

# RESEARCH ON THE APPLICATION OF BIM TECHNOLOGY IN THE PROJECT MANAGEMENT OF HOSPITAL CONSTRUCTION

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## **Abstract:**

Nowadays, with China's hospital construction in full swing, the demands for building comprehensive hospitals and the complexity of construction technology bring out higher construction cost as well as longer construction time. Applying Building Information Modeling (BIM) in the project management of hospital construction can provide a 3D building model for all parties involved in conducting full life cycle management, which will fundamentally change the traditional way of presenting building products using 2D models and the decentralized designs based on construction phases. This paper first presents an overview on the current implementation of BIM in China, introducing BIM-related works and application results. Then it illustrates the benefits of BIM through a case study-a 5D model using BIM, which helps all the related parties coordinate their project proposals, enhance the plausibility of the project, eliminate contradictions in time, and significantly reduce possible engineering changes due to the above mentioned, all of which would help shorten construction time, reduce cost growth caused by project coordination and enhance productivity in construction sites. This article ends by pointing out the present social and technological obstacles and challenges faced by Chinese BIM industry practitioners in applying BIM technology, based on which some countermeasures are proposed.

**Keywords:** BIM ,Full life cycle management ,5Dmodel, Reduce cost

## **1. INTRODUCTION**

Architecture is the department responsible for planning, designing, and constructing buildings and other physical structures, and has contributed to worldwide economic development significantly. From the Shanghai Center, Beijing Bird's Nest Stadium, Sydney Opera Theater, and Three Gorges Dam, Hangzhou Bay Bridge, Channel Tunnel, architecture has made remarkable achievements, which were built over enormous expenses and waste. On one hand, architecture consumes 40% of our world's energy and raw material. On the other hand, the architecture industry's efficiency is extremely low, compared to those of other industries. According to the US labor union, during 1964-2003, industry and service business have increased their production efficiency by 230% , while architecture 's production efficiency decreased by 19.2%. Also, according to the US National Institute of Building Science, there is a 57% waste in the architecture industry, while only a 26% waste exists in the production industry, a disparity of 31% <sup>[1]</sup>

The main reason of the current difficulties in architecture is the split industry structure, severe information lost, overemphasis on construction cost, and neglecting the value of life cycle. In order to address these issues, we must approach them by adopting cutting-edged ideas. In recent years, architecture industry has absorbed technologies from construction, aerospace and other advanced

industries--PLM(Product Lifecycle Management), and constructed the architecture product lifecycle management theory--the BLM(Building Lifecycle Management). As the main technology to realize the BLM concept, BIM(Building Information Modeling) has received tremendous attention and research. BIM, a digital expression for buildings' physical and functional properties, was originated in the United States. Different parties in construction projects can pull out information from the model in the lifecycle to update, insert, draw, and share project data, in order to coordinate and improve management efficiency. In other words, BIM is a digital management technique in engineering construction projects.

As a result of digital development, BIM's advantage besides visualization, synchronization, simulation and optimization, is its strong ability in organizing information. The traditional information exchange method is a split mode, since every party involved has to exchange with every other party in order to retrieve and pass along information. While in BIM, each party only had to submit the information to BIM database and pull out the information they need, which simplifies information transmit mechanism and improves transmitting efficiency.

## **2 RESEARCH AND APPLICATION OF BIM TECHNOLOGY IN CHINA**

BIM was first introduced to China in 2002 by Autodesk, and was gradually extended in the country's architecture industry. Both government and industry personnel have realized that this will be a revolutionary force in architecture. Software companies, design companies, real estate companies, construction companies and university research centers have all started establishing BIM research institutes. China's "Eleventh Five-Year plan" made BIM a emphasized national technology project, while the "Twelfth Five-Year Plan" continues to make BIM an important digital research project. In China, the research and application on BIM technology focuses on three areas:

### **1)The development of BIM software.**

The existing BIM software can be divided into two categories: creating BIM modeling software and utilizing BIM software. Some primary BIM software existing in the industry include architecture Revit, ArchiCAD, construction Tekla, and device MagiCAD, RevitMEP. Tsinghua Sware, Luban, and Glodon are representatives of BIM application software in China.

### **2)The research on the basic theory of BIM.**

From China Knowledge Resource Integrated Database's statistics on the number of BIM relevant essays during 2003-2015, it is evident that BIM technology has received wide attention from Chinese researchers, and the level of attention is consistently increasing. Research on BIM basic theory mainly focuses on BIM related standard and BIM software theory. Construction engineering software based on BIM mainly has two kinds of open standard<sup>[2]</sup>: BIM guidelines and standards, such as NBIMS, CBIMS, IDM and IFD, and data exchange criteria, such as IFC, bXML, CIS/2, PSCS, and COBie<sup>[3-6]</sup>. The first refers to construction personnel using BIM to provide specific instructions on construction management, and the second one stipulates the format for data exchange as well as the data modeling description. The research on basic software theory focuses on top designing on the software, improving the traditional work method in architecture industry which involves managing great and complex information, and discussing ways to practice and applying BIM software.

### **3)The research on BIM application in engineering, which focuses on ways to apply existing BIM software on engineering construction, and to solve issues in the application.**

Nowadays, BIM application mainly focuses on the design and construction, the application mode mainly includes: design party leading mode, construction party leading mode, and owner party leading mode. What's notable is that a great number of construction projects in China is using BIM technology in different stages. Nowadays, the highly complex designs and techniques often result in higher cost and longer construction time in the fledgling Chinese hospital construction. Applying BIM can change the traditional fragmented designs and 2D representation of building products into 3D product models and streamlined full life-cycle management in the near future. The Sun Yixian Cardiovascular Hospital is an evident example of the application of the full life-cycle BIM. The project was led by the owner, using BIM to plan the design, construction and management. The application of BIM in Chinese hospital construction was the first in our country, and laid foundation for wider application as well as promoted the development of BIM technology.

### 3 THE DESIGN OF WORK ASSIGNMENT AND INFORMATION COLLABORATION ROAD IN BIM

#### 3.1 BIM workflow process

From the beginning to the end of engineering projects, BIM provides engineering modeling, hardware support, and regulated modeling principle and criteria. Utilizing the visualization, synchronization, simulation and optimization aspects, BIM can revolutionize engineering project by creating relevant regulation, quality control process, and hazard preventing measurement. The working process has three stages(Fig.1)

Planning stage, which refers to confirming the BIM application and planning the application process based on the traditional engineering project proposal and plausibility report.

Organization stage, which refers to confirming the responsibilities of all parties related and defining the corporation process based on the different information requirement of BIM.

Construction stage, which refers to each participating personal creating the BIM application and information sharing process.

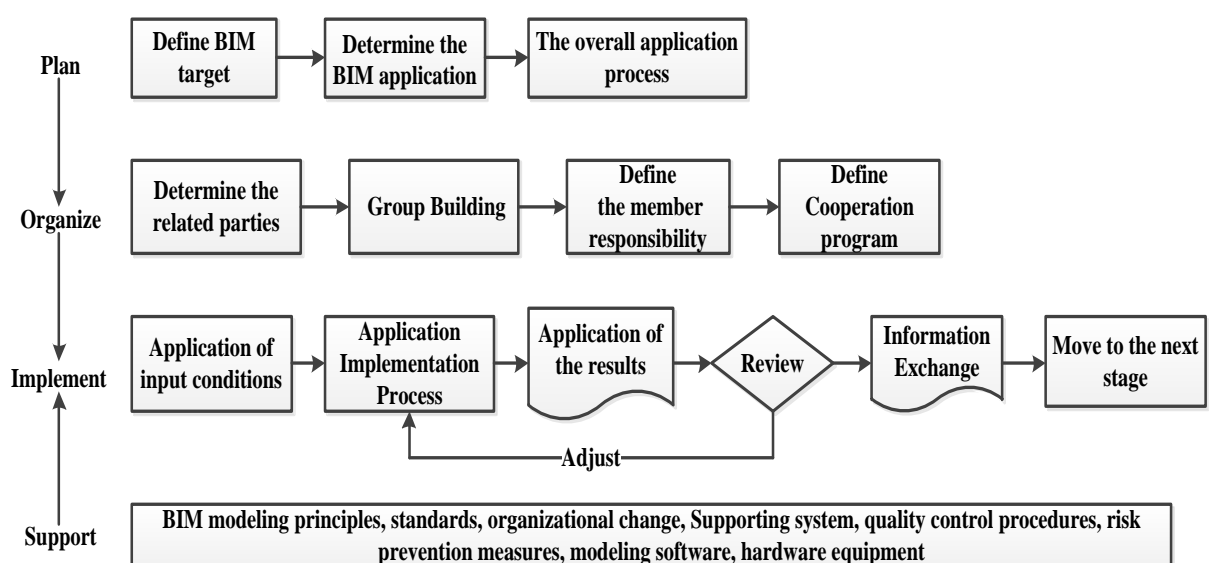


Figure1 BIM workflow in construction project life-cycle

### **3.2 Work assignment and information coordination road design of IPD stakeholders in BIM**

The general international engineering project construction has 7 phases, which are project planning, initial design, deepening design, construction drawing design, institution review, construction and construction management. All BIM parties should complete their own responsibilities, while actively corporation with other related parties to promote the application of BIM. All related parties should constantly update their BIM models to make sure that the models are timely effective. The party responsible for reviewing should complete their works and give feedback to ensure the process of the works.

This information coordination route design under BIM refers to the drawings in Autodesk(Fig.2). The design party handles the construction and perfection of BIM modeling, as well as the organization and coordination of all the information, and is in charge of constructing the engineering models at the project planning phase. The Construction owner should constantly provide necessary information for the design party, and listens to the feedback from designers and construction parties. The construction party should begin constructing engineering models from the deepening design phase, and constantly provide construction modeling information to the Construction owner and design party before the end of the project. Material providing party and special contractors should add professional engineering information during the initial design phase, and construct professional models to combine with engineering construction models.

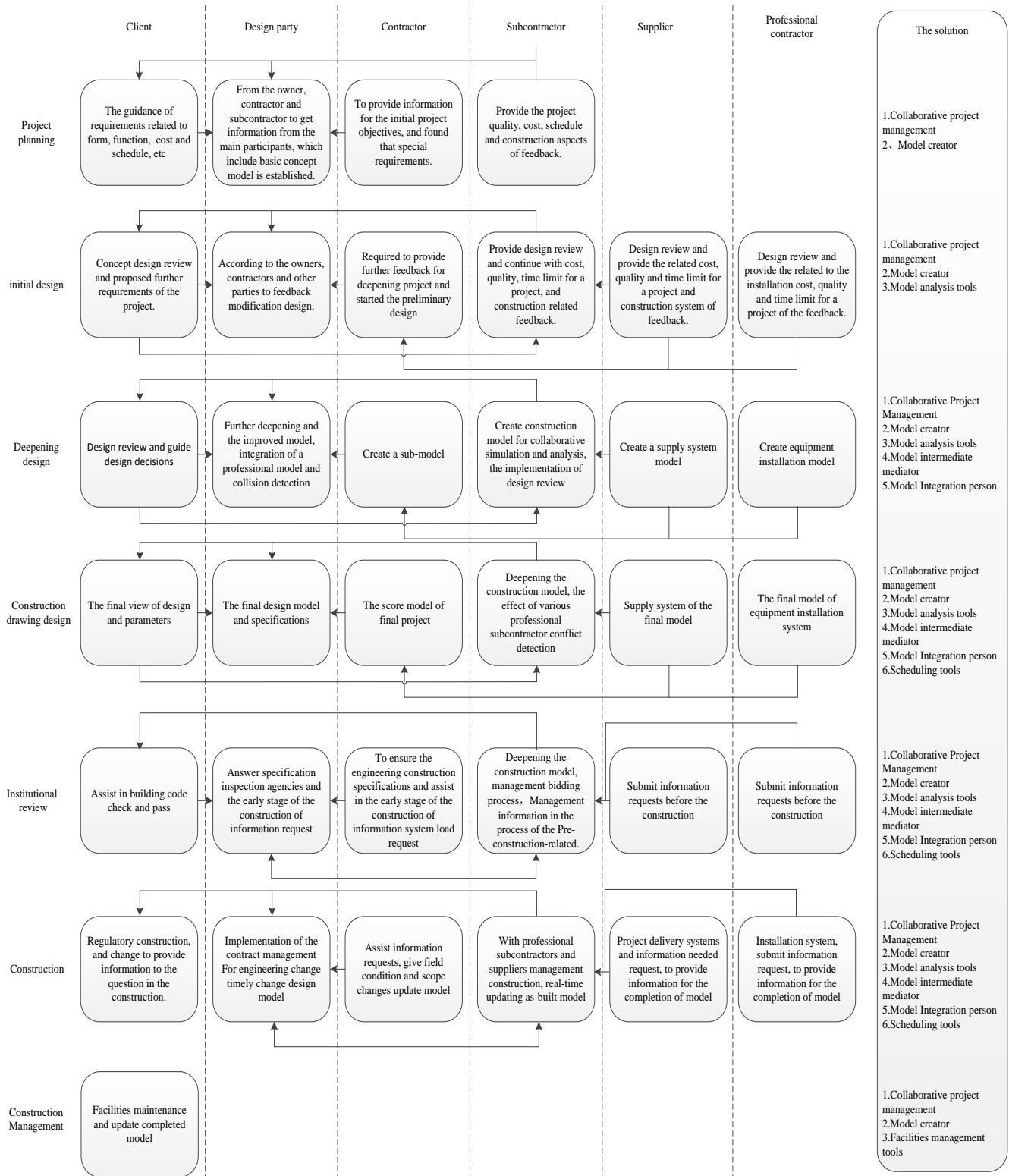


Figure 2 Work assignment and information collaboration road of IPD stakeholders in BIM

## 4 CASE STUDIES

### 4.1 Project overview

The Sunyixian Cardiovascular Hospital project is located on the crossroad of Nanshan Road and Keyuan Road in Nanshan District, Shenzhen city. With a total land area of 22458 square meters, total

construction area of 88470 square meters. It includes a twenty floors comprehensive building(including clinic center, emergency center, in-patient department) of height 93.15m, and a six floors administration building(including offices, file rooms and conference center) of height 23.95m, Two building shared 3 floors basement. Estimated total investment is 514 million yuan .To better organize the resources, the hospital used BIM architecture information management in the development of this administration building, and improved the design quality, effectively controlled the cost and design of this project.

## 4.2 BIM application in the engineering project

The BIM application team in the project is led by construction company, and covers all phases and parties of the project. The team is also responsible for hiring professional BIM consultants and operation according to the designed BIM application process.

BIM database is the core of the information management system in the engineering project, including all the data information in the full life-cycle. Through applying BIM modeling, we can complete the design, analysis, optimization, simulation and information management during different stages of the project. At the same time, we can gradually update and perfect BIM modeling by adding relevant drawings and documents to ensure the comprehensiveness and continuity of engineering information.

### 4.2.1 Design phase

The design phase usually has the most influence on the cost, benefit and architecture properties, while the design changes during construction phase cause the most cost waste. Thus, applying more advanced BIM technology to enhance design quality during this phase can effectively increase the influence on the design and construction cost, which means the sooner the application of BIM, the more insurance the project has.

#### 4.2.1.1 Multi-specialties coordination design

Architecture, structure, equipment and other expert engineers use BIM to construct their design models (Fig.3), which is the basic data source of a BIM database. Using a united design platform can realize the seamless connection of different engineering data, and enables personal to discuss their designs from the original idea to the specific charts and drawings in order to provide better design, faster document production and more effective team corporation. Engineers can also combing the models with Robot, Etabs, Ecotect and other analysis software to make sure of the quality of the design.

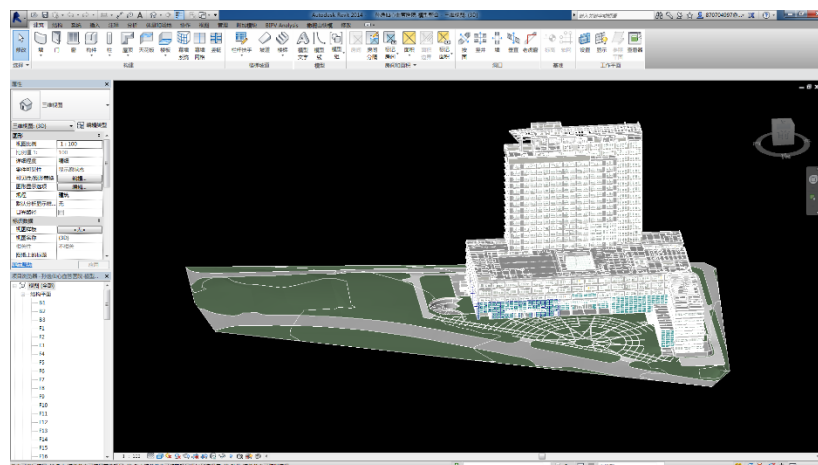


Figure 3 The BIM model of Sunyixian Cardiovascular Hospital project

#### 4.2.1.2 Visualization design

Models can be loaded into advanced design visualization tools(3ds Max, Maya) to analyze the visual effect, without having to build models again. Highly realistic renderings as well as special animation effect can help designers expand the visual environment of the design plan in order to realize more effective design testing and communication (Fig.4) .



Figure 4 Architecture presentation from BIM model

#### 4.2.1.3 Detail design

The calculable information can be derived to assist in the engineering calculation. At the same time, the information in the models can be used to check the predicted budget, and realize synchronized budget prediction with the design process based on BIM modeling (Fig.5) , in order to achieve real detailed design.

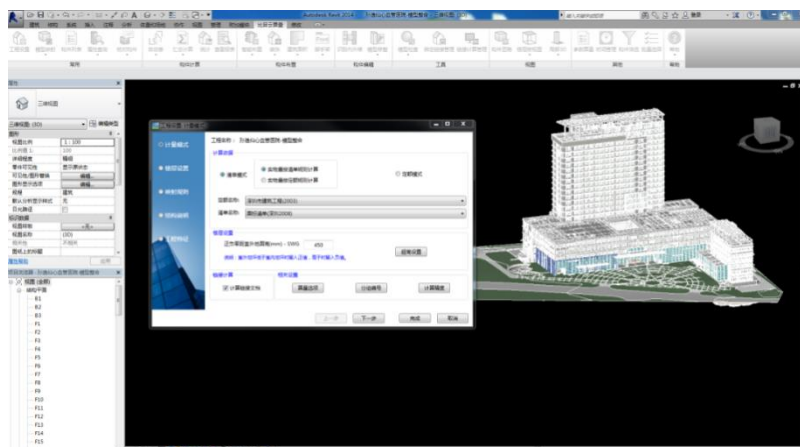


Figure 5 Tsinghua Sware BIM-3D engineering quantity calculation For Revit

#### 4.2.1.4 Green sustainability design

On one hand, personal can use BIM modeling to acquire the geometry properties, essential physics characteristics and function properties in digital forms before actual construction, and analyze the energy consumption from multiple perspectives, in order to effectively combine BIM technology with energy-saving architecture design (Fig.6-7) .

On the other hand, BIM models contain a lot of other sustainable green design information. For example, we can acquire the chart of architecture units in order to confirm the recycle of materials as well as the proportion of reusing. We can also export the models into different assisting software to analyze and track various sustainable designs.

The green sustainable design based on BIM technology provides ample information for the building's LEED rating and national green building certification.

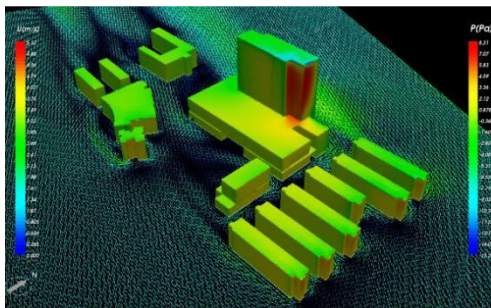


Figure 6 Wind environment analysis

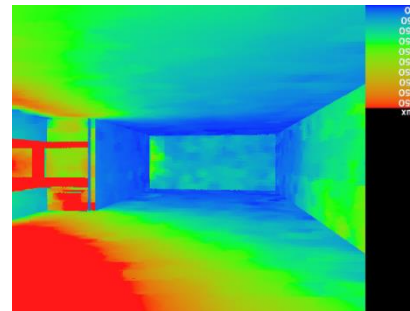


Figure7 Day-lighting analysis

#### 4.2.1.5 Design coordination

Using tools like Navis works in BIM modeling to conduct collision detection(hard collision and soft collision) ,Check the fault, leakage, touch and lack of the components designed by different professional design (Fig.8). using the method of collision check report and 3D pipeline synthesis, It can prevents multiple digging, material waste and trash production in later construction. It can also solve the great on construction site coordination in advance by design coordination and effectively reduce the needed labor, material and time cost.

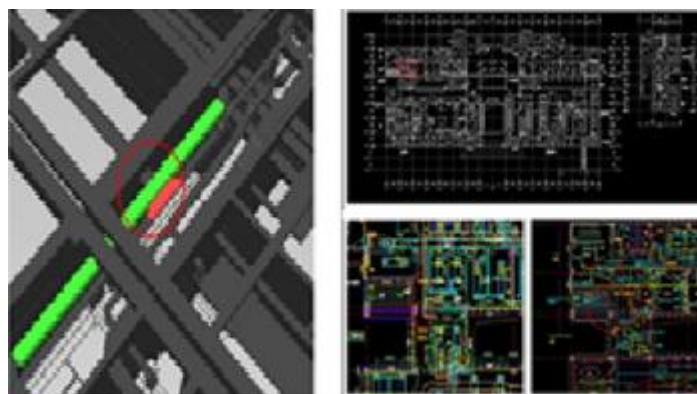


Figure 8 Collision detection



#### **4.2.1.6 Traffic simulation**

This technology can conduct simulation based on the neighborhood traffic, and analyze the traffic network abilities in construction scope during normal, peak and emergency situation, in order to provide visualized technical support for traffic design(Fig.9)



Figure 9 Traffic simulation

#### **4.2.2 Construction phase**

Entering the construction phase, the BIM modeling can continue to support the optimization of construction plan, 5D construction simulation, quality surveillance and the enhancement of digital management during construction.

##### **4.2.2.1 Construction plan optimization**

Using the BIM modeling, personal can choose and optimize multiple construction plan, and come up with the best plan through quantity analysis(Fig.10). At the same time, the shared data platform reforms the communication route between design and construction party, and the construction can decide the plausibility of the design more conveniently. When hazards in the quality, safety and plausibility are found before the construction, effective measurement can be taken.

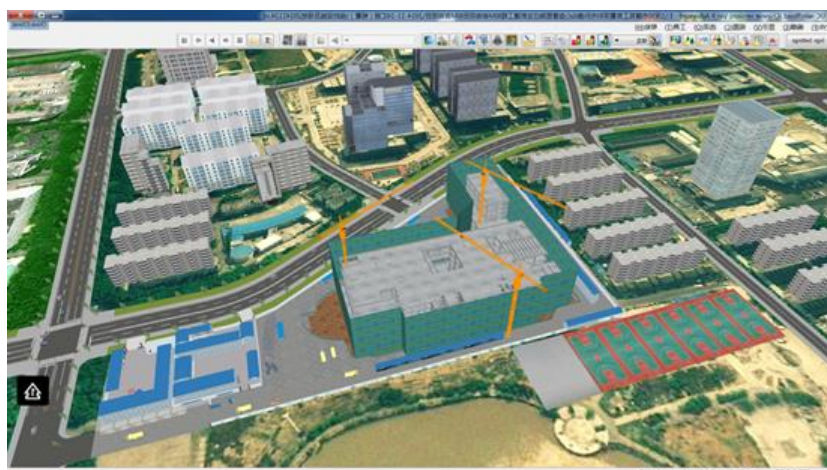


Figure 10 Construction general layout simulation

##### **4.2.2.2 5D construction modeling**

During construction, 5D construction modeling can be realized by combining BIM modeling with schedule and cost information, which means using computers to accurately determine the sequence, duration time and relationship between different works in engineering project, in order to maximize the financial benefit with advanced management and the smallest amount of consumption. At the same time, the creation of 5D models enables the various participants (from architects, designers, contractors to owners) of a construction project to visualize the progress of construction activities and its related costs over time. This BIM-centric project management technique has potential to improve management and delivery of projects of any size or complexity

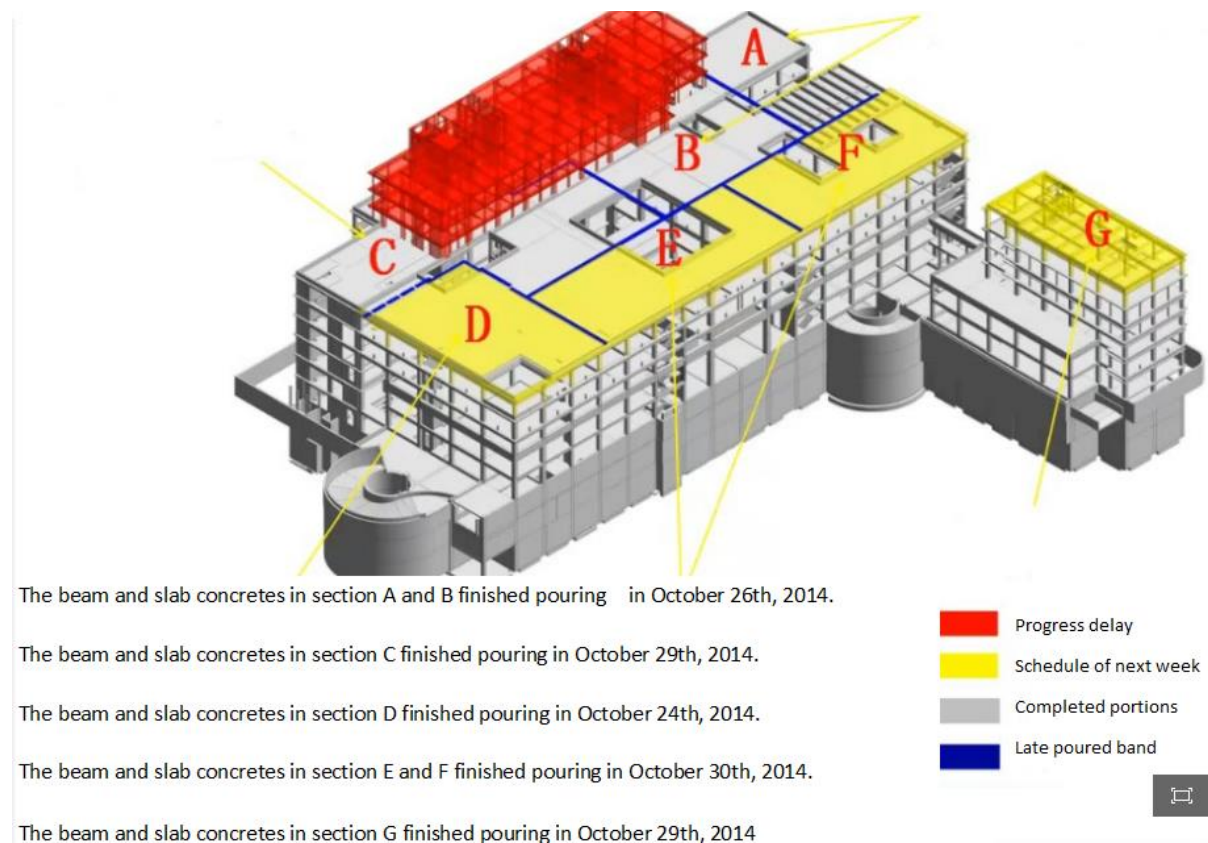


Figure11 5D construction modeling

#### 4.2.2.3 Construction safety and quality surveillance and report

At the construction site, personal can combine BIM models with laser mapping technology, RFID radio frequency identification technology, smart phone transmission, digital camera probe and other advanced technology and tools to realize digital surveillance and better manage the construction site as well as supervise construction quality. This project used the digital camera probe and enables management personal to have more time on advanced control of the construction site as well as the strict control of essential parts and process of the construction. This not only enhanced work efficiency, but also reduced the need for management personals. Also, this mode enables discovering and solving quality issues immediately, and the awareness of construction site through remote surveillance to effectively control engineering pace.

#### 4.2.3 Operation phase

After the construction is done, the finished BIM model, BIM application documents and device information can make sure that building management companies have enough information to realize true information delivery. During the operation phase, personals can predict the change in thermal load due to device adjustment in the data center by using BIM modeling. Through thermodynamic calculation and validation, they can make the adjustment plan for air condition system, and effectively reduce the energy consumption of the building and increase the utilization ratio while eliminating thermo hazard and enhancing the availability of the engine room.

What's more, this office building expands the application of BIM technology to the assessment of the architecture's energy efficiency through data collection and application, providing data support for sustainable green management. The ample information during the operation phase of this architecture leads to a more comprehensive exhibition of the BIM research and application in this project.

## **5 CONCLUSIONS AND FUTURE WORK**

### **5.1 Conclusions**

BIM technology uses digital simulation to organize architecture information throughout the life-cycle to manage the design, construction and operation .The construction industry worldwide has realized the BIM technology will bring revolutionary force to architecture. BIM technology should not only be limited to the design and construction of civil engineering, but should also be an advanced management idea.

- (1) Through the application of BIM technology on the Sunyixian Cardiovascular Hospital in Shenzhen, the project management was enhanced, engineering time and cost were reduced, project quality was increased ,the various participants established the ability to use BIM. Besides that, combining BIM technology with traditional building management increased the building management level while realizing green operation.
- (2) BIM technology will reform the traditional thinking mode and operation method of architecture, and create new ways of designing, constructing and operating. It will solve the problem of information loss during engineering projects and realize the effective use and management of engineering information, in order to significantly enhance engineering quality and efficiency, and bring huge profits to architecture industry.
- (3) BIM technology is changing the methods of internal and external team corporation during project development, and broke the fixed boundaries of different companies and digital users to realize information sharing management .

### **5.2 Future work**

Although BIM is developing rapidly in China, a lot of issues exist in design, construction and other fields. The author believes the following aspects are worth further researching:

#### **(1)BIM technical issues.**

Construction projects involve designs in multiple areas, and the engineering specialty leads to the pluralism of BIM modeling platform. Thus, different BIM modeling platforms have various data structure and format, and thus caused the issue of data exchange criteria and compatibility of these cross-platform BIM models.

## (2)The ownership issues of BIM modeling

The BIM modeling was mainly handled by the design party, while the construction party applies and continues maintaining. Nowadays, a charging criteria on BIM modeling is yet to be decided, because the design party constructs the model and the owner is the beneficial party, which leads to the lack of incentive for the design party to construct models. However, if the construction party constructs them yet cannot fulfill the objectives of a full lifecycle, the owner cannot acquire the ownership of the BIM modeling, and controversies still exist in later operation management.

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