EFFECTIVE VENTILATION

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Paper 19

A VENTILATION CONCEPT FOR FUTURE DWELLING-HOUSES

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SYNOPSIS

To avoid the shortcomings and problems that occur in today's ventilation systems a ventilation concept for future dwelling-houses is under development. The concept responds to the way of living and building in the future. The real living functions are chosen to design principles, that's why the system has to be capable of operating at varying air flow rates. The building in the future is based on a hierarcical modulated system, in which from a small set of standard components can be assembled versatile alternatives. A system designation adaptable to the new building system is under development.

1. INTRODUCTION

There are without dispute many lacks in the performance of ventilation. These lacks have caused resistance against mechanical ventilation. On the other hand, more requirements are imposed on the indoor air, including the possibility of the inhabitant to control ventilation according to his likes and habits. The more control we want the more technique is needed.

In order to improve and develop the present ventilation systems to meet the increasing requirements the problems and faults of the present systems were analyzed. Information and experiences were gathered from the occupants mainly through demonstration projects financied by the Ministry of Trade and Industry.

Based on the analysis of the operational faults and development needs arose the research project "Ventilation systems of the future dwelling-houses". The aim of the project is to develop ventilation systems that fit to the way of living and building in the future.

2. PROBLEMS OF TODAY'S VENTILATION SYSTEMS

The most typical lacks in the demonstration buildings equipped with mechanical exhaust ventilation proved to be draught, stuffiness of indoor air, spreading of odours inside the flat and between flats and condensation problems in the constructions. Mechanical extract ventilation system is quite usual in the building stock in Finland (e.g. it covers 60 % of the blocks of flats). It's not possible to say in general, how usual the above mentioned problems are, because the examined material was small.

The complaints in the demonstration buildings equipped with mechanical supply and exhaust ventilation or air heating concerned mainly noise, spreading of odours inside the flats and the difficulties in use and maintenance. The amount of residencies equipped with mechanical supply and exhaust ventilation system

is under 10 % of the stock of residencies.

The satisractory operation of the ventilation system depends also on the characteristics of the constructions especially on the internal and the external tightness of the building. For example in multi-storey blocks of flats the air leakages through the intermediate floors can't be avoided only by the means of the pressure differencies or air flows of the ductwork. However, ventilation system merely is blaimed easily for odour or condensation problems.

For example, the prerequisities for satisfactory operation of the mechanical supply and exhaust ventilation system in a multi-storey block of flats are according to the calculations /1/ the following:

- the pressure difference over the terminal devices is over 100 Pa
- the ratio between supply and extract air flow rates is 0,8
- the air leakage number of the building envelope is smaller than 0,5 1/h
- the air leakage of the intermediate floors at the pressure difference of 50 Pa is about 0,1 l/sm^2
- the air leakage of the staircase doors is about 2 l/s at the pressure difference of 50 Pa.

3. THE REQUIREMENTS SET ON THE VENTILATION SYSTEMS OF THE FUTURE

3.1 Climate

From the ventilation point of view, the outdoor air temperature is the most important meteorological factor. The outdoor air temperature influences on dimensioning the aparatus, the need of capasity and energy consumption conclusively. Ventilation systems that are developed for the mild climate countries don't usually operate energy efficiently in the Finnish climate conditions.

There are heating and cooling loads in the buildings in Finland. The outdoor air temperature changes from about -30 °C to +30°C. The special characteristics of the climate is that outdoor air can be used for cooling nearly always in the summer.

The big temperature difference between outdoor and indoor air at winter time causes big pressure differencies between the floors and inside the ventilation system. The big pressure differencies change the air flows in the building the more the higher the building is.

3.2 Social development

The residencies are more cramped in Finland than in the other Nordic countries. As a reason to that has been given that the

Finns value the housing less than other nationalities, the building sector hasn't been capable on answering to the changing demands, most residencies are owned by the occupants and the repayable times of the loans are short. Anyway, the residential spaciousness is estimated to grow from 28 m^2 per person to 35 m^2 per person by the year 2000. The bigger residential spaciousness makes it possible to provide e.g. the kitchens and bathrooms with better facilities.

The working hours of single persons will become shorter. The shorter working hours will not lead to increase in actual leisure time, but the free time will be used mainly to increasing household management. The increase in household management is due to increasing qualitative requirements and increase in the property to be taken care of.

In the year 1986 a Finnish pilot study /2/ was completed, the goal of which was to identify future needs and requirements for the development of building HVAC and electrical systems. The study was carried out by interviewing experts in different fields (research scientists, designers, manufacturers, building contractors, architects, social scientists and sociologists).

As a result it was concluded that new needs and requirements focus especially in shortening contruction time, raising quality and improving energy management. Moreover the results emphasized individual requirements of occupants, and the influence of indoor air on health and comfort of the occupants.

3.3 Building technology

The basic problem in building technology is to solve the complicated interactive contradiction between the requirements: quality, serviceability, flexibility and economy. Traditionally the view has been that industrialized production can lead to economical result, but with the loss in quality and flexibility.

The solutions are developed in many research projects at the building sector in Finland (fig. 1). In one of the research projects there is a new modulated hierarchical building system (TAT) under development /3/. The technical realization of the economic production is mechanised and automatized production of structures in the factory and rapid erection of structures at the building site. In the finishing phase both mechanical and handwork is used to get a personal look to the building which else is produced by the industrialized building system.

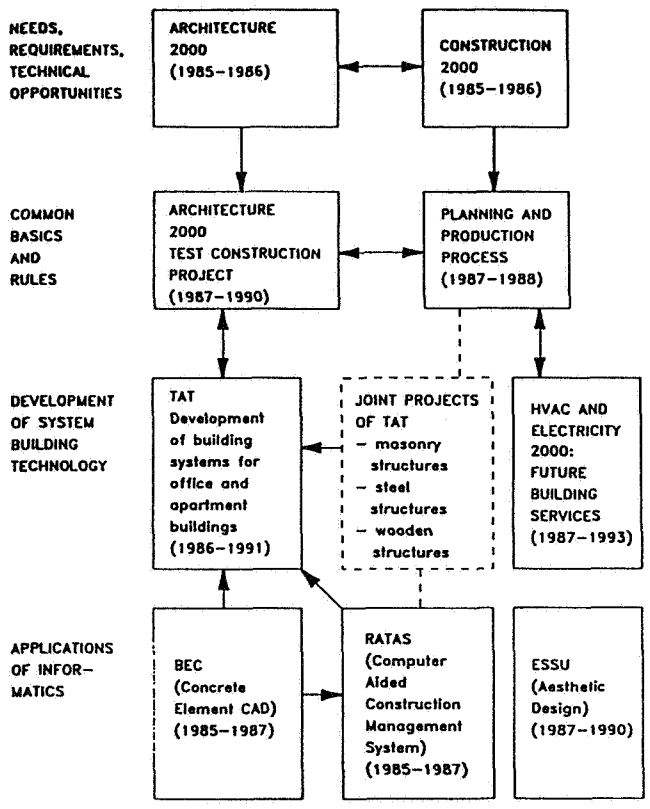

Fig. 1. The Finnish innovation process towards the computer integrated industrialized building technology. /3/

The modulated hierarchical building system can be defined by the new concepts (table 1).

The basic idea in the industrialized building system is that a large number of versatile combinations can be made up of a few components. The levels of hierarchy are building level, sub-building level, module level, component level and basic element level, which are defined as follows:

sub-building: an independent part of the building defined according to operation, design or manufacturing

module: a combination of pre-fabricated components

component: a separate, prefabricated part of a technical system, a component will be delivered as a solid element to the building site

basic element: a detail of a component.

The TAT-building system has two levels of quality: basic level and high level. The quality level is defined at the component (basic element, module) level. Both quality levels can be used in

the same building and the quality level can be improved afterwards.

Table 1.The modulated hierarchical building system (TAT).

TAT–Building system									
Leves of hierarchy	Architectural and technical systems								
	A	S	H	W	V	E	T	W	D
1. Building level	Architectural system	Structural system	Heating system	Water supply system	Ventilation system	Electricity system	Teleinformatics system	Waste management system	Dimensioning system
2. Sub–building level									
3. Module level									
4. Component level									
5. Basic element level									
	Sub–systems								

3.4 Occupant behaviour

The writers of this paper don't have available generally applicable research results concerning the occupants hopes and requirements that they put on the ventilation systems. Some observations on the occupants' behaviour have been gained from the demonstration projects. For the needs of building services research and development projects (figure 1) will be made a study of the demands of housing and working in the long term (15 - 20 years).

For example, information about the occupants increasing habits was got in a demonstration project /5/, in which there was a

mechanical supply and exhaust ventilation system with ventilation units in every dwelling. The building had totally 35 dwellings. The central exhaust system was equipped with a fan which was to provide the basic exhaust air flow rate. The exhaust fan of the ventilation unit in the kitchen was used to increase the exhaust air flow rate from the kitchen hood when needed. The running times of the exhaust fans in the kitchens were monitored during 16 months period.

The household actions, e.g. cooking, cause a temporally changing impurity load in the apartment. That's why there were great differencies in times of increasing as well as in duration of increasing. The residents forced the kitchen ventilation 50 minutes per day in the mean (fig. 2). The ventilation needs of individual apartments can't be satisfied with a centralized increasing.

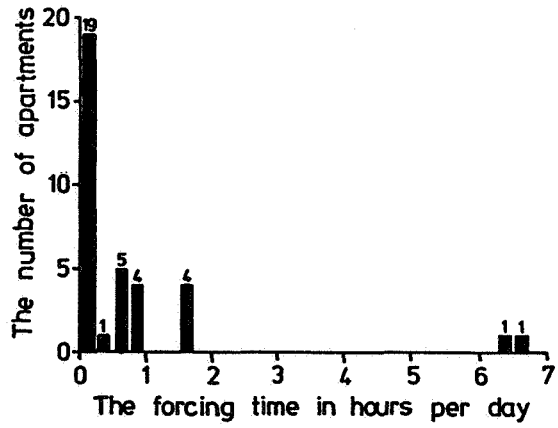

Fig. 2. The distribution of increasing duration of the kitchen ventilation hoods in the 35 apartments in March 1987. In two apartments the increasing was not used at all. /5/

3.5 Loads

The spatiotemporally changing impurity load consists of the impurities coming from the human beings, household actions and materials. The minimum ventilation rates are determined according to health aspects so that the concentration of unhealthy impurities from building materials don't exeed the allowed values in room spaces. Bigger air flows than the minimum are needed, if also other impurities should be exhausted by the ventilation system. Maybe, the maximum air flow rates are needed in cooling the apartments in summertime by using the outdoor air.

The starting point for the development of future ventilation systems is a system with variable air flow rate. After the loads which need the minimum and maximum air flow rates are determined, it is not important, whatever the other loading profiles and needed ventilation rates are, because the system is able to operate between the minimum and maximum.

3.6 General concept

The results from the above research projects form limits, that concern social development, building technology and occupants' comfort, health and consuming habits. Keeping in mind these limits, the following targets have been put to the ventilation systems:

- The possibility to vary the air flow rates according to individual needs (demand controlled)
- Good ventilation efficiency especially in living spaces.
- Independency of external disturbancies.
- Good energy economy (heat recovery).
- The possibility to improve the quality level afterwards.

The ventilation systems which meet the given requirements are developed by handling the ventilation as one of the technical systems of the building and by determining the functional requirements of the components. This means that the idea of a modulated hierarchical system will be introduced also to ventilation.

4. THE DEVELOPMENT OF THE HIERARCHICAL SYSTEM

4.1 The components of the ventilation system

According to industrialized building system, the technical systems are assembled rapidly at site from prefabricated components. The components of the ventilation system are ventilation unit, air duct, air flow controller, room device and control unit (fig. 3).

Depending on the quality level of the system, the ventilation unit component consists of an appropriate selection of the following functions:

- exhaust (damper, fan, silencer, filter, heat exhanger)
- supply (damper, fan, silencer, filter, by-passing of the heat exchanger, heating, cooling, humidifying, recirculating).

The air distribution is accomplished so that only one supply and one exhaust air duct enters the apartment. The exhaust air flow of the apartment or the ratio between the supply and exhaust air flows of the apartment are controlled by the air flow controller or the ventilation unit. Inside an apartment the exhaust air flows can be forced spatiotemporally. The increasing does't change the total air flows of the apartment.

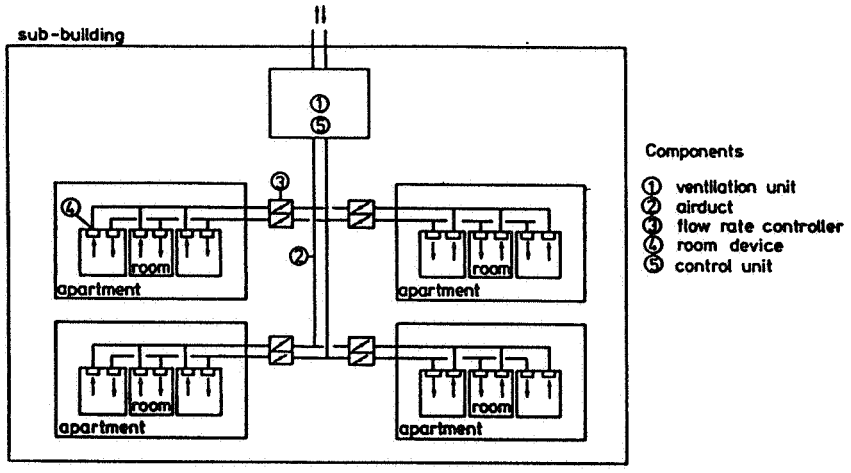

Fig. 3. The components of the ventilation system. An example of a mechanical supply and exhaust ventilation system, where the machine supplies a sub-building.

The exhaust air flows inside the apartment are delivered by the room devices. Depending on the quality level, the room device component consists of an appropriate selection of the following functions:

- exhaust air terminal device (damper, measurement of air low rate, silencer, filter)
- supply air terminal device (measurement of air flow rate, damper, filter, heating, cooling, humidifying, silencer).

The pressure differencies and air flows are regulated at the predetermined values by the means of the control unit component.

4.2 The characteristics of the hierarchical system

All the ventilation systems can be arranged to groups, as it can be seen in the table 2. The ductwork at the basic level is designed and built so that improving the quality level afterwards is possible inside the system group. Improving the quality level of the system is done at the sub-building, apartment or room level.

Table 2.Groups of ventilation systems and the functions of the system at different levels.

FUNCTION	1. GROUP OF CENTRALIZED EXHAUST SYSTEMS				2. GROUP OF CENTRALIZED EXHAUST AND SUPPLY SYSTEMS				3. GROUP OF DECENTRALIZED EXHAUST AND SYPPLY SYSTEMS			
	Basic level	High level	Air heating	Ventilation heating system	Basic level	High level	Air heating	Ventilation heating system	Basic level	High level	Air heating	Ventilation heating system
1. FUNCTIONS AT THE SUB-BUILDING LEVEL Exhaust Damper Sound attennuator Filter Heat recovery Supply Damper Sound attenuator Filter By-passing the heat recovery Heating Humidifying Cooling Recirculating												
2. FUNCTIONS AT THE APARTMENT LEVEL Exhaust Damper Sound attenuator Filter Heat revovery Supply Damper Sound attenuator Filter By-passing the heat recovery Heating Humidifying Cooling Recirculating												
3. FUNCTIONS AT THE ROOM LEVEL Exhaust Damper Sound attenuator Filter Heat recovery Supply Damper Sound attenuator Filter By-passing the heat recovery Heating Humidifying Cooling Recirculating												

5. DISCUSSION

The ventilation systems of the future dwelling-houses have to respond to the way of living,housing and building in the future.

The operational disturbancies in the today's ventilation systems, such as the spreading of odours inside the apartments, stuffy indoor air and condensation on structures refer to the fact, that the ventilation systems are not capable of exhausting the impurities that come from the real household actions. That is because the local air flow rates are too small and the occupant has no possibility to adjust them more appropriate.

The key to the solution is a ventilation system with variable air flows, in which the ducts, fans and terminal devices are designed to operate at varying air flows. This kind of ventilation system has been simulated by calculations, and it is possible to create tables, with which the dimensioning of the systems will be easy and rapid in practice in the future.

The building technology R&D projects in Finland focus on new component based building system, in which bigger and more refined prefabricated structures are connected at site. The goal of the whole building sector should be to make the technical systems totally compatible. The ventilation branch itself will also benefit from the economic, qualitative and serviceability aspects of the component building.

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Discussion

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P. Hartmann (EMPA Duebendorf, Switzerland) You explain the requirements for future ventilation systems. What kind of heating systems will be combined with these systems?

M. Luoma (Technical Research Centre of Finland) The system can be separate (radiators) or it can be combined with ventilation (air heating). The systems under development will mainly not include heating.

G. Gottschalk (Institute fur Energietechnik, Zurich, Switzerland) Are you planning to adapt the components of Finnish heating and ventilation systems to be controlled from a central computer - i.e. the "smart home" concept? It might open new perspectives for energy management and optimised operation.

M. Luoma (Technical Research Centre of Finland) "The ventilation concept for future dwelling houses" research project concentrates on the technical components and operation of the ventilation systems. In this phase control by computer has not been developed.

C-A. Roulet (Ecole Polytechnique Federale de Lausanne, Switzerland) Which kind of "room device" do you plan to use to allow the occupants to change air flow rate?

M. Luoma (Technical Research Centre of Finland) There are some adjustable room devices available. The principle of operation involves adjustment of opening size. A more advanced "room device" operates with a new cascade control method (see paper by Rolf Holmberg: Spatiotemporal control of mechanical exhaust air ventilation). This device is not yet commercially available.

W. Raatschen (Dornier Systems GmbH, W. Germany) What ventilation rates are used in Finland to remove contaminants released by building materials and how have they evolved?

M. Luoma (Technical Research Centre of Finland) A ventilation rate of Ø.5 air change/hour is needed to evacuate the contaminants released from the building materials. It is based on measurements and calculations.