Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

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AIVC

Introducing . . .

The Air Infiltration and Ventilation Centre

The Executive Committee of the IEA Programme of Research and Development on Energy Consumption in Building and Community Systems unanimously supported the proposal that the Air Infiltration Centre should in future be called the Air Infiltration and Ventilation Centre. This change of name reflects the Centre's growing role in providing technical support and specialist information on all energy and indoor air quality related aspects of building ventilation. This change heralds the commencement of a new three year programme concentrating on measurement techniques, numerical studies of air movement patterns and airborne moisture problems (see 'AIC Plans its Future', Air Infiltration Review, Vol. 6, No. 4, 1985).

The structure of the Centre's staff has also undergone change. Martin Liddament has been promoted to Head of the Centre with increased responsibilities for the technical programme and day-to-day management. Peter Charlesworth, recently appointed as an expert in measurement techniques, will concentrate initially on producing a Handbook of measurement methods. A new information specialist, with responsibility for expanding and improving AIVC's information and library service, is currently being recruited. Jenny Elmer continues as secretary while new recruit, Emma Young, provides clerical assistance to the information and administration services. Peter Jackman, the Centre's former Head, has reduced his commitment to AIVC activities but will continue to be involved technically as Programme Advisor. Steve Irving of Oscar Faber Consulting Engineers continues as Operating Agent.

Our new logo reflects the name change but has been designed so that the former identification as AIC can be easily recognised.

These changes streamline the Centre's structure and will enable it to provide even better technical and information services than those for which its high reputation has been gained.

Inside this issue:

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Air Infiltration Calc – An Applic

Martin W. Lidd

Air infiltration and ventilation has a profound influence on both the internal environment and on the energy needs of buildings. Inadequate attention to ventilation may result in an unacceptable indoor climate which, under extreme conditions, can be harmful to occupants. On the other hand, unnecessarily high air change rates will present an excessive burden on a building's heating (or cooling) system, resulting either in an unnecessary waste of energy or in the inability of the heating or air conditioning system to satisfy thermal requirements. Problems relating to moisture migration, cold draughts and a generally uncomfortable living or working environment may also be experienced. This subject has therefore become a key factor in both energy conservation and indoor air quality studies.

Air exchange in buildings occurs as a consequence of natural air infiltration and through the use of purpose provided ventilation. Although air infiltration suffers from many disadvantages, this process, coupled with the use of openable windows, vents and stacks, continues to play a dominant role in meeting the ventilation needs for many varieties of building and in a large number of countries. However, problems associated with widely varying air change rates, poor control and uncertain air distribution, have become important considerations in both modern building design and in the upgrading of existing buildings. Although purpose-provided mechanical ventilation systems can overcome these problems, the benefits provided by such methods may easily be destroyed by inadequate attention to the interaction of intentional ventilation with that caused by air infiltration. Thus a poorly implemented ventilation strategy, combined with an inappropriately designed building shell, may adversely affect both energy needs and indoor climate. Poor design may also be expected to affect the reactions of occupants, especially in relation to window opening behaviour.

Despite the importance of the process of air infiltration, it is still an aspect of building physics about which there is considerable uncertainty. In part, this problem has been made more difficult by the diverse range of buildings, each constructed according to widely varying specifications and site practices. In the past, progress has also been hampered by the inherent difficulty of actually making measurements which, in turn, has resulted in a wholly inadequate database for use in the development of predictive techniques. Furthermore, the complexities of the flow mechanisms themselves have added to the difficulty of quantifying infiltration rates. It is this lack of understanding which has frequently resulted in deficiencies in design. Often airtightness measurements are misunderstood and are applied without due consideration to ventilation needs or ventilation approach. The outcome may be reflected in moisture problems, severe contamination of the indoor air and possibly backdraughting from flues and exhaust vents. Clearly, good design will minimise the problem, yet without explicit guidance there is little that can be accomplished to improve design methods.

From the point of view of design, the principal task is to minimise energy consumption by reducing air infiltration while maintaining good indoor air quality. To achieve this design objective, it is necessary to provide guidance on the optimum conditions for either natural or mechanical ventilation, particularly in relation to the airtightness of the building shell and to climatic parameters. It is equally important to provide information on calculating the cost effectiveness of alternate ventilation strategies and to illustrate the importance of each approach in relation to minimising indoor air quality problems.

Recently, advances in both experimental techniques and mathematical modelling approaches have resulted in a considerable improvement in the undertstanding of air infiltration. The use of tracer gas as a direct measure of air infiltration and ventilation rates has been developed to the point where measurements are relatively straightforward to perform while, in some countries, the pressurisation test for measuring the airtightness and air leakage characteristics of the building shell is becoming routine and, in some instances, is mandatory. Furthermore, measurement methods that were once only suitable for small single family dwellings have now been adapted to suit the needs of large industrial and commercial buildings. Unfortunately, however, measurement methods suffer from a number of drawbacks. In particular, the tracer gas technique requires many discrete measurements to be made over an extended period of time to determine the long-term weather-dependent infiltration behaviour of a building. Also, measurement methods are of little direct value in the design process, since they can only be used to assess the performance of exisiting structures. However, by combining the results of many measurements, a general pattern of air change relationships emerges. Additionally, by using the data to verify the performance of numerical calculation techniques it has become possible to develop very powerful predictive methods. As a consequence, mathematical methods are now capable of playing a fundamental role in the design and evaluation of energy ventilation strategies. By combining the design air leakage and ventilation parameters of a building with local terrain and climatic data, mathematical models provide an alternative route to the estimation of air change rates.

The intention of the AIVC Applications Guide is to provide both researchers and designers with a detailed background to air infiltration modelling and to give step-by-step guidance on the application of modelling techniques in design. Particular emphasis is devoted to providing specific guidelines on the calculation of steady-state air infiltration and on air change rates in industrial, commercial and domestic buildings. Associated calculations include the determination of infiltration heating and cooling loads, air flow and internal pressure distribution, the prediction of pollutant concentrations in buildings and an analysis of cost effective ventilation strategies. In addition to providing these guidelines, the rationale behind each calculation technique is described in full.

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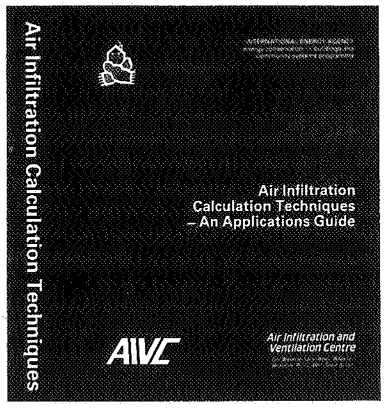
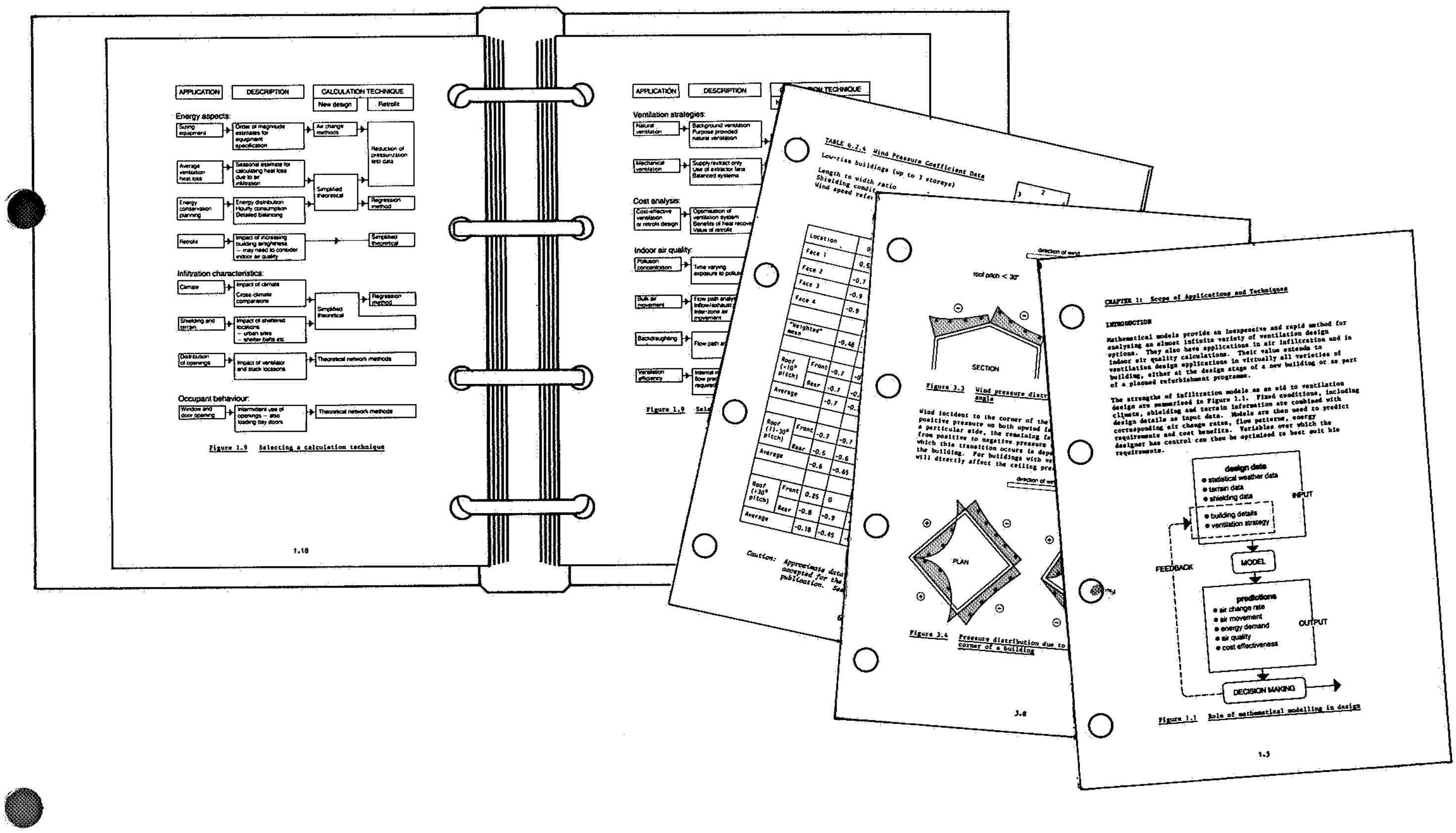
nent, Head of AIVC





The guide is presented in loose leaf format to enable fresh examples, country data and new concepts to be readily accommodated.

The Guide is presented in six chapters. Chapter one is a general introduction to the subject which outlines ventilation needs, strategies and options and then describes the essential components of air infiltration calculation techniques. Guidelines on the selection of an appropriate technique are presented.

Chapter two covers the empirical methods which may be used in the analysis of simple ventilation problems.

Chapter three deals with theory-based calculations, beginning with a formal description of air infiltration theory. This section sets out the fundamental concepts behind calculation techniques, since a clear understanding of these is essential in understanding the limitations of the various modelling methods. The numerical representation and the significance of the forces driving the process of air renewal is also described in detail.

Chapter four deals with subsidiary calculations using the air infiltration results obtained through either empirical or theoretical means. The calculations cover ventilation and air infiltration heat loss, heat recovery, cost-effectiveness and indoor air quality.

Chapter five is devoted to algorithms and worked examples/case studies. The algorithms outlined have been published in the literature and are freely available in the form of annotated computer listings. The worked examples are chosen to illustrate the various techniques available and the assumptions necessary to perform numerical calculations.

The final chapter is for reference. It covers climatic data, air leakage information and wind pressure coefficient data. This chapter also contains a glossary of the major terms used in the Guide.

Copies of the Guide are currently available (to organisations in participating countries only)*, free-of-charge, through your national Steering Group Representative (see back cover of this newsletter).

*Belgium, Canada, Denmark, Finland, Federal Republic of Germany, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom, United States of America.

The Validation of a Multiple Tracer Gas Technique for the Determination of Airflows Between Three Interconnected Cells

C Irwin and R E Edwards
Department of Building Engineering, UMIST, Manchester, UK.

Introduction

This paper describes the extension of the previously described UMIST technique for the determination of airflows between two interconnected cells to the case of three connected cells, and gives the results obtained for a series of validation experiments carried out under controlled conditions.

Sampling system

The tracer gas sampling and measurement system used is well documented, (for example references 1 and 2). Briefly, it consists of an Analytical Instruments Model 505 portable gas chromatograph, modified so as to be fitted with two chromatographic separation columns fitted in parallel. A system of sampling valves is used such that samples passing through each column can be passed alternately to the electron capture detector in the chromatograph. A more rapid sampling rate is attained by virtue of the fact that the 'dead time' associated with waiting for a sample to pass through a single column is eliminated.

The separation columns used are of stainless steel, being 3m in length, 6mm internal diameter, and with a column packing of 10% squalaine on a CNAW support. For two cell measurements, these columns are held at 30°C in a thermostatically controlled water bath/stirrer unit. Using Freon 12 (dichlorodifluoromethane) and Freon 114 (dichlorotetrafluoromethane) as tracer gases, a 30 second sampling interval is achieved. The third tracer gas used in this piece of work is B.C.F. (bromochlorodifluoromethane). If the water bath temperature is increased to 50°C, then a sampling interval of 45 seconds for three gases can be achieved, without loss of peak resolution.

Test procedure

The environmental chamber facility used in reference 1 was again used for this piece of validation work. To create a three-chamber arrangement, one of the chambers was partitioned by means of a PVC sheet. The volumes of the cells used are shown in Figure 1. Air movements between the three cells were induced by means of ducted low speed fans, in combination with the air supply system feeding the chambers. Air velocities in the supply ductwork were measured using a Pitot tube and inclined-tube manometer, whilst the air velocities between cells were measured using a hot wire anemometer probe. The tracer gases were injected remotely into all cells from cell 1, using PVC tubing.

Test results and analysis

Initially, a simple single chamber ventilation rate measurement was taken using all three tracer gases. This is now adopted as a standard check on performance of the separation columns and the detector/sampling system. Three series of measurements were then carried out, twelve tests in all.

Typical results of the multi-chamber airflows measured are shown diagrammatically in Figures 1 to 3 inclusive where the measured airflow rates (m^3/hr) are in brackets.

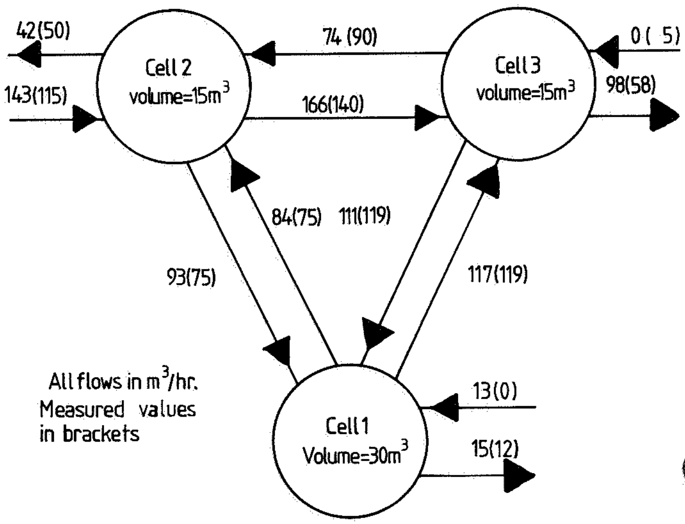


Figure 1. Comparison of measured and calculated airflows (typical of series 1)

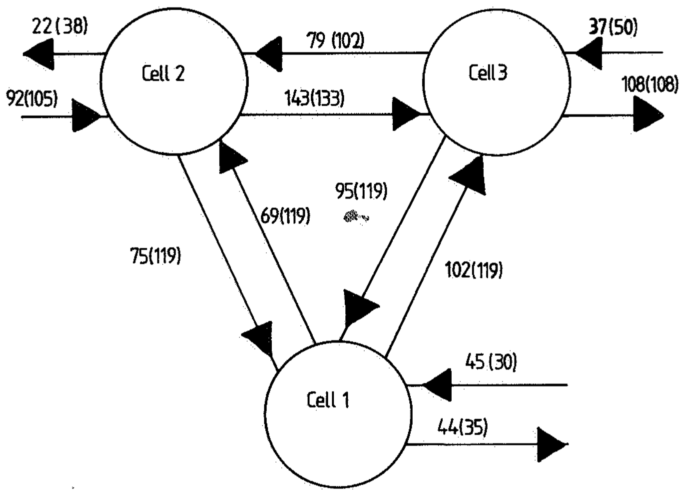


Figure 2. Comparison of calculated and measured airflows (typical of series 2)

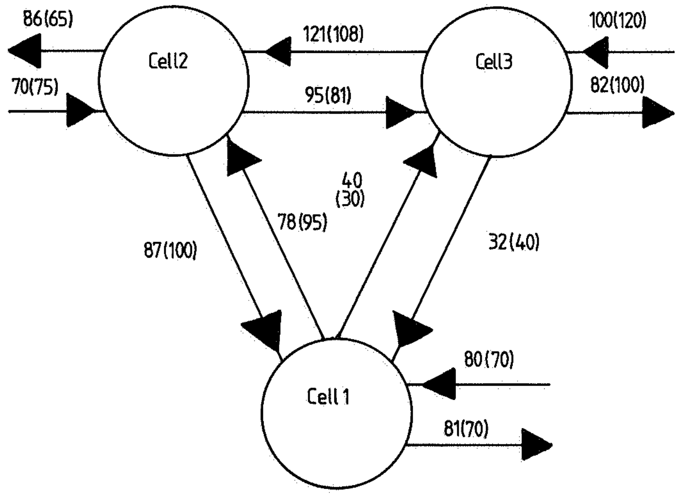


Figure 3. Comparison of calculated and measured airflows (typical of series 3)

The errors found between calculated airflow rates and measured airflow rates are approximately ± 20%, the effect of these errors on chamber air change rates being about ± 10%. Figure 4 shows the variation of tracer gas concentration with time for chamber 3 during a multiple tracer gas test. It is worth noting that the high air change rates occurring in all chambers cause rapid changes of tracer gas concentration with time; all three tracer gases tending to equilibrium in twelve minutes.

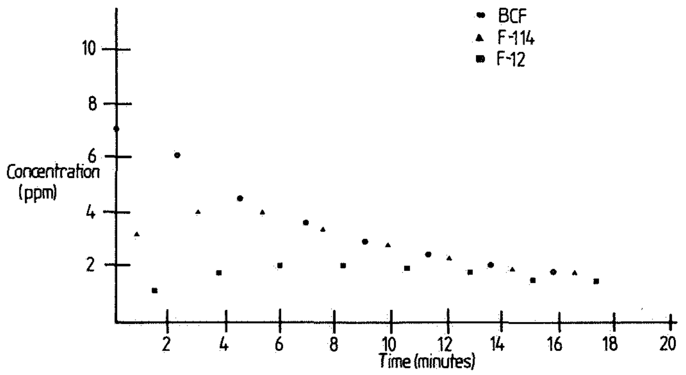


Figure 4. Changes in tracer gas concentrations in cell 3.

Discussion

The magnitude of the chamber connecting airflows was large with respect to the chamber volumes. This encouraged recirculation of tracer gas between connected chambers.

Where two-directional air movement occurs between connected spaces, the shape of the tracer decay curve in the source room will not be a simple exponential function. Defining the shape of the tracer gas concentration/time variations as the sum of two or more exponential functions enables calculation of the cell air change rates and intercell air movements[3].

This 3 cell validation work of the UMIST multiple tracer gas system shows that sufficiently accurate estimations of airflows can be obtained using this method over a period of about 20 minutes.

Acknowledgements

The authors thank Dr A T Howarth and Mr Alan Taylor-Firth of the Department of Building, Sheffield City Polytechnic for their kind co-operation in making available the environmental chambers.

References

1. C Irwin, R E Edwards and A T Howarth. An improved multiple tracer gas technique for the calculation of air movement in buildings. AIC Review, Vol. 5, No. 2, pp. 4-5, 1984.

2. C Irwin, R E Edwards and A T Howarth. The measurement of airflows using a rapid response multiple tracer gas technique. Building Services Engineering Research and Technology, Vol. 6, No. 4, pp. 146-152, 1985.

3. C Irwin. A method of measuring air movements in compartmentalised buildings. PhD Thesis, UMIST, June 1985.

The New Staff at the AIVC

Dr Peter Charlesworth joined the staff of the Air Infiltration and Ventilation Centre on 1 June 1986. He graduated in physics at the University of Lancaster in 1982 and went on to obtain his PhD from the University of Sheffield where he studied convective heat transfer from flat-plate solar collectors. Until taking up the position of Scientist with the AIVC he was involved in research work at Sheffield City Polytechnic, dealing with the development of a tracer gas technique to measure multi-zone air movement in buildings.

Peter is currently working on a guide to techniques for the measurement of air infiltration and air leakage. He is also involved in the collection and analysis of the replies to the AIVC's 1986 survey 'Current reseach into air infiltration and related air quality problems in buildings'.

Emma Young joined the Air Infiltration and Ventilation Centre in May as a school leaver from Easthampstead Park Comprehensive School in Bracknell. She acts as a general assistant to all members of the Centre Staff, with particular responsibility for information and administration services.

Determination of Leakages in the Building Envelope Using Pressurization Test Measurements

Lars Jensen
Lund Institute of Technology, Sweden

Introduction

There are several methods by which the airtightness of a building can be measured. One method involves the use of a fan to pressurize or depressurize the building. This creates a known pressure difference across the building envelope. The corresponding air flow through the fan is measured and this is an indication of the airtightness of the building. This air flow rate can be expressed as the number of building air changes per hour, a useful unit when comparing buildings of different volumes.

The air flow rate could also be given in m^3/h per m^2 of the surface area of the building. However, this simple type of test does not indicate where the air leakage paths are located or if the leakages are laminar or turbulent.

A development of this method, which enables the position and type of leak to be evaluated, requires several pairs of pressure difference and air flow measurements to be made. One important condition, for this type of test, is that there should be a temperature difference between the inside and outside of the building. This in turn produces a pressure difference across the building envelope which varies with height. A second condition is that the wind speed around the building should be close to zero, thus avoiding undesirable wind pressures.

So far only simple methods have been employed to analyse this condition. However, it is possible to use a more strict scientific approach based on mathematical models and known parameter identification methods. These techniques are described in this article.

Measurements

The test is performed by making a number of discrete pairs of measurements of the net leakage air flow (flow out of the building is taken as positive), and reference pressure difference (inside overpressure taken as positive). Alternatively a continuous measurement of the same variables can be transformed into discrete measurement pairs. The measurement pairs will be denoted (y_i, p_i) (i = 1,m), and the whole measurement denoted by the flow vector, y, and the pressure vector, p.

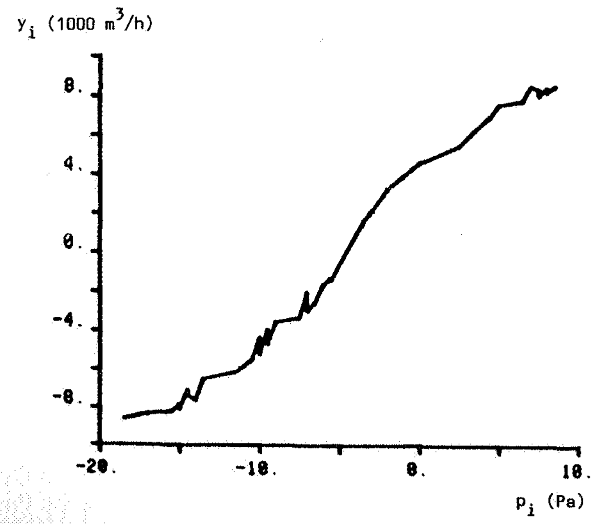


Figure 1. Net leakage flow out of the building y_i (1,000 m^3/h) as a function of pressure difference p_i (Pa).

An example of discrete measurements with 45 samples is shown in Figure 1. The building is a sports hall with a height of 16m. The indoor and outdoor air temperatures were 18°C and −2°C respectively. This gives a pressure difference gradient of 0.9 Pa/m. The measurements were performed and made available by Sune Häggbom of Tyréns.

Mathematical Models

The mathematical model describes the air flow through a given leakage structure as a function of its own parameters, the reference pressure difference, p_i, and the pressure difference gradient, g. The leakage model parameters are leakage area, vertical position and function type. The area can be concentrated at a single point or distributed along the building height. The leakage width can, in the latter case, be constant forming a rectangle or vary linearly with vertical position forming a symmetric triangle.

The flow through a concentrated leakage number, j, during measurement number, i, can be given by

$$q_{ij} = a_j \, \mathrm{sign}(p_{ij})(\mathrm{abs}[p_{ij}])^{c_j} \quad (1)$$
$$p_{ij} = p_i + gz_j \quad (2)$$

where q_{ij} = leakage flow
p_{ij} = pressure difference
a_j = leakage area
c_j = leakage function type
z_j = leakage vertical position
g = pressure difference gradient
p_i = reference pressure difference

The total net leakage flow composed of n leakages can, for a given measurement, i out of m, be written as

$$q_i = \sum_{j=1}^{n} q_{ij} \qquad (i = 1,m) \quad (3)$$

All the model parameters a_j, c_j and z_j can be arranged in a vector, x. The total model flows can also be given in vector form q (x, p) as a function of the parameter vector, x, and the pressure difference vector, p.

General Parameter Identification

It is required that a vector, x, be found to minimize the loss function V(x) which describes how well the model fits the measurements. A common loss function is the sum of the squared model error given by

$$V(x) = e^T e \quad (4)$$

and

$$y = q(x,p) + e \quad (5)$$

where e = model error vector

A method to determine a solution is to start from an initial guess of $x = x_s$. The equations in (5) are linearized with respect to x, for $x = x_s$ and e = 0, giving

$$y = q(x_s,p) + F(x_s,p)\,(x - x_s) \quad (6)$$

$F(x_s,p)$ is a derivative matrix where element from row i and column k is given by

$$F_{ik} = \frac{d\, q(x_s,p_i)}{dx_k} \quad (7)$$

which means the derivative of the model flow for the measurement number, i, with respect to the model parameter, x_k.

The solution, x, or the change, $dx = x - x_s$, can be calculated with the QR-method which minimizes the equation errors in (6) if $m > n$ (over determined problem).

The calculated change is used to make a linear search that minimizes the non-linear loss function, V(x), which means

$$\min_s V(x_s + s + dx) \quad (8)$$

The estimation of the parameter vector, x, is now updated as

$$x = x_s + s_{min}dx \quad (9)$$

All computational steps are then repeated until the solution converges.

It should be pointed out that there can exist several minima to the type of non-linear problem stated above. The problem is also badly conditioned because the different leakage functions are not orthogonal to one another. The method has been tested on simulated data for up to three separate leakages, each with four parameters. The convergence was slow.

Another problem is that all the model parameters are bounded and naturally positive. Poor measurements could lead to impossible model parameters occurring, eg negative leakage areas.

The large number of model parameters also presents a difficulty.

A single rectangular leakage with both three and four parameters has been identified from the measurements presented in Figure 1. The model parameters and the mean absolute error are shown in Table 1.

Table 1

Model	a area (m^3/h)	b width (m)	z position (m)	c type (–)	mean abs error (m^3/h)
G3	2377.	11.605	5.426	(0.500)	411
G4	1426.	2.190	5.730	0.712	393

Limited Parameter Identification

A method by which the number of parameters can be limited is to distribute the leakages evenly at fixed positions, and to have a fixed function type and leakage width. The leakage width is chosen to be equal to the leakage interval for rectangular leakages and twice the leakage interval for triangular leakages.

The leakage areas are the only free parameters. This turns the problem into one of linear identification where the model flow function can be written as follows:

$$q_i = \sum_{j=1}^{n} a_j f_j(V,p_i) \quad (10)$$

where f_j = known function
V = known model parameters

The method of least squares could be used, but the model parameters, a_j ($j = 1,n$), could then become both negative and positive.

A minimization method which works only with non-negative parameters is the well known linear programming (LP) method. This can be stated as follows:

$$\min_{x \geq 0} V(x) = d^T x \quad (11)$$

when x fulfills

$$Ax = y \quad (12)$$

where A is a given matrix and y and d are given vectors and x is an independent vector.

For each measurement, i, the following linear equation is set up to suit the LP method

$$y_i = \sum_{j=1}^{n} a_j f_j(v,p_i) + pe_i - ne_i \qquad (i = 1,m) \quad (13)$$

where pe_i and ne_i are positive and negative model errors respectively. One of them is always zero. The loss function in this case becomes equal to the sum of the absolute model error

$$V(x) = \sum_{j=1}^{m} (pe_i + ne_i) \quad (14)$$

The independent parameter vector, x, is composed of the area vector, a, the positive model error vector, pe, and the negative model error vector, ne.

This method has been tested on 25 simulated leakages and 50 measurements with good results.

The leakage profile has been determined for the sports hall, mentioned earlier, with 5, 10 and 20 leakages within the vertical interval (0,20)m and a fourth control case with 30 leakages within (–5,25)m. The leakage patterns have also been produced with combined concentrated and distributed leakages, both rectangular and triangular. The mean absolute errors are given in Table 2 and the leakage profiles are shown in Figure 2. The point leakage profile is drawn with a width of half the leakage position interval.

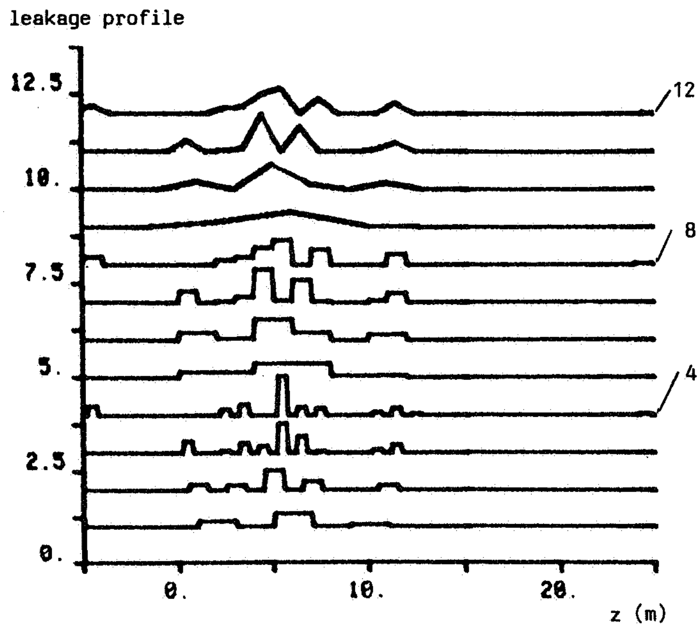


Figure 2. Twelve leakage profiled as a function of vertical position z (m) and with an offset equal to the profile number in Table 2. Point leakages number 1–4 are drawn with a width half the position interval.

Table 2

Model	Number of leakages	Mean abs error, m³/h		
		Point	Rectangular	Triangular
S5	5	277 (1)	253 (5)	253 (9)
S10	10	220 (2)	224 (6)	224 (10)
S20	20	218 (3)	215 (7)	215 (11)
S30	30	198 (4)	196 (8)	198 (12)

Numbers within brackets indicate leakage profile number in Figure 2.

It can be seen from Figure 2 that the three geometric leakage functions give about the same leakage profile for the same number of parameters. Only minor changes occur in the profiles when the number of parameters is increased. At the same time, the mean absolute error decreases. The control case S30 indicates that only two minor leakages occur outside the building.

This simplified method gives a model error that is approximately half of that given by the general method (compare the results shown in Figures 1 and 2).

The modelled net leakage flow, q_i, and the model error, e_i, are shown in Figure 3 for model S20 with triangular leakages (profile number 11 in Table 2 and Figure 2).

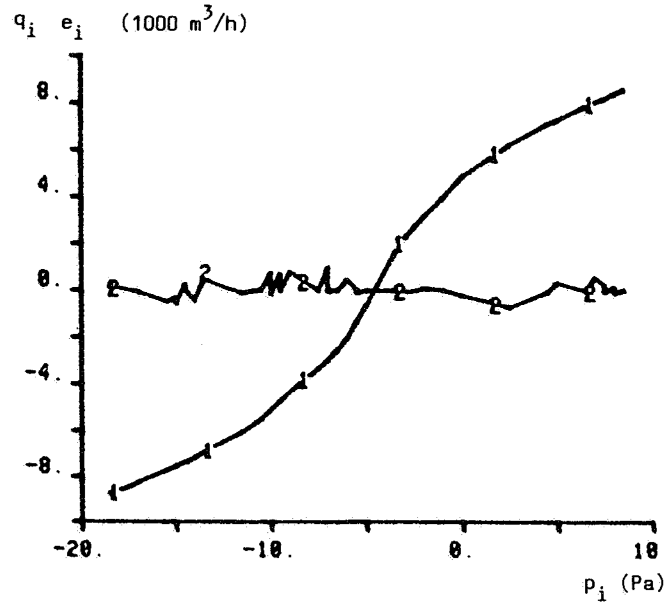


Figure 3. Modelled net leakage flow out of the building $q_i(1)$ and model error $e_i(2)$ (1,000 m_3/h) as a function of pressure difference p_i (Pa) for model S20 with triangular leakages (profile number 11 in Table 2).

Conclusions – Summary

The work presented here represents only a short study and is not part of any research project. The aim of this study has been to assess the possibilities of using different mathematical models and different known parameter identification methods to describe and determine leakages in the building envelope.

Models can always be fitted to measurements, but the results should always be tested with care. So far only two measurement cases have been studied. The better one was used as an example.

Several more suitable measurements have to be studied in order to determine whether the method is useful. The number of measurements must be at least twice the number of parameters. In the cases examined the zero pressure difference plane was outside the building envelope. This means that all the leakages were either under overpressure or underpressure for any given measurement sample. Some measurements which have the zero pressure difference plane within the building should also be made. The resolution in leakage position is crudely given by the resolution of the zero pressure difference position.

The methods should also be tested using data obtained in the laboratory from experiments with known leakages.

Both theoretical and numerical aspects of the studies should be examined further. It is important to note that laminar leakages can only be determined in terms of their total area and the centre of that area. This means that all *laminar* leakages cannot be determined in detail. Only *non-linear* leakages can be determined.

One model condition is that the function type of a leakage remains constant. In reality a leakage might be laminar at low pressure differences and turbulent at high pressure differences. In these cases it has been shown that it is possible to describe such a concentrated leakage in terms of a distributed turbulent leakage.

Another model condition is that the leakage function is an odd symmetric function with respect to the pressure difference. A leakage might, in reality, change. This can be modelled by using one leakage profile for positive pressure differences and a second leakage profile for negative pressure differences.

Reference

Jensen, L., 1985, Determination of leakages in buildings with measurements from pressurization test. Department of Building Science, Lund Institute of Technology. Internal report 1985:5 (in Swedish).

Air Infiltration Review

Air Infiltration Review has a quarterly circulation approaching 3,500 copies and is currently distributed to organisations in 34 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration are welcome for possible inclusion in AIR. Articles intended for publication must be written in English and should not exceed 1000 words in length. They should also contain two or three diagrams or photographs highlighting the main theme of the text. If you wish to submit a contribution, please contact Jenny Elmer at the Air Infiltration and Ventilation Centre for further details.

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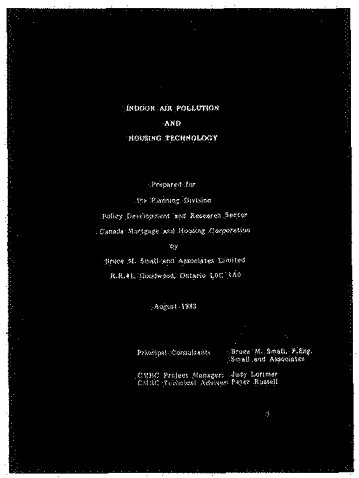
Book Reviews

Indoor air pollution and housing technology

Prepared for the Planning Division, Policy Development and Research Sector, Canada Mortgage and Housing Corporation, by Bruce M Small and Associates Limited. Principal Consultant: Bruce M Small.

The objectives of this study were a) to review the scientific literature relating to residential indoor air pollution and to low-pollution design and construction, b) to comment on the significance of indoor air pollution problems in Canada, and c) to make recommendations for further research and application of low-pollution housing techniques in Canada.

Part 1 contains succinct summaries of the known sources, concentrations, incidence, and effects of all the major known pollutants, as reported in the literature. The relevant Standards are also cited where applicable. Factors aggravating and reducing indoor air pollution are also covered, including ventilation and infiltration, indoor humidity and temperature, building materials, combustion processes, and building design and maintenance. Specific solutions for achieving a reduction in contaminant levels, such as air filtration, ventilation of specific sources and warning devices and controls, lead on to a summary table of the options available. The book therefore serves as a handy quick reference guide to the state of knowledge on contaminants in the indoor environment. There are over thirty pages of bibliographic references, four pages of recent conferences on the subject and excellent indexes to authors and subjects.



Part 2 deals with low pollution design and construction. Bruce Small has undertaken the building of a 560 m^2 experimental building in Ontario, Canada, known as the Sunnyhill Low-Pollution Research Centre. This building has been designed for the lowest possible indoor air pollution. The principles and construction techniques employed are described in detail and their applicability to conventional housing in Canada is also discussed.

While the extreme chemical susceptibility of the author limits the general applicability of the totality of his house design and construction methods, he does provide a comprehensive list of feasible methods of avoiding the various sources of indoor air pollution, some of which could be of more widespread application and which could provide a useful basis for investigating the causes of pollution in existing homes. The need for constant surveillance during the construction process is stressed. Ways in which energy conservation measures can be introduced without bringing on major indoor air quality problems are also discussed.

The final part of the book is devoted to the author's recommendations for future research and policy on indoor air pollution in housing in Canada.

Available from: Technology and Health Foundation R.R.#1, Goodwood, Ontario, Canada, LOC 1AO.

Price per copy: $20 CAN including postage, $22 US in USA, other countries $22 CAN by international money order.

Indoor air and human health

Eds. R.B. Gammage and S.V. Kaye
Tech. Ed. V.A. Jacobs
Oak Ridge National Laboratory, Tennessee, USA.

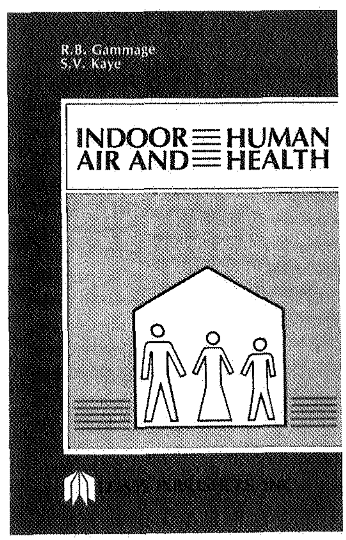
This is the published proceedings of the 7th Life Sciences Symposium held in Knoxville, Tennessee, USA on 29–31 October 1984. This annual series of symposia focusses on subjects of particular interest to the US Department of Energy, the scientific community and the public. The subject of indoor air quality has been growing in popularity over the past few years as a theme for conferences, but this conference focussed more specifically on the health implications.

Five principal classes of pollutant were considered for their health effects on humans and animals:

- radon
- micro-organisms
- passive cigarette smoke
- combustion products
- organics

The history of concern about indoor air quality is traced from the days when the focus of interest was on the outdoor air through the gradually increasing awareness of the role that the indoor air also played, to the time from the energy crisis of 1973–74 when the increased airtightness of buildings brought the problem to the fore.

The emphasis of the conference was on the actual current exposure of the population to the various pollutants and how these had been measured or modelled, source characterisation and risk analysis.



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Forthcoming Conferences

1. CIBSE/ASHRAE 1986 Conference
   Dublin, Republic of Ireland
   14–17 September 1986

   Topics:

   – *Building design construction and management*
   – *Equipment advances*
   – *Case studies*

2. Advanced Building Technology
   10th CIB Congress
   Washington DC, USA
   21–26 September 1986

   Noël J. Raufaste
   Director CIB.86
   Center for Building Technology
   National Bureau of Standards
   Gaithersburg
   MD 20899
   USA

3. 7th AIC Conference
   Occupant interaction with ventilation systems
   Stratford-upon-Avon, England
   29 September – 2 October 1986

   Further details from:

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   Old Bracknell Lane West
   Bracknell
   Berkshire
   RG12 4AH
   Great Britain
   Tel: +44 344 53123
   Telex: 828488 BSRIAC G

4. 2nd International Conference
   'System simulation in buildings'
   Chateau de Colonster, University of Liege, Belgium
   1–3 December 1986

   Further information from:

   J. Lebrun
   Thermodynamics and Building Physics Laboratories
   University of Liege
   Avenue des Tilleuls 15 – Bat. D1
   B-4000 Liege
   Belgium
   Tel: (041) 52 01 80 Ext. 367/416

5. Symposium
   'Guidelines for air infiltration, ventilation and moisture transfer'
   Worthington Hotel, Fort Worth, Texas, USA
   2–4 December 1986

   Further information from:

   Building Thermal Envelope Co-ordinating Council
   1015 15th Street NW
   Suite 700
   Washington DC 20005
   USA

6. ASTM Symposium
   Design and Protocol for Monitoring Indoor Air Quality
   Cincinnati, Ohio, USA
   Week of 26 April 1987

   Further details from:

   ASTM
   1916 Race Street
   Philadelphia
   PA 19103
   USA

7. Roomvent -87
   Air Distribution in Ventilated Spaces
   International Conference at the Royal Institute of Technology, Stockholm, Sweden
   10–12 June 1987

   Call for papers:

   Abstracts (in English, maximum 200 words) on the following topics should be submitted to the address below no later than 30 September 1986:

   – *Measurement of air movement and measurement equipment*
   – *Measurements of ventilation and air exchange efficiency and local flow rates of air*
   – *New measuring and visualisation techniques (e.g. image processing)*
   – *Methods for predicting air movement*
   – *Case studies*
   – *Methods for testing the performance of air terminal devices*
   – *New trends in room ventilation technology, ventilation in the future*

   Further information from:

   Roomvent -87
   GLSM
   Box 5506
   S-114 85 Stockholm
   Sweden

8. Indoor Air '87
   Berlin (West), Germany
   17-21 August 1987

   Further information from:

   Conference Secretariat
   Indoor Air '87
   c/o CPO Hanser Service GmbH
   Schaumburgalee 12
   D–1000 Berlin 19
   Federal Republic of Germany
   Tel: (030) 305 31 31
   Telex: 186 11 cpo d

9. ICBEM '87
   Third International Congress on Building Energy Management
   Lausanne, Switzerland
   28 September – 2 October 1987

   Further information from:

   ICBEM '87 Secretariat
   p.a. Prof. Andre P. Faist
   EPFL – LESO Building
   CH 1015 Lausanne
   Switzerland
   Tel: 021 47 11 11
   Telex: 24478

3rd fold (insert in Flap A)

1st fold

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