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Technical Note

Summary A technique for identifying and measuring air leakage through the fabric of buildings is presented. The leakage characteristics of a few selected full-scale building details are illustrated. The data derive from both laboratory and real-world buildings, and indicate the importance of design detailing and construction of junctions to control air leakage.

Air leakage measurements on full-scale construction

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1 Introduction

This is a short note to illustrate the complementary use of thermography and air flow measurement in assessing building characteristics *in situ*.

Thermographic survey combined with depressurisation of the building space is a documented technique for locating air leakage sites rapidly[1]. However, the subsequent quantification of the air leakage is more problematic. This note reports on one technique to address this problem by direct measurement. The air flow at the leakage site is measured as follows. A measurement box is placed securely over the leakage site, providing an enclosure around the site (Figure 1). The room is then depressurised to a pressure difference ΔP by means of a fan mounted in a suitable opening (door or window). A second fan connected to the measurement box is adjusted so that the pressure difference between the box and room is zero. Hence there is no air flow around the perimeter of the box. The air flow through this second fan is measured accurately by means of a volume flow meter and is attributed to the leakage site. A more detailed explanation of the method and equipment may be found in Reference 2.

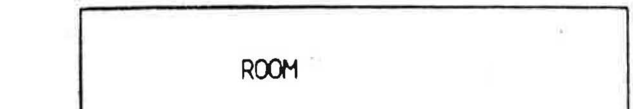

Figure 1 Scheme of test method: fan a is used to depressurise the room to pressure ΔP; fan b is adjusted to maintain a zero pressure difference ($\Delta P_c = 0$) between the measurement box c and the room. The leakage flow (Q) through the target area d is then measured at Q.

An internal thermographic survey of a building will indicate sites of varying thermal transmittance and the principal air leakage sites. If the building is depressurised, the colder external air penetrates the construction at leakage sites and causes rapid local cooling. This cooling can be detected easily by the thermographic survey, especially when compared with thermal images obtained before depressurisation. In this way the locus of the leakage site may be determined and direct measurement of the leakage site obtained from the air flow measurement box. This combines a practical rate of application with a maximum of significant information.

In the present study air leakage measurements were carried out using a rig on both a floor/wall junction built full-scale in a laboratory and on a ceiling/wall junction in a real building.

2 Laboratory construction

The construction built full-scale in the laboratory represented a fairly typical timber-frame ground floor/wall detail as shown in Figure 2. Three variants of this detail were tested: perfect as shown; discontinuity and mortar bed filled with 18 mm depth timber member; and discontinuity and mortar bed void.

The discontinuity is between the polythene vapour barrier and the solid floor polythene damp-proof membrane. These variations reflected possible design or workmanship deviations from a typical detail[3], and would lead to different levels of air infiltration into the building via a route in the vicinity of the skirting board.

Without knowing the construction it was possible to distinguish between the perfect detail 1 on the one hand and details 2 and 3 on the other, using thermography and whole-building depressurisation[4] non-destructively. Air flow measurements were necessary to determine the flow rate through the detail. To that end, the measuring box was positioned at the skirting junction between floor and wall, and occupied a length of about 0.5 m along the junction (Figure 3). The leakage rate in $m^3 h^{-1}$ measured over a 0.5 m section was doubled to give a figure in $m^3 h^{-1}$ per metre run of junction.

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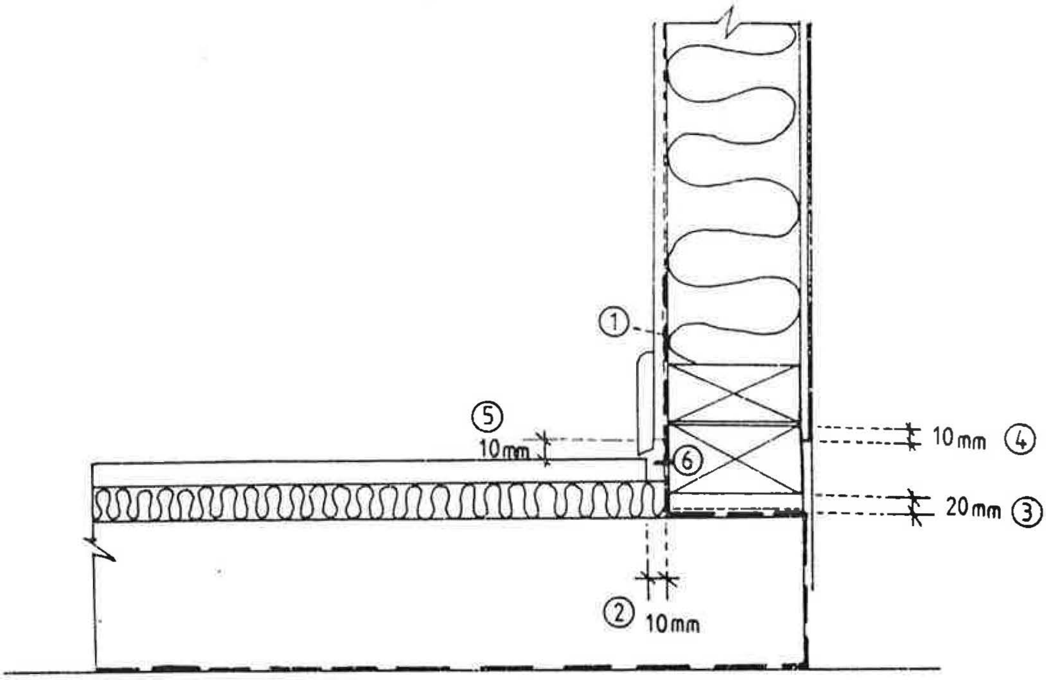

Figure 2 Solid ground floor/wall junction (not to scale): 1 VB/DPM overlapped at least 150 mm and taped; 2 Chipboard floor 10 mm movement gap; 3 Soleplate bed 20 mm mortar, supported on timber @ 600 mm c/s; 4 Plywood sheathing overlaps soleplate 10 mm; 5 Plasterboard 10 mm above FFL; 6 Possible air leakage reservoir

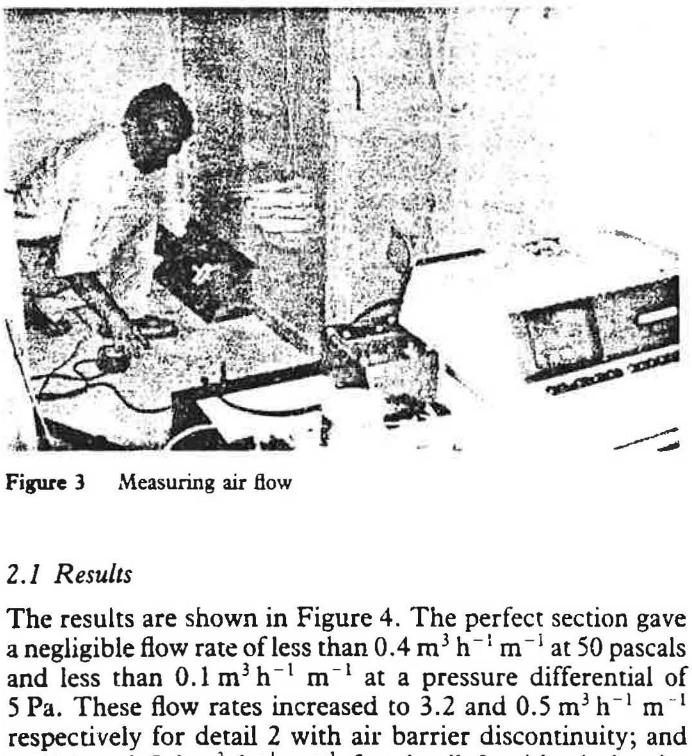

Figure 3 Measuring air flow

2.1 Results

The results are shown in Figure 4. The perfect section gave a negligible flow rate of less than 0.4 $m^3 h^{-1} m^{-1}$ at 50 pascals and less than 0.1 $m^3 h^{-1} m^{-1}$ at a pressure differential of 5 Pa. These flow rates increased to 3.2 and 0.5 $m^3 h^{-1} m^{-1}$ respectively for detail 2 with air barrier discontinuity; and to 7.4 and 2.1 $m^3 h^{-1} m^{-1}$ for detail 3 with air barrier discontinuity and mortar bed void.

Although the thermograms correlated well with the subsurface building defects positionally, and the airflow measurement ranked the defects correctly, the location of the greatest leakage rate was marginally displaced from, but overlapped, the sub-surface building defect zone. This was mainly due to variation in the fit of the skirting board along the examined section of the test room, which deflected the air leakage path through a reservoir to the most accessible entry point to the room.

Although no alternative validation of the magnitude of the leak through these complex joints has yet been attempted, the technique is robust enough for simple engineered cracks to suggest its validity in the present use[5].

These leakage rates would have a significant influence on real buildings. In a typical bungalow scenario, junction number 3 by itself is likely to account for 0.5 air changes per hour at 5 pascals pressure difference. Houses are normally 'designed' with an air change of a similar magnitude (between

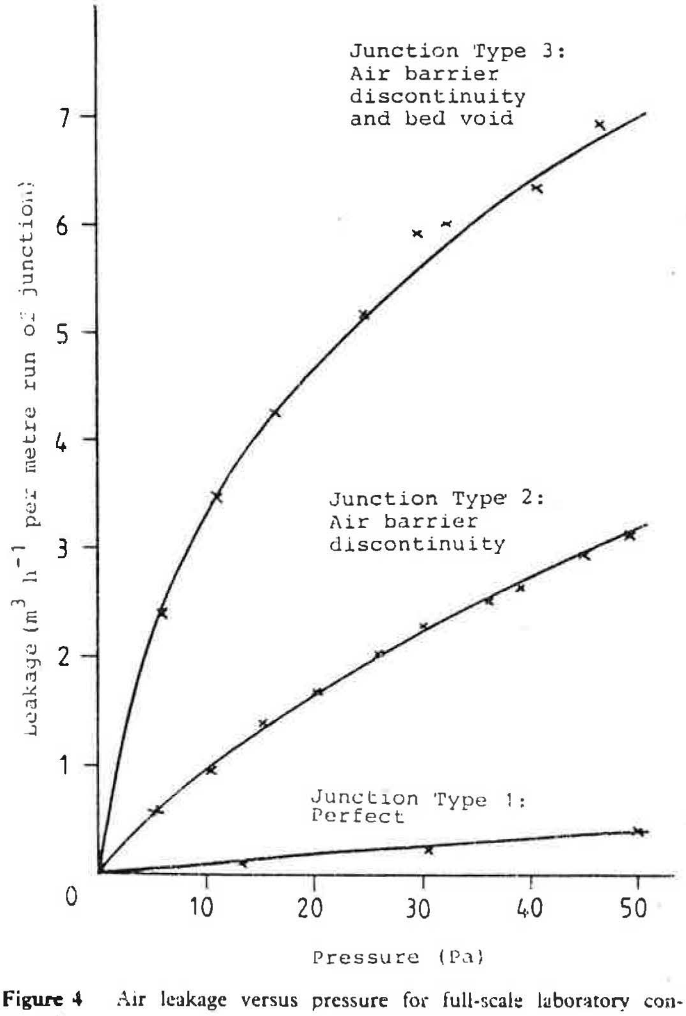

Figure 4 Air leakage versus pressure for full-scale laboratory construction

0.5–2.0 ac h^{-1}), and by virtue of this one junction the minimum ventilation requirement is supplied. With the addition of other leakage sources it would seem likely that any design intentions will be exceeded.

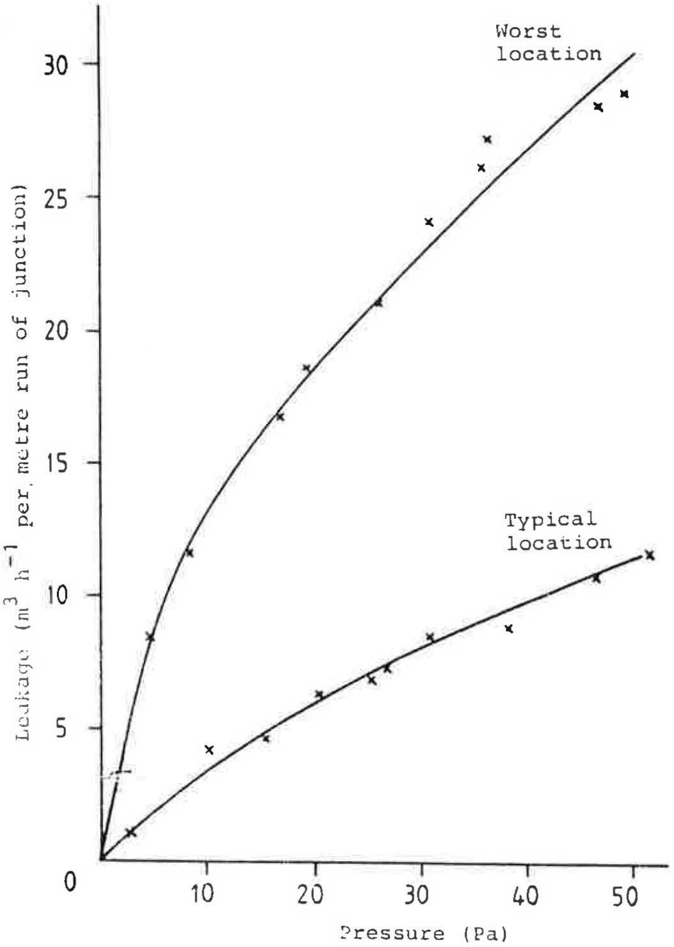

Figure 5 Air leakage versus pressure for 'real-life' ceiling/wall junction

3 Real-life building

As an indication of possible 'real-world' crack performance the results in Figure 5 illustrate the airtightness characteristics of a wall/ceiling junction in a recently built single-storey hospital. The building detail was the junction between a plastered wall and the metal angle section of a suspended ceiling. Gaps up to 3 mm wide were visible between wall and ceiling, which connected the conditioned space to an unconditioned, highly ventilated roof space. Two locations (one typical and one severe) were first identified as air leakage sites using thermography/whole-unit depressurisation and then measured using the airflow box. The section considered representative of the leaky junction had leakages at 50 and 5 pascals of 11.6 and 2.0 $m^3 h^{-1} m^{-1}$, while the more severe leakage site exhibited flow rates of 30.6 and 9.0 $m^3 h^{-1} m^{-1}$.

For a junction length of 30 m and room volume of 60 m^3, a leakage rate at 5 pascals of say an average of 5 $m^3 h^{-1}$ per metre run would result in an overall air change rate of 2.5 per hour, attributable solely to the junction. Even allowing for the fact that this was the most severe leakage junction in the building, it seems an excessive amount of ventilation through one junction. This partly explains why a whole-unit pressurisation test gave a complete air change rate of 5 ac h^{-1} at 5 pascals. This type of leakage can quite easily account for over 70% of the space heating energy loss, much of that figure being wasted.

4 Conclusion

The results of detection and measurement of air leakage of building details at individual locations are presented. These illustrate the air flows experienced in a few selected full-scale laboratory and real-world buildings. The limitations of thermography are such that air leakage cannot be quantified, while the limitations of airflow measurement are such that extensive sampling has to be undertaken to establish leakage sites. However, used in conjunction, thermography rapidly locates sites and airflow measurement time is reduced. This results in the identification of maximum leakages and their measurement in a practical time scale. The indications are that the design and construction of junctions is a major parameter to be considered when effective control of energy consumption and air quality within a building is to be achieved.

Acknowledgement

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References

1 Pettersson B and Axen B *Thermography: Testing of Thermal Insulation and Airtightness of Buildings* (Swedish Council for Building Research) (1980)
2 Siitonen V *Measurement of Local Airtightness* Nordtest project 176–79, Espoo (July 1982)
3 Hall T Getting it right on site *Building Trades J.* 20–21 (6 Dec 1984)
4 Dudek S J-M, Hardy A C, Valentine G and Wiltshire T J *Thermographic analysis of laboratory constructions—Junctions and air leakage paths* Internal report, Building Science Section, University of Newcastle upon Tyne
5 Baker P, Sharples S and Ward I Internal report, Building Science Department, University of Sheffield