Sustainable Design and Maintenance of Buildings

Pleša, Valentina; Obradović, Dino

EJSDR
European Journal of Sustainable Development Research
e-ISSN : 2458-8091

Sustainable Design and Maintenance of Buildings

Valentina Pleša[1], Dino Obradović[2] *

[1]*The Licensed Architect Office Mario Kvež, Brestovec Orehovički, Croatia, ,(junior architect).*

[2] *Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering and Architecture Osijek, 31000 Osijek, Croatia.*

**Corresponding Author email: dobradovic@gfos.hr*

Abstract

The world's population is increasing, hence the growing demand for accommodation and the construction of buildings. Therefore, the amount of wastewater is increasing. Natural areas (lawns, arable land, forests, etc.) are being used for building buildings. In this manner, natural surfaces become impermeable, which leads to natural unbalance. As a result, we are witnessing formation of heat islands, an increase in temperature and rainfall runoff into the sewerage system as well as uprising consequences of climate change generally. The construction industry is one of the biggest polluters in the world, but by using sustainable construction it is possible to reduce its negative impact on the environment. The principles of sustainable construction should be applied to all phases of the life cycle of a building: design, construction, maintenance, and removal of the building. In the construction design phase, it is possible to modify the building with a slight increase in cost, which will lower future maintenance costs. It is essential to use materials thoughtfully through construction since people spend a large part of their time indoors. Environmental impact assessment is the basis of sustainable design, construction, use, and disposal of the building. Of course, various social issues involve the health and well-being of building users. We must not forget the economic aspects and total costs of the building. This is where the concept of green construction comes into play. Green building refers to both the structure and the application of environmentally responsible and resource-efficient processes throughout the building's life cycle. Green building also refers to saving resources to the maximum extent, including energy, land, water and material saving, etc., during the whole life cycle of the building, protecting the environment and reducing pollution, providing people with healthy, comfortable and efficient use of space, and being in harmony with nature.

Key words

Design, Green building certifications, Maintenance, Management, Sustainability

1. INTRODUCTION

Today, the world has reached an enviable degree of urbanization (on average, about 50% of the population live in cities), but developed regions are far more urbanized than undeveloped areas of the Earth (the proportion of the urban population is twice as high in developed than in underdeveloped countries). Such trends will continue, so the projection of the further development of urbanization indicates that in 2030, 61% of the world's population will be urban, but that the disparity between the developed and the underdeveloped will continue to be maintained, although it can be predicted that it will decrease (by that time, developed regions will have an

average of about 82%, and undeveloped only 55% of the urban population, so the ratio from 2000, which was 2:1 in favour of developed regions, will decrease to 1.5:1 by 2030) [1]. When talking about energy consumption, it is observed that the share of urban population is directly proportional to energy consumption (more urban population - higher energy consumption, less urban population - lower energy consumption) [1].

The process of urbanization entails much more changes than just the increase of population in cities. Urbanization of a certain region leads to changes in economic, social, and political structures. The accelerated development of cities leads to a decrease of the ability to provide various services such as energy, education, health care, transportation, and physical security. Further problems caused by urbanization are increased traffic, air and water pollution, destruction of agricultural lands, parks, open spaces, etc. [2]. Given that, present urban spaces hold less and less capacity as the time goes by as due to its population growth rate more and more buildings are being built, faster than ever, thus creating skyscrapers of a new generation [3].

Urbanization is also reflected in the construction of buildings. The number of building permits issued can be seen as a good indicator of building constructions. Figure 1 shows the number of issued building permits. In 2021, building permits (in terms of useful floor area, measured in millions of square meters; m²) went up by 15% in the EU (in absolute terms, +52 m²). This growth followed a decline of 8% in 2020, the peak year of the COVID-19 crisis [4].

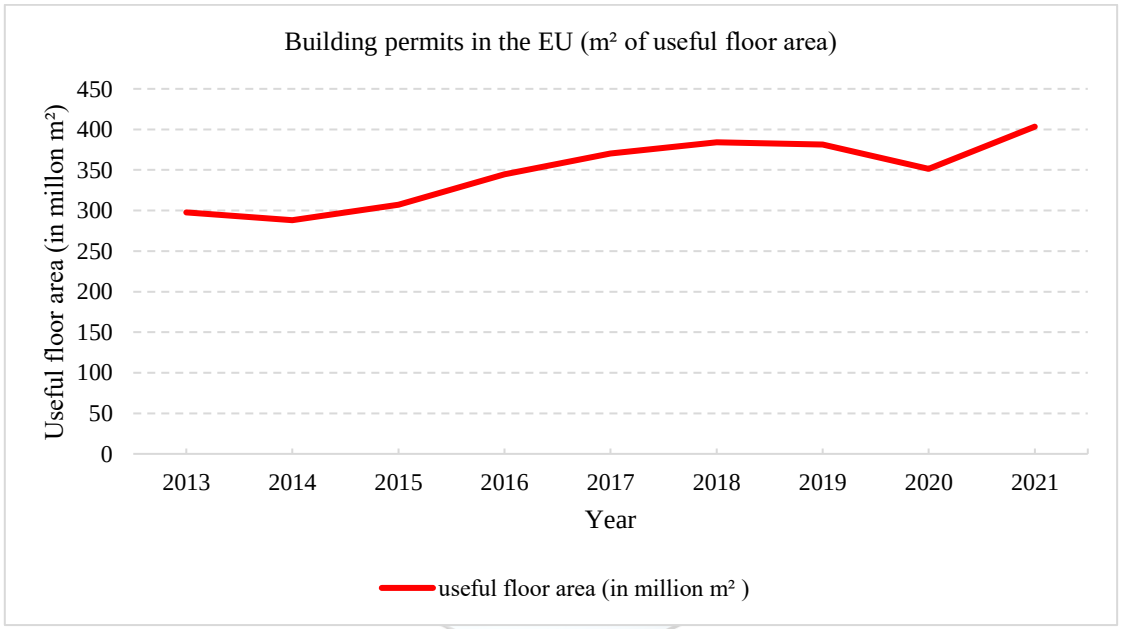

Figure 1. Building permits in the EU, 2015 – 2021 (according to [4])

Today, more than ever, the shortage of resources used in the construction of buildings is emphasized, the number of inhabitants is growing very quickly, and increased urbanization and the construction of new buildings is emphasized. New buildings occupy arable areas or areas that were under greenery, so it is important to think about the maintenance activities of existing buildings, and strive to reduce the construction of new buildings, of course, to the possible extent. It is necessary to use all the resources available to men sparingly and wisely, to build buildings carefully in the sense of paying attention to the types of materials used, the proper execution of the envisioned or designed building, the proper use of the building - use the building for the purpose for which it was designed and built, and finally, when the useful life of the building comes to an end, about the proper disposal of waste from a demolished building [5]. Certain challenges in building management, i.e. building maintenance, are shown in Figure 2.

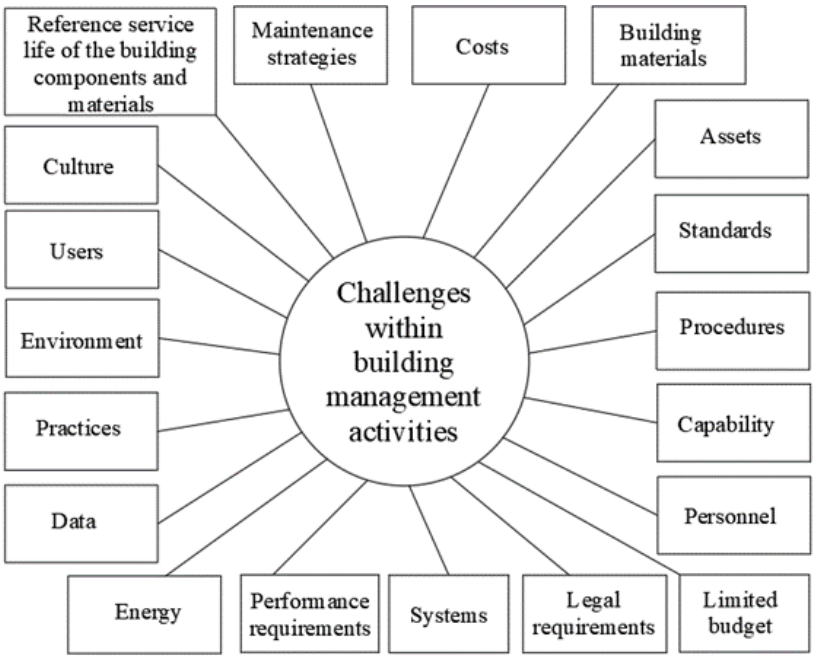

Figure 2. Challenges within building management activities (according to [6])

When it comes to building management, one can see more requirements that need to be met. There are requirements of a limited budget, it is necessary to meet certain standards and there is an increasing number of legal regulations as well as the degree of public acceptance [7]. The impact of construction on the environment takes place throughout the entire life cycle of the building, which includes execution (production of building materials and their installation), use of the building (use and maintenance), and the end of the life cycle (removal of the building) [8]. Buildings play an important role in the energy consumption all over the world. The building sector has a significant influence on the total natural resource consumption and the emissions released [9].

Effective use of natural surfaces, water, energy and materials should be considered in the design process in accordance with the principles of ecologically sustainable design. Economic difficulties should be considered through the effective use of resources and cost analysis in the context of economically viable design. On the other hand, the quality of life in interior spaces should be increased, and innovative ideas and applications should be applied to a greater extent within the framework of socio-culturally sustainable design [10]. All this leads to the need for sustainable design of buildings and their sustainable maintenance. This issue will be presented in greater detail as we move further along.

2. SUSTAINABLE DESIGN OF BUILDINGS

A sustainable building is a building that incorporates environmentally responsible and resource-efficient practices from planning to design and construction, operation, and demolition to provide a long-term comfortable, healthy, and productive environment for its occupants bringing the negative impact on the surrounding environment to the minimum [11].

By looking at a full life-cycle of a building we can characterize it more specifically. For example, during planning, every impact on the environment should be considered in order to minimize the eventual harmful impact. During the design process architects should make an effort and consider using natural lighting, ventilation, window placement, and all other factors that could save up energy. The construction phase is another good example where we can use natural resources as well as limit energy consumption and proper waste disposal that includes recycling everything that can be recycled. Maintenance is also very important. If the planning is done right, cost of maintenance, energy, and water cost should be very low and used efficiently. Especially by using renewable energy and other resources to operate as a net producer, not just as a net consumer. Demolition is the final stage of the building life cycle. But it's not the least important. After demolition, it is important to dispose, recycle and handle all materials so they don't make a negative impact on the environment [11]. The building life cycle is shown in figure 3.

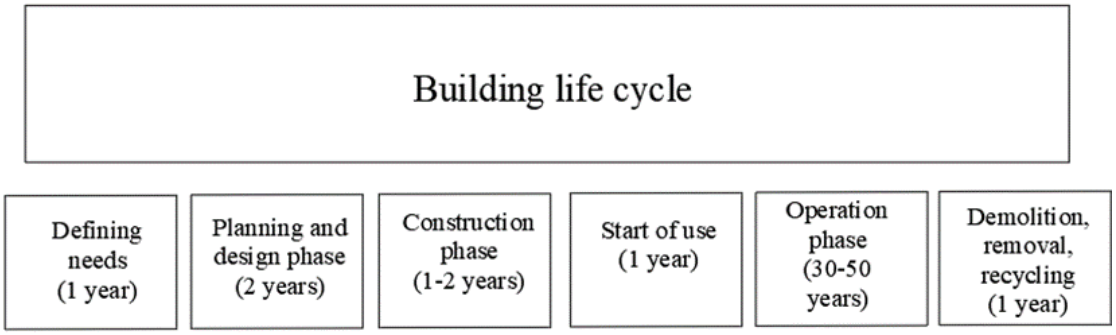

Figure 3. Building life cycle [12]

Sustainable design principles include the ability to:

- Optimize site potential;
- Minimize non-renewable energy consumption;
- Use environmentally preferable products;
- Protect and conserve water;
- Enhance indoor environmental quality;
- Optimize operational and maintenance practices [13].

By knowing all of the above, we can reduce a sustainable design definition by saying that sustainable design not only seeks to reduce a negative impact on the environment, but also to assure the health and comfort of building occupants.

We cannot stress enough how important is good early planning and good building design because it has a major impact on reducing all sorts of costs, pollution and energy used. The sooner sustainable construction is inplemented into the planning, the better. Building Research Establishment Environmental Assessment Method - BREEAM is the world's longest-running method of assessing, rating, and certifying the sustainability of a building. The BREEAM Assessment investigates different categories such as materials, transport, water, energy, and waste [14].

Five of the green systems that are being utilized in building engineering are radiant floors, gray water recycling, solar power, geothermal systems, and energy-efficient window systems. These systems working together can achieve an owner's energy and water conservation goals while also reducing utility bills. Sustainable buildings create a win for the environment, the building owner, and its occupants. Radiant floors are an excellent way to efficiently heat a space with less energy. They can contain water tubing that is heated by solar panels that collect solar energy and deliver it to the tubing in the form of heat. Gray water is the water that runs off from condensation from air conditioning units and other equipment that uses water. Unlike wastewater, however, gray water can be reused to fuel boilers, hydronic cooling equipment, and even irrigate plants. With the price of solar panels dropping, solar energy is becoming one of the most cost-effective, as well as practical ways to install a renewable energy source on a commercial building. Geothermal systems are one of the best ways to efficiently heat or cool a building with a renewable source. It uses the naturally cool temperatures below ground to cool water in pipes and then runs it through chilled water coils, just like a chilled water system. It can also be used for heating by a similar process. Windows are responsible for 25% of the heat gain and loss in a building, typically from heat flow through window panels and around poorly sealed frames. Energy-efficient windows provide glazing in the form of double panes and triple panes that are designed to inhibit the heat flow. The right window placement is also important for letting in enough light throughout the day to reduce electricity use [15].

And finally, sustainable materials can be explained as materials that have no direct impact on the environment and do not use non-renewable resources [14]. So, by using these materials you can also save money while not having a bad impact on the environment.

Examples of sustainable buildings materials:

- Timber instead of steel;
- Concrete reinforced with natural fibers;

- Geo-textiles made from crops;
- Straws bales;
- Materials that are accredited as being responsibility sourced such as the FSC timber [14].

After all, it can be categorized into six basic elements (Figure 4) that need to be investigated when planning and building a sustainable building.

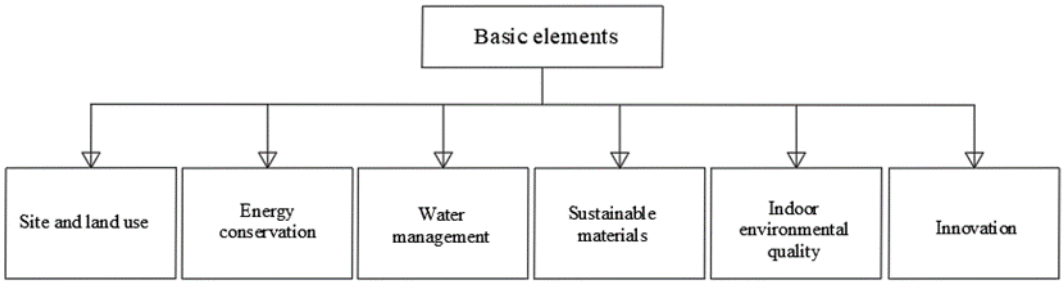

Figure 4. Six basic elements for sustainable building design [16]

Before we start explaining green buildings there is a key difference between sustainable buildings and green buildings. Sustainable buildings operate with all three sustainability pillars in mind (people, planet, and profit), whereas green buildings focus solely on the environment [11].

In green buildings there are four main elements on which it is designed: materials, energy, water, and health to make green building more sustainable [17]. So, materials used for green buildings are always recycled or obtained from natural renewable sources. When talking about energy systems in green building we have to say that the less energy is used the better. The natural daylight is carefully planned so that electricity is reduced to a minimum. Also, carefully planned and placed windows improve people's health and productivity. Speaking of electricity, it is carefully planned to use energy-efficient lighting, low-energy appliances, and renewable energy technologies which can be incorporated by installing wind turbines and solar panels. Even though there are two main differences: passive solar design and passive solar heating. Passive solar design is transforming the sunlight into heat, also the cooling, as well as providing light to a home. Passive solar heating is based on materials in a building that are absorbing heat for later use or keeping the space inside at a comfortable temperature. We cannot forget about water management in green buildings since it is an important part of the building itself. The main thing is installing greywater and rainwater catchment systems that can recycle water that can later be used to flush toilets, for water-efficient appliances, showers, etc. Health components are also very important. It can be accomplished by using non-toxic materials and products that will improve the life of occupants. These materials are emission-free, have low or no volatile organic compounds (VOC) content, and are moisture-resistant to deter molds, spores, and other microbes. Indoor air quality also cannot be forgotten and it is best accomplished by ventilation systems and materials that control humidity [17].

Even though green buildings seem much more appealing than sustainable design, we must mention that green building can be a part of a sustainable building.

By this we mean a green building cannot be built sustainably, and sustainable buildings can operate without green initiatives. Green buildings can be part of sustainable building design but not the other way around since sustainable design has many more things on its to-do list [11]. So, when thinking about how you can take advantage of the opportunities that sustainability and green initiatives bring, here are a few suggestions:

1) Reduce your energy waste: Small steps such as smart meters, switching to LED lighting, and monitoring water usage and CO_2 levels can make a big difference.
2) Improve your buildings', and occupants' health: You can do this with air quality monitoring, to make sure the building and your occupants are operating at their healthiest.
3) Reduce your environmental impact: Solar and other forms of renewable energy can go a long way in lessening your reliance on fossil fuels.
4) Get certified [11].

Operating as a green and sustainable building benefits all parties involved. Not only are you doing your bit for the planet, but you'll be creating an attractive space for occupants to reside, prolonging the life and health of all

those involved [11]. So to sum it all up it can be said that there are "The 7 principles of sustainable construction" (Figure 5).

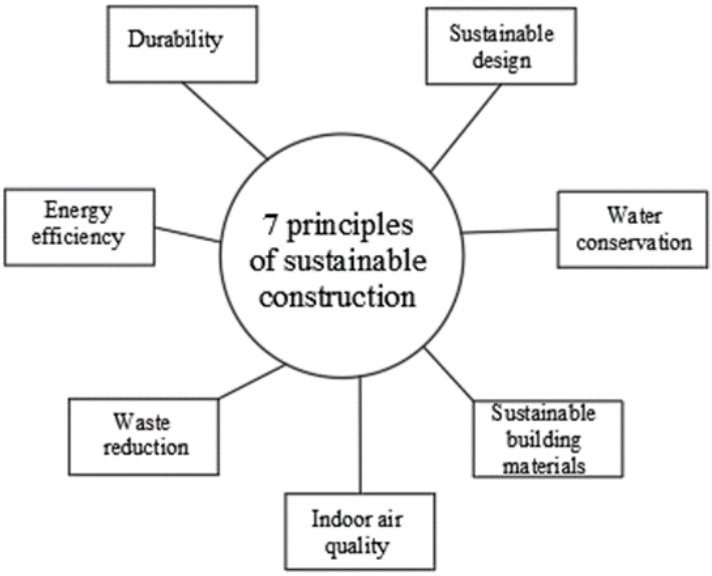

Figure 5. The 7 principles of sustainable construction (according to [14])

For sustainable design, durability, and energy efficiency materials play a big part, prefabricating materials. That is made possible by precutting all materials to the exact length and width in a factory or someplace else. So, when materials are delivered to the construction site there is no additional waste made. Especially because some materials are recyclable on-site. For example, concrete can be crushed and reused for foundations or as aggregate beneath parking lots. The waste made by workers needs can also be reduced efficiently. More and more countries are enforcing the no smoking rule on the site, "walk-off mats" are used to remove dirt, lead, and other potentially dangerous chemicals from their shoes and lunches that are brought in recycling containers for food to decrease organic waste [18].

So not only building is sustainable, but also more and more construction sites are also becoming greener and more nature friendly. The off-site fabrication, improved on-site maintenance, lean practices, landfill avoidance, and green materials acquisition have begun to fundamentally, albeit slowly, transform the way buildings are constructed today as more owners feel a responsibility to build sustainability [18].

3. SUSTAINABLE MAINTENANCE OF BUILDINGS

Building maintenance is an integral part of comprehensive building management. It is defined as undertaking all necessary activities to maintain or improve every part of the building and for the purpose of preserving the value and purpose for which the building or property was built. In order to be able to perform maintenance, it is necessary to analyze the causes of failures, and based on the analysis decide on the measures to be taken to prevent the cause [19].

Although there are many different definitions of building maintenance, the simplest (and probably the shortest) says that building maintenance is ensuring the condition of the building is suitable for use [20]. Of course, it would be very desirable to have a building that does not need to be maintained, but this is difficult to do. To ensure that a building is fit for use, it must be maintained to certain standards. Thus, maintenance costs include all the costs of repairs that occur every day, as well as preventive works and work on improving building elements. These are direct maintenance costs. However, apart from these direct maintenance costs, there are also indirect costs such as fines because the building is not available for use, or it can be a loss of value of the building [20].

The goals of building maintenance are as follows:

- Ensuring the security requirements of the building and associated services;
- Ensuring the suitability of the building for use;

- Ensuring that building requirements are met regarding legal regulations;
- Performance of necessary maintenance work to preserve the value of the property;
- Performing the necessary maintenance work to preserve the quality of the building [21].

It can also be said that building maintenance includes tasks such as cleaning, landscaping, and electrical system maintenance. It is needed to preserve a safe, functional, and comfortable environment for tenants at all times. However, most individuals give little thought to the behind-the-scenes work required to meet these expectations. Maintenance is "out of sight, out of mind" until something goes wrong. Maintenance can be categorized as routine maintenance, preventive and corrective maintenance. Running an effective program can streamline maintenance activities and save costs (using CMMS software for example). Property owners and managers rely on building maintenance to ensure functionality, comfort, and safety for occupants.

4. SUSTAINABLE BUILDING CERTIFICATION SYSTEMS

Assessment and certification systems have been developed to quantify the level of sustainability of buildings. During such evaluation, parameters such as space design, construction, and use are observed, and the certificate itself ultimately provides building owners and users with information about the energy and other ecological properties of the building, depending on the type of certificate. Namely, some certification systems cover only certain criteria of building sustainability, such as energy efficiency, and some cover the entire approach to green building, looking at criteria such as location sustainability, human and environmental health, material selection, ecological quality of the interior, social impact and building economy. For each criterion, there is one or more quality criteria that must be proven in order to receive a certain number of points, i.e. meet the requirements [22].

Rating systems have been developed to measure the sustainability level of Green Buildings and provide best-practice experience at their highest certification level [13]. Federal government agencies in the United States, among other things, requires:

1) Reduce portfolio-wide Scope 1 and 2 greenhouse gas (GHG) emissions (onsite combustion and purchased energy) by 65% by 2030, compared to a 2008 baseline.
2) Use 100% carbon pollution-free electricity on a net annual basis by 2030.
3) Pursue building electrification strategies in conjunction with carbon pollution-free energy, efficiency, and space reduction/consolidation.
4) Design new construction and modernization projects greater to be net zero ready (able to achieve net-zero operational emissions) by 2030.
5) Move toward net-zero emissions from Federal procurement, including through a Buy Clean policy promoting the use of construction materials with lower embodied GHG emissions [13].

The Sustainable Facilities Tool is an online resource to support decision-making regarding sustainable building principles, materials, and systems. The Sustainable Facilities Tool helps users understand and select environmentally preferable solutions for renovations, alterations, and leases [13].

The code for sustainable homes is the national standard for the sustainable design and construction of new homes. It aims to reduce carbon emissions and promote higher standards of sustainable design above the current minimum standards set out by the building regulations. The code provides nine measures of sustainable design: energy/CO_2, water, materials, surface water runoff (flooding and flood prevention), waste, pollution, health and well-being, management and ecology. It uses a 1 to 6-star system to rate the overall sustainability performance of a new home against these nine categories [23].

Table 1. Comparison of different Rating Systems for Sustainable Buildings [24]

Certification systems (Country of origin)	Initiation	Key aspects of assesment	Versions	Level of certification
DGNB (Germany)	2007	- Ecological Quality - Economical Quality - Social Quality - Technical Quality - Process Quality - Site Quality	Offices Existing Buildings Retail Industrial Portfolios Schools	Bronze Silver Gold
LEED (USA)	1998	- Sustainable Sites - Water Efficiency - Energy & Atmosphere - Material & Resources - Indoor Air Quality - Innovation & Design - Management - Health & Well-being	New Construction, Existing Buildings, Commercial Interiors, Core and Shell, Homes, Neighborhood Development, School, Retail	LEED Certified LEED Silver LEED Gold LEED Platinum
BREEAM (Great Britain)	1990	- Energy - Water - Material - Site Ecology - Pollution - Transport - Land consumption	Courts, EcoHomes, Education, Industrial, Healthcare, MultiResidential, Offices, Prisons, Retail	Pass Good Very good Excellent Outstanding
CASBEE (Japan)	2001	Certification on the basis of building environment efficiency factor, BEE=Q/L Q … Quality (Ecological Quality of buildings); L … Loadings (Ecological effects on buildings)	-	C (poor) B B+ A S (excellent)
Mingerie (Switzerland)	1998	4 Building standards are available: (1) Minergie (2) Minergie-P (3) Minergie-Eco (4) Minergie-P-Eco	-	Minergie Minergie-P Minergie-Eco Minergie-P-Eco
Green Star (Australia)	2003	- Management - Indoor Comfort - Energy - Transport - Water - Material - Land Consumption & Ecology - Emissions - Innovations	- Office – Existing Buildings - Office – Interior Design - Office – Design	4 Stars: ‚Best Practice‘ 5 Stars: ‚Australien Excellence‘ 6 Stars: ‚World Leadership‘

5. CONCLUSIONS

Climate change and increasingly rapid urbanization are causing a growing problem, which should be the trigger for a new way of thinking. Integral (sustainable) management is being mentioned more and more in all areas of work and life. Urbanization has reached large proportions. Large-scale urbanization entails various consequences such as increased traffic, air and water pollution, destruction of agricultural land, parks, and open spaces, and increased building construction. An indicator of building construction can be the number of issued building permits (in terms of useful floor area). In the European Union, there is an increase concerning this indicator. The increased construction of buildings also increases the impact of climate change. Buildings play a major role in the total energy consumption, so attention should be paid to choosing a suitable (sustainable) way of supplying energy and water. An example of efficient use of water is net zero water buildings, where such a building collects rainwater and recycles its wastewater for reuse, eliminating the need for water supply from the public water supply and connection to the sewage network.

All available resources must be carefully used when building new buildings, as well as when maintaining the existing ones. Effective use of natural surfaces, water, energy, and materials should be considered in the design process in accordance with the principles of ecologically sustainable design. The same applies to the maintenance of the buildings. Materials used for the maintenance should be environmentally acceptable, and their reuse should be possible. It is important to develop a circular economy model in which the flow of resources and energy is maintained in a closed loop model, aiming the circulation of products in the circular cycle as long as possible. In the circular economy model, among other things, eco-design, advanced technologies, energy efficiency and the use of renewable energy sources stand out. Innovative ideas and applications need to be applied to a greater extent in the case of continuous design and maintenance.

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest.

REFERENCES

[1]. S. Bjelajac and D. Vrdoljak, "Urbanizacija kao svjetski proces i njezine posljedice", *Zbornik radova filozofskog fakulteta u Splitu*, Split, (2009/2010), no. 2/3; pp. 3-19., 2009.
[2]. Funkymem. Globalna urbanizacija i njezine posljedice. (2023). [Online]. Available: https://funkymem.com/zones/globalna-urbanizacija-i-njezine-posljedice (Accessed: 04.04.2023.)
[3]. A. Bogdan, "Nova tehnologija pošumljavanja metropola", *Građevinar*, vol. 68, no. 6, pp. 513-519, 2016.
[4]. Eurostat, Building permits up by 15% in 2021. [Online]. Available: https://ec.europa.eu/eurostat/en/web/products-eurostat-news/-/ddn-20221019-1 (Accessed : 28.04.2023.)
[5]. D. Obradović, "Doprinos povećanju učinkovitosti održavanja kanalizacijskih sustava primjenom modela procjene troškova održavanja". Doctoral dissertation, Josip Juraj Strossmayer University of Osijek, Faculty of Civil Engineering and Architecture Osijek, Croatia, March 2023.
[6]. D. Obradović, M. Šperac and S. Marenjak, "Challenges in Sewer System Maintenance". *Encyclopedia*, vol. 3, no. 1, pp. 122-142, January 2023.
[7]. Y. C. Wijnia and P. M. Herder, *The state of Asset Management in the Netherlands*, in Engineering Asset Lifecycle Management, D. Kiritsis, C. Emmanouilidis, A. Koronios, J. Mathew, (Eds). Springer, London, pp. 164–172., 2010.
[8]. M. Dubraja and N. Mikulić, "Pregled sustava održive gradnje: LEED, BREEAM, DGNB", *POLYTECHNIC & DESIGN*, vol. 6, no. 1, 2018.
[9]. A. Sharma, A. Saxena, M. Sethi, V. Shree and Varun, "Life cycle assessment of buildings: A review", *Renewable and Sustainable Energy Reviews*, vol. 15, no. 1, pp. 871-875, 2011.
[10]. S. Yavaşbatmaz and A. Burcu Gültekin, "Sustainable design of tall buildings", *Građevinar*, vol. 65, no. 5, pp. 449-461, 2013.
[11]. Amtivo Group Limited T/A British Assessment Bureau, What's the difference between green and sustainable buildings? [Online]. Available: https://www.british-assessment.co.uk/insights/whats-the-difference-between-green-and-sustainable-buildings/ (Accessed: 03.03.2023.)
[12]. A. Čaušević and N. Rustempašić, *Rekonstrukcije zidanih objekata visokogradnje*. Sarajevo, Bosna i Hercegovina: Univerzitet u Sarajevu, Arhitektonski fakultet, 2014.
[13]. [Online]. Available : https://www.gsa.gov/real-estate/design-and-construction/design-excellence-program-overview/sustainability/sustainable-design (Accessed: 23.03.2023.)
[14]. BuildPass, The 7 Principles of Sustainable Construction (2021) [Online]. Available: https://buildpass.co.uk/blog/the-7-principles-of-sustainable-construction/ (Accessed: 02.04.2023.)
[15]. VIP Structures, 5 Examples of Green Building in Engineering, [Online]., Available: https://www.vipstructures.com/5-examples-green-building-engineering/ (Accessed: 03.04.2023.)

[16]. M. H. M. Zin, and N. L. N. Ibrahim, "Six Basic Elements For Sustainable Building Design", *Australian Journal of Basic and Applied Sciences*, vol. 6, no. 13, pp. 5-10, 2012.
[17]. Elements or Components of Green Building-Material, Water… [Online]. Available: https://theconstructor.org/building/elements-of-green-building/5375/ (Accessed: 16.03.2023.)
[18]. J. Lombardo, For Construction Pros.com, 5 Techniques for Sustainable Building Construction, https://www.forconstructionpros.com/business/article/12068798/five-techniques-for-sustainable-building-construction (Accessed: 02.04.2023.)
[19]. D. Vugrinec, *Facility Management Handbook* - Priručnik za upravljanje poslovnim zgradama. Zagreb: 2G2E - Udruga za gospodarenje građevinama, energijsku efikasnost, promicanje znanja i vještina, 2012.
[20]. M. A. El-Haram and M. W. Horner, "Factors affecting housing maintenance cost", *Journal of Quality in Maintenance Engineering*, vol. 8, no. 2, pp. 115–123, 2002.
[21]. S. Marenjak and H. Krstić, "Analysis of buildings operation and maintenance costs", *Građevinar*, vol. 64, no. 4, pp. 293–303, 2012.
[22]. T. Dokšanović, M. Farkaš and N. Njegovanović, "Tržišna prihvatljivost građevinskog materijala s malim udjelom ugljika - Dio II: Zakonodavni okvir", *Electronic Journal of the Faculty of Civil Engineering Osijek-e-GFOS*, no. 6, pp. 1-12, 2013.
[23]. IEA, Code for Sustainable Homes, (2019), [Online]. Available: https://www.iea.org/policies/397-code-for-sustainable-homes (Accessed: 03.04.2023.)
[24]. M. Bauer, P. Mosle and M. Schwarz, *Green Building - Guidebook for Sustainable Architecture*, Stuttgart, Germany: Springer, 2007.