RESEARCH REPORT

NATURAL VENTILATION — MEASUREMENT AND PREDICTION

P R Warren looks at current research into developing techniques for measuring and predicting natural ventilation and infiltration rates in buildings.

One of the main objectives of the building services engineer is to provide a safe, healthy and comfortable environment for the occupants of buildings while at the same time keeping capital and running costs to a minimum. Ventilation has a significant part to play, both in relation to summer-time cooling and, more particularly, in the control of indoor airborne contaminants by dilution with outside air.

A balance must be struck between the conflicting claims of energy conservation and the maintenance of a satisfactory environment. To achieve this it is necessary to specify minimum fresh air requirements, and to have techniques available for measuring performance in practice as well as methods for predicting natural ventilation and infiltration rates for design purposes. The BRE research programme continues to contribute to all three of these aspects.

Until recently measurements of natural ventilation and infiltration were largely restricted to housing. Simple tracer gas techniques were used which involved mixing the gas evenly throughout the space and measuring the decay in concentration. Results of BRE research on a range of post-war houses gave typical air infiltration rates which were substantially higher than those in countries with more extreme climates such as Scandinavia and North America (1). However, although on 10% of occasions infiltration rates were above 1·3 air changes per hour (ac/h), on 50% of occasions rates were less than 0·6 ac/h. This indicates that, in the absence of alternative provision for outside air supply, there may be an increasing tendency for houses to be under-ventilated.

Tracer gas measurements are time-consuming, so in order to provide a more rapid basis for assessing the infiltration performance of housing a simple pressurisation technique, developed in 1973/74 by BRE Princes Risborough Laboratory, has been used. This involves a portable fan unit, sealed into one of the external door openings, which is used to apply a pressure difference (usually in the range 20 to 60 Pa) across the external envelope of the house. The flow rate is measured at each pressure difference and a characteristic air leakage curve obtained. This characteristic not only enables the house to be classified in general terms as "leaky" or "tight" but also, taken in conjunction with simple prediction procedures, discussed later, enables infiltration performance to be predicted (2).

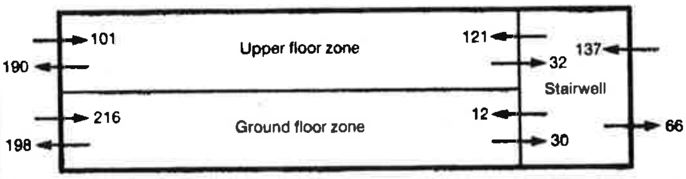

Figure 1: **Section through a 2-storey, naturally-ventilated office building showing measured air exchange flow rates (litres/s).**

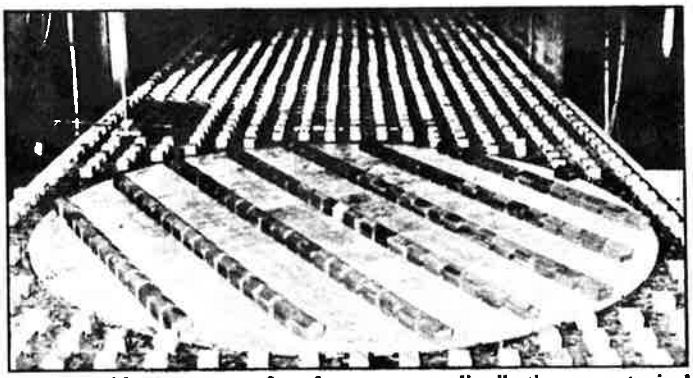

Figure 2: **Measurement of surface pressure distribution on a typical housing layout in the BRE environmental wind tunnel.**

Recent work has been concerned with developing techniques for measuring infiltration and ventilation rates in larger, multi-celled buildings, such as offices (3). These techniques range in complexity depending upon the type of information required. For instance, in order to obtain both the exchange rate of air between zones within a building and outside air and also the exchange between zones it is necessary to use several tracer gases simultaneously. Techniques have been developed to achieve this; figure 1 illustrates the results obtained in a naturally ventilated building, using three different tracer gases.

When less detailed information is required a new approach may provide a simple technique for use in naturally ventilated, multi-celled buildings using only a single tracer gas. The gas is distributed in a selected zone and concentrations monitored over a long period of time. Under most circumstances, independent of the relative size of the zone, the longer term measurements allow the whole building ventilation rate to be estimated. It is hoped to publish details of this approach and its application shortly in *BSER&T*. Progress is also being made with the development of simple, but reliable, tracer gas dispersal and sampling techniques to avoid the requirement for long lengths of tubing in buildings such as offices. Samples are collected in suitable containers, either instantaneously or continuously over a longer period, giving a long term average, and returned to the laboratory for analysis, thus avoiding the use of expensive equipment on site.

Measurements provide information on existing buildings, but it is also necessary to be able to estimate air infiltration, or to predict natural ventilation rates at the design stage, as in Section A4 of the CIBS *Guide*. Recent improvements in the understanding of the underlying physical mechanisms and the availability of computers has enabled more sophisticated prediction methods to be developed. BRE has several such computer programs, including BREEZE which is designed to predict the natural ventilation rates and inter-zone movement in multi-celled buildings, and a simple single-cell model for predicting housing performance. These programs, and the good agreement that they show with actual measurements, will be discussed in more detail in a future article.

Whether simple or complex, all models require input data, in particular surface pressures generated by the wind and the position and flow characteristics of air flow paths, especially through the building envelope. Surface pressures generated by the wind depend upon wind direction, the overall building shape and surrounding terrain and obstructions. A series of measurements is currently being undertaken in the BRE environmental wind tunnel to determine pressure distribution on houses in typical arrangements, and on other low-rise buildings, in order to provide reliable, tabulated data for use in prediction. Figure 2 shows the wind tunnel containing a model housing layout. Air flow characteristics are more difficult to obtain since many flow paths are not clearly defined. The pressurisation test provides some information for houses, but very little data are available for other types of building. An important part of the research programme is to gather such data to provide a sounder basis for ventilation prediction.

When attempting to predict performance the behaviour of occupants should not be neglected. This is particularly true in naturally ventilated buildings where users have control of natural ventilation by opening or closing windows. A paper to be published shortly in *BSER&T* (4) discusses window opening behaviour in office buildings and the consequent effect on energy conservation during the heating season (see *BRE Research Report, Building Services*, August).

References

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