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AIRTIGHTNESS 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 results of the airtightness measurements that were undertaken in 51 of the 200 investigated dwellings. These measurements revealed that the global airtightness depends strongly on the building type: on average, terraced houses are more airtight than detached houses, but less airtight than apartments. There is a wide spread on the results, especially for detached houses. The worst results are mainly caused by a poor finishing, due to the fact that a lot of owners do a part of the finishing work themselves.

LIST OF SYMBOLS

n_{50} - air change rate for a pressure difference of 50 Pa (h^{-1})
Q_{50} - leakage air flow rate for a pressure difference of 50 Pa (m^3/h)
V - volume of dwelling, room (m^3)

1. INTRODUCTION

Each year about 35 000 new dwellings are constructed in the Flemish region (i.e. the 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 building airtightness.

2. BELGIAN VENTILATION STANDARD

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.

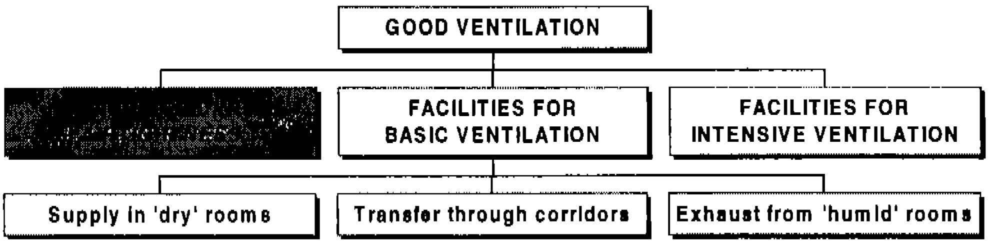

Figure 1: Elements for a good ventilation strategy, according to the Belgian ventilation standard

With respect to building airtightness, the Belgian ventilation standard only gives some guidelines for specific cases, no requirements. These guidelines are the following:

⇨ In the case of balanced mechanical ventilation: $n_{50} < 3\ h^{-1}$

⇨ In the case of balanced mechanical ventilation with heat recovery: $n_{50} < 1\ h^{-1}$

3. MEASUREMENTS: RESULTS AND DISCUSSION

3.1 Global airtightness

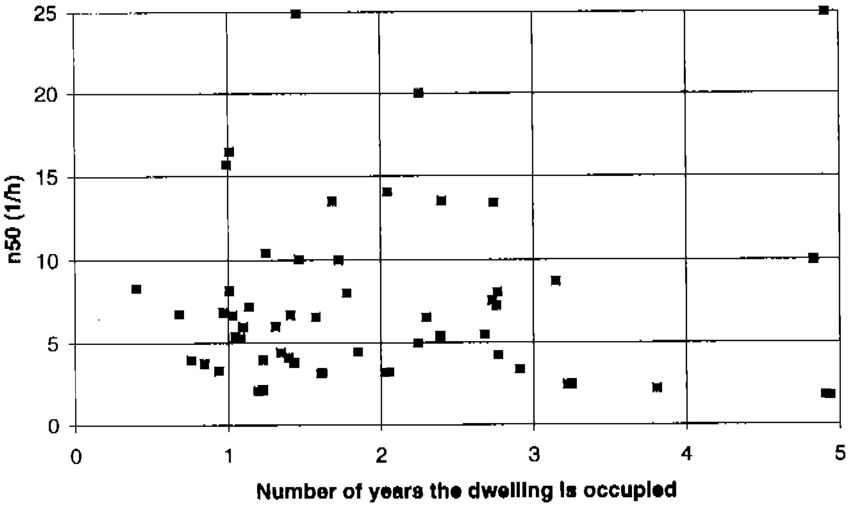

Figure 2: Global airtightness as a function of the number of years the building is occupied

The following remarks can be made:

⇨ There is a large scatter on the results of the global airtightness: the values are situated between 1.8 h^{-1} and 25.0 h^{-1}; this means a difference by more than a factor 10. The average n_{50}-value is about 8 h^{-1}.

⇨ The worst results are caused by a poor finishing (at inclined roofs, connections between windows and walls, etc.), which is probably due to the fact that a lot of owners do a part of the work themselves.

⇨ It is important to mention that the measurements were performed on the insulated volume and not only on the heated volume, which means that the garage and the attic are often part of the measured volume.

⇨ On first sight there seems to be no clear relation between the airtightness and the number of years the building is occupied. One of the dwellings with a n_{50} of 25 h^{-1} was already occupied for 5 years !

⇨ The airtightness seems to depend strongly on the type of building. This is shown clearly in Figure 3, where the average, minimum and maximum of the measured n_{50} values are shown for each building type. This tendency is caused by the fact that the airtightness of common walls is normally better than of external walls, due to the absence of windows, doors, etc.

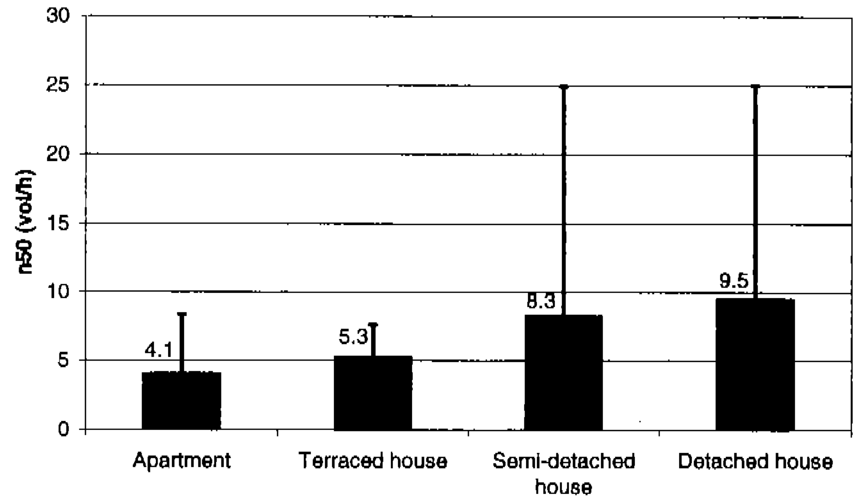

Figure 3: Airtightness as a function of the building type

3.2 Airtightness of separate rooms

To determine the distribution of the leaks over the building envelope, the leakage air flow rate at 50 Pa (Q_{50}) was determined for most of the rooms, by means of a compensating flow meter.

3.2.1 Garages and insulated attics

A first remarkable conclusion is that the most important leaks are usually found in garages and attics. The following figure (histogram) shows the contribution of garage and attic to the total leakage of the building. It can be seen that the influence of these rooms can be very high (up to more than 50% of the total leakage). On average garages and insulated attics are each responsible for 1/3 of the total leakage.

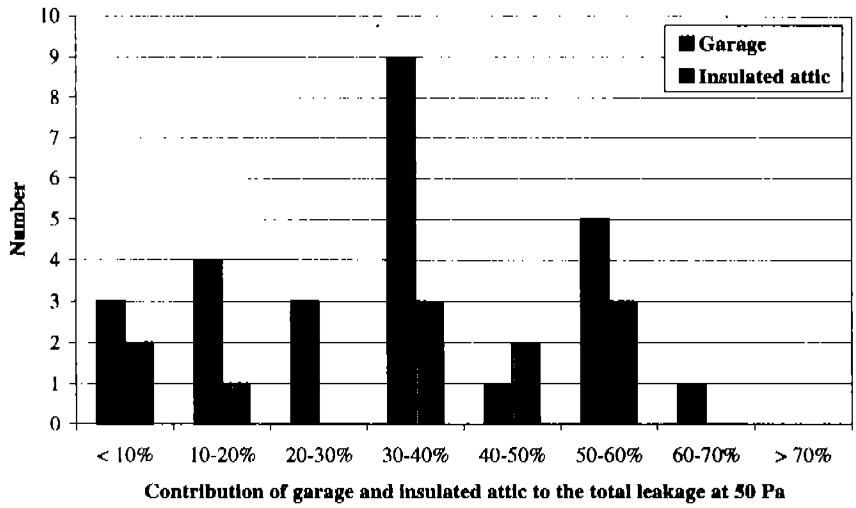

Figure 4: Contribution of garage and insulated attic to the total leakage at 50 Pa.

The inclusion of insulated, but unoccupied, garages and attics in the measurement of the global airtightness is an approach that is open to discussion:

⇨ On the one hand, these rooms are insulated with the objective to reduce the heat loss, and as a consequence the airtightness has to be very good in order to reduce heat loss by infiltration of outdoor air.

⇨ On the other hand, these rooms are not occupied, which means the comfort requirements are not so high. Moreover, the ventilation standard NBN D50-001 requires a rather important basic ventilation in garages, which is often obtained by leaving a gap at the bottom of the gate of the garage.

In order to demonstrate the importance of the chosen approach, the n_{50} was recalculated for the houses with a garage, assuming that the garage is not a part of the insulated volume of the house. This was done in the following way:

$$n_{50(without\ garage)} = \frac{\left(Q_{50(total)} - Q_{50(garage)}\right)}{\left(V_{total} - V_{garage}\right)}$$

The following figure shows the result of this calculation.

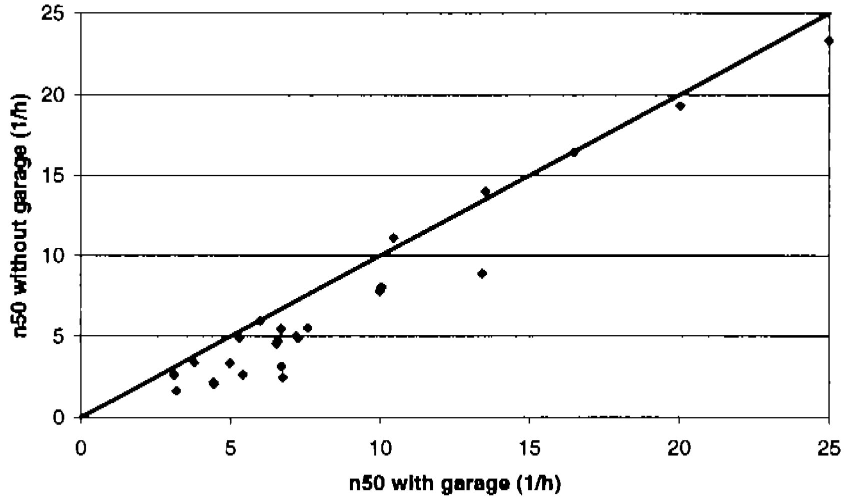

Figure 5: Influence of the garage on the n_{50}-value

One can see that mostly the n_{50}-value decreases when the garage is not taken into account. In the case of airtight garages with a high volume there can however be a slight increase.
On average the n_{50}-value decreases with 1.7 h^{-1}, but sometimes the effect is more important.

3.2.2 Other rooms

The measurement of the leakage distribution over the different rooms revealed that certain types of rooms are usually very airtight, especially bedrooms and bathrooms. Figure 6 shows the Q_{50}-values for the bedrooms of the different dwellings for which a pressurisation measurement was performed.

The following observations can be made:

- 70% of the bedrooms have a Q_{50} value that is lower than 100 m³/h. Assuming that the average pressure on the facade of a dwelling is about 2 Pa, the average infiltration air flow rate for bedrooms with a Q_{50} lower than 100 m³/h will be lower than 20 m³/h. The minimal nominal air flow rate necessary in a bedroom according to the ventilation standard is 25 m³/h. One can see immediately that in bedrooms with a high airtightness the presence of ventilation facilities is very important to avoid problems with the indoor air quality. This certainly doesn't mean that bedrooms should be made less airtight. On the contrary, a good airtightness combined with the presence of a correct ventilation device is the only guarantee for a good indoor air quality with a minimum of energy loss. Examination of the ventilation facilities in the 200 dwellings learns that most of the bedrooms don't have ventilation devices installed ! This is discussed in detail in [3].

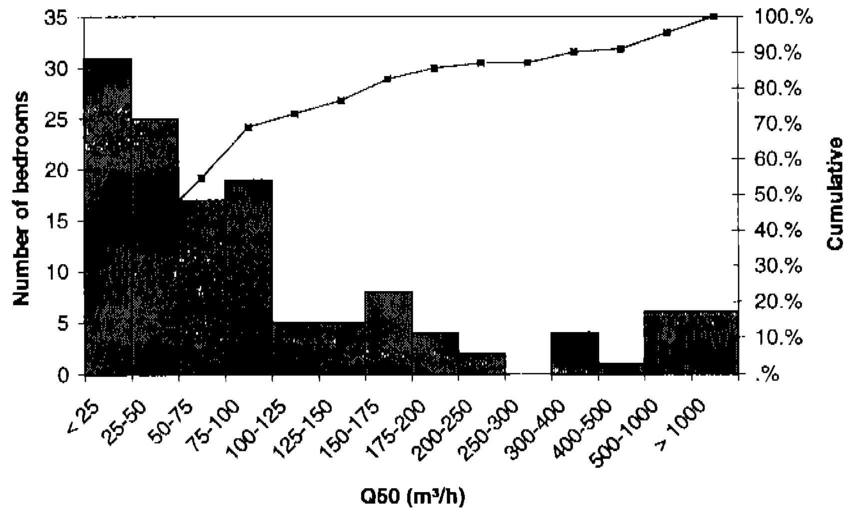

Figure 6: Q_{50}-value of the bedrooms from the SENVIVV-study

- About 10% of the bedrooms have a Q_{50} value higher than 500 m³/h. Mostly, these are bedrooms situated under an inclined roof, where the finishing was not done in an airtight way.
- Sometimes very airtight rooms can be found in dwellings with a very bad global airtightness, which demonstrates clearly that leaky dwellings are no guarantee for an acceptable indoor air quality if no ventilation devices are installed. This is shown in Figure 7.

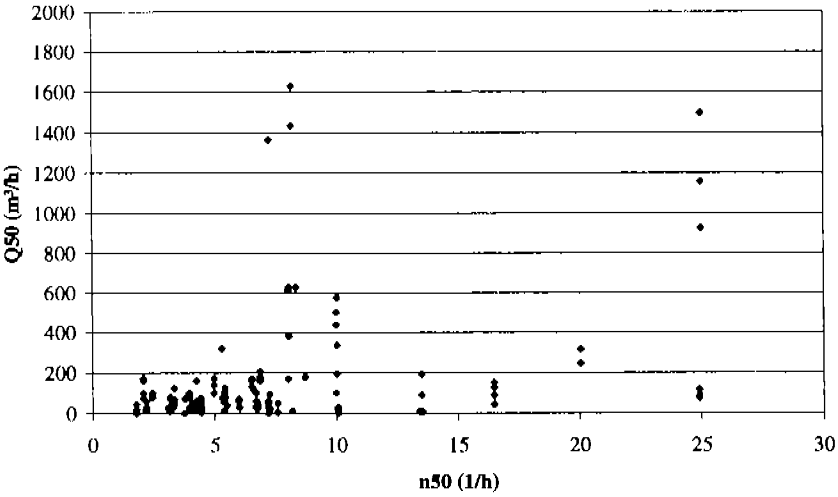

Figure 7: Relation between the airtightness of the bedrooms and the global airtightness of the corresponding dwelling.

The same remarks can be made for the bathrooms, where the situation is even more critical due to the high production of water vapour.

4 VISUAL ESTIMATION OF THE GLOBAL AIRTIGHTNESS

4.1 Goal and principle

The measurement of the airtightness of a dwelling is rather time-consuming. To investigate whether it is possible to estimate the lower limit of a dwelling's leakage in a visual way, a method was developed within the SENVIVV-study. It consists of assigning a Q_{50} value to the different building components of a dwelling and making the sum of all these values.
A distinction is made between the following groups of building components.

- Walls, floors and ceilings (Q_{50} per m²)
- Connections between wall and floor/ceiling (Q_{50} per m)
- Joints in cabinetwork (Q_{50} per m)
- Connections between cabinetwork and walls (Q_{50} per m)
- Openings and other leaks (Q_{50} per piece)

For each of these building parts Q_{50} values are given for several materials and building types. More explanation is given in [4].
The values used are based mainly on information from [5]. These values are averages of different measurement results with a rather important scatter. This means that a leak can as well be overestimated as underestimated. But, as certain leaks will be forgotten during a visual inspection, the final value will be rather a minimum value for the global leakage.

4.2 Results and discussion

The following figure compares the measured airtightness with the visually estimated value.

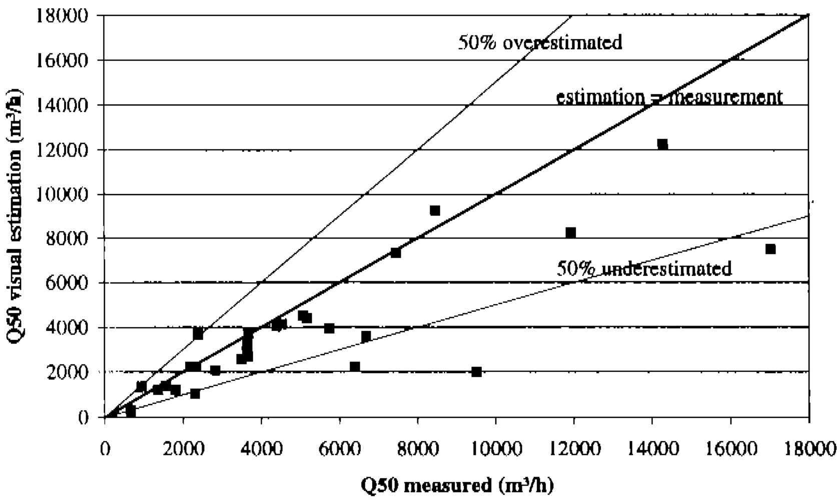

Figure 8: Comparison between the estimated and measured Q_{50} values for some dwellings of the SENVIVV-study.

The method was tried out in 28 dwellings. The following observations can be made:

- The visually estimated value seems to be smaller than (or equal to) the measured value in nearly all the cases. The method can therefore be seen as a reliable way to estimate the lower limit of a dwelling's leakage.

♦ In three cases the visual inspection gives an underestimation of more than 50%; in only 2 cases there is an overestimation of more than 50%.

5 CONCLUSIONS

The airtightness of Belgian dwellings is often very bad. An important reason for the worst cases is that the owners do a lot of the finishing work themselves, which is often only done after a long period of time and sometimes in a very bad way. On average, apartments have the best airtightness, while detached buildings are giving the worst results.
Garages and insulated attics seem to be responsible for an important part of the leaks in a dwelling. Even in dwellings with a bad airtightness some rooms can be very airtight, especially bedrooms and bathrooms.
It seems possible to make a quite good visual estimation of a dwelling's airtightness.

6 ACKNOWLEDGEMENTS

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