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An Overview of Research Activity on Ventilation in Italy

Gian Vincenzo Fracastoro* and Marco Masoero†

(*) Universita della Basilicata
(†) Politecnico di Torino

Introduction

In Italy, until the oil crisis, air infiltration, airing and ventilation were considered mainly from the indoor air quality viewpoint. Energy related topics were considered to be less important. Codes and standards, resulting from hygiene-oriented research, established minimum values of air change rates, depending on room or building designation.

Actually, given the poor quality of average Italian window systems, these requirements could be easily met in naturally ventilated residential buildings. There were few problems even in the windless regions of the Po valley, where almost 75% of the Italian heating demand is concentrated. Whenever natural ventilation was not sufficient, the occupant would provide some extra outdoor air by opening the windows (airing).

However, the absence of insulating materials in walls and roofs and the use of single glazed windows caused very high conduction losses, outmatching by a factor of four to six the ventilation losses, even in large buildings. In any case, the relatively mild climate made this issue fairly unimportant.

The dramatic increase of oil prices in the mid seventies did not lead directly to any substantial improvement of the energy efficiency of the existing building stock. This was mainly due to the relatively low number of owner-occupants in Italy, and the related fatal distinction between those who pay for retrofitting a building and those who save money out of the heating bill: a question yet unresolved in Italy.

Around the end of the seventies, however, a compulsory regulation (Law 373, 1976) came into force. This was aimed at reducing the energy consumption for space heating of newly built residential and commercial buildings by limiting the installed power of the heating plant. In particular, this law specifies the maximum admissable value of transmission heat losses as a function of climate (heating degree-days) and shape of the building (surface-to-volume ratio). In the case of ventilation heat losses, a conventional maximum value of 0.5 ach is specified for all buildings.

This upper limit often conflicted with previous standards, which specified minimum ach values according to the space designation. Moreover, no standard provides any information about how to relate the envelope design to the ventilation requirements. This is particularly crucial when the building is naturally ventilated (the usual case for residential buildings in Italy).

The tendency in new constructions was to use insulating materials which gave a substantial reduction in conduction heat losses. As a result, especially for large buildings in the northern area (in which average u-values of less than 1.4 W/m^{2}K were imposed), ventilation losses, in spite of the conventional reduction to 0.5 ach, became an important part of the energy budget.

There was no knowledge of the actual Italian buildings, but there were strong suspicions that ventilation heat losses could now be as high as 40% of the total heat losses. Some energy conscious designers started installing more airtight double-glazed windows, especially in the northern regions.

The final result was that in many of these buildings, low indoor temperatures (mainly due to the imposed practice of night temperature set-back), cold bridges (arising from incorrect placing of insulants), low naturally induced Δ p's (due to low wind velocities), and airtight envelopes, all contributed to dramatic condensation effects, with mould and fungus growth.

These reasons explain why, especially for indoor air quality reasons, the 'ventilation issue' now enjoys renewed concern among Italian researchers. A short description of previous and ongoing research in Italy is given in the following sections.

Experimental Research

Air Permeability Testing

Pressurization tests have been performed on windows since the mid sixties. Currently there are at least ten laboratories which officially certify windows in terms of airtightness, this is according to the Italian standard UNI-EN 42. The standard defines three categories (A1, A2, A3), depending on whether the window permeability at 50 Pa is below 60, 20, or 7 m^3/(h m^2).

In order to evaluate the effect of craftmanship and window assembling techniques, ISTEDIL, the Research Institute of Building Constructors, is performing an extensive measurement campaign in the field. This work is done by means of a portable device for component pressurization tests.

An original and interesting technique to quantify window airtightness has been developed by the IENGF (National Institute of Electrical Engineering 'Galileo Ferraris'): this technique is based on the correlation observed between air permeability and sound transmission through windows. Unfortunately, the accuracy of the method depends strongly on the type of window, and is not always satisfactory (Brosio et al, 1980).

The strong interest in window permeability rather than other components of buliding envelopes as a whole is due to the fact that the particular construction techniques adopted in Italy lead to air leaks in the envelope being mostly concentrated in and around the window system (including the roller blinds box). Walls themselves and wall joints are usually fairly tight.

This explains why overall pressurization tests are seldom applied to buildings. However, such techniques are customary for testing the air permeability of automobiles (Vacchelli, 1985).

Tracer Gas Techniques

The first systematic laboratory campaign with tracer gases was performed at the Politecnico di Torino by Cali, Fracastoro and Vacchelli (1986). Previous experience has been gained by one of the authors at the Swedish Institute for Building Research, under the guidance of Sandberg (1984). The aim of the experimental campaign was to assess the accuracy of the decay technique under different experimental situations (mixing procedures, air change levels, number of sampling points, air immission techniques). Nitrous oxide and (less extensively) water vapour, were used as tracer gases. A summary of the results is shown in Tables 1 and 2. An attempt to establish a correlation between the degree of mixing and the measurement accuracy was also done during the investigation.

Table 1: Number of air change in different experimental conditions

	n = 0.50			n = 1.00			n = 2.00		
	Position of the grid			Position of the grid			Position of the grid		
	A	B	C	A	B	C	A	B	C
Point									
1	0.63	0.66	0.65	1.15	1.16	1.13	2.19	2.15	2.13
2	0.61	0.57	0.59	0.99	0.98	1.13	1.88	2.04	2.00
3	0.62	0.65	0.64	1.12	1.15	1.13	2.17	2.15	2.13
4	0.62	0.65	0.63	1.12	1.13	1.11	2.20	2.12	2.16
5	0.64	0.65	0.65	1.13	1.15	1.12	2.16	2.14	2.15
6	0.63	0.66	0.63	1.12	1.14	1.13	2.16	2.15	2.16

Table 2: Air changes measured using water vapour as a tracer gas

Reference value	0.53	1.06	1.59	2.38	3.18
Measured value	0.87	1.30	1.54	1.82	2.83
Percent deviation	+64%	+23%	−3%	−24%	−11%

Large ventilation test chambers are currently under construction or in the planning stage at the Politecnico di Torino and at the University of Basilicata (Potenza). These will be used to test the accuracy of tracer gas methods under different experimental procedures, to investigate the diffusion of pollutants within inhabited spaces and to test the performance of demand-controlled ventilation systems.

In-the-field investigations with tracer gases have been extensively performed by De Bortoli et al (1985), which assessed the air change rates in 15 homes using SF6 and bag sampling. However, the number of research units which are able to carry out air infiltration measurements using even the simplest tracer gas technique, is, at the moment, still very small.

Occupant Behaviour

A large and exhaustive investigation was made in 1979 within the Progetto Finalizzato Energetica of the National Research Council in order to assess the behaviour of the Italians with respect to the heating system operation. This study contained the results of a questionnaire distributed to 10,000 families, concerning the frequency and duration of window opening in each room of their apartment (CNR. 1979).

The investigation showed that airing by window opening is very common in Italy: 85 to 90% of the people open the windows during the heating season for 40 to 65 minutes per day as a means of improving the air quality.

Air Infiltration Models

Research on theoretical models concerning air infiltration is still in its early stages. An analytical one-zone model with constant pressure on each horizontal plane was first implemented by Cali and Fracastoro (1979). A simplified formula for the evaluation of the air flow through a single – and two-sided opening, in the absence of wind, was developed by Agnoletto (1981).

Monaco et al (1980) established the first simplified procedure for the calculation of the seasonal average air changes per hour in a building. This model requires that the permeability and area of windows, the wind zone, and the building height be known.

Following this same line, Fracastoro and Pagani (1987) deduced from an analytical model including the effect of horizontal partitions, the infiltratiion volume flow rate in a large number of different buildings in different situations. The results were fitted into simple monomial formulae which provided the 'equivalent pressure difference', i.e., the homogeneous infiltration. This was determined as a function of building typologies, terrain conditions, wind velocity, outdoor air temperature, and 'internal resistance flow coefficient'. The structure of the formulae was derived from dimensional analysis.

Conclusions

Research on air infiltration and indoor air quality has been stimulated, in Italy, by the problems caused by the incorrect application of the Law for energy saving in buildings. When some external action (as a compulsory design code) alters the well established equilibrium of a complex system (such as building construction practice), unexpected problems may easily arise. The technical community has now to play an important role in overcoming the present situation. This can best be achieved by promoting research aimed at developing design codes, testing standards and on-site checking procedures in the ventilation and air quality sector.

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