VENTILATIOAN SYSTEM PERFORMANCE

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Paper 28

HUMIDITY CONTROLLED NATURAL VENTILATION WITHOUT AUXILIARY ENERGY SUPPLY

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1. Introduction

As a consequence of measures required for reducing the heating energy consumption in residential buildings, there have been more and more complaints in the last few years on the appearance of mould in dwellings. In most cases, it is retrofitted or renovated old buildings which are affected [1]. Mould growth is frequently the result of a severe reduction in the natural air change rate in old buildings following the installation of airtight windows, while user habits remain the same as before. Each day, an average amount of 8 to 15 liters of moisture is generated in dwellings, which is usually conveyed to the outside through window joints. However, airtight windows and insufficient ventilation cause indoor air humidity to rise. This may lead to surface humidity on cold external walls, e.g. at thermal bridges, thus providing ideal conditions for mould growth. The effect is enhanced unless the insulation level of the external wall is greatly improved so that the surface temperature of the exposed areas is increased. According to [2], mould growth is influenced by the following parameters: nutrient availability, temperature, ph-value of the substrate and, in a decisive manner, the amount of water in the substrate. According to [3], in one third of all cases, the damage is obviously caused by user-related, high indoor air humidity (see Table 1). This is the result of tests performed in 300 old buildings, where several examinations were

Tab.1: Compilation of the parameters most frequently analysed in the test. Often, the cause of damage is not clearly attributable to a single parameter. Therefore, the sum of the parameters is a value above 100 %.

<table>
<tr><th colspan="3">Influential factors for moisture damage</th><th>Frequency [%]</th></tr>
<tr><td rowspan="6">Building</td><td rowspan="3">Thermal bridges</td><td>Parapet</td><td>21</td></tr>
<tr><td>Window reveal</td><td>18</td></tr>
<tr><td>Others</td><td>5</td></tr>
<tr><td rowspan="2">Rain protection device</td><td>Small cracks</td><td>37</td></tr>
<tr><td>Large cracks</td><td>15</td></tr>
<tr><td colspan="2">Rising moisture</td><td>9</td></tr>
<tr><td>Occupant</td><td colspan="2">Indoor air humidity (mould growth on furniture)</td><td>31</td></tr>
</table>

carried out in different dwellings. Besides, structural deficiencies such as thermal bridges or insufficient humidity protection of the building envelope were identified as being responsible for the remaining cases of damage. It can therefore be concluded that, supposing the construction is sound, it is the user-related indoor moisture load that should be reduced to prevent humidity damage and resulting mould growth.

2. Ventilation

While items such as missing or unsufficient thermal insulation and bad humidity protection as well as insufficiently insulated thermal bridges are inherent in the construction itself, humidity production and release can be influenced by the user. In the absence of building defects (sufficient thermal insulation and humidity protection), it is indoor air humidity that becomes the major cause for mould growth. Free ventilation through windows and untight window joints is the kind of ventilation most frequently performed in dwellings. An increased air change through window ventilation is something that is done subjectively by the user. As continuous ventilation results in increased heat losses during the heating period (often with mould contamination of the window reveal caused by convective cooling), it seems that short periods of intensive ventilation would be most efficient for energetic and hygric reasons. However, as the assessment of the indoor air quality is a subjective thing, ventilation controlled by the user may result in air change rates which are either excessively high (heat losses!) or dangerously low (risk of mould!).

3. Free ventilation according to actual parameters

A humidity controlled ventilation unit based on the principle of free ventilation (see Fig. 1) has been developed and patented at the Fraunhofer Institute of Building Physics. The device is a ventilation valve which may be installed in external walls or window frames, thus establishing a connection between indoor and outdoor air. It is automatically opened and closed by way of a sensor, without mechanic or electric auxiliary energy being required. Based on the principle of the hair hygrometer, the opening works according to humidity dependent length variations of suitable natural or chemical fibres employed to provide a mechanic force. For this reason, the unit does not require auxiliary energy and will operate automatically for years. The unit will stop the air change between indoor and outdoor air, if the indoor air humidity decreases to values which do not lead to critical surface humidity at the external wall. Simultaneously, increased heat losses are avoided.

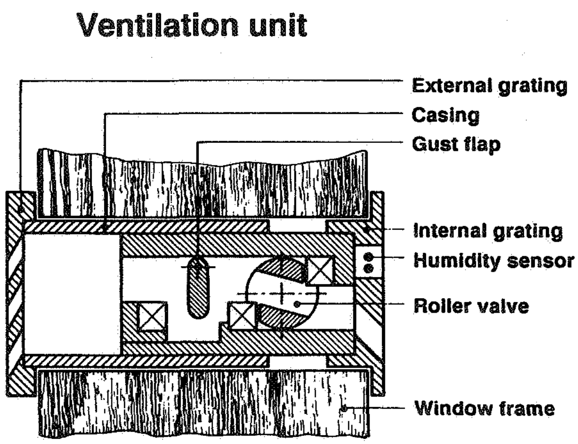

Fig.1: Schematic representation of the humidity controlled ventilation unit.

4. Function

The cross section of the unit is controlled by the sensors according to actual parameters, i.d. in case of high indoor air humidity, the valve of the unit will open to enable an air change. The opening characteristic is illustrated in Fig. 2.

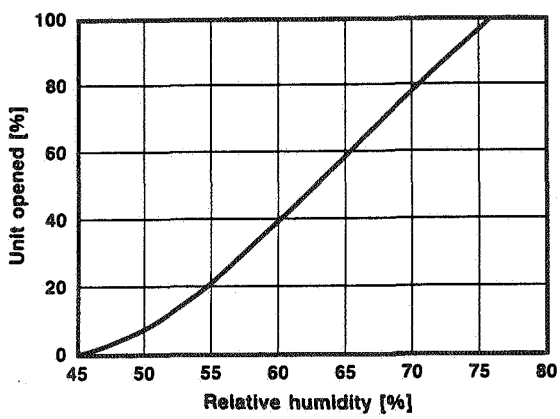

Fig.2: Opening characteristic of the ventilation unit developed by the Fraunhofer Institute of Building Physics.

The air change rate is dependent on the pressure difference between inside and ambient environment. Figure 3 presents the air flow rate through the valve in closed and open state dependent on the existing pressure difference for the prototype of a wall unit. Pressure differences of 10 to 20 Pa already lead to air flow rates of app. 15 to 20 m^3/h through the ventilation unit.

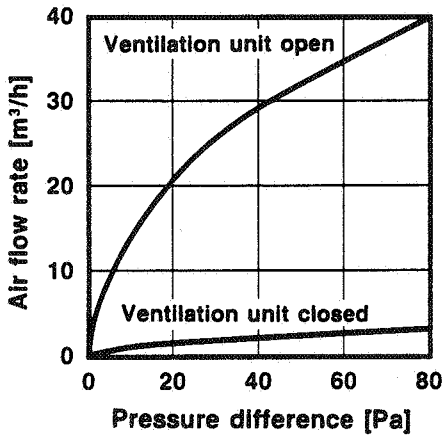

Fig.3: Air flow rate through the ventilation unit while open and while closed. The measurements were carried out according to German standard DIN 18055.

In order to examine the process of free ventilation by means of this device, four units were mounted in the unoccupied test house [4] as it can be seen in Fig. 4.

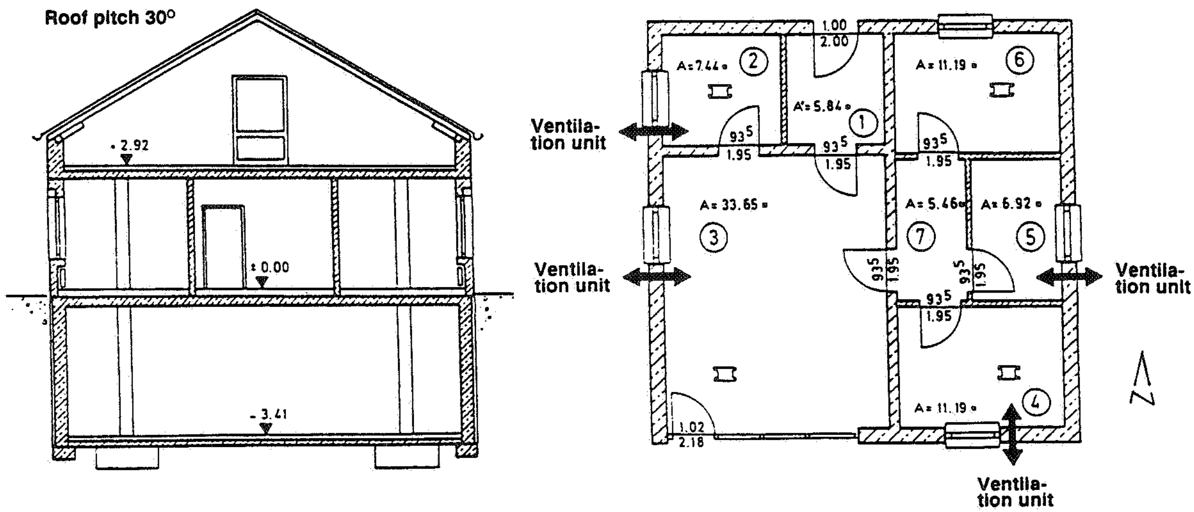

Fig.4: Floor plan and section of the test building and location of the ventilation units according to [5].

In this connection, different installation situations were subject to investigation. Using tracer gas measurements, it was possible to determine the air change rate in single rooms under realistic wind pressure conditions with the units fully open or closed. It was observed that closed units hardly increased the airtightness of the entire building in comparison to the basal air change rate without units [5]. The measurement results are shown in Fig. 5. The values recorded for each room are plotted dependent on wind speed for open and closed units respectively. The hatched section between the curves represents the increased ventilation rates which result. The values for room 2 in Fig. 5 examplarily demonstrate that the unit increases the air change rate from 0.3 to 1.0 h^{-1} at a wind speed ranging from 2 to 7 m/s.

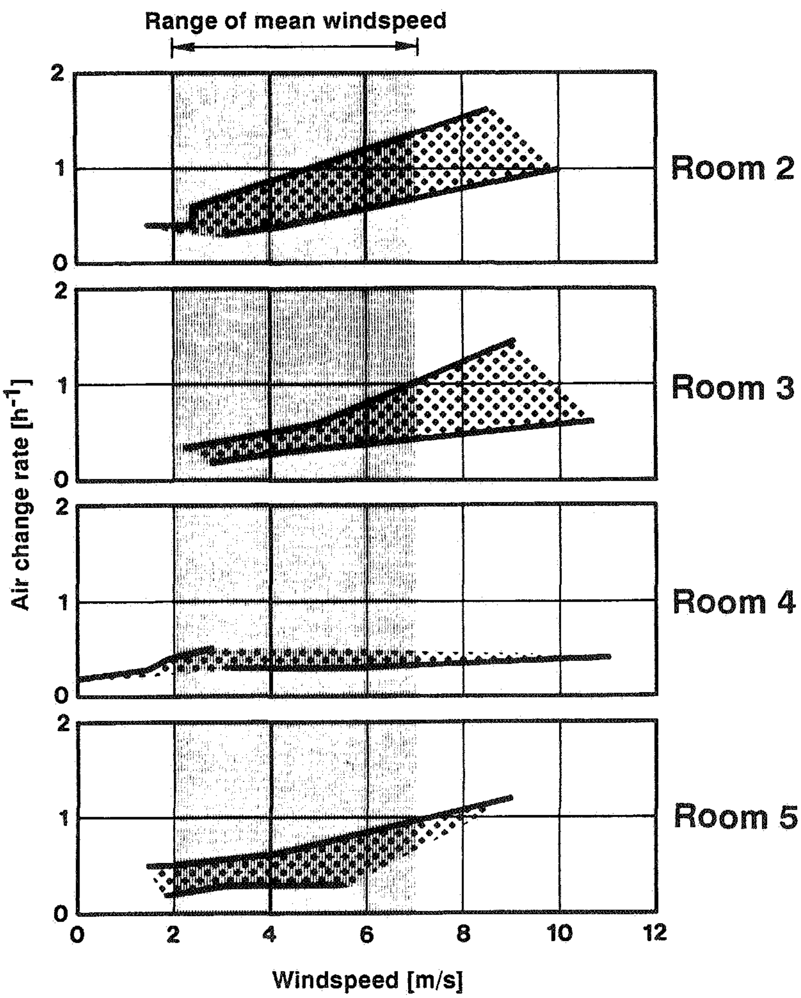

Fig.5: Comparison between the air change rates recorded within the test building for the rooms 2 to 5 with the unit being closed (lower curve) and open (upper curve). The hatched section demonstrates the increased air change rates obtained by way of the ventilation unit according to [5].

Figure 6 displays the mean wind speeds for the heating periods according to the 12 test reference years developed by [6] at different reference locations in Germany.

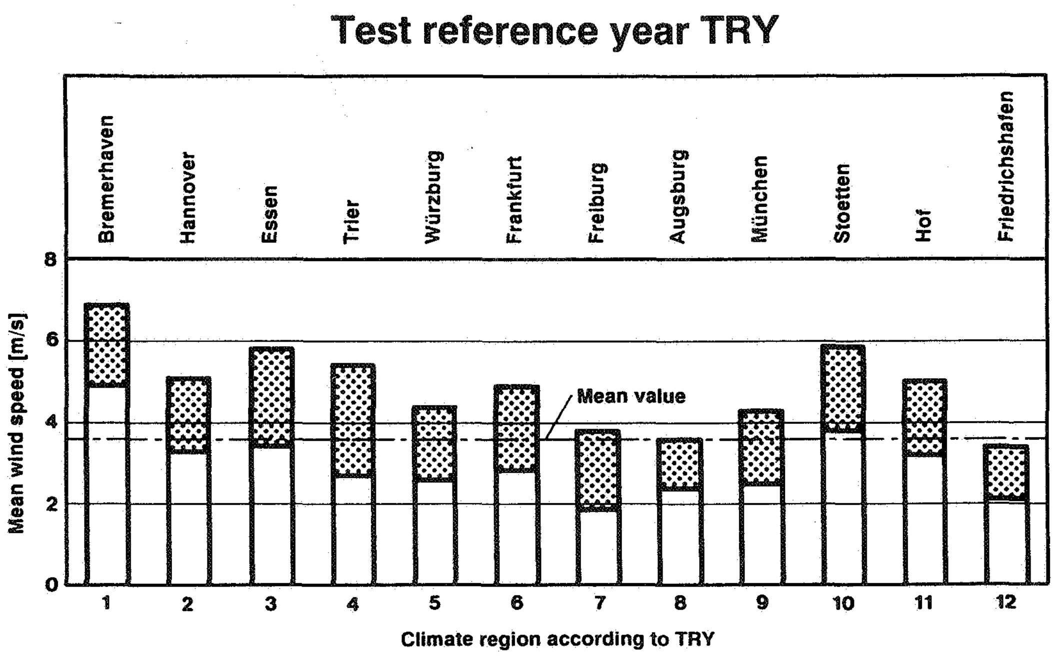

Fig.6: Mean wind speeds during the heating period as they were recorded by the 12 stations in the test reference years developed by [6] for the Federal Republic of Germany.

The mean wind speed of all locations is 3.6 m/s; the lowest mean value being 2.5 m/s, the highest 5.4 m/s. At the location with the lowest wind speed, the air change rate is 0.6 h^{-1} for room 2 with the unit open.

It can be concluded from the measurements that given mean wind speeds, free ventilation by way of the units described results in air change rates of > 0.5 h^{-1} which are recommended in [6] to prevent mould growth caused by too humid indoor air.

Besides, the measurement demonstrates that it is useful to install several units in order to provide supply and exhaust air valves depending on wind pressure.

5. Conclusion

To prevent mould in dwellings with a sound building fabric, it is necessary to convey humid air to the outside. To this end, the paper at hand presents an efficient device for free ventilation developed at the Fraunhofer Institute of Building Physics. The unit functions automatically (without auxiliary energy). Depending on the relative air humidity, it can adjust air change rates such that the r.h. will not remain critical for a longer period of time. It is advisable to test this unit in practice in order to prove the intended effect of preventing mould due to excessive indoor air humidity.

6. Literature

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Discussion
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C-A Roulet (LESO, Switzerland)

In many countries it is shown that air inlets are often taped or closed by the occupants. Is it not time to take this fact into account and act in order to avoid this behaviour? (E.g. hide the inlets, avoid the draughts, inform inhabitants, etc).

M Szerman (Fraunhofer Institut fur Bauphysik, Germany)

I agree completely that the occupant should not be able to adjust or close demand controlled internal ventilation units. In fact our developed unit cannot be closed by the user.

W. Raatschen (Dornier GmbH, Germany)

a) Your system works about in the same way as the French AERECO system. Do you expect the same performance? b) Why was there a need for you to develop a new system if such systems do already exist?

M Szerman (Fraunhofer Institut fur Bauphysik, Germany)

a) Respectively the air change rate due to this element, we expect nearly the same performance as the AERECO. But our element avoids problems with thermal and acoustic bridge effect due to the element, by the special construction. AERECO elements don't consider this, so that it is expected that this element will get problems, even in the German market. b) When we develop our system, AERECO was not on the market. Besides that, our element takes into account that much different outside temperature/humidity conditions different air change rates are required, to reduce the indoor air humidity by the same amount.

H Hens (Leuven, Belgium)

Comment: 1) Tricky paper, proving that the larger an air inlet opening, the higher the ventilation rate. 2) Humidity control = correct solution. To avoid mould one should monitor or the RH against the coldest surface or ********* (outside temp, inside temp, RH)