Build tight – ventilate right

by Earle Perera and Lynn Parkins

It should be the basis of good design to make any building envelope airtight and then to provide controlled ventilation, ie the concept of 'build tight - ventilate right'. Earle Perera and Lynn Parkins investigate.

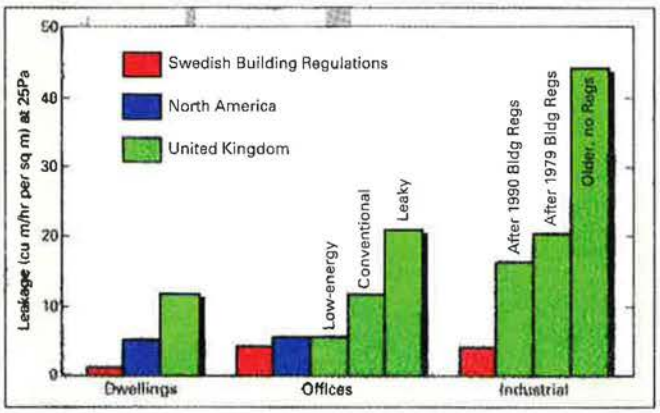


Figure 1: Fabric leakage of different building types in different countries.

Adequate ventilation is essential for the health, safety and comfort of building occupants, but excessive ventilation leads to energy waste and sometimes to discomfort. A building needs to be ventilated by design (eg openable windows). Air leakage (infiltration) through cracks and gaps in the building fabric tends not to be designed for, and may therefore be considered as an overhead or penalty.

It should be the basis of good design to make the building envelope airtight and then to provide controlled ventilation, ie the concept of 'build tight - ventilate right'. This approach reflects and addresses current concerns regarding indoor air quality (eg sick building syndrome), energy conservation and associated environmental issues such as carbon dioxide emissions (arising from space heating and cooling) and use of cfcs. It needs to be emphasised that a building cannot be too tight – but it can be underventilated.

Build tight

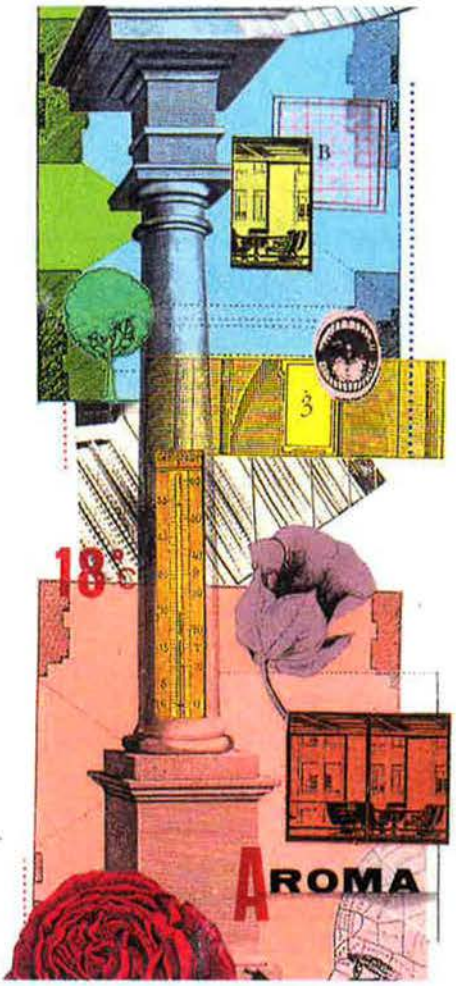
The airtightness of a building envelope can be measured by using a 'fan pressurisation' method[1]. This involves sealing a portable fan into an outside doorway and measuring the air flow rates required to maintain a series of pressure differentials across the building envelope.

BREFAN is a new pressurisation system built by the Building Research Establishment (BRE) and designed for use with large buildings. The airtightness of buildings with different forms and volumes can be compared using a leakage index, Q25/S, where Q25 is the flow rate at a pressure difference of 25 Pa and S is the total permeable envelope area.

Figure 1 shows the measured leakage index of different building types in the UK compared with North American and Swedish buildings. The average UK dwelling is twice as leaky as the average North American building and four times more leaky than the average Swedish building. In the office sector, however, the purpose-built BRE low-energy office is as tight as a representative North American building and almost tight enough to conform with the present Swedish *Building Regulations* requirement for non-domestic buildings. By contrast, a typical conventional office building is twice as leaky, while a problem building (where staff dissatisfaction had been expressed) is four times as leaky.

Some of the leakiest UK buildings are single-celled industrial constructions. Even the tightest UK industrial building (satisfying current *Building Regulations*) is five times more leaky than a similar Swedish building, while the older building is 10 times more leaky.

Figure 1 shows that there is considerable scope for making UK buildings tighter. A study[2] has shown that just sealing an



uninsulated loading door of a factory unit (built to *1979 Part FF* standard) reduces the leakage by 14%, the average infiltration rate by 24% and, consequently, the total space heating requirement (over the heating season) by 14%.

Approximately three-quarters of the air leakage could be through background and hidden paths rather than identifiable gaps and cracks in the envelope. It is, therefore, more effective to make buildings tighter at the design stage than to retrofit them. Some benefits can be obtained by tightening existing buildings, but often post-constructional remedial measures may have only a minimal effect on an already leaky building.

To make new buildings tighter, the designer should, in his drawings, identify a continuous airtight envelope. This should encompass the conditioned internal zone and exclude any unintended exchange of air with unconditioned zones, with the outside and with any adjoining zone.

Information about design for tighter domestic buildings is available in various forms, eg in the architectural press[3] or as guidance documents to international practice[4]. But there is little guidance relating to office-type buildings. BRE is addressing this issue now and will offer advice in a forthcoming handbook entitled *Guide to minimising air infiltration in office buildings*.

For industrial buildings, some design information is available, eg those relating to the low-energy factory units being built by the Welsh Development Agency[5]. In this instance, the integrity of the external envelope is being confirmed by pressure testing. For all these types of buildings, there are many organisations within the UK which can carry out post-construction compliance testing.

Ventilate right

With tighter buildings, greater attention has to be paid to providing adequate controlled ventilation. In dwellings, ventilation is needed not only for good indoor air quality, but also to control condensation and to ensure safe and efficient operation of combustion appliances. *Building Regulations Approved Document F (1990)* gives guidance on meeting these requirements by controlled ventilation.

At present, *Building Regulations* do not deal with provision for ventilation requirements in non-domestic buildings except for rooms containing sanitary conveniences. In office buildings, ventilation requirements are mainly governed by comfort criteria, which are usually set by aspects relating to body odour, smoking and, in the summer, to overheating.

CIBSE[6] gives guidance on fresh air requirements relating to metabolic needs and controlling body odour (8 litres/s fresh air per person) as well as on tobacco smoke (from 16 to 32 litres/s per person depending on the proportion of occupants smoking). The recently published government *Code of Practice* on smoking in public places also contains suggestions on ventilating smoking areas and rooms.

Some industrial processes may generate large amounts of pollutants. Recommended measures[7] to deal with the pollutant sources and to control indoor levels to safe and acceptable limits are available. It should be noted that, although general dilution ventilation of the workplace is usually perceived to be the only remedial measure, it ranks very low in the list of recommended measures. Other strategies, eg local extract ventilation, may be better and more economical. Guidance is given by the Health and Safety Executive[8].

If a building is not deep, adequate ventilation can be provided naturally through single-sided ventilation[9]. For deeper buildings, either mechanical ventilation or natural cross-ventilation will be necessary. Design guidance[10] is available for simple building forms, while multicell computer prediction procedures can be used to design more complex buildings[11].

When designing for natural ventilation, calculations should also take into account the expected ventilation performance of the building; ie by combining the influence of expected local weather with the ventilation characteristics of the building[11]. Guidance[12] is also available on ventilation and shading necessary to minimise summer overheating.

Tracer gas techniques are available to monitor ventilation performance of both relatively small domestic buildings[13] and large, complex buildings like offices[14]. In offices where there is no smoking, the internal CO_2 level may be used as a surrogate measure of the adequacy of the indoor air.

With an ambient outdoor level of 350 parts per million (ppm), simplified calculations indicate that a monitored CO_2 level below 1000 ppm, should ensure that the requirement of 8 litres/s per person is being met.

In summary, tight buildings can be built in the UK without compromising ventilation requirements. Guidance on both these aspects is available and, for all new-builds and major refurbishments, the concept of 'build tight - ventilate right' needs to be encouraged.

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