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Construction Quality Management and Evaluation of PE Gas Pipeline Based on BIM Technology

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As a pillar, the construction industry in China specifies a schedule control in project operation phases which matters project cost, materials and security. Unlike general construction projects, the chemical production and construction processes have an awfully cumbersome management for the field schedules such as fire protection and hydropower installation. This paper takes the chemical construction project PVC complex as an example, analyzes the application of BIM technology in the schedule management of the whole construction project. The findings show that the BIM technology implemented with the Revit platform, Project platform and Navisworks software can improve the field construction efficiency in the operation phase of the PVC complex construction project by the schedule management, reduces labor and time costs, shortens the construction period, and improves the work efficiency of project managers. This study provides the important clues to the development of chemical construction industry towards industrialization and modernization.

1. Introduction

Construction industry plays an unusual part in China's economy, just like a backbone of GDP growth (Costin et al., 2012). Chemical production and construction projects have sprung up year by year, but they seem much more complex than ordinary residential and infrastructure construction (Kojo et al., 2010; Li et al., 2017). The construction industry has always been a low-information-based type. During the practical construction operation, many valuable information will be misrepresented in the disorderly management process (Getuli et al., 2016; KWON et al., 2014). In the operation of construction projects, the advent of BIM technology has improved the management level of building construction. Many scholars and experts have found that the BIM technology has a positive effect on the improvement of the construction efficiency in project schedule management process (El-Omari and Moselhi, 2011; Alizadehsalehi and Yitmen, 2016).
It is not a long time since the BIM technology was introduced into China, but it has gained an extremely fast development (Lee et al., 2006). China's construction informatization has experienced three phases, i.e. modernization-industrialization-informatization (Jupp, 2017). BIM technology, as a means of informatization process, has six features, i.e. integrity, sharing, uniformity, synergy, visibility and simulation (Matthews et al., 2015). Unlike the general construction projects, the chemical production and construction project adopts the long-span space, and more concern fire protection architecture and structural anti-corrosion. It sets an extremely high standard for building. Compared with traditional technology, the BIM technology makes the advantages of chemical construction project more prominent in the life cycle of the building (Bayne et al., 2016; Li et al., 2017). This paper takes the PVC complex construction project in chemical production as an example, analyzes the application of BIM technology in the schedule management of the whole project, and proposes a system platform for the fine management in combination with BIM technology.

2. Construction schedule management advantage based on BIM technology

2.1 Project schedule management based on BIM technology

In the operation phase of the construction project, BIM technology can store the damages and functions of the in-service equipment in the construction project from the time dimension, so as to establish appropriate

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dynamic inspection mechanism (Patching and Best, 2014). As shown in Figure 1, the relationship between the information modification cost and impact in the full life cycle of the project is given. It is clear that, as the construction project gradually moves forward, the impact produced by the information modification decreases. However, the cost paid gradually increases. The traditional project management adopts the bar charts, as shown in Figure 1, easily drawn and from which the lap joint relationship can be seen clearly, but usually compiled manually. The schedule information should be provided by units. There are cases of misinformation or information error occurred in the transmission process; the overall workload is heavy; the program is complex, and errors are prone to occur (Gollakota and Mcdonald, 2014). However, BIM technology provides a new framework for the schedule management in the construction operation phase, and all parties should build a platform to achieve project schedule tracking and analysis.

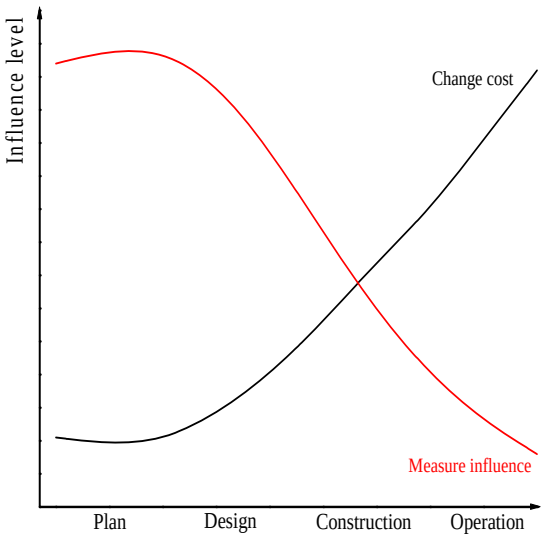

Figure 1: The cost and effect relationship of information modification in the life cycle of a project

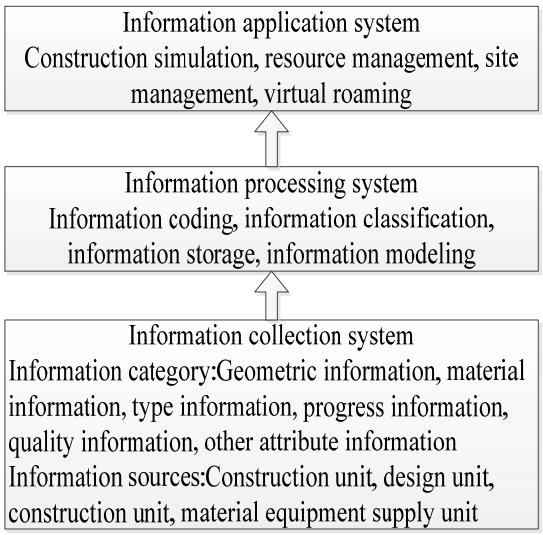

Figure 2: BIM information platform overall architecture

Table 1: Cross plot

Procedure number	Duration Time	Time/month 1	2	3	4	5	6	7	8	9	10	11	12
A	2												
B	3												
C	2												
D	7												

2.2 Schedule management based on BIM technology

Judging from the practical experience of foreign projects, the function of BIM technology in the construction of large-scale projects is becoming increasingly obvious. However, the development of BIM in China has not been integrated with the construction project management (Abourizk et al., 2011). As shown in Figure 2, the overall architecture of the BIM information platform includes the information collection system, information processing system and information application system. in the last system includes, the schedule curve of the project can be given, as shown in Fig 3. BIM technology clearly shows the schedule curve of the project and the change trend of work quantity over time. As shown in Figure 4 and 5, the overall and the secondary schedule preparation processes are given, respectively. The BIM database is used to determine the work quantity. Units jointly develop overlapping relation with completion time and prepare the overall schedule, preform 4D simulation inspection and adjustment. BIM technology helps acquire complete construction information, highly collaborative operations and visual simulations, allows 4D simulation for schedules and key tasks to check the rationality of working hours and logical relationship.

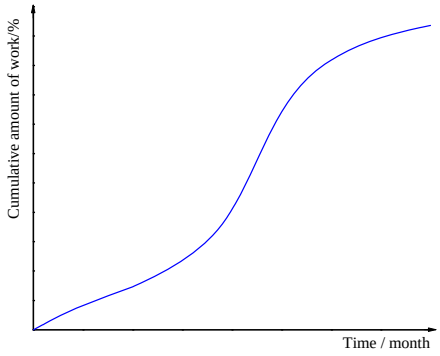

Figure 3: Progress curve

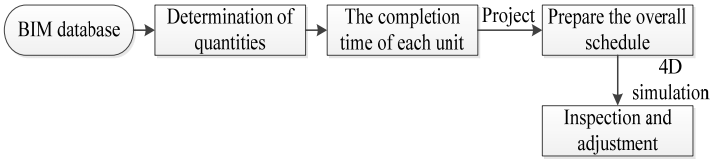

Figure 4: Total schedule preparation process

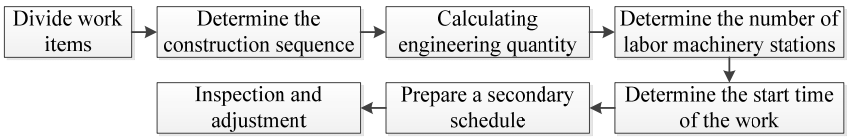

Figure 5: Secondary schedule preparation process

3. Application of BIM technology in project construction schedule management

3.1 Building 3D model

In the project construction schedule management, the introduction of BIM technology has accelerated the informatization of the schedule management in the operation phase. The core operation in BIM technology is the 3D modeling of Revit. The project schedule dynamic management is simulated by Navisworks. Compared with the traditional floor plan, BIM technology can achieve visual modeling, and via the Revit modeling, can get the floor plan, elevation and profile maps for the 3D building model. If the information changes, consequential change also occurs on other information, greatly reducing the change time and cost. The primitive structure of the building unit includes three parts: model, view, and callout primitives. The primitive data structure includes basic and extended data. As shown in Figure 6, it is a BIM-based schedule management system architecture. The BIM schedule management platform consists of data, model, platform and application layers, whose final function is to develop the schedule, real-time supervision and optimization of schedule, schedule dynamic demo and tracking.

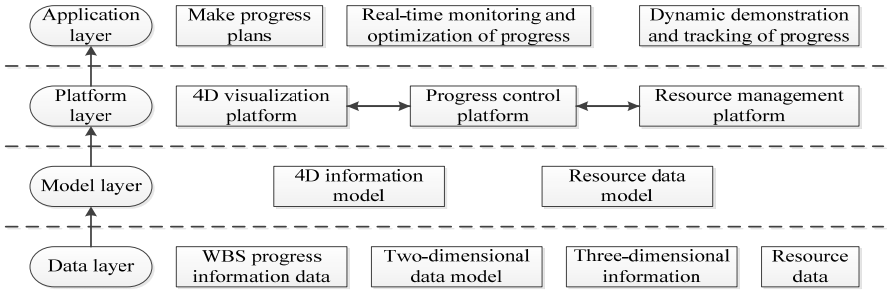

Figure 6: BIM-based schedule management system architecture

3.2 4D simulation for construction project

The 3D model and time dimension built by the Revit constitutes a 4D model proposed during the whole life cycle of the project. Over time, the project schedule manager performs schedule control on the site as the model changes. The 4D model can be expressed by data exchange and dynamically on the identical platform. As shown in Figure 7, the three levels of data exchange, i.e. the model, view and the control layer, have working mechanisms independent of each other, but with one purpose. Figure 8 is a flowchart of BIM-based schedule management implementation. The implementation of schedule management includes three steps: the first step is to build a BIM 3D construction information model via the Revit platform; the second step is to

use the Project platform to create construction schedule data; the third step is to adopt the Navisworks software to demonstrate the construction schedule.

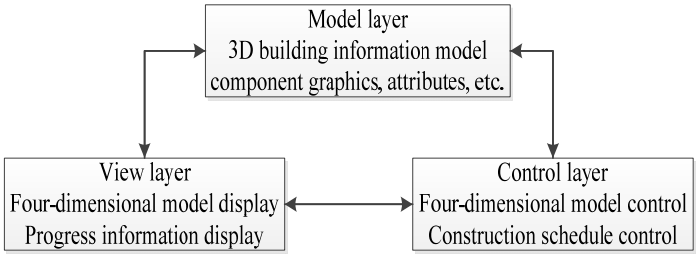

Figure 7: Three levels of data conversion

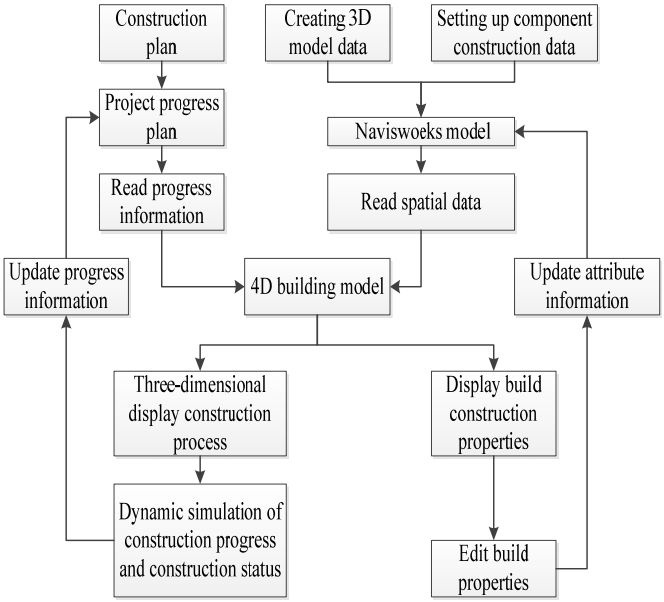

Figure 8: BIM-based progress management implementation flow chart

4. Feasibility analysis of fine management of PVC complex construction project based on BIN technology

4.1 Application of BIM technology in progress management of PVC production and construction project

Here, a PVC complex construction project in Hebei is instantiated. It consists of 13 subprojects, 6 workshops and 2 warehouse buildings. The workshops and warehouse buildings are different from office and residential buildings since the former have diversified construction branches and massive information. The fire-fighting and water and electricity installation projects during chemical production make the field construction schedule more cumbersome, including the complex coordination, information sharing and shorter construction period.

During the preparation work before construction, the BIM studio and the foundation model are set up for verification and drawing. In the early stage, the construction site simulation should also be carried out: animation display, large machinery collision analysis and construction simulation. Throughout the BIM studio, schedule data in each division will be integrated into the BIM, and the overall construction project will be analyzed to make clear whether there is a room for optimization. As shown in Figure 9, there is loss of information in the life cycle of the PVC complex construction project. With the advancement of the construction period, the total information content shows a monotonous upward trend, but most of them will have a fold line in two adjacent phases, which shows that there is fully unused information in in the project. It is found from the study of BIM technology in the PVC complex construction project that there are some issues, including standards, software, technical cognition and management model.

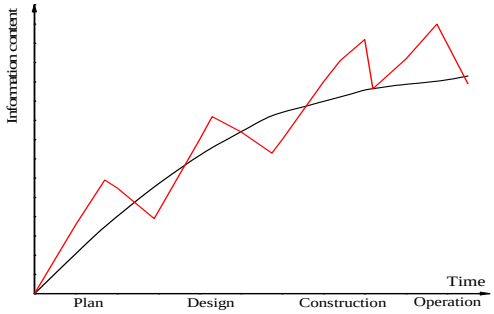

Figure 9: Loss of information in the life cycle of a PVC production complex construction project

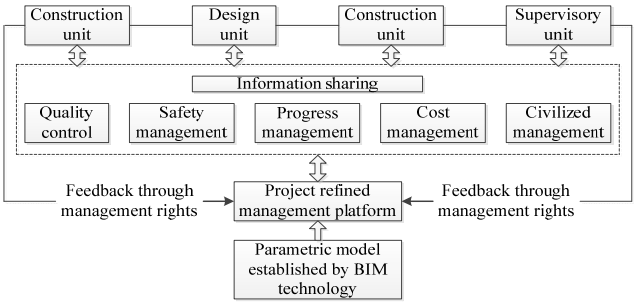

Figure 10: BIM management platform refined management flow chart

4.2 System platform for fine management of PVC production and construction projects by BIM technology

Construction management is a relatively complicated system. The primary management demands of PVC production and construction project is shown in Table 2. The design unit does not participate in the management processes of schedule, cost and material equipment. Each project entity requires management contents in different degrees. Information sharing and exchange are important content for collaborative work. In order to avoid problems occurred in the management model in PVC production and construction projects, a fine management system platform is created. The refine management process of the BIM management platform is shown in Figure 10. After the BIM parametrized model is improved, it is imported into the BIM management platform for project fine management. The framework and functional objectives of the project management platform integrated with BIM technology are shown in Figure 11. The whole system framework includes four parts: BIM operation, construction simulation, event system and construction log. The BIM model can be combined with CAD drawings for sync view, along with viewing module attributes, and event system and construction log in the drawings can be sorted according to different situations, searched by keywords, and shared in real time on webpages and mobile phones.

Table 2: Management demand statistics table for the main body of PVC production and construction project management

Management content	Construction unit	Supervisory unit	Construction unit	Design unit
Quality control	√	√	√	√
Safety management	√	√	√	√
Progress management	√	√	√	—
Cost management	√	√	√	—
Material equipment management	√	√	√	—

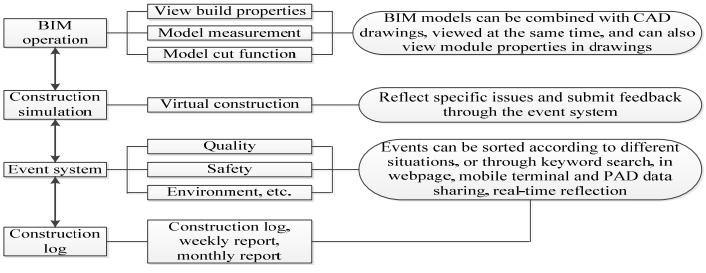

Figure 11: Engineering management platform system construction framework and functional task objectives combined with BIM technology

5. Conclusion

(1) With the BIM technology, we can clearly see the curve of the project schedule and the change trend of work volume over time. It helps obtain complete building information, highly collaborative operation and visual

simulation, and a 4D simulation can be performed for schedule and key works to check the rationality of working hours and logical relationship.
(2) The BIM schedule management is implemented by three steps, that is, establish BIM 3D construction information model by the Revit platform, create data about the construction schedule by the Project platform, and demonstrate the construction schedule by the Navisworks software.
(3) The PVC production complex construction project have made it difficult to manage the field construction schedule such as fire protection and hydropower installation. It is found by the study of the application of the BIM technology in the PVC production complex construction project that there are some obstacles, including standards, software problems, technical awareness issues, and management model and other issues.

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