Research on the Application of BIM + VR Technology in the Project

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Abstract: At present, the research of BIM + VR technology is the forefront of BIM technology application research. BIM technology can solve some design problems and provide collaborative design solutions for various professions. Virtual reality technology (VR) technology can make up for some of the shortcomings of BIM technology, BIM technology and VR technology can complement each other and be used in actual engineering projects. For this case, the actual application results show that BIM + VR technology can effectively solve the visualized expression of the integrated design of the interior pipe of the building, the decorative design and management.

1. Overview of BIM and VR technology

1.1 Overview of BIM technology
The full name of BIM Technology is Building Information Modeling (BIM). It is a digital model integrating engineering data information and it is made by 3D digital technique. It contains all kinds of relevant information about the project. During the project design phase, BIM technology provides collaboration for all specialties, solves the expression problem of engineering technology software and dramatically improves the efficiency of design work. However, the experiencing effect of buildings, i.e. the model of the construction process and the final building effect, is expressed insufficiently and even rigidly, and it cannot provide a vivid subjective sensory effect[1].

1.2 Overview of VR technology
Virtual reality technology (VR technology in short) refers to creating a virtual reality world by electronic equipment such as computers, which brings users real sensory experience in vision, hearing, touch, etc., improves users’ sensory degree and makes users immersed in it. VR technology has broad application prospect, such as engineering construction, medical care, education and entertainment. In the project design, VR technology can improve the reality degree of the model, make designers and users feel the construction effect in advance and make designers and users perform the effective communication effectively, etc.

1.3 Overview of BIM + VR technology
There is still a big gap between the visualization of the model made by BIM technology and the real scenario. It cannot truly reflect the building materials, environment, etc. Its reality is insufficient, so it is complementary with VR technology. Due to its unique immersive experience, VR technology can effectively enhance the visual effect of BIM model in the design phase, and it can interact with the building model, e.g. check and modify results [2].

BIM platform transforms two-dimensional drawings into three-dimensional models, transforms and
imports them into VR software to realize immersive virtual reality experience through VDP2019 virtual reality design platform (http://www.izsw.net). BIM model provides data support, VR technology provides immersive experience and high reality, simulates the plane layout and other scenarios, verifies the engineering design in the real environment, and optimizes the scenarios.

2. Introduction to the project
This project is located in Tianjin. The total floor area is around 2,823 m². The total building area is around 15,377 m². The maximum height of the building is about 30 meters and the maximum span is 8 meters. It is an industrial building and it is a frame structure.

Project construction features:
(1) The deadline is tight and the requirements for safety and construction quality are high;
(2) The development of 2D design drawings cannot meet the requirements, and the design shall be continuously changed according to the requirements of all parties.
(3) There are a lot of mechanical and electrical pipelines, and specialty crossing operation is frequent. In BIM model, collision checking test is carried out to provide evidence for pipeline integrated optimization and modification when using BIM software and VR software.

3. Application of BIM + VR technology in the project

3.1 Application process of BIM + VR technology
According to the features of the case project, BIM technicians from all specialties formulate a complete and detailed BIM proposal and implementation scheme during the conceptual design phase. BIM parametric technology is used by professionals in the basic design phase to design and build BIM model. In the detailed design phase, specialties mutually cite the models among all specialties for dynamic design according to their interface conditions, integrate the design models which are completed preliminarily by each specialty, discover problems and give timely feedback, as well as update the design. After continuous adjustment, the final assembly results will be imported into VR virtual reality software through plug-ins. Designers will review the collision test, space rationality and aesthetics of the design so as to ensure the feasibility of the project design. The overall application process of BIM + VR technology in this project design phase is conceptual design, basic design, detailed design, VR inspection and display respectively [3].

3.2 BIM parametric modeling
After planning the application process of BIM+VR technology, the BIM parametric modeling of the project is carried out. This case project adopts Revit software of three-dimensional modeling. Due to its provided parametric function and seamless integration with Unity 3D software, virtual reality visualization can be realized quickly and efficiently. On the basis of the model, it integrates the idea of project design, adjusts the key parameters of the model according to corresponding software development tools and software knowledge such as standards and regulations and design experience, realizes the optimization of project buildings and solves the professional knowledge and experience, software interface and plug-ins [4]. The following is the buildings, structure and electromechanical BIM model flow in this case: collect construction drawings, read drawings, unify modeling standards, build models, communicate, compose and optimize models among all specialties, as shown in Fig.1.

Fig. a Building BIM Model  Fig. b Structure BIM Model  Fig. c Electromechanical BIM Model
Figure. 1 Project's building, structure, electromechanical BIM model
3.3 Collision test
In this case, the mechanical and electrical pipeline of the building is complex. The pipeline contains lots of systems. Through collision test, a large number of hidden design problems can be found, especially the blind spots in vision, which provides the premise for solving the collision problem and develop the design of the pipeline. It can be used to check whether the layout of various pipelines is reasonable and beautiful, the installation of valves, the inspection of reserved holes, and the inspection of the clear height of pipelines. In theory, if Navisworks software is used to check the BIM model before the actual construction, all pipeline conflict points can be checked, the pipeline can be optimized, and all pipeline collision problems can be eliminated. It can optimize the layout of pipelines, reduce rework, shorten construction period and save costs. The inspection diagram of the collision between the cable bridge and the wall, the water pipe and the wall, and the air pipe and the wall in this case is shown in Figure 2 below.

![Collision drawing between cable tray and wall](image1)

**Fig. a** Collision drawing between cable tray and wall

![Collision drawing between water pipe and wall](image2)

**Fig. b** Collision drawing between water pipe and wall

![Collision drawing between air ducts and wall](image3)

**Fig. c** Collision drawing between air ducts and wall

Figure. 2 Collision check diagram

3.4 Integrated pipeline optimization design

3.4.1 Basic principles of integrated pipeline optimization
After the collision test, the collision report is obtained. The integrated pipeline optimization is carried out on the basis of the collision report. The following is some specific basic principles of integrated pipeline management optimization. At first, the cable shall be laid above the air ducts and water pipes; secondly, for the existing pipeline in reserved holes in the primary structure, the movement at the pipeline position shall be minimized; thirdly, during arrangement, consider the space of reserved inspection and maintenance and secondary construction and raise the pipeline as highly as possible, but reserve sufficient space between the ceiling and the pipeline; fourthly, do to arrange pipelines at the entrance and exit; fifthly, the pipes with fragile materials where people cannot stand on shall be arranged
on the top, e.g. composite air ducts which must be arranged on the top; sixthly, the clear distance between horizontal main of exposed indoor supply water pipeline and wall and trench walls may not be less than 100mm (Code for Acceptance of Construction Quality of Water Supply Drainage and Heating Works) and its clear distance with beams and pipes may not be less than 50mm (no joint) (Building Construction Handbook); seventhly, the distance between the riser center and the column surface may not be less than 50mm and the clear distance with wall may not be less than 25mm when DN is less than 32 mm, not less than 35 mm when DN is 32 to 50, not less than 50mm when DN is 75 to 100, not less than 60mm when DN is 125 to 150mm.

3.4.2 Integrated pipeline optimization based on BIM technology

According to the collision report, the 3D model in Revit software is quickly browsed, problems are found, the pipeline is optimize and the collision problems are solved. Integrated pipeline optimization can reduce pipeline material waste, lower construction difficulty, reduce rework, improve construction and installation efficiency, provide efficient construction and save costs [5].

During development of pipeline design, the unique parameterization function of BIM Technology can be used. For example, when changing a component attribute of the model in this project, the overall model information can be modified synchronously when modifying a parameter information. All specialties can modify the model any time and update it synchronously, which strengthens the effective communication among all specialties, reduces construction conflicts and rework amount. BIM model realizes the three-dimensional visualization of design drawings. The layout of pipelines can be more intuitively seen. The overlapping conflict points of pipelines can be found in the dense area of pipelines, and the pipelines can be effectively optimized[6]. In this project, after collision detection, it is found in BIM model that the length of air outlet end and air duct interface is more than 300 mm, so the return air duct deviates for 300 mm downward, and the maintenance and inspection space for 150 mm is reserved, which solves the crossing collision point and meets the standards required by the design space, (as shown in Fig.3,4).

![Fig. 3 Before the optimization of air duct](image1)

![Fig. 4 After the optimization of air duct](image2)

However, there are some problems in integrated pipeline optimization based on Revit software:
(1) The reality of model presentation in the software is insufficient.
(2) There are some blind spots for pipeline tour.
(3) The design development and modification are complicated.

3.4.3 Integrated pipeline optimization test based on BIM+VR technology

The BIM + VR technology is applied to integrated pipeline development design. The VR software Unity 3D is used to simulate scenarios of the BIM model, the pipeline is detected, the pipeline design is developed from the perspective of the user, and the reasonable and beautiful layout is guaranteed. The application of BIM+VR technology improves the reality of the model display. When optimizing the integrated pipeline, the optimization can be seen very clearly and the modification of development design is simple and it can be marked, which greatly reduces workload and relieves the problem which exists using Revit software to perform the integrated pipeline optimization [7]. In the case, VR equipment is used to conduct the pipeline adjustment of the pipeline development design and the detection of pipeline layout for the BIM model imported in Unity 3D software. The layout inspection of
the pipeline is shown in Fig.5.

Fig. 5 BIM+VR technology for integrated pipeline optimization

3.5 Decoration design
The application of BIM+VR technology into decoration design is a new and economical design method. At first, use Revit software to build the model, import the BIM model which has been built very well into 3DMAX to add model details and high-end rendering effects of the model, then import the modified model into Unity 3D software, and adjust the properties of the model such as adding special effects and lights finally, as shown in Fig. 6.

The following are the advantages of BIM+VR technology in decoration design:
(1) 3DMAX is used to render the model effect so as to reach more realistic display effect.
(2) The data layer of 3DMAX in Unity 3D has a high-end rendering effect.
(3) BIM model has information data such as geometry, materials and scale of components, which can be quickly searched, modified, etc.
(4) Realistic simulation scenario can act as the basis of presenting the construction drawing so that the construction results can be displayed in advance and the construction personnel have a clear understanding of the final construction results in advance.
(5) The real simulated scenario enables designers and users to have a direct experience of the final result and assists owners for delivery.

4. Conclusions
This paper introduces the application process of BIM+VR technology in the architectural engineering design phase with practical engineering project design. The case of this project also proves that BIM+VR technology is accurate, scientific and rational during the engineering design phase, which can push ahead the development of architectural design industry [8].

At present, VR technology is limited because it can’t eliminate the poor experience brought to users, such as sense of vertigo, insufficient screen resolution, and high technical requirements for operators in
engineering projects. However, along with the continuous development of social science and technology, the promotion of national policies and the perfection of BIM + VR technology, BIM + VR technology will have a broader application prospect and research direction in the field of construction industry.

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