NATURAL CONTROLLED VENTILATION: PERFORMANCES AND STANDARDS

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ABSTRACT

As everybody knows, today the air quality of an indoor environment may have several effects on our health; the beginning of serious breathing pathologies and of some forms of cancer, are with no doubt due to the presence of polluting and extremely noxious agents in the places we most frequently use.
That's the reason why it is very important that indoor rooms are correctly aired also in our homes where, due to several incidental factors, the healthiness of the environment is still guaranteed by the mere and discretionary operation of users of opening the windows.
In considering the growing attention drawn to these problems and in agreement with the provisions of the 3rd essential requirement laid down in Common Directive 89/106, 'Hygiene, Health and the Environment', ICITE has undertaken to develop a research and experimentation study aimed at establishing a device for the controlled natural ventilation of residential environments.
The main objectives have focused on the technical and performance-oriented characteristics of the devices that are already available on the Community markets and on the regulative aspects for what concerns air healthiness in domestic environments, while the final phase of the work, still in progress, will give new developping guidelines, both in regulative and productive terms.
Surveys carried out on existing buildings pointed out a preference for one particular device, supplied with a self-adjusting ventilator which works according to the changing weather conditions, but able to control a certain kind of natural ventilation even with strong external winds and rain. Such a device was chosen mainly because of the declared peculiarity of mechanical factory control in any situation, since the greatest part of the market supply is oriented towards closing devices beyond fixed levels of internal pressure, thus restoring the tigthness conditions of the environment.

KEYWORDS

Natural ventilation, Indoor air quality, Indoor ventilation, Indoor air quality, Study on controlled ventilation device, Natural ventilation device, Test medology, Italianal legislations, Italian standards.

INDOOR AIR QUALITY

The Common Directive on building products 89/106, relative to the proximaty of legislative, regulatory and administrative provisions of the Member States, adopted in Italy on 21 april 1993, with D.P.R. n. 246, specifies, among other things, the following essential requirements, to which every structure has to answer:

- Health, safety and environment

In order to satisfy this requirement, each structure has to be conceived and built so that it does not constitute a threat fto the health and safety of the occupants or neighbours. This threat is caused in particular by noxious gas, particles or dangerous gas present in the air, dangerous radiation emission, polluted or contaminated water or soil, evacuation defects of water, smoke and solid or liquid residuals and formation of humidity in some parts or within the interior surface of the structure.

In particular, the interpretative documents of the Product Directive, in underlining the principles to verify the respect of essential requirements, (re- point above-mentioned) indicate ventilation (natural or artificial) as one of the most important aspects in order to pursue healthy and safe environment in buildings.

In this way, the technical specifications require that the presence of polluting agents are brought back to safety levels, applying evalutation criteria of air quality, calculus methods to forecast the renovl rate, starting from climatic conditions and ventilation systems. Further measures referred to the calculus rate of the ventilation in building, determining its effectiveness, indentifying the kind of pollution and its concentration indoors.

In general, the complete characteristics of ventilation systems have to be verified in terms of their speed and air flow and differences of pressure.

The Directive 89/106 also highlights, through its *nouvelle approche* to building products, that past cares about indoor aeration have continued to increase during last few years and the absence of ventilation has been shown as a great threat to human health.

On the basis of a statistics study, carried out in the United States on a sample of 350 buildings, demonstrated that the effects due to the absence of ventilation (50%), the wrong air distribution, inadequate conditions of temperature and humidity, on top of tobacco smoke and endogenous pollution, are responsible for bodily discomfort known as 'sick building syndrome'. This syndrome causes various symptoms, such as headaches, fatigue, nose and throat irritation, etc.

The incidence of endogenous pollution is responsible for a smaller part of this temporary bodily discomfort, but they have a biggest responsibility to long term, in supporting great pathologies, not always curable with the up-to-date medicine. This is the case, for instance, of some adhesives and sealants delivering carcinogent and toxic substances, such as formaldhehyde, radon, etc., in the environment.

The absence of ventilation also allows the increase of relative humidity, which causes condensing phenomena and, as a consequence, mould formation accountable of respiratory pathologies.

THE RESEARCH PROPOSAL

These further elements of knowledge, point out very clearly that the termal and hygrometric performances of a building and its components, have to satisfy environmental safety and healty needs, with optimum energetic consumptions.

In fact, after superseding the economic restrictive worries, which imposed "hermetic sealing", the attention is today turned on indoor microclimate as an essential factor for the comfort of the occupants.

In this way, the frequence of air changes, especially in winter, is the crucial point of the problem, in considering that the energetic consumption has to be compared with air safety.

External windows have always met the primary need of air change allowing, with easy operations, the opening of one or more of its components, but living to frequency and the amount of air to be recycled to the discretionality of the occupants.

The increased attention drawn the objectives of safety and healthiness of domestic rooms has to be beyond the occupants' discretion, imposing on to external window additional performances able to guarantee permanent safety conditions.

The window, also known as 'the intelligence of walls', is still able to fulfil new expectations, as simply as in the past, but it needs receive new inputs in the technical and standard fields.

The modern construction sector in Italy, having to face several problems, doesn't seem to relying a satisfactory way on ventilation, and also the route of natural ventilation systems seems,to have still a long way to go.
In such a situation, indoor natural ventilation is affected by multidisciplinary factors, having to interact with technical, normative, sanitary and economic variables.
So, in order to give some acceptable answers to the up-to-date needs and to give useful orientation to the industry of the sector, and on the occasion of a specific demand coming from production world, the Systems and Components Department of Icite deemed it necessary to undertake a research study on the subject of natural controlled ventilation.
The work programme has prelimanarily, outlined the necessity to follow directions:

- study of the ideal performances of a device for controlled natural ventilation and development in the laboratory of a prototype and the instruments required for testing it.
- laboratory characterization and performance evaluation of a window filled with a ventilation unit;
- analysis and evaluation of national laws and standards, with reference to indoor ventilation criteria;

In this field, the analytical phase of the study under way, aims at defining a reference framework in order to investigate and outline the existing gaps, concerning both need and performance aspects and legislative and normative aspects, all contributing to make a correct evaluation.

Study of the ideal performances of a device for controlled natural ventilation and development in the laboratory of a prototype and the instruments required for testing it.

The prototype should seek to mainta n the exchange air flow rate as constant as possible in view of the change in pressure difference between the interior and exterior. In the laboratory this condition can be obtained experimentally by imposing preset pressure differences and measuring the air flow rate, and hence permeability, by means of the device.
Since the flow of air through the opening is, in general, proportional to the surface of the opening itself and to the difference in pressure raised to the nth power, a mechanism is to be developed which, as the pressure difference changes, modifies the useful ventilation section in a calibrated manner to achieve a constant flow rate.
The behaviour of this device can in fact be compared to the case of narrow openings where the flow of air tends to remain within the transition range between laminar and turbulent flow. The following equation governs it:

$$Q=kA\Delta p^{n}$$ where:

$Q(m^3/h)$ is the flow of air through the device
$A(m^2)$ is the useful ventilation section
$\Delta p(Pa)$ is the difference in pressure between interior and exterior
$k(m^3/hm^2Pa)$ is a flow coefficient
n is the flow exponent.

In order to characterize the system, the test chamber for the measurements of low pressures was built, according to the provisions contained in the Belgian standard NBN D 50-001.
The $3m^3$ test chamber was built with bolted and silicone-bonded sandwich panels and provided with vertical walls allowing to apply a constant air pressure in the inside. The opposite closing walls were prepared to contain the test device and the air intake, with negative pressure, generated by a fan. A pressure gauge was used to measure the pressure difference between the test chamber and the laboratory, while inside the duct placed between the fan and the chamber, the air flow rate was measured by means of a Pitot tube. The device was installed with the

internal face turned towards the laboratory and the external one towards the test chamber, in order to simulate, inside the chamber, the actual external atmospheric conditions.

The instruments used for measuring the air flow rate and the pressure difference between the interior and exterior of the airtight chamber are the following:

- hot-wire precision anemometer for low speeds
- differential pressure sensor

In order to keep potential external influences under control, the environmental conditions of temperature and relative humidity were measured in a continuous process.

To acquire the data relating to the instrumental measurements and for the control of the performance of the tests a computerised system was developed, consisting of data acquisition hardware interfaced with a personal computer and specially written software based on a graphic programming language, which allows the dat to be pre-processed, displayed graphically in real time on the monitor and finally stored on disk. In particular a program was written for measurements of air pressure in the airtight chamber and the flow rate of air in the air feed conduits and another program for measurements relating to the environmental conditions affecting the tests.

Laboratory characterization of the ventilation system and preparation of test methodology

The investigated ventilation system is of the self-adjusting type, it is conceived to be fitted in the upper part of the window, breadthwise, between the transom and the glazing unit, reducing this way the glazed surface. Inside the system works a ventilation grid that with faint or no wind, allows for a satisfactory level of natural ventilation of the indoor environment, while it automatically stops working due to the action of the external pressure as soon as the atmospheric conditions change. The system is conceived in a way hat it allows to keep acceptable conditions of indoor ventilation even when there is a strong wind outside.

The system works thanks to the internal grid with self-adjusting air intake consisting of punched thin plates oscillating perpendicul rly to the ventilator a d of two baffles, the former being placed on the outside for the natural collection of air, the latter inside, turned upwards, to convey the air flow indoors avoiding air draughts and rain water seepage.

According to the characteristics declared a d checked in the laboratory, it is envisaged that with external air pressures greater that 20 Pa, the internal thin plates, by automatically placing themselves against the internal face of the system, manage to prevent a certain amount of air from seeping inside, by limiting the flow just to the air passing through the holes of the thin plates a d throught the little gaps between them.

With pressures less than 20 Pa, the system must ensure a constant air flow lying between 15 m^3/h and 30 m^3/h, according to the size of the system.

In order to characterize the system, the "ad hoc" test chamber for the mea urement of low pressures, already described in the previous chapter, was used.

Laboratory characterization of the window frame fitted with the ventilation system

The performance evaluation of the window system was carried out by means of official testing equipment for windows and structural glazings belonging to the "Components" service laboratory of ICITE, and thanks to the experience made over many years of activity in the field of compulsory and voluntary certification. In this connection, it must be remembered that ICITE is an active member of UEAtc and EOTA, the European organizations in charge of the harmonization of stand rds for granting technical agréments.

The whole system, consisting of an aluminium window fr me with a horizontal bascule opening and provided with a ventilation system, was then fitted into the test wall and tested according to the methodologies envisaged by standards UNI EN 42-77.

Air permeability was measured by constantly increasing pressure at 50 P asteps, from 50 to 500 Pa. The test was at first executed by sealing the system in order to assess the extent of the losses caused by the window frame, then, after removing the seal, the total losses were recorded; the

difference between the two values provided the amount of air passing through the system. Permeability values resulted to be quite high, thus contradicting the limits suggested by the official standards.
The watertightness test was not judged to be meaningful since it is not possible to make a comparison with the criteria suggested by the standards establishing that the nozzles used to spray water on the sample are to be fixed few centimeters below the upper transom of the window frame in the same place of the test set-up in which the ventilation system is to be installed.
The wind resistance tests previously carried out on the window frame not including the ventilation system, allowed to assign the highest resistance class. The same window frame, including the system and submitted again to the previous test, did not resist the 1800 Pa pressure due to the disjuntion of the lateral glazing beads.

NATIONAL LEGISLATIONS AND STANDARDS AND ASSESSMENT OF THE EFFECTIVENESS OF CURRENTLY USED WORKING INSTRUMENTS

Indoor ventilation

The present national legislative situation on the subject of ventilation refers to Law No. 10 of 1991 "Standards for the accomplishment of the national energy Programme concerning the rational use of energy, energy saving and development of renewable energy sources" which somehow introduces the problem regarding the change of indoor air.
This law is very important since it goes beyond the restrictions imposed by Law 373/76, issued following the serious energy crisis which took place during the 70's, and it introduces important innovations about how to plan and realize living comfort and hygiene; moreover, it is structured on three levels of enforcement and this shows that the CPD has been satisfactorily adopted.
While the first level of the legislative apparatus provides the general directives, the intermediate level, consisting of the compulsory D.P.R. (Decree of the President of the Republic) No. 412, precisely defines and reaffirms the basic role of thermal insulation in view of energy saving and environmental welfare, delegating the application procedures to the technical standards drawn up by UNI.
In particular, D.P.R. No. 412 of 26 August 1993 "Regulations containing standards for the planning, installation, operation and maintenance of thermal plants of buildings in order to restrict energy consumption, in accordance with article 4, sub-section 4, of Law 10/'91 and following amendments" defines, among other things, the climatic areas, subdivides the buildings according to their intended use and provides the specifications of the plants. As regards dwelling buildings and buildings with similar intended uses, the D.P.R. assumes a room temperature, during the winter working period of the air-conditioning unit and a maximum value determined on the basis of the arithmetical mean of air temperatures of all the individual premises of the buildings, defined and measured according to the specifications contained in the technical standard UNI 5364.
Article 8 of the Decree also indicates the daily mean over 24 hours of the minimum number of air volumes that can be recycled in one hour, fixing it conventionally to 0,5 for dwelling buildings, if no controlled mechanical air changes are envisaged.
The whole regulative course outlines the calculation of energy requirements for an indoor environment as a physical magnitude depending on several interacting factors. In this sense, the ventilation requirement should act to correct and integrate the building's performances, to intermediate between the inside and the outside but , as specified by UNI 5364, it also depends on the intended use of the considered room, on its type, extent, orientation, on the resistance of frames, etc.
Nevertheless, as far as ventilation is concerned, the conventional value fixed by D.P.R. No. 412, is still 0,5 m^3/h.
What's more, in some cases, regional regulations provide for minimum ventilation limits; that's the case of Lombardia where the hygiene regulation in force establishes that for private premises the external filtered air change should not be less than $20m^3/h$ per person.
Uncertainties and misunderstandings could arise from such a complex situation; hence the need of having a national law taking charge of providing all necessary references, also related to the progress of other countries in this field.

FUTURE DEVELOPMENTS

The situation so far described clearly shows that future developments will mainly follow two ways: the technical/performance-oriented way and the legislative way.
The proposition of optimum ventilation values for indoor environments to be included in the Italian legislative and normative body becomes more and more meaningful also with reference to the present stage of the study which is trying to define, through a number of corrective actions to be applied to the studied prototype, performance-oriented criteria to be effectively applied to any atmospheric situation. To sum up, instead of completely closing the window when atmospheric conditions are bad, the application of a highly sensible mechanical regulator will ensure an air flow as an inverse funtion of the external pressure. Present difficulties concern the possibility of managing the air flow with pressures greater than 50 Pa, although even the most advanced standards ruling this subject do not envisage such a possibility.