



Industrial Design and Production of Buildings

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ABSTRACT

“Industrial Design and Production of Buildings” might be considered as one of the most important contemporary trends in architecture domain which is also considered as the logical response to the difficulties and problems of the present age. Rapid population growth and increasing demand, the need for reducing the delivery time of civil engineering projects, accelerating the return on investments and the factors alike have caused necessity for transforming the traditional methods of construction to be felt even more day by day. The purpose of writing this article is to review some of the essential components of industrial production of buildings from two viewpoints of "opportunism" and "threat detection".

KEYWORDS: Industrial Production, Industrial Construction, Prefabrication, Module.

1. INTRODUCTION

Statistically proven, building industry and construction projects, in terms of amount of investment and volume of human force involved are considered among the largest industries in the world. Undoubtedly, the nature of such a process in construction is rooted in historical events of the human life and it should also be derived from needs and requirements of human life. The thought of prefabricated components production in the West dates back to the seventeenth century AD. The British people settled in America made use of the prefabricated walls that were made of wooden frames (Bleicher et al., 2014; Zhivov et al., 2001). In Europe, the idea of modular construction of buildings, took shape in the late nineteenth century and industrial Revolution on its way with the advent of new constructional materials such as steel beams and other steel products, steel and finally reinforced concrete the Industrial Revolution led to enhancement of the construction of industrial and modular buildings. By the end of the First World War and in great need of repairing the war damages and mass production of buildings, the tendency toward modernization of the architecture was increased. Therefore, the use of technology, modern materials, prefabricated, performance-orientation and staying away from the historical flashy styles was brought to the great attention. Labor shortages after the World War II, was the real motive to accelerate the modular buildings in different countries. At first, these products were used in the construction of bridges, factories, port facilities, wheat silos, public buildings followed by residential buildings (Despeisse, Ball, Evans, & Levers, 2012; Dong, Soebarto, & Griffith, 2014; Yildirim, 2012; Zainol, Yusof, Mastor, Sanusi, & Ramli, 2012).

If we would consider the modern technology of construction meant as entering the industry to the constructions, this technology entered Iran in the late (solar) forties and appeared in the form of settlement building in some big cities such as Isfahan, Ahwaz, Tabriz and Tehran.

Today, taking advantage of modern constructional technologies and understanding the importance of this fact caused that countries would review their practices of construction. It should be noted that the "industrialization" is a relative concept that evolves gradually. The gap in terms of production paradigm which is growing between the developing countries and industrial countries has necessitated the need for restructuring and rapid mutation in the countries like Iran so that stop, inactivity and even regress would be prevented (Galloway & Newman, 2014; Gonela & Zhang, 2014; Ulrik Sørensen, 1999; van Gassel, Láscaris-Commeno, & Maas, 2014).

2. The Definition of Industrial Production of Buildings

The definition used for industrial architecture is various and diverse. But, a simple definition which can describe it is the use of modern and advanced technologies in construction. So that the “wet” Architecture becomes “Dry” Architecture and the main construction operations would be devoted to the “assembly” instead of “production”. In this approach, parts and components of the buildings are manufactured in a factory which are conducted in mass and in accordance with modular and chain standards and while observing the development standards (Jaillon & Poon, 2014; Jani & Patel, 2013; Torreggiani, Benni, Corzani, Tassinari, & Galassi, 2011; Torreggiani & Tassinari, 2012).

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In fact, mass production or industrial production of construction is a process that involves every stage of construction from financing to obtainment of the necessary permits, selection and application of construction technology, sales and marketing, after-sale services, operations management, etc. Basically, mass production is associated with industrialization of the production techniques. Constructional industrial systems are divided into two categories: open and closed systems. Open Systems includes a part of performing the constructional operations. In this method, the designer is capable of benefiting some kind of "microsystems" in different parts of their construction. The second type is the closed modular system which is a complete process and therein the user is consumer of a formed phenomenon and manipulation will become very limited (Karni & Gal-Tzur, 1990; Katunsky et al., 2013; Olsmats, Edghill, & Towill, 1988; Santos, Martins, Gervásio, & Simões da Silva, 2014; Sathre & González-García, 2014; Silvestre et al., 2012).

According to some definitions provided, if between 50 to 80 percent of a building would be prefabricated and manufactured in factory; it can be called Industrial Construction. Based on the above classification, the entry of industrialization from the open system type has been precedent and common in Iran for many years. But, the inadequacy and non-industrial assembly techniques common in Iran would indicate a strong determination to review the way of benefiting the industrial production of buildings topic.

3. Opportunities

3-1. Possibility to respond to the ever-increasing demand for housing

With the increasing rate of population, the growing need for housing and inefficient traditional and common systems in mass production of housing, approach to use industrial methods of housing (construction) production appears to be essential and necessary. Providing one million required housing units per year across the country in traditional way is not possible and industrialization approach is necessary. As it comes from the statistics, the average age of Iranian citizens is under 30 years and for this the Iranian society is considered a young society, so that a large number of new demands for housing will be made up to the next 10 years. Meanwhile, total people without housing currently are so that responds to the need for housing today is among the concerns of governments in Iran. On the other hand, the useful life of the buildings in Iran is estimated under the thirty years and this means that for example, up to ten years many of the current buildings which are currently considered as the buildings suitable for residence will be in the row of building to be remodeled and renovated. Total properties located in the old city texture –which sometimes shocking statistics of them are announced- should be added to the items listed as well (Radhi & Sharples, 2014; Salvador & Grieu, 2012; San-José Lombera & Cuadrado Rojo, 2010; San-José Lombera & Garrucho Aprea, 2010).

Due to the need for construction (considering the factors such as population growth, depreciation of residential units, disasters, etc.) approximately 35 million housing units are built annually in the entire world. Total investment in construction in Iran is about 33% of Iran's economy. However, in some data provided by relevant institutions, in total, only 3% of the construction rate has been allocated to the industrialization in Iran that this index reached 40% in countries such as Turkey and Malaysia. With the increase of the urban population in Iran it is forecasted to reach 73 percent of the total population till year 2021, necessity of a new attitude and quick approach to this sector is felt strongly.

To estimate of demand for housing, economists use some of functions which one of them is the Cobb-Douglas function which first introduced by Charles Cobb and Paul Douglas (Askaripour-Lahiji, Dadashpour, & Sameni-Keivani, 2013; Jalali & Sameni-Keivani, 2013a, 2013b; jouzbarkand, keivani, khodadadi, Seyed-nezhadfaahim, & aghajani, 2013; Sameni-Kievani, khodadadi, & Jouzbarkand, 2013). It is written as follow:

$$Q = AX_1^{\alpha} X_2^{\beta}$$

Where, A, α and β are parameters. In this function, α and β show the elasticity of X_1 and X_2 , respectively. In this form, the marginal demand of X_1 can be estimated as the following equation:

$$Md_{X_1} = \alpha AX_1^{\alpha-1} X_2^{\beta}$$

And the marginal demand of X_2 is obtained as follow:

$$Md_{X_2} = \beta AX_1^{\alpha} X_2^{\beta-1}$$

Hence, the marginal rate of technical substitution between X_1 and X_2 , MRS_{x_1, x_2} , is:

$$MRS_{x_1, x_2} = \left(\frac{\alpha}{\beta} \right) \left(\frac{X_1}{X_2} \right)$$

3-2. Possibility of Including "Energy" Topic to the "Industrial Production of Building"

Traditional methods of construction of required housing units of the country, in addition to contradictions to the standards, such as increased energy consumption and environmental pollution has serious consequences. Studies indicate that energy consumption of buildings in Iran is equal to the advanced countries and are estimated equivalent to 310 kWh per square meter per year, while the industrialized countries this consumption has been listed equal to 120 kWh per square meter per year.

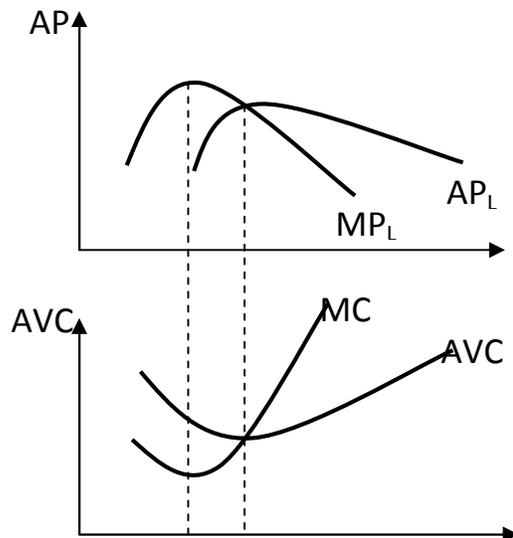
Per capita energy consumption in Iran is double that of China and five times of India. What is a lot of regrets is that 55.5% of the country's energy production is consumed in residential, offices and commercial buildings. This figure represents the community as being consumed that a solution should be found as soon as possible.

The cases mentioned above, are related to the energy loss during the operation of the building. Another important issue is focused on the energy in the production of buildings process. Many constructional materials used in traditional method results from costly, low-efficient and high waste processes. For example, production of brick in traditional and even industrial method is a typical example of this claim. Amount of energy used to produce one cubic meter of brick, has been estimated to be three times the amount for lightweight concrete. However, heat exchange of a block with a thickness of 20 cm of gas lightweight concrete is equal to a block with a thickness of 130 cm of compressed brick. On the other hand, the constructional production in traditional method has been associated with environmental degradation and this is by no means consistent with the principles of sustainable development. For example, to produce a cubic meter of lightweight concrete we take the raw materials from nature and five cubic meters (five times) of lightweight concrete is produced; whereas in the production of bricks, it will be less than twice the said number. The current system of global energy consumption patterns in construction industry is far from Iran's pattern and this makes extensive research required in this regard (Khalili-Sourkouhi, Sameni-Keivani, Mohammad-RezaAlmasi, Bayat, & Makouei, 2013; Safabakhsh-Ghasemi, madrakian, & Sameni-Keivani, 2013; Sameni-Keivani, 2013; Sameni-Keivani, Almasi, & Bayat, 2013).

3-3- Possibility to Reduce the Cost Price of Building

In the housing construction industry due to the high efficiency of production factors and the replication process, affordable and economical construction of housing is possible. Generally, the technical factors that influence the price of buildings - aside from macroeconomic and also land prices issues - are observable. Undoubtedly, such factors as the quality of raw materials, loss (pert) of material, lack of efficient and effective monitoring system, non-trained workers and technicians, the impact of human error, the employer's role in project, etc. are among the reasons for the rising cost of building that the footprint of all these factors is evident in traditional construction. Now, if all the production steps from the workshop are taken to the factory and only assembly operations would be done in place, all of the mentioned factors can be adjusted and even in some cases are removed which this itself will bring down the cost price of the building (Sameni-Keivani, Almasi, & Bayat, 2014; Sameni-Keivani, Almasi, Kamranzadeh-Ezmareh, & Bayat, 2014; Sameni-Keivani, Almasi, Khalili-Sourkouhi, Makouei, & Bayat, 2013; Sameni-Keivani, Almasi, Safabakhsh-Ghasemi, et al., 2013; Sameni-Keivani, Bidarian, Najibi, & Ghasemi, 2014; Sameni-Keivani, Jouzbarkand, Khodadadi, & Aghajani, 2013).

The relationship between production and costs functions are shown in the following figure:



Considering the high cost of housing in Iran, housing is considered as an investment good that this has led to speculation in the housing market and this gives rise to irregularities available in this area. Meanwhile, in most developing countries housing is the consumer good. Certainly, by the possibility of mass production of buildings in the form of scientific and industrial techniques of construction, decline in housing prices and the change of consideration of the housing from investment to consuming will occur.

3-4-Specialization of Construction and Proprietary Management of Professionals in the Industrial Production of Buildings Process

The executive management of workshops that are implemented by industrial method is among the elements of planning and implementation of the project. Regulating of implementation procedures and coordination of them with each other and avoiding waste of time in projects are among management arts of these complexes. Therefore, industrial construction workshops management system should be changed and also should be subject to the modern management method. Programming to advance the executive operations requires the needed knowledge and experience and understanding of the electoral system for implementation of construction. Execution management in the industrial construction system must be enabled in building design phase so that by transferring the practical experience to the design team and consideration of expertise and art viewpoints of the design group, it would be helpful in procurement required for implementation, qualitative and quantitative improvement of product (building). In fact, it is the reverse engineering referred to as requirement for operation of industrial constructional projects. From considerable points we can mention the financial problems for such projects. Financing industrial projects need a mechanism different from conventional methods. Large initial investment needed to start the project and the project's funding allocation, needs a different investment method for the contractor and requires an objective and scientific financial management.

On the other hand, considering that all the production process has become scientific and requires specialty and experience, therefore, constructional human from the current state that is in the form of non-expert workers will be transformed into the trained and experienced technicians and workers. Because, given the wide working scope, everyone could not be trained with more than one or a few specialties which in addition to raising the qualitative production of buildings, it will improve the cultural issues involved in the present in workshop environment as well.

4. Threats

4-1- Change of Transport Scale in Industrial Production

Considering that in the industrial production of buildings process, the place of "production" is separated from "assembly", For example, prefabricated buildings is produced in Tehran and use in various cities. Therefore, transportations become wider and sometimes bulkier and heavier. For instance, in a closed modular system (such as a tunnel system) transportation of the parts would be changed from conventional form into huge displacements that it can impose some costs to the project.

On the other hand, the change of parts sizes and transportation of them in the current situation of configuration of cities in Iran could sometimes lead to some problems. Major problems in the railway sector are as follows:

- 1- Lack of belief in the privatization of the railway sector
- 2- Shortage of wagons and locomotives
- 3- Imbalances in the rail network of the country.

Narrow and densely streets of the most cities of the country sometimes rule out the possibility of the construction industry. This must be considered in the future definitions of urban development projects, especially in metropolises.

4-2- The Risk of Exclusivity of Benefits and Limitation of Competitive Strength in the Construction Market

The prefabrication of building (especially heavy prefabrications), requires large investments and establishment of huge manufacturing plants. This while being beneficial, can restrict the competition and lead to exclusivity in market. Among these, the State as a trustee to regulate the market is responsible to prevent price increases of construction technology and finally cost price of the building by controlling and monitoring policies.

4-3-Possibility to Reduce the Individual Creativity and Human Skills

Architecture in every society is the mirror of its ethnic identity. In fact, abstract and results of aggregation and interaction of the factors such as history, climate, social characteristics, and governmental conditions such as capitalist or communist Islamic system, economic and living conditions, religious ideas, natural landscape and many other identical factors form the architectural community. Now, mass and series construction of housing may largely

contribute to the fading of the artistic and creative dimension of the architecture and lead to the element of creativity among industrial creatures. It can be seen as the most important challenge in industrial production of buildings.

5. Conclusion

Undoubtedly, some opportunities and threats are laid within any new phenomenon or scientific and technical findings. Unfortunately, in the contemporary history of Architecture of Iran (from Qajar era to the present) the ways of dealing with the emerging events, has not been so thoughtful and insightful, so that many of scientific achievements imported to our country have led to unpleasant results.

Considering that a few researched have been conducted in industrial production of buildings in Iran and therefore in this area we are more reliant on the research results of foreign industrial countries, thus, it is necessary for the researchers of the country to conduct researches in the fields of design, construction, type of materials and their sustainability in industrial production of buildings, cultural and social consequences and implications, by support of the relevant academic and scientific research organizations so that lack of access to these resources would be resolved and so the first and most important obstacle in the industrial production of building would be removed. In the theoretical principles discussion a policy should be made while considering the human and climate conditions, which some standards would be prepared and formulated that while consistency with national conditions, industrialists and designers would select the framework of activities and the right path of design and construction by accessing to them.

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