ENERGY EFFICIENT DOMESTIC VENTILATION SYSTEMS FOR ACHIEVING ACCEPTABLE INDOOR AIR QUALITY

3rd AIC Conference, September 20-23 1982, London, UK

PAPER 6

VENTILATION AND INTERNAL AIR MOVEMENTS FOR SUMMER AND WINTER CONDITIONS

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2. SUMMER AND WINTER VENTILATION

Opening lights in windows have served the purposes of ventilation for many years and it may be questioned why they cannot continue to do so. In this context it is important to distinguish between the requirements of summer time ventilation and the problems of minimum ventilation rates in winter. In non air conditioned buildings opening lights in windows serve fairly effectively to control the high rates of ventilation appropriate to summer conditions. Disturbance of papers and curtains can represent an annoyance but generally speaking the degree of controllability afforded by relatively large opening lights works well.

It does not work well in winter conditions and particularly so in circumstances where security demands that, while occupants are absent, windows should be secured. In winter time even a very narrow opening of a large opening light gives relatively high rates of ventilation and is likely to result in draughts being experienced because of the usual location of opening lights. Prolonged closure of the windows did not however represent a serious problem in the past. Habitable rooms were required to have either a flue or a special ventilator to fresh air. Quite apart from these provisions, the general level of airtightness of both the construction and the windows themselves tended to be low so that a significant rate of ventilation would take place even when the opening lights themselves were shut. Window manufacturers have, for some time, been concerned to improve the effectiveness of sealing of their windows and this, coupled with the abolition of the requirement for ventilation of habitable rooms and the powerful motivation in both new and existing buildings to reduce ventilation rates to save energy, results in potentially very low ventilation rates in the winter in many dwellings. It is therefore becoming apparent that opening windows, whilst meeting the requirements for summer ventilation do not provide a solution to the problem of winter ventilation. The situation is a particularly critical one since, to be effective, ventilation rates have to be controlled within narrow limits. From the point of view of energy conservation the ventilation rate in the heating season should be reduced to a minimum, but from the point of view of condensation risk it is vital that an adequate flow of air is maintained. Thus, although reducing ventilation is an extremely cost effective way of reducing heat loss, it is clearly very important that effective ways of control should be developed to prevent the disastrous consequences which can arise from over-enthusiastic but injudicious attempts at reducing ventilation.

3. CONTROLLED VENTILATION

Quite apart from the great differences in the living habits of occupants individual dwellings vary very greatly in their air-tightness. Siting, microclimatic factors, orientation and fenestration all play significant parts in addition to the effects of choice of materials and standards of workmanship. In a series of measurements of ventilation rates in dwellings built in the ten years prior to 1925, Warren[1] found variations between 0.45 and 1.25 air changes per hour with windows closed. The trend is clearly towards lower rates of natural ventilation (see section 3.2).

It is not possible to predict in advance what ventilation rates will be encountered in dwellings and it is difficult to do so, except by actual tests, in existing buildings. Unless a careful window opening regime is maintained, ventilation rates in the lower range are likely, giving rise to higher than normal moisture concentrations in the internal air and consequently to increase the risk of condensation.

One approach to this problem might be the careful study of materials and workmanship to determine which design features and standards of workmanship could be used to give desired standards by means of infiltration through the fabric. If possible this would certainly be a highly cost effective way of dealing with the problem. In practice, however, there seems no practical possibility that the necessary factors could be sufficiently closely specified or controlled and the only quick practicable method of testing, the pressurisation technique, will give a good measure of airtightness but there is no direct correlation between this and the mechanism of ventilation.

3.1 Full Mechanical Ventilation

A realistic approach to the problem, which has already been adopted in some countries, is to make the whole of the basic construction, including doors and windows, as airtight as possible and then to provide specific controllable features for winter ventilation.

Clearly the most predictable way to control low levels of ventilation is by mechanical means. In some countries where energy conservation is very important this method is being adopted. It is said that 95% of new Swedish dwellings are built to be as tightly sealed as possible and equipped with mechanical extract systems extracting through kitchens and bathrooms giving an overall ventilation rate of one half air change per hour. Although this may be a very effective solution in Sweden there are several reasons which prevent it being readily adopted as a solution in this country. Although temperatures in this country occasionally do drop to extremely low levels by any standard, such occasions are comparatively short lived and do not occur every year. A more consistent level of cold in Sweden means that window opening in kitchens and bathrooms is not a feasible ventilation measure in winter and the building regulations require the provision of quite expensive means of permanent natural ventilation. Thus there is a more acute situation recognised by occupants and the cost of the natural ventilation provisions can be set against a large part of the cost of the mechanical ventilation system which requires much simpler exit provisions through the building fabric. To ensure that the controlled low rate of ventilation is maintained the background infiltration is minimised by very high standards of workmanship in sealing the building and also, if condensation with low rates of ventilation is to be avoided, in ensuring that no cold bridges will cause trouble. In addition the amount of moisture basically present in the atmosphere at very low temperatures is much less than that at higher temperatures. In terms of condensation risk, therefore, the low temperatures represent an advantage.

In the U.K. climate where typical winter temperatures hover just above freezing and the relative humidities are extremely high it is by no means certain that the ventilation rates used successfully in Sweden would be adequate. The additional expense of full mechanical ventilation in the U.K. would be considerable, designers could be less certain that they would function efficiently, the noise levels would give rise to complaint and, on the experience associated with mechanical systems installed to overcome aircraft noise it is very likely that the fans would not be adequately maintained or repaired when necessary. In this country one must, therefore, look to the possibilities of providing natural means of controllable ventilation, perhaps operating in conjunction with simple extract fans.

3.2 Natural Ventilation

The first prerequisite is to separate the winter ventilation function from the opening lights. A system of controllable ventilators separate from but perhaps included in the window opening is an obvious possibility. One factor which does appear to be quite clear is that there should be a manually operated adjustment, the position of which can be observed by the users so that repeatable settings can be made to meet differing conditions.

In a range of weather conditions the whole house ventilation rate with internal doors open was measured using the tracer gas decay method. Fig. 1 shows the results, plotted against wind speed. The internal-external temperature difference varied between 5°C and 9°C. Inevitably there is scatter but there is a clear indication that the use of the ventilator openings is likely to produce a higher rate of ventilation, especially at higher wind speeds. The superimposed lines are obtained by linear regression analyses of the results with closed and open vents respectively. The distance between the lines suggests that the ventilation rate may be expected to increase by 16 - 27% when all the ventilators are opened.

During the course of a broad investigation of ventilation rates and internal air movements in a range of dwellings results have emerged which indicate the effects of built in hit and miss slot ventilators and of extract fans. The houses so equipped are

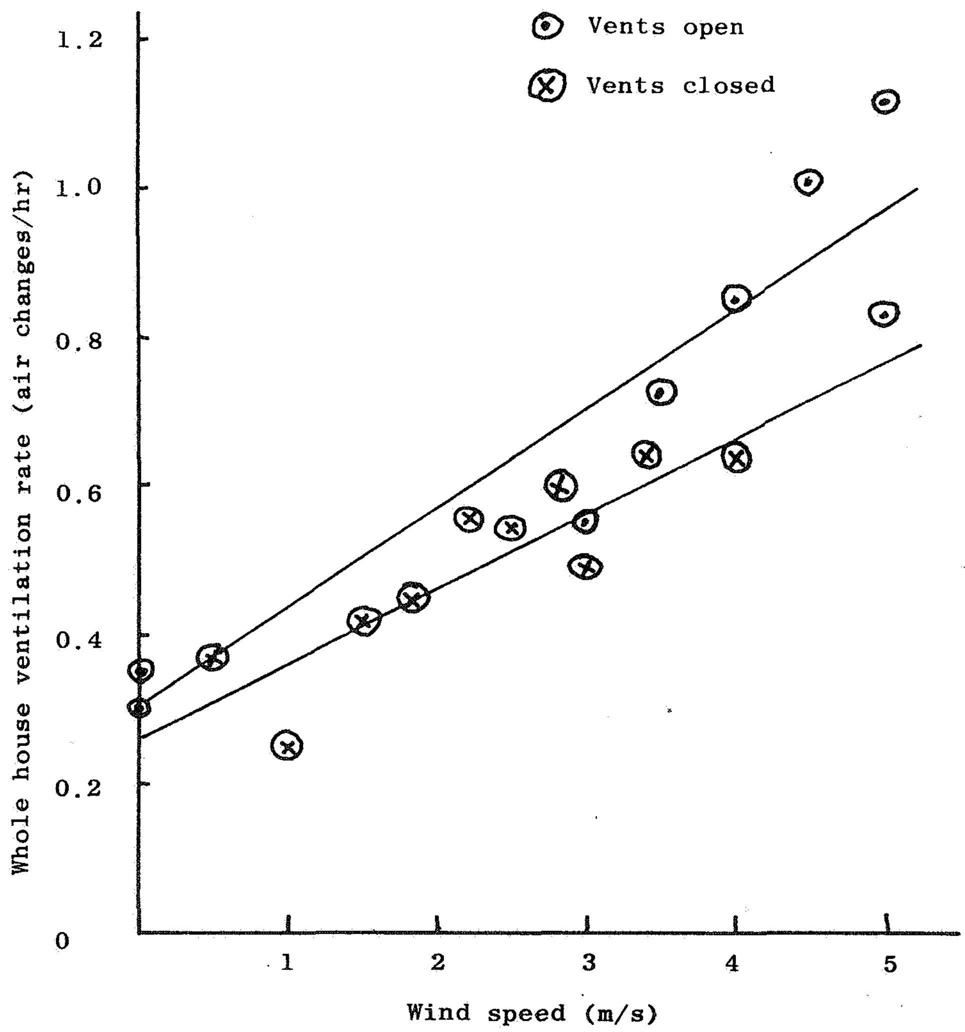

FIG. 1. Comparison of ventilation rates with ventilators open and closed.

newly constructed with double glazing and storm porches. Each window frame incorporates a slot ventilator most of which may be closed or opened to produce an open area of 7000mm^2. The ventilator in the kitchen is permanently open. The dwelling tested was end-terraced with a volume of 200 m^3.

The ventilation rates were measured by a tracer gas decay method which employs multiple tracer gases so that the internal air exchanges between major zones can be assessed. In addition, a pressurisation test was performed at 50 Pa.

The results show the effectiveness of the simple slots employed in one particular dwelling. It is clear that they do provide an increased rate of ventilation without the disadvantage of the relatively large opening lights.

Many devices of this type are on the market at present, some of which have a flap arrangement intended to give fixed ventilation rates irrespective of pressure differences across the unit. There is an important need to evaluate the performance of these units, both when installed and over a period of time.

A possible method of testing such devices when installed is the use of the pressurisation technique.

During the investigations described, the average of pressurisation and depressurisation tests at 50 Pa produced a throughput of 0.675 m^3/s with the slot ventilators closed and 0.785 m^3/s with the ventilators open - an increase of 16%. Some measure of correlation between the pressurisation results and the ventilation measurements is evident; both techniques giving a similar assessment of the effect of the ventilation openings.

It should be noted from Fig. 1 that low levels of ventilation rate are to be found in still atmospheric conditions with values as low as 0.25 - 0.30 air changes per hour.

3.3 Simple Extract Fans

The houses tested were equipped with simple extract fans discharging through the wall near to the cooking appliance. In a series of decay tests, the whole house ventilation rate varied between 1.1 and 1.9 air changes per hour with the fan on and the window vents closed. The combined effect of the fan and the open window vents was to produce higher ventilation rates of between 1.6 and 3.0 air changes per hour. An important effect of the fan is to produce a different flow pattern throughout the house. Fig. 2 demonstrates the changes of direction and flow rates. Strong evidence is also indicating that flow into roof spaces and cavities is considerably reduced when an extract fan is running in the house. Thus the primary effect is to remove moist air from the zone in which water vapour is generated but the secondary effect is to reduce the flow from the ground floor to the first floor thus minimising convection of warm moist air into remote rooms with low occupancy and a likely minimum of heating.

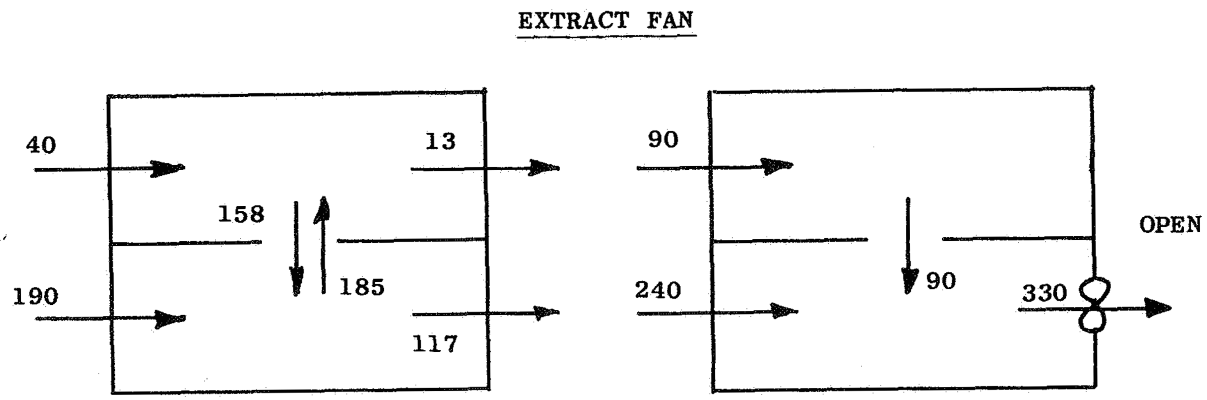

FIG. 2. Whole house air flows with open ventilators and the effect of kitchen extract fan. (Flows in m^3/hr).

4. CONCLUSIONS

1. There is a clear and conflicting distinction between the requirements for summer ventilation and for winter ventilation.

2. Built in controllable ventilation slots can provide a level of ventilation compatible with winter requirements.

3. The appropriate sizing of ventilators (and hence the extent of the increased ventilation which they provide) is not known; further research which correlates the winter ventilation requirement with ventilation size is necessary.

4. Kitchen extract fans are highly effective means of keeping moisture generated in cooking out of the main part of the house and its roof space. Reversals of stair well flows have been clearly observed.

5. REFERENCES

1. WARREN, P.R.
"Factors influencing air change in houses"
University of Aston Conference, Sept. 1975.