

PAPER • OPEN ACCESS

Experimental study of hygrothermal conditions in a wooden room for numerical comparisons

To cite this article: C Legros *et al* 2021 *J. Phys.: Conf. Ser.* **2069** 012209

View the [article online](#) for updates and enhancements.

You may also like

- [Acceleration of degradation by highly accelerated stress test and air-included highly accelerated stress test in crystalline silicon photovoltaic modules](#)
Soh Suzuki, Tadanori Tanahashi, Takuya Doi et al.
- [Influence of environmental effect on thermal and mechanical properties of welded PPS/carbon fiber laminates](#)
Izabely Gonçalves Araújo, Luis F P Santos, Luis F B Marques et al.
- [Study on the hygrothermal aging behavior and diffusion mechanism of Ti/CF/PMR polyimide composite laminates](#)
Yubing Hu, Cheng Liu, Chen Wang et al.



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Experimental study of hygrothermal conditions in a wooden room for numerical comparisons

C Legros^{1,2}, A Piot¹, M Woloszyn² and M Pailha²

¹ University of Grenoble Alps, CEA, LITEN, Grenoble, France

² University of Savoie Mont Blanc, CNRS, LOCIE, Chambéry, France

E-mail : legros.clemence@outlook.fr

Abstract. The use of hygroscopic materials indoors has a significant impact on the hygrothermal balance of a room air. It affects both the temperature and the relative humidity. Numerical tools still lack of accuracy in predicting these parameters and some discrepancies are observed between their predictions and experimental measurements. It may be caused by the model itself or by incorrect inputs data (materials properties, occupancy schedule, ventilation rate, etc...) Therefore, an experimental study has been carried out at the room scale under real climate to obtain an experimental dataset as a basis for numerical comparisons. The hygrothermal parameters of the room air have been measured for different loads while all the inputs (heat and moisture generation, air exchange and materials properties) have been properly quantified. This article presents the experimental setup and some of the experimental data obtained.

1. Context

To address current and emerging environmental issues, the building industry is increasingly using bio-based materials (wood, earth, straw, etc...). They are made of raw natural materials and are mostly porous. They are therefore hygroscopic. It means that they are able to exchange water vapour with the surrounding air. This behavior impacts both the thermal and the mass balances of the indoor air.

During the design process or a retrofitting project, the energy demand of the building is calculated using numerical tools. However, several studies have shown that these software still lack of accuracy in predicting the hygrothermal parameters of the air, especially when hygroscopic materials are used indoors. These observations have been made by comparing the numerical predictions to experimental measurements at different scale : from a small volume of air under controlled conditions [1] to an occupied building with real outdoor conditions [2]. The present work complements the benchmarking work done in the project EBC Annex 41 [3]. The scaling up comes along with a complexification of the parameters needed as numerical inputs: ventilation rate, infiltrations, heat and moisture generation related to human occupancy and activities for instance. These discrepancies may have some experimental explanations (as the measurement uncertainty and quantification of each physical parameters) and numerical explanations (as the model itself and the solving algorithm).

Due to the limited number of pages allowed, this article only presents the work done on the improvement of experimental data collection. The aim was to obtain a complete experimental dataset with both most of the input parameters properly quantified for the numerical implementation and hygrothermal measurements of the room air against time for several solicitations.



2. Method

The study has been carried out on an experimental detached house dedicated to scientific research in the French Alps, close to Chambéry. An overview of the climatic data is presented in Figure 1.

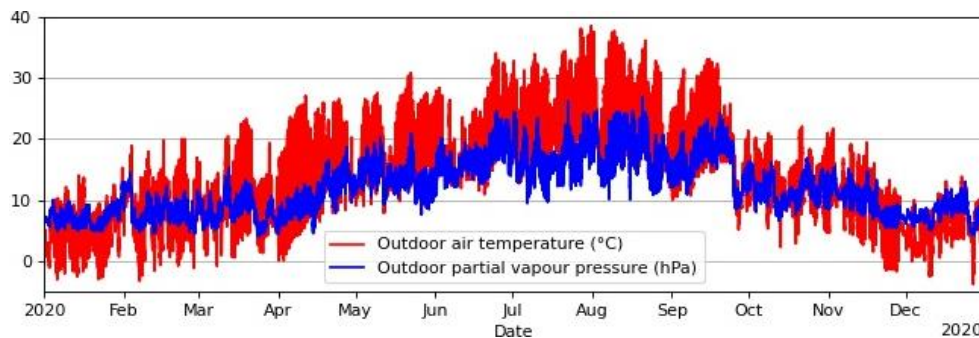


Figure 1. Evolution of the outdoor air condition in Chambéry in 2020.

At the first floor of the house, there is a 30 m³ room covered with raw spruce paneling. The human occupancy has been reproduced by technical equipments (heat generator, moisture generator and fan). The ventilation rate is ensured by a dedicated mechanical ventilation system and the air is conditioned before being insufflated in the room. There is no natural ventilation.

Different ventilation rates have been tested (no ventilation rate, 0.3 ach, 1 ach and 2 ach) as well as different occupancy schedules, in winter and summer conditions. The Table 1 presents the amount of heat and moisture generated by the equipments to reproduce the human occupancy. The bedroom is characterized by a long and low intensity step during the night time: two people, no light, no electrical appliance. The living room is characterized by shorter and more intense steps during the day time: one people for the breakfast, two people for the diner, lights when occupancy, electrical appliances all the day and clothes drying in the morning.

Table 1. Occupancy schedule details.

Schedule type	Time	Heat generation	Moisture generation
Bedroom	10 pm – 7 am	120 W	80 g/h
	otherwise	0 W	0
Living room	7 am – 9 am	180 W	60 g/h
	9 am – 1 pm	10 W	120 g/h
	6 pm – 10 pm	280 W	120 g/h
	otherwise	10 W	0 g/h

The air temperature and relative humidity of the air are recorded with a time step of 1min with a Sensirion SHT 75 sensor located in the middle of the room at 1.1m above the ground. A fan ensures a complete mixing of the air in the room.

All the data, including climatic condition, construction details and materials properties are available on demand to the corresponding author.

3. Main results and discussion

The heat generation has been regulated with a power control system. The moisture generation is recorded with a scale. The ventilation rates and infiltrations have been characterized with tracer gas tests. The materials properties have been determined with laboratory measurements. Therefore, most of the inputs are properly quantified to be set as input parameters in a calculation software.

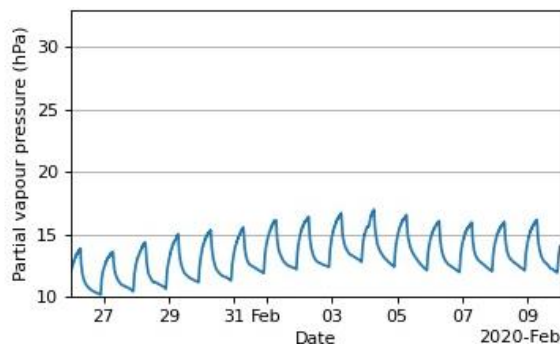


Figure 2. Evolution of the partial vapour pressure of the air in a bedroom with a ventilation rate of 1 ach in winter conditions

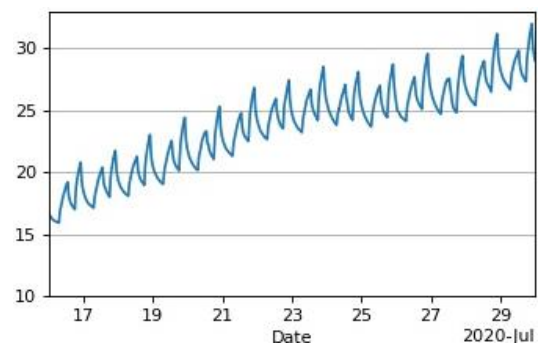


Figure 3. Evolution of the partial vapour pressure of the air in a living room with a ventilation rate of 2 ach in summer conditions.

Figure 2 presents the evolution of the partial vapour pressure in a bedroom with a ventilation rate of 1 ach during winter. Figure 3 presents the evolution of the partial vapour pressure in a living room with a ventilation rate of 2 ach during summer. Other combinations of ventilation rate, occupancy schedule and season have been tested but are not presented in this article. Each combination lasted at least three weeks before changing to another combination. Finally, more than 150 days of data have been collected throughout the experimental campaign.

From the presented graphs, a very good repeatability is observed from day to day. The evolution of the partial vapor pressure is consistent with the moisture and heat gains, the ventilation rate used and the season of each test, confirming that these data are robust enough to serve as reference for a numerical comparison.

4. Conclusion and perspectives

The experimental data collection is a key point on the way of numerical predictions improvement. It is therefore essential to quantify and reduce as much as possible all the experimental uncertainties. This is particularly relevant for the room scale studies since the larger the study scale, the more complex and coupled the phenomena.

Then, the experimental set up has been modelled with the software Energy Plus and all the data collected during the experimental campaign (outdoor climate, heat and moisture generation in the room, heat and moisture exchange through the ventilation, hygrothermal conditions of the next rooms and material properties) have been implemented as inputs data in the numerical tool. The comparison results will be subject of a coming paper.

Acknowledgments

Authors wishing to acknowledge the French Environment Management Agency (ADEME) and Smart-Reno program supported by French Certificats d'Economie d'Energie (CEE) for funding this work.

References

- [1] Busser T, Piot A, Pailha M, Rouchier S and Woloszyn M 2017 Experimental and numerical study of wood-based materials: from material to room scale. *Energy Procedia*. **132** 747-52
- [2] Moujalled B, Aït Ouméziane Y, Moissette S, Bart M, Lanos C and Samri D 2018 Experimental and numerical evaluation of the hygrothermal performance of a hemp lime concrete building: A long term case study. *Build Environ*. **136** 11-27
- [3] IEA 2007 EBC Annex 41 Whole Building Heat-Air-Moisture-Response (MoistEng)