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# THE STUDY OF NATURAL VENTILATION OF A ROOM

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***Abstract:*** *Natural ventilation is an effective measure for reducing energy consumption and improving air quality inside buildings. Differences between indoor and outdoor temperatures, and differences in wind pressure along the façade, create a natural exchange between indoor and outdoor air. These physical processes are complex, and predicting ventilation rates is difficult. This paper shows a research of natural ventilation, which will contribute to a better understanding of specific phenomena and for finding tools for estimating ventilation flow according to external conditions and openings configuration.*

***Key words:*** *Ventilation, energy consumption, thermo-aeraulic simulation .*

## 1. Introduction

Increased focus on sustainability and the environmental impact of energy use has resulted in natural ventilation becoming an attractive option for many buildings. With careful attention early in the design, a natural or hybrid ventilation system can be a viable option for many systems and climates. It has been found that, under certain circumstances, the energy consumption of a naturally ventilated building can be less than half of a fully air-conditioned, mechanically ventilated one [4].

But to design a system of natural ventilation is necessary to understand specific phenomena, more complex than with mechanical ventilation, and to have reliable tools to estimate the ventilation flow in the external conditions and opening configuration [3].

In a real situation, the air flow in the natural ventilation is caused by two mechanisms: thermal effect created by the temperature difference and the effect caused by the wind.

## 2. Adopted natural ventilation system

Adopted natural ventilation systems operates under a natural upward displacement strategy in summer and a high-level mixing strategy in winter. The winter mode utilizes the heat gains in the building to temper the incoming fresh air, dramatically reducing the heating energy required for the building.

In winter mode the system operates under a mixing strategy, where the cold incoming air is mixed with the warm air in the room. The heat gains within heavily occupied spaces (e.g. school classrooms) are often sufficiently high that additional heating is not needed until the external temperature falls to somewhere in the range of 5 to 10˚C, depending on the U-value for the room. This is in contrast to

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traditional upward displacement systems, which require heating at much higher external temperatures.

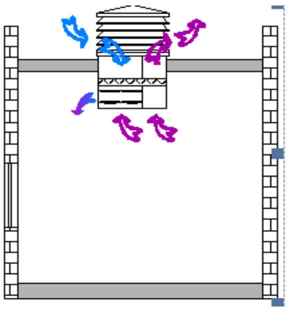

Fig. 1. *Mixing ventilation in winter mode*

In summer mode, once the external temperature has increased such that air can be brought in at low level directly onto occupants without pre-heating, the ventilation strategy for the system changes to a natural upward displacement mode. This strategy does not require wind to drive the flow, so ventilation is provided throughout the summer, even on still days.

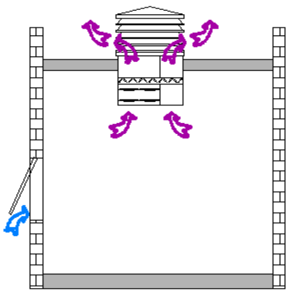

Fig. 2. *Displacement ventilation in summer mode*

In addition, it is known that every building has thermal mass that is either designed explicitly into the structure in the form of exposed concrete, or just through the normal building materials and finishes. This mass can be leveraged in warm seasons to offset the total cooling load through night cooling. Cooler night air can be used to reject heat accumulated during the peak loads of occupied hours. On warm days, as internal temperatures rise, the building material absorbs heat, reducing further rises in the internal temperatures. The heat is then purged with lower temperature night air from the building material when the space is not occupied. The use of thermal mass within a building can provide significant benefits in terms of both thermal comfort and energy use.

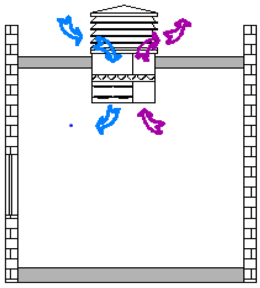

Fig. 3. *Night cooling in summer mode*

## 3. Determination of Natural Ventilation Airflow with Empirical Models

*Natural ventilation due to the temperature difference*

When there is a temperature difference between the indoor and outdoor, airflow takes place due to buoyancy or stack effect. ASHRAE suggests the following equation for estimating airflow rate due to stack effect:

$$Q_{st} = C \cdot A\sqrt{h\frac{\Delta T}{T_w}} \qquad (1)$$

(1) where $h$ is the height difference between the inlet and exit in m, $T_w$ is the warm air temperature in K, $\Delta T$ is the temperature difference between warm and cold air, $A$ is the free area of the inlets or outlets in m$^2$ and $C$ is a constant that takes a value of 0.0707 when inlets and outlets

are optimal (about 65% effective) and 0.054 when inlets or outlets are obstructed (about 50% effective).

From the above equation, it can be seen that compared to the height *h* and temperature difference *ΔT*, the airflow rate due to stack effect depends more strongly on the area of the openings.

*Natural ventilation due to wind*

It is known that when wind blows over a building, a static pressure difference is created over the surface of the building, that depends on the wind speed, wind direction, surface orientation and surrounding structures. The pressure is positive on the windward direction and negative on the leeward direction.

The pressure difference across the building due to wind creates a potential for airflow through the building, if openings are available on the building. The airflow rates through the buildings due to wind effect can be obtained approximately using the equation suggested by ASHRAE:

$$Q_w = C \cdot R \cdot A \cdot v_w \qquad (2)$$

where $Q_W$ is the airflow rate in m$^3$/s, *A* is the area of opening (m$^2$), *C* is a constant that takes the value of 0.55 for perpendicular winds and 0.30 for oblique winds, and *R* is a factor that is function of inlet and outlet areas ($A_i$ and $A_o$) of the openings.

The areas to be used in the calculations are the net free area of the openings, not the total opening areas. When outlet area is greater than the inlet area ($A_o>A_i$), then greater speeds are obtained at the inlet compared to the outlets and vice versa.

The factor *R* varies from 1.0 to about 1.38 depending upon the ratio of inlet and outlet areas.

Since the wind speed varies with season, for design calculations 50 percent of the summer wind speed as provided by the meteorological data can be used.

*Natural ventilation due to combined temperature difference and wind*

Complications arise when it is required to estimate the airflow rate due to the combined effects of wind and stack effects. The total airflow rate has to be obtained using the combined pressure difference due to wind and stack effect, and not by adding up airflow rates due to stack effect and wind effect separately. This is due to the non-linear dependence of flow rate on pressure difference across the openings.

Generally, taller the building with small internal resistance, stronger will be the stack effect, and higher the area of exposure of the building, stronger will be the wind effect.

Several models have been proposed to estimate the airflow rate due to combined effects of wind and stack. For example, one such model uses the equation given below for estimating the total airflow rate due to stack and wind effects:

$$Q_{total} = \sqrt{Q_{st}^2 + Q_w^2} \qquad (3)$$

## 4. Determination of Natural Ventilation Airflow with Nodal Models Coupled with CFD Thermal Simulation Programs

For the study of natural ventilation, in the Department of building services, we conducted a plant for natural ventilation of an amphitheater of the Faculty of Civil Engineering.

To this, were mounted in the amphitheater air inlet and outlet louvres, which are shown in Figures 4 and 5 below.

Wall mounted fresh air louvres, 4 of number, 1000x500 mm (Lxh), were placed on the side only exterior wall of the amphitheater, at +0.3 m from the floor.

Penthouse turrets, 2 at number, 1000x

1000x1500 mm (Lxlxh) were placed on the amphitheater roof terrace**.**

Fig. 4. *Two of grilles fitted in front for introducing air*

Fig. 5. *Turrets mounted on roof for exhaust air*

Nodal models have been implemented in many simulation programs air system, of which the best known are COMIS (Feustel et al, 2001) and accounting (Walton and Dols, 2005) [1]. They have however, the drawback that take no account of the turbulence created by the wind, which is one of the main engines of natural ventilation [2].

Therefore, in order to obtain better results close to the real situation, and to perform thermo-aeraulic simulations of buildings that have complex ventilation strategies, nodal models can be coupled with CFD thermal simulation programs.

In this research program, we have two objectives:

• The thermo-aeraulic simulation of the amphitheater with the aid of TRNSYS 16 (respectively dynamic model building Type 56), in which will introduce the natural ventilation modul from CONTAM. The results of this simulation will be air flows from natural ventilation, and temperatures in the interior of the amphitheater.

• Comparison of simulation results with the values obtained with empirical models, and by measuring air flow rates and inside temperatures. For this, in the amphitheater was installed a measuring and data recording system.

## 5. Conclusions

To design a natural ventilation system is required accurate estimate of the flow of ventilation depending on the outside conditions. Or, natural ventilation, and generally airflow in buildings, are poorly studied in the technical literature from us, which is why we proposed this research program.

We hope that the results of research that will be conducted, will contribute to a better understanding of the phenomena, and to a broader promotion of natural ventilation systems to us.

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