building progress
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Diary

1979

Essen
27 Jan – 4 Feb. 1979
Building Exhibition and International Congress.

Philadelphia
29 January–1 February
International air conditioning, heating and refrigerating exhibition.

York
5–9 February
Short course on maintenance of historic buildings.

Brussels
9 – 18 Feb. 1079
International Building Materials and Accessories Exhibition – BATIBOUW.

Birmingham
19 – 25 Feb. 1979
Energy Show (Institute of Fuel)

Basle
20 – 25 Feb. 1979
Third Building Industries Exhibition – SWISSBAU.

Copenhagen
24 Feb. – 4 March 1979
Scandinavian Building Exhibition – Building for the Billions.

London (Cunard International Hotel)
13 – 15 March 1979
Tunnelling 79 – International Exhibition and Symposium.

London
21 – 23 March 1979
Conference on the Design and Construction of Piles (Institution of Civil Engineers)

Frankfurt
28 March – 1 April 1979
Tenth International Sanitation, Heating and Air Conditioning Exhibition – ISH.

Ventilation and Air Infiltration in Buildings

by Ian Cowan, IIRS

Introduction

Heat loss in dwellings due to exchange of air between inside and outside is known to be an important factor in determining energy expenditure for space heating. This factor becomes even more important for highly insulated houses, in which fabric losses are relatively low and heat loss by ventilation is therefore a large proportion of the total.

In the course of technical studies at IIRS on energy conservation options in housing it was found necessary to model air change in buildings in order to estimate closely the magnitude of the air change rates occurring under Irish conditions, for which only crude estimates have hitherto been used. The article describes briefly the approach used, and the results obtained by simple computer modelling.

One of the difficulties in studying energy expenditure is assigning values to the parameters which classify the built environment.

The structure itself is thermally characterised by parameters such as the U-values and the air infiltration factor. This infiltration is a very important factor in determining energy requirements of buildings, and becomes even more important in the light of fabric insulation, for, although infiltration may account for say 20% of the heat demand for an uninsulated building, fabric insulation can raise this up to 50% under typical conditions.

Modelling of Ventilated Spaces

The infiltration into a space will equal the exfiltration from it under steady conditions. It is usual to divide the air flow in cubic units per unit time by the volume of the space to obtain an air change rate (per unit time) for the space. The heat demand Q_v (in watts) accruing is given by

$$Q_v = 0.33\, NV \Delta T$$

where N is the number of air changes per hour, V is the spatial volume in m^3, ΔT is the temperature difference in degrees C between inside and outside, and 0.33 is a factor accounting for the heat capacity of air under normal conditions of temperature and pressure. Since the heat capacity of air is very small in comparison with that of building elements, the heat transfer can be taken as occurring instantaneously, so that steady-state conditions can be applied.

The problem is thus reduced to the determination of N. The value of N must not be too low, for it is essential to provide adequate fresh air; similarly, the risk of condensation occurring must be minimised. Typical values for non-domestic premises are given in the IHVE Guide. For domestic premises, the values can be quite variable. Tests done on a large sample of British houses have shown that most have average whole house air change rates of between 0.6 and 1.0 per hour with rather more at the lower end of this scale. Due to the fact that most of these houses were fairly well heated, these air change rates were generally high enough to prevent the incidence of condensation. Unfortunately, there are no comparable measurements for Irish housing. However, due to the absence of British regulations concerning the existence of wall ventilators, it was felt that the air change rates occurring in Irish houses were commonly substantially higher. This was found correct on calculation.

The infiltration into a zone is dependent on the number and size of the various openings – doors, windows, chimneys, ventilators, and other cracks which may fortuitously exist. The external conditions of wind and exposure have also to be known. Flow into the space arises due to a pressure difference. There are two major determinants of pressure difference, wind effect, and stack effect. The wind effect gives a dynamic pressure difference Δp_w:

$$\Delta p_w = C_p \cdot \tfrac{1}{2} \rho v^2$$

where Cp is a pressure coefficient, ρ is the air density, and v the wind velocity. The stack effect is due to buoyancy forces caused by difference in temperature between ends of a vertical air column such as exists in a chimney; here Δp_s, the stack pressure difference is

$$\Delta p_s = 3462\, h \left\{ \frac{1}{T_o} - \frac{1}{T} \right\}$$

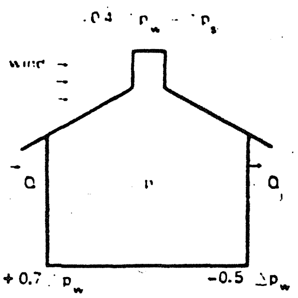
where h is the stack height in m, T_o and T are the respective outside and inside absolute temperatures in K, and Δp_s is given in Pa. Stack effect only becomes important in the case of tall buildings with, for example, lift shafts; in normal houses the wind effect predominates.

The flow of air through an opening can be obtained from the pressure difference across it by means of the equation:

$Q = \text{const.} \times (\Delta p)^n$

where n is a positive fraction.

The boundary conditions to the zone have first to be stated. In general, the pressure distribution around a building is dependent on the direction of the prevailing wind, the exposure of the building, and its plan and elevation characteristics. On average, if the wind pressure difference be Δp_w, one authority recommends that the pressure on the windward facade be taken as $+0.7\ \Delta p_w$ (over normal atmospheric pressure), on the leeward facade as $-0.5\ \Delta p_w$, and on the roof as $-0.4\ \Delta p_w$. A chimney opening on the roof will decrease this last by a further amount Δp_s as shown below.



Pressure Distribution around a building

If Q_i be a series of infiltrations, and Q_j a series of exfiltrations, then since the rate at which air enters and leaves the zone must be equal:

$$\Sigma_i Q_i - \Sigma_j Q_j = 0$$

This yields a non-linear equation in one unknown p_i, the internal pressure of the building. Solution can be conveniently effected by iteration – this has been done on a programmable calculator. Back-substitution yields the infiltration. If the building be divided into 2 zones a windward and a leeward zone – then 2 simultaneous non-linear equations result; substitution and iterative solution was still found possible on a programmable calculator, although the solution becomes rather complex. An even more generalised development based on a 4 zone model was formulated but the equations became very complex, and resort to another method, a modified Newton method and to a computer had to be made. The program – INFIL – together with its simpler 2 zone relative were used to test the effect of weather stripping internal doors which diminished the infiltration to leeward parts of the building when the windward side had very large openings and was hence subject to high ventilation rates. However, due to the low resistance of internal partitions, it was found that there was not a significant variation in internal pressure under normal conditions, and therefore, the 1 zone mode was used for extensive study.

Model Study of Typical Ventilation Conditions

Empirical values of the constants to be used for tightly-fitted windows and doors and for wall ventilators were obtained from published literature. Empirical values for more loosely-fitted components were calculated from first principles.

Typical meteorological wind speeds assumed are:

High 9.0 m/sec.
Average 5.5 m/sec.
Low 3.0 m/sec.

Tables (g) through (h) give results obtained for a number of parameter variations for typical Irish houses. These are also illustrated in the Figure. (Note: weather stripped: weather stripped windows and doors).

(a) Effects of Wind Speed – Loose Fit

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Low wind speed	–0.97	303	1.52
Avg. wind speed	–2.02	551	2.75
High wind speed	–4.06	9.6	4.58

(b) Effects of Wind Speed – Tight Fit

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Low wind speed	–1.31	253	1.27
Avg. wind speed	–2.99	454	2.27
High wind speed	–6.53	747	3.74

(c) Effects of Wind Speed – Weather Stripped

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Low wind speed	–1.66	214	1.07
Avg. wind speed	–4.04	376	1.88
High wind speed	–9.32	609	3.05

(d) Zero Wind Conditions

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Loose fit	–0.22	116	0.58
Tight fit	–0.30	115	0.57
Weather Stripped	–0.41	112	0.56

(e) Zero Stack Conditions (Average Wind)

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Loose fit	2.90	450	2.25
Tight fit	2.90	361	1.81
Weather Stripped	2.90	292	1.46

(f) No Wall Ventilators (Average Wind)

Conditions	P_i (N/m²)	Q (m³/hr)	(Volume = 200m³) N (per hour)
Loose fit	–5.79	250	1.25
Tight fit	–8.24	148	0.74
Weather Stripped	–12.49	44	0.22

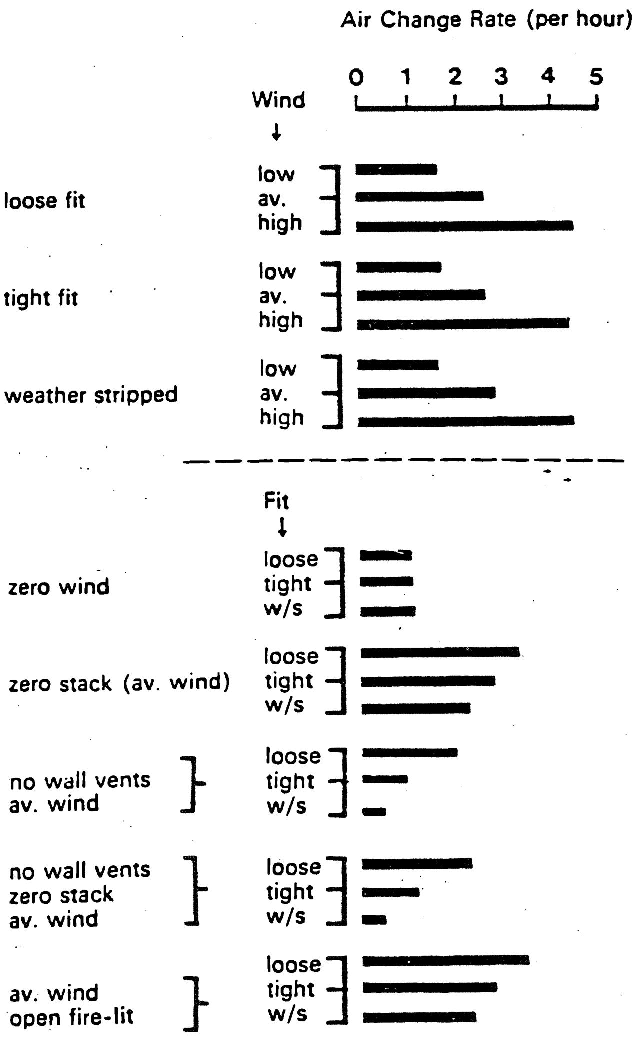
(g) No Wall Ventilators; Zero Stack Conditions (Average Wind)

Conditions	PI (N/m^2)	Q (m^3/hr)	(Volume = 200m^3) N (per hour)
Loose fit	2.90	177	0.89
Tight fit	2.90	88	0.44
Weather Stripped	2.90	19	0.10

(h) Average Wind Conditions – Open Fire Lit

Conditions	PI (N/m^2)	Q (m^3/hr)	(Volume = 200m^3) N (per hour)
Loose fit	–2.63	562	2.81
Tight fit	–3.73	464	2.32
Weather Stripped	–4.90	385	1.93

Typical Infiltration Rates for Dwellings



Conclusions

It can be seen that these can be significant changes in infiltration for changes in the parameter values which are subject to some uncertainty anyway. One of these parameters is, of course, the pattern of occupancy and the habits of the occupants. Since these are never known with exact certainty, the infiltration derived can only be approximate averages.

It appears that in general, air change rates existing in Irish housing are frequently excessive, and usually incompatible with an integrated energy conservation policy. The only times the air change rates approach the lower end of the desirable scale, or perhaps fall below, are under zero wind conditions and/or tests made with no wall ventilator openings and no flue. The existence of non-controllable ventilators often leads to the deliberate blocking of them by occupants who may feel discomfort under severe conditions; this is undesirable, as it may lead to very low air change rates under normal conditions, hence, significantly increasing the risk of condensation. It appears, therefore, that a more rational approach to ventilators is indicated, providing fresh air by controlled rather than fortuitous means, and consonant with energy conservation action.

New Irish Construction Directory

This new IIRS directory produced with the co-operation of the CIF will list manufacturers, contractors and service companies operating in the Irish construction industry.

If you want your company listed in this definitive reference please send in your completed questionnaire now.

If you have not yet received a questionnaire ring Miriam Breslin or Olive Brennan at 370101, Extension 340, or write to Technical Inf. Div., IIRS, Ballymun Road, Dublin 9.

Licensing Opportunity

An expansion joint for concrete floors made from Hostalit PVC is available for manufacture under license. The product is called 'Regle-Joint Toffolo' and the licensor is M.A. Toffolo, 64480 Ustaritz, France. It is covered by French Patent No. 2,292,907. It has the form of a hollow section tapering towards the top and having flanges at the bottom. The apex is reinforced so as to resist and support loads and facilitate levelling when laying the concrete. Services such as telephone or electric cables can be run through the hollow section. Further information can be obtained from the licensor at the above address or from the Commercial Counsellor, French Embassy, Dublin.

Abstracts

Standards News

New Irish Standards

IS 197: Part 2: 1977
Aluminium alloy windows. (This is based largely on BS 4873: 1972. It does not specify sectional sizes or details, other than a minimum web and wall thickness. Materials and constructional requirements are specified and performance requirements and tests are included.

IS 198: Part 1: 1977
Metal doorsets—dimensions.

Draft Irish Standards

S5C/4/5 Fabricated steel manhole covers and frames
S5C/41 Dimensions of modular rooflights.
S8C/89/A/1 Prestressed precast concrete lintels.
S5C/35P, 36P & 37P
Draft provisional standard specifications for metric modular dimensions of lintels and sills.

New British Standards and Codes

BS 952: Part 1: 1978
Specification for glass for glazing: Classification (Glasses for building purposes classified in three groups. Thickness normally available and cutting tolerances.)

BS 5493: 1977