

**Review Article**

**USE OF "GREEN" TECHNOLOGIES IN URBAN PLANNING AND ARCHITECTURAL SOLUTIONS**

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**Abstract**

The purpose of the work is to examine theory and practice in the application of "green" technologies in urban planning and architectural solutions. In the framework of the concept of sustainable development, the consideration of environmental requirements in construction is becoming highly relevant. The high level of dynamics in the development of public sector institutions, the goal of which is to solve a number of environmental problems, has led to the growth of the information array regarding the ecology of residential premises, which has brought to life the development of the institutional environment of ecological construction. Certain standards of environmental construction are being formed, designed to stimulate market participants to use environmentally friendly building materials and technologies and, as a result, the development of innovations in this area. Accordingly, the basis for the development of green building should be considered its innovative platform, on which the participants in the process come together to solve a common goal that is to implement the innovative process of green building. At the same time, the participants in the indicated process should be guided by the standards and rules of interactions. In addition, participants of the process need to rely on formal and informal norms in this field of communication: the former include joint ventures, state standards and environmental legislation, the latter include a combination of value characteristics of the quality of construction products, their environmental friendliness, comfort and safety for all subjects of an innovation and investment project.

Stable development is increasingly becoming a key factor for construction practitioners, politicians, and industry as the world moves toward green building. When buildings have green consumption, the effect of embodied energy and greenhouse gas emissions becomes very important. A green building can be constructed using various materials and construction methods. Green foods can have very low energy consumption and can also benefit the environment and nature. Therefore, the use of environmentally friendly materials, as the most important renewable materials, in all spheres of human existence seems to be the most effective way to optimize the use of resources and reduce the environmental impact associated with human activities.

The priorities for the development of environmental construction today are the cost-effectiveness of the buildings being built, their safety, the balanced use of natural resources, the reduction of harmful environmental impacts, as well as the use of innovations in architectural design.

**Key words:** "green" technologies, building innovations, LEED-technologies, architectural solutions.

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**INTRODUCTION**

It is known that architectural and construction solutions, based on a number of environmental principles, are today the key to the harmonious development of the environment of modern cities.

However, today there is still no definite methodology, as well as a mechanism for organizing integrated life support systems for the population at both the local and city levels in construction. However, without a doubt, in an era of growing technanthropogenic impact on the environment, there is a need for greening design and construction with the involvement of scientific directions in the ecology of the city and home.

In an urban environment, the life support system is designed to best meet the social, economic, aesthetic and environmental needs of a person. The city is a complex system, all the elements of which are interconnected and the changes that occurred in one of them entail changes in all components and the system as a whole. Being an artificially created material part of natural landscapes, cities have a negative impact on them. The state of all natural elements is reflected directly in the city environment. An unfavorable ecological situation, in turn, negatively affects the state of the ecological environment of a person's direct residence.

The last decade has seen a decline in industrial and agricultural production, the pace of housing construction has decreased, and the number of rented living space has decreased.

Nevertheless, the problems of ecology and environmental protection are still sharp and relevant. Pollution of Factory Resources and atmospheric air remains high due to outdated equipment and insufficient implementation of modern technologies and treatment facilities. Road transport has increased urban air pollution. Due to the significant growth of passenger transport, the reduction of trucks in traffic flows does not reduce the overall air and noise pollution on the main territories. Due to the lack of funding, the sanitary condition and level of improvement of urban and adjacent territories have deteriorated.

Imported construction and finishing materials, construction materials made from industrial waste, do not always have sufficient environmental quality, which is difficult to predict in the future. So, a number of thermal insulation materials in 10-20 years begin to emit toxic substances and lose their thermal properties. Used local and imported construction materials require assessment for radiation, power lines and repeaters cause electromagnetic radiation.

Environmental safety of construction is one of the factors that affect the quality and price of housing demand. In addition, the use of environmentally friendly technologies in the construction of buildings helps to save resources and energy during the construction and operation of buildings, and consequently increases the profit of developers. All of the above determined the relevance of the research topic.

**MATERIALS AND METHODS**

The work considered foreign research on the problems of greening construction, as well as presented ways to reducing the negative impact of the construction industry on the environment.

**RESULTS**

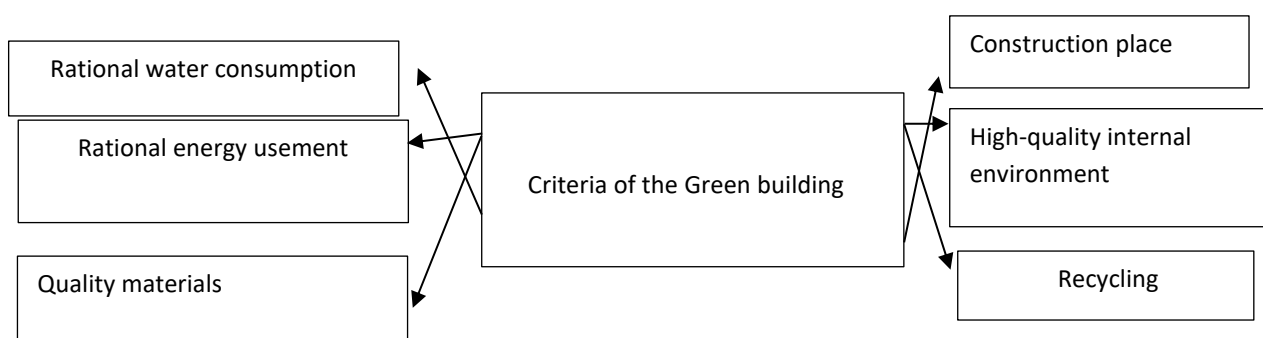
Humanity has always been interested in issues of interaction with nature and its environment. At the person in the natural environment, a number of factors have always affected and are now affecting: climatic conditions (temperature and humidity, aeration regimes), aboveground and underground water regimes, the soil layer, and green areas adapted to it. At the same time, he sought to adapt the natural environment to his needs. As a result, there were cities in which anthropogenic factors changed the natural environment. Industry, transport, and utilities increase the pressure on the urban environment. Such factors as noise, gas, dust, vibration, electromagnetic radiation, changes in species perspectives, the presence of dangerous industries, negatively affect the human body, causing various diseases. It should be noted that they most often have a cumulative and synergistic effect: the impact of one factor is amplified by the impact of others [17].

The solution of environmental problems of the city involves the use of a whole range of different natural science and sociological disciplines that determine the goals and objectives of modern urban ecology and environmental construction.

Green building (ecological construction) — this is a type of construction and operation of buildings whose impact on the environment is minimal. Its goal is to reduce the level of consumption of energy and material resources throughout the entire life cycle of the building: from the selection of the site for design, construction, operation, repair and demolition.

Ecological or green construction is very relevant in the modern world. Such buildings are aimed not only at building from environmentally friendly materials, but also at saving all types of energy. The world statistics are inexorable: about 40% of the world's energy is consumed by buildings for living, and carbon dioxide emissions are about 35%. We can't help but think about solid waste, 50% of which is urban waste.

The scientific literature defines criteria for eco-building (illustration 1).



**Illustration 1. Green building criteria**

Let's consider the basic principles of green building.

The first principle is the use of natural building materials. This principle implies the use of not only natural materials, but also renewed ones. At the same time, preference is given to precisely those materials that are in the place of construction of the building.

Natural building materials include:

- wood, lumber, straw or even flax, that is, everything that grows in the forest or in the field;
- sand, limestone, natural stone or granite, i.e. all types of rock;
- clay products, it can be adobe, bricks and masonry mortar;
- heat-insulating materials, peat and wood shavings mixtures.

For example, today a house of this type is being built in a very short time. But there is one drawback: they have a very high degree of fire hazard.

The second principle is environmental safety. Such a factor is very important at all stages: construction, operation and destruction.

The third principle is energy efficiency. An eco-friendly house does not have to consume much energy, that is, electric energy, heating and so on. Ideally, an ecological house should not be dependent on any type of energy [12].

Guided by the principles of environmental construction [11], it is possible to reduce the harmful effects at all levels of urban life, starting with a living cell, courtyard, microdistrict, residential area (urban area) and ending with the city as a whole, production and the territory adjacent to the city. At the same time, the impact of environmental factors on the urban system is presented as human exposure.

**DISCUSSION**

Reducing the impact of harmful factors on urban development projects is a more complicated task. This is achieved by landscaping, landscaping, the implementation of the master plan of the city. These measures require additional funding and significant costs. The transfer from a relatively favorable to a favorable zone is possible using ecological construction methods [11].

At the present stage, one of the pressing issues is the greening of building materials. Research is currently focused on developing alternative binders for conventional Portland cement (OPC) due to the huge greenhouse gas emissions associated with its production. Geopolymer binders based on GGBFS-FA are an innovative alternative to OPC, which can be widely used: in addition to environmental friendliness, its production does not require high energy, and also contributes to sustainable development through the use of industrial waste.

Steel slag, an industrial by-product from steelmaking, can be identified as an alternative to natural aggregates for concrete production, as there is a possibility of an acute shortage of natural aggregates in the future. One of these solutions is the production of geopolymer concrete GGBFS-FA.

GGBFS-FA geopolymer concrete with steel slag coarse aggregates are obtained by replacing natural granite aggregates at various substitution levels, i.e. 0%, 25%, 50%, 75% and 100% (by volume) and various fresh and mechanical properties have been studied. The bending-fatigue behavior of GGBFS-FA geopolymer concrete with steel slag was also studied in detail. Efforts are also being made to model the probability distribution of the fatigue data of GGBFS-FA geopolymer concrete at various stress levels using two Weibull distribution

parameters. The results showed that the inclusion of steel slag in the geopolymer concrete GGBFS-FA leads to a slight decrease in mechanical strength. Water absorption and the volume of permeable voids showed higher values with the inclusion of steel slag.

In geopolymer concrete mixtures containing steel slag, a decrease in the number of fatigue failure cycles was observed compared to granite aggregates. In general, the performance of steel slag was found to be satisfactory for use in structures and pavements, and steel slag can be recognized as a new building material. The development of environmentally friendly and sustainable building materials has attracted much attention from the construction industry.

With increasing greenhouse gas emissions, high energy consumption and environmental hazards resulting from increased cement production, researchers have focused on developing possible alternatives to conventional Portland cement (PC).

Activated binders, such as geopolymers, alkaline activated slags, can be considered as possible alternatives to OPCs that are of interest in the modern research community. Geopolymer concrete has excellent mechanical and strength properties (Davydovits, 1982, 1984; Swanepoel and Strydom, 2002).

Geopolymers can be obtained by activating aluminosilicate-rich starting materials using a strong alkaline medium. Several studies have been reported on the use of fly ash (FA) in the synthesis of geopolymer materials (Swanepoel and Strydom, 2002; Palomo et al., 1999; Fernandez-Timenez and Palomo, 2000). The main reaction product formed in the aggregate polymers is alumina-silicate hydrate (A-S-H) gel. Slow setting and slow strength development are few disadvantages when using FA in geopolymers (Swanepoel and Strydom, 2002).

The activation energy required for FA is high, and therefore thermal cure becomes an important parameter when activating FA-based geopolymers (Jiang and Roy, 1990). However, the addition of fine-grained granular blast furnace slag (GGBFS) to the Geopolymer-based Concrete has achieved sufficient strength properties even at ambient conditions (Nath and Sarker, 2012; Rajamane, 2013) without the need for thermal curing, which is mainly due to the formation of calcium silicate hydrate (CSH) as a result of the activation of GGBFS (Li and Liu, 2007).

The properties of FA-based polymers depend on the type of alkaline activator, the activator module and the dosage of sodium oxide of the alkaline activator, the type of cure, the curing time and temperature, the ratio of water to binder, etc. (Vooraa and Dave, 2013). Demand for aggregates for concrete production has increased along with the growth of large-scale infrastructure and construction projects in many countries. This has led to increased attention to identifying alternatives to natural aggregates in order to preserve natural aggregates for the future and maintain an ecological balance [14].

Waste generated in the industry is considered as possible alternatives for use in the production of concrete. Steel slag, a product of processing waste from the steel industry, can be considered as a potential alternative to natural aggregates.

Disposal of steel slag in landfills is usually associated with high costs and a negative impact on the environment. The use of steel slag in concrete will not only help preserve the natural resources of the aggregate, but also reduce the area of the landfill, which will reduce the environmental hazard arising from its disposal.

Steel slag is usually produced using a basic oxygen furnace or electric arc furnace, and therefore, based on the technology used, steel slag can exist as a basic oxygen slag (BOF) or electric arc furnace (EAF). Based on the types of additives used in steel production, EAF steel slag differs slightly in its chemical and physical properties from BOF steel slag (Fruehan, 1985). However, steel slag aggregates are associated with problems such as bulk deformation, which is mainly due to the presence

of free lime or magnesia. When free lime comes into contact with water in the presence of atmospheric carbon dioxide, it undergoes a reaction to form calcium carbonate, thereby causing bulk deformation.

Another problem associated with steel slag is the high specific mass of aggregates. Because of these problems related to steel slag, the use of steel slag in concrete is limited. One possible solution to the problem of the expansive nature of steel slag aggregates is to allow aggregates to be weathered for a period of three to six months to bring free lime and magnesia within acceptable limits (Australian Slag Association, 2002). A thin layer of calcium carbonate ( $\text{CaCO}_3$ ) is formed, which is visible on the surface of steel slag after weathering, which leads to minor changes in its physical characteristics (van Der Laan et al., 2008).

Research conducted by a number of authors in the past using coarse-grained steel slag aggregates in OPC concrete has shown that the performance of coarse-grained steel slag aggregates is satisfactory or better than that of natural aggregates such as limestone, gravel, gabbro, etc. (Shekarchi et al., 2003; Maslehuddin et al., 2003; Alizadeh et al., 1996; Taha et al., 2014). Examinations have shown that the steel slag aggregate has improved mechanical properties due to its angular shape, better grip and rough texture. However, few authors reported that the inclusion of steel-slag aggregates in OPC concrete resulted in a similar or insignificant decrease in the strength properties of concrete compared to natural aggregates (Manso et al., 2004; Carloet et al., 2013; Gonza Les-Ortega et al., 2014). However, to date, no attempts have been made to investigate the effectiveness of coarse-grained steel slag agglomerates in alkaline-activated binding concrete, and therefore there is a need for further research in this area [12].

Concrete sidewalks are usually subject to heavy traffic and must withstand a large number of repetitive cyclical loads over their entire service life. Fatigue failure due to repeated cyclic loads is one of the main causes of concrete pavement failure, and therefore the design of concrete pavements with fatigue failure is mandatory in most design standards.

Research on the dynamic behavior of geopolymer concrete is very sparsely presented in the special literature. But the main conclusions of the testing of the above method are as follows: the inclusion of steel slag in geopolymer concrete GGBFS-FA gave satisfactory results for use in structures and road surfaces. The consumption of aggregates from steel slag in the production of concrete will solve the problems associated with the shortage of aggregate, as well as partially solve the problem of utilization of steel slag. specific literature.

Also today, researchers are focusing on the use of BIM technologies in managing the results of lean and green projects.

Today, most of the construction work is done in the form of complex projects, and therefore good project management methods are considered very important (Mayloret Al., 2008). Construction projects must be expertly analyzed in terms of not only budgets and schedules, but also quality and environmental impact (Formoso et al., 2002; Howell and Ballard, 1998), as the construction industry faces acute pressure regarding profitability, environmental management and sustainability (Planning Commission Government of India, 2013; Wang, 2014). Given the current conditions and the overall state of the sector, it is clear that business as usual is not viable, and it is therefore important that the industry has an agenda for change and continuous improvement. Their inherent problems, such as excessive material and technological waste, excessive dependence on resources, energy use, and carbon footprint, are being addressed at the global level [7].

There is a high need to solve environmental problems related to the depletion and degradation of natural resources in order to accelerate the achievement of the sustainable development Goals (MoEF, 2011). The built environment sector, in particular, is a major contributor to carbon emissions that lead to climate change (Allu and Ebohon, 2015). For example, the construction

sector in India accounts for almost 24% of total direct and indirect CO<sub>2</sub> emissions and is the highest consumer of natural resources and energy compared to other sectors (Parikh et al., 2009). Energy efficiency and the use of renewable energy, resource conservation, recycling and waste minimization are of paramount importance. The design, construction, operation and end-of-life processes associated with this sector must continue to evolve in order to become highly efficient and sustainable. It is important not only to deliver assets that are resource-efficient and sustainable (through the green principles), but also the delivery process itself should become highly efficient (through the lean principles). To deliver assets that are resource-efficient and sustainable, the industry has adopted green principles. With low additional construction costs, the adoption of passive design strategies and reusable secondary materials in new construction significantly reduces the environmental impact of construction activities (Chen et al., 2015; Coelho and de Brito, 2012). Certified green buildings reduce operating costs by 8-9 percent (Braham, 2007), and productivity and health savings account for 70 percent of all life cycle cost savings (Kats, 2003).

In the construction sector of the environment, a separate scientific direction has emerged that focuses on eliminating waste and inefficiencies that exist in the design and construction processes themselves. The traditional system of interaction between manufacturers of building materials and construction organizations increases the likelihood of waste generation. This has also led to many problems, such as cost overruns, schedule delays, poor quality, insufficient security, disputes and litigation. Along with the development and implementation of lean construction technology, a new project delivery system, called Lean Project Delivery System (LPDS), has been developed, positioning itself as a method to reduce costs, increase productivity, and maximize efficiency at all stages of the project, including planning, design, and construction (Ballard and Zabelle, 2000).

The industry has developed in two paradigms: the principles of lean principles and green initiatives independently of each other, without realizing the relationship between these two agendas. This work explored how green principles and lean principles are interlinked, determine the benefits for projects when they are considered together, and how they can be integrated into a single model. The combination of lean and green methods is not only possible, but also makes it possible to get better results on construction projects. It is in this regard that the use of BIM technologies becomes effective, allowing to solve problems on a global scale in organizing and supporting the implementation of construction projects of eco-friendly buildings [18].

Among the directions of greening construction and improving the architectural appearance of the city in this regard, the use of "green roofs" technology should be highlighted.

The use of this technology was noted in the gardens of Babylon and the Roman Empire. During the 19th and 20th centuries, roofs in major cities in the United States were greened to reduce the growing cost of building parks in inner city (Herman, 2003). Currently, the world leader in this technology is Germany, where more than 10% of homes have green roofs (Kohler, 2006).

Kohler (2006) reports that the first wave of green roof construction in Germany occurred at the end of the 19th century. Already from 1983 to 1996, incentive programs were launched that required the installation of expanded green roofs for buildings in the Central part of the city and allowed to reduce additional installation costs.

Currently, green roofs are widely distributed in other European countries, such as France and Switzerland. In addition, the government of Portland has organized several incentive programs to ensure that green roofs are installed on buildings. In Canada, Toronto has also promoted more widespread construction of green roofs with sustainable alternatives to address urban environmental problems.

Green roofs are usually built in the inner city. There are generally three types of green roofs: namely, an intensive green roof, a semi-intensive green roof, and an extensive green roof. Different types of green roofs require different vegetation, and therefore different depth of overgrowth of the environment (Bunting et al., 2005). Researchers have proposed several characteristics of extensive green roof plants: they grow quickly and reproduce effectively; they are short in height and form pillows or mats; their roots are shallow but spread out; their leaves are juicy or capable of storing water (Snodgrass and Snodgrass, 2006; MacIvor and Lundholm, 2011).

Four other types of vegetation can be used in semi-intensive green roofs: herbaceous plants, wild small woods, small woods and shrubs; these types of vegetation require a deeper nutrient medium. There are also a number of plants that can be planted on intensive green roofs: lawn, low-lying shrubs and groves, medium-sized shrubs and groves, tall shrubs and groves, large shrubs and small trees, medium trees and large trees. They require an even deeper nutrient medium.

An extensive green roof is the most expensive of the three types of green roofs that are in between installation and maintenance, since it can be saved on its own. Since installing extensive green roofs was easier and more flexible, most research focused on the harsh conditions on extensive green roofs [2].

The installation of green roofs has been widespread around the world, especially in European countries and the United States. Extensive green roofs are often the subject of scientific research, as they are cheaper than intensive green roofs. However, extensive green roofs face harsh climates, such as high solar radiation, limited precipitation, and shallow growing substrate, so this limits the ability of plants. These factors become obstacles to building an extensive green roof, while a comprehensive humidification system can be installed on intensive green roofs. Thus, water efficiency is not the main problem for intensive green roofs [2].

The survival rate of plants directly affects the aesthetics of green roofs, and therefore their perception by the public. Plants on roofs can purify the air; plants and soil can purify runoff, as well as hold back wind. After reviewing the study mainly from an environmental point of view, from the installation of green roofs to its environmental benefits in relation to urban areas, it was concluded that green roofs are good for restoring green areas in urban areas. However, this should not cause the destruction of the outer green belts, since green roofs cannot replace the natural environment.

## CONCLUSION

Achieving sustainable and environmentally friendly architecture is one of the main goals that people have made the ultimate model for all their professional activities in order to create a better life. For this reason, the movement towards greener architecture and greener construction is the main goal of this industry.

Sustainable development is increasingly becoming a key factor for developers of construction practices, politicians and industry representatives, as the world moves towards green construction. When buildings have green consumption, the impact of embodied energy and greenhouse gas emissions becomes very important. A green building can be constructed using a variety of materials and construction methods. Green products can have very low energy consumption, and can benefit the environment and nature. Therefore, the use of environmentally friendly materials as the most important renewable materials in all spheres of human existence is the most effective way to optimize the use of resources and reduce the environmental impact associated with human activities. Moving towards a true green architecture, which implies the effective use of all living natural elements and existing energies in nature, is an imperative requirement in modern architecture.



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