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Contents

Study on Application of BIM Technology in Structural Design of Constructional Engineering

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Abstract: Constructional engineering is the fundamental industry of China and along with the constantly improving of science and technology level in recent years, BIM technology has been gradually applied in constructional engineering field of China, and it has exerted relatively sound application effects, thus actively proving the construction efficiency and quality. In this study, mainly based on BIM technology, I analyze the application of BIM technology in structural design of constructional engineering respectively from field data analysis, structure parameter design, interior design and professional coordination design, and analyze the application effects of BIM technology in structural design of constructional engineering by combining practical cases, which is expected to serve as the effective theoretical basis for the improvement of structural design of constructional engineering in China.

Keywords: BIM technology; Constructional engineering; Structural design; Development trend

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1. Introduction

Along with the widespread application of BIM technology in the engineering field, BIM technology, a modern information model technology, has gradually developed to be the channel for sharing data information among different majors and different companies, and it can provide designers with actual digital design information, which may exert positive effects on the design of the digital model structure. However, according to the current development status of BIM technology, its development in the structural design field is relatively slow, and when compared with drainage and electrical engineering, BIM technology fails to manifest the application value in structural design. Meanwhile, how to achieve the effective application of BIM technology in structural design of constructional engineering also has aroused the great attention of numerous structural engineers.

2. Concept and Characteristics of BIM Technology

BIM technology, short for "Building Information Modeling Technology", as an intact information model, can summarize different engineering information and processes at different construction phases of the constructional engineering project and demonstrate the information and process by virtue of model, which can be used by other engineering participants. By virtue of three-dimensional digital simulation technology, BIM technology can carry out the synthesis simulation of the true information owned by buildings, thus exerting proactive effects on the successful implement of engineering design and constructional engineering.[1] Based on characteristics of BIM technology, one of the main manifestations is the visualization of BIM technology. In the construction industry, the application of visualization plays a crucial role in the overall design

and optimization of constructional engineering. Compared with traditional design technologies, BIM technology can visualize the overall design of architectural structure, and design effect drawings based on BIM technology can feed back and analyze the engineering design in a deeper level and improve the overall construction level of the constructional engineering.[2] Another main manifestation is the simulation characteristics of BIM technology, namely, BIM technology can not only be used to simulate the building model, but also simulate operations that cannot be carried out in the physical world, thus enhancing the authenticity of designing the constructional engineering project and promoting the successful implementation of design works.[3]

3. Application of BIM Technology in Structural Design of Constructional Engineering

3.1 Application of Field Data Analysis

When analyzing data on the construction site, the effective application of BIM technology can effectively improve the capacity of designers analyzing and designing the model. Along with the effective enhancement of model analysis process, the analytical accuracy on building land and its peripheral ecological environment will be further enhanced, thus ensuring a better combination of waters, greening and other external ecological factors by designers.[4] Meanwhile, by virtue of effective application of BIM technology, its performance simulation analysis can be further used to carry out the comprehensive analysis of water combination, greening and external ecological factors, and the imagination and simulation of all kinds of structural design status can further improve the steady improvement of the economic benefit level of design of architectural structure.

3.2 Application of Structure Parameter Design

When designing the architectural structure, design information involved in the design model and design parameters related to design will be uniformly integrated in the general database, with certain relevance among parameters. During implementing the design of architectural structure, building designers can combine all related parameters in the architectural and structural model comprehensively to construct an all-round architecture, and achieve the comprehensive treatment of all data by taking advantage of BIM technology, which can make it meet the overall practical demands of engineering construction.[5] By applying BIM technology, the three-dimensional model can be fully used to demonstrate all components of buildings in a comprehensive way, which makes the structure and shape of buildings more intuitive. Compared with traditional CAD technology, BIM technology can be used to establish a more realistic three-dimensional model, which can be used for carrying out a comprehensive analysis of functional analysis of buildings and overall functions and calculating the corresponding dimensions of the architectural structure by summarizing the data information.[6] Meanwhile, BIM technology can also be used accelerate the transmission of design information, thus making it convenient to query and analyze the problems existing in the overall design of architectural structure, facilitating the improvement of design quality of overall engineering structure, realizing the visualization of structural parameter design of constructional engineering and exerting better application effects.

3.3 Application of Interior Structural Design

As the space for long-term life and work, how to achieve the effective design of interior structure has also developed to be the concern of numerous scholars and key components of the structural design of constructional engineering.[7] Considering the close relevance between the environment quality in the traditional interior space and living feelings of residents, BIM technology can be effectively applied to carry out the comprehensive design of the interior structure of architectural structure, analyze the influence of different materials on the overall space structure according to different demands of residents, establish the simulation model related to the quality and structural design by combining the modern system technology, and carry out the simulation analysis by establishing the virtual model, thus accelerating the realization of the overall optimization of the architectural structure.

3.4 Application of Professional Coordination Design

BIM technology not only plays better application effects on the structural design of constructional engineering, but also exerts certain application value in the professional coordination design.[8] By virtue of effective application of BIM technology, exchange of water heating, structures, buildings and other systems can be realized by applying model components, and information carried by three-dimensional models which are developed by different professional designers can be summarized and summed up based on the application of the integrated design model, which can also be shared to other professional design teams. Meanwhile, the all-round sharing of constructional engineering information can improve the participation degree of designers from different construction projects and help master more building information, thus carrying out the effective design of construction structures. For exam-

ple, in case that designers carry out the design by adding components, structural engineers of constructional engineering will input information of walls, pillars, girders and other structures with different materials in BIM model, which can be optimized and adjusted by designers based on the analysis of data, thus accelerating the coordinative implementation of constructional engineering projects.

4. Case Analysis of Structural Design of Constructional Engineering Based on BIM Technology

Since BIM technology is the modern technology which is widely applied in structural design of constructional engineering, this paper will analyze the case of structural design of constructional engineering case by combining the specific application case of BIM technology from the following aspects.

4.1 Engineering Overview

The engineering selected in this study is one product packaging workshop in Kunming, with the total floor area of 3811.42m2, a 10-floor building with the fire resistance rating being Class II. This building is mainly used to process corn starch, with the reinforced concrete frame structure, 50-year designed service life period, seismic fortification intensity being 7, earthquake group being Group II, the designed basic acceleration of earthquake being 0.1g, and the characteristic period being 0.35s.

4.2 Establishment of Structural Models

When designing the structural model, the structural analysis model developed via Revit software is applied in this study to link nodes of design & analysis model automatically. Wherein, the establishment targeting at geometric models is to construct the information model with attributes of structural components by applying category, family, pel and other classification standards of different components. Since this targeted engineering belongs to reinforced concrete structure, the basic components of structural design of BIM model include girders, structural columns, structural plates and other fundamental factors, and the construction of this structural model can be achieved by optimizing the fundamental factors. When establishing the model, the first step is to select the structural sample file, then establish column grid of models and elevation respectively by connecting to the professional BIM model of constructional engineering, and carry out the construction by selecting corresponding components. Refer to Figure 1 for the physical model formed via Revit software.

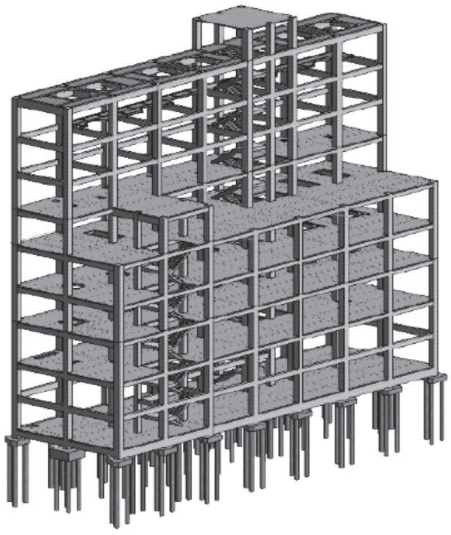

Figure 1. Professional Physical Model in Revit Software

Upon completing the professional physical model construction, it is necessary to position the elevation of the building model properly for preventing the occurrence of elevation difference in the structural model. During the process of constructing the structural information model, it is necessary to build individual family files and define parameters of family attributes targeting at certain components when processing the special shaped components of the project since families equipped in the software fail to meet the basic needs in practical design. In Revit software, the analysis models targeting at girders mainly consist of red, green and orange. Wherein, green represents the starting point of girders, orange represents the total girder body and red represents the end point of girders, which is similar to the finite element software that can distinguish the starting point and end point by setting system parameters, as shown in Figure 2.

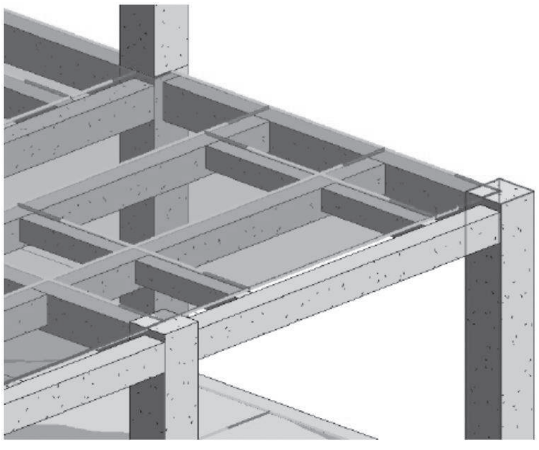

Figure 2. Girder Body Analysis Line

Model analysis in Revit software adopting BIM technology is same to that of models in the structural analysis software. Wherein, there is a good deal of analytical information included. For example, during the layout of framed girders, the attribute design of the girder body contains corresponding constraint conditions, therefore, there shall be corresponding constraint settings, with the position of analysis model of girders analyzed and judged via a physical model of girders. Please refer to Figure 3 for the overall structural model.

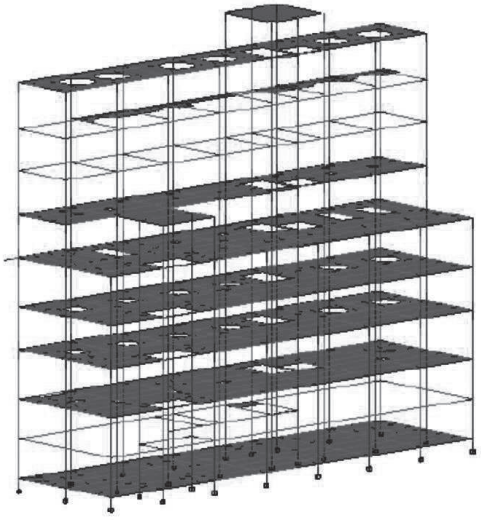

Figure 3. Overall Structural Model

4.3 Structural Analysis

The first step of analysis of traditional structural design model is usually to carry out the professional structural analysis on buildings, then determine the corresponding structural system, complete the structure selection, carry out the comprehensive improvement on the layout of architectural structure according to specific architectural working drawings, establish the corresponding analysis model, carry out the comprehensive analysis on the security of the overall structure and space stress, and demonstrate the design requirements in the plane construction drawings via two-dimensional approaches, with a relatively independent process. However, based on BIM technology, the structural design of constructional engineering works compatibly with building design, and BIM model will change on the basis of changes of the structural analysis model, without repeated modeling, which will exert positive effects on the improvement of model utilization. BIM technology can be used to update model, and generate the corresponding construction drawings from the general database of buildings. Meanwhile, BIM can also be constructed by applying another modeling approach, namely constructing the BIM based on the existing construction drawings by taking the construction plan as the foundation. Wherein, structural stability is the key to designing the constructional engineering structure. Since there are large amounts of analytical information and geometrical information contained in the structural model of building engineering, BIM data management platform can achieve the effective management of all kinds of data, making it possible for users to use and invoke statistical data as soon as possible, and generate the construction drawings automatically. During the two-way link modeling process, ETABS2013 structural calculating software and Revit2016 software can be used to achieve the comprehensive interaction and two-way link of data, with the generated structural analysis model diagram referred to Figure 4.

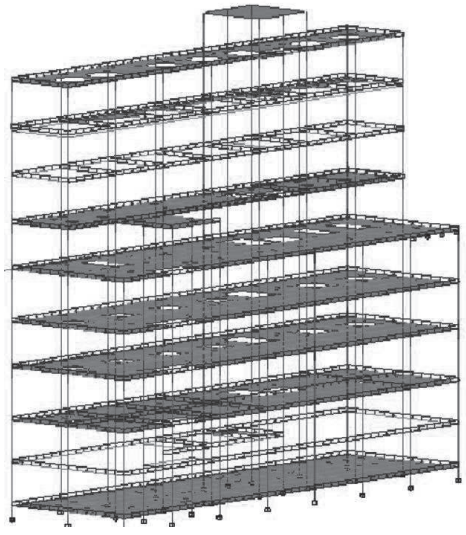

Figure 4. Model Adjustment via Revit Software

4.4 Construction Drawing Design

Construction drawing design is the main application link during the structural design of constructional engineering. Therefore, it is necessary to achieve the effective integration of building information model and construction drawings by applying BIM technology during the construction drawing design process. During the process of designing construction drawings, the first step is to design reinforcement parameters, and carry out statistics of results generated from analysis software for designing the reinforcement in components. For this project, C30 concrete is selected, with the strength characteristic value being 20.10, HRB335 ribbed bar applied as the main reinforcement of girders and columns, and reinforcement shall be adjusted according to the practical engineering conditions.

The second step is to draw the construction drawing. When drawing the construction drawing via Revit software, it is necessary to apply the sharing parameter function. As the characteristic function, the sharing parameter function can share parameters of other parties who also use Revit software, thus applying the shared parameters as the parameter type. The use pattern is the same as that of other parameters, but the difference lies in that sharing parameters can be saved in any irrelevant file in Revit software and used in other irrelevant files. After setting sharing parameters, it is necessary to build the corresponding labeling family, namely, building the labeling family file according to the related engineering regulations, recording it to the corresponding projects and then perfecting the label of column structural construction drawings. Wherein, the generated construction drawings can be exported into graphic files in CAD and other formats. However, the application of BIM technology at current time shall still rely on two-dimensional drawings for most engineering details shall be expressed with two-dimensional graphics.

5. Conclusion

In conclusion, as a modern technology that widely applied in engineering design in recent years, BIM technology can be used to not only improve the engineering quality, but also exert sound application effects during the structural design of engineering, thus achieving the intellectualization of engineering structure design. However, most engineering enterprises fail to introduce BIM technology to the engineering structural design. According to the analysis carried out in this paper, we can find out that BIM technology can be applied effectively in every link of structural design of constructional engineering, and it also exerts positive effects on the improvement of engineering construction quality and scientificity and rationality of engineering design. This study on the application analysis of BIM technology in the structural design of constructional engineering will serve as the effective theoretical basis of the application of BIM technology in the field of constructional engineering for further improving the structural design level of architecture engineering enterprises.

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The Application and Prospect of Virtual Reality Technology in the Future Architecture Design

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Abstract: the rapid development of computer technology has accelerated the progress of construction technology, and the application of virtual reality technology has become more and more common, which has caused earth-shaking changes in the thinking and mode of traditional architectural design. It plays an important role in optimizing the construction design scheme and improving the science and rationality of the architectural design. In order to realize the effective application of virtual technology in the future architectural design, it is necessary to intensify the research on its application and give full play to its application value and advantages. This paper discusses and analyzes the application and realization of virtual reality technology in the future architectural design, and predicts its future application prospects.

Keywords: Virtual reality technology; Future architecture; Architectural design; Application; Prospect

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1. Introduction

The integration of virtual reality technology and architecture is a historic innovation for the development of the construction industry. It can present the architectural design scheme in a three-dimensional form and make up for many defects in the traditional design model. The use of virtual reality technology can not only improve the efficiency and design quality of architectural design, but also reduce the workload of designers and reduce the appearance of design irrationality, and can effectively ensure the scientific nature and feasibility of architectural design solutions. In addition, It can also reduce the cost of building design and bring more considerable economic benefits to construction enterprises. It can be seen that it is very important and necessary to increase the research on the application of virtual reality technology in architectural design and apply it effectively.[1]

2. A Brief Introduction to Virtual Reality Technology

Virtual Reality(VR) refers to providing users with a simulated reality operating environment, using computers to generate a realistic three-dimensional vision, hearing, and tactile perception of the world, so that people can obtain their own experience of the object and environment studied. The feeling, thus, the breadth and depth of human cognition will be enhanced, and the "understanding space" and "method space" of human understanding of the objective world will be widened, and finally the essence of the objective world will be reflected more fundamentally. The nature of virtual reality technology is a new type of computer technology. It has strong integration and comprehensive characteristics and covers many technologies such as computer graphics, simulation, artificial intelligence, sensing, display, and network processing. It can achieve effective fusion of vision, hearing, and feeling, and present the real situation with a realistic three-dimensional virtual situation. People and the virtual environment can interact well, and then optimize and perfect the deficiencies in the design plan. Make the real product more consistent with people's various sensory experiences. Virtual reality technology uses different angles, and its human-computer interface interaction process is also different. From the user's point of view, virtual reality technology allows it to enter directly into virtual reality and observe the steps of interactive operations. The observation method is mainly called by the first person, and the hidden interface will only appear when used. From the perspective of monitors, users can monitor the reality of virtual reality in a third-person manner and monitor and control virtual objects in the environment. However, the interface generation has no absolute relationship with the type of virtual

reality. Based on the many advantages embodied in virtual reality technology, it has been widely used in many industries and fields and is an inevitable development trend of future architectural design.

3. The Application and Prospect of Virtual Reality Technology in the Future Architecture Design

In the future architectural design, virtual reality technology will become an indispensable and important technical means; its specific application is mainly reflected in the following aspects.

3.1 Application and Prospect in Animation Display

With the help of virtual reality technology, it is possible to present architectural effects maps in a more comprehensive and detailed manner, making various architectural information at a glance. At the same time, it can also present architectural design intuitively and three-dimensional in the form of three-dimensional models. Supplementary information, in addition, it is also possible to use VR equipment to transform the architectural effect map into a virtual architectural space structure, give people a sense of real space experience, and deepen the understanding and control of architectural design details. Taking terrain design, landscape planning, road layout, etc. as an example, virtual reality technology can be used to construct a three-dimensional architectural model, which is convenient to examine the architectural design scheme from any one angle, and find out the shortcomings to improve and optimize it. At the same time, the user can watch the virtual reality animation, master the final effect of the architectural design, propose amendments to the unsatisfactory areas, and communicate with the designer to improve the science and operability of the architectural design. In addition, it can make up for the defects in the plane display diagram, and show the architectural structure in a three-dimensional and intuitive form. The problems in the design will also be revealed. The adjustment and optimization of the design plan will become more convenient. It can significantly improve the level of architectural design.

3.2 Application and Prospect in Program Comparison

For architectural design, it is not only the only design plan. When the design idea is different, the design plan given is also different. This makes the same construction project often have multiple design ideas. Therefore, it is necessary to determine the most suitable one through the comparative analysis of multiple design schemes and the actual construction requirements in order to maximize the architectural design and construction benefits. The comparison and analysis method of the original architectural design scheme is relatively backward and the efficiency is low. Using the virtual reality model technology, the construction of the architectural model can present different design schemes. The adjustment of the model by computer software can realize the real-time switching between multiple design schemes. Designers can compare the advantages and disadvantages of different design schemes by observing the changes of a certain position or component of the model, and select the most suitable design scheme based on the final comparison results. In this way, not only can the efficiency of comparison and analysis of architectural design schemes be improved, but also the optimization and improvement of design schemes have become more convenient. The status before and after the modification of architectural design can be compared in real time, providing there are the best design solutions for construction projects to ensure building quality.

3.3 Application and Prospect in Construction

There are many factors affecting the construction. In the actual construction process, it is often necessary to adjust the construction plan to ensure the smooth progress of the construction. However, this will easily cause delays in the construction period and reduce the construction efficiency. At the same time, it will also increase the construction cost due to rework problems.. In this regard, virtual reality technology can be used to simulate the construction process, find out the possible problems in the construction process and make adjustments, and avoid adjusting the construction plan in the construction process as much as possible. The specific operation is to demonstrate the construction operation in accordance with the construction plan and the construction organization plan before the formal construction is carried out. The defects and shortcomings are found to be optimized, and targeted preventive measures and emergency measures are taken to reduce the impact of construction problems as much as possible. And make a rapid response after the problem occurs, control the harm caused by it to a minimum, and provide guarantees for the smooth and orderly construction. It can be seen that virtual reality technology also has a high application value in the construction process, and plays an important role in improving construction accuracy and construction efficiency, and can significantly improve the actual construction quality and construction level.

3.4 Application and Prospect in Real Estate Sales

Real estate sale is also an important aspect of virtual reality technology applied to architectural design. For ar-

chitectural design, the ultimate goal is to obtain customer recognition and achieve more ideal sales results by improving customer satisfaction. In order to seize the sales market, pre-sale has become the most important means of real estate sales, especially high-end construction projects. In order to bring customers a more realistic architectural experience before the completion of the project, the construction company will make it easier to sneak a peek. Usually use virtual reality technology to display the entire picture of real estate, including the appearance of real estate, landscape gardens, sample rooms, so that users can objectively and truly understand the specific situation of real estate, get a good home purchase experience, and improve users 'recognition of real estate. As shown in Figure 1, the prototype room is presented using VR technology. In this way, after the formal opening of the stock market, the real estate can be quickly cleared and help the building developers to correct and better their sales performance. For construction developers, who can master advanced technology, the effective application of virtual technology science to real estate sales, who can occupy the initiative and advantages in the sales link.

Figure 1. VR Sample Room

3.5 Application and Prospect in Building Renovation

Interior decoration design is also an important branch in the field of architecture, but there is a large space for improvement in the current level of architectural decoration design, and it is difficult to achieve a more ideal decoration effect. In addition, the renovation design workload is large, and large errors often appear in the cost and budget link. Based on this, it is necessary to use virtual reality technology to simulate the decoration process. Relying on the three-dimensional model, the expected decoration effect will be presented. According to the shortcomings, it will be improved and adjusted to improve the decoration design level. At the same time, it can also reduce the intensity of the renovation staff and make a more accurate budget and control of the renovation costs.

4. Implementation of Virtual Reality Technology in Future Architectural Design

In order to realize the effective application of virtual technology in the future architectural design, we should consider three aspects: three-dimensional scene, hardware system and software system construction, so as to better serve the architectural design and fully demonstrate the power of advanced technology.

4.1 Construction of a Three-dimensional Virtual Environment Space

The construction of three-dimensional virtual environment space is the core and key to the application of virtual technology in future architectural design. It can provide basic guarantees for the follow-up work. This requires the collection of various types of building information, including floor plans, facades, and profiles. Then all the information is presented in the three-dimensional model. The construction of a three-dimensional architectural model is usually done using 3D Studio MAX software. The establishment of the model is first completed using geometric and two-dimensional graphics using editing commands to create a precise image scale architectural model, including characters, plants, and landscapes. Then edit the attributes of the architectural model, such as color, shade, bump, reflection, and transparency, and create animations by setting objects, cameras, light sources, and paths, changing the light source and camera position, and performing simulation drills in animation to simulate real visual effects.

4.2 Construction of Virtual Reality Hardware Systems

The effective application of virtual reality technology in the future architectural design needs corresponding hardware system as the foundation support to build a virtual reality system. Under normal circumstances, if the requirements for real virtual systems are low, the hardware system configuration is relatively simple. It only needs input and output functions to achieve good human-computer interaction. However, if the virtual reality system requires higher functions and truly embodies its various technical features such as visualization, interactivity, and immersion, it needs to use more specialized hardware equipment to complete the construction of the hardware system. Information input equipment and information output equipment are the main hardware devices that make up the virtual reality system. Keyboards, mice, etc. belong to input

devices, display adapters, impact instruments, polarizers, stereoscopic glasses, etc., all belong to the more common professional output equipment. With the help of sensing devices, users can present their behavior in the real world by mapping in the virtual environment. The realization of this process requires user incarnation to complete. This is also the key point of the virtual reality technology interaction function. When the user makes specific actions in the real world, the azimuth tracker in the virtual reality system will use its own measurement function to collect user behavior and map it in the virtual environment in the form of user incarnation. Then in the virtual environment, using the geometric collision detection algorithm, combined with the force feedback technology of the sensor, the measurement information of the virtual environment can be fed back to the user in real time, and then the interaction between the real scene and the virtual environment can be realized. In this way, users can not only experience a more realistic visual experience in the virtual environment, but also can obtain feedback effects from the tactile aspect, which can ensure the scientific and rational nature of the architectural design scheme, and facilitate the control and optimization of the design scheme., It has significantly improved the level and quality of architectural design.

4.3 Construction of a Virtual Reality Software System

For future architectural design, when applying virtual reality technology, the most important thing is to build a virtual three-dimensional scene based on the design plan and follow the objective law as the basic principle, and then create a feeling of being in the field. It truly embodies the characteristics of virtual reality technology and brings into play its application value and advantages in architectural design. The establishment of a three-dimensional model of architecture needs to be achieved with the help of professional software. It is not only necessary to be able to truly express the objective world of architecture, environmental layout, and indoor space, but also to color, darkness, and material. Improve the fidelity of the model. This requires the assistance of related software to complete the construction of a three-dimensional model of the building in three steps, including geometric modeling, image modeling, and behavior modeling. It mainly completes the establishment of geometric configurations, the editing of attributes such as model materials, colors, and so on. The motion and behavior description of geometric modeling is the basis for constructing a three-dimensional visual architectural model. It mainly refers to the geometric transformations of objects in three-dimensional space such as convergence, intersection, difference, and rotation, translation, and scaling, resulting in the more complex three-dimensional model that the designer hopes to obtain. The process of, 3DSMAX, AUTOCAD, SKECHUP, REVIT, etc., are all widely used 3D modeling software at this stage. By performing operations such as parallel, intersection, and difference on simple geometric objects, they are translated, rotated, and scaled. The composition forms a complex geometry that presents a complete picture of the building project. Moreover, these modeling software have the characteristics of interactivity. When the basic geometry of the three-dimensional architecture model is a triangular surface, the introduction and exchange of three-dimensional architecture models are unrestricted. In addition, the more the number of vertebral bodies and the smaller the volume, the more sophisticated the architectural model will be. Its fidelity will be significantly improved, but the amount of software computing will also increase, and its computational efficiency will be reduced. Therefore, in the application of virtual reality software, according to the architectural design requirements, the mesh density of three-dimensional model should be controlled, and the efficiency of software operation should be improved as much as possible on the basis of ensuring the fidelity of the model.

5. Conclusion

The design of construction projects is highly specialized, the entire design process is complex, the overall cost is high, and it has irreversible characteristics. Once there are design mistakes or mistakes, it will cause greater losses and serious impacts, and the effective application of virtual reality technology. Such problems can be avoided. By applying it to architectural animation display, scheme comparison, construction, real estate sales and other aspects, it can significantly improve the efficiency, design level and design quality of the architectural design, and ensure the scientific and operability of the architectural design scheme to the greatest extent. Moreover, with the continuous deepening of research, virtual reality technology also has good application prospects in the mechanical design and decoration design of buildings, and plays an important role in promoting the development of the construction industry.

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Cause and Prevention Measures of Concrete Cracks during the Construction of Road and Bridge Engineering

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Abstract: Road and bridge engineering is an indispensable part of socialist economic construction in China, whose construction quality significantly affects the infrastructure construction level in the whole society. To meet the rapid economic development of various regions, construction scale and quantity of road and bridge engineering have been continuously expanded and increased, therefore, higher requirements for construction quality and construction standard are also presented. During the construction of road and bridge engineering, concrete crack is a key problem which affects the construction quality. In this regard, this paper analyzes cause and prevention measures of concrete cracks during the construction of road and bridge engineering, and hopes to provide construction personnel with valuable references.

Keywords: Road and bridge engineering; Concrete crack; Prevention measure

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1. Introduction

In recent years, with China's economic prosperity and development in all fields, and continuously increased infrastructure construction, more and more people have attached great importance to the quality problem of infrastructure construction while enjoying more convenient services. In terms of the road and bridge engineering that has been built in various regions, it provides convenience for people's life, work and production, however, it also does great harm to people due to problems incurred during construction. Among them, concrete crack is the most common one during the use of road and bridge engineering. Given this, I will discuss relevant aspects in combination with the actual situation of road and bridge engineering.

2. Harm Caused by Concrete Cracks on Road and Bridge Engineering

Harm caused by concrete cracks incurred during the construction of road and bridge engineering mainly includes the following aspects: firstly, concrete cracks incurred on the road and bridge will damage the overall structure of the bridge, exert adverse effects on the structural performance of the bridge, and make the bridge lose the original usability, therefore, the structural performance of the entire engineering will be gradually adversely affected. Generally, concrete cracks are first formed on the surface of the road and bridge, and then slowly spread into its internal part, which will have an increasingly impact on the internal structure, thus further destroying the structure of the overall bridge engineering and overall construction quality.[1] Secondly, when concrete cracks incur on the surface of road and bridge, some materials inside road and bridge will be exposed to the air, such as steel bar. Such construction materials exposed to the air, influenced by long-term natural environments and weather conditions, will be gradually corroded, thus losing their original usability and affecting the overall quality of road and bridge engineering.[2] Finally, concrete cracks incurred due to various reasons mentioned above on road and bridge will shorten the service life of road and bridge engineering, and quickly destroy the structure and material.

3. Cause Analysis on Concrete Cracks during the Construction of Road and Bridge Engineering

3.1 Poor Quality of Construction Materials

Generally, the concrete construction material is composed of sandstone, water, aggregate, additive and cement, which are stirred together in a certain proportion to form a heterogeneous material with certain elasticity-concrete mixture. However, the concrete crack often occurs due to unreasonable mixture proportion and quality defect of materials during the actual construction.[3] For example, too large skeletal particle or too small particle size of materi-

als will affect the construction quality of the concrete, thus causing concrete cracks. Meanwhile, the unreasonable use of concrete additives can also result in serious concrete shrinkage, thus causing concrete cracks. Moreover, the higher the strength of concrete material is, the easier it tends to crack.

3.2 Defective Design Scheme

Defects in scheme design would also result in concrete cracks in the process of designing concrete construction plans. Actually, the structure of steel bars and their reasonable collocation will more or less affect overall stability of the material during concrete construction. And when it comes to onsite working, the lack of scientific analysis, the defective design as well as the failure to cover all aspects of the work will result in certain flaws in strength, depth and structure of the final concrete construction.[4] Meanwhile, the designer failing to consider deformation of material during the construction will also bring in quality risks.

3.3 Impact of Internal and External Temperature Differentials

For concrete pouring processes in road and bridge projects, the pouring temperature will be largely affected by external environment temperature, and the fluctuation of concrete temperature will notably decide the construction quality. To be specific, when the external environment temperature is high, pouring temperature will significantly rise; Otherwise, the concrete pouring temperature will go down.[5] As environment temperature fluctuates, the gradient changes of internal and external concrete temperatures will affect the stress of concrete construction, which, when excesses certain value, will result in concrete cracks.

3.4 Impact of Hydration Heat

Hydration heat mainly occurs in the curing and hardening process of concrete materials, as some ingredients of the concrete will react with water to produce a lot of heat, causing internal temperature fluctuates of the concrete, which will change the temperature stress and finally bring concrete cracks.[6] In fact, concrete material has the feature of heat dissipation, and when its internal temperature continues to rise, the concentrating heat will bring notable change in temperature differential between the internal and external, thus causing cracks.

3.5 Impact of Shrinkage Frost Heave

During concrete constructions of road and bridge engineering, shrinkage frost heave is a major factor of concrete cracks. As the environment temperature reaches 0℃, the concrete surface will start to freeze, affecting the surface strength of the concrete, and resulting in frost heave and sequent concrete cracks.[7]Shrinkage mainly refers to the large scale of concrete deformation due to temperature and external forces. When the surface and inside of concrete deformation are unmatched, cracks will appear.

3.6 Impact of Construction Environment

In fact, as road and bridge engineering is regularly carried out outdoors, it would always be affected by all kinds of factors on the construction site during the construction, such as high temperature, rains and human factors, etc. At the same time, a lot of heat will be produced as a result of curing of the concrete during the construction, the heat will, if without efficient control, evaporate a huge amount of water, generating lots of pores to further form concrete cracks.[8] In addition, high-temperature working environment will also continuously add the tensile stress on the concrete surface, thus producing cracks. On the other hand, low temperature will hinder curing of concrete and adversely impact the project quality. In a word, construction environment could cause concrete cracks.

4 Prevention Measures of Concrete Cracks during the Construction of Road and Bridge Engineering

4.1 Strict Selection of Construction Materials

To guarantee the quality of construction materials, relevant personnel shall be able to apply the concrete shrinkage-compensating technology as well as learn the category, usage amount and performance of materials. Besides, the usage of swelling agent shall be decided upon sufficient experiments to make sure that the agent used in concrete construction is able to meet construction standards. Moreover, grade and category of concrete materials shall be selected in conformity with specific requirements of construction structures. It should be noted that, as road and bridge engineering always lasts long, construction materials stored for more than three months shall be tested before usage.

4.2 Guarantee of the Reasonability of Design Scheme

During the construction of road and bridge engineering, concrete cracks arising from engineering structure and modeling are common. Thus, construction personnel must take measures to effectively deal with the positions that have or might have concrete cracks, while closely paying attention to the stress concentrating problem caused by structural changes; aside from that, measures (such as adding more steel bars or strengthening them) shall be taken to effectively control the corners, so as to keep the struc-

ture stable.[9] During the process, construction personnel could use steel bars with small diameters to enhance overall crack resistance of the concrete construction. In addition, in the manufacture process of concrete material, sand is preferred as it could improve the concrete tightness, or adding certain amount of cement mortar to enhance loading capacity of the concrete construction.

4.3 Measures to Eliminate the Impact of Temperature Differential

During the construction of road and bridge engineering, concrete cracks arising from temperature differential are one of the common problems. Targeted measures could be taken as shown below: Firstly, support displacement and expansion joints could be applied on bridge surface to eliminate concrete cracks. Secondly, construction personnel shall take protective measures according to weather changes to avoid noticeable temperature gradient at construction positions that may be affected by temperature changes. In addition, the construction shall be carried out in favorable weather conditions, to avoid sun exposure and maintain construction effect during the construction. During the construction, construction personnel shall strictly follow relevant standards regarding concrete pouring thickness, thus avoiding impacts on pre-stressing force brought by temperature differential change of inside and outside concrete and cracks.

4.4 Reduction of the Impact of Hydration Heat

During the manufacturing of concrete mixture, the usage of single cement ingredients shall be controlled completely in strict accordance with relevant stipulations, to maximally use cement materials with low hydration heat. Meanwhile, the temperature when pouring fine aggregate into molds shall be kept as low as possible. Construction personnel could use thin-layer continuous placing technology or circulating cooling system to dissipate internal heat outwards. It is worth mentioning that, for fine aggregate, large diameter is preferred, and certain quantities of rubbles shall be added while mixing concrete materials according to the actual condition to reduce the percentage of cement and water in concrete mixtures.

4.5 Reasonable Construction and Improvement on Maintenance

During the concrete construction of road and bridge engineering, ingredient proportions of the concrete mixture shall be tested repeatedly to accurately decide the water-cement ratio before pouring so as to get the same result on the construction site as in tests. The temperature of mixing concrete mixtures could be lowered by the way of cold air supply to guarantee concrete construction quality and performance. To ensure the evenness of concrete construction, continuity of pouring and ordered vibration shall be performed in the process of concrete pouring. When pouring is finished, processes including compaction and screeding shall be strictly in conformity with construction standards to avoid concrete cracks. It needs to be noted that, for the construction at low environment temperatures, certain surface protective measures are needed to prevent cracks from forming in the stage of concrete curing.

4.6 Improvement of Construction Site Management

Construction site management is an essential part of road and bridge engineering, and its performance and effectiveness of onsite management will impact the construction quality; besides, it also plays quite a significant role in preventing concrete cracks. Construction site management mode shall be decided upon different working environments, which requires professional quality and management skill of management personnel. Therefore, relevant personnel shall be cautious and serious on all processes of the construction on the construction site, while continually improving their professional skills and experience. Construction site management personnel may feel stressed due to the large construction scale of road and bridge engineering. Thus, the construction unit shall further execute responsibility system, defining each one's work division and appointing assistants for such personnel to guarantee management efficiency. Meanwhile, management plan shall be made in advance during construction site management, and the person in charge shall be appointed for periodical inspection to ensure the quality. In case that any problems are detected in the course of construction site management, solutions shall be clearly given, and measures shall be taken to effectively deal with concrete cracks and guarantee overall project quality.

4.7 Enhancement of Professional Quality of Construction Personnel

During the construction of road and bridge engineering, professional quality and skill of construction personnel will largely affect the performance of construction. Therefore, the construction unit shall provide training on professional skill and professional quality for relevant personnel. In the meantime, the unit shall make all construction personnel aware of the importance of construction quality and ensure that they understand their tasks, responsibilities as well as construction standards and specifications. Moreover, for posts that require more technical and theoretical knowledge, assessments are needed to make sure that personnel on such posts well know their working

modes, tasks and standards. This will ensure professional quality of construction personnel and further improve the efficiency of construction.

5 Conclusion

In conclusion, concrete cracks of road and bridge formed during construction or usage stage might be caused by various factors, including unqualified construction material, defective design scheme, internal and external temperature differential and hydraulic heat. Accordingly, to guarantee the overall quality of road and bridge engineering, the construction unit, together with all relevant personnel, shall strictly manage the selection of construction material, ensure the reasonability of the design scheme, reduce the temperature differential and eliminate the impact of hydraulic heat. With joint efforts of construction unit and personnel, we believe that concrete cracks of road and bridge will be settled after all, and the overall quality of China's road and bridge engineering will further get improved to promote the development of our economy.

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Analysis on the Problems of Solutions of Water Conservancy & Hydropower Engineering Cost Management

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Abstract: With the continuous development of society and economy in China, the number of water conservancy & hydropower engineering in China increases unceasingly and China's water conservancy industry also enters into the stage of rapid development. The construction of water conservancy & hydropower engineering promotes social and economic development, so in order to safeguard the benefits of the engineering, cost management shall be done well, which is also an important channel for companies engaging in water conservancy & hydropower engineering to obtain economic benefits. Based on this the paper firstly investigates the problems in water conservancy & hydropower engineering cost management and then brings up relevant solutions.

Keywords: Water conservancy & hydropower engineering; Cost management; Problem; Solutions

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1. Introduction

In the new era, in order to promote social and economic development in a good and fast way, the number of water conservancy & hydropower engineering in China increases unceasingly. As for construction unit, market economy intensify the competition between different enterprises in the same industry, so that if the construction unit want to obtain more benefits in the engineering construction and occupy more market resources, it must have an advantage in bid prices, which puts forward a higher demand for water conservancy & hydropower engineering cost management.[1] Construction unit is required to have construction technology, conduct fund flow analysis, improve fund utilization rate and avoid wasting of resources, thus obtaining economic benefits on the basis of quality and price guarantee.

2. Existing Problems in Water Conservancy & Hydropower Engineering Cost Management

2.1 Problems in Design

Engineering design directly decides the construction engineering direction and trend, and also plays a significant role in construction cost of later period of the engineering. Under normal conditions, there are mainly two links in water conservancy engineering design, namely preliminary design and construction design of the engineering. In the water conservancy & hydropower market, the design mainly adopts the methods of bidding and quota. Construction unit determines the final plan through competitive bidding. Apart from satisfying the requirements of construction party, engineering design shall also ensure that construction cost is within reasonable range, thus actually controlling cost in design. The actual situation, however, is that construction enterprise only wants to control engineering cost in construction, and pays less attention to design, which causes difficulties in implementing cost management work fundamentally.[2]

2.2 Construction Materials Management Problems

As for water conservancy & hydropower engineering, construction materials will directly influence the construction cost and quality. In engineering budgeting, the cost is mainly composed of material cost, labor cost, construction equipment cost and other cost. But due to the operating mechanism of market economy system, the prices of construction materials and equipment may have big fluctuations, especially in the peak season of water conservancy & hydropower engineering construction. The situation of demand exceeding supply for materials is very easy to happen, which will cause the rise in price for construction

materials. Many engineering contractors don't predict the prices of construction materials, and blind purchasing also exists, so the prices of construction materials become hard to control.

2.3 Budget Quota Problem

In the construction of water conservancy & hydropower engineering, budget quota has a direct influence on engineering cost. Especially in the new period, a large amount of new equipment and new materials appear in the current building material market, and their application scope continuously extends. These factors make a tremendous impact on labor productivity and cost management. Quota shall be done in combination with design drawing with rational design, so as to ensure budget quota conform to real needs of engineering. But in real budget quota, construction enterprise's not conducting reasonable budget on construction materials, process cost, equipment price and labor cost, and merely referring to average price released by government as standard cause budget quota's deviation from market and difficulty to control cost.

2.4 Construction Factor

In order to ensure the successful construction of water conservancy & hydropower engineering, construction management work shall be done well to ensure every construction detail is done according to the preset plan. On the basis of ensuring the quality of the construction of the project, control the construction progress and construction cost of the project. In water conservancy & hydropower engineering construction, however, lots of construction enterprises pay less attention to construction management. In order to obtain more economic benefits, they try their best to simplify construction management, causing the construction management to exist in name only. In order to increase their profits, part of the enterprises even cut corners and operate in violation of regulations in construction, which causes the engineering quality doesn't meet the national criteria and reworking. Such method cannot improve the enterprise's economic benefits, but also increase construction cost and period.

3. Solutions to Problems of Water Conservancy & Hydropower Engineering Cost Management

3.1 Optimization of Design Plan

Construction enterprise needs to formulate perfect cost management system and ensure the comprehensiveness of system construction. At the same time, construction plan optimization shall be done well, which is the basis of water conservancy & hydropower engineering cost management and also an indicator of engineering cost quota. In design plan optimization, construction unit shall participate in design to ensure the conformity of design plan and cost management. The standard process shall be observed in reality is as follows: Predesign-research design-construction design-altered design. Meanwhile, layout shall also be optimized to simplify construction links as soon as possible, especially some unnecessary links shall also be eliminated, and thus ensuring engineering cost is controlled within a reasonable scope. At the same time, in order to guarantee the design plan's conformity to actual standard, design personnel and construction management personnel shall bring up opinions and suggestions on cost management, and cost budget scope in the early stage of design to conduct budget in every link of engineering, thus ensuring the rationality of design plan.[3]

3.2 Conduct Material Budget and Control Its Use

In the construction of water conservancy & hydropower engineering, construction cost shall, in combination with requirements of contract standard, strictly control the use of construction materials to avoid resource wasting and improve fund utilization rate. Meanwhile, new equipment, new process and new materials in current engineering field emerge in endlessly. If construction enterprise adopts new process, market investigation shall be done in advance to improve the mastering degree of new process, strengthen the communication with construction party and ensure the cost of application of new process is controlled within a rational scope. Meanwhile, in order to control the rationality of construction materials price, apart from analyzing the market reference price provided by government, the material price trend shall also be analyzed. Since the direct acting factor for commodity prices has been changed from productivity to supply-demand relationship (the market price of materials), so it is hard to conduct cost management and provide basis for cost control if the material cost cannot be controlled. Therefore, specially-assigned person shall be sent to conduct market investigation, analyze the rational price fluctuation domain of materials, and do well the material budget starting with the lowest price.

3.3 Strengthen Cost Budget

Firstly, in the budgeting of construction materials, specially-assigned person shall be sent by construction unit to follow engineering construction unit to enter into construction market and building material market. At the same time, cost management liability system shall also be constructed to record every item of content involved with capital for the basis of water conservancy & hydropower engineering completion settlement;

Secondly, the control on design stage shall be strengthened to adopt diversified method for participation in design. If there is any problem needing to be solved timely, design alteration shall be avoided to ensure the controllability of engineering cost. At the same time, the approval system of design alteration shall also be perfected. If it is necessary to alter the design, construction volume and construction cost shall be effectively analyzed in advance to bring up design alteration cost budget and conduct negotiation with construction party and design party;

Finally, if the engineering cost is uncontrollable in real construction, negotiation among three parties (contractor, construction party and design party) shall be conducted to avoid the situation of excessive cost due to design alteration, improvement of design standard and increase of construction link. Meanwhile, the contract content shall be clarified, and the project approval principle, pricing principle and approval process of projects not included in the contract and newly-increased engineering.[4]

3.4 Adopt dynamic Management Mode

In the control of water conservancy & hydropower engineering cost management, the control of design and construction alteration shall be comprehensively strengthened to ensure visa quality and avoid the situation of false certificate. Hidden certificate shall be noted with hidden project, process, and location with construction drawing as carrier. If the hidden content is not noted clearly, remarking or redrawing shall be needed. As to construction, the system shall be further perfected to effectively implement the relevant responsibility of construction management. The engineering construction cost shall be calculated and summarized every month. The comprehensive cost management is divided into installment cost control and periodically verifies construction process and construction cost to avoid uncontrollability of cost and conduct dynamic management mode. In addition, water conservancy & hydropower engineering investment control mechanism shall be done well, and project progress funds shall be verified every month to ensure the rationality of project investment.

4. Conclusion

In conclusion, since there are many factors influencing water conservancy & hydropower engineering cost management, so targeted at the existing problems in cost management and relevant solutions, advanced engineering cost management method shall be adopted and every link of engineering shall be grasped to continuously improve engineering cost management and safeguard the economic and social benefits of water conservancy & hydropower engineering.

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Application Status of BIM Collaborative Design in Architecture Major

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Abstract: After the concept of BIM (Building Information Modeling) was proposed around 2000, it developed slowly. With the rapid development of hardware, the IFC standard provides reference standards for BIM collaborative design, enabling BIM collaborative design to effectively solve the shortcomings of traditional 2D drawing design and become a new market trend.

Keywords: BIM; Collaborative design; Collision test; VR

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1. Introduction

China's fixed assets investment, from 3.7 trillion in 2001 to 60.65 trillion in 2016, increased by about 20 times in 15 years, belonging to the national pillar industry. One of the main manifestations of fixed assets is engineering projects. The complexity of engineering projects is constantly improving and the design cycle is compressed. The traditional design methods can no longer meet the market demand.[1] The design fee is generally less than 1% of the total life cost of the construction project, but it is the cost of this less than 1% that affects the investment up to 75%.[2] In the design of individual projects, the choice of construction and structural schemes and the selection of construction materials have a great impact on investment.[3]

Collaboration is the process of sharing information, analyzing information, and improving information. The high efficiency, synergy and collision verification of BIM collaborative design effectively solves the contradiction between project complexity and design cycle compression.

In China, BIM technology started to lag behind Western countries, and it was not until 2001 that it was valued and developed, but the penetration rate has not been high. With the continuous improvement of green building, energy conservation and environmental protection requirements, and the to reduce design loopholes and errors, the "Architecture Industry Informatization Development Outline (2011-2015)" proposes: Promote the construction and application of collaborative design systems based on BIM technology, improve engineering survey problem analysis ability, improve the level of detection, monitoring and analysis, and improve the degree of design integration and intelligence. The "Architecture Industry Informatization Development Outline (2016-2020)" further proposes to promote BIM-based collaborative design, carry out data sharing and collaboration among multiple professions, optimize the design process, and improve design quality and efficiency. Conduct research and development of BIM-based integrated design systems and collaborative work systems to achieve information integration and sharing of architecture, structure, plumbing and other professionals.

With the development of technology and economy, the complexity of a construction project is increasing, and the design work becomes a team work. The team involved various professional designers, based on the architectural drawings to do secondary design in structure, water supply and drainage, ventilation and air conditioning, fire alarm, strong electricity, weak electricity and other professional design. At present, all majors in the society are developing corresponding BIM software, each with its own advantages and disadvantages. Therefore, communication between majors requires a public BIM platform.

The international IFC standard (Industry Foundation Class) enables data on different software to be shared without loss, providing a common platform for collaborative design. There are also two standards in the IDM (Information Delivery Manual) and IFD (International Framework for Dictionaries).[4] Collaborative design is to use the same set of standards to complete the same design project in the same environment. During the design process, each major is designed in parallel, and the communication is accurate and timely.[5]

2. BIM Collaborative Design Support Software

Currently, BIM software commonly used in the architectural engineering design market includes Revit, Tekla, MigiCAD, Lumion, Navisworks and other software.

Revit software is one of the BIM products of Autodesk in the United States, which can realize 3D design work in architecture, structure and installation in the same model. Because of professional features and database issues, it is commonly used in architecture and structural design. Basic models and platforms can be provided for BIM collaborative design through the IFC standard.

Tekla is mainly used in the design of steel structures. It can automatically generate steel structure details and various reports after creating a 3D model to achieve convenient view functions.

MigiCAD is an installation design software based on AutoCAD or Revit software for secondary development. Mainly used for professional module design of heating, ventilation, air conditioning, water supply and drainage, spraying and electrical. The software integrates conventional installation equipment and well-known brand equipment to ensure the normal installation and use of the equipment and to solve collision problems.

Lumion is a real-time 3D visualization software that can deliver live demonstrations, increase lighting, ventilation, surrounding environment, climate and other factors for simulation rendering, providing a foundation for VR and AR technology implementation.

Navisworks enables real-time visualization while supporting roaming and checking user time and space coordination. A model with all kinds of professional architecture information is formed by integrating 3D data of various formats of various professions. Promptly check and discover errors and collisions in the building. Allowing designers to modify building models before plotting can effectively avoid design changes caused by errors, collisions, and omissions.

3. Collaborative Design Goals

3.1 Reduce the Occurrence of Errors Such as "Errors, Missing Items, and Collisions" and Improve the Quality of Drawing Design

The construction engineering design involves a wide range and a wide range of professions. Complex projects require high depth requirements and precision, while the designers have a single business capability and do not understand other professional design technical points. Designers who specialize in the industry are difficult to coordinate in depth and breadth. Therefore, there will be design parameter errors, missing items, and collisions between different professions.

When structural engineers and installers design their own professional architectural drawings, the space requirements and understandings form a hard collision due to insufficient communication. These collisions led to later modifications to the design and changes to the design drawings. At the same time, some designers have limited professional knowledge and generally only engage in a single business content. Due to insufficient coordination between the various professions, there is a conflict between the occupations of space between different professions. BIM collaborative design can test collisions between different professions during the design process. Based on the Revit platform, MigiCAD can perform collision testing for building and installation professionals to solve some collision problems. All professional softwares are imported into Navisworks through the IFC protocol, which enables collision testing between majors.

3.2 Visual Design to Form a "What you See Is What you Get" Design pattern

In the conventional architectural design, the designer needs to form a two-dimensional drawing through the projection of the three-dimensional engineering design plan through the flat, vertical and sectional views according to his own imagination to the space. Other designers based on this design drawing need to convert the 2D into 3D according to the 2D drawings and further design. Then the design is formed into a two-dimensional drawing, which is passed down in turn. Everyone needs to see a three-dimensional building by imagination. BIM collaborative design can realize three-dimensional design, transfer the model downward through IFC protocol, realize the whole process three-dimensional design, and visually visualize.

3.3 Solve Complex Engineering Design Accuracy, Optimization and Control Issues

Among the many reasons for engineering quality accidents, design quality problems rank first.[6] Many large and complex construction projects are not reasonable enough due to the design of the functional design, or the lack of precision control, affecting the normal use of the building. Some professional designs conflict with each other, causing the construction process to occur due to design errors, rework, and change. Some cause quality defects and safety hazards, causing huge losses to the country and the people, resulting in waste of investment and increased project cost.[6]

3.4 VR (Virtual Reality) and AR (Augmented Reality) Technology Enhance Design Interaction and Enable Customers to Participate in Design and Improve Design Quality

In the conventional design, after the customer proposes the design requirements, the designer needs to design according to his own understanding. In the process of information exchange, deviations often occur due to differences in expression and understanding. For non-professional customers, it is not possible to use 2D drawings to understand the appearance, size and size of the construction project. Deviations from information exchange will continue until the project entity is created, causing irreparable defects or increased costs due to program changes.

VR design can create a virtual simulation system through BIM software to simulate the design environment. Customers can intuitively feel the design through the VR eye design. Correctly correct and modify the design deviation caused by the expression and understanding deviation to improve the design quality.

AR technology is based on the development of VR technology, which can superimpose virtual design schemes in real world information for seamless integration. The design that could not be experienced in the real world is perceived by human senses in a certain time and space.

4. There Are Still Existing Problems with BIM Collaborative Design

4.1 The Penetration Rate of BIM Technology Is Not High

Experienced designers are not well-recognized with new technologies and can't master new technologies in a short time. Young designers have the ability and speed to accept new things, but lack practical design experience and are difficult to be responsible for complex projects. Complex projects require multi-person collaboration and it is more difficult to organize BIM design teams.

4.2 BIM Collaboration Costs Are Too High

Because BIM technology is developing rapidly, software and hardware are getting shorter and shorter, and Revit, for example, will release a new version every year. The addition of new software features means more and more hardware space. The single interface software is tens of thousands, and the professional drawing workstation market price ranges from tens of thousands to hundreds of thousands. At the same time, it takes more time and money to train the designers. The IFC protocol can transfer models almost perfectly and requires near-perfect model design. Short-term training is difficult to meet the demanding model requirements.

5. Conclusion

The BIM collaborative design is based on a unified universal protocol, which can solve the problem of poor communication of designers in the traditional two-dimensional drawing design because of relative independence. BIM collaborative design improves design quality while shortening design cycle, better meeting the design needs of complex construction projects while reducing costs. At the same time as the rapid development of BIM technology, it is also necessary for all parties to work together, and BIM really plays its role.

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- Manuscripts should be in MS Word format. Authors are advised to download the document, Manuscript Submission Template, as a template or for more details on preparing their submissions for consideration.
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Please find the information below for the declarations section (to be included in the manuscript or cover letter).

Conflict of interests: Researcher A is an employee of XXX. Researcher B has received grants from XXX.

Informed consent: Written informed consent was obtained from all subjects prior to the study.

Ethical approval: The ethics committee of XXXX has approved this study (REC number: XXXX).

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Contribution: Researchers A and B researched literature and conceived the study. Researcher A was involved in protocol development, gaining ethical approval, patient recruitment and data analysis. Researcher B wrote the first draft of the manuscript. All authors reviewed and edited the manuscript, and approved the final version of the manuscript.

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