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Title: Study of the Ventilation in an Ancient Building Located in the Centre of Rome and Now Used as a University Office

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Study of the Ventilation in an Ancient Building Located on the Centre of Rome and now Used as Universitary Office

G.Fasano[1], G. Giorgiantoni[2], F.Raponi[3], V. Leonelli[4]

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SYNOPSIS

An investigation of some Indoor Air Quality (IAQ) parameters in a significant office of the State in the area of Rome was undertaken.The aim, in future, will be to cover a wide range of situations in vaiious buildings and organizations, to achieve data to improve the working conditions, to have a more healthy working environment, to optimize energy consumption and energy management.Analisys of IAQ parameters was performed by field measurements; conditions of the ventilation system were checked by local inspections, code simulations by the multizone model CONTAM96 by NIST (National Insttute of Standard and Technologies USA) were undertaken and compared with the field measures, reproducing the local conditions with data extracted from the technical literature.

LIST OF SYMBOLS

Pa = Pressure (1 N/m^2)
ppm = Concentration (parts per million)

METHODS

The considered office is located in the City of Rome downtown. It is an hystorical building (16th century) and the activity of the organization is devoted to the scientific technical and administrative services of the Institute for Applied Physics of Nuclear Engineering.It is a multistorey building near a heavy all day traffic road and the office is a typical technical office with three employees located in the ground floor of the building.One of the threee smokes regularly and furthermore two personal computers are turned on.The duration of working activity is about eight hours (8-17) with one hour interval during lunchtime.Air handling system (AHU) is not provided in this room.The office door, to comply with office regulations is constantly kept opened.The investigation period is february 1997.

Therefore the main characteristics of the room can be summarized as follows:

Room dimensions:4.30*6.50 h 3.80
door: 1.24*2.10 kept opened
window:class A1,permeability 12.5 $m^3/h/m$ of joint @ 100 Pa (from UNCSAAL Italian Windows Manufacturers Associations)

Outdoor conditions
Since the period is from Feb 3 to 8 the outside temperature varies from 0 to 14 °C.Usual metheorological conditions in this period for this climate lead to clear sky and weak wind velocity (max 5 knots).

These outdoor conditions which include the values for the pressure are available from the metheorological station of Urbe Airport located in the North of Rome approximately 10 km from the related building.
These data are important because they allow to assess the fluidodynamic behaviour of the building, in case of remarkable wind velocities leading to local variations of the pressure, this resulting in changes of the internal-external pressure differences and consequently in different trends of the contaminant migrations.All these data have been used to compile the metheorological *.wth* files used to make the simulations with the model.

Field measurements

The procedure includes two actions :

- information collection on the occupancy behaviour during working time
- measurement of the concentration of CO,CO_2,moisture, VOC.

The sampling points were chosen near the positions of the three employees at a height from the floor which is the most probable during work i.e. 1.10 m.
The adopted istrumentation is a BRUEL & KJEAR analyzer which includes :

- Multi Gas Monitor 1302
- Multipoint Sampler and Doser 1303
- Personal Computer

This instrumentation is based on the principle of photoacustic absorbtion using a photoacustic measurement chamber.The system sensibility is 0.16 ppm for carbon monoxide, 3.2 ppm for carbon dioxide and 50 ppm for water vapour ;the answering time,which includes the suction lines is about 10 s .Before the sampling, the following calibration tests were performed :

- zero calibration,through nitrogen N50
- humidity calibration, through humidified N50 nitrogen
- span calibration through gas mixtures having known concentration
- filters calibration to avoid the humidity interference

The ciclic sampling system operates round the clock alternatively in the selected points.The analyzed concentrations are stored in an ASCII file.The sampling time is from 11 :30 of Dec 4 1996, up to 10 :30 of Dec 6 1996.

Computer simulations

It was decided to undertake code runs to have much confidence with the related phenomena, to achieve a flexible and reproducible procedure to be used in other places and in other circumstances, because it may happen that the possibility of the measuring interval is shorter than the planned one. It is not easy to have a continuous operating analyzer during working time. The instrument produces a repetitive noise during the suction phase and the room is heavily crossed by the sampling pipes.These inconvenients in a productive structure have to be minimized and also occupancy may have obstacles to the normal activity.Then the field measurements might not be so abundant as required. Furthermore, multiple simulations can enlarge the investigation cases, different climatic conditions, different occupancy can be studied and evaluated.
It was realized that Computational Fluid Dynamic (CFD) codes such PHOENICS which is available in our division were too critical and particular to investigate such cases.
To calculate air flows and contaminant dispersal in multizone buildings CONTAM 96 by NIST (National Institute of Standard and Technology) was used(1).This code uses the multizone network

approach to airflow analysis.The building is treated as a collection of zones connected by airflow paths.These zones may represent groups of rooms,individual rooms,or even portion of rooms,as well as shafts and portion of the building air handling system.Within each zone the temperature and contaminant concentration is considered to be uniform.The airflow paths include doorways, small cracks in the building envelope, and eventually the air handling system (AHU) can be modeled.
The main problems to be solved to perform the simulations were:

- Identification and emission rate of the sources
- airflow paths modeling
- Occupancy, windows, vent system timeschedule.

These values were on the literature(2) par.41.6-7 (3).Emissions from tobacco smoking were got from the same source.

Bioeffluents emission
CO_2 (p.m.44) $32*10^6$ µg/h/pp C1
NH_3 (p.m.17) 15 600 µg/h/pp C2
CO (p.m. 28) 10 000 µg/h/pp C3

Tobacco smoke emission
CO_2 360 mg/sigarette C1
NH_3 5.9 mg/sigarette C2
CO 43 mg/sigarette C3
lighting time 5 min/sigarette
max frequency: 2 sigarette/h/pp
Data files were processed through normal spreadsheets.

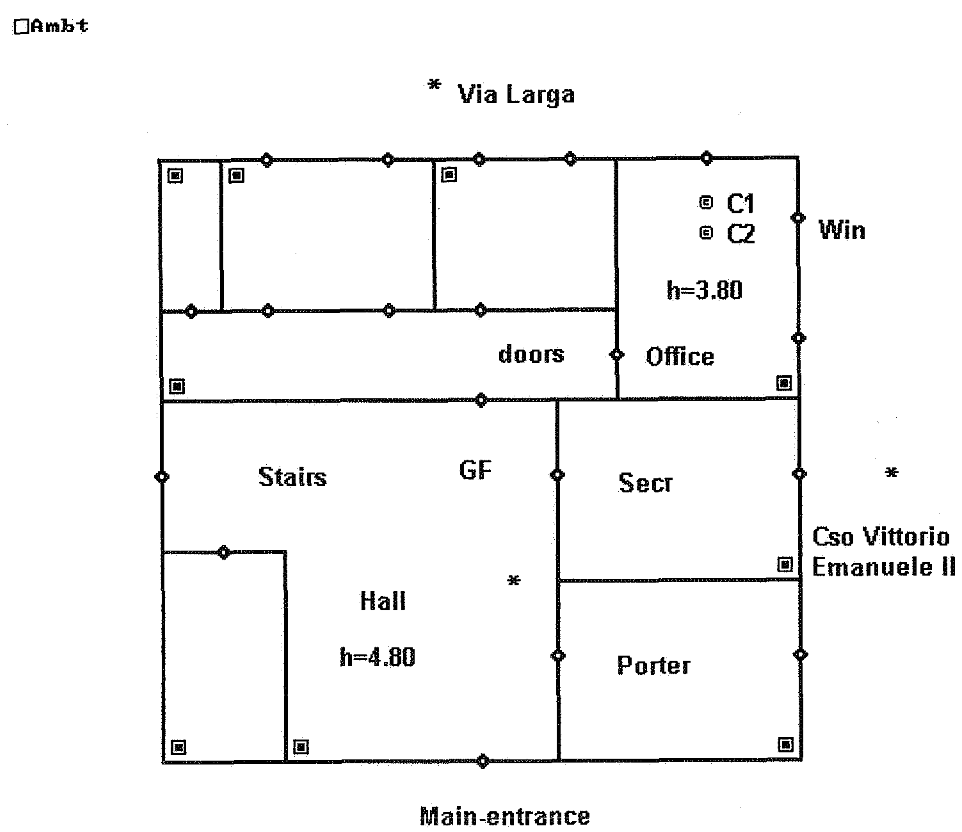

Figure 1 Office scheme for simulations

RESULTS

The field measurements in the technical office gave the following average readings:

Table 1 Contaminants Concentrations in technical office, field readings

TWA Average Concentration ppm															
External (8-18)				External (18-24)				External (24-8)				Internal Office			
CO	CO_2	VOC	H_2O	CO	CO_2	VOC	H_2O	CO	CO_2	VOC	H_2O	CO	CO_2	VOC	H_2O
4.72	536	3.69	8347	10.57	604	4.57	10170	2.97	546	2.63	7471	5.58	607	4.19	8687

The average concentrations attributed to Dr.Fargione, the smoker are therefore (CO_2 607 ppm=1099 mg/m^3, CO 5.58 ppm= 6.42 mg/m^3 at 23.2 °C int.temp and 101325 Pa int.press).
External readings (CO_2 536 ppm=1045 mg/m^3, CO 4.72 ppm= 5.9 mg/m^3 at 0 °C ext.temp and 101325 Pa ext.press).

The readings in the technical office were taken from 9:00 Feb 3 up to 24:00 Feb 9 1997.
As far as the office is concerned, the simulations with the code gave the following results:

table 3 Simulations results for contaminants concentrations

Avg Concentrations (mg/m^3)			
CO_2 (mg/m^3)	Δ(%)	CO (mg/m^3)	Δ(%)
5356	512	58	983

Regarding the mass exchange, the simulations produced the following output :

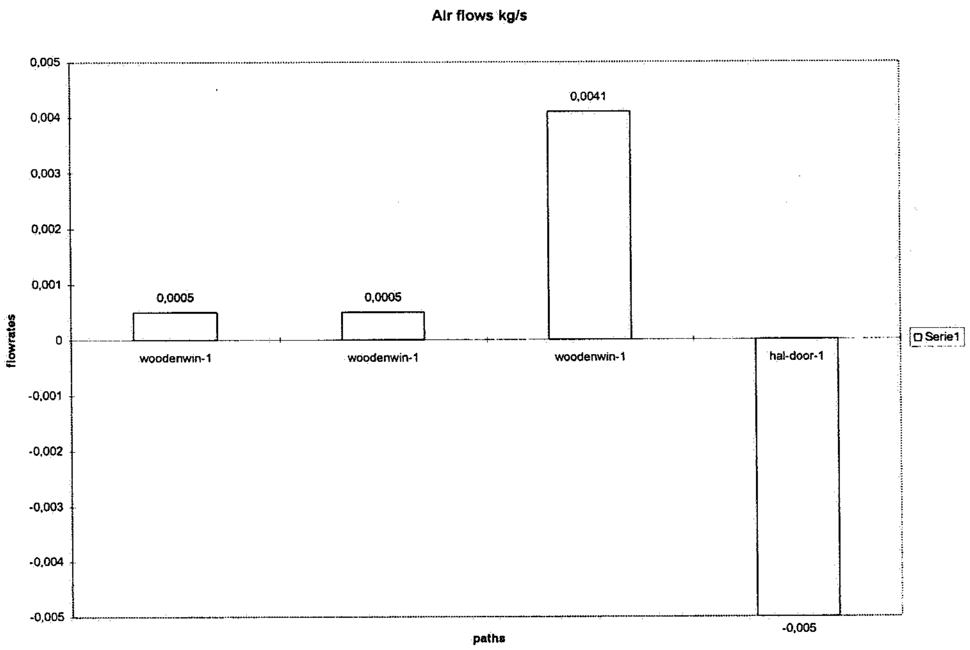

Figure 2 Mass exchange

DISCUSSION

The first point to be recognized is that all the concentration readings are well below the limits recommended by **ACGIH** (Industrial Hygienist Association) (TWA CO_2 5000 ppm, CO 25 ppm). The smoker was only one and the sampling point was located near the employee.
As far as the simulations are concerned we can focus our attention to the following points :

- The code calculates the concentrations in the zones as perfectly mixed ones.
- All the main characteristics of the sources, of the windows, such as capacities and air permeability were taken from the technical literature or from the manufacturers.
- Air permeability of windows is hard to be assessed because they were installed in the nineteenth century, probably infiltrations are greater than the assumed values.
- The lacking of mechanical ventilation results in a very low air mass exchange between the various flow paths.The underestimated air permeability may lead to the excessive growth of the internal pollutants concentration.This case of natural ventilation is stack effect driven by the wide stairwell at the centre of the building.The pressure differences driving the air masses are very low, 1-2 Pa.
- Being an Universitary Institute, the crossing of the main entrance is continuous, the entr-door is continuously opened and closed, i.e. op-close schedule should be completely assessed.

It is understood that the bad agreement between the code and the field measurements needs further comparisons.
Different results have been observed between the various codes of IAQ (Indoor Air Quality) and the field measurements, underestimation or overestimation of the final figures is commonly accepted. Many codes are able to handle better some situations than others in the same study.
A further step is to build up an airtightness measure matrix, to be implemented in parallel to these evaluations.These measures would generate the necessary link between the field and the computer codes.
The evaluation of the air permeability would produce the test point which would refine the code input to achieve a better comprehension of the trend of the mass exchanges.

REFERENCES

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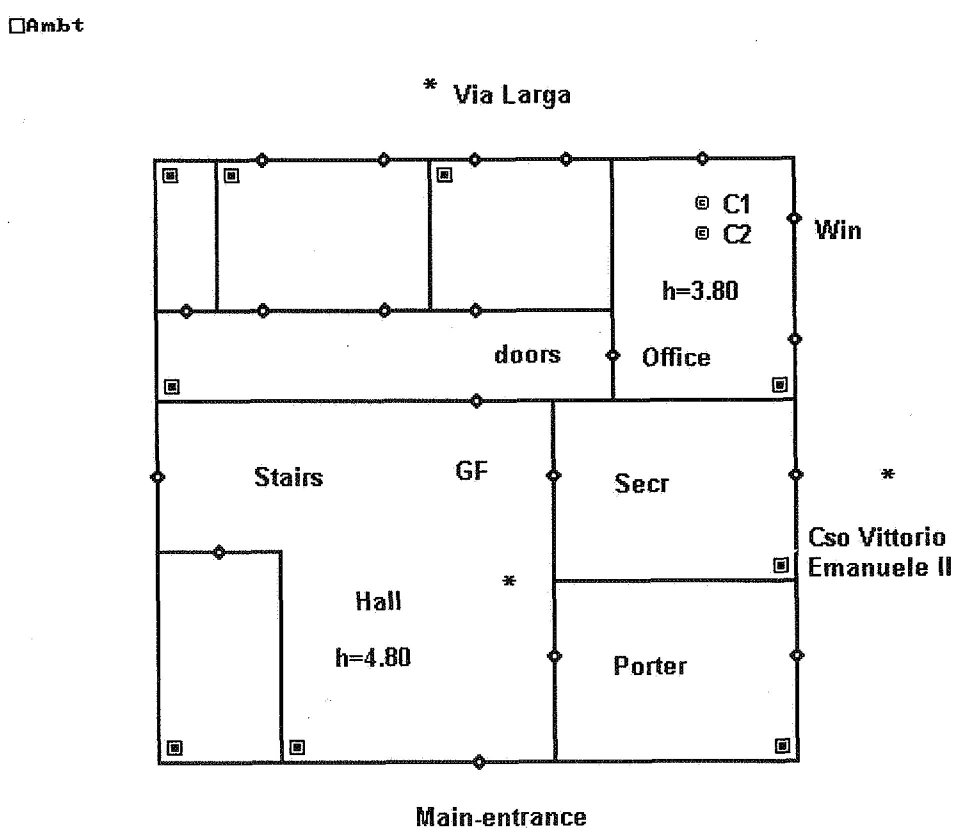

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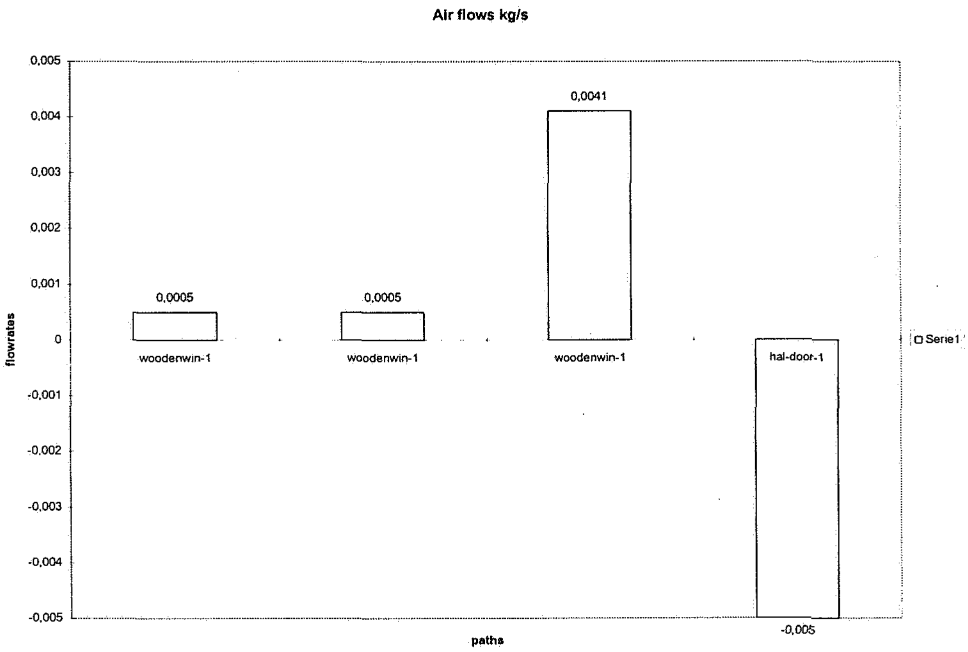

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