DDD ENEA/CVA 01-108C

AIVC 22nd Annual Conference
Market Opportunities for Advanced Ventilation Technology
11th - 14th September 2001
Bath, United Kingdom

Ventilation in the new French thermal regulation RT 2000

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SYNOPSIS

Ventilation plays an important role in the RT 2000 regulation. This new French thermal regulation takes into account energy for heating and lighting through a C coefficient (primary energy in kWh), as well as summer comfort for non air-conditioned buildings.

The paper focuses on the calculation of the C Coefficient. For the ventilation side of it, the calculation method aims both to have simple input data and physically based algorithms. The fact that it was chosen to have a computer based approach made this possible.

The algorithms are based on an implicit method as the TC 156 WG2 (prEN 13465) extended to non-residential buildings. Different ventilation or airing system can be taken, into account, based on the possibilities offered by the hygienic regulation:

Mechanical system and passive duct systems for residential building (additional window airing is also considered),

Windows opening, mechanical system in non-residential building (passive duct is also possible but the algorithms focuses on the use for residential buildings).

For each situation of climate and system behaviour the implicit method calculates the different airflows through the ventilation system and the building envelope in a first step and the energy impact in a second step. The paper describes the physical basis of the method and it uses in the RT 2000 approach, and gives some examples of results.

KEYWORDS

ventilation system, energy needs, ventilation heat losses, ventilation codes,

INTRODUCTION

The ventilation efficiency is part of the new French thermal regulation (RT2000). Both building airtitghness and ventilation system characteristics and running are taken into account.

The paper describes the general principles of the RT2000, and focuses afterwards on its.

1 THE RT 2000 ENERGY REGULATION

This new regulation aims to improve the energy efficiency and the summer comfort of new buildings. It is based basically on 3 items :

1. The respect of "minimum" values for building and components characteristics (for example a maximum value of U coefficient is stipulated for windows)
2. The C coefficient (primary energy in kWh/year) must be less or equal to a Cref coefficient. C and Cref are calculated with a computer tool. Cref is obtained by replacing in the building under consideration the planned components by reference ones. The references are defined in the law (arrêté du 29 Novembre 2000). The C and Cref coefficients are calculated according to the Th C calculation method, which is also part of the law. When a building component has no reference value, the planned characteristic is maintained for the Cref calculation. For some cases, it is possible to apply default values.

3. The Tic calculation (maximum operative temperature in summer for a reference day) follows the same logic as the C calculation. Tic and Tic ref are calculated by a computer tool according to the Th-E algorithms. Reference values mainly focuses on the window solar protection. This part rely also on ventilation (window or mechanical) but is not described in this paper.

2 THE C COEFFICIENT

The C coefficient is a conventional primary energy index, based on European standards for its calculation. The heat needs are calculated on a monthly basis taking into account different energy sources. For fossil ones, a conversion to primary energy of 1 is used and for electricity of 2.58. District heating and renewable energies are also taken into account.

For air conditioned buildings, only heating is taken into account at the present time. Works are in progress to build a specific regulation within two years, in order to calculate and regulate both heating and cooling needs.

For non residential buildings, electrical lighting is also part of the C and Cref coefficient.

Some principles used for the elaboration of this new regulation can be mentioned :

- It must be possible to verify the buildings and system characteristics or behaviours. All other parameters (for example occupancy schedules) are described as conventional values.
- The Th C and Th E algorithms are based as much as possible on building physics.
- The calculation method is the same for residential and non residential buildings is the same, but some reference values can differ.
- The basis of the approach is to compare the actual and the corresponding reference building. The most important point is then to focus on the relative impact (difference between C and Cref) more than on the absolute value of C and Cref. This enables to make some simplifications. For example for the heat needs calculation, France is described by 3 climatic areas H1,H2 and H3 from north to south.

3 THE VENTILATION PART OF THE C COEFFICIENT

According to the general framework of the C Coefficient, the ventilation part provides input to the C calculation at four levels :

1. Static heat losses Hv (W/K), added to the building envelope heat losses,
2. Internal gains,
3. Fan energy consumption,
4. Air preheating needs.

The calculation is based on a 2 step approach :

1. Calculation of the airflows,

2. Calculation of the heat needs and direct energy impact.

3.1 AIR FLOW CALCULATION

The building airflows calculation first focus on the ventilation system airflows calculation and in a second time to the building envelope airflows (air flows through vents, infiltration and exfiltration through air leakages).

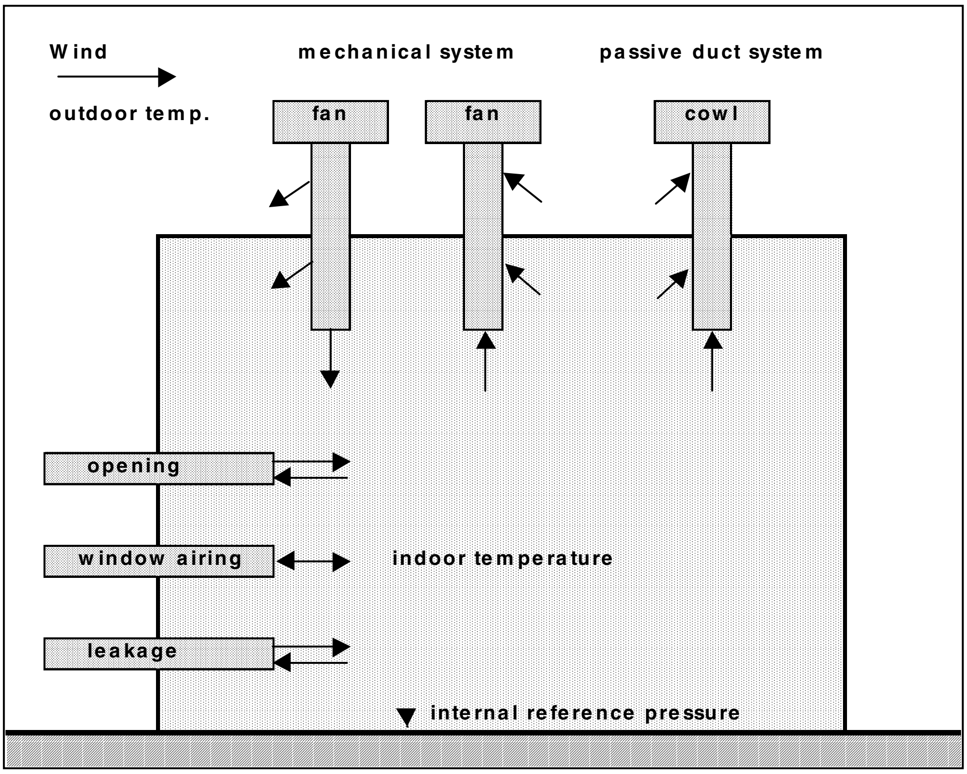

figure 1 main components and parameters for air flow calculation

3.1.1 Ventilation system

The ventilation system description starts of course form the fresh air to provide to habitable rooms or the extract air from service rooms as stipulated by the sanitary regulation (which is not part of the RT2000).

Nevertheless, the sanitary airflows must be corrected according 2 phenomenas :

- The inaccuracy of the ventilation components characteristics and system design : For example to extract 100 m^3/h in a kitchen (which is a minimum value) The actual extract flow will be higher (for example the French certification defines a mechanical outlet by an airflows ranging from the minimum to a value 30 % higher, and provides acceptable pressure differences corresponding to these values. This it taken into account by a Cd coefficient which multiply the sanitary flows. Cd can vary depending on the component and system characteristics . A default value of 1.3 can be applied.

- The duct air leakages : This phenomena corresponds to air supplied to or extract from the building but not directly to and from the rooms. The duct leakages can be characterised by a K coefficient. In practice, the actual air losses are also the result of the duct area and the pressure in the duct. These values are seldom known at the moment the C coefficient is calculated. Default values are therefore taken into account. The air leakages are taken into account through a Cfr coefficient (air losses) based only on the K coefficient. The reference value (Cfr=1)corresponds to an air leakage of 6 % of the supply or air extract airflow. The range vary from 0 (ideal case of no air leakages) to 15 % (default value for high pressure ducts).

ducts	**Class**	**K_{res} ($m^3/(s.m^2)$ under 1 Pa)**	**C_{fr} (-)**
Low pressure(< 20 Pa)	A	0,027 10^{-3}	1/3
	B	0,009 10^{-3}	1/9
	C	0,003 10^{-3}	1/27
	Default value	0,0675 10^{-3}	0,833
Other cases	A	0,027 10^{-3}	1
	B	0,009 10^{-3}	1/3
	C	0,003 10^{-3}	1/9
	Default value	0,0675 10^{-3}	2,5

Table 1 : examples of Cfr for mechanical ventilation systems

These points can be directly taken into account for mechanical system.

Window opening is taken into account through a single sided balanced air flow. For residential buildings, the sanitary regulation imposes a ventilation system. Window airing is therefore considered as an additional flow depending on the outdoor (temperature and wind) conditions. For non residential buildings, it is permitted to use only window airing. It this case it is considered that, due to the difficulty to adjust the window openings, a coefficient of 1.8 is applied to the sanitary airflow.

Passive ducts are taken into account in a more physical way starting from the components duct and cowls characteristics. The pressure losses or gains are calculated for a given air flow. The final result is obtained by using an implicit resolution method.

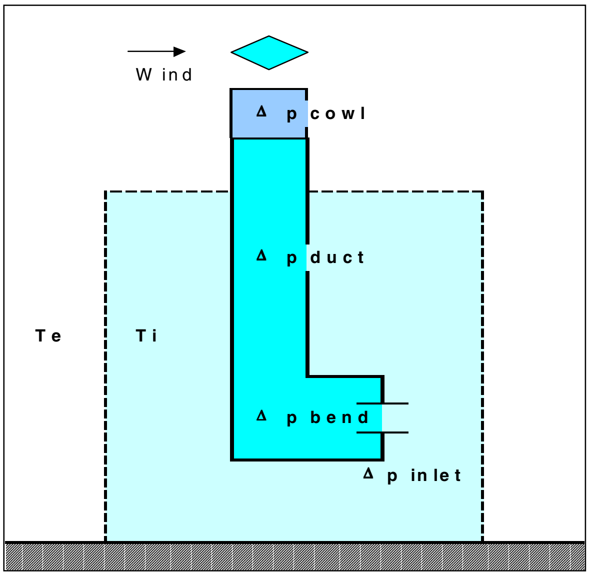

figure 2 : passive duct description

For all systems, the ventilation system airflows are described as time scheduled values taking into account for example the occupancy / non-occupancy period. For some systems, the control devices are also taken into account. For example meeting room ventilation can be reduced of 10 % in case of presence sensors, and 20 % for C02 sensors. Works are in progress to improve theses values through a certification process. For two speeds mechanical residential system, the highest flow rate is considered to occur 2 hours a day in case of manual on-off device and 1 hour if it switch off automatically .

For residential building, the reference ventilation system is a mechanical extract only one. For non residential a balanced system was chosen.

3.1.2 Building enveloppe airflows

An implicit method is used to calculate the internal pressure, balancing the air flows. The ventilation system flows are already known as defined in the previous paragraph.

The other input parameters are :

- The outdoor wind and temperature :

One must find a compromise between accuracy and complexity. Sensitivity analysis were performed and have shown that in was possible to base the calculation for each month on the average outdoor temperature, and 5 wind speeds corresponding to a 20 % probability of occurrence,

- The Cp coefficients :

Conventional values are taken into account depending on the building height, and the facade orientation.

For the building or zones with possible cross ventilation, the Cp coefficients are :

Building height	C_p windward facade	C_p side facade	C_p leeward faced
$h_{bat} < 15$ m	+ 0,25	-0,5	- 0,5
$15 < h_{bat} < 50$ m	+ 0,45	-0,5	- 0,5
$h_{bat} > 50$ m	+ 0,60	-0,5	- 0,5

Table 2 : Cp values for building with possible cross ventilation

For the building and zones without possible cross ventilation the equivalent Cp taken into account are as follows :

C_p over pressured part of the facade»	C_p under pressured part of the facade »
+ 0,05	- 0,05

Table 3 : Cp values for building without possible cross ventilation

- The building envelope airtitghtness :

It is described by a Q4Pa value. Q4Pa is the airflow through the building envelope for à 4 Pa pressure difference divided by the area of the building envelope. This value is more representative than the n50 as it corresponds to pressure difference observed in practice, and permits to use a default value for the exponent (taken as 0,667). The reference and default values are as follows:

	Reference value	Default value
Detached houses	0.8	1.3
Residential, office; schools	1.2	1.7
Industrial buildings, stores	2.5	3.0

Table 4 : values of Q4Pa ($m^3/(h.m^2$ of external envelope))

- The air inlets :

Used for mechanical exhaust only ventilation system or passive duct systems, these components are characterised by their flow / pressure difference curves.

Building leakages and air inlets are split on the different facades orientation through typical ratios.

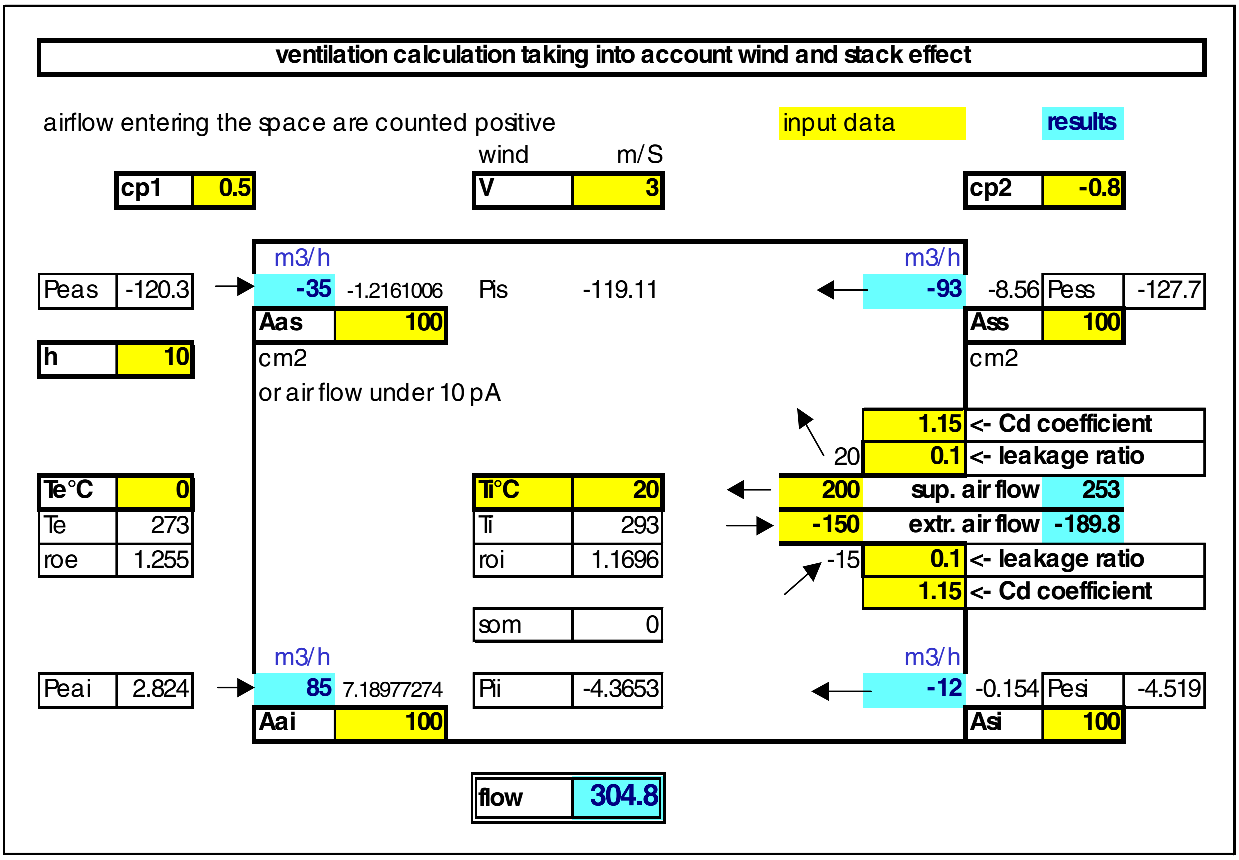

figure 3 : example of calculated airflows by the implicit method

3.2 ENERGY CALCULATION

Depending on the ventilation system, the following rules are applied :

3.2.1 Window airing

In this case, the only output required for the C calculation is the airflow (through air leakages and window) which is directly used as an Hv (W/K) value to calculate the building heat losses. According to the C calculation structure, Hv is calculated separately for occupancy and non-occupancy periods. For each period, it is calculated for each case of outdoor wind and temperature taking into account the duration for each case.

3.2.2 Mechanical exhaust and passive ducts system

In this case the fan electrical needs are also calculated and added to the C calculation. The fan energy is taken into account all over the year. The calculation is based on the extract airflows through the ventilation system and the exfiltred values through air leakages and inlets when it happens (their sum is of course equal to the total airflow entering the building).

3.2.3 Balanced system

Additional points taken into account are:

1. Heat losses through ducts, characterised by the thermal losses in W/K,

2. Heat recovery efficiency,

3. Air heat gains due to supply and exhaust fan : It is assumed that 80 % of the electrical power is transferred to the air,

4. Supply air preheating: a set point is asked to the user, and the corresponding heat needs are calculated.

The heat recovery gains depends on the outdoor indoor temperature difference. Therefore, they are applied as a reduction of the Hv coefficient.

It is not the case for air heat gains due to fans and air preheating. Their impact is calculated as an additional internal heat gain in the building. This means than an utilisation factor is in this case applied, following the general rules of the Th C calculation method.

The figure 4 describes how the different temperatures are calculated for this system. The heat recovered through the fans depends on the presence of a heat exchanger and on their position (in the figure both positions are displayed).

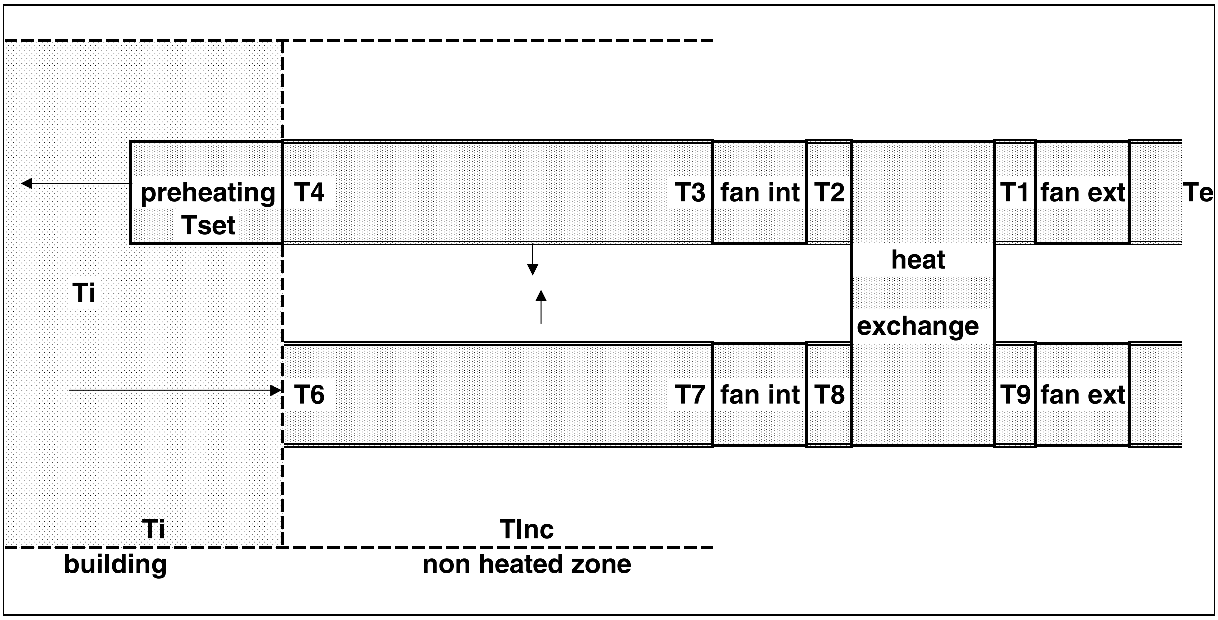

figure 4 : scheme for the balanced ventilation system

4 EXAMPLE OF RESULTS

We performed a sensitivity analysis for detached house. 264 different houses were defined in order to check the impact of the different input datas. We present here the results for ventilation.

The parametric study compares the C coefficient to the Cref one.

The ventilation system is a mechanical exhaust one. We modified the following points :

- mechanical air flows (factor from 0.6 to 1.2). A reduction of mechanical airflow can be obtained for example by a humidity-controlled system.
- airtightness (reference value : 0.8 ($m^3/(h.m^2)$ + or – 0,5)

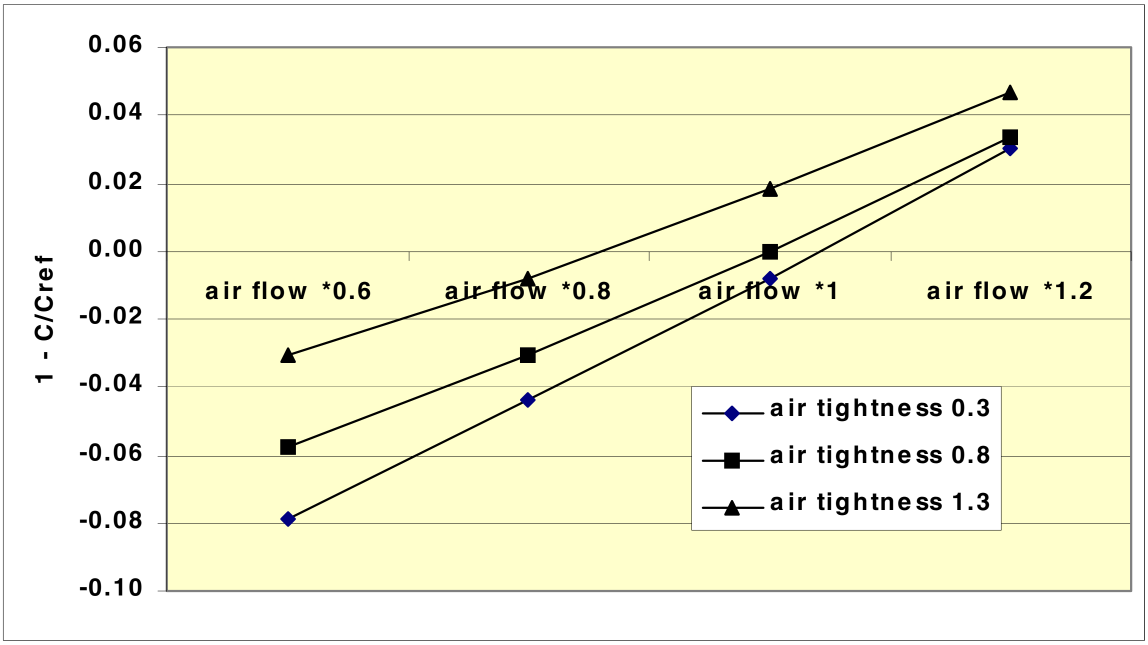

figure 5 : sensitivity analysis for airflow and air tightness

The relative impact of the airflow and airtitgHness are correlated: for airflow multiplied by 1.2 for example, reducing the airtightness from 0,8 $m^3/h/m^2$ to 0,3 has a low impact. This due to the fact that in this case the pressure difference between indoor and outdoor generated by the ventilation system is enough to avoid exfiltration in most cases of wind and stack effect.

On the opposite, increasing the airtighthness from 0.8 to 1.3 has the same impact than increasing the airflow from 0.6 to 0.8.

5 CONCLUSION

The ventilation part of the new French energy regulation RT2000 aims to improve the energetic ventilation efficiency of residential and non-residential buildings.

As the calculation is based on computer tools, physical models are used, which enables to describe building and system components as close as possible to laboratory or in situ measurements.

This approach has two advantages:

- It clarify the discussion on the levels of performances stipulated by the regulation, as they are directly related to products efficiencies,
- It simplifies the improvements to the method, as a physical model can be more easily modified than for example a correlation based approach.

The complexity of the calculation is hidden to the final user, as the inputs and outputs remains simple, focusing on the characteristics of importance for energy.

For the ventilation side the different items taking into account can be summarised as follows:

- Building and ducts airtightness,
- Duct heat losses,
- Air inlets and outlets characteristics,
- Fan and cowls airflow characteristics,
- Heat exchanger and air preheating,
- Energy needs for fan,
- Control devices and strategies,

The large variety of possible improvements should help the designer to optimise the building and ventilation system energetic efficiency without reducing the indoor air quality and will be the basis for the development of new products.

Acknowledgement

CSTB thanks the French Ministry for Building and the Ademe for their support.

References

RT 2000 : Arrêté du 31 Novembre 2000

RT 2000 : Règles Th C règles Th E, arrêté du 1 décembre 2000

CEN PrEN 13465 "calculation methods for the determination of air flow rates in dwellings"