

## Typological characterization of the Portuguese traditional schist constructions

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### Abstract

Schist constructions represent an important cultural, architectural and historical legacy in Europe, and particularly in Portugal, that urges to preserve. Included among the traditional Portuguese architectural heritage, there are many traditional buildings in schist masonry, distributed from North to South, varying the types of buildings, the constructive methodologies and even the material schist, which may vary in properties and characteristics, depending on the region where it is extracted. Over the years, this traditional architecture has implemented a sustainable construction through the use of natural materials available in the region, as today it is desired to implement in the contemporary construction practice. The constructive techniques and solutions of these traditional structures have been developed in direct relation with various factors as economic, environmental and social, adapting to different requirements over the time, originating a wide diversity of construction typologies that today exist in Portugal. The present study intends to describe and characterize the different building typologies of the traditional schist construction in Portugal mainland. Examples of more prominent constructions, considering its dimensions and/or patrimonial importance are presented and analyzed.

## 1 Introduction

Within the broad traditional Portuguese architectural heritage, traditional schist masonry buildings are spread over several regions from North to South, varying the typology, construction methods and even the schist material itself, which, depending on the area where it is extracted, may have very different properties and characteristics.

The survey of the traditional schist constructions in the different regions of the country allows understanding that there are significant variations in construction methods related to the local geology, namely the masonry construction is closely related to the schist material existing in the neighbourhood of the construction. According to Boeri [1], the natural stones when used in the constructions have the same characteristics as they were on the nature. Furthermore, Ribeiro et al. [2] state that this type of construction is closely linked to nature, which holds its roots and where it is raised, resulting in a symbiosis between nature and human work. It is certain that the social, environmental and economic impacts are related to the different construction methodologies observed in the Minho, Trás-os-Montes and Beira provinces.

In the Northern region two types of settlements are considered: dispersed and crowded. The first is usual in Minho province, while the second is common further inland, particularly in Trás-os-Montes province [3]. The dispersed settlement is usually composed of a set of constructions that underpin the family farm. On the other hand, the crowded settlements are composed of a small group of houses clinging to the sides of the mountains or hills and have a development that could be considered circular, as opposed to linear development particularly common in parts of the Central Coast and Alentejo provinces.

Beyond the influence of settlement in the different architectural legacies of the Portuguese households, the architectural variation can be analyzed taking into account the scattering of buildings in the country. Thus, four general areas can be considered where a pronounced typological variation stands, namely the North, the Central Coast, Alentejo and Algarve.

As the present study is focused on the schist constructions and those are located in areas where naturally the schist is abundant, this analysis was directed to the Northern, Trás-os-Montes and Beiras regions, where the "Minhota", the "Transmontana" and the "Serrana" houses are dominant, respectively [3].

The "Minhota" house is common in landscapes of dispersed settlement, it is traditionally built on granite, usually matched, or schist, composed of two floors with rectangular shape. The ground-floor contains spaces for animals, cellar and storage, while the rooms and halls are located upstairs. Some details such as access made by a stone stairway, the lack or the existence of a rudimentary chimney and a wooden roof structure with four waters of gutter tile are typical of this type of house.

As the "Minhota" house, the "Transmontana" house lies in landscapes of dispersed settlement, normally has schist walls with misaligned pairing, with two floors and rectangular shape. Traditionally, the first floor was used for storage and for animal shelter, while the rooms and the living room were located in the upper floors. Among other architectural details, the access to the upper floor was made by a stone staircase access to a terrace covered by the roof. The roof has made of a wooden structure of two or three waters with ceramic tile or slate tile.

The "Serrana" house is very similar to the "Transmontana" house typology [3], consisting of two floors of square or rectangular plan containing on the ground-floor the animal's shelter and in the upper floor, which is accessible by a stone stairway, one or two rooms (kitchen with fireplace and/or living room). The wooden roof is composed of two or four waters, and it can be covered with gutter tile boards, schist, slate or culm, according to the geographical location. The construction materials used are granite, which is rarely paired, and schist used without mortar. The schist, present in the form of small slabs, means that the posts, lintels and aprons are made of wood or granite, as well as the corners which are generally formed by large granite blocks.

In general, the schist traditional houses have slightly square or rectangular in-plan geometry, with two or three floors at most. As these buildings are traditionally built in mountain areas, it is usual that the first floor has a facade leaning to the ground and thus, the second floor is at ground level at that facade. Thus, it is clear that the different typologies of the schist constructions in Portugal, see Figure 1, are closely related to the material available, the population itself, its culture, traditions and knowledge, as well as its economic power.



(a)



(b)

Figure 1 - Examples of building typologies: (a) Trás-os-Montes; (b) Beiras.

## 2 Foundation system

The constructive system adopted in this type of construction is not much different of the commonly used in other traditional masonry buildings. However, differences are detected in the foundations between large and small schist constructions, and also between popular simple constructions and more noble constructions.

The foundations of the schist rural constructions are normally also made of schist, except in some constructions at Minho region where they are made of granite. These constructive elements are practically an extension of the walls to the foundation soil, with a current depth of 60 cm, but it may vary depending on the soil type implantation of the building, and dimensions of the building.

Schist constructions are often located on land with steep slopes, especially in the Beiras region.

## 3 Masonry walls

According to Tubi and Silva [4], the walls are intended to provide a robust and safe casing, resisting to the vertical loads (dead-load of masonry walls, and horizontal elements as pavements and roofs) and horizontal actions. But the walls have also accommodated the apertures not only for accessing and communicating through the spaces but also to guarantee the adequate lighting and ventilation conditions. In the schist masonry walls construction, typically larger stones were used at the corners, where concentration of larger stresses tends to occur, so appropriate connection between the wall panels should be provided. Stones of smaller dimensions are used in the remaining wall, facilitating their handling in the walls construction process.

The walls stiffness and strength, as well as of their connections, depends on the quality and size of the stones used in their construction, but also their arrangement and constructive method. An adequate arrangement of the schist stones in the construction of the walls has an extreme importance, largely affecting their mechanical properties and structural performance.

Relatively to the typology, in the Minho region, where it is possible to extract larger schist stones and where was usual the combination of schist stones with granite stones in the walls construction, they are

usually simple. When it is not possible to extract larger schist stones, the walls can present two leaves, see Figure 2, as is the case of many buildings in Portugal. In these cases, the schist stones are neatly arranged and the binding mortar is usually made of earth. In this type of schist fabric, wood or stone connectors can be found. They play a fundamental role for the monolithic behaviour of the masonry walls.



Figure 2 – Two leaves walls without connection.

An aspect varying considerably in the different types of schist masonry in Portugal is the presence or absence of mortar connecting the schist stones, see examples Figure 3. In existing walls, different types of mortar connecting the schist stones can be found, such as lime or simple earth mortar. But, it can be also found masonry schist walls without mortar, for which the meticulous settlement of the schist provide imbrications which ensures the adequate mechanical behaviour of these walls.



Figure 3 – Joint in schist masonry: (a) With earth mortar; (b) Without mortar.

The employment of plaster on the masonry walls of schist construction was somewhat unusual and they can be found mostly in religious or noble buildings. In Portugal, they are more easily found in the South and in the Minho regions.

The partition interior walls, when are structural as in larger buildings, are usually constructed also in schist. In some particular cases can be found a combination of schist with granite, see example in Figure 4a. However, the partitions walls are most commonly made of “tabique”, a partition wall with timber frame with cover made with lime, as illustrated in Figure 4b.



Figure 4 – Interior partition walls: (a) Schist with granite; (b) “Tabique”.

Masonry corners play an important role in the building structural performance, since on one hand they ensure the connection between perpendicular walls. But, on the other hand, these elements in masonry structures tends to concentrate larger stresses, due to the horizontal loadings induced by wind and earthquakes, as well as the resulting thrust from the roof structure. The quality of the materials and its arrangements in the corners is even more important for buildings with multi-leaf walls, considering that for these cases the quality of the masonry is lower, as stated before, due to the smaller dimensions and poor mechanical properties of the stone units.

In the Trás-os-Montes and Beiras regions, where it was common to build walls composed of two leaves, the corners were typically made with larger schist stones, see Figure 5a, or combining schist blocks with quartzite. In the Minho region, the corners were made in schist units of larger dimensions, because extracting larger schist blocks at this region was easier, or in some cases can also be found granite, see Figure 5b.



Figure 5 – Building corners: (a) Schist; (b) Granite.

#### 4 Floor and roof systems

In rural areas, the floors of the traditional schist buildings commonly makes the division between the ground-floor, on which are sheltered the animals, and the residential area upstairs. These floors systems, traditionally made of wood, have a structural and partitioning function.

The floors were usually made with wooden beams and joists overlap perpendicular to the beams. Stone, usually granite or slate, can be found in ground floors. In some houses can be found floors with a beamed structure made with metallic elements.

The roof systems in schist constructions are similar to those founded for other traditional masonry constructions. The roofs can have two, three or four sides, depending much on the region where the constructions are located, as well as on the socio-economic conditions of the owners.



The structure of the roof is typically made of wood, in which its elements are connected by their own self-weight, which may or may not have isolation with wood lining under the covering elements.

The roofs covering is one of the most differentiating elements for the schist constructions in each region. In the Beiras and Trás-os-Montes areas is still possible to find some constructions with its covering frame made of wood covered by straw, see Figure 6a. However, the most usual traditional roof covering in the Beiras region recourse to schist, slate type, Figure 6b. For the other regions the dominant roofing system is made of wooden structure covered with ceramic tiles, Figure 6c.

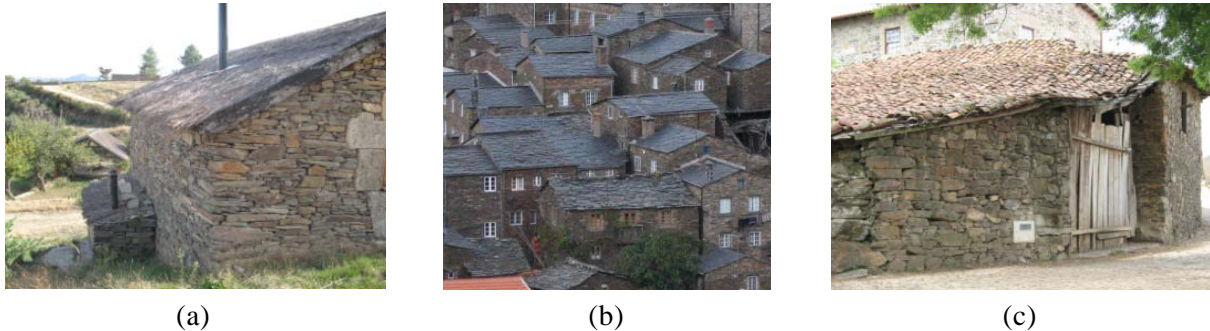


Figure 6 – Roof covering: (a) Straw; (b) Slate schist; (c) Ceramic tiles.

## 5 Apertures and stairs

Windows and doors on the walls deserve a particular attention, since they induce a structural discontinuity. In its construction, many solutions can be found to strengthening it, allowing to a proper stress distribution of the forces that tend to concentrate particularly in the windows and doors corners.

Taking into account the loads carried by the door and window lintels, as well as its typical span, and the limited masonry tensile strength, usually were adopted elements made of other materials. In Trás-os-Montes and Beiras regions these elements were usually made of timber, see Figure 7a, while in the Minho region these elements were mostly made of large granite stones, see Figure 7b.



Figure 7 – Lintels: (a) Timber; (b) Granite.

Apart from their rational functions, as guarantee the access to the spaces, lighting and ventilation, windows and doors play a fundamental role in the definition of the regional building architecture. Variations associated with the type of material locally available and local traditions in construction are relevant in the building architecture characteristics.

Due to regional, social and economic factors, it is possible to identify the different types of solutions for the windows and doors founded in schist buildings. Windows surrounded by three schist elements

are often founded in the Minho region, see Figure 8a. This solution can be also found also in some constructions in the Trás-os-Montes region.

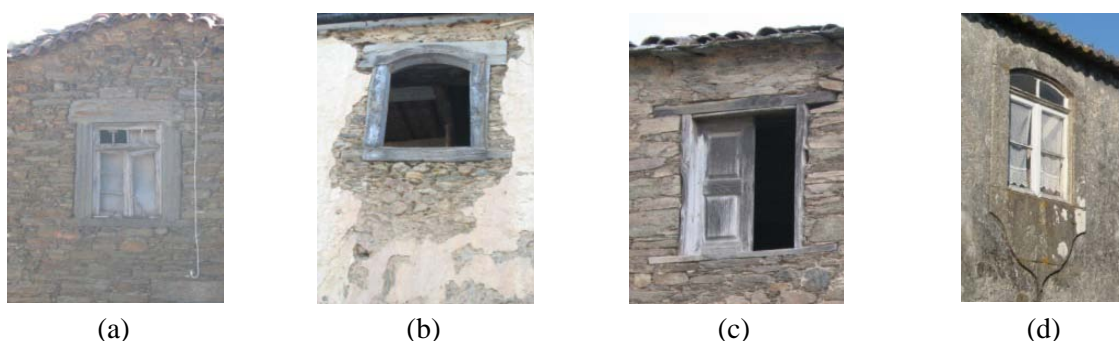


Figure 8 – Windows surroundings: (a) Schist monolithic elements; (b) Worked timber elements; (c) Simple timber structure; (d) Worked granite elements.

The reinforcing of the windows surroundings system in wood are often found in the Trás-os-Montes and Beiras regions, being more elaborated in the case of noble buildings (Figure 8b), and very simple in popular buildings (Figure 8c). In the Minho region, it is possible to find more rich windows surroundings systems made in granite, as shown in Figure 8d, an example of an emblazoned house.

On most of the schist constructions, the access stairs to the upper floor of the house are usually exterior to the building, and provide direct access to first floor, usually to the kitchen, traditionally the central compartment of the house.

There can be found several types of exterior stairs, varying the materials and the structure itself, depending on the region and on the economic power of the owner. In Trás-os-Montes region, the exterior stairs are mostly made of schist, with the steps made of slate or wood. In this region, the exterior stairs can be a major architectural element, which characterizes the constructions, distinguishing from those found in other regions, see Figure 9a. In some cases, the stairs are covered by a wooden frame and wood or slate covering elements, making this buildings style particular and unique.

In the Beiras region, the stairs are usually built entirely in schist, while in Minho region can be found cases where the stairs are made of granite.

Interior stairs are not very common, considering that the ground-floor typically serves to shelter the animals. However, in some particular buildings, stairs can be found in the interior, made entirely in wood, with simple structure, as shown in Figure 9b.



(a) (b)

Figure 9 – Traditional stairs from Trás-os-Montes region: (a) External, made of stone; (b) Internal, made of wood.

## 6 Final considerations

In Portugal mainland abound metamorphic rocks, being the schist one of the most common. Nearly three quarters of the national territory soil consists of the called "old massive", occupying the regions of Minho, Trás-os-Montes, Beiras and part of Alentejo. In fact, the schist stone itself is a major factor that distinguishes the building typologies found in each region, due to variations in the type of schist available locally.

But, the differences in schist masonry structures found in Portugal are obviously also related to the population, i.e. its traditions and technical experience, but naturally also with its economic conditions. The analysis of all these factors is crucial to better understanding the typological variation founded in traditional constructions in Portugal.

Nowadays, the schist as a masonry construction material starts to gain the attention of architects, builders and owners, due to its recognized value in terms of local historical and patrimonial value, but also due to other intangible values associated with traditional construction methods.

Future work involves the study of the types of schist constructions in Algarve and Alentejo regions, as well as to characterize the schist as a construction material and the mechanical characteristics of schist structures.

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