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.

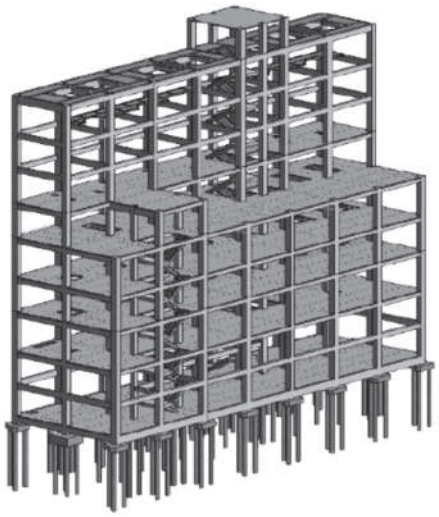

Figure 1. Professional Physical Model in Revit Software

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.

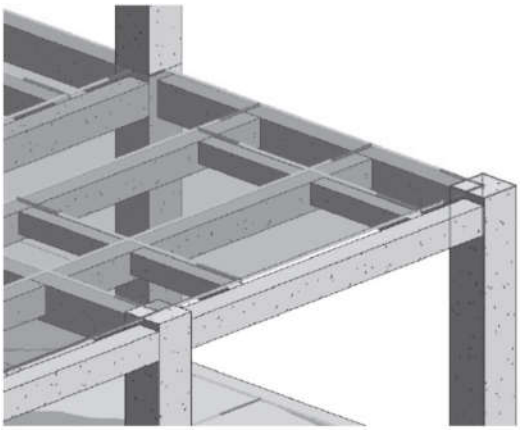

Figure 2. Girder Body Analysis Line

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.

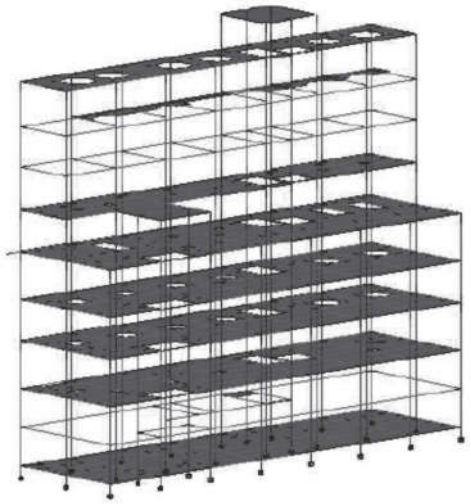

Figure 3. Overall Structural Model

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.

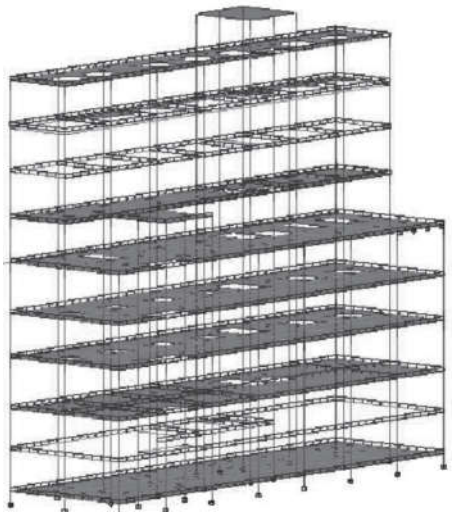

Figure 4. Model Adjustment via Revit Software

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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