Importance of a Proper applied Airflow in the Façade Air Gap when Moisture and Temperature are Calculated in Wood Framed Walls

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ABSTRACT

The airflow in the air gap behind the façade panel has shown to be of importance when risks of moisture and mould damages in wood frame walls are calculated. This study demonstrates the importance of a properly applied outdoor air flow in the air gap behind the façade panel when temperature and moisture conditions are calculated. The paper present and compare how variations in airflow in the air gap influence temperature and moisture conditions in a modern Swedish wood framed wall. Different references present various air flows that are adapted in the air gap. Calculations are made in the one dimensional temperature and moisture calculation program WUFI 4.2. The results shows that the air flows in the air gap behind the panel affect relative humidity in all positions outside the vapour retarder. At the same time temperature in the whole construction and relative humidity inside the vapour retarder is not affected by different air flows in a significant way. The conclusion is that a correct airflow in the façade air gap is of importance for calculated moisture conditions in modern Swedish wood constructions. An incorrect air flow can also give significant errors for calculated moisture conditions.

KEYWORDS

Wood Framed Walls, Airflow, Air gap Moisture calculations, WUFI.

INTRODUCION

Background

In order to prevent moisture damages, the revised regulations in Sweden require a moisture design process in the early planning process (Boverket, 2008). A consequence of increased insulation for energy saving reasons is that critical parts of the building envelop become more exposed to higher relative humidity and increased risk of mould growth. To minimize the risk for mould and moisture damages the Swedish wood house industry need a reliable method to predict moisture conditions in wood constructions.

A great number of simulations with WUFI show that the outdoor air flow in the air gap behind the façade panel is of great importance when the moisture conditions in the wall are calculated (Hägerstedt, O., 2010, Nore, K., 2009). In order to make a good assessment of future moisture conditions in Nordic climate it is of vital importance to assume a proper air flow in the air gap behind the façade panel.

Aim

The purpose of this study is to show how the air flow, in an outdoor ventilated air gap behind the façade panel affects calculated results of relative humidity and temperature in modern wood house walls. This is shown by repeating calculations in the same model with different air flows in the air gap. The report compares differences of calculated relative humidity and temperature with different air flow in the air gap.

Illustrations of the importance of using a proper air flow in the air gap in calculations are shown by comparing calculated relative humidity for two different air flows with measurements in the same position.

Limitations

This study does not discuss how airflows are affected by the design of the air gap. Detailed function and data for parameters and boundary conditions in used calculation program are not concerned. All calculations are limited to a one dimensional case.

The construction refers to a modern Swedish exterior wall made of wood. The façade is facing north because it usually becomes the most critical direction for moisture conditions in this type of wall. Apart from the example is WUFI 4.2 standard climate data used. A comparison with actual climate data between calculated and measured values of temperature and relative humidity are presented in Thermophysic conference 3 to 6 November 2010, Valtice, Czech Republic.

RELATIVE HUMIDITY AND RELATION TO TEMPERATURE

Climate conditions with a relative humidity above 75% can cause mould growth on organic materials. There are a several factors that affect if mould growth arises but temperature seems to have a big importance of possibility and intensity of mould growth. Lover temperatures generally reduce the risk of mould growth and increase the critical level of relative humidity. Normally there is no mould growth at 0°C, or lower. In contrast gives higher temperature increased probability of mould growth. Higher temperature also provides a faster establishment of mould spores. Below 75% relative humidity the general opinion is that there is no risk of mould growth regardless of temperature (Boverket, 2008). Besides temperature the material structures and exposed time are also factors of importance when the risk for mould is estimated. (Viitanen, H., 1996)

METHOD

In this chapter is a briefly method description given. A complete detailed method description, with defined sources of error and specified parameters, is given in a separated report (Hägerstedt, O. 2010)

Calculations of relative humidity and temperature have been carried out for different air flows in three positions, B, C and D, in a modern wood framed wall with WUFI 4.2 (WUFI 2009). In the air gap behind the panel, position A, is a constant outdoor air flow of 0, 1, 5, 10, 20 or 50 air changes per hour applied for each calculation. Used air flow in the air gap behind the panel is based on available literature in the field. In real cases the air flow is not constant and depends on several factors such as air gap design, wind and other climatic factors. The airflow could also vary in different parts of the air gap. (Wadsö, L. 1996, Nore, K. 2009) The wall and calculations are supposed to reflect a real case. From the outside the wall are constructed by: 21 mm Spruce radial (IBP) including paint Sd = 1 m (Nevander, L-E. et al. 1994), 30 mm Air layer with varied air flow (IBP), 1 mm Weather resistive barrier Sd = 0,2 (IBP), 195 mm Mineral wool (IEA Annex 24 1996), 1 mm Vapour retarder (IBP), 70 mm Mineral wool (IEA Annex 24 1996), 13 mm Chipboard (IBP), 13 mm Gypsum board (Krus, M. 1996). (Hägerstedt, O, 2010)

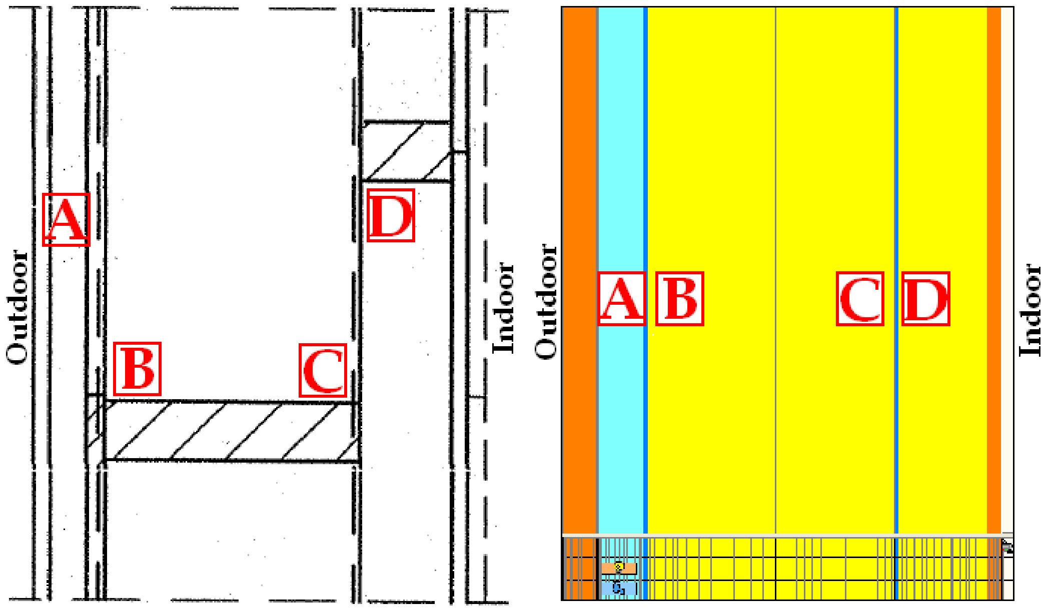

Figure 1: Drawing of estimated wall construction and WUFI 4.2 model. Air gap with different air flow for each calculation (A). Calculated positions (B, C and D).

The calculations are carried out with the one dimensional moisture and temperature calculations program WUFI 4.2. (WUFI 2009). Calculated results for stable conditions after four years loops are presented. Used outdoor climate come from WUFI 4.2 (WUFI 2009) climate data base and concern the Swedish city Växjö. Indoor climate are based on standard EN 15026 (EN 15026) and set to normal moisture load and dependent on outdoor climate. Calculations are performed hour by hour. Since the Swedish climate used in WUFI does not include radiation we have used a built in function in WUFI 4.2 (WUFI 2009) for the radiation balance.

Sources of error

Besides the example connected to measured values this is a parameter study. This mainly limits the sources of error to deficiencies in WUFI 4.2 physical model and input errors. Compared to real conditions there is a number of other sources that can end in errors. The most general errors can be traced to errors in boundary conditions, the model conformity with real conditions and that the calculations are made in one dimension.

RESULT

The results shows one dimensional calculations in WUFI 4.2 (WUFI 2009) for relative humidity and temperature for three positions in a modern wood wall when different air flows with outdoor air are applied in the air gap behind the panel.

Comparison between calculated relative humidity and temperature with different air flow in the air gap for position B are shown in chart 1.

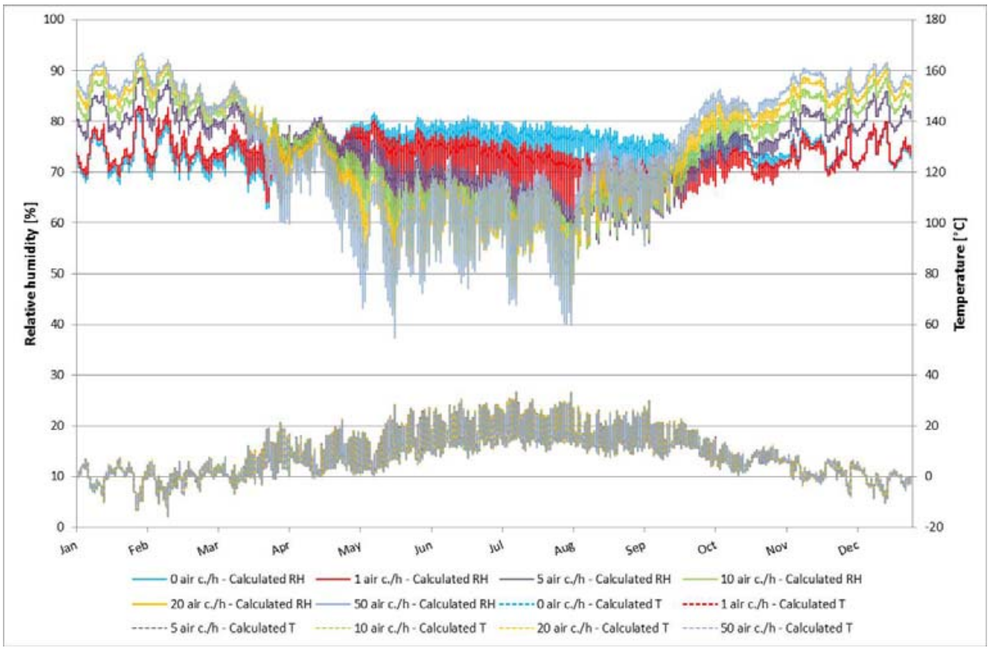

Chart 1: Position B. Calculated relative humidity and temperature with different applied air flow in the air gap. Different colors show different flow.

In order to increase transparency fore temperature calculations the difference between temperature for the lowest air flow, 0 air changes per hour and maximum air flow of 50 air changes per hour are presented in chart 2. Other temperature differences between used air flows in the air gap are lower than what is shown in chart 2.

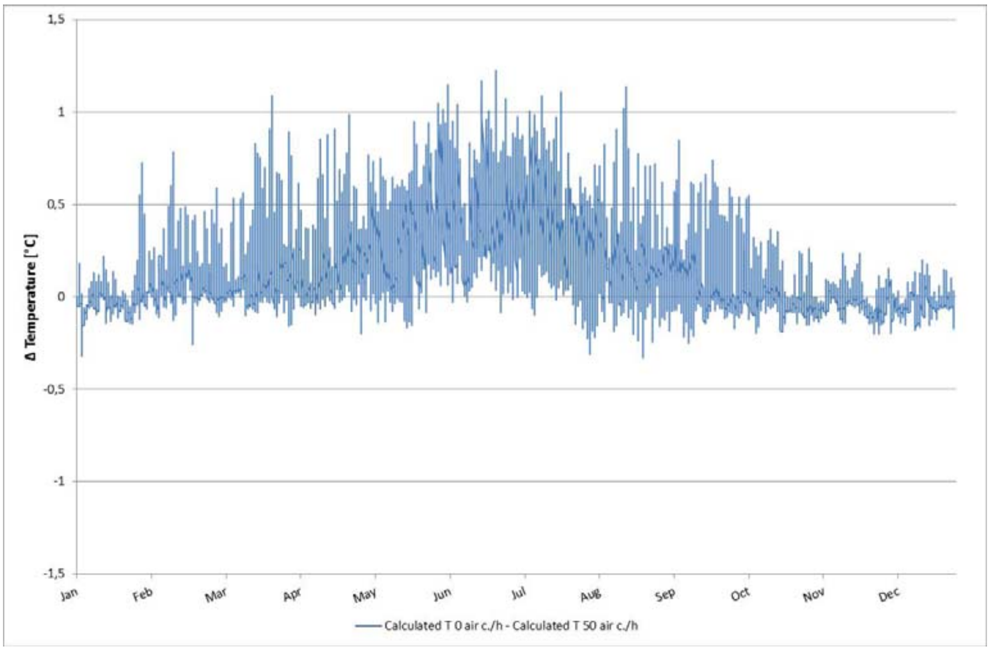

Chart 2: Difference between calculated temperature in position B for the lowest air flow of 0 air changes per hour and maximum air flow of 50 air changes per hour.

Comparison between calculated relative humidity and temperature with different air flow in the air gap for position C are shown in chart 3.

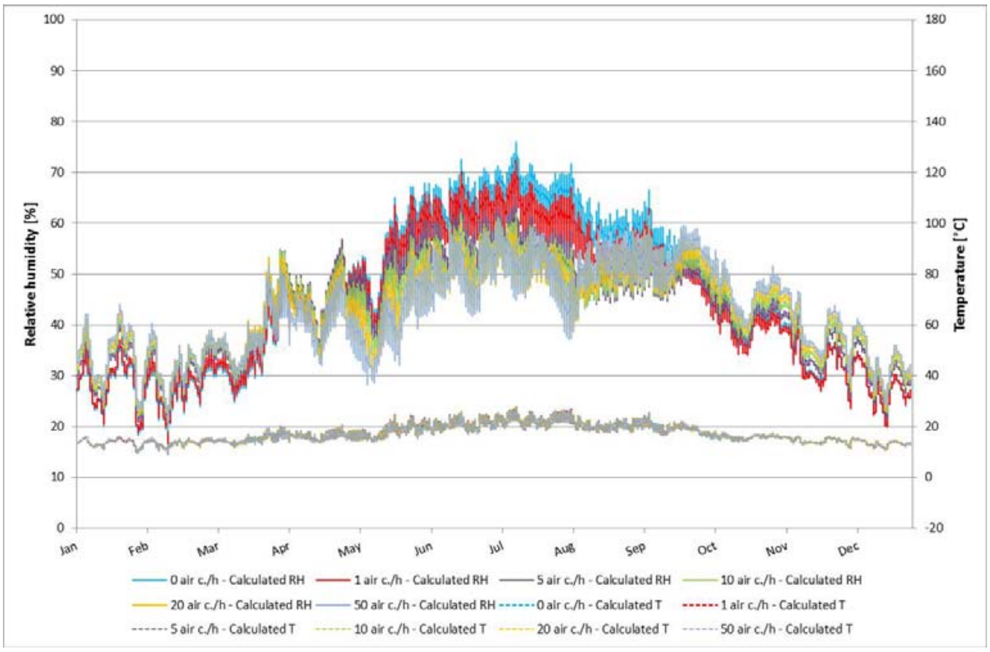

Chart 3: Position C. Calculated relative humidity and temperature with different applied air flow in the air gap. Different colors show different flow.

In order to increase transparency for temperature calculations the difference between temperature for the lowest air flow, 0 air changes per hour and maximum air flow of 50 air changes per hour are presented in chart 4. Other temperature differences between used air flows in the air gap are lower than what is shown in chart 4.

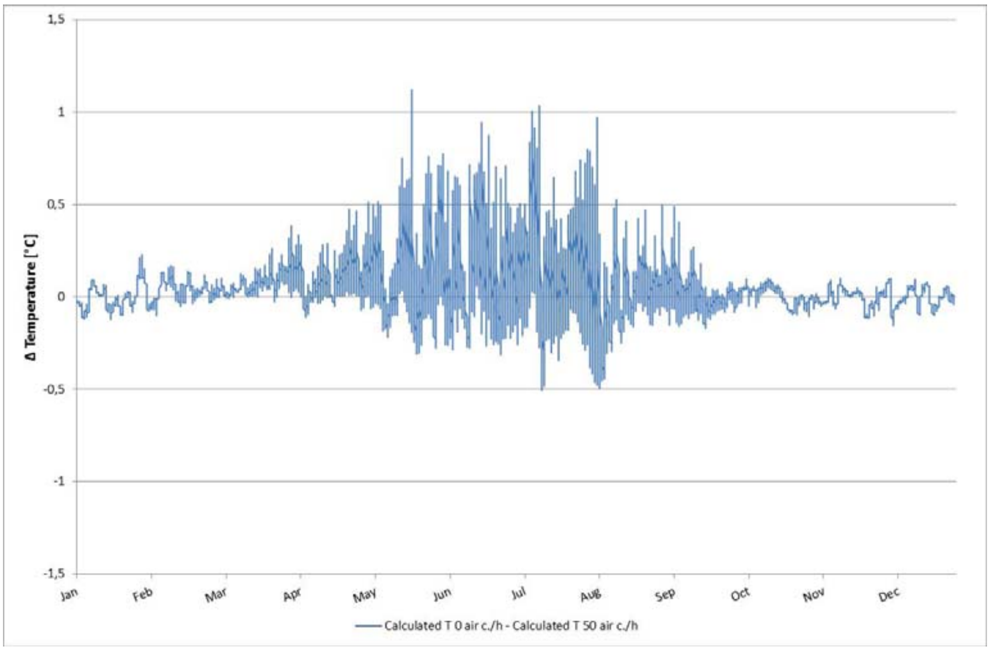

Chart 4: Difference between calculated temperature in position C for the lowest air flow of 0 air changes per hour and maximum air flow of 50 air changes per hour.

Comparison between calculated relative humidity and temperature with different air flow in the air gap for position D are shown in chart 5.

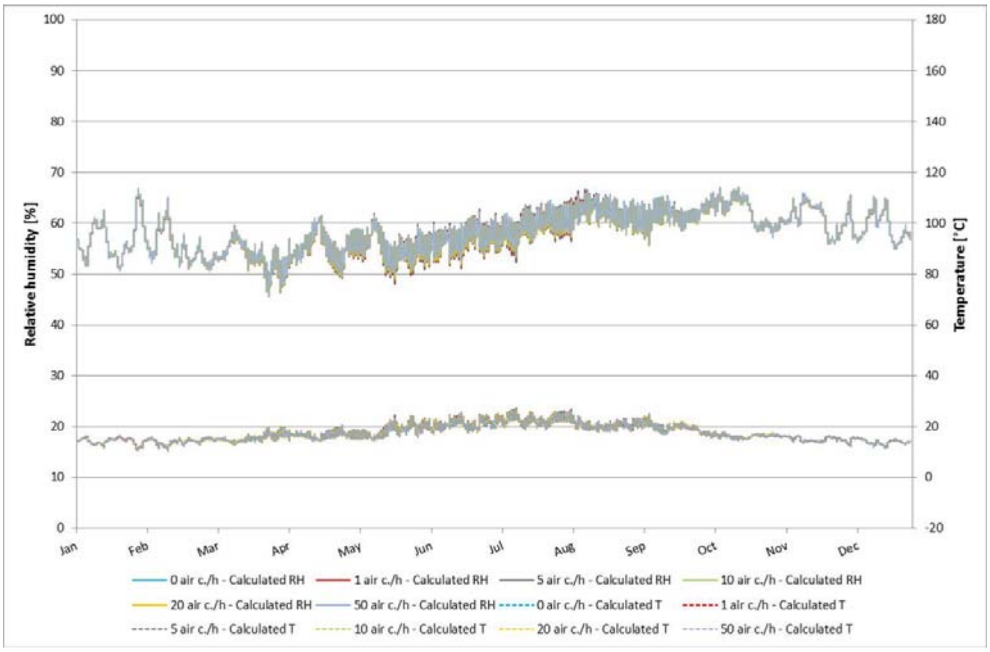

Chart 5: Position D. Calculated relative humidity and temperature with different applied air flow in the air gap. Different colors show different flow.

Temperature difference between the lowest air flow, 0 air changes per hour and maximum air flow of 50 air changes per hour in position D are almost the same as for position C as shown in chart 5. A closer illustration is therefore unnecessary.

COMPARISON BETWEEN MEASUREMENTS AND CALCULATIONS

In order to demonstrate consequences of an incorrect airflow in the air gap behind the façade panel an example is shown below. Both measurements and calculations are based on construction in figure 1 above. Chart 6 shows a comparison between measured and calculated relative humidity for two different flows.

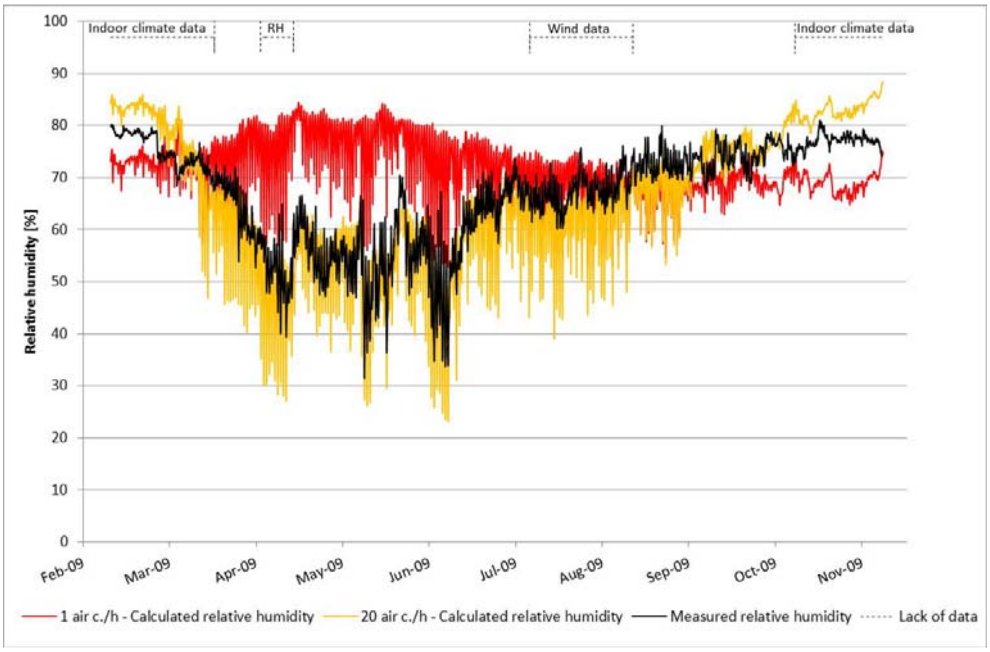

Chart 6: Example on comparison in position B. Measured relative humidity (black). Calculated relative humidity for 1 air changes per hour (read). Calculated relative humidity for 20 air changes per hour (yellow). Periods with gaps in boundary conditions are shown in the top.

ANALYSIS

Comparison of calculated relative humidity in position B and C, outside the vapour retarder, during summer shows that one air change per hour or less in the air gap results in higher relative humidity compared to higher air flows over five air changes per hour. During the winter period the conditions are reversed which means that for higher air flows a higher relative humidity is calculated in both position B and C. In positions outside the vapour retarder is calculated relative humidity with five air changes per hour close to the results from calculations for higher flows in the air gap behind the panel. Calculated relative humidity with flows of 20 air changes per hour and 50 air changes per hour are consistent. For position D inside the vapour retarder is calculated relative humidity independent of the flow in the air gap behind the panel.

Calculated temperature has compliance in all positions for all applied flows in the air gap. During the period October to April the difference is not more than 0,3°C. During the summer the biggest difference is 1,5°C. Calculated temperature is constant or higher for flows lower than one air change per hour. Therefore it cannot be differences in temperature that causes higher relative humidity in positions outside the vapour retarder for flows below one air change per hour in the air gap behind the panel. If that would be the case, the higher temperature should instead make the relative humidity to decrease. Calculated relative humidity is also different and acting different on the inside of the vapour retarder compared to outside of the vapour retarder. This ensures that the air flow in the air gap behind the panel only affect calculated relative humidity in positions outside the vapour retarder.

Calculated relative humidity with air flow of five air changes per hour in the air gap are nearly similar to the same calculations with higher air flow in the air gap. Comparison for calculated relative humidity with flows at 20 to 50 air changes per hour show a good agreement. This depends on that air flows from five air changes per hour in the air gap makes the excess moisture to start move away. From 20 air changes per hour there is no more moisture left and 50 air changes per hour compared to 20 air changes per hour doesn't make any difference in this case.

Calculations show that position B is the most critical. Bad moisture conditions mainly occur with air flows below one air change per hour during the summer. The reason is a high relative humidity at the same time as the temperature is high. The high calculated relative humidity for flows over ten air changes per hour during the winter might be a problem. During the winter the temperature is also lower in position B and therefore it could be possible to avoid mould growth. The high relative humidity in position B during the winter could be traced to the fact that the air gap is ventilated with outdoor air that has high relative humidity in the winter. To ensure that there is no risk of mould growth in position B there has to be a careful moisture design process in this case where relative humidity and temperature are weighted together.

The example shows measured relative humidity compared to two cases of calculated relative humidity with different flow in the air gap behind the panel. The graphs in chart 6 clearly show that the calculation with one air changes per hour deviate significantly from the other two curves.

CONCLUSION

The main conclusion of this study is that calculated relative humidity in positions outside the vapour retarder is affected by the air flow in the air gap behind the panel. In order to make reliably moisture calculation for modern Swedish wood frame houses a relevant air flow in the air gap behind the panel is of great importance. The example also shows that an incorrect assumption of the air flow in the air gap behind the panel could give significant errors in the result.

Calculated moisture conditions inside the vapour retarder are not affected significantly by the air flow in the air gap behind the panel. The temperature in all positions is either not significantly affected by different air flow in the air gap.

Flows above 20 air changes per hour do not have any big impact of calculated relative humidity because there is no more excess moisture that can be transported.

The calculations also show that relative humidity become lower further into the wall, from the outside. This mainly depends on a higher temperature which gives a lover relative humidity.

Because it is important to consider the airflow in the air gap in moisture calculation it could also be relevant to discuss if the moisture part of Glaser calculation is applicable to outdoor ventilated facades with air gap.

According to the calculations the best conditions is achieved if the air flow in the air gap behind the panel are high during the summer period and low during the winter period. A higher air flow in the air gap is preferable because it gives low relative humidity during the summer and the high relative humidity during the winter is not a big problem because of the low temperature.

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