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THE NECESSITY OF ENVIRONMENTALLY FRIENDLY BUILDINGS IN THE CITY OF IAŞI

BY

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Abstract. The tremendous amounts of materials consumed, the high volume of equivalent carbon dioxide released during the processes specific to the built environment, its significant contribution to every national economy, and the perpetual social influence it exerts represent the main arguments that are transforming the construction sector into one of the most important factors in achieving the primary dimensions of sustainability at the global scale. It is well known that this industry exerts a significant ecological impact; therefore, civil engineering specialists should promote and use solutions that reduce the impact of the built environment over the natural one. Taking into account the above, the goal of the present paper is to underline the necessity of building new constructions in the city of Iaşi by taking into consideration the sustainability concept and analysing and understanding the issues specific to the local context.

Keywords: equivalent carbon dioxide; national economy; social influence; construction sector; sustainability.

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1. Introduction

Achieving the primary dimensions of the global sustainable development represents the most important task that humankind should tackle at the beginning of the present century. The environmental load over the Earth's ecosystem resulted from daily human activities has reached a critical level that could endanger future generations' capability of evolving. The present rates of natural resources consumption significantly exceed the Earth's capability of renewing the stock that will be needed to support the fulfilling of our basic needs in the near future (Maxineasa & Țăranu, 2017; Maxineasa *et al.*, 2018). Another important issue that has a significant influence over quality of life and at the same time a negative effect over human health is represented by the alarming amount of greenhouses gases (GHG) emitted into the atmosphere. The above mentioned facts only constitute a small part of the argument that should be used to raise public awareness on the importance of the environmental aspect of sustainability and the way it is influenced by each action people take.

While all economic activities exert a certain ecological influence, taking into account the tremendous volume of energy and raw materials consumed and the amounts of GHG emitted from the numerous processes specific to the built environment, the construction sector can very well be considered as one of the most pollutant; it thus has an important effect over the global efforts of achieving the goals of sustainable development (Agusti-Juan *et al.*, 2017; Ding, 2014; Margarido, 2015; Maxineasa & Țăranu, 2017; Maxineasa *et al.*, 2018; Pacheco-Torres *et al.*, 2017; Zhao *et al.*, 2017). Therefore, using building solutions to minimize the global environmental footprint of the construction industry will represent one of the most important assignments that the scientific community and civil engineering experts should resolve in the near future.

Considering the above, the present paper aims at describing the implications resulted from considering the concept of sustainability in the construction sector at the global scale. Taking into account that it is recommended that sustainable development should be implemented by considering and applying at the local scale the global sustainability principles, a short characterization of the context encountered in the city of Iasi is offered. This part of the study has been completed by considering some of the most important aspects regarding the local built environment. At the same time, the authors attempt to demonstrate the necessity of considering and employing an environmental thinking in the design process of the buildings.

2. Global Context

The extreme weather events registered in the last decade as a direct result of the climate change phenomena have significantly increased the level of awareness regarding the tremendous impact of the human race over the natural environment (Maxineasa *et al.*, 2018). As stated before, the amount of materials consumed and the level of environmental burdens resulted from different economic activities exert a significant pressure over the Earth's ecosystem and its capability of providing the possibility of evolving to the future generations.

At present, the built environment is considered to be one of the most import factors in assuring a suitable living standard at the global scale. At the same time, the construction sector has a tremendous negative influence over the natural environment. It is estimated that this industry is responsible for approximately 60% of the total amount of raw materials consumed globally (Bribian *et al.*, 2011; Maxineasa, 2015; Maxineasa & Țăranu, 2017). Also, the processes specific to the built environment consume over 40% of the total amount of energy, and more than 15% of the volume of fresh water used globally. At the same time, the construction sector is accountable for more than 40% of the total quantity of GHG emitted around the world (Ramesh *et al.*, 2010; Maxineasa, 2015; Maxineasa & Țăranu, 2017; Mokhlesian & Holmen, 2012; Ding, 2014; Pacheco-Torgal, 2014). Apart from its environmental impact, this industry has a significant economic and social influence as well. It is considered that at the global scale, more than 7% of jobs have a direct link with the construction sector (Tautsching & Burtscher, 2013).

Among other factors, the ecological impact of the built environment is directly influenced by the types and amounts of construction materials used. Hence, an important phase of the life cycle of a building that has a significant influence over the overall environmental footprint is represented by the selection of the building materials. The following section presents a short description of the environmental implications resulted from using traditional construction materials (concrete, steel, masonry and timber).

Concrete is the material used in the highest quantity in the built environment. The overall amount of consumed concrete is over two times higher than the sum of the volumes of other traditional construction materials used in this sector. It is estimated that more than 25 billion tons of concrete are produced and consumed every year. Also alarming is that in the last 60 years the amount of concrete has increased by almost 10 times, this material being the second most consumed resource, after water (EPC, 2009; Gursel *et al.*, 2014; Marinkovic *et al.*, 2014; Maxineasa & Țăranu 2013; Maxineasa & Țăranu, 2017). Apart from the significant quantities of natural aggregates and water consumed to produce concrete, the environmental impact of this material is significantly influenced by the use of cement. Taking into account that for every kg of cement produced approximately 1 kg of CO_2 is emitted, and also considering that in the near future the amount of cement produced around the world is estimated to reach the value of 4.40 billion tons, it can be rightfully considered that the ecological influence of this component material is very significant (Estrada *et al.*, 2012; Habert, 2014; Maxineasa & Țăranu, 2017; WBCSD, 2009). Considering all the above, it can be stated that the use of concrete without a life cycle planning has serious environmental implications.

Steel is another traditional construction material that has a significant influence over the construction sector's environmental impact. It is estimated that during the processes that are specific to the manufacturing of steel almost 9% of the total CO_2 global emissions are released into the atmosphere (Moynihan & Alwood, 2012). In the last 40 years, the volume of steel produced worldwide has increased about 2.5 times, with almost 50% of this quantity being consumed in the construction sector (Maxineasa & Țăranu, 2017; Moynihan & Alwood, 2012; Wang *et al*., 2007; WSA, 2013a, b). The environmental impact of this material is significantly influenced by the manufacturing technique. The two generally used methods are the electric arc furnace (EAF) and the basic oxygen furnace (BOF). The EAF method is considered to have a lower environmental impact; this assumption is based on the larger amount of recycled material that can be used during the manufacturing stage, as well as the fact that being an electricity based technological process, the EAF steel can be produced by using renewable energy. Compared with other traditional building materials, steel has a unique property: it can be 100% recycled multiple times without losing any of its mechanical characteristics (Maxineasa & Țăranu, 2013; Maxineasa & Țăranu, 2018; Estrada *et al*., 2012; Strezov *et al*., 2013). It must be mentioned that the goal of the steel industry is to produce, in the near future, a carbon neutral material.

In the case of masonry units, their environmental impact is highly influenced by the type of constituent materials used in the manufacturing stage. The concrete masonry bricks (or concrete masonry units) have a lower level of embedded energy compared with the fired clay bricks, a direct result of the fact that during the production stage of the clay masonry units a significant amount of energy is used in the burning process of these elements. In order to obtain fired clay bricks, temperatures between 900°C and 1,050°C have to be reached and maintained for a long period of time (the heating and cooling processes can last up to 150 hours) (Bingel and Bown, 2010; Lourenco & Vasconcelos, 2015; Maxineasa & Țăranu, 2017; Volz & Stonver, 2010). In the case of the concrete based masonry units, the environmental effects are similar with the ones registered in the case of concrete. The ecological impact of these masonry blocks is highly influenced by the amount of cement used in the production mixes (Bingel & Bown, 2010; Maxineasa & Țăranu, 2017; Volz & Stonver, 2010).

Timber is one of the oldest materials used for building different structures (Isopescu & Astanei, 2012; Maxineasa *et al.*, 2018). Its good mechanical and thermal properties as well as wide availability around the globe have turned this material into one of the most important natural resources (Asif, 2010; Maxineasa, *et al.*, 2018). It is well known that trees represent the most powerful tool of the Earth's ecosystem, capable of ensuring and improving life conditions by removing a significant amount of CO_2 from the atmosphere and replacing it with oxygen (O_2). At first glance, the use of timber can be regarded as a carbon negative solution, but we have to take into consideration that the sequestered CO_2 will be released back into the atmosphere at the end of the life cycle of the trees or timber products (through the decomposing process or by burning the wood in order to obtain energy). Another problem posed by using timber as a construction material is represented by illegal and uncontrolled deforestation (Asif, 2010; DeStefano, 2009; Estrada *et al*., 2012; Fouquet *et al.*, 2015; Maxineasa *et al.*, 2018). As shown briefly above, the use of wood in the construction sector is quite a sensitive environmental problem that should be tackled by taking into account all life cycles of a timber product, as well as considering, in the design process of a construction, wood harvested only from sustainable certified plantations.

In order to have a better understanding of the environmental implications resulted from the use of the above mentioned traditional construction materials, the authors make mention of a set of results obtained by Maxineasa & Țăranu (2017). The values describe, from a cradle-to-gate perspective, the carbon footprint of the following materials: 1 kg of C20/25 concrete, 1 kg of fired clay bricks, 1 kg of structural steel, and 1 kg of timber. In order to analyse the ecological effects, the GaBi ts software and the Global Warming Potential (GWP) impact category have been considered.

Fig. 1 presents the resulted values describing the amount of CO_2 released into the atmosphere over the pre-operation phase of a construction product's life cycle. It can be observed that of all analysed materials, structural steel has the highest carbon footprint. At the same time, if biogenic carbon is not considered, concrete has the lowest impact for the GWP environmental parameter. Analysing the resulted values, it can be seen that evaluating the amount of CO_2 equivalent emissions by adding the biogenic carbon causes timber to have a positive impact (negative value). Considering that at the moment there is a debate regarding the accounting of biogenic carbon in a LCA analysis, the authors think that it is more accurate to assess the carbon footprint of timber without considering the biogenic carbon. Therefore, it can be observed that in this case, the amount of CO_2 released into the atmosphere from the wood processing surpasses the one resulted in the case of concrete and fired clay bricks. It is also worth mentioning that in order to make the right decision regarding the best environmental choice of the material used to build a structure, a full LCA analysis must be considered.

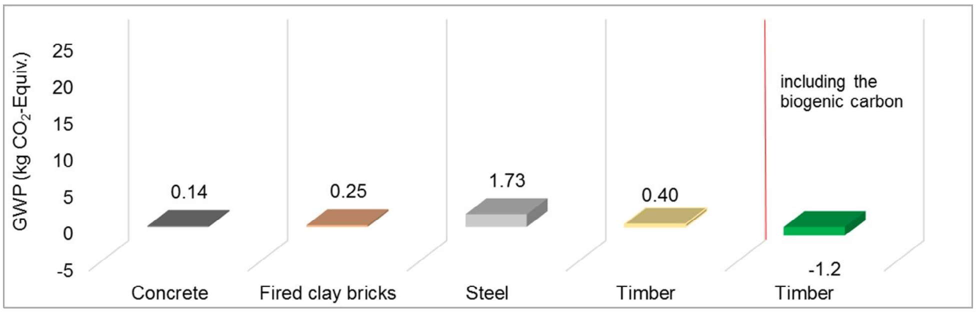

Fig. 1 – The carbon footprint of the traditional building materials (Maxineasa & Țăranu, 2017).

As briefly shown, the negative environmental impact of the construction sector is a serious issue that should be tackled as soon as possible by civil engineering specialists. The carbon footprint results presented above demonstrate the difficulty of designing a building that can be considered sustainable, as well as the intricacy of making the right choice in terms of the materials considered in the design process.

3. Local Context

In the last years, the city of Iasi has become an important regional development pole, being the main power source behind the socio-economic development of the North-Eastern region of Romania. Due to several real estate investments that have created a significant number of new commercial and office spaces, the upgrading works for the existing airport, as well as the large number of universities with an historical background in scientific research, recent years have seen the city become increasingly attractive for a great number of important economic players. Economic advancement has led to a significant increase of the number of jobs, which has a direct impact over the population dynamics of the city.

Data from the National Institute of Statics (INS) shows that at the beginning of 2017, the city of Iasi had approximately 10000 more residents than the value registered in the same period in 2016 (Fig. 2) (INS, 2018). It must be mentioned that this number does not reflect the increasing population in the neighbouring areas of the city. Since it is expected that economic development will continue in the next years, the trend registered nowadays regarding the increasing number of inhabitants will accelerate.

Another important aspect that should be considered in the early stages of designing a new building stock is represented by the housing deficit. At the moment, there are no official statistics regarding this issue, but a number of recent market studies completed by different real estate agencies show that at the national scale over 1 million houses are still needed, with more than 200,000 in the Bucharest area. Taking into account that a 2017 INS report places Iasi on the second place by number of inhabitants, it can be considered that a large number from the national houses deficit is registered in the city of Iaşi and its neighbouring areas. Therefore, in the near future more residential areas should be developed in the city of Iaşi.

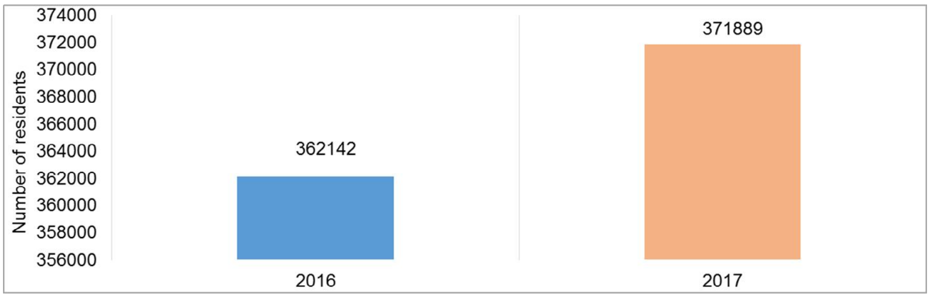

Fig. 2 – Comparison between the numbers of inhabitants registered in 2016 and 2017 in the city of Iaşi (INS, 2017; INS, 2018).

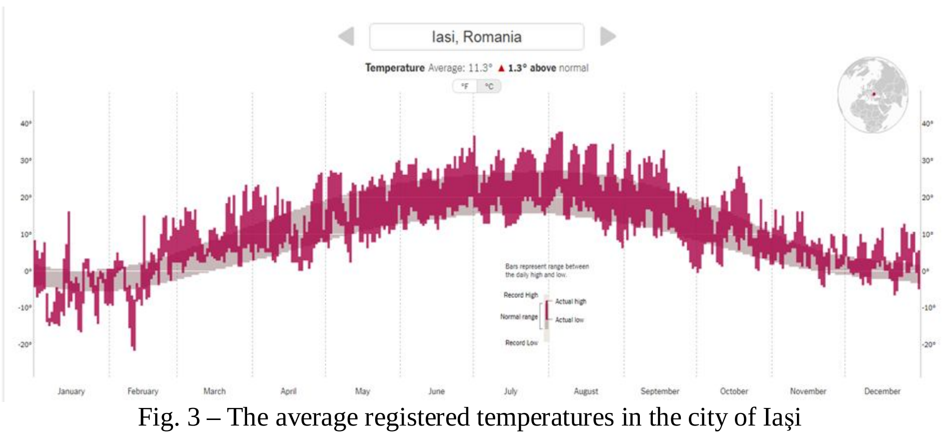

Fig. 3 – The average registered temperatures in the city of Iaşi (AccuWeather, 2018).

In the processes of designing a new building stock, information regarding the environmental situation of the city should be considered. It is well known by now that the city has problems with regards to fine particles PM 2.5 and PM 10, as well as CO_2 concentration; the maximum limits of these environmental burdens are highly exceeded. Another environmental issue with a direct effect over the city's inhabitants is represented by the registered average value of the exterior temperature. In Fig. 3, it can be observed that the average temperature in 2017 was 1.3°C higher than the normal value.

Taking into account the above, it can be stated that the environmental performance levels of the city of Iasi are rather critical. A new residential building stock, that is needed in order to house a significant number of new residents, can increase the already negative environmental influence of the city. At the same time, if environmental thinking is used in the design processes, the new constructions can be built with a minimum ecological influence and could also improve, within certain boundaries, present environmental conditions.

4. Considerations for an Environmentally Friendly Building

As stated before, the construction sector has an important ecological impact, thus designing new sustainable buildings is a must, but at the same time a very difficult task in the present local context. As a first step, all the implicated parties should completely understand the problems related to the built and natural environment. The design process of a new group of residential buildings with a minimum impact over the natural environment should take into consideration the following key aspects (CIB, 2010):

– the implementation of the main principles of sustainability;

– all the interested parties should work together in order to satisfy the new building occupants' needs;

– the complete integration of the construction into the existing city and environmental planning schemes;

– using the Life Cycle Assessment approach in order to minimize the overall environmental impact;

– using the Whole Life Cycle Costing methodology in order to reduce the construction cost and obtain an improved economic value over time;

– the taking into consideration of social and cultural aspects;

– providing a user-friendly, healthy and comfortable inner space;

– designing a modular structure in order to obtain an adaptable throughout service life construction.

Apart from the above mentioned aspects, in the design process, the thermal performances of the building should be optimized in order to reduce the energy consumption needed for heating and cooling the interior space. The European legislation regarding the energy performances of a new building must be consulted in order to satisfy the imposed limitations.

5. Conclusions

The construction sector has a significant influence over the global efforts made for achieving the primary aspects of sustainable development. The tremendous volume of material consumed and the significant amount of GHG emitted into the atmosphere have turned this sector into one of the most pollutant economic activities. Adding to this is the complex situation of the natural environment at the local scale, making the building of a new residential building stock with a lower environmental impact in the city of Iasi a challenge.

As stated in the present paper, in order to achieve this goal, the dimensions of sustainability should be considered through a Life Cycle thinking in the design process. Starting from the selection of the structural material and the type of the structure, to the technologies used for creating and maintaining a proper quality of the inner climate, all decisions should be considered by bearing in mind the environmental performances over all life cycle stages of the new building. Interested parties should work together in order to achieve the occupants' demands with a minimum environmental, economic and social effort, while at the same time assuring structural safety.

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NECESITATEA CONSTRUIRII DE CLĂDIRI CU UN IMPACT REDUS ASUPRA MEDIULUI ÎN ORAŞUL IAŞI

(Rezumat)

Cantitățile impresionante de materiale consumate, volumul ridicat de dioxid de carbon echivalent emis în timpul proceselor specifice mediului construit, efectele importante asupra oricărei economii naționale, şi influența asupra aspectului social reprezintă principalele argumente care transformă sectorul construcțiilor în unul dintre cel mai important factor în atingerea dimensiunilor principale ale sustenabilității la nivel global. Este deja cunoscut faptul că această industrie are unul dintre cele mai importante efecte negative ecologice, astfel încât specialiştii în inginerie civilă ar trebui să promoveze şi să folosească, din ce în ce mai mult, soluții care să limiteze impactul mediului construit asupra celui natural. Ținând cont de informațiile menționate anterior, obiectivul prezentei lucrării constă în determinarea necesității realizării de noi construcții în oraşul Iaşi care vor fi proiectate considerând conceptul de sustenabilitate prin analizarea şi înțelegerea problemelor specifice contextului local.