

Evaluation of the advantages of usage of containers in Housing production in terms of sustainability

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ABSTRACT

Sustainable building construction aims to create a system that provides people with humanely and equitable economic opportunities through the harmony of the built environment with the natural environment. To this end, different approaches are utilized such as re-functioning, use of environmentally friendly methods in production, employment of building items suitable for climate and topography, consideration of energy efficiency in the building life cycle, utilization of renewable energy sources, use of local or traditional materials and minimization of waste generation during construction and destruction process of buildings. One of the most popular approaches among these is the "utilization of containers in the production of sustainable buildings", which is a sub-field of the re-functioning approach. In this context, the objective of this study is to evaluate the advantages of utilization of containers in the production of sustainable buildings through a systematic approach. However, the realization of this assessment within a single study for all building types is quite difficult to achieve as a scientifically significant result. As such, as a methodology, the first stage of the study will determine which structure type should be considered. Subsequently, the criteria to be based on, in the evaluation of the advantages of producing this structure type (containers) in terms of sustainability will be described. At the last stage, certain criterias that the containers should meet in line with the data obtained from the literature will be determined.

Keywords: Design of sustainable housing, re-functioning in the construction industry, utilization of containers in housing production

INTRODUCTION

The term "Ecology" has been used in the "General Morphology" work of Ernst Haeckel, to identify all kinds of information about the economy of nature and determine the organic and inorganic environmental relations of animals. Haeckel has been inspired by the idea of the economy of nature, mentioned by Charles Darwin in his book titled "Origin of Species" published in 1859, while preparing this work and developed this idea under the ecology term of Thoreau [1]. Much as ecology was accepted as a science only in the 19th century, humanity has been intertwined with ecology since the creation of mankind [2]. In this context, human being had no purpose to be superior to the natural surroundings according to the mechanistic view [3]. However, human beings have began to think that they can change nature as they wish with developments in industrialization, urbanization and technology. Humans have tried to make the nature adapt to themselves instead of living in harmony with nature within the

whole ecosystem. This understanding has led to the natural resources to be consumed unconsciously or made them unusable, and in this way numerous global problems have arisen. Construction industry has been considered as one of the most important stakeholders of this destruction, hence global warming. According to an article published by the American Institute of Architecture (AIA), the construction sector is at the top of the list, according to data showing distribution of emissions by sectors [4].

Destruction of ecology over time has required the emergence of new understandings and trends. Modern analysis techniques and technology have come together to take the first steps of today's environmentalist movement in the 1950s and 1960s. The idea of not living "against nature" but living "with nature", which has emerged in this period, has revealed how the way followed in the world's most advanced industries and countries is wrong [5]. In this way, the term "sustainability", which is one of most commonly concepts of today, has begun to be addressed for the first time in 1970s [6].

Sustainability is the continuous processing capability of a society, ecosystem or other similar interactive systems without consuming the basic resources thereof and without adversely affecting the environment [7]. Sustainable design comprises strategic use of design to meet the current and future humanitarian needs without harming the environment [8]. Sustainable design determines the relation of products and periods with the environmental, economic and social systems that surround them and develops approaches to prevent non-sustainable effects in these systems. [9]. Sustainable design in the construction industry has begun to show a significant movement since 2000s. Sustainable building production aims to create a system that provides people with humanely and equitable economic opportunities with the harmony of natural environment and the structures built in this environment [10]. To this end, different approaches are utilized such as re-functioning, use of environmentally friendly methods in production, employment of building items suitable for climate and topography, consideration of energy efficiency in the building life cycle, utilization of renewable energy sources, use of local or traditional materials and minimization of waste generation during construction formation and destruction process of buildings. One of the most popular approaches among these is the "utilization of containers in production of sustainable buildings", which is a sub-field of the re-functioning approach. The most important reason for this is that the containers are being manufactured at very high rates and they are being replaced after an average of 7 years by most of the transport companies and in this case hundreds of containers that have not yet reached their lifespan are turned into high quality waste [11]. According to data obtained in 2008, approximately 80% of the world transportation is carried out by containers [12]. According to the World Bank, in 2010, a total of 542.2 million TEU (Twenty-foot Equivalent Unit) containers were carried around the world. In 2014, this figure has increased to 679.2 million TEU [13].

This apparent increase in container traffic has also accelerated container production. There are 20.28 million TEU containers actively used for transportation in the world currently according to most recent statistics [14]. When the container manufacturers with the largest share in the container production market in the world are examined, the current orders received by the leading companies reveal that there will be further increases in the cited numbers in the coming periods. For example; APM-Maersk, indicated as the largest container producer in the world and which has 3,25 million TEU containers, has 367.130 units of pending container orders for 2017. The expected increase in container production between 2014 and 2017 is

5.3% [15]. Containers that are produced at high rates, will be turned into high quality waste in a very short time.

The scope of the work, in line with all these data obtained from the literature is to assess the advantages of the use of containers, with "re-functioning approach" in building production in terms of sustainability with a systematic approach.

PURPOSE AND METHODOLOGY

The objective of the study is to assess the advantages of the use of containers in building production in terms of sustainability with a systematic approach. However, the realization of this assessment within a single study for all building types is quite difficult to achieve as a scientifically significant result. As such, as a methodology, the first stage of the study will determine which structure type should be considered. Subsequently, the criteria to be based on, in the evaluation of the advantages of producing this structure type (containers) in terms of sustainability will be described. At the last stage, whether the usage of the containers in the housing production is appropriate enough in terms of sustainability and certain criterias the containers should meet in line with the data obtained from the literature will be determined.

Determination of the building type to be considered in the scope of the study

The types of buildings are divided into different categories within the classification systematic systems defined in line with the aimed usage in the construction sector having a big share in ecological damage and annual energy consumption. These categories show great similarities as much as they are defined separately for each and every country. The buildings are divided into five categories in the classification system of Turkey, and their features are described within the purview of the communiqué on "Approximate Unit Costs to be Used in the Account of Architectural and Engineering Service Charges" promulgated through the Ministry of Environment and Urbanization every year in the Official Gazette [16]. Many institutions such as the Chamber of Architects of Turkey, the Chamber of Mechanical Engineers of Turkey and the Chamber of Interior Architects of Turkey accept the types of buildings specified in this communiqué.

When the structural building types defined in the classification system in Turkey are evaluated in terms of their production rates, it is observed that the production rate of the "residential" building type is much higher than the other building types. One of the most significant statistical data revealing this situation with full clarity is the counting results of the amount of buildings as of 2010 by the Turkish Statistical Institute (TÜİK) specified in the Current Situation Assessment Report of Turkey's Climate Change National Action Plan Development Project. The percentage of building types in the building stock according to the purpose of use is 75% according to these results, [17]. Furthermore, again according to the counting results of the amount of buildings as of 2010 by the Turkish Statistical Institute (TÜİK), the number of buildings was 4.3 million in 1984 and increased by 78% in 2000 to 7.8 million while the number of houses reached 16.2 million with a 129% increase in the same year [18]. When these rates are taken into account, it is observed that the ratio of houses in the number of existing building stock and the types of buildings produced is much higher.

Furthermore, as a result of the literature studies, it has been observed that the energy consumption of houses is very high compared to the total energy consumption. It is observed when the distribution of TÜİK (Turkish Statistical Institute) Net Electricity Consumption by Sectors is examined that 25% of electric energy consumption which was 156,894 GWh in total in 2009 was made by residences [19]. 20%, 31%, 20%, 14% and 11% of the total energy

consumption in houses in Turkey is met by coal with low thermal value and high humidity and sulfur content; wood obtained from forests which are very important to keep the atmosphere combination in balance and which increase emission of CO₂; petrol; animal and plant residues; natural gas which is the reason of 3% of the CO₂ emissions; and electricity respectively. [20] When the data of TÜİK (Turkish Statistical Institute) dated 1998 as to Fuel Consumption for House Lighting and Heating table is examined, it is observed that 1,043,398 tons of fuel oil with high sulfur content has been employed for heating the houses in one year [21].

In this context, it has been decided that the building type within the scope of the study will be "residential", as it is the most produced building type in Turkey, as well as it has having a significant share in energy consumption of Turkey.

Determination of the criteria to be based on the evaluation of the advantages of container utilization in housing production in terms of sustainability

A literature research has been carried with intend to determine the criteria to be taken into consideration in evaluating the advantages of container employment in terms of sustainability in housing production [22; 23; 24; 25; 26; 27; 28; 29; 30; 31; 32; 33; 34; 35; 36; 37; 38; 39; 40; 41; 42; 43; 44; 45; 46; 47; 48; 49; 50; 51; 52; 53; 54; 55]. As a result of these researches, it has been decided to base the study on the following evaluation criterias in line with the data obtained:

1. Easy access to materials,
2. Effective use of energy during production process,
3. Less waste generation during production process,
4. Lower production costs,
5. Lower transportation costs,
6. Efficient use of energy during life cycle,
7. Recyclability,
8. Reusability,
9. Conformance with building biology

A literature research has been carried out to evaluate the advantages of container employment in terms of sustainability in housing production according to the criteria listed hereinabove [11; 56; 57; 58; 59; 60; 61; 62; 63; 64; 65; 66; 67; 68; 69; 70; 71; 72], and the data obtained are the same as the ones provided in Table 1.

Table 1. Evaluation of benefits of container usage in housing production in terms of sustainability

Evaluation criteria	Literature																	
	[11]	[56]	[57]	[58]	[59]	[60]	[61]	[62]	[63]	[64]	[65]	[66]	[67]	[68]	[69]	[70]	[71]	[72]
Easy access to materials	X			X				X	X	X			X		X	X	X	X
Effective use of energy during production process		X	X	X	X	X		X	X			X		X	X	X		
Less waste generation during production process				X					X			X			X	X		X
Lower production costs		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lower transportation costs				X	X	X	X		X						X		X	
Efficient use of energy during life cycle	X		X			X			X	X		X				X		
Recyclability	X			X	X													
Reusability	X			X	X	X		X	X	X		X	X		X	X	X	X
Conformance with building biology	X	X	X	X	X	X	X	X	X	X	X	X	X	X				

It was seen that the containers met all of the evaluation criteria determined based on 34 different sources when the data in Table 1 were evaluated. Containers' allowing housing production at very low cost is the most emphasized feature in terms of sustainability. This feature has a special significance for the construction sector in which production costs are very high. Furthermore, it was concluded as a result of the literature research done that the containers have substantial additional features in terms of sustainability in addition to the evaluation criteria described in Table 1 inasmuch as they are resistant to difficult climate conditions, have longevity, are not easily damaged while being transported from one place to another, are prefabricated and modular and their construction process takes short time and is easy. It has been observed that the utilization of containers in the production of housing in line with all these obtained data will furnish significant advantages in terms of sustainability.

RESULTS

Increase of container usage in housing production will allow the re-functioning of this material providing liveable spaces which has superior qualities of sustainability in terms of availability, workforce, waste generation and cost reductions and efficient energy use. This application will reduce material consumption in the construction sector and provide substantial contributions to the efficient use and protection of natural resources.

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