How Information Technology Can Improve Construction Management for General Contractor: A Case Study

Yunyi Zhang[1], Jiarui Lin[2], Jianping Zhang[3], Dongdong Fan[4], Zhenzhong Hu[5]
1) PhD student, Department of Civil Engineering, Tsinghua University, Beijing, China. Email: yunyi2525@foxmail.com
2) Research Assistant, Department of Civil Engineering, Tsinghua University, Beijing, China. Email: jiarui_lin@foxmail.com
3) Professor, Department of Civil Engineering, Tsinghua University, Beijing, China. Email: zhangjp@tsinghua.edu.cn
4) Chief engineer, China Construction Third Bureau First Engineering Co., Ltd., Beijing, China.
5) Associate Professor, Department of Civil Engineering, Tsinghua University, Beijing, China. Email: huzhenzhong@tsinghua.edu.cn

Abstract: Information technology such as Building Information Modeling, 3D-printing provides an innovative approach for construction project management, aiming at increasing efficiency, improving quality and reducing cost. Construction corporations in mainland China are making active attempts to increase the informatization level in construction projects. This paper discusses Beijing Headquarter building project of Tencent as a case study for the information technology application in the construction phase in terms of how information technology can improve construction management for general contractor.

The project for case study is designed as a large public building located in Beijing, with a footprint area of 334,386 square meters. Considering the complexity of the structure, tight schedule and difficulties in detailed construction, various of attempts of information technology application have been made in the project, including 4D-BIM integrated management, 3D-printing, construction simulation. These attempts cover schedule, quality, safety and cost management, resulting in reduction of redundant work, optimized detailed design, improved efficiency, etc. This paper examines the process of each application and analyzes the necessity of each technique by comparing the benefits and the devotion. This project won the first prize in "Longtu Cup" national BIM competition in 2015 and held an exhibition presenting information technology application.

The paper also discusses the value and challenges appeared during the application of information technology in the case. Information technology application can result in resource and workload reduction, problem solving in advance and realizing precise management, thus improving construction management for general contractor. However, promoting information technology application can be challenging at first, given the management team is not familiar enough with the techniques. Countermeasures are proposed regarding the challenges and difficulties arose in the case.

Keywords: Information Technology, BIM Application, Case Study, Construction Management

1. INTRODUCTION

Information technologies such as Building Information Modeling (BIM) provides an innovative approach for construction project management, aiming at increasing efficiency, improving quality and reducing cost. Construction corporations in mainland China are also making active attempts to increase the informatization level in construction projects.

This paper presents a large-scale public building construction project as a case study where various of attempts of information technology applications have been made. This project, Beijing Headquarter Building project of Tencent, is located in Beijing, with a footprint area of 334,386 square meters. Several challenges are faced in this project: The overhang of the steel structure is up to 81 meters; several crews form different disciplines have to collaborate simultaneously; the schedule of the project is quite tight.

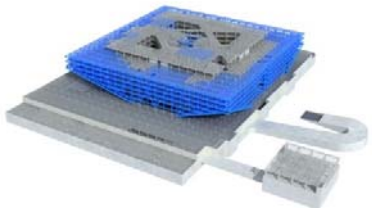

Figure 1. Structure of the main building

Considering the complexity of the structure, tight schedule and difficulties in detailed construction, various of attempts of information technology application have been made in the project, including 4D-BIM integrated management, 3D-printing, construction simulation. This project utilizes 4D-BIM management system developed by Tsinghua University, which consists of C/S-B/S integrated platforms. The C/S client is capable of detailed management and model modification on site. And the B/S interface makes it possible for management group to master construction information off site. These attempts cover schedule, quality, safety and cost

management, resulting in reduction of redundant work, optimized detailed design, improved efficiency, etc. This project won the first prize in “Longtu Cup” national BIM competition in 2015 and held an exhibition presenting information technology application.

2. BIM-BASED PROJECT MANAGEMENT

2.1 Model Establishment

(1) Model Establishment and Clash Detection

A complete and accurate BIM model is the basis of model-based integrated management, so the model setup process is given a lot of emphasis in the beginning of the project. The general contractor is not able to acquire a design model straight from the design constitute according to contract, hence they hire a team to setup models on site in advance of construction according to construction drawings. The model includes concrete structure, steel structure, MEP system and curtain walls. In addition to geometrical information, material, flow section, subcontractors, etc. are also integrated to related entities.

After the model is established, BIM manager will check and accept the model if it agrees with the construction drawing. Clash detection is implemented and hundreds of clashes are found before construction, hence avoiding waste of material and labor in case of reconstruction, and shortening the construction period.

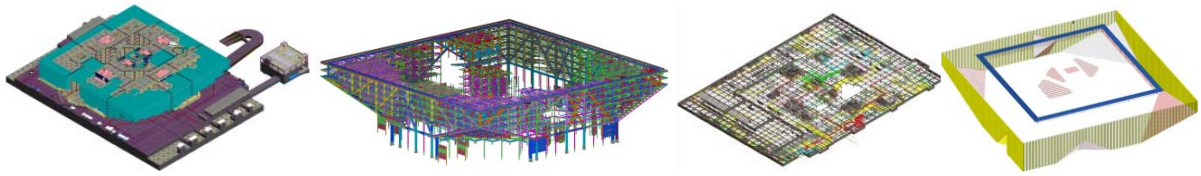

Figure 2. Concrete, Steel, MEP and curtain wall model

(2) Relative Information Linking

Ahead of the project, general contractor had made a rough schedule for construction. At the end of each month, a detailed schedule for next month is established in the form of work breakdown structure (WBS), thus each work can be recognized to be related to certain model entities so they can be linked to each other. The manager could easily query the construction date and duration for a certain area.

A large amount of unstructured files are produced in the process of construction (Simoff & Maher, 1998). Some of them, such as 2D-drawings, construction method illustrations, design change, etc. are closely related to a certain entity. In the management system, the linkage could be established where a document is related to an entity, and it is made easier to retrieve corresponding information.

2.2 Schedule Management

(1) Construction Simulation

Accomplishing each milestone on time is general contractor’s major concern. In addition to the schedule made by general contractor, the chief of each construction crew is required to input daily progress according to the WBS, thus construction simulation can be implemented according to the schedule plan or actual progress and comparison can be made between them.

The hoisting of steel members requires collaboration between several disciplines. In a conventional environment, a 2D-drawing is the basis of all the communication, and misunderstandings often occurs. However, a construction simulation according to 3D-model and actual schedule is very helpful for crews to comprehend, hence avoiding confusions while constructing.

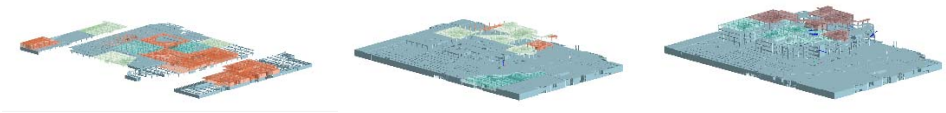

Figure 3. Construction simulation

(2) Predecessor and Successor Task Analysis

According to the logic relationship between tasks, predecessor and successor tasks can be analyzed automatically and it is rather useful when the schedule needs to be controlled between several construction crews. Under a conventional circumstance, chiefs from different crews have to hold a meeting every day to confirm each one’s own task in order to collaborate with each other. However, predecessor and successor task analysis could tell how the milestone could be affected if one certain task is delayed, so that corrective action can be made timely.

2.3 Quality and Safety Management

Quality and safety management is general contractor's responsibility and is also given much attention. In the management system, quality and safety key points can be labeled to 3D model as a thumbnail and notify related faculty to correct. Both quality and safety thumbnail can be added manually by the general contractor, and viewed in the 3D-model. After correctness, the rectification could be recorded and the thumbnail will no longer display in the model.

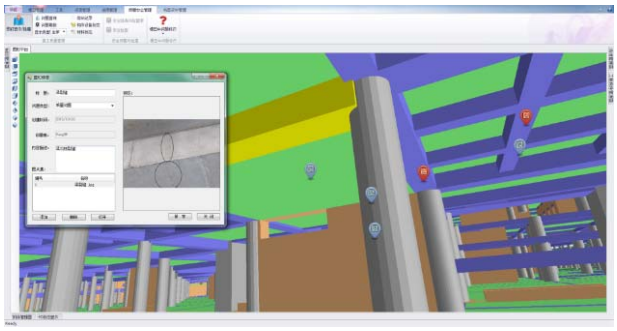

Figure 4. Thumbnail notation

2.4 Attempts to Utilize Emerging Technologies

In addition to the technologies mentioned above, this project also made attempts to utilize emerging technologies such as 3D-printing. After the BIM model is set up, it is possible to convert it to one that is capable of printing after some detail adjustment. As for the joints that is so complex that is hard to express on a drawing or screen, making a scaled-down real-world model using a 3D-printer is much easier to understand.

Such real models can aid technical disclosure and ensure workers to comprehend construction method and quality requirement. However, the high cost and long time elapsed may be a drawback, and the scale of the model is restricted to the printer's size.

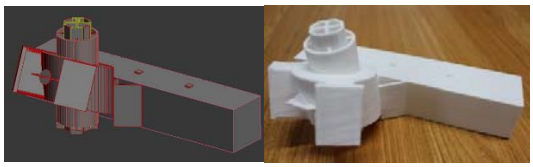

Figure 5. 3D-model and 3D-printed entity

3. EVALUATION

The general contractor has been managing this project for over one year and the project is still in progress. However, much benefit, such as compressed schedule and cost saving, has already been achieved. Table 1 below shows the self-evaluation the general contractor gives in terms of application items.

Table 1. Self-Evaluation

Item	Benefit
Clash Detection	Clash are detected ahead of construction, hence avoiding waste in time and cost for reconstruction.
Construction Simulation	Visualizing construction process can aid the communication between different crews and optimize the schedule.
Schedule Management	It is easier for general contractor to arrange work for crews in different discipline, aid communication between crew chiefs, and corrective actions can be made timely.
Quality and Safety Management	Thumbnails in the model could make it clearer the places that need inspection and correctness, avoiding security threat.
Emerging Technologies	Emerging technologies such as 3D-printing can make it easier for workers to understand construction method and quality requirement.

National BIM Standard in the United States (National Institute of Building Sciences, 2015) proposed a model to evaluate the maturity of BIM utilization called BIM Capability Maturity Model (CMM), in which 11 characteristics are taken into consideration, and is an objective evaluation method. In the following table, each aspect is evaluated and given a maturity level (out of 10) according to this project.

Table 2. BIM Capability Maturity Model

Item	Maturity Level	Evaluation
Data Richness	7	Data with mostly authoritative information
Life-cycle Views	5	Includes construction/ supply & fabrication
Roles of Disciplines	5	Partial plan, design & construction supported
Business Process	4	Most business process collect information
Delivery Method	5	Limited web enabled services
Timeliness/ Response	5	Most response information available in BIM
Change Management	7	Change management in place and early implementation
Graphical Information	9	4D - add time
Spatial Capability	6	Spatially located with full information share
Information Accuracy	5	Full ground truth - both internal and external
Interoperability/ IFC Support	9	Most information uses IFC for interoperability

4. DISCUSSION AND CONCLUSIONS

According to the self-evaluation of the general contractor and the evaluation of BIM capability maturity model, an integrated management based on information technology is achieved and acquired much benefit. According to this case study, information technology can bring benefits in construction management in at least the following aspects:

(1) More precise schedule control. By making work breakdown structure and assign each task to its corresponding model entities, it is made possible to visualize and optimize the construction process, forecast whether milestone can be accomplish on time and collaborate with different disciplines. Thus, improved achievement of milestone dates and a compressed schedule can be expected.

(2) Workload reduction. By establishing a virtue 3D-model, problems such as clashing can be solved in advance. Hence, reduced rework and fewer unplanned changes can be achieved.

(3) Improved labor productivity and less material waste. Based on 3D-model and information management system, it is made clearer how a complicated construction method is accomplished. Management group can also see it clearer what should be put an emphasis on. Therefore, an improved workers' understanding of construction and a more precise management can be acquired.

However, there are also series of challenges when pushing forward information technology for project management due to the following reasons, and countermeasures are put forward respectively.

(1) According to investments Dodge Data & Analytics carried out (Dodge Data & Analytics, 2016), lack of interest and support for BIM is a main obstacle to success, and this project is no exception. Because the management team was not used to work on an information management system, nor did they fully understand the benefit of this change, they are reluctant to work with the proposed methods in the beginning. Under this circumstance, a policy support is necessary. Therefore, a detailed process and manual is made and reviewed by the general contractor, several training periods have been made, and meetings are held every Monday to ensure the proposed information technology application are implemented smoothly.

(2) Although information technologies, especially BIM, are devoted to cancel out unnecessary work, some redundant work still remains. For example, the corporation requires each project to fill out a series of semi-structured reports, so the management team still face extra work except for the work on site. The management system could help to retrieve some information, but manual work cannot be cancelled out completely.

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