CHEMICAL ENGINEERING TRANSACTIONS

VOL. 71, 2018

A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.aidic.it/cet

Guest Editors: Xiantang Zhang, Songrong Qian, Jianmin Xu

ISBN 978-88-95608-68-6; **ISSN** 2283-9216

DOI: 10.3303/CET1871214

Whole Process Cost Management Control of Dangerous Chemical Product Construction Projects

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The purpose of this study is to strengthen the effect of whole process cost management (WPCM) in the Dangerous Chemical construction projects. To this end, this paper studies the WPCM control of Dangerous Chemical construction projects. Building Information Model (BIM) technology was introduced into Dangerous Chemical building, to analyse the application of BIM technology-based Dangerous Chemical construction project in all stages of WPCM management. The study found that the pipeline collision and rework phenomenon on the site are greatly reduced, the construction cost drops directly, and the cost change is reflected in time. Therefore, BIM Technology has changed the traditional ways of work. It can process the engineering information quickly and accurately. The application of BIM technology in the WPCM is conductive to achieving accurate, dynamic and real-time cost management.

1. Introduction

Thanks to the development of the market economy, the demand for urban infrastructure construction has been increasing. However, the engineering cost management of most Dangerous Chemical enterprises is a static management method, focusing only on the engineering cost management at a certain stage. In an increasingly competitive market environment, if enterprises want to stand out from the crowd, they must pay full attention to the dynamic management of project cost. The project cost comprehensively reflects the technical level and management ability of the enterprise. It refers to the sum of all the expenses required in the construction of the project. The survival and development of enterprises are closely related to the project cost. Balancing the relationship between schedule, cost and expense is an important part of project cost management. Dangerous Chemical enterprises are the pillar industries of the national economy, and the WPCM of Dangerous Chemical construction project plays an important role in the long-term development of Dangerous Chemical enterprises. Based on this, this paper analyses the WPCM control of the Dangerous Chemical construction projects.
In this paper, based on BIM technology, the building information model was established to analyses the application of Dangerous Chemical construction project in all stages of management.

2. Literature review

Zuo and Zhao (2014) pointed out that the German government managed construction engineering technology through associations and societies. In nature, industry associations and trade associations were non-governmental organizations, but they not only protected the interests of the industry, but also promoted government decision-making. FIDIC's international contracts were usually the provisions adopted by German Engineering Budget Institute. Some measures and fees could be quoted separately, and some project management fees could also be quoted. Profits, risks and taxes could not be ignored in the quotation. Because of the fierce competition, the lowest price was usually applied to win the bid, which was not lower than the cost price and necessary for the needs of professionals. Being more familiar with the price of labor, machinery and materials was conducive to determining and composing the unit price of various quantities so as not to deviate from the total price (Zuo and Zhao, 2014). Sturzenegger et al. pointed out that the Ministry of

Please cite this article as: Shan R., Xiao X., Luan J., Guo Y., Kang Q., 2018, Whole process cost management control of dangerous chemical product construction projects, Chemical Engineering Transactions, 71, 1279-1284 DOI:10.3303/CET1871214

Construction designed a set of project pricing standards for Japanese project cost management. This standard could be used as the basis of consumption and workload. It implemented the quota system of separating quantity from unit price, which was open in quantity, confidentiality in unit price and living unit price. Private investment projects and government invested projects were managed in different ways. From the point of view of government-invested projects, sub-departments directly managed the whole process of project cost, including the investigation and completion of the project; from the point of view of private-invested projects, the management was standardized with the help of the market, and the way of bidding was adopted to determine the contract price (Sturzenegger et al., 2016). Ding et al. pointed out that the maturity model level of engineering cost management could be divided into five levels, gradually improved from the first level to the fifth level, and gradually developed towards maturity. From the basic knowledge of cost to the standardization of management process, and then to the organization of the whole process, they were all completed in the effective valuation of the unit project through transformation and quantification. It considered not only construction cost, but also operation and maintenance cost, and achieved the optimization of target cost management (Ding et al., 2014). Brady and Davies highlighted BIM's arguments in their research, and also emphasized the related technologies of BIM implementation, including the following aspects: relational database, intelligent parameterized components, automatic mapping and three-dimensional modeling, etc. A case was also used to illustrate their concepts (Brady and Davies, 2014). Elmualim and Gilder pointed out that through digital method, the whole process of BIM concept sharing, management and project construction, from design concept to construction completion, then to maintenance and operation, and finally to demolition and reuse, the core process of "design-construction-management" was realized through information integration and collaboration. The BIM technology was widely used in later maintenance management, construction management and cost management (Elmualim and Gilder, 2014). Braglia and Frosolini pointed out in their research that it is necessary to establish a life cycle cost management information system. Based on this method, theory and thought, they made a detailed analysis of the functions and characteristics of the information system, and realized the required technical support on the basis of the information system, so as to establish a life cycle cost management information system. The technical core of the cost management information system was BIM, and the network architecture was C/S+B/S. The specific functions of each module in the system were emphasized, and the operation of each stage of the whole life cycle was highlighted (Braglia and Frosolini, 2014). Cao et al. pointed out the effective role of BIM in cost refinement management: information transmission was real and complete, conducive to information sharing and communication. Information calculation was fast and accurate and information expression was intuitive and efficient (Cao et al., 2015). In the study, Oesterreich and Teuteberg identified the application value of BIM in the cost phase, including project completion and transfer, construction, bidding, design and decision-making (Oesterreich and Teuteberg, 2016). In the study, Azhar et al. believed that, from the point of view of project management at all levels, BIM technology was not only fast and accurate in obtaining engineering basic data, but also played a very good role in controlling the project cost of participants (Azhar et al., 2015). Mok et al. held that, virtual 3D model and 5D associated database of BIM technology also played an important role in ensuring the progress and cost control of the project. BIM technology not only realized the sharing of information, but also realized the collaborative work of various management lines, which improved the management efficiency (Mok et al., 2015).

In summary, the above research work mainly focuses on the research status of the whole process cost management, building information model and so on. However, research tends to be theoretical and practical aspect is less studied. Therefore, based on the above research status, the whole process cost management and control of Dangerous Chemical construction projects is mainly studied, mainly using cases to illustrate, looking for the problems and obstacles encountered in the whole process cost management, and exploring specific solutions.

3. Principles and methods

BIM means building information model. Chuck Eastman first proposed the related concept of BIM. That is, the purpose of BIM is to establish a digital information model, which includes not only all physical features of the construction project throughout its life cycle, but also process control and construction progress. But BIM hasn’t been developed perfect enough, and its definition is constantly improving. So far, no BIM definition has been fully accepted. The following definitions are the most recognized ones until now. BIM is based on the premise of various related information data in the construction projects, to simulate the real information of buildings through digital information. All participants learn the value of BIM from their own perspective. In certain studies of Stanford University, the United States, different units were quantified in the integration of facilities engineering, to obtain the building information model (Figure1). It has the advantages as follows: avoid 40% extrabudgetary changes; control the accuracy of cost estimation within 3%, and reduce the estimated time of the cost by 80%; decrease the contract price by 10% based on conflict resolution and discovery.

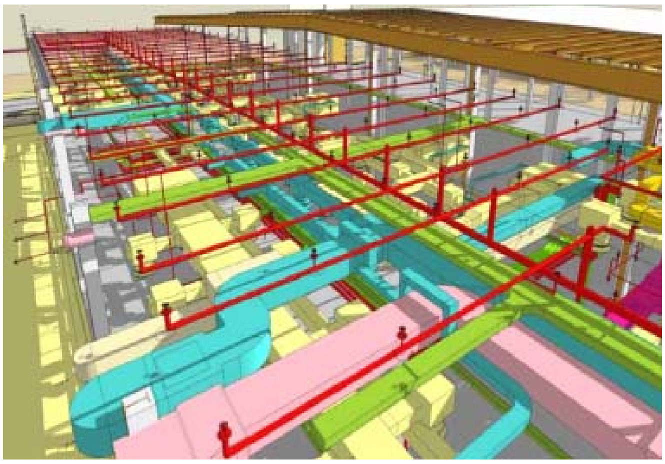

Figure 1: Electromechanical pipeline engineering information model in Dangerous Chemical construction equipment

In the investment decision-making stage, the construction scale is the primary factor affecting the project cost. The construction scale, also the project production scale, refers to the production capacity or use efficiency that the project may achieve in its normal production and operation years. Its main restricting factors on its rationalization include market factors, technical factors and environmental factors: the technical factors are the basis for the In the initial planning of the project, there are often “multiple information” and “multiple management”, while BIM centralizes the information, and make optimized screening, to avoid the information blocking caused by the conventional management process, and then achieve the information service model (Figure2). According to the resource integration of the server, the construction scale and annual generation capacity can be drawn up. With the relevant data integration of BIM, the break-even point is calculated through financial analysis to ensure production efficiency.

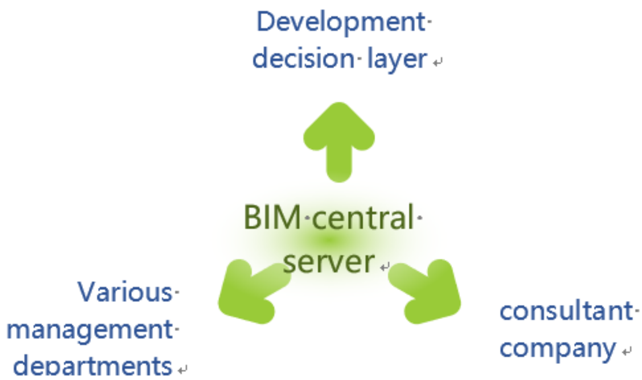

Figure 2: BIM collaborative management process

For the BIM-based information modelling of the surrounding environment, when the production unit chooses a piece of land for construction and production, it must consider various factors, such as public water, electricity consumption, raw material status, transportation route status, and the impact of the external factors (e.g., whether it needs to be close to the ocean; Dangerous Chemical plants are generally located in relatively concentrated industrial parks) on its scale production, etc. The information above is recorded into the model during modelling. For the BIM-based break-even point calculation, the total investment of the break-even point construction project includes both the working capital and the investment of fixed assets. The construction is the process of asset formation. There is no economic benefit during the construction period, and for the questions about at what kind of production capacity, the enterprise can be profitable, it depends on the break-even point. When the sales revenue is higher than the break-even point, the enterprise is profitable, otherwise, the enterprise loses. The establishment of the BIM information model can provide important breakeven point calculation data for financial department, as shown in Figure 3.

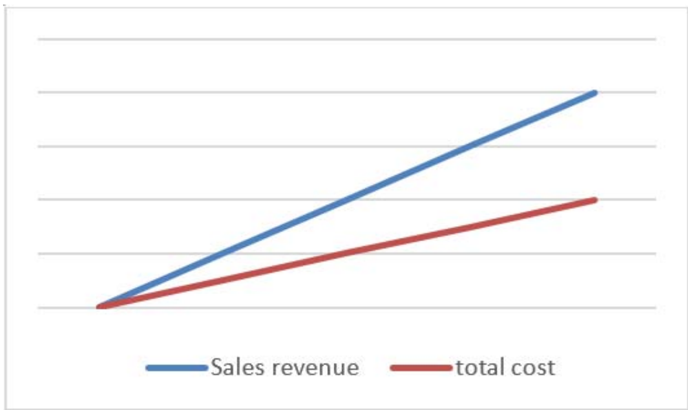

Figure 3: Breakeven analysis chart

The preliminary design budget estimate refers to the rough calculation of the investment amount in the construction project according to the design requirements in the preliminary design stage. It includes all the construction funds from the project approval, feasibility study, design, construction, trial operation to completion acceptance, etc. It's an important part of the preliminary design document. Figure4 shows the flow chart of quota design. For projects with more complicated processes, in addition to the preliminary design and construction drawing design, technical design is also needed, which is the detailed design of the key process. For this, the application of BIM design software can ensure to make detailed design of components with abstract process in a vivid and dynamic way, and also better perform the cost calculation of key equipment and process.

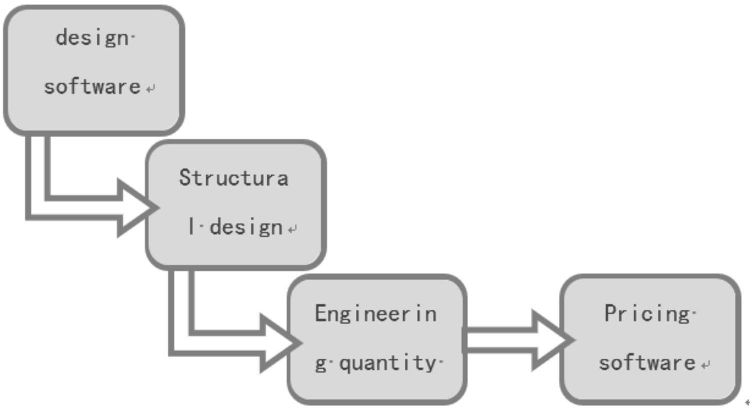

Figure 4: Quota design flow chart

The preparation of the BIM-based design budget estimate document should be made in three-level budget calculation form: unit project budget estimate, the unit project comprehensive budget estimate, and general estimate of construction, as shown in Figure5. Different from traditional CAD, BIM database was used to load the software such as Luban and Glodon etc. and extract BOM list for budget calculation. BIM is convenient and practical, and makes calculation at design stage more accurately, effectively and quickly.

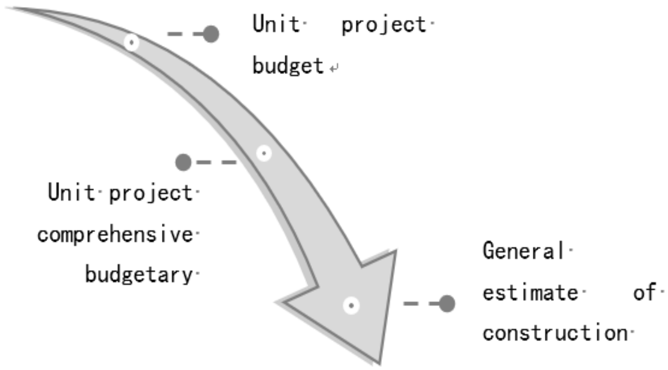

Figure 5: Cost relationship and mutual composition between the three levels of budget estimates

4. Results and analysis

The project introduced in this case has an annual output of 80,000 tons of siloxane polymer. It consists of 2 tank areas, 3 common pipe corridors, 2 warehouses and 1 factory building. The total investment of the project is 800 million RMB. It has also various professional equipment and pipelines: 500 sets of equipment, welding volume of 90,000 inches, different complicated pipelines of cooling water pipes, chilled water pipes, steam pipes, various material pipes, air conditioning air ducts, cable trays, fire sprinkler pipes, water supply and drainage pipelines. The project was implemented based on BIM technology, and more than 1,500 collision points were eliminated, which greatly reduces unnecessary cost and guarantees the timely delivery.
The complete BIM model depicts the constructed state of the project. In this model, the pipelines of different systems were represented by different colours. Clicking any pipeline in the model, the relevant technical parameters such as pipeline number, diameter, material, and length, etc. can be shown. In this model, the intersection of various equipment and pipelines, such as the layout of the pipeline, the orientation of the bridge, the laying route of the cable, and the installation location of the lamp, drainage of water supply and drainage pipelines, form of steel structure platform, installation position of brackets, etc. CAD drawings, BOMs (workload list) can be exported from the system, including all material names, specification materials, unit attributes, quantities, etc. Figure6 shows the model of the tank area in the project.

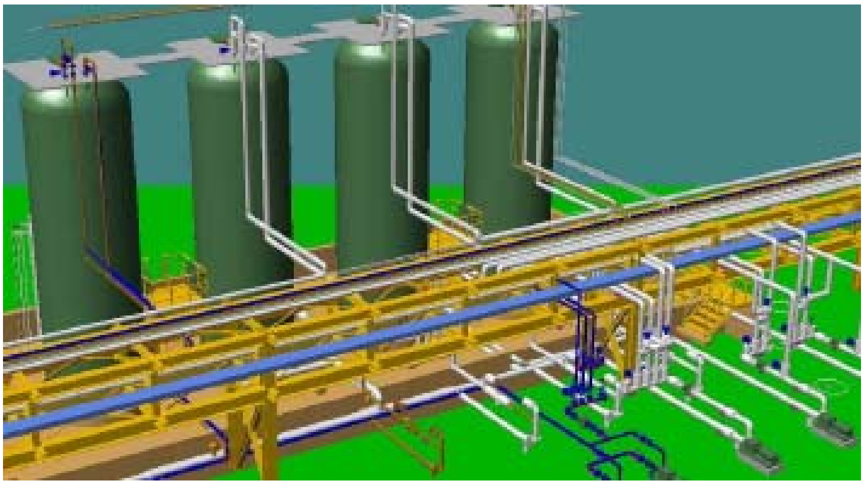

Figure 6: Tank area model diagram

The project is adjacent to the raw material production base. Using the BIM model, its annual production capacity was accurately calculated to be 80,000 tons. However, according to the market demand for the final product of the device and the financing of internal funds, the project was constructed in two phases: the annual production capacity of the project is 50,000 tons of output value, and the total investment is 500 million yuan in the first phase; in the second phase construction, it’s 30,000 tons of output value, the total investment is 300 million yuan, and the estimated value of imported major equipment is made. The project has carried out a two-stage design, namely, preliminary design and construction drawing design. Based on the BIM's budgetary estimate, the project's design budget includes 3-level estimates: equipment and installation project budget estimates; civil engineering budget estimates and other unit project budget estimates; the comprehensive budgetary estimates such as plant single projects, single project in A tank area, and the single pipeline gallery project. The preparation of the budget workload list has been well applied with the help of the BIM model. It is found that the pipeline collision and rework phenomenon was greatly reduced, the construction cost dropped directly, and the cost change was reflected in time.

5. Conclusions

Based on BIM technology, the whole process cost management of the construction project has been realized. Besides, the following conclusions have also been made: Through BIM technology, the project construction participants and the staffs in the project implementation process can mutually share and exchange information at each stage, avoiding the loss of information, and thereby improving work efficiency. BIM technology has changed the traditional ways of work, and it can process engineering information quickly and accurately. The application of BIM technology in the WPCM makes it possible to achieve accurate, dynamic and real-time cost management.

In China, the system to guarantee the development of BIM technology is still not perfect. So far, paper-based data such as project design drawings and as-built drawings still occupy a dominant position in China's construction engineering field. The application of BIM technology in the WPCM is very difficult and challenging, but, with the development of national BIM technology education in China, the national awareness of BIM technology has deepened, and they have started to realize the positive effect of BIM technology and WPCM on the project cost management and even the whole construction industry.

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