Research on BIM Digital Collaborative Design under the Background of Intelligent Construction

Zhen Liu

Dalian Vocational and Technical College, Dalian, Liaoning,116035, China

12245759@qq.com

Abstract. With the rapid development of the new generation of information technology, intelligent construction, as an innovative engineering construction mode, has become a key method to solve many practical problems in the construction industry, and it is also an important starting point to promote the transformation and upgrading of the traditional construction industry. With the digital construction system as the core, intelligent construction will fully integrate the practical advantages of BIM, cloud computing, big data, Internet of Things, artificial intelligence and other new generation information technologies, realize data integration of the whole industry chain, and provide support for the whole life cycle management of construction projects. In the process of intelligent construction, BIM can improve the application of software by relying on its three-dimensional graphic visual description and the characteristics of digital collaborative design of the whole process, thus promoting the interconnection and two-way integration of engineering construction process. Based on this, this paper will complete building modeling, structural modeling and MEP modeling in turn with the help of BIM technology, and explain the collaborative design methods among various disciplines to complete the application summary and analysis of complex design problems such as stress analysis and collision detection, so as to verify the popularization significance of BIM digital collaborative design in intelligent construction.

Keywords: Intelligent construction; BIM; Collaborative design; Revit software

1 Introduction

In recent years, China has entered a new period of social development. Based on the new journey of the "14th Five-Year Plan", the construction industry, as a pillar industry of the national economy, is in the stage of transformation from high-speed development to high-quality development. Faced with the increasingly prominent problems in the industry, such as backward construction mode, aging population, limited information level, shrinking external market demand and changes in national policies, it is urgent to have new technologies and new models to open up a new direction for the traditional construction industry and rebuild a new industry ecology. [4] The key path for the high-quality development of the construction industry lies in the integration, innovation and

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collaborative construction of industrialization, digitalization and greening. Among them, digitalization not only represents an important means of transformation and upgrading of the construction industry, but also clarifies the future development trend of the construction industry. Under the guidance of the new generation of digital information technology, intelligent construction, as an innovative mode of engineering construction formed by the deep integration of modern information technology and advanced construction technology, can efficiently integrate all aspects of the whole life cycle of engineering projects, and give play to the practical characteristics of BIM, cloud computing, big data, Internet of Things, artificial intelligence and other technologies to build an intelligent construction control platform for engineering projects. It has become an important support to solve many practical problems in the current construction industry, and it is also an important starting point for the high-quality development of the construction industry. [5]

During the implementation of intelligent construction, BIM, as an important part of the intelligent construction system, can not only describe and show the products of construction projects and the construction process with visual three-dimensional graphics, but also promote the interconnection and two-way integration of data resources and production factors in the construction industry chain with visual collaborative design, so as to achieve the overall improvement of calculation data, calculation power and algorithm, and then provide an efficient control platform for the intelligent construction of engineering projects. [10] In view of this, this paper will focus on the collaborative design mode of architecture, structure, MEP and other majors under BIM technology, and show the comprehensive application of BIM technology in the design stage of intelligent building by example analysis, and complete the application summary and analysis of complex design problems such as force analysis and collision detection, further confirming the important significance of BIM technology in intelligent building system.

2 BIM and BIM collaborative design

2.1 BIM technology

Building information modeling (BIM), the core role is to achieve a high degree of integration of various parameters and information by establishing a virtual and visible three-dimensional model of building engineering. It can also support the transmission and sharing of all links or processes in the whole life cycle of construction projects, realize convenient and efficient collaborative management, and improve the overall cost and schedule control of construction projects. [1] As shown in Figure 1, the digital expression of physical characteristics and functional characteristics of construction projects by BIM technology covers all stages of construction projects.

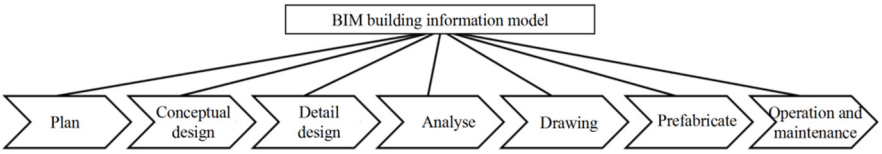

Fig. 1. Application of BIM technology

BIM technology is obviously different from traditional architectural engineering design and management in practical application, which needs the support of a large number of computer application science and technology and software engineering. Under the BIM technology system, there are two parts: BIM platform and BIM tools. BIM platform tends to store, analyze, process and apply environmental data information of construction projects, while BIM tools focus on the targeted solution of specific problems or the centralized display of some functions. At present, there are four common BIM software platforms: Autodesk, Bentley, Nernetschek Graphisoft and Gery Technology Dassault. Under the platforms, there are design software, analysis and calculation software, engineering cost software and construction management software, etc. Table 1 shows the classification information of BIM software. For the research object of this paper, Autodesk Revit series software is widely used in the field of civil architecture, and has excellent performance in structure, electromechanical and other aspects, which is suitable for collaborative design research and application.

Table 1. Summary of BIM technology software types

	Application direction	Representative software	Application direction	Representative software
BIM modeling software	Core modeling	Revit	Visualization	3DSMax, Artlantis
	Geometric modeling	Rhino	Collision inspection	Navisworks
	Sustainable analysis	PKPM	Cost management	BIM5D, VICO
	Electromechanical analysis	Designmaster	Operation management	ArchiBUS
	Structural analysis	ETABS, PKPM	Release audit	DesignReview

2.2 BIM collaborative design

Collaborative design is a novel architectural design method introduced under the background of BIM technology, which can help designers of different majors to complete the same design project efficiently. The premise of collaborative design is to build an information resource sharing platform at the initial stage of the project, and classify and store the design information of each specialty. At the same time, users involved in the construction of engineering projects, such as designers, constructors and owners, are given access rights, so as to realize better information sharing and improve the high

performance and efficiency of design, construction and management, thus saving design costs and reducing construction period. [8]

BIM-based collaborative design requires high overall design work, high dependence on design resources and design elements, and complicated implementation process, which requires preparatory work to clarify the staffing, model creation norms, model fineness and collaboration mechanism of each major. Figure 2 shows the common organizational structure of collaborative designers.

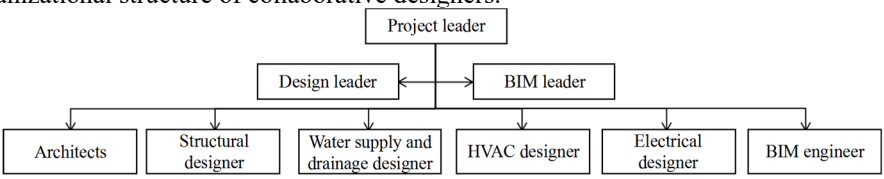

Fig. 2. Organizational structure of collaborative designers.

3 BIM collaborative design application

In the BIM collaborative design, all professional designers must follow the BIM model creation specification, adopt the same Revit software and Buzzsaw collaborative platform, and express in a standardized and parameterized way, so as to facilitate data transmission and sharing, promote communication and collaboration among professional designers, and finally improve the completion and integration of engineering project design tasks. [7]

3.1 Building model creation

This paper takes a comprehensive application building of an enterprise as an example. The basic information of the project is as follows: the building area is 26,314.88 square meters, of which the aboveground part is 14,513.50 square meters, the underground part is 11,801.38 square meters, and the building height is 52.55 meters. Figure 3 shows the building model and the basic rendering model.

Fig. 3. Building model and the basic rendering model

3.2 Structural model creation

BIM technology runs through all stages of engineering construction, and different professional models are closely related. The structural model of the project is born out of the architectural model, and the construction process does not need to start again, only by deleting, modifying and redeploying the architectural model. The overall structural model is shown in Figure 4. [2]

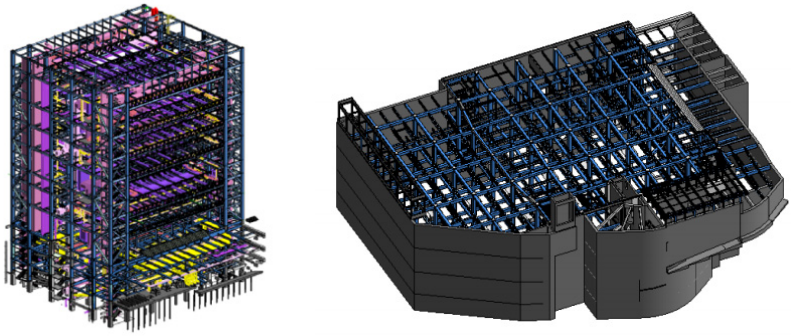

Fig. 4. Overground and underground structure models

In the structural design scheme, the main building on the ground is a steel frame and the underground is a concrete frame structure. Among them, reinforced concrete underground external wall is added inside the underground continuous wall to further improve the bearing, deformation, stability and overturning resistance of the superstructure. [9] After completing the basic physical model construction, the structural designer will continue to build the structural analysis model, that is, add the corresponding structural attributes and load information to the structural model and complete the structural analysis. Table 2 shows some component data information.

Table 2. The component data information

Column section (mm)	Material quality	Main girder section (mm)	Material quality
Reinforced concrete columns: 600*600, 900*900, 800*1200	C45	Reinforced concrete beam: 200*400, 400*600	C30
Steel reinforced concrete: 550*200*40*20	C45, Q345C	500*200*10*15 450*200*8*12	C45, Q345C
Square steel concrete: 550*25	Q345C	500*200*10*15 450*200*8*12	Q345C, Q345B
Square steel pipe: 550*18	Q345C	500*300*10*15	Q345C, Q345B
Round steel pipe: Φ400*10	Q345C	500*300*10*15	Q345C, Q345B

Structural analysis involves data preprocessing, stiffness and freedom information calculation, earthquake action analysis and structural internal force analysis in PKPM software. [6] Taking the combined calculation of load conditions in seismic design as an example, when the wind load is 0.44KN/m^2, the roof load is 0.5KN/m^2, and the

indoor load is 2.0KN/m^2, the calculation results of structural displacement under various simulated conditions are shown in Table 3. The results show that the control purpose can be achieved under working conditions 02 and 04, and the maximum displacement meets the requirements of the code.

Table 3. Calculation results of structural displacement in earthquake design

Working condition number	Maximum longitudinal displacement	Maximum horizontal displacement		Load
		X direction	Y direction	
01	20.55mm	-	-	Constant load
02	31.60mm	-	-	Live load + constant load
03	-	84.4mm	134.2mm	Wind load + constant load
04	-	174.6mm	184.9mm	Earthquake action + constant load, live load

After structural analysis, designers can accurately determine whether the materials and dimensions of components meet the design requirements, and can quickly export various types of views through collaborative models, and make one-click modification through the linkage relationship between models, thus reducing the problem of repeated modification of drawings by buildings and structures.

3.3 MEP model creation

MEP modeling in Revit can be divided into three parts: Mechanical part, Electrical part and Plumbing part. [3] The overall complexity of MEP model is high, and there are many types of pipelines. Besides colliding with the structural model, it is also prone to similar problems. As far as this project is concerned, the layout of pipelines is mostly concentrated in the steel truss, and Figure 5 shows the effect diagram of comprehensive collaborative design of pipelines in the steel truss.

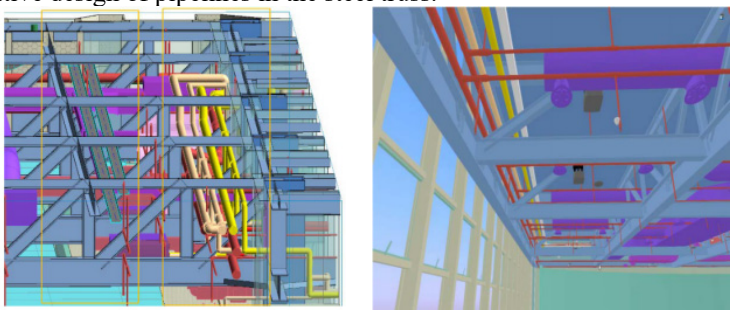

Fig. 5. Comprehensive collaborative design effect of pipeline

Through collaborative design, MEP designers and installation units can further deepen the design of complex and centralized pipeline parts, and integrate the later installation, maintenance and clearance requirements to adjust the deployment of pipelines. Figure 6 shows the comparison results of clearance effect before and after pipeline optimization. After optimization, the clearance of basement is increased from 2.2m to 2.55m.

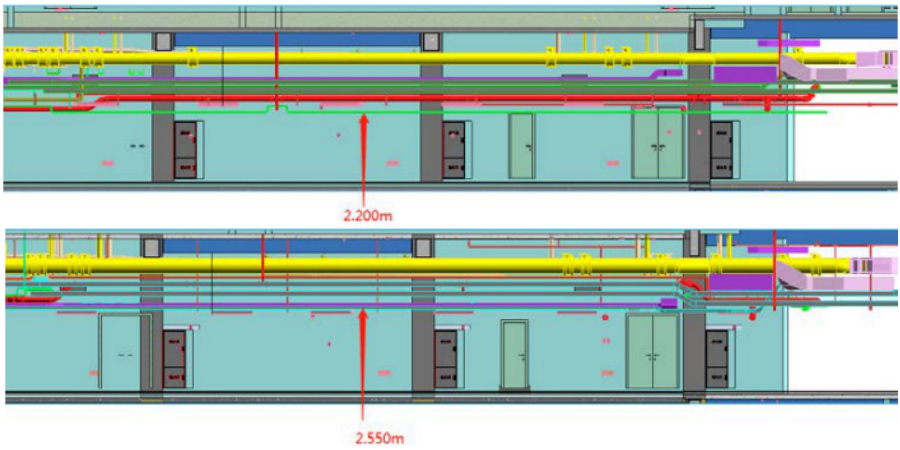

Fig. 6. Effect comparison before and after pipeline optimization

For the crossing and collision between pipelines, Navisworks software is needed to carry out professional and comprehensive collision detection. Figure 7 shows an example of collision detection. When a collision occurs, a collision detection report will be automatically generated, as shown in Table 4.

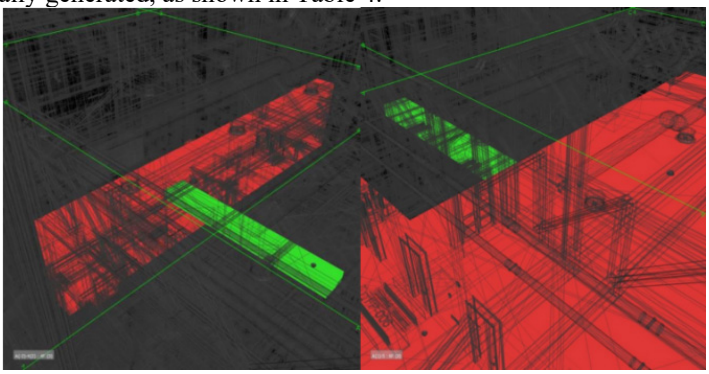

Fig. 7. The collision detection process

Table 4. Collision detection report

No.	Distance	Collision point	Project ID	Project 1 Name	Type	Project ID	Project 2 Name	Type
001	-1.22	x:31.030 y:14.950 z:7.451	326641	Air conditioning air supply galvanized sheet	Entity	325810	Air conditioning air supply galvanized sheet	Line
002	-0.166	x:5.041 y:6.937 z:8.611	561063	Air conditioning condensate pipe	Entity	501621	Stainless steel plate	Entity

4 Conclusions

Based on the understanding of the concept of BIM technology, this paper selects Revit

as the support of software platform, and confirms the practical application and popularization significance of BIM technology in collaborative design under the background of intelligent construction by combining design practice and actual engineering projects. The 3D digital model with visualization, parameterization and high correlation under BIM technology improves the shortcomings in the traditional design process and provides the necessary technical support for the implementation of intelligent construction mode. In the follow-up research, the application scope of BIM technology will be further expanded, and the connection between design, construction and operation and maintenance stages will be strengthened, so as to contribute to the digital development of modern construction industry.

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