# Study of the traditional *tabique* constructions in the *Alto Tâmega* region

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## Abstract

*Tabique* constructions can be found almost everywhere in Portugal. In fact, it is one of the most used traditional building techniques using raw materials, such as earth and wood, particularly for interior partition walls. A *tabique* constructive element can be described as a timber structure, more or less complex and robust, filled and plastered on both sides by a composite earth based material. The Trás-os-Montes e Alto Douro region is the northeast region of Portugal where the *tabique* heritage is very vast/the most significant. *Tabique* can be found in many kinds of constructions, from the very simple rural dwellings to more important buildings and constructions, such as castles, villas, etc. Many of the existing *tabique* constructions present an advanced stage of deterioration, partially justified by the maintenance knowledge and practice that has been lost over time about these techniques and their rehabilitation procedures, due to the fast introduction of new materials in the construction. Considering this, research work has been developed with the main objectives of studying the building process of *tabique* construction elements, typifying dimensions of *tabique* walls and their components, and characterizing constitutive materials. Within this research project, it was intended to create a knowledge base that can guide and stimulate future rehabilitation actions in this field. At the first stage, this study was developed at one of the six council associations of the Trás-os-Montes e Alto Douro region, namely the Alto Tâmega. A selected group of constructions,



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representative of the existing heritage in the region, were studied in detail. The results of their characterization can help one to recuperate/recover the practice knowledge concerning this traditional eco-construction technique, supporting the rehabilitation of the existing construction heritage, but also its eventual application in new construction.

*Keywords: sustainability, raw materials, tabique, composite timber-earth construction elements, characterization, rehabilitation.*

## 1 Introduction

The most popular traditional Portuguese building techniques that use earth as a building material are *taipa*, *adobe* and *tabique* [1]. A *tabique* wall is formed by a timber grid-structure filled and plastered on both sides by an earth-based mortar. This research work is focused on the study of the *tabique* technique in the region of *Trás-os-Montes e Alto Douro*. This is the northeast region of Portugal, where this traditional Portuguese building technique has a significant incidence.

Taking into account that the traditional technical knowledge has been lost, and that there is still a lack of scientific studies and work on this subject for the aforementioned region and also that traditional *tabique* constructions show generally an advanced stage of deterioration, this research work is justified, intending to guide and support future conservation and rehabilitation actions on this huge architectural heritage. From preliminary research works [1], it was concluded that due to the diversity of *tabique* solutions and to the size of the region, it would be convenient to divide the above region in sub-regions, making it feasible for this study to be highly supported by field work, understanding the local particularities. Thus, the *Trás-os-Montes e Alto Douro* region was divided into six sub-regions, which are *Alto Tâmega*, *Terra Quente Transmontana*, *Terra Fria do Nordeste Transmontano*, *Vale do Douro Norte*, *Vale do Douro Sul* and *Vale do Douro Superior*. The *tabique* constructions of the *Vale do Douro Sul* sub-region [2] and *Vale do Douro Norte* [3] were already studied and reported. Meanwhile, a study of *tabique* constructions in the sub-regions of *Terra Quente Transmontana* and *Terra Fria do Nordeste Transmontano* are being developed. This research work is related to the sub-region of *Alto Tâmega*. To achieve the objectives of this work, several technical visits to this sub-region were done in order to locate and select representative *tabique* constructions, to collect data on the selected buildings and the related construction details. All the information collected was organized in appraisal worksheets. For each construction studied, material samples were collected, whenever it was possible, for the experimental material characterization.

For this region, it was found that the most common use of *tabique* construction technique was in interior partition walls, but it can also be found in exterior façade walls. The most common solution of the existing *tabique* constructions are detached houses with two floors and, generally, these constructions show an advanced stage of deterioration, which can dangerously develop until the total construction loss. From the research done on the selected representative constructions, it was concluded that the most common materials

used are the *pinus pinaster* for the timber structural elements and earth for the mortars covering the timber structure.

## 2 Municipal Association of *Alto Tâmega* and location of the constructions studied

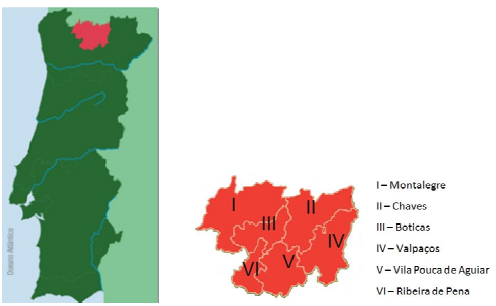
The Municipal Association of *Alto Tâmega* (MAAT), Fig. 1a, is one of the six Municipal Associations that form the *Trás-os-Montes e Alto Douro* region. It has a 2922 km$^2$ area. These six Municipalities of the MAAT are *Montalegre*, *Chaves*, *Boticas*, *Valpaços*, *Vila Pouca de Aguiar* and *Ribeira de Pena*, Fig. 1b. Through this research work it was possible to notice that there are *tabique* constructions all over MAAT. However, it is in the urban centres where it is more commonly find this type of traditional Portuguese construction and, in particular, in *Chaves* city. One hundred *tabique* constructions were used as study cases.

The number of *tabique* constructions that were selected for this study in each Municipality was: 5 in *Montalegre* (constructions #84 to #88); 64 in *Chaves* (constructions #1 to #64); 7 in *Boticas* (constructions #89 to #95); 19 in *Valpaços* (constructions #65 to #83); 4 in *Vila Pouca de Aguiar* (constructions #96 to #99); 1 in *Ribeira de Pena* (construction #100). The number of *tabique* constructions studied in each municipality is proportional to the construction density in the MAAT sub-region. It is evident that the likelihood of finding this type of traditional Portuguese construction is higher in *Chaves* city.

Fig. 2 shows examples of the studied *tabique* constructions, which were in total 100. As can be observed from the images in Fig. 2, a large variety of architectural solutions can be found in the existing *tabique* constructions in MAAT. Fig. 2 also includes the coordinates of the buildings location.

## 3 Description of the *tabique* constructions

As stated previously, in Portugal the *tabique* construction is spread out along different parts of the country. However, this Portuguese traditional construction




a) MAAT`s location b) Municipalities of MAAT

Figure 1: MAAT and its Municipalities.

a) Examples of the constructions studied

| N° of the construction | Latitude | Longitude | N° of the construction | Latitude | Longitude | N° of the construction | Latitude | Longitude | N° of the construction | Latitude | Longitude |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 41° 44' 15,62" | 7° 27' 57,30" | 26 | 41° 44' 19,03" | 7° 28' 04,02" | 51 | 41° 44' 20,47" | 7° 28' 12,40" | 76 | 41° 36' 21,74" | 7° 18' 38,86" |
| 2 | 41° 44 '14,81" | 7° 27' 56,38" | 27 | 41° 44' 19,16" | 7° 28' 04,20" | 52 | 41° 44' 19,69" | 7° 28' 11,65" | 77 | 41° 36' 21,89" | 7° 18' 37,38" |
| 3 | 41° 44' 14,82" | 7° 27' 55,86" | 28 | 41° 44' 19,29" | 7° 28' 04,46" | 53 | 41° 44' 19,87" | 7° 28' 11,04" | 78 | 41° 36' 23,17" | 7° 18' 37,19" |
| 4 | 41° 44' 14,98" | 7° 27' 55,71" | 29 | 41° 44' 19,60" | 7° 28' 04,92" | 54 | 41° 44' 19,66" | 7° 28' 11,59" | 79 | 41° 36' 23,41" | 7° 18' 37,29" |
| 5 | 41° 44' 15,23" | 7° 27' 55,50" | 30 | 41° 44' 16,74" | 7° 27' 59,55" | 55 | 41° 44' 18,95" | 7° 28' 10,59" | 80 | 41° 36' 24,13" | 7° 18' 34,46" |
| 6 | 41° 44' 15,94" | 7° 27' 54,71" | 31 | 41° 44' 16,25" | 7° 27' 58,77" | 56 | 41° 44' 25,87" | 7° 28' 12,85" | 81 | 41° 36' 08,45" | 7° 18' 30,70" |
| 7 | 41° 44' 17,04" | 7° 27' 55,41" | 32 | 41° 44' 19,33" | 7° 28' 06,05" | 57 | 41° 44' 26,04" | 7° 28' 12,69" | 82 | 41° 36' 26,02" | 7° 18' 30,56" |
| 8 | 41° 44' 20,97" | 7° 27' 54,49" | 33 | 41° 44' 19,09" | 7° 28' 06,36" | 58 | 41° 44' 27,06" | 7° 28' 13,61" | 83 | 41° 49' 30,22" | 7° 47' 28,92" |
| 9 | 41° 44' 21,89" | 7° 27' 50,90" | 34 | 41° 44' 18,80" | 7° 28' 06,63" | 59 | 41° 44' 24,35" | 7° 28' 09,06" | 84 | 41° 49' 30,87" | 7° 47' 24,78" |
| 10 | 41° 44' 22,92" | 7° 27' 45,36" | 35 | 41° 44' 18,55" | 7° 28' 06,99" | 60 | 41° 44' 26,23" | 7° 28' 17,29" | 85 | 41° 49' 30,05" | 7° 47' 31,40" |
| 11 | 41° 44' 25,47" | 7° 27' 42,12" | 36 | 41° 44' 19,28" | 7° 28' 06,85" | 61 | 41° 44' 27,28" | 7° 28' 23,18" | 86 | 41° 49' 25,87" | 7° 47' 30,89" |
| 12 | 41° 44' 26,22" | 7° 28' 03,53" | 37 | 41° 44' 19,64" | 7° 28' 06,50" | 62 | 41° 44' 24,17" | 7° 28' 08,79" | 87 | 41° 49' 22,44" | 7° 47' 33,46" |
| 13 | 41° 44' 25,89" | 7° 28' 03,43" | 38 | 41° 44' 20,32" | 7° 28' 06,03" | 63 | 41° 44' 24,54" | 7° 28' 05,87" | 88 | 41° 41' 17,70" | 7° 40' 14,04" |
| 14 | 41° 44' 25,13" | 7° 28' 03,33" | 39 | 41° 44' 20,10" | 7° 28' 05,69" | 64 | 41° 36' 50,20" | 7° 16' 27,98" | 89 | 41° 41' 17,67" | 7° 40' 13,81" |
| 15 | 41° 44' 24,59" | 7° 28' 03,27" | 40 | 41° 44' 19,51" | 7° 28' 06,27" | 65 | 41° 36' 48,48" | 7° 16' 26,87" | 90 | 41° 41' 15,59" | 7° 40' 07,19" |
| 16 | 41° 44' 24,25" | 7° 28' 03,20" | 41 | 41° 44' 19,21" | 7° 28' 08,05" | 66 | 41° 36' 47,53" | 7° 16' 29,73" | 91 | 41° 41' 15,84" | 7° 40' 07,94" |
| 17 | 41° 44' 23,93" | 7° 28' 03,11" | 42 | 41° 44' 16,93" | 7° 28' 09,03" | 67 | 41° 36' 27,30" | 7° 18' 32,01" | 92 | 41° 41' 17,70" | 7° 40' 14,82" |
| 18 | 41° 44' 23,67" | 7° 28' 03,02" | 43 | 41° 44' 17,01" | 7° 28' 09,57" | 68 | 41° 36' 25,92" | 7° 18' 32,32" | 93 | 41° 41' 16,78" | 7° 40' 11,56" |
| 19 | 41° 44' 23,36" | 7° 28' 02,99" | 44 | 41° 44' 17,14" | 7° 28' 09,89" | 69 | 41° 36' 24,42" | 7° 18' 34,52" | 94 | 41° 42' 39,35" | 7° 38' 28,55" |
| 20 | 41° 44' 22,29" | 7° 28' 02,67" | 45 | 41° 44' 17,27" | 7° 28' 10,11" | 70 | 41° 36' 23,36" | 7° 18' 34,47" | 95 | 41° 30' 03,44" | 7° 38' 49,12" |
| 21 | 41° 44' 21,26" | 7° 28' 03,23" | 46 | 41° 44' 18,84" | 7° 28' 12,86" | 71 | 41° 36' 23,73" | 7° 18' 34,81" | 96 | 41° 30' 03,94" | 7° 38' 48,66" |
| 22 | 41° 44' 19,07" | 7° 28' 02,86" | 47 | 41° 44' 19,07" | 7° 28' 13,19" | 72 | 41° 36' 24,04" | 7° 18' 35,15" | 97 | 41° 30' 01,94" | 7° 38' 40,81" |
| 23 | 41° 44' 19,63" | 7° 28' 03,76" | 48 | 41° 44' 21,72" | 7° 28' 15,22" | 73 | 41° 36' 24,23" | 7° 18' 35,31" | 98 | 41° 30' 03,05" | 7° 38' 43,32" |
| 24 | 41° 44' 18,72" | 7° 28' 03,46" | 49 | 41° 44' 21,34" | 7° 28' 15,26" | 74 | 41° 36' 24,52" | 7° 18 35,90" | 99 | 41° 31' 12,44" | 7° 38' 35,88" |
| 25 | 41° 44' 18,88" | 7° 28' 03,78" | 50 | 41° 44' 21,37" | 7° 28' 14,41" | 75 | 41° 36' 24,96" | 7° 18' 38,36" | 100 | 41° 44' 00,99" | 7° 28' 09,63" |

b) Location of the constructions (coordinates)

Figure 2: *Tabique* constructions used as study cases.

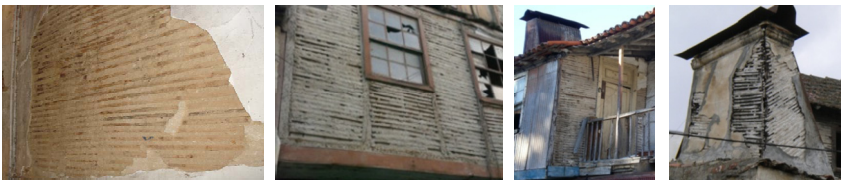
technique is more commonly found in the north and, in particular, in the region under study in this research project. The existing *tabique* construction were built mainly during the XVIII and XIX centuries, and it started to fall into disuse in the beginning of the XX century, when the reinforced concrete and the ceramic bricks were introduced in the construction. The most common structural solution for buildings is composed by external granite stone masonry walls and interior/partition *tabique* walls, Fig. 3a. Meanwhile, building structural solutions using *tabique* in exterior and interior/partition walls for the upper floors can be also found in the region, which is of particular interest for this study, Fig. 3b.

A *tabique* constructive system can be found in several building components or elements such as interior/exterior walls, balconies or even chimneys (see examples in Fig. 4).

Based on the data collected from the one hundred *tabique* constructions used as study cases, Fig. 2, during the fieldwork of this research, it was possible to conclude that: i) An expressive amount of the constructions (about 50%) require a conservation process since they are very deteriorated; ii) Frequently, these constructions are dwellings of 2 floors (about 70%); iii) The adoption of *tabique* walls in the ground floor was normally avoided, in particular, concerning exterior *tabique* walls; iv) White wash, zinc plate, ceramic tiles and slate boards are finishing solution options for exterior *tabique* walls commonly adopted. However, white wash was the finishing option most frequently chosen (65%).


a) Exterior granite masonry walls b) Exterior *tabique* walls

Figure 3: Two examples of *tabique* dwellings.



a) Interior wall b) Exterior wall c) Veranda d) Chimney

Figure 4: Examples of *tabique* building components.

## 4 Characterization of the timber structural system in *tabique* walls

The reported research work done in the framework of this project, mentioned above, show that it is not common to find uniform dimensions of timber elements. From the inspections done, it was observed the typical details, as well as component dimensions, of this type of structural system, schematically represented in Fig. 5. In figure, A represents the width of the vertical timber element, B is the existing gap between vertical timber elements, C is the width of horizontal timber elements, D is the gap between horizontal timber elements, E is the thickness of horizontal timber elements and F is the thickness of the vertical timber elements). For the studied constructions in the MAAT Municipal Association, representative dimensions of these components were collected.

From the studied constructions in the MAAT region, the following average values for the geometry of the *tabique* system were derived: i) for exterior *tabique* walls: A=17.67cm, F=2.10cm, B=2.33cm, C=3.30cm, E=1.67cm, D=3.00cm; ii) for interior/partition *tabique* walls: A=19.00cm, F=1.98cm, B=1.99cm, C=3.53cm, E=1.42cm, D=2.37cm.

Timber samples (10 as a total) were collected during the fieldwork and tested in the Laboratory of the Forest Department, of UTAD University, in order to identify the typical wood species used to build the timber structural system of *tabique* walls. The results obtained indicate that, basically, *pinus pinaster* species was used and, only occasionally *tilia cordata* species was used. It should be stated that these both two species can be abundantly found locally. It was also noticed that these timber samples generally showed a good conservation condition, which indicates that the earth based mortar used as a finishing has a function of biological protection of the timber structural system.

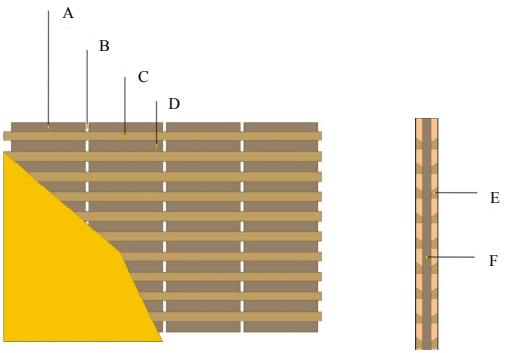



Figure 5: Detail of the typical timber structural system of a *tabique* wall.

## 5 Identification/characterization of the earth-based mortar

Unfortunately, it was only possible to collect mortar material samples in seven of the studied *tabique* constructions. A granulometric analysis was done at the Material and Soil Laboratory, of UTAD, using the mortar samples collected. Examples of analysis results are presented in Fig. 6, which show that the soil typically used for the production of these earth-based mortars in the MAAT region was approximately composed by 80% of sand and 20% of silt and clay.

In order to identify the chemical elementary composition of the earth based mortar samples collected, scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) tests were performed at the Microscopic Electronic Unity of the UTAD. Similar tests have already been done in the framework of other research projects [2] and [3], to characterize the available and used materials for the local traditional earth constructions. The results obtained by the SEM/EDS test are presented in table 1.

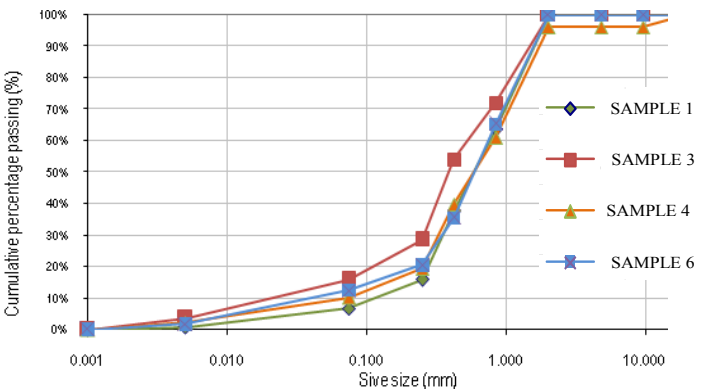



Figure 6: Granulometric curves.

Table 1: Results of SEM/EDS tests.

| Chemical element (%) | Sample # | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Fluorine (F) | -- | 1.95 | 1.19 | 3.01 | 2.93 | 2.60 | 2.48 |
| Sodium (Na) | 0.85 | 0.61 | 0.33 | 1.01 | 0.60 | 1.08 | 1.00 |
| Magnesium (Mg) | 0.99 | 1.15 | 0.51 | 1.52 | 2.20 | 2.78 | 1.07 |
| Aluminium (Al) | 17.58 | 26.59 | 10.86 | 26.96 | 23.71 | 28.45 | 28.67 |
| Silicon (Si) | 30.62 | 58.14 | 82.40 | 48.97 | 50.44 | 45.95 | 54.74 |
| Chlorine (Cl) | 0.47 | 0.14 | -- | 0.20 | 0.53 | 0.46 | 0.75 |
| Potassium (K) | 1.78 | 8.10 | 2.19 | 3.47 | 9.39 | 5.14 | 4.78 |
| Calcium (Ca) | 45.11 | 0.27 | 0.33 | 10.18 | 0.85 | 6.39 | 2.38 |
| Titanium (Ti) | -- | 0.44 | 0.18 | 0.32 | 1.20 | 0.85 | 0.47 |
| Iron (Fe) | 1.93 | 2.56 | 1.62 | 4.22 | 8.15 | 6.30 | 3.11 |
| Copper (Cu) | 0.67 | 0.05 | 0.39 | 0.14 | -- | -- | 0.55 |

The SEM/EDS results obtained confirm that the earth-based mortar used in *tabique* traditional constructions of MAAT is either a natural mixture of sand and clay, since the main chemical elements detected in the samples were Silicon and Aluminium (samples 2, 3, 5 and 7) or an earth based mortar since the percentage of Calcium was detected in an expressive amount in some samples (samples 1, 4 and 6). This last consideration is justified because limestone is uncommon in this region of Portugal, which also indicates that lime was used.

## 6 Main conclusions

In the Municipal Association of *Alto Tâmega* abundant examples of *tabique* construction can be found. The *Trás-os-Montes e Alto Douro* region has a valuable heritage of this type of traditional Portuguese construction, which uses basically natural and local building materials such as stone, timber and earth. This fact associated to the required small amount of energy consumption in the building construction with this technique may classify the *tabique* system as a very sustainable building option, which should be preserved, but should also give guidance for the development of modern sustainable building solutions.

The data collected during the fieldwork contributes to the characterization of this type of construction. An expressive amount of the existing constructions require urgent conservation measures, since they are very deteriorated. Frequently, these constructions are dwellings of 2 floors. The ground floor location of *tabique* components was normally avoided. White washed *tabique* components was a very common finishing solution.

The structural timber system of a *tabique* wall usually does not present wood elements with regular dimensions, and uses locally available *pinus pinaster* species. However, typical details and component dimensions of the internal timber structure of *tabique*, for exterior and interior/partition walls, were proposed, based in the most commonly observed detailing and in the average dimensions obtained through the fieldwork. The results of the testing campaign for mortar characterisation indicate that, commonly, the mortar used was composed mainly by natural materials, representing the common practice at that time.

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