THE PERFOMANCE OF VENTILATION IN SOVIET DESIGN APARTMENT BUILDINGS IN ESTONIA

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ABSTRACT

The purpose of the study was to measure the performance of natural ventilation in 5- and 9-storey apartment buildings, and to offer solutions for the improvement of ventilation. In the four most common building types, the functioning of the old ventilation system was measured during a spring and summer period. The economically feasible improvement solutions, as installing the auxiliary fans and mechanical exhaust ventilation, were analysed with measurements and calculations. The old natural ventilation system with stacks and leaky windows can maintain a certain basic level of ventilation. The air change was in an average two-room flat 0,4...0,5 1/h during the measuring period. The simplest and economically most feasible way for improving ventilation is to install in the first stage the kitchen exhaust fans, and in the second stage, the exhaust airflows in bathrooms and toilets can be improved by installing the fans on the top of the stacks.

INTRODUCTION

The 5- and 9-storey prefabricated houses are the most common apartment-type buildings in Estonia. These apartment blocks, built in the Soviet time from beginning of the sixties to the end of the eighties, are now arguably the biggest problem in the building sector of again independent Estonia.

A natural ventilation system is built by using prefabricated concrete stack elements. There are two exhaust outlets for every apartment, one in the kitchen and one in the bathroom. Thus, the two connecting stacks extend from each apartment through the two or three storeys to the main stack. The last two or three upper storeys have their own stacks opening directly onto the roof, and are, thus, not connected to the main stack. The functioning of ventilation system is based on leaky windows because there are no special air intakes.

Improving the ventilation system is usually not considered to be the first measure in renovation process. However, the ventilation rate is directly connected to indoor air quality. Furthermore, there have been a lot of problems with condensation, stuffiness and mold after completing the additional internal insulation and draught-proofing the windows. Thus, improving the ventilation is a necessity before the building envelope is tightened.

METHODS

The measurements of ventilation and indoor climate were carried out in the four most common building types that are "new" and "old" 5- and 9-storey houses. Measurements were done in 33 apartments during the time period from the beginning of March to the end of July. From each apartment, the next instantaneous measurements were done at frequent intervals:

- exhaust airflows in the kitchen and toilet
- indoor air temperature
- relative humidity
- visible water damages and surface moisture content

Solutions for improvement were studied by measurements and calculations. The auxiliary fan was installed in the kitchen and the behaviour was tested by simple exhaust airflow measurements in different weather conditions. The possible spreading of odours was also investigated with tracer gas technique. Ventilation with auxiliary fan was analysed with calculations by using the programme for static flows PFS (L. Jensen 1996, Lund, Sweden) for modelling the building and ventilation system.

Functioning of exhaust ventilation (fans on the roof) were tested in repaired buildings by instantaneous exhaust airflow measurements.

RESULTS

The measurement results of extract airflows show that the old natural ventilation system with stacks and leaky windows can maintain a certain basic level of ventilation. Figure 1 and 2 show the measured results from 5- and 9-storey houses. During measurements no clogged stacks were found.

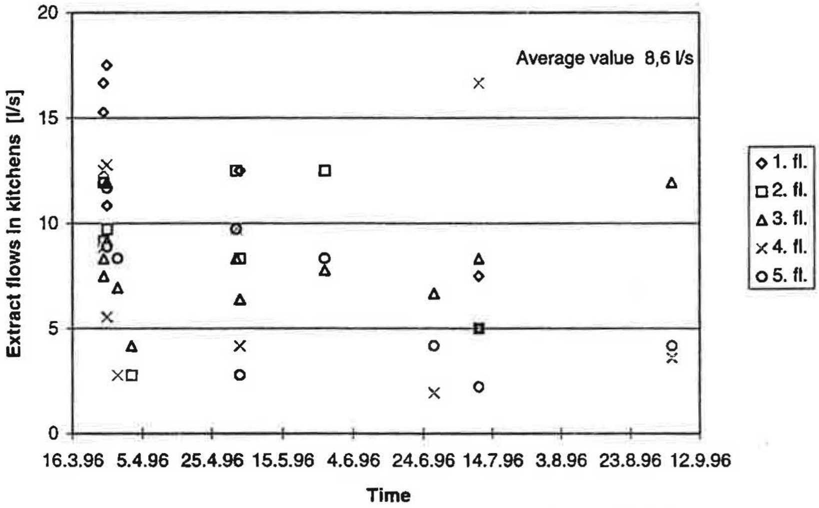

Figure 1. Measured extract flows in kitchens. 5-storey buildings.

The extract airflows were slightly more stable in 9-storey buildings (Figure 2) and also the average value of airflows was slightly larger. However, this difference is not remarkable and can be explained by bigger height of 9-storey buildings.

The air change was in an average two-room flat in both 5-storey and 9-storey buildings 0,4...0,5 1/h during the measuring period. Because there is the same number of stacks in apartments with different size, the air change is bigger than the mentioned 0,4...0,5 1/h in one-room flats and smaller in three and four-room flats.

The results measured show a large variation in exhaust airflows, and exhaust airflows even below 5 l/s were measured in many cases. Back-flows in exhaust stacks were observed in some cases, especially on the upper floors.

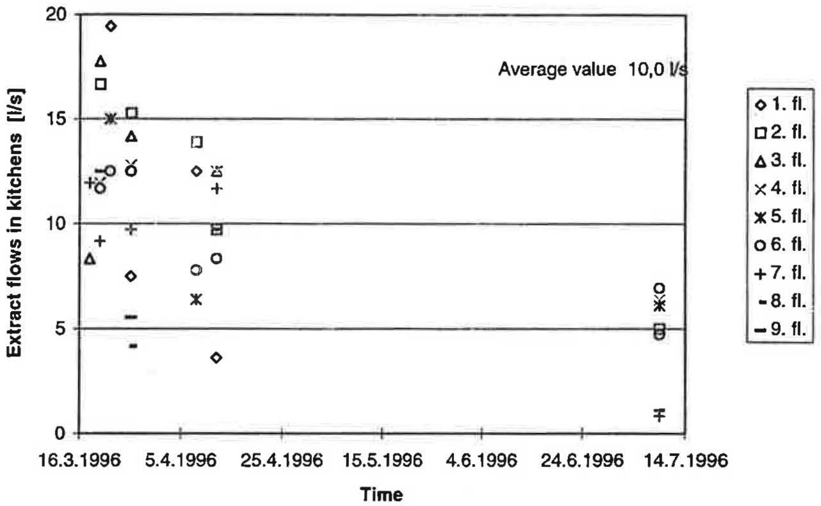

Figure 2. Measured extract flows in kitchens. 9-storey houses.

When designing improvement for air change, the structure of exhaust stacks and lack of designed intake air must be considered. The renovations must not reduce the air change. The long connecting stacks rising from every apartment through the two or three floors to the main stack and the separate stacks on upper floors, make it possible to use the auxiliary fan solutions in the apartments.

The functioning of the old ventilation system is based on leaky windows because there are no special air intakes. Changing the windows or draught-proofing the old ones to save energy have led in practice to insufficient air change, and condensation and mold problems. Solutions for improving controlled ventilation and saving energy have to include the possibility to control the extract and intake airflows. The possibility to increase the exhaust in kitchens is particularly important during cooking since the air space of older kitchens is very small (area 5,8 m^2).

In mechanical exhaust ventilation, the level of expenditure is the biggest problem. Also, it is not known how well the stacks are sealed and, thus, must be measured in follow-up studies.

On the basis of this research, the simplest and economically most feasible solution for improvement is a so-called combined solution, where in the first stage the kitchen exhaust fans are installed in kitchens, and in the second stage, the extract air flows in bathrooms and toilets are improved by installing the fans on the roof on top of the stacks.

Connecting the kitchen exhaust fans directly to the stack causes overpressure inside the connecting stack. This overpressure may cause a reverse flow to the other apartments when the fan is on in only one or a few apartments. A reverse flow in the other stack of the same apartment is also possible. However, this is probably the easiest way to increase extract flows, and it has already been used by residents in a small scale.

Possible reverse flows, caused by kitchen exhaust fans were studied by measurements and calculations in a 5-storey building. The programme for static flows PFS (L. Jensen 1996, Lund, Sweden) was used and the problem was described with simple graphical models containing the apartments, ventilation system with fan, stairwell and outside conditions. The modelling is discussed in (2).

Measurements and modelling showed roughly the same result. When the fan is on in the first floor, there is no remarkable affect to the other floors' airflows. Also the last two ("new" buildings) or three ("old" buildings) upper floors have their own stack and the fans do not have any side effect. Thus, in "old" buildings the second floor and in "new" buildings the second and third floor are problematic.

The results calculated with outside temperature of +10°C and no wind and with different fan locations are shown in Figure 3. The worst fan location in the case of one help fan is the second floor. When it is on, the extract airflow on the first floor kitchen is reduced, as shown in Fig. 3. The worst situation is when the fans are switched on simultaneously on the second and third floor (in kitchens). In this case, there is a 1,7 l/s reverse flow on the first floor. The reverse flows can be avoided by reducing the pressure rise of the fan. Calculations with different fan curves and fan locations showed that the maximum static pressure rise generated by fan cannot exceed 20 Pa.

Calculations and measurements showed that there are no reverse flows in bathroom stacks in any cases studied (the fans are acting in kitchens only). Still, closing the kitchen door gives stable exhaust flows in every floor and for example in the case shown in Fig. 3 increases the smallest exhaust from 5 l/s up to 11 l/s.

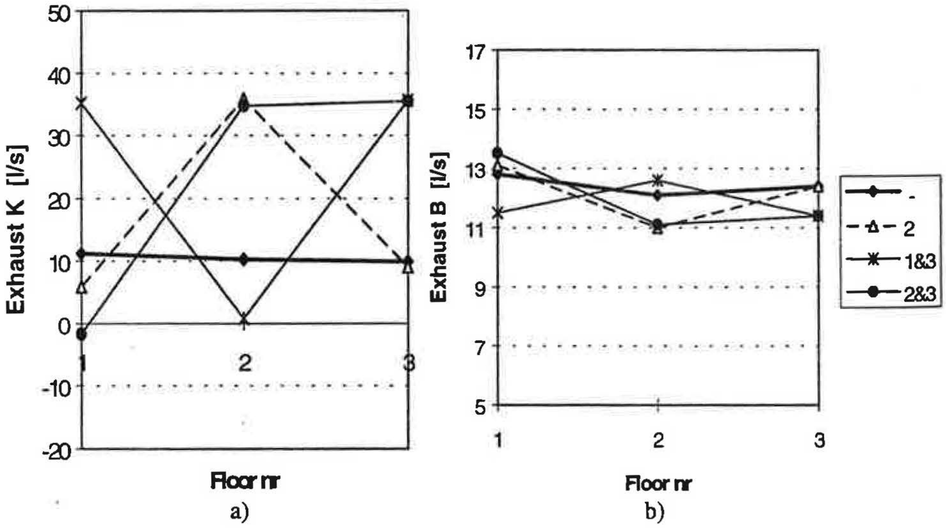

Figure 3. Exhaust air flows a) in kitchens and b) in bathrooms with different fan locations

According to these results, the kitchen exhaust fans can be installed on the first floor and on the upper floors that have separated stacks. The other floors and also 9-storey houses need follow-up research where the kitchen exhaust fans would be installed in the kitchens of a test house and the functioning of these and also the functioning of one-way valves would be tested in practice.

DISCUSSION

The measurements showed that old natural ventilation system with stacks and leaky windows can maintain a certain basic level of ventilation. The air change was in an average two-room flat 0,4...0,5 1/h during the measuring period. However, there was a large variation in exhaust airflows. In the cases calculated, the leakage of 7 1/h at 50 Pa leads to air changes from 0,3...0,5 1/h at +10°C outdoor temperature. In general, the old natural ventilation system functions satisfactorily in the spring, summer and autumn period when the windows can be opened. In the cold period, the windows must be sealed temporarily to avoid draught.

As there are no special air intakes, the functioning of the ventilation is based on leaky windows. It means also that changing the windows or draught-proofing the old ones to save energy leads to insufficient air change.

The long connecting stacks extending from each apartment through the two or three storeys to the main stack, and also the separated stacks in upper floors make it possible to use auxiliary fan solutions. In order to avoid reverse flows, low-pressure and low-speed axial fans should be used. The limited number of the cases calculated and measured showed reasonable results, and the solutions with auxiliary fans are therefore worth further research.

According to the results, the kitchen exhaust fans can be installed in 5-storey buildings without any side effects on the first floor and on the upper floors that have separated stacks. The other floors and also 9-storey buildings need follow-up research, where the kitchen exhaust fans would be installed in the kitchens of a test house and the functioning of these and also the functioning of one-way valves would be tested in practice.

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