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THE ROLE AND POSITION OF BUILDING INFORMATION MODELING (BIM) FRAMEWORK IN ASSEMBLED CONCRETE BUILDINGS

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ABSTRACT

Generally, according to the improvements in construction industry in developed countries, the path and direction of applying different construction such as buildings (with different usages), bridges, dams and etc. is in a way that the important factor of time and costs would be in a balance in all situations. For this purpose, its necessary to use modern technologies of construction in addition to the techniques and managing solutions. In this research we have tried to more an effective step in the way of optimizing the construction process by integration of modern concrete technology and building information modeling (BIM). In this research, implementation process and executive framework of BIM in assembled concrete structures will be checked.

Keywords: BIM, Assembled Concrete, Framework, and Implementation

1. INTRODUCTION

In many countries around the world, construction industry faces challenges such as low productivity, high construction safety risk, and poor environmental performance Wu et al. (2017). On the other hand, the construction industry has been criticized for its low productivity, high lifecycle costs, and poor environmental performance Abanda et al. (2017), Li et al. (2019). According to the important advantages of assembled concrete in comparison with traditional and common ways of concrete production, usage of its production technology in all over the world is faced by a growing process and remarkable developments. Due to the production and processing of prefabricated concrete under standard and controlled factory conditions, in comparison with traditional cast-in-situ concrete buildings, prefabricated buildings own lots of advantages, such as reducing environmental burdens, saving on-site construction labors, increasing on-site construction quality and efficiency Jaillon and Poon (2014), Zhengdao et al. (2014), Polat (2008).

Considering the advantages mentioned, it is necessary to use advanced and up-to-date management technologies that have been widely welcomed in industrialized countries to modernize the Pre-fabricated concrete production technology and implementation process of these structures. AEC projects such as buildings, infrastructure systems and plants are part of the scope of urban spatial planning and design Colding (2007). It should be noted that Any modifications in building design will be automatically reflected in other related parts Park (2011). Therefore, BIM is one of the most efficient and management technologies that can be used in prefabricated concrete industry. In this research, we will look at the status of BIM technology in the prefabricated industry and the implementation process and the framework proposed for its implementation in pre-fabricated concrete projects.

2. THE ROLE AND POSITION OF THE BIM FRAMEWORK IN THE PREFABRICATED CONCRETE INDUSTRY

As previously mentioned, prefabricated concrete has significant advantages compared to other concrete production methods (at the workshop site). In addition, there is a great potential in the field of optimization of structures in this industry, but there is still a question for the construction industry that why most concrete structures continue to be implemented on-site.

For this question, two answers can be presented:

- Prefabricated concrete constraints
- The lack of evolution and relative maturity of BIM technology

2.1. ARCHITECTURAL FLEXIBILITY

In general, one of the important advantages of manufacturing concrete units outside the workshop site is their architectural flexibility. So that one of the most important advantages of prefabricated concrete is the possibility of producing concrete components in challenging forms under controlled factory conditions. Therefore, one of the factors influencing the profitability of the project is the possibility of repeated use of the templates. In practice, this restricts the production space of prefabricated pieces with different architectural forms. At the same time, manufacturers of prefabricated concrete components should pay attention to the production of standard parts with more economic costs. This will have the effect of reducing the diversity and flexibility of prefabricated pieces of architecture.

Meanwhile, BIM technology has been developed with the help of the pre-made concrete industry and increased flexibility in design, due to the increased ability of manufacturers to share models and production formats for engineers. At the same time, the ability to provide design tools for formatting with the BIM model is also provided. This reduces the cost of mold production and at the same time makes precast concrete manufacturers able to compete with concrete production methods at the workshop site.

2.2. FLEXIBILITY AND ENGINEERING TRANSPARENCY

One of the most important issues with prefabricated concrete is the limitation of input data in its execution process. Therefore, the use of Information Modelling Technology (BIM) improves collaboration between manufacturers and engineer architects, and thus, more efficient products are produced. Therefore, intellectual property issues, model ownership and the role of objects are among the most important challenges Succar (2009).

2.3. PRODUCTION PROCESS

Production, transportation, and assembly of parts are key points in the study of the benefits of prefabricated concrete industry compared with the traditional methods and the biggest challenge facing the industry is also considered.

In order to prevent breakdown in prefabricated concrete industry, lean manufacturing methods and balances in production are commonly used Low and Mok (1999).

Due to the flexibility in designing, producing, and assembling parts more desirable, it is necessary to establish close cooperation between architects and structural engineers. In the prefabricated industry in the United States, the need for this is very evident and for this purpose the IDM has been prepared Lanier et al. (2009).

This is considered as the first step in integrating the production process with the BIM flow of work that is accepted by architects and structural engineers.

Prefabricated concrete industry usually works using its own software and hardware system. Which is usually a combination of manufacturing, manufacturing, or dedicated systems.

In general, it is recommended that building information modelling technology be implemented along with the current production system.

2.4. TRANSPORTING AND ASSEMBLING (ASSEMBLING PARTS)

In accordance with the method of transporting and assembling prefabricated concrete components, which are two very important issues in the prefabricated concrete industry, BIM can quickly improve the process and benefits for the system. In traditional ways, this is achieved through management tools. BIM software has a high potential for integrating executable functions. So as to create greater transparency in the work and participation of as many stakeholders as possible in the process of its implementation. It should be noted that External motivation has been identified as an important factor affecting BIM implementation Ding et al. (2015). In addition, the four dimensional modelling capabilities (4D) provided by the BIM, enhance the visualization and modelling details in the process of manufacturing and assembling precast concrete components Succar (2009).

The possibility of integrating different stages using BIM technology is considered as one of the most important advances in prefabricated concrete industry.

Therefore, prefabricated concrete, in comparison with other construction technologies, has many potential and many of its features, have not yet been discovered.

The emergence of BIM as a dominant model and its integration with information technology (IT) in the construction industry has created significant opportunities, especially in the concrete industry. One of the most important points in this field is the flexibility to design engineering and architecture. In addition, various stages of prefabricated concrete industry, such as the transportation of production components and assembling and final assembly, can also be improved with the help of the BIM. Another achievement of using BIM technology in prefabricated industry is the possibility of product optimization. In order to get all the benefits and benefits of using BIM technology in the prefabricated industry, it is necessary to establish close cooperation between manufacturers, researchers and relevant software providers Succar (2010a).

3. METHODS FOR PRESENTING THE BIM FRAMEWORK IN THE PREFABRICATED CONCRETE INDUSTRY

3.1. OBJECT-BASED MODELING

In the first phase of the BIM, presented in the framework of Succar, companies are developing single-strike models in the design, construction, or operation phase of the project. For example, architectural models, engineering models, or prefabricated models are used in the early stages to provide two-dimensional and three-dimensional documentation Succar (2010b).

The first step in implementing BIM in prefabricated concrete structures is very similar to the one described above. And in practice, this means that the BIM software is implemented in one of the project stages. This is usually done in bidding, design, or construction. In general, at all stages, the model is produced by the design department of the prefabricated concrete factory. In general, object-based modelling is a standardized set of symptoms and methods for selecting them in the form of a model of an object-oriented software design or system design. Some organizations use them extensively in combination with a software development methodology to get from a basic profile to an implementation plan and link that design with the entire team of developers. Because it's a real modelling language, it's a bit more abstract than the code. The use of models encourages a generation of shared views that may prevent problems later on. Sometimes modelling software tools are used to build these models that may have their automatic conversion capability to code. The early stages of the BIM include initial input data and initial three-dimensional models without any parametric modifications Succar et al. (2012), Rad (2022)

Primary data usually includes a list of materials, two-dimensional maps, and three-dimensional maps, as well as a sequence of parts installation. In general, the idea of objects and parametric elements is an important and significant concept in understanding better the modelling of building information and their differences with three-dimensional objects in the traditional system, which are as follows:

- Objects with geometric definitions and information and rules are connected and integrated.
- The geometry of these objects is defined unambiguously without additional information.
- Parametric rules apply automatically when placing objects in the model.
- Objects can be defined with different degrees of composition and define an object along with layers and components within it.

- In the event of a contradiction, the incompatibility detected by the parametric rules is detected.
- Objects have the ability to allocate some attributes and attributes to them.

The method of work in the first stage of the BIM is similar to the Pre-BIM stage. Typically, the exchange of information between different parts of the project is directional, indicating that although sometimes two-dimensional maps are used instead of 3D maps, prefabricated concrete production units are still mapped with each other Communication and cooperation. For example, when implementing reinforcement in molds or installing precast concrete components in place. Since usually only minor changes occur in the first stage of the implementation of the BIM, the contractual relationships and criteria, risk allocation and organizational behaviour are usually the same as the Pre-BIM stage. But in object-based modelling, it is possible to run faster phases and stages of the project. And when the project is still in the implementation phase, the design phase is usually done simultaneously Succar et al. (2013).

In the following figure, the linear representation of various phases of the project life cycle is shown in the first step of the BIM. So that there is no overlap between the different stages. After implementing BIM in one of the departments of a prefabricated concrete factory, it is clear that the benefits of that department will transfer modelling activities to other parts of the company.

Figure 1

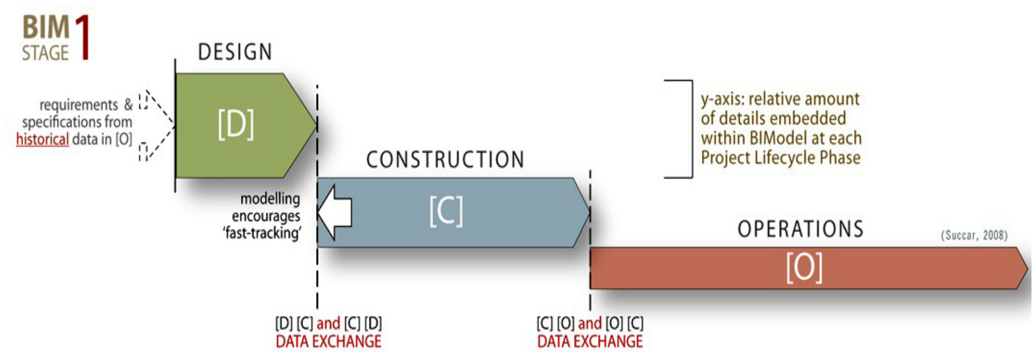

Figure 1 The Various Phases of the Project Life Cycle in the First Stage of the BIM

From the perspective of reengineering, at the initial stage of BIM implementation, companies are implementing information technology applications, and it is necessary for this purpose to use the BIM software and with minimal change in the work process. The first stage (level) of implementation of BIM, information technology solutions are different from the organization's specific goals and are used for internal organization purposes.

Both BIM and reengineering support each other and have the same function as the first implementation stage of the BIM.

3.2. COMMUNICATION AND COLLABORATION MODELING

When companies used a single-line modelling technique to implement the first BIM phase, they were able to collaborate with other active team members in the second phase of implementation.

So that this method of communication and collaboration is possible with the help of various technologies Eastman et al. (2006).

After the first implementation stage of the BIM, the department at the prefabricated concrete manufacturing plant used BIM as part of its work process, and in the second step, it began to establish and actively collaborate between departments Inside the company.

Although sometimes in the initial stages, the design department uses object-based techniques, the internal management view of the organization can focus on a collaborative approach and link between departments and departments.

A collaborative model and communication may be used between two different phases in project life cycle. (Second step BIM)

This method may also include exchange models that interchange between teams and even include non-specialized formats. In the case of prefabricated concrete manufacturers, this means that the models developed by the design department will be shared between the executive teams. Most of the time, the collaboration between the design and implementation department requires the existence of overall design models, while the executive department needs information about the entire project.

In the meantime, if the design section works with other departments, the partial designs of the project (related to a specific part of the project) will usually be preferred over the overall models. It is true that the various departments of the project will work on parts of the project (not the entire project). At the same time, in the initial stages of work, the need for information and partial data over general data will be preferable.

Although the collaboration and communication between BIM users in a project may be synchronous, the pre-BIM stage boundaries and boundaries that make separation and separation of criteria and criteria will lead to gradual phasing out of the project's lifecycle.

In the following figure, the linear representation of various phases of the project life cycle is shown in the second stage of the BIM. As you can see, unlike the first stage of implementing the BIM, there is an overlap between this stage and the various stages of the project. For prefabricated concrete manufacturers, the existence of this overlap means that in the second stage of implementing the BIM, it is necessary to define and policy on how to communicate and collaborate with different project teams (not just modelling). At the same time, prefabricated concrete manufacturers must, at their work stages, reengineer their work steps in accordance with the workflow based on the model, in order to benefit from all the benefits of implementing the BIM.

Figure 2

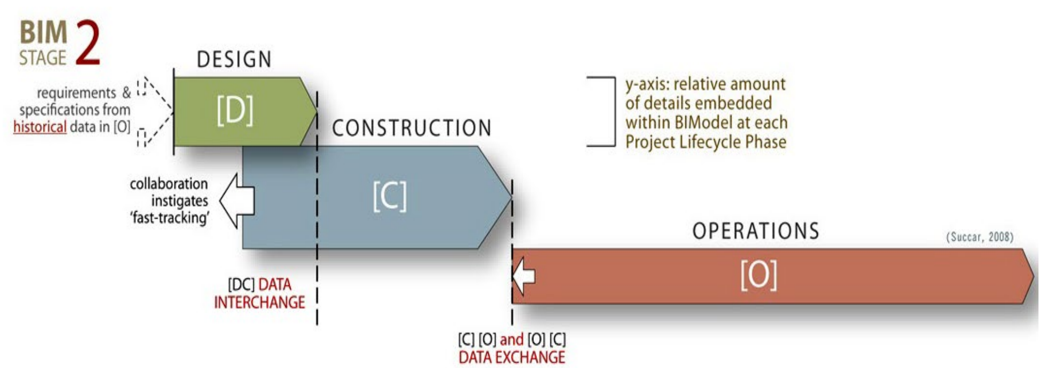

Figure 2 The Various Stages of the Life Cycle of the Project in the Second Stage of the BIM

The second phase of BIM implementation suggests a more systematic effort to implement information technology at different stages of the work. Therefore, in the second stage of implementation, the interdependence between technical and commercial sectors is quite evident, because none of them alone is enough and the benefits of implementing information technology will not be fully reflected.

Therefore, in the second stage of implementing the BIM, the integration of information technology within the company, regardless of the structure and work stages of the work, is a sound and principled method for the implementation of information technology.

Meanwhile, pre-fabricated concrete manufacturers, before starting the actual implementation of the BIM, pay attention to the fact that when integrating BIM software as part of the company's internal workflow and workflow, which steps should be changed to the appropriate level of interest To get a cure.

3.3. NETWORK-BASED MODELLING

In the third step of the BIM, using various technologies, databases or software services, models containing integration information are prepared and shared and maintained at all stages of the project's useful life Succar (2009).

The prerequisite for entering this stage is the evolution of software and networking technologies so that they can share existing information. This means that at this stage of the implementation of BIM, prefabricated concrete manufacturers will prepare, share, and maintain integrated models in different parts of the project and in the domestic departments.

In the third stage of the BIM, the models become multi-dimensional models (nD models) so that complex analyzes can be made at the early stages of design and construction.

Accordingly, the use of multidimensional models (for example, the fourth and fifth dimensional BIMs that are related to time and cost), contrary to the use of features of traditional objects in the design, create the basis of lean manufacturing, systems Green (eco-friendly) and also the ability to estimate the cost of the project in its useful life cycle. Concerning the BIM implementation steps, this means that prefabricated concrete manufacturers should pay attention to the various factors that each section of the project needs them and consider them in their calculations. For Succar, the simultaneous exchange of the model and the existing documentary data allows the various stages of the project life cycle to overlap. Which will ultimately become a one-stop process. (Figure 3)

Network-based integration makes the various stages of construction work simultaneously, especially when all project activities are integrated and all aspects of design, construction, and operation are planned simultaneously, so that the value of the target functions Maximize.

According to Succar, the implementation of the third BIM requires revision of contractual relationships, risk allocation models and workflow trends. The third stage of BIM implementation focuses on policies, especially from a network perspective. In the meantime, changes must be made to some existing steps.

For Eastman, there are four methods for transferring model information between two software applications: Eastman et al. (2006).

- Direct links between BIM special tools
- Exclusive file format (DXF files)
- General-level transfer formats (Revit Architecture, Bentley

Architecture, ArchiCAD and ...)

• File formats based on XML

Figure 3

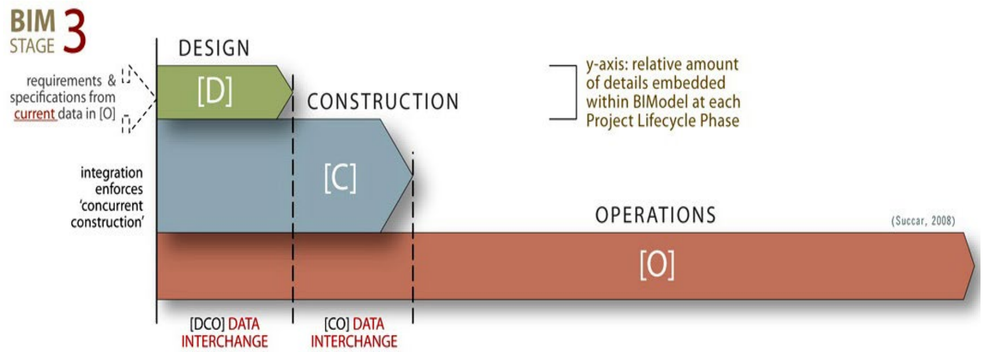

Figure 3 The Various Stages of the Project Life Cycle in the Third Stage of the BIM

In general, the three factors of manpower, technology, and workflow are three main parts of the BIM when implemented. At the same time, based on the framework provided by Sucker and considering how the classification of qualifications is similar to BIM Fields, we will have:

- A BIM competence set that influences the process, including contractual qualifications, regulation and regulations, infrastructure, production, and services.
- The BIM competencies that impact on people, including leadership, human resources, and education.
- A BIM competence set that has an impact on technology, including software, hardware, and networks.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

The use of Building Information Modelling Technology (BIM) in the prefabricated concrete industry facilitates the management process of these structures and, on the other hand, allows systematic and digital management of the project. At the same time, due to the importance of implementing BIM principles in projects, in order to implement BIM technology in various projects, including prefabricated, it is necessary to implement the process in accordance with a predefined framework. For this purpose, the Succar framework, the implementation of which is based on three methods of modelling, has been used. These three methods are:

- Object-based modelling
- Communication-based modelling
- Network-based modelling

In all three of the above-mentioned modelling, three stages of design, construction, and operation are considered, the difference being in the overlapping of the above steps.

In general, defining a comprehensive framework for implementing BIM in prefabricated concrete structures accelerates the implementation process while at the same time increasing the accuracy of the implementation and reducing the related risks.

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