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Experimental characterization of physical and mechanical properties of schist from Portugal

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HIGHLIGHTS

- Schist constructions represent an important landmark of vernacular architecture.
- Material and mechanical properties of schist stone were experimentally assessed.
- Anisotropy planes have a leading role in the schist's mechanical behaviour.
- Strong correlations were established between physical and mechanical parameters.

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ABSTRACT

The schist used in traditional masonry constructions, extracted from the construction site, provides them traits that distinguish and characterize the local architecture. The understanding of the mechanical behaviour of schist constructions requires a detailed knowledge of the schist as a material. This study aims at filling the gap in scientific knowledge by characterizing the schist as a construction material. This paper provides a characterization of schist's from five distinct areas of Portugal. Tests have been carried out to characterize schist's regarding porosity, density and mechanical strength. Results indicate that it is possible to apply schist as a construction material with a higher degree of confidence, by suiting the schist type to the physicochemical and mechanical needs of the construction; furthermore, it is possible to evaluate the existing schist constructions according to the schist type used, allowing less intrusive and more appropriate forms of intervention.

1. Introduction

Existing schist constructions represent an important cultural, architectural and historical heritage worldwide, and particularly in Portugal, which must be preserved [1–3]. In Portugal, the traditional schist masonry constructions are disseminated from north to south of the territory, depending on the local geology and the availability of outcrops in rocks with appropriate physical characteristics. For a better understanding of schist constructions, it is necessary to study the various schist's used in construction in the different regions of Portugal. The knowledge of the physicochemical and mechanical properties of the material is critical to the development of buildings' conservation and repair actions with a greater level of confidence.

The term schist is here applied in the sense proposed by the IUGS Subcommission on the Systematics of Metamorphic Rocks [4], i.e., rocks that possess a well-developed schistosity as defined by Schmid et al. [4]: "preferred orientation of inequant mineral grains or grain aggregates produced by metamorphic processes". This is a field oriented terminology and will be also more agreeable for industrial applications and engineering studies.

Schist's result from regional metamorphisms, i.e., metamorphism related to deformation processes over large areas with pressure as the dominant factor and the cause of the planar preferred orientation. Variations on pressure and temperature define different regional metamorphism facies and textural variations (namely granularity). Regional metamorphisms could involve different deformation phases and these deformation phases introduce anisotropies with different orientations. Schist's are rocks that, due to their geological formation, may have a great directional variability in terms of their properties. The anisotropy planes existing on schist should be considered in its characterization; as referred

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by Hundson and Harrison [5], anisotropic rocks may have different properties in each direction, such as the deformation modulus, strength, and permeability.

In determining schist's properties, a correct and accurate preparation of samples for testing is critical. In fact, due to its schistosity, schist is very difficult to cut, not only due to its fragility, causing it to chip easily, but also due to the existence of multiple anisotropy planes (depending on the geological history) and the diversity of the orientation of these anisotropy planes.

The lack of documentation related to schist justifies the development of destructive and non-destructive tests on the diverse schist's used in traditional construction in Portugal, in order to know the main properties of this material. For a better interpretation of the properties of the schist and its application in construction, it is important the comparison with the properties of other stony elements commonly applied in construction.

This study intends to be a contribution to the development of the scientific and technical knowledge, through the characterization of schist's physicochemical and mechanical properties. The knowledge of these properties is critical for the development of actions, with a high degree of accuracy, for the construction or rehabilitation of traditional schist masonry constructions.

2. Experimental program

Schist samples were collected from five locations in the country, geographically distributed across the main areas of existing vernacular schist constructions over the centuries. In the region of Minho, samples were collected in Serra de Arga and Barqueiros, and, concerning the region of Trás-os-Montes, samples were collected in Carrazedo de Montenegro. In the region of Beiras, known for the numerous schist villages, samples were collected in Vila Nova de Foz Côa and Sobral de São Miguel (see Fig. 1).

Fig. 1. Geographical origin of the five schist samples tested.

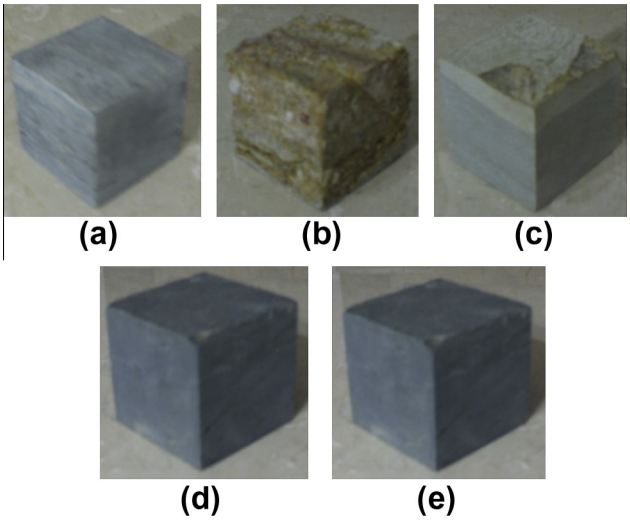

Fig. 2. Samples: (a) Vila Nova de Foz Côa; (b) Serra de Arga; (c) Carrazedo de Montenegro; (d) Sobral de São Miguel; and (e) Barqueiros.

The orientation of the schistosity planes requires particular care in the preparation of samples for testing. Thus, for this study, despite the high heterogeneity of the schist, the attempt was made to obtain samples that would be regular and with anisotropy plane that was parallel to one of the samples faces (see Fig. 2).

Obtaining samples with an anisotropy plane that was parallel to one of the faces of the samples allows considering only two test directions, the direction that is normal to the anisotropy plane and the direction that is parallel to the anisotropy plane (see Fig. 3).

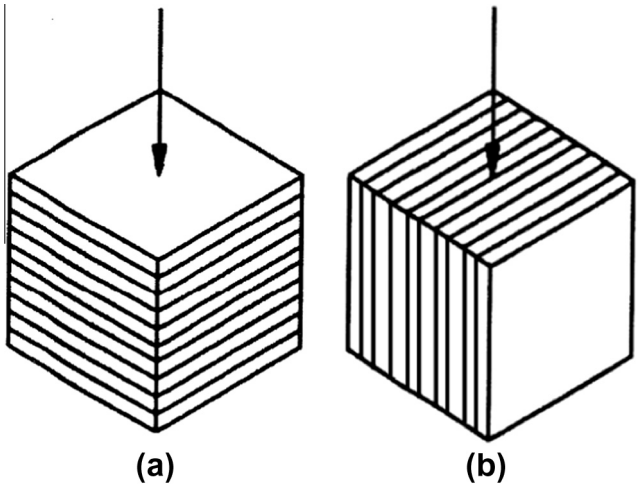

Fig. 3. Test directions: (a) normal to the anisotropy plane and (b) parallel to the anisotropy plane (adapted from EN 1926).

Table 1
Nomenclature adopted for the samples.

Schist type	Acronym	Symbol	
		Normal ⊥	Parallel //
Vila Nova de Foz Côa	FC	▲	△
Serra de Arga	SA	■	□
Carrazedo de Montenegro	CM	◆	◇
Sobral de São Miguel	SM	⬟	⬠
Barqueiros	BA	●	○