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Thermal and hygrometric properties of traditional calcarenite stones in the area of Palermo

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Abstract

The energy improvement of historic buildings requires detailed knowledge of the thermal and hygrometric properties of traditional materials and components. These data should be collected for specific local contexts, where the features of historic constructions are comparable. For the purpose of developing this tool for the architectural heritage of Palermo, this research focuses on calcarenite stones, the material traditionally used in the construction of the local historic masonry, and illustrates the thermal and hygrometric characterization of three calcarenite samples, taken from two historic buildings in the Sicilian city.

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1. Introduction

Detailed literature on the material and construction features of historic buildings, both monumental and vernacular, exists for several geographic areas. However, the availability of few data on the thermal and hygrometric properties of

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traditional materials and components is generally observed [1-4]. This lack of information influences significantly the assessment of the energy performance of both historic building stocks and single constructions. Indeed, several problems impede the accurate diagnosis of historic architecture, especially the scarce homogeneity of the materials and construction techniques used, even in the same building, and the recurring conflict between conservation needs and destructive tests. Therefore, collecting data on the thermal and hygrometric characteristics of traditional materials and building components could support in the detailed energy assessment of the architectural heritage. These collections should refer evidently to local contexts, where the construction features of buildings are comparable.

From this perspective, relevant uncertainties regard masonry both in determining their actual layers and in using existing data collections. Mainly because of transformations and reinforcements, different materials and masonry techniques, generally hidden by plasters and decorations, often coexist in the same building, even in the same wall. Moreover, whereas a comparison with current materials and components is easier in the case of floors and roofs, the wide range of local stones and the variable features of historical bricks further affect the reliability of current data collections, which report a limited list of traditional masonry materials.

This paper describes the results of thermal and hygrometric laboratory tests carried out on calcarenite stones, the most common material in the construction of historic masonry in Palermo. The purpose is contributing to the development of a collection of thermophysical data for the local context of Palermo and Western Sicily, in order to support detailed energy diagnosis and compatible improvements of this architectural heritage.

2. State of the art

The historic walls of Palermo are characterised almost only by the use of calcarenites, stones widespread in the urban territory and in a significant part of Western Sicily. Owing to the large supply of this natural material, easy to be quarried and carved, bricks were limited essentially to light structures and reinforcements.

In the basin of extraction of Palermo three sectors have been distinguished for calcarenites [5]. Along the centuries, they have been exploited through several quarries, first inside the historic town, afterwards in the neighbourhood and finally in farther areas. La Duca [6] provides an extensive list of quarries and for each one he reports the average values of bulk density and compressive strength of calcarenite. For the area of Bagheria, close to Palermo and particularly rich in quarries, a detailed analysis has been carried out by Fricano [7].

The quarry calcarenite was carved from influences considerably its physical and mechanical properties. From this point of view, the traditional practice of selecting calcarenites for specific structural functions, even in the same building, is significant [6, 8]. In the second half of the 19th century, Giovanni Salemi Pace studied the physical and mechanical properties of calcarenites for the most worked quarries, by means of laboratory tests whose results were published in the last two decades of the century [9]. According to the quarry and the depth of extraction, the findings reported in 1890 show ranges of 1,214 ÷ 1,865 kg·m^{-3} for bulk density and 17 ÷ 117 kg·cm^{-2} for compressive strength.

Alaimo et al. [5] investigated the chances to identify at least the sector of extraction, if not the quarry, by means of laboratory tests. Especially for monumental constructions, the origin of the stone may be revealed by archival sources, at least for some phases of the building history. Unknown in the majority of cases, this information is valuable to assess the contribution of masonry to the energy performance of historic constructions. Indeed, the physical and mechanical properties of calcarenite stone influence the thermal ones.

Already in the end of the 19th century, the building materials commonly used in the area of Palermo were examined in their physical and hygiene characteristics. For calcarenites quarried in the main sectors of extraction, measurements provided porosity (36.66 ÷ 47.56 %), capillary saturation (12.51 ÷ 27.19 %) [10] and air permeability [11]. Heat transmission was also investigated for some calcarenite stones [12], but it was expressed through a comparison with local bricks, whose physical and mechanical properties were specified only partially. More recent systematic studies concerning the thermal and hygrometric properties of calcarenite stones have not been found. Some data are available for products currently on the market, which do not include the historical quarries, almost all fallen into disuse within the first half of the 20th century. By analogy with other geographic areas, interesting findings are reported by French studies on tuffs and limestone [13, 14] and particularly by Italian researches on Puglia's calcarenites [15]. Furthermore, the existing collections of thermophysical data for building materials (UNI 10351:2015, UNI EN ISO 10456:2008 and UNI EN 1745:2012) provide a set of data, though limited.