Abstract

Almost unparalleled inside Portugal and akin only to neighbouring Spanish Extremadura, the incorporation of vertical brick vaults and timbrel vaults is a distinguishing feature of even the most common housing types in inner Alentejo. Research based on *in loco* architectonic and photographic surveys in four inner Alentejo cities combined with analysis of archive documentation from the 20th and 16th–18th centuries has produced data on the usage and types of vaults, including identification of the various types and geometries employed. This research proposes a chronology of vault construction in housing, indicating a likely beginning in the 17th century and its proliferation during the 18th century. Besides presenting the results, this paper examines various hypotheses to explain the transfer of an erudite technique into traditional housing by contextualising the historic and constructive moment of the Early Modern Age in Alentejo, with urban transformation due to warfare and consequent fortification.

keywords:

TRADITIONAL HOUSING
VAULT
VERNACULAR CONSTRUCTION TECHNIQUES
TYPOLOGICAL STUDY
HERITAGE VALUES
ALENTEJO
EARLY MODERN AGE

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The incorporation of vaults in the traditional housing of the inner Alentejo

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Introduction

This paper addresses the inclusion of brick vaults inside the traditional urban house of the Alentejo, Portugal. The data was gathered within the scope of a research project dedicated to traditional urban housing of the Alentejo region, carried out between 2017 and 2022.[1] The data recorded also includes many other housing type related techniques, materials and information that enables the study of these vaults within the framework of the Alentejo's traditional housing and its respective evolution, thereby enhancing our understanding of the relationship between vault construction and other aspects of house construction in Early Modern Age Alentejo. The project's results were partially published in 2019, 2021 and 2022. The current paper adds new information to the 2021 and 2022 papers, namely additional cases in the city of Borba and archival data not presented in 2021.

This paper focuses on specific data regarding vaults found in Alentejo's common housing and presents hypotheses to be explored regarding their dissemination in the vernacular context. In this text, the terms 'vertical brick vault' and 'timbrel vault' will be applied to differentiate, respectively, between the curvilinear self-supporting structures built with bricks adjoining at their wider face ('vertical bricks'), and those with bricks placed with their wider side facing the inner surface of the curve ('horizontal bricks'). Nevertheless, when referring either to the broader category of tiled self-supporting ceilings or when the construction system is unclear or unidentified, such structures are referred to simply as 'vaults'.

[1] Financing from Fundação para a Ciência e Tecnologia (FCT), Portugal (SFRH/BD/116130/2016).

Ever since the records produced by the *Inquérito à Arquitectura Popular em Portugal* [Survey of Popular Architecture in Portugal] (Keil do Amaral et al. 1961), vertical brick vaults and timbrel vaults have been perceived as a prominent characteristic of traditional housing in the inner Alentejo. Nevertheless, the differentiation between each particular type of vaulting system is hardly ever provided in either the bibliography or historical documentation, thus hindering efforts to define the geographical scope and dating of vertical brick vaults and timbrel vaults. While some authors, such as Ribeiro (1961), indicate that we may trace vaulting techniques back to Roman times, there is still no actual evidence of recourse to brick vaults in common dwellings prior to the Early Modern Age (16th-18th centuries). Nonetheless, in erudite housing, vaults appear under roof terraces in the Alentejo region in around the early 16th century (Conde 2011). Over the 16th century, vaults in erudite housing became notably more numerous, a trend which continued into the 17th and 18th centuries. This accompanies a trend towards vaulting specific compartments of these houses, namely the noble spaces and the kitchen, in order to minimise the spread of eventual fires (Caldas 2009). In common housing, the chronology of usage becomes harder to determine, though there is little evidence of vaults in common housing in the neighbouring Algarve region prior to the 19th century (Caldas 2009, Pacheco 2021).

Regarding the particular case of timbrel vaults, their areas of distribution are more restricted than those of the more widely spread vertical brick vaults. On the Iberian Peninsula they have been identified on the Mediterranean shore of Levante, in the Murcia region, in the former kingdom of Aragón (Zaragoza 2012), and in the southwest area of the Guadiana valley. Timbrel vaults are often deemed less erudite than their vertical brick counterparts (Fortea Luna 2009) as they do indeed provide a cheaper solution given that fewer materials are required and the construction process is shorter due to a lack of any recourse to formwork (Santos 2000). Furthermore, their incorporation into religious and erudite buildings in Spain may be traced back to the Medieval Islamic *Shark-Al-Andalus* (Zaragoza 2012) and has been well documented through to contemporary times (Redondo Martínez 2013). Their usage in common domestic buildings has not yet been documented to the same extent.

Even given this perception as a 'second-class' solution (Fortea Luna 2009), the optimisation of costs, materials and construction saw this option become progressively favoured for traditional housing (Rosado 2021). In residential buildings in the region bordering the Guadiana Valley, the application of the traditional vaulting system, with bricks adjoining at their wider face, seems to disappear prior to the emergence of timbrel vaults. Sánchez (2000), Fortea Luna (2003) and López-Mozo et al. (2023) have produced inventories of vertical brick vaults and timbrel vaults across the border region in Extremadura (Spain), highlighting how the study of the technique in the area around the Guadiana Valley necessarily requires a transnational approach.

Nevertheless, these studies do not detail which buildings the vaults were constructed in (Sánchez 2000, Fortea Luna 2003) or record erudite housing (López-Mozo et al, 2023). Carmona Barrero proposes that the timbrel vault technique was imported from Portuguese Alentejo to Spanish Extremadura in around the 19th century by migrant masonry workers (Carmona 2011), a hypothesis the author bases on a study of masonry builder lineages (Carmona 2007). The frequent 19th century recourse to timbrel vaults in common houses in Southern Portugal is recorded in both the Alentejo and the Algarve regions and, in the latter case, at times associated with the regional pitched roofs *'telhados de tesouro'* (Pacheco 2021).

Nomenclature

One of the major issues concerning the study of the vaulting technique derives from the different nomenclature applied both in erudite texts and in popular construction, with variations even occurring in the naming of certain types of vault in accordance with the geographic scope of incidence. The names applied in this article to the different vault types are those registered in the inner Alentejo region and as used by local masons and inhabitants. They are barrel vaults (with *berço* being the Portuguese regional term, with those barrel vaults with very low arches under 120° described as segmental and corresponding to the Portuguese *berço abatido*), groin vaults, lunette vaults and sail vaults. The most difficult to translate was the trough vault,[2] a vault similar to the cloister vault but where the four concave surfaces meet on a horizontal plane instead of at a point as they would in a cloister vault, and which is referred to in Portuguese as *abóbada de engras* and in Spanish as *bóveda esquifada* (*plana*) (Mendez Lloret 2002). Thus, these are the six types of standard vault geometry found in the inner Alentejo. **[Fig. 1]**

Other examples incorporating mixed geometries are harder to label. Some examples blend characteristics of at least two types mentioned above, such as the appearance of lunettes in trough vaults, for example. A further study of cases in the region might eventually allow for the definition of new categories but, in the meanwhile, those cases of eccentric geometries have been assigned to one of the six previously described types. **[Fig. 2]**

We also clearly need to clarify the term 'row'. In this paper, it serves to name the area of a house between two load bearing walls, parallel to the façade. Hence, the front row consists of the rooms adjoining the façade, the second row relates to the first inner compartments, and the third row commonly references the compartments next to the backyard.

[2] Also referred to as a coved vault: 'a vault composed of four coves meeting in a central point, and therefore the reverse of a groined vault'. 'Coved vault'. *Webster's Revised Unabridged Dictionary* (1913). Retrieved 11 July 2024 from https://www.thefreedictionary.com/Coved+vault.

Fig. 1A

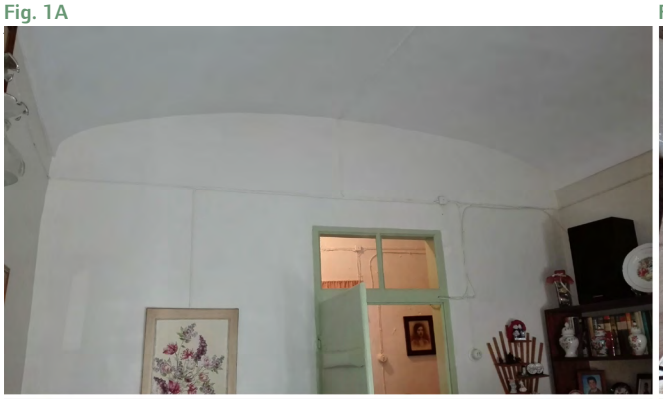

Fig. 1B

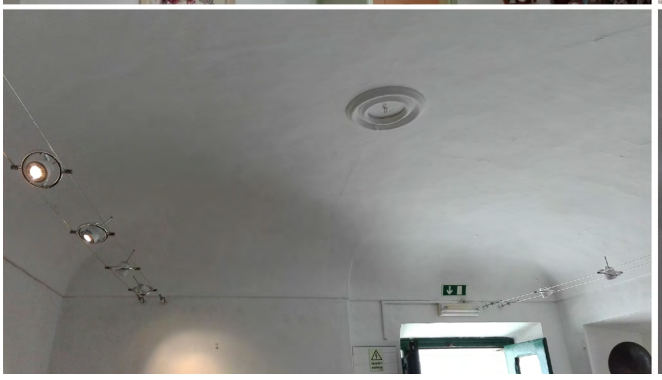

Fig. 1C

Fig. 1D

Fig.1 Examples of four of the vault's geometries described, as seen in the region. **A.** Segmental vault, Rua Magalhães Lima, 77-79, Estremoz; **B.** Groin vault, Rua Dr Garcia Peres, 71, Moura; **C.** Trough or cover vault, Largo D. Diniz, 8, Estremoz; **D.** Lunette vault, Largo D. Diniz, 8, Estremoz. Source: author, 2019-2021.

Fig.2 Uncommon vault geometry found in Rua de S. Pedro 50, Moura. Source: author, 2019.

Fig. 3 Location of the cities of Estremoz, Borba, Moura and Serpa, inside the Alentejo Region in Southern Portugal. Source: author, 2024.

Methodology

While the collection of data on vaulting solutions was not the prime objective of the research project, traditional construction techniques nevertheless represent one of the features of vernacular architecture documented and studied within the scope of traditional housing typologies and their chronologies. The project's methodology combined fieldwork with morpho-typological analysis to correspondingly identify eleven types of traditional urban housing in the Alentejo region. The data was obtained via fieldwork involving architectonic and photographic surveys[3] of houses in four different cities – Estremoz, Borba, Moura and Serpa – all located in the inner Alentejo, in close proximity to the border with Spanish Extremadura and Andalusia. The cities of Estremoz and Borba are part of the sub-regional unit 'Marble Area' and Moura and Serpa are located in the sub-regional unit 'Left Bank of the Guadiana River'. We would duly emphasise that this border has no natural barriers; even the Guadiana River that defines some of its extension is shallow here. Thus, cross-border relationships have always been fluid, with an almost constant movement of people and ideas (Cosme 2000) in a dynamic that is hardly inconsequential to the history of construction techniques. [Fig. 3]

[3] Architectonic survey means measuring the entirety of a building, wall dimensions, angles and heights. In this case, measurements were made with laser meter and then used to produce technical drawings – plans and sections – of the building that register all its constructive elements. They are often accompanied by a thorough photographic register.

The research combined building surveys with documentary research covering both the private construction registers maintained by municipalities – *processos de obras* – and historic archive records from the 17th to 19th centuries. The former documents, municipal records, represent the building permits that include a description of the project, the property's location, one set of technical drawings detailing the existing situation and a second set with the proposed alterations. This information thus generates a complete understanding of the constructive characteristics of buildings alongside more recent alterations. The historic documentation presents descriptions of dwellings in a given time period, sometimes even with dimensions of houses/rooms, and allows for the representation of the evolution in housing and construction from the 1600s/early 1700s onwards, including changes both in the nomenclature and in the functions of compartments/rooms.

The total sample of buildings studied amounts to 507 cases, with 313 obtained from architectonic surveys and 194 from municipality construction permits. Of the latter, 108 buildings included some type of vaulting solution, with their regional distribution set out in **Table 1**. With the exception of two recently surveyed houses in Borba, the buildings studied in the sample, their respective vaults and the indication of the provenience of data, can be consulted in cartographic format, in open access (Rosado 2022).

In Borba, some vaults were identified in houses beyond the scope of the project but taken into consideration in this paper. In all four cities, houses with vaults account for around a fifth of the sample, as shown in **Table 1**. In total, the houses with vaults account for 21.3% of the case study sample.

	Total houses	Houses w/ vaults	% of houses w/ vaults	Vaults
Estremoz	141	29	20.6%	63
Borba	24	9	37.5%	28
Moura	143	30	21%	192
Serpa	201	40	19.9%	167
Total	511	110	21.5%	450

Table 1. Sample sizes for the cities of Estremoz, Borba, Moura and Serpa. Indication of the total number of houses studied, the number of houses identified as containing vaults, the percentage they represent in their samples and the total number of vaults per city.

The historic documentation analysed encompasses books of records [1], the property records of both municipalities and religious organisations [2, 3, 4], and tax inventories [5, 6] from 1626 to 1883, thereby enabling the drafting of an evolu-

tionary line for the traditional house types in the Alentejo from the mid-1600s onwards. In these records, the earliest mention of the construction of vaults inside a common house dates from 1673 [2] in the city of Serpa. The book of property records of the *Santa Casa da Misericórdia* religious institution registers and describes 123 dwellings of which five contained some type of vault. Of the total sample, houses with vaults made up a share of only 4%. In 2018-2019, in the same city of Serpa, the project's surveys registered 201 houses with 40 houses containing vaults – a sample percentage of approximately 20%. This apparent post-17th century spread in the vaulting technique is addressed below in the discussion.
The methodology based on *in loco* direct recollection of data and of primary sources ensures the sample of cases is diverse and, as all building data was registered in the context of the research, can be studied from urban scale to constructive details. Data obtained through other sources may be incomplete or lack the details the research is looking for.

Results

The Marble Area – Estremoz and Borba

The cities of Estremoz and Borba are located in an interior Alentejo sub-region named the Marble Area after a geological anticline formation of marble stone that spans 30 km in length by 10 km wide. Its territorial importance derives from its strategic location both on the ancient Mérida-Lisbon route and on the confluence of several key routes in the southern Portuguese road network. The cities of Estremoz and Borba were located on the second historic line of defence from Spain, protecting the road to Lisbon.
Traditionally, housing construction techniques included the use of marble stone for door and window frames but also alongside stone masonry for erecting load-bearing walls, almost always 60 cm thick. Besides stone, ceramics constituted a fundamental piece to this ensemble, whether applied in the form of brick, thin floor tiles or as semi-cylindrical roof tiles. Bricks served for masonry, often combined with stone, and almost always applied in the framing of doors and windows. Floor and roofing structures were often made out of timber beams and joists covered by thin tiles of approximately 30 x 15 cm, or, in the case of roofs, by roof tiles. Even if timber is the most common solution to structure upper floors, vaults are easily found, particularly over ground floors in the central and commercial areas of the cities.
In the Marble Area, the vaults identified were of the groin, trough, barrel and segmental types. There was only one sail vault registered in Estremoz and three vaults

Fig. 4 Vault in the entrance hall in Borba, Rua Marquês de Marialva 1. Source: author, 2022.

akin to the lunette type reported in Borba, which explains the classification of these two types as rare. These vaults, akin to lunettes, display eccentric geometries that resemble the intersection of a large groin vault with smaller lunettes, while not ascribing to the room's geometry, as represented in Fig. 4. The largest number of vaults are found at ground floor level (52 out of 62 in Estremoz and 2 out of 24 in Borba) and mainly located in the front divisions of the respective residences. These areas of a house are more easily identifiable by outsiders and serve either a social function – as sitting and guest rooms and entrances –, or host trading activities open to the public, such as shops or wine stores. In the former case, the recourse to vaults seems motivated by a display of ornamentation and wealth. In the second, there is a utilitarian character to the purpose of the vaults, that, when combined with arched walls, enable the installation of open space layouts. [Fig. 4]

In Estremoz, the majority of houses with vaults are located either within the castle walls (14 of 29) or in the downtown neighbourhoods of the late 16th century expansion (10 of 29). This duly reflects how the castle and its surroundings are not only the oldest area of the city but also remained the administrative centre until the 18th century. In Borba, 72% of the houses with identified vaults are located in the 17th and 18th century urban expansions, extending along the city's exit routes (Simões 2007). Furthermore, those found in older parts of the city correspond to wine stores. [Fig. 5] [Table 2] [Table 3]

Fig. 5 Borba. Rua Marquês de Marialva 19. Four different ceiling structures in the same ground floor. The second and third compartments are covered by groin vaults; the front compartment shares an almost flat though timbrel vault, and timbrel vaults combined with metallic beams; and the side corridor displays a barrel vault. Source: author, 2024.

ESTREMOZ	*G	T	B	Seg.	L	Sa.	Tot.
Ground Floor	**25**	**7**	**14**	**7**	**0**	**0**	**53**
Front Row	15	4	4	1	0	0	24
Hall	1						1
Shop	3		1				4
Winery	2						2
Multi-use room		3	3	2			8
Sitting room	2		1	1			4
Kitchen		1					1
Garage	4						4
Second Row	4	2	9	1	0	0	16
Corridor			1				1
Circulation			1				1
Shop	1						1
Winery	2						2
Multi-use room		1	3				4
Bedroom	1	1	2				4
Kitchen			2	1			3
Third Row	6	1	1	5	0	0	13
Corridor	2						2
Circulation				1			1
Sitting room	11		1	1			3
Bedroom	2	1		3			6
Kitchen	1						1
First Floor	**1**	**5**	**0**	**3**	**0**	**1**	**10**
Front Row	0	4	0	0	0	0	4
Sitting room		2					2
Bedroom		2					2
Second Row	1	1	0	2	0	0	4
Circulation	1						1
Sitting room				1			1
Bedroom				1			1
Kitchen		1					1
Third Row	0	0	0	1	0	1	2
Bedroom				1			1
Kitchen						1	1
Total	**26**	**12**	**14**	**10**	**0**	**1**	**63**

Table 2. Vault types and distribution in Estremoz. *G – Groin; T– Trough; B – Barrel; Seg. – Segmental; L – Lunette; Sa. – Sail; Tot. – Total. Source: author, 2021.

Table 3. Vault types and distribution in Borba. *G – Groin; T– Trough; B – Barrel; Seg. – Segmental; L – Lunette; Sa. – Sail; Tot. – Total. Source: author, 2021 with updates in 2024.

Borba	*G	T	B	Seg.	L	Sa.	Tot.
Ground Floor	**12**	**4**	**7**	**1**	**0**	**3**	**27**
Front Row	5	2	1	0	0	3	11
Hall	2					2	4
Shop	1	2					3
Winery	2		1				3
Multi-use room						1	1
Second Row	6	2	3	1	0	0	12
Circulation			2				2
Shop	4	2	1				7
Multi-use room	1			1			2
Winery	1						1
Third Row	1	0	3	0	0	0	4
Winery	1		1				2
Multi-use room			1				1
Kitchen			1				1
First Floor	**0**	**0**	**1**	**0**	**0**	**0**	**1**
Bedroom			1				1
Total	**12**	**4**	**8**	**1**	**0**	**3**	**28**

In this area, the incidence of groin and barrel vaults clearly predominates. Shops and rooms without any specific assigned use (multi-use rooms) account for those most frequently covered with vaulted ceilings. It is further worth mentioning the inclusion of vaults in kitchens, which often feature simple and unornamented vaults, with the barrel and segmental types emerging as the most common.

The building of vaults in non-residential spaces accounts for 1/6 of the total cases in Estremoz, while in Borba, the sum of working compartments such as shops and wine stores totals 16 cases of vaulted spaces out of a total of 28, reflecting the prevalence of vaulting in non-residential areas. Vaults are deployed in combination with brick arches with the goal of achieving wide open spaces to serve as wine stores, such as the example at Rua dos Banhos, 1, with 90 m^2 area of unrestricted space. [Fig. 6]

The left bank of the Guadiana River – Moura and Serpa

The area designated as the Left Bank of the Guadiana Region constitutes that area comprised by the border between Portugal and Spain, across the Sierra Morena

Fig. 6 Estremoz, Rua dos Banhos 1. Former open-plan winery. Plan and photographs, 2018. Source: author, 2018.

and the course of the Guadiana River. The Guadiana River defines the border between the two countries from Badajoz to Mourão, and then again from Pomarão to the river mouth in Vila Real de Santo António. Between Mourão and Pomarão the river enters Portuguese territory, and the border is primarily terrestrial. Unsurprisingly, the Portuguese Left Bank of the Guadiana was prone to instability and sovereign disputes ever since the drawing of the border in the 13th century (Cosme 2000). The notion of disputed lands would prevail in the name *Contenda* (dispute) used for the zone around Noudar. Later, the War of Restoration (1640-1668) heightened the level of conflict prevailing in the area and contributed to its depopulation and poverty. While the need for defensive structures would characterise the main cities of Moura and Serpa and their urban planning, the permeability of the border meant not only conflict but also fluid relations between the two sides, reflected in trade, migration and family bonds (Cosme 2000).

The presence of vertical brick vaults and timbrel vaults in southern Alentejo, and particularly on the Left Bank of the Guadiana, has long been documented in conjunction with the greater incidence of vaulting as the means of supporting upper floors, with the contrast prevailing to northern latitudes described in *Arquitectura popular em Portugal* (Keil do Amaral, 1961). Even if the proportion of housing with vaults in the sample is akin to that of the Marble Area, the total numbers of vaults registered are substantially higher. In broad terms, the common urban house of the Left Bank of the Guadiana takes up plots with long and narrow proportions. Both Moura and Serpa display the consequences of successive planned expansions, combined with organic growth along the routes leading out of the cities. Their constructive system is based on load bearing walls of stone and, to a lesser extent, rammed earth. In addition to vaults, wide masonry chimneys are pointed out as another distinctive local feature. **[Table 4]**

Similar to our findings for the Marble Area cases, the largest concentration of vaults appears in Moura in the city's commercial centre, the Arrabalde Novo, originally dating to the 15th-16th centuries, and the city's southern expansion in the 16th-18th centuries, structured around Rua de S. Pedro. It is important to highlight that in Moura the research registered 192 vaults found in 21% of the houses surveyed. In the older medieval neighbourhoods, the application of vaults is barely noticeable (4 vaults in 20 houses), while in the Arrabalde Novo they become standard, with 77 vaults counted only at the ground floor level. Furthermore, different vault and timbrel vault types frequently co-exist inside the same building in keeping with the different ceilings required for different purposes: the barrel and segmental types, for instance, appear linked to deep rectangular rooms, such as corridors, with their dimensions varying from 1.30 to 1.90 m in width and 4.70 to 20.90 metres in depth. Half of the barrel vaults identified (22 out of 41) in Moura cover corridors and circulation spaces.

Moura	*G	T	B	Seg.	L	Sa.	Tot.
Ground floor	**61**	**17**	**36**	**29**	**11**	**5**	**159**
Front Row	30	9	5	11	7	3	65
Hall	8	4	2	2	1	1	18
Corridor	1	1	2	2			6
Shop	6			4			10
Multi-use room	10	2		2	1		15
Sitting room	3	2			1	2	8
Kitchen			1	1			2
Garage	2				4		6
Second Row	20	5	16	11	3	2	57
Corridor			6		1		7
Circulation	9	3	4	3			19
Shop	3						3
Multi-use room	5	1	4	3	1	1	15
Sitting room	1						1
Bedroom	2	1	2	4	1	1	11
kitchen				1			1
Third Row	11	3	15	7	1	0	37
Corridor			4	2			6
Circulation	3	1	3				7
Multi-use room	3	1	4	3	1		12
Sitting room		1					1
Bedroom	1						1
Kitchen	4		3	1			8
Garage/ Stable		1	1			2	
First floor	**10**	**8**	**5**	**5**	**2**	**3**	**33**
Front Row	6	7	2	2	2	0	19
Corridor		1					1
Circulation		1					1
Multi-use room	1					1	
Sitting Room	4	1	2		1		8
Bedroom	2	3		2	1		8
Second Row	3	1	3	2	0	3	12
Corridor			3				3
Circulation		1		2		1	4
Multi-use room					1	1	
Sitting room						1	1
Bedroom	3						3
Third Row	1	0	0	1	0	0	2
Bedroom	1						1
Kitchen				1			1
Total	**71**	**25**	**41**	**34**	**13**	**8**	**192**

Table 4. Vault types and distribution in Moura. *G – Groin; T– Trough; B – Barrel; Seg. – Segmental; L – Lunette; Sa. – Sail; Tot. – Total. Source: author, 2021.

Table 5. Vault types and distribution in Serpa. *G – Groin; T– Trough; B – Barrel; Seg. – Segmental; L – Lunette; Sa. – Sail; Tot. – Total. Source: author, 2021.

Serpa	*G	T	B	Seg.	L	Sa.	Tot.
Ground Floor	**71**	**22**	**14**	**33**	**6**	**1**	**147**
Front Row	32	9	9	5	3	1	59
Hall	8	4	3	3	1	1	20
Corridor			2				2
Shop	10	1	1	1			13
Multi-use room	3	1	3				7
Sitting room	1	2		1	2		6
Kitchen	2	1					3
Garage	8						8
Second Row	29	10	2	17	3	0	61
Corridor				1			1
Circulation	7	3	1	6			17
Shop	6	1					7
Multi-use room	12		1	3	2		18
Sitting room	1	3		3			7
Bedroom	3	3		1	1		8
Kitchen				3			3
Third Row	10	3	3	11	0	0	27
Corridor			3	2			5
Circulation	2	1		3			6
Shop	2						2
Multi-use room		1		2			3
Sitting room	1						1
Kitchen	5	1		3			9
Garage				1			1
First Floor	**5**	**8**	**1**	**0**	**2**	**4**	**20**
Front Row	5	4	0	0	2	3	14
Circulation		1				1	2
Reception/Visits		1			1		2
Sitting room	4	1			1	1	7
Bedroom	1	1				1	3
Second Row	0	2	1	0	0	0	3
Corridor			1				1
Circulation		1					1
Multi-use room		1					1
Third Row	0	2	0	0	0	1	3
Multi-use room		1					1
Sitting room		1					1
Kitchen						1	1
Total	**76**	**30**	**15**	**33**	**8**	**5**	**167**

Serpa provides an equally high number of vaulted ceilings, with 167 cases found in 201 houses studied (19.9%). Unlike the other examples above, in Serpa, the city centre inside the Medieval Wall still remains the administrative and commercial centre of the city, reflected in an almost constant updating of its buildings. The distribution of vaults in Serpa is therefore more heterogeneous than in the previous cases, and there are no immediately noticeably concentrated areas of vaults. The association between barrel and segmental vaults and corridors and circulation spaces also clearly emerges in Serpa, with 45% of the barrel vaults and 36% of the segmental cases constructed for these areas.
The kitchens once again register a greater predominance of simple vaults such as the segmental (6 out of 16). While there are six cases of segmental versus seven groin kitchen vaults, four of the seven groin vaults report to the kitchen in the same erudite house, thereby unbalancing the sample (kitchens otherwise almost always having only one vault). In that same erudite house, one upper floor kitchen features the only sail timbrel vault found in this room typology – Rua de Nossa Senhora, 1. **[Table 5]**

Overall sample

Following analysis of the total sample numbers, we encounter four common vaulting solutions, in addition to two occasional types and sporadic hybrid geometrical applications. The most common type in the sample is the groin vault, by a wide margin, followed by the barrel, trough and segmental types. The lunette and sail types, although not rare, were reported in smaller numbers, even if still accounting for a transversal presence across the study area. **[Table 6]**
The spaces most susceptible to finishing in vaults are those rooms that do not otherwise have a single specific purpose but which can instead hold several functions (90), and sitting rooms (51) for family gatherings and receiving visitors. The spaces dedicated to traversing the house, such as entrance halls (43), corridors (35) and circulation rooms (62) – thus, those rooms with proportions akin to other divisions in the house but without any other function other than passage between areas – are often vaulted and sometimes also decorated with stucco floral motifs. These cases also reflect a correlation between the vault types and the function and shape of their host rooms. The clearest example is the relationship between corridors and circulation rooms with barrel vaults and, to a lesser extent, with segmental vaults. Kitchens are the domestic space where vaulting appears in its simpler forms, with segmental types taking the lead (when overlooking the data imbalance caused by the kitchen in Serpa – Rua de Nossa Senhora, 1). Groin and

Table 6. Vault types per housing compartment. *G – Groin; T– Trough; B – Barrel; Seg. – Segmental; L – Lunette; Sa. – Sail; Tot. – Total. Source: author, 2021.

	*G	T	B	Seg.	L	Sa.	Tot.
Hall	19	8	5	5	2	4	43
Corridor	3	2	22	7	1	0	35
Circulation	22	12	11	15	0	2	62
Shop	36	6	3	5	0	0	50
Multi-use room	37	13	18	14	5	3	90
Sitting room	18	13	4	7	5	4	51
Kitchen	12	4	7	11	0	2	36
Garage	14	0	1	2	4	0	21
Winery	8	0	2	0	0	0	10
Bedroom	16	12	4	12	3	2	49
Reception/Visits	0	1	1	0	1	0	3
Total	**185**	**71**	**78**	**78**	**21**	**17**	**450**

trough vaults are associated with almost square-shaped compartments, regardless of their function. This also establishes a preference for more complex vaulting types in front rooms.

A significant proportion of the vault spaces on the ground floor of these urban houses have served for utilitarian purposes as shops (50), wine stores (10) or spaces nowadays transformed into garages (21). This fact is further highlighted by the concentration of houses with vaults in the commercial areas of the cities studied, such as the main shopping streets or the main squares and their immediate surrounding areas. Houses with vaults are also more common in the areas of these cities that correspond to their 16th-17th century expansions, which would undergo consolidation during the 18th century.

Chronological hypothesis

Traditional processes of architectural transformation, particularly in traditional housing, only ever advance at a slow pace. Many of the construction techniques documented in the surveys made for this research have in effect stood, with little alteration, for centuries. Yet, there are also periods when many simultaneous changes take place and the 17th century in Alentejo is one of those bubbling, breakthrough periods. This characterisation of the 17th century urban house draws

on the historical records of Borba's 'Books of Records' for 1626-35 and 1670-80 (Cartório Notarial de Borba), on the Santa Casa da Misericórdia de Serpa 'Book of Records' of 1673, and on the Council of the City of Estremoz 'Book of Records' of 1674. The later 18th century changes were documented in the City of Estremoz 'Book of Records' of 1746-61 and the Estremoz 1789-1845 tax inventory.

Emerging from these records is an urban house that often mixes residential usage with productive activities, best exemplified in the existence of the wine stores in the Marble Area dwellings and that generally come with a backyard for storing crops, tools, or animals. During the 17th century, the occupation of entire upper floors – unlike the timber mezzanine *sobrados* –, particularly in central urban areas, underwent consolidation and became increasingly common. The second major theme in the transformation of the layout relates to both separating functions and the need to access the back of buildings. During medieval times, house compartments hosted more than one function, with the main prevailing division being that between the tasks ongoing in the public sphere – socialising, hosting, cooking – carried out in compartments adjacent to the front door, and the private sphere, with activities such as sleeping and storage taking place in inner rooms. As the rooms were adjoining, circulation and access to the backyard were achieved via the inner compartments. Early Modern Age records indicate how in houses with adjacent rooms, the existence of two rooms in the second section of the building allowed for the easy introduction of passages to traverse the house without compromising private domestic spaces. In the city of Serpa, historical records (1673) convey how these spaces for circulation resembled the other rooms in shape and dimensions, with a mistake in one house description entry reading '(…) another room that serves as corridor (…).'[4] Over time, the crossing of the house no longer takes place through the 'rooms that serve as corridors', as a new space with the sole function of circulation appears. There is the likelihood that allocating an entire room for circulation began to be perceived as excessive (although this would also always have been combined with other purposes such as storage), and so the need to optimise space may have led to reductions in the width of circulation spaces, thereby adopting a width/length ratio that we today identify as corridor proportions.

In this context of housing transformation, the construction of the upper floors gained in solidity, the average number of rooms in houses grew, and the dwelling layouts became more complex, with the separation of the production and living functions of the building through the introduction of corridors. All these changes drove a greater differentiation among spaces inside the dwellings. As a period of transformation, this nurtured the conditions for experimenting with new construction techniques and solutions. The written records of 1673 – but not those for 1626-1635 – register

[4] AMS/SCMS/M/E1/fl24/n.º 64.

the first mention of the incorporation of vaults into common houses. Out of a sample of 123 houses, there are five mentions of vaults. The first covers half a corridor,[5] while the other half is covered by an upper storey. The second is located over a squared compartment of 4.5 x 4.5 metres, with entrance from the main street, and there is an upper storey over the vault.[6] Two others are in ground floor rooms with upper floors above, and one of the rooms (reference 119) spans 4.5 x 2.75 metres.[7] A fifth is found in a front yard and is referred to as a 'narrow vault', with a 'narrow' storey above it.[8] The geometries of these vaults are never detailed.

Discussion

The open question regarding the building of vaults in common housing remains that of their chronology, particularly the beginning of their construction in domestic environments. The paragraphs above sought to add data to the analysis of this question. With vaults being a feature of erudite architecture, undergoing continuous application in religious buildings, the query remains how and when this erudite technique encroached into the vernacular sphere.

As stated above, the earliest documentary records on the usage of vaulted ceilings in common houses reported by this research study were those in Serpa dating to the year of 1673. Contemplating the construction panorama prevailing in the Alentejo region in those times, one finds a particularly interesting scenario. The second half of the 17th century was impacted by the instability prevailing since the beginning of the War of Restoration (1640-1668) and that would drag on – albeit with varying levels of conflict intensity – until the end of the War of the Spanish Succession (1701–1714). As a border area, and especially as a permeable frontier, the Alentejo region became one of the main stages of conflict. Hence, the last third of the 17th century and all of the 18th century would be marked by continuous construction of and experimentation with military fortifications, hosting large numbers of military construction experts and serving as a field of practice for almost all military engineers in the country (Conceição 2001). Around the same time, the teaching of Military Architecture in Portugal was encouraging the translation of state of the art foreign works and the development of Portuguese manuals, such as the 1660 presentation of João Nunes Tinoco's calculation tables for the building of vaults *Taboadas gerais para com facilidade se medir qualquer obra do officio de pedreiro, assim de cantaria como de alvenaria, com outras varias curiozidades da geometria pratica* (Pacheco 2021). In ensuing the adaptation of former – and now obsolete – fortifications to gun-powder age technological requirements, many constructive advances were implemented alongside the

[5] '(…) uma morada de casas que estão na Rua da Fonte Santa que estão po rcima das casas acima descritas as quais são duas casas térreas e um quintal das quais a dianteira tem de comprido seis varas e de largo três varas folgadas e um corredor tem de comprido quatro varas e meia e de largo duas varas folgadas e tem encima um sobrado que tem metade deste corredor e a outra metade é de abóbada e o quintal tem de comprido nascente e poente catorze varas e de largo cinco varas e terça e tem um poço mistigo às casas de bacho acima descritas (…) serem umas e outras da misericórdia e antigamente andarem ambas em uma e hoje estarem devididas (…) e partem (…) pelo levante com rua publica'. AMS/SCMS/M/E1, fl. 23, nº 60.

[6] '(…) uma casa que serve de sotão e que está metido nas casas que hoje são de Bento de Almeida e tem a porta para a Rua o qual tem de comprido quatro varas folgadas com o mesmo de largo e é de abobada e tem um sobrado por cima que tem a mesma medida e partem da parte do nascente com casas de Bento de Almeida (…) e pela parte norte com rua pública das pedras'. AMS/SCMS/M/E1, fl. 32v, nº 83.

[7] '(…) as casas que estão em quando se vem para o poço da talha em que hoje está um sótão de abóbada com uma alcoba e uma janela em a quina do canto da parede e tem por cima uma varanda de tijolo, digo, uma grade de tijolo e consta outro sim terem sido estas casas foradas antigamente a Pedro Afonso de Sousa em seiscentos Fs.[?] Por natal de cada ano e depois disto se fizeram obras e se puseram no estado em que hoje estão (…)'. AMS/SCMS/M/E1, fl. 43v, nº 113; '(…) uma casa que serve de sótão em umas casas que João de Jorge [?], que estão na Rua do Poço Sameiro o qual tem de comprido norte e sul quatro varas folgadas e de largo duas varas e meia e é de abóbada e tem uma janela para a rua e parte pela parte do norte com Rua Publica do Poço Sameiro'. AMS/SCMS/M/E1,Fl. 47, nº 119.

[8] '(…) uma morada de casas as quais antigamente tinham uma porta por onde se servião para a Rua de João Bocarro Raposo e hoje está tapada e estão as casas metidas em outras que hoje são do

requirement for many structures other than city walls. Some of the equipment necessary to upgrading fortress-cities included headquarters, hospitals, water cisterns, bakeries and barracks. The techniques employed varied from the development of bastions to strategies to optimise space and resources, all detailed in Luís Serrão Pimentel's treatise on fortification *Método Lusitânico de Desenhar as Fortificações* (1680), a key to the theoretical framework of the then contemporary Portuguese military architecture. In this manual, Pimentel often orders the installation of vaults ('strong vaults'), especially in artillery buildings and the recourse to stone vaults for gunpowder storage facilities. Soon, vaults would begin appearing in other fortified buildings.

Barracks deserve a closer look as, given they were designed as lodging units, they shared constructive techniques and materials with the region's traditional housing. Nevertheless, in the spirit of military construction, their design follows a model (which evolved over time) and is based on the repetition of a module with easily and quickly built, standard dimensions (Rosado 2019). One of the early barracks models devised this module as a squared space covered by a barrel vault, and was built in Elvas-Corujeira (1697), Castelo de Vide (1714) and Estremoz-Loureiro (pre-1758). A more refined barracks model, with two storeys, was designed in the second quarter of the 18th century, with examples in Almeida (Conceição 2002) and Moura, where the barrel vaults had become a given feature over the ground floor compartments. Indeed, barracks represent the best example of the juxtaposition of state-of-the-art military engineering advances and the region's prevailing vernacular background, demonstrating how military techniques, such as vaults, could easily be implemented in common buildings – such as housing – throughout the region. **[Fig. 7]**

The large number of masons being trained in these techniques, and throughout such a large span of time, should be taken in consideration when searching for a vector of dissemination for vaulting in the interior border areas of the Alentejo, especially when portraying the overlap between the zones where vaults are more common and where the fortification campaigns focused their greatest efforts. Moreover, according to the written records, the time span between the last third of the 17th century and the beginning of the 19th century coincides with the rise in the number of vaults incorporated into common houses. Taking the city of Serpa as our example, in the book of property records of the religious institution Santa Casa da Misericórdia, a sample of 123 dwellings reports five containing at least some type of vault, resulting in a percentage of houses with vaults in the 1673 sample of 4%. In 2018-2019, the project surveyed 201 houses, of which 40 houses featured vaults – a sample percentage of approximately 20%.

Dr. Antônio da Costa Monteiro e são duas casas térreas e um pátio que antigamente era casa dianteira das ditas casas o qual tem de comprido cinco varas e meia folgadas e de largo quatro varas folgadas e tem este pátio uma abóbada estreita e que toma de comprimento a largura do dito pátio e tem em cima um ourado [?] estrito e tem uma casa que serve de adega dentro deste pátio que tem de comprido quatro varas folgadas e de largo três varas e meia e outra casa que está de bacho da abobada entrando pelo pátio à mão direita tem de comprido três varas e meia e de largo uma vara e duas terças e tem em cima um sobrado que tem a mesma medição e partem pela parte do norte com casas do próprio Dr. (…) nas quais estão metidas (…) e pela parte do nascente com Rua publica de João Bocarro Raposo [Rua do Governador]'. AMS/SCMS/M/E1, fl. 45v, nº 116.

Fig. 7 Barracks in Largo Terreiro do Loureiro. Group view and the inside of one of the modules. Source: author, 2019.

Conclusions

The differences in the percentages of houses containing vaults between the sample gathered from historical records and that resulting from the 2018-2019 survey of the houses of Serpa indicates a very likely dissemination of the construction of vaults in common homes during the 18th and 19th centuries. This increase in number of constructed vaults in common dwellings extrapolates to the other three cities analysed, as – with the exception of Borba, which has a smaller sample of cases – the percentage of houses with vaults in the remainder cities also stands at around 20% in present day samples [Table 1], as is the case in Serpa. The four cities display continuous recourse to these structures during the Early Modern Age, which extends until the middle of the 20th century, especially in domestic buildings located within the commercial or central areas of these cities. These primarily incorporate four main geometries: groin, the most common by a wide margin, followed by barrel, trough and segmental vaults. Lunette and sail vaults, albeit not as common, also appear in the buildings of this region. It is also worth noting that some eccentric geometries appear, interweaving the characteristics of the more common vault types and sometimes not even adjusting to the shape of the compartment they are built in. It is highly likely that these eccentric geometries arise out of recourse to timbrel vaults in keeping with their greater flexibility in creating shapes.

In summary, the study presented here attests to the usage of vaults in common houses in the area of the Left Bank of the Guadiana River from as early as 1673.

The appearance of vaults in common houses in the last third of the 17th century coincides with a period of deep typological and constructive transformation that the urban house was then undergoing. This spanned a process of growth in area, in the number of housing compartments, and in the complexity of houses. Said complexity emerges in the physical separation of the productive household areas and the domestic spaces reserved for family life. The transformation also extends to the introduction of rooms solely dedicated to internal circulation, such as corridors to create paths and separate the passage of animals to the backyard and/or the transportation of crops, wine or olive oil from family living spaces. This separation would eventually lead, in the most commercially active areas of the cities, to the transfer of domestic spaces to the upper floors and thereby freeing the ground floor level – often entirely vaulted – to serve for commercial purposes.

Within this context of housing transformation, several factors certainly appear to explain the introduction of vaults into common housing and their subsequent dissemination, and should be pursued as future lines of research. One important factor within the context of the inland areas of the Alentejo region – bordering Spanish Extremadura and Andalusia – stems from the consequences of hosting major military construction campaigns for over a century. The constant works meant that the Alentejo was home to expert military engineers applying first-hand the innovative military construction techniques developed during the 17th century, such as defensive bastioned structures. Moreover, the constant working on fortifications ensured a regular flow of workers, and many of the region's builders and masons must have learned their trade on the military construction sites. As vaults – both stone and brick – were often employed in the building of fortifications, they would represent one technique military-trained masons were proficient in and likely willing to employ in other works outside the military context. Future research delving into the possibility of knowledge transmission from military construction to common buildings in the Alentejo region should analyse the impact of masonry workers as a vector of transference. A second path to explore vault dissemination inside vernacular housing should contemplate the study of the border area between Alentejo (Portugal), Extremadura (Spain) and Andalusia (Spain) as a whole region, considering the fluxes of trade, migrations and family relations that have been constant in the border area.

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