AIR LEAKAGE MEASUREMENT IN DWELLINGS

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1 - Introduction

The air change in recently constructed dwelling is composed of:

- a specific air change induced by the operation of ventilation systems;
- an air change by opening of windows;
- a supplementary air change resulting from deficiencies in the building's airtightness.

These airtightness deficiencies must be combatted, for they disturb the operation of the ventilation system and are the cause of an important increase (on the order of 30 %) of the losses by infiltration. In addition, they can be the source of discomfort in winter owing to air currents passing through the cracks in the building envelope.

Airtightness measurements carried out on a large sampling of recently constructed dwellings (75 single-family houses and 45 apartments) have made it possible to identify the air leakage patterns of these buildings and to quantify the importance of these deficiencies.

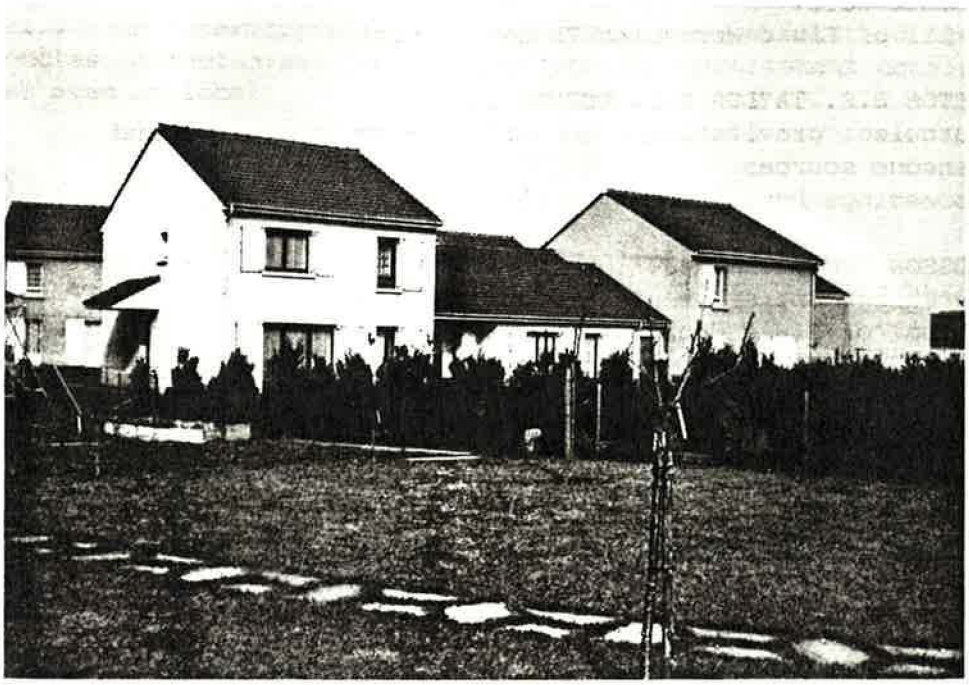

Figure 1: example of dwelling used in the measurements

2 - Measurement methodology

2.1 - Principle -

The test consists of placing the entire building under a negative pressure through use of a fan and measuring the air flow extracted for different values of the pressure difference ΔP between the interior and the exterior.

This principle was selected because the dwellings normally have a negative pressure owing to the mechanical exhaust systems with which they are equipped.

2.2 - Test equipment -

The test equipment was composed (see Figure 2) of a "false door" applicable in an airtight manner to the grooves of the existing door frame, a fan, and a series of diaphragms and pressure gauges.

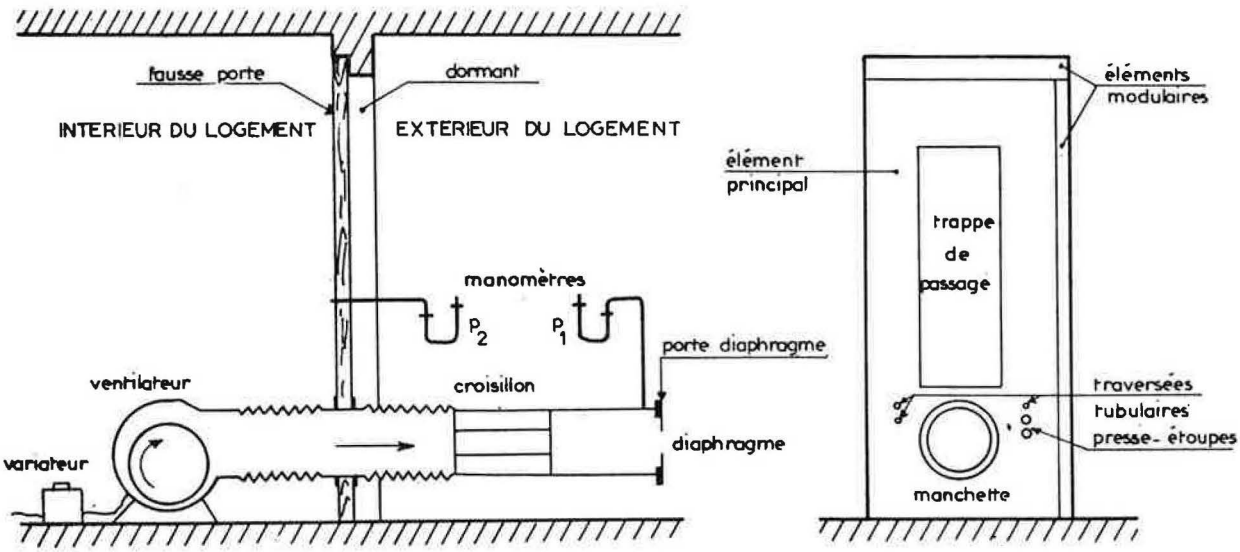

Figure 2 Principle of instrumentation for in situ measurement of air leakage value.

2.3 - Making the measurements

Once the test equipment was set up, all the air outlets were closed off, then the overall air leakage of the dwelling was measured.

In general, an effort was also made to separately quantify the air leakage of the different components comprising the building envelope (doors, windows, specific air inlets,....). To do this, supplementary measurements were made with these components blocked off, thus permitting the desired result to be obtained by measuring the differences.

3 - Results -

3.1 - Determination of overall air leakage of the dwellings

The flow rate Q extracted by the false door was measured for at least four differences of the pressure ΔP, generally falling between 10 and 40 Pa. Then the value of the coefficients C and n, characteristic of the airtightness deficiencies of the dwelling were determined using the best fit for the following equation:

$$Q = C.(\Delta P)^{n} \qquad (1)$$

3.1.1. - Values of n

The histogram of the values of the exponent n is represented on Figure 3 for all the dwellings measured. It was observed that the mean value was close to n = 2/3; moreover, the analysis of the results shows that there is no strong correlation between the value taken by this exponent and the dwellings' overall air leakage value. Thus, in view of later calculations, the value n = 2/3 can be considered as representative of the dwellings' air leakage deficiencies.

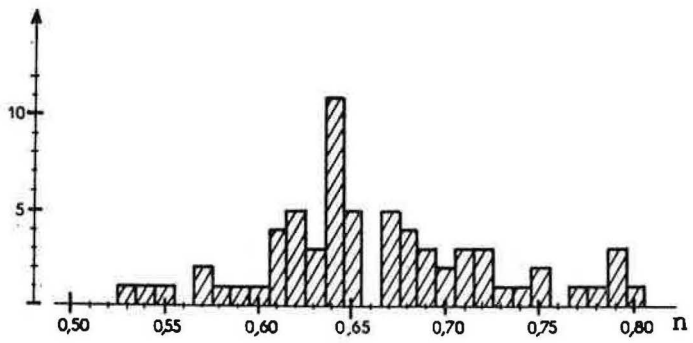

Figure 3 Infiltrations through the opaque walls. Histogram of the values of n of the law $Q = C.\Delta P^{n}$

3.1.2. - Air leakage values -

a) the air leakage formula:

The air leakage C relative to an airtightness deficiency is by definition (see equation 1) equal to the air flow, expressed in m^3/h, when the pressure difference is 1 Pa.

Consequently, in order to take into account the fact that the air leakage obtained corresponds to a certain value of the exponent n, and not to the standard value n = 2/3, it is necessary to make a correction. The principle consists of expressing the air leakage so that at 10 Pa (usual value in a dwelling equipped with mechanical ventilation), the flow calculated on the basis of the coefficient n = 2/3 corresponds to the real flow; hence we get the following correction:

$$C_1 = 10^{(n-2/3)} \cdot C$$

The air leakage value is generally expressed in m^3/h for a pressure difference of 1 Pa. It sometimes happens that for certain components (doors, windows) it may be restored to the surface of this component. It is then expressed in $m^3/h.m^2$. It may also be restored to the dwelling volume. It becomes then equal to the air change value and is expressed in h^{-1}.

b) results:

The histograms of Figure 4 represent the distribution of overall air leaks measured on the sampling of houses and apartments.

It appears that dispersion of the measurements is considerable and that the airtightness deficiencies observed in apartments are considerably less than in houses.

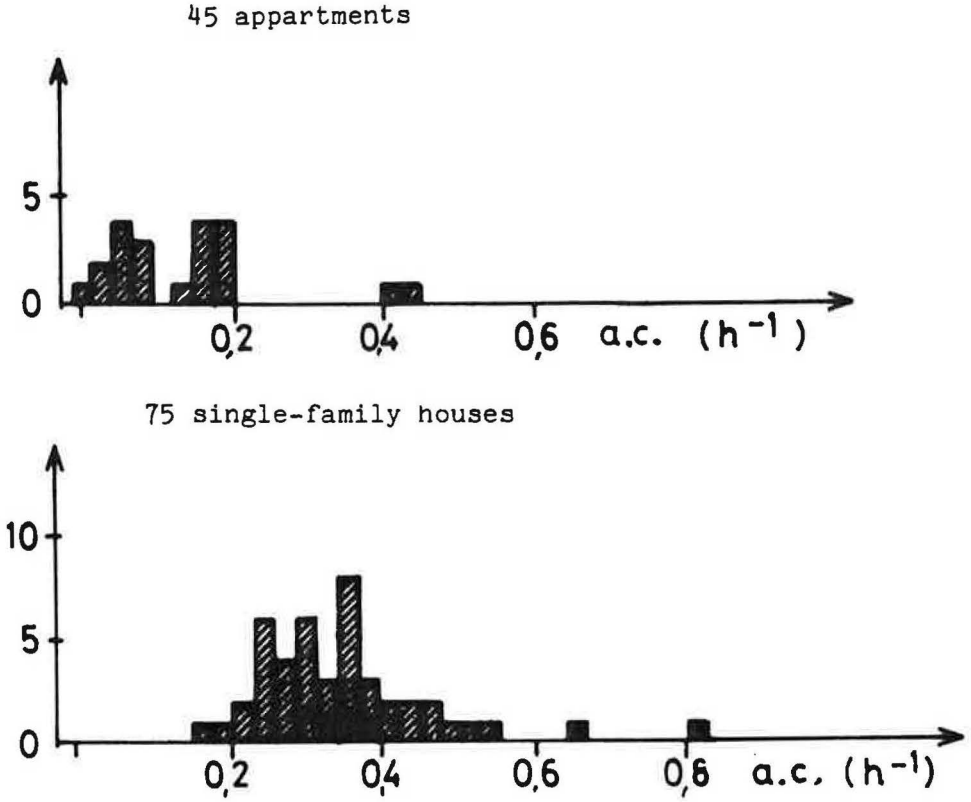

Figure 4 : Air infiltration rate through air tightness deficiencies in 75 individual houses and 40 apartments for a pressure difference of 1 Pa.

3.2 - Distribution of the airtightness deficiencies

The tests have made it possible to identify the most frequently encountered airtightness deficiencies:

a) exterior walls

The airtightness deficiencies are rather important and are found particularly on walls with interior insulation made up of bonded plasterboard + insulation complexes.

The leaks arise from the fact that the air space separating the insulating complex from the supporting wall is in communication with the exterior; the air penetrates through the door and window frames, or the electrical ducts.

b) miscellaneous:

- water pipes passages,
- cables connected to the mains distribution network,
- service ducts traps, and in single family houses: attic access trap doors.

c) doors opening to the exterior

The air leakage through dwelling entrance doors is not very high (on the order of 1.2 $m^3/h.m^2$). On the other hand, doors opening onto unheated premises (garages, etc...) are generally mediocre (about 4 $m^3/h.m^2$).

d) windows:

In France, manufactured windows are built in accordance with conformity standards which guarantee a certain level of airtightness. For the most common type of window (A2) this is equal to m = 0.8 $m^3/h.m^2$.

The measurement results have shown that, after installation on the site, this airtightness level was usually obtained, thus corresponding to good performances. On the other hand, the airtightness level between the window frame and the wall (see 3.2.a,) was generally mediocre.

4 - Conclusions

- The measurement results carried out on more than 100 recently constructed dwellings demonstrated that air leakage of dwellings was important. The air change through air tightness deficiencies is on the order of 0.10 h^{-1} under 1 Pa as an average for an apartment and on the order of 0.35 h^{-1} under 1 Pa as an average for a single-family house.

- The airtightness deficiencies depend on the type of construction and the quality of workmanship (airtightness deficiencies of windows represent only a small fraction of the total). Some provisions are envisioned (see ref. 1) - within the framework of the regulatory calculation methods - to calculate the losses by air change as a function of wall type. It is hoped that this work will motivate building owners to choose better airtightness solutions for wall construction.

5 - References

(1) C. MOYE, "Perméabilité à l'air des bâtiments d'habitation" (Air Leakage in Dwellings) - Cahier of the C.S.T.B. no. 2019, September 1985.