

The Evaluation of Hygroscopic Inertia and Its Importance to the Hygrothermal Performance of Buildings

Nuno M. M. Ramos and Vasco Peixoto de Freitas

Abstract Heating and ventilating are fundamental actions for the control of humidity in the indoor environment, but the hygroscopic inertia provided by the materials that contact the inside air can be a complement for that control. The hygroscopic behavior of the walls and ceiling finishing materials, as well as furniture and textiles inside the dwellings, defines their hygroscopic inertia. Reducing the persistence of high relative humidity values inside buildings is essential for the control of mould growth on material surfaces, that can otherwise cause degradation and bring about social and economical problems for the users. As the hygroscopic inertia concept can be very difficult to approach for building designers, a definition of daily hygroscopic inertia classes is presented, based on numerical and laboratory work on this subject. An outline of a simple method, using those classes, that allows for the evaluation of the reduction of mould growth potential associated to a configuration of inside finishes is proposed. The extensive experimental campaign aiming the characterization of the moisture buffering capacity of interior finishing system and the assessment of a room's hygroscopic inertia is described. The MBV—Moisture Buffer Value is evaluated for different revetments. The assessment of hygroscopic inertia at room level is implemented using a flux chamber designed specifically for this experiment. A daily hygroscopic inertia index, $I_{h,d}$, is defined using MBV as a basis for the assessment of materials contribution to the buffering capacity of a room. The correlation between that index and peak dampening is proved using the presented experimental results. Systematic simulation of the set of dynamic experiments of transient moisture transfer in

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the hygroscopic region is presented; allowing to verifying and correcting the modeling assumptions and the basic data used in simulations, and conclude on the most effective strategies to conduct this type of simulations.

1 Introduction

The variation of inside Relative Humidity (RH) is influenced by the moisture exchange between air and building elements. The relevance of that exchange is linked to the active moisture buffer capacity present in a room, which can be identified with its hygroscopic inertia.

Relative humidity the air inside buildings can have an influence on thermal comfort, on the perception of indoor air quality, users' health, materials durability and energy consumption. This dependency has been established by science but the common user will not always recognize it. Mould growth on building element's surfaces, on the other hand, is easily associated with the persistence of high RH levels even by users and can be tied not only to durability but also to PAQ and health.

The work of several researchers has already demonstrated the benefits from inside relative humidity variation control provided by hygroscopic materials [7, 11], and the International Energy Agency (IEA) research project, IEA-Annex 41 contributed to a deeper understanding of that process.

Laboratory experiments are a way of demonstrating and quantifying that capacity and can be implemented in three different levels.

At material level, international standards already support the determination of the basic properties that condition moisture storage performance, such as sorption isotherms (ISO 12571 [3]) and vapour permeability (ISO 12572 [4]). A property defined as MBV, Moisture Buffer Value, was proposed by [9], allowing for a direct experimental measure of the moisture accumulation capacity of a material under transient conditions.

At element level, where several materials can be combined by their application in different thicknesses, MBV can also be applied as an experimental measure of each specific element configuration moisture accumulation capacity.

At room level, the authors believe that a laboratory measurement of the active moisture buffer capacity should be directly linked to the RH peak dampening promoted by the room's interior configuration, compared to the peaks in the same room without any active hygroscopic surfaces.

The relation between the three levels of experimental measurements is explored using numerical simulation of element and room behaviour using the material properties measured in the first level.

This text also defines daily hygroscopic inertia classes and proposes their implementation as an easy way of including the building materials moisture

storage capacity influence on RH variation and mould growth risk analysis. A proper selection of interior finishes can obviously benefit from that inclusion.

2 Material Properties

2.1 Materials

In these experiments, an option was made in using specimens of common commercial materials used finishing systems for walls and ceilings. The experiments were therefore performed in specimens of, gypsum plaster ($\rho = 1200 \text{ kg/m}^3$) as base material, either naked or combined with a coating.

This type of gypsum is blended in factory and, after addition of water, can immediately be applied. The coating is also commercially available and, therefore, formulation is unknown. It was known, however, that it was composed of 25 μm acrylic primer and 50 μm vinyl finishing layer.

The procedure for the preparation of the gypsum plaster specimens tried to replicate the conditions that are used in practice. The dry plaster powder (2 kg) was mechanically mixed with water (1 dm^3), during 5 min, to produce a homogeneous mass. After casting in wood frames for 24 h, the specimens were dried in the air.

2.2 Sorption Isotherm

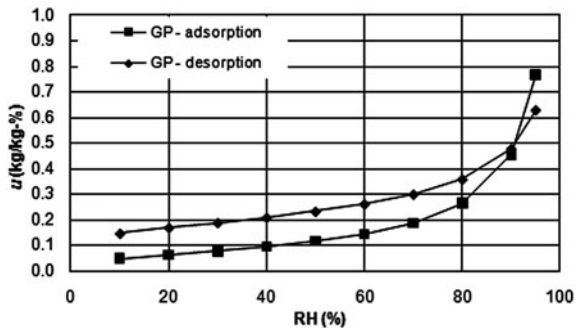
Most building materials are hygroscopic, which means that they adsorb vapour from the environment until equilibrium conditions are achieved. This behaviour can be described by sorption curves over a humidity range of 0–95% RH. The sorption isotherms represent the equilibrium moisture contents of a porous material as a function of relative humidity at a specific temperature.

The experiments were performed in accordance with ISO 12571 standard. At a temperature of $23 \pm 2^\circ\text{C}$, four of five available relative humidity ambiances were used in the characterization of each of the three base materials. Each ambience was obtained in desiccators using a specific saturated salt solution (NH_4Cl -77%, NH_4Cl -84% and KNO_3 -91%) or in a climatic chamber (33 and 50%).

The gypsum plaster specimens had dimensions of $60 \times 60 \times 6 \text{ mm}^3$. The specimens were initially dried at ambient temperature, during 30 days, in desiccators containing CaCl_2 , guaranteeing a relative humidity below 0.5%.

For sorption measurements, the test specimen is placed consecutively in a series of test environments, with relative humidity increasing in stages, until equilibrium is reached in each environment. Equilibrium between moisture content and relative humidity has been reached when successive weightings,

Fig. 1 Sorption isotherms obtained for gypsum plaster



at time intervals of at least one week, show a difference in mass lesser than 0.1%. The starting point for the desorption measurements was above 91% RH. While maintaining a constant temperature, the specimen is placed consecutively in a series of test environments, with relative humidity decreasing in stages, until equilibrium is reached in each environment. With the objective to gain time, different specimens were used for the different ambiences in the sorption phase. Finally, the specimens were dried at the appropriate temperature to constant mass. From the measured mass changes, the equilibrium moisture content (u), at each test condition, could be calculated and the sorption/desorption isotherm drawn (see Fig. 1).

2.3 Vapour Permeability

Vapour permeability was determined for samples of the base material, both naked and combined with the coating. The tests were conducted according to ISO 12572 standard. For each combination of base material and coating, three permeability values were defined, corresponding to three different ranges of RH differences across the sample.

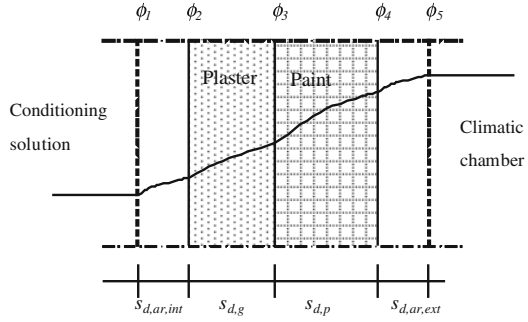
Prior to testing, all the specimens are preconditioned in a climatic chamber at $23 \pm 2^\circ\text{C}$ and 50% RH, for a period long enough to obtain three successive daily determinations of their weight lesser than 0.5%.

After stabilisation, the specimens are placed in cups with a saturated salt solution below the bottom surface of the specimen. The sides of the specimens were covered with vapour impermeable tape. Due to the dimensions of the cups, the dimensions of the samples corresponded to $210 \times 210 \times 11$ mm.

The change of weight of the cup was measured periodically, with a precision of 0.1 mg, on an electronic balance until the steady state was obtained.

The sketch presented in Fig. 2 shows the relative humidity profiles admitted for the painted samples during the permeability experiments, in accordance with the theory presented below.

Fig. 2 Relative humidity profiles during the vapour permeability experiments



The vapour permeability, δ_p , is a material property defined as the transport coefficient for vapour diffusion in a porous material subjected to a vapour pressure gradient. The permeability can be calculated using,

$$\delta_p = g \frac{d}{\Delta P} \quad (1)$$

where g is the mass flux density and d is the sample thickness exposed to a vapour pressure gradient ΔP .

Other properties derived from vapour permeability can be used, as the transport coefficient under a vapour concentration gradient: vapour resistance factor, $\mu = \delta_a / \delta_p$ or vapour diffusion thickness, $s_d = \mu \cdot d$.

Although a constant value is derived for δ_p after each permeability test, it's well established that this property is RH dependant, $\delta_p(\phi)$. To determine these functions for the tested materials, the permeability type Eq. 2, and its adapted form for $s_d(\phi)$ value (3), proposed by Galbraith et al. [2], was used and the regressions were carried out using the Levenberg–Marquardt method and SPSS 14.0 program.

$$\delta_p(\phi) = A_1 + A_2 \cdot \phi^{A_3} \quad (2)$$

$$s_d(\phi) = \frac{\delta_a \cdot d}{A_1 + A_2 \cdot \phi^{A_3}} \quad (3)$$

The empirical constants of Eq. 3 were derived by the regression method described above for naked specimens as $A_1 = 1.83 \times 10^{-11}$, $A_2 = 2.91 \times 10^{-11}$ and $A_3 = 3.21$.

For the coated samples, however, a more complex methodology was applied in the results analysis. With the knowledge of the base materials $\delta_p(\phi)$ function, assuming fixed values for $s_{d,air,int}$ and $s_{d,air,ext}$, and accepting that for each test $s_{d,g+p} = s_{d,g} + s_{d,p}$, as represented in Fig. 2, it was possible to obtain the A_1 , A_2 , A_3 coefficients for the $s_d(\phi)$ function of the coating applied on the gypsum base material. The results were $A_1 = 2.51 \times 10^{-14}$, $A_2 = 8.44 \times 10^{-13}$ and $A_3 = 6.031$.

Figure 3 shows the results obtained for the measurement results for the vapour permeability of the unpainted specimens and s_d value of the applied paint.

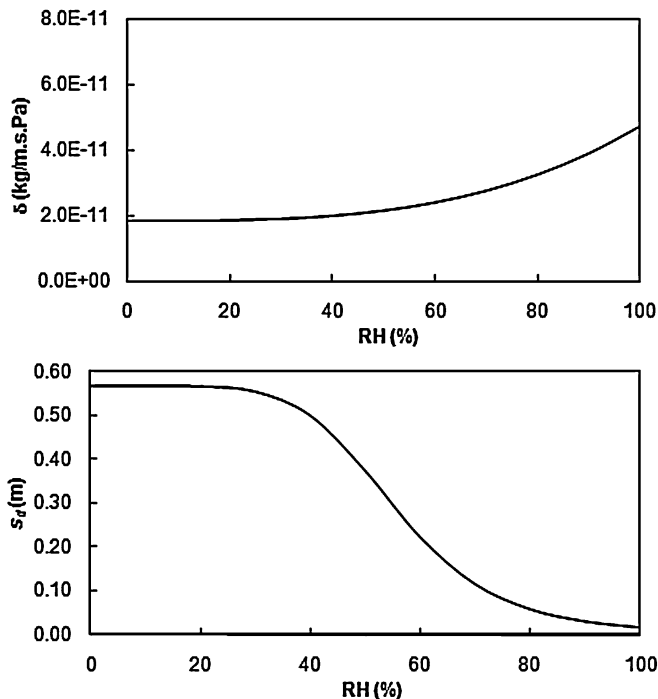


Fig. 3 Vapour permeability of gypsum plaster and sd value of applied paint

3 Moisture Buffer Value

The MBV experiments, as described in [9], propose a cyclic climatic exposure which consists of 8 h of high relative humidity, followed by 16 h of low relative humidity. This test tries to replicate the cycle seen in bedrooms. For the specific tests described in this article, low value was fixed at 33% RH and the high value at 75% RH, for a constant temperature of 23°C, which is the basic test configuration proposed in the protocol. The cycles were repeated until the specimen weight over the cycle varied less than 5% from day to day.

The tests were conducted in a climate chamber ensuring a good control level of the test conditions. All the samples tested were put into the chamber at the same time. Three similar samples were tested for each configuration. Each sample was put on a balance when it was likely to have reached a stable mass variation over the cycle. With this procedure it was possible to test a large number of samples. The balance was connected to a computer allowing for a continuous record of the sample mass variation.

The samples were placed horizontally on the balance. The back of the samples was previously treated with epoxy paint and the four edges were covered with aluminium tape, allowing vapour transfer only in the main face.

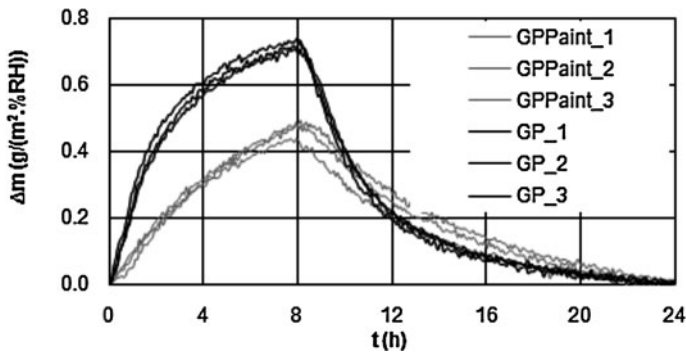


Fig. 4 Mass variation stable cycle in MBV experiments with gypsum plaster based materials

The stable cycle for each configuration is presented in Fig. 4. This type of experiment is interesting in the way it provides an easy assessment of the transient behaviour of a building element. Just by watching the curves, the effect of painting is easily highlighted.

4 Flux Chamber Tests

4.1 Test Facility

The test facility is a small compartment where finishing materials contribution to hygroscopic inertia can be evaluated. To do so, a flux chamber where RH can float freely as a function of boundary conditions and amount of moisture buffering was developed. A strict control of the heat, air and moisture balances of that chamber was therefore crucial. According to this idea, several guidelines were defined: the base element should be a small size chamber with control of moisture and air fluxes; the whole set should have temperature control and; temperature and RH should be continuously monitored. Figure 5 displays a scheme of the test facility, following these guidelines.

The flux chamber was built inside an existing climatic chamber (Fig. 6). This chamber has a capacity for controlling temperature in the range 15–35°C and RH in the range 30–90%. That control can be done using fixed values or using programmable cycles including variation of one or both parameters. A continuous log of the actual values is registered in a computer.

The size of the flux chamber (Fig. 7), to be stored inside, corresponds to a box with a volume of $(1500 \times 524 \times 584) \text{ mm}^3$. Thinking of a regular bedroom with $(3 \times 4 \times 2.7) \text{ m}^3$, the volume scale factor is around 1/70.

By placing all the elements inside a climatic chamber, a strict temperature control was secured. The ventilation system uses a pump (Fig. 8) controlled by flow meters (Fig. 9) that extracts air in two points inside the box and an inlet on

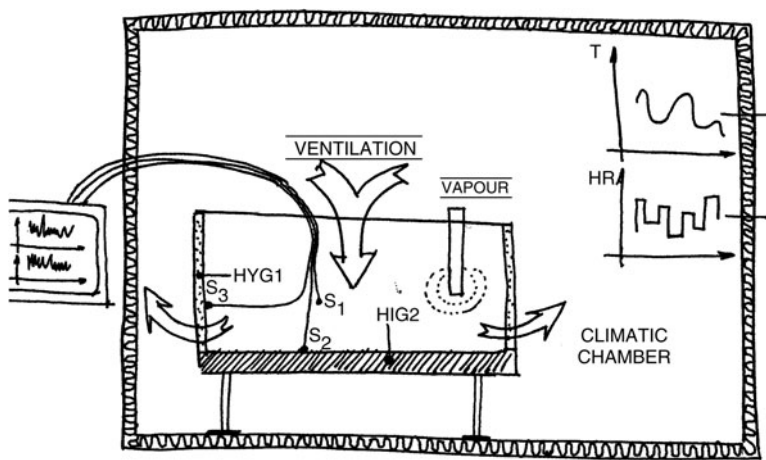
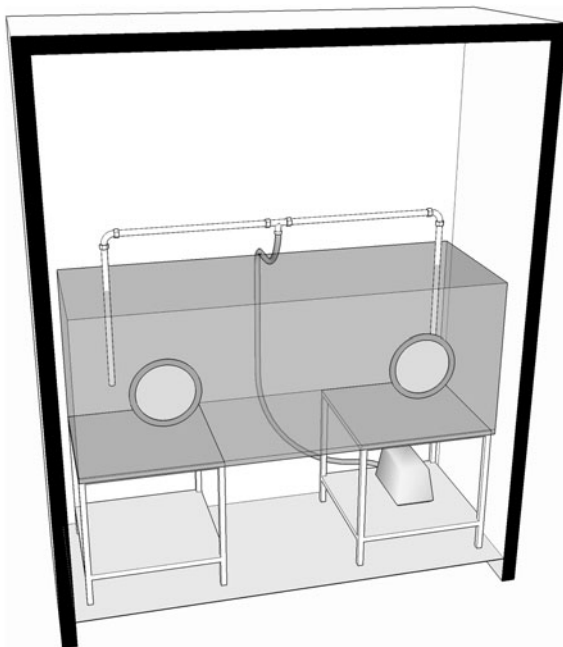
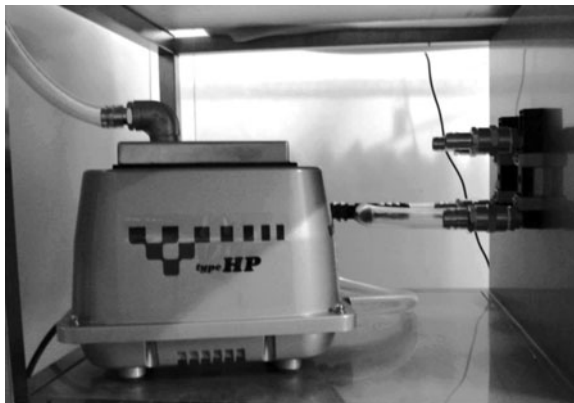


Fig. 5 Flux chamber scheme

Fig. 6 Climatica chamber



Fig. 7 Flux chamber**Fig. 8** Air pump

top allows for the air to get in and, at the same time, prevents pressure differences. The air that enters the box comes directly from the climatic chamber, and therefore its characteristics are known. The air flux value corresponds to a range of the air exchange rate (ach) of $0.26 - 17 \text{ h}^{-1}$.

The temperature and humidity of the air being sucked inside are known, since the whole set is inside the climatic chamber. Also for that reason, infiltration through the openings doesn't affect the overall balances of heat, air and moisture.

The monitoring system (Figs. 10, 11, 12) is composed of a set of temperature and Relative Humidity sensors connected to a data logger. The data logger is

Fig. 9 Flow meters**Fig. 10** Monitoring system

Fig. 11 Data logger



Fig. 12 Temperature and relative humidity sensors

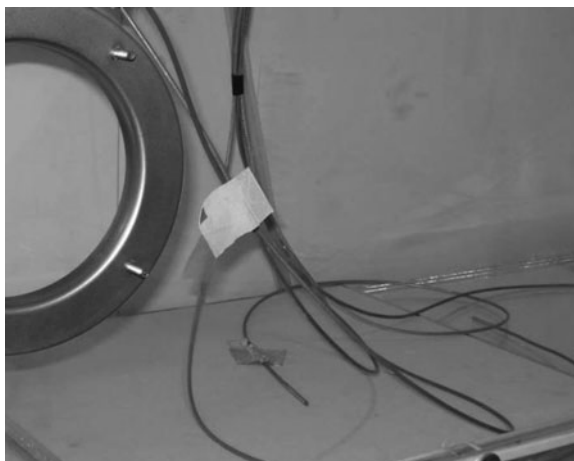


Table 1 Flux chamber tests configuration

Test	Period (h)	Climatic chamber		Flux chamber	
		T (°C)	RH (%)	Rph (h ⁻¹)	Samples
HI1	0–8	23	80	0.5	–
	8–24	23	40		
HI2	0–8	23	80	0.5	0.75 m ² GP
	8–24	23	40		
HI3	0–8	23	80	0.5	0.75 m ² GPPaint
	8–24	23	40		

Table 2 Flux chamber tests results

Ensaio	RH _m (%)	RH ₉₀ (%)	RH ₉₀ –RH _m (%)
HI1	54.6	73.2	18.6
HI2	54.3	63.9	9.6
HI3	54.7	66.8	12.1

connected to a computer allowing to keep track of results and store them in a hard-drive.

4.2 Test Results

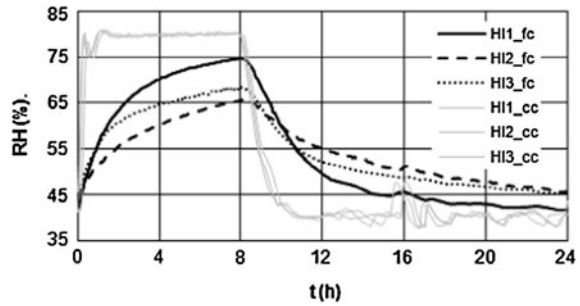
The tests performed in the flux chamber reported in this text, consisted of the definition of the stable daily RH cycle for a hygrothermal scenario. The selected scenario was defined assuming the number of air changes per hour, Rph, of 0.5 h⁻¹ and a vapour production of 2 g/h, during 8 h in the daily cycle. As the temperature of the system was fixed at 23°C, the vapour production was obtained with the RH variation of the climatic chamber between 40 and 80% RH. Using those scenarios, different combinations of samples were placed inside the flux chamber, resulting in different RH cycles. For each configuration, the daily hygrothermal cycle is repeated until the flux chamber RH falls in a stable cycle. The different test conditions used are specified in Table 1.

The results of the tests are presented in Table 2 and Fig. 13 displays the RH variation inside the flux chamber for the tested combinations. For quantification of the test results, the difference between the average RH and the RH 90th percentile, RH₉₀–RH_m, is used. The average RH value obtained for each stable cycle showed a small variation, demonstrating the high control level of the experiments.

These results clearly illustrate the application of the flux chamber in measuring the actual RH dampening caused by the presence of different levels of moisture buffering in contact with inside air.

The observed variations highlight the contribution of different elements to hygroscopic inertia and its effect on RH peak dampening. Test HI1 resulted in a

Fig. 13 RH variation inside the flux chamber (fc) and the climatic chamber (cc)



difference between peak and average of 18.6% RH. The introduction in the flux chamber of a porous material, naked gypsum plaster, in HI2 test resulted in a difference between peak and average of 9.6%, a clear effect of hygroscopic inertia. The same type of material, but with a coating applied, corresponding to test HI3, resulted in less peak dampening, a difference between peak and average of 12.1% RH. This result clearly demonstrates how a coating influences materials contribution to hygroscopic inertia.

5 Hygroscopic Inertia Classes

A method of bringing the hygroscopic inertia concept closer to practitioners has been developed and experimentally evaluated by [8]. The basic idea, illustrated in Fig. 14, is to have a prediction tool that can establish a relation between the dampening of the RH variation in a room and its hygroscopicity level, which is mainly dependant on the surface finishing materials and furnishing.

According to the principle, a hygroscopic inertia index was defined as a single number, representing the hygroscopic inertia of a room and that can correlate to the expected reduction of the RH fluctuation. It was decided that this index should concentrate only on daily cycles and it should be derived from room configuration and known material properties.

The MBV—Moisture Buffer Value was the selected material/element property thus acting as a base for that index definition. The proposed daily hygroscopic inertia index, $I_{h,d}$, is defined by [8] as a function of MBV, according to expression (1), where MBV_i = Moisture buffer value of element i ($\text{g}/(\text{m}^2 \cdot \% \text{RH})$); S_i = surface of element i ; MBV_{obj} = Moisture buffer value of complex element j ($\text{g}/\% \text{RH}$); C_r = Imperfect mixing reduction coefficient (—); N = air exchange rate (h^{-1}); V = room volume (m^3); TG = Vapour production period (h). The $I_{h,d}$ can be understood as the room MBV, homogenized to air renovation conditions and vapour production period variations.

$$I_{h,d} = \frac{\sum_i^n C_{r,i} \cdot MBV_i \cdot S_i + \sum_j^m C_{r,j} \cdot MBV_{obj,j}}{N \cdot V \cdot TG} \rightarrow \left[\frac{\text{g}}{\text{m}^3 \cdot \% \text{HR}} \right] \quad (4)$$

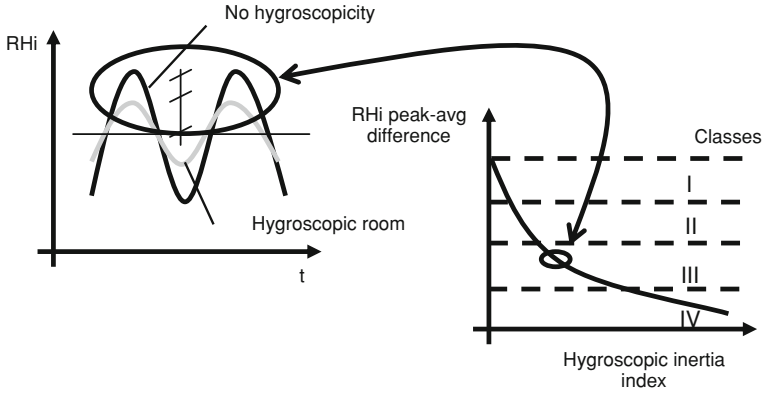
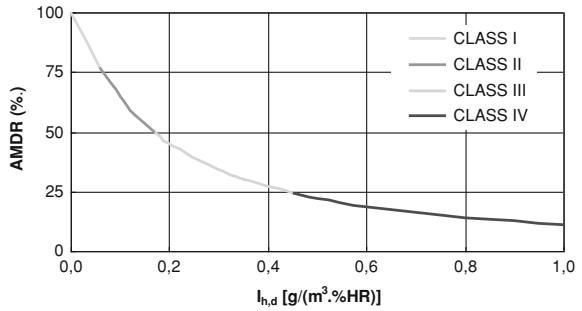


Fig. 14 Hygroscopic inertia classes definition principle

Fig. 15 Graphic relation between AMDR and $I_{h,d}$



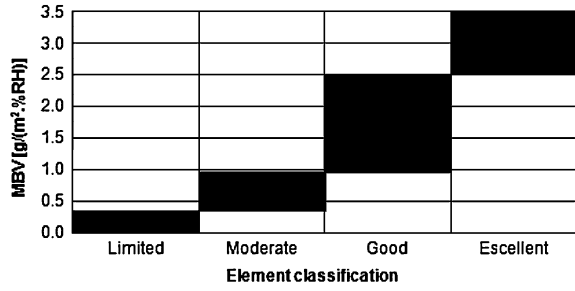
The evaluation of a RH variation curve in time should be based on a single number, keeping in mind the principle described.

The AMDR parameter was defined according to Eq. 5, where HR_m is the average relative humidity variation and $\overline{HR}_{90}$ stands for the daily average of the 90th percentile of the relative humidity variation. The index *ref* refers to the base scenario of a room without hygroscopicity and *sim* identifies a scenario under study for that same room. The AMDR parameter can therefore be interpreted as relative daily average amplitude of a RH variation of a room hygroscopic configuration. This parameter is interesting since the average RH variation in long-term analysis will not be affected by daily hygroscopic inertia.

$$AMDR = \frac{(\overline{HR}_{90} - HR_m)_{sim}}{(\overline{HR}_{90} - HR_m)_{ref}} \quad (5)$$

The selected parameters were proven by [8] to be connected by Eq. 6. The resulting curve supports the definition of daily hygroscopic inertia classes, according to Fig. 15.

Fig. 16 Building element classification as a function of their contribution to a room's hygroscopic inertia



$$AMDR = \frac{1}{0.00998 + 0.0793 \cdot I_{h,d}^{1.16}} \% \quad (6)$$

The adopted classes support a new classification of building elements contribution to the hygroscopic inertia of a room, based on their MBV and on a ratio between room volume and area of application of 0.7 (Fig. 16).

6 Numerical Simulation

6.1 Numerical Model

A decision was made to numerically simulate the behaviour of a room and the moisture buffer capacity of the materials used in the room simulation. This provided data that can illustrate the desired relation between hygroscopic inertia and room configuration.

The authors chose to use for these simulations the software program HAM-Tools [5]. The International Building Physics Toolbox, is a software library specially constructed for HAM system analysis in building physics.

As part of IBPT, HAM-Tools is open source and publicly available on the Internet. The library contains blocks for 1D calculation of Heat, Air and Moisture transfer through building materials. The toolbox is constructed as a modular structure of the standard building elements using the graphical programming language Simulink. All models are made as block diagrams and are easily assembled in a complex system through the well-defined communication signals and ports.

6.2 MBV Simulations

An assembly of HAM-Tools modules was used for simulating the MBV experiment. The simulations were performed using the virtual specimens listed in Table 3. The data for the chosen materials used in the simulations was retrieved from [6]. The different β (convective water vapour transfer coefficient) values used

Fig. 17 Moisture content variation of all the specimens in a stable cycle

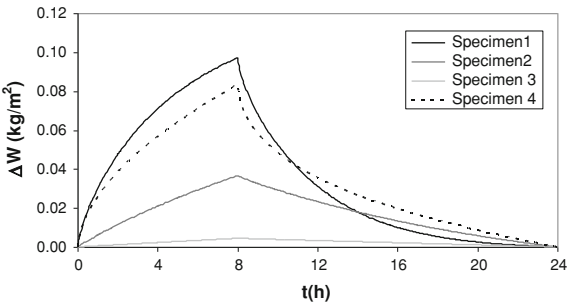


Table 3 Virtual specimen’s characteristics

Specimen	Material	β (s/m)	Thickness (m)
1	Gypsum board	2e-8	0.01
2	Gypsum board	2e-9	0.01
3	Gypsum board	2e-10	0.01
4	Spruce	2e-8	0.01

represent the possibility of coatings with different additional vapour resistances applied in the gypsum board specimens.

In Fig. 17, the mass variation of all the specimens in the steady cycle is presented. The MBV for each specimen is presented in Table 4. As we can see, this number, when associated to the tested elements, provides the means to compare them. But as it was said before, this number is used ahead for hygroscopic inertia analysis.

6.3 Room Simulations

A different HAM-Tools modules association allowed for the simulation of a room’s hygrothermal behaviour in yearly cycles. The virtual room is $3.5 \times 3.5 \times 2.5 \text{ m}^3$, with one exterior wall, containing a 1 m^2 window, facing south. The surrounding rooms are assumed to have similar conditions of temperature and relative humidity as the simulated room. The climate conditions were defined for Lisbon, using Meteonorm software. The inside temperature was allowed to float between Tmin and 28°C , and RH was allowed to float below 90%. The ventilation rate is constant and the vapour production takes place between 0 and 8 h, with a constant value. On walls and ceiling the admitted material was gypsum board and on the floor spruce. Tables 5 and 6 describe the conditions that were changed for each simulation. It can be easily inferred that the room configuration in the first line of Table 6 stands for the room with no hygroscopic inertia, the reference room.

Partial results from simulations SG1 and SG2 are presented in Figs. 18, 19, 20 and 21 illustrating the tested scenarios.

Table 4 MBV for the four specimens tested

Specimen	1	2	3	4
MBV(kg/m ²)	0.0971	0.0366	0.0045	0.0832

Table 5 Hygrothermal parameters adopted in simulations

Simulations	Tmin (°C)	G (g/h)	N (h ⁻¹)
SG1–SG2	18	100	1.0
SG11–SG12	18	150	1.0
SG15–SG16	15	100	1.0
SG19–SG20	21	100	1.0
SG23–SG24	18	100	0.67
SG27–SG28	18	100	0.33

Table 6 Room configurations

Simulations	Walls		Ceiling		Floor	
	Area (m ²)	β (s/m)	Area (m ²)	β (s/m)	Area (m ²)	β (s/m)
SG: 1-11-15-19-23-27	34	2e-12	12.25	2e-12	12.25	2e-12
SG: 2-12-16-20-24-28	34	2e-8	12.25	2e-8	12.25	2e-12

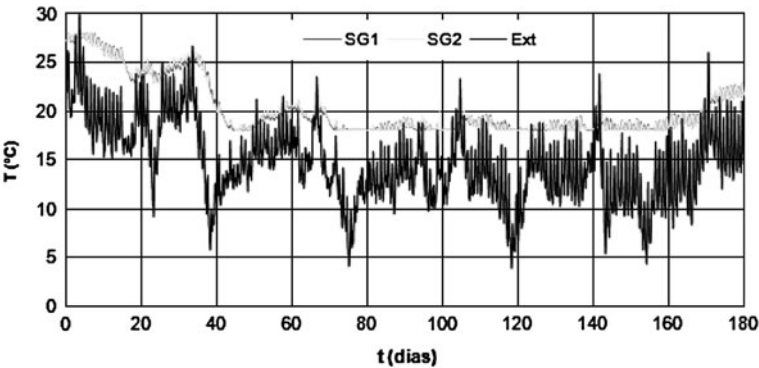


Fig. 18 Results from simulations SG1 and SG2—temperature values from October to March

The temperature variations, presented in Fig. 18 showed almost no influence of hygroscopic inertia.

The relative humidity variation, on the other hand, is highly influenced by hygroscopic inertia, as it can be seen in Fig. 19. That result is also visible in vapour pressure variation, presented in Fig. 20. That influence however, is only important on peak level. The average values will tend to be the same, with or without hygroscopic inertia. That is quite clear on Fig. 21 where monthly values are close and as periods are more extended, that difference tends to be even smaller.

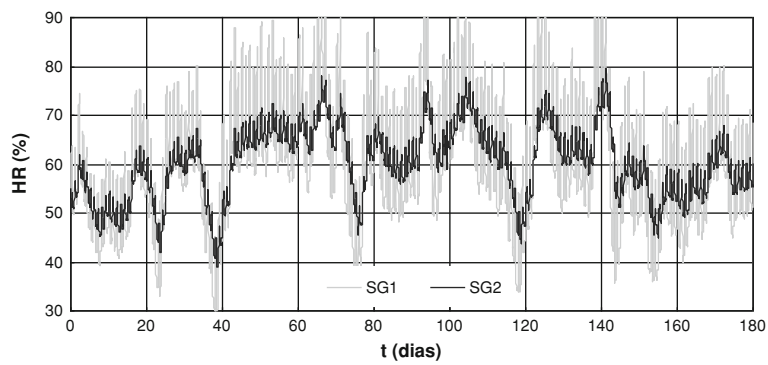


Fig. 19 Results from simulations SG1 and SG2—relative humidity values from October to March

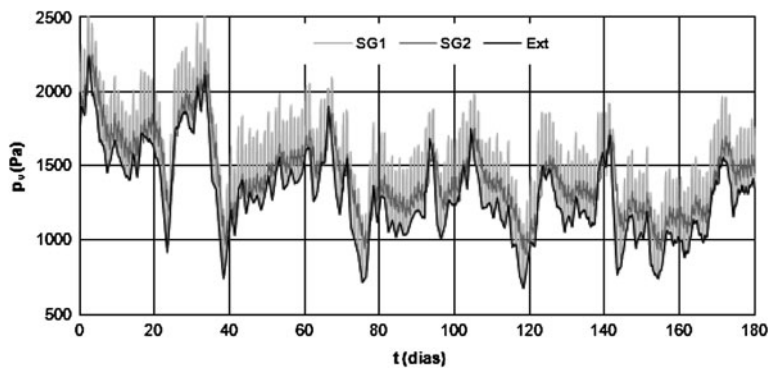


Fig. 20 Results from simulations SG1 and SG2—vapour pressure values from October to March

Fig. 21 Results from simulations SG1 and SG2—relative humidity average values

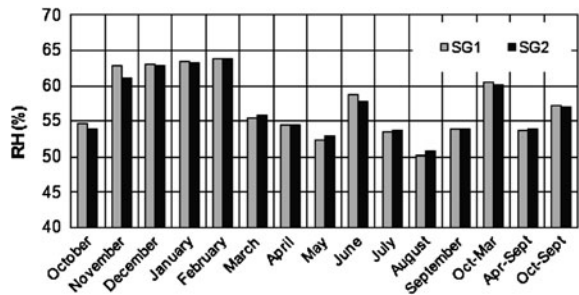


Table 7 Parameters for hygroscopic inertia analysis

Simulations	$I_{h,d}$ (g/(m ³ .%RH))	AMDR (%)
SG: 1-11-15-19-23-27	0	1.0
SG2	0.438	0.23
SG12	0.438	0.24
SG16	0.438	0.24
SG20	0.438	0.23
SG24	0.653	0.18
SG28	1.326	0.12

6.4 Hygroscopic Inertia Analysis

The application of the hygroscopic inertia classes method allows for the definition of parameters AMDR and $I_{h,d}$ corresponding to the simulation scenarios. The values obtained are presented in Table 7, and reveal that the scenarios hygroscopically active would be placed in class III-IV.

6.5 Mould Growth Risk Assessment

Several authors have studied the relationship between water activity in a substrate and the development of mould on its surface (e.g. [1, 10]). The mould development under transient conditions of temperature and humidity is highly complex. Reference [1] proposed a model based on the TOW (time of wetness) concept to solve this problem. TOW is the quotient between the time period where the surface RH is above 80% and the total duration of the period under analysis. Using that model in several laboratory tests, there was evidence that for $TOW < 0.5$ the risk for mould growth is very low. Using the TOW concept when simulating a room’s hygrothermal behaviour it is possible to define the number of days with $TOW > 0.5$, $nd_{tow} > 0.5$, as a simplistic indicator of the mould growth risk. This approach loses accuracy if the simulations indicate actual surface condensation and the analysis tool is unable to treat that process with high precision.

Additionally, the authors use another parameter, nd_{cond} , representing the number of days when surface condensation was detected. The objective of these indicators is not to accurately estimate mould growth risk, but rather to compare hygrothermal scenarios. Using these parameters in the above simulated scenarios and imposing an additional condition of the existence of a rather extreme thermal bridge, defined by $f_{Rsi} = \frac{T_{surf,i} - T_e}{T_i - T_e} = 0.5$, the results for each scenario are as presented in Fig. 22.

This result shows the importance of hygroscopic inertia and the benefits that can derive from a sss RH variation with important peak reduction. A design method for the prevention of mould growth can be derived from this analysis. The method itself can have different levels of complexity. The basic idea is:

Fig. 22 Mould growth risk analysis

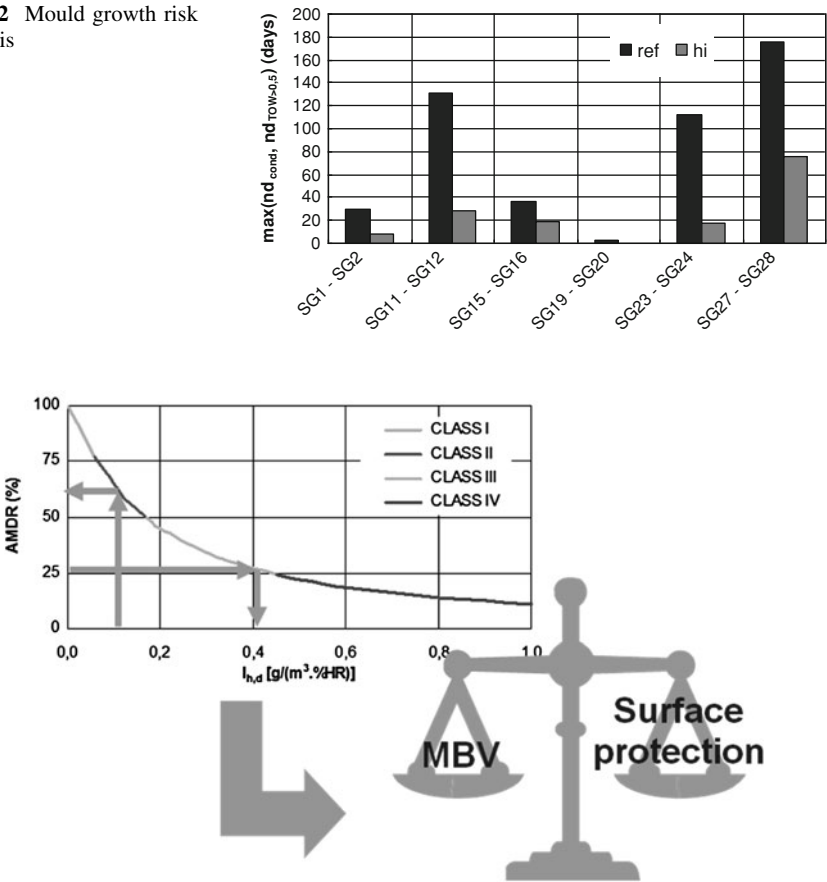


Fig. 23 The relevance of balance between hygroscopic inertia and surface protection

- define the risk associated with the room’s RH variation for the four classes of hygroscopic inertia;
- select the adequate $I_{h,d}$ value and define the room’s renderings to provide that value.

7 Conclusions

This text presents research that allows for the following conclusions:

- Moisture buffering tests were conducted at element level. Renderings finished with different coatings were tested for MBV determination, allowing for buffer effect comparison. The finishing coating has a relevant influence on that effect.

- Hygroscopic inertia tests were conducted in a flux chamber that represents a small scale room. The influence of different elements on RH variation was obtained. The experimental evidence of daily hygroscopic inertia was demonstrated.
- The definition of daily hygroscopic inertia classes based on a room's index allows for the prediction of the RH variation amplitude;
- The MBV property can be used as an indicator of an element's contribution to the room's hygroscopic inertia;
- Mould growth risk is lower for higher values of hygroscopic inertia, admitting the same composition of the surface's final rendering;
- The design and selection of interior finishes in practice can benefit from the proposed approach to the hygroscopic inertia concept. But the balance between the MBV supplied by a surface and its protection against biological defacement (Fig. 23) must be achieved.

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