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QUALITY ASSESSMENT OF VENTILATION TECHNIQUES IN RESIDENTAIL BUILDINGS

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ABSTRACT

Many different ventilation techniques (mechanical, natural, pollutant controlled,...) are used for ventilation of residential buildings.

In most cases, ventilation rates are highly fluctuating and one cannot rely on the usual requirement (minimum ventilation rates in each room) to assess the system efficiency.

More basic acceptance criteria should therefore be enforced.

A proposed method is to use a computer code in order to calculate, over a one year period, pollutant concentration, heat losses and condensation hazards in each room. Results are highly dependent on the choice of hypothesis (for instance : wind pattern, building shell air permeability, moisture production,...) whose variability must therefore be taken into account.

Other criteria such as noise level, fire transmission hazard, air draughts prevention, are also reviewied.

1 - INTRODUCTION.

Ventilation of residential buildings may be achieved according a wide range of different techniques, among them natural ventilation using vertical shafts (fig. 1), mechanical ventilation systems (fig. 2) and many other techniques.

These systems are designed to ensure both a sufficient level of air quality and good operating conditions, which include low energy consumption.

Quality assessment of these various systems is an important issue because it may ease the development of more efficient systems.

This paper is intended to propose some guidelines for the identification of acceptance criteria.

2 - EFFICIENCY ASSESSMENT.

The efficiency of a ventilation system may be defined as the capability of this system to ensure an acceptable air quality level (i.e : mean pollutant concentration in the air, condensation hasards,...) with as low energy consumption as possible.

It is well known that for some kinds of systems, for instance natural ventilation or humidity controlled systems, the air change is highly varying against time.

Fig. 3 depicts a typical distribution of exhaust flowrates in a natural ventilation system.

It is easily understandable that in this case the variations in air change does not improve the over the year efficiency. Actually, the best efficiency would have been achieved with systems providing low exhaust flowrates when outdoor temperature is low, which is exactly the opposite of natural ventilation systems.

An efficiency assessment method should therefore tend to take into account these phenomena.

It is felt that the only way to evaluate the efficiency is to calculate over the heating season a mean value of pollutant concentration and condensation hasards.

This work may be completed, provided reliable computer models with realistic hypothesis and assessment criteria are avalaible :

Computer models.

Computer models must take into account all the driving forces that influence air movement : thermal differences, wind velocity, fans,...

Moisture transfer in the walls and furniture have also to be computed.

Taking properly into account all this phenomena requires an important effort in model development.

As an example, fig. 4 and 5 show how the air movement may be dependent upon wind velocity fluctuations.

Hypothesis.

Calculations require choice of hypothesis regarding for instance moisture production (fig. 7), moisture capacity of the furniture, wind pressure coefficients, air leakage distribution throughout the building shell.

An important difficulty is that calculation results are highly dependent on the choice of hypothesis (see for instance fig. 6). Realstic hypothesis have therefore to be carefully defined.

Assessment criteria.

Proposed assessment criteria would be the following :

- evaluation of the mean percentage of time during which there is a chance of condensation in each room,

- calculation of the total quantity of pollutants breathed by the occupants over a one year period.

3 - OTHER CRITERIA.

Taking into account such major issues as air quality and heat losses must not let forget other important requirements, for instance phonic protection, fire safety or reliability.

Meeting these requirements makes it necessary to select appropriate components, to properly design and realize the installation, and, ultimately, to control it :

a) Choice of components.

Flowrate curve as well as acoustic characteristics (i.e : sound transmission between dwellings and noise generated by the exhaust vent itself) must be known in order to allow an appropriate sizing of the system.

When advanced components (for instance self regulated vents or humidity controlled systems) are used, more attention should be paid to quality problems. For instance it must be ensured that the sensors reponse time is not too important and fabrication control procedures should be implemented in order to guarantee a sufficient steadiness of characteristics.

. Other requirements are the following :

- components must be easily dismountable in order to cope with fouling problems, and their reliability with respect to aging and shock resistance must be sufficient,

- air inlets and supply vents must be properly designed in order to prevent disturbances due to cold air draughts.

Test methods do exist but still have to be improved in order to yield an easier qualification of components performance.

b) Installation design.

- provisions must be taken in order to prevent odour transmission from the kitchen to other rooms due to the cross ventilation. A solution to limit odour transmission is to allow great enough a peak flowrate (i.e : in the range of 150 m^3/h) in the kitchen, and not to use air inlets in the kitchen itself.

- **fire hasards :**

  in multifamily houses, smoke transmission between dwellings should a fire occur, must be prevented : a solution is to design the ventilation network so that most of the smoke goes outwards, even in case of fan failure due to temperature.

- **unvented gas appliances :**

  air renewal inside each room and particularly the kitchen must be calculated so that the air flowrate is always greater than the flowrate required for correct operation of the gas appliance.

- **Flue shaft :**

  when flue shaft (for instance vented gas appliances or chimney) are present in the dwelling, provisions must be taken to prevent reverse flow.

- **Pressure :**

  the pressure of the dwelling must be limited to a figure in the range of 10 or 20 Pa.

c) Installation realization.

Provisions must be taken in order to :

- ensure airtightness of ducts,

- prevent too important pressure drops, especially in bends when flexible ducts are used,

- prevent water condensation and stagnation in horizontal parts,

- prevent sound transmission between dwellings because of poor acoustic insulation at the floor crossing by vertical ducts.

d) Installation control.

Installation must be controlled in order to check they were properly realized :

- flowrates or pressure head should be controlled,
- noise level should be measured,
- ducts airtightness should be checked.

4 - CONCLUSIONS.

Basic acceptance criteria should be enforced in order to make it possible to compare the efficiency of whatever kind of ventilation strategy. These criteria must primarily take into account condensation and air quality problems. Their enforcement still requires progress in building physics knowledge and modelization.

Implementation of standards, codes of practice and control procedures is a prerequisite for achievement of quality.

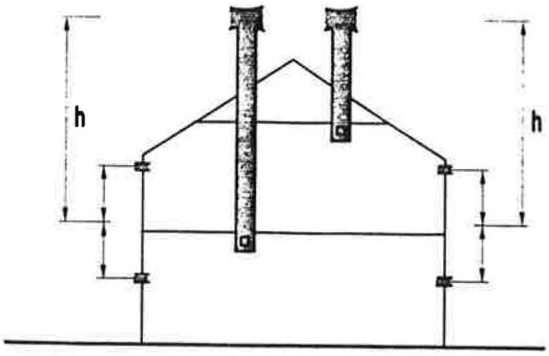

Fig. 1 : Scheme of a natural ventilation system in single family dwelling

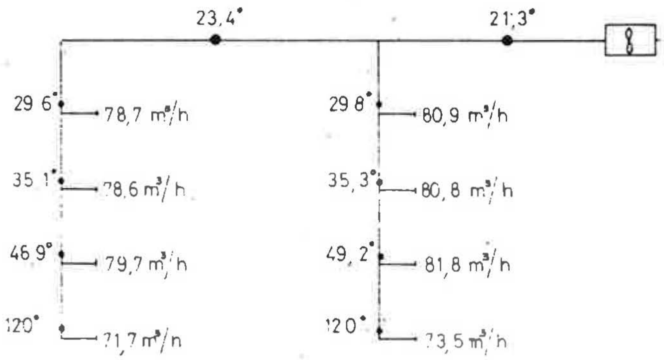

Fig 2 : scheme of a mechanical exhaust ventilation network in a multi-family dwelling

Computed flowrates values are given ; They vary according to pressure drop in ducts and buoyancy effects.

In this example gas heater appliances are linked to the exhaust netword.

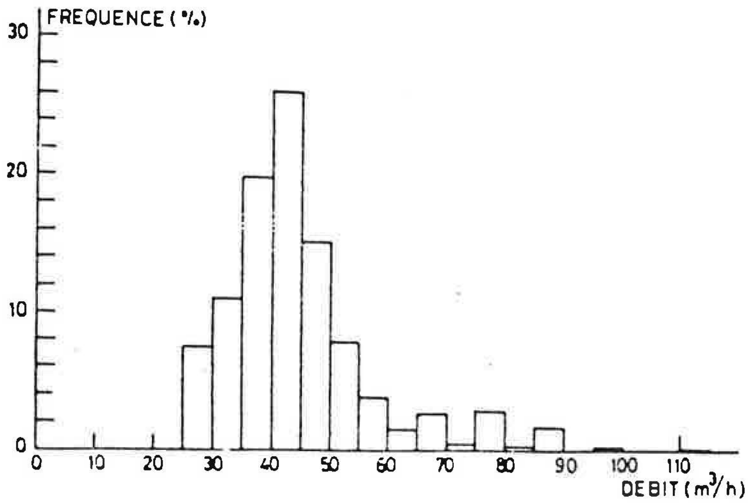

Fig 3 : Distribution of exhaust flowrate during the heating season in a natural ventilation system with vertical shaft (computed values).

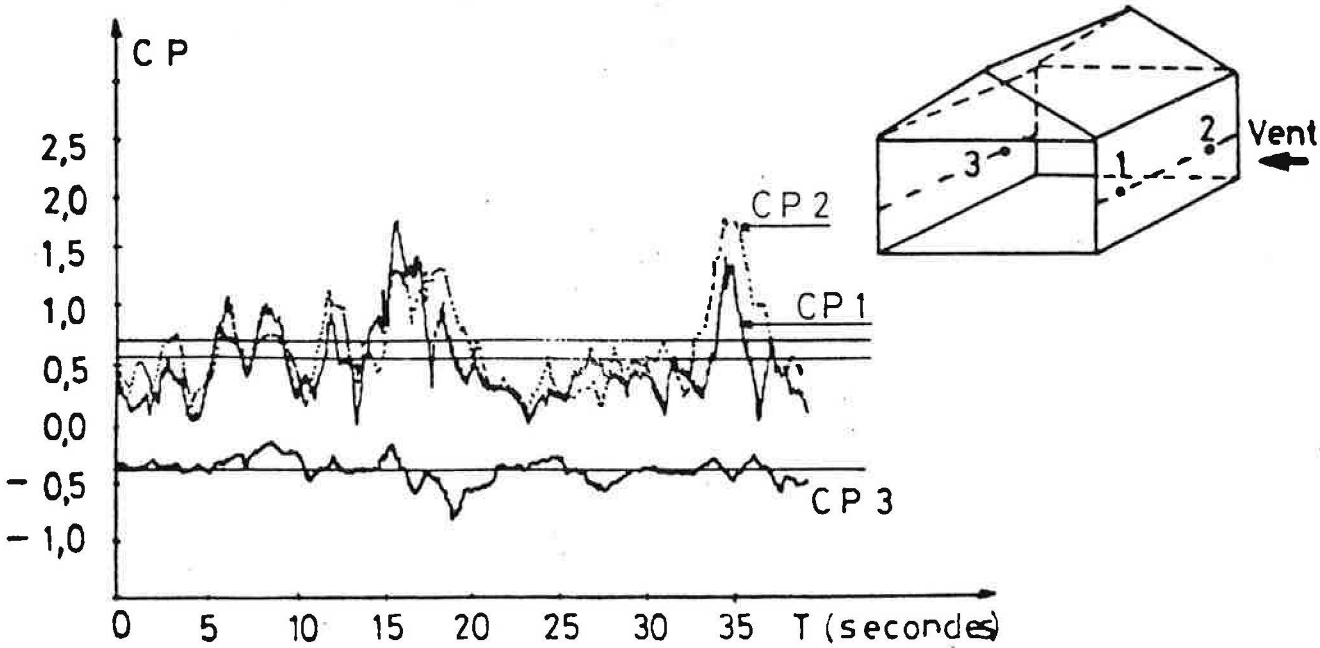

Fig 4 : Measured values of wind pressure coefficient versus time.

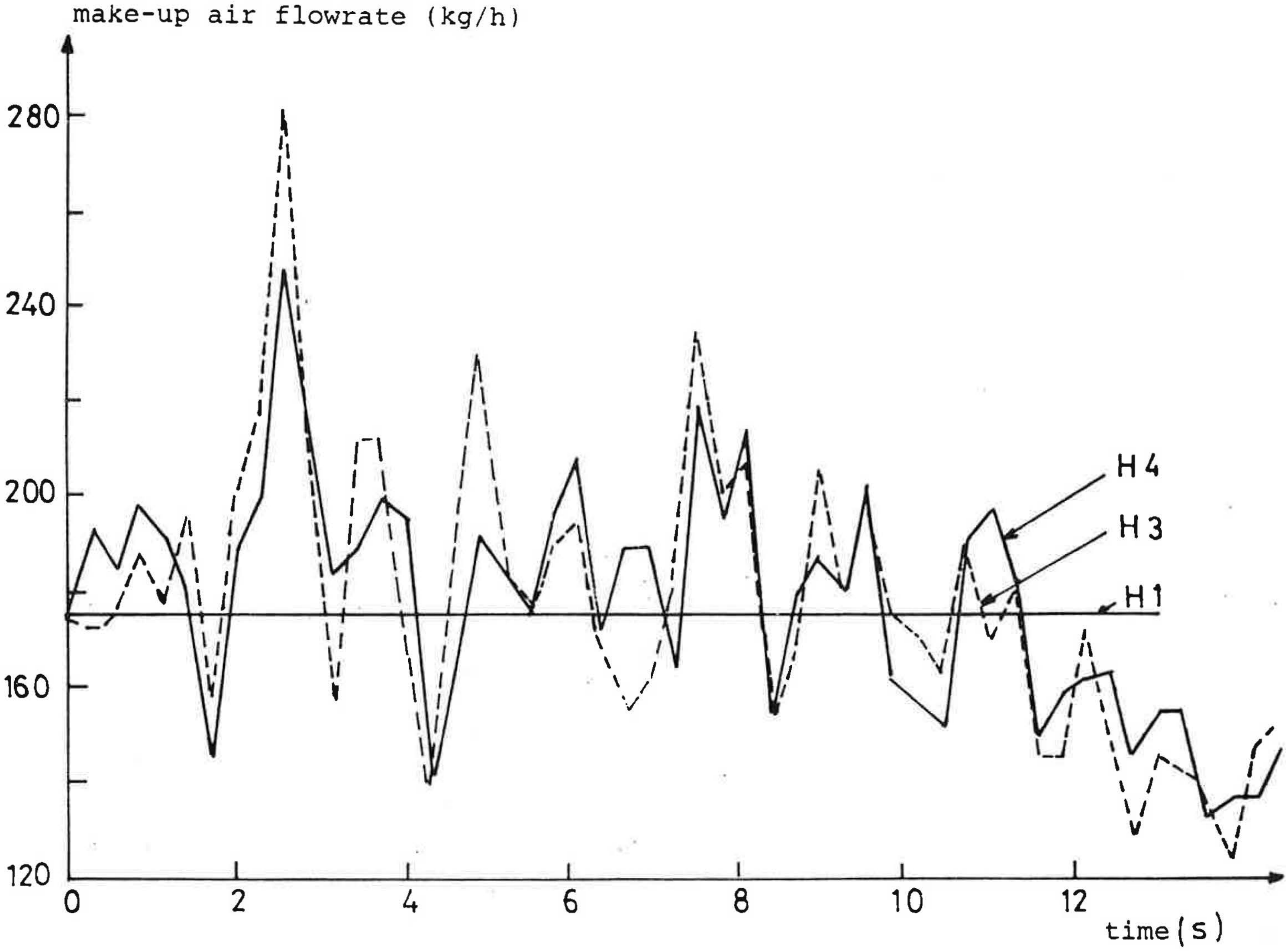

Fig 5 : Computed values of make up air flowrate in a two-cell building with air inlets according to different hypotheses :

H1 : wind pressure fluctuations are not taken into account
H3 : wind pressure fluctuations are taken into account
H4 : wind pressure fluctuations and air compressibility are taken into account.

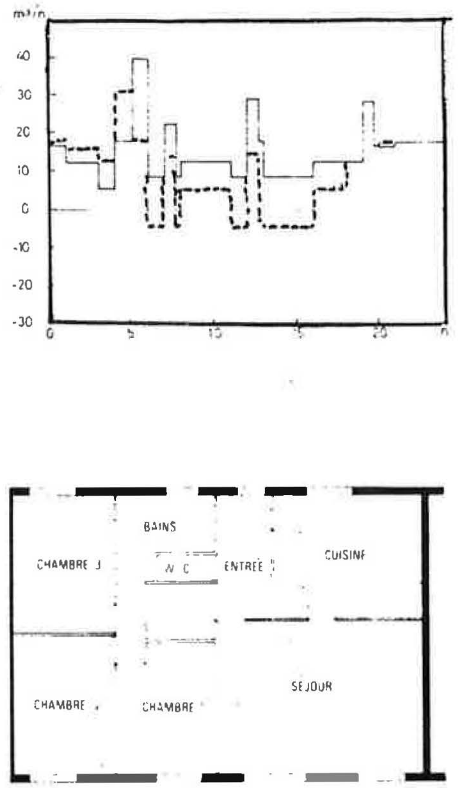

Fig 6 : Sensitivity of air movements to environmental conditions.

Air movement inside a dwelling are very much dependent upon the environment (meteorological conditions, air leakage distribution of the building shell, building orientation,...).

This figure shows the air renewal computed value versus time in bedroom n° 1 according two different hypotheses :

- plain line : southward orientation of building
- dotted line : orientation of building is SWW.

	Bedroom n° 1	other bedrooms	living-room	kitchen	bathroom
06	84(*)	42(*)			30(*)
07	42	42		42	30
08				384	630
12			21		30
13				684	30
17			21		30
18			42		30
19			42	142	30
20			100	968	430
22	42		84	42	30
23	42	42	42		30
24	84	42			30
Total :	756 g	378 g	562 g	2 304 g	1 720 g

(*) each hour between 0 and 6

Fig 7 : Proposed values for moisture production pattern inside a dwelling during a 24 hours period.