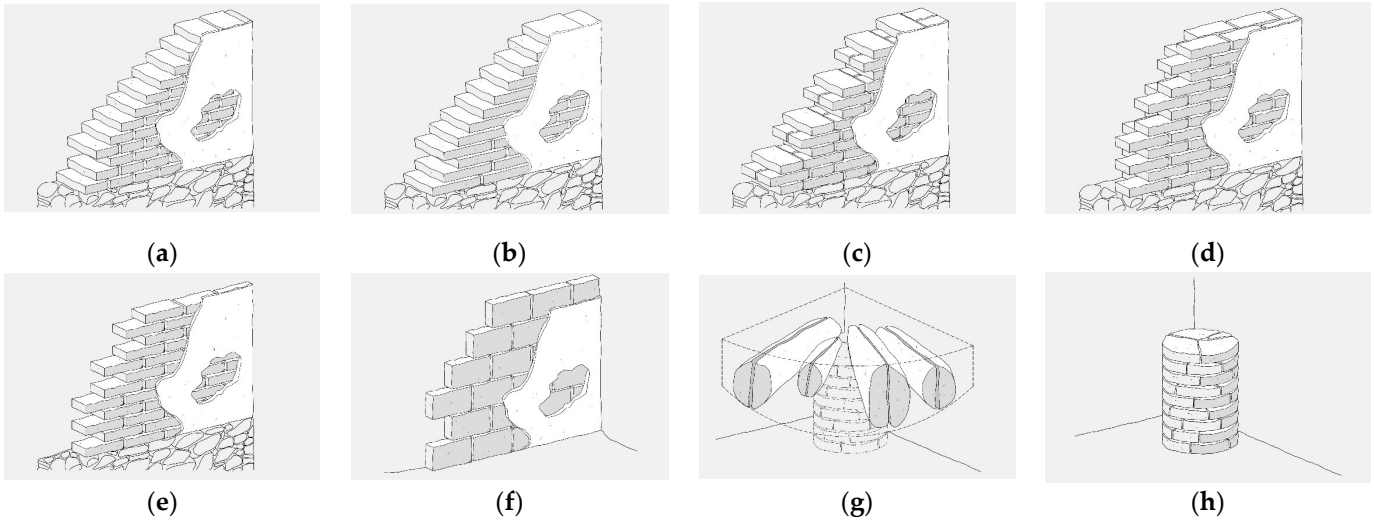


Figure 12. Interpretative variables in case studies: (**a**) stretcher and header load-bearing walls; (**b**) header load-bearing wall; (**c**) double stretcher load-bearing wall; (**d**) load-bearing wall with quadrangular adobes; (**e**) stretcher load-bearing partition walls, upper walls or domestic elements; (**f**) compartmentation walls in shiner bond, (**g**) supporting structures, plano-convex or bar-shaped support for grates; (**h**) pseudotriangular adobe bricks in columns or central pillars.

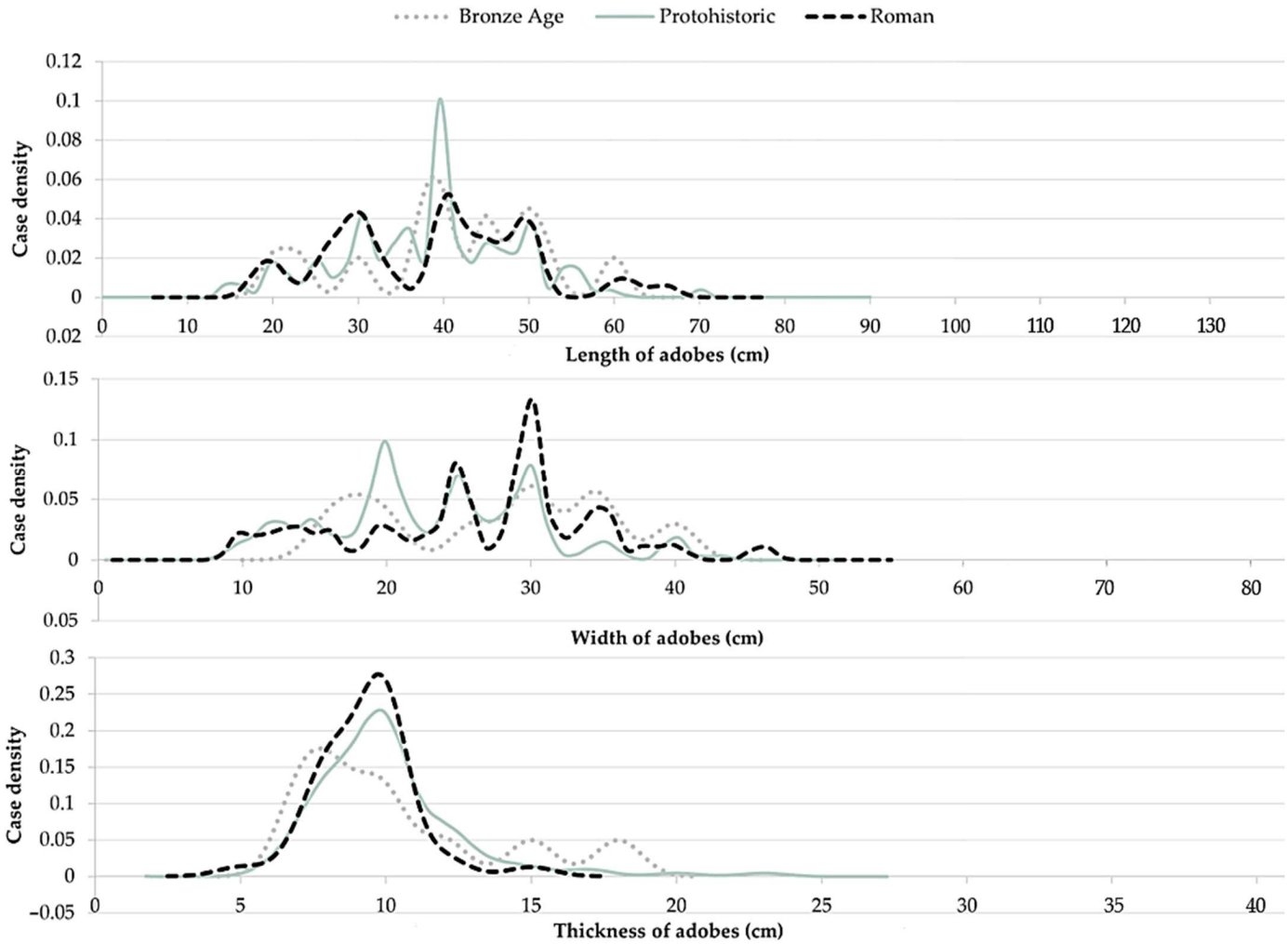
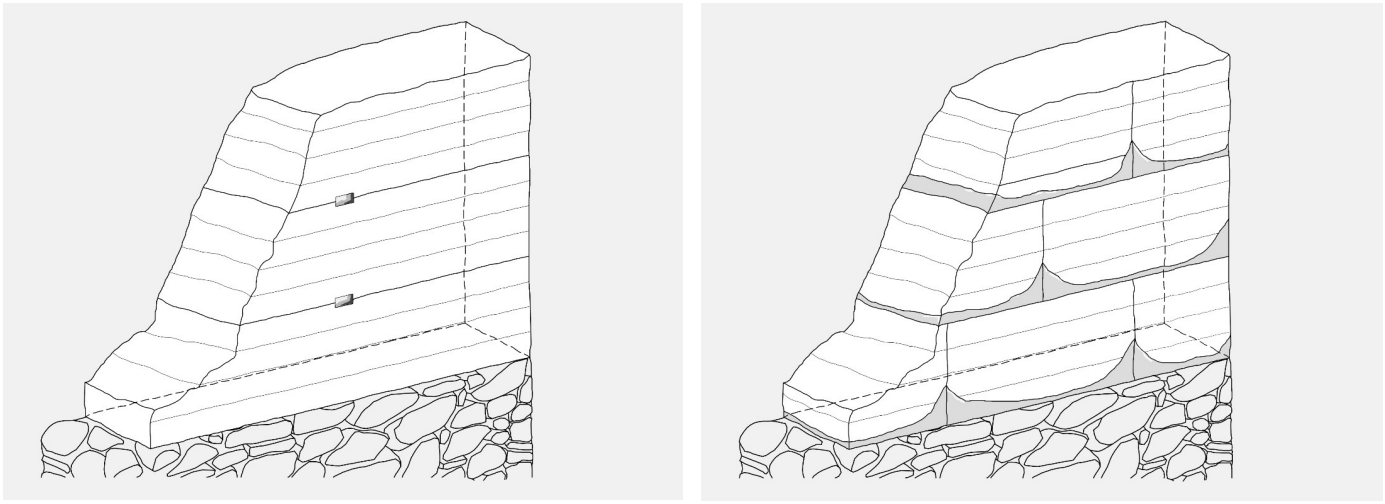


Figure 13. Most probable lengths, widths and thicknesses according to kernel density estimations of the different case studies.

Rammed earth (*pisé* or *tapia*), the result of using a rammer to compact layers of earthen elements within a wooden formwork (*tapial*), was conclusively identified on the Iberian Peninsula in the Roman domus in Ampurias [42]. Although its origin is still subject to debate, on an international scale, it can be dated back to the Punic period in Carthage [64]. While the range of subvariants currently known for earthen construction with rammed earth is very high [9], the variability found in the archaeological case studies selected is significantly lower. This includes rammed earth walls in Rábita Califal (Guardamar del Segura, Alicante) (Figure 14a), as well as walls in masonry and gypsum or with gypsum reinforcement, such as those found in the Mosque of Cortijo del Centeno (Lorca, Murcia) and Medina Siyasa (Cieza, Murcia) [65] (Figure 14b).



(**a**) (**b**)

Figure 14. Interpretative variables in case studies: (**a**) simple rammed earth; (**b**) rammed earth with gypsum reinforcement.

According to the sample, 15% of case studies feature at least one historic structure in rammed earth, dated in 9% of cases to the Roman period and in 6% to the Islamic Middle Ages. While the range of metrics is much wider, given the smaller database sample, these structures can be found in a range of 30 to 80 cm in Roman times, peaking between 30 and 50 cm. This metric increased slightly to 100 cm in the Middle Ages, although 50 cm remains be the most common measurement. As these ranges only varied relatively recently, measurements of between 40 and 90 cm can be found in rammed earth constructions in Comunidad Valenciana [66].

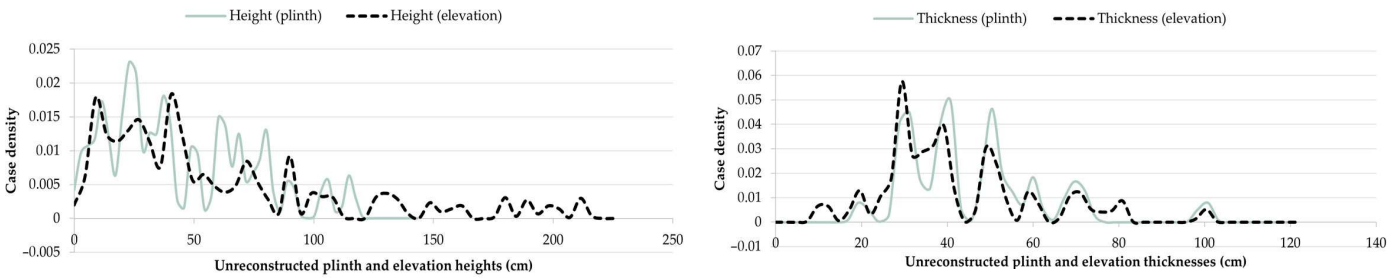
3.2.3. Stabilizing Agents

In 86% of case studies, it was not possible to identify stabilizing agents, as information on their composition is limited by the general lack of microscopic studies on the fragments found. This lack of information can mostly be attributed to much of the prospecting carried out predating the existence of solid professional knowledge of earthen construction. This means that the assessment is currently being called into question, although the widespread use of plant elements in their composition is assumed.

Cases with the confirmed use of stabilizing agents are distributed as follows: plant elements were used in 12% of cases; lime additions in 2%; stones, such as aggregate or other smaller stones, were used in 2% due to the limitations of the moulds or joints. Carbons, ceramic and gypsum are each found in 1% of case studies. It should be noted that according to these studies, no stabilizing agents are found in 1% of the sample, which are composed solely of raw earth.

3.2.4. Complementary Techniques and Materials

According to the case studies, the most common complementary solution was the use of stone masonry. It is found in 86% of the total samples, acting as a plinth or stem wall in 53% of cases, as seen in Casa de los Grifos (Alcalá de Henares, Madrid). However, as documented in 17% of cases, fired brick was also frequently used. Stone masonry was generally found together with other materials from the start of the 1st century BC [13], as confirmed in 1% of plinths from Roman times or later, in El Molinete (Cartagena, Murcia) and Contrebia Belaisca (Botorrita, Zaragoza). This setting is displayed with the same percentages in the opus caementicium, visible in sites such as Els Munts (Altafulla, Tarragona) [67]. Finally, stone slabs are documented in 7% of the sample, specially positioned for thresholds and other systems; while ashlar and timber are each found in 5% of samples, although the latter is not conserved in situ, as mentioned above. Despite mainly being combined with other techniques in plinths, stone slabs are not found in the remaining 46% of cases. This is the case particularly in most domestic furniture and in thinner interior partitions, such as those in la Rábita Califal (Guardamar del Segura, Alicante) [68], where certain types of wall sprang from the ground itself. This absence can be attributed to a number of general factors: the smaller size of elements, material availability, savings or quality of construction. These factors tend to be noticed mostly in the supporting system of the building. For the most part, these plinths are under 100 cm high, with numerous examples of around 50 and 23 cm. Their thickness tends to be in line with the documented elevations, and most of the sample displays thicknesses of between 30 and 50 cm, with peaks at 40 and 50 cm (Figure 15).



(**a**) (**b**)

Figure 15. Characteristics of the most probable plinths according to kernel density estimations in earthen elevations in the different case studies: (**a**) heights; (**b**) thicknesses.

These architectural statistics can also be observed by establishing a direct relation between the construction techniques and their degree of exposure, location, stabilization and complementation. In keeping with the descriptions above, some additional results to be extracted include the higher degree of exposure of rammed earth compared to the total case studies or the notable burial and destruction of cob.

Furthermore, the greater presence of cob in lower sections of walls is in direct correlation to its greater presence in domestic elements, which tend to be low and have no plinth. When examining similar executions in rendering and continuous paving, it can be observed in 92 and 95% of case studies, respectively. In contrast, limited use is made of adobe with no plinth, which appears complemented in up to 89% of the case studies complemented. Its lower presence in rendering and paving of less than 15% should also be noted. Rammed earth is only detected in the execution of walls.

Finally, the proportionally high combination of rammed earth and fired brick in the sample should also be noted, as should the exclusive use of adobe with ashlar and its predominance with flat stone. Although, statistically, the higher number of cases of this technique is also widely complemented with masonry, especially in relation to cob, andthe use of rammed earth is remarkably only 20% lower in the use of these plinths compared to the total case studies selected for the individual techniques (Table 3).

Table 3. List of architectural and construction characteristics in case studies.

Construction Technique	**Sites**		**Visible**		**Buried**		**Collapsed**	
Mixed techniques	6	3.5%	0	0.0%	0	0.0%	6	100.0%
Cob	32	18.8%	12	37.5%	11	34.3%	10	31.2%
Adobe	149	87.6%	68	45.6%	55	36.9%	41	27.5%
Rammed earth	24	14.1%	12	50.0%	10	41.6%	2	8.3%
Compacted earth pavements	82	48.2%	41	50.0%	31	37.8%	22	26.8%
Clay pavements	27	15.8%	11	40.7%	9	33.3%	9	33.3%
Unidentified	1	0.6%	1	100.0%	0	0.0%	0	0.0%
Presence of Earth	**Sites**		**Cob**		**Adobe**		**Rammed Earth**	
Wall elevations	114	67.0%	9	7.8%	102	89.4%	23	20.1%
Wall basing	21	12.3%	4	19.0%	14	66.6%	3	14.2%
Domestic elements	84	49.4%	18	21.4%	71	84.5%	1	1.2%
Production structures	50	29.4%	4	8.0%	46	92.0%	0	0.0%
Funerary structures	12	7.0%	2	16.6%	10	83.3%	0	0.0%
Pavements	100	58.8%	92	92.0%	13	13.0%	0	0.0%
Renderings	61	35.8%	58	95.1%	3	4.9%	0	0.0%
Stabilizing Agents	**Sites**		**Cob**		**Adobe**		**Rammed Earth**	
Plant	20	11.7%	5	25.0%	16	80.0%	4	20.0%
Lime	4	2.3%	1	25.0%	3	75.0%	1	25.0%
Ceramics	3	1.7%	0	0.0%	2	100.0%	1	33,3%
Gypsum	1	0.6%	0	0.0%	1	100.0%	0	0.0%
Small stones	4	2.3%	1	33.3%	2	66.6%	1	33.3%
Carbons	2	1.1%	1	50.0%	0	0.0%	1	50.0%
No stabilizing agents	1	0.6%	0	0.0%	1	100.0%	0	0.0%
Unknown	141	82.9%	23	16.3%	127	90.0%	21	14.8%
Complementary Techniques	**Sites**		**Cob**		**Adobe**		**Rammed Earth**	
Masonry	147	86.4%	6	4.1%	128	87.0%	16	10.8%
Fired brick	15	8.8%	1	6.6%	10	66.6%	4	26.6%
Flat stone or stone slabs	11	6.4%	0	0.0%	10	90.9%	1	9.0%
Ashlar	8	4.7%	0	0.0%	8	100%	0	0.0%

Sites can display different techniques or structures in a single location (elements $\geq$ sites). The percentages for the columns Visible, Buried, Collapsed, Cob, Adobe and Rammed earth are calculated in relation to the subtotal of case studies (Sites column) for each of the characteristics listed.

4. Discussion

The overview of earthen architecture constructions in archaeological sites on the Iberian Peninsula provides a broad variety of case studies and construction techniques. This makes it possible to identify some of the most frequent characteristics, documented separately for their independent and combined examination.

Based on the sample observed, the most common urbanistic profile is that of an isolated context that is neither urbanized nor built up. These are usually found in small mounds in strategic locations and are the result of the material collapse of the habitats and the passing of time. These spaces account for almost a third of the samples, are mostly publicly owned, and are dedicated to exhibition or cultural use. This solution is the main strategy supporting the conservation and operation of these heritage enclaves, which are not suited for residential or administrative use. Another strategy is the re-burial of the remains or granting professionals and academics priority access over the general public, postponing valorization until a later stage. It should be noted that the state of abandonment

or destruction is seen in a fifth of the sample, where preservation is at great risk and the sites may be irrecoverable.

Furthermore, the most common visitable typological profiles on the Iberian Peninsula are those with residential functions, mostly structural (41%) or with fixed furniture (33%). Of these, only 4% are located in the same area as earthen production structures, as in the case of Ampurias (La Escala, Girona). Less than 1% are found together with funerary structures. This expands the joint vision of the general use in different sectors, characteristic of these techniques. It also enables the valorization of finds with mostly independent typologies but with wide distribution across the whole peninsula.

In the specific analysis of structures, in the case studies, the observed earthen techniques are identified in wall elevations, paving and domestic elements. The most prevalent combination is that of uncarved stone plinths over fired brick or ashlar. In addition, there are only a few cases of walls built with earth from the base, something found more frequently in fixed furniture, where it usually springs from the flooring inside the rooms.

The recurring construction techniques have provided information on the different forms of conservation represented. While mixed structure systems are completely lost in situ, reconstructions can be found in smaller geographical settings, clustered in the provinces of Granada (Andalucía) and Soria (Castilla y León) (Figure 16).

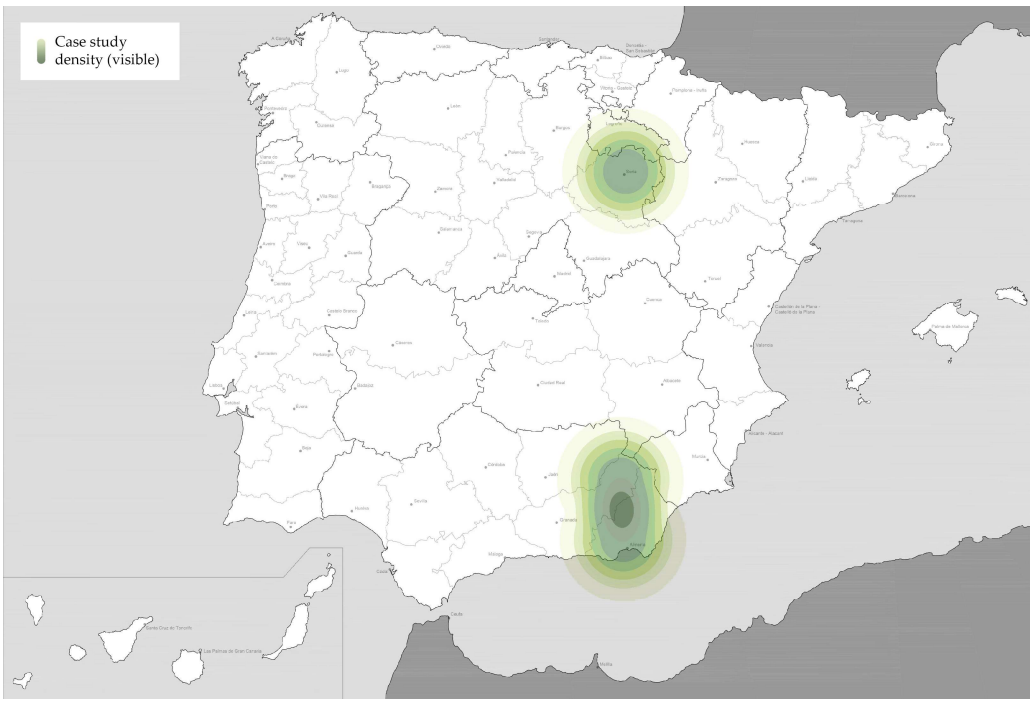


Figure 16. Heatmap showing the density of reconstructed and exposed mixed structure case studies.

In contrast, adobe is widely identified throughout the Iberian Peninsula (Figure 17). In this case, the sample displays a higher density of exposed and visible cases in the Levant, with a greater concentration in Catalonia and Alicante, as well as in other parts of the provinces of Zaragoza, Valencia, Badajoz and Jaén. However, the locations with the highest number of buried structures analyzed in the sample are the provinces of Zaragoza, already mentioned, and Murcia, Madrid, Valladolid and Seville. These are thus concentrated in the central Iberian Peninsula, most notably the valley of the river Ebro or the area surrounding the estuary of the river Segura. Although these elements can remain unaltered thanks to the earthen protection of natural substrate, they entail the introduction of new social risk factors, potentially muting and hindering the dissemination of this knowledge.

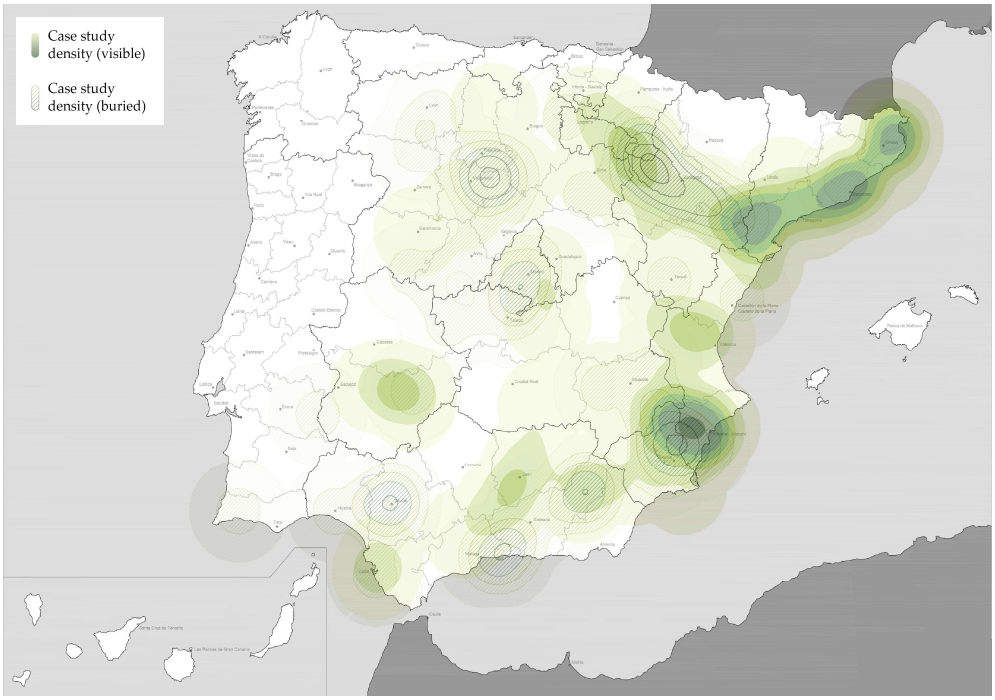


Figure 17. Heatmap showing the density of adobe structure case studies which are exposed, buried or lost.

Cob (Figure 18) and rammed earth (Figure 19) are the second and third most observed categories for monolithic walls, while the first includes indoor fixed furniture featuring no brick constructions. In spite of this, fewer cases of cob walls have been identified, and rammed earth walls are recorded in domestic buildings from Roman times. Although both can provide solutions with a wealth of varied construction techniques, their presence is quite limited, and some variations, such as ball cob or gypsum-reinforced rammed earth, are especially scarce in domestic constructions.

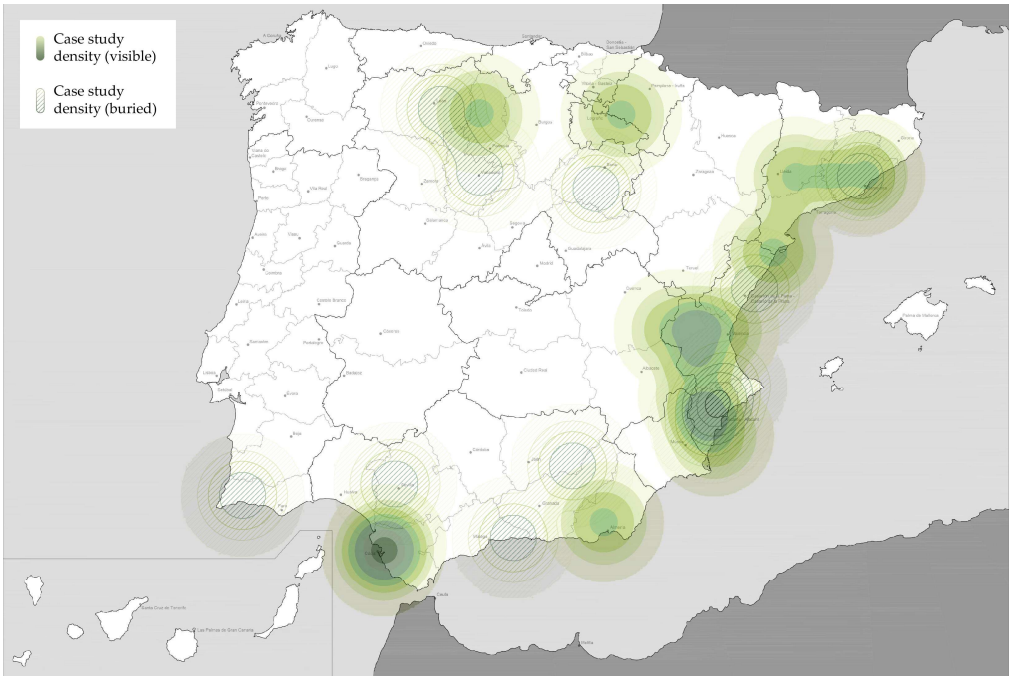


Figure 18. Heatmap showing the density of cob structure case studies which are exposed, buried or lost.

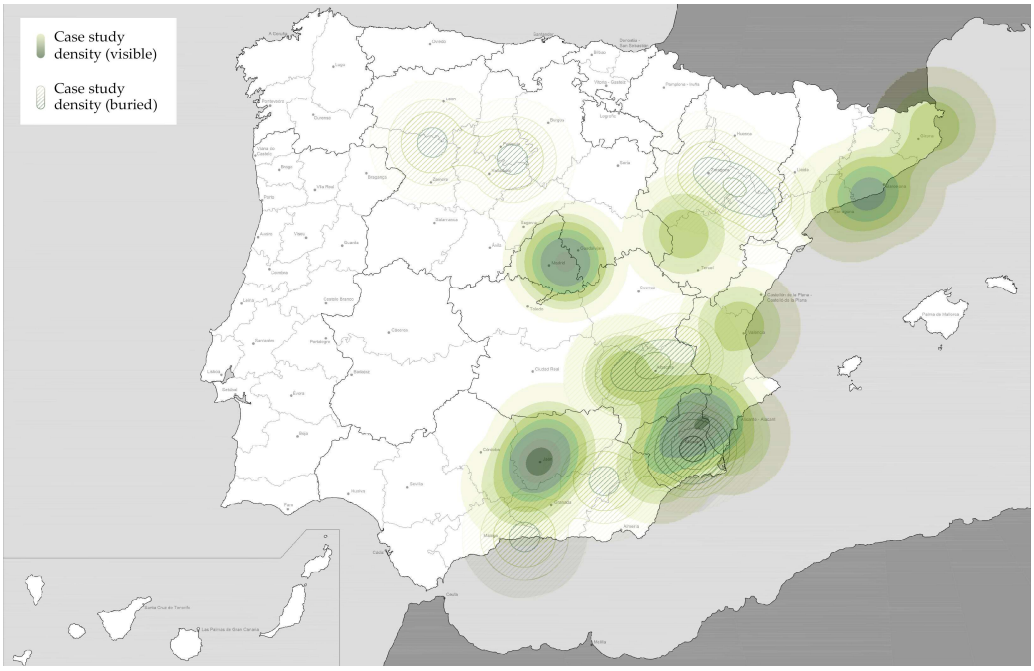


Figure 19. Heatmap showing the density of rammed earth structure case studies which are exposed, buried or lost.

The limitation of the sample and the variability of the fixed furniture also constrain conclusive results in terms of metrics and dimensions, as the main purpose of these was to provide precise answers to individual construction needs. However, peaks have been recorded for 50-cm-thick rammed earth walls in Roman times, while cob walls between 35 and 45 cm thick have also been found.

Adobe is the most frequently found construction technique for the periods and cases consulted. It is overwhelmingly found in the sample, possibly because of standardization in the Iron Age and its practicality and ease of execution. This may also be due to overuse of the term and more straightforward identification of the pieces. Found in all types of bond, adobe is also the only technique used to build kilns combined with the removal of earth from the terrain. This earth is then used to render and construct low walls, pillars or grates. Adobe is far more frequently represented than cob or rammed earth monolithic systems.

Although probability studies seemingly reflect a representative attribution of metrics and dimensions for the different historical periods, no clear distinction has been identified that will allow the use of these characteristics to study the scope and construction traits of particular societies. In general, pieces that are over 30 cm wide and 10 cm thick have been documented from the Roman period, although length barely differs. Protohistoric pieces are considerably longer and broader in relation to the other periods, at times reaching lengths of 40 cm and widths of 20 cm. Case study samples from the Bronze Age show that these pieces, which are between 37 and 50 cm long, are also thinner (around 7 cm). Although width is highly variable, the most common range tends to be 30–35 cm. Nevertheless, given the general high variations in metrics, it is advisable to err on the side of caution. Considering that these chronological variations may not be conclusive but rather just another factor based on construction needs as dictated by individual situations, buildings or pieces of furniture to be executed, this approach becomes significant.

It should be stressed that there is work still to be done in these classifications, conducting microscopic studies, such as micromorphology [69], petrography [70] or XRD [71]. Those are needed to analyze the composition of the different subvariants, including the presence of lime, gypsum or carbon in the original mixes.

In up to four-fifths of the sample, this information is yet to be completed but should enrich the original assumed use of plants. This can often remain unnoticed in macrovisual surveys as the decomposition of fibres caused by water runoff on surfaces during degradation processes leaves spaces that are then filled in.

5. Conclusions

The overview provided in this analysis is a documentary and statistical basis for the current conservation situation of earthen architecture, capable of combining the results and finds in current society. The keen interest in representing this current state of the art in the field of study is motivated by the dispersion of the data, which tend to be managed and presented on a regional or individual basis. After collating different forms of data, information can be handled in GIS, enabling search and filtering tasks to be carried out in relation to context and architectural characteristics.

Although this could be considered a limited sample for the purposes of obtaining correlations in an extremely complex context, a degree of convergence can be observed between case studies. This establishes a solid basis for developing future case studies for risk prevention and minimization. Thus, this type of architecture is characterized as generally isolated, public and mostly involving domestic and productive typologies that can be visible or buried as well as widely developed in protohistory. The construction richness observed sheds light in the different uses and degree of conservation of techniques, such as cob, adobe or rammed earth on the Iberian Peninsula, depending on architectural or technological needs. It also highlights the compromised exposure of certain systems, such as mixed techniques.

Furthermore, a partial response, limited to the selected sample, is provided for the metrics of this type of heritage. Kernel density estimations provide a visual synthesis of thickness probabilities according to the database and also provide brick lengths and widths, identifying major groups by period. Although there is notable interest in the field of archaeology in linking metrics to periods, societies and locations, a single potentially high and variable metric should be borne in mind, as it only answers to the adaptation of constructions according to the needs dictated by the circumstances.

The difficulties of classification and the legacy of the lack of professional knowledge of these types of techniques when studying the past societies of the Iberian Peninsula compromise the accuracy of its scope. The undocumented loss due to the absence of relief measures calls for a growing multidisciplinary involvement in identifying these systems and joining forces to offer new reflections, backed by geographical scope and recurring cases. Likewise, monitoring and reviewing information on systems from different periods has helped update their in-situ implementation and dissemination. Their lack of protection is directly associated with the existence of rapid and intense changes in the state of preservation over short periods of time. This in turn entails the loss or temporary or long-term burial of physical documents in situ.

Reflection on case studies and pressing needs currently presents the main challenge as the tasks of prevention, planning and intervention [72]. The general identification of issues, complemented by the painstaking study of individual case studies, constitute fundamental pillars to be developed in parallel to the suitable characterization, both present and future, of finds based on the new knowledge generated. The consideration of sustainability requirements [73] for this type of heritage, as well as the selection of conservation methods that address the contradiction that stems from retaining authenticity without maintenance, are necessary to its survival. By paying as much attention as possible to minimum interventions, the use of materials analogous to the original ones or recurring surface consolidation can help consolidate and enhance future studies transmitted to coming generations.

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Appendix A. Selected Archaeological Sites as Case Studies

Comprehensive list of selected archaeological sites for general overview with domestic, productive or funerary earthen structures mainly preserved in situ.

Table A1. List of case studies used for the development of this research.

Archaeological Site	Archaeological Site
1. El Amarejo	23. Horno Camp d'en Ventura de l'Oller
2. Libisosa	24. Doña Blanca
3. Tossa de les Basses	25. Horno de la Torrealta y Camposoto
4. Tossal de Manises	26. Puig de la Nau
5. Peña Negra	27. Orpesa la Vella
6. Illeta dels Banyets	28. Cerro de las cabezas
7. El Arsenal	29. Cerro de la Cruz
8. Caramoro I	30.Horno villa romana El Ruedo
9. La Alcudia	31. Turó Rodó
10. El Monastil	32. Mas Castellar
11. La Fonteta	33. Ampurias
12. Rábita Califal	34. Horno Clos Miquel
13. El Oral	35. Illa d'en Reixac
14. Cabezo Redondo	36. Cerro Santuario/Basti
15. Los Millares	37. Cerro Cepero/Basti
16. La Mata	38. Necrópolis de Túgi
17. Casas del Turuñuelo	39. Castellón Alto
18. Casa del Mitreo	40. Cerro de la Virgen

Table A1. *Cont.*

Archaeological Site	**Archaeological Site**
19. Cancho Roano	41. Cástulo
20. Domus Avinyó	42. Vilars d'Arbeca
21. Ca L'Arnau y Can Rodón	43. Casa de los grifos
22. Turó d'en Roïna/Can Taco	44. Casa de Hippolytus
45. El Molinete	93. Castro de las Cogotas
46. Medina Siyasa	94. Turó de la Font de la Canya/
47. Coimbra del barranco ancho	95. Turó del Font del Roure
48. Villa de Los Cipreses	96. Turó de la Florida Nord
49. Mezquita cortijo del centeno	97. Can Roqueta
50. Villa romana de Los Torrejones	98. Bòbila Madurell
51. Villa Romana Piecordero I	99. Horno Sant Vicenç dels Horts
52. Alto de la Cruz	100. Can Vinyalets
53. Horno La Jericó	101. Casa del Sótano-Rauda
54. Villa romana La Olmeda	102. Hornos La Milagrosa
55. Cerro de San Vicente	103. Torrelló de Boverot
56. Numancia	104. Vinarragell
57. Moleta del Remei	105. Mas d'Aragó
58. Villa romana Els Munts	106. Sitjar Baix
59. Tossal del Moro	107. C/Isabel Losa (Córdoba)
60. Calvari el Molar	108. Ercávica
61. Horno de Fontscaldes	109. Los Dornajos
62. Coll del Moro	110. Espinhaço de Cão
63. Castellet de Banyoles	111. Conjunto megalítico de Alcalar
64. Turó del Calvari	112. Ciudad ibérica Ullastret
65. Ciutat Ibèrica de Calafell	113. Alfar La Cartuja
66. El Palao	114. Cerro de La Encina
67. Cabezo de Alcalá	115. El Ceremeño
68. La Caridad	116. Castanheiro do Vento
69. Hornos Mas de Moreno	117. C/Ciudad de Aracena, 10 (Huelva)
70. San Cristóbal	118. Castellones del Ceal
71. Plaza de los moros	119. Puente Tablas
72. La Celadilla	120. La Cabrera
73. Alquería de Bofilla	121. Libia
74. Castellet de Bernabé	122. Hornos de Lancia
75. Los Villares/Kelin	123. Els Missatges
76. Tossal de Sant Miquel-Edeta	124. C/Hospital Viejo (Logroño)
77. Bastida de les Alcusses	125. El Pelícano
78. Tos Pelat	126. C/Santa Juana (Cubas de la Sagra)
79. Lloma de Betxí	127. Loranca (Fuenlabrada)
80. Cerro de La Mota	128. Cerro Redondo

Table A1. *Cont.*

Archaeological Site	Archaeological Site
81. Soto de Medinilla	129. Morro de Mezquitilla
82. Contrebia Belaisca	130. Horno de Arroyo Villalta
83. Bílbilis	131. Poblado de San Telmo
84. Lépida Celsa	132. Acinipo
85. La Oruña	133. Toscanos
86. La Hoya	134. Las Chorreras
87. Alto de Castejón	135. El Castellar
88. La Casa Grande	136. Cementerio islámico de San Nicolás
89. Niuet	137. Castejón de Arguedas
90. Saladares	138. El Castillo
91. Necrópolis de Villaricos /Baria	139. El Castillar
92. Alfar La Rumina	140. Vertabillo el Viejo Breto
141. La Solana	156. Tossal Montañés
142. Alfar de Cauca	157. Cerro de la Mesa
143. Cuéllar (Cuéllar)	158. La Alberquilla
144. C/Juan de Ortega, 24 (Carmona)	159. La Cervera
145. Horno C/Montánchez, 4 (Carmona)	160. Puntal dels Llops
146. Hornos cerámicos de Orippo	161. Las Quintanas/Pintia
147. Cerro Macareno	162. Castro El Pesadero
148. Horno Pajar del Artillo	163. Bursau
149. Las Eras/Ciadueña	164. Loma de los Brunos
150. Casa del acueducto de Tiermes	165. Cabezo de Monleón
151. Sant Jaume	166. Cabezo Muel
152. Puig Roig	167. El Calvario
153. Barranc de la Premsa Cremada	168. Cabezo de la Cruz
154. Horno de l'Aumedina	169. Los Castellazos
155. Alto Chacón	170. Caesaraugusta

Appendix B. Metrics of Case Studies

The metrics used for the various analyses correspond to different instances of data collection in the case studies selected, including reconstructions, and using the bibliography consulted for the sites [8,17,18,22,26,28,33,35,36,42,53,55–63,65,74–168], in combination with compilations and metric studies of original pieces previously carried out for different volumes [36,37].

Table A2. Metrics of length, width and height of different adobes.

Archaeological Site	L	W	H	Source	Archaeological Site	L	W	H	Source
El Amarejo	30	20	10	Broncano, 1985 [74]	Cerro de la Mota	-	35	-	Manzano, 2023 [17]
	40	30	8	Broncano, 1985 [74]		50	-	-	Manzano, 2023 [17]
	45 *	40 *	8 *	Manzano, 2023 [17]		-	15	-	Manzano, 2023 [17]
Libisosa	50	40	9	Uroz et al., 2004 [75]	Soto de Medinilla	38 **	19 **	-	Arnaiz et al., 2017 [83]
	48	38	8	Uroz et al., 2004 [75]	Contrebia Belaisca	40	30	10	Beltrán, 1981 [84]
Tossa de les Basses	50 **	30 **	8 **	Rosser y Fuentes, 2007 [76]		30	20	10	Beltrán, 1982 [85]
Tossal de Manises	40	25	8	Pérez, 2008 [77]		50	30	8	Beltrán, 1981 [84]
	40	35	8	Pérez, 2008 [77]	Bílbilis	29	10	8	Uribe, 2006 [8]
	40 *	30 *	8 *	Manzano, 2023 [17]		40	35	10	Manzano, 2023 [17]
Peña Negra	30	-	10	González, 1983 [78]	Lépida Celsa	31	-	10	Beltrán, 1991a, b [86,87]
	40 *	30 *	8 *	Manzano, 2023 [17]		26	-	7	Beltrán, 1991a, b [86,87]
	38 *	32 *	9 *	Manzano, 2023 [17]		45	30	10	Manzano, 2023 [17]
Illeta dels Banyets	40	-	10	Olcina et al., 2009 [79]	La Hoya	50	25	10	Llanos, 1974 [88]
	55 *	34 *	9 *	Manzano, 2023 [17]		30	20	10	Llanos, 1974 [88]
La Alcudia	19	14	9	Ramos, 1983 [80]	La Casa Grande	30	17	9	Broncano et al., 1988 [89]
	50 *	30 *	12 *	Manzano, 2023 [17]		36	22	-	Broncano et al., 1988 [89]
El Monastil	45 *	30 *	9 *	Manzano, 2023 [17]	Saladares	35 **	-	8 **	Arteaga et al., 1979 [90]
La Fonteta	40	32	9	Rouillard et al., 2007 [81]	Los Villaricos	55	43	10	Astruc, 1951 [91]
	55	30	9	Rouillard et al., 2007 [81]	Castro de las Cogotas	40	20	10	Menéndez, 2010 [92]
	36.5	28	9	Rouillard et al., 2007 [81]	Bòbila Madurell	30	21	17	Miret, 1992 [93]
El Oral	30	20	10	Abad et al., 1993 [37]	Casa del Sótano	20	11	9	Abarquero et al., 2012 [94]
	40	30	-	Abad et al., 1993 [37]		22	12	10	Abarquero et al., 2012 [94]
	50	40	-	Abad et al., 1993 [37]	Hornos La Milagrosa	30	16	10	Bernal et al., 2004 [35]
La Mata	38	19	10	D74/2020, 2021 [82]		21	12.5	10	Bernal et al., 2004 [35]
	50	25	12	D74/2020, 2021 [82]	Vinarragell	45	40	12	Mesado et al., 1979 [95]
	40 *	20 *	10 *	Manzano, 2023 [17]		60	30	7	Mesado, 1974 [96]
Casas del Turuñuelo	40	20	-	Rodríguez et al., 2017 [61]	C/Isabel Losa	-	20 **	8 **	Ruiz, 2003 [97]
	55	40	8	Celestino et al., 2016 [53]					

Table A2. *Cont.*

Archaeological Site	L	W	H	Source	Archaeological Site	L	W	H	Source
Cancho Roano	48	35	9	Celestino et al., 2016 [53]	Alfar La Cartuja	25	14	10	Moreno et al., 2017 [108]
	37	29	6	Hernández et al., 2000 [55]		27	16	12	Moreno et al., 2017 [108]
	48	35	9	Manzano, 2023 [17]	El Ceremeño	-	15	10	Cerdeño et al., 2002 [109]
Domus Avinyó	28	-	8	Huertas, 2017 [98]		32	22	-	Cerdeño et al., 2002 [109]
	20	12	9	Vilardell, 2006 [99]		20	20	-	Cerdeño et al., 2002 [109]
Ca L'arnau/ Can Rodón	42 **	29 **	-	Martín, 2002 [100]	C/Ciudad de Aracena	58	40	10	Prera et al., 2003 [110]
Turó d'en Roina	47 **	27 **	10 **	Chorén et al., 2007 [101]		32	20	10	Prera et al., 2003 [110]
	45	25	-	Manzano, 2023 [17]	La Cabrera	30	30	10	Moreno et al., 1996 [63]
Hornos Torrealta y Camposoto	40 **	20 **	11 **	Sáez, 2008 [102]		62	33	8	Moreno et al., 1996 [63]
Puig de la Nau	25	12	10	Gusi et al., 1995 [103]	Libia	40	-	9.5	Marcos et al., 1979 [111]
	25	12	17	Gusi et al., 1995 [103]		31	-	10	Marcos et al., 1979 [111]
	37 *	28 *	11 *	Manzano, 2023 [17]	Els missatges	45	30	-	Badias et al., 2002 [112]
Orpesa la Vella	40	-	10	Gusi et al., 2014 [104]		35	15	-	Badias et al., 2002 [112]
Cerro de las cabezas	30	20	10	Vélez et al., 1987 [105]		25	14	12	Badias et al., 2002 [112]
	40 *	20 *	10 *	Manzano, 2023 [17]	C/Hospital Viejo	60	30	-	Martínez, 2013 [113]
Cerro de la Cruz	50	30	10	Manzano, 2023 [17]		40	28	15	Martínez, 2013 [113]
	41	34	10	Vaquerizo et al., 1994 [106]	El Pelícano	41 **	28 **	8 **	Juan, 2013 [114]
	26	19	12.5	Vaquerizo et al., 1994 [106]	C/Santa Juana	34 **	25 **	-	Juan, 2013 [114]
	35	32	8	Vaquerizo et al., 1994 [106]	Loranca	50 **	30 **	-	Juan, 2013 [114]
Horno El Ruedo	66	33	7	Muñiz, 2001 [33]	Cerro Redondo	47	25	7.5	Blasco et al., 1985 [115]
	30	10	5	Muñiz, 2001 [33]		40	30	-	Blasco et al., 1985 [115]
	66	33	7	Manzano, 2023 [17]		55	25	-	Blasco et al., 1985 [115]
Turó Rodó	40 *	22 *	10 *	Manzano, 2023 [17]	Morro de Mezquitilla	52	36	12	Díes, 2001 [116]
Mas Castellar	50	30	-	Pons et al., 2016 [56]		40 **	-	-	Schubart, 1985 [117]
	25	25	6.5	Pons et al., 2016 [56]	Horno Arroyo Villalta	33	30	10	Fernández, 2010 [118]
	35	25	9	Pons et al., 2016 [56]	Toscanos	40	20	12	Díes, 2001 [116]
Ampurias	44	22	9	De Chazelles, 1990 [42]	Las Chorreras	20	12	3	Aubet, 1974 [119]

Table A2. *Cont.*

Archaeological Site	L	W	H	Source	Archaeological Site	L	W	H	Source
Illa d'en Reixac	35 **	25 **	8 **	Martín et al., 1999 [107]	El Castellar	50	35	18	Ros, 1989 [120]
Cerro Cepero	30	15	7	Adroher, 2019 [121]		48	28	10	Ros, 1989 [120]
	40	40	-	Adroher, 2019 [121]		40	22	10	Ros, 1989 [120]
	45	30	7	Adroher, 2019 [121]	Castejón de Arguedas	40	19	-	Castiella et al., 2002 [28]
Necrópolis de Túgugi	60	30	20	Rodríguez, 2008 [26]		50	27	-	Castiella et al., 2002 [28]
	40	30	10	Rodríguez, 2008 [26]		31	29	7	Bienes, 1994 [130]
Cerro de la Virgen	37.5 **	18 **	-	Schüle et al., 1966 [122]	El Castillo	40 **	30 **	8 **	Faro et al., 2003 [58]
	20 **	20 **	-	Schüle et al., 1966 [122]	El Castillar	42.5	25.5	10	Fonseca et al., 2021 [131]
	28 *	21 *	-	Manzano, 2023 [17]		40	12	14	Castiella, 1987 [132]
Cástulo	-	50	-	Manzano, 2023 [17]		40	30	15	Castiella, 1987 [132]
	-	60 *	-	Manzano, 2023 [17]	Vertavillo el viejo Breto	32	12.5	12.5	Abarquero et al., 2006 [133]
Vilars d'Arbeca	39 **	20 **	-	G.I.P, 2005 [123]		20	13	11	Abarquero et al., 2006 [133]
	37 *	35 *	8 *	Manzano, 2023 [17]		15	13	9	Abarquero et al., 2006 [133]
Coimbra del barranco ancho	40	20	10	Molina et al., 1976 [124]	Alfar de Cauca	44	19	8	Blanco, 1992 [134]
	60 *	40 *	10 *	Manzano, 2023 [17]		47	20	9	Blanco, 1992 [134]
Piecordero I	50 **	25 **	-	Gómara et al., 2020 [125]	Cuéllar	42	22	7.75	Barrio, 1999 [135]
Alto de la Cruz	40	20	10	Maluquer et al., 1986 [62]		28	14.5	8.5	Barrio, 1999 [135]
	-	28	-	Maluquer et al., 1986 [62]	C/Juan de Ortega	42	-	10	Gómez, 2003 [136]
	-	23	10	Maluquer et al., 1986 [62]		50	-	10	Gómez, 2003 [136]
Horno La Jericó	40	30	10	Ayto. H. de Pisuerga, 2020 [126]	Horno C/Montánchez	60	25	10	Cardenete et al., 1991 [137]
	-	30	8	Manzano, 2023 [17]	Cerro Macareno	49	26	8	Pellicer et al., 1983 [138]
Cerro de San Vicente	40 **	20 **	-	Blanco et al., 2022 [22]		52	34	-	Pellicer et al., 1983 [138]
	26 **	24 **	-	Blanco et al., 2022 [22]	Horno Pajar del Artillo	42 **	35 **	10 **	Luzón, 1973 [36]
Numancia	40	-	12	Mélida, 1908 [127]	Casa del acueducto	47	23	8	Argente et al., 1994 [139]
	45	-	12	Mélida, 1908 [127]		27	19	12	Argente et al., 1994 [139]
	40 *	-	9 *	Manzano, 2023 [17]	Horno de l'Aumedina	30	22	10	Pérez y Rams, 2010 [140]
Moleta del Remei	25 *	25 *	9 *	Manzano, 2023 [17]	Alto Chacón	30	27	7	Atrián, 1976 [141]
Els Munts	50 **	-	-	Tarrats, 1997 [128]	Tossal Montañes	22	12.5	10	Moret, 2001 [142]
Tossal del Moro	36	22	13	Arteaga et al., 1990 [129]		22	10.5	8	Moret, 2001 [142]
	35	20	8	Manzano, 2023 [17]	Cerro de la Mesa	24	20	10	Charro et al., 2009 [143]
	45	28	9	Manzano, 2023 [17]		33	17	12	Charro et al., 2009 [143]

Table A2. *Cont.*

Archaeological Site	L	W	H	Source	Archaeological Site	L	W	H	Source
Coll del Moro	50	25	13	Rafel et al., 1994 [18]	La Alberquilla	47	27	8	Gutiérrez et al., 2007 [144]
	40	14	14	Rafel et al., 1994 [18]		30	19	8	Gutiérrez et al., 2007 [144]
Castellet de Banyoles	55 **	28 **	-	Sanmartí et al., 2012 [60]		44	27	8	Gutiérrez et al., 2007 [144]
	35	25	10	Vilaseca, 1949 [145]	La Cervera	28 **	25 **	7 **	López et al.,2013 [153]
Turó del Calvari	35	18	12	Manzano, 2023 [17]	Puntal dels Llops	40	30	9.5	Bonet et al., 1984 [59]
Calafell	48	24	10	Pou et al., 1995 [146]		30	20	10	Bonet et al., 1984 [59]
	30 *	15 *	8 *	Manzano, 2023 [17]	Las Quintanas/Pintia	47	20	10	Gómez et al., 1993 [154]
El Palao	38	28	9	Melguizo et al., 2021 [147]	El Pesadero	54	24	-	Misiego et al., 2013 [155]
	40 *	23 *	8 *	Manzano, 2023 [17]		44	21	-	Misiego et al., 2013 [155]
Cabezo de Alcalá	40	25	15	Beltrán, 1976 [148]		19	16	-	Misiego et al., 2013 [155]
La Caridad	44	30	10	Herce et al., 1991 [149]	Bursau	30	30	15	Royo et al., 1981 [156]
	-	30 *	-	Manzano, 2023 [17]		40	20	10	Royo et al., 1981 [156]
Mas de Moreno	35	20	8	Manzano, 2023 [17]	Loma de los Brunos	16	9	7	Eiroa, 1982 [157]
San Cristóbal	36	22	9	Fatás et al., 2005 [150]	Cabezo de Monleón	38 **	-	7 **	Beltrán, 1962 [158]
	46	17	17	Fatás et al., 2005 [150]		45 **	-	15 **	Beltrán, 1962 [158]
	40	15	15	Manzano, 2023 [17]	Cabezo Muel	40	26	9	Zapater et al., 1989 [159]
Plaza de los moros	28 *	20 *	9 *	Manzano, 2023 [17]		33	15	10	Zapater et al., 1989 [159]
La Celadilla	40	28	13	Manzano, 2023 [17]	Cabezo de la Cruz	31	20	10	Picazo et al., 2009 [160]
Castellet de Bernabé	45	33	10	Guérin, 2003 [151]		43	20	10	Picazo et al., 2009 [160]
	40	30	8	Guérin, 2003 [151]	Los Castellazos	15	10	8	Maestro et al., 1991 [161]
	40 *	30 *	10 *	Manzano, 2023 [17]		45	25	10	Maestro et al., 1991 [161]
Los Villares	35 **	25 **	8 **	Mata et al., 1991 [152]	Caesaraugusta	50	30	10	Galve, 1987-88 [162]
	40 *	30 *	9 *	Manzano, 2023 [17]		18	-	10	Galve, 1996 [163]
Tossal de Sant Miquel	35	30	8	Bonet, 1995 [57]	Bastida de les Alcusses	40	30	10	Bonet, 2011 [164]
	31	15	11	Bonet, 1995 [57]		35	25	12	Fletcher et al., 1965 [165]
	27	20	10	Bonet, 1995 [57]		40 *	30 *	10 *	Manzano, 2023 [17]

* Measurements from in situ reconstructions of the case studies. ** Metric approach drawn up by the manuscript authors based on original graphic documentation.

Table A3. Metrics of length, width and height of different rammed earth structures.

Archaeological Site	L	W	H	Source	Archaeological Site	L	W	H	Source
Rábita Califal	-	37	-	Manzano, 2023 [17]	Calafell	-	50	-	Manzano, 2023 [17]
Cerro de la Cruz	-	70 **	-	Manzano, 2023 [17]	La caridad	-	46	-	Herce et al., 1991 [149]
Ampurias	-	50	-	De Chazelles, 1990 [42]	Alquería de Bofilla	-	47.5	-	Manzano, 2023 [17]
	-	45	-	Manzano, 2023 [17]	Los Dornajos	-	100 **	-	Galán, 2016 [166]
Medina Siyasa	-	80	-	Navarro et al., 2011 [65]	Cementerio de San Nicolás	-	45 **	-	Navarro, 1985 [167]
	-	65	-	Manzano, 2023 [17]	Casa de los grifos	-	30	-	Manzano, 2023 [17]
	-	30	-	Manzano, 2023 [17]	Libisosa	-	40 **	45 **	Uroz, 2006 [168]

** Metric approach drawn up by the manuscript authors based on original graphic documentation.

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