IP 6/89
BRE Information Paper
April 1989
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CI/SfB (57.5)(B8v)

#3643

Use of BREFAN to measure the airtightness of non-domestic buildings

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BREFAN is a fan 'pressurisation' rig designed to carry out air leakage tests on the whole building envelope of most non-domestic buildings, like offices and hangars. This paper describes field measurements with BREFAN in two office buildings and shows how a 'leakage' index can be evaluated and then used as a diagnostic measure of the constructional quality of the external fabric of the building. BRE provides a BREFAN measurement service to other organisations, and this paper will be of interest to architects, builders, building services engineers, surveyors and others concerned with the provision and control of ventilation in buildings.

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INTRODUCTION

Adequate ventilation is essential for the health, safety and comfort of the occupants of buildings, but excessive ventilation leads to energy waste and, in some cases, to discomfort. In naturally ventilated buildings, the leakiness of the building envelope is a major factor in ventilation through air infiltration. Envelope leakiness is usually quantified by measuring the whole-building air leakage rate at appropriate applied pressure differentials between the inside and outside. This is most conveniently done by using the fan pressurisation technique[1] whereby a portable fan is sealed into an outside doorway and the airflow rates required to maintain a series of pressure differences are measured. Over the last decade, use of this technique for dwellings has increased, but problems of scale and the lack of appropriate equipment have deterred any extensive investigations of bigger, more complex buildings like offices.

Although there are no reports of air leakage measurements in office-type buildings either in the UK or elsewhere in Europe, some measurements have been made in mechanically ventilated buildings in North America. In most instances, the building's own system fans were used to pressurise these buildings[2]. This is not particularly suitable for the UK since most buildings here are naturally ventilated. In a few instances in Canada[3], a greatly scaled-up version of the equipment used in dwellings, consisting of a large trailer-towed fan (with its own electrical generator), was used. A large single fan, however, lacks true portability and, more importantly, flexibility to accommodate buildings of different sizes and/or leakiness.

The BREFAN system was designed and built by BRE to address all these problems. Each of its three fan units is fully portable and can be powered from conventional 13 amp sockets. They can be used to pressurise most large (and naturally ventilated) non-domestic buildings (Figure 1).

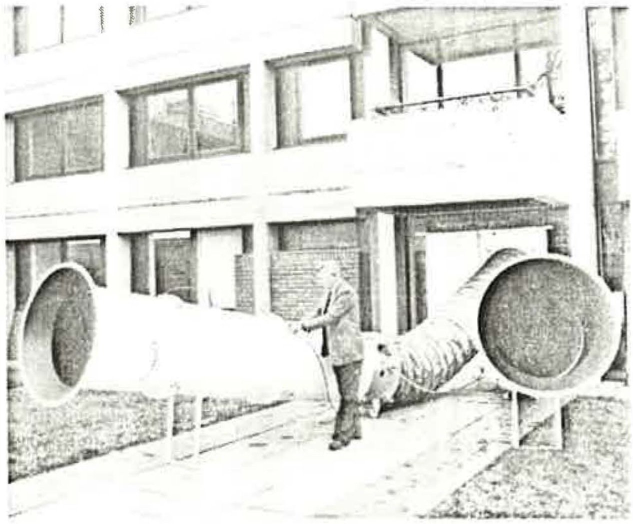

Figure 1 Two BREFAN fan pressurisation units installed in an external doorway of an office building

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BREFAN SYSTEM

The BREFAN system consists of three identical fan pressurisation units, each drawing less than 3 kW of electrical power from conventional 13 amp sockets. Each fan is 762 mm (30 inches) in diameter, is of the direct drive, single stage, axial flow type, and is capable of providing a flow rate of 5.5 m^3/s against a building envelope pressure difference of 50 Pa. Airflow through each fan is measured using a conical inlet designed to British Standard BS 848[4].

On any particular building, the number of fan units used is set by that required to achieve the target envelope pressure difference. Single-phase to three-phase (variable-frequency inverter-type) speed controls are used to operate the fans from generally available single-phase power supplies and also to stabilise their speeds which would otherwise fluctuate during multiple-fan operation (R K Stephen, unpublished results).

FIELD MEASUREMENTS

Buildings

Whole-building pressurisation tests were carried out in two medium-sized office buildings at the BRE site in Garston. The first is a conventional naturally ventilated office building (Figure 2) with an estimated volume of 6254 m^3. Its outer face consists mainly of single-glazed, steel-framed windows and 13 mm thick insulated infill panels. Behind each panel there is a 114 mm air gap followed by a 114 mm thick brick wall lined with 16 mm of plaster on the inside. The external surface area (walls and roof) is estimated to be 2195 m^2.

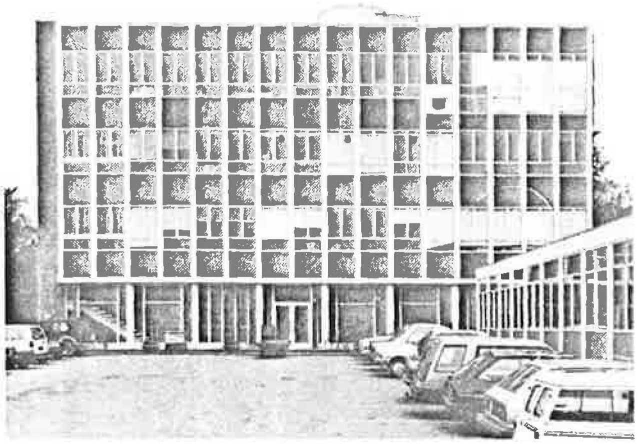

Figure 2 The conventional office building

The second building (Figure 3) was built[5] as a 'low-energy' office (LEO). The windows are all double-glazed with aluminium frames, and the wall construction consists mainly of 9 mm thick clay tiles on the outside face followed in succession by 125 mm thick precast concrete panels, a 300 mm void filled with blown polystyrene beads, and plasterboard (12.5 mm thick) with an aluminium foil vapour barrier. The total volume and the external surface area of this building are estimated to be 5315 m^3 and 1750 m^2 respectively. The LEO has a mechanical ventilation system which allows a varying amount of fresh air to be taken into the building, depending upon the setting of mechanical dampers at the air-handling unit. The occupants, though, are free to open the windows whenever they choose.

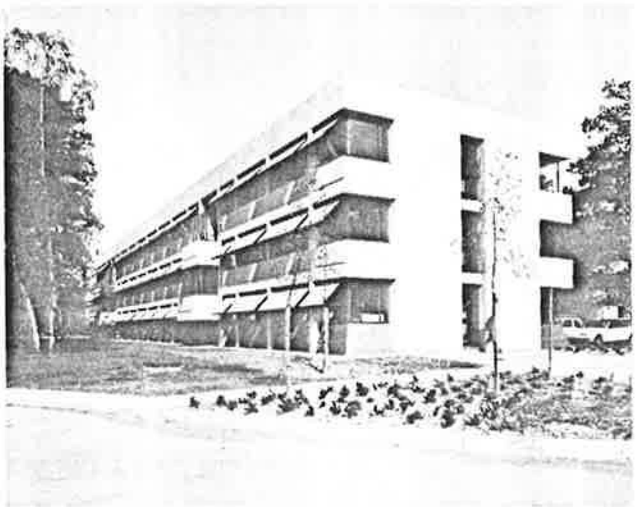

Figure 3 The low-energy office building

Tests and results

Three tests were carried out with pressurisation units connected (via short lengths of flexible ducting) to 'false' plywood door panels temporarily sealed (Figure 1) into open external doorways. One test was in the conventional office building. The other two were made in the LEO building with its mechanical ventilation system switched off, the first test with the dampers in the air-handling unit kept open, the second with them blanked off. During all three tests, all outside doors and windows were kept shut while all internal doors were wedged open. As is usual for tests in dwellings[1], all measurements were made when the outside wind speeds were relatively low.

Figure 4 shows the airflow rates, Q, plotted against the applied pressure difference (at ground-floor level), ΔP, across the outside wall envelope for the LEO building. Best-fit power-law profiles of the form $Q = K \Delta P^n$ were fitted to all the data and the constants, K and n, evaluated (Table 1).

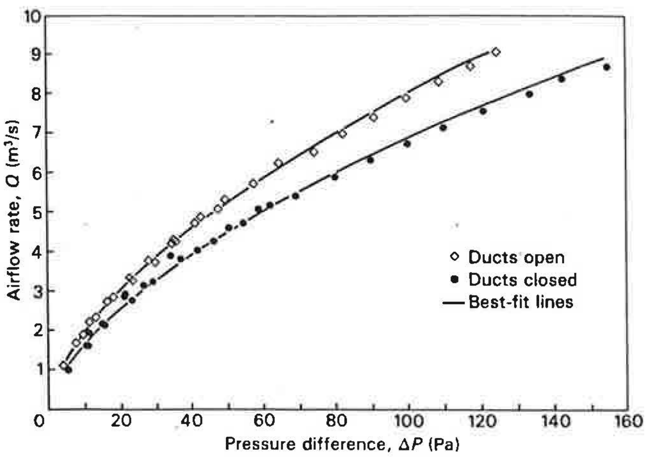

Figure 4 Tests in the low-energy office building

Table 1 Values of the constants K and n derived from the tests

Building tested	Coefficient, K [$(m^3/s)/Pa^n$]	Exponent, n
Conventional	1.388	0.51
LEO: ducts open	0.498	0.60
LEO: ducts open	0.424	0.60

Discussion of results

A suitable measure[6] of the overall permeability of a building envelope to air flow is Q_{25}/S where Q_{25} is the leakage rate at 25 Pa and S is the total permeable external surface area. This index can be regarded as one of the measures of the constructional quality of the external fabric of a building with respect to air infiltration.

Making use of the above power-law constants, Figure 5 shows the computed values of the Q_{25}/S index for all three tests. It also gives, for comparison, averaged values of this index for a number of mechanically ventilated buildings in the USA and Canada[7]. This figure shows that, whilst the purpose-built LEO is nearly as tight as the North American buildings, the more conventional building is twice as leaky. It also shows that, at a 25 Pa pressure difference between inside and outside, the duct opening in the air-handling unit of the LEO contributes about 15% to the total leakiness of this building.

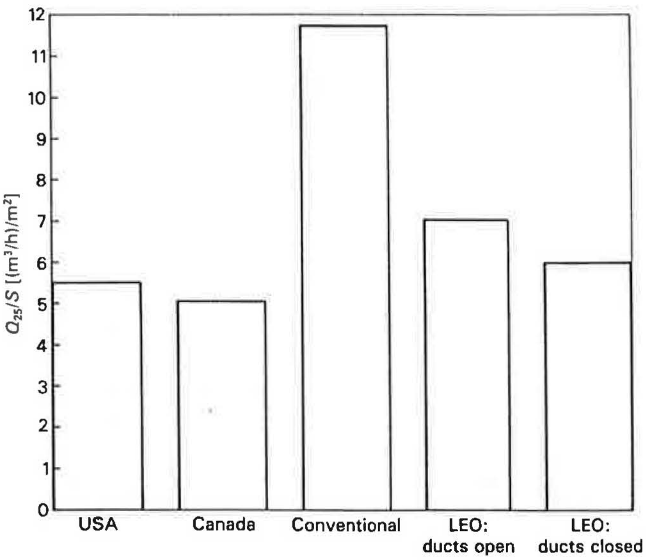

Figure 5 Envelope leakage of office buildings

CONCLUSIONS

At present, there is no information on the leakage characteristics of UK office buildings. This is because no suitable equipment has been available until now to pressurise these large, and mostly naturally ventilated, buildings. Such information, however, is important for the assessment of quality assurance of an individual building[8].

The BREFAN system was designed and built to supply this knowledge. Important design considerations have included flexibility, portability and operation from conventional 13 amp electrical power points. Leakage measurements in two UK office buildings have been carried out as a preliminary step towards a programme of further measurements in similar buildings. Also, as part of its Wind Engineering Technical Consultancy service[9], BRE can undertake BREFAN measurements for other organisations. (For information on this service, contact BRE Technical Consultancy, Building Research Establishment, Garston, Watford, WD2 7JR; Telephone (0923) 664800.)

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