BUILDINGS AND THEIR IMPACT ON THE ENVIRONMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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Abstract

The manufacture of construction products is responsible for several types of impact that are also the most important on the environment. They shall take into account both the resources used and a possible impact on the ecosystem and the emissions resulting from the extraction, processing and transport of raw materials. The use of resources depends on the amount of waste generated during the manufacturing, construction and demolition process on the site, which can be significant, as a proportion, in the total material flows from the construction site. This emphasizes how important it is to design and establish specifications for a more efficient use of resources, thus, the most important elements of a building, which should be followed, are the floor, roof, structure and exterior walls, respectively. As a result, the recycling and reuse/reintegration of building materials and products, as well as of the construction elements as a whole, can contribute to the reduction of the environmental impact as well as to the development of the circular economy. In the built environment, the sustainability assessment covers the stages of the life cycle of a building, namely: material production, construction, operation, maintenance, demolition and disposal.

Taking into account the fact that in the current conditions, in a modern society, without no doubt, a life perspective is needed, in these conditions the life cycle assessment takes into account all the stages that lead from raw materials, through production, distribution and use to the final elimination.

In this article we will address aspects related to buildings and their impact on the environment in the context of the circular economy and sustainable development.

Keywords: *sustainable development, life cycle cost, sustainable buildings, circular economy, energy efficiency, low energy, low cost building.*

JEL Classification : *A10, A12, D24, L70, L74*

1.Introduction

Sustainable development in general refers to a dynamic process from one state to another, which means that there is no exact definition of it, but in fact, every society, country and city, evolves with time passing to become more superior or inferior (United Nations, 2013)[13]. Therefore, in the opinion of the authors Kamari et al., (2017)[8], quoting Brophy, (2014), our goals, including visions, ambitions and technical possibilities, are all topics that can change over time. The authors, quoting Williamson et al., (2003) note that sustainability can be described as an undeniable development of society and the long-term economy based on the continued inclusion of earth's ecosystems. Similarly, the development of major upgrading alternatives for existing buildings, for example, including sustainability initiatives, can reduce operational costs and environmental impact and increase the adaptability, durability and resilience of those buildings. For this reason, buildings can be less expensive in terms of operation, increase in value, last longer and contribute to a preferable, healthier and more convenient environment for the occupants who live and work there. Therefore, improving interior comfort, quality in general, reducing humidity and improving efficiency, all this can lead to improved health and productivity of users of the respective buildings. (Bluyssen & Cox, 2002)[3].

From a sustainability perspective, there are factors that need to be taken into account together in order to achieve the ultimate goal, known as 'sustained prosperity', which is relevant for the different stakeholders as well as their different priorities. Therefore, in the opinion of the authors Kamari et al., (2017)[8], quoting Boeri et al., (2014), optimal renovation solutions represent a compromise between a number of factors related to energy and other factors that are not related to energy, which, in fact, must be taken into account.

2.Buildings in the context of sustainable development

Once with the development of sustainability, the development of communication between industry and authorities, as well as increased awareness of sustainability in public, the ability to assess the impact on sustainability and opportunities of construction projects become essential. As a result, given where/when the building design industry meets sustainability solutions, building designers can anticipate a greater demand for systematic strategies to modernize the existing or new buildings, as noted by the authors Kamari et al., (2017)[8]; especially when the sustainability paradigm is based on modern information and communication systems. (Afghan & Carvalho, 2002)[1]

However, if for human settlements sustainability is established or is to be established as an objective, in these conditions we are also of the opinion that it is necessary to issue and develop different methods of establishing the criteria, plans, design and evaluation thereof. It is also necessary to have different methods as a scientific basis in terms of comparison between different projects, as well as to look at how they should be developed over time. (Nguyen and Altan, 2011)

Currently, sustainability in architecture is considered to be the most important factor in design (AlQahtany et al., 2013)[2], on which most architects try to base their project (Majedi & Siadati, 2015)[10]. In these circumstances, as the authors of Fatourehchi & Zarghami (2020)[5] also mention, one of the most important measures needed to be taken in this regard is to introduce aspects of sustainable development and place this category in the overall long-term planning.

According to some authors, the construction industry is responsible for the largest amount of resources used, waste and emissions of all industries (Ness & Xing, 2017)[11]. A more sustainable construction industry is therefore needed to ensure the stability of the global economy and natural ecosystems. As far as sustainability is concerned, there are many definitions of it in the literature, but in the study carried out, the authors Jansen et al., (2020)[7] propose the use of a much more comprehensive definition of sustainability, namely: "balanced and systemic integration of intergeneration and intergeneration economic, social and environmental performance".

In the opinion of the authors Jansen et al., (2020)[7], quoting the authors of Ness & Xing, (2017)[11], over time, sustainability research in the construction industry has focused mainly on reducing the operational energy consumption of buildings and their related emissions. As a result, as the authors argue, reducing the consumption of material resources also reduces CO_2 emissions.

In another approach, lately, at a global level, in the field of constructions, the emphasis has been shifted to the integration of the 4 pillars of sustainable development, thus, on the ecological, economic, social and cultural component; which in the construction industry led to the appearance of "green building" and "sustainable building" models respectively. In the opinion of the authors Grecea et al., (2011)[6] the line that the buildings have taken, through the prism of sustainable development, represents an interesting development, as the authors call it, extremely fast (about 20 years), from a "market niche" to a global current.

Thus, regarding the evolution of the typology of buildings through the energy component, we can distinguish:

1) The building with low energy consumption – the building with much better energy performance than the usual ones (with an energy requirement lower by 50% compared to the usual consumption);

2) Passive building - the building with energy needs for heating and cooling <15 kWh/m^2 usable per year, which corresponds to an optimal of the needs of a "standard" building. In addition, there are other criteria that must be met, such as air exchange volume max. 0.6 vol./hour – clear criteria, precise methodology for achievement, orientation towards cardinal points, insulation.

3) “Zero energy” building – the building where the total primary energy consumption is equal to or below the amount of energy produced on site (through active systems using renewable energies);

4) The building that produces more energy than it consumes – the first edifice of its kind was created in 1994 at Heliotrope – Freiburg under the guidance of the arch. Rolf Disch;

5) Fully autonomous building – utopian model.

The evolution of the "energy buildings" models through the integration of the four pillars of sustainable development was made through two generations with distinct definitions:

1) The green building – the first generation (green building) represents the building where the concept is enlarged and includes besides the energetic and ecological aspects, with emphasis on the use of local materials, of natural, reusable materials; the focus is also on integration and minimal impact on the environment; the relation with vegetation in all its forms; the connection between the inner and outer environment; water and waste management; LCA (life cycle assessment) and LCC (Life cycle cost).

2) The sustainable building – the second generation (sustainable building) represents the building in which the concept of sustainable development is present in all its aspects – ecological, economic, social and cultural; the buildings are classified according to ambient certification systems. (Grecea, 2011)[6]

Regarding the environmental certification diagrams, we mention that although the main systems take into account the 4 pillars of sustainable development, as mentioned above, they take into account the different weights of the 4 pillars in the final score.

Therefore, the main environmental certification systems are the following:

-the Anglo-Saxon system, being the oldest has an asset (BREEAM);

-the US certification system (LEED), with a high penetrating power due to the ease with which it can be used and the fact that it is subject to permanent updating in relation to the reactions in the political, legislative and construction market areas;

-the systems developed in the north are countries (where both the technical databases and the legislative framework are extremely well developed, which makes them very efficient at the local level, but more difficult to implement in less advanced countries);

-systems coming from the adaptation of the SB Tool (with Canadian origin), this being an instrument with great flexibility and versatility, which leaves the possibility of adapting to local conditions (imported in mediterranean countries: Portugal, Italy – "Protocolo Itaca");

-HQE – french system;

-DGNB – the German system, the newest, but the most complete, with great ability to adapt, starting from clearly defined and well-grouped parameters. (Grecea, 2011)[6]

2.1.Impact of buildings on the environment in the context of sustainable development

The evidence regarding the buildings shows that the most significant impact of a building on the environment relates to energy consumption during residence. Thus, in the material published by the European Commission it is mentioned that the most important energy consumptions are generated by the lighting, heating, cooling and ventilation system. Their relative importance differs primarily depending on the thermal efficiency of the building and the climatic zone in which it is located. This highlights the importance of taking into account the overall energy performance of a building, which could include the potential to generate less polluting energy.

The manufacture of construction products is responsible for several types of impact that are also the most important on the environment. They shall take into account both the resources used and a possible impact on the ecosystem and the emissions resulting from the extraction, processing and transport of raw materials. The use of resources depends on the amount of waste generated during the manufacturing, construction and demolition process on the site, which can be significant, as a proportion, in the total material flows from the construction site. This underlines how important it is to design and establish specifications for an efficient use of resources, thus, the most important elements of a building, which should be addressed, are the floor, roof, structure and exterior walls, respectively. As a result, the recycling and reuse/reintegrate of building materials and products, as well as of the construction elements as a whole, can contribute to the reduction of the environmental impact as well as to the development of the circular economy.

An important role in the case of some construction materials, of high volume and weight, is played by the impact of transporting aggregates (natural, recycled or secondary) to the places where the production is carried out. The transport of materials is usually carried out on land, by truck, which leads to significant emissions related to fuel consumption, which, in general, are greater than or even equal to those resulting from the production of some of these materials. For example, if materials are transported over a distance of more than 25 km, means, the resulting emissions can contribute significantly to the environmental impact of the production phase for the main elements of a building. Minimising these emissions from transport can help to promote the use of means of transport that have a lower impact, as well as rail or sea transport for different materials. In conclusion, the use of recycled materials, such as building aggregates as well as some waste resulting from demolition, can contribute to the development of the market for those materials in line with the objectives of an EU circular economy and can provide certain benefits associated with resource efficiency.

Another factor that should be taken into account is the lifetime of a building as well as its elements, sometimes also known as the service life of the building. As a general rule, the longer the service life of the main structural elements of a building, the less environmental impact associated with the duration of their life cycle. However, this makes the life cycle energy performance of a building as a whole (including both the use and manufacturing stages of construction products) as a priority as part of an overall approach over the service life. Thus, a design that facilitates the adaptation of the building and its structure, once it has reached the end of its service life for the owner, is another important aspect to be taken into account when aiming to increase the service life of that building.

There are other factors that can also influence the service life. For example, the functionality of the building as a healthy and attractive working environment can contribute to a longer service life and minimise the need for renovations. It is mentioned that there is clear evidence that shows that in a healthy building with good air quality inside the building and natural light, the workforce has higher productivity and there are fewer cases of absence due to illness.

The integration of certain nature-based solutions, such as roofs and ecological walls, living areas in yards and on terraces, sustainable urban sewerage networks as well as diversified street vegetation, can have multiple advantages (in addition to supporting biodiversity). These include limiting rainwater/storm water runoff, increasing thermal efficiency through natural cooling, improving air quality inside buildings and creating a working and resting environment that is more attractive and conducive to productivity and living conditions.

2.2Approach method of the impact of life cycle building materials in the european commission's view

As already pointed out above, building materials are associated with a significant impact on the environment. The material diversity in the market also provides buyers and suppliers with several variants on how to assess this impact as well as how to choose certain construction elements that have a lower impact. At the same time, the diversity of the materials may offer as an option the possibility to carry out the overall assessment of the life cycle impact of different materials in order to allow suppliers as well as their design team to decide on improvements. From a technical point of view, according to the European Commission, the criteria for green procurement are very important and demanding at the same time, which makes them particularly suitable for more advanced projects with experienced design teams. But, nevertheless, there are also certain criteria on green procurement that only target some of the specific stages in the life cycle of the building. The latter will only be intended to promote certain measures to address specific types of known impacts as well as certain associated improvement options for different materials. Thus, these criteria will be less technically demanding and may be more suitable for less advanced projects and less experienced design teams.

In the material published by the European Commission it is mentioned that the award criteria that are available to buyers/users for green procurement are, in descending order of the level of requirements as well as the technical complexity, the following:

1. Life Cycle Assessment (LCA): carrying out the life cycle assessment (LCA) requires bidders/suppliers to carry out the life cycle impact assessment for the main elements of a building;

2. Product Environmental Statements (PES): The aggregation of product environmental statements (PES), if the PES criterion is used, will result in total emissions of CO_2 equivalent resulting from the production process (global warming potential) for the main elements of a building also being declared;

3. The need for recycled and reused content: it will require suppliers to provide materials respecting a minimum requirement on the amount recycled and reused for concrete and masonry, for example;

4. The need to reduce emissions from the transport of heavy-duty materials: it can reward low emissions of CO_2 equivalent resulting from the transport of aggregates used for concrete and masonry.

If an owner/beneficiary decides to reward recycled or re-used content (point 3) or reduced emissions from transport (point 4), it should consider establishing specific criteria that take into account the conditions prevailing on the local market for building materials. The European Commission recommends that possible compensation on types of environmental impact be addressed by combining requirements for recycled and reused content with a reduction in emissions from the transport of materials. Thus, a relative weighting of the two criteria should at the same time ensure and lead to effective competition between potential suppliers, and, of course, with the encouragement of offers that will bring overall environmental benefits.

2.3Justification of high-performance buildings

High-performance green buildings can be associated with the best characteristics of conventional construction methods with emerging high-performance approaches. Under these conditions, green buildings achieve a rapid penetration into the construction market for three main reasons (Kibert, 2016, pp.14)[9]:

1. Sustainable construction provides an ethical and practical response to issues related to environmental impact and resource consumption. Sustainability assumptions encompass the entire life cycle of the building and its components, from the extraction of resources to their disposal at the end of the useful life of materials. Thus, the conditions and processes during the manufacture are taken into account and transmitted, together with the current/actual performance of the manufactured products, in the completed building. As a result, the design of high-performance green buildings is based on renewable resources for energy systems; recycling and reuse of water and materials; integration of native species and their adaptation for spatial planning; passive heating, cooling and ventilation; and other approaches that minimise environmental impact and resource consumption.

2. In the author's opinion, green buildings are practically always economically justified, based on the life cycle cost, although they may be more expensive based on the cost of capital or the first cost. For example, actual systems with energy conservation, lighting and air conditioning functions, with an exceptional response to indoor and outdoor climatic conditions, will cost more than conventional ones, those that have similar technical characteristics. Also,

rainwater abstraction systems, which collect and store rainwater for non-potable uses, will necessarily require pipes, pumps, control and guidance equipment, storage tanks as well as additional filtration components. But, nevertheless, the most important systems embedded in green buildings will recover their initial investment in a relatively short time. Thus, the author, quoting Kats (2003), points out that as energy and water prices rise due to increased demand and reduced supply, the depreciation period will decrease.

3. Sustainable design takes into account the potential effects of the building, including through its operation, on the health of occupants, of people in particular. As proof, the author cites a 2012 report by the Global Indoor Health Network that suggests that, globally, about 50% of all diseases are caused by indoor air pollution. If conventional methods of construction have routinely paid less attention to the shaky construction syndrome, as the author calls it, as well as to multiple chemical sensitivity, until the processes occur; instead, green buildings are designed to promote the health of occupants; thus, these include measures such as the protection of pipes during installation, in order to avoid contamination during construction; specification of finishes with volatile organic compounds, from low to zero, to prevent the elimination of potentially hazardous chemicals; more accurate sizing of heating and cooling components to prevent dehumidification, thereby reducing mould; and the use of ultraviolet radiation to kill/remove mould and bacteria from ventilation systems etc..

In other news, when carrying out sustainability assessments, there is a strong and constant emphasis on including the benefits of high-performance buildings. Thus, in the opinion of some authorities, the guidelines "increase efficiency, optimize performance, eliminate unnecessary use of resources, ensure the health of occupants, protect the environment, generate cost savings and reduce risks to assets".

As a result, six general principles have been identified that can support the authorities in promoting their mission to implement sustainable buildings, as follows:

-the use of integrated design principles;
-optimization of energy performance;
-protection and conservation of water and other natural resources;
-improvement of the indoor environment;
-reducing the impact of materials on the environment;
-assessing and considering building resilience, efficiency and safety.

Although more efficient building components may cost more financially, there are still costs imposed on society if the energy efficiency is not optimised – for example, by increasing electricity consumption and, in turn, by increasing emission rates from the grid. In this context, the design of the building can be financially efficient, for example; however, when extending the analysis to include all external stakeholders that are affected, the decision to move away from energy efficient investments would no longer be cost-effective due to high societal and environmental costs, which are likely to outweigh the potential financial cost savings. But by accounting for both the internalized and outsourced impact of inefficient buildings, and in our opinion, efficiency and effectiveness with regard to life cycle cost (of the sorts - an effective method is a method that has brought successful results) can lead to the appropriate allocation of costs and benefits to all stakeholders, involved people.

In the future, life cycle cost-effectiveness should be anchored in all public and private design practices to ensure that only the most successful/valuable projects receive funding and that such projects lead to fair and resilient results. Throughout the life cycle, the impact of building design should be transparent and provide accountability beyond the initial financial costs and benefits. By assessing the design of buildings in a global and integrated way from economic, financial, social and environmental perspectives, buildings can be optimised for resilience to climate change, maximising public benefits and minimising costs to all stakeholders.

As mentioned above, the green building is part of the broader concept of "sustainable development", characterized by Sara Parkin as "a process that allows all people to realize their potential and improve their quality of life in various ways that in turn protect and improve the systems of supporting the life of the Earth".

For its part, the World Committee on Environment and Development (Brundtland Commission) made the following statement: "Humanity has the capacity to make sustainable development - to ensure that it meets the needs of the present without compromising the ability of future generations to realise their own needs". (RSMeans, 2011, pp. 3)[12]

In the author's opinion, the green building is not only an assembly of "environmental" components, but no partial modification of an already designed-existing building, standard building. Thus, in the case of green buildings, different incremental approaches are added to the cost of the building, while producing marginal resource savings. It is much more effective to adopt a holistic approach to programming, planning, designing and building (or renovating) buildings. As the author argues, this involves the analysis of various interconnected aspects such as the building and certain climatic considerations, orientation as well as the shape of the building, thermal lighting and comfort, systems and materials and, finally, the optimization of all these aspects in an integrated design.

As a result, the potential benefits of green buildings may be as follows:

• reduction of capital costs;
• reducing operating costs;
• certain marketing benefits (free publication/advertising and product differentiation);

• increased valuation premiums and absorption rates;
• in some cities, certain building and zoning approvals can be simplified;
• reducing the risk of liability;
• significant gains in health and productivity;
• attracting and retaining employees;
• maintaining a constant position before the rules which appear;
• new business opportunities;
• the satisfaction of doing the right thing. (RSMeans, 2011, pp. 3)[12]

In view of the above, we are also of the opinion that the construction of green buildings is, without a doubt, the right direction. Thus, sustainably designed new green buildings can produce more energy than they consume; they can use local materials that are not toxic, for example, with low energy consumption; and, last but not least, they can improve the experience of the occupants while benefiting from the surrounding community/surroundings. As a result, when systems are integrated correctly, the overall primary costs can be considerably lower for green buildings compared to standard buildings, while operational costs are almost always lower for green buildings.

In the opinion of RSMeans (2011, pp. 3)[12] even more important is the fact that studies have shown that in green buildings, people, in general, are more productive and have fewer days of illness, students learn faster and are missing less often, and patients in hospitals heal faster and require less treatment. In other words, green buildings are undeniably better than standard/traditional buildings, so we also believe that it is time for them to become something normal and not an exception.

3.Conclusions

The development of major retrofitting alternatives for existing buildings, for example, including sustainability initiatives, can reduce operational costs and environmental impact and increase the adaptability, durability and resilience of those buildings. For this reason, buildings can be less expensive in terms of operation, increase in value, last longer and contribute to a preferable, healthier and more convenient environment for the occupants who live and work there. Therefore, improving interior comfort, quality in general, reducing humidity and improving efficiency, all this can lead to improved health and productivity of users of the respective buildings.

From a sustainability perspective, there are factors that need to be taken into account together in order to achieve the ultimate goal, known as 'sustained prosperity', which is relevant for the different stakeholders as well as their different priorities.

Currently, sustainability in architecture is considered to be the most important factor in design, on which most architects try to base their project. In these circumstances, one of the most important measures to be taken in this regard is the introduction of sustainable development aspects and the placement of this category in the overall long-term planning.

Another factor that should be taken into account is the lifetime of a building as well as its elements, sometimes also known as the service life of the building. As a general rule, the longer the service life of the main structural elements of a building, the less environmental impact associated with the duration of their life cycle. However, this makes the life cycle energy performance of a building as a whole (including both the use and manufacturing stages of construction products) as a priority as part of an overall approach over the service life. Thus, a design that facilitates the adaptation of the building and its structure, once it has reached the end of its service life for the owner, is another important aspect to be taken into account when aiming to increase the service life of that building.

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