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Interface influence on moisture transport in buildings

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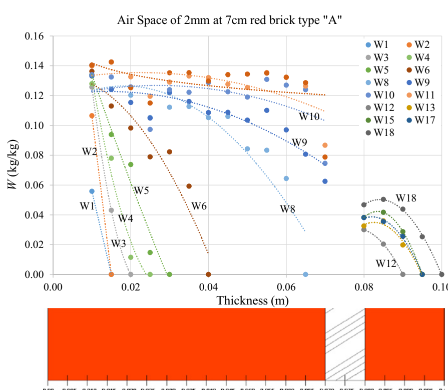
HIGHLIGHTS

- Experimental campaign and critical analysis of water absorption in red brick samples.
- Interface influence on moisture transport.
- New experimental interface hygric resistance values.
- Different experimental methods used: gravimetric method and gamma ray's attenuation.

GRAPHICAL ABSTRACT



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ABSTRACT

Moisture damage is one of the most important factors limiting building performance. A moisture measuring device based on non-destructive method of gamma rays attenuation, allows measures to deepen concepts in building physics related to the moisture transfer; study the influence of the interface between layers in moisture transfer; analyse the influence of gravity on absorption and drying of different building materials; study the kinetics of absorption and drying of walls of one or more layers; analyse the importance of the temperature gradient in the movement of moisture; calculate the coefficient of water diffusivity of some building materials.

This work presents an experimental campaign and a critical analysis of water absorption in samples of red brick with different densities, with and without joints at different height positions and different contact interface configurations, using two experimental methods (gravimetric method and gamma ray's attenuation).

The results show a slowing of the wetting process due to the interfaces hygric resistance. The samples with hydraulic contact interface (cement mortar) present lower absorption rate than the samples with lime mortar. The influence of air space between layers was also demonstrated, i.e., the air space interfaces increase the coefficients of capillary significantly, as the distances from the contact with water increase.

1. Introduction

Intervening in old buildings requires extensive and objective knowledge. The multifaceted aspects of the work carried out on these buildings tend to encompass a growing number of specialties, with marked emphasis on those allowing to understand

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the causes of the problems that affect them and to define appropriate treatments.

The study of moisture migration in the inner parts of the materials and construction building components is of great importance for its behaviours characterization, especially for its durability, waterproofing, degradation appearance and thermal performance.

For example, the study of rising damp phenomenon allowed the investigation of a technique to solve this problem that can already be used, with the necessarily revisions, to treat building walls after a flood [1–5]. In Portugal we have historical buildings near water courses with degraded walls by the permanence of water. Moisture in buildings can have different origins and rising damp is probably the most current one. Floods are extreme occurrences but can introduce large amounts of water in the walls. In conclusion, rising damp, because of its high occurrence frequency, and floods, because of the seriousness of their consequences, represent both a high risk in terms of building humidity.

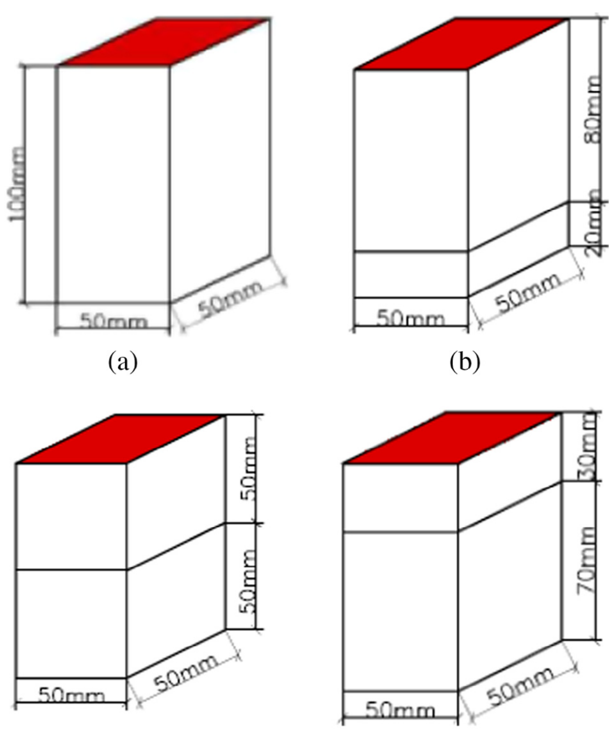

Fig. 1. Sketch of the samples tested: a) monolithic samples, b) samples with interface at 2 cm, c) samples with interface at 5 cm and d) samples with interface at 7 cm.

The analysis of moisture migration in building materials and elements is crucial for its behaviour knowledge also affecting its durability, waterproofing, degradation and thermal performance. A building wall, generally, consists of multiple layers, and thus the investigation of the moisture transfer presumes knowledge about the continuity between layers. Freitas [6,7] considered three different interfaces configurations:

- Perfect contact – when there is contact without interpenetration of both layers porous structure;
- Hydraulic continuity – when there is interpenetration of both layers porous structure;
- Air space interface – when there is an air box of a few millimetres wide between layers.

In literature, although several studies concerning the liquid transport in multilayered porous structures only a limited number of experimental values for the interface resistance in multilayered composites are found [8–11]. Qiu [9] shows that if the interface resistance is determined after capillary saturation of the first layer the change in material properties could be neglected. The author analysed experimentally the liquid transport across the interface between aerated concrete and mortar and compared the experimental results with numerical results obtained by use of an interface resistance. Derluyn et al. [12] considered an interface resistance as well as a change in mortar properties. The authors' show that for dry cured mortar a higher interface resistance was obtained compared to the wet cured composite. Similar interface resistances analytically obtained by Janssen et al. [8] prove the validity of Derluyn's study.

In this work, new experimental values of water absorption in samples of red brick, with different densities, with and without interfaces, at different height positions, and analysing the three different interfaces configurations, are reported and analysed in detail.

2. Materials and methods

Red brick samples have different densities, type "A" with 1800 kg/m^3 and type "B" with 1583 kg/m^3. The samples area is 40 × 40 mm^2 (sectional area), with a height of 100 mm, for red brick type "A" and 50 × 50 mm^2 (sectional area), with a height of 100 mm, for red brick type "B" (see Fig. 1).

In this work different interface configurations were analysed (see Table 1). The impact of perfect contact interface on moisture transport was evaluated by comparing the moisture flux of these

Table 1
Summary of the interface configurations analysed.

Material	Interface configurations analysed			
	Monolithic	Perfect contact	Hydraulic contact	Air space
Red brick Type "A"		At 2 cm	Cement mortar at 2 cm	Cavity of 2 mm at 2 cm
		At 5 cm	Cement mortar at 5 cm	Cavity of 5 mm at 2 cm
		At 7 cm	Cement mortar at 7 cm	Cavity of 2 mm at 5 cm
			Lime mortar at 2 cm	Cavity of 5 mm at 5 cm
			Lime mortar at 5 cm	Cavity of 2 mm at 7 cm
			Lime mortar at 7 cm	Cavity of 5 mm at 7 cm
Red brick Type "B"		At 2 cm	Cement mortar at 2 cm	Cavity of 2 mm at 2 cm
		At 5 cm	Cement mortar at 5 cm	Cavity of 5 mm at 2 cm
		At 7 cm	Cement mortar at 7 cm	Cavity of 2 mm at 5 cm
			Lime mortar at 2 cm	Cavity of 5 mm at 5 cm
			Lime mortar at 5 cm	Cavity of 5 mm at 7 cm
			Lime mortar at 7 cm	