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THE VENTILATION PROBLEM

TOWARDS MORE EFFICIENT VENTILATION SYSTEMS

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ABSTRACT

- In a first part, the different ventilation systems (existing or projects) are reviewed ;

- In a second part, some domains where international research collaboration is thought to be more effective are indicated :

. building retrofitting because, it accounts for about 50 % of construction activities and a lot of improvement in IAQ and energy conservation is possible, particularly when use of mecanical systems would be too expensive
. residential buildings because the relative homogeneity of buildings is likely to ease possibility of international research collaboration
. large volumes (atria, assembly halls, ...) which requires improvement of models, particularly with respect to temperature stratification
. etc...

- In the last part, research areas are proposed :

. passive stack ventilation and combined systems (with respect to retrofitting)
. models in order to predict IAQ level and energy efficiency (models should handle items such as pollutant stratification or absorption-desorption : reliable and validated models are likely to ease the assessment of systems with respect to the construction products directive.
. specific research on ventilation related pollutants (H_2O, radon, NOx, CO) : mould growth, combustion products emission as a function of ventilation rates, radon ingress as a function of pressure difference, ...
. pollutant recirculation around building
. comfort problems (draughts, ...)

A/ INTRODUCTION

Reduction in energy loss from the fabric has probably reached a point of decreasing returns and further substantial reductions in energy use from this source are likely to be uneconomic. However there is substantial potential for energy saving in ventilation. Dwellings represent about 30% of EEC countries energy use, most of it in heating. Thus ventilation in dwellings could in future represent up to 15% of energy use. Therefore even relatively small reductions in overall ventilation levels could represent significant savings in total energy use.

B/ DIFFERENT SYSTEMS IN USE IN EEC

Today, depending on national practice, there is a vaste range of different ventilation strategies in the different OECD countries. The final goal of this project is to improve the performance of existing and new systems. Broadly domestic ventilation may be divided into:

1/ Adventitious ventilation,
2/ Natural/passive stack v2entilation,
3/ Mechanical extract ventilation,
4/ Combination of passive stack ventilation and extract ventilation, here after called hybrid system,
5/ Balanced supply and extract ventilation.

Of these, probably, the most interesting currently are natural/passive stack and mechanical extract. Adventitious ventilation is known to be unsatisfactory and balanced ventilation is economic only in colder climate. Natural/passive stack ventilation are easy to maintain; however there performance are likely to be uneconomic because of higher flow in winter, at a time when energy consumption per each m^3/h is higher. Hybrid systems which combines feature of both systems are likely, if property sized, to give appropriate results.

C/ POSSIBLE RESEARCH SUBJECTS

1 - RETROFITTING OF COLLECTIVE RESIDENTIAL BUILDINGS WITH PASSIVE STACK SYSTEMS

When existing buildings are retrofitted, the air leakage of the building enveloppe is often improved, which may cause condensations or IAQ problems, unless the ventilation problem is dealt with. Use of existing stack is often a convenient way, both in single family houses and collective buildings, to create a ventilation system.

Work programme :

- cowls characterization (wind tunnel tests and analysis, flowrate model, influence of obstacles)
- modelling work
- experimental validation in real buildings (les Ulis, Namur,...)
- drafting of European climatic Zones (wind and temperature) with respect to natural ventilation
- ...

2 - CALCULATION OF AIR CHANGE IN RESIDENTIAL BUILDINGS

Air change in residential buildings is depending on the following :

- building air leakage
- climatic conditions
- occupant behaviour
- thermal effect
- cross ventilation due to wind
- air change due to ventilation provisions
- ....

Different calculation methods (for instance CEN TC 89 WG 4) have been derived, but none of these methods takes completely into account all these parameters. Moreover, basic research is still needed in order to improve the understanding of basic phenomena, for instance the effect of wind on air passages in the facade accounting for the wind turbulence, the eddy flow and the air mass. On the other hand accurate methods are needed in order to have a better assesment of the performance of some new components, for instance : advanced air inlets.

3 - RADON MEASUREMENT AND MITIGATION TECHNIQUES

a/ Radon concentration in houses is very much dependent on ventilation conditions. Measurement for diagnosis purpose should therefore account for this source of uncertainty.

Combined expertise of radon measurement specialists and ventilation experts would allow to draft recommendations for cost efficient and reliable measurements :

Work programme :

- analysis of building ventilation systems and computation of radon concentration as a function of time
- drafting of a measurement methodology
- assessment of this methodology for houses in different countries comparing the results with long term radon monitoring.

b/ Radon mitigation techniques are dependent on the architectural and ventilation provisions and may differ according to the different countries.

Work programme :

- investigate, with respect to national habits, the interest of different solutions (cost, heat losses, efficiency,...), both for existing and new buildings
- field experimentations in order to assess their interest.

. Particular emphasis could be paid to the dependence of radon concentration on negative pressure inside the house, which is of great importance with regard to ventilation techniques.

4 - FLOW AROUND BUILDINGS

Two problems need scientific investigations :

1°) which is the distance (both vertical and horizontal) required between air exhaust terminals and air intake (both on the roof and on the facade) in order to prevent significant air recirculation ?

2°) location of passive stack cowls with respect to roof slope, roof ridge, obstacles,...

. Work programme :

- wind tunnel
- CFD analysis
- field experimentation

5 - EFFICIENCY OF VENTILATION SYSTEMS IN RESIDENTIAL BUILDINGS

It is recognized that most of the ventilation systems does not always provide time constant air flowrates. Accordingly, the development of energy efficient advanced ventilation systems would be considerably enhanced if recognized and validated methods enabling to predict the efficiency (i.e. indoor air quality level versus heat losses) of the ventilation systems could be drafted.

This would also concern existing ventilation techniques and allow performance comparison on rationnal basis.

A possible product could be a technical guide for the assessment of ventilation systems. This guide would specify and develop the requirements :

- air quality
- condensation
- comfort (draughts,...)
- safety
- acoustic
- ....

6 - COMBUSTION PRODUCTS

Carbon monoxyde poisoning (both acute and low level) is a major problem in many countries (hundreds of death each year in France for instance). Better design of ventilation systems (both in existing and new buildings) with respect to this problem is necessary.

Work programme :

- monitoring of CO and NO_2 in houses and analysis
- survey of houses where accidents occured in order to understand how it happened
- laboratory experimentation on vented gas and coal appliances
- modelling work on flue stacks

7 - DRAUGHT PROBLEMS

Cold draught prevention is a major requirement of air inlets. Climatic chamber tests and analyses would help to improve the design of air inlet and their location in the room. Research is needed for establishing correlation between jet characteristics and temperature/velocity profile in the room.

8 - MOISTURE

Humidity level of the indoor air is highly depending on moisture capacity. More experimental and theoretical work is required for improving models. Relation between RH level and mould growth is also required in order to yield a better knowledge of the requirements.

9 - POLLUTANT CONCENTRATION GRADIENT INSIDE ROOMS

methods : CFD, Zonal models, laboratory experiment
product : predictive calculation tool
goal : guidance for design and location of air terminal devices, particularity in the kitchen.

10 - AIR MOVEMENT IN LARGE ENCLOSURES AND ASSEMBLY HALLS

Models of air movement and temperature stratification accounting for wind and thermal effect would help to improve the design of heating devices, particularly with respect to temperature stratification.

11 - WIND TURBULENCE

This topic and its influence in multizone buildings or chimneys flues needs further theoretical experimental study.

12 - AIR QUALITY IN VAV SYSTEMS

In variable air volume systems, the air change can be very different in the rooms of a building, depending or the heat imputs. A study of these systems would help to ensure that minimum hygienic air flow rate is always obtained.

13 - NEW DESIGN OF AIR CONDITIONNING AND CONTROL SYSTEMS IN NON RESIDENTIAL BUILDINGS IN ORDER TO COPE WITH THE FOLLOWINGS :

- human occupancy variation
- heating or cooling load spatial and temporal variation.

14 - AIR CLEANING DEVICES

Pollution of the make up air by aerosols or dust should be kepts as low as possible:

work programme

. new design of air ducts in order to limit fouling
. research and development of centralized air cleaning devices
. basic research on dust deposition as a function of air inlet flowrate as a function of time.

15 - DESIGN OF COST EFFICIENT VENTILATION SYSTEMS

The objectives would be to produce guidelines:

- for architects on the choice of ventilation systems for new and refurbished buildings,
- for engineers on an energy efficient design of ventilation systems for residential buildings, meeting the need for a healthy indoor climate,
- on maintenance of ventilation systems.

These guidelines should deal with the following:

- design criteria,
- economic criteria,
- installation recommendations,
- cooling requirements in summer,
- fire precautions,
- acoustic problems,
- maintenance and operation,
- climatological factors,
- radon protection,
- combustion products.

work programme

a/state of the art in different countries and basic requirements:

According to national practice, many different designs of natural, hybrid or mechanical systems do exist. A preliminary stage will therefore be to gather any relevant information (design tools, real performance ,....)on these systems.

A very important issue will be then to draft the basic requirements (e.g: acoustic requirements, condensation prevention, air flowrate constancy vs time,...) which will have to be met by each kind of system

b/Research topics:

- pressure drop in converging ducts,
- modelling of combustion appliances with respect to combustion product temperature and pollutant release.
- investigation of the failure modes (for instance failure of fan),

- actual performances of heat recovery units and modelling,

- fire problems, acoustic problems,

- flow bistability of venting systems.

- influence of heat losses and duct thermal inertia on exhaust flowrates,
- condensation hazards in ducts,
- analysis of air flow in ducts at low Reynolds numbers,
- analysis of climatological data.

c/laboratory and field work

will include:

- testing cowls in wind tunnel,
- testing vented combustion appliances,
- validation of models.