Airtightness of buildings, measurements on houses with a very low heating energy consumption

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SUMMARY

A basic condition for low energy houses is a demand controlled ventilation combinded with a air-tight building envelope. Within the scope of different research projects financed by public grants and measurements effected by private order mainly in the south of Germany, the airtightness in low energy and minimum energy houses has been checked according to the DC pressurization method and the places of leakage have been determined.

Considering the results with respect to the recommendations of the SIA 180 (standard of Switzerland), 40% of approx. 50 one-family and block of flats which have been tested, are not tight enough to run the ventilation system in an energetically useful way. Main weak points are found where wooden lightweight constructions are used, the same in entrance and cellar doors. A low leakage can be measured in houses where the air-tightening building envelope has been thoroughly planned and controlled during its construction.

1. TARGET OF THE AIRTIGHTNESS MEASUREMENTS

First of all airtightness measurements serve for controlling the workmanship. As far as possible and necessary, the traced leaks should be mended to avoid loss in comfort, unnecessarily high ventilation heat losses and to avoid damage at the building itself.

In addition, measurements done by public order should show typical weak points. As a result recommendations for further construction of new low energy houses may be concluded./1/ Prefabricated house companies and manufacuterers of sealing systems have tested the airtightness of their buildings to prove the suitability of their products.

2. MEASURING THE AIRTIGHTNESS AND LOCALIZING LEAKAGES

For measuring the airtightness according to the DC pressurization method, a fan is installed air-tightly in the entrance door or in the terrace door ("blower door"). This fan creates a depressure or an overpressure compared to the outdoor air. According to the swedish measuring standards /2/, all windows and outside doors are closed and all ventilation openings are luted. The measurements consider the volume flow as a function of the differential pressure over the building envelope. As the mass flow at the blower is equal to the air mass that passes through the building leaks, the result is a measure for the leakiness of the building. Usually the air volume flow at 50 Pa differential pressure (average value for depressure/overpressure measurement) divided by the building volume is indicated ($n_{L,50}$, unit h^{-1}).

Besides the quantitative determination of the leakage, the position of the leaks is determined too. For this purpose a depression of about 50 Pa is created in the building. All constructive connections, windows, outside doors and cable passages are checked for incoming air by means of an anemomter. In case that the surrounding temperature is low, there is a possibility to detect the leaks by means of an inside thermography during depressurization and, above all, to make a descriptive documentation.

3. QUANTITATIVE RESULTS

The results of airtightness measurements performed in 48 one-family and blocks of flats built in low energy style in the Federal Republic of Germany is shown in figure 1 (compare /3/ and /4/). Taking the SIA 180 for judgement, only 60% of the checked houses, those with $n_{L,50} \leq 3\ h^{-1}$, meet all requirements for buildings with an exhaust ventilation system. Eight of them meet the limiting value $n_{L,50} \leq 1\ h^{-1}$ for exhaust-supply ventilation systems. Disregarding the zero enery house in Dörpe and the 4 residential units of the passive house in Darmstadt Kranichstein, which may not be considered to be typical because of the intensive scientific support during the planning, only 3 buildings remain in which an exhaust-supply ventilation system could be run efficient.

44 of the checked houses are built with solid walls and have a garet storey for living. The average value of the air change rate at 50 Pa is $2.6.h^{-1}$. The 4 houses built in wooden lightweight style have a mean

value of 7 h^{-1}. However, not all lightweight construction houses are untight: whilst 2 reach a value of 10 h^{-1}, the other two houses have a value of n_L 50 = 0.9 h^{-1} resp. 1.1 h^{-1}. Mainly the pressurization test results do not depend on the construction style but on the way the air-tight building envelope has been planned and how the construction work has been controlled (see /5/).

Calculations show that in the region of Frankfurt (Germany) the specific heat losses caused by air infiltration are about 10 kWh/(m^2a) for a building of n_L 50 =3 h^{-1}./9/ In the passive house in Darmstadt Kranichstein, the tightest of the checked buildings, where the air change rate at 50 Pa is only $n_{L,\,50}$ = 0.3 h^{-1}, the infiltration losses are about 1 kWh/(m^2a). [6,7]

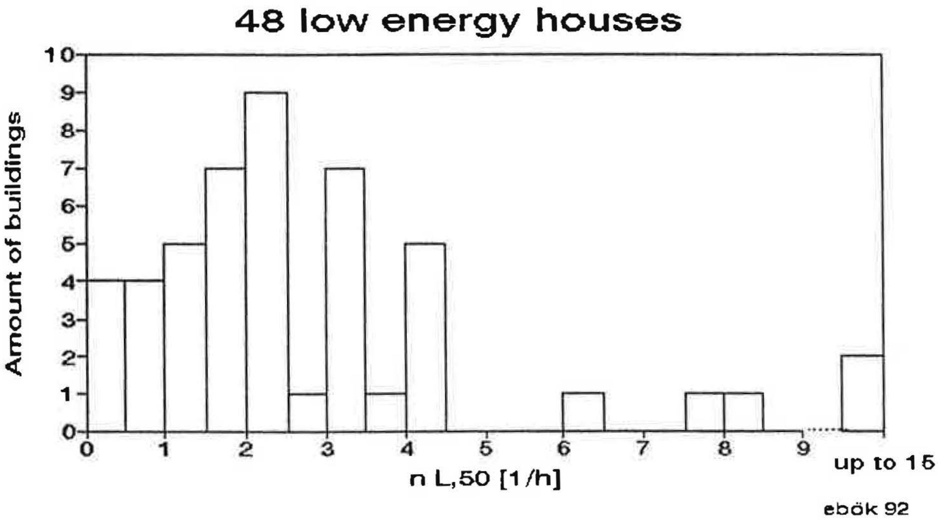

Figure 1: Histogram of the air change rate at 50 Pa of different low energy houses (one-family houses and blocks of flats) in the Federal Republic of Germany. The selection is not representative.

4. MAIN SOURCES OF FAULTS

Most leaks are in the sector of wooden lightweight constructions. The major problems, which at the same time have strong quantitative consequences, consist of untight foil connections. This concerns for example the connection between roof area and brickwork wall, the connection to the embrasures of roof windows, as well as the embrasures of dormer windows to attics. Installations to the outside are often untight.

In the sector of constructions with solid walls, the leaks are mostly found in the joints of windows and jalousie boxes as well as in entrance and cellar doors. Although entrance doors are mostly equipped with sealings they do not work properly because of contamination or inexact adjustment of the armatures. Cellar doors are often standard room doors which cannot be tight because of the construction (no sealing at the lower edge). Furtheron the frames are not sealed against the wall. The result is, especially for houses with an exhaust ventilation systems, that not only fresh air is taken in from outside, but that air from the cellar gets to the living rooms.

5. RECOMMENDATIONS

The most important recommendation with respect to energy saving, conservation of the building substance and a healthy indoor climate is that air-tightening should be planned carefully. Installation passages in the air-tight building envelope should be avoided if possible. In case they are unavoidably necessary, they should be sealed exactly. All sealing measures should be controlled on the building site.

Exhaust-supply ventilation systems with air-air-heat exchanger can only be recommended when the air tightness of the building envelope is guaranteed according to the SIA 180./8/

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