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New Directions towards Industrialization in Construction

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Abstract

Due to its great advantages such as quality increase, mass production and so on, industrialization in construction has been so much considered within recent years. Therefore it is really necessary because of current problems of building construction in the country and ever-increasing need to housing. Industrialization has been presented through different periods of time with increasing of demands and economic necessities and different points of view. It has different explanations and definitions through the time. Recently and upon a change of attitudes about industrialization and its necessity for quality increase there are some other methods for related definitions, concepts and degrees of industrialization. In this paper we have new definitions and attitudes about industrialization by reviewing new resources and papers with an explanatory and analytical method. These attitudes have been presented in three sections of quality, economy, sustainability and personalization. Therefore all industrial constructional methods in recent period are generally open constructional systems for further quality increase and economy and personalization of product and in parallel with resistance. For this purpose there are new definitions and concepts with special degrees of industrialization which have been considered in this paper. The present study may specify new points of view about industrialization along with required studying fields for further consideration of suitable industrial methods in Iran.

Key words: Industrialization in construction, new directions, sustainability, definitions and concepts, industrialized building systems (ibs).

1. Introduction

There is a reconsideration of industrialization idea in architecture due to the quick and great production, economy and quality building and also better finding out the resistance and optimization at different conditions. Industrial architecture does not include only pre-fabrication but it is a wide scope of architectural methods including simple and even traditional up to pre-fabricated methods. After *World War II* great necessity to housing and building and high demand were the real reasons for applying of industrial methods based on economic goals and finding quick and cheap and so mass housing. Again it was re-presented after a standstill period at the end of 1970 (Olia,?). But industrialization was not the only goal of economic ideals at that time. The quality increase was also the center of attention with some important abilities in industrial methods. Therefore some other definitions of industrialization presented accordingly and new attitudes and concepts were presented in this regard with pointing out to new ideas and goals. There is a consideration and comparison of different types of presented concepts within recent years about industrialization. Then all contemporary concepts will be considered in this field.

2. Presented Definitions and Concepts in industrialization

Generally the construction methods would be defined in a scope of definitions while we have completely industrial methods in one end and completely traditional methods at the other. We have common methods at the middle of this scope including improved building construction methods up to semi-industrialized ones. As a result all industrial methods could be defined in a scope with different degrees of industrialization (Abdullah, et al, 2009 and Ghasemzadeh,et al,2008). In addition these methods have a lot of variable types and forms.

Upon any changes in our attitude against industrialization there are different definitions for this item. Industrialization in its public word means any pre-fabrication. But today by providing new concepts and attitudes in this regard, researchers provided different industrial construction methods as a process and/or technique as well. There are different definitions in this regard as mentioned below.

2-1-Industrialization definitions

Industrialization is a socio-economic process through which a society will change from pre-industrialization form into industrialization (Abdullah et al, 2009). This is mainly a part of wide modernization process through development of new methods of production and technology. This means that factory production is based on centralization and ordering of activities and mechanization of operations by focusing on mass production (Abdullah et al, 2009, Thanoon et al, 2003).

Industrialization is based on high capacity for reducing the prices and betterment of quality and further access to complex products is for a wide scope of people. This is one of the reasons which will be presented today by different products including building materials

(such as ceiling beams, pre-fabricated concrete parts of windows & walls, etc). In addition we have industrialization in building construction as a non-executive part. If an automobile is manufactured with the same method of building construction a little number of people would be able to purchase it. If a computer is made with the same method it would be considered as a real wealth (Richard, 2004).

In a comprehensive definition of industrialization, it is a general organizing based upon quantity in which there is a completed and personalized product (Richard, 2005).

A - General organizing means group making of all participants (Craftsmen, Founders, Designers, Managers, Distributors and installers ,etc) in a continuous interaction completely like sub-contractors and partners.

B-It is based upon quantity and as a great market of continuation of production and capital depreciation in a process with simplification of product.

C-To provide a completed & personalized product that means obtaining a variety through mass orders.

Perhaps the completed product in building industrialization is not a standard building because the necessities of end user and the relevant site are completely different in each case. The completed product is preferably a constructional system. A constructional system is a similar collection of harmonized parts or tools for producing of different buildings with different forms, sizes, functions and locations. We have equal details in a constructional system. But there are completely different buildings. In other word a constructional system is a collection of different parts with relevant rules while the details solved before the real building plan. There is no repetition of construction method for a plan of building but there is a collection of drawing activities like traditional attitude in which we may behave with a building like a variant. Therefore the products in industrialized construction are not the buildings but the constructional systems. In addition it is necessary for each process to provide two requests of production simplification and proposing an intelligent job distribution between factory and site. The most important part of a constructional system is the relevant sub-systems which are generally related to the most important functions of a building (Richard, 2005). A constructional system is generally includes five sub-systems of formation, external part, separation walls, services and equipment (Richard, 2005). We have industrialization as a process in some of the mentioned definitions and /or a technique in some others. In addition there are different attitudes in new and old definitions (Jaillon and Poon, 2009, Thanoon et al, 2003).

2-2-The scope of relevant concepts with industrialization

Today there is a wide scope of terms and concepts in the field of building industrialization due to the development of industrial methods along with different definitions and meanings. Although most of the mentioned concepts and/or terms have similar meanings but they are mostly included in different industrial methods and/or procedures. By the way it is necessary to provide an exact definition of all concepts and terms in accordance with current valid resources. Then it is possible to use correctly the real meaning of specified terms.

The considered concepts show a change of attitude towards industrialization in contemporary period while the wideness of concepts and terms will explain the wideness of industrialization in recent years accompanied with replacement of centralization from process to

manufacturing process. With regard to concepts it is obvious that industrialization includes some new concepts for presenting some new attitudes to this item.

3. Different degrees of industrialization

Industrial methods include a wide scope of construction methods with regard to the scope of industrial methods as mentioned in previous sections with different types, variants and classifications. In a general classification and according to the industrialization degree all common construction methods will be divided into advanced degrees methods (or optimized construction), semi-industrial methods and industrial methods (Ghasemzadeh et al, 2008). It is possible to provide a new attitude of 5 steps or degrees for industrialization (Figure 1). The first four items are pre-fabrication, mechanization, automation and robotic (Richard, 2005). These cases need a considerable primary capital for production facilities. But in most cases it is possible to increase traditional production process and only transfer of works from human force to machine. The fifth degree which is named re-production indicates to research and development of renovation process which is able to have production simplification (Richard, 2005). Following is an introduction of different steps and degrees.

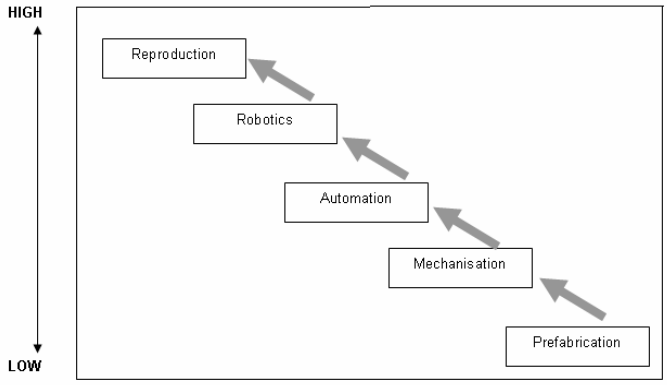

Figure 1: Degrees of Industrialization
(Abdullah, et al, 2009), Adopted from Richard (2005)

1-3-Prefabrication

Prefabrication in building industry generally means manufacturing of different parts (in factory) or complete modules similar to the same in traditional building workshop and in most cases there is an application of similar processes and materials. Prefabrication could reduce construction costs up to %15 due to the following reasons: (Richard, 2005)

- Keeping the environment
- Logical duties in production line
- Exclusive tools & application of equipment
- Semi-professional human forces
- Better quality control
- Purchase & major supply of raw materials

3-2-Mechanization

Mechanization means applying of machine for simplification of human force. Generally we have prefabrication with mechanization.

3-3-Automation

By automation it is possible to enable the tools to do all duties of human force. In this case we have the supervisors as the industries engineers and programmers. According to a study of wooden panels manufactured by automation show an increase in economy up to %27 in comparison with traditional manufacturing methods, while they could obtain %90 of continuous single-unit houses market in 1990 (Richard, 2005) .

3-4- Robotics

Similar tools will find multi-model reflection for providing various duties due to the robotics. Future robots related to production by computer (CAD) are able to manufacture complex forms which could be different from one product to another. This method will make the way easy for personalization through mass production and finally mass ordering production (Richard, 2005).

3-5-Reproduction

Reproduction term has been borrowed from printing industry. In comparison with printing industry, there is a method for further economy and production in architecture. Reproduction is an introduction for innovative technology with increasing simplification ability or complex production. The major goal of reproduction is to shorten repeating linear functions as a special attitude of handicrafts (Craftsmanship). Instead of a direct attitude towards mechanization, we have reproduction as the first request in researching and developing of ideas for simplified production process. Reproduction is not necessarily an applicable option and is generally accompanied with other degrees of industrialization (Richard, 2005).

The important point in different degrees and steps of industrialization is that these procedures are not necessarily pre-requisite and/or introduction of each other and industrialization could be applied at any step. This means that industrialization even could be applied at the final step which means re-production. This is really a chance for under-developing countries in order not to pave the long way of industrialization again (Richard, 2005, 2004).

4. New Attitudes in Industrialization

4-1. Industrialization & quality and economy

Any efforts for industrialization of building will be divided into three periods with regard to the history of industrialization in architecture history (Olia, ?). The first period includes the middle section of 19th century up to World War II as the writing period of theoretical bases and industrialization theories. The second period starts from World War II up to the end of 1960 as the executive period of theoretical bases.

All industrial constructional methods were considered for supplying of cheap & quick mass housing production. In other words the major goal of applying of industrial methods was economic ideals. For this purpose all industrial buildings of this period had no more architectural qualities and even suitable executive situation. Therefore the mentioned buildings were involved with lack of variety and harmony. For these reasons and even with

economic bottlenecks and removing any crisis there was not any consideration of those methods.
Then it was the time of standstill in applying of constructional industrial methods at the end of 1960 in order to focus on those methods with modifying the attitude and changing he process. The third period of industrialization was started from the beginning of 1970 and after the standstill period. The only goal of pioneer countries in this period was not economic ideals only but to upgrade the quality by the use of different methods and applying of advanced technology in designing and production and manufacturing and betterment of architectural qualities with different methods including reflection, personalization and so on. In addition some new problems were presented in this period including re-production, mass order, personalization of industrial products and other cases. As a result the third period is named as infra-industrial period.
Ideally in industrial methods we have the high number of units for production (quantity) may cause distribution of the price of a process in a lot of small parts. In contrast of this process it may reduce the amount of functions and make it simple and with more care. The result of which is better quality with lower price exactly like what is happening in other industries. For example production of industrialized houses has been started in Japan from previous decades. It is like 3-dimensional modules and pre-fabricated panels in a continuous production line completely similar with what is happening in automobile industry. Therefore the product has changed in to an order as simple as possible. All production lines are able to satisfy the necessities of customers through reflective tools and equipment and combination of them with a higher level of ordering production.
All pre-fabricated houses in Japan would be designed and manufactured in accordance with the necessities and demands of purchaser while different parts of the plan have been completely standardized and produced in a mass situation (Richard, 2006).

4-2. Industrialization equal with sustainability

Compatibility with socio-economic and environmental condition is one of the most important goals of fixed development. Some of its most important specifications are income programming, easy compliance and changing of designing for reduction of costs and maintenance of natural & environmental values.
Although most of these items are considered as general principles but it is necessary to find some executive guidelines and applicable methods for them. One of the special ideas in this regard is to apply an industrial thought in planning and execution most of which may cover our fixedness goals.
Industrialization is a power in parallel with fixedness. Followings are different points in relation with economy, factory production and compatibility: (Richard, 2006)

1- General organization will promote a product with continuous production in which similar methods, knowledge and experience would be applied instead of concluding a new group for new projects.
2- Simplification of process will reduce long-term workshop functions step by step from traditional manufacturing and resulted consumed energy in each project.
3- Working at factory will prevent from time wasting out of any changes in climatic conditions.

4- Dimensional coordination, total purchase of raw materials and completed factory product will reduce any wastes %40 to %100 in comparison with traditional construction at site.
5- It will provide an insurance coverage for quality control of factory and as a result it is possible to prevent from unnecessary shortages which may need further repairs.
6- There will be a reduction in maintenance functions at site due to the full care in production of factory while the manufacturing process is performing at sight in a clean and wastes free condition.
7- Dry connection methods will be applied in different parts or reflective sub-systems which may make it possible to have any repairs without any normal destruction of partitions at the time of renovation. It is also possible to have more changes or changing of building location without any wastes out of destruction.

Also the following items are discussable about fixed designing and architectural idea based upon industrial thought: (Mirsaeedie, 2009)
One of the most important items in fixed architecture is a transaction between technology and environment or better to say a relation between technology and environment. It is a permanent case upon benefiting from daily technology and with a suitable relation with environmental conditions (in its public meaning). It is possible to say that this trouble is also present in any designing based upon industrial thought. Today most of designing and manufacturing methods have been innovated in this regard and in contrast with previous samples, today industrial methods are compatible with this situation.
Fixed architecture is a type of architecture in compliance with continuous conditions and necessities. One of the most important problems which are the focus of industrial thought is compliance with conditions and necessities as obvious in new methods. Also continuity is also one of its basic principles.
Efficient programming (for designing of a fixed environment) includes easy compliance and changes and responding to different conditions. New construction technologies may consider the subject of compliance and changeability and responding in different conditions. For example we may point out to Habraken open system Construction theory which is intending to create this property besides benefiting from pre-fabricated structure.
Furthermore a complete programming is also the other principle of industrial thought while all designing and construction activities are defined in a combined, efficient and programmed system in order to provide optimized situation.
Designing is used for making a change in fixed architecture by a simple and modular designing in a way to be compatible with development and increasing the needs. Modular designing is the most important principle of industrial thought in architecture which is performed with the goal of optimization and standardization. Minimizing the applicable spaces in optimized designing and reducing any non-used spaces due to the dimensional coordination and benefiting from modulation are also applicable in industrial thought.
It is possible to minimize any establishment and maintenance costs of building by an efficient programming and designed process by the help of constructional system in industrial architecture. Most of industrial architecture solutions including designing of constructions with changing possibility of parts and so on may also reduce the costs.

According to the above-mentioned items it is possible to consider the idea of industrial thought in architecture as a guideline in reaching to fixed architecture. This type of architecture which would be named as industrial and fixed industrial architecture should bear some other specifications in order to be included in the scope of fixed architecture. Most of modern industrial methods have developed in this way and based upon relevant conditions and necessities. Modern industrial architecture could be defined in the scope of fixed architecture in accordance with the idea of quality increase and coordination with the environment and go toward more flexibility and with a suitable planning and further optimization.

4-3. Industrialization & Individualization

One of the suitable specifications of industrial product is to provide better options and selection for a customer. It could be presented as a most important and suitable facility. A completed product means all customers are entitled to try it before receipt of product. This is exactly with the same condition in a trial driving in automobile industry. But in traditional industries any financial obligation of customers would be based upon one set of primary drawings which are hardly understandable in most services (Richard, 2005, 2006).

Individualization of a building means any creation of identity and its dependency while all family members bear a personal space and in compliance with their own expectations and conditions. This subject that was the most important weak point in previous periods and was the real reason of removing any industrial methods intends to enter into industrial methods in current decades.

There are four guidelines for creation of individualization through mass production in other industries as: flexibility of the Product, flexibility of tools and equipment, a framework with multipurpose framework and combinability (Richard, 2006).

1- Flexibility of the Product

The product should be flexible at the time of usage such as transportable separators. Of course this type of product would be more complicated due to the related mechanism. But it has been reasonable for manufacturers due to a greater market and high reflections.

2-flexibility of the tool: Variety in products is applicable by the used tools and through one of the variable geometry ways such as multiple framing, changing the element form of machine producer, changing the instructions. Obviously any computer-assist manufacturing may accelerate reaching to reality point of finding mass order.

3-Multipurpose framework: An equal product means a framework for different functions through the following cases:

- Adding specified parts such as S.A.R attitude which has been designed by N.J.Habraken (1976). In this concept we have the connection of separating units for construction of compliable residential units to a supporting formation.
- Minimum rate of modifications & changes: It is like factory modular houses in different sizes and types. These items are in different cases accompanied with personalized pack (Arc windows, balcony, door back and …)

4-Combinability: It means providing a lot of compounds out of a group of fundamental parts which have been produced in high quantity and high quality. It is possible to provide a great number of changes by modular dimensional coordination such as spacing and simple connective elements (Including screws and nuts).

5. Conclusions

In this paper, after a comprehensive review of definitions and concepts in industrialization, new directions of industrialization have been discussed in three sections, quality and economical advantages direction, sustainability direction and individualization direction. As a result, contemporary industrialized building systems, very often, should be open systems, and have been designed posses high quality, economical advantages and individualized production, so they are towards sustainability. The main objective of this paper is to study new directions of industrialization in construction, which leads to discuss contemporary and progressive trends of this subject, so this paper offers a background study for the hazardous subject of industrialization in construction in Iran.

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