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# Application of BIM Based on Security in the Process of Engineering Construction

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## Abstract

In recent years, BIM has brought many opportunities and challenges to the construction process. With the development of high-rise buildings and large scale complex civil engineering projects in China, the new height, attention and research have been focused on the impact of BIM technology on construction projects. As a result, security has become increasingly prominent. Some knowledge of BIM optimization construction scheme and development of protection and emergency measures to deal with and control the safety risk, reduce or avoid the impact of safety factor on the project construction. This paper not only includes personal property safety problems, but also includes the inherent defects in the management mode, which leads to some problems such as delay, quality is not qualified, efficiency is low, and the safety management system is not perfect and all parts of the project.

## Keywords

BIM; Safety; Whole Process of Project; BIM5D; Data Integration.

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## 1. Introduction

The construction industry has been one of the pillar industries of our country and promote the rapid development of the national economy. According to China Economic Net Information: in 2012, the national construction industry output value about 135303 billion yuan, an increase of 16.2%; in 2013, total output of construction industry is about 159313 billion yuan, year-on-year growth of 16.1%; in 2014, the gross output value of construction was about 176713 billion yuan, an increase of 10.2%; in the first half of 2015, gross output value of construction was 72374 billion yuan, an increase of 4.3%. High income must have high risk, construction industry is also one of the frequent accidents of the industry.

There are many reasons for the safety accidents in the process of project construction, and several possible reasons are listed below: Firstly, with the rapid development of China's economy, the requirements of people's function and the quality of construction engineering is gradually improving, besides the ground area is limited, in this way, the height of construction and the difficulty-construct of the building is also increased, which leads to the increase of the frequency of construction accidents; secondly, the subtle relationship between the three management goals which are quality, schedule and cost. Developers hope that the cost is low, the progress is fast and the quality is good, in order to pursue their own profits to reduce the cost and security facilities are not in place, the workers over fatigue owing to speed up the progress, in this way, the occurrence probability of personal safety accident has been increased, there may be a risk of substandard quality which are cost reduction and progress to speed up. Thirdly, safety management is relatively backward need to use advanced information management model to upgrade and scientific management, for example, BIM concept.

Data show that China's construction industry information rate is only about 0.027%, with the international construction industry information on the average level of 0.3%, up to 11 times the gap.

Survey report on the current situation and development trend of information of national construction enterprises point out that About 20% large and medium-sized construction enterprises in China to carry out the work of information technology, however, the proportion of the enterprise management level is only 39%; there are still 61% companies are still in the level of office word processing and simple tool software applications, the overall level of information management is very low.

BIM has a mission to change the domestic construction industry to the international integration of information technology development, BIM is not only a new design software, but also a pioneering way of thinking and working methods. Firstly, the three-dimensional digital design scheme is established in the BIM model, and the building model is built on the basis of this scheme, and the detailed functional expression of the model has been established using the relevant digital information. In the original three-dimensional model add to time dimension, the formation of BIM four-dimensional model, the four dimensional model of the project construction period for strict control, reduce the delay in the production of accidents. Adding the cost dimension in the four-dimensional model, formed a five dimensional model of BIM, Five dimensional model controls the balance in the process of engineering construction, greatly reduces the cost overruns of the accident. Similarly from BIM 5D model adding other control dimension, it developed into basing on BIM n-dimensional digital and attribute model, implementation of the project design, construction, operation and other processes of visual management.

## 2. The meaning of BIM

BIM is the abbreviation of Building Information Modeling, which was a multidimensional model(design visualization -3D; overall schedule planning -4D; energy consumption analysis, life cycle simulation -5D; cost budget, engineering quantity estimation -5D; construction warranty, facility management, completion information -6D, etc.)and information integration technology developed on the basis of CAD in recent years, it can make the project of all the participating parties operating the information in the digital virtual building mode and operating model in the information, so that the work efficiency and quality in the construction of the whole life cycle to be improved, as well as to achieve the goal of reducing the risk of errors and various risks.

BIM has the characteristics of visualization, coordination, simulation, optimization, and so on. The application of BIM technology through the project decision-making, design, construction, operation of the whole process.

BIM has a very powerful function to analyze and guide the work of each process.(Figure 1-1)

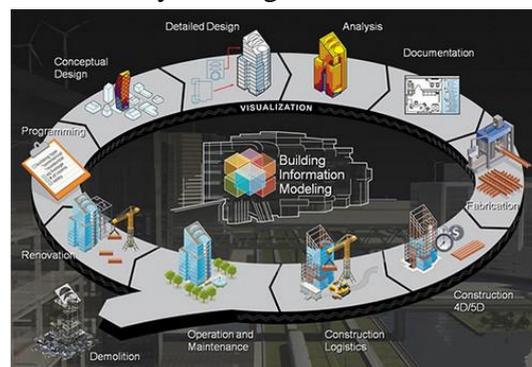


Figure 1-1 BIM function chart

## 3. Core modeling software of BIM

BIM core modeling software is the basis of BIM technology to achieve the platform, Making good use of BIM core modeling software is the foundation of engineering construction safety evaluation. At present, the international supplier of BIM software mainly has four and their software is very complete, covering a wide range.(Figure 2-1)

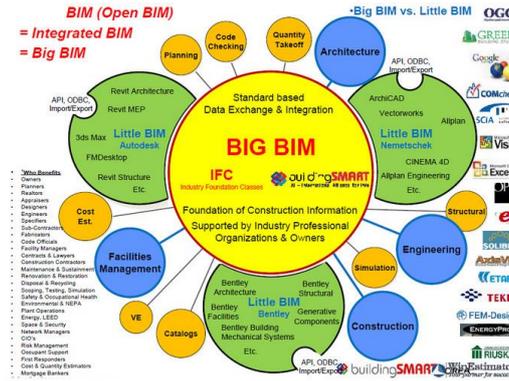
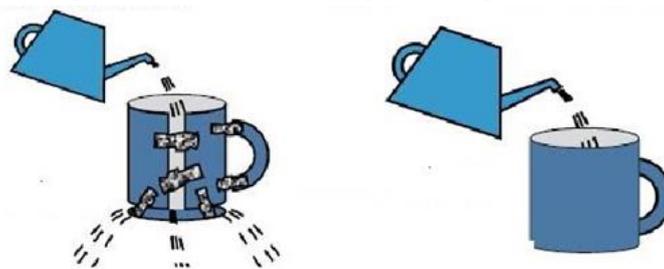


Figure 2-1 BIM related software

This paper briefly introduces the Autodesk and Bentley introduced some of the commonly used software.

(1) Autodesk by virtue of the influence of AutodeskCAD, it has a very strong market competitiveness in civil construction. Revit series professional software includes: Revit Architecture、Revit Structure and Revit MEP .

(2) Bentley company has the industry's top level in the field of plant design and infrastructure ,including Bentley Architecture 、 Bentley Structural and Bentley Building Mechanical Systems.



(Figure 3-1 Different results of information processing by CAD graphics and BIM model)

#### 4. Comparison of CAD and BIM in engineering safety information

Autodesk CAD is manual drawing of the revolutionaries, it's advanced in that labor intensity is reduced, the surface is clean, tidy, with high precision, convenient data storage, etc. As a two-dimensional mapping tool, it can predict some of the problems but the processing of information is not comprehensive enough, without taking into account the safety risks of the various parts of the project construction, formation of "information island". There may be another safety accident, As 2D construction drawings AutodeskCAD transfer information in the project construction safety is still not perfect enough.(Figure 3-1 Left)

BIM is considered to be the second revolution in the field of architecture after relaying CAD, BIM is used as a method of skill, mechanism and opportunity. Through the collection, management, exchange, update, storage process and project business process of the integration project information, to provide timely, accurate and adequate information for each stage in the life cycle of the construction project. Maintain project between the stages, different projects in the exchange of information between the parties and the need to build the project various application software and sharing, in order to improve the project planning, design, construction, operation, and maintenance of quality and efficiency. As well as to enhance the level of industry productivity in the construction industry, a comprehensive consideration of all aspects of the project, as well as a combination of possible new safety accidents. And be able to effectively identify the possible security problems from the various stages of the model and the project, the objective analysis of the possible causes of the accident and solutions, and strictly implemented. BIM has become a platform for security information integration and sharing. (Figure 3-1 right)

## **5. The application of BIM in personal and property safety**

According to the Chinese Ministry of social statistics, the construction industry is currently employed nearly 45 million people. The construction industry is the industry with high risk of injury. In 2011, the national construction industry a total of 561 security incidents, resulting in 707 deaths; in 2012, a total of 451 security incidents occurred in the country, resulting in 585 deaths; in 2013, a total of 524 security incidents occurred in the country, resulting in 670 deaths; in 2014, a total of 489 security incidents occurred in the country, resulting in 623 deaths. In summary, the personal safety of the project construction process is still in the process of the important issues that occur more frequently, resulting in a significant loss of personal property, so we must adhere a policy which is "safety first, prevention first".

The factors that cause personal safety accidents in the field are divided into: falling at high altitude, object strike, collapse, mechanical damage, etc. The failure of hazard source identification is often due to the implementation of security norms, the construction personnel's professional knowledge is not qualified or the security personnel's supervisory ability is limited. If we refer to the BIM technology in the engineering construction, the project will be all the construction process simulation, identify the possible safety incidents at a certain stage. In advance for them to solve and improve, so that can greatly reduce the construction of the safety problems that may arise, to avoid unnecessary loss of property.

## **6. BIM application in the cost and schedule of the whole process of the project**

In the original 3D BIM model to join the time and cost dimensions, and the formation of the building information model of the 5D application model. In this mode, all the information BIM gathering project, the project will provide construction planning and cost management aspects of the relevant data.

Through the BIM information sharing platform, the project participants can understand the construction process is very clear, the different time points of the construction situation and the construction cost fully understood. According to the need, we can have a monthly or weekly or even daily control of the specific construction situation, access to the time node of the project cost information, so that the project real-time modification and adjustment is very convenient. On the other hand, it also ensures the full use of construction materials, that is, saving the construction cost, so that the project cost has been the maximum control. Reduce the management mode of the existence of congenital defects, and lead to the construction process of the project delay, cost overrun and so on.

### **6.1 The application of BIM in the cost and schedule for the project decision-making stage**

In the decision-making phase of the project, the cost and schedule of the whole project are greatly influenced by the technological and economic decisions. In these decisions, especially in the construction of the project to determine the standard level and the selection of the construction area, construction technology, construction equipment, construction materials, etc., the project cost and schedule caused a direct impact. From the relevant survey and statistics, in the whole process of the project, the decision-making phase of the project cost and schedule as high as 80% ~ 90% impact.

The cost level and the speed of the progress of the project depends basically on the investment decisions made by the decision-making stage.

BIM can provide investors with the benefits of each project plan and schedule indicators, according to the relevant data provided by BIM to help investors to make decisions, improve the scientific and effectiveness of decision-making. The advantages and characteristics of BIM technology and its derivative functions are introduced into the cost and schedule control, which constitute the cost and schedule control system based on BIM technology platform. Since the duration of the decision to reduce errors caused by delays, cost is too high and other accidents.

## **6.2 The application of BIM in the cost and schedule for the project design stage**

The design stage of the project has played an indelible role in the process of technical and economic relations. From the relevant survey and statistics, design stage of the project cost and schedule have 45% to 65% of the impact in the whole process of engineering project.

Building model is a kind of information integration and processing technology based on computer 3D model. A variety of information data model related to engineering is presented and applied in building model. Under normal circumstances, the project decision-making stage to determine the information related to the data, the participating parties can get the project's flat, vertical, profile and other geometric drawings by BIM. The integration and analysis of the resulting drawings and reports can be considered as the project's engineering quantity, and the cost of the project can be analyzed. Derived from the BIM Gantt chart can progress, analysis of the project. In order to make the BIM can be optimized and adjusted in real time, the construction unit and the construction unit can modify it, BIM automatically generate new engineering cost report and the corresponding Gantt chart, so that the construction unit to quickly make a comparative the optimal scheme is obtained, so as to achieve the purpose of cost and schedule control.

## **6.3 The application of BIM in the cost and schedule for project bidding stage**

The bidding is the request of the buyer (the tenderer) through the prior public bidding to attract a large number of sellers (bidders) fair competition. In accordance with the provisions of the procedures for the organization of technical, economic and legal aspects of the evaluation of a large number of experts on the seller (bidder) for comprehensive assessment, thus selecting the winning bidder.

The bidding system based on BIM can use the BIM information platform to get the relevant information of engineering quantity when calculating the project budget, so for the bidder, it will greatly reduce the amount of time to calculate the amount of time, saving human and financial resources. Therefore, the engineering quantity information obtained by the BIM information platform is accurate and the quantity of the engineering calculation is not accurate, so use of BIM bidding system to calculate the budget error is far less than the traditional fixed price method to calculate the error.

## **6.4 The application of BIM in the cost and schedule for engineering construction stage**

As the biggest change, the most complicated engineering construction stage is the main stage of the consumption of manpower, financial resources and material resources, and buildings will be formed in this phase by the model forming entities. So at this stage of control costs and schedule safety has become a top priority.

Using BIM data sharing technology, the first to establish the 3D model, and then through the BIM automatic calculation function can be achieved by a number of departments to share the results of the calculation of a platform, so you can reduce costs and save time. BIM for each component of the properties and materials have a clear definition. If the model established by the AutodeskRevit software can be exported with the door, window, hole, steel, concrete and other details of the table. If the site construction has been modified, we only need to modify the corresponding data in the model, the model will automatically statistical summary. This can greatly reduce the amount of work in the construction process. On the other hand, because AutodeskRevit can define material, then we can fully consider the requirements of the model in the procurement, so as to save resources and avoid the delay in the delivery of the material caused by the delay.

## **6.5 The application of BIM in the cost and schedule for project completion stage**

Completion stage has a very important position in the whole project cost process, at this stage, the cost engineer will complete the final total cost. After the acceptance of the project, the amount of each claim and breach of contract by construction unit in construction stage retrieval of project recorded on BIM platforms, and according to the construction stage, the data of the model is modified according to the specific situation, then the completion settlement document is generated. This way to avoid a lot of

controversy caused that money is not clear, thus it can improve the ability of the construction unit to control the cost effectively.

## **7. The application of BIM in engineering quality and safety**

Construction quality is the focus of the users and government departments. Once appear the accidents of quality, the damage and loss will be immeasurable.

### **7.1 The application of BIM5D in construction quality and safety**

The traditional construction quality control, mainly by the engineering technical personnel and supervision personnel to achieve. If BIM5D can be used in construction simulation, the construction process can be more intuitive, accurate and dynamic presentation to avoid a lot of unnecessary mistakes lead to engineering quality accidents. BIM5D has many advantages, as follows:

(1) To make the prior control more precise: During the construction preparation stage, the conflict between the various processes in the construction of BIM 5D. Let the construction unit can be intuitive understanding and timely adjustment and deal with it, reducing safety accidents due to errors in construction process; BIM 5D can show different construction processes of the same project, then the comparison is made to obtain an optimal construction scheme, reducing safety accidents due to improper construction scheme.

(2) To make concurrent control more explicit: In the construction process, it can be built in the single project or sub project and 5D model for comparison, whether the error is within the allowable range. If it exceed the allowable range, you need to find out the reasons and make improvement and treatment in time, this can avoid construction safety and quality problems.

### **7.2 The application of BIM completion model in the quality of completion**

The BIM engineer of the construction unit can modify and maintain the BIM model according to the requirement of the design change and the actual situation of the construction site. Completion stage to develop BIM completion model. This model not only reflects the authenticity of the final product, it is conducive to the government's supervision and management, but also the BIM delivery operation management, the value of the whole life cycle of the model can be extended.

## **8. The application of BIM in data integration management system**

With the promotion and application of the general contracting model, more and more people pay attention to the data integration management system. The information model sharing and mutual transformation is the core function of BIM in the whole life cycle of the construction project.

Data integration management system, which is the project management module, project planning management module, bidding management module, schedule management module, investment control management module, quality management module, contract management module, material equipment management module, post operation and evaluation module in the early data information centralized management, presented the data in the BIM information sharing platform to provide real-time data information to facilitate their exchange and check.

The purpose of BIM data integrated management system is that the BIM database is built on the basis of the value engineering standard, and combined with the actual situation of the project, the development and application of a variety of BIM software, so that the building information model of sharing and mutual conversion can be truly realized.

Based on BIM of the multi-dimensional data integration management, that is, through the establishment of the model in the corresponding logical relationship and to the relevant 3D components assigned to the data, Then, the relationship model between the 3D component and the engineering quantity is generated, which is related to the fixed document data. After the integration of the data can be carried out the following operations:

(1) Visual environment analysis in the early stage;

(2)Design stage of energy consumption analysis, energy saving analysis, collision test, check design vulnerabilities, etc.

(3)Construction phase of the construction simulation, generate schedule file, the generation of the accurate bill of quantities, automated production of prefabricated components;

(4)Operation phase of the project operation evaluation, facilities maintenance management, equipment management and emergency management of the property management and so on.

## 9. Conclusion

BIM concept and its application is a revolution in the construction industry, it is not only a technological revolution, but also a thinking revolution, only the spherical mode of thinking can guide the development of BIM. The visualization, big data, Internet of things and the "cloud" technology into the BIM technology, greatly improve the production efficiency, so that the design and management process is more simple and convenient.

Safety in the process of engineering construction has a pivotal position. This paper describes the application of BIM technology in various stages of the project, the potential safety problems and the advantages of BIM technology used in these areas are discussed in this paper. We can acquire the mission of BIM: BIM integrates data information into the same platform by means of technical information. BIM is the core of technology information and various aspects of the information gathering of the bridge. In order to make the project the participants and information between all kinds of software to model management and sharing, BIM made irreplaceable contributions.

With the deepening of the research and application of BIM, the content of BIM will continue to update and change. It is expected that BIM can bring the greatest value to the overall production efficiency and quality of China's construction industry as soon as possible.

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