

# Research on the development of BIM technology based on the application in the field of civil engineering

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**Abstract.** The compliance of civil engineering structural design is the fundamental condition that determines the subsequent safety and life of civil engineering buildings. At the present stage of civil engineering structural design, most of them are based on two-dimensional planar structural design, which is less expressive and covers a single amount of information, and it is difficult to play its proper value in the actual design and construction process due to certain limitations. In such a background, BIM technology was born and has been promoted and applied to some extent. Compared with the traditional design system, BIM technology can gather data processing, data caching and data sharing and other mechanisms, and is valued by major design companies. This paper introduces BIM and describes the current situation and frontier of structural engineering discipline, and takes the application of BIM technology in civil engineering structural design as the basic research point to explore its application in civil engineering structural design and its possible problems and measures to solve them.

## 1 Introduction

With the continuous development and maturity of BIM technology and ideas, and the continuous upgrading and updating of BIM software products, BIM technology has been applied in various fields of civil engineering design, construction and operation in China. This paper specifically discusses the application of this technology in the design of civil engineering structures and the possible problems and measures to solve them, hoping that the research in this paper can better lay the foundation for the promotion and application of BIM technology.

## 2 Study on the development process of structural engineering discipline

Structural engineering develops with the development of social production and human activities, and its basic connotation includes structural analysis, structural testing, structural design, structural construction, structural testing and maintenance, and other aspects. Theoretical research of structural engineering includes structural performance control, structural reliability theory, structural disaster resistance research, structural analysis, calculation and design theory, in terms of construction technology, structural engineering requires new technology, new engineering, new theory and new methods. In terms of height, the structures of buildings are getting taller and taller, from the 381-meter Empire State Building in New York, USA, to the 828-meter Burj Dubai in the United Arab Emirates. In the direction of bridges, with larger spans, more flexible loads and an emphasis on bridge

aesthetics and environmental protection.

Throughout history, advances in engineering materials have often led to qualitative changes in structures. From the use of earth, wood and stone to the use of steel and concrete materials, structural engineering has made a quantum leap. With the development of materials science, it is expected to produce new materials that can be used by human beings in large quantities with high efficiency, environmental protection and energy saving. For example, high-strength concrete, concrete compo-sites, and FRP. the rapid development of Internet technology provides new opportunities for the development of structural experimental techniques. Internet-based communication technology can provide a large amount of data transmission and sharing capabilities, and can provide a near real-time means of communication for control and feedback between laboratories and equipment in different locations. This also provides the possibility of remote structural collaborative experiments using the Internet, which is forming the focus of attention on a global scale. Meanwhile, large multifunctional experimental machines, multi-point multi-degree of freedom seismic simulation shakers, structural laboratories that simulate complex environments, and field test techniques are becoming new highlights in the development of experimental technology since recent years.

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### **3 Analysis of the application of BIM in the field of structure**

#### **3.1 Application of BIM in structural engineering design**

BIM software can realize the basic design functions in all aspects of civil engineering structural design, [6] which can be divided into three aspects, such as integration of models, automation of parameters and sharing of information, as follows: First, in the integration of model applications, BIM technology is used to fix the relevant models through a parametric description system. It can not only make the description of information unit more specific and reasonable, but also form the import and combination of similar data. Especially in the design process of civil engineering structure construction, it can give the internal integration of the model according to different parameter settings, and further reduce the design workload. Secondly, in the automation of parameters, the parameter automation system provided by BIM is mainly manifested in two aspects: on the one hand, it can store and call the specific database model in the form of parameters, which makes the subsequent application more specific and forms an efficient feedback mechanism[1]. On the other hand, it can be automatically converted into relevant parameters during the construction of new structures, and combined with the already formed design system to form mutual parameter rules, so that the model design can be better connected with the actual construction. Third, in terms of information sharing, BIM provides information sharing and transformation module, which not only can directly read all the information in the completed design, but also can establish a complete analysis model. At the same time, it provides the function of layering out the layout structure of 3D model, so that 3D construction drawings can be smoothly transformed into construction floor plans.

#### **3.2 Application of BIM technology in creating steel structure model**

Along with the increase in the number and scale of construction projects, new building structure design models and materials are becoming more and more advanced, especially steel structures, which continue to expand in span and space and are then widely used. Nowadays, many structures with strange shapes are modeled using steel structures, and it is more difficult and complicated to connect and design components in steel structure design. Therefore, the design of building structure is difficult. The problem can be solved in time by applying BIM to calculate the steel structure beam unfolding connection components, select the parameters independently and analyze the influence of each parameter. Using BIM technology data information sharing function to calculate the number of bolts, the number of welds, spacing, etc. in the steel structure, and control the design distance. If new components need to be added to the model, designers can simply adjust the data and prepare large sample drawings through BIM to facilitate smooth on-site

construction. At the same time, the designers can accurately grasp the position of the components through the sample drawings to ensure the stability of the steel structure[2].

#### **3.3 Application of connection between architectural model and structural analysis model**

Revit is the representative software of BIM application technology, which can realize the collaborative design of each profession and also has its own structural analysis software. However, because it is a foreign software, it is not yet well adapted to the requirements of China's structural codes. In China's engineering community, PKPM is widely used as the mainstream software for domestic structural calculations, and the software closely follows the national codes. In recent years, a bidirectional data interface between PKPM and Revit has been developed on the Revit platform, which really realizes the bidirectional connection conversion between building model and structural analysis model[3].

#### **3.4 BIM application of building structure**

In terms of defining structural components, in the current IFC system, a complete structural model system is established to better describe components such as beams, slabs, columns, stairs, and foundations. Taking the wall structural components as an example, firstly, the building entities are defined, secondly, the association of floor entities and building entities is performed using the set of associated entities, and finally, the wall entities are defined, and the association of floor entities and wall entities is completed using the spatial structure associated entities to define the wall model. In defining the properties of components, there are various properties in BIM model such as construction information, mechanical properties, cost, material, geometry, etc[4]. The current IFC model can meet most of the properties of model components, and the following is the example of wall to define the association relationship. Material properties are defined, followed by the definition of material model using material layer collection using entities, material layer collection entities, material layered entities, etc. Finally, material association entities are used for the association of wall materials with the wall.

#### **3.5 Optimize design details using BIM technology**

In the process of building structure design, the reasonable use of BIM technology can also optimize the details of the construction drawings and determine the hole reservation, etc., which has an important role in optimizing the design plan. The optimization of architectural design details through BIM technology is mainly to determine the location of sunlight windows, the direction of the lines in the walls, the holes of the entry lines, the selection of insulation materials and the selection of insulation materials, etc. If there are problems in these details, then it will lead to the reduction of the overall performance of

the building. For example, in the selection of insulation materials, usually in the late autumn in the north, the temperature will drop rapidly, until the next spring the temperature will gradually rise, at this stage the north is in the centralized heating period, and the building structure outside the temperature will still be very low, if you can not reasonably choose insulation materials, reduce the wall insulation performance, will also have an impact on the indoor temperature[5]. The selection of insulation materials can be achieved through BIM technology to continuously simulate, set the temperature under fixed conditions at -10°C, 0°C and 10°C, etc., in order to achieve full judgment and analysis of the actual insulation efficiency of different materials themselves, and optimize the selection of insulation materials.

## 4 Problems and solutions for the application of BIM in the frontier progress of structural direction

### 4.1 Problems

- Influence of subjective factors: In the process of designing the building project, we will encounter special building forms with complex internal structures, so we also have to choose special structural modules to control the internal building forms. In some cases, sectional views and 3D graphics do not achieve satisfactory results, leading designers to abandon the use of BIM technology and use the original scheme design. Therefore, in the process of selecting software for construction projects technical staff will be influenced by subjective factors and give up using this technology, leading to resistance to the application of BIM technology in construction projects.

- Parameter mismatch: BIM technology is the basis for most 3D tools, and the resulting renderings are significantly different from the traditional 2D created views. Because the BIM software has to ensure the connection and coherence with the 2D customary design approach, the application of BIM technology can be affected when the BIM software and 2D created views do not match or when the parameters are set improperly.

- BIM structural geometric model and calculation model: BIM structural application important problem is reflected in the contradiction between geometric model and calculation model, as an important part of BIM model, geometric model should strive to be accurate, for example, drop plate, floor flap and other practices should be expressed clearly, otherwise it will cause misleading to other professions and difficult to meet the delivery requirements. However, the structural calculation model is as simple as possible and usually simplifies the structure. Excessive pursuit of accurate model geometric information will instead increase the calculation volume and even affect the calculation accuracy. The inconsistencies between the structural geometry model and the calculation model are reflected in the following: local lowering slabs, local lowering beams, local openings, floor flaps, suspended slabs, overbeams, structural columns, steel structure nodes, enclosure structures

expressed in the form of loads, etc. In the traditional design process, the differences between the calculation model and construction drawings are often coordinated by manual means, while the emergence of BIM technology provides the possibility to solve this contradiction, while the concept of BIM design also requires the coordination of this contradiction through software.

- Some architectural engineering design does not combine static and dynamic: Through investigation and analysis, it can be found that at this stage in China, most of them are static renderings to show the architectural design concept, and in order to highlight the beauty and colorfulness of the whole building, most of them are adjusted at a later stage, and do not show the specific actual information. Through the static display of the building, often only the basic information of the external structure can be seen, but not the internal structure of the whole building and the specific structure of the complete display. At the same time, such beautiful and colorful architectural drawings often differ to a certain extent from the actual building structure, which may even produce a certain confusing effect for the development of architectural work.

- BIM technology application cost is high: the use of BIM technology for the design of construction engineering capital demand is relatively large, because this technology on the professionalism of the personnel and the equipment itself high demand, must require the construction personnel have a fairly high professional skills, in order to make good use of BIM technology in construction projects, so the contractors and construction units of construction projects need to invest a certain amount of money for the personnel to Hire, where the government can provide certain financial support, staff training, and more advanced equipment, etc., the overall application includes human, material and financial resources, it can be seen that the application of BIM technology is more costly.

### 4.2 Improve the application measures of BIM

- Correlating BIM structural geometric model and computational model: There are two solutions, one is to simplify the geometric model to computational model, and the other is to enrich and modify the computational model to geometric model. No matter which form is adopted, the two must be distinguished and related to each other. That is, the computational model should be automatically reflected into the geometric model after adjustment, which cannot be done by current software.

- Establish a complete project sample: In the overall design process of the building structure, the project sample has a fundamental role, mainly involving the use of limited standardized processing of various families, line types, fonts, symbols and expressions. The formation of a good sample in BIM technology can essentially reduce the duplication of work and also accelerate the design speed, gradually build a set of design standards to meet the national conditions of China, and provide some guidance for most design users, even those by special needs.

- Realize design visualization: Optimization of the

structural plan is now based on a 3D solid model, which can express the spatial relationship between the components in a visual way and is more conducive to technical communication between designers, constructors and builders. For large and complex structure building projects, it is difficult to find out the problems existing in the design of their own professions and the problems existing in the collaboration of different professions just based on the flat and elevation drawings. Based on this, the 3D visualization technology in BIM can be used to demonstrate the dynamic roaming of the structural model and equipment model to observe its dynamic changes in real time, and then realize the design visualization.

- Designing structural members that meet the requirements: For the main components in the design of the building mechanism, there are usually foundations, columns, walls, beams, floor slabs, stairs, etc. In the project construction process, the above components are prefabricated components, cast-in-place components and steel components, and the reasonable design is based on various structural components under the premise of the main design form of the building. In the current situation, cast-in-place elements are the most common form of structure, so when the design of the structural scheme is selected, the design is often based on the functional requirements and the specific direction of the pipeline for a reasonable arrangement, in order to avoid the occurrence of multiple factors conflicting with each other in the structural elements.

- Enhancement of BIM technology level: With the rapid development of economy and the emergence of high and large buildings, the use of BIM, a new technology in the construction industry, has become a trend. The function of BIM technology is indeed very powerful can greatly improve the efficiency of work, saving personnel and material resources, but its practical operation is more difficult to require, so the application of this technology is very high requirements for designers, the need for designers to continuously improve their comprehensive ability and professionalism, a comprehensive and accurate grasp of BIM technology, to understand the shortcomings of the technology has been in the design work of the problems that often arise. Strengthen the further study of science and technology to improve it efficiently and enhance the level of BIM technology.

## 5 The future direction of BIM

In the background of the era of big data, combined with the basic direction and development focus of structural engineering discipline, the future BIM should be developed and improved from the following aspects.

- Establishing a perfect BIM standard system and compiling supporting BIM application standards.
- Development and formulation of relevant policies, laws and regulations as well as research on BIM application models, directions and guidelines.
- whole life cycle BIM system architecture and information sharing environment, whole life cycle BIM data storage and management technology.

- Theories, methods and key technologies of BIM-based design, construction, operation and maintenance and management. BIM-based analysis, simulation and dynamic monitoring technologies for the whole life cycle of building investment, performance, resources, environment and disaster prevention. BIM-based virtual design and construction technologies.

## 6 Conclusion

Along with the penetration and development of advanced materials, information technology, sensing technology and control technology and other high technologies into civil engineering in the past two decades, a series of new concepts such as intelligent structures and sustainable structural engineering have been proposed in recent years in the international context. Compared with traditional methods, BIM technology has many advantages of its own. Therefore, BIM technology has been widely used in China's structural industry, and the development prospect of BIM technology is very broad, with the development of economy and social progress, the use of BIM technology is expanding, and the use of BIM technology in the design of building structure will promote the progress of building structure design work. Although there are many problems in the application of BIM technology in the process of structural design work, with the progress of knowledge, BIM technology will become more perfect, while promoting the progress and development of the structural design industry. Technical personnel should improve their knowledge of BIM technology to provide a reliable guarantee for the quality of building structures..

## References

1. Liu Q. (2017) Application of BIM technology in civil engineering. *Quality Management*, 4: 28-30.
2. Su L. (2017) BIM technology and its application in structural design. *Construction-Building Materials-Decoration*, 8: 245-246.
3. Lu Q, Qu L. (2018) Talking about the application of BIM technology in civil engineering. *Building materials and decoration*, 49: 218-219.
4. Zhang H. (2018) Ruminations on the application of BIM technology in the design of civil engineering structures. *Construction Engineering Technology and Design*, 21: 665.
5. Guo Chong. (2019) Application of BIM technology in the design of building structures. *Commodity and quality*, 20: 192.