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CONTEMPORARY ARCHITECTURE AS A RESULT OF DEVELOPMENT OF ECOLOGICAL BUILDING TECHNOLOGIES AND COMPUTER AIDED DESIGN

Currently there exist a variety of techniques and technologies associated with passive construction, energy-efficient smart homes, the use of renewable energy sources. The task of modern architects is the creative and innovative search for new functional and aesthetic architectural solutions that are technically and technologically conditioned to guarantee its users a healthy and secure life in a friendly environment.

Key words: architectural design, ecology, innovative technologies, intelligent buildings, computer-aided design.

Подано огляд сучасних методів «розумного» проектування і технологій будівництва. На прикладах розглянуто інтелектуальні та енергозберігаючі технології на альтернативних джерелах енергії – «Екологічний будинок». Проаналізовано спроби пошуку сучасними архітекторами креативних ідей та інноваційних технологій, перетворення функціональних та естетичних рішень в умовах безперервного розвитку технології і техніки будівництва, для забезпечення найвищого рівня комфорту і безпеки в інтуїтивно зрозумілому оточенні.

Ключові слова: архітектурне проектування, екологія, інноваційні технології, інтелектуальні будівлі, системи автоматизованого проектування.

Introduction

Ecological and systemic point of views in contemporary architecture leads to the consideration of designed buildings as a functioning whole, which becomes a part of a larger whole that is the ecosystem. Modern green technologies of energy efficient construction, including passive and intelligent building technologies [1], offer a chance for realization of modern architecture as a "machine for living" and at the same time as part of the ecosystem. It may be that this idea is an architectural utopia which rationally and harmoniously leads to sustainable development of the architectural environment.

The idea of "machine for living" through the use of ecological solutions (eg. renewable energy sources) leads to a harmonious coexistence with architectural nature as technical creations of man. The integration of natural and artificial environment (including the architectural environment) takes place at the micro-and macrostructure levels of these environments [2,3]. The currently existing variety of techniques and technologies used in architecture, energy efficient and passive construction are often associated with both energy saving and with the use of renewable energy sources such as solar energy [3,4].

The modern intelligent building management systems and energy-saving technologies: solar panels, photovoltaic panels, heat recuperators, used for example in the architecture designed by Frank Gehry [5], present environmental trends in architecture and construction cause the modern architecture home to increasingly become a "machine for living". This view is consistent with the concept expressed by Le Corbusier [6,7,8], who is considered the great founder of modern architecture. In this sense, modern architecture is the reflection of the age in which it is formed. It is technically and technologically conditioned and focused on meeting the needs of man and his environment.

Architecture as a result of technological developments in the past and present.

The development of technology involves the development of technique and all areas of human functioning. The use of technology for electricity and solar energy, for example currently used photovoltaic panels on the roof of the building, raises the question of whether that operation is still adding, gluing the modern equipment which in itself is unfamiliar to the architectural form of the building or whether it is an integral form of modern architecture?

In the past a brick chimney built in house required wisdom and knowledge as well as a great discovery for those times that a brick laid in a certain way can create a chimney as a technological device that is indispensable even until now. This idea, therefore, allows a brick serve not only a constructional function but also a technological function. This element in past times, for aesthetic reasons received an architectural detail, which created a kind of "crown" of the entire building.

The current trend is to create designs in which the device (eg. chimney) or other modern and contemporary device will be combined with the whole building or even an imminent part of the building that will not disrupt either its form or function while creating composition and beauty of the building. Such technical elements of the building cease to be unwanted additions and get their place in the spatial composition of the building.

Presently such elements are eg. solar panels (Fig. 1) and solar roof tiles (photovoltaic tiles) (Fig. 2.) which due to their shape do not disturb the current construction methods and traditional form composition of buildings.

Fig. 1. Solar panels form the plane of the roof [9]

At present, commonly used solar panels can be both glued to the traditional form of the roof or be completely integrated with this element forming an effective outer layer of the roof. Therefore, for example it becomes important in what way is the modern device integrated with the architectural form; as can be seen in the photograph (Fig. 1, 2).

For example, a solution that is fully integrated with traditional form of a building was proposed by scientists of the Massachusetts Institute of Technology MIT. They have developed a technology called Thermeleon which is a photovoltaic roof tile able to change its color automatically. (Fig. 2, 3).

Fig. 2. Roof tiles with integrated solar photovoltaic cells [10]

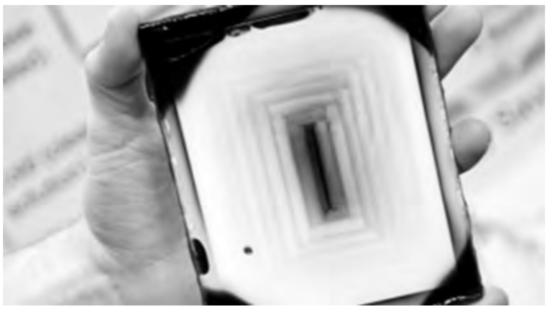

Fig. 3. Thermeleon color-changing roof tiles for regulating indoor temperature [11]

The material used is a smart polymer gel that changes phases under the influence of temperature. The principle of this device is to change the degree of self-absorption of solar energy by the roof cover. The roof cover changes its color from black to white and vice versa under the influence of its own temperature. The use of white instead of dark roof in a hot climate can reduce the indoor temperature by up to 4ºC.

Similar considerations can be applied others building components which are constantly being created and modernized thanks to the achievements of modern science and technology. A question arises: how to choose a roof color in a temperate climate zone with hot summers and cold winters? In the future, Thermeleon smart roof tiles can completely replace their conventional counterparts [11]. Currently, researchers are also working on a paint for coating roofs with similar properties [11].

Passive houses as examples of the positive impact of technological development.

The idea of passive houses is a comprehensive approach to the building as part of the artificial human living environment ecosystem. Passive house (Fig. 4) [12,13,4,14] is an example of modern green technology application in the construction industry.

In an attempt to define a passive house we can generally say that such building does not need a separate active heating system because a passive house heats up and cools down itself – that is, in a passive way. A passive house is a building which ensures the heating comfort of its inhabitants while using not more than 15 kWh of energy per 1 m2 of floor area.

In practice, this means that heating one square meter of such building during the heating season requires a maximum of 15 kWh which corresponds to 1.5 l fuel oil or 1.7 m3 of gas or 2.3 kg of coal. In comparison the demand for heat in conventional modern buildings is about 120 kWh/m2 per year.

In passive houses the overall total energy demand is four times lower than for currently built energy-efficient buildings and up to 8-10-times lower than for traditional ones built according to the standards.

In a passive house the thermal comfort is ensured by passive heat sources that used to be underestimated. These can be people, electrical equipment, heat from the sun and the heat from the ventilation that is by recuperation.

Fig. 4. In Poland, the first demo house certified as passive was built in Smolec near Wroclaw by copyright office project Lipińscy The Passive House and developed in collaboration with specialists from the Institute of Passive House at the National Energy Conservation Agency [15]

In a passive house the total energy demand for room heating, hot water and the operation of a household electrical must not exceed 120 kWh / (m2/year).

Some passive technologies have been used in ancient times. An example is a ground heat exchanger, which was used by the Romans in the system known as hypocaustum. It was built next to Roman public baths where rooms with pools and relaxation spaces were heated with hot air distributed in spaces under the floor. [16]

Intelligent buildings as a positive effect of technological development.

Intelligent buildings are the next step in the evolution of construction and architecture. These buildings adapt to the needs and habits of the inhabitants and take autonomous decisions for raising the quality of life of their users.

Intelligent buildings require the installation of high-tech and software management systems. These systems integrate the operation of all systems and equipment in the building. A steering component is a device equipped with the appropriate software (this can be a computer, tablet or smart phone). The equipment and systems controlled by them communicate with each other in order to collaborate more effectively and consequently meet the needs of their owners better. Such a close coordination and cooperation of the building wiring equipment makes management of the available resources of the building at a minimum cost of operation more efficient [13].

Smart buildings are the result of technical or technological progress of our civilization. The new technologies as systems of maintenance of the building and information technologies as the automatic control systems of equipment and installations of the building have the direct impact on their action. The interaction of these systems, monitoring and controlling of the building leads to saving energy, protecting the environment, enhancing users` safety, improving the quality of living and working conditions [1]. In this way the intelligent buildings beyond the technical and environmental requirements also take into account social, cultural and economic issues. This is a big step in the humanization of human residential environment and raising living standards.

As a result of introducing the idea of intelligent buildings is also the increase of the demand for the production of systems and equipments related to their operation. Moreover, perhaps a new branch of industry was created in which a growing number of people find the employment.

Passive smart buildings as examples of the positive impact of technological development.

Of particular interest for our topic is a building that is passive and intelligent at the same time. It was built in 2002 in Germany in Ulm as the largest passive office building known as "Energon" (Fig. 5, 6, 7). Energon was built on a large strip of land in the middle of a scenic park, surrounded by bodies of water – ponds collecting rainwater from the roof of the building. The building has an area of six thousand square meters. It is a place of work for 420 people. Thanks to the technologies used it consumes only 25 percent of the energy for heating, air conditioning, etc. normally needed in this type building.

Fig. 5. Energon: smart passive office building in Ulm, area 6000 sq ft, Germany.
The front elevation. [17]

In this building a large glass roof atrium (Fig. 6) provides a sufficient amount of light in the rooms inside the building which minimize the use of artificial lighting. To maintain a comfortable temperature, the passive building in Ulm uses an intelligent air conditioning system.

Fig. 6. The interior of a passive office building in Ulm [17]

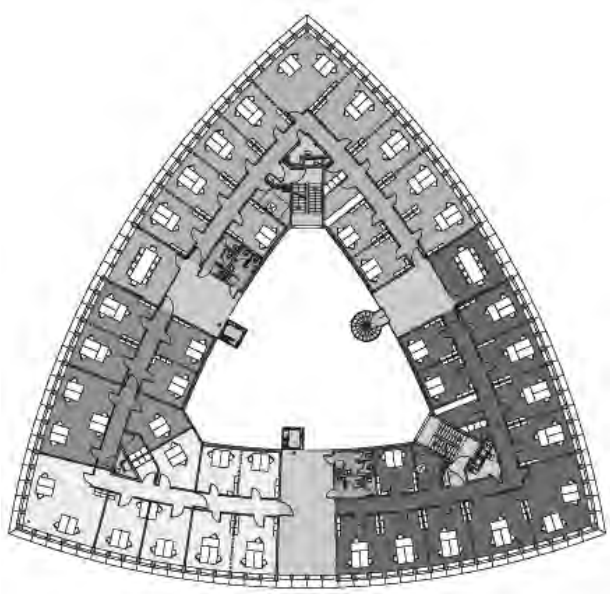

Fig. 7. Passive house Energon Ulm 2002 horizontal plan [17]

There is about 350 m of synthetic material pipes mounted in the ceilings. Depending on the needs, they may be used to flow warm or cold water or be used for heating or cooling of rooms. 40 probes reaching 100 meters into the ground were placed around the building to dispose of excess heat. The earth accumulates the heat which then can be used back to pre-heat the cold air during other seasons. Changes in outside temperature and sunlight cause overcooling or overheating of the building. 44 percent of Ulm's building facade consist of glass surfaces giving good visibility. Mechanically controlled blinds are used to protect against excessive sunlight. The building's facade hardly conducts any heat. The building's facade uses a 35 centimeter insulation layer. The insulation layer under the foundation slab is 20 centimeters thick and the insulation layer on the roof is 50 centimeters thick. To ensure a high level of insulation the building uses 3 glass layer windows.

When the use of electric lamps become necessary, the office lamps are automatically activated and electronically dimmed and brightened depending on the measured intensity of light that reaches the room. The motion sensors turn the lights off in a room when no one is present in a room.

Additionally, outside of the atrium part, the Energon's roof is covered by photovoltaic panels on the surface of 328 m2, which raise 12 000 kWh per year.

Fully automated systems are responsible for the supervision and regulation of building's control devices. Specific individual technical features and technical systems used in them did not negatively affect the structure and aesthetics of the building's architecture. On the contrary, they made the aesthetics more attractive. The passive building in Ulm exemplifies a realized ecological architecture which meets diversified and multi-faceted needs of people and the environment.

The presented office building Energon in Ulm (Fig. 5, 6, 7), which is a passive intelligent building is a proof that energy-efficient architecture may create landscapes that are aesthetic and people- friendly, and that it is also possible to improve the quality of the architectural environment by building intelligent passive houses.

Buildings designed with computer-aided design as examples of the positive impact of the development of science

Contemporary architecture is a common demonstration of possibilities of computer-aided design.

Fig. 8. The Guggenheim Museum Bilbao is a museum of modern and contemporary art, designed by architect Frank Gehry and located in Bilbao, Basque Country, Spain [18]

An example of a building designed with computer-aided architectural process is presented in the figure (Fig. 8) a museum building in Bilbao. It is visually attractive and technologically advanced architecture created by Frank Gehry (Fig. 8) [5].

This building is a result of the development of modern technologies in construction and architecture and computer-aided architectural design. In this building titanium plates were used in roof covering.

Conclusions

The presented view of contemporary technical and architectural problems fosters innovation, including innovation in the development of modern architecture. The innovative "smart" contemporary architecture is increasingly influenced by the development of new green technologies in construction and technologies supporting computer-aided design including architectural design. Equiped with these modern tools and technologies, today's architects are able to realize previously unrealistic visions of architecture.

The examples of ecological architecture realized in recent years allow us to hope that the ecological architecture of the twenty-first century can be designed as beautiful, comfortable and implemented in accordance with the natural environment and human nature, and that future energy-efficient buildings will help to preserve the harmony of the natural and designed environments.

Ecological and systemic point of view in contemporary architecture leads to the consideration of designed building as a functioning whole, which becomes a part of a larger whole that is – the ecosystem. Modern green technology, including construction of energy-efficient passive and intelligent building technologies [8,16], gives a chance for the implementation of modern architecture as a part of the habitat. [16]

The idea of habitat can reasonably and harmoniously lead to a safe and sustainable development of the architectural environment and architecture.

This idea leads to a harmonious coexistence between every person and nature, integrating natural and artificial environment as a architectural environment at the micro-and macrostructure levels of these environments.

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