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Quality of the inside environment and the energy efficiency of buildings

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Summary

The assurance of the indoor environment quality, having in view the hygiene and comfort aspects, has today a special importance in the present energy context. This means the energy consumptions decreasing, especially those from fossil fuels and the promotion of the renewable energy resource, having in view the diminution of the pollutants emissions with green house effect at the planetary scale.

In this context, it is imposed more and more the "energy efficiency" concept or the "energy efficient building" one in the buildings conception and also in the certification and rehabilitation process.

Starting from the criteria that are defining the indoor environment quality, this paper wants to present the main passive measures that may lead to this aim, with examples of real achievements met in the literature.

KEYWORDS: energy consumption, energy efficiency, indoor environment quality, thermal insulation, indoor comfort

1. INTRODUCTION

The main role of a building is to ensure for the inhabitants a healthy, pleasant and comfortable environment, and as possible independent of the outside conditions, such as meteorological or acoustical conditions.

The present requirements concerning this aspect are much more restrictive than those accepted during the previous historical periods, because of the changes in the nature and complexity of the internal and external actions that are occurring on the buildings, on one hand, and because of the inhabitants' requirements evolution, on the other.

To fulfill these requirements, directly connected to the energy consumption, is as important as the stability and safety requirements, or the architectural or the environmental framing aspects.

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INTERSECTII
INTERSECTIONS
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The energy used for the buildings operation is dedicated to the achievement of a healthy and comfortable inside environment, respectively to the heating of spaces during the cold seasons of the year or to the cooling during the warm season, to the lightening and ventilation. Before the period of the energy crisis, period in which the assurance of the environment quality was exclusively an equipments problem, it was generally accepted the idea concerning the direct relation between the energy consumption and the inside environment quality, which means that an increase of the energy consumption leads automatically to the increase of the inside environment quality, in general, and especially of the comfort, and conversely. The energy consumption decreasing has as consequences the inadequate life and comfort conditions. It is even accepted a ineluctable conflict between a low energy consumption and a healthy and comfortable environment.

The researches focused on the identification of some strategies and solving ways of energy problems, and recently of the environmental issues, in the sustainable development concept frame, have shown that through an interdisciplinary and multicriterial approach of the buildings concept is entirely possible an architectural quality, an agreeable comfortable and healthy inside environment, and a low energy consumption too.

All these attribute define an **energy efficient building.**

A complex analysis of the connection between the energy consumption and the inside environment quality at the dwellings and administrative buildings has been achieved in the frame of the European Project HOPE (Health Optimization Protocol for Energy Efficient Buildings) with 14 participants from 12 European countries, during 2002-2005 /1/. There were studied more than 160 buildings from the administrative and dwelling sector, half of them having a low energy consumption. The investigation means a general inspection, a discussion with the building superintendent and questionnaires distributed to the inhabitants.

The results have been invalidated the theory concerning the direct relation between the energy consumption and the quality of the inside environment. This made possible to frame the buildings into 4 categories:

- - buildings with high energy consumption and a good quality inside environment;
- - buildings with a high energy consumption and a low quality of the inside environment;
- - buildings with low energy consumption and a low quality of the inside environment;
- - buildings with low energy consumption and a good quality of the environment.

In this way it was noticed that the consumed energy does not depend on the inside temperature value, on the climate conditions and the ventilation rate, but in a grater measure, on the architectural and constructive solutions and the way of use. There was recorded an important insatisfaction percentage and even SBS symptoms in buildings that consume a high quantity of energy for mechanical ventilation, but it is not paid attention to the moisture, occupation degree or noise protection. On the other hand, the buildings with low energy consumption, natural ventilated, present a healthy and comfortable inside environment.

2. THE INDOOR ENVIRONMENT QUALITY

The inside environment quality, a decisive factor concerning the health and well being of the inhabitants, is influenced by the air composition (regarding the chemical, physical and comfortable and healthy pollutants) and by comfort (with the main components, acoustic, thermal and optical)

2.1 Air composition. Indoor pollution sources

A building may present risks for the inhabitants' heath, depending on the presence of chemical and physical pollution sources or ensure favorable conditions for the microorganisms' development.

The main sources of pollution in buildings may generate:

a. Chemical pollutants

The chemical synthetic products are parts of our environment. They are met in food, water, air, being emitted by building materials, furniture, domestic products, etc. The effects of the chemical pollution on health are multiples and are going from simple sense perception to very serious effects that may affect the respiratory, nervous or the gastro-intestinal system. Certain chemical pollutants are framed in the cancerigenic substances category. If the individual toxicity of the grater part of these pollutants is known, practical it is not known almost anything about their toxicity when they are in a combination or they have low concentrations, as they are frequently met in the inside air of the buildings where we live and work.

b. Physical pollutants

The main physical pollutants met in the inside environment are the excessive the moisture, the radon, the dust, the fibers (especially asbestos), the electric and magnetic field of low and high frequency. The presence of these pollutants may cause different symptoms, from the dryness of the respiratory ways, to the memory loss and concentration difficulties and cancer diseases.

c. Biological pollutants

In this category of biological pollutants are included the microbes, viruses, bacteria, pollen and smells that are developing in the interior air and are coming from the human beings, animals, acarians, beetles, room plants, mould, etc. They can cause allergies, affections of the respiratory ways, the most vulnerable being the children and the old people. The risks concerning these pollutants are as much important as the concentration is higher.

A good quality of the air means the knowing of the pollutants sources, the decreasing to the minimum possible of the emissions and continuous exhaust of the pollutants by ventilation.

2.2. The comfort

Generally speaking, the comfort means a thermal, acoustic and optical comfort. The perception of the comfort level implies a certain subjectivism degree, but in the same time is the result of the simultaneous action of objective factors, measurable, as architectural, constructive or operation factors.

If the assurance of the acoustic comfort is not directly connected to the energetic factor, the thermal and optical comfort assurance during the whole year requires certain energy consumption for heating, lightening and air –conditioning.

a. The thermal comfort

The thermal comfort is achieved by:

- - the assurance of a mean operative temperature, as a result of air temperature, of border surfaces, of moisture and air speed, in concordance with the activity nature and the inhabitants cloths;
- - the asymmetry limitation of the radiant temperature and temperature gradients to acceptable values;
- - the situations avoiding in which the inhabitants are coming in contact with surfaces too cold or too hot;
- - the avoiding of air currents (limitation of air speed).

All these requirements must be fulfilled in winter conditions and summer as well.

b. The visual comfort

The optical comfort is get by the assurance of a lightening adopted to the activity nature in the visual field, avoiding the contrast too strong, especially the blindness. The used light spectrum must be continuous, and the color temperature must be adapted to the lightening. The natural lightening is comfortable in the measure in which its intensity may be controlled.

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c. The acoustic comfort

The acoustic comfort may be ensured by avoiding the annoying noises, by decreasing of their intensity at source or by acoustic insulation to the air noise or the impact one. The admitted noise level has values connected to the activity nature (intellectual, rest, health caring)

3. STRATEGIES AND WAYS OF ACHIEVEMENT OF A HEALTHY AND COMFORTABLE INDOOR ENVIRONMENT WITH LOW ENERGY CONSUMPTION

The decreasing of the necessary energy consumption for a healthy and comfortable environment may be achieved by adopting passive measures, associated with minimum energy consumption, integrated in the architectural and constructive conception of the building. For example, the equipments for the mechanical ventilation or air-conditioning, correct conceived and operated could contribute to the assurance of a healthy and comfortable environment, is framed in the active measures category, while the thermal protection or the controlled ventilation are active measures.

In general, the measures for the thermal comfort assurance with low consumption contribute (or does not affect) to the air quality.

One of the measures that intervenes in meeting the both requirements categories, in certain circumstances in a contradictory way, is the ventilation, that reduced under a level aiming an energy saving, becomes insufficient from an air quality point of view or condense risk.

3.1. The thermal insulation of the envelope

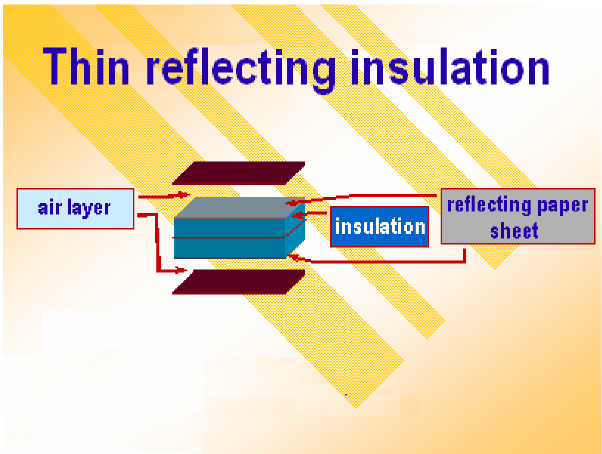
This means the rational use, in the building envelope structure, of some materials that hinder the heat transmission from inside to outside, during winter, and from outside to inside during summer.

The usually used materials for thermal insulation have low thermal conductivity and density. They have an organic or inorganic nature and they are presented in forms of blocks, plates or mattresses. Their proprieties and application fields are in general well known, and also the constructive solutions where are included: light homogeneous structures, compact stratified structures, ventilated structures, green roofs, walls with translucid insulation, etc.

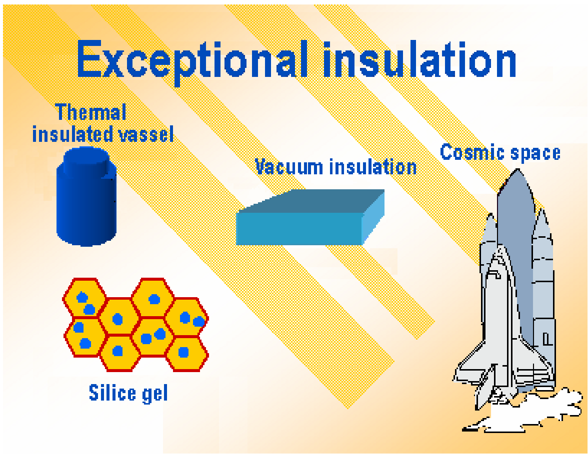
There are also materials with high thermal characteristics that are not well known in the usual practice:

ISSN 1582-3024

- - insulation materials in form of thin layers associated with reflecting sheets, having the role of reflecting the infrared radiation and in this way they suppress the heat transfer through radiation;
- - insulation materials under vacuum get by air exit from a fibrous or cellular support packed in a air thigh sheet; from all these the silicon nanogel has special proprieties, being less conductive than the air at normal pressure;



a.



b.

Fig.1. Thermal insulation of high efficiency a. thin reflecting insulation; b. exceptional insulations /2/

The thermal insulation efficiency requires its continuity on the whole envelope surface. Any physical or geometrical discontinuity generates a thermal bridge characterized by additional thermal losses, condense risk and lack of comfort. These thermal bridges must be avoided as much possible or treated in a suitable way when they could not be avoided.

3.2. The shape and orientation of the building

The contact aria between the building and the outside environment influences both heat losses and gains. A smaller external surface increases the thermal insulation efficiency, the compactness index being one of the most important parameters in establishing the energy indicators.

The glazed surfaces correctly dimensioned and oriented contribute to the decreasing of heat losses and solar gains utilization.

The adequate orientation toward the dominant winds and the cardinal points is important for the air infiltration control and for the assurance of a convenient route of the air circulation during summer for spaces air conditioning.

3.3. Thermal mass and inertia

The thermal inertia represents the building capacity to maintain an inside temperature as much closer to the outside temperature in the absence of a heat or cooling source. This means the envelope and partition elements capacity to damp and diphase in time the external temperature fluctuations and the fluxes generated by the solar radiation and internal gains.

The thermal inertia has two components:

- - the transmission inertia concerning the opaque elements is get by their damp and diphase capacity and intervenes depending on the temperature variation and external fluxes;
- - the absorption inertia concerning the elements being in contact with the indoor air and intervenes depending on the energy flux that are crossing over the glazed arias or are resulted from the using process.

An important inertia get by disposing the layers with high mass to the interior is adequate to the continuous heating. The discontinuous heating regime requires a low inertia that enables the rapid heating or cooling. This is get by placing to the interior the insulation layer or by plating the internal surfaces with a thin layer of thermal insulation material associated with a thin layer of light material as the wooden paneling, plastic material or gypsum cardboard.

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3.4. Ventilation

The role of ventilation is complex and consisting of air refreshing by exhausting the polluted inside air and replacing it with fresh air and of comfort assurance, especially during summer. The energy saving requirements and mainly the air conditioning requirements have generated a reorientation toward the controlled natural ventilation, not only in the dwelling case, but also in the public multistoried buildings case. The references present many examples of public, multistoried buildings, new or rehabilitated, where the ventilation is achieved by a natural way (fig.2). There have been developed some systems that emphasize the stack effects by architectural elements utilization such as the internal courtyard or atrium or by rational use of solar energy and wind pressure (active façades, double-peau façades).

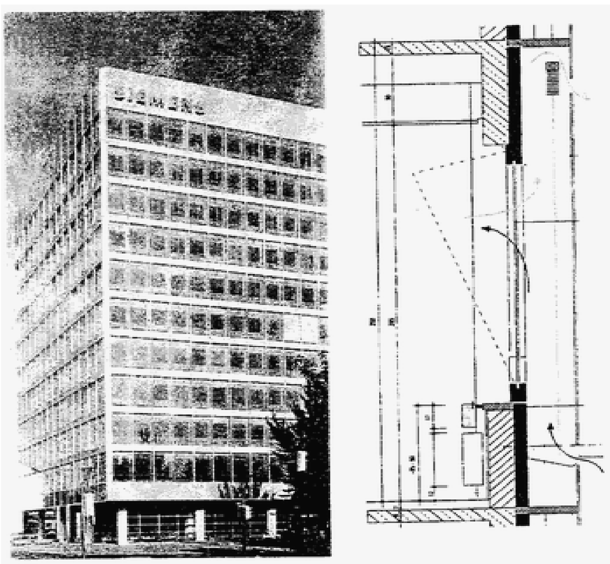

Fig.2. Natural ventilation of tall buildings with double façades (Siemens building, Dortmund) /2/

3.5. The climatic advantages of the ground

The important thermal mass of the ground generates a progressive attenuation of the yearly and daily temperatures variations of the outside air, associated with a diphase in time. These can be used to the underground constructions achievement, to the conception and achievement of seasonal storage systems of solar energy and some preheating/precooling systems of fresh air introduced in buildings by ventilation process.(Fig.3.)

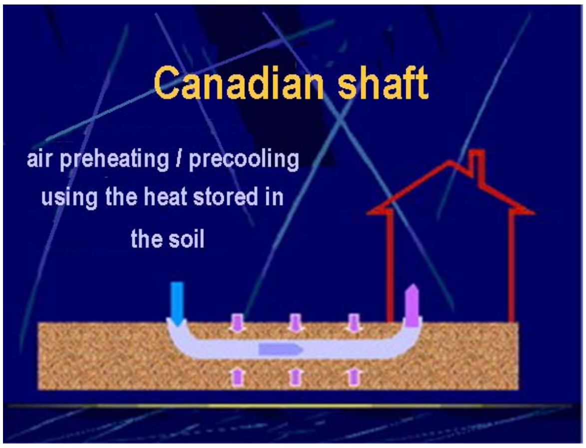

Fig.3. Preheating/ precooling of air by passing through the ground/2/

3.6. Solar energy utilization

Passive systems of solar energy utilization consisting of greenhouse spaces, greenhouse walls, solar façades of different types, etc. have penetrated in the basic vocabulary of contemporary architecture. Their working is based on the greenhouse effect, thermal inertia, air circulation by natural thermal convection. A high level of development consists of the introduction of the photovoltaic panels in façades of high performance.

The utilization of these principles has as a result the elaboration of some complex solutions and systems based on the summation of many more effects and on the integration in the general architectural conception. The passive systems of solar energy utilization associated with systems of taking over the polluted air, of air conditioning by using some heat switch ground-air, or cooling systems with evaporation for summer conditions lead to important energy saving in ecological buildings, with real adaptation qualities to the fluctuations of the outside environment parameters.

The technological progresses in the constructions materials and products offer to the designers' complex technique solutions, with high efficiency like: translucide thermal insulations, thermal insulated windows with selective optic proprieties, active façades involved in the spaces ventilation, photovoltaic surfaces, etc.

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3.7. The energy decreasing by lightening

The decreasing of the energy used for lightening implies the increasing of the using time of the day light, which is obtained by different architectural measures: the best shape and dimensions adoptions for windows, the avoiding of windows obstruction by trees, equipments and buildings, coloring the opposite surfaces to the windows in light colors, the enlarging the windows to the exterior to increase the aria of visible sky. The placing in front of the windows of some anidolic systems, consisting of mirrors with a certain shape and construction, having the role of concentration and directing the spot light toward arias less lighted, during a certain day period. In this way, it is obtained an uniform lightening and a decreasing of the time using of the artificial light.(Fig.4.)

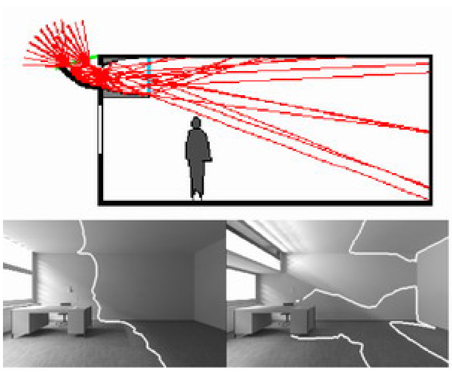

Fig.4. Efficient systems for a natural lightening/2/

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