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Pre-cast concrete, a key option for the reconstruction phase in Syria

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Abstract

 This days Syria is concerned in the development of integrated strategy, starting with a provision of regional, structural and organizational planning for the affected areas, followed by the architectural and construction and environmental studies, etc. This strategy is achieved through the preparation of detailed plans and programs necessary for the implementation of public and private projects that achieve the objective of development and reconstruction. This study includes a range of plans that must overlaps and integrates with each other to produce reconstruction operations. Must be involved in the implementation of these plans work team composed of officials and experts, technicians and consultants, and bound together through a flexible structure composed of a group of sub-committees that are related to higher body for reconstruction. In the stage of the housing plan, researches were done in order to assess the reality of the construction of buildings in Syria, and compared with the concepts and the construction industry characteristics (IBS), and determine the Syrian experiment site regarding to these concepts, as well as evaluating the factors affecting this industry, and proposals to apply it in reconstruction stage. Cast-in-place concrete in the case of the reinforced walls, got 13.1%, while in the case of the framework structure was 34%, and templates tunneling 64%, composite order (pre-cast and Cast-in-place concrete) 61%, composite order (concrete and metallic) 67.25% , and the pre-cast concrete from 82% up to 86%. The questionnaire also shows that the trend towards a modern building industry faces significant challenges in spite of its inevitability as a strategic decision in finding solutions to the problems of housing and reconstruction. The research arranged the priority use of technical systems in construction in Syria, using the method of AHP. The advanced technology system (pre-cast concrete) had the first place with 39.4%.

**Keywords:**

Regional planning commission; integrated map; industrial building systems IBS; modern building systems; construction industry in Syria

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 and gross national product, and the magnitude of its employees [1]. The world has seen a significant expansion in the field of building and construction in the aspects of technology and productivity, but this industry is currently facing in our country unprecedented developmental pressures as a result of lack of resources and rising raw material prices and instability of environmental factors surrounding it. This is what prompts us to think about the system to frame the industry in order to evaluate it and advancement towards the best, in order to achieve the requirements of sustainable development. The advancement of construction sector towards the foundations of the construction industry requires the use of developed technological and administrative systems, compatible and in harmony with the architectural and constructional and technical systems for buildings so that they can get the product within sophisticated modern standards. Therefore, and due to the magnitude of the housing crisis and the deficit in securing the required modules, speed factor become an urgent need [2].

Research importance:

* Improvement of the attributes of engineering projects, especially in the light of current circumstances in Syria to reach fast construction that achieves the required quality and technology.
* The control of traditional methods on construction systems.
* Achievement of project objectives and secure the growing pressure on the construction.
* The need of using advanced technology and administrative systems.

Research objective:

This research aims to assess the reality of experience of the construction of buildings in Syria and compare them with the concepts and the characteristics of the construction industry IBS, and to identify the Syrian experiment site of these concepts.

Research methodology:

* Review of previous studies about the construction industry and modern techniques used.
* Assessment of the reality of Syrian construction experience and measurement of the IBS degree for the Syrian construction projects.
* Using a questionnaire to find out the most important factors affecting the construction industry and the extent of the current application and the importance of development in the future and analyze the results of the questionnaire using SPSS program.
* Determination of priority to choose one of the technical systems used for construction in Syria using Expert Choice program.

Previous studies:

The terminology used in the construction industry hardly could be defined, and definitions rely heavily on user experience and the amount of understand, which vary from one country to another, but also there are several definitions developed by some researchers in this field, defined [3] IBS as the components’ 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 the 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 [4]. Defined [5] 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 [6] 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 get the IBS and is 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 [7]. Each of the construction systems is represented in accordance to their own construction methodology, and its advantages in additions in construction technology, and the engineering and functional composition [8] as shown in Figure (1).

Figure 1: Types of Building Systems (Source: author with use [8])

The different templates systems offer a wide range of concrete construction solutions that can be selected to suit the required development needs [9]. 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.

Results and discussion

Assessment of the level of IBS for the executive solutions patterns used for buildings in Syria (IBS SCORING):

Description of implementation modalities in Syria:

The dominant pattern of systems implemented in Syria is the using of templates of woody tambourines in the implementation of building structures (columns and walls and slabs cast in place), and there are less cases of using the templates of small panels, or large panels of slabs and walls, and some cases of the use of tables templates, and tunneling templates that are used for walls and ceilings. Construction experience in Syria refers to the use of pre-cast for the construction of residential suburbs, also the use of composite implement (cast-in-place and pre-cast) in some partial solutions in construction. A review of Syrian experience in the evaluation of some performance indicators (time, quality, cost) refers to a low level of these indicators [10]. The proposed system to assess the level of the construction industry in Syria IBS is a systematic and structured evaluation system, it can be used to measure the amount of using the IBS appropriately. Among the criteria adopted to measure the IBS is the measurement of the Construction Industry Development Board in Malaysia (CIDB) which is an important criteria with clear scientific methodology that supports our adoption of this approach for measuring the construction industry [4].

Principles applied to evaluate the construction industry (PRINCIPLES OF IBS SCORE):

The system of calculation of the IBS points focuses on several features of the construction specifications, such as using pre-cast components, production of components off-site, the use of standardized components, and the repetition, in addition to the design using the concept of consistent units. The method of determining IBS points is designed to be simple but scientific and effective. Points are awarded on the basis of IBS transactions of the components of structure and walls, and taking into account the contribution of repetition proportion in the design in total points. It should be noted that the maximum points for IBS of the building is 100 points are calculated according to the equation (1), the formula according to [4].

IBS calculation formula:

$IBS=50 \sum\_{}^{}\left[\frac{Q\_{S}}{Q\_{ST}}F\_{S}\right]+20\sum\_{}^{}\left[\frac{Q\_{W}}{Q\_{WT}}F\_{W}\right]+S$ (1)

QS: Construction area of a structural system

QST: Total construction area of building

FS: IBS Factor for structural system

QW: Length of a wall system

QWT: Total wall length

FW: IBS Factor for wall system

S: IBS Score for other simplified construction solutions, as build ability and repetition.

Calculation of IBS degree for patterns of structural and executive solutions used for buildings in Syria:

The IBS degree for patterns of structural and executive solutions used for buildings in Syria was calculated based on the projections and building's data, and using the equation (1). Results were assembled in Table 1, which shows the degree of IBS that have been calculated for each type of buildings that vary in construction regulations and executive, with reference to the pre- cast concrete system has been account its points for one floor and two floors and four floors to clarify the difference between them. Note from the table (1) the high points of the IBS for pre-cast concrete system in Syria (82% - 86%), and this shows the importance of this system and the large role in the technological and production development required in Syria. Where it offers many advantages in terms of the production of a large number of units and the reduction in cost and time and improve the quality of the work [4]. The composite system comes in second place, as shown in Figure 2, which has a limited use in the shelters housing (pre-cast concrete and metal) increased by 67.25%, this shows the important role of this system in limiting the effort at the site and reduce the time necessary to accomplish the task to a large extent. In third place, is the cast-in-place concrete system with tunnel templates by 64%, features of this system is that it does not need trusses to support the slabs, which requires less operations on-site and less effort and thus less time.

Table 1: IBS score according to building system (Source: Authors’ own calculation, 2015)

|  |  |
| --- | --- |
| Building System | IBS Score (%) |
| Cast -in-place: case of reinforced walls | 13.1 |
| Cast -in-place: case of framework structure | 34 |
| Composite (pre-cast and cast- in-place) | 61 |
| Cast- in-place: tunnel form | 64 |
| Composite (pre-cast and metal) | 67.25 |
| Pre-cast concrete | 82-86 |

In fourth place got composite system (pre-cast concrete and cast- in- place) to 61%. Followed by cast-in-place concrete system in the case of a framework structure by 34%, and it is noted that this system existing in many of the Syrian buildings and must work to improve its points in the future. Comes in last place the cast-in-place concrete system in the case of reinforced walls by 13.1% and this low rate is due to the absence of the use of technology and the need for a lot of effort at the site. It is therefore concluded that the use of a high proportion of the components of IBS in order to obtain building industry needs to move towards prefabrication and other advanced technologies. The figure (2) shows the disparity IBS values for each of the sections, according to the systems of studied buildings. Units manufactured in Japan account for about 20% until the year 2000 [11]. While in Malaysia up to 10% of the total overall housing units [12]. In the United States, prefabricated houses gained a large share of the market that amounted to 30% of all residential buildings [13]. The manufacturing use in Syria is low, due to lack of local knowledge in many aspects, especially its application, and the prefabrication factories are rare, despite that plans for reconstruction depends on the rapid construction systems and turnkey construction.

Figure 2: IBS Scores according to building system (Source: Authors’ own calculation, 2015)

Identification and analysis of factors affecting the construction industry in Syria:

There are many important factors affecting the construction industry, and due to the complexity of these factors, must be identified and determine their importance according to the Syrian reality and meets the needs of reconstruction, so it was resorting to the questionnaire, which is good means for the collection of field data and is characterized by the possibility of collecting information from multiple sources of the study sample and analyzing it to reach specific results.

The design of questionnaire:

It has been reviewing several previous international research studies, including [14], [15], [16], which looked at evaluating the performance of the construction industry, and found a number of important factors affecting this industry. The questionnaire was distributed to 100 of establishments operating in the field of engineering; the experience of each individual in the sample is ten years in minimum and up to 40 years. The study sample ended with 51 acceptable responses has been analyzed.

Statistical methods used in the study:

To test the availability of internal consistency and coherence between the answers, were calculated a Cronbach's alpha coefficient (Alpha- cronbach) as reliability coefficient was calculated, where the result coherence coefficient for the current application part is 96.1%. And for the part of future importance is 98.4%, knowing that the acceptable value of Cronbach's alpha coefficient is (60%), as well as we observed high truth values of both parts so can depend on the study sample answers and then data analysis, to analyze the data from the questionnaire, we used SPSS 19 program. Analysis shows from economic point significant decline to adjust the construction time, and this indicates a clear deviation in controlling the duration of the projects. But from the human resource management side, note high repetition of answers in the low category for each of the variables *security and safety of workers* and *training and education*, which refers to the urgent need to achieve safety requirements in the projects and provide the necessary rehabilitation courses. In terms of infrastructure, we note the low application for *availability of factories and support mechanisms for the construction industry*, and *provide a means of specialist technological transport*, which leads us to work on the supply, and importing logistics and technology suitable to reconstruction plan in Syria. Note reduction of all the environmental variables indicating the omission of the environmental aspect in the Syrian construction projects, and can be minimized construction waste through correct planning for the production of components and how to deal with it. Also note reduction of the majority of technical variables, which shows the lack of the modern construction techniques in projects, while providing it in the current circumstances is a must. According to the regulatory and streptococcus management side, note the heavy reliance on the lowest price in the bidding management, high government bureaucracy which constitutes a major obstacle for the success of the Syrian construction projects. Administratively, note decline the availability of managerial skills, as well as reduced government intervention through the enactment of laws and regulations, and follow-up of existing projects, and this is what refers to the importance of developing the administrative enactment of laws adequate with the reconstruction plans.

Prioritizing the use of one of the technical systems in construction within the reconstruction scheme in Syria:

Research shows that IBS was calculated based on the design and technical considerations, but the final decision about implementation options associated to factors that have been identified through the questionnaire and 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, a method of hierarchical analysis of the AHP.

Steps to implement the AHP:

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

After preparing the overall shape of the model, and introduction of the preference values to the program of (expert choice) for comparison of the alternatives (technical systems) for standards, was obtained the result of the final paired comparisons of alternatives according to figure 3.

Figure 3: order of technical building systems after a paired comparisons using expert choice (Source: Authors’ illustration, 2015)

Shown in Figure (3) that technical system which received the highest importance, among other technical systems is the technology advanced prefabrication system and that winning percentage of 39.4%, and the researcher return it 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 the housing needs of the Syrian citizen especially in light of the risks to the destruction of Syria and the pressures of development and the great need of reconstruction. Comes second the technical composite system (cast-in-place, pre-cast) by 21.8%. Followed in third with a low difference developed technology cast-in-place by 20.8%. As stated in the last ranking: traditional methods and tools, 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 technological package appropriate and in accordance with the conditions and factors existing andemerging.

Conclusions and Recommendations

This paper looked at the definition and classification of IBS, and characterization their own construction techniques, as this paper discussed the level of the construction industry (IBS) in the Syrian construction projects, and discussed the evaluation of the factors affecting the construction industry through accurate and comprehensive field study.

Given the importance of existence 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 the building within the reconstruction system in Syria, and reached to 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.
* Getting High level in the IBS requires a move towards industrialization.

**Figure 4: Hierarchical analysis to determine the priority alternative (Source: Authors’ illustration, 2015)**

* Through the assessment of the IBS value for patterns executive solutions used for buildings in Syria, a system of cast-in-place concrete in the case of a reinforced walls had 13.1%, while for cast-in-place concrete in the case of the framework structure was 34%, the composite system (pre-cast and cast-in- place) 61%, tunneling templates 64%, for the composite system ( concrete and metal ) 67.25%, and pre-cast concrete from 82% up to 86%.
* IBS is facing significant challenges in Syria, according to the survey results, which showed a significant reduction in the current application of most of the factors affecting the construction industry.
* Using the method of AHP, advanced technology prefabricated system was on the first place with 39.4%, followed by the composite technical system (cast-in- place + pre-cast) by 21.8%, in third place advanced cast-in-place technology by 20.8%, as stated in last rank traditional methods and tools.

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