IMPACT OF PREFABRICATION ON PROFITABILITY OVER TRADITIONAL CONSTRUCTION

Evanjaline Libie
PG Student
Department of Civil
Arunachala College of Engineering for Women
Mail id: evanjalinelibie@gmail.com

Abstract- Prefabrication has been widely regarded as a sustainable construction method in terms of its impact on environmental protection. One important aspect of this perspective is the influence of prefabrication on construction waste reduction and the subsequent waste handling activities, including waste sorting, reuse, recycle, and disposal. Nevertheless, it would appear that existing research with regard to this topic has failed to take into account its innate dynamic character of the process of construction waste minimization; integrating all essential waste handling activities has never been achieved thus far. This paper proposes a dynamic model for quantitatively evaluating the possible impacts arising from the application of prefabrication technology on construction waste reduction and the subsequent waste handling activities. The object of this project is to identify new technologies or methodologies in the Construction Industry that could require new training or up-skilling of the trades and semi-skilled workforce.

Keywords: **Prefabrication, Industrialization, Modularization, Preassembly, waste reduction**

1. INTRODUCTION

1.1 Need of the Project

- Prefabrication is one of the key elements of industrialization in construction.
- Prefabricated construction methods are presenting a range of techniques to improve the building construction, quality and how to reduce the negative impact of building production on the environment.

1.2 Scope of the Project

- My project deals about the theoretical apparatus defining a classification of prefabrication in construction.
- It deals about the criteria that influence the decision on the deployment of prefabricated elements to the project.
- It also brings the results of survey focused on the application of prefabricated construction methods.

1.3 Problems of the Construction Industry

The subject of construction as an environmentally unfriendly activity has become arguably redundant. The level of pollution generated by construction alone is overwhelming and has been worsened globally due to the rapid rate of urban development. The challenges faced by and imposed by the construction industry on the environment and human life have been identified as construction waste, GHG and carbon emissions, high energy and resource consumption rates, and the lack of technological advancement in the face of the fast-paced movement of other industrial sectors.

1.4 Structures And Policies

In the precast concrete industry, outlined some of the constraints of the construction industry. Chief amonpg them were the economy of a nation, government and labour policies, and climatic conditions. The author stated that it was the response of the construction industry to these constraints that has set in which has guided the industry's path to efficiency and effectiveness.

With the unpredictability of any nation's economy, its governing policies as well as the changing climatic conditions in any given period, the construction industry has had to, and still has to cope with fluctuating demands in its effort to maximize flexibility. Thus, the construction industry has grown to become a characteristically fragmented industry. More so, there is a deficient working relationship that exists among the various participants of the construction process. Each sector looks to meet its inherent needs, disregarding the need for harmony required to effectively implement a complete construction process. The long-term results are seen in the industry's enduring inadequacies, its increased difficulty in meeting the demands and specifications of more complex projects with the required standards and quality, and expectedly, high costs of construction.

1.5 Lack of Research And Development

Another issue of major import is the patent lack of research and development in the construction industry. Although there has been a significant improvement in this regard over the last few years, the attempts are at best few and far between. Only in more recent times with the growing urgency to 'curb the excesses' of the industry have there been noticeable tracks on the path to sustainability in construction. Specifically apropos construction methods, the transition to the post-industrial age seems to be a perpetual struggle, set back by the industry's outright preference for the customary methods - the conventional construction systems - and it's rather slow acceptance of industrial or factory-based building systems.

Unlike other industries of the economy that are quick to embrace technological advancements such as the manufacturing industry which has a constant influx of new products that improve productivity and product quality, the construction industry is set back by its snail-paced adoption of technology. As a result, where mass-customization of goods and services has enhanced and continuously so, the quality of work and life, especially from the beginning of the 21stcentury till date, the construction industry seems to be experiencing regression

1.6 Environmental Impacts

As earlier stated, construction activities propagate environmental pollution which eventually causes climatic change that is fast becoming the bane of human existence. Overwhelming scientific evidence points to climate change as the gravest threat to humans by humans. Since the 18th century, precisely 1750, the concentration levels of GHG have increased considerably. The most notable of these atmospheric pollutants is carbon dioxide (CO2). From that time till the present, CO2 emissions from both the combustion of fossil fuels and the manufacture of cement, a prime construction material, have contributed to over 75% increase in atmospheric CO2.

According to CO2 Data, CO2 concentrations have increased from the mean monthly value of 315.71 in 1958 to the most recently recorded value of 396.18; a rise that has resulted in global warming. Climate scientists have declared that there is very limited time - years and not decades to balance CO2 and other GHG (CO2now.org 2011). Hence, energy conservation has become a crucial factor in mitigating the consequential emission of carbon and GHG attributed to the buildings. Referred to in terms of CO2, the energy and carbon emissions associated with a building's life cycle occur in three uniquely interdependent stages: construction, occupation and demolition.

As long as there is production, the extraction, refinement, manufacture, transportation and eventual use of raw materials, expend energy and create environmental impacts. Despite the fact that these impacts are considered 'hidden 'or 'embodied' and are usually regarded as inconsequential to the overall amount of energy consumed during the design and construction of a building, the total embodied energy and carbon emissions are markedly influenced by the choice of construction materials and construction technology. The energy associated with construction waste is another area of grave concern. In order to address the problem of embodied energy, it is important that the efficiency of construction and use of buildings be revised.

1.7 Waste

Construction waste has been construed to be one of the major pollutants of the environment. Waste by definition is anything in excess of the minimum requirement of equipment, labour, time and materials essential for production, which should be eliminated for its lack of added value to the product in question waste is defined as the excess material resulting from human and industrial activities, with no additional worth. Another definition of waste is any: substance which constitutes a scrap material or an effluent or other unwanted surplus, arising from the application of any process, [and is required] to be disposed of as being broken, worn out, contaminated or otherwise spoiled.

More specifically, construction waste is defined as "the by-product generated and removed from construction, renovation and demolition workplaces or sites of building and civil engineering structure" identify two main classes of building construction waste: structure waste and finishing waste. Structure waste refers to waste generated during the course of construction, such as abandoned timber plates/pieces, reinforcement bars and concrete fragments. As such, the classes are concrete, mortar, roof tiles, sand lime bricks, piles, stone tablets and other fragments of wood and metal. Sources of waste are categorized under design inaccuracy, equipment handling error, material management, procurement and residual sources

The impact of construction waste on the environment is borne on a global scale. For instance, 17% (70 million tonnes) of the total generated waste in the world per year is solely from construction and demolition operations, making the construction industry the highest producer of controlled waste in the world. This amount is estimated to be 24kg of waste per week per UK resident, four times as much as that generated by household activities. Similarly, in Australia, 44% of the 14million tonnes of waste reported annually is contributed by its building construction industry.

In Wei (2006)'s extensive study on waste management, several causes of the high levels of waste encountered in the construction sector are analysed. One such cause is the poor attitude towards waste management which is blamed on the mind-set of operatives, for whom it is predetermined that waste generation is inevitable in construction, and minimization efforts are of non-priority. In addition, the cultural attitudes of the employees of any organization play a large role in their perception of waste management practices. Where such practices have been successfully implemented, there are higher chances of a positive attitude towards their constant implementation. On the other hand, the fear of diversity that has long held back the construction industry could be a major hindrance to the acceptance of new construction methods that will adopt waste management. This fear is particularly attributed to a severe lack of knowledge about the environment, although in Chan's (1998) opinion, the media's influence has bridged this gap. Another main cause of poor waste management is design changes, of which the belief is that constant changes in design details during construction due to insufficient knowledge, experience and miscommunication, play a major role in high levels of construction materials waste (Wei, 2006).

To summarize, the building construction industry is in dire need of sustainable development. According to Ramesh, Prakash and Shukla (2010), this kind of development is characterized by low-level environmental impacts and high-level socio-economic benefits. The realization of sustainability in the building construction industry requires an adoption of strategies that include a reduction in energy demand, enhanced use of materials and resources, efficient waste management and subsequently, stabilization of carbon and GHG emissions.

1.8 Prefabrication: A Relevant Definition

Prior to this research, it was the belief of the author of this work that prefabrication existed as a construction method on its own. However, it has been found that the term "Industrial Building System" has several related terms: modularization, prefabrication, preassembly and industrialization. The categorization of these terms will be discussed in detail in the sections below based on a thorough literature review of these terms and their scope of use. For the purpose of this research, prefabrication is considered as the main IBS under study, and the term will be used in reference to modern construction methods. Several studies indicate that the definition of prefabrication is as widely varied as its terms of reference.

Prefabrication could either be classified under IBS or modularization, or defined independently. In order to establish an understanding of the term and its relevance to this research, and allay the erroneous, an appropriate definition will be established based on previous related works. According to Haas et al. (2000), the various definitions which exist are subjective to time, industry and the purpose of the study as there is no organization monitoring the progression of these technologies, besides the Manufactured Housing Institute for the residential sector.

Modularization:

Modularization is defined as the off-site construction of a whole system prior to its transportation to the site of construction. The modules may often be required to be broken down into smaller sizes for ease of transportation. Modularization usually involves more than one trade.

Prefabrication:

This usually involves a single skill or trade and is generally defined as a production process, which normally takes place at a specialized factory where different materials are combined to form the component of an end-product. As long as the component is manufactured at a factory and is not a whole system, it is regarded as prefabricated.

Preassembly:

By definition, preassembly is the combination of various materials and prefabricated components at a separate facility before installation as a single unit. This installation is carried out similar to the process of modularization in which the manufactured components are assembled close to the site, followed by on-site installment.

Industrialization:

This term refers to an inclusion of all three aforementioned categories of offsite construction. Industrialization is based on the concept of manufacturing and is defined as the procurement of technology, equipment and facilities in order to increase productivity, reduce manual labour and improve production quality. Kok (2010) identified several definitions of prefabrication from previous literature.

Another defines prefabrication as "… a manufacturing process taking place at a specialized facility, in which various materials are joined to form a components part of final installation" (p. 16); and finally a prefabricated building is one: which consists of elements that are manufactured or fabricated in a location (off site) which is not its final destination. They are transported to the site, and connected one to another to form a complete structure. Usually the elements are limited by size of transport vehicles and lifting equipment. The prevailing definitions of prefabrication depend on the authors' perceptions.

According to the definitions above, the general perception is that prefabrication is a process that primarily occurs in a factory or facility (factory); in other words, anywhere but on the actual site of construction. However, prefabrication is not limited to a factory or an offsite location. The manufacture of components can be carried out at the actual site of construction or in close proximity.

1.9 Objectives

- This project proposes a dynamic model for quantitatively evaluating the possible impacts arising from the application of prefabrication technology on construction waste reduction.
- The object of this project is to identify new technologies or methodologies in the Construction Industry that could require new training or up-skilling of the trades.
- Correlation and regression analyses will be used to analyse the data.

2.LITERATURE REVIEW

2.1 Introduction

By nature, the activities of the construction industry while highly productive and beneficial, are environmentally unfriendly. The present global shift to sustain and protect what is left of the endangered environment has led to studies covering various aspects of GHG, energy savings and environmental protection as a whole.

2.2 Review of Literature

1)WajihaShahzad, Jasper Mbachu, and Niluka Domingo.,Prefab content versus cost and time savings in Construction projects

Using a case study research approach, 30 light to medium commercial buildings completed New Zealand, were investigated. The project details acquired included initial cost estimate, final completion cost, estimated duration, actual duration, gross floor area and the value of prefab content as percentage of the final contract sum.

2)ChantelleGrills.,Industrialization of the Construction Industry through Prefabrication and Adoption of Current Technologies

In this project, it is performed in a factory, allowing for the use of automated equipment to reduce labour and full-time factory employees ensure that project delays due to the unavailability of skilled tradespeople are avoided. Improved product quality is achieved through highly sophisticated equipment, better supervision, and climatic protection.

3)The Impact of New Technologies on the Construction Industry By Construction Training Fund, U.K May 2014

There is no single system of building construction classification (as opinionated by Warswaski, 1999). The author believed that such a classification was relative to the user/producer and varied from one to another, usually based on the choice of construction technology. Based on this, it was asserted that four systems could be distinguished as determined by the main structural and enveloping materials of the building: timber, steel, cast in-situ concrete, and precast concrete systems. Warswaski (1999) also suggested that for further classification, the geometric configuration of the components of the building's mainframe could be used as follows: linear or skeletal system (beams and columns); planar panel) system; and three-dimensional.

4) By Majzub .,Prefabrication and Modularization in Construction, 2013 Survey Results

Industrialization of the Construction Industry through Prefabrication and Adoption of Current Technologies.By On the other hand, three building classifications are proffered by Kok (2010) primarily based on their methods of construction: conventional, cast in-situ, and prefabrication construction methods. Furthermore, whereas Abdul Kadir et al. subcategorised prefabrication and cast in-situ under IBS, Kok sub-lists IBS as a prefabrication method. Kok (2010) then defines CBS as the on-site prefabrication of a building's components using the methods of installation of timber or plywood formwork, steel reinforcement and in-situ casting. Cast in-situ construction method involves on-site implementation of formwork, a method that can be retrofitted for all types of building construction. Prefabrication method is defined as the process of manufacturing industrialized or precast construction components, offsite (in a factory), before delivery for erected on the actual construction site.

5)Amanda Marquit.,A History of Prefabricated and Modular Housing

Commissioner Robert D. LiMandrin carrying out the literature review, a note-worthy conflict in the classification of prefabrication was observed. Several definitions of prefabrication are clearly in favour of a system that consists entirely of offsite (factory-based) production of its components. However, Abdul Kadir et al. (2006) state that a fully prefabricated system could be one of two categories depending on the site of production: on-site or off-site (factory-produced). They argue that on- site prefabrication differs from the cast in-situ method. Here, the on-site system means that structural building components are cast in the site before being erected at the actual location. In their opinion, the on-site system also provides more advantage over the cast in-situ method.

6)By WajihaShahzad, Jasper Mbachu, and NilukaDomingo.,Prefab content versus cost and time savings in Construction projects: a regression analysis

Meeting the construction needs requires the utilization of large amounts of energy and natural resources (Balaban, 2012). The construction industry consumes 60% of the earth's extracted raw materials, of which buildings consume 40% (Broun and Menzies, 2011); hence it is referred to as the '40% Industry'. Apart from basic construction processes, the manufacture and transportation of building materials is a significant consumer of energy (Thanoon, 2003). The United States Green Building Council (2003) data on the resource consumption levels of buildings in the United States shows 37% for total energy, 68% in electricity and 40% in terms of raw materials (Jaillon and Poon, 2010).

The growing awareness of this challenge has consequently increased the pressure exerted on professionals in the construction industry to improve the performance and status of the environment (Shen et al., 2005). As such, the need has arisen for a critical review and modification of traditional/conventional construction methods, manufacturing technologies and building functionality.

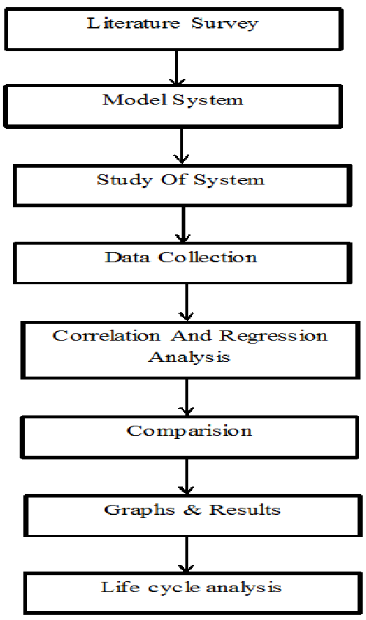
7)By ElzbietaRadziszewska-Zielina, Monika Glen.,Studies of the Prefabricated Housing Construction Market in Poland

An Poland to compare the economic benefits of traditional construction methods to prefabricated building systems indicated that the latter provided site labour savings of up to 70% while its incurred total construction where savings of close to 50% are achieved through the use of whole prefabrication methods. These examples are pointers to the immense positive benefits of prefabrication , in addition to reduced energy consumption, waste minimization, mitigation of GHG emission and overall negative environmental impacts.

An appraisal of building systems, their characteristics and the challenges they pose to the construction industry, especially in urban, fast-paced regions like the UAE, constitutes the background of this study.

3. DATA COLLECTION

3.1 Building Plan



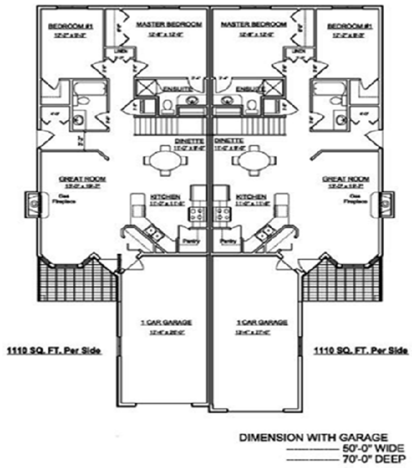


Figure 3.1: Building Plan

3.2 Savings

Cost estimation is done for both conventional and prefabrication construction. By comparing both conventional and prefabrication an amount of **31 lakhs** is saved in prefabrication

3.3 Cost Estimation of Conventional Concrete Building

S.L. NO	Qty	Description	Rate	Per	Amount
1.	4613	Earth work excavation	45.00	M^3	2,07585.00
2.	46.08	P.C.C 1:5:10 for foundation works	3315.31	M^3	152769.48
3.	1703.28	Sand filling	104.00	M^3	178844.40
4.	0.414	R.C.C 1:2:4 for Lintel beam	11700.20	M^3	4843.88
5.	29.30	R.C.C 1:2:4 for sun shade	5202.23	M^3	153465.78
6.	272.45	R.C.C for column	13791.74	M^3	3757559.56
7.	283.98	R.C.C for slab	7868.37	M^3	2234.46
8.	104.55	Flooring with C.C. 1:5:10	3315.31	M^3	346615.66
9.	73.17	R.C.C 1:2:4 for beam	11700.20	M^3	856103.63
10.	387.99	B.W. in C.M 1:5	2904-86	M^3	1127056.63
11.	5993.18	Plastering in Cm :1:5	89.65	M^2	537288.58
12.	48.80	Weathering course in 75mm thick	238.26	M^2	11627.08
13.	5993.8	White washing	11.19	M^2	67063.68
14.	15.84	Flooring in c:m 30mm thick	3315.31	M^3	52514.51

15.	168	Iron hold fasts	11.30	Kg	1898.40
16.	44	Grill Iron work	7000.00	Nos	308000.00
17.	2.001	Wood work	150.00	M^2	300.75
18.	L.S 35%	Miscellaneous	L.S	-	350000
			Total	**RS**	**8108002.81**

3.4 Cost Estimation For Prefabricated Building

S.L. NO	**Qty**	**Description**	**Rate**	**Per**	**Amount**
1.	4613	Earth work excavation	45.00	M^3	2,07585.00
2.	46.08	P.C.C 1:5:10 for foundation works	3315.31	M^3	152769.48
3.	1703.28	Sand filling	104.00	M^3	178844.40
4.	322	living room size 3.5m x 4.0m b) bedroom size 4.35m x 3.6m, c) Toilet 1.80m x 2.0m, d) kitchen 2.15m x 2.0m, e) verandah 1.2m wide.	10000	M^3	3220000
5.	30	f) Doors 3 nos. of size 2.1m x 0.9m and one no. of size 2.1m x 0.75m with powder coated GI frame and powder coated G.I.flush doors 44 mm thick with honey comb construction	58333	M^3	1750000
6.	100	Kraft paper/Mineral wool/PUF infill, with reinforcement at hinges, door closer and lock case fitment infill in desired colors and fittings	6000	M^3	600000
7.	25	g) Windows 4 nos. of size 1.2m x 0.9m of G.I. powder	4000	M^3	100000

		coated fully glazed with two sliding shutters each 25mm th ick in desired colors and fittings			
8.	10	h) Ventilator 1 no. of size 600mm x 600mm with powder coated G.I. frame	5000	M^3	50000
18.	L.S 35%	Miscellaneous	L.S	-	100000
			Total	**RS**	**5050000**

5.CONCLUSION

Evidence from several studies showed that precast concrete construction, besides the improvement of a building's sustainable performance, include shortened construction time; overall reduced costs; enhanced quality and durability; improved health and safety, conservation of materials and energy; waste reduction; and finally reduced environmental emissions. This phase is concluded with estimation of cost for both conventional and prefabricated construction. Further in next phase I am going to find out waste, energy savings, man power using correlation and regression analysis. Also, research on comparative life cycle assessment (LCA) of the performance of the conventional construction method in relation to the use of a selected prefabrication method – precast concrete construction is going to be undertooked. Using a case study high-rise commercial building the aim of the study was to evaluate the differences in energy consumption and environmental impact profiles for both construction technologies throughout the 50-year lifespan of the building, in order to determine which of the two had long lifetime.

REFERENCES

(1)Abdallah, A. (2007). Managerial and economic optimisations for prefabricated building systems. Technological and Economic Development of Economy[online]. Vol. 13 (1), pp. 83-91. [Accessed 10 December 2011].Available at http://dx.doi.org/10.1080/13928619.2007.9637780.

(2)Abdou, O. A., Murali, K. &Morsi, A. (1996).Thermal performance evaluation of a prefabricated fiber-reinforced plastic building envelope system.Energy and Buildings (24), pp. 77-83, (online ScienceDirect).

(3)Abdulkadir, M.R., Lee, W.P., Jaafar, M.S., Sapuan, S.M. & Ali, A.A.A. (2006).Construction performance comparison between conventional and industrialised building systems in Malaysia. Structural Survey [online]. Vol. 24 (5), pp. 412-424. [Accessed 10 December 2011].Available at www.emeraldinsight.com/0263-080X.htm.

(4)Architectural Record (2012). Villa Savoye : Le Corbusier, Pierre Jeanneret[online]. [Accessed 10 December 2011].Available athttp://archrecord.construction.com/community/toptenphotos/2011/110718/slideshow.asp?slide=2.

(5)Andrews Prestressed Concrete (2003). Double tee panels [online]. [Accessed 10 December 2011].Available at http://www.andrewsprestressedconcrete.com/id26.htm.

(6)Asif, M., Muneer, T. & Kelley, R. (2010). Life cycle assessment: a case study of a dwelling home in Scotland. Building and Environment (42), pp. 1391–1394, (online ScienceDirect).Page | 242

(7)Aye, L., Ngo, T., Crawford, R.H., Gammampila, R. &Mendisa, P. (2012).Life cycle greenhouse gas emissions and energy analysis of prefabricated reusable building modules.Energy and Buildings (47), pp. 159–168, (online ScienceDirect).

(8)Balaban, O. (2012). The negative effects of construction boom on urban planning and environment in Turkey: unraveling the role of the public sector. Habitat International (36), pp. 26-35, (online ScienceDirect).

(9)Baldwin, A., Li, H., Huang, T., Kong, C.W., Guo, H.L., Chan, N., and Wong, J. (2009).Supporting pre-tender construction planning with virtual prototyping.Engineering, Construction and Architectural Management [online]. Vol. 16 (2), pp. 150-161. [Accessed 10 December 2011]. Available athttp://www.emeraldinsight.com/journals.htm?articleid=17