VENTILATION SYSTEM PERFORMANCE

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Paper 25

MEASUREMENT OF SUB-FLOOR VENTILATION RATES-COMPARISON WITH BREVENT PREDICTIONS

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ABSTRACT

The performance of ventilation provision in subfloor cavities is relevant to the fields of energy efficiency, condensation risk, and air quality. Thorough programs of site measurements of ventilation rates by means of tracer gas tests are in general protracted and expensive, and it is quite clear that would be highly desirable to be able to predict ventilation rates given details of building design, ventilation provision, and degree of exposure.

This paper describes a series of sub-floor cavity tracer gas ventilation measurements performed upon a low energy test house, and compares the results with a set of ventilation rates predicted for the sub-floor cavity by the Building Research Establishment ventilation prediction program BREVENT.

Agreement between measured and predicted values is generally good, although significant discrepancies are observed at certain incident wind angles. This is thought to be due to difficulties in obtaining reliable data pertaining to wind pressure effects on ventilation openings at very low levels.

INTRODUCTION

Knowledge of ventilation rates in subfloor cavities is assuming an increasing significance : methane seepage from landfill sites and radon gas ingress from certain rock formations come to mind as examples of comparatively new areas of research in which reliable subfloor ventilation data would be of value. It is unfortunately the case that the demand for data is not matched by the supply. Data sets produced within the United Kingdom are rare and far from comprehensive (see for example [1]). It could be reasonably supposed that two of the reasons for the deficiency in data are the relatively labour intensive, time consuming nature of tracer gas studies, coupled with the difficulties associated with achieving tracer gas injection and uniform mixing in cavities of extreme aspect ratios. It would be decidedly advantageous to have at one's disposal a means of predicting ventilation rates in subfloor cavities. To this end, BRE have extended the BREVENT computer program so as to cover subfloor cavities.

This paper describes a tracer gas study of subfloor cavity ventilation rates carried out by UMIST as part of a programme of research undertaken by The Timber Research and Development Association (TRADA) on behalf of the Department of the Environment. The data thus produced is compared with predicted ventilation rates generated by BREVENT using parameters for the test house used in the tracer gas study.

EXPERIMENTAL DETAILS

(i) Tracer gas tests

The test house is shown in figure 1. It is semi-detached, has three bedrooms, and is of low energy design. The whole house ventilation rate is of the order of 0.15 air changes per hour at a mean windspeed of 3m/s. It should be noted that the north side of the house is shielded by a 2 metre high wooden fence approximately 6 metres away.

The subfloor cavity is more accurately described as a crawl space, since its height is approximately 1 metre. The cavity volume is approximately $45m^3$. Ventilation is provided by means of four airbricks, each with 8no $675mm^2$ rectangular slots. On one of the airbricks, 5 of the slots are obscured by a concrete doorstep. The total open area of ventilation openings is $18225mm^2$, corresponding to $985mm^2$ open area per metre run of exposed external wall. This compares with the $1500mm^2$ per metre run <u>or</u> 500mm2 per m^2 of floor area (whichever is the greater) recommended by BS 5250[2].

Subfloor cavity ventilation rates were measured using the standard parallel column portable gas chromatograph developed at UMIST. This apparatus is well documented,(see for example[3]) and will not be described here. The height of the cavity enabled a standard tracer gas injection strategy to be used: mixing was achieved by means of oscillating desk-top fans. A set of 56 ventilation rate measurements were performed over a range of windspeeds and directions.

(ii) BREVENT simulations

BREVENT is a computer model, written in BASIC, that has been developed by the Building Research Establishment to predict ventilation rates in a building which is represented by a single zone. The program is most suited to domestic buildings. The model is based upon the work of Warren and Webb[4]. BREVENT calculates a ventilation rate for a building by considering the effects of temperature difference, windspeed and wind direction. the calculation procedure assumes an initial pressure difference, and then, on the basis of this pressure difference calculates the flows across each element of the building envelope. These flows are recalculated by means of an iteration procedure until all airflows are balanced.

Recent developments allow the program to include a wide range of flow elements, such as vertical ducts, extract fans, flues and combustion appliances, and windows. It is also possible to include a ventilated subfloor space within a building configuration, and in this circumstance the model has two zones. For more information on the current BREVENT model, reference [5] is recommended.

The key input variables to BREVENT are as follows:

(i) The air leakage of the building fabric at a reference internal/external pressure difference (obtained by fan pressurization testing);

(ii) pressure coefficient data for the building surfaces and air bricks (in the case of these predictions derived from BRE wind tunnel measurements and summarised in Tables 1 and 2 respectively);

(iii) floorboard and skirting air leakage data (based on site measurements);

(iv) the area of ventilation openings to the subfloor cavity.

	Wind angle											
Face No.	0	30	60	90	120	150	180	210	240	270	300	330
2	-.09	-.12	-.13	.04	-.11	-.13	-.09	-.13	-.06	.08	-.06	-.14
3	.29	.34	.23	.08	-.072	-.15	-.15	-.13	0	.1	.16	.24
4	-.2	.02	.29	.32	.29	.06	-.2	-.33	-.07	.07	-.08	-.33
5	-.18	-.18	-.12	.08	.31	.47	.38	.3	.19	.13	0	-.16
6	0	0	0	0	0	0	0	0	0	0	0	0

TABLE 1 - Surface pressure coefficients (nb face numbers refer to Figure 1)

For the purposes of the validation exercise, BREVENT was run with the following temperature and wind parameters:

(i) internal and external temperatures set equal at 17 deg C (bearing in mind that the site measurements were performed in early summer);

(ii) wind direction varying in increments of 30 degrees from 0 to 330 degrees (note that 0 degrees corresponds to a Northerly direction);

(iii) wind speed at 10 metres height varying in increments of 0.25m/s between 1.5 to 4.0m/s.

Face No.	Wind angle 0	30	60	90	120	150	180	210	240	270	300	330
3	.33	.4	.3	.12	-.05	-.14	-.15	-.12	.05	.15	.21	.29
4	-.17	.02	.24	.25	.25	.04	-.18	-.31	-.05	.09	-.07	.29
5	-.14	-.14	-.06	.1	.31	.46	.35	.29	.19	.15	.04	.1
6	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 - Pressure coefficients at air bricks

RESULTS AND DISCUSSION

(i) Tracer gas tests.

The results obtained are presented graphically in figures 2 and 3. It should be noted that during the test period, the wind was not observed to blow from either the east or north-east, meaning that the range of experimental data did not completely match the range of BREVENT predictions.

From the results, it can be seen that the ventilation rates associated with each wind direction tend to merge together at windspeeds approaching 1m/s: the range of ventilation rates exhibited at this windspeed seems to lie between 0.15 and 0.2 air changes per hour. The clear directional influence of prevailing wind direction can be seen as windspeed increases. Northerly and Southerly winds give ventilation rates which are substantially higher than for any other wind directions: of the two, Southerly winds appear to induce ventilation rates which are approximately 30% higher than for a Northerly wind of the same strength. It is suggested that this is a reflection of the sheltering afforded by the 2 metre high fence which surrounds the north side of the test house.

Of all wind directions, the West, parallel to the ridge, gives the lowest ventilation rate for a given windspeed. At 3.5m/s, the ventilation rate for a westerly wind is approximately 0.4 air changes per hour, that is, only of the order of 22% of the ventilation rate associated with a Southerly wind of the same mean speed. At higher windspeeds, the difference becomes more pronounced. These results demonstrate that to optimise ventilator performance, ventilation openings should ideally be distributed between all external walls. The distribution of ventilation openings on two sides of a building only should, if possible, be avoided. Ventilation rates for other wind directions fall between the extremes shown by the North, South, and Easterly directions.

(ii) Comparison of tracer gas tests and BREVENT predictions.

A detailed comparison was carried out between the tracer gas test results and the BREVENT predictions by plotting graphs showing the measured and predicted ventilation rates over a range of windspeeds for a range of wind directions. These are shown in figures 4 to 9.

Reasonable agreement can be seen between measured and predicted values for most of the wind directions compared. The notable exceptions to this are the 180 degree (South) and 315 degree (North West) directions, for which measured ventilation exhibited a greater straight line increase with increasing windspeed than did the BREVENT predictions. It is suggested that the principle reason for this under-estimation by BREVENT is the choice of surface pressure coefficients made in order to try and make allowance for the 2 metre high boundary fence to the North of the property. The sets of surface pressure coefficients used by BREVENT are a reflection of the general terrain conditions around the building in question: any allowances for shielding on individual faces has to be made by the program user. In the particular case of these predictions, the presence of the fence was estimated to result in a 20% reduction of the standard surface pressure coefficient at 10% housing density for the North face of the building. Clearly this estimate may not have been as accurate as might have been desired:however, no experimental data existed upon which to make a more reliable assessment of the fence. The consequences of the inaccuracy in the assessment of the shielding effect is accentuated by the close proximity of the ventilation openings to the ground. There is an obvious need for further research into the effects of shielding on the performance of ventilation openings.

CONCLUSIONS

Based upon the findings of this limited validation exercise, BREVENT would appear to provide reasonable estimates of the air change rate within a ventilated subfloor cavity. However, some discrepancies exist between predicted and measured ventilation rates for certain wind directions which clearly indicate that the reliability of BREVENT predictions could be enhanced by a better knowledge of the influence of local shielding upon surface pressure coefficients, particularly in the vicinity of ventilation openings at low levels.

ACKNOWLEDGEMENTS

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References

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(4) P Warren, B C Webb: Proceedings of the 1st AIVC Conference, Windsor, United Kingdom, 1980.

(5) R P Hartless: Proceedings of CIB-W67,1990.

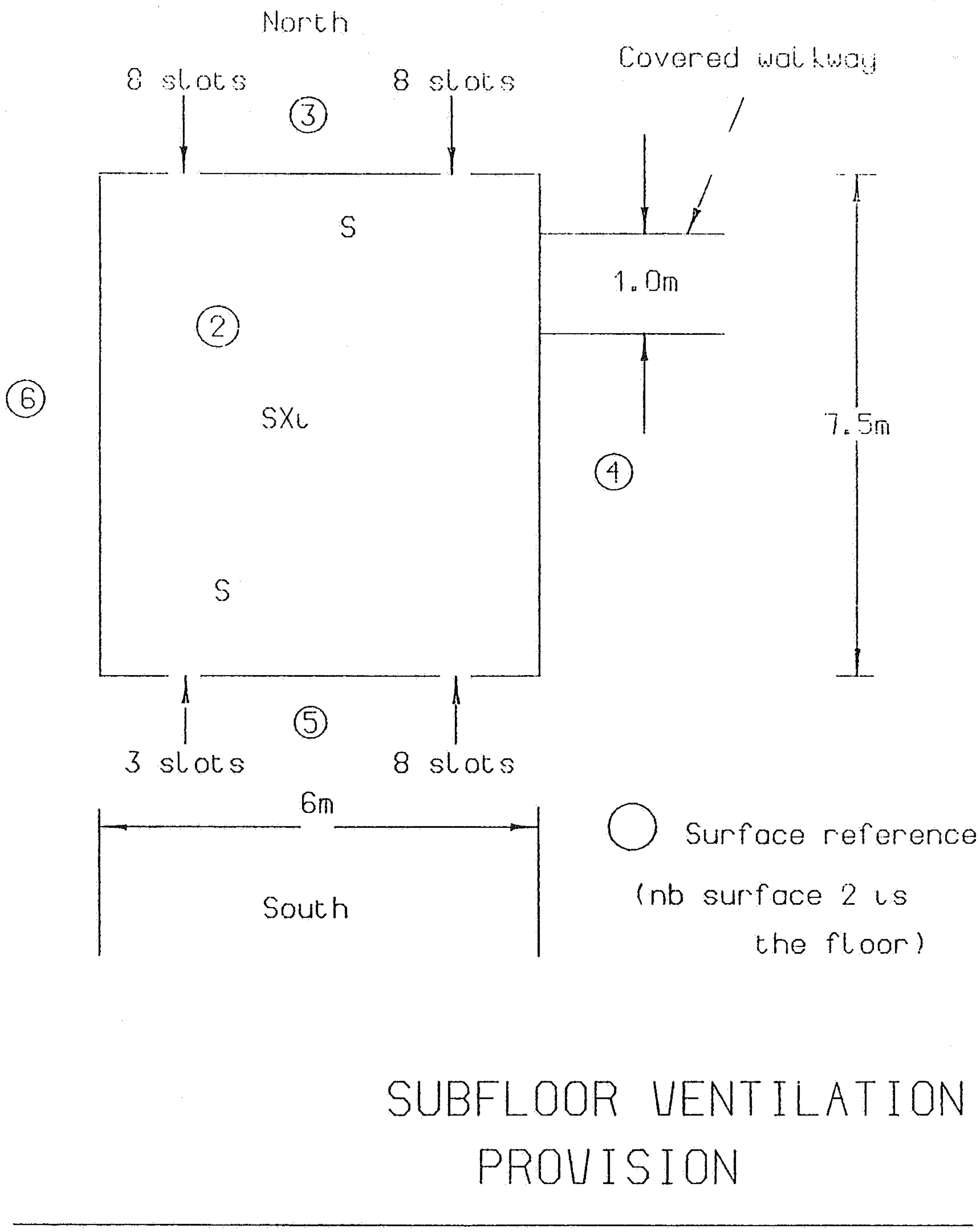
North
8 slots
8 slots
Covered walkway
3
S
1.0m
2
6
SXL
7.5m
4
S
5
3 slots
8 slots
6m
Surface reference
(nb surface 2 is the floor)
South
SUBFLOOR VENTILATION PROVISION

Figure 1.

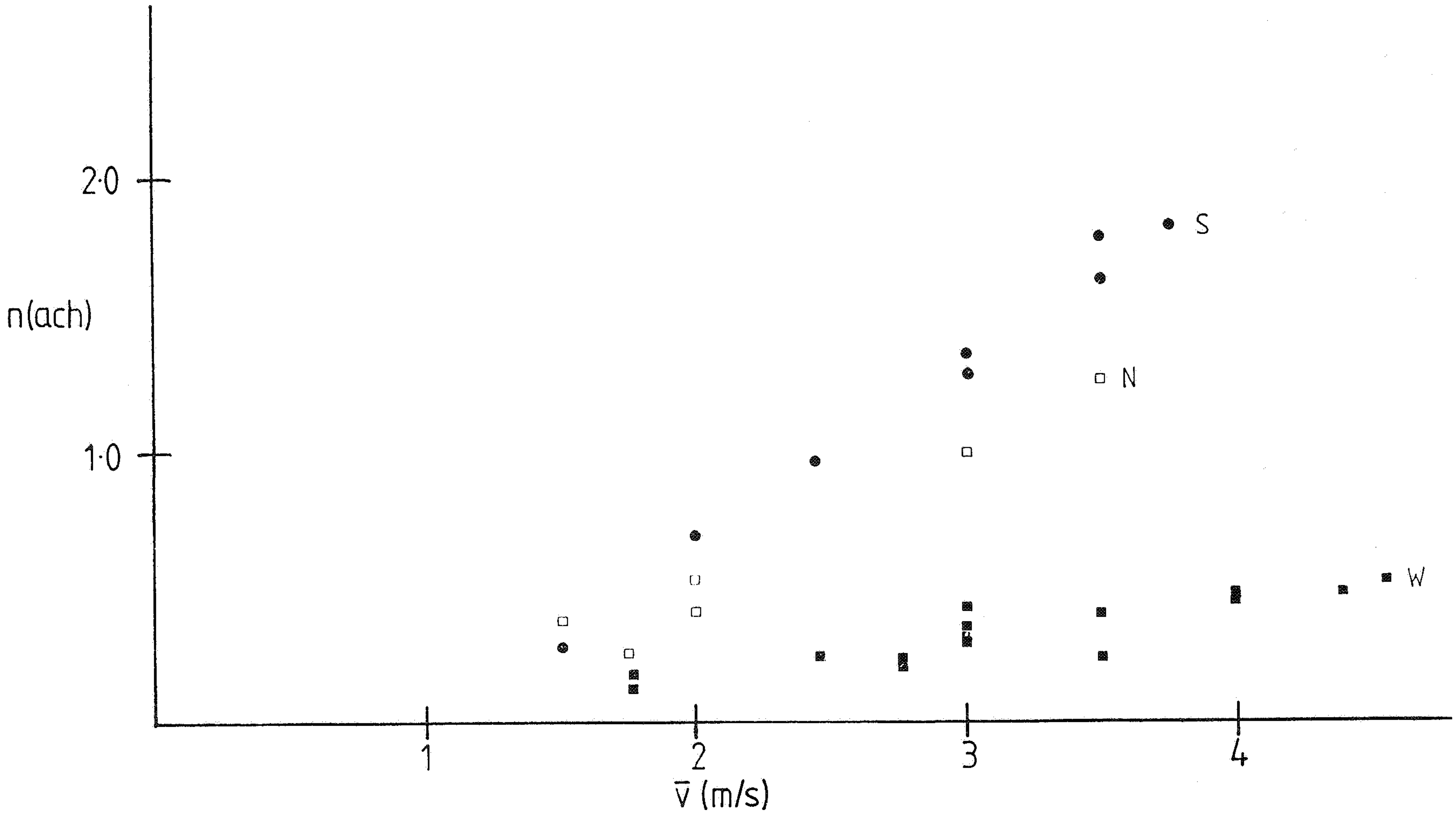

Figure 2.

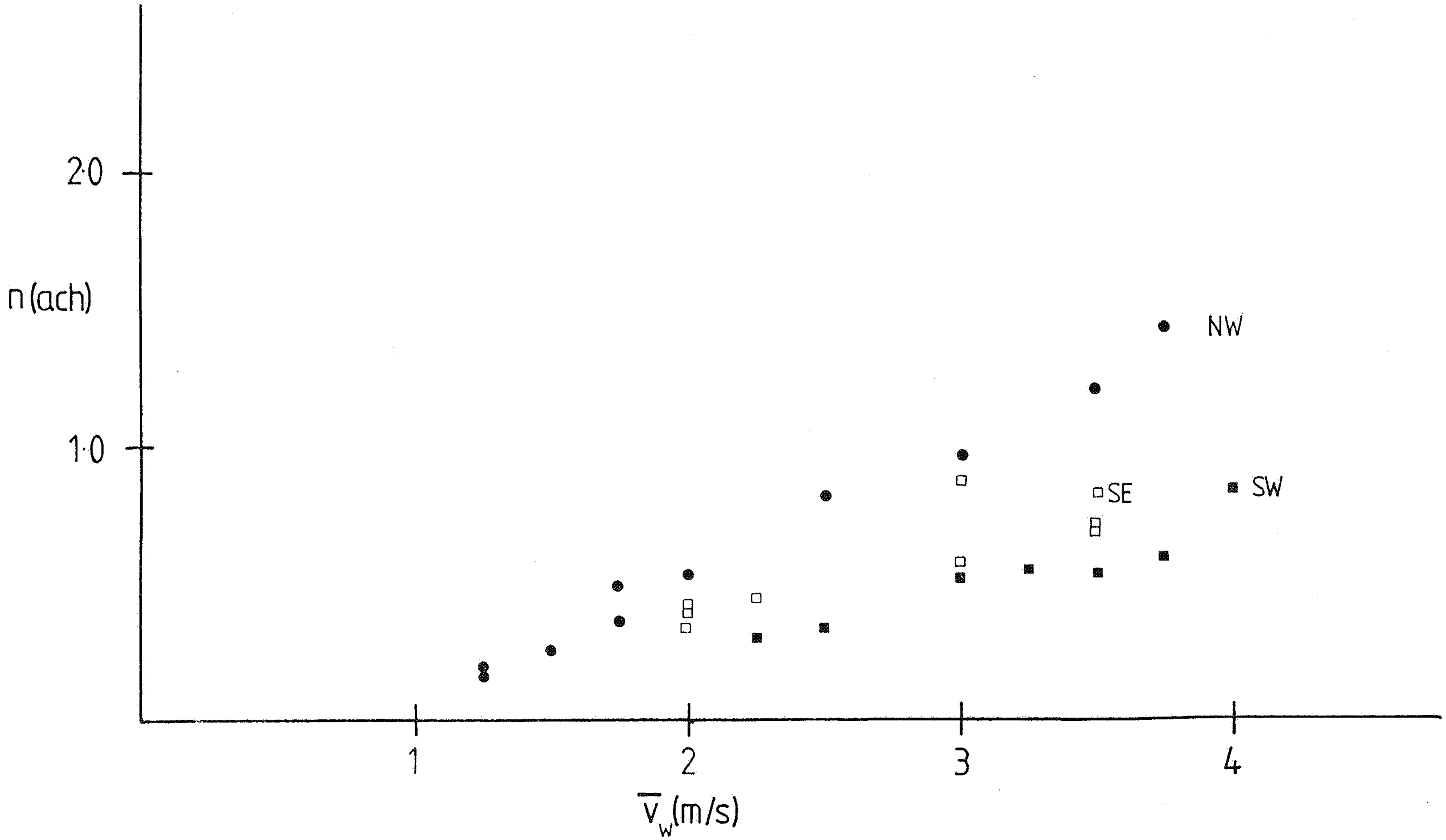

Figure 3.

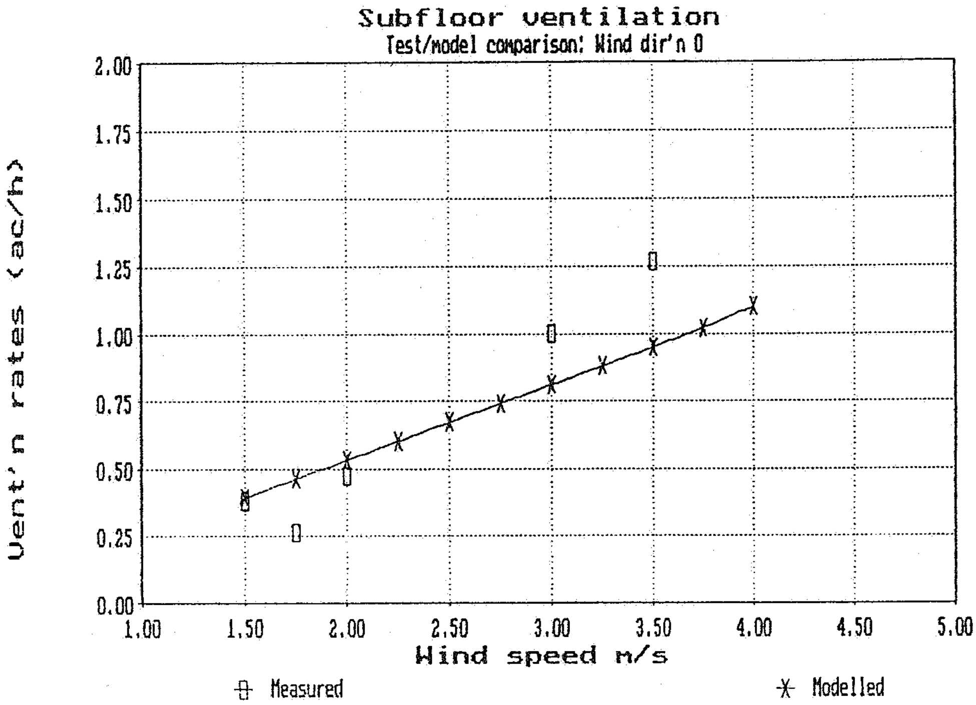

Figure 4.

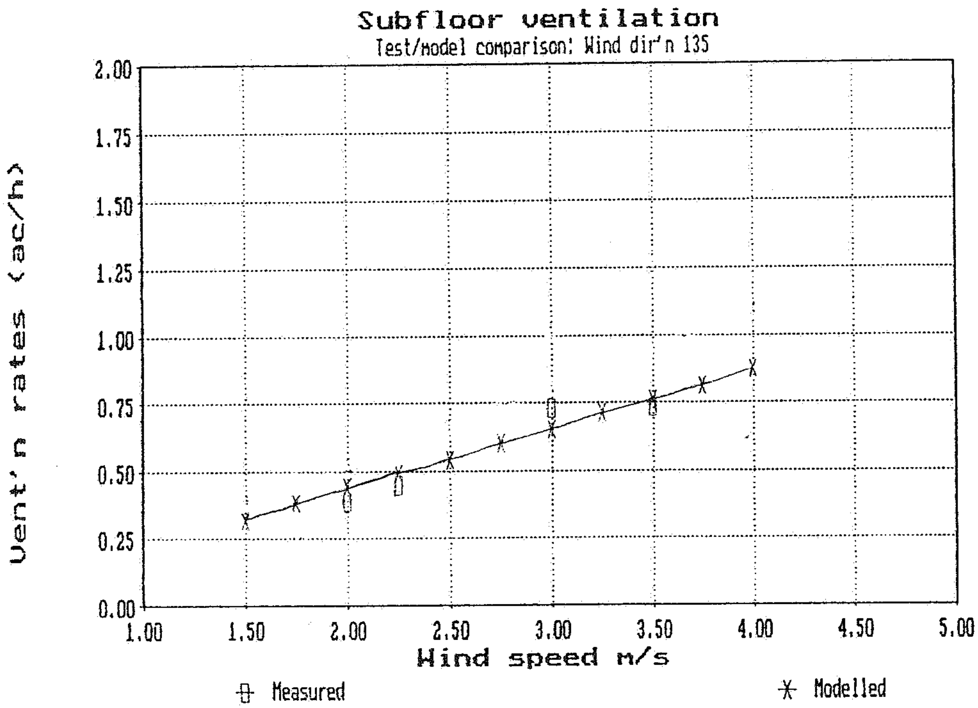

Figure 5.

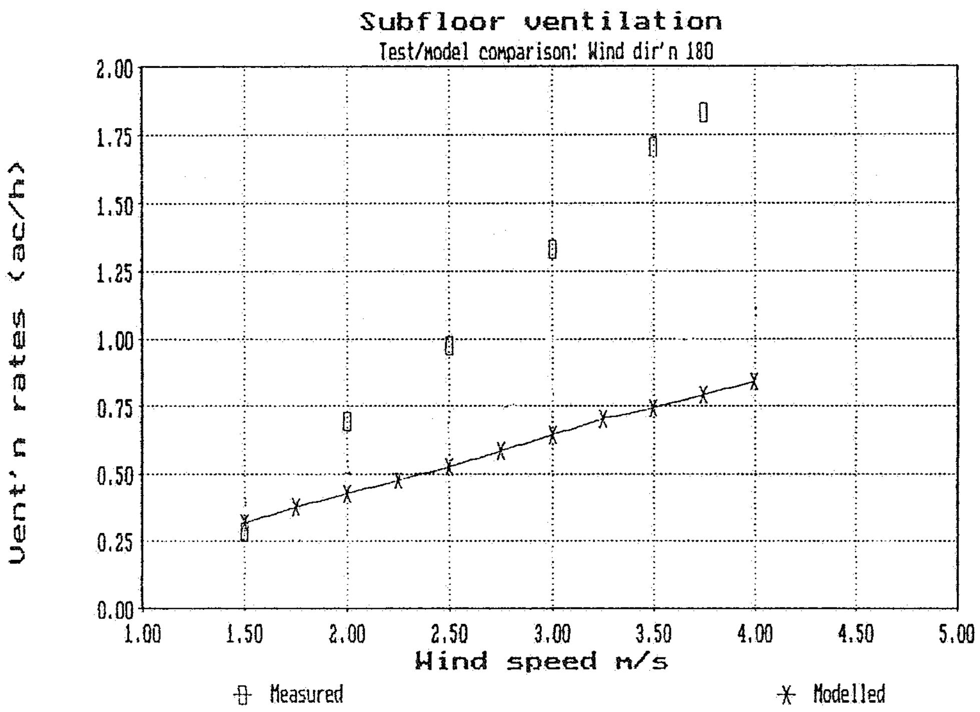

Figure 6.

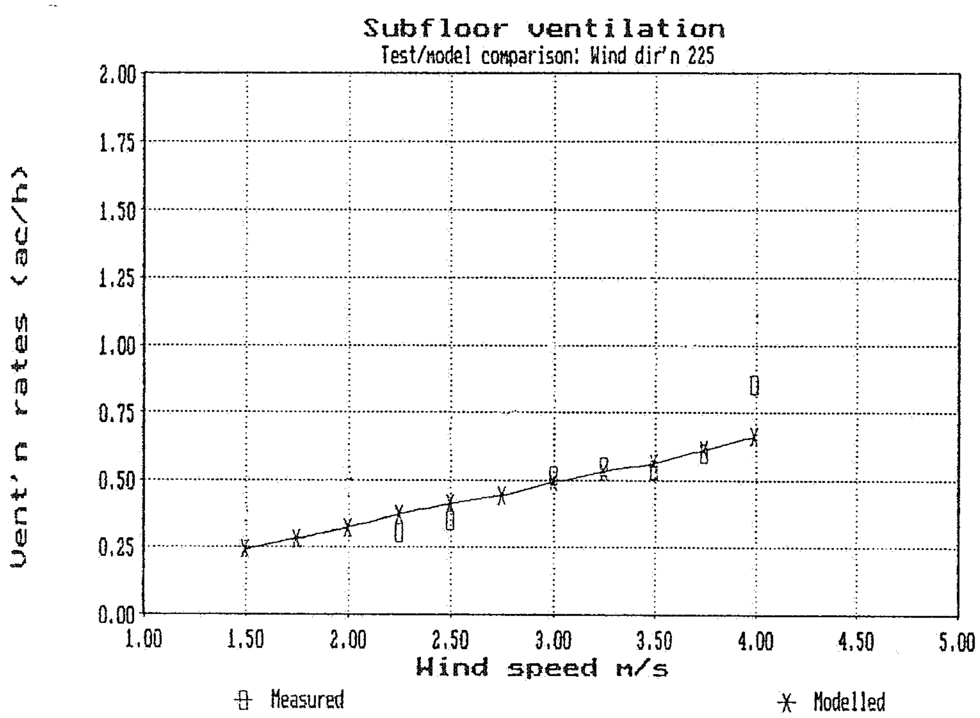

Figure 7.

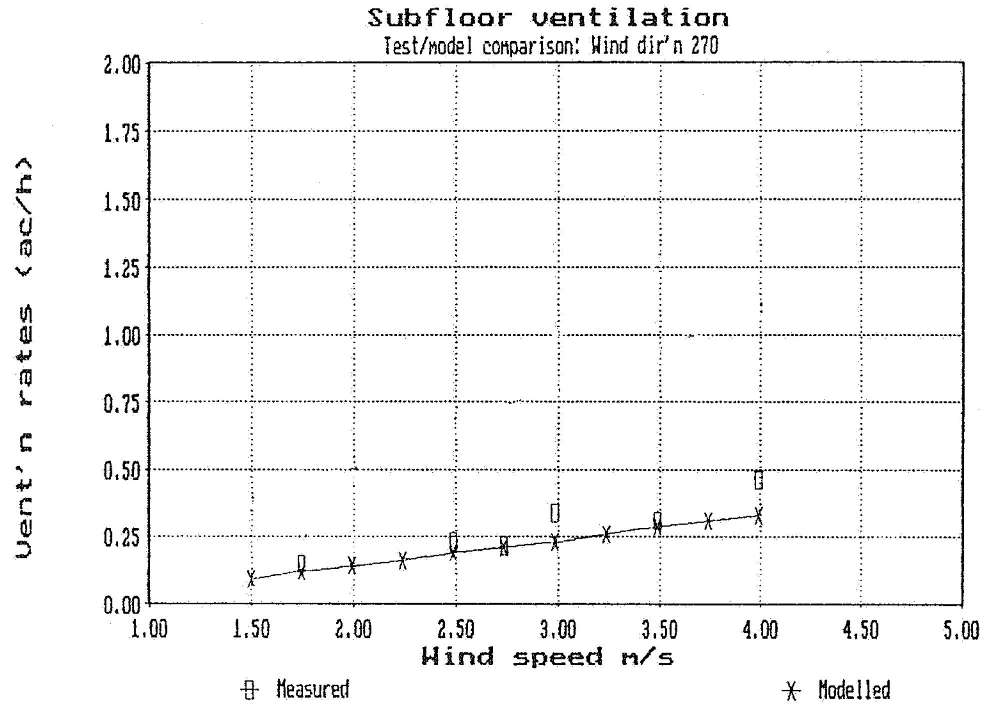

Figure 8.

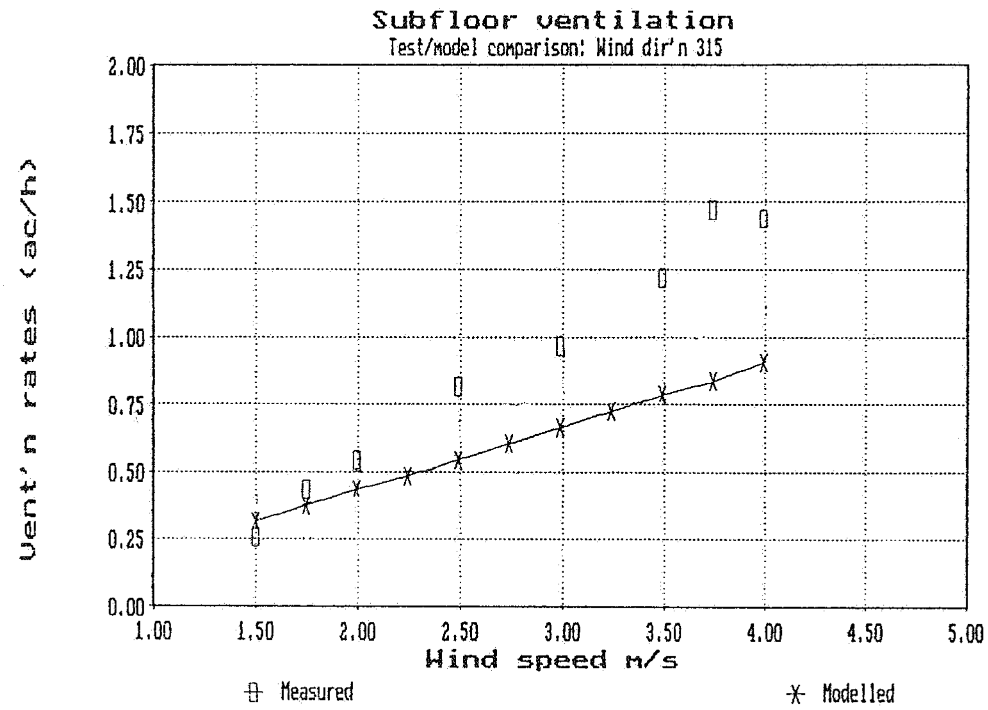

Figure 9.

Discussion

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H Hens (Leuven, Belgium)

Groundfloor - first floor ventilation loop. Be careful that loop is established between living space and kitchen and sleeping rooms. Not only in-transfer but also a very active vapour flow and heat flow.

R Edwards (UMIST, UK)

We know.

H Hens (Leuven, UK)

Ventilation of crawl spaces - condensation problems in winter time? Reason: ventilation = lower temperatures, through that: refer RV, etc.

R Edwards (UMIST, UK)

The test was only a calibration test for the BREFAN programme.