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Building Information Management (BIM), A New Approach to Project Management

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Abstract

Building Information Modeling/Management (BIM) technology has attracted the attention of many researchers and academicians as a new concept that has increased rapidly in the construction sector in recent years. The time-dependent changing society has affected the expectations and demands of the construction industry and triggered/resulted the production of more complex and original projects accordingly. Building Information Modeling/Management (BIM) concept has become a necessity in today's construction industry in terms of providing integration between project stakeholders and providing the possibility of processing and storing the project data in a common point. Examining international studies, it is seen that the implementation of the Building Information Modeling/Management (BIM) approach is a mandatory job and/or task in the construction industries of the developed countries. It is observed that they follow this new trend in their rapidly developing countries. This study proposes a procurement framework based on the implementation of Building Information/Management (BIM) to achieve 'best results' in construction projects. A case study presented in this study proves the applicability and usefulness of the proposed Building Information Modeling/Management (BIM) approach in a complex construction project funded by the private sector. Contractual arrangements recommended for the project with an effective resource management approach, one of the basic principles of Building Information Modeling/Management (BIM); benefits such as improved productivity, better coordination and minimized errors and repetition of works.

Keywords: Building Information Modeling/Management (BIM), Project Management, 3D Modeling, Cost Management.

1. Introduction

In this paper a case study, in which it belongs to the construction process of a sales-office of a complex construction project that will serve as Hotel, Shopping Mall and Residences. The sales-office is planned to be completed with a budget of 850000 USD in duration of 135 days, has been reviewed and discussed. This sales-office is a two-storey, luxury, high class structure and has a net area of 457.3 square meters. Particular attention has been paid to the project to be prestigious and flamboyant in which a luxury flats and shops would be promoted and sold.

In recent years, new technologies and applications have fundamentally changed the construction methods of construction projects. These technologies include a wide range of tools including visualization, simulation, and analysis tools in order to predict how the construction/building are going to behave, perform, and/or appear from the new tools used to model the project. In today's architecture, engineering and construction industry, these new

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technologies and applications bring significant differences in the completion of construction/building projects. Business owners (employers, shareholders), contractors, consultants, architects, engineers and subcontractors use communication platforms that allow collaboration to standardize business processes as well as managing and sharing the information. At the same time, project stakeholders are able to visualize how a building behaves, how it is going to perform, or how it will look much more realistic than ever and simulate and analyze the structure with the help of advanced modeling tools. Here, defining the roles and responsibilities of the parties/ shareholders, the detail and scope of the information to be shared in the project and the supporting software to be used in the construction implementation processes are very important. To sum up, Building Information Modeling/Management System's (so-called "BIM") technology and applications help to complete construction projects in shorter time, at a lower cost as well as in a more sustainable way.

There are very little experimental research-based evidences about the increased efficiency of BIM implementation. Becerik and Rice referring to the complexity of such evaluations, claiming that the statements made on BIM efficiency are generally limited and anecdotal based on case explanations. Both researchers and project participants reported that successful implementation of BIM saves time and improves the quality. However, there are significant difficulties in developing realistic measurements, since it is very difficult to distinguish BIM from other factors that benefit the success of a project, as well as it is very difficult to organize comparative research designs. Becerik and Rice has concluded that "BIM industry is very early in the adoption by the sector, and it is too early to determine the value of BIM" in a survey prepared by many respondents in 2010 [11].

Hee Sung Cha and Dong Gun Lee made a case study of the time / cost analysis for an old-house restoration using a ready BIM Database Structure [12]. Borup et al, indicate that technological visions are abstractions for the future. They tend to transform the technological potential into a picture that disregards many of the conditions of reality at the same time of the future and restricts the reality that it will become complicated and will delay the realization of vision. Technological visions tend to not take into account the social and humanitarian conditions, especially in the application of technology [13].

All new technologies have the potential to develop productive activities according to Howard and Björk. These potentials are expressed in the visions of the future, when the new technology is started to be fully implemented. Such visions are also called by some people as BIM "Utopias" or "idealistic purposes" of BIM [14].

Akbarnezhad et al. using the information provided by a typical structure information management system, the cost of construction suggests a framework for evaluating and comparing the effects of various alternative deconstruction strategies on energy use and carbon footprint in their study [15].

Penttilä et al. conducted a research study evaluating the possibilities of the structure information management system in the restoration of important architectural, historical or cultural buildings [16].

In recent years, there has been an increasing demand for GIS models and the tools that enable the incorporation of Building Information Models (BIM). Experts from both areas are involved in building and construction analysis, urban planning, tourism, cadastre, country security and so on. They are looking for solutions to seamlessly integrate such models for various purposes. Researchers have suggested that the best approach for such integration is a harmonized semantics that will provide formal mapping between design (BIM) and real-world (GIS) models. Although, many geometric models have been developed in both domains, the number of semantic models is relatively small. The design and the two most important semantic models in the real world are currently IFC and CityGML. Several studies show the transfer of information from IFC models into CityGML. However, there is no formal and explanatory framework for automatic generation of buildings in CityGML using IFC models in the literature. Isikdag and Zlatanova present preliminary ideas to define a semantic mapping that will provide automatic conversions between the two models in their study [17].

2. Building Information Modelling/Management

The word "BIM" is defined as an acronym that stands for English words "Building Information Modeling". Since, BIM is a management process rather than a model, which is often make a confusion in the market, the name "Building Information Management" has become to be used more widely in recent times. Therefore, this term will be used in our article from now on.

There is not a single satisfactory description of what BIM, namely, "Building Information Modeling/Management" is. In addition, it is claimed that BIM should be analyzed as a multidimensional, historically evolving and complex phenomenon. BIM can express different meanings to different people. BIM can be defined primarily as a digital representation of a construction, as an object-oriented three-dimensional model, and/or as a repository of project information to facilitate the interchange of information with interoperability and related software applications. BIM is based on collaboration between architects, engineers, contractors, employers, and consultants in a three-dimensional common knowledge environment and provides information sharing among these disciplines. BIM is an information management system for a structure to be constructed, extending from the initial design process to the construction phase, as well as the termination of the service and its continuation after implementation. In addition to increasing the coordination and cooperation between architect, engineer, subcontractor, contractor and employer/shareholders, BIM also builds a knowledge database for the building/structure [1].

This new system, which includes the necessary information to carry out communication perfectly and smoothly in construction project management, enables us to reduce our design and building costs by providing cooperation, interoperability, and communication. It ensures that all stakeholders acquire the information they need at all stages of the construction project by using necessary tools/programmes/software designed to identify the organization and project standards and responsibilities from the very beginning of the project.

Eastman et al. said that “A building model can now be defined by its content “which objects it describes?” or by its capabilities “what kind of information needs it can support?”. Among them, capabilities define what you can do with the model rather than how the database is constructed”. They furthered; “What a wall, flooring or roof is?” is determined by the relationship obtained by object classes according to their interaction forms with other objects. Essential attributes of objects are needed to create an interface with analyzes, cost estimates and other applications. One of the important steps in the evolution of the transition from CAD to parametric modeling is the need to share parameters of all objects. For example, if a wall is carried from one place to another, everything connected to it must be updated as well. Any change to an object may also affect other objects. For this reason, a BIM Manager analyzes these changes in order to improve their ability to analyze and selects the most efficient way to sort and update them. This capability is one of the most important technology available in BIM and parametric modeling [2].

In addition to these, Azhar said that BIM is not just a software; it is a process at the same time. According to his manifest; BIM is more than just 3 Dimensions Intelligent Models; it also consists of significant changes in workflow, project management and delivery. In addition, BIM supports the concept of "Integrated Project Delivery", which is a new project delivery approach to integrate people, systems, work structures and practices into a common process to optimize efficiency, effectiveness, productivity, performance and waste reduction at every stage of the project life cycle [3].

The UK Government had made it mandatory to use BIM technology for state contracts made by the central procurement until 4 April 2016. It had been decided to make the systems of all the state departments compatible till 3 October 2016.

According to Uysal; BIM is the job of keeping all kinds of information related to a construction structure with the help of the creation of a computer model. Uysal, makes the word “information” a little clearer by claiming that he had 3 main breakdowns, which are as follows [4];

1. 3D computer model (Architectural, Statical, Mechanical and Electrical)
2. Work schedule
3. Cost information/estimation

Since the first of these 3 main breakthroughs is a 3D computer model, it is defined as 3 Dimension (3D). The addition of the work schedule, i.e. time information, gives the model the 4th dimension (4D). When you add cost information to it, you have a 5-dimensional model (5D). Therefore, in the literature, the definitions such as 5D BIM is often encountered.

In a narrow sense, the data output or functionality of the BIM depends on the data output software provided with it, building or project requirements, and at the same time the life cycle of the buildings. On the other hand, functions determine information or organizational issues (e.g. related to data exchange or communication processes). This relationship will be evident in the following example; if a building's energy analysis is needed, certain information (e.g. component values, radiation level or orientation of the building, etc.) is required to perform the analysis. If this information is not included in the narrow BIM model, a structured data exchange between the BIM model and the professional functionality must be performed. The organizational and legal structures specify input and analysis data, their access to their correctness, and their responsibilities [2,5].

Depending on the desired functionality, model-compatible information structure and data exchange are required to ensure interoperability between different software systems without loss of information. The functional and information requirements also specify the technical model features (Level of Detail, LoD), the required model capacities and therefore the necessary modeling processes. Organizational and legal issues specify partners' roles, information rights and obligations, model access (visual, written) or obligation to provide specific functionality or data output [6].

Similar to Azhar, Smith and Tardif said that the main purpose of implementing a new technology in the construction industry is to increase efficiency, effectiveness and productivity of a construction throughout the entire lifecycle of a project. Here, the main idea is to build the construction faster, cheaper and in a better quality. An investment should increase efficiency, effectiveness, productivity, the quality of goods/services produced, reduce the operating costs, and accordingly increase the total profit. Otherwise, it should not be applied because it does not accommodate to the definition of technological progress in construction industry [7].

Since, BIM technology is relatively new, it is not easy to measure and present its benefits because of its separation from existing standard practices in the construction industry. Nevertheless, BIM provides many benefits by increasing efficiency, effectiveness and productivity in the construction industry. Some of the potential benefits that will be provided by the implementation of the Building Information Management System in construction projects are the following [4,8,9];

• Better communication and cooperation among all project team members (interoperability),

• Reduction of project's time/schedule, cost, quality and scope problems,

• Delivering projects to be more economical, quicker, reliable and/or less stressful in the construction environment.

• Faster and more efficient processes

• Increased effectiveness and productivity

• More controlled data and Life cycle

• Avoiding the cost of recurring/repeat of work

•More secured construction contracts

• More realistic visualization work can be produced from the BIM System with shorter time and budget.

• Classic CAD data and Cost estimating can be provided better and directly from the 3D BIM model.

• All superposition work, which takes too much time consuming, can be done in a 3D environment in a better coordinated way by using BIM System. Thus, the expected/unexpected problems between construction elements and systems are automatically detected (Clash detection), reported and solved by BIM System before starting work in the construction site.

• Construction works, and site planning can be done more smoothly with 3D, 4D, 5D and so on visual features. Prevent disputes/conflicts between works and provide best resolution in order to ensure more efficient/effective flow of the project. Employers, Contractors, and sub-contractors can start business planning with BIM in the early stages of design.

• Thanks to this new BIM system, much better visual/relevant information is obtained in the construction site. The previously manufactured components/elements can take their place in the construction site in a timely and more accurate manner. Working with this new BIM system allows for less information change requests (RFI), and problems, conflicts, and disputes to be solved in the construction site will be reduced.

• More manufacturing opportunities, better cost control as well as efficiency, effectiveness and productivity gains can be achieved by working with new BIM system.

The new BIM system also provides a lot cost savings in many areas, which are as follows;

• It accelerates the design processes since design changes can be made in the very early design process without a much impact on the cost of the project.

• It reduces the quantity of information change requests (RFI) after construction begins with a more accurate model and provides the ability to communicate more efficiently/effectively with other contractors/subcontractors.

• Cost estimates are automatically generated from the 3D, 4D, 5D BIM models more correctly/accurately and quickly compared to the traditional methods.

• Even after construction is completed, it can be used for maintenance and/or restoration of the building/structure by using ready BIM models as well as can do space occupancy assignments much more easily the traditional methods.

BIM Technology enables teams of design and builds in order to communicate with the project design and coordinate/cooperate the information-flow at various levels in an unprecedented way.

BIM helps employers, consultants, contractors, architects, engineers and subcontractors to achieve uninterrupted/continuous implementation of the construction project information and across all different phases (planning, bidding, implementation and operation). However, these parties need a perfect communication structure and must choose the right and/or best tools before applying this new BIM management system.

This management system also helps to identify the right project teams, the main processes and/or dependencies that will be involved throughout the project lifecycle, identifying roles and responsibilities, and selecting the right software/tool that provides collaboration communication to reduce project costs. [10].

BIM can be used in a wide range of projects, such as a new dam, building, airport, highway and/or a railway project. The use of BIM goes beyond the planning and design phases of the project and shortens the time duration of the implementation of construction. It helps/supports processes such as project management, construction management, facility/asset management, time management, and cost management etc.

That's why the UK Government has made it mandatory to use BIM management system for government contracts made by the central procurement since 2016.

According to the original BIM application in new constructions, BIM functionalities concentrate on design and visualization, procurement, manufacturing, construction management and coordination rather than on commissioning, facility management or deconstruction. But recently, planning and transferring processes shift from design-bid-built to integrated project delivery (IPD) in a collaborative atmosphere, considering the value of "as-built" BIM information for facility management, retrofit and de-construction processes [11].

3. Case Study

3.1. Building Manufacturing Process and Problems Encountered

The cost of the project and the duration of the project were determined with a work schedule and cost estimation by the project team. Figure 1 shows the project 2B architectural project.

Fig. 1. Architectural Project (2D)

The completed project was analyzed chronologically in the direction of the work schedule/program and the manufacturing/implementation errors, time delays and material losses were analyzed within the scope of this study. As a result of this analysis conducted in the first stage of our study, when the total time and budget overruns were examined together with the reasons, an additional cost of 120.400.000 USD and a 95-day overrun period were determined. The problems experienced during the project implementation phase are listed below:

1. Since the foundation concrete was not poured properly, the thickness of the screed/cement finish which had to be 13 cm thick, which is 6cm thicker than it should be (7 cm thick) and the cost of screed/cement finish increased by 3107 USD accordingly.

2. Since the thickness of the screed/cement finish had to be 13 cm thick, the floor height had to decrease 6cm from 270cm to 266cm and a low/stuffy/depressed room was created accordingly.

3. Due to these kinds of problems in the foundation concrete, the project manager/director resigned.

4. As the rest of the construction was completed with a new project manager and some revisions, repeats of works resulted in the project and these caused an additional cost of 1700 USD.

5. As the design changed because of the project revisions and because of the change in floor height, the production of mezzanine floor and suspended ceilings had to be changed completely and these changes resulted in an additional cost of 11900 USD and a delay of 1 month duration.

6. Due to the change in the production of suspended ceilings, the air conditioning system which was already installed on the ceiling had to be changed as well. The chiller cooling systems had to be converted to VRF air conditioner system. This resulted in an additional cost of 18700 USD.

7. Due to the change of the architectural project, the exterior design had to be redesigned. It was understood that this process resulted in a cost of 13600 USD and an additional 40 days of time duration.

8. The 3cm thick marbles ordered according to the present project had to be sent back because of the elevation difference due to the previous foundation error. 2cm thick marble had to be used instead. Due to the expectation of the production of these 2cm thick marbles, a time loss of 4 weeks occurred. Since the new 2 cm thick marbles did not have sufficient strength, they had to be used in smaller sizes of marbles and this caused aesthetic weaknesses and therefore the architectural office not to achieve the desired design.

9. Due to the changes in the rough construction and the revision in the architectural project, electrical and mechanical projects had to be revised, which resulted in an additional cost of 3400 USD.

10. Due to the revision of the electricity project, there has been a conflict with the electricity sub-contractor. Since no mutual agreement could be reached, the sub-contractor had to be changed in this item. This resulted in extra costs and a 15-day loss of time.

11. Due to all these, the landscape project has not fit to architectural concept after the production completed and the completed landscape has been completely disassembled and had to be rebuilt. This resulted in a cost of 15300 USD and an additional 12-day time duration.

12. Since the appropriate insulation solution is not preferred in the roof construction, a significant portion of the fine manufacturing is deformed. This has caused a loss of approximately 34000 USD.

The new insulation has resulted in an additional period of 23 days with an additional cost of 17000 USD.

13. An additional ceramic order had to be made since the estimated quantity of ceramic tiles were wrong and this caused that activity to be incomplete. Therefore, 40-days has to be waited for missing ceramics to be produced in the factory. This led to the delay of the project by causing all the fine works to be done after the ceramics installation activity.

14. Ellipse shaped sales office around with an elliptical marble frame is planned to be made with the help of the cnc/waterjet cut machine. However, since the poured concrete did not conform to the architectural project, the cut marble shapes did not fit on the actual concrete slabs and had to be cut by hand workmanship in the construction site and these caused an additional cost of 1020 USD with an additional time period of 15 days.

15. Due to the time constraint, the special size cut marbles under the aluminum joinery windows had to be made with marble pieces left from the free-length marbles used in the landscape with the project manager's initiative and this resulted in a serious loss of aesthetics and prestige accordingly.

16. Since the under-coping concrete in the landscape are poured incorrectly, the coping stones had to be removed because they were not in the right level and balance. The under-coping concrete had to be destructed and corrected, but since the coping stones were damaged during the dismantling, new coping stones had to be ordered and purchased. This additional activity resulted in an additional period of 1 week and an additional cost of 680 USD.

3.2. Approach to Process with Building Information Management System

In this study, as the project is updated in the real business program as well as it is updated in BIM software and simulated with BIM software. You can see some of the project's interior design images in Figure (a) and (b). Thus, the risks and impacts of the errors in the implementation of the project during the execution of the project were determined in advance.

Fig. 2. (a) Interior Visual Design 1 (3D)

Fig. 2. (b) Interior Visual Design 2 (3D)

With the help of BIM applications, it will be determined what the new level of foundation will be with the lack of 7cm of concrete and how much the amount of the screed concrete will increase and the height of the ceiling will change and how this change will lead to a change in the design of the suspended ceiling.

With this new system, it has been concluded that the cost of revision of the foundation concrete will be more favorable and less costly, than the cost of the screed cost and time loss in addition to the additional cost of 11900 USD for the new suspended ceiling and the 1-month delay taking into account.

As a result, the air conditioning system, which is connected to the suspended ceiling design, will not change and an additional cost of 18700 USD would be avoided. Again, it would be previously determined that the difference in the level of the difference in the problem of the marble covering also caused a new marble order and a loss of time and cost of 4 weeks.

In this new system, the project would be visualized as 3D and the necessary changes would be decided before the implementation phase and there wouldn't be an additional cost of 13600 USD and 40 days of extra time. It was seen that how the changes in the rough construction would change the electrical and mechanical projects and therefore how the delay could be avoided. If the landscaping project was modeled in 3D, and the appropriate design would be decided on the visuals, an additional cost of 15300 USD and 12-days time loss would not be experienced.

In the project discussed in the case study, not only the visual outputs of BIM systems but also the metering calculations were used. It was revealed that the project team calculated the ceramic quantity wrong and the order would be incomplete over the model before the execution. Then this miscalculation would not cause a delay of 40 days.

4. Conclusion

The interest in the use of Building Information Modeling/Management (BIM) in the construction sector has continued to increase over the recent years, as it provides tremendous advantages and resource savings during drawings, planning and implementation of construction.

The case in the study belongs to the implementation process of the sales-office project of the construction, which will serve as a big Shopping Mall, Hotel and Residences. The sales-office is planned to be completed in a budget of 850000 USD in a time duration of 135 days. It is a luxury class structure and has a net area of 457.3 m2. Particular attention has been paid to the prestigious and elegant construction of a luxury project.

As a result of this study, an awareness was made about employers, contractors, architects, engineers and subcontractors about the importance of using BIM technology and the use of BIM applications for faster and less costly and more sustainable projects. As a result, when the errors caused by labor are put aside, it has been proved that BIM applications will reduce the additional cost of 120400 USD at the end of the project and 95-day time limit significantly.

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