VENTILATION TECHNOLOGIES IN URBAN AREAS

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VENTILATION PERFORMANCES IN NEW BELGIAN DWELLINGS

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SYNOPSIS

A systematic analysis of recently constructed dwellings in the Flemish Region has been undertaken within the SENVIVV-project (1995-1998) [1]. In total 200 dwellings have been examined in detail. The study involved various aspects: energy related building data (thermal insulation level, net heating demand, installed heating power, etc.), indoor climate (temperature levels in winter and summer), building airtightness, ventilation, appreciation of the occupants, etc. This paper focuses on the findings concerning ventilation facilities in the investigated dwellings. The following aspects were investigated:

- Required air flow rates according to the Belgian ventilation standard;
- Presence of ventilation facilities in the investigated dwellings;
- Air flow rates of the installed ventilation devices;
- Facilities for intensive ventilation.

The study revealed that the prescriptions in the ventilation standard are usually not well adopted.

1 INTRODUCTION

Each year about 35 000 new dwellings are constructed in the Flemish region (northern half of Belgium). During the nineties a standard related to ventilation and building regulations related to thermal insulation came into force. As little was known about the building practice and the compliance with the new regulations, a thorough study [1] was set up to examine the energetic performances of new dwellings. From 1995 to 1998, 200 representatively selected houses and multifamily buildings were investigated in detail. This paper discusses the findings concerning the ventilation facilities in the investigated dwellings.

2 BELGIAN VENTILATION STANDARD

2.1 General

The Belgian standard NBN D50-001 (March 1992) [2] describes the requirements for ventilation in dwellings. In the Flemish region this standard is not compulsory (except for social housing), but every standard has to be seen as a rule of good practice, and as a consequence the performances have to be comparable with the requirements of the standard.
The philosophy of the standard is that a good ventilation consists of different aspects, represented in Figure 1. The items in a grey box are discussed in this paper.

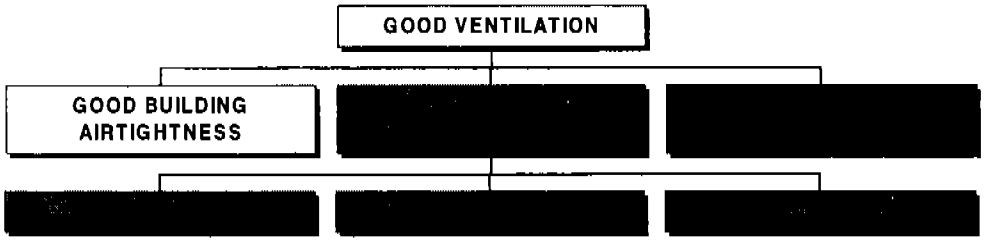

Figure 1: Elements for a good ventilation strategy, according to the Belgian ventilation standard

2.2 Facilities for basic ventilation

The ventilation standard prescribes which air flow rates have to be achievable in different types of rooms: these are called the nominal air flow rates (see Table 1).

Basic requirement: for all rooms	1 l/s.m² floor area (3.6 m³/h.m²)	
Additional requirement:	*Minimum*	*Can be limited to...*
Living rooms	21 l/s (75 m³/h)	42 l/s (150 m³/h)
Bedroom, study, etc.	7 l/s (25 m³/h)	10 l/s (36 m³/h.person)
Bathroom, washhouse, separate kitchen, etc.	14 l/s (50 m³/h)	21 l/s (75 m³/h)
Open kitchen (combined with living room)	21 l/s (75 m³/h)	----
Toilet	7 l/s (25 m³/h)	----

Table 1: Required air flow rates according to the Belgian ventilation standard NBN D50-001

Ventilation can be achieved as well in a mechanical way as in a natural way. In the case of natural ventilation the nominal air flow is defined as the air flow rate through the device at a pressure difference of 2 Pa. The crucial point is that the philosophy of the standard is always respected: supply in 'dry' rooms (living rooms, bedrooms, studies,...), exhaust from the 'humid' rooms (bathroom, toilet, washhouse, kitchen,...) and transfer from the dry rooms to the humid rooms through registers in doors (also a gap under the door is accepted) or inner walls (possibly via corridors). The standard requires that the sum of the transfer openings of a room has a nominal air flow rate (at 2 Pa) of 14 l/s for a kitchen and 7 l/s for all other rooms. The ventilation standard gives also requirements for the ventilation of garages, attics, basements, etc. These are not mentioned here.

2.3 Facilities for intensive ventilation

During cooking, painting and other specific activities the air flow rates provided by the facilities for basic ventilation are not sufficient to guarantee an acceptable indoor air quality. Also during periods with a lot of sunshine additional ventilation can help to avoid excessive overheating. Therefore the Belgian ventilation standard requires the presence of facilities to increase the air flow rate during certain periods of time.

- Kitchens without external doors or windows that can be opened: intensive ventilation (cooker hood) of at least 200 m³/h.
- Bedrooms, studies, playrooms, living rooms and kitchens: requirements for the minimal area of windows and doors that can be opened.
  - ⇨ Openings in only one facade: sum of the openings = at least 6.4% of the floor area
  - ⇨ Openings in two facades: sum of the openings = at least 3.2 % of the floor area and a uniform distribution of the openings over both facades (at least 40 % per facade).

3 RESULTS OF THE STUDY AND DISCUSSION

3.1 Required air flow rates at house level

The required air flow rates according to the Belgian ventilation standard were calculated for all rooms of the investigated dwellings. For each house the total supply air flow rate and the total exhaust air flow rate were calculated. The result is represented in Figure 2.

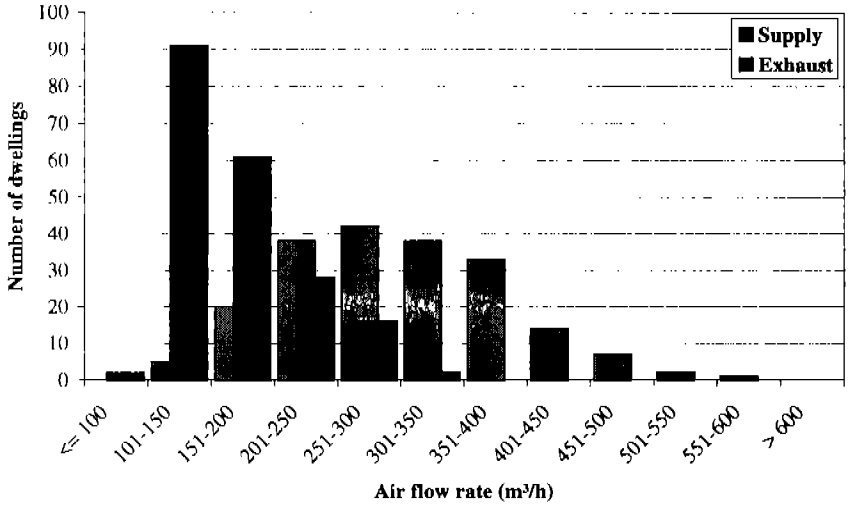

Figure 2: Histogram of the total supply and exhaust air flow rates per dwelling.

The following remarks can be made:

- Except for 5 small apartments the total required supply air flow rate is always higher than the total required exhaust air flow rate.
- The average exhaust air flow rate per dwelling is about 180 m³/h, while the average supply air flow rate is about 300 m³/h.
- On the base of the supply air flow rate an average air change rate of 0.60 h^{-1} is found. Large variations are possible: between 0.30 h^{-1} for bigger houses and 0.95 h^{-1} for small dwellings and apartments. The relation between the required air change rate and the volume of a house is illustrated clearly in Figure 3.

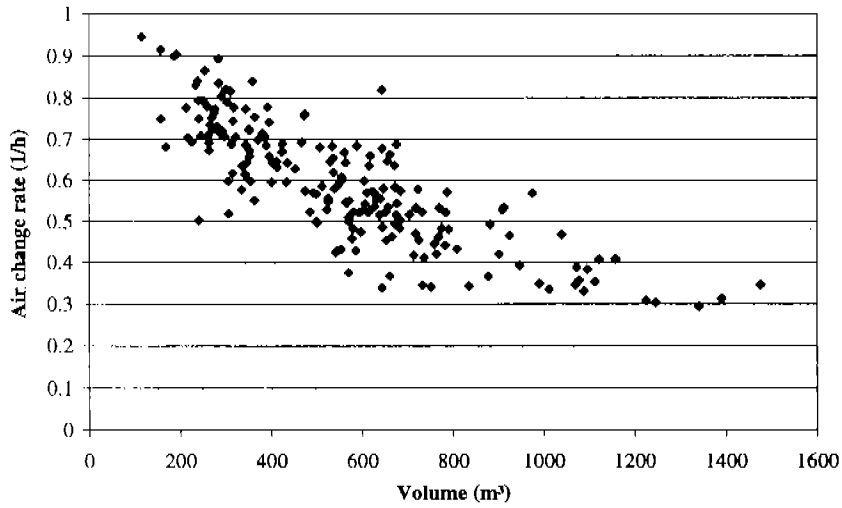

Figure 3: Relation between the air change rate of a dwelling (calculation based on the required supply air change rates according to NBN D50-001) and the volume.

3.2 Ventilation facilities for basic ventilation in the investigated dwellings

3.2.1 Presence of ventilation devices

Figure 4 shows the presence of ventilation facilities in the different room types of the investigated houses.

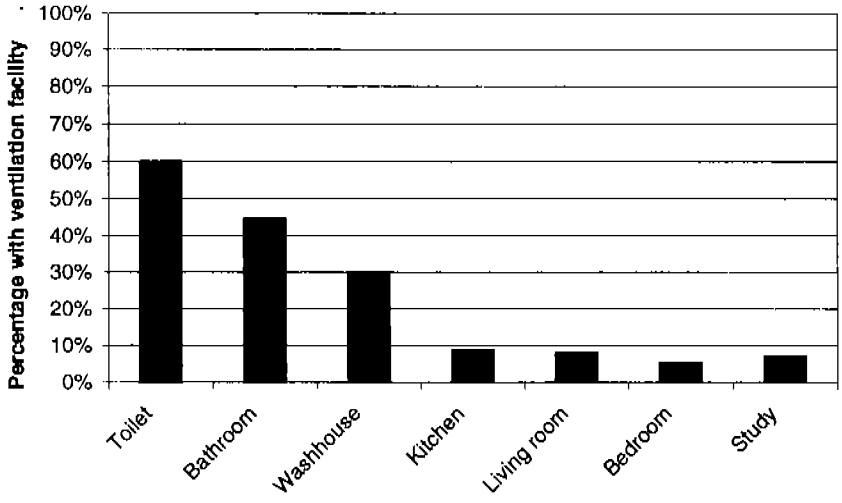

Figure 4: Presence of facilities for basic ventilation in the investigated dwellings

The following observations can be made:

- The installation of ventilation devices seems to be most common in humid rooms: toilet, bathroom and washhouse. On the contrary, dry rooms are rarely equipped with ventilation devices (less than 10%). However, measurements revealed that certain types of rooms are often very airtight (especially bedrooms and bathrooms) [3], which makes the presence of ventilation facilities essential for a good IAQ.
- In dry rooms the ventilation facilities are nearly always window registers (= natural ventilation).
- Small windows are not taken into account as ventilation device.
- It is important to mention that the devices that are taken into account don't always comply with the prescriptions from the ventilation standard because the nominal air flow rate is too high or too low (see further).
- Humid rooms are sometimes equipped with registers in the vertical wall or in the window, although this is not in agreement with the philosophy of the Belgian ventilation standard (*"supply in the dry rooms and exhaust from the wet rooms"*), because exhaust is only guaranteed by mechanical extraction or by natural ventilation through a vertical duct with an outlet on the roof.
- Most of the kitchens are equipped with a cooker hood (see further). Strictly, a cooker hood could be used for basic ventilation, but normally they will only be switched on for intensive ventilation due to high noise levels and high air flow rates. Therefore, cooker hoods are only taken into account in Figure 4 if they are connected to a duct with continuous extraction. In this case the cooker hood will usually be equipped with a flap and have an extraction in the closed position.
- About 1/3 of the exhaust ventilation devices in the humid rooms are mechanical systems.

For the exhaust systems in apartments a distinction has to be made between centralised (= several apartments connected to 1 system) and individual (= per apartment) exhaust. The distribution is represented in Figure 5. It can be seen that the most common system is the centralised natural exhaust. Only a minority of the buildings doesn't have any exhaust system.

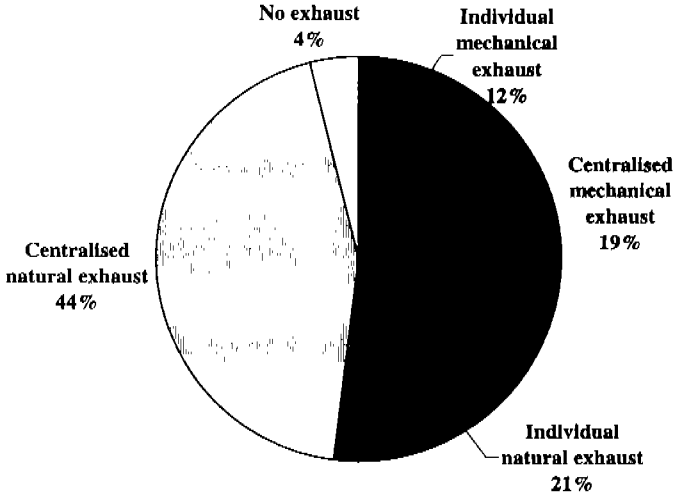

Figure 5: Exhaust in apartment buildings

To guarantee a good air transfer from the dry rooms to the humid rooms there should be transfer openings in the inner doors (or walls).

- In only 12 % of the investigated dwellings transfer registers were found, but even then only in a limited number of rooms (especially in bathroom, storage and toilet).
- The only other way to guarantee a good air transfer is by leaving a gap under the door. In all investigated dwellings the free space under the door was measured. Only in 2% of the cases the gap was higher than 1 cm, which indicates that in the majority of the rooms there are no transfer openings in compliance with the ventilation standard.

3.2.2 Nominal air flow rate

3.2.2.1 Dry rooms

In Figure 6 the nominal air flow rates of some rooms equipped with window registers are compared with the required air flow rates according to NBN D50-001.
The nominal air flow rates of the window registers are calculated on the basis of information from the manufacturer and the register length.
The ventilation standard mentions that in all rooms the nominal air flow rate of the installed natural ventilation devices has to be lower than the double of the required air flow rate.
It can be seen that an important number of rooms don't comply with this rule, especially rooms with a 'low' required air flow rate. It seems that in a majority of these rooms more than one register has been installed, which means that compliance with the requirements could be achieved by simply reducing the number of registers.
Only in a small number of cases the installed registers have a nominal air flow rate that is too small.

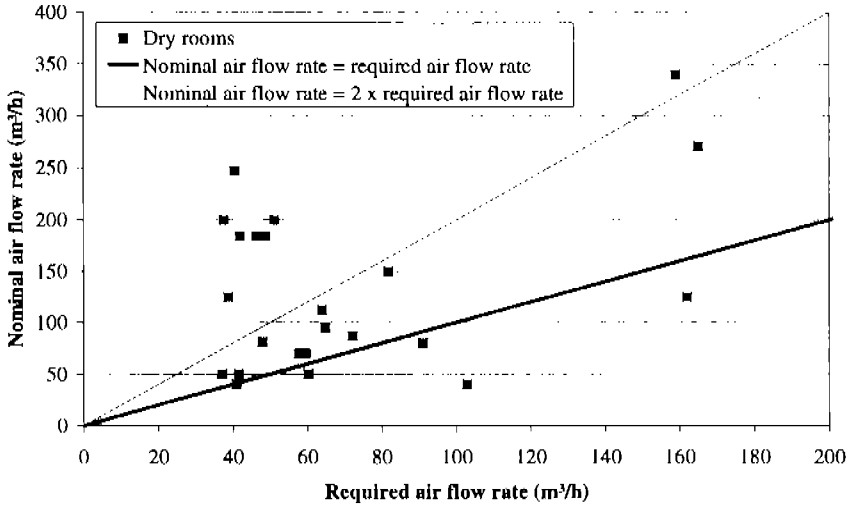

Figure 6: Comparison between installed and required nominal air flow rate.

3.2.2.2 Humid rooms

In 60 % of the rooms equipped with a mechanical extraction the real air flow rate was measured by means of a compensating flow meter. The result is shown in Figure 7.

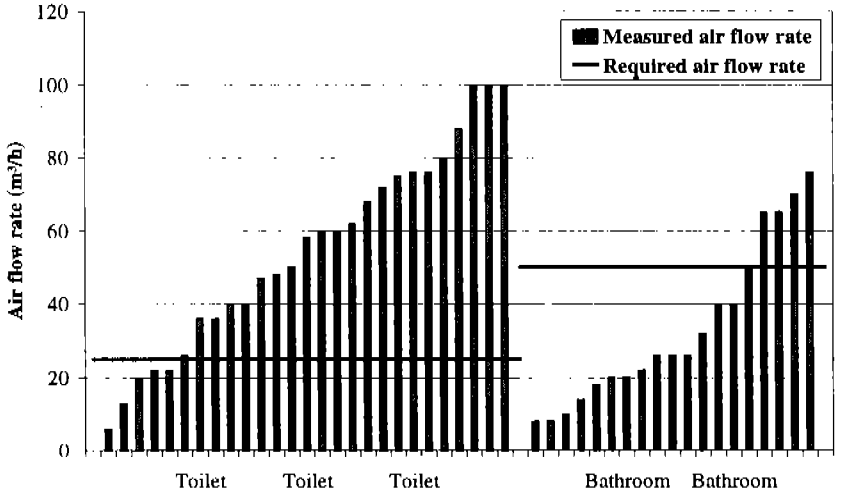

Figure 7: Measured mechanical exhaust air flow rates (the dark bars represent centralised, continually working systems).

The following observations can be made:

- The installed air flow rates often seem to differ from the prescription in the standard. In the toilets the air flow rates are usually higher than the value in the standard, while in the bathrooms the opposite is true. The average measured air flow rate is 33 m³/h for bathrooms and 55 m³/h for toilets.
- It is clear that in rooms with an insufficient air flow rate problems can occur with the indoor air quality. On the other hand an excessive air flow rate causes unnecessary energy losses. An important distinction has to be made between temporarily operating systems (= only during occupation and a limited period of time afterwards; often operated by the light switch) and continually working systems. In the first case it is certainly no problem that

the air flow rate is higher than the value from the standard, on the contrary, it will have a positive impact on the IAQ. In the second case the energy aspect is much more important as the additional air flow rate will be extracted continuously.

In the case of natural exhaust systems the Belgian ventilation standard not only gives prescriptions for the nominal air flow rate, but also for the section of the ductwork. The minimal section should be 70 cm² (≈ ∅ 10 cm) in toilets and 140 cm² (≈ ∅ 14 cm) in other rooms (bathroom, kitchen, washhouse,...). Figure 8 shows the existing situation in the investigated dwellings. In 75% of the toilets the section of the duct is sufficient, while only 1/3 of the bathrooms comply with the ventilation standard.

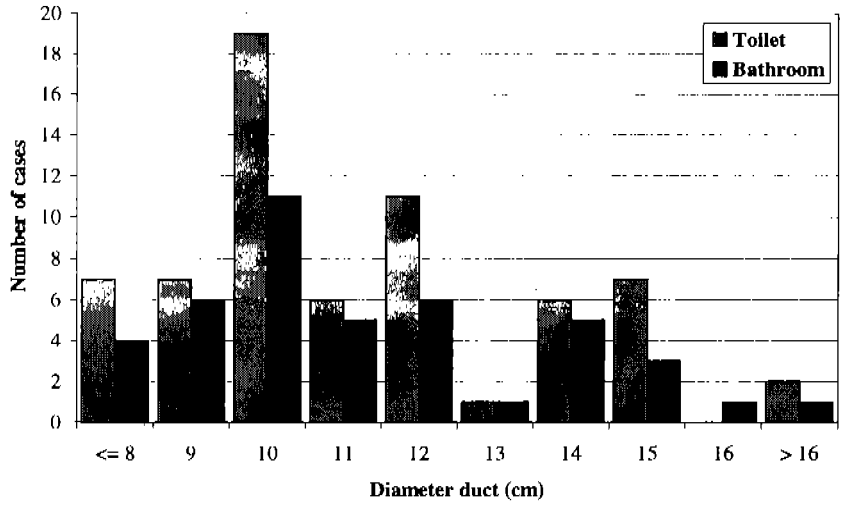

Figure 8: Diameter of the exhaust ducts for natural ventilation (behind the register).

3.3 Ventilation facilities for intensive ventilation in the investigated dwellings

In living rooms, bedrooms, studies and kitchens there must be a certain area of doors and windows that can be opened. If a kitchen doesn't have external doors or windows that can be opened a cooker hood must be installed.

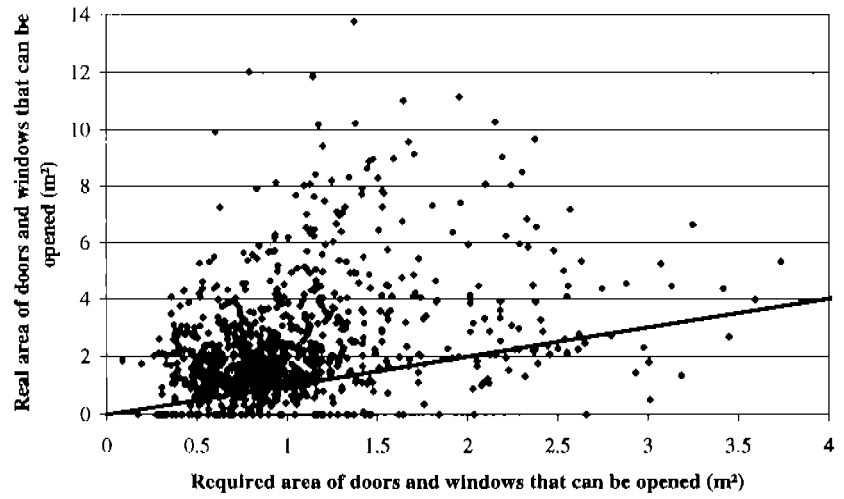

Figure 9: Area of doors and windows that can be opened.

In Figure 9 the area of doors and windows that can be opened per room is compared with the requirement. It is obvious that in most cases (more than 80%) the requirement is fulfilled.
Although a cooker hood is only required in kitchens without an external door or window that can be opened, this device for intensive ventilation is found in the majority of the kitchens: more than 95% !

4 CONCLUSIONS

In spite of the existence of a standard for ventilation in dwellings, the presence of ventilation facilities is quite poor in new houses in the Flemish Region, especially in the dry rooms. Moreover, quite often the performances of the installed facilities doesn't seem to be in accordance with the prescriptions from the ventilation standard.
It was remarkable that a lot of complaints (in about 30% of the investigated dwellings) about IAQ were recorded. This indicates that there is a lack of understanding of the importance of ventilation and the way it can be achieved correctly.
The situation could probably be improved significantly by the implementation of a performance check on site.

5 ACKNOWLEDGEMENTS

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