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# Hygrothermal behaviour of timber frame walls finished with a brick veneer cladding

Michiel Vanpachtenbeke[a,b,*], Jelle Langmans[a], Jan Van den Bulcke[b], Joris Van Acker[b], Staf Roels[a]

*[a]KU Leuven – University of Leuven, Department of Civil Engineering, Building Physics Section, Kasteelpark Arenberg 40 – bus 02447, BE-3001 Heverlee (Leuven), Belgium*
*[b]UGent – Ghent University, Department of Forest and Water Management, Laboratory of Wood Technology – Woodlab, Coupure Links 653, BE-9000 Ghent, Belgium*

**Abstract**

In this study, two typical timber frame walls with brick veneer cladding have been constructed at KU Leuven to investigate the hygrothermal response of these constructions in a moderate sea climate. Main topic of research is the contradictory criterion for the wind barrier when it comes to the risk on interstitial condensation for winter and summer conditions: in winter a vapour open wind barrier is appropriate, in summer a more vapour tight. Therefore, similar walls but with different types of wind barrier have been investigated. In one set-up a vapour open bituminous impregnated wood fibre board is used as wind barrier, whereas in the second set-up a more vapour tight wood fibre cement board is used. The study shows that a high relative humidity can be expected at the interface between insulation and wind barrier during winter conditions, leading to a high mould growth index. In contrast, the relative humidity at the interface between insulation and inner vapour retarder during summer is lower than expected. This can be caused by the buffering capacity of the hygroscopic materials in the wall.


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*Keywords:* timber frame wall, brick veneer cladding, interstitial condensation, wind barrier, mould risk

* Corresponding author. Tel.: +32 16 37 63 16; fax: +32 16 32 19 80.
*E-mail address:* michiel.vanpachtenbeke@kuleuven.be; michiel.vanpachtenbeke@ugent.be

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## 1. Introduction

An important role of building enclosures is to protect the indoor climate from environmental loads. The control of in- and outward energy and mass flows by the exterior building components is therefore an essential aspect. To reduce the risk of damage, it is appropriate to keep the moisture levels in the walls low enough, especially in case of timber frame constructions. According to Straube and Finch [1], the most important moisture sources leading to the deterioration of the building envelope are 1) precipitation, 2) vapour transfer through the wall by diffusion and/or advection, 3) built-in and stored moisture and 4) capillary or gravity-driven ground water. Regarding the second point, the building component should be designed in a way that a high relative humidity and interstitial condensation are avoided. Today, it is common practice in Europe to provide a vapour barrier/retarder at the inside of the wall, while the layers to the outside have an increasing level of vapour permeability [2]. In this way, the condensation risk of outward vapour flow in the outer layers is limited. However, according to Sandin [3], the optimum moisture design cannot be generally stated. It depends, among others, on the climate and indoor conditions. In winter conditions for moderate European climates, mainly an outward vapour flow will take place through the building component, whereas in summer conditions solar driven inward diffusion may occur. According to Wilkinson [4], the factors that influence solar driven inward diffusion are: 1) exposure to wind-driven rain and solar radiation, 2) moisture absorptive and buffer capacity of the cladding, 3) presence of cavity ventilation, 4) vapour permeability of the sheathing layers behind the cladding and the interior finish/vapour control layers and 5) interior temperature. In case of brick veneer cladding, a cladding with a high moisture buffer capacity yet with low cavity ventilation rates, the relative humidity in the wall will greatly depend on the moisture transfer from the masonry to the inner leaf. In order to reduce the relative humidity in the wall during summer, Sandin [3] proposes three solutions. A first solution is to keep the masonry dry, resulting in no inward vapour transport. This can be achieved by hydrophobation of the wall. Another solution to lower the humidity levels in the wall is to limit the inward moisture transport, for example by a well-ventilated cavity or a wind barrier with a certain vapour resistance. A last solution is to make sure that moisture can freely flow through the building component. This means that no vapour barriers are provided. Furthermore, a study conducted by Geving et al. [5] showed that insulation with a high moisture capacity (e.g. wood fibre insulation) can also help to reduce the relative humidity peaks in the wall. In contrast, during winter conditions, the relative humidity levels are high only in the outer parts of the wall [3]. Wilkinson [4] stated that, compared to summer condensation, the risk on mould growth is lower since temperatures are lower. Nevertheless, providing thermal insulation at the outside of the inner wall will lead to higher temperatures, and consequently a lower relative humidity in the inner wall [3].

In this paper, the hygrothermal conditions in a timber frame wall with brick veneer cladding are studied. Therefore, in-situ measurements on two timber frame walls were conducted at KU Leuven. The only difference between the two walls is the vapour permeability of the wind barrier. A more vapour open wind barrier is advantageous to avoid interstitial condensation in winter conditions, however solar driven condensation in summer may occur. On the other hand, a more vapour tight wind barrier will better resist solar driven moisture ingress yet in this case interstitial condensation in winter conditions may occur. The aim of this study is to investigate which role the exterior sheathing can play in the reduction of moisture related problems in timber frame walls located in a moderate sea climate.

## 2. Experimental set-up and material properties

Two typical timber frame walls with brick veneer cladding exposed to real outdoor conditions have been constructed at KU Leuven (Figure 1). The height of the walls is 2.7 m, whereas the width is 0.8-0.9 m. The walls are oriented to the South-West, which in Belgium is the direction of prevailing winds and solar radiation. The two walls are identical except for the wind barrier. In one set-up a bituminous impregnated wood fibre board, here a Celit board [6], is used as wind barrier. The second set-up is provided with a wood fibre cement board, in casu a Duripanel board [7]. Both wind barriers have a thickness of 18 mm. The wall's insulation consists of mineral wool with a thickness of 20 cm yet compressed to 18 cm. The wall is finished with a 22 mm thick OSB board at the inside. Furthermore, the thickness of the brick veneer cladding is 9 cm and the cavity depth is 4 cm. The cavity is ventilated by 1 open head joint (3.5 x 1.5 x 9 $cm^3$) both at the top and bottom. A measuring grid of sensors is installed throughout the wall to monitor temperature and relative humidity (see Figure 1). In addition, the exterior climatic conditions are also registered by the building's weather station.