Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol. 12, No. 3, June 1991

A Preliminary Comparison of Calculated Building Ventilation Rates Using Six Different Pressure Coefficient Datasets

James Piggins, Project Scientist, Air Infiltration and Ventilation Centre

Numerical Database

As part of the Air Infiltration & Ventilation Centre's Numerical Database development programme, Wind Pressure Coefficient data are being collected from many published sources, much of which will contribute to the Centre's own Pressure Coefficient database.

To ensure the compatibility and validity of the various datasets, a preliminary comparison has been carried out of the data in use. The work has concentratated on an analysis of the effects of Cp values, for vertical walls, on calculated wind driven infiltration and ventilation rates. The intention is to demonstrate the reproducability of results for similar datasets, and to produce some guidelines for their use.

Ventilation results have been compared using a simulation of a single zone building. Since most comparable data is published for vertical surfaces, this preliminary analysis is concerned with comparing the performance of such data on the prediction of ventilation rates for a structure having leakage paths in four vertical walls only. This comparison is based on wind tunnel datasets for twenty three broadly similar building types, taken from pressure coefficient data from six different sources.

Building Simulation

The building has been chosen to be typical in volume and leakage distribution (Figure 1). It is six metres wide, eight metres long, and six metres high. It thus has a volume of two hundred and eighty-eight cubic metres. Leakage equivalent to 3 air changes per hour at 50 Pa is evenly distributed on the facades, excluding the roof. Added to this is one purpose provided opening of 0.004 square metres, in each of the rooms.

In this issue

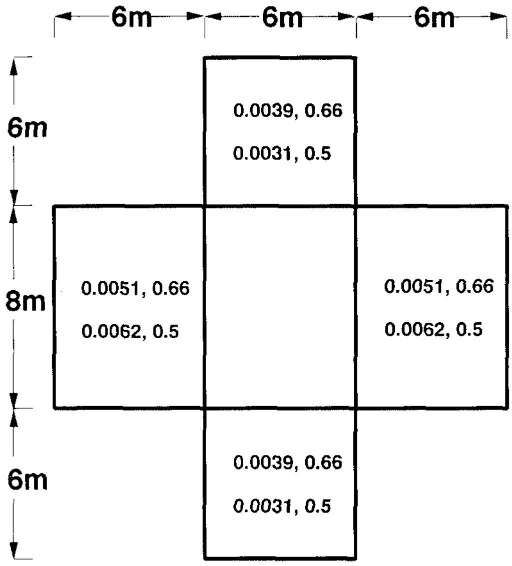


Figure 1. Building Dimensions and Leakage Distribution

The building has been modelled using the AIVC AIDA *single zone algorithm* (1), implemented in the dBASE IV language. The simulations have been carried out assuming a zero temperature difference between the building and its surroundings, thus enabling an analysis of wind effects only. All simulations have been carried out for wind incident at 0 to the longest face of the building.

Pressure Coefficient Data Sources

The available data sources mostly contained pressure coefficients datasets for several different building shapes and situations, each for a number of different wind directions. The pressure coefficients used were all expressed using a reference pressure taken at building height. The most appropriate building type/s were chosen from each source, corresponding to the building to be modelled. For an initial comparison data were taken for an isolated building. Datasets from two sources (BRE (2) & Wiren (3)), were then used for a comparison of the effects of differing surrounding building densities. In both of these cases, the surrounding buildings are assumed to be of the same height as the building being modelled.

The datasets used were from the following sources:

The BRE Pressure Coefficient Database (2):

> This soon to be published database, includes datasets from scale representations of two storey detached dwellings, terraced dwellings, and industrial buildings. For the detached dwellings, a number of roof pitches and surrounding building densities, for two different spacing arrangements, have been considered. Surface average pressure coefficients from this database will be included in the AIVC Numerical database.

The National Swedish Institute for Building Research data produced by Wiren (3):

> This data was produced using wind tunnel scale models of 11/2 storey detached houses with a roof pitch of 45 degrees and various surrounding building densities. It is included as part of the CPBANK 2.0 wind pressure coefficient database package from the Hungarian Institute for Building Science.

CPBANK 1.1 (4):

> This is an early version of a wind pressure coefficient database from the Hungarian Institute for Building Science, a copy of which has been purchased by the AIVC. This database includes a handling program which allows for the automatic selection of data via interactive graphical and menu screens. Three terrain types, are included, open, suburban and urban, and three types of shielding, these being unshielded, shielded to half the building height and shielded to building height. All shielding is placed two building heights away. The data is mainly representitive of larger buildings such as tower blocks and medium to large industrial buildings. Some simple block shaped

Air Infiltration Review

Editor: Janet Blacknell

Air Infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations in 40 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration and ventilation are welcome for possible inclusion in AIR. Articles intended for publication must be written in English and should not exceed 1,000 words in length. If you wish to contribute to AIR, please contact the Air Infiltration and Ventilation Centre.

Conclusions and opinions expressed in contributions to Air Infiltration Review represent the author(s)' own views and not necessarily those of the Air Infiltration and Ventilation Centre.

smaller industrial buildings are also included, which have been used for this comparison.

Averaged pressure coefficients for rectangular buildings reported by Akins et. al. (5):

Two of these datasets have been used in this analysis, those for buildings of aspect ratios 1:1 and 1:2, these being the closest to the building being modelled

Gandemer (6):

This data includes: Wind tunnel measured pressure coefficients for cube, tall block and dwelling shaped buildings for isolated and built-up surroundings. The dwelling shaped buildings have 22 pitched roofs, while the cube and tall block buildings are flat roofed.

Bowen (7):

A comprehensive set of pressure coefficients for flat roofed, block type buildings of varying heights in an urban terrain. The highest of these buildings has been taken as an example of an isolated building for the purposes of this analysis.

Simulations & Analysis

The initial analysis involved comparing similar buildings from all the available sources for isolated structures (Table 1) with various upstream terrain roughness conditions (Table 2). Buildings with length to width ratios between 1:1 and 2:1 were chosen, since they most represent the building to be simulated. Some of the selected buildings were of the block or cuboid type with flat roofs, while the remainder were of the dwelling type with pitched roofs. It was for this reason that no leakage was ascribed to the roof of the building to be simulated. Where available, a number of buildings were used from each source (Table 3). For example, five buildings from the BRE database met the criteria, their only difference being differing roof pitches of between 10 and 40.

SOURCE	L/W Ratio	L/H Ratio	Roof Pitch
BRE	1.3	1.2-2.0	10-40 Deg
Wiren	1.5	1.73	45 Deg
Akins	1.0-2.0	0.25-2.0	0 Deg
Gandemer	1.0-1.6	1.35-1.5	0-22.5 Deg
Bowen	1.5	0.5	0 Deg
CPBANK	1.0-2	1.0-4.0	0 Deg

Simulated Building: L/W = 1.3 L/H = 1.3

Table 1: Isolated Buildings L/W, L/H Ratios, Roof Pitches from each source

SOURCE	Terrain	p
BRE	Suburban	0.29
Wiren	Open	0.14
Akins	Mixed	0.12-0.38
Gandemer	Open	0.14
Bowen	Urban	0.43
CPBANK	Suburban	-

p = power law exponent of the mean velocity profile

Table 2: Terrain types and velocity profile exponents for each source

SOURCE	Number of Datasets Averaged	Percent Deviation from Mean
BRE	5	+4%, -7%
Wiren	1	-
Akins	2	+-1%
Gandemer	2	+-6%
Bowen	1	-
CPBANK	3	+-3%

Table 3: Number of datasets for similar buildings averaged and percent deviations from mean for each source

Each selected set of pressure coefficients was entered into the simulation in turn, and the whole building air change rate calculated, for building height wind speeds of between 0 and 10m/s. The results were then averaged to provide a typical result from each source, the percentage deviations from the mean of each group are shown in Table 3. The deviations due to differences between the buildings within each dataset were as follows: the two Akins buildings have a deviation of +-1%, from the mean value the three buildings selected from CPBANK has a deviation of +-3%, the five buildings from the BRE data source deviate by +4%-7% and the two buildings from Gandemer have a deviation of +-6%. These differences between different buildings of the same data source are relatively small and can probably be explained by experimental error and the minor differences in length to width ratios, length to height ratios and the differing roof pitches.

The calculated infiltration rates using each data set in turn are plotted in Figure 2. The results show a deviation of plus or minus 13% from the mean of all the simulations. It can be seen that the two sets of results exclusively involving pitched roofs (BRE & Wiren), are similar and are higher than those for flat roofed block shaped buildings. The result from the Gandemer set of data, which includes results from both flat roofed and pitched roof buildings is close to the mean of the simulations.

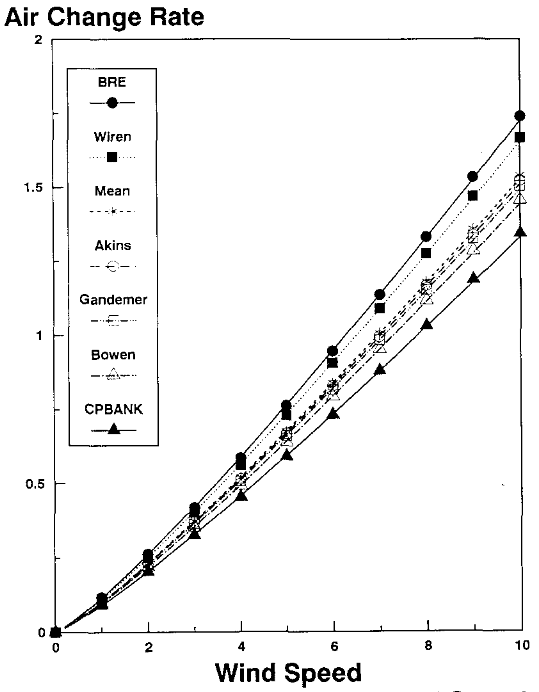


Figure 2. Air Change Rate vs Wind Speed for buildings of L/W ratio between 1:1 & 2:1 0% surrounding building density

Variable Density Correlations

To continue this exercise in data comparison the effect of surrounding building density was examined for the two sources for which such information was available (BRE & Wiren). Surrounding building density is defined as :

$$\% \text{ Density} = \frac{\textit{Ground Area of Buildings}}{\textit{Total Ground Area}} * 100$$

These two independent sources have been shown to produce similar results in a simulation for 0% surrounding building density as described above. A comparison was also attempted between the results for differing densities for each source in turn, and for similar densities from each of the two sources.

Firstly, a number of simulations were produced from the BRE data for densities between 0% and 35%. This database also includes a number of pressure coefficient datasets for two different building arrangements, involving different ratios of side distance, between buildings, to frontal distance, between buildings. Some have a side to front ratio of 1:5 and others have a side to front ratio of 1:2 (Figure 3). The first group includes pressure coefficient datasets for seven different densities, all for 30 roof pitches. The second consists of pairs of results at 0% and 15% densities for four different roof pitches. The first group was used at this stage of the analysis.

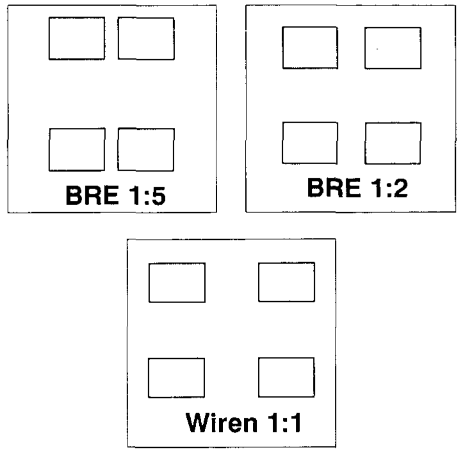


Figure 3. Side to Frontal Distance Ratios for the BRE and Wiren datasets

As for the 0% density simulations described above, simulations were carried out for roof height wind speeds between 0 and 10m/s. The results are shown in Figure 4, and are plotted as before as Air Change Rate vs Wind Speed. The effect of surrounding building density on the air change rate is clearly illustrated. As the density increases, the building air change rate is correspondingly reduced. A 5% surrounding density

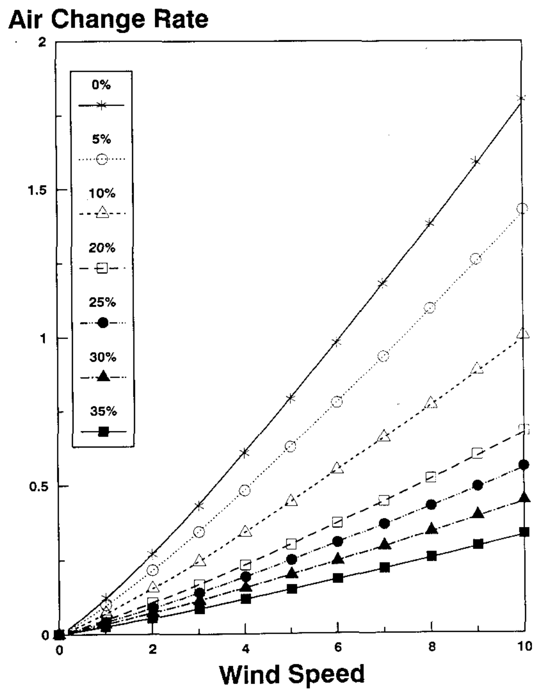


Figure 4. Air Change Rate vs Wind speed BRE dataset for building densities 0% to 35%

reduces the air change rate by 21%. This continues until, at a surrounding density of 35%, the air change rate is reduced by 81% compared to that of an isolated building. This emphasises the need to incorporate the correct shielding detail in any numerical exercise.

A similar set of simulations was performed using the Wiren data, which included four different datasets for surrounding densities of between 0% and 20%. The side to front ratio of these buildings is different again to the BRE data, being 1:1 for all densities (Figure 3). All buildings in this group have roof pitches of 45. The results from these are shown in Figure 5. Here a similar trend is seen with building air change rate reducing with increasing surrounding density. At 8% density, the air change rate is decreased by 30%, and at 20% density, a 52% reduction is observed compared to an isolated building.

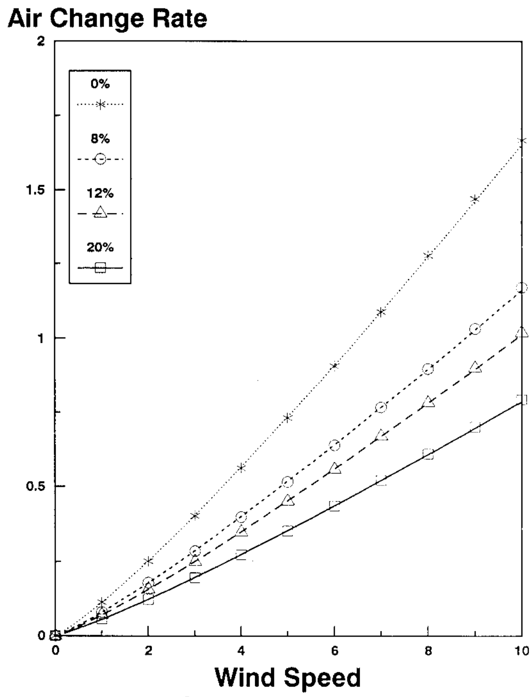


Figure 5. Air Change Rate vs Wind Speed
Wiren dataset
for building densities 0% to 20%

Dataset Comparisons

These two sets of variable building density simulations (BRE & Wiren datasets) described above, were then compared directly. Also included in this comparison was a simulation using data from a group of BRE datasets for buildings with a 15% surrounding density and 1:2 side to front surrounding building ratio (Figure 3). The result of this comparison is shown in Figure 6.

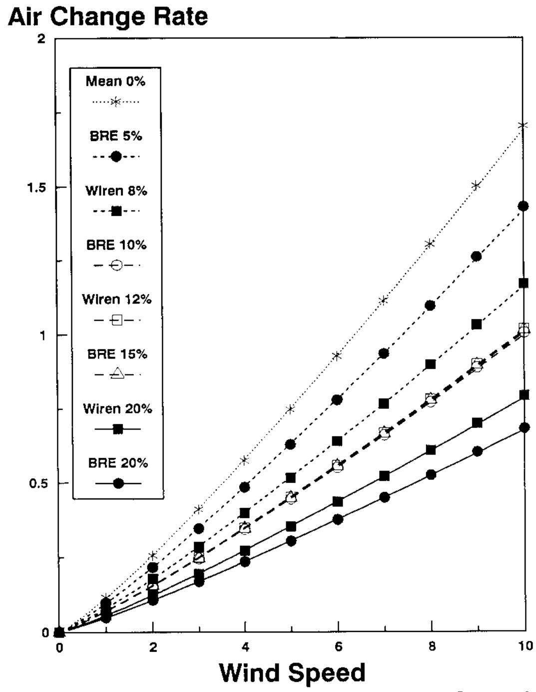


Figure 6. Air Change Rate vs Wind Speed
BRE & Wiren Data
Various surrounding densities

As can be seen the Wiren 8% (1:1 ratio) density result rests between the BRE 5% and 10% (1:5 ratio) results. Three lines run together in the centre of the graph, these being the 12% density simulation (1:1 ratio) from the Wiren dataset, the 15% simulation (1:2 ratio) from the BRE dataset and the 10% simulation (1:5 ratio) from the BRE dataset. In addition, the 20% density (1:1 ratio) Wiren simulation lies within 15% of the 20% (1:5 ratio) line for the BRE dataset.

Conclusions

The datasets used for the 0% surrounding building density comparison were chosen as being similar to the building being simulated. Despite the obvious differences of aspect ratios, roof pitches and terrain simulations between datasets, good general agreement was observed with the calculated results varying between plus and minus 13% of the mean. Overall, the results did not vary greatly between datasets, thus seemingly indicating a relative insensitivity of calculated ventilation rates to applied pressure coefficients. For simple ventilation rate estimations, careful selection of a dataset from a broadly similar building and terrain would therefore appear sufficient.

For the variable density comparison, the two data sets (BRE & Wiren) illustrated very clear and consistent variations of calculated building air change rate with density. The correlations between the two datasets also look extremely good, giving a high level of confidence in the results.

Further analysis of the datasets themselves is continuing at the AIVC. In particular the effects of building shape, surrounding density and roof pitch on the absolute values of both the pressure coefficients and on the resultant calculated air change rates are to be examined. The effect of building separation relative to building height also warrants investigation. The final results will lead to the generation of a new set of Cp tables and algorithms taking account such factors as building type and surrounding density. It is hoped to include such information in the AIVC Numerical Database for the benefit of future modelling applications.

References

1) Liddament, Martin (1989) "AIDA - an Air Infiltration Development Algorithm" Air Infiltration Review, Vol.11, No.1, December 1989.

2) Perera, MDAES, (1991), Building Research Establishment.

3) Wiren, Bengt G., (1985), "Effects of Surrounding Buildings on Wind Pressure Distributions and Ventilation Losses for Single-Family Houses. Part 1: 1-Storey Detached Houses." The National Swedish Institute for Building Research, Bulletin M85:19. (AIRBASE #2077)

4) Balazs, Karoly, (1989), "A Wind Pressure Database from Hungary for Ventilation and infiltration Calculations" Air Infiltration Review Vol. 10, No. 4, September 1989

5) Akins, R.E., Peterka, J.A. & Cermak, (1979), "Averaged Pressure Coefficients for Rectangular Buildings." (AIRBASE #823)

6) Gandemer, J. et al, (1978), "Champ de Pression Moyenne sur les Contructions Usuelles" Cahiers du Centre Scientifique et Technique du Batiment No.187, March 1978. (AIRBASE #1871)

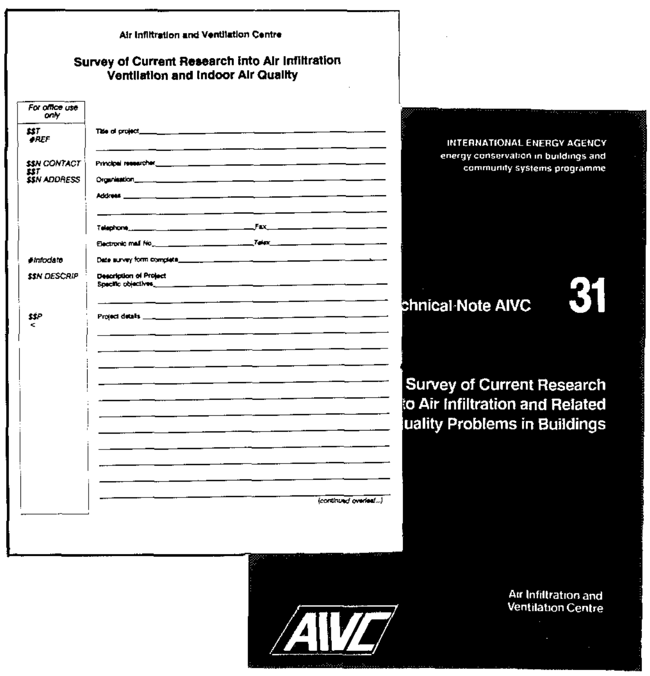
7) Bowen, A.J., (1976), "A Wind Tunnel Investigation Using Simple Building Models to Obtain Mean Surface Wind Pressure Coefficients for Air Infiltration Estimates." Laboratory Technical Report, LTR-LA-209, National Aeronautical Establishment, National Research Council Canada. (AIRBASE #441)

The AIVC's Update Survey of Research into Air Infiltration, Ventilation and Indoor Air Quality

Following the success of the Air Infiltration and Ventilation Centre's Fifth Worldwide Survey of Research, a yearly review of those projects that have been completed or are nearing completion is presently underway. This will keep the database version of the survey, which runs alongside AIRBASE, as up-to-date as possible. The information obtained from this survey provides many organisations with updated information about ongoing research in this field. The survey encourages an international exchange of research ideas and promotes cooperation between research organisations in different countries.

Since the first survey was conducted in 1980, there has been an increasing response, with 233 replies being entered into last year's survey.

Anyone wishing to be entered into this year's updated survey, who has not already replied please contact the AIVC for a survey form. Those who replied to the Fifth Survey will shortly be receiving a new survey form together with a copy of their original form, to be amended if necessary. We look forward to receiving your forms.



The Use of Acoustic Intensimetry to Size Air Leakage Cracks

D J Oldham, School of Architecture, Building Engineering and Architectural Studies, University of Liverpool, UK
A Zhao, School of Architectural Studies, University of Sheffield, UK

Abstract

The sound intensity technique and reverberant sound excitation have been used for the measurement of sound transmission loss through narrow slits in rigid walls. As predicted by theory, the dimensions of the apertures determine the magnitudes and resonant frequencies of the sound transmission loss curves. It should thus be possible in principle to size air leakage cracks using the technique described in this paper.

Introduction

Recent work on the design of energy efficient buildings has resulted in considerable attention being paid to energy losses due to air leakage via small constructional cracks. Baker et al [1] have carried out an investigation of air flow through cracks in walls by the method of room pressurisation. Their results show a quadratic relationship between the pressure drop, Δp, across the crack and the air flow rate Q as follows:

$$\Delta p = AQ + BQ^2 \qquad (1)$$

Where A and B in Eq.(1) are constants which are functions of the crack dimensions width, w, depth, d, and length, l.

The following expression for the transmission coefficient of a slit shaped aperture has been given by Gomperts and Kihlman [2]:

$$\tau^s = \frac{mk\cos^2(Ke)}{2n^2\{\frac{\sin^2K(L+2e)}{\cos^2(Ke)} + \frac{K^2}{2n^2}[1+\cos k(L+2e)\cos KL]\}} \qquad (2)$$

where K is the product of the wave number of the incident sound, and width, w, of the slit, L is the depth-to-width ratio of the slit (d/w) and e is an end correction.

Figure (1) shows predicted transmission loss characteristics for a number of different slits. The dependence of these characteristics on slit dimensions is marked. Since the same parameters determine the air leakage characteristics, it suggests that measurement of the sound transmission loss of small cracks might be an effective indirect method of determining the air leakage characteristics of building elements.

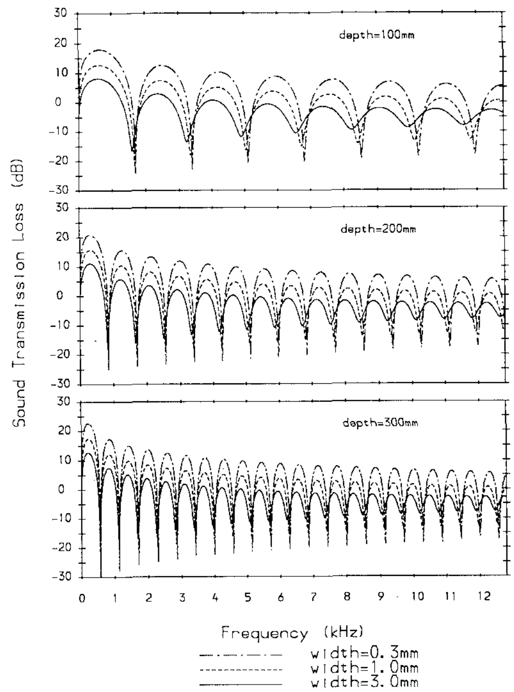


Figure 1: Predicted Values of Sound Transmission Loss for Different Crack Dimensions

The Experiment

In the present work the two microphone sound intensity measuring technique was selected for the measurement of the sound transmission loss of slit shaped cracks in a rigid wall. The use of sound intensity for the measurement of transmission loss of partitions has been developed since the early 1980's. For example, Crocker, Raju and Forssen [3] used it to measure the sound transmission loss of panels. The technique has a number of advantages over the other methods when dealing with sound transmission by very small apertures. If reverberant field excitation is employed in the experiment then only two parameters, sound pressure level in the source room and sound intensity level on the receiving side, need to be measured. The use of an intensity measuring system based upon a two channel FFT (Fast Fourier Transform) Analyser enables the frequency characteristics of the transmission loss to be determined with a high degree of resolution. This is essential if the resonance effects predicted by the theory of Gomperts and Kihlman are to be detected.

The experimental arrangement consisted of an enclosure with an internal volume of $3.3m^3$, containing two loudspeakers which generated a reverberant field of white noise. For good insulation the walls of the enclosure were of cavity construction with mineral wool between two layers of dense chipboard.

The test slits were situated on the top surface of the enclosure which consisted of layers of dense 18mm thick chipboard. The slits, which were all 500mm in length, were made using two parallel steel bars. The width of each slit was set using end spacers of known thickness and different depths of slit were obtained by employing different sizes of steel bars.

The sound pressure level in the source room was measured using a Bruel and Kjaer a quarter inch condenser microphone (B&K 4135) mounted on the end of a pipe which passed through holes made in two walls of the enclosure. It was thus possible by sliding the pipe along through the different apertures to measure the sound pressure level at a number of positions in the enclosure. The spectra at the microphone positions were determined using one channel of a B&K Type 2032 Dual Channel Analyser.

A Bruel and Kjaer sound intensity probe (B&K 3520) was employed with the Analyser to measure the sound intensity radiated from the aperture.

The Measured Transmission Loss of Slit Shaped Apertures

The acoustical power, W_i incident onto an aperture is equal to the product of incident intensity I_i and the area of the aperture i.e.

$$W_i = I_i W 1 \quad (3)$$

The acoustical power, W_o, radiated from the aperture will be

$$W_o = I_i w 1 \tau_c \quad (4)$$

where τ_c is the transmission coefficient of the aperture.

Assuming hemi-cylindrical radiation from the slit, the intensity at a point a distance r is

$$I_r = \frac{power}{area} = \frac{W_o}{\pi r 1} = \frac{I_i w \tau_c}{\pi r} \quad (5)$$

Using the relationship between sound pressure level, SPL_i and sound intensity level, in a reverberant enclosure yields the expression

$$TL_s = 10 log \tau_s = SPL_i - IL_r - 6 + 10 log\left(\frac{W}{\pi r}\right) \quad (6)$$

Where IL_r is the measured intensity level at a point distance r from the aperture on the receiving side.

Figures (2-3) show experimental results for slit shaped apertures compared with the predicted values of transmission loss obtained using the Gomperts-Kihlman expression. Good agreement exists between the experimental results and the theoretical predictions.

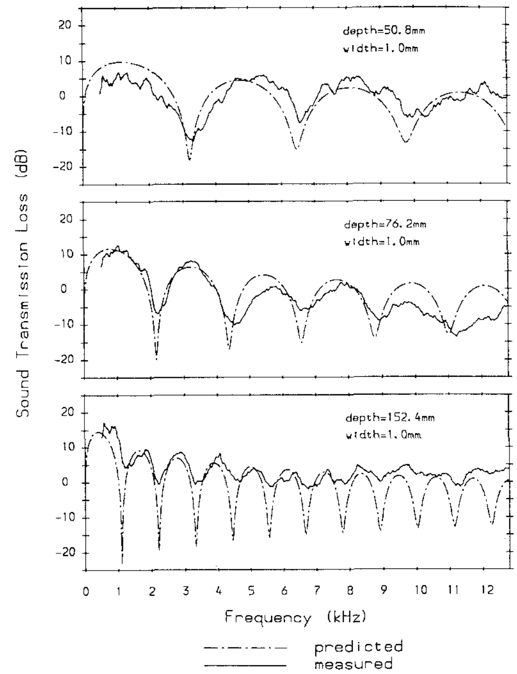


Figure 2: Comparison of Predicted and Measured Transmission Loss Characteristics for Slits of Width 1mm.

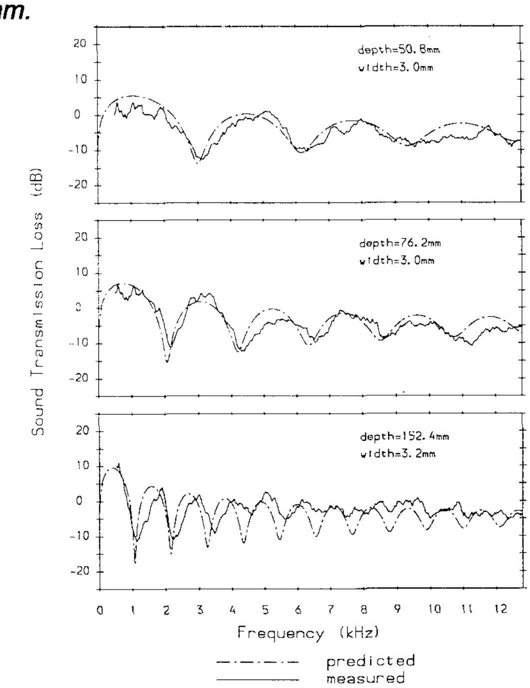


Figure 3: Comparison of Predicted and Measured Transmission Loss Characteristics for Slits of Width 3mm.

Conclusions

The sound intensity technique and reverberant sound excitation have been used for the measurement of sound transmission loss through narrow slits in rigid walls. The experimental results obtained in this study agree very well with the Gomperts-Kihlman predictions. As predicted by the theory, the dimensions of the apertures determine the magnitudes and resonant frequencies of the sound transmission loss curves. It should thus be possible in principle to size air leakage cracks using the technique described in this paper.

References

1. P.B. Baker, S. Sharples and I.C. Ward 1987, Building and Environment 22 n4, 293-304. Air Flow Through Crack.
2. M.C. Gomperts and T. Kihlman 1967, Acustica 18, 144-150. The sound transmission loss of circular and slit-shaped apertures in walls.
3. M.J. Crocker, P.K. Raju and B.Forssen, 1981. Noise Control Engineering Journal 17 nl July-August, 6-11. Measurement of transmission loss of panels by the direct determination of transmitted acoustic intensity.

AIVC 12th Annual Conference

Air Movement and Ventilation Control within Buildings

Tuesday 24th - Friday 27th September, 1991, Château Laurier, Ottawa, Canada

Intensive analysis on the characteristics and control of air flow into and within buildings is currently taking place. The purpose of the 12th AIVC Conference is to review progress in this field with special emphasis on applicability for ventilation design, optimisation and diagnostic analysis. The following programme lists the various topics to be considered.

Programme

Tuesday, 24 September 1991

Morning

Technical tour of National Research Council

Arrival and registration

SESSION 1

Air Flow Patterns Within Buildings - IEA Annex 20

Afternoon

Opening and keynote presentation

The message of Annex 20: Air Flow Patterns within Buildings *A Moser (Switzerland)*

Air Flow patterns within buildings *G Whittle (UK)*

Simplified models for the prediction of room air distribution *P V Nielsen (Denmark)*

Single sided ventilation *D Bienfait (France), H Phaff (Netherlands), L Vandaele (Belgium), J van der Maas (Switzerland), R Walker (UK)*

Modelling of large openings *R Pelletret (France), G Liebecq (France), F Allard (France), J van der Maas (Switzerland)*

Wind induced fluctuating air infiltration in buildings *J Rao, F Haghighat (Canada)*

Airflow driven contaminants *H Phaff (Netherlands)*

(Continued over...)

Wednesday, 25th September, 1991

SESSION 2

Demand Controlled Ventilation Systems - Annex 18

Morning

Dispersion pattern of contaminants in a displacement ventilated room *H Stymne, M Sandberg, M Mattson (Sweden)*

Demand controlled ventilation: application to auditoria *M Zamboni, O Berchtold, C Filleux, J Fehlmann (Switzerland)*

Demand controlled ventilation systems in office buildings *B Davidge, F Vaculik (Canada)*

Source book presentation of Annex 18: Demand controlled ventilation system *L G Mansson, S Svennberg (Sweden)*

Design guidelines for thermal envelope integrity in office buildings *A Persily (USA)*

Controlled natural ventilation *B Knoll (Netherlands)*

Performance evaluation of humidity controlled natural ventilation in apartments *P Wouters, D L'Heureux, B Geerinckx, L Vandaele (Belgium)*

Free Afternoon

SESSION 3

Parallel Display Presentations

3a : Annex 20 Air Flow Patterns

Evening

Simulation of a multiple-nozzle diffuser *Q Chen, A Moser (Switzerland)*

Measurement techniques related to airflow patterns within building: an application guide *C Roulet, L Vandaele (Switzerland)*

Inhabitant behaviour *C Roulet, J Scartezzini (Switzerland)*

The use of test chambers for characterising the emissions of volatile organic compounds from indoor construction materials *R Gehrig, M Affolter, P Hofer (Switzerland)*

A CFD analysis of moisture distribution and condensation in a multizone enclosure *Z Jiang, F Haghighat (Canada)*

Ventilation flow analysis - flow visualisation and LDA measurements in water scale models, validation of numerical results *F Biolley, J Fontaine, R Rapp, J Serieys (France)*

Scaling of air flow patterns in room ventilation *A Moser (Switzerland)*

Concentration distribution in a ventilated room under isothermal conditions *P Heiselberg, N Bergsoe (Denmark)*

Multi-room ventilation efficiency *F Haghighat (Canada), D Bienfait (France), H Phaff (Netherlands)*

Turbulence characteristics in rooms ventilated with a high velocity jet *M Sandberg, C Blomquist, M Mattson (Sweden)*

Simulation of thermal coupling between a radiator and a room with zonal models *C Inard, D Buty (France)*

Preheating and cooling of the incoming air of dwellings using an earth-laid pipe *H Trumper, K-J Albers (Germany)*

A new control algorithm for the measurement of variable air *R Rabenstein, F D Heidt (Germany)*

3b : Annex 18 - Demand Controlled Ventilation Systems

Evening

Humidity control through demand controlled mechanical ventilation in dwellings *J Nielsen (Denmark)*

Demand controlled ventilation : full scale tests in a conference room *P Fahlen, H Anderson (Sweden)*

Demand controlled ventilation - evaluation of commercially available sensors *P Fahlen, S Ruud, H Anderson (Sweden)*

Should further HVAC systems be demand controlled? *W Braun (Switzerland)*

Performance analysis of demand controlled ventilation system using relative humidity as sensing element *A Parekh, M Riley (Canada)*

Potential for residential demand controlled ventilation *T Hamlin (Canada)*

A demonstration of low cost DCV technology on five Canadian houses *S Moffatt (Canada)*

Demand controlled ventilation in a school *L Norell (Sweden)*

Air movement and ventilation control in museums and galleries *P O'Sullivan, T Oreszczyn (UK)*

Warm air heating with a constant high supply air flow rate without recirculation *T Carlsson, A Blomsterberg (Sweden)*

Ventilation control within exhaust fan ventilated houses *A Blomsterberg (Sweden)*

Evaluation of different heating and ventilation systems in a day-care centre *M Hult (Sweden)*

Control algorithms for rooms with displacement ventilation system *V Prochaska, A Schreiber, B Kegel (Switzerland)*

Thermal plumes in ventilated rooms - vertical volume flux influenced by enclosing walls *P Kofoed, P Nielsen (Denmark)*

Performance evaluation of kitchen hoods *P Wouters, B Geerinckx, L Vandaele (Belgium)*

Thursday, 26th September, 1991

SESSION 4

Energy Implications and Field Measurements

Morning

Buildings, health and energy *J Kronvall (Sweden)*

The simulation of infiltration rates and air movement in a naturally ventilated industrial building *P Jones, D Alexander, G Powell (UK)*

Energy cost and program implication *T Steele, M Brown (USA)*

Field measurements of interaction of mechanical systems and natural infiltration *L Palmiter (USA)*

Single zone stack dominated infiltration modelling *M Sherman (USA)*

Comparison of airtightness, IAQ and power consumption before and after air sealing of high-rise residential buildings *A Parekh, K Ruest, M Jacobs (Canada)*

Determination of flow direction by a globe sensor containing thermal anemometers *F Steimle, U Eser, S Schadlich (Germany)*

SESSION 5

Parallel Display Presentations

5a : Measurements

Afternoon

Ventilation for control of IAQ, thermal comfort and energy conservation by CO2 measurement *G Dionnini, F Haghighat, V Hiep Nguyen (Canada)*

Measurement of the entrance length and friction-factor of ducts using tracer gas techniques *S Riffat, K Cheong, M Holmes (UK)*

Interzonal airflow measurement - a tool to solve pollution problems *B Kvisgaard, L Schmidt (Denmark)*

A new passive tracer gas technique for ventilation measurements *H Stymne, A Eliasson (Sweden)*

Use of tracer gas to determine internal leakage in domestic heat recovery units *R van Gerwen (Netherlands)*

A novel infrared absorption spectrometer for use in ventilation studies *D Phillips, G Bragg (Canada)*

Analysis of errors associated with multizone tracer analysis procedures *J Ludwig, C DeLuca, J McCarthy, J Spengler (USA)*

An integral mass balance formulation of the constant concentration tracer technique *J Axley (USA)*

New approach for the determination of interzonal air flows from tracer gas *S Zad, H Jarausch, W Raatschen (Germany)*

Turbulence parameters from laser doppler velocity measurements in ventilated rooms as boundary conditions for computer simulations *M Ewert, U Renz (Germany)*

Contaminant dispersal measurement using laser light sheet illumination and digital image processing techniques *J Axley (USA)*

Ventilation effectiveness - the AIVC guide *C Brouns, J Waters (UK)*

Investigation of a combined ventilation and heating system for residential buildings *F Steimle, B Mengede, J Roben (Germany)*

5b : Simulation Models

Afternoon

Thermal coupling of leakage air flows and heating load in building components and buildings *M Virtanen (Finland)*

Simultaneous calculation of airflows temperatures and contaminant concentrations in multizone buildings *K Klobut, P Tuomaala, K Siren, O Seppanen (Finland)*

An evaluation of a computer code for predicting indoor airflow and heat transfer *Y Li, L Fuchs, S Holmberg (Sweden)*

Turbulent modelling of airflow patterns and ventilation effectiveness *H Han, T Kuehn, J Ramsay (USA)*

A multizone model to facilitate predicting natural ventilation through buildings *A Field, W Batty, S Probert (UK)*

Simulation of airflow in naturally ventilated classrooms *D Croome, H Awbi, M Yusof, G Gan (UK)*

Modelling of airflows, temperatures and contaminant levels for localized ventilation systems *R Grot (USA)*

Numerical prediction of airflow patterns and ventilation effectiveness in an open office environment *J Fang, A Persily (USA)*

Modelling complex inlet geometries in CFD - applied to air flow in ventilated rooms *M Skovgaard, P Nielsen (Denmark)*

Numerical investigation of low Reynolds number effects *M Skovgaard, P Nielsen (Denmark)*

Modelling of supply air terminal for room air flow simulation *J Heikkinen (Finland)*

Symmetry of flow field *J Fuerst (Germany)*

Estimation of air leakage in high-rise residential buildings *A Parekh (Canada)*

5c : Field Tests and Analysis

Afternoon

Influence of radiative participation of inside air on natural convection in a room *F Allard, C Inard, A Draoui (France)*

Crack flow: a power law estimation technique *J Kronvall (Sweden)*

Using thermofoil heaters for the experimental determination of the air flow patterns in a room *G Cannistraro, C Giaconia, G Rizzo (Italy)*

HotWire/Film Anemometry for room air motion studies *J Zhang, L Christianson, G Wu (USA)*

Evaluation of an on line mathematical model for control of energy and mass transportation in a 3-dimensional room *D Berckmans, P Vandenbroeck, B DeMoor, S VanHuffel (Belgium)*

Theoretical and experimental analysis of different ventilation strategies in a test room *N Cardinale, G Fracastoro, M Mantegna, E Nino (Italy)*

Measured air flows in residential attics under natural conditions *W Rose (USA)*

The use of acoustic intensimetry to size air leakage cracks *D Oldham, X Zhao, S Sharples, I Ward (UK)*

Ventilation and humidity in bathrooms *J Fransson (Sweden)*

Integrated forced-air heating and ventilation systems: evaluation and design considerations *M Jackson (USA)*

Long term ventilation effectiveness in residential buildings *J Sateri (Finland)*

Advanced humidity control device for the prevention of mould *W Raatschen (Germany)*

Advanced ventilation systems *B Knoll (Netherlands)*

Evening

Banquet and tour of museum of civilisation

Friday, 26th September, 1991

SESSION 6

Measurements

Morning

Wind shelter effects on air infiltration *D Wilson, I Walker (Canada)*

Assessing intake contamination from atmospheric dispersion of building exhaust *E Perera, R Tull, M White (UK)*

Airflow patterns in a five-storey apartment building *C Shaw, J Reardon, M Said, R Magee (Canada)*

PFT measurements in ventilation ducts *J Sateri (Finland)*

The reliability of infiltration and air movement data obtained from single tracer gas measurements in large spaces *H Sutcliffe, J Waters (UK)*

Application of tracer gas analysis to industrial hygiene investigations *R Grot, P Lagus (USA)*

Single-sided natural ventilation - how deep an office? *M White, R Walker (UK)*

Summing up

A Brief Review of Building Simulation Techniques

John F Kendrick, Senior Scientist, Air Infiltration and Ventilation Centre

Abstract

Increasing design standards within the building industry mean that some form of pre-construction testing of the building envelope is required. Expensive and time consuming field tests are becoming more impractical whereas the cost-effectiveness and greater flexibility of computer simulations will allow them to play an increasing role in building design. An expanding database of actual construction properties is needed to assist the use and advancement of existing models.

The present work program of the Air Infiltration and Ventilation Centre focuses on this problem with the development of an interactive numerical database alongside a comprehensive study of existing and future models. The model survey is presently investigating the capabilities of computer analysis techniques involving the combination of flow codes and heat transfer properties. The primary concerns of this database are air leakage properties, wind pressure distributions and climatic parameters.

Introduction

Advances in both experimental techniques and mathematical modelling have resulted in a greater understanding of the air and heat flow patterns in and around buildings. The extensive use of tracer gas techniques to determine building infiltration has meant that the investigation of potential flows has become relatively straightforward. The pressurisation tests for measuring the airtightness and leakage flows within the building envelope is also becoming routine. Unfortunately these measurement techniques suffer from several drawbacks. The tracer gas method requires many discrete measurements to be made over a relatively long period of time. The measurements made are of little use in the design stages as they can only be used to assess the performance of existing structures or simplified scale models.

In spite of its importance, the analysis of air flows has not been developed fully due to the lack of consistent input data, computational difficulties and the restrictions imposed by the incompatible methods for analysing different flows (Walton 1989). Methods have been developed to analyse airflow in ducts (ASHRAE 1985) and to estimate infiltration (Liddament 1989) and ventilation (ASHRAE 1985) but the relationship between these processes has rarely been studied.

The modelling of airflow within buildings requires: Determination of the boundary conditions (primarily wind pressure), the location and mathematical representation of the critical airflow paths, calculation of the resulting airflows and a user system which is easy to manipulate. The aim of this project is to analyse the potential flow codes in order to focus on their points of application and the development of numerical databases to take full advantage of the models.

Air Flow and Heat Transfer Model Review

There is a wide range of calculation methods currently being used to tackle the problem of airflow and related phenomena (Hammond 1988). These range from low-level methods through intermediate-level (zonal) models to high-level (field) computer codes. The current survey is investigating the applicability of these codes in a working environment. There is a need for combined heat and flow codes to complement present testing systems. The ability to predict the indoor environment in the initial stages of design is of increasing importance, to save both time and money. The validity of the codes is greatly dependent on the information required and supplied to the model. The complex codes developed to model the whole building envelope (Clarke 1990, Walton 1983) require complex initialisation parameters. For an inexperienced user the high level of information required may limit the effectiveness of the code.

Input parameters include: Climatic information, Building design and terrain characteristics, building materials and their properties, leakage data, external wind pressure coefficient (Cp) values, the design of the heating/cooling system, occupancy behaviour and the presence of internal sources. It is possible to collate a large proportion of this data in a single numerical database to be used in the application of the codes. To review the codes available it is necessary to look at the potential users of the systems. The practitioner is looking towards quick solutions to relatively simple problems whereas the designer needs a accurate appraisal of the situation to support the design decisions.

The model survey includes the investigation of the transfer mechanisms involved in the modelling of single and multi-zone problems. The transfer of properties from heated to unheated zones and the characteristics of airborne moisture transport within and between related zones are considered. The heat conduction of solids has to be appreciated alongside the properties of the transport medium. All this information needs to stored in such a way as to be readily accessible to the model user.

Combined heat and air flow models have been developed from the interaction of separate codes with a similar model base. This technique also allows for the inclusion of other considerations such as moisture (Cunningham 1988) and contaminant dispersal. Figure 1 shows interaction of all these parameters in developing a computer model.

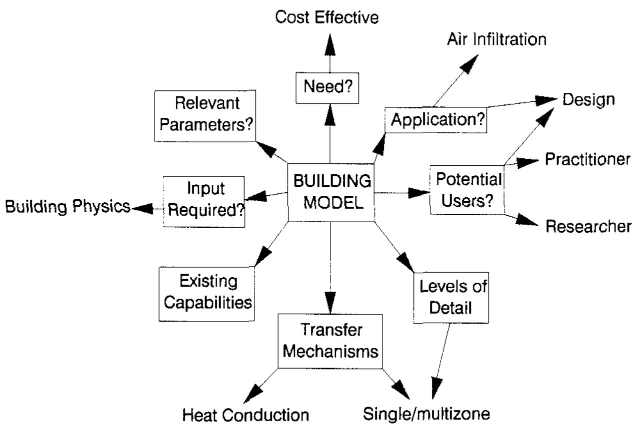


Figure 1: A Brief Review of Building Models

Initially multizone simulation techniques were confined to mainframe computer systems. Now, however, they are available for operation on pc based systems on which quite complex networks can be investigated. This has resulted in wider availability but many still lack 'user friendliness'. Other problems include the lack of suitable input data and inadequate validation through a lack of supporting measurement data. The IEA annex 23, 'Multizone Airflow Modelling', has been created to address these points in order to provide a method which may be reliably used for research and design applications. The results of this annex as well as previous IEA work will be incorporated into the present research.

Annex 23 is divided into three subtasks: Model development with a user friendly front end, data acquisition for model evaluation and model evaluation. The first subtask is an extension of the COMIS project (AIVC TN29, 1990) in which an 'intelligent simulation environment' (ISE) is to be developed to assist a user in setting the critical model parameters and developing a flow network (Liddament 1990). The work also includes the incorporation of pollutant transport and demonstrating the coupling of a multizone model with a thermal building simulation model. The essential feature is to couple to a model via a series of graphic data input screens. Data is then provided by the user or retrieved from internal databases. An expert system is also available to assist the user in selecting the best information.

The aim, therefore is to provide the user with the necessary knowledge and tools to use a model. Essential to all this work is the development of a suitable algorithm for the simulation of multizonal air flow. Modules for incorporation in this algorithm include flow through large openings, single sided flow, and crack flow. The addition of recent research, reviewing building air flow simulation techniques (Liddament 1991), allows for a comprehensive study of the methods available.

In providing new datasets, emphasis has been directed at clearly defining the objectives of each measurement in the context of evaluation needs, standardising the format of data collection and standardising procedures for estimating errors (AIVC 1991). The annex experimental program will include measurements on isolated systems within the laboratory, the use of test cells, field measurements on 'simple' buildings of different constructional techniques and field measurements on more complex buildings such as multi-storey office buildings. Also a wide range of exposure and climatic conditions are being applied. The advantage of the international collaboration in the research is that it enables the widest range of construction, ventilation and climatic conditions to be included within the study.

The final section of the research is concerned with establishing a protocol for model evaluation. This would be applicable to any multizone technique and hence has a wide application area by providing usable datasets for general validation purposes. The AIVC's own numerical database will draw on this work for application in future validation studies. The goals of this area of research are to ensure that a model performs according to specific criteria, to determine the domain of application and, by means of feedback from the results, improve model performance. There are many criteria by which the model may be judged and the specific details have yet to be determined. Also, when comparing a model against measured data, the deviation of the measurements from the physical quantities being investigated must be understood.

Conclusions

The present research program provides an opportunity to evaluate air flow patterns within buildings. In addition to air flow analysis, such computer fluid dynamics techniques may be used to predict the propagation of pollutants, fire and smoke, and to evaluate flow velocities and temperature distributions. These methods therefore have potentially important applications in the prediction of the building environment. The advantages gained in such techniques are related to the quality and consistency of the information provided to the codes and the interpretation of the ensuing results. To make full use of the models and mathematical techniques a base of data is being prepared within the Centre, coupled with an research review of the available models to create a system of the greatest use to the user.

References

AIVC, 1990. Technical Note 29 "Fundamentals of the Multizone Air Flow Model-COMIS". Air Infiltration and Ventilation Centre, UK, May 1990.

AIVC, 1991. Harrje, D.T. and Piggins J.M. Technical note 32. "Reporting Guidelines for the Measurement of Airflows and Related Factors in Buildings". Air Infiltration and Ventilation Centre, UK, Jan 1991.

ASHRAE 1985. ASHRAE Handbook- 1985 Fundamentals. Atlanta: American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.

Clarke J.A. 1990. ESP, A Building and Plant Energy Simulation System. Version 6, Feb 1990, ESRU Manual.

Cunningham M.J. 1988. The moisture Performance of Framed Structures - A Mathematical Model. Building and Environment, Vol 23, No 2, 1988, pp123-135.

Hammond G.P. 1988. Modelling Building Airflow and Related Phenomena. Building Environmental Performance and Analysis Club, Dec 1988.

Liddament M.W. 1989. AIDA, an Air Infiltration Development Algorithm. Air Infiltration Review, Vol 11, No 1, Dec 1989 pp 10-12.

Liddament M.W. 1990. Annex 23, Multizone Air Flow Modelling - A new IEA Annex. Air Infiltration Review Vol 12, No. 1. Air Infiltration and Ventilation Centre, Dec 1990.

Liddament M.W. 1991. A Review of Air Flow Simulation. Air Infiltration and Ventilation Centre Technote 33, March 1991.

Walton G.N. 1983. TARP, Thermal Analysis Research Program. US Department of Energy reference Manual, March 1983.

Walton G. N. 1989. "Airflow Network Models for Element-Based Building Airflow Modelling". ASHRAE Transactions Vol 95, p2.

Recent Additions to AIVC Library and AIRBASE

Trends '90 A Compendium of Data on Global Change

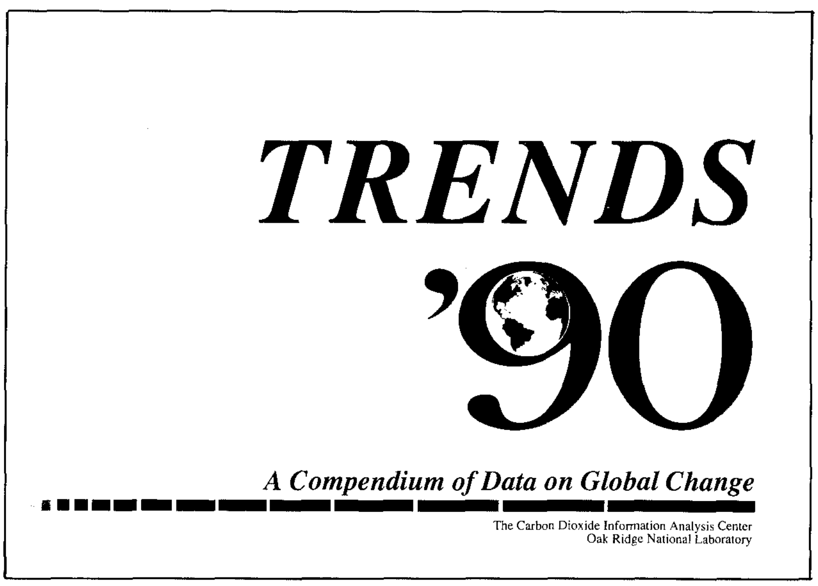
by Thomas A Boden, Paul Kanciruk, Michael P Farrell, Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, 37831-6335, USA

August 1990

Abstract

This document is a source of frequently used global change data. This first issue includes estimates for global and national CO2 emissions from the burning of fossil fuels and from the production of cement, historical and modern records of atmospheric CO2 and methane concentrations, and several long-term temperature records. Included are tabular and graphical presentations of the data, discussions of trends in the data, and references to publications that provide further information. Data are presented in a two page format, each dealing with a different data set.

All data are available in digital form from the Carbon Dioxide Information Analysis Center.



Modeled and Measured Infiltration : A Detailed Case Study of Four Electrically Heated Homes

by Larry Palmiter and Tami Bond, Ecotope, Inc., 2812 East Madison St., Seattle, Washington 98112, USA

February 1991

Abstract: Detailed infiltration and pressure measurements were made by Lawrence Berkeley Laboratories on four electrically heated homes in the Pacific Northwest. The primary purpose of the study was to investigate the impacts of wind, temperature and mechanical systems on infiltration in real homes, with a view toward resolving infiltration modeling problems raised in recent studies.

The predictions of two natural infiltration models (LBL and AIM2) air compared in detail with one another and the measured data. The separate influences of stack- and wind-induced flow are analyzed. The LBL model predictions are 23-97% greater than the AIM2 model; the measured data fall within the range bounded by the two models. An improved method of calculating the height perameter for both models is proposed.

A simple model is presented to incorporate the infiltration effects of exhaust and supply systems and unbalanced flows due to duct leakage. An unbalanced flow to the conditioned space induces approximately one half of its magnitude in additional infiltration when it is small relative to natural infiltration. The measured data agreed closely with the theoretical model.

The homes in this study were relatively tight, and the infiltration was dominated by the stack effect. The homes were typically well sheltered, and the predicted infiltration due to wind was small.

Forced-air distribution systems were investigated in detail. Air handlers and associated duct leakage can have large effects on living-zone infiltration rates. At two sites, the infiltration rate increased by more than 50% when the air handler was running. Duct leakage was found at all three sites with air handlers.

Closing even a single bedroom door can cause a major increase in infiltration when the air handler runs. Pressures measured across a single closed door ranged from 2-6 Pa. At one site, closing the bedroom door more than doubled the added infiltration produced by the air handler.

Investigation of Air Distribution System Leakage and its Impact in Central Florida Homes

by James B Cummings, John J Tooley, Jr., Neil Moyer, Florida Solar Energy Center, 300 State Road 401, Cape Canaveral, Florida 32920, USA

January 1991

Abstract: Testing for air leakage in air distribution systems was done in 160 central Florida homes. Tracer gas tests found that infiltration rates were three times greater when the air handler was operating than when it was off, indicating that there are large leaks in the air distribution system. Infiltration averaged 0.91 air changes per hour (ach) with the air handler (AH) operating continuously and 0.28 ach with the AH off. Return leaks were measured by tracer gas and found to average 10.7% of AH total flow. House airtightness, in 99 of these homes, determined by blower door testing, averaged 12.7 air changes per hour at 50 Pascals (ACH50). When the duct registers were sealed, ACH50 decreased to 11.1, indicating that 12.7% of the house leaks were in the air distribution system.

Duct leaks were repaired in 50 of the 160 homes. Blower door tests were done on these houses before and after repair. Before repair airtightness was 12.5 ACH50. After repair house ACH50 decreased to 11.2, indicating that 63.7% of the duct leaks were repaired. Infiltration tests were done before and after repair on 25 of these homes. Infiltration rates with the AH on decreased from 1.10 ach before repair to 0.54 after repair. Return leakage decreased from 16.0% to 4.5% of total air handler flow.

Cooling energy use decreased as a result of duct repairs. Data was available for 46 of the 50 homes. Air conditioner energy use decreased by an average 17.2%, yielding estimated space conditioning energy savings of $110 per year. Duct repairs are a very cost-effective retrofit. At an average cost of $200 per home, duct repairs have a simple payback of less than two years.

Duct leaks have a dramatic impact upon peak electrical demand. While no peak demand data has yet been measured, theoretical analysis indicates that a 15%

return leak from the attic can increase cooling electrical demand by about 90%. Detailed theoretical analysis of a winter Florida morning indicates that duct repairs in a typical, electrically heated Florida home reduce winter peak demand by about 1.6 kW per house at about one sixth the cost of building new electrical generation capacity. Repair of ducts in three million Florida homes could reduce winter peak demand by 5000 megawatts, or 13% of the state's generating capacity. This effort would be very cost-effective, since the generation capacity made available by duct repair would cost only about one third to one eighth what new capacity would cost, depending upon type of generation facility.

EXPOSURE Version 2
A Computer Model for Analysing the Effects of Indoor Air Pollutant Sources on Individual Exposure

Author: Leslie E. Sparks

The program is accompanied by a detailed report describing the theories behind the simulation, the experimental validation work which has been carried out and containing a user manual for the program.

The report presents a model for calculating individual exposure to indoor pollutants from sources. The model calculates exposure due to individual, as opposed to whole population, activity patterns and source usage. The model uses data on source emissions, room to room airflows, whole building air change rates and indoor sinks to predict concentration/time profiles for each room for an individual pollutant type (Fig 1). The concentration/time profiles are then combined with up to three individual activity patterns to estimate personal exposure to this pollutant (Fig. 2).

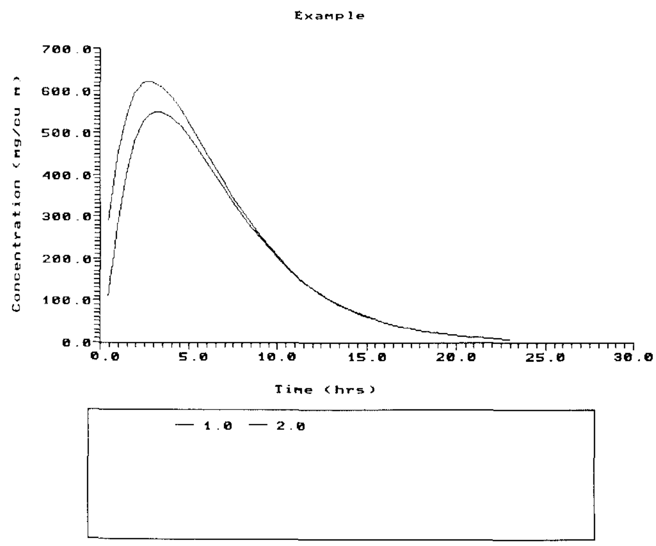


Figure 1. A Concentration/Time Profile for Two Rooms

The model allows analysis of the effects on indoor air quality (IAQ) and exposure, of air cleaners located in the central air conditioning unit and/or individual rooms. Provision is made for simulation of a wide range of sources including long term steady state sources, on/off sources, and decaying sources. Several sources are allowed in each room. The effects of sinks and sink re-emissions on IAQ can also be simulated.

The report details the results of test house experiments which are compared with model predictions. The agreement between predicted concentration/time profiles and experimental data is good. The average deviation of the predicted from the experimental values is less than 30%, and the maximum deviation is less than 60%.

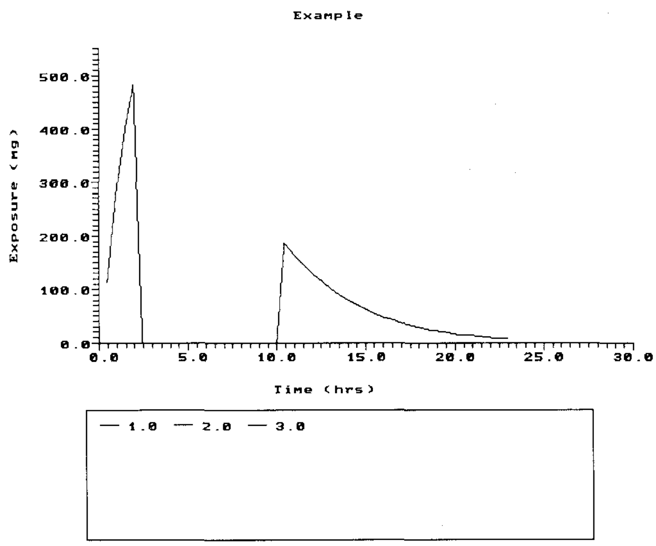


Figure 2. Personal Exposure to a Single Pollutant

Copies of the Program and Report are available from:

Les Sparks, U.S. Environmental Protection Agency, Air and Energy Engineering Research Laboratory, MD 54, Research Triangle Park, NC 27711 USA

Telephone: +1-919-541-2458

Forthcoming Conferences

17-24 August 1991

ISES 1991
Solar World Congress

Denver Marriott City Center Hotel, Denver, Colorado, USA

Further details from:
American Solar Energy Society, 2400 Central Avenue, Suite B-1, Boulder, Colorado 80301, USA Tel: 303 443 3130 Fax: 303 443 3212

20-22 August 1991

IBSPA-BS 91
Building Simulation '91
2nd World Congress on Technology Improving the Energy Use, Comfort, and Economics of Buildings Worldwide

Nice, Sophia-Antipolis, France

Further details from:
IBSPA-BS '91, Society for Computer Simulation, c/o Philippe Géril, Coupure Links 653, B-9000 Ghent, Belgium, Tel and Fax: 32 91 23 49 41

25-28 August 1991

ISEE 1991
1991 International Symposium on Energy and Environment

Espoo, Finland

Further details from:
ISEE International Symposium, Energy and Environment, Helsinki University of Technology, Centre of Energy Technology, Otakaari 4, 02150 Espoo, Finland, Tel: +358 0 451 3580, Fax: +358 0 451 3419, Telex: 125161 htkk sf

4-8 September 1991

ASHRAE/CIB Symposium
Healthy Buildings - IAQ '91
Planning, designing, construction, renovating and occupying buildings: recommendations and benefits

Washington, DC, USA

Further details from:
Jim Norman, ASHRAE, 1791 Tullie Circle NE, Atlanta, GA 30329, USA

16-20 September 1991

Ventilation '91
3rd International Symposium On Ventilation For Contaminant Control

Omni Netherland Plaza, Cincinnati, Ohio, USA

Further details from:
Ventilation '91, American Conference of Governmental Industrial Hygienists, 6500 Glenway Avenue, Building D-7, Cincinnati, Ohio 45211-4438, USA

24-27 September 1990

Air Movement and Ventilation Control within Buildings
12th AIVC Conference

Château Laurier, Ottawa, Canada

Further details from:
AIVC, Barclays Venture Centre, University of Warwick Science Park, Sir William Lyons Road, Coventry, CV4 7EZ, Great Britain

24-27 September 1991

PLEA 91
The Ninth International PLEA Conference: Architecture and Urban Space

Seville, Spain

Further details from:
Adesa, PLEA 91, Apartado 1.183, 41080 Seville, Spain Tel: (34) (5) 4 23 55 11, Fax: (34) (5) 4 23 62 68

5-8 November 1991

Environmental Quality
ASHRAE Conference

Hong Kong Convection and Exhibition Centre, Hong Kong

Further details from:
ASHRAE, Program Coordinator, 1791 Tullie Circle, NE, Atlanta, Georgia 30329, USA

18-22 May 1992

CIB 92
World Building Congress

Montreal, Canada

Themes and Viewpoints: 1. New Materials and Systems, 2. Rehabilitation and Restoration, 3. Environment, 4. Globalization, 5. Computers and Robotics

Further details from:
Congress Secretariat, CIB '92 World Building Congress, National Research Council Canada, Ottawa, Canada K1A 0R6

2-4 September 1992

Roomvent '92
Third International Conference on Air Distribution in Rooms

Aalborg, Denmark

Further details from:
Conference Secretariat, Danish Association of HVAC Engineers, Orholmvej 40B, DK-2800, Lyngby, Denmark Tel: +45 42 87 76 11 Fax: +45 42 87 76 77

3rd fold (insert in Flap A)

1st fold

Air Infiltration and Ventilation Centre
University of Warwick Science Park
Barclays Venture Centre
Sir William Lyons Road
Coventry CV4 7EZ
Great Britain

2nd fold (Flap A)

AIVC Publications

AIVC Publications can be obtained by completing the order form opposite and returning it to us. An AIVC Introduction Pack is available for new readers, including sample copies of the AIVC quarterly magazines, notes on the use of the AIVC Information Service, and a Publications leaflet giving brief summaries of all current publications. For pricing details see order form.

PERIODICALS

Air Infiltration Review. Quarterly newsletter containing topical and informative articles on air infiltration research and application.

Recent Additions to AIRBASE. Quarterly bulletin of abstracts added to AIRBASE, AIVC's bibliographic database.

GUIDES AND HANDBOOKS

Applications Guide 1 (1986) Liddament, M.W. 'Air Infiltration Calculation Techniques - An Applications Guide'

Applications Guide 2 (1988) Charlesworth, P.S. 'Air Exchange Rate and Airtightness Measurement Techniques - An Application Guide'

Handbook (1983) Elmroth, A. Levin, P. 'Air infiltration control in housing. A guide to international practice.'

TECHNICAL NOTES

TN 5 (1981) Allen, C. 'AIRGLOSS; Air Infiltration Glossary (English edition)'

TN 5.1 (1983), 5.2 (1984), 5.3(1985), 5.4(1988) Allen, C. 'AIRGLOSS'; Air Infiltration Glossaries (German, French, Italian and Dutch) Supplements.

TN 10 (1983) Liddament, M,, Thompson, C. 'Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography'

TN 11 (1983) Liddament, M., Allen, C. 'The validation and comparison of mathematical models of air infiltration'

TN 13 (1984) Allen,C. 'Wind pressure data requirements for air infiltration calculations'

TN 13.1 (1984) '1984 Wind Pressure Workshop Proceedings'.

TN 16 (1985) Allen,C. 'Leakage Distribution in Buildings'

TN 17 (1985) Parfitt, Y. 'Ventilation Strategy - A Selected Bibliography'

TN 20 (1987) 'Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review'

TN 21 (1987) Liddament, M.W. 'A review and bibliography of ventilation effectiveness - definitions, measurement, design and calculation'

TN 23 (1988) Dubrul,C. 'Inhabitants' behaviour with regard to ventilation.

TN 24 (1988) 'AIVC Measurement Techniques Workshop: Proceedings and Bibliography'

TN 25 (1989) Blacknell,J. 'A subject analysis of the AIVC's bibliographic database - AIRBASE',

TN 26 (1989) Haberda,F and Trepte,L. IEA Annex IX 'Minimum ventilation rates and measures for controlling indoor air quality.

TN 27 (1990) Bassett, M. 'Infiltration and leakage paths in single family houses. A multizone infiltration case study.'

TN 28 (1990) Sutcliffe, H. 'A guide to air change efficiency.'

TN 29 (1990) Feustel, H E, et al 'Fundamentals of the multizone air flow model - COMIS.'

TN30 (1990) Colthorpe, K 'A review of building airtightness and ventilation standards.'

TN31 (1990) Limb, M 'AIVC's fifth worldwide survey of current research into air infiltration, ventilation and indoor air quality.'

DCV (1990) Raatschen, W (ed.) Demand controlled ventilating system: state of the art review.' Annex 18 report.

TN32 (1991) Harrje DT, Piggins JT 'Reporting guidelines for the measurement of airflows and related factors in buildings.'

TN33 (1991) Liddament M W 'A review of building air flow simulation.'

AIVC CONFERENCE PROCEEDINGS

- 1st 'Instrumentation and measuring techniques',Windsor, UK, 1980.
- 2nd 'Building design for minimum air infiltration', Stockholm, Sweden, 1981.
- 3rd 'Energy efficient domestic ventilation systems for achieving acceptable indoor air quality', London, UK, 1982.
- 4th 'Air infiltration reduction in existing buildings', Elm, Switzerland, 1982.
- 5th 'The implementation and effectiveness of air infiltration standards in buildings', Reno, USA, 1984.
- 6th 'Ventilation strategies and measurement techniques', Het Meerdal Centre, Netherlands, 1985.
- 7th 'Occupant interaction with ventilation systems' Stratford-upon-Avon, UK, 1986.
- 8th 'Ventilation technology - research and application', Uberlingen, West Germany, 1987.
- 9th 'Effective Ventilation' Ghent, Belgium, 1988
- 10th 'Progress and trends in air infiltration and ventilation research' Espoo, Finland, 1989
- 11th 'Ventilation System Performance' Belgirate, Italy, 1990
- mf Proceedings of AIVC conferences numbers 1-10 are also available in microfiche form.

LITERATURE LISTS

AIVC Literature Lists are short searches on popular topics. Each list contains between ten and twenty of the latest records found in the AIVC's bibliographical database, AIRBASE. Copies of documents listed may be obtained from the AIVC library, and a more extensive search may be performed on request.

1) Pressurisation - infiltration correlation: 1. Models.
2) Pressurisation - infiltration correlation: 2. Measurements.
3) Weatherstripping windows and doors.
4) Caulks and sealants.
5) Domestic air-to-air heat exchangers.
6) Air infiltration in industrial buildings.
7) Air flow through building entrances.
8) Air infiltration in commercial buildings.
9) Air infiltration in public buildings.
10) Carbon dioxide controlled ventilation.
11) Occupancy effects on air infiltration.
12) Windbreaks and shelterbelts.
13) Air infiltration measurement techniques.
14) Roofs and attics.
15) Identification of air leakage paths.
16) Sick buildings.

*For list of participating countries see back page.

AIVC Publications - Order Form

Name...Date...

Address...

....Country..

Telephone..Fax..

Periodicals		P	NP
[ ]	Air Infiltration Review	Free	Free
[ ]	Recent Additions to AIRBASE	Free	N/A

Guides and Handbooks		P	NP
[ ]	Calculation Techniques Guide	Free	50.00
[ ]	Measurement Techniques Guide	Free	N/A
[ ]	Handbook	12.50	12.50
[ ]	Handbook (mf)	10.00	10.00

Conference Proceedings		P	NP			P	NP
[ ]	1st	microfiche*		[ ]	8th	25.00	25.00
[ ]	2nd	microfiche*		[ ]	9th	30.00	30.00
[ ]	3rd	23.50	23.50	[ ]	10th	35.00	35.00
[ ]	4th	16.00	16.00	[ ]	11th	35.00	35.00
[ ]	5th	16.00	16.00	[ ]	mf set	75.00	75.00
[ ]	6th	22.00	22.00				
[ ]	7th	25.00	25.00				

Technical Notes		P	NP			P	NP			P	NP			P	NP
[ ]	TN5	Free	10.00	[ ]	TN13	Free	20.00	[ ]	TN24	Free	20.00	[ ]	TN31	Free	N/A
[ ]	TN5.1	Free	7.50	[ ]	13.1	Free	Free	[ ]	TN25	Free	20.00	[ ]	TN32	Free	N/A
[ ]	TN5.2	microfiche*		[ ]	TN16	microfiche*		[ ]	TN26	15.00	25.00	[ ]	TN33	Free	N/A
[ ]	TN5.3	microfiche*		[ ]	TN17	Free	20.00	[ ]	TN27	Free	N/A	[ ]	DCV	12.00	12.00
[ ]	TN5.4	Free	10.00	[ ]	TN20	microfiche*		[ ]	TN28	Free	N/A				
[ ]	TN10	microfiche*		[ ]	TN21	microfiche*		[ ]	TN29	15.00	25.00	Literature Lists			
[ ]	TN11	microfiche*		[ ]	TN23	15.00	25.00	[ ]	TN30	Free	N/A	Nos			

I enclose a cheque made payable to Oscar Faber Partnership for: £.......................................drawn on a UK bank

Signed...................................Master/Visa Card No..Expiry Date...................................

* Technical Notes which are out of print and not due to be reprinted are sent in microfiche. Please state if loan preferred.

P Participating countries NP Non Participating countries mf Microfiche NB All prices are in UK pounds Sterling

Representatives and Nominated Organisations

Belgium

*P. Wouters, Belgian Building Research Institute (WTCB/CSTC), Arlon Street 53, 1040 Brussels, Belgium. Tel: 02-653-8801 Fax: 02-653-0729

P. Nusgens, Université de Liège, Laboratoire de Physique du Bâtiment, Avenue des Tilleuls 15-D1, B-4000 Liège,Belgium. Tel: 041-52-01-80 Telex: 41746 Enviro B.

Canada

*M. Riley, Buildings Group, Energy Efficiency Division, Efficiency and Alternative Energy Branch, Energy, Mines and Resources Canada, Ottawa, Ontario, K1A 0E4 Canada Tel: 613-996-8151 Telex: 0533117 Fax: 613-996-9416

*J. Shaw, Inst. for Research in Construction, National Research Council, Ottawa, Ontario, Canada K1A 0R6 Tel: 613-993-1421 Telex: 0533145 Fax: 613 954 3733

J.H. White, Research Division, Canada Mortgage and Housing Corporation, Montreal Road, National Office, Ottawa, Ontario, Canada K1A 0P7 Tel: 613-748-2309 Telex: 052/3674 Fax: 613 748 6192

Denmark

*O. Jensen, Danish Building Research Institute, P.O. Box 119, DK 2970 Hørsholm, Denmark. Tel: 45-42-865533 Fax: 45-42-867535

P.F. Collet, Technological Institute, Byggeteknik, Post Box 141, Gregersensvej, DK 2639 Tastrup, Denmark. Tel: 42-996611 Telex: 33416 Fax: 45-42-995436

Finland

*R. Kohonen, Technical Research Centre of Finland, Laboratory of Heating and Ventilation, Lämpömiehenkuja 3, PO Box 206, SF-02151 Espoo 15, Finland. Tel: 358- 0-4561 Telex: 122972 Fax: 358-0-4552408

France

J L Plazy, AFME, Route des Lucioles, 06560 Valbonne Cedex, France Tel: 33 93 95 79 00 Fax: 33 93 65 31 96

D. Bienfait, CSTB, 84 Ave. Jean Jaurès, BP 02 Champs sur Marne, 77421 Marne la Vallée, Cedex 2, France Tel: (33-1) 64 68 83 13 Fax: (33-1) 64 68 83 50

Germany

*Prof. Dr.-Ing. F. Steimle, Fachinstitut Gebäude-Klima, Danziger Strasse 20, 7120 Bietigheim-Bissingen, Germany Tel: 071 42/54498 Fax: 071 42/61298 Telex: 7264754 fgk

J. Gehrmann, Projektträger Biologie, Energie, Okologie in der KFA Jülich GmbH, Postfach 1913, D-5170, Jülich, Germany Tel: 02461/614852

G Mertz, Fachinstitut Gebäude Klima, Danziger Strasse 20, 7120 Bietigheim-Bissingen, Germany Tel: (49) 7142 54598 Fax: (49) 7142 61298

Italy

*M. Masoero, Dipartimento di Energetica, Politecnico di Torino, C.so Duca delgi Abruzzi 24, 10129 Torino, Italy. Tel: (39-11) 556 7441 Telex: 220646 POLITO Fax: 39 11 556 7499

Netherlands

*W.F. de Gids, TNO Building and Construction Research, Dept of Indoor Environment, Building Physics and Systems, P.O. Box 29, 2600 AA Delft, Netherlands, Tel: +31 15 608608 (Direct: +31 15-608472) Fax: +31 15-608432

New Zealand

*M. Bassett, Building Research Association of New Zealand Inc (BRANZ), Private Bag, Porirua, New Zealand. Tel: 64-357600 Fax: 64 4 356070

Norway

*J.T. Brunsell, Norwegian Building Research Institute, Box 322, Blindern, N-0314 Oslo 3, Norway. Tel: 02-46-98-80 Fax: +47-2-699438

H.M. Mathisen, SINTEF,Division of App Thermodynamics, N-7034 Trondheim, Norway. Tel: 07-593870 Telex: 056-55620

Sweden

*J. Kronvall, Lund University, P.O. Box 118, S-22100 Lund, Sweden.Tel: 46 107000 Telex: 33533 Fax: 46 10 47 19

A. Logdberg, Swedish Council for Building Research, Sankt Goransgatan 66, S-112 33, Stockholm, Sweden Tel: 08-6177300 Fax: 08-537462

Switzerland

*P. Hartmann, EMPA, Section 175, Ueberlandstrasse, CH 8600 Dübendorf, Switzerland. Tel: 01-823-4175 Telex: 825345 Fax: 01-821-6244

UK

S. Irving (Operating Agent), Oscar Faber Consulting Engineers, Marlborough House, Upper Marlborough Road, St. Albans, Herts, AL1 3UT, Great Britain. Tel: +44(0)81-7845784 Telex: 889072 Fax: +44(0)81-7845700

*MDAES Perera, Environmental Systems Division, Building Research Establishment, Garston, Watford, WD2 7JR , UK Tel: +44(0)923 664486 Telex: 923220 Fax: +44(0)923 664010

M. Trim, Building Research Energy Conservation Support Unit (BRECSU), Building Research Establishment, Bucknalls Lane, Garston, Watford, Herts, WD2 7JR, Great Britain. Tel: +44(0)923 894040 Telex: 923220 Fax: (0)923-664010

P.J.J. Jackman, BSRIA, Old Bracknell Lane West, Bracknell, Berks, RG12 4AH, Great Britain. Tel: (0)344-426511 Telex: 848288

USA

*M. Sherman, Indoor Air Quality Division, Building 90, Room 3074, Lawrence Berkeley Laboratory, Berkeley, California 94720, USA. Tel: 415/486-4022 Telex: 910-366-2037 Fax: 415 486 5172 e-mail:MHSherman@lbl.gov

A. Persily, Building Environment Division, Center for Building Technology, Building 226, Room A313, National Institute for Standards and Technology, Gaithersburg MD 20899, USA. Tel: 301/975-6413 Fax: 301/975-4032

J. Talbot, Department of Energy, Buildings Division, Mail Stop Ce-131, 1000 Independence Avenue S.W., Washington D.C. 20585, USA. Tel: 202/586 9445 Telex: 710 822 0176 Fax: 202 586 4529/8134

*Steering Group Member

AIVC

Head of Centre Martin W Liddament

Published by

Air Infiltration and Ventilation Centre
University of Warwick Science Park
Barclays Venture Centre
Sir William Lyons Road
Coventry CV4 7EZ, UK

Telephone: +44(0)203 692050
Fax: +44(0)203 416306

Operating agent for IEA Oscar Faber Consulting Engineers, UK