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Impact of time and personnel on measurements of the hygric properties of building materials

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Abstract

This paper studies the impact of time and personnel on measurements of hygric properties. Vacuum saturation, capillary absorption, vapor diffusion and static gravimetric tests have been done twice on calcium silicate and autoclaved aerated concrete, first in 2013 and again in 2016-2017. All these tests have also been performed by two different operators on ceramic brick. Results show that the impact of time is very limited, and that different operators also give very similar results, except for the vapor resistance factor, which is sensitive to varied sealing and data processing methods.

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Keywords: hygric property; porous building material; experimental error; time; personnel

1. Introduction

Hygric material properties are crucial input parameters for analyzing moisture related processes in building components and whole buildings. Currently these properties are commonly obtained through experiments. Albeit many international and regional standards are available to prescribe the experimental methods and procedures, large discrepancies still exist, as revealed by many round robin projects [1-4]. It is therefore of great significance to investigate and reduce these deviations in experimental results.

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Errors with respect to measurements can be classified into many categories [5], and the ones that draw most attention are random errors. In general, for the same method, random experimental errors may stem from material inhomogeneity as well as time, personnel, equipment, and/or environment [6]. Disregarding the material error and considering a given experimental method, when the same operator repeats measurements with the same equipment in the same environment within a short period of time, the error involved is defined as the repeatability error. On the other hand, when these factors are all different, the reproducibility error can be defined accordingly [6]. Clearly, repeatability and reproducibility errors define the two extremes of random errors.

Our earlier research studied the material, repeatability and reproducibility errors profoundly [5]. It shows that material and repeatability errors are typically quite limited, whereas reproducibility errors are usually far larger. The random errors involved in real measurements are often in between repeatability and reproducibility errors. For instance, cement materials can experience slow chemical changes over years, due to e.g. carbonization and hydration [7, 8]. Thus the experiments on them may be susceptible to time. Another case to the point is that in the same laboratory different operators can perform the same experiment, and their experimental results are not necessarily the same. This paper thus focuses on the impact of time and personnel on the determination of hygric properties. In the following sections, we will first introduce our experimental methods, then results will be presented and analyzed, and finally conclusions will be drawn.

2. Materials and methods

Three typical building materials - calcium silicate (CS), autoclaved aerated concrete (AAC) and ceramic brick (CB) - are chosen as test materials. CS is strong in both hygroscopicity and capillarity, AAC is strong in hygroscopicity but weak in capillarity, and CB is weak in hygroscopicity but strong in capillarity. Due to these variations, the chosen materials can represent many porous building materials with widely different hygric characteristics.

To study the impact of time on the hygric properties, the same operator (Operator #1) performed vacuum saturation tests, capillary absorption tests, vapor diffusion tests and static gravimetric tests on samples of the same batch of CS and AAC twice, separated by a time interval of over three years (2013 and 2016-2017). For the investigation of the impact of personnel, two operators (Operator #1 and #2) performed these tests on samples of the same batch of CB. The experimental procedures are detailedly described in our earlier publications [5, 7], with Table 1 summarizing the most important information.

Table 1. Experimental layout (4-10 duplicate samples for each condition)

Test	Impact factor		Sample size (cm)	Test	Impact factor		Sample size (cm)
Vacuum saturation	Time	2013	5×5×1 [a]	Vapor diffusion	Time	2013	10/4
		2016-2017	8×4×3			2016-2017	8/3 (CS), 10/4 (AAC)
	Personnel	Operator #1	5/0.5 [b]		Personnel	Operator #1	8/3
		Operator #2	8×4×1			Operator #2	8/2
Capillary absorption	Time	2013	15 [c] (CS), 6 (AAC)	Static gravimetric	Time	2013	5×5×1
		2016-2017	12 (CS), 6 (AAC)			2016-2017	5/0.5
	Personnel	Operator #1	12		Personnel	Operator #1	5/0.5
		Operator #2	15			Operator #2	8×4×1

[a.] Length×Width×Thickness for square samples;
[b.] Diameter/Thickness for round samples;
[c.] All samples have the same bottom size of 8×4 cm^2, but differ in heights (shown in the table).

3. Results and discussion

In this section, the impact of time and personnel is investigated. When quantifying the "relative difference", the results obtained in the year 2013 (for time impact) or by Operator #1 (for personnel impact) are used as reference. To evaluate observed differences, we mainly resort to material and repeatability errors [5]. For differences comparable with or smaller than such errors, we consider the impact as limited.