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Study on the Exigency Demands of Residential Buildings' Users

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Abstract: The aim of the study is to emphasize the actual demands of residential buildings' users and to explore new methods, yet less used, that could improve the buildings environmental comfort. The residential buildings, constructed by man in order to function as shelter where multiple processes of the social and material life takes place, are influenced by many factors that have to be taken under consideration when projecting, constructing, using and post-using them. All aspects emphasized in this study should be first considered in the processes of their interaction and interdependency and then to be systemically approached and analyzed. During the second half of the twentieth century, the urban population knew an incredible growth. This growth led to an exponential increase of the energy consumption and a more than alarming exceeding of noxious gases in the air and wastage. There was a time when the energy consumption was considered an indication of the quality of life. Therefore, from the point of view of the energy consumption, many differences appeared between the developed countries and the developing ones. At the same time a person living in one of the developed countries has energy consumption twenty-five times greater than one living in a poor country. A popular idea was that we can fight poverty with increased energy consumption. However, the facts showed a disturbing reality energy wastage.

Key words: Thermal comfort, energy consumption, predicted mean vote

INTRODUCTION

During the second half of the twentieth century, starting with the fifties till the nineties, the urban population knew an incredible growth. Before the 1950s the urban population was around two hundred million, while at the end of the century the number grew to almost three billion. The specialists' foresight for the current century considers a further growth of the urban population. However, this growth will be quite diminished by the new economic development which implies a change from the industrial society to a post industrial, computerized one.

The new economic development no longer requires a huge concentration of individuals, of people working together in a delimited headquarter; the physical contact becomes unnecessary. The ongoing development of the internet, the real-time on line communication and teleconference make possible the collaboration and brainstorming between people miles away, as well as a mutual exchange of the most intimate, profound and creative ideas.

From an objective point of view it no longer requires residential programs within the same urban area. As the progress of the society takes place in accordance with its needs, a new process of de-urbanization appeared, leading to the creation of suburbs and satellite towns and a renewed development of the rural area. This trend is obvious in the developed counties where the residential areas are located in the suburbs.

The urban population is growing at a much faster rate than the rural one. It is estimated that during the years mentioned above the urban population knew an exponential growth. Statistics show that almost 80% of the growth is found in the urban concentration. Therefore, at the end of the twentieth century there were nineteen cities which had a population more than ten million people, twenty-two cities had a population between five to ten million inhabitants, three hundred and seventy cities had one to five million people and four hundred and thirty cities had a population of up to one million people. This growth led to an exponential increase of the energy consumption and a more than alarming exceeding of noxious gases in the air and wastage.

There was a time when the energy consumption was considered an indication of the quality of life. Therefore, from the point of view of the energy consumption, many differences appeared between the developed countries and the developing ones. Almost a third of the world population has no access to electricity. At the same time

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a person living in one of the developed countries has energy consumption twenty-five times greater than one living in a poor country.

A popular idea was that we can fight poverty with increased energy consumption. However, the facts showed a disturbing reality energy wastage.

In the light of the new facts, a new approach is absolutely necessary:

- Improving and promoting an efficient energy consumption
- Discovering and developing new unconventional sources of energy

Reducing the energy consumption for the material production by using high-tech and computerized procedures.

It is particularly necessary to analyze the energy consumption in the residential sector.

The construction industry with its processes of building, practical application and essential services constitutes an important sector for the growth of the economic progress. Specialists state the construction sector to be an important indicator of the economic growth; that is when constructions are going well, so is the economy. However, based on statistics, the construction field is also a major resource user: 40% of the global energy, 16% of the water consumption and 25% of the wood consumption. At the same time the construction sector is a major polluter: 70% of sulfur dioxide, 50% of carbon dioxide, etc.

A fair analysis of the resource consumption, especially energy and the management of noxious gases show differences between the developed countries and the developing ones.

The main issue concerning the developed countries is that of an energy consumption exceeding the production of natural resources, combined with a level of pollution beyond the possibilities of neutralizing its own ecosystem.

The ecological footprint is an assessment of the human resource demands. It represents the amount of productive land area needed to produce the resources human population consumes and to absorb the corresponding waste (Wackernagel and Rees, 1995). Thus, in the developed countries, this indicator is 10 ha per person, while in the developing countries is less than one hectare per capita.

Another indicator is the living standards represented by the space a person needs for living; this standard is measured in square meters per person. Thus, there can be observed significant differences: 11.6 m^2 per person in Moscow, 28.2 m^2 in Paris, 47.2 m^2 in Oslo and only 14.3 m^2 in Bucharest.

The over-consumption of resources becomes an ever more alarming issue in large cities where the growth of energy consumption is accelerated by the use of air conditioning, especially the cooling mode. Starting with the summer of 2003 Italy has experienced serious problems in this field.

During the summer of 2002 the energy supply system of California went into collapse leading to a substantial increase of prices within a year; from 50 to 150 $/MW h.

The pollution is also a major indicator of poor or high standards of living and economic development. According to UNCHS (United Nations Centre for Human Settlements), the quality of the air was unsatisfactory in more than 50% of the worldwide buildings. The population of the poor countries spends on energy 15-20% of their monthly income. Similarly, the transition economies spend 6.6%, while in Great Britain the population spends 2%.

The Indoor Air Quality (IAQ) in the developing countries is inferior to that in the developed countries, because of the population private use of coal and fossil fuels, as well as inadequate stoves and kitchen machines. The IAQ might be low in the developed countries also for reasons of poor ventilation (Bas, 2003).

The statistical markers prove that no proportion can be established between the energy consumption and comfort improvement.

This study aims at presenting other methods, yet less used, which could improve the environmental comfort of the individual residential buildings. These are:

- The analysis of all possibilities for a natural ventilation, especially for dwellings in the temperate continental areas, during summertime
- Ensuring optimum levels of thermal inertia so as the temperatures inside stay within standardized limits during summer time, with no energy consumption
- Natural ventilation systems to maintain within standardized limits the pollution level inside the dwellings
- Determining the minimum energy consumption needed to heat the air changes during winter time
- Benefiting from the thermal inertia of the buildings, during the warm seasons

An ergonomic organization of the space, the fulfillment of anthropometric demands, rational volumes, vertical and horizontal air courses.

CONDITIONS FOR THERMAL COMFORT

Human thermal comfort is defined by the thermal state of the body. Thermal comfort depends on the level of the physical activity and clothing. It is also influenced by the environmental conditions, such as air temperature, the mean radiant temperature at a certain place in the room, air velocity and humidity.

When the above parameters are estimated or measured, the thermal comfort of the body can be anticipated by calculating the PMV (predicted mean vote). The PMV index is based on the thermal balance of the body. The human body is in thermal balance when the heat generated by the metabolism is equal to the heat dissipated in the surroundings. The physiologic temperature regulation system modifies, in certain limits, the skin temperature and the activity of the sweat gland in order to maintain the thermal comfort. In a moderate microclimate and wearing clothing suited for the activity performed, the thermal equilibrium is maintained without overworking the temperature regulation system. In this case the person has a neutral thermal relation with the surrounding environment that is he/she has a neutral thermal sensation.

The PMV index represents the average opinion of a large group of people asked to express their thermal comfort using the following scale:

- + 3-hot; +2-warm; +1-slightly warmer; 0-neutral; -1-slightly cooler; -2-cold; -3-very cold

The PMV index can be estimated considering the following parameters:

- The energy produced by the human metabolism for different levels of activity
- Insulating clothing
- Air temperature
- Mean radiant temperature
- Relative air velocity
- Partial pressure of the water vapors

The PMV index, the physiological response of the temperature regulation system, statistically results from the opinions expressed by more than one thousand three hundred individuals regarding their thermal comfort.

The PMV index can be calculated using the following experimental relation:

$$PMV = (0.303e^{-0.036M} + 0.028) \cdot (M-3.05 \cdot 10^{-3} \cdot (5733-6.99M-p_a) -0.42 \cdot (M-58.15) - 1.7 \cdot 10^{-5} M (58667-p_a) -0.014M (34-t_a) -3.96 \cdot 10^{-8} \cdot F_{cl} \cdot (t_r+273)^4 - F_{cl} \cdot h_c \cdot (t_{cl}-t_a)) \quad (1)$$

Where:

M = Metabolic rate of human body (W m^{-2})
p_a = Water vapor pressure in ambient air (Pa)
f_{cl} = Clothing area factor, dimensionless
t_{cl} = Mean temperature of the outer surface of the clothed body (°C)
t_a = Air temperature (°C)
t_r = Mean radiant temperature (°C)
h_c = Convective heat transfer coefficient (W/(m^2·°C))

The PMV index calculated using the above ratio applies for a static level of activity, yet it can be used for a variable level. For the last case the parameters have minor changes and are considered with their mean value in accordance to time and level of activity. The use of PMV index is limited to values between -2 and +2 and the parameters considered in relation (1) with values ranging between the following:

M = 46-232 W m^{-2} (0.8-4 met)
p_a = 0-2700 Pa
t_r = 10-40°C

One met represents the energy produced by an average person while sitting. The total body surface of an average person is considered to be 1.8 m^2. (1 met = 58.2 W m^{-2}).

The energetic metabolism M is the production of the human body in connection to the level of activity. It is commonly expressed by watt per square meter or by metabolic units, met. The production of metabolic energy, depending on the level of activity, can be estimated as follows:

- Lying rest position-46 W m^{-2}; 0.8 met;
- Sitting rest position-58 W m^{-2}; 1.0 met;
- Sitting light activities (home, office, school) -70 W m^{-2}; 1.2 met
- Standing light activities-116 W m^{-2}; 2.0 met
- Medium activities-165 W m^{-2}; 2.8 met

The PMV index can also be determined using charts presenting different combinations of activities, clothing, temperature, humidity.

The predicted percentage of dissatisfied: The average predictable point established by the PMV index represents a statistic value based on the opinion of a group of people exposed to the same microclimate (Parsons, 2003).

The PPD index (predicted percentage of dissatisfied) determines the predicted number of individuals (in percentage) that may not be satisfied with the surroundings, either because it's hot (level +3), warm (level +2), cold (level -2), very cold (level -3).

The PPD index can be calculated based on the PMV index using the following experimental equation:

$$PPD = 100 - 95e^{-\left(0.03353PMV^4 + 0.2179PMV^2\right)} \quad (2)$$

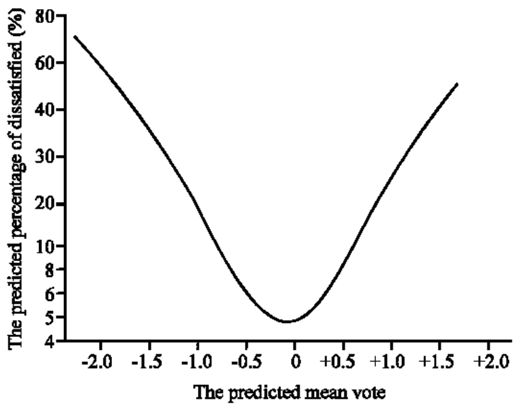

Fig. 1: The predicted percentage of dissatisfied given by the predicted mean vote

The PPD index anticipates the number of dissatisfied due to thermal reasons, while other people appreciate the microclimate as being neutral, warm or cool. The predicted distribution of estimation is presented in Fig. 1.

Draught rating: A draught of air is mainly a movement of the air which produces a decrease of the human body's temperature and it's perceived as being uncomfortable. The discomfort produced by air draughts can be expressed by the predicted percentage of dissatisfied with the draught. The "DR" index, draught rating, can be calculated using the following experimental ratio:

$$DR = (34-t_a)\cdot(v-0.05)^{0.62}\cdot(0.37\cdot v\cdot t_u + 3.14) \qquad (3)$$

Where:
DR = Draught rating index
t_a = Local air temperature (°C)
v = Mean air velocity (m sec^{-1})
t_u = Local intensity of turbulence

The method of evaluating the discomfort produced by the air draughts is based on the opinions of a group of people exposed to temperatures between 20-26°C when the mean velocity of the air ranged between 0.05-0.4 m sec^{-1}. The level of activity is light, mainly sedentary. It is common knowledge that the discomfort is less felt when the activity is energetic (Bust and McCabe, 2005). In order to limit the discomfort produced by air draughts, that is DR<15%, the local mean air velocities should be maintained below the values indicated in Fig. 2.

The curves are based on the model of evaluation for the discomfort produced by air draught in the case of 15% dissatisfied performing a light, sedentary activity and having a metabolism of 1.2 met.

The PMV and PPD indexes describe a warm or cold sensation of the human body. The thermal discomfort can

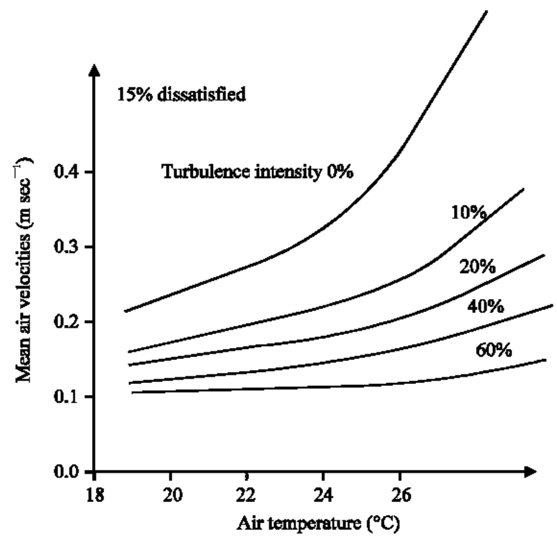

Fig. 2: Admissible mean air velocity given by air temperature and turbulence intensity

also be produced by a cooling or warming of a small part of the body. In this case the discomfort is local; one of the main causes of local discomfort is air draughts.

THE EXIGENCIES OF THERMAL COMFORT

Human thermal comfort is defined as the state of mind that expresses satisfaction with the surrounding environment. The discomfort can be caused by different sensations of either too cold or too warm. The discomfort is expressed by PMV and PPD indexes. Thermal discomfort can also be sensed when only one part of the human body gets too cooled or too warmed, due to:

- Air draughts
- Difference between the temperature of body and that of ankles
- Asymmetric thermal radiation
- Malfunctioning metabolism
- Improper clothing

However, it is virtually impossible to find a thermal regime that could satisfy each and every individual, considering all objective or subjective differences between people. There will always be a percentage of dissatisfied. Nevertheless, it is possible to establish the parameters of a microclimate that could satisfy the demands for thermal comfort of a large group of individuals living or in the same surroundings.

There are cases when a higher value of the parameters adopted for a specific microclimate lead to a

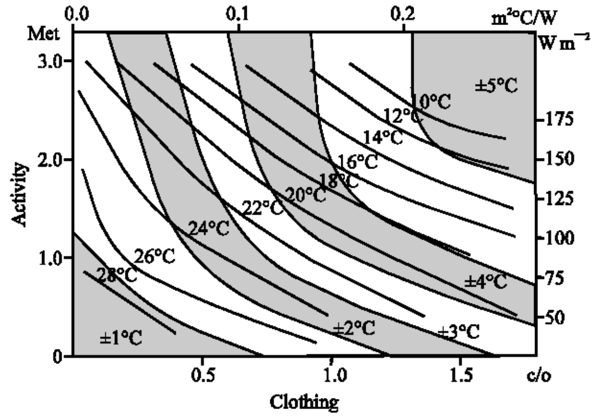

Fig. 3: The optimum temperature considering the level of activity and clothing

small percentage of dissatisfied, whilst an inferior quality of the parameters lead to a larger percentage of dissatisfied. Figure 3 shows the optimum temperature considering the level of activity and clothing. The optimum operative temperature corresponds to a PMV = 0. The darker surfaces indicate comfort areas ±Δt close to optimum temperature. The following relation applies: $0.5<PMV<+0.5$.

Thermal resistance of clothing

- Nude body-0 m² °C/W, 0 clo
- Shorts-0.015 m² °C/W, 0.1 clo
- Summer clothing (light trousers, short-sleeved shirt, sandals)-0.08 m² °C/W, 0.5 clo
- Light/casual clothing (trousers, jacket, shoes) -0.11 m² °C/W, 0.7 clo
- Winter indoor clothing (trousers, jumper, socks, slippers)-0.16 m² °C/W, 1.0 clo
- Winter outdoor clothing (long-sleeved underwear, vest, suit, overcoat, winter shoes) -0.23 m² °C/W, 1.5 clo

Where:
clo-clothes, 1 clo = 0.015 m² °C/W

It is generally accepted a PPD index below 10% corresponding to PMV index ranging between- $0.5<PMV<+0.5$. Light, sedentary activities, 1.2 met, are especially under consideration since they are specific to a large number of occupied spaces, such as dwellings, offices, schools.

Light, mainly sedentary activity during winter time: The situation refers to winter time activities considering clothing of 1 clo and thermal resistance of 0.16 m² °C/W. Thus:

- Acceptable operative temperature 22±2°C and temperature for a definite space 20-24°C
- Vertical air temperature difference below 3°C
- The temperature of floor surface range between 19-26 °C, but no more than 29°C for the under floor heating systems
- The asymmetry of the radiant temperature of windows or other surfaces be less than 10°C
- The relative humidity range between 30-70%

Light, mainly sedentary activity during summertime: The situation involves summer clothing of 0.5 clo, respectively a 0.08 m² °C/W thermal resistance. Thus:

- Acceptable operative temperature 24.5±1.5°C, in a definite space the temperature should be 23-26°C
- Vertical air temperature difference should be less than 3°C

Radiant temperature asymmetry: The radiant asymmetry is defined as the difference between the plane radiant temperatures of two opposite sides of a small plane element. The mean radiant temperature is calculated using the relation:

$$(t_r + 273)^4 = T_r^4 = F_1 \cdot T_1^4 + F_2 \cdot T_2^4 + \ldots + F_i\, T_i^4 \quad (4)$$

Where:
T_r = Mean radiant temperature (K)
t_r = Mean radiant temperature (°C)
F_i = Form factor between subject and interior surface
T_i = Temperature on internal surface (K)

The heat exchange between human body and environment: The thermal comfort of a person is the result of the equilibrium between energy produced by human body and loss of heat conduction, convection, radiation and evaporative heat loss (Awbi, 2003). When the equilibrium fails, that is the loss of heat is rather significant, the person starts to feel cold or hot, leading to changes of temperature at skin level. Figure 4 shows heat loss during light, mainly sedentary activity.

Experiments showed that in the buildings with natural ventilation, the thermal comfort depends only on the internal operative temperature and the external one. During the experiment, thermal comfort was reached when the temperature ranged between 20-24°C and the heat radiation, convection/conduction and perspiration/ evaporation losses were almost equal.

When the temperature of the environment rises, the process of evaporation becomes predominant in order to

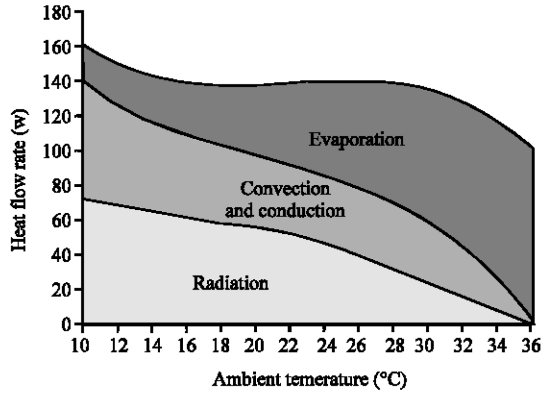

Fig. 4: Heat loss during light, mainly sedentary activity

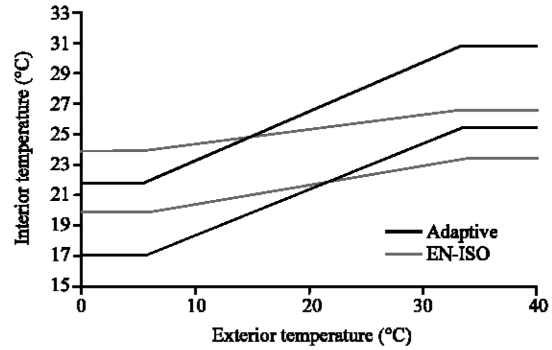

Fig. 5: Peoples temperatures variation adaptability

regulate the body's temperature around 37°C; otherwise, the amount of heat lost through evaporation rises and thermal discomfort is felt. When the surrounding temperature is low, the metabolic activity has to increase to compensate for heat losses. A healthy body will always tend to maintain equilibrium between the produced metabolic heat and conduction, convection, radiation and perspiration-evaporation losses. This equilibrium is necessary to keep a constant body temperature of 37°C. Subconsciously, the equilibrium is obtained through metabolic processes; consciously, the level of activity and thermal insulation of clothing help maintain equilibrium.

Also, a moderate metabolism in a certain type of microclimate is maintained when the person wears adequate clothing that does not interfere with the activity.

Environment adjustment of the inhabitants of a built space, a dwelling: Thermal comfort requirements (Hawkes and Forster, 2002) stipulated by standards are based on measurements performed on subjects having a passive reaction to thermal stimuli. Day-to-day experience shows that the sensation of thermal comfort is not a constant. Secondary to opportunities, persons can change the interior climate or they can adjust to thermal climate by changing their clothing or the level of activity. Experiments also demonstrated that people can accept wider variation of temperatures. Thus, in the case of buildings with air-conditioning systems thermal comfort can be determined using agreed standards, while the inhabitants of spaces with natural ventilation tolerate wider variation of temperatures (Fig. 5).

Ninety percent of the subjects agreed that temperatures between 17-22°C make them feel slightly cold, while the range 25.5-30.5°C make them feel hot. These facts lead to adopting a new type of thermal regime during summertime in the natural ventilated buildings (Givoni, 1998).

Requirements of indoor air characteristics: These requirements deal with ensuring certain characteristics of the indoor air in residential buildings that will satisfy a large percentage of the inhabitants. Thus, the following measures can be taken:

- Limiting/reducing odd odors to the level of perception of an individual with a medium olfactory sense; mostly these odors come from the disposal of industrial and household sewage and waste
- The maximum accepted concentration of volatile formaldehyde is 0.035 mg m^{-3}, considering it a medium value of the most polluted 30 min within 24 h range. Consequently, there will be used construction materials that have less than 25 mg formaldehyde/100 g solid material
- The maximum accepted concentration of radon 220 or 222 is 140 Bg/m^3/year
- It is forbidden the use of construction materials containing radioactive substances
- It is strictly forbidden the use of radioactive waste, sand, slag and lime residue from chemical fertilizer processing; all these substances contain a higher percentage of natural or artificial radioactive elements that is usually accepted in construction materials
- The accepted maximum concentration of carbon monoxide is 6 mg m^{-3} air, considering the most polluted 30 min within 24 h range. This concentration of carbon monoxide in air keeps the concentration of carboxyl-hemoglobin in blood within agreed value, that is 1.5% COHB
- The accepted maximum concentration of carbon dioxide is 1600 mg m^{-3}, not exceeding 0.05% of the room volume. The amount of carbon dioxide found in the air is mainly due to the metabolism of people occupying a specific space.

The production of CO_2 during metabolic processes happens because the organic elements inside the organism oxidize. These processes largely depend on the way the glucose, lipids and proteins are absorbed by the organism, their preponderance and the heat produced through physiologic burnings.

The volume/amount of CO_2 produced by the human organism can be determined using the experimental ratio:

$$K = 85 \cdot 10^{-4} \cdot M \cdot A \ (m^3 \ h^{-1}) \tag{5}$$

Where:
M = Metabolic rate of human body during a specific activity ($W \ m^{-2}$)
A = The total surface of the human body, $A \approx 1.8 \ m^2$

The concentration of water vapor:

- Summer: max 15.400 mg m^{-3} ($t_{med} = 25 \pm 3°C$)
- Winter: max. 9.450 mg m^{-3} ($t_{med} = 20 \pm 2°C$)

The content of water vapor found in the air is due to the metabolism of the people occupying the space, the level of different household activities and the number of plants. The air contains a specific amount of water vapors expressed by the concentration of water vapor in the air, C, also named absolute humidity, in g m^{-3} or in g kg^{-1}.

At a specific temperature, the quantity of water vapors cannot be over a certain agreed limit, called saturation point or absolute humidity at saturation C_s expressed in g m^{-3} or g kg^{-1}. The maximum quantity is closely related to air temperature. Currently, the term relative humidity of air is used; it is expressed in% and represents the ratio between the actual vapor pressure of the air and the saturation vapor for the air. When reaching a certain temperature the air contains the maximum quantity of water vapor, that air is saturated and the relative humidity is 100%. The relative humidity is an important indicator of the thermal comfort, as the values of the air humidity must be situated within agreed limits, closely related to human metabolism. The oxygen concentration should be a minimum 16.3% of the room volume and never below this value (Heinsohn and Cimbala, 2003).

There are many standards recommending natural ventilation systems or mechanical aspiration so as the occupants of the building would not breathe noxious gases. This is the case of:

- The utility rooms without windows facing the exterior (bathrooms, shower rooms, toilets, pantries)
- The rooms having windows facing the exterior which are used for cooking or heating water on open fire (bathroom, kitchen), rubbish dump room, basements

During the designing stage of a building and further on during examination the changes of air/transformation are extremely important. In order to make estimative calculus, the composition of the external dried air is as following: Oxygen O_2: 20.94%; Carbon dioxide CO_2: 0.03%; Nitrogen N_2 and inert gases 79.03%.

The quality of the air largely depends on the concentration of different substances like gases, vapors or dusts that form the air. These concentrations can be expressed in different ways:

- Volume or mass percentage (%)
- Mg of polluting substance/kp of air (mg kp^{-1})
- Parts of polluting substances related to 1 million parts of air expressed in volume (ppm)

The percentage of CO_2 found in the air might be less than 0.03% in the rural areas, while in the urban areas might be higher, up to 0.04%.

The composition of the air also presents other particles and water vapors:

- The relative humidity can reach 80-95% in the winter
- The relative humidity can reach 50-75% in the summer

It is strongly forbidden to place residential or public buildings in areas where the concentration of noxious gases in the air is over the agreed limits. The concentration of noxious substances cannot be more than 10 ppm, which is the average value for short periods of time, or 4 ppm, the mean day value. The above-mentioned values regarding the air humidity, the following relations (Eq. 6, 7) take place:

$$\varphi_a = \frac{p}{p_s} \cdot 100 = \frac{C \cdot (803 + C_s)}{C_s \cdot (803 + C)} \cdot 100 \ (\%) \tag{6}$$

$$C = \frac{803 \cdot C_s \cdot \frac{\varphi_a}{100}}{803 + C_s \cdot \left(1 - \frac{\varphi_a}{100}\right)} \ (g \ m^{-3}) \tag{7}$$

Where:
ϕ_a = Relative humidity (%)
p = Partial effective pressure of water vapors (Pa)
p_s = Partial saturation pressure of water vapors (Pa)
C = Concentration of water vapors (g m^{-3})
C_s = Saturated concentration of water vapors (g m^{-3})

When the concentration are expressed in g kg^{-1}, than the relations Eq. 8, 9 are:

$$\varphi_a = \frac{p}{p_s}\cdot 100 = \frac{C\cdot(621+C_s)}{C_s\cdot(621+C)}\cdot 100(\%) \quad (8)$$

$$C = \frac{621\cdot C_s\cdot\frac{\varphi_a}{100}}{621+C_s\cdot\left(1-\frac{\varphi_a}{100}\right)}(g\ m^{-3}) \quad (9)$$

The indoor air humidity may come from different sources:

Metabolic activity: The emission of metabolic water vapors comes from:

- Breathing, the air exhaled from the lungs is saturated with water vapors
- Diffusion of water vapors through the skin, perspiration
- Evaporation of sweat; the degree of perspiration is correlated to the sensation of thermal comfort

The production of water vapors for a person experiencing thermal comfort, 0.5<PMV<+0.5, is represented by the following experimental relation Eq. 10:

$$K = 87\cdot 0.185\cdot A\cdot(M^2+0.4\cdot M)\cdot 10^3\ (mg\ h^{-1}) \quad (10)$$

Where:

K = Debit of water vapors ($mg\ h^{-1}$)
A = Total surface of the body (met)
M = Metabolic rate of human body ($W\ m^{-2}$)

In the case of an adult ($A = 1.8\ m^2$) the relation (Eq. 11) is:

$$K = 29\cdot(M^2+0.4\cdot M)\cdot 10^3(mg\ h^{-1}) \quad (11)$$

The quantity of water vapors produced by the body of an adult experiencing thermal comfort varies in accordance to the level of activity performed, thus (Table 1):

Household activities: The activities performed indoors (cooking, dish washing) generate water vapors. Experiments showed that, statistically, four inhabitants of the same residence produce:

- 700 g water vapors in the morning
- 1700 g water vapors at noon
- 800 g water vapors in the evening

Table 1: The quantity of water vapors produced by the body

Activity (met)	Quantity of water vapors ($mg\ h^{-1}$)
1.0	40.000
1.2	55.000
1.6	95.000
2.0	140.000

An estimated water vapors debit of 120 $g\ h^{-1}$ is an average daily rate, as follows:

- Bathing, shower-4 persons-600-1000 $g\ day^{-1}$
- Laundry washing-3000 $g\ week^{-1}$ and laundry drying-9000 $g\ week^{-1}$
- Floor cleaning-300 $g\ week^{-1}$
- Electronics having special burning systems-natural gases 160 $g\ h^{-1}$, paraffin oil 100 $g\ h^{-1}$, bottled gas 130 $g\ h^{-1}$
- Construction humidity

Construction humidity refers to the quantity of moisture in a building after the execution works are completed. The causes of this humidity are:

- The water contained by the construction materials after pre-fabrication, usually higher than the equilibrium humidity
- The mixing water needed to work the materials on situ
- The water from rainfalls during different stages of execution

It is estimated that the amount of water that has to evaporate after the completion of a building ranges between 3000-5000 L. Two years after the building has been completed its humidity should be 10 $l\ m^{-2}$

The specialists' recommendations refer to:

- Water proof finishing (polymeric paint coats, washable plastic wallpapers) should be avoided
- After the building starts being exploited, it should be heated and ventilated more than the norms stipulated, for a period of 2-3 years

The equilibrium humidity is determined many years after the building started functioning and it has to be maintained within normal limits. The following procedures are used to maintain the equilibrium humidity:

- In the rooms with moderate humidity emission, permeable finishing are used to take over and then transfer the humidity (lime-based plaster, water vapor permeable painting)

- The rooms with high emissions of humidity, during short periods of time, should be provided with natural ventilation systems and/or mechanical ventilation that will absorb the humidity

EXIGENCIES ON ODOR ISSUE

Apparently, the human olfactory system is inferior to that of animals. This statement is confirmed not by the size of the human olfactory mucous membrane (5 cm^2), but by the size of the feline one (100-200 cm^2). The olfactory sense is not indispensable for human survival and does not ensure the perennial existence of our race.

Certain smells can unconsciously set off hormonal stimuli that control our appetite, our body temperature, different superior functions of the brain, emotional behavior, ability of thinking and memories. The nose is concerned with conditioning the entering air by warming and humidifying its temperature. The viscous layer of mucous secreted by the nasal mucous membrane is there to intercept and exclude any solid matter in the air we breathe (dust, pollen, bacteria, viruses etc.). The surface of the membrane is covered with countless cilia, tiny hair-like cell structures which normally undulate to keep the mucous moving towards the pharynx.

Smells, as a result of the olfactory system's function, are stimulated by chemicals and are different from any other sense because of the unwanted reactions they cause. A pleasant smell will bring to mind a nice, comfortable sensation, while an unpleasant one will trigger ugly, uncomfortable sensations.

Although the nose warns us about chemical pollutants existing in the air we breathe, it is not infallible. Several compounds like benzene, ammonia or formaldehyde are detected by the olfactory system only when their concentration exceeds a certain limit. Several noxious gases, like carbon monoxide or radon, are not detected even when their concentration is extremely high, sometimes even lethal.

There are several methods of quantifying the smells; one of them consists in determining the percentage of persons that might feel uncomfortable because of an odor. This percentage will be then compared to that obtained when testing the people reaction to body odor.

One Olf is defined to be the quantity of body odor from an average adult with a daily hygienic standard and regularly changed underwear. The Pole is the concentration of body odor resulting from an on-going emission of one Olf in a volume of 1 l/s air.

In order to avoid more than 10% of dissatisfied it is necessary to ensure a flow/amount of 16l/s/Olf, 60 m^3/h/Olf or 15 m^3/h/pers.

Calculating the quantity of fresh air necessary to satisfy the demands of users; the design stage: Realizing a synthesis of the conditions mentioned above, there can be determined the values of indoor air characteristics, correlated with the demands of the users (Table 2).

The number of air changes in the residential buildings: The individual residences intended for the use of one family require the following air change rate per hour (n h^{-1}) (Table 3).

Where:

According to the type of protection and shelter (Table 3):

- **No protection:** Very tall buildings, buildings placed at the periphery or in open markets
- **Partially protection:** Buildings inside the city, having at least three other buildings nearby

Buildings placed in the city centre or in the woods. According to the degree of permeability (Table 3):

- **High:** Buildings having the exterior joinery without any type of air-tightening systems
- **Medium:** The exterior joinery of the buildings has air-tight seals
- **Low:** The exterior joinery has special hermetic systems

Table 2: Values of indoor air characteristics

Activity type	Metabolic rate	The necessary air for a concentration $O_2 \geq 16.3\%$ (m^3/h/human)	The necessary air for a concentration $O_2 \geq 0.05\%$ (m^3/h/human)	Water vapors (g/h/human)
Rest	0.7-1	0.5	3	120
Light activity	1-1.5	0.5-1	4-9	120-180
Medium activity	1.5-2	1-1.5	9-14	180-260

Table 3: The air change rate per hour

	Permeability class		
Class	High	Medium	Low
No protected	1.5	0.8	0.5
Medium protected	1.1	0.6	0.5
Protected	0.7	0.5	0.5

CONCLUSIONS

The residential buildings constructed by man, function as shelter where multiple processes of the social and material life takes place. Therefore, there are many factors to take under consideration when projecting, constructing, using and post-using these buildings.

All aspects should be first considered in the processes of their interaction and interdependency and then to be systemically approached and analyzed. During the first stage, that is the design and project of the building, it is not completely professional or sufficient enough to simply juxtapose principles, calculus, construction elements and building blocks.

The process of design work for residential buildings should be an act of creation; the professional should be not only a man of science, but also an artist, a creator. Both the architect and the engineer cease being just a designer or a calculus machine; the result of his work should carry the mark of his personality.

It is also important to take the time and observe the elements of progress in order to understand the major differences between reiterative activities and creative ones, between calculus and conception, quantity and quality, law and phenomenon, pure science and creation, rational and intuition, routine and new activities. Man has always been concerned with discovering the factors leading to performance and progress.

Science by itself is not progressive. It represents quantitative, rational, conscious and logic accumulations of information. The processing of the information does not lead to progress by itself; information only represents the known, the old and the past.

Science, with its accumulation of information and processing of facts create favorable conditions for infralogic activities starting the need for quality, the creation, the new, the present and the future.

Science does not nor cannot give solutions. The solutions are acts of creation; they are unique, rising in the mind of an individual. Science, with its reasoning, logic and methods, only prepares the field for finding solutions; it provides optimum, sometimes multi-criteria conditions but it cannot establish their importance. Science is schematic, sometimes even stiff; it works with simplified hypothesis, with physical models representing a poor, sometimes rough image of reality.

The apparently unique, quantifiable solutions provided by science come from ignoring many aspects of the reality; closer to reality is the multitude of solutions found in an optimum field.

Choosing the optimum solution in that field is an act of creation, of art specific to one individual only; his/her subconscious is properly stimulated. Simple actions such as gathering information, synthesis, analysis and comparison of results does not make it be new, does not lead to progress.

The result of the work and efforts of specialists should be an act of creation, of realizing the new; the sum of all results should lead to a qualitative decision for the achievement of progress. The whole should be greater than the sum of all parts.

The professional is the result of a subtle osmosis phenomenon between learning, research, creation and real economic life. The professional has titles and diploma to certify his status, but he is validated only by true realizations that generate progress. The architect or the constructor should stop acting as simple sketcher, project planner and start being a creator of forms and structures. The computer overtook the technique, the routine and the repetitive. The act of creation, the only generator of progress, is an exclusive characteristic of the living material, the superior, organized material, the grey matter, the human brain. The progress and its amplitude are ensured by the relation between the act of creation and the routine. There is no progress without new, without creation.

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