On the influence of cavity ventilation on moisture content in timber frame walls

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1. INTRODUCTION

A ventilated cavity behind the cladding of timber frame walls is usually considered good practice in order to avoid moisture-induced damage in the construction. The functions of the cavity are multiple (Kumar 1998). The cavity allows for removal of moisture from the cladding through ventilation. Also, the cladding provides a path for gravity drainage path for penetrated rain to drain. Furthermore, a cavity acts as a capillary barrier. Finally, a vented cavity allows for pressure equalisation across the cladding when it acts as rainscreen. However, ventilating with dry air will remove moisture from the construction whereas ventilating with humid air might add moisture to the construction. Tenwolde, Carll and Malinauskas (1995) found "that cavity ventilation was not always successful at providing dry conditions in wall cavities".

Simulations of heat and moisture conditions in timber frame walls were made using the model MATCH (Pedersen 1990). From the simulations it was seen that the most critical moisture conditions often were to be found behind the wind barrier. Also, the simulations indicated that a ventilated cavity behind the cladding might increase the moisture content behind the wind barrier.

On the basis of the simulations two series of experiments were designed where full-size wall elements in a test building were exposed to natural climate on the outside and to a humid indoor climate on the inside. The results from the first series are described in (Andersen *et al*. 2002). The present paper describes a part of the results from the second series.

2. EXPERIMENTAL

In the experiment there were 12 different wall elements with 285-295 mm stone wool thermal insulation. The test parameters included ventilated cavity/nonventilated cavity/no cavity behind the cladding, type of wind barrier and type of cladding. All elements had a 0.15 mm polyethylene vapour barrier with a nominal water vapour resistance of 375 GPa m^2 s/kg. Tables 1 and 2 give further information on the construction details of the elements and the applied materials. Figure 2 shows a typical plane section of the wall elements investigated.

The dimension of the wall elements was thickness $\times$ 584 $\times$ 2683 mm. Two replicates were made of each element. The elements were installed in the south facade and the north facade of a 11.5 m by 7.9 m moisture test house at Danish Building and Urban Research such that identical elements were tested on both facades. Outdoor temperature and RH is shown in Fig. 1. The indoor climate in the test house was maintained at 20 °C and 60 % relative humidity.

Elements with a nonventilated cavity had an EPDM-band between the distance battens and the cladding. Elements with a ventilated cavity had one distance batten with and one distance batten without EPDM-band between distance batten and cladding.

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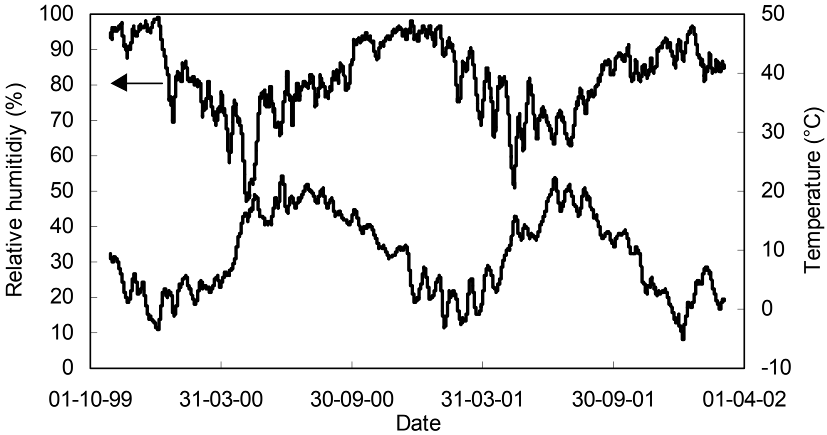

Figure 2 Outdoor relative humidity and air temperature during the period.

Table 1 Construction details of the elements. Cavities were 25 mm. WFB: wood fibreboard.

Element	Cladding	Cavity	Wind barrier
1	19 mm pine lapped board[1]	ventilated	9 mm gypsum board
2	19 mm pine lapped board[1]	nonventilated	9 mm gypsum board
3	15 mm plywood	none	none
4	15 mm plywood	ventilated	9 mm gypsum board
5	15 mm plywood	nonventilated	9 mm gypsum board
6	19 mm vertical pine board[2]	none	9 mm gypsum board
7	19 mm vertical pine board[2]	none	asphalt impregnated WFB
8	19 mm vertical pine board[2]	nonventilated	spunbonded polyethylene
9	15 mm plywood	ventilated	asphalt impregnated WFB
10	8 mm fibre cement board	ventilated	12 mm plywood
11	8 mm calcium silicate board	nonventilated	12 mm plywood
12	8 mm fibre cement board	nonventilated	spunbonded polyethylene

[1]:horizontal, 19x150 mm square edged boards, 35 mm horizontal lap.
[2:]vertical boards had tongue and groove.

Table 2 Water vapour diffusion resistance of cladding materials, wind barriers and stone wool. Air leakage not taken into account.

Material	thickness mm	water vapour diffusion resistance GPa s m^2/kg	Source
gypsum board	9	0.4	manufacturer
gypsum board	13	0.5	manufacturer
pine lapped board	19	10	Andersen *et al.* (1993)
vertical pine board	19	10	Andersen *et al.* (1993)
asphalt impregnated WFB	13	0,7	manufacturer
plywood	12	4	manufacturer
plywood	15	5	manufacturer
fibre cement board	8	2,5	manufacturer
calcium silicate board	8	1.8	manufacturer
spunbonded polyethylene		0.1	manufacturer
polyethylene vapour retarder	0.15	375	Andersen *et al.* (1993)
stone wool	290	2.1	manufacturer

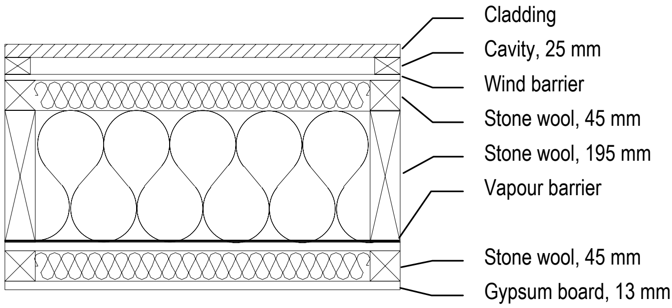

Figure 1 Plane section of wall element.

3. MEASUREMENTS

Temperature and relative humidity of indoor and outdoor air was measured and datalogged every hour. Precipitation was measured and datalogged every hour. In the last part of the measurement period wind speed and wind direction were measured with an ultrasonic anemometer and datalogged as 1-hour averages and standard deviation. Also in the last part of the measurement period, the differential pressure between indoor and outdoor air over the north wall and the south wall were measured every 10 min. and the average was datalogged every hour.
Moisture content was measured with moisture measuring dowels according to NT Build 420 (1993). Moisture measuring dowels were 10 mm^{Ø} beech wood dowels that had two electrodes embedded. The electrical resistance between the electrodes was measured and converted to wood moisture content using a calibration curve. The electrical resistance was temperature compensated. The electrical resistance becomes very high when the wood becomes dry, hence the lower limit of moisture content measurement was in the order of 11 weight-% with the applied datalogger.

The moisture measuring dowels were used to measure the moisture content in the studs, in the distance battens between cladding and wind barrier, in the wood based claddings, in the cavity, and in the thermal insulation adjacent to the wind barrier. The moisture content measurements were datalogged 2 times every 24 hours.

Temperatures were measured with thermistors in places close to the moisture measuring dowels. The temperature measurements were datalogged 2 times every 24 hours.

4. RESULTS

Despite the fact that the measurements presented in this section were all made in the stone wool adjacent to the wind barrier they are expressed as wood moisture content. This is due to the nature of the results obtained by the moisture measuring dowels. The presented measurements of moisture content are averaged using a running average over 30 points corresponding a measurement period of 15 days.

Figure 3 shows the moisture content behind the wind barrier as function of time for the north facing elements 4 and 9. Both elements were ventilated and the only difference between them was the type of wind barrier. Element 4 has a 9 mm gypsum board as wind barrier whereas element 9 has an asphalt impregnated wood fibreboard.

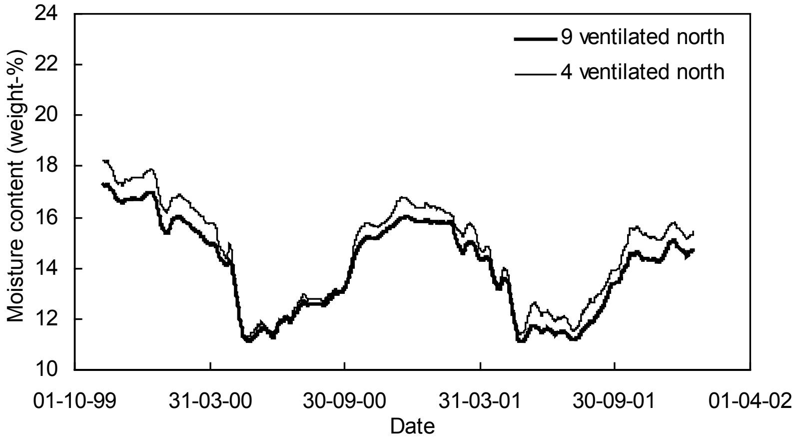

Figure 3 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated elements 4 and 9 facing north.

Figure 4 shows a similar comparison for the corresponding south facing elements. The relatively large difference between the moisture content in the south facing elements 9 and 4 in the first 7 months of the measurement period can be attributed to differences in initial moisture content originating from the construction period.

Figure 5 shows the moisture content behind the wind barrier as function of time for the north facing elements 2 and 1. The elements are identical except for the cavity. Both elements had 19 mm lapped pine board as cladding and 9 mm gypsum board as wind barrier. The cavity of element 1 was ventilated whereas the cavity of element 2 was nonventilated. Nonventilated in this context means that the inlet and the outlet of the cavity were blocked. However, there was still a possibility for some ventilation through the lap between the boards of the cladding. Figure 6 shows a similar comparison for the corresponding south facing elements.

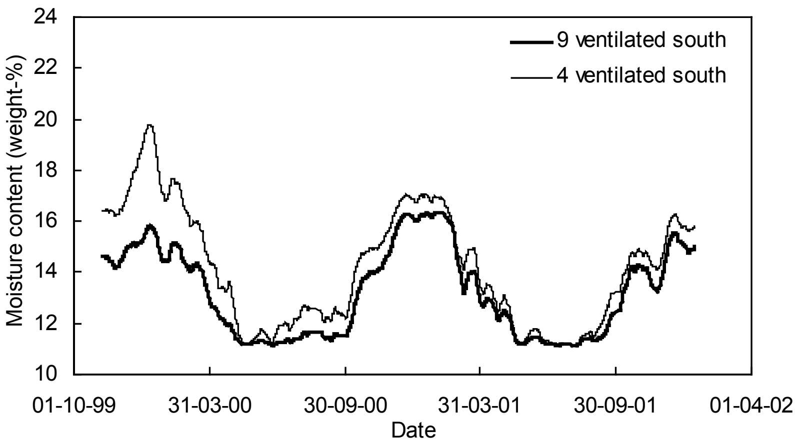

Figure 4 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated elements 4 and 9 facing south.

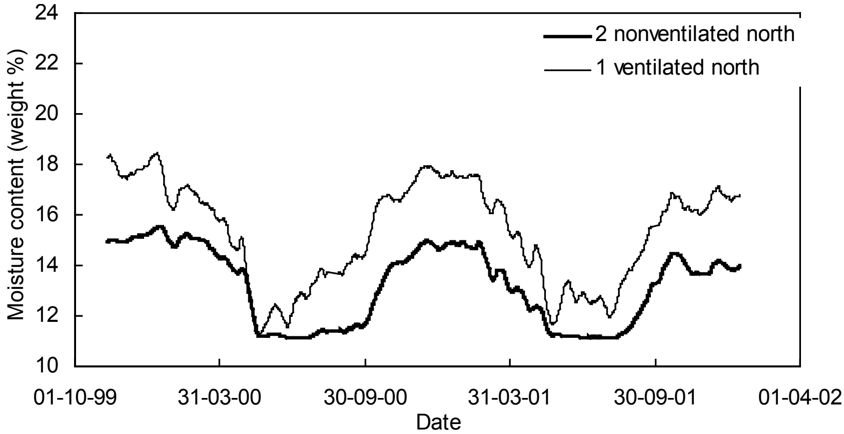

Figure 5 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 1 and nonventilated element 2 facing north.

Figure 7 shows the moisture content behind the wind barrier as function of time for the north facing elements 4 and 5. Again, the elements were identical except for the cavity. Both elements had 15 mm plywood as cladding and 9 mm gypsum board as wind barrier. The cavity of element 4 was ventilated whereas the cavity of element 5 was nonventilated. Figure 8 shows a similar comparison for the corresponding south facing elements.

Figure 9 shows the moisture content behind the wind barrier as function of time for the north facing elements 10 and 11. Element 10 and element 11 had an 8 mm fibre cement board and a calcium silicate board, respectively, as cladding. Both elements had 12 mm plywood as wind barrier. The cavity of element 10 was ventilated whereas the cavity of element 11 was nonventilated. Figure 10 shows a similar comparison for the corresponding south facing elements.

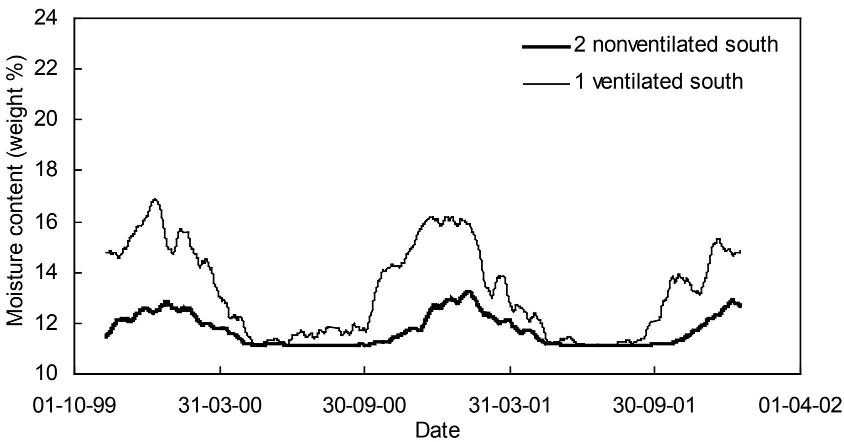

Figure 6 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 1 and nonventilated element 2 facing south.

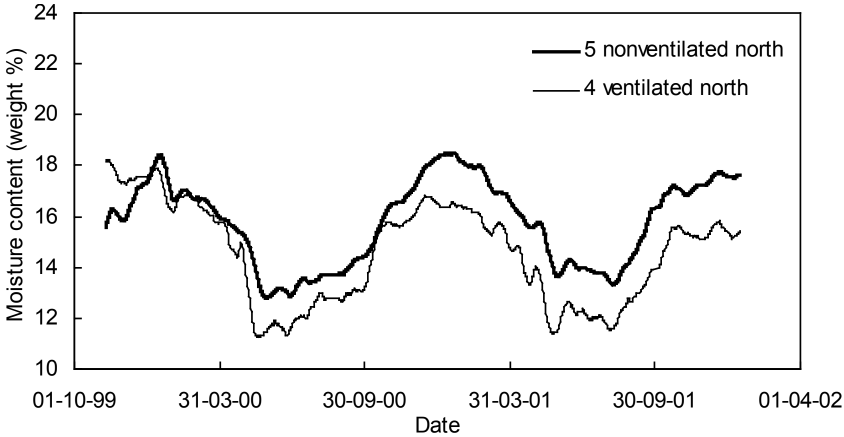

Figure 7 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 4 and nonventilated element 5 facing north.

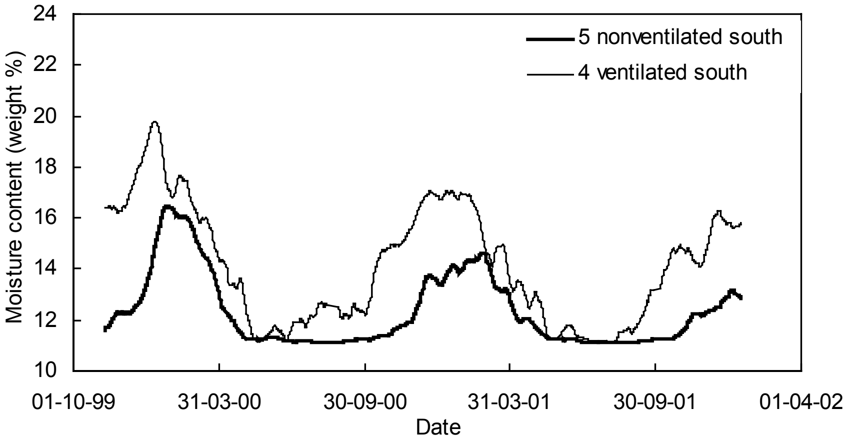

Figure 8 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 4 and nonventilated element 5 facing south.

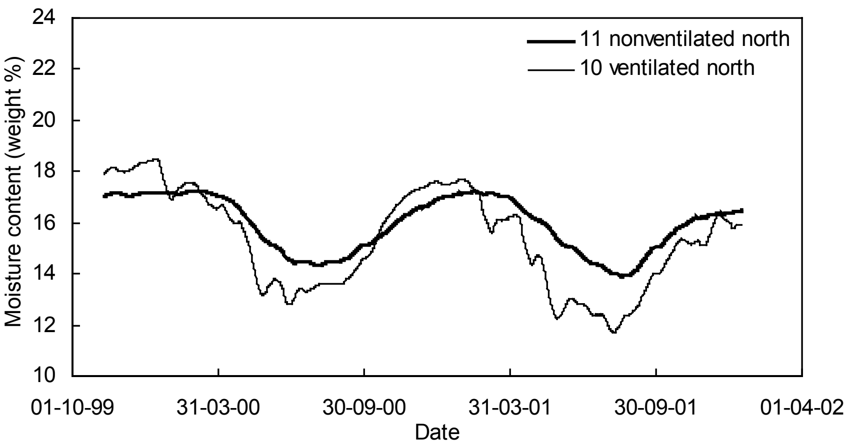

Figure 9 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 10 and nonventilated element 11 facing north.

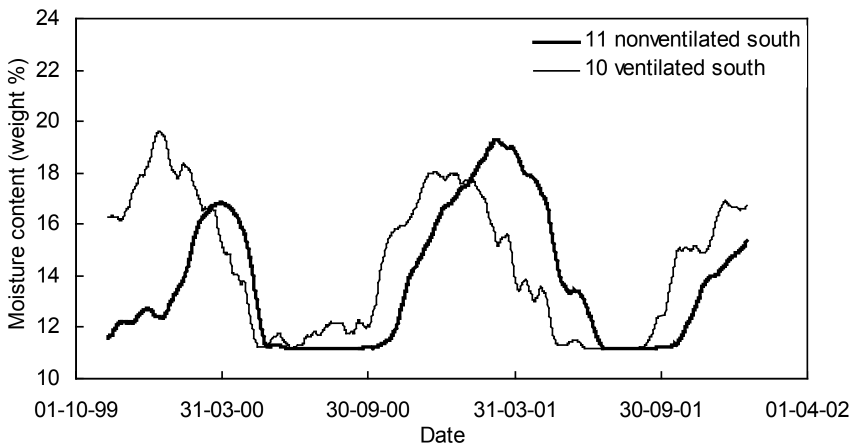

Figure 10 Moisture content in wood dowels behind wind barrier as a function of time. Ventilated element 10 and nonventilated element 11 facing south.

Similar trends were observed in the measurements of moisture content in distance battens, in cavities, in wood based claddings, and in the studs.

5. DISCUSSION

Despite the difference in wind barrier, the ventilated elements 9 and 4 showed almost the same moisture content variation during the period of measurement on the north side as well as on the south side. This implies that the difference in performance of the gypsum board and the asphalt impregnated WFB, regarding the influence on the moisture conditions behind the wind barrier in a ventilated cavity, is small. Furthermore, the relatively small difference gives a rough indication of the repeatability of the measurement method.

In none of the elements a critical moisture content was observed in the thermal insulation adjacent to the wind barrier. Critical moisture content in this context is defined as 20 weight-%, which often is used as criteria for the onset of rot and growth of wood decaying fungi.

Comparing the results from measurements on ventilated and nonventilated, but otherwise identical, elements shows that in 3 cases the nonventilated elements had the lowest moisture content through the entire period of measurement (Figures 5, 6 and 8). In one case the ventilated element had lower moisture content than the nonventilated element (Figure 7). In two cases ventilated and nonventilated elements had nearly the same moisture contents but the moisture content of the nonventilated element was phase lagged (Figures 9 and 10). In the comparison of the behaviour of elements 10 and 11 it has been tacitly assumed that the difference in using calcium silicate board or fibre cement board as cladding is negligible.

From the presented measurements is it hardly possible to conclude that nonventilated cavities perform better than ventilated cavities. But it is even more difficult to find conclusive evidence that a ventilated cavity is to be preferred. Having said this, it should be borne in mind that cavities always should be drained in the event of rain penetration. Also venting in order to equalise the pressure differential across the rain screen might prove necessary at exposed sites.

6. CONCLUSIONS

The behaviour of wood frame walls with a nonventilated cavity, in terms of the moisture content behind the wind barrier, was not found to be inferior to the behaviour of wood frame walls with a ventilated cavity.

The difference in performance of gypsum board and asphalt impregnated WFB used as wind barrier in wood frame walls, regarding the influence on the moisture conditions behind the wind barrier in a ventilated cavity, is small.

7. REFERENCES

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