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Experimental investigation of moisture properties of historic building material with hydrophobization treatment

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Abstract

Moisture has a great impact on the building performance. Moisture accumulated in the building facade can lead to frost damage, mould growth, condensation, and decrease of thermal resistance, which reduce the sustainability and durability of the building structure. Wind-driven rain is one of the most important moisture sources affecting the building facade. Hydrophobization treatment on the exterior surface of the buildings with the water repellent agents can effectively reduce rain absorption and penetration. This is especially important to renovate the historic buildings, for which the exterior appearance needs to be conserved.

In this paper moisture properties of the building bricks from a historic building before and after the hydrophobization treatment were experimentally investigated. The building bricks were impregnated in the water repellent agents with different concentrations of the active ingredients. Water absorption test and water vapor diffusion test were conducted to observe the influence of the hydrophobization on the moisture transport behaviors of the brick. The results are beneficial for the researchers to find the optimal solution to improve the hygrothermal performance of the building facades.

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Keywords:hydrophobization; impregnation; moisture properties; building materials

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1. Introduction

Moisture has a great impact on the durability and the service life of the building structure. The building components instantaneously interact with the surrounding environment. The wind-driven rain, which is addressed as one of the most important moisture sources, can induce the several moisture related issues, e.g., frost damage, mold growth, crack and the spalling of the mortar joints. The interiorly insulated construction is very sensitive to the wind-driven rain due to the reduced inward drying potential. Thus, the amount of the absorbed wind-driven rain should be limited to the minimum [1]. Water repellent treatment can prevent and reduce the moisture penetrating into the material by altering the surface tension of the pore wall of the substrate. There are several water repellant agents used to improve the performance of both the historic and newly erected buildings. Among others, the silicon-based water repellent agents are popularly used.

Good knowledge of the material characteristics is one of the important prerequisites to make the proper decision on the renovation of the historic building in the design phase. In this study the investigated building is built in 1938 and composed of a 365 mm thick brick layer and a 15 mm inner lime plaster layer. It was previously used as a storage place for cereals and is designed to be a residential building in the future. To improve the energy efficiency and to protect the exterior appearance of the building, the interior insulation retrofit is adopted. For that purpose, the lab test is conducted to measure the moisture related properties of the external brick layer before and after the application of the water repellent agent.

Nomenclature

ρ	bulk density (kg/m^3)
c	specific heat capacity (J/kgK)
λ	thermal conductivity (W/mK)
θ_{cap}	capillary saturation moisture content (m^3/m^3)
θ_{por}	open porosity (m^3/m^3)
μ	water vapor diffusion resistance factor (-)
A_w	water absorption coefficient (kg/m^{2}s$^{0.5}$)

2. Measurement

The exterior brick samples taken from different orientations of the historic building were collected and their basic properties were measured. A photo of the samples is shown in Figure 1. After the long-term weathering and exposure to the air pollution from the industrial facilities in the nearby, the surface of the brick becomes dark and dirty, especially for the south side due to the prevailing southwest wind.

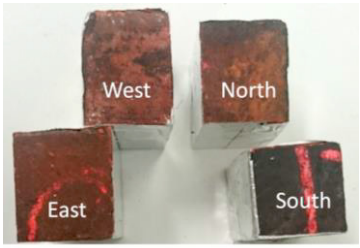

Fig. 1. The photo of the brick samples taken from different orientations of the historic building.

Prior to the test, the samples were dried at 105 °C and their bulk densities were measured. Thereafter, the samples were conditioned for different measurements. Water vapor diffusion test was performed in accordance to EN ISO