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Energy Saving and Airtightness of Blocks of Flats in Lithuania

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Key Words
Airtightness · Residential houses · Air change rate

Abstract
Measurements of the airtightness of blocks of flats in Lithuania were carried out between 1995 and 1997 to assess the effectiveness of energy saving measures. At that time there was no real data on the airtightness of such dwellings available. The aim of the measurements was to evaluate how much heat could be saved by diminishing the air change rate. Since there are no thermostats installed in the dwellings, 'tightening' becomes the only measure available to increase indoor temperature. Unfortunately, the results show that the popular expectation that energy was being wasted are not well grounded. We conclude that there is no real possibility for saving heat in small dwellings without contravention of health requirements except in isolated cases. The mean air change rate was found to be approximately 1.5 h^{-1} and further steps to tighten the building envelopes could only save energy in some large dwellings of three and more rooms.

Introduction

The price of oil per tonne in Lithuania today has risen from one twentieth of the average monthly salary in the 1980s to two thirds today. Heating taxes have become an important part of the family budget and affect the state budget as well. Because most of the urban population in this region lives in similar prefabricated concrete panel houses along the East Baltic sea coast, the same economic problem affects the people and governments of Latvia and Estonia as well as Lithuania. Various ways have been proposed to ease the burden of expensive energy. One of them is to tighten building envelopes. All residential buildings are naturally ventilated with the exceptions of some tall buildings over 10 floors in height which have mechanical ventilation and part of the newer buildings. In some buildings wooden door and window frames have been changed by the owners for modern plastic or newer wooden frames. Such steps to reduce adventitious air change result in increased internal temperatures, but the diminished air change rate too often causes complaints of high humidity or mould growth.

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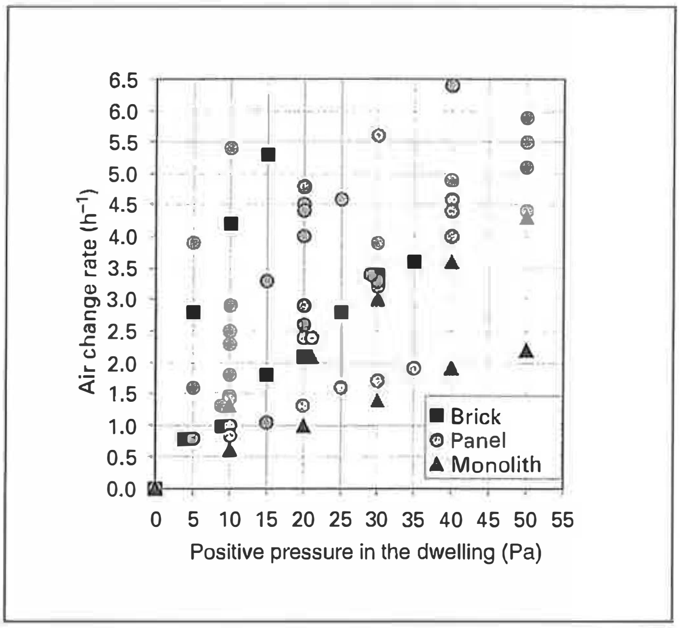

Fig. 1. Air change rates measured at positive pressure in dwellings.

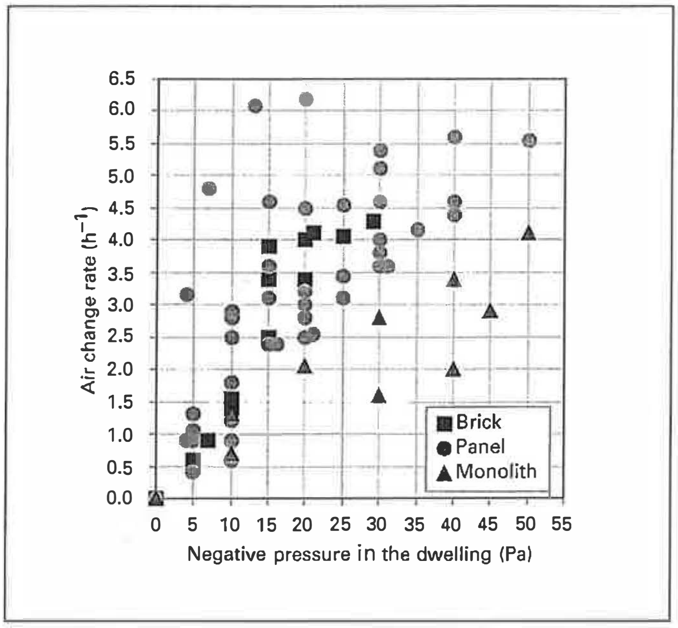

Fig. 2. Air change rates measured at negative pressure in dwellings.

Materials and Methods

The monitoring programme included, inter alia, long term measurements of indoor and outdoor air temperatures and building tightness and was carried out over the 1995/6 and 1996/7 'heating seasons'.

All buildings selected for study were built in the period 1960–1990. They took their heat supply from a district heating system. In most of the buildings the type of heating system used was a one-pipe central heating system using water. No thermostats were installed in the dwellings. Windows and balcony doors were all double glazed with wooden frames. The windows were easily opened. Often they were 'tightened' with polyurethane strips and sometimes joins were sealed with glued paper. Building envelopes were either brick, prefabricated middle-weight concrete panels (1,000 $kg \cdot m^{-3}$) or were 'monolith', moulded from middle-weight concrete on the building site. The heights of the buildings varied between 4 and 16 floors. All buildings and dwellings selected for study were examined with the consent of their owners.

Temperatures were measured by Gemini Tiny Tag data loggers (Gemini Data Loggers Ltd., UK) which had an accuracy of ± 0.2 °C, over the period December–April. The heating season generally lasts from October to April starting after the outdoor temperature has fallen below 8 °C. The indoor design temperature for such buildings is 18 °C.

During the measurements a fan was used to supply or exhaust air from dwellings at rates required to maintain a specified pressure difference across the building envelope. The air flow and the pressure difference were measured. After the test conditions were stabilized, the air flow and the pressure difference were recorded. The air flow was recorded at a number of pressure differences, positive and negative, for instance at ± 10, ± 20, ± 30, ± 40 and ± 50 Pa. The calculated air flows were corrected for the difference between indoor and outdoor temperatures with reference to the calibration temperature. Before the test was carried out, all openings in the envelope of a flat that were intended for ventilation purposes were sealed, other openings were kept closed. The outdoor temperature during a test period in February was between 0 and –10 °C, and the average wind speed was less than 10 $m \cdot s^{-1}$. In several buildings it was not possible to obtain a pressure difference of ± 50 Pa due to air leaks. In these cases the air change rate was calculated by the equation $n_{50}/n_i = (50/p_i)^m$, where n_{50} is the expected air change rate at 50 Pa, n_i the actual air change rate measured at the maximum pressure difference achieved and p_i is the actual pressure difference (Pa).

The index m of the equation was obtained after averaging appropriate measurements from figures 1 and 2.

Results

Plotting the experimental points of pressure difference versus air change rate shows a wide spread of data (fig. 1 and 2). When the the measurements made with air supplied were compared with those in which air was exhausted, there appeared to be no appreciable difference although this was not examined for statistical significance.

Other work had noted that the number of floors in a building or the year in which it was built showed no correlation with airtightness. Buildings constructed using the 'monolith' technique seemed to be tighter than the others, J

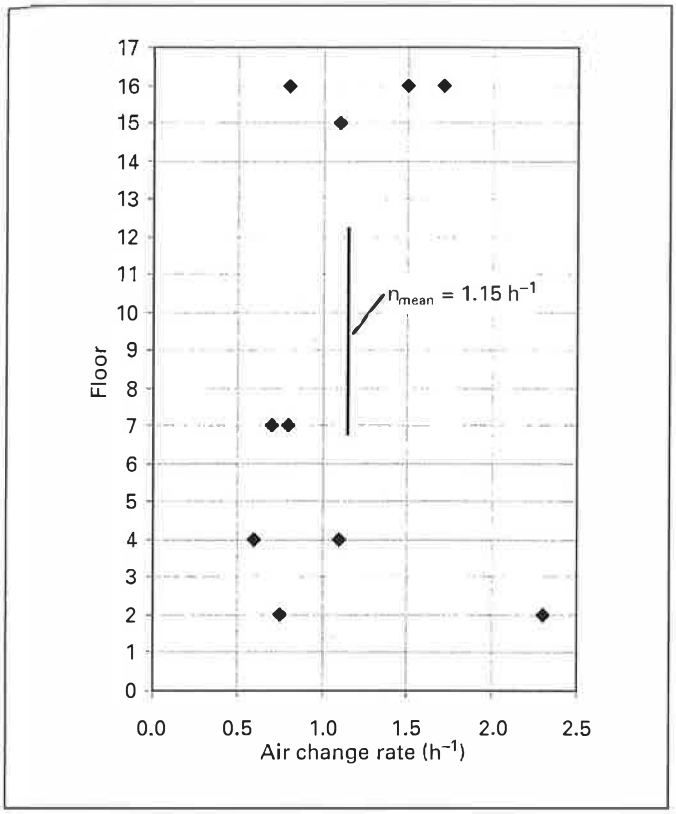

Fig. 3. Mean actual air change rate on various floors of a tall residential building (Courtesy of M. Gedgaudas, Vilnius Technical University).

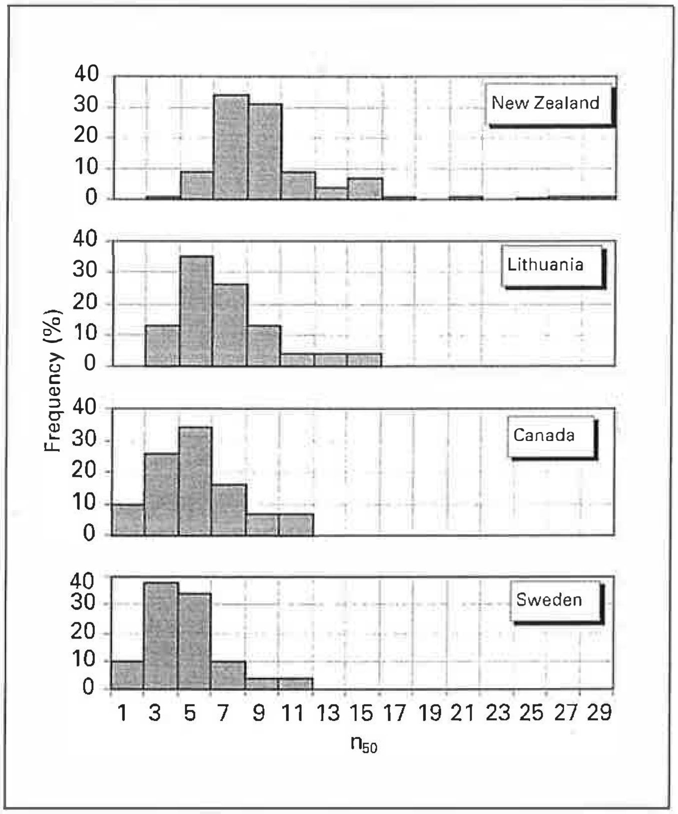

Fig. 4. A comparison of n_{50} values for houses in four countries.

but because of the small number of such dwellings there was not enough data to make a reliable comparison. There were negligible cracks around the wall panels to permit ingress of air in this type of building. Further, flats in 'monolith' construction buildings are more expensive than in other types of construction and their owners look after their houses more carefully. Between the various buildings the ratio of air change rate between the leakiest and the tightest flat in the same building varied in the range from 3:1 to 10:1. This suggests that the main cause of 'leakiness' is a lack of owners' attention and maintenance of their dwelling.

Table 1. Leakiness of dwellings

Country	Air changes per hour at 50 Pa		
	arithmetic mean	standard deviation	sample size
Belgium	8.2	7.2	57
Netherlands	10.1	6.7	303
UK	13.6	5.7	385
Lithuania	6.7	3	33

The advantage of using pressurization to examine leakiness of a dwelling is that it outweighs the influence of natural draught. Other methods have been used including long-term measurements using gas evaporation and measuring decay by some indicator, either a direct reading analytical instrument or absorption tubes. An example of measurements made in this way is given in figure 3 which shows small differences between dwellings on the same floor and no correlation between floors. Similarly, measured leakiness of dwellings in a number of countries is compared in figures 4 and 5 and in table 1 [1]. The average rate value air change found in the Lithuanian dwellings studied was 6.7 h^{-1} at ± 50 Pa.

Measurements were taken to establish the relationship between leakiness and internal temperature of dwellings (fig. 6).

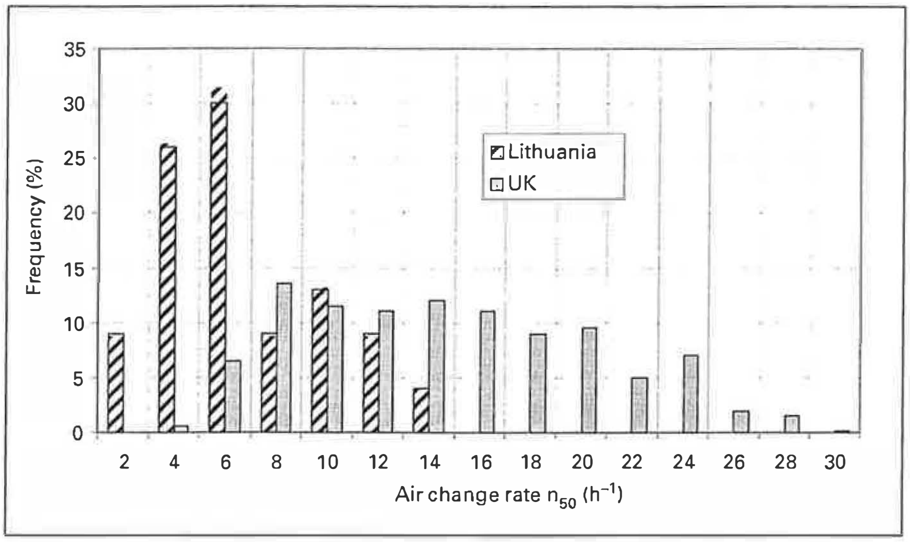

Fig. 5. Distribution of air leakage of dwellings at ± 50 Pa.

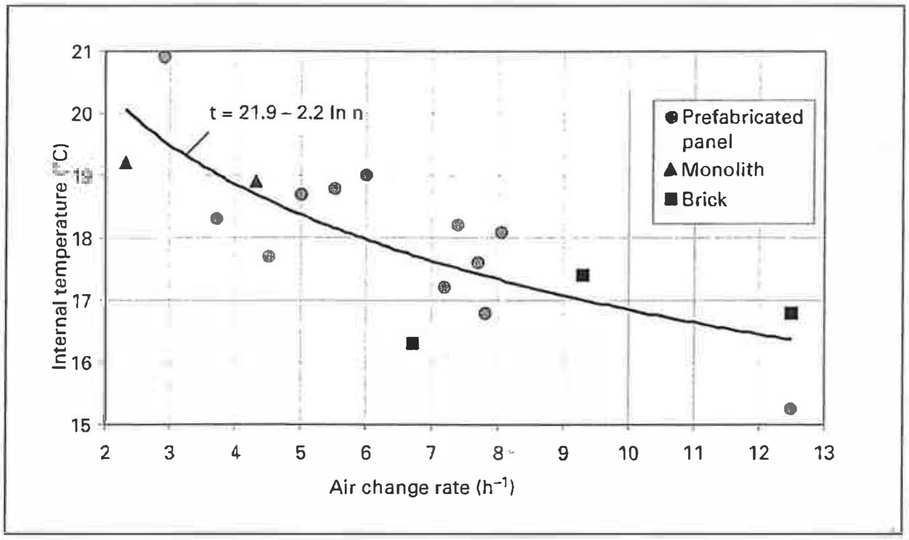

Fig. 6. Mean temperature of flats built by different construction methods and their airtightness.

Discussion

The comparison between countries shows an evident tendency to tighter houses the further north one goes in Europe. It should be noted that Soviet Building Codes did not contain any requirements for the airtightness of whole buildings. However, after Lithuania had regained independence, such requirements were included in the appropriate regulations and building codes.

The measurements taken to establish the relationship between leakiness and internal temperature of dwellings (fig. 6) show that in spite of economies imposed during the heating seasons the internal mean air temperature was maintained at the lower limit of moderate [2]. When the Lithuanian figures are compared with those from the UK and Sweden (table 2) it can be seen that they are comparable with those in the UK. Swedish temperatures are about 3°C higher and similar to those found in Lithuanian dwellings in which n_{50} does not exceed 3 h^{-1} at ± 50 Pa [3].

One important issue which needed to be resolved in this work was to establish the effect of reducing leakiness in dwellings in terms of any effects on health and on the economics of the heating system. Because so little actual data is available in Lithuania, we rely on data collected in other countries for comparison purposes. As a start we compared floor area per person (in square metres) in dwellings in several countries (table 3) [1]. The figures

Table 2. Indoor temperature (°C; °F in parentheses)

	UK	Sweden	Lithuania
Mean indoor temperature	17 (62.6)	20.9 (69.6)	17.8 (64)
Standard deviation	2.8 (5.0)	1.5 (2.7)	1.6 (3.0)
Mean outdoor temperature	7 (44.6)	–	–4 (25)

Table 3. Area per person

Country	Persons/dwelling	Area, m²/person
Netherlands	2.6	–
UK	2.7	27
Sweden	2.1	47
Finnland	2.5	30
Germany	2.5	35
USA	2.3	61
Lithuania	–	18

show that the floor area per person in Lithuania is approximately half that in some other Western European countries where the mean seasonal air change rate, according to ISO standards, is assumed to be 0.5 h^{-1}. From this study we calculate a seasonal mean value of air change rate due to natural draught to be comparable with the mean value of measurements made at 5–10 Pa (fig. 1, 2) which is 1.5. Another Lithuanian study gave a mean value of 1.15 h^{-1} (fig. 3). From a comparison of the two studies we estimate that a reasonable value to expect for the mean seasonal air change rate would be near 1.5 h^{-1}.

Taking this figure of 1.5 h^{-1} allows us to calculate the effectiveness of further tightening buildings. Health requirements for ventilation are for 36 $m^3 \cdot h^{-1}$ (10 $l \cdot s^{-1}$) of air to be exhausted from a toilet, 54 $m^3 \cdot h^{-1}$ from a bathroom and 72 $m^3 \cdot h^{-1}$ from a kitchen giving in total 162 $m^3 \cdot h^{-1}$ [4]. For a single-room dwelling of 80 m^3 volume this gives a minimum air change rate of 2 h^{-1}, proportionally less for a two-room dwelling of 130 m^3. Thus, energy-saving possibilities through further restriction of air change are doubtful. There is some possibility that energy may be saved by restricting the air change rate in large dwellings, which for all practical purposes are those with 3 rooms, because larger dwellings were not often built. However, frequent claims of high humidity and/or mould growth after new ‘tight’ windows had been fitted and the necessity to comply with ventilation health requirements show that the expectations that considerable energy could be saved by building tightening were not well grounded. The results of this study do not confirm the popular opinion about the extremely high ‘leakiness’ of residential blocks of flats built in the years 1960–1990. Overall this work shows that there are no heat-saving reserves in the smaller flats without contravention of health requirements except in isolated cases. Heat saving while maintaining a good indoor air quality may be possible in dwellings of 3 and more rooms. Unfortunately, since no thermostats were installed in the dwellings tightening is the only practical measure available to occupants to increase indoor temperature.

Acknowledgements

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