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Review paper

CONTEMPORARY ARCHITECTURE AND ITS IMPACT ON THE ENVIRONMENT – MODERN SUSTAINABLE BUILDING SYSTEMS

Vukašin Stefanović[1], Anđela Stevčić[2]

Abstract

Rethinking contemporary construction goes beyond conventional building techniques and is conditioned by the context of technological progress. The aim of this paper is to analyze the transformation of the city, the impact of contemporary design solutions, and the assessment of their effectiveness after implementation in modern projects. Transformations experienced by cities in underdeveloped countries indicate a loss of the human character, which was the fundamental idea of architects of the modernist movement. Such change can be interpreted in various ways, but in the context of cities, it can be reduced to certain aspects such as comfort, infrastructural equipment, aesthetics, content, and other elements that must meet contemporary needs. Their interconnection is crucial for the creation of high-quality physical spaces. This paper calls for further research and re-examination of construction techniques with the aim of reducing negative environmental impacts.

Key words: *modern construction, sustainable construction, ecological principles, green materials, technological progress, development, Masdar City.*

[1] Phd student and junior researcher, Innovation Center of the University of Niš , Serbia, vukasin.stefanovic@icun.ni.ac.rs, ORCID number 0009-0002-7852-0439
[2] Phd student and junior researcher, Innovation Center of the University of Niš, Serbia, andjela.stevcic@icun.ni.ac.rs, ORCID number 0009-0007-1295-9998

1. INTRODUCTION

The environment as we know it today is the result of established economic, political, social, and ecological processes. Fundamentally, it is a natural space, but it can be said that under the influence of the mentioned processes, it has become a social product, shaped according to the needs of the people living in that space. The transformation of natural space into physical space is the task of urban planners and architects. This space can be defined through the relation of space-time-activities and depends on the relationship between the actors of that space. Creating the living environment for people is essentially the study of the relationship between humans and the environment in which they live, that is, understanding the complexity and changes of those relationships that occur over time [1]. The fate of the environment depends on people, and its development will look the way humans define it. Problems affecting its development require a responsible approach in order to eliminate the consequences of inadequate human behavior towards nature. Historically, viewed as a conscious being, humans have from the beginning used nature and its resources for their own benefit. Although we are not the only living beings on the planet, we have shaped nature exclusively according to our needs. The question arises whether nature or humans come first, and whether nature is necessary for humans. All actions so far indicate an anthropocentric view that nature exists because of humans. If we talk about sustainable development, it is necessary to change the anthropocentric attitude and establish a framework of equality for all living beings to whom nature also belongs [2].

If we accept that the living environment of modern humans is a product of their activities and that architecture is the most visible result of their work, then cities can be seen as a personification of that product. The problems of modern cities primarily stem from the increase in the number of people on Earth. This problem brings with it more built-up areas, pollution, increased resource consumption, traffic, and climate change. The growing number of people on Earth and the anthropocentric view leave little room for sustainable urban development unless there is a change in the ethical principles by which people currently live. If sustainability is defined as development that solves the problems of the present generation without preventing future generations from performing the same activity, then in order to establish such a model of operation, changes in thinking must be made. Sustainable development will have a future when humans overcome their primitive instinct to place personal needs and interests above the needs and interests of others. Without a sense of responsibility for the people and nature around them, a healthy future cannot be discussed [2]. In this regard, the paper explores the impact of contemporary architecture on the modern living environment of people, or in other words, the relationship between contemporary construction and the city. Sustainability is no longer an academic aspiration but a necessary way of life and thinking. Examples of such functioning should be sought in many European countries. There is no rational reason preventing this, especially when sustainable technologies are present and ideas and strategies are implemented.

"Contemporary architecture is a real product and reflection of new times," is part of the thoughts of Prof. Nikola Dobrović [3]. The development of architecture and technological progress run in parallel, and their separation has never been possible. Therefore, we speak of buildings that use and will use innovative systems to be adequate for their users and environmentally friendly for their surroundings and nature.

2. THE IMPACT OF CONTEMPORARY ARCHITECTURE ON THE ENVIRONMENT

2.1. About contemporary cities

The environment is an integrated system that includes natural ecosystems, social values, and economic aspects, but viewed through the prism of architecture, it is a physical space shaped to fulfill human needs. Its variability is the product of different geographical, social, and economic parameters, and architecture is their articulation (concretization) in physical space. The scope of the environment is defined by the number of inhabitants and the facilities it provides. It is certain that the environment experiences certain pressures caused by population growth, construction, climate change, and other current negative phenomena, whose impact is most visible in cities.

The city represents a civilizational achievement, a symbol of progress in every sense. We define it as a complex organism composed of systems of buildings, infrastructural flows, and public spaces. To live, it needs people who use these spaces to establish social interaction. Utopians see the city as an ideal place to live, but its sustainability depends on thorough changes based on sustainable development and ecological design.
The dualism of human action is reflected in his power to create but at the same time to destroy. Humans build but simultaneously disrupt natural ecosystems and the natural balance. The result of their activities is rapid resource consumption, fewer forested and green areas, pollution, climate change, and the disappearance of many species of plants and animals, which are also inhabitants of the Earth. Environmentalists define these phenomena as the Sixth Extinction, viewing humans as the cause of such occurrences. Sustainable architecture is the construction industry's response to rapid negative changes in the Earth's environment and its ecosystems [4].

2.2. Tendencies of the contemporary construction industry

The construction industry is also attempting to improve sustainable building techniques due to the increased needs of certain countries for natural resources. Their production and economy are based on increased consumption of fossil fuels, which causes shortages and rising prices of certain materials and agricultural products. China is a good example of a country facing problems of overpopulation and resource scarcity. Their appetite for materials is growing due to increased production volume. Leadership in all branches of global trade and production has been based on constant construction and expansion, which significantly reduces free physical space and leads to other negative phenomena such as the expansion of the Gobi Desert due to frequent droughts and water shortages. The solution to the problems of overpopulation and limited available space is being sought through sustainable construction and the introduction of new typologies in residential and social architecture. The construction industry is heavily reliant on the consumption of these resources (fossil fuels), and in order to remain healthy and solvent, it must change.

2.3. High-performance buildings

Contemporary buildings are designed to meet high standards in terms of energy efficiency, comfort, durability, and sustainability. They stand out for the use of advanced materials that reduce environmental impact, and their efficiency and impact assessments are continuously reviewed during the design phase through advanced software technologies. To better understand the aspirations of modern construction, the design strategies that achieve these standards will be explained below [4].

- *Transparency regarding energy efficiency and materials*

Awareness of human health requires architects to use quality materials that do not negatively affect the condition and health of space users. In this regard, it is very important that green architecture adopts a transparent approach to design and provides information about product composition, potential toxicity, and the energy efficiency of buildings themselves. When discussing building performance, it is important that data about it be accessible to facilitate monitoring of their performance and environmental impact. Such data allow modernization and optimization of systems that do not meet required conditions [4].

- *Application of BIM technology (Building Information Modeling)*

The use of BIM-based software significantly improves the design process and allows easier tracking of construction phases and processes. Its implementation provides an integrated solution for the entire building. Thanks to this, multiple users can work simultaneously, which leads to faster work, better overview of solutions, and reduced risks of errors. BIM can be understood as a comprehensive methodology for more efficient management of construction and infrastructure projects. The difference from CAD design lies in the software's intuitiveness, which simultaneously develops a three-dimensional model while working on 2D drawings, enabling spatial visualization of solutions during all design phases. In other words, the solution is generated based on a model consisting of real elements. All changes to it are simultaneously reflected in all relevant technical drawings [4].

- *Life Cycle Assessment (LCA)*

LCA is a methodology and analysis of the life cycle that is gaining increasing importance because it enables quantification of the ecological impacts of design decisions throughout the entire project lifespan [4]. What this assessment provides before building construction is the comparison of certain systems, materials, constructions, or other aspects of solutions relevant to the building's effect on specific natural phenomena (such as the greenhouse effect, global warming, etc.) or simply its impact on the environment where it will be built. This allows the selection of solutions for which the assessment determines the least possible negative impact on the environment and phenomena, or solutions that will be completely neutral to the environment [4].

- *Zero energy consumption*

A pressing problem of modern architecture is the high energy consumption of buildings, which increases the amount of emitted carbon dioxide resulting from the burning of fossil fuels, which remain the most common energy sources. Zero-energy buildings are considered carbon neutral precisely because of their use of renewable energy sources, predominantly solar energy. An example of such a building in Serbia is an urban villa in Belgrade called Zero Energy, designed by architect Vladimir Lojanica. This building is formed as a photovoltaic monolith, whose envelope consists of a total of 405 panels providing 90% of the building's total energy needs, together with panels on the roof. All other systems are connected as a smart system, enabling automation of ventilation, cooling, and heating processes [5]. The goal of such buildings is to achieve a net-zero energy balance, meaning that energy consumption for maintenance, heating, and cooling is minimized. This implies that the amount of renewable energy the building produces is equal to the total amount it consumes annually. Of course, to achieve zero energy consumption, it is not only necessary to use renewable energy sources but also to synchronize the influences of construction, materials, and other systems in such buildings [4].

- *Carbon Footprint Calculation*

The increase in population requires a greater number of buildings for various purposes, which entails occupying areas that were once green spaces. This leads to an increase in the amount of emitted CO2, one of the causes of climate change. Global warming causes droughts that lead to the dying of trees, which further increases CO2 levels. Carbon footprint calculation is done per capita, and high values are characteristic of developed countries (countries with large populations and developed industries). The previously mentioned strategies and their implementation can help reduce it. In other words, the goal must be the gradual phasing out of pollutants from everyday use in order to restore climatic balance [4].

3. SOME CURRENT SUSTAINABLE SOLUTIONS

3.1. Green roofs

Although greening of roof surfaces is not a new concept, given technological advancements, their application should by now be standard in the design and construction of buildings in urban areas. However, in practice, the situation is different; for example, in Serbia, there is no significant use of this system, even though its implementation would significantly improve parameters indicating the level of urban pollution. Green vegetative roofs, as one of the methods of greening building envelopes, are an innovative technology that largely compensates for losses in the urban environment caused by the construction of new buildings. Like other modern methods, designing green roof coverings is applicable to existing buildings with flat roofs. Their use is even recommended for buildings undergoing redesign to increase their energy efficiency.

For roof greening, a mixture of sedum plants is used, chosen according to the climatic conditions of the area. These plants are drought-resistant, and their maintenance involves annual feeding and care. The effectiveness of green roofs depends on various factors such as soil layer thickness (a thicker soil layer means better interior cooling and greater possibilities for planting various plant species), greenery and its planting density (greenery creates shade that positively affects cooling), and climatic elements (precipitation, solar exposure, relative humidity, etc.). Green roofs are categorized into three types: extensive (requires minimal maintenance), simple intensive (requires occasional maintenance), and intensive (requires intensive maintenance) [6].

3.2. Green facade walls

Another method to address pressing urban issues related to the lack of greenery in cities is the greening of building facade walls. This is also a modern method of urban design and architectural planning of buildings. Such walls help improve the energy performance of structures, promote the restoration and development of biodiversity, and contribute to the reduction of air pollution [7]. By greening the facade wall structure, an interaction between the environment and the interior space is established, resulting in certain indoor comforts, energy harmony, as well as enhancing the exterior appearance of the building. To enrich the walls with greenery, mainly vines and climbing plants are used, which require three to five years for full development. The formation of a vertical garden on walls can be achieved by installing ready-made panels or modules with already planted vegetation on a substructure. The use of such systems is more common in areas with intensely warm climates where overheating is a frequent problem. In regions with a Mediterranean climate, the effect of green walls can reduce solar heat load by up to 20%, especially when the green facade is designed on the east side of the building [8]. The longevity of such walls is ensured through regular maintenance and feeding of the vegetation. Designing green walls does not have to be a characteristic only of newly designed buildings; the existing urban fabric can also be energetically renovated by applying this system, simultaneously redesigning the urban tissue [6].

3.3. Photovoltaic Facades

Designing photovoltaic facades represents yet another innovative method for improving buildings with the goal of achieving energy efficiency. This refers to a glass envelope made of vertical photovoltaic panels mounted on a substructure attached to the building's primary structure. These systems are also known as BIPV – Building Integrated Photovoltaics. Their efficiency depends on several factors, including the number of sunny days, the building's surface area coverage, shading, the angle of installation, and the technology used in manufacturing the panels. There is no single definition of such systems, but the term generally encompasses the technical, functional, and aesthetic integration of solar modules into buildings. Differences between systems arise from the degree of integration of photovoltaic modules into the building structure. The most commonly used systems are semi-integrated, which do not involve embedding solar cells into building materials or structural elements of the building. In contrast, there are also fully integrated systems [9].

3.4. Modern wood-based constructions (GLT, CLT)

Wood is still used as a construction material due to its natural origin, relatively low cost (especially for "light" structures), fire resistance, weight, and its constructive capabilities. Naturally, the environmental impact of wooden structures is significantly lower compared to reinforced concrete, which is most commonly used for structural assemblies. However, for the needs of demanding modern architecture and construction, wood-based materials/constructions are used, namely GLT – glued laminated timber and CLT – cross laminated timber. The characteristics of these systems include the improvement of the natural basic properties of wood while minimizing or completely eliminating the negative impacts.The goal of lamella bonding is to use a relatively small volume of wood while simultaneously increasing load-bearing capacity and strength under compression and tension. Their application covers various uses and typologies, and compared to reinforced concrete, construction proceeds significantly faster. Structural elements are produced in specialized factories, meaning that the structure is assembled on site by joining prefabricated elements.CLT (Cross Laminated Timber) technology is used for panel production, where lamellas – boards – are arranged in two directions at a 90° angle. These panels are used for walls, floor structures, and roofs. To achieve the desired load capacity and quality, the pressure intensity is precisely determined.

The importance of these constructions also lies in the renewability of wood as a resource used for their production, as well as the fact that during its growth period, wood binds large amounts of carbon dioxide, which has been repeatedly mentioned as a major current pollutant [10, 11].

4. ANALYSIS OF THE MASDAR CITY PROJECT – THE MOST SUSTAINABLE CITY IN THE WORLD (UAE)

Masdar City is conceived as an urban hub — a desert community designed and built to be carbon-neutral and zero-waste. The project was initiated by the Abu Dhabi government with the goal of advancing renewable energy and technology development, aiming to create a model for sustainable cities in the post-fossil fuel era. Masdar covers an area of 640 hectares, located adjacent to Abu Dhabi, leveraging its transport infrastructure while connecting with neighboring communities and the international airport.

The purpose of Masdar City is to integrate various innovative fields to pool knowledge that will result in technologically advanced yet truly sustainable settlements. Although situated in a desert, the city is designed to offer optimal living conditions while surrounding land is allocated for wind farms, solar farms, research activities, and plantations, ensuring energy self-sufficiency and independence. The project was designed by architect Norman Foster and is considered the first sustainable eco-city in the Arab world. It explores the feasibility of future cities based on three pillars of sustainability: social, environmental, and economic.

Masdar City is designed to be free of carbon dioxide emissions, cars, and waste. It relies solely on renewable energy, with 80% coming from solar power, and the rest from wind turbines and waste processing. Cutting-edge infrastructure and construction technologies reduce energy and water consumption by about 70%. For transportation, Masdar uses electric vehicles and is connected to a light rail public transit system [12, 13]. To further sustainable development, Masdar is developing a university (Masdar Institute of Science and Technology) in cooperation with MIT, focusing exclusively on sustainability research [13].

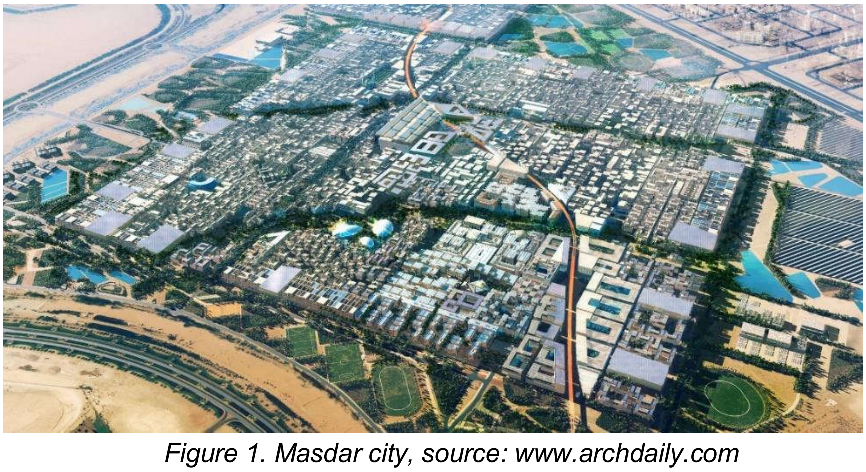

Figure 1. Masdar city, source: www.archdaily.com

The urban design of Masdar is inspired by traditional Arab architecture and urbanism, featuring narrow streets, low-rise buildings, public spaces with high density, mixed uses, and walkability — all aimed at overcoming harsh desert climate challenges. The city is oriented southeast-northwest to create shade during the day and to align with prevailing winds, aiding natural cooling. The landscape design, called the "three fingers" park system, channels airflows through linear parks. Both public and private spaces are designed to maximize fresh air and cooling, including water features that provide evaporative cooling. The vegetation consists mostly of drought-resistant local plants that require minimal irrigation, enhancing the city's green feel.

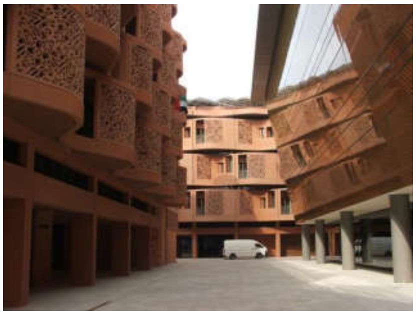

Figure 2. Streets of Masdar city, source: www.archdaily.com

Figure 3. Streets of Masdar city, source: www.rethinkingthefuture.com

Masdar has succeeded in reducing water use by 54% compared to other UAE cities. About 75% of its hot water is produced by solar collectors installed on rooftops, which also provide additional shading. The city is exploring geothermal potentials with deep wells (2,500 m) providing water for cooling and sanitation — crucial for desert living. Irrigation efficiency is increased by 60% using special nozzles and by using 100% recycled wastewater, preserving potable water supplies.

Sustainability is also reflected in material choices, with extensive recycling of steel, wood, and concrete waste. Materials are sourced locally to reduce costs and environmental impact from production and transportation. Masdar has a dedicated recycling center divided into sectors for wood, metal, concrete, and other materials. Non-recyclable waste is incinerated to generate additional energy [14].

Figure 4. Masdar city landscape, source: www.rethinkingthefuture.com

The city's power supply comes primarily from a solar farm covering 22 hectares with 87,777 photovoltaic panels, the largest in the Middle East. The farm is expected to generate 17,500 megawatts and reduce CO2 emissions by 15,000 tons annually, equivalent to removing 33,000 cars from the road. A major challenge is dust and sand accumulation on the panels, requiring frequent cleaning that increases maintenance costs. Photovoltaic panels are also installed on building rooftops, supplying 30% of the campus's energy needs [14].

4. DISCUSSION

Although contemporary architecture offers innovative solutions that address many of today's problems, their application in our practice is often not rational. First and foremost, there is a lack of understanding and interest in society to introduce changes that would enhance the environment. If we return to the example of Masdar, we can conclude that it is easier to implement sustainable development strategies when an entire city is rebuilt from scratch, with the investor's goal being sustainability and a green future. Cities that already have an established urban fabric respond differently to implementation, both from the perspective of the physical and built environment, and from the psychological perspective of users. A problem also arises with project investors; private individuals are generally not interested in investing in innovative systems that are often not affordable. In this case, government projects offer greater possibilities, so some projects have been developed using some of the mentioned systems. Viewed this way, projects developed in the Middle East become exemplary models of good practice for solutions we try to apply in our environment. Their innovation often sets precedents even for the European community, which leads the way toward a green future.

Specifically in Serbia, problems also include the lack of infrastructure for recycling construction waste, which is often dumped in unsanitary landfills, high initial costs, and a lack of incentives such as government subsidies, tax relief, and favorable loans. Legal and regulatory frameworks represent another barrier discouraging the implementation of energy-sustainable solutions (the lack of clear and binding regulations complicates the adoption of sustainable standards). Furthermore, the centralization of capital affects the localization of positive examples mainly to Belgrade. Finally, technical challenges in the use of recycled materials require testing and adaptations to ensure the materials are used adequately. This refers to the fact that recycled materials do not possess the properties of the originals, so their rational reuse is necessary.

5. CONCLUSION

As mentioned in the introduction, this paper calls for further research into the needs, development, and function of contemporary cities. In the context of sustainability, awareness of its necessity is essential to understand the solutions that lead to it. Without this, projects aimed at a green future will lack understanding and acceptance from the community. In such cases, everything boils down to a small number of projects whose effectiveness is not at a satisfactory level unless the entire system functions cohesively. The problems mentioned in the previous section can be overcome if the government initiates a few measures to improve legislation through clear and binding regulations, launches subsidies for the application of energy-efficient materials, systems, and other solutions, and decentralizes financial distribution across various regions to expand the network of positive project examples. Along with these proposals, education is an indispensable factor—both in educating space users and training professionals who will participate in related projects in the future.

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