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An approach on the thermal behaviour assessment of *tabique* walls coated with schist tiles: Experimental analysis

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ABSTRACT

Tabique construction is part of the Portuguese heritage and similar techniques are applied worldwide. Therefore, research works developed on this field may be an added value to future retrofitting processes. In this context, an experimental analysis of the thermal behaviour of three different solutions of *tabique* walls is presented. These solutions are an uncoated *tabique* wall, a *tabique* wall coated with schist tiles and a *tabique* wall coated with schist tiles and thermally retrofitted with the application of a current insulation material. The obtained experimental results may give a contribution to better understand the thermal behaviour of this type of traditional building elements and also to help future studies focused on achieving energy efficiency solutions to be applied in this context. It was concluded that a simple *tabique* wall has adequate thermal behaviour for current applications, that coating this building element with a schist tiles layer improves its thermal insulation ability and adding a current thermal insulation material is possible and thermally efficient.

1. Introduction

Maintenance and rehabilitation may contribute for achieving a more sustainable building construction. The deterioration of traditional buildings and the lack of knowledge concerning this type of construction may justify the relevance of research works focused on proposing appropriate repair solutions based on criteria of sustainability and thermal efficiency [1,2].

Tabique is an example of a traditional building technique which corresponds to an important Portuguese heritage. In brief, a *tabique* building component such as a wall is formed by a regular timber frame covered with an earth mortar. Examples of this traditional building technique exist all over the country. In Portugal, the *tabique* building technique fell into disuse after the massive introduction of the reinforced concrete technique.

Different terminologies of *tabique* or similar building techniques exist all over the world. For instance, in Brazil, *taipa de mão*, also known as *pau-a-pique* or *taipa de sebe*, is a similar building technique. In this case, a building component is also formed by a timber structure covered with a clay mixture. The timber structure tends to be more improvised and the earth mortar includes a higher amount of clay. This traditional Brazilian building technique is widely applied in rural areas. Furthermore, in other South America countries such as Chile or Peru, *quincha* is the terminology adopted for a traditional building technique similar to *tabique*. The corresponding Anglo-Saxon terminology for similar construction is *wattle and daub* [3].

Taking into account that, in Portugal, a typical *tabique* building was built before the early twenty century it is expected to find signs of deterioration. This fact has been underlined in some research works [4–6] in which over three hundred *tabique* buildings were studied in the North-East part of Portugal. In the *tabique* construction context, the relevance of having a regular maintenance process guarantees a good conservation level of a *tabique* building. However, it has been noticed that this procedure is rarely applied. Economic limitations and the fact that most of the *tabique* buildings are private properties are the main causes of this scenario, as was pointed out in [7]. Additionally, and as it was stated above, there is still a lack of technical knowledge in terms of *tabique* construction, which makes the retrofit processes more difficult. A wall (external and/or partition) is the main *tabique* building element type. At

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the same time, it is also the main vertical structural building element in a *tabique* construction. Therefore, its structural, thermal and sound insulation behaviours are some relevant properties that still require to be studied. These technical aspects have an important impact on the overall performance of a *tabique* building. The information obtained by these studies will guide the proposal of retrofit solutions.

Exterior walls are quite often under the effect of the rain which may lead to the occurrence of mechanical and/or physical degradation phenomena [8]. Therefore, it is convenient to apply a proper external wall covering system [9].

In the case of *tabique* walls, in which earth mortar and timber are the main applied materials, their vulnerability to the rain is even more expressive. This aspect justifies that they are quite often coated with the main purpose of to increasing their waterproof ability. The application of metal corrugated plates, schist tiles and ceramic tiles are the most common traditional solutions used as external coating of *tabique* walls. In addition, exterior walls also have an important role in the building thermal performance [10,11]. Thus, studying the thermal properties of *tabique* walls is also required.

In this context, the main goal of this research work is to give an input on the knowledge of the thermal performance of *tabique* walls and also on their possible thermal retrofit.

These aspects are relevant in a rehabilitation process of a *tabique* building in order to achieve an energy efficient solution able to offer simultaneously the current standard comfort requirements.

There are a wide range of alternative insulation materials which may be applied in a thermal retrofit process. Usually, the existing building solutions and the climatic conditions are the main factors that help deciding the most appropriate one [11,12].

The location of the thermal insulation material in the wall is another technical aspect that has to be considered in the thermal retrofit process [13]. Taking into account that each building has its technical particularities, it is risky to generalise retrofitting measures [14].

Therefore, the thermal insulation improvement of a traditional building element (such as a *tabique* wall) resulted by the application of a current thermal insulation material (such as extruded polystyrene (XPS)) is worth to be assessed.

The choice of this type of insulation material was done because it is the most current insulation material used in building construction and retrofitting. However, other ecological insulation materials and materials with acoustic properties should also be studied in order to improve the sustainable character of this traditional solution.

This research work may also give information about the assessment of the thermal performance of this traditional solution, which experimental methodology can be used for studying other types of earth constructions, such as adobe and rammed earth [15].

In order to achieve these aims, an experimental study was performed in laboratory using different *tabique* wall samples built specifically for this purpose. The *tabique* wall samples were instrumented and monitored during several days in a test room in order to analyse their thermal behaviour. This experimental analysis allowed obtaining and comparing the thermal transmission coefficient of each solution tested.

This paper is structured as follows: firstly, a brief description of *tabique* construction is presented. The traditional coating materials of *tabique* walls are also identified and the, constructive details of the schist tiles coating solution is emphasized. Secondly, the experimental analysis of the three *tabique* walls solutions is presented. The samples preparation, the experimental set up and the methodology used are also presented in this section. Thirdly, the results are presented and discussed. Finally, the main conclusions are drawn.

2. *Tabique* construction characterization

2.1. Constructive details

In general, a *tabique* element can be found in buildings with several floors [6] and it may have different constructive details depending on the location of the building (e.g. urban or rural areas) [16]. External (I, Fig. 1a) and partition (Fig. 1b) walls are the most relevant *tabique* building components. However, there are other types of *tabique* building components reported such as chimneys [6,7], (II, Fig. 1a). Basically, a *tabique* building component is formed by a regular timber frame structure filled with an earth mortar (Fig. 1b). Local wood species, earth and metal nails are the main materials used [7]. Usually, the regular timber frame structure is composed by vertical boards (IV, Fig. 1b) linked to each other by laths (V, Fig. 1b). Laths are applied on both sides of the vertical boards. The connection between vertical boards and laths is done with metal nails. In general, the timber boards have irregular geometry and present a rugged finishing. This particularity contributes to a better adhesion of the earth on the timber structure. Laths also have an important role on this process. The geometry of laths is currently not regular. Often is thicker in the exterior surface than in the interior surface. On the other hand, the earth mortar (VI, Fig. 1b) may be exclusively composed by soil without the inclusion of any hydraulic binder or it may be a mixture of soil and lime [4,5]. This information leads to the conclusion that there is a significant material variability of *tabique* walls. In order to complement this description, Fig. 1b) shows a partition *tabique* wall in which it is possible to see an example of an earth mortar and of a timber frame structure of this type of traditional building element.

As it was stated earlier, the most currently applied coating solutions of exterior *tabique* walls are metal corrugated plates, schist tiles or ceramic tiles. The main function of these building solutions is to increase the durability of the *tabique* wall by improving its waterproof ability. Fig. 1a includes simultaneously the application of all the identified types of coating. Schist tiles are applied in the upper *tabique* walls (I, Fig. 1a), metal corrugated plates are also applied (III, Fig. 1a) and ceramic tiles are applied on the chimney (II, Fig. 1a). In this case, the exterior *tabique* walls stand on granite stone masonry walls as being the resistant constructive elements, built at the ground floor level. In the North of Portugal it is unlikely to find *tabique* walls at the ground floor [7].

2.2. Schist tiles coating solution

Schist has been used traditionally as a building material. It can be used as a structural building material (e.g. for masonry walls, Fig. 2a), and as a coating material of walls (Fig. 2b), of roofs (Fig. 2c), of chimneys (Fig. 2d) and of pavements.

The application of schist tiles as exterior coating of *tabique* walls presents specific technical details. Typically, the schist tiles coating (I, Fig. 3a) is applied on the upper floors where the *tabique* walls usually exist. For example, the *tabique* construction of Fig. 3 presents exterior *tabique* walls on the first floor and they are built on schist masonry walls placed at the ground floor level (II, Fig. 3a). Timber boards are used to build the required abutments which characterize this type of coating. The junction of *tabique* walls (III, Fig. 3a), the junction of wall and window or door (IV, Fig. 3a), and the junction of the wall and the roof (V, Fig. 3a), are some of these types of abutments. Additionally, the detail VI of Fig. 3a) shows the relevance of the application of this type of coating concerning the durability of the wall. It is possible to notice the progressive damage of the *tabique* wall due to the removal of some schist tiles. Typically, the schist tiles have a shape similar to a fish scale, as shown at Fig. 3b). Usually, each tile has two holes, Figs. 3 b and 4 . These holes are used to fix the tiles to the *tabique* wall. Nailed or fastened are the