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Using Renewable Energy Criteria for Construction Method Selection in Syrian Buildings

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Abstract

Renewable energy criteria can be considered as the first step in the development of the IBS construction industry. They illustrate global criteria that define direct design and construction processes. IBS (Industrialized Building System) has many advantages and benefits that are closely related to renewable energy requirements. The construction sector in Syria - especially in the field of building – is characterized by the domination of traditional methods of building systems. The introduction of modern IBS construction technologies that are compatible with the requirements of renewable is not accompanied by a proven scientific fit and consistent with the administrative decision-making programs for construction and project operations in general. Syria is currently suffering from the great needs of construction imposed by reality, and the need for reconstruction within the possibilities of benefiting from the concept of renewable energy. It has become imperative for everyone working in the field of engineering to keep pace with this development to get the best performance of the work. The research aim is to prioritize the selection of construction methods used in Syria, and to determine how the renewable energy criteria affects the selection within the reconstruction scheme by using the AHP method. The results were as following: The technology advanced prefabrication system had the winning percentage of 37.9% (39.4% in part1). The technical composite system (cast-in-place, pre-cast) came second with 26.5% (21.8% in part1); followed in third place by a low difference developed technology the cast-in-place system gaining 19.9% (20.8%, in part 1); and the last place for conventional building system with 15.6% (18.1% in part 1). Taking renewable energy criteria into consideration will modify the ranking of technological alternatives for construction according to the adaptation of these methods, with the possibility of using renewable energies to replace the traditional ones used to meet the requirements of reconstruction in Syria.

Keywords: Industrialized Building System in Syria, Industrialized Building System (IBS), Renewable Energy criteria, Priority of Construction Methods;

1. Introduction

Construction industry forms an evolutional orientation for construction sector, which is considered one of the important economic sectors, in terms of its role in the formation of fixed capital, gross national product, and the magnitude of its employees [1]. This industry is currently facing unprecedented developmental pressures in our country as a result of the lack of resources and the rising prices of raw material and the instability of environmental factors surrounding it [2]. This encourages us to introduce the new construction, industrial technologies of industrialized building systems (IBS), which are symmetrical with the necessities of renewable energy. Industrialized building systems must keep up with the global trend towards reducing and rationalizing energy consumption in all its forms, and depending on the renewable natural resources in procuring energy which Commensurate with the necessity of introducing the concept of renewable energy in Building techniques.

Due to the size and magnitude of engineering projects in Syria, it is imperative that everyone working in the field of engineering keeps pace with this development to get the best performance of the work. Hence the need to find a clear approach that enables the project owner to choose the best technical building system, the success of the selection process will be an important tool for project success in general, and management of obstacles that may encounter work environment, and therefore achieve goals of reconstruction in Syria within the possibilities of taking advantage of the concept of renewable energy.

Determining the best technical building system is complicated because each has its own advantages and disadvantages. One of the best decision-making methods in engineering management is the AHP method, where different choices are arranged according to different criteria.

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1.1. Research methodology

- Review of previous studies about the construction industry and modern techniques used.
- Determine of the priority to choose one of the technical systems used for construction in Syria using the Expert Choice program.
- And then introduce the criteria of renewable energy in choosing the method of construction and comparing the results with each other.

1.2. Benefits of adopting IBS

The Questionnaire and field survey showed that despite the promotion of benefits in IBS adoption, the industry stakeholders and contractors are still skeptical about the IBS usage since issues such as technical difficulties, enormous capital cost, design conflicts and skill shortages during the construction phase represent the barriers. Accordingly, in addressing a knowledge gap in the construction level, this paper has tried to explain the benefits of using IBS components. The numerous benefits of adopting IBS had been reported by academicians around the world and became the driving force to the construction industry players in deciding whether to use IBS or not [3]. The benefits of IBS adoption are summarized in Table 1.

1.3. Previous studies

The terminology used in the construction industry could hardly be defined, and definitions rely heavily on user experience and the amount of understanding, which vary from one country to another, but also there are several definitions developed by some researchers in this field, [7] defined IBS as the component manufacturing, assembling, transporting, and placement construction using minimum additional work possible inside or outside the site. While the Construction Industry Development Board (CIDB) in Malaysia defined IBS as a building system where components being manufactured in the factory or off-site, then developed and assembled into a structure with a minimum of extra work at the site [9]. [11] Defined the IBS as an integrated manufacturing and building process, organized and planned well to achieve efficiency in the management, setup and control of resources used and support the activities and results using sophisticated components. There are different classifications of IBS according to [4] depends on: materials, processes and systems. It is important to develop a clear vision for different types of construction systems and modern techniques used that contribute to getting the IBS and are an integral part of it. Generally, there are four types of building regulations in accordance with the Badir-Razali Building System Classification which are: traditional building systems, cast in place, pre-made, and composite [12]. Each of the construction systems is represented in accordance with their own construction methodology, its advantages in addition to construction technology, and the engineering and functional composition [5] as shown in Figure 1.

The different template systems offer a wide range of concrete construction solutions that can be selected to suit the required development needs [13]. In Syria, reconstruction requirements impose significant challenges on this sector in terms of the need for the introduction of modern technology systems and following the designing solutions and management decisions that fit these challenges, in addition to the production of buildings within time and economic constraints.

Table 1. Summary of IBS benefits resource (author and Izatul laili Jabar [8] et al Idrus, [6] 2013)

Benefits	Explanation
Cost and financial	IBS offers cost saving through:
Advantages	- Earlier completion time (Kamar et al.,2011; Pan et al., 2007). Repetitive use of system formwork made of steel, aluminum, etc. (Thanoon et al., 2003; Besharah et al., 2015). - Less wastage (Idrus et al., 2008). - Reducing site infrastructure and overhead (Kamar et al., 2011). - Increased certainty less risk (Pan et al., 2007).
Construction speed	IBS construction process is governed by the speed of production and controlled environment of manufacturing facilities (Aburas, 2011), thus the need for fast delivery can easily be met by increasing the production capacity (Abdullah et al., 2009).
Reducing labor	The using of foreign labor (Jabar, 2013). The using of IBS component, which is manufactured in centralized factory, automatically will reduce labor requirements at construction site (CIDB, 2010).
Better quality	Better quality products can be produced with the adoption of IBS as it uses good quality components and involved numerous expertise throughout the process starting with manufacturing, installer, engineers, contractors and others (Kamar et al., 2011; Thanoon et al., (2003).
Health and safety measures	IBS application will improve site safety by providing cleaner and tidier site environment (Pan et al., 2007; Rahman & Omar, 2006) as the site activities become minimum (Besharah., 2015).
Flexibility	IBS allows flexibility in architectural design, in order to minimize uniformity of repetitive facades. Simultaneously, the flexibility of different system used in IBS construction process produced own unique prefabrication method (Thanoon et al., 2003).
Waste minimization	All IBS components are manufactured from the factory, resulted in less wastage (Kamar et al., 2011).
Improving productivity	Productivity (CIDB, 2010; Kadir et al., 2006). At the same time, it enhances productivity by removing difficult operation off-site and less site disruption (Arif & Egbu, 2010) [10].

2. Factors affecting the consumption of renewable energy during the construction phase of the building

There are a number of factors affecting the consumption of renewable energy in the construction phase of the building. It is noted that these factors control the modality and the amount of energy consumption at this stage, as their characteristics affect the method of energy consumption through its impact on the various consumption elements, namely equipment, Construction and mismanagement of project implementation [14]. It is noted that these elements are collectively governed by a combination of factors as shown in Figure 2: building materials used, building systems followed, methods of implementation used, design process and time control, noting that the characteristics of each of these factors have a direct impact on consumption in the construction phase of the building.

With regard to our research, it is important to clarify the impact of building systems and methods of implementation used to consume renewable energy during the construction phase of the building.

2.1. The effect of building system followed on the energy consumption in the construction phase of the building

The structure of the building system reflects the energy type used in the construction process, whether human or mechanical, or both, specifying the ratio of each of them. It also determines the nature of each of these energies according to this ratio.

For example, the human energy varies between the unskilled labor force and the trained labor force, the percentage of their use varies according to the construction system used, as well as for equipment, the equipment capacity used is determined according to the ratio of equipment and labor, which is also determined by the building system used.

The effect of the building system on the amount of energy consumption in the construction phase of the building is reflected in: [15]

- The ratio of equipment use to labor, on the basis of which the effort to accomplish a task is determined by specifying the capacity used in the implementation of each of them. It is necessary to access through the equipment and labor to the optimum time of achievement and thus access to optimal energy. For example, it is not preferable to use many labors in the case of large projects. In addition, it is not preferable to use full mechanization in the case of small projects. The impact of the construction system on the percentage of equipment to labor is not limited to the capacity used, but rather to the time of implementation.
- The quality of employment used; According to the type of construction system used, different levels of employment are shown, from skilled labor to regular labor. Thus, the amount of energy used by these workers varies, as does the amount of energy spent.
- The degree of accuracy and proficiency depends on the quality of elements implemented in the building, the proportion of labor and equipment. The degree of the possibility increases in introducing electronic control methods on the proportion of equipment used in the project, which helps the speed, accuracy and quality of work while reducing equipment capacity and mortality rate, and it improves the management of project implementation in the construction, storage, finishing and petty operations. [16],[18]

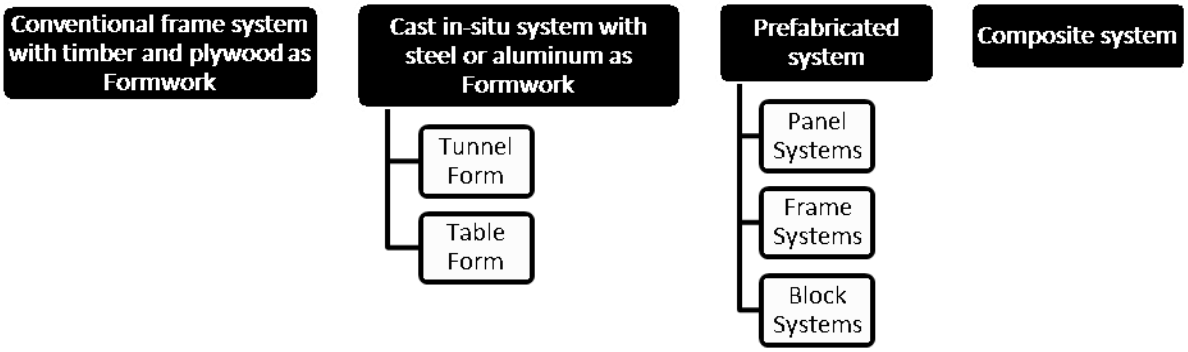

Figure 1. Types of Building Systems (Source: author by using [5])

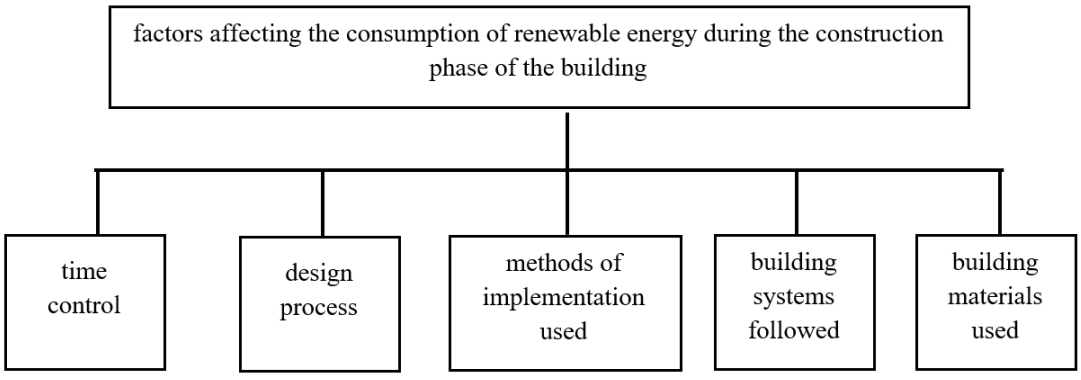

Figure 2. Factors affecting the consumption of renewable energy during the construction phase of the building [14]

2.2. The impact of the implementation method used on energy consumption in the construction phase of the building

The implementation method is the main control of the executive power. Therefore, it controls the energy of the labor and the implementation equipment. It is important to ensure good control and prevent waste, especially when most of the work is carried out at the construction site, which may cause material waste. The effect of the choice of implementation methods used on energy consumption in the construction phase of the building is illustrated by: [19]

- Transportation capacity; where, for example, using precast or Pre-processing items leads to the initial transfer from raw material sites to the factory and transfer elements to the site. While using traditional methods leads to transfer raw materials directly to the site. Therefore, transport capacity depends heavily on the method of implementation used.
- Energy equipment and labor; where the least energy spending method of implementation is chosen for both the labor and equipment, which does not conflict with the quality of the product, and commensurate with the time of implementation required.
- The materials used in the implementation methods; some methods specify that certain materials should be used such as clamps, and these methods determine the type of these materials. For example, the implementation method specifies the use of wooden or metal clamps or others, thus controlling the manufacturing capacity of some materials used in the implementation.
- Materials waste, as the choice of implementation method affects the amount of waste in building materials.
- Finishing capacity, where the method of implementation used determines the shape of the final surface of the building as well as the properties of the building material used, and thus affects the amount of finishing the building needs and determines the energy of manufacturing finishing materials as well as the energy of finishing work. [17]

3. Prioritizing the selection of construction methods and how the renewable energy criteria affect the selection within the reconstruction scheme in Syria

The final decision about implementation options associated with factors that have been identified through a large questionnaire that can affect this decision, and therefore it is important to make the order of priorities for the use of one of the technical systems, for decision-making about the technology that must be followed using one of the decision-making tools, hierarchical analysis method AHP.

The decision will be divided into two parts:

Part 1: prioritize the use of one of the construction methods used in Syria using the AHP method.

Part 2: introduce the criteria of renewable energy in choosing the method of construction and comparing the results with each other.

3.1. Steps to implement the AHP

The process of the AHP includes three basic steps: the first step is to build a model of hierarchical analysis, which consists of the primary goal, alternatives and the main and sub- criteria, the second step is to demand from decision makers to individually express their opinions regarding the relative importance of the criteria and preferences between alternatives using paired comparisons, the third step is to prioritize the decision.

Part 1: After preparing the overall shape of the model (as shown in Fig.3), and introducing the preference values to the program (expert choice) for comparison of the alternatives (technical systems) according to the criteria, the result of the final paired comparisons of alternatives according to figure4 was obtained.

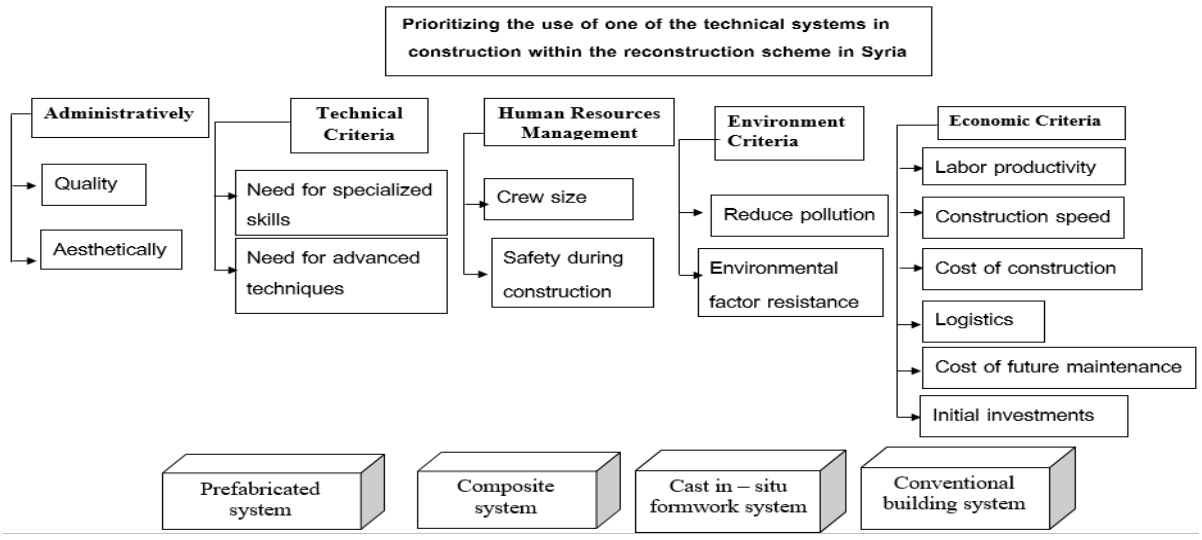

Figure 3. Hierarchical Analysis Model for Priority Determination

As shown in figure 4, the technical system which received the highest importance is the technologically advanced prefabrication system which had the winning percentage of 39.4%. The researcher referred that to the extent of the actual importance of the advanced prefabrication technology, which stems not only from its large contribution in the rapid construction, but also in its ability to fill a large proportion of housing needs of the Syrian citizens, especially in light of destruction risks of Syria and the pressures of development and the great need of reconstruction. The technical composite system (cast-in-place, pre-cast) came second with 21.8%; followed in third place by a low difference developed technology the cast-in-place system gaining 20.8%; stated in the last ranking: traditional methods and tools with 18.1%.

Part2: preparing the overall shape of the hierarchical analysis model (as shown in Fig.5) With the use of renewable energy criteria obtained from previous studies and advanced research in this field, and introduction of the preference values to the program (expert choice) for comparison of the alternatives (technical systems) according to the criteria, the result of the final paired comparisons of alternatives according to figure 6 was obtained.

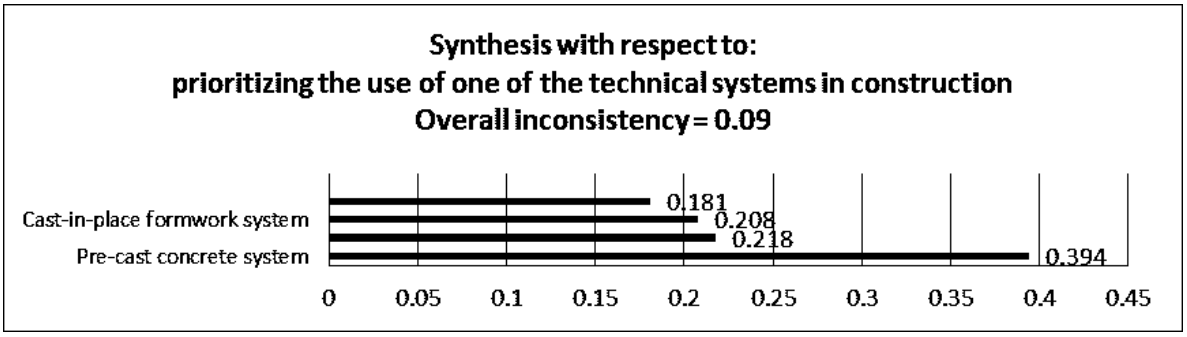

Figure 4. order of technical building systems after a paired comparison using expert choice.

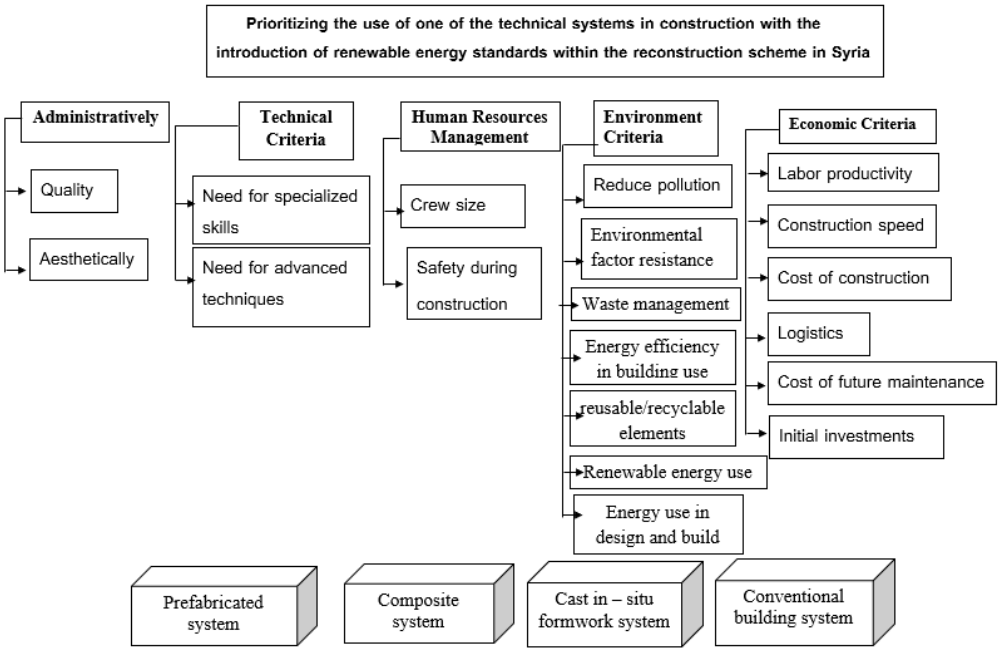

Figure 5. hierarchical analysis model for priority determination with the use of renewable energy criteria

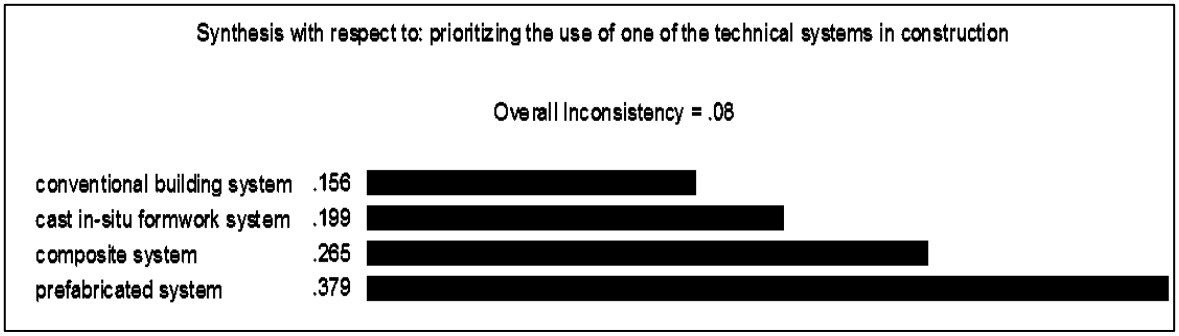

Figure 6. order of technical building systems after a paired comparison using expert choice with the use of renewable energy criteria

3.2. comparing the results with each other

The use of renewable energy criteria modified the ranking of technological alternatives for construction, according to the adaptation of these methods. The technology advanced prefabrication system had the winning percentage of 37.9% (39.4%, in part1). The technical composite system (cast-in-place, pre-cast) came second with 26.5% (21.8%, in part1); followed in third place by a low difference developed technology the cast-in-place system gaining 19.9% (20.8%, in part 1); and the last place for conventional building system with 15.6% (18.1%, in part 1). Therefore, the renewable energy criteria have emphasized the importance of industrialization and mechanization with the possibility of using renewable energies which meet the requirements of reconstruction in Syria to replace the traditional ones

This relative convergence of alternatives can set the direction of development in accordance with all of these alternatives and not toward a single so that they form with each other a technological package appropriate and in accordance with the conditions and factors existing and emerging.

4. Conclusions and Recommendations

This paper looked at the definition and classification of IBS, and characterization of their own construction techniques. As this paper discussed factors affecting the consumption of renewable energy during the construction phase of the building. Given the importance of having a comprehensive methodology in Syria to adopt strategic issues for the Syrian construction industry (the IBS), we have identified priorities for choosing the right technical system for building within the reconstruction system in Syria, and introduce the criteria of renewable energy in choosing the method of construction and comparing the results with each other, we reached the following conclusions and recommendations:

- The use of the building industry systems (IBS) in Syria can offer the benefits of speed, quality and safety for construction projects, and achieve the construction requirements.
- Obtaining a high level in IBS requires a move towards industrialization.
- IBS is facing significant challenges in Syria.
- Using the method of AHP, the advanced technology, prefabricated system was in first place with 39.4%, followed by the composite technical system (cast-in-place + pre-cast) with 21.8%, in third place advanced cast-in-place technology with 20.8%, as stated in last rank were traditional methods and tools.
- The use of renewable energy criteria modified the ranking of technological alternatives for construction methods which emphasized the importance of industrialization and mechanization with the possibility of using renewable energies which meet the requirements of reconstruction in Syria to replace the traditional ones.

References

[1] Beshara, M., Hassan, B. Construction Industry as a Requirement for Reconstruction Phase in Syria. 2015. The 1st Engineering Conference on Reconstruction and Development Priorities. In Arabic.

[2] Mohee, M., Bayati, H. Study of the Efficiency Performance of Precast Building: Practical Research on Civil Engineering Department of Building - University of Tikrit. Diyala Journal of Engineering Sciences, 2011, pp. 1-22. ISSN 1999 – 8716. In Arabic.

[3] Pan, W., Gibb, A. G. F., & Dainty, A. R. J. (2007). Strategies for Integrating the Use of Off-site Production Technologies in Housebuilding. Journal of Construction Engineering and Management.

[4] Mohd Kamar, KA., Abd Hamid, Z., Azman, MNA., Ahamad, MSS. Industrialised Building System (IBS): Revisiting the Issues on Definition, Classification and the Degree of Industrialisation. International Journal of Emerging Sciences, 2011. 1: 120-132.

[5] Thanoon, W.A, Kadir, M. R. A., Jaafar, M. S., & Salit, M. (2003). The essential characteristics of industrialised building system.International Conference on Industrialised Building System KL. Malaysia.

[6] Idrus, A., Hui, N. F. K., & Utomo, C. (2008). Perception of Industrialized Building System (IBS) Within the Malaysian Market. International Conference on Construction and Building Technology, ICCBT2008, (07), 75 92.

[7] Abdullah, MR., Mohd Kamar, KA., Mohd Nawi, MN., Haron, AT., Arif, M. Industrialised Building System: A Definition and Concept. ARCOM Conference. 2009, Nottingham, United Kingdom.

[8] Jabar, L, I., Ismail, F., Mustafa, A., A. (2013). Issues in Managing Construction Phase of IBS Projects. Procedia - Social and Behavioral Sciences 101 (2013) 81 – 89. Available online at www.sciencedirect.com.

[9] Construction Industry Development Board (CIDB). Manual for IBS Content Scoring System (IBS SCORE). 2010, CIDB, Kuala Lumpur, Malaysia.

[10] Arif, M., & Egbu, C. (2010). Making a case for offsite construction in China. Engineering, Construction and Architectural. Management, 17(6), 536 548. doi:10.1108/09699981011090170

[11] Lessing, J., Stehn, L., Ekholm A. Industrialised Housing: Definition and Categorization of the Concept. IGLC-13 Sydney, Australia. 2005.

[12] Badir, YF., Kadir MRA, Ali AAA. Theory of Classification on Badir-Razali Building System Classification. Bulletin of Institute of Engineer. 1998.

[13] Baxi, CK. Formwork – A Concrete Quality Tool. 36th Conference on Our World in Concrete & Structures. 2011.Singapore, August 14-16.

[14] Shams al din,A. Energy conservation in the building construction phase. 2003, Master Thesis in Ain Shams University, Egypt.

[15] Youssef,O. Building Technology - The Foundations and Criteria that Control Construction in the Modular Unit (Self-Building Method and Methods of Evaluation), PhD Thesis, Cairo University, 1996.

[16] Arnold,B. Philippe, M. High energy performing buildings: Support for innovation and market uptake under Horizon 2020 Energy Efficiency, Publications of the European Union, Project number 2018.4202. 2018.

[17] Thapa, S, Kr. Panda, G.Energy Conservation in Buildings – a Review, International Journal of Energy Engineering, India, 2015, Vol. 5 Iss. 4, PP. 95-112.

[18] Stephan, André & Stephan, Laurent, 2016. "Life cycle energy and cost analysis of embodied, operational and user-transport energy reduction measures for residential buildings," Applied Energy, Elsevier, vol. 161(C), pages 445-464.

[19] Dixit, Manish K., 2017. "Life cycle embodied energy analysis of residential buildings: A review of literature to investigate embodied energy parameters," Renewable and Sustainable Energy Reviews, Elsevier, vol. 79(C), pages 390-413.