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INTELLIGENT BUILDINGS, INTEGRATING DESIGN

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Abstract

According to the apt wording of a university lecture on the future of architecture[1]:

‘The growing focus on the issues of sustainable architecture may be evaluated as a paradigm change of building science, which reflects the changes in social priorities.’

The following article takes on to expound some important elements of this phenomenon, discussing:

1. the effects that form of energy, form of society and building activity impose on one another,
2. the change in the energy approach,
3. the definition of architecture-related intelligence,
4. the connection between ecology and high-tech,
5. the characteristics of integrating design and
6. the relationship between the building and its users.

Keywords: intelligent building constructions; intelligent buildings; integrating design; ecological building; high tech.

1. Form of Energy, Form of Society and Building

When examining the history of mankind, the fact that form of energy, form of society and building activity are related may be realized. After the societies of wood, coal and oil, the age of post-oil society has arrived, and to the people of today this change seems to be the most significant of all. One of the most important tasks is to replace the consumption of energy and resources with their circulation.

The report entitled ‘The Boundaries of Growth’, published by The Roman Club in 1972, was the first to state that industrial production, the increasing consumption of raw materials and environmental pollution threaten the future of mankind. According to the ‘Brundtland Report’, published in 1987, that marked an important stage in the search for the way out: ‘Only that development is acceptable which satisfies the needs of the generation of today in a way that does not jeopardize the possibilities of future generations to satisfy their own needs.’ The definition of sustainable architecture, as worded by Charles Kibert, is explained in Chart 1.

Chart 1: The Scheme of Sustainable Architecture

THE ENFORCEMENT OF ECOLOGICAL REQUIREMENTS		
Saving resources (materials, energy)	Protection of the environment	Protection of health
THROUGHOUT THE ENTIRE LIFE-SPAN OF THE BUILDING		
while constructing: – during exploitation – while producing the material – while producing the structure – during the building process	during its usage: – during operation – during maintenance – during renewal – during reconstruction	during abandonment: – during demolition – if the building is changed then used for another purpose – during destruction.

The following must be considered when discussing the topic:

– Building activity, in itself, has harmful effects on the environment, already. It kills the vegetation, destroys natural soil tissues, blocks the drainage of rainwater thus making the micro-climate worse.
– The amount of energy used for erection and operation of buildings is enormous. Its level reaches half of the total energy consumption of the nation and the resulting toxic emission harms the environment.
– However, it is obvious that the needs of the ever-growing population of Earth can only be satisfied by increasingly efficient building activity of ever-growing volume.

2. The Change in the Energy Approach

Traditional building methods are characterized by massive structures. Their primary purpose was to protect the internal space from environmental, climatic effects. This behaviour may be described as defensive and passive.

The program of modern architecture, born after World War I, was to let light, air and sun enter the apartments. It was a protest against narrow streets, small windows and unhealthy, semi-dark interiors. In the spaces behind the huge glass facades, however, the air, overheated by solar radiation, was suffocating and the intense radiation resulted in glare. The will to improve was hindered by the lack of sufficient knowledge of building physics and technical opportunities. In the beginning, modern architecture was only able to satisfy people's need for light, air and sunshine in a formal manner.

Later it gradually became possible for the developing science of building engineering to counterbalance the architectural, structural weaknesses of buildings by means of technical devices. By the late 70s the technical background for active temperature control has become sufficient, so air conditioning became common in public and industrial buildings of a higher standard. This solution, however, is insupportable due to its high energy consumption and environmental effects.

After the Energy Crisis of 1973–1974, specialists analyzed the light, heat, and air currents and the energy system of buildings, in depth. They realized that there was a constant exchange between the building and its surroundings. The surfaces of the building reflect, transmit, absorb, store and transfer currents of energy. Today – by the further development of the concept of passive temperature control and by deliberately making use of these effects – the building itself becomes its own air conditioning. The architecture of the 21^{st} Century breaks away from tradition and tries to gain energy from radiation in the winter, while in the summer it tries to minimize or store heat gain, by means of shading and ventilation. It responds to the effects of the surroundings in an interactive manner.

The solar energy radiated to the outer surfaces of an average family house in Middle Europe exceeds the energy need of the house 6-8 times, as recorded data has justified. Besides, other forms of regenerative energy are also available, such as wind, water, geothermal, etc. energy. Up-to-date buildings, that only use regenerative energy throughout their operation, not only save fossil resources, but also save the environment from harmful substances generating when such materials are burnt. The form of use of regenerative energy can only be determined in each situation by a specific case-study.

Up-to-date design looks at a building as a unified energy system by coordinating its shading, ventilation, natural and artificial illumination. Furthermore, making use of the waste heat produced by technical devices means that beside the characteristics of the natural surroundings the technical surroundings are also considered.

After the Energy Crisis, not overlooking ecological considerations, regulations of thermal control became stricter step by step. The heat energy usage related to the useable surface area of an average family house was set to 250(kWh/m^2,year) in 1984, in 1995, however, the 100(kWh/m^2, year) level was required. At the turn of the century, houses with low, 20-30 (kWh/m^2, year), energy consumption appeared. In cases of special buildings they reached the '0-energy' level and the first energetically completely self-sufficient house was created.

In the case of the row-houses in Freiburg-Sauergarten (*Fig.1*), a rather appealing intention has succeeded. In the years following moving in, when the families get over the financial effort of the construction, the buildings can be further developed. The heat energy consumption of the standard version is 43 (kWh/m^2, year). This value may be improved to 38 (kWh/m^2, year) by applying a glass windbreak on the Northern elevation, to 26 (kWh/m^2, year) by building a winter garden on the Southern facade and to 18 (kWh/m^2, year) by installing the heat-regaining ventilator.

By putting photo-voltaic panels on the Southern roofs, the houses will collect more energy than they need for heating and to make hot water. This way, the buildings can step up from the low-energy to the plus-energy level.

The 'E-autark' house in Freiburg represents the high end of development .

Fig. 1. Row-houses, that can be improved to reach the 'plus-energy' level, in Freiburg-Sauergarten. (Architect: Diesch R., Freiburg, 1995)

Fig. 2. The Central Stock Exchange in Berlin. The atrium of the Ludwig Erhard house. (Architect: N. Grimschaw and Partners, London, 1988-)

The designers added new technical solutions, such as devices for seasonal energy storage, to the existing means of passive and active solar architecture. This way they have achieved that the building supports its entire energy need from regenerative resources, including the operation of technical devices.

The examples above also show that the appearance of houses built according to the new approach towards energy differs from the traditional. Energy has become a form-generating factor.

3. Defining Intelligence in Architecture

The 15% window-surface area typical for the architecture of the late 19*th* century had increased to 80% by the beginning of the 1970s. This had results such as the increase of winter heat-loss and summer heat-gain and the increasing heat stress on the external surface materials. In order to prevent damage, an entire line of construction measures were necessary.

It is widely known that large glass surfaces without shading can only be constructed using special glasses. The results of the researches following the First Energy Crisis – heat and radiation preventing, diffuse etc. – glasses have a common disadvantage: constant performance. To eliminate this disadvantage, thermo-, photo- and electro-chrome glasses may be used that react to the changing radiation intensity by changing transmission characteristics and therefore may be called intelligent building materials.

An up-to-date glass facade that conforms to the technical, economic and aesthetic requirements of today is almost a machine. Double glass facades, due to the sheets of glass built parallel to each-other, have a three-dimensional mass. The space between them forms a transition zone between exterior and interior, in the physical and psychical sense as well. These glass elevation structures with heat, light and air transfer abilities, are equal to well-insulated solid walls, or even better, as they use solar energy for temperature control and illumination and thermic air currents for ventilation. The elevation reacts to the changes of the environment and the interior space in a dynamic manner, by changing its transmission characteristics and regulating energy currents between the building and its surroundings, therefore it may be called an intelligent building construction.

According to ecological principles, buildings should not work against the environment, but use its forces when operating, instead. The new-old tool for the architect to achieve this is the atrium with a glass roof, that forms a climatic buffer zone between the inner and the outer worlds. The glass surface materials serve the direct illumination of the adjacent spaces, the panels that can be opened serve the protection against overheating in the summer, the shaft-like air circulation is a solution for natural ventilation, as the example of the Ludwig Erhard House demonstrates (*Fig.2*). The energy usage of the atrium-type building, in the case of proper operation, is rather favourable, due to the greenhouse effect. Thus it may be declared that energy defines space. Furthermore, glass atriums used in urban design offer a new platform for city life and also represent an original architectural quality.

In 1959, Le Corbusier, designer of the Phillips pavilion for the Brussels World Expo, called his design an ‘electron composition’. The building performed a light, sound and colour show following a score-like plot. The Zeil Galerie in Frankfurt am Main (*Fig. 3*) is the electron composition of the 1990s. The facade of the building responds to the weather and noise effects of the environment by changing its color and by light signals. From a certain perspective, it behaves in an intelligent manner. Intelligent buildings, in the real sense of the word, are more than this. In their case the reactions do not only mean formal effects, but a real change in performance.

The following buildings are the examples of intelligent building constructions – double glass facades, diffuse glass roof – and ecological space structuring – atriums, winter gardens.

One of the new buildings in the bank district of Frankfurt am Main is the Commerzbank headquarters (*Fig. 4*). The building makes use of all the available forms of regenerative energy. The atrium, the winter gardens placed in a rising spiral pattern and the double glass facade supply the offices with natural light and fresh air, while the rounded corners of the elevation are clad by transparent heat insulation that gains heat from solar radiation.

Natural energy supply was the main principle behind the design of the Congress

Fig. 3. The Zeil Galerie in Frankfurt am Main. (Architect: Kramm, R. 1993.)

Fig. 4. Ecological tower block in Frankfurt am Main. (architect: Foster and Partners, London, 1997.)

and Exhibition Hall built in Linz, in 1993. One of the most significant parts of the building is the glass roof, which protects the interior against glare, overheating and overcooling and makes use of natural light, at the same time. The ventilation grid and spoiler system built in the crown of the arched roof help natural ventilation.

The buildings including all the engineering devices, are monitored and operated by central computers. Data from the several thousands measuring points is analyzed, taking into consideration not only the changes of the weather but the changes in the use of internal spaces and noise, fire and traffic information, as well. The computer runs the system according to the result of this analysis.

The in-depth discussion of the material summarized above is the topic of the university textbook entitled 'Transparent Building Constructions'[4].

4. The Connection Between Ecology and High-Tech

Considering the tendencies in the last quarter of the century, it can be stated that specialists of building have tried to answer the problems of running out of fossil and non regenerative energy resources and pollution of the environmentin two ways: by following the principles of ecology or by applying high technology. The aim of ecological architecture is to serve the building activity of families and small communities by fitting ‘harmless technology’ into buildings showing redefined traditional forms. The major building tasks of society are realized by means of high technology. The main guiding idea behind intelligent buildings is active temperature control, their operation is supported mainly by natural energy due to the controlled connection of the external and the internal climate. This proves that ecological principles and high-tech are no longer in contradiction, moreover, their synthesis gives the solution to the problems.

5. The Characteristics of Integrating Design

The past centuries were characterized by intuitive design. The success of the specialist’s work fundamentally relied on his knowledge, talent and skills.

By the 1980s, the number of factors to be considered during the design process had increased, and as a result of their interactions, structures became more complicated. The tasks were no longer possible to solve by applying traditional methods, therefore deliberate design methods have taken shape and spreaded.

To answer changes of the weather, all the structure of interior spaces, the shape and the constructions of the building have to be optimized. It is a proven fact that the majority of the energy a building needs can be saved by only applying architectural solutions -atrium, double glass facade, transparent heat insulation, etc. –, so it is basically up to the architectural solution whether a building has to be air conditioned or can be operated using natural resources. Architectural design, in this sense, becomes an instrument of climate control.

All these are naturally escorted by the fact that some principles, that were thought to be indispensable earlier, have lost their validity and their right to exist, by today. The polymath architect of previous centuries has become the ‘conductor’ of a work-group comprising many people. Integrating design means the cooperation with the members of this work-group – the structural engineer, the building engineer, the energy specialist, the price analyst, the organization expert and several other specialists, including the building construction designer-, at a very early stage of the design process. The adjustment of the climatic concept to the architectural task is possible by the utilization of computer-aided design and simulation techniques. As a result, the boundaries of design that existed earlier have vanished. This does not mean that the architect’s role is becoming less significant, as the primary purpose of these up-to-date design tools is only to check his concept rather than to create it. Their goal is to reach the optimal technical solution while preserving the artistic value of the building. The architect’s task is to create a work of new esthetic quality by making all these into architecture.

6. The Relationship between the Building and its Users

Finally, the relationship between the buildings representing the new energy approach and their users has to be mentioned. These houses require proper operation. They rely more on the cooperation of the operators, as the way they are run has major influence on their energy consumption.

The successful projects of environmental protection have influence on the public and this means a new economic chance in the construction sector. This is especially true if the social considerations of sustainability are reflected in the financing of projects that represent the new approach from central resources.

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