

Research on Collaborative Mechanism of design and construction based on BIM technology and application of typical cases

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Abstract. As the popularization and application of the BIM technology has been widely recognized in the industry, this article starts with analyzing the value of BIM industry to compare traditional design and collaboration mechanism based on cloud BIM with plus their advantages and disadvantages; at the meantime, multi-layer cloud platform system based on the P-BIM concept leads to collaborative mode of design and which designed procedure for the construction WEB collaborative mode; at last, typical construction cases are applied to analyze value of BIM. With the development of big data and cloud computing, BIM will lead the trend of technology and provide technical support for improving the efficiency of engineering construction, reducing costs and reducing errors.

1. Introduction

The engineering construction industry involves many fields. There are 12 categories [1] of general contracting according to construction enterprise qualification standards" notice (No. [2014]159 building city) issued by Ministry of Housing and Urban-Rural Development, and 46.27 million people work in this filed in reference[2]. Data released by the National Bureau of Statistics show that in 2015 total output value of construction industry reached 18075.7 billion Yuan, an increase of 2.3% over the past year. Compared with growth of 10.2% in 2014, the total output value of construction industry in 2015 for the first time fell into a single digits, and the growth rate has also fallen sharply, which worried industry insiders. Therefore, the construction industry as the country's main support industry, has always been large-amount capacity and labor intensive. According to the data analysis from the National Institute of Standards and Technology in the United States Trade and Technology Management Department, it's found that 40% of the construction practice was spent in information research (positioning) and confirmation, and poor communication between people and systems cost 30% of project expense, and for completed construction, reliable document handover can help save 14% fee of operation and maintenance per year.

When compared with manufacturing industry, although total production value of construction industry is bigger, the profit rate is quite low. In the final analysis, compared with assembly line production mode of manufacturing filed, the construction industry has always been in a condition of low energy consumption, lots of manual operation error and low construction management efficiency. With popularization of BIM technology (Building Information Modeling, BIM), intensive



management mode based on BIM is pilot projects in major cities, which makes prefabricated construction structure distributed processing and integration largely improved construction efficiency[3]. With the development of cloud technology, remote storage computing becomes possible, leading development and design of remote collaboration platform based on cloud BIM turning into the mainstream research trend. Therefore, it is essential to design a collaborative platform based on BIM technology.

2. Comparison between 2D and 3D design

2.1. Characteristics of traditional engineering design

Design institute work mode in our country has always been sequential undertaking, and work flow of each specialty is one-way as shown in Figure 1. Communication in this kind of design relationship is difficult. Information delivery and modification mainly stuck in paper media, and correction cannot be made timely when a design issue is found, thus to delay project design efficiency, and also increase the risk of delaying construction schedule.

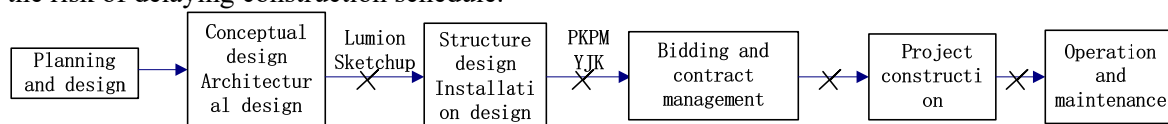


Figure 1. Traditional engineering construction process

In a sense, the collaboration of multi professional design is mainly based on personal understanding of professional knowledge, and cross-trade issues cannot be found in time; for instance, problems like top and bottom plumbing pipelines passing through the main beam. Drawbacks during traditional architectural design process concluded in the literature[4] are as follows:

- Generally speaking traditional construction project design is linear type;
- Lack of communication between professionals;
- Hard to control design schedule;
- Comparatively low design efficiency; duplicated design;
- Risk of bad design quality.

Therefore, it's important to improve collaborative capacity of each trade during design and construction phase, which can fundamentally improve work efficiency and ensure the design quality.

2.2. Characteristics of 3D collaborative design and construction

1. Change of design organization and process. Compared with traditional design organization, 3D collaborative design breaks the time order of traditional mode, without front and back design process that traditional mode has, designers of each specialty can take directly.

2. 3D visualization can promote thorough communication between designers. Traditional 2D CAD drawing has poor visualization effect, designers cannot check out problems such as cross-trade collisions, while 3D collaborative design plus the application of VR enjoys a biggest advantage of achieving visual communication, reflects design intent from VR scenes.

3. Collaborative work and multi professional participation. 3D design break point to point communication under linear working mode in previous design projects, which performs low information delivery efficiency, and prone to errors, while the establishment of 3D collaborative real-time mode has been greatly improved the work. Each specialty can work together, has real-time sharing, and greatly reduce workload of everyone, with significant improvement of design efficiency and quality.

4. Provide the possibility of intensive project management. With the implementation of BIM series standards, there are specific regulations for font, size and layer of all specialties of drawing, which makes project responsible individual have easier and unified management and maintenance of 3D model database, effectively avoid large quantity of duplicate design, provide a guarantee for

consistency and integration of all design phases, and thus to improve working quality and efficiency of the entire project team.

The parameterized 3D collaborative mode also has an advantage of being convenient to project measurement. Software interface opening in the future and rapid and accurate data identification can divide project and have contrastive analysis, which can provide accurate foundation data for you to introduce subcontractors, and also further provides the possibility of elaborate decision for project cost, project management and progress payment management.

A multi-purpose or early application can further refine the enterprise project management, including manpower, material and equipment management, greatly reduce the waste of resources and logistics, and provide strong technical support for the realization of the control limits of consumption, and further enhance the level of intensive management project and project cost control.

2.3. 3D collaborative design concept

At present, the value of BIM technology has been widely recognized in China's engineering construction industry, and realized positive application in some construction project design, with expanding application scope and depth. Also the construction department conducted lots of policies on application of BIM technology from top to bottom levels. The digital technology based on construction situation represented by P-BIM, which was implemented by China Institute of Architectural Science, obtained extensive attention from domestic and international construction industry [5], as shown in Figure 2. Due to restriction of software function, drawing standard, drawing review regulation, etc., the method of 3D design with direct application of BIM technology has not been popularized yet, which exists at the same time with 2D and 3D collaborative design mode, and 3D verification after 2D design completion.

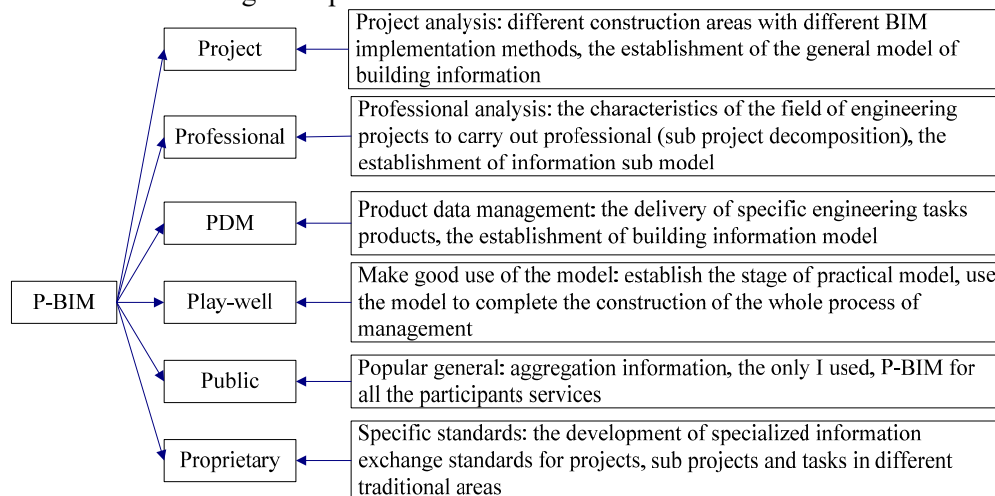


Figure 2. P-BIM implementation methods based on engineering practice

3. Level analysis on collaborative software

Collaborative design is classified in accordance with time and space. When classified by time, it can be divided into synchronous collaborative design and asynchronous collaborative design; when classified by space, it can be divided into centralized collaborative design and distributed collaborative design. With the development of BIM software and implementation of BIM standard, data transmission and sharing has become possible [6]. The development of cloud technology put information mode on the cloud server, to complete the rapid upload and download to make collaborative design possible.

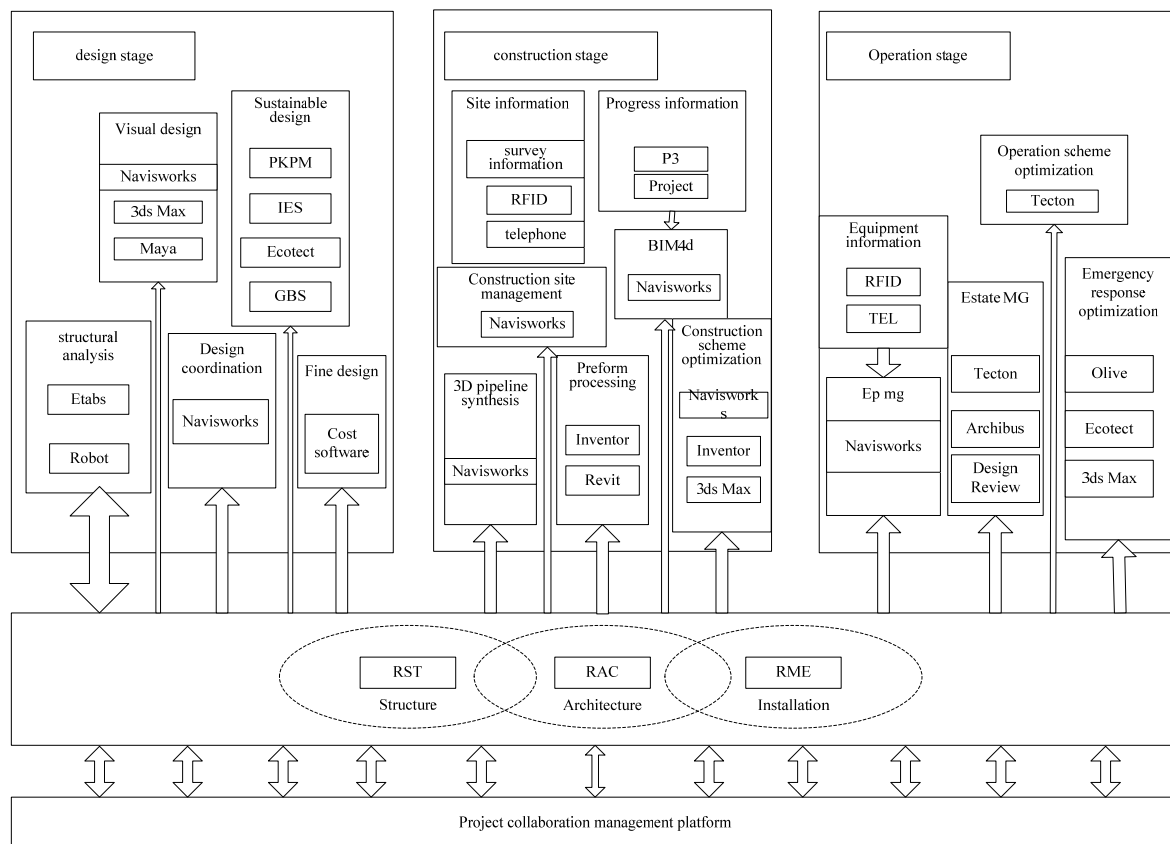


Figure 3. Whole process design platform and BIM software constitution

4. Online construction collaborative platform process based on cloud BIM technology

The concept of BIM construction collaboration is based on internet plus technology, to realize remote monitoring, data approval and sharing, combined with VR 3D scene, to stimulate construction process per construction organization, and then to adjust and optimize the construction sequence and method to finally get a comparatively best construction method. The construction management flow chart based on cloud BIM is as shown in Figure 4:

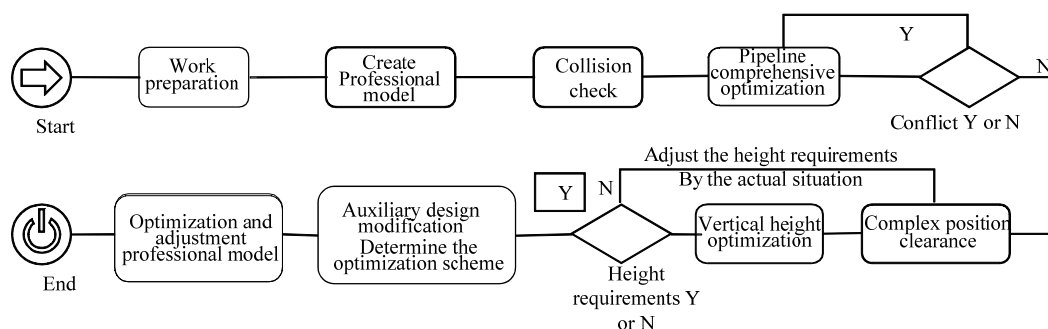


Figure 4. Operation process of BIM application during design and construction

BIM model can simulate the whole construction process. This simulation can modify construction process with application of modeling and simulation technology, and as for construction efficiency and accuracy improvement, it has below traits:

- Simulation of full range digital construction environment.
- To integrate construction sources like manpower, equipment, materials, etc.

- Distributed collaborative working environment.
- High reliability of simulation results.
- Good effect of human computer interaction.

When construction information model is establish, BIM model can be used for construction process management, such as technical disclosure and remote quality monitoring based on BIM model, and its main work flow as shown in figure .

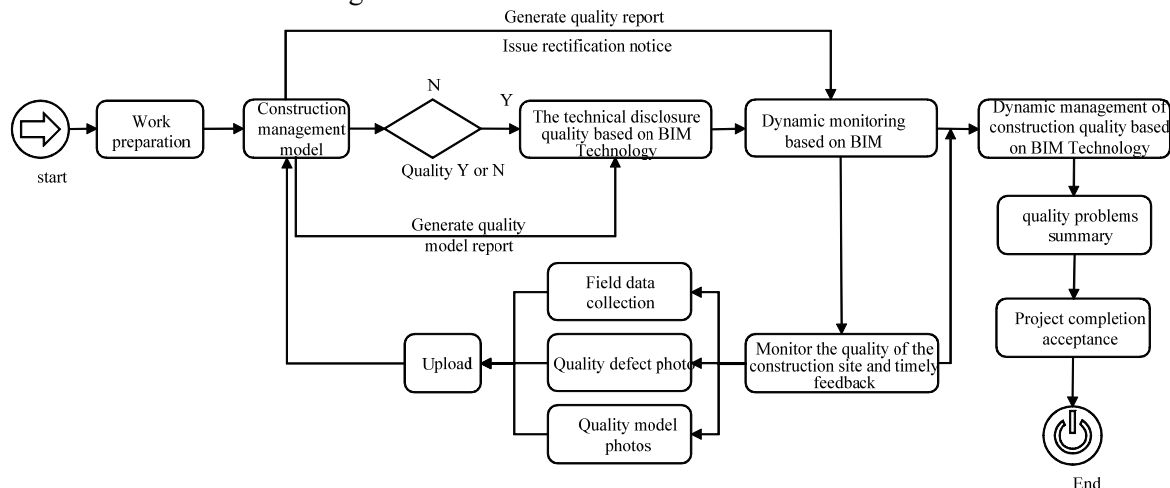
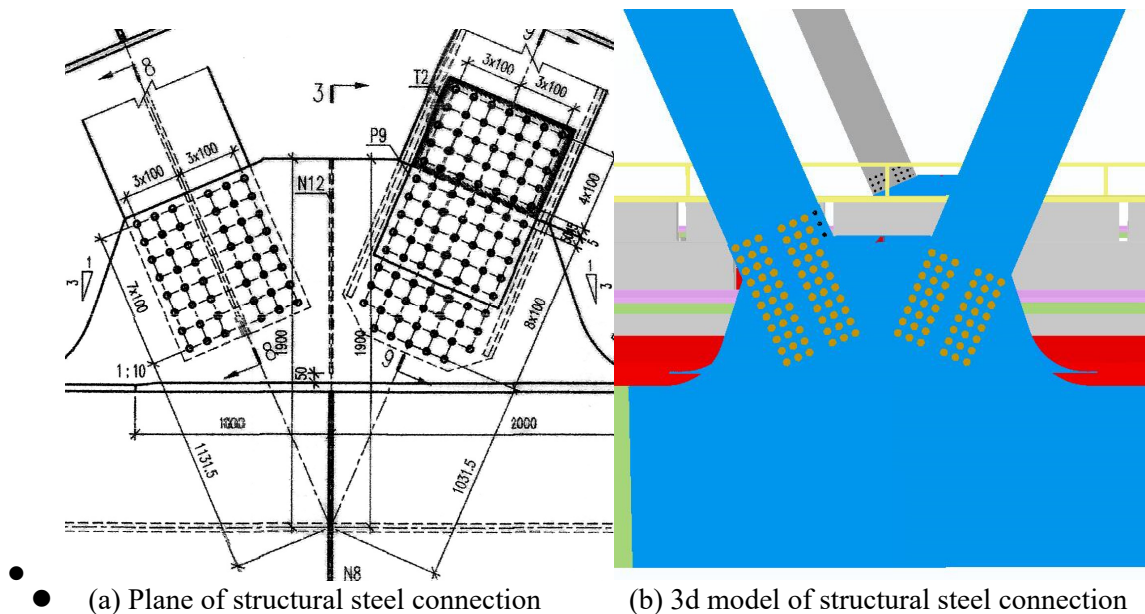


Figure5. Control process of BIM quality and safety management

5. Typical applications of collaborative design and construction

With the use of BIM becoming more and more wide and thorough, it performs well in error reduction, efficiency improvement, cost saving, project innovation, collision detection, material calculation, progress simulation, crane installation simulation, roaming browsing and performance. Take structural steel design as an example. The combined highway railway bridge crossing the main channel of Yellow River, located in Ji'nan, Shandong, with the bottom railway as Shi Ji, Han Ji and Jiaoji contact line at both left and right, and two-way six lanes on the top. Ji'nan Yellow River bridge, using (128+3 * 180+128)m rigid cable continuous steel truss beam across the main channel of the Yellow River, with a total length of 798.3m, weight 36249t, is the first Chinese built highway railway bridge with large span rigid stiffened cable continuous steel truss.

For chords connection model it's not easy to express the joint dimension, neither the construction. BIM 3D model as shown in figure6 can solve material and connection problem.



● Figure6. From plan to 3D BIM model

- A set of bolts created on one side of the splicing board and the rod piece
- Another set of bolts created on the other side of splicing board, and screw holes to be made at corresponding place of adjacent rods.

The complementation of BIM model can also so accurate bolt positioning, torque pressure and weld size. Another example is that monitoring of deep pit slope has always been a tough problem, in the deep well of super high-rise buildings and bridge piers, safety of deep excavation must be guaranteed, which would have great impact in case of problems. The application of BIM model can achieve real-time model to contact monitoring of slope and excavation, with sensor displacement limit value set, to contact model with the real-time alert.

6. Conclusions

This paper designs the BIM collaborative framework to solve the shortcomings of traditional design and construction, from the process engineer to solve the problem of lack of coordination, lack of communication and coordination, The solution of information sharing is put forward on the BIM theory, and the practical application value of BIM is fully proved by a BIM engineering application. But BIM collaborative technology currently has the data interface is not fully developed, the network information transmission is slow, remote coordination is more difficult, and the quality of the BIM staff has yet to be improved.

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