DEMAND CONTROLLED VENTILATION SYSTEMS IN THREE FINNISH DEMONSTRATION DWELLING HOUSES

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ABSTRACT

In this study the multifamily demonstration buildings with demand controlled ventilation systems are discussed. Furthermore, the heating systems together with demand controlled ventilation are looked at.

There are given examples of the centralized supply and exhaust ventilation system, the centralized exhaust ventilation system and the apartment based ventilation system. All the systems are mechanical, natural ventilation is not discussed here. In cold climates natural ventilation, i.e. opening of the windows, can't meet the requirements on good indoor air quality and thermal comfort and leads to poor energy economy.

INTRODUCTION

The air exchange rate of smaller flats dimensioned according to the Finnish Building Code can become unnecessary big. Correspondingly the ventilation rate of some rooms of bigger flats can be insufficient. In such rooms, where the impurity loads vary plenty (i.e. kitchen and bathroom), ventilation can be unnecessary big for the most of the time, but however insufficient in the loading situation.

In the national research project concerning residential ventilation the aim was to develope ventilation systems, where the occupant has the possibility to control the air flows according to his own needs (1).

First, the needed air flows in different rooms were determined with so called Monte Carlo -method (2) on the basis of impurity loads and criteria of acceptable levels found in the literature. As a result the appropriate range of air flows for different rooms and loading situations were got.

In the project the flow technical characteristics of the ventilation systems with variable air flows were developed, too. The aim was to control the air flow rates and pressure differences both in the basic and in the loading situation.

Three categories of ventilation systems for blocks of flats were examined: centralized mechanical supply and exhaust

ventilation system; centralized mechanical exhaust ventilation system and apartment based ventilation system. Each ventilation system is presumed to incorporate functional components as: ventilation unit, ductwork, flow controller, terminal devices and control unit.

The increase in the air flows can be achieved either by increasing the total air flow of the apartment or by concentrating the air flow rate of the apartment partially to the desired space. In the paper, the first way is discussed.

Heating of the rooms in a block of flats is usually done with a separate network, i.e. radiator heating system. The behaviour of the room air temperature in the case of increasing the air flows is studied by calculations. In the mechanical supply and exhaust ventilation system the decrease in the room air temperature can be avoided with the appropriate temperature of the supply air. In the mechanical exhaust ventilation system, where the supply air is unheated, draught problems occur easily. This limits the maximum amount of the increased air flow (3).

In this paper, the accomplishment of demand controlled ventilation systems is handled by three examples of demonstration objects, where the results of the calculations have been applied. Also the heating system in these objectives is presented.

CENTRALIZED MECHANICAL SUPPLY AND EXHAUST VENTILATION

Ventilation

In the centralized mechanical supply and exhaust ventilation system, there is a ventilation unit equipped with heat recovery at the top of the building. The ventilation unit serves several flats. Two supply air duct enters and one exhaust air duct leaves the apartment for the ventilation unit (Figure 1). The supply air terminal devices are mounted to bed and living rooms and correspondingly the exhaust air terminal devices in the kitchen, bathroom, toilet, cloak room and sauna.

In order to keep the pressure losses small in the ductwork, the velocities in the ducts should not exceed the following values (4): main duct 4 m/s, branch duct 3 m/s and stub duct 2 m/s. The pressure differential of the terminal devices has to be sufficient (50-100 Pa) and their pressure differential has to form at least half of the total pressure loss of the ductwork.

The desired pressure level of the ductwork is achieved by a constant pressure adjustment at the central ventilation unit. Constant pressure is kept in the exhaust duct. As the increase in the exhaust air is not big, the supply air flow is kept constant (5).

In the demonstration object (Figure 1) that kind of centralized ventilation unit is located on the top of the building. A constant pressure of 100 Pa is hold in the ducts. The ratio between supply and exhaust air is 0.8. The occupants are able to increase the air flows in the kitchen and wc. The hollows in the hollow core slabs and elements are used as air ducts.

Heating

The exploitation of the building mass for storage of energy as a part of the heating and ventilation system is profitable when combined radiation and ventilation heating is used. The building mass can be heat accumulated by preheating the supply air led into the hollow core structures or by installing electrical heating cables into the hollows. A room-based air terminal device heats the supply air and controls the indoor air temperature (6).

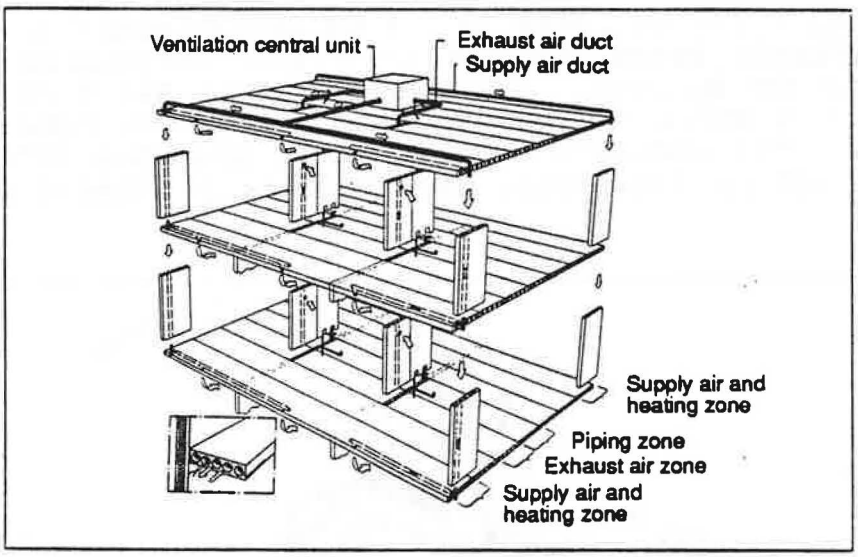

FIGURE 1. A demonstration building with centralized mechanical supply and exhaust ventilation system.

Monitoring

The ventilation unit and terminal devices are tested in laboratory. The operation of the ventilation and heating system is tested under the building phase.

The house will be completed by March 1991 and the monitoring of one year lenght will start after that. The automatized monitoring includes the monitoring of temperatures, air flows, pressure differentials and use of electricity.

The results will show how electrically heated block of flats operates energy economically and in other respects.

CENTRALIZED MECHANICAL EXHAUST VENTILATION SYSTEM

Ventilation

In a conventional mechanical exhaust ventilation system, the exhaust air is sucked from the kitchen, bathroom and cloak room. The exhaust air flows of the kitchens are gathered to a branch air duct and on the top of the building there is an exhaust fan, common for several flats.

In the centralized mechanical exhaust ventilation system, a special arrangement for constant pressure in not necessarily needed. The increase in the air flows can be achieved also in that case, when the pressure curve of the fan is slanting. In a demonstration object, where there is centralized mechanical exhaust, both alternatives are build in order to be able to use them by turns.

The demonstration building is a four storey building equipped with apartment based exhaust duct and adjustable terminal deviced in the kitchen. The basic exhaust air flow from the kitchen is 6 dm^3/s and the increased air flow rate at least 20 dm^3/s. The ductwork has the total pressure differential of about 120 Pa available. The ductwork is presented in the Figure 2.

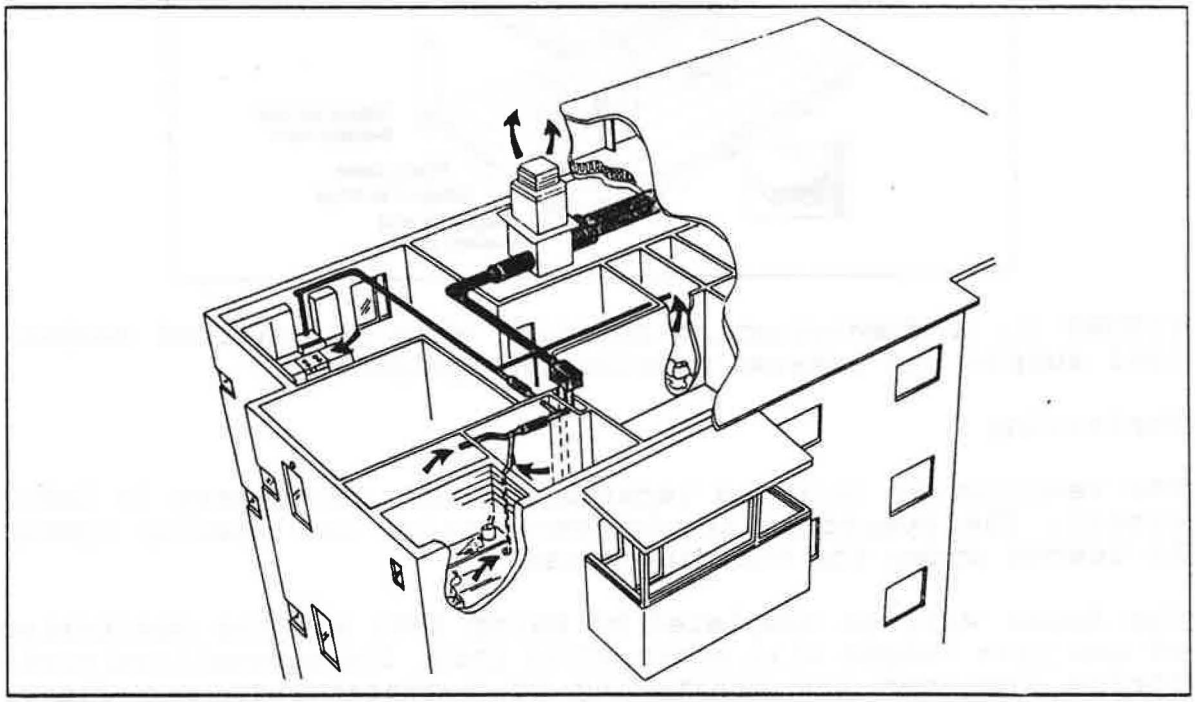

FIGURE 2. A demonstration building equipped with a centralized mechanical exhaust ventilation system.

The outdoor air inlets are dimensioned with the basic air flow rate. Besides, the function of the ventilation system in the case of increasing is examined in order to ensure that

the pressure differential over the building envelope do not exceed 30 Pa.

Heating

The heating of the building is done by a traditional radiator network. The heating system is dimensioned with the maximum air flow rate.

Monitoring

The critical component of this system is the kitchen hood, which will be tested in laboratory.

The house will be ready in March 1990 and monitoring will start after that. The operation of the ventilation system is monitored during one years period. The exhaust air flows, temperatures and sound levels will be measured in different situations and also occupant enquiries will be made.

If the ductwork works well without the constant pressure arrangement, there are good prequisities to begin to build blocks of flats equipped with the demand controlled ventilation with only small changes to the prevailing way of building.

APARTMENT BASED VENTILATION SYSTEMS

Ventilation

In the apartment based ventilation system, every apartment has a ventilation unit equipped with heat recovery. The ventilation unit is located usually in the bathroom or kitchen.

In Finland used apartment based ventilation systems the occupant has already today the possibility to vary the air flow according to his own needs. The purpose have been achieved by the means of several rotational speeds on the fan.

Heating

Usually there is a radiator heating network separate from the apartment based ventilation system. If the apartment based ventilation system is used also to heating, the supply air is heated nowadays by electricity in Finland. In the demonstration object the heating coil for the supply air will be connected to the radiator heating network.

Monitoring

The study includes the designing and making the components. The components will be tested in laboratory. In the first step, the system will be tested in a pilot house during the heating season.

The results will show, wheather an alternative heating system for block of flats can be developed.

SUMMARY

Because the impurity loads in residencies vary, a demand controlled ventilation system is needed. In this study general principles of the accomplishment of ventilation systems with variable air flows have been studied. The goal in the national R&D work is to get well functioning tested solutions which are ready to larger use in the country.

The accomplishment in three demonstration objects have been presented. The first of them is an electrically heated building with mechanical supply and exhaust ventilation system. That kind of system needs arrangement for constant pressure, when the air flows are increased.

A demonstration building with mechanical exhaust ventilation system is not far away from the prevailing way of building, though the possibility of increasing the exhaust air flow in the kitchen makes the ventilation system more modern.

Apartment based ventilation systems are also under development. In the demonstration project, the aim is to heat the supply air besides by the heat recovery, also by radiator heating.

In the previous demonstration projects, the target of the project sometimes haven't been achieved, because the system hasn't operated properly. In these new demonstration projects, the critical components are tested in laboratory and the operation of the systems are tested under the building phase.

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