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Technical Note

Summary A standard method for investigating the air leakiness of a building or component involves the use of fans to generate pressure differences across building cracks. It is often found that the air flow characteristics of such cracks vary depending upon whether the pressure differences are positive or negative with respect to a reference pressure. This note suggests one possible mechanism for explaining these flow differences, based on laboratory measurements using L-shaped cracks.

Air flow through asymmetric building cracks

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1 Introduction

In practice, the air leakage characteristics of a building or component measured by overpressurisation may differ from those determined by underpressurisation (see for example Fig. 1, after Ward and Sharples[1]). It is commonly held that such differences are due to leakage paths opening or closing due to pressure or suction, thereby increasing or decreasing the overall crack leakage area. Current work suggests that the asymmetric geometry of some cracks with respect to flow direction may explain significant changes in leakage characteristics with no change in leakage area.

2 Pressurisation of asymmetric cracks

Crack flow equations have been tested on a series of typical building cracks. The results suggest that the nondimensional equation proposed by Etheridge[2] describes flow through cracks of known geometry satisfactorily. This equation is of the form

$$\frac{1}{C_z^2} = B\frac{z}{d_h}\frac{1}{Re_y} + C$$

where C_z is the discharge coefficient, z is the distance through the crack, d_h is the hydraulic diameter, Re_y is the Reynolds number, and B and C are constants. This equation was found to describe the flow characteristics of most symmetrical crack types adequately, and was independent of the flow direction.

However, for a series of L-shaped asymmetric cracks having one right-angle bend, and fabricated with 'arms' of unequal length (20 and 50 mm), the flow characteristics departed from the above relationship and depended upon the direction of flow. Fig. 2 shows the relationship between Reynolds number and discharge coefficient for three such cracks.

Considering the 6 mm thickness crack, for the same Reynolds number, the discharge coefficient is lower when the short section forms the exit with respect to the flow direction compared with the corresponding value when the long section is the exit. Calculations based on the assumption that the bend acts as a boundary layer 'trip' indicate that the flow profile is not fully developed in the short section, so raising the hydraulic resistance of the crack. Conversely, when the long section forms the flow exit, it is hydrodynamically long enough to allow fully developed flow, thus increasing the discharge coefficient.

These observations apply to reasonably wide cracks. When the crack thickness is reduced to about 1 mm the effects of flow reversal become less significant since the short exit tends to become hydrodynamically long.

The flow versus pressure difference curves for the 6 mm thickness L-shaped crack (Fig. 3) show, for example, that under a pressure difference of 10 Pa the flow is 20% lower with the short arm as exit than with the flow reversed. Such a result, which simulates the leakage through a section of gap around a leaky casement window, illustrates that the asymmetry of leakage paths may be sufficient to cause the changes in measured leakage between under- and overpressurisation.

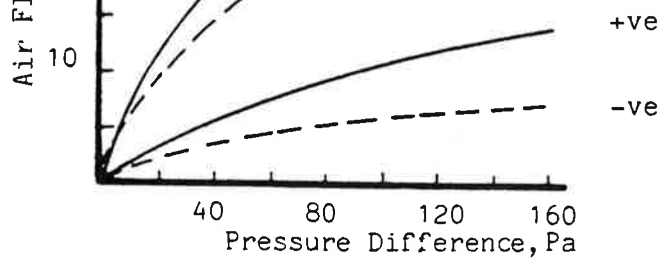

Fig. 1. Air leakage characteristics of a window before and after weather-stripping for positive and negative pressurisation (after Ward and Sharples[1]).

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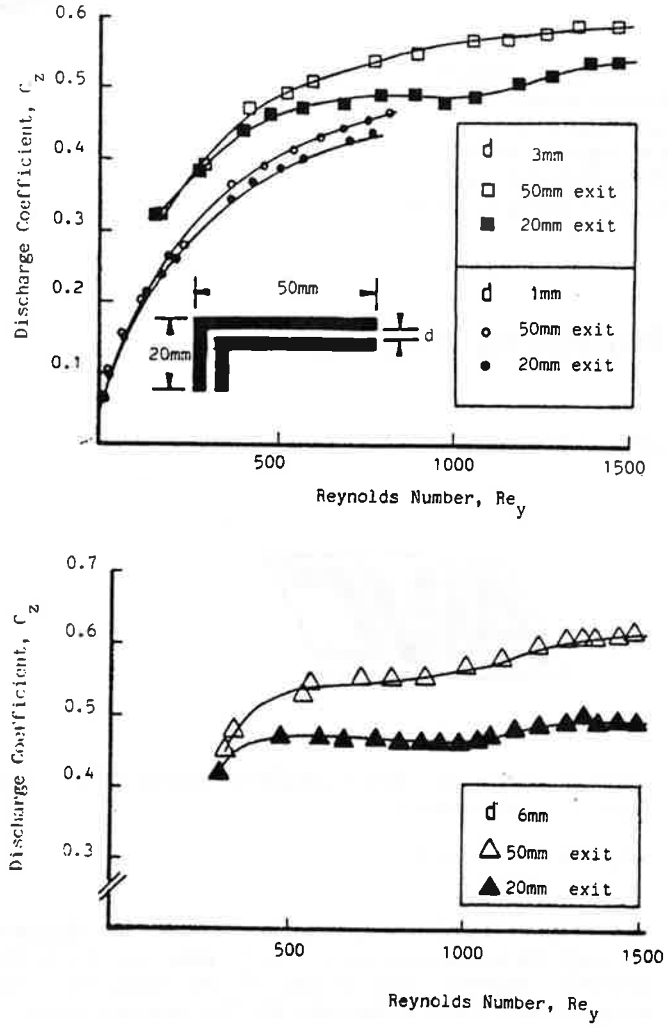

Fig. 2. Discharge coefficient—Reynolds number relationship for three asymmetric L-shaped cracks.

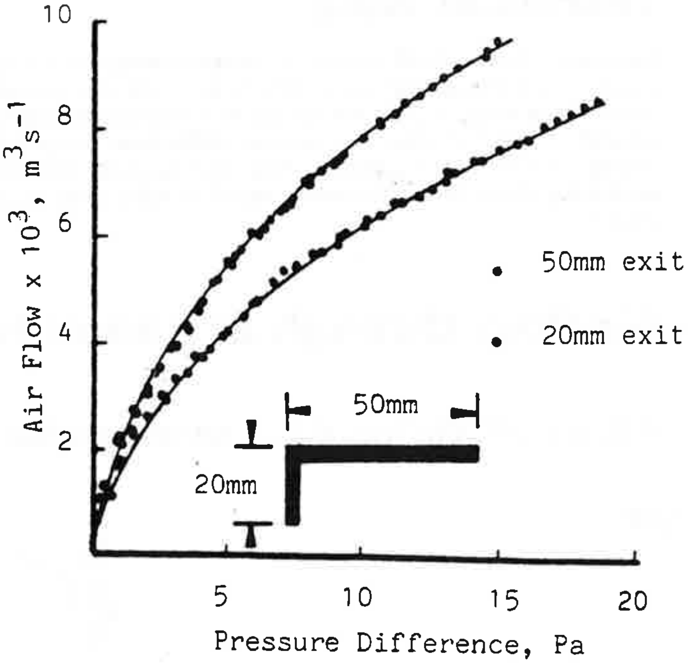

Fig. 3. Flow–pressure difference curves for the 6 mm thickness L-shaped crack, showing the effect of flow reversal.

Acknowledgement

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References

1 Ward, I. C. and Sharples, S., 'An investigation of the infiltration characteristics of windows and doors in a tall building using pressurisation techniques', Department of Building Science Report BS68, University of Sheffield (1982).

2 Etheridge, D. W., 'Crack flow equations and scale effect', Building and Environment, 12, pp 181–189 (1977).