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ASPECT OF SUSTAINABLE DEVELOPMENT IN CONTEMPORARY ARCHITECTURE

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Abstract. *Modern architectural aesthetics is conditional on sustainable development as the basic principle of the balance between man and nature. Among the most complex problems of modern society are reduction of pollution and energy resource expenditure within the building sector. Most of the buildings are not built in accordance with the requirements of environmental protection, and are therefore energy-inefficient and costly to maintain. Problem solving requires implementation of certain design principles and application of different materials and systems for producing and saving energy. One of the most important aspects of the architecture is a selection of sustainable building materials that are least energy-intensive over their entire life cycles, the materials that can be recycled after use and reused in a new object. The aim of this study is to assess the basic architectural principles of sustainability as well as the selection of materials in order to preserve the environment and natural resources for future generations.*

Key words: *sustainable architecture, ecological architecture, energy-efficient materials, ecological building materials, life-cycle assessment, green building*

1. INTRODUCTION

Sustainable development is a challenge to harmonize and meet the growing needs of humankind for natural resources, industrial products, energy, food, transport, waste management, the conservation and protection of the environment and basic resources for the life of future generations and their development. This concept includes a belief that, in the long run, the planet cannot meet human needs without preserving the physical, chemical and biological systems on the planet [1]. It is necessary that the damage to the environment and depletion of natural resources is reduced to a minimum. Environmental issues, which are in the core of sustainable development, are inextricably linked with economic and sociological component. Community cohesion with its environment is

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complex, and involves the exploitation of resources and energy, which is visible on the local and global scale [2].

Contemporary architectural aesthetics is conditional on sustainable development, environmental protection and the application of the system for producing and saving energy [3]. One of the most complex problems of the modern age is the integration of contemporary architecture into nature, where an object, supposed to represent the inherent energy system, uses local natural resources and energy from renewable sources. Reducing energy consumption through the design relies on using different materials and systems for producing and saving energy. By understanding the laws of nature and their implementation through the design and construction of the facility, it is possible to build structures with high efficiency and of specific forms and compositions [4].

2. THE CONCEPT OF ENVIRONMENTAL IN ARCHITECTURE

Buildings significantly change our environment. Most buildings are not in accordance with the requirements of environmental protection, because they are energy inefficient, too cold or too hot and expensive to maintain [5]. Modern architectural issues refer to the integration of modern aesthetics and ecological architecture. A possible approach to the problem is to design the objects according to the principles of bioclimatic architecture, in which the building becomes a part of the environment. According to these principles, the facility must be as energy efficient as possible, and the ultimate goal of green building is to build full energy-independent object through the use of renewable energy [6]. Environmentally sustainable design minimizes negative effects and maximizes positive effects of architectural design on environmental systems over the life cycle of the building. Indoor environmental quality measures should provide an indoor environment that is physiologically and psychologically healthy. The social benefits of sustainable design are related to improvements in the quality of life, health, and well-being. These benefits can be achieved at different levels – in the buildings themselves, the community, and society in general. As for the buildings, research on the human benefits of sustainable design has focused on three primary topics: health, comfort, and satisfaction [7]. There are a number of different technologies and design approaches and interpretations of what sustainable in architecture should mean:

- Energy-efficient design means insulation and ventilation to help keep a building warm in winter and cool in summer through, for example, site layout and form, natural ventilation and shading, passive solar design and thermal mass, thus reducing the energy required for heating and cooling buildings.
- Energy-efficient fixtures and fittings can be installed to reduce energy consumption, for example, SMART meters, energy-efficient white goods, low-energy lighting.

Sustainable energies are renewable and low-carbon energies result in either zero-carbon emissions or a significantly lowered carbon emissions due to energy-efficient technologies. They include, though not exclusively:

- Solar uses energy from the sun to create electricity to run appliances, lighting or to heat water directly.
- Ground source heat pumps (GSHP) which extract heat from the ground, upgrade it to a higher temperature and release it where required for space and water heating. The GSHP function can be reversed for cooling purposes.
- Combined Heat and Power (CHP) sometimes known as Cogeneration is the use of a single plant to generate both heat and electricity.

- Innovative waste facilities enable and encourage on-site recycling.
- Rainwater harvesting and recycling is a means of attenuating water consumption, allowing the reuse of rain as greywater in the garden or in the home.
- Water-saving devices can reduce daily water consumption through, for example, flow regulated fittings and greywater recycling.
- Sustainable Urban Drainage Systems (SuDS) are a sequence of management practices designed to drain surface water in a more sustainable fashion than some conventional techniques.
- Biodiversity enhancement is the provision of natural habitats and sites suitable to support feeding, nesting and breeding for wildlife.
- Sustainable materials and construction is the management of the demolition and construction process to minimize environmental impact.

The promotion of the use of renewable energy sources is a priority at the global level, because increasing the share of renewable energy in energy consumption significantly reduces the consumption of fossil fuels and also reduces the emissions of greenhouse gases in the atmosphere [8].

3. LIFE CYCLE OF BUILDING MATERIALS

In consideration of the global sustainable development, in addition to the above principles, a very important role plays a choice of organic materials and structures for construction. Materials and resources all have environmental, social and economic impacts beyond their use phase in a project. Facilities are usually made of materials that badly affect the health and the environment. A facility construction usually consumes about 40% of the stone, fine and coarse aggregate, a 25% of the timber [5]. The manufacture, transport and installation of a building made of materials such as steel, concrete and glass, require a large quantity of energy, but it still represents a minimal part of the ultimate energy requirement of the building as a whole. A study of the environmental impact of building materials is based upon the examination of their behaviour from the process of getting raw materials and concluding all operations until the final return to the natural environment in the form of waste [9]. Environmentally friendly building materials are the ones with least harmful effect to the environment. Environmentally unacceptable materials are those which excavation and processing into building materials adversely affect the environment. The group of these materials include materials such as steel, aluminum, cement, clay and sand. Environmentally friendly building materials require a simpler technological processing and lower power consumption. They should be supplied from local sources - renewable and recyclable. In addition, they must have premium features in terms of maintenance, thermal performance, stability and durability. ISO 14.040 regulation defines life cycle as the “consecutive and interrelated stages of a product system, from the acquisition of raw materials or the generation of natural resources until their final elimination” [10].

The life cycle of the construction material consists of the following stages (Figure 1):

- Production, which involves obtaining or extraction of raw materials, which are then further transported to where the raw material is processed.
- Construction phase includes aggregated transport of raw materials to the construction item, and the installation of obtained materials in the building.
- Use phase in which the materials are used to repair and mainten once completed building.

- End of life phase, which is related to destruction of the building and transport of residual materials. At this stage, the aim is to reuse or recycle the material or dispose it in a storage of residual waste.

Fig. 1 Life cycle of building materials [14]

Taking the raw materials from nature means spending natural resources, making geomorphological changes and consuming non-renewable or slowly renewable sources. All these processes of obtaining raw materials require the use of energy and they are very often accompanied by air pollution, which has negative consequences on the environment. When considering the phase of raw materials extraction, priority in selection should be given to the materials obtained from natural, quickly renewable, available and wide–spread resources, materials with recycled and harmless content, materials which originate from raw materials obtained in ecologically safe processes, with the minimum use of energy, water and minimum land occupancy [11].

Transport of materials to the site is a necessary step, but it causes air pollution and fuel consumption. The process can be conceived as a transformation process: the state of materials, including their position in space, changes.

The installation of building materials is followed by the generation of dust and other harmful particles which pollute air, soil (when they get to the surface) and water (by rainfall draining). Installation normally requires the use of energy, necessary for the work of machines and equipment, for lighting, heating or cooling the working environment, etc. Large quantities of waste are generated during the installation of building materials due to the use of packed building materials, damaged materials, the production of materials on the site, etc. The highest percentage of the waste generated during the installation is disposed; only a small part of it is reused or recycled into new building material. From the aspect of environmental impacts occurring during the phase of installation, priority should be given to the materials which are installed with a minimum use of energy and water, the materials that pose no risks to the workers' health, and the materials which can be installed with a minimal occurrence of noise, dust and waste. For the purpose of reducing the quantity of waste generated during installation, priority should be given to prefabricated materials (components), materials resistant to damage, materials of standard dimensions, as well as materials in which the wrapping material also has a usable value or the potential to be biologically decomposed, reused or recycled [11].

After a period of decay, a building's life comes to an end. The demolition of buildings or their service life makes it very difficult to separate different materials, and most end up in landfills and/or incinerators. Therefore, for the recycling of construction materials to be possible, it is necessary to promote a radical change in the design of buildings, to favour the disassembly of the construction materials at the end of their service life. For this purpose, the joints between the different materials must be reversible, such as bolted joints, avoiding adhesion as far as possible [12]. The biggest flow is rubble, which causes problems because of dumping limitations. Since reinforced concrete and high-rise buildings have been introduced, it is a much more complicated and expensive matter to modify a construction to revised standards and also to demolish it at the end of the service lifespan [13].

Disposal / reuse / recycling helps decrease land occupation, soil pollution and the degradation of the environment. If the life cycle of a certain building material ends up in material reuse, then the negative impacts in the earlier phases (raw materials extraction, production and disposal) are partially compensated. Additionally, if the source of reused material is local, than the negative environmental impact that would occur in the phase of transport is reduced to a minimum; if the source of reused material is the construction site itself, then the potential negative impacts of transport are totally cancelled. Recycling cancels negative environmental impacts that would occur during the phases of raw materials obtaining and disposal, and partially reduces negative environmental impacts that would occur in the phase of production of new building material. Priority in selection should be given to building materials that can be, or are reused, to the materials that have the potential to be recycled or already are carrying recycled content, and finally to materials with the potential of biological degradation [11].

4. Conclusion

Overall economic growth has led to irrational consumption of fossil fuels, leaving huge consequences on the environment and endangering the lives of future generations. The increasing apprehension towards the environment is leading to the origin of the sustainable architecture. Correlation of the environment and contemporary architecture leads to the application of modern technology, presenting a challenge to designers to create new objects of aesthetic quality of form, function, design and to aesthetically contribute to the use of renewable energy. The new systems, relying on the production of green energy, are becoming important architectural elements. The consideration of sustainable building materials, makes significant impact on the environment, hence their ecological performance became one of the key topics in the field of sustainability. Materials and equipment may contain very dangerous and harmful materials. From architectural point of view, the use of building materials is one of the critical factors of environmental pollution and degradation, because of their potential negative environmental impact in every phase of their life cycle. From the aspect of sustainability, primacy should be given to the materials that are renewable, which processing does not require a lot of energy, materials from local sources and recycled and reused materials.

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ASPEKT ODRŽIVOG RAZVOJA U SAVREMENOJ ARHITEKTURI

Savremena arhitektonska estetika uslovljena je održivim razvojem kao osnovnim principom uravnoteženosti čoveka sa prirodom. Jedan od najkompleksnijih problema savremenog društva predstavlja zagađenje i potršnje energetskih resursa u građevinskom sektoru. Većina građevinskih objekata nije u skladu sa potrebama zaštite životne sredine, energetski su neefikasni i skupi za održavanje. Primarno rešavanje problema može se postići poštovanjem određenih principa projektovanja, a zatim i primenom različitih materijala i sistema za proizvodnju i uštedu energije. Jedan od najvažnijih aspekata u arhitekturi predstavlja izbor održivih građevinskih materijala koji zahtevaju najmanje energije za obradu tokom svojih životnih ciklusa, koji mogu biti reciklirani posle upotrebe i ponovo korišćeni na novom objektu. Cilj ovog rada je sagledavanje osnovnih arhitektonskih principa održivosti kao i izbor materijala u cilju očuvanja prirode i prirodnih resursa za buduće generacije.

Ključne reči: *održivi razvoj, ekološka arhitektura, energetska efikasnost, ekološki građevinski materijali, životni ciklus materijala, zelena gradnja.*