BIM-based Technology Implementation on Quality Management in Construction Engineering

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Abstract: The quality management is an important indicator that affects building projects value and practicability on people's work and life. When building quality cannot reach the standards, it would bring personal safety and property into danger. BIM-based technology has been proved that it can effectively provide specific solutions to deal with quality issues and improve quality management efficiency in the entire project life cycle. It is a significant technology to upgrade the traditional construction industry into automation and intelligence through stimulating specific construction works into a visual reality. Therefore, quality management efficiency can be enhanced on labour, material and equipment sources through BIM-based system. This paper would analyse how BIM-based quality management methods can improve the efficiency and accuracy of building project quality issues.

1. Introduction

In the past decades, China has made significant achievements in the construction industry. Based on the statistics of the National Bureau of Statistics, the total output value of the construction industry in 2011 reached 11.7734 trillion RMB for the first time [1-3] in China. However, with the rapid development of construction industry, exposed quality issues are increasing tremendously as well. Construction engineering faults have been frequently released on the mass media, such as structural cracks in buildings, external wall layer falling and leaking water supply pipe. These quality issues would cause not only dysfunctional performance but also endanger personal safety. In 2011, the ministry of construction issued "Outline of the 12th five-year plan for construction enterprise", which explicitly proposed to strengthen the government's functional departments to supervise the construction project quality, and formulated the quality targets and safety supervision at the end of the 12th five-year plan. BIM technology has been identified as a unique position and direction in the construction industry due to its advanced methods which can stimulate the real construction building into digital elements to test its potential faults. Among them, "the outline for the development of the construction industry informatisation from 2011 to 2015" is the leading representative, which starts a prelude to information intelligence in the construction industry in China. With the development of BIM-based information technology, quality management level would be improved significantly, especially for large-scale and complex construction projects. In this paper, a BIM-based position inspection method would be introduced and analysed to provide persuasive help for quality management [4-6].
2. Technical features of BIM

BIM is an acronym for Building Information Modeling. It is a deeply correlated digital process which allows multiple professionals and stakeholders to share information and collaborate in the lifecycle of a digital 3D model in AEC (Architecture, Engineering, Construction). This geographic data would assist stakeholders and professionals to make decisions according to pertinent information before the building is constructed and quality issues exposed. Blueprints and drawings were primary methods to express and share information about a particular building project. The 2D expression method poorly visualise dimensions and imitate potential quality issues. For instance, with the help of BIM objects, the project contractors can simulate the use of different materials to detect quality issues of the building structure to prevent construction faults in the future. With the development of BIM-based technique, turning AutoCAD into 3D modelling, virtual reality can finally detect these quality issues shown on the geographic information.

![BIM Life Cycle Diagram](image)

Figure.1 The life cycle diagram of BIM

2.1 Visibility and simulation:

With the implementation of BIM technology, digital building components can interact with each other to acquire feedback information. This function can experiment with quality issues encountered in the design process to obviate during the construction and operation phases [8]. Therefore, BIM can predict the construction engineering faults in the entire life cycle based on specific geographic data rather than relying on sophisticated professionals.

2.2 Optimization:

In modern architectural design, the complex building projects take a significant possession of the entire AEC. It is difficult for architects to complete their design activities on their capabilities; most of them have to consult and collaborate with external expertise to finish the design. BIM-based technology can not only help shareholders simple the design of the complex project, but also optimise the test potential faults.

2.3 Quality issues detect on site:

The on-site crew can use BIM-based technology on mobile devices to collect defects and share this information on a platform to the server with the designer, engineers to shorten the reaction time (Chen et al.). Furthermore, AR, VR combined BIM quality management system can help discover dimension errors and omissions at construction sites (Kwon et al.)
3. Analysis on BIM Technology in Building Engineering Construction and Quality Management

3.1 Investigation on the main application problems of BIM technology in Engineering

Operation stage is relatively low. As shown in Table 1, In the 11-application stage survey, the average application value in the operation period is in the reciprocal fourth. It shows that the effect of BIM technology application facilities management has deviated from the original design.

Table 1: The value level generated by BIM at each stage of the 11 construction stages

| Engineering stage       | Nothing | A little bit | Some  | Larger | Great | Average value |
|-------------------------|---------|-------------|-------|--------|-------|---------------|
| Feasibility             | 39%     | 25%         | 12%   | 19%    | 8%    | 2.34%         |
| Predesign               | 12%     | 42%         | 28%   | 12%    | 12%   | 2.7%          |
| Design                  | 12%     | 15%         | 23%   | 31%    | 24%   | 3.43%         |
| Building a document     | 12%     | 23%         | 23%   | 25%    | 21%   | 3.23%         |
| Bidding                 | 59%     | 20%         | 12%   | 11%    | 3%    | 1.88%         |
| Simulation              | 6%      | 12%         | 17%   | 25%    | 42%   | 3.87%         |
| Build                   | 3%      | 0           | 28%   | 42%    | 20%   | 3.96%         |
| Construction drawing    | 20%     | 6%          | 25%   | 33%    | 120%  | 3.26%         |
| Submit                  | 42%     | 15%         | 22    | 17%    | 3%    | 2.18%         |
| Shipment clearance      | 36%     | 15%         | 21%   | 20%    | 8%    | 2.48%         |
| Operate                 | 38%     | 19%         | 19%   | 16%    | 8%    | 2.38%         |

At the same time, the current situation and prospect of the implementation of BIM technology to facilities management are investigated. The user's summary of the BIM-based technology effect and the prediction of BIM technology's effectiveness are summarized. It takes two months to complete the survey. A total of 693 people have interviewed which show that 60 people participated in the questionnaire, and 38 respondents completed the questionnaire. The result revealed that the application of BIM technology still lacks appropriate adoption; a deep gap exists between the vision and the reality in facilities management.

In Figure 2, equipment information, contact information and the time of the necessary operation process have been illustrated, which indicates the need for both the transfer of information and the need for new information.

![Figure 2: Information needed for the maintenance process of facilities management](image)

Based on investigation shown the Table 2, about half of the respondents believed that the content of facilities management had a deep connection with the design and construction stages. The main issues of facility maintenance is that lacking of facility accessibility, blurring facility layout, small operation
space, and insufficient design space of MEP system of the ceiling. during the survey operation.

Table 2: Problems arising during maintenance.

| Type                        | 0   | 25% | 50% | 75%  | 100% | Uncertain |
|-----------------------------|-----|-----|-----|------|------|-----------|
| Lack of facility accessibility | 25% | 28.6% | 28.6% | 7.1% | 0    | 10.7%     |
| Low design deployment quality | 11.1% | 40.8% | 29.6% | 7.4% | 0    | 11.1%     |
| Lack of space               | 7.4% | 37.1% | 29.6% | 18.5% | 0    | 7.4%      |
| Lack of MEP system          | 3.7% | 25.9% | 29.6% | 18.6% | 14.8%| 7.4%      |
| AHU has limited space       | 19.2% | 26.9% | 26.9% | 15.4% | 0    | 11.6%     |

3.2 The application content and problem of BIM technology in facility management

According to the research of the large enterprise research institute, the author conducts a sample survey on the relevant employees of Chinese construction enterprises. The survey period was two weeks, and the survey was divided into two types of paper and web pages. Limiting a person can only fill out a questionnaire, and ten questions were investigated, and 150 questionnaires were collected. The main problem was to verify the problem of BIM technology in facilities management. 65% of them responded that the enterprise did not use BIM. 35% of the people feedback enterprise has the application of BIM.

Figure 3: BIM Technical application degree

4. Application of BIM Technology in Building Engineering Construction and Quality Management

4.1 Application framework

The application framework, as shown in Figure 5, includes four layers: the resource layer, the sharing layer, the core layer, and the domain layer. The resource layer includes new data and transfer information. The sharing layer is mainly transferred by model mode before the operation phase. The facility service management system takes IFC XML format as a common standard and uses the network to serve more people. The core layer is the BIM model, the content of which is the BIM model of the entire construction process. The domain layer is the resource data based on the BIM, which is created and modified by different participants and invokes the information of all the participants to establish BIM. Storage formats include IFC format and non-IFC format, and the non-IFC format needs to be converted.
4.2 Data interaction

Using IFC XML way to carry out the interaction of data, and the steps of data interaction are shown below.

4.2.1 Checking all the building information documents, which includes the location of the building elements and all the equipment installed. Preparing the BIM model, determining the essential building elements, creating the material layer, and defining the structure of the workspace.

4.2.2 Replicating, collecting and binding all the previously submitted materials and construction drawings, and creating an operation and maintenance binding unit that integrates multiple files. In this process, each of the building elements stored is located, and the IFC XML is used to define the open architecture object exchange.

4.2.3 Importing the knowledge database of building product, building command information and operating emergency data programs into these binding building units, which makes the information required for the construction process can be operated by itself. In accordance with the requirements of the facility management, the deviation of the design and building process is appropriately corrected, and the new data are stored.
4.2.4 Saving the final result of the information and linking the operable information to the building position of each building element. Finally, the whole process information of the whole building is linked and entered into the BIM model, and the records are stored in the BIM centre database. The part of the BIM model diagram in building engineering construction is shown in Figure 5.

4.3 Principle of BIM technology

The application process of facility management mainly relies on the operation information model of the BIM model and relies on the BIM centre database. Its work is to meet the two main contents of the facility management: the operation service part and the equipment service part, which are divided into four specific modules: the financial management module, the user management module, the space management module and the facility operation module. The financial management module includes the necessary daily information checked by managers, the income and expenditure required by the building services and other contents. The user management module is the part of the facility management system that can be extended to the customers, which includes user satisfaction with building facilities, the required building service’s needs and so on. The space management module is mainly responsible for the use of building space, the layout of space, and the location of the equipment. Under the help of BIM, the effect of 3D display is realized. The financial management module, the user management module and the space management module belong to the operation service management content of the facility management. It was distinguishing the operation management separately, which includes the management of buildings and structures, the management of building equipment and the management of the building environment. BIM technology serves the information approval, entry, storage and calculation of four modules.
4.4 BIM-based Position inspection technology in quality management

BIM technology can provide assistance to the quality management of building engineering by simulating the actual construction of building projects and storing a large amount of relevant information. A BIM-based positioning technology based on MaLoc module to combine WLAN and magnetic field will be introduced and analysed in this research.

Wireless Access Point (AP) signals and the corresponding Received Signal Strength Indication (RSSI) will be collected and sent to the server through mobile devices on the construction site. Before using this function, the user need to upload the floor plan for inspection onto the mobile device. Users can walk along the route through the instruction of positioning technology showing on a mobile device. Connected sensors will be installed to automatically collect data of magnetic field and Wi-Fi signals from each AP, and the corresponding coordinates for uploading a set of data on the server. Then, the module will obtain accurate 2D coordinates through matching the magnetic field with the fingerprints in the geographic database. Later, BIM-based system would display a real-time position on the corresponding floor. Therefore, the correct entry of inspection data would be detected automatically in the BIM-based system to remove faults. When all items in the inspection lot passed the quality check, the confirmation notification will be sent to the supervisor subsequently to conduct next site inspection for the re-check. When supervisors disagreed on the results of the check, they would require relevant companies to rework, and a deadline message for reworking will be sent to the contractor. At the same time, the user can also search checklist and the original inspection data. However, the construction process may have a negative effect on the accuracy of the magnetic field and Wi-Fi signals. Therefore, calibration work is needed for accurate positioning. Although BIM-based system requires approximately 30% more time due to unskilful operation and fingerprint collection of the magnetic field and Wi-Fi signals compared to traditional methods, the time consumption of inspection tasks, summarising the inspection results and writing, delivery of the communication letters are saved. Based on Zhiliang et al. study, the system can save approximate 50% of the entire time during the inspection with higher accurate check quality management.
5 Conclusion
This study introduced the application of BIM-based technology in quality management. One of the BIM-based technology, inspection positioning method is analysed on its functions. The system assures that the shareholders follow the rules strictly, without omissions in the checking items, target objects during the inspection. The process of inspection has the advantages of simpler, less time consumption and more accurate results. However, this research still has its limitation on current knowledge. Automatic association with construction schedules are relatively rigid and simple based on the current system. It needs more flexible construction plan especially complex, large scale projects. Moreover, customisation of inspection check should be developed further to satisfy the customers’ needs. In the end, the interoperability would be studied for integrating AR, VR technology to augment its functions.

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