OPTIMUM VENTILATION AND AIR FLOW CONTROL IN BUILDINGS

17th AIVC Conference, Gothenburg, Sweden, 17-20 September, 1996

FRENCH VENTILATION SYSTEM PERFORMANCES IN RESIDENTIAL BUILDINGS

Jean-Robert Millet, Jean Georges Villenave, Jacques Riberon

Centre Scientifique et Technique du Bâtiment (CSTB), Marne La Vallée, France

FRENCH VENTILATION SYSTEM PERFORMANCES IN RESIDENTIAL BUILDINGS

Jean-Robert MILLET, Jean Georges VILLENAVE, Jacques RIBERON

Centre Scientifique et Technique du Bâtiment (CSTB), Marne la Vallée, France

ABSTRACT

The comparison of the performances of ventilation systems must take into account different issues. For indoor air quality, different kinds of pollutant sources have to be defined. To make an evaluation of the results, the best approach is to consider the people exposure. Four generic pollutants are taken into account : rooms components or furniture, human metabolism, cooking activities, passive smoking. As the definition of the unit for each pollutant is free, it is useful for their comparison to press them on a common "normalised" basis. This enables to make a distinction between the simulations based on generic pollutants and their interpretation which could be derived for many kinds of pollutants without having to do additional calculations as far as the considered pollutant follows the conventional patterns. The pressure difference , for example can be related to radon issues as to running of some heat appliances. The room parameters are mainly related to humidity issues as condensation, mould growth or house dust mites. For energy issues, a distinction has to be made between the direct energy use (fans) and the heat needs due to ventilation.

Such a methodology has been defined within the IEA annex 27 project. After a presentation of the different parameters taken into account, we describe the computer code SIREN95 developed at CSTB in order to obtain the required results and we present a sensitivity analysis for the basic ventilation system used in France (mechanical exhaust).

1. - INTRODUCTION

A methodology to compare the performances of ventilation systems has been defined within the IEA annex 27 project.

After a presentation of the different parameters taken into account, we describe the computer code SIREN95 developed at CSTB in order to obtain the required results and we present a sensitivity analysis for the basic ventilation system used in France (mechanical exhaust).

2. - PRESENTATION OF THE STUDIED PARAMETERS

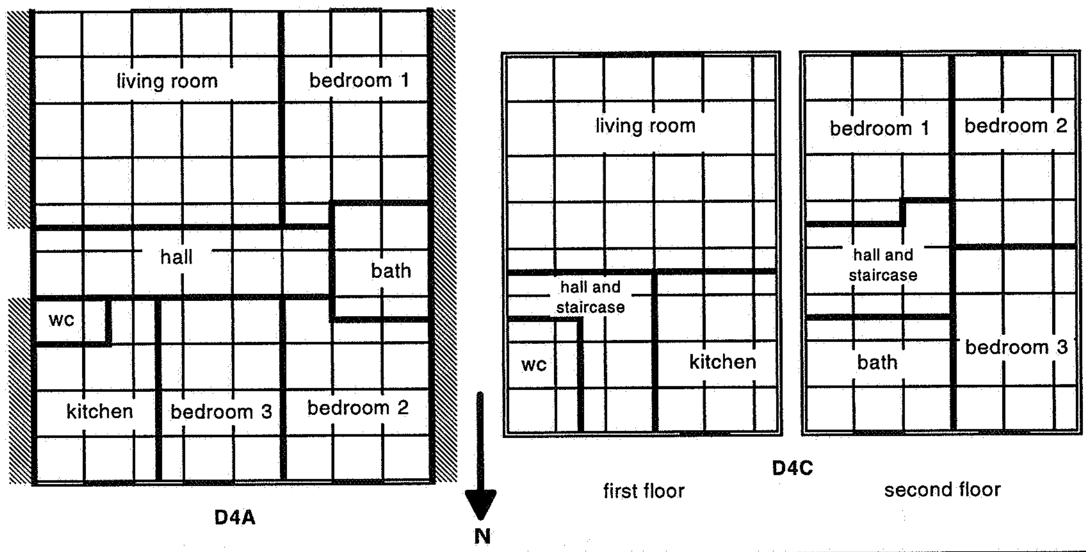
In the IEA annex 27 project ventilation systems are study : 9 dwellings (3 plans and 3 airthightness), 3 occupancy (spacious, average, crowded), 3 climates (cold, mild, warm). [1]

Results are given in term of indoor air quality (pollutant exposure for each inhabitant) and energy.

2.1 - DWELLINGS

Three dwellings are considered :
- D4A : flat located on ground floor in a four storey building.
- D4A : flat located on top floor in a four storey building.
- D4C : single family house (detached)

Plan of the dwellings (1 square = 1 m²)



Leakage values are given in the table hereafter :

	n50 (ach)			
D4A	1	2.5	5	*0.46*
D4C	2.5	5	10	*0.67*

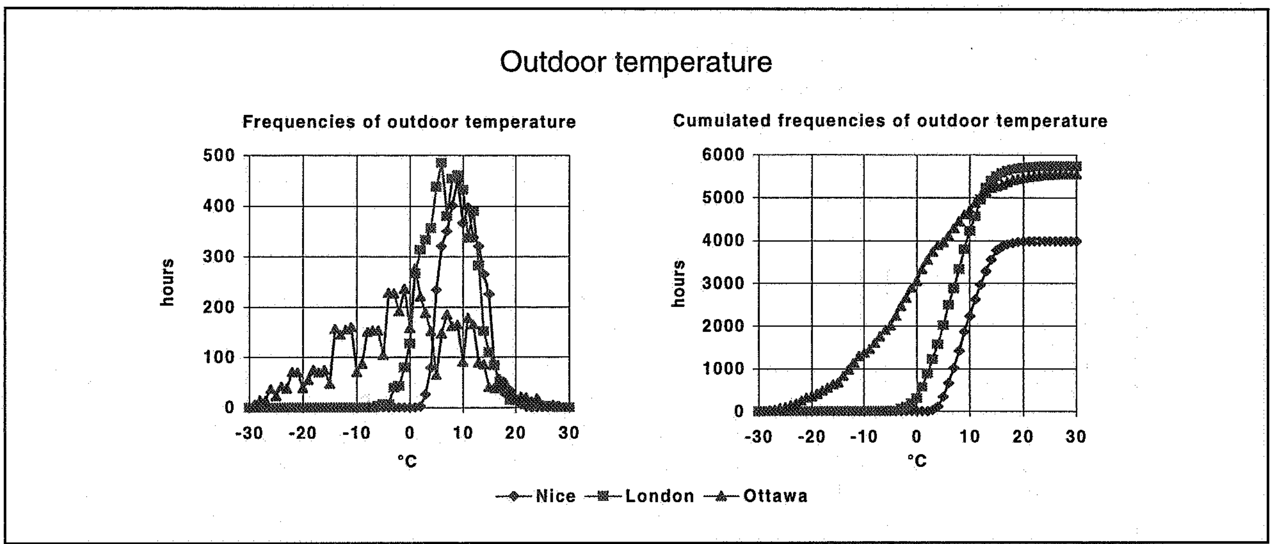
The values in italic are those given by the French standard for design and dimensioning the mechanical extract ventilation systems (they correspond to 40 m^3/h under 20 pascals for the flat and to 75 m^3/h under 20 pascals for the detached house) : these values are not take into account in the annex27 assumptions.

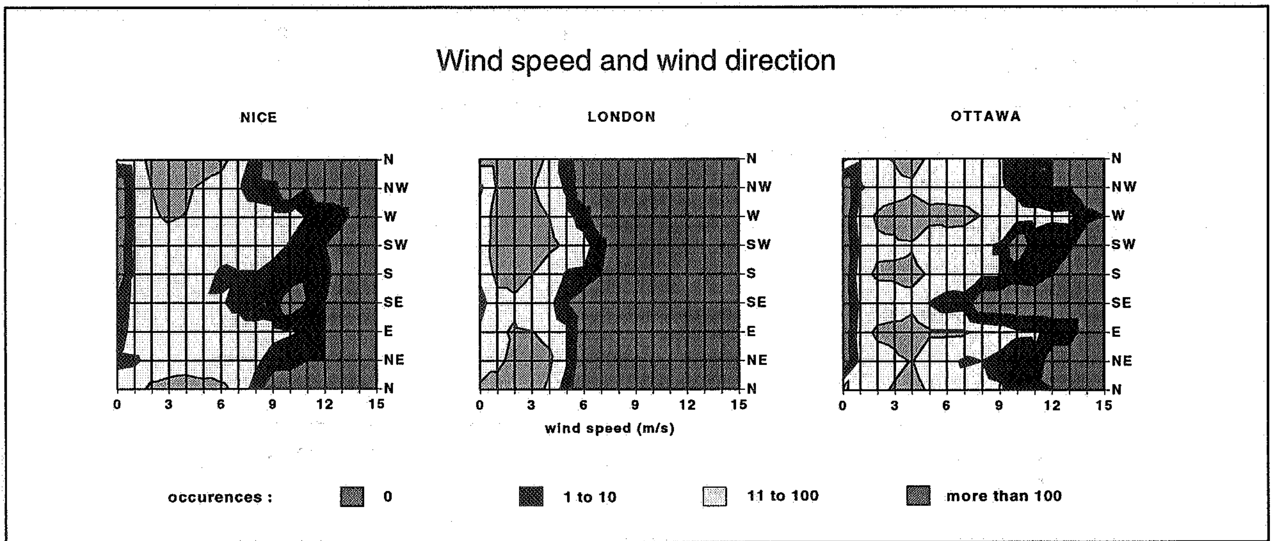
Half of the cracks are located at 0.625 m from the floor and the other half 1.875 m from the floor for the leakage 1 , 2.5 and 5 . For leakage 10 the additional cracks are located at the floor and at the ceiling.

2.2 - CLIMATES

The climates are related to meteorological data from :
- cold : Ottawa (heating season from 2nd of october to 20th of may).
- mild : London (heating season from 24th of september to 20th of may).
- warm : Nice (heating season from 13th of november to 27th of april).

The charts hereafter give frequencies of outdoor temperature and wind speed and direction for this three climates.





2.4 - INDOOR AIR QUALITY FOR PEOPLE

Definition of generic pollutants : For the study of a pollutant source, it can be noticed that the main important point for comparison is the pattern of its production (level versus time and place), whatever this pollutant is . Therefore it is possible to define some generic pollutants which will be defined only by their pattern. For human feeling and health we propose at first to base the comparisons on 5 main generic pollutants :

- Plt1 : this pollutant is based on a constant emission related to the room area. It could be related to pollutant emission by the rooms themselves.
- Plt2 : this pollutant is related to the human metabolism. It is based on the CO2 production.
- Plt3 : this pollutant is related to the cooking activities. It is proportional to the water evaporated during cooking and could be related to odours production, as to CO or NOx production in case of gas appliance.
- Plt4 : this pollutant is related to passive smoking . It is based on a constant production of pollutant for the hours and place when and where people are smoking.

- Indoor humidity : this one is here only related to the dryness feeling. It is not a generic pollutant as it can be expressed directly in terms of indoor relative humidity.

Results :It is possible, for each inhabitant, to give the curve of the number of hours above a pollutant level concentration Ci : Nh (Ci). These results can also be given in a condensed form based on the calculation of the cumulated value above a threshold limit Cimax. For CO_2 the limits are 0.7 and 1.4 (in 1000 ppm) : the condensed output are expressed in ppm.h above this 2 levels. In this paper we give only results for CO_2 (1400 ppm).

2.3 - OCCUPANCY AND POLLUTANT PRODUCTION

A weekly schedule of the dwelling occupancy has be defined by IEA annex 27 [1].

The CO_2 concentration inside rooms is calculated taking into account pollutants production due to occupation, air renewal due to ventilation system operation and CO_2 outside concentration. The CO_2 outside concentration is assumed as 350 ppm.

The production of pollutants by occupants metabolism is :

		CO_2 (l/(h*p)	H_2O (g/(h*p)
Adult ≥ 15 years	awake sleeping	18 12	55 30
Children 10 and 13 years	awake sleeping	12 8	45 15
Child 2 years	awake sleeping	8 4	30 10

The production of pollutants by occupants activities is :

Cooking g/h by person present at home			Shower g/person	Smoking
breakfast	lunch	dinner		
50	150	300	300	20 U4/h in the living when woman is present between 13 - 24 o'clock

2.5 - ENERGY NEEDS

The energy needs must be split into heat needs and electrical needs for fan.

The heat needs can be calculated knowing the air flows to the outdoor and the temperature difference between outdoor and indoor. The air flows can be separated into 3 parts :

- air exhausted by the ventilation system,
- air exfiltred through the envelope,
- airing (by opening windows : not studied in this paper).

The average air flow and air change per hour are the direct averages during the heating season of the overall air dwelling air flow. Nevertheless, it is not of direct interest as it is neither related to indoor air quality nor to heating needs. For example with the same average air flow, the heat needs will be increased if the ventilation in winter is higher (passive stack systems) and decreased if the ventilation is lower (humidity controlled systems).

Focusing on a single way to express the heat needs efficiency independently of the climate conditions, it is better to calculate heat needs equivalent air flow rate and air change rate which are the constant air flow (or air change rate) which would lead to the same heat needs as the ones calculated. It is simply calculated by :

$$Qave = \frac{\int 0.34 \times Q(t) \times (Ti - Te(t)) \times dt}{\int 0.34 \times (Ti - Te(t)) \times dt}$$

The electrical needs will be calculated on the whole year if this corresponds to the system running.
The power is considered to be 40 W for a dwelling : the annual consumption is 350 kWh.

3. - THE COMPUTER CODE *SIREN95*

The computer code SIREN95 is an evolution SIREN ("SImulation du RENouvellement d'air") developed in C.S.T.B [2]. It is used to calculate the air flow throughout the entire heating season (about seven months) in a dwelling. The code uses hourly meteorological data (temperature, relative humidity, wind speed and orientation) ; occupancy and pollutants production (CO_2 and H_2O) are defined with an half an hour step. Each component (air inlets, outlets, cracks, fans, windows, ...) is characterised by its flow rate curve as a function of the pressure difference and also when relevant, of the temperature or relative humidity. Pollutants and humidity concentrations are assumed to be uniform in each room.

In SIREN95 (unlike SIREN) internal pressures are assumed an hydrostatic field ; the inside temperature is considered to be constant in an horizontal plane (only vertical gradient : stack effect is taken into account). The calculation procedure has been changed : now the curves of components can be given by functions (not necessary smooth) or tables : a possible hysteresis is taken into account.

4. - RESULTS FOR THE BASIC SYSTEM USED IN FRANCE

The French mechanical extract system has been described otherwise [3], [4] ; is a permanent extract system, with self regulated inlets in each habitable rooms and outlets in each service rooms : the flows values (for a 4 principal rooms dwelling) are given hereafter :

	living room	bedroom	kitchen	bathroom	toilets
inlets (m3/h under 20 Pa)	45	30	/	/	/
outlet (m3/h)	/	/	45 (120 at cooking)	30	30

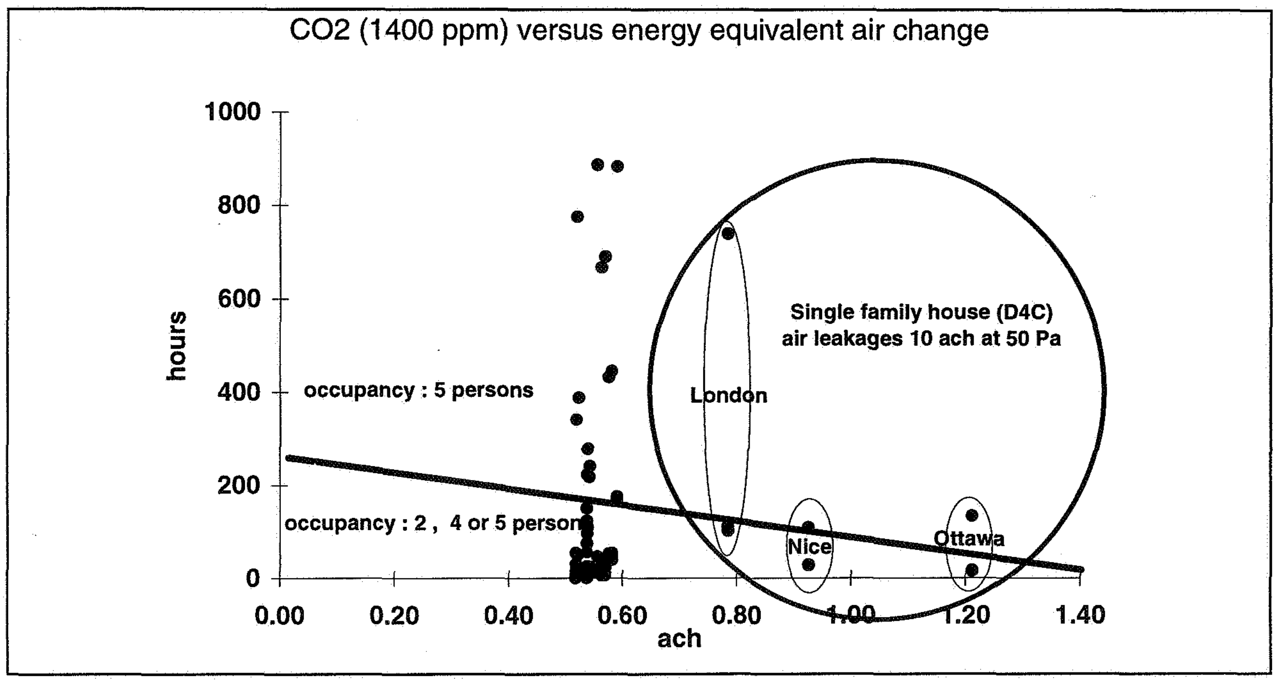
Results show that the equivalent air change rate is little dependant of the air leakages, except for the single family house when air leakages are 10 ach under 50 pascals (circle on the chart).

Air quality (CO2 based) depends on :

- occupancy (all the better since occupancy is low),

- climate (depends on the length of the heating season and on windspeed and wind direction)

- air leakages.



Energy :

	Ottawa	London	Nice
Fans (kWh)	350	350	350
Heat losses (kWh) for 0.55 air change	4470	2690	1470
Total (kWh)	4820	3040	1820
Part of fans consumption (%)	7.3	11.5	19.2

REFERENCES

[1] IEA Annex 27 "Assumptions for the simulations"

[2] Villenave JG, Millet JR, Ribéron J "Theoretical basis for assessment of air quality and heat losses for domestic ventilation systems in France". 14th AIVC conference on Energy Impact of Ventilation and Air Infiltration, Copenhagen, September 1993.

[3] Ribéron J, Millet JR, Villenave JG. "Assessment of energy impact of ventilation and infiltration in the French regulations for residential buildings". 14th AIVC conference on Energy Impact of Ventilation and Air Infiltration, Copenhagen, September 1993.

[4] Villenave JG, Ribéron J, Millet JR, "French Ventilation in dwellings", Air Infiltration Review, vol. 14, n°4, pp 12-15, September 1993.

ACKNOWLEDGEMENTS

The authors wish to thank the ADEME, EDF and GDF for her financial support.