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Determination of hygrothermal performance of clay-sand plaster: influence of covering on sorption and water vapour permeability

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Abstract

Indoor finishing materials considerably influence indoor climate because of their moisture buffering ability occurring due to the sorption and diffusion properties of materials. Hygroscopic sorption properties were determined in accordance with the standard EVS-EN ISO 12571 and the principles given in the standard EVS-EN 1015-19:2005 were followed when determining water vapour permeability properties. The same specimens (thickness 2.4 cm) were used for both tests. To describe the dynamics during the first hours, the specimens were weighted at 1, 2, 3, 6, 12, 24, 48, 72 hours after changing the humidity level. Moisture uptake (kg/m^2) and moisture uptake rate kg/(m^{2}h) within the very first hours at 0-30, 30-50 and 50-80%; moisture content at RH level of 30%, 50% and 80%; points (30, 50 and 80%) at sorption curve were monitored. Six different covering materials were used: fine finishing mortar with cellulose, fine finishing mortar without cellulose, casein paint, cellulose base coat, lime paint, casein base coat, clay plaster not covered. The rate of moisture uptake was highest within the first hour after a sudden change in moisture level. Water vapour diffusion equivalent air layer thickness S_d=0.11-0.13 m was recorded.

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Keywords: water vapour permeability; sorption; clay plaster

1. Introduction

The paper focuses on the influence of finishing materials on the hygrothermal performance of boarders. To describe the situation several different parameters have been worked out. For indoor climate and thermal comfort inside the room besides temperature, relative humidity (RH) is one of the key parameters. Relative humidity is determined by

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measuring indoor moisture generation, air-change rate, and the release or uptake of moisture by hygroscopic surface materials as well as moisture flow through structures [1]. Necessary ventilation rate of a room depends on several aspects - heat production, CO_2 or other gases, moisture, particles, smoke, body smell etc. Ventilation rates calculated by CO_2 balance could differ from the rate calculated by moisture balance. Several household activities e.g. showering, food cooking increase moisture production significantly and regulating ventilation rate by one criterion results in too high or low relative humidity. The buffering ability of materials is useful in that case.

Moisture buffering performance of the room is the ability of materials within the room to moderate variations in the relative humidity [2]. The moisture buffering value of materials was studied by Rode [2], and a definition scheme for the moisture buffer phenomena in indoor environment divided into three descriptive levels – material level, system level and room level – was offered. Fluctuating variation can be seasonal or diurnal, but in practice attention is paid to the moisture buffering diurnal variations mostly. According to Rode [2, 3] the practical Moisture Buffer Value ($MBV_{practical}$ [kg/(m^2·%RH)]) indicates the amount of water that is transported in or out of material per open surface area during a certain period of time, when it is subjected to variations in relative humity of the surrounding air. Normal case suggested by Rode is RH of 75 and 33% and cyclic change is 8 and 16 hours accordingly [4,5] while air temperature at testing is 23°C. Ramos [6] also added tests/results at air temperature 15°C into testing series. Ge et al [7] used 10/14h and 2/22 h cycles.

Janssen [5] introduced the Nordtest protocol formula for $MBV_{practical}$ [g/(m^2·%RH)] calculations (Formula 1):

$$MBV_{8h} = \frac{m_{\max} - m_{\min}}{A \cdot (\varphi_{high} - \varphi_{low})} \tag{1}$$

Where $m_{min/max}$ is moisture mass (min and max) in finishing sample (g or kg), A – exposed area m^2; $\varphi_{high/low}$ -h igh/low RH (-) levels applied in the measurement.

Using the Moisture buffer values [g/(m^2·%RH)@8/16h] materials can be classified as follows [3]: negligible (0-0.2), limited (0.2-0.5), moderate (0.5-1.0) good (1.0-2.0), excellent (2.0-).

Materials behave differently and also moisture load regimes in the buildings and rooms could be different. Ge et al. [7] studied at 10/14 h (moisture generation of 100 g/h) 1 kg total and 2/22 h (200 g/h) 400 g as total of moisture load and got different results of moisture buffering for different materials (volume of 21.4 m^3). For uncoated gypsum panel and wood panelling the adsorption of moisture for 10 hours was similar. That is an interesting result because a quite fixed list of well-known and popular "breathing" materials like timber, clay and lime plaster is often drawn out, probably because of final sorption values. For example, Ge et al. [7] found the stabilised moisture content 313 g/m^2 (achieved at 342 hours) for wood and 38 g/m^2 (10 h) for gypsum board at environment with RH of 75%). Ge et al. [7] also categorised materials into 3 groups depending on **moisture capacity** and **vapour permeability**. **Group A** materials have high moisture capacities but low vapour permeability **Group B** materials have low moisture capacity and high vapour permeability Materials in **Group C** have both high moisture capacity and high vapour permeability.

Ramos [6] focuses on finishing materials properties that can enhance their moisture buffering performance and can be easily demonstrated to designers and builders. Ramos [6] tested gypsum board, gypsum plaster and gypsum + lime plaster for their sorption and water vapour permeability. He used acrylic and vinyl paints with and without primer and concluded that materials tested with painting schemes including a primer presented much lower vapour permeability. Based on ranges for practical MBV classes, it can be said that the base materials tested have a "moderate class" [0.5–1.0 g/(m^2·%RH)] of moisture buffering efficiency, which can be reduced to a "limited class" [0.2-0.5 g/(m^2·%RH] by the effect of coatings.

The influence of different paints depending on time was studied by Minke [8]. On silty loam substrate lime, casein and cellulose glue paint only slightly reduce the absorption (after a sudden increasing RH from 50-80%), whereas double latex and single linseed oil coating can reduce absorption rates to 38% and 50% respectively. One material can have different properties. Šemjakin [9] studied linseed oil paint made on the basis of different recipes. Water vapour diffusion equivalent air layer thickness S_d was estimated as 0.1 and 0.2 m for 1-layer primers, 0.2 to 0.9 m for 1-layer paints and 0.4 to 0.9 m for 2-layer paints. Maddison [10] studied clay plaster sorption properties dependent on different