Application of BIM Technology in Road Engineering Design

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Abstract—This article analyzes the basic concepts, basic characteristics, and commonly used software of BIM technology. The author studied the specific application of BIM technology in geological data collection, design scheme comparison and selection, design modeling, engineering quantity and cost calculation, design drawing output, collaborative content design, urban landscape design, construction simulation design, and comprehensive pipeline design. The purpose of this article is to improve the rationality of road engineering design schemes and prolong the service life of road engineering.

1. INTRODUCTION
Road engineering is the basic condition for the stable development of regional economy, and the rationality of its design content is directly related to the convenience of regional residents' daily travel and the exchange of materials between regions. When designing road projects, BIM technology is often used for assistance. By sorting out the relevant content that needs to be paid attention to in the design and application of BIM technology, it can not only refine the relevant content in the road engineering design plan, but also has a positive meaning for accelerating the construction speed of subsequent work.

2. OVERVIEW OF BIM TECHNOLOGY RELATED CONTENT

2.1. Basic Concept
BIM is the abbreviation of building information model, it is synonymous with specific software. It is not a specific tool, but a brand-new concept or idea emerging in the construction field. BIM is the collection of project information between different types of work departments in a three-dimensional data model. This is the work process of data generation and management throughout the life cycle of an engineering project, that is, from project plan planning, design, construction, operation and maintenance to final dismantling. It is a complete narrative and expression of relevant information about construction projects. BIM does not simply integrate digital information, it is also an application of digital information. It can be used in design, construction, management and other fields to support the integrated management environment of construction engineering. It integrates the relevant information of various projects through the parameter model, and shares and transmits it during the whole life cycle of project planning, operation and maintenance (as shown in Figure 1). In this way, engineers and technicians can make a correct understanding and efficient response to various building information, and provide a basis for collaborative work for the design team and all parties including the building operation unit. At the same time, it can play an important role in improving production efficiency, saving costs and shortening the construction period. In addition, it can also significantly improve the efficiency of the construction project and greatly reduce the risk in its entire process.
2.2. Basic Features

2.2.1. Visualization
In the traditional design process, the design drawings used in it stay on the two-dimensional level, that is, the shape and size of all buildings are displayed using lines. This also puts forward higher requirements for the designer's own spatial imagination ability. If the designer's ability is relatively poor, it will also interfere with the subsequent construction activities. The application of BIM technology has very strong visual characteristics. It relies on a computer for virtual modeling, and the two-dimensional information is also re-displayed in three-dimensional form. In this way, the correlation, specific shape, length between the building structures can also be displayed more intuitively. This also provides more convenient conditions for subsequent program discussion.

2.2.2. Synergy
In traditional road engineering design, its coordination with other professions is relatively poor. The main reason is that the two-dimensional drawings used cannot show the spatial relationship of the components, and the loopholes in the preliminary design can only be reported after the construction has reached this link. For example, in the past, there were often conflicts of steel components in the design. Demolition and repouring would waste a lot of construction resources. BIM technology can also conduct collision experiments on the structure while building the three-dimensional model to understand whether there is a large conflict between the design contents, and adjust the design parameters in time. This can make the design more reasonable, which also reduces rework. Moreover, in this way, the model can also be used to evaluate its impact on other operations, thereby improving the construction quality of the construction project.

2.2.3. Simulation
After using BIM technology to complete the establishment of the three-dimensional model, not only can the provided convenience conditions be used to complete the parameter verification in the early stage of construction, but also the feasibility, adaptability, and energy saving of the project itself can be analyzed. In addition, this can also simulate the entire construction process, understand in advance the related problems that may be encountered during the construction process, and formulate measures in advance to deal with them, so as to reduce the negative impact of such problems. At present, 4D and 5D simulations are also carried out in the system simulation process, which further enhances the problem identification ability and improves the orderliness of the construction activities.
2.2.4 Target
In the application process of BIM technology, it also possesses targeted application characteristics. In practical applications, it can also perform detailed calculations on engineering-related content to understand the unreasonable content in the design. Meanwhile, it can also optimize the relevant content of the engineering cost calculation process in time, and improve the standardization and rationality of the designed content. Moreover, there are also some difficult processes in the construction of road projects. Before its construction, BIM technology can also be used to simulate the process to find the most appropriate operation mode. Companies can use this to speed up operations during actual construction and reduce the probability of safety issues.

2.3. Most Used Software

2.3.1. Autodesk Software
Autodesk software is an application software based on Auto CAD. The tools commonly used in the use process are as follows. (1) Civi 3D. This software is a professional route and roadbed design software. We can use relevant horizontal and longitudinal design information to create a preliminary bridge layout plan, and then import the terrain model and route design into Revit in the form of plug-ins for structural detail design and reinforcement design. (2) Revit software. A professional structural design platform can create a rich library of upper and lower bridge components in the form of a family library, and use Civi 3D route design information to complete professional bridge parametric design. (3) Infraworks. The brand-new plan design platform is based on real terrain and environmental scenes, designs and analyzes routes, bridges and tunnels, optimizes the preliminary plan design and structural layout, and counts the number of preliminary projects. In the meantime, it can transfer the plan design data to Civi 3D and Revit software for detailed design.

2.3.2. Bentley Software
Bentley software is a design software based on the Microstation platform. In use, the same data format will be used for communication to achieve real-time collaboration throughout the life cycle. At present, the software that is used more in road engineering design is as follows. Firstly, Power Civil for China software. This software is an application software used in some basic engineering design, which can participate in the management of the entire life cycle of road engineering. At the same time, the three-dimensional information model provided by it also laid a reliable foundation for the development of comprehensive analysis. Secondly, Bridge Master Modeler software. The software is classified as correction software. It can perform operations such as rendering, dynamic view processing, construction simulation, and collision experiments on the model, and it has a very strong attribute analysis function.

3. SPECIFIC APPLICATION OF BIM TECHNOLOGY IN ROAD ENGINEERING DESIGN

3.1. Geological Data Collection
Compared with civil construction projects, the distribution of road projects is in the form of belts, and the distance across the area is longer. The progress of its construction activities will also be closely related to the original geological conditions of the region. The application of BIM technology in this link is mainly to establish a regional geological model to display regional topographic changes, soil layer changes and other content. This also provides reference conditions for the subsequent development of collaborative work.
3.2. Design Scheme Comparison
In the road engineering design process, many design schemes will participate in the selection. This also requires a reasonable selection of the participating schemes to lay the foundation for the orderly progress of subsequent construction activities. BIM technology will make full use of the advantage of visualization in this application link. It can build a virtual society within the software. The content includes the participating design plan, geographical location conditions, social and economic development, etc. It will adjust other development factors to simulate the visual content during program selection, and evaluate the feasibility of the program based on the simulation results. Moreover, it will also establish a priority order to select a more scientific and effective design plan.

3.3. Design Modeling Aspects

3.3.1. Digital Terrain Model
During the establishment of the digital terrain model, the calculation of the 3D model will be completed according to the collected measurement point data. Moreover, BIM technology can also arrange irregular surfaces so that they can generate the required surface structure. This is also an important condition for the subsequent optimization of the design scheme. Compared with the previous design method, the design work efficiency based on this model can be improved by more than 150%. BIM technology can also check the details of the generated model, such as using the DTM system to optimize the collected data, so as to obtain more reliable analysis data.

3.3.2. Subgrade and Pavement Modeling
In the process of subgrade and pavement modeling, the following points should also be paid attention to. (1) Reasonably select feature points. Its content includes the edge point of road engineering, the center point of road engineering and so on. Moreover, it also needs to sort out the constraint relations and sort the feature points to provide convenient conditions for subsequent modeling [1]. (2) Component structure selection. As shown in Figure 3, the component is a simple pavement component, and the whole is a closed parallelogram. The roadside edge point EOP is obtained by extending the horizontal distance from the road center point CL. Other points can also be obtained in the same way, which is also an important reference for modeling and analysis. (3) End conditions. It is a voucher used to solve the restriction conditions of the roadbed, so as to obtain a reliable data analysis model.
3.3.3 Fast Road Modeling
BIM technology will use existing programs to carry out three-dimensional analysis in expressway modeling processing. After the horizontal, vertical, and horizontal design of the road project is completed, the route content will be stretched in the three-dimensional model. It can use this to realize the smooth connection of various point structures and build a three-dimensional analysis network [2]. The road corridor model belongs to the core content of BIM modeling and can be automatically generated and stored in the software. Compared with the traditional two-dimensional drawings, this type of model can give a stronger analysis of the road extension, and the accuracy has been improved several times. This also effectively improves the reliability of the analysis content to meet different application requirements.

3.4. Engineering Quantity and Cost Calculation
The construction process of road engineering includes many construction contents such as grassroots operations, bottom operations, earth excavation operations, curb distribution, surface operations and so on. In actual application of these contents, computers are also used to complete data integration, and cloud computing platforms are used for calculations. Meanwhile, BIM technology will also establish a virtual model during the application process to assist the computer in completing the cost of different construction stages, reducing the error tolerance rate in manual calculations, and improving the accuracy by several times [3]. Besides, the model established during engineering quantity analysis can realize 1:1 reduction. This can also further improve the accuracy of the calculation results. Moreover, the speed of work can also be increased by 5-10 times. This also reduces the time cost of the design phase and speeds up the development of subsequent construction activities.

3.5. Design Drawing Output
The design drawings drawn in the previous design mode will be directly submitted to the owner for review. If there is a construction change in the middle, supplementary drawings need to be made, which consumes a lot of resources. In the application process of BIM technology, paper drawings are not required before the final design plan is determined, and the established models are gradually replacing traditional design drawings. Relying on the three-dimensional model obtained by BIM technology can more intuitively reflect the designer's thoughts, but also facilitate the timely discovery of some design problems [4]. After determining the final design plan, BIM technology can generate plane graphics, vertical section graphics, detailed thematic graphics, etc. according to actual needs. The whole process has strong automation characteristics, which helps to reduce the time cost used.
3.6. Collaborative Content Design
Road engineering does not belong to a completely independent operation content during the construction period. During construction, it is also necessary to take into consideration border buildings, existing road projects, existing bridge projects, underground pipelines, etc., which also requires a high degree of collaboration during construction. The application of BIM technology in this link will establish corresponding conflict experiments, and conduct collision experiments on the established road engineering model and other models to understand the content of conflicts. If it is found that there is a large conflict, then the content of the design plan needs to be adjusted to avoid the risk of conflict [5]. If both parties in the conflict experiment belong to the project to be built, then the parameters need to be modified through information communication. This can make it possible to reduce the possibility of subsequent construction changes while ensuring the standardization of the design content.

3.7. Urban Landscape Design
As the skeleton structure of regional development, road engineering also needs to take into account the landscape design during the road design period. In previous designs, the content of the landscape was communicated using two-dimensional drawings. Because the design content has a poor three-dimensional effect, more communication time is required [6]. In the application process of BIM technology, the established three-dimensional model can be used for intuitive communication with the designer. Moreover, it can better integrate design thinking into design. Before preparing the map, it can also conduct a scientific analysis of the system to understand more reliable service information. In the meantime, it will also allocate and process owner information. In this way, reliable analysis content can be obtained, and the use value of the analysis results can be improved.

3.8. Construction Simulation Design
BIM technology can also be used for construction simulation during the application process. In the specific simulation design, the construction simulation environment can be established according to the known conditions. Its contents include detailed design plan, geographical location conditions, and frequency of construction environment changes. It will adjust other development factors during simulation to simulate the visual content. It can evaluate the possible problems in the application of the selected design scheme based on the results obtained from the simulation, and clarify the difficulty of problem solving and the solution measures. If the problem encountered is difficult to solve, then you need to adjust the content of the design plan and re-simulate it at this time. After many adjustments and improvements, a more scientific and effective design scheme can be obtained [7].

3.9. Integrated Pipeline Design
As mentioned above, there are many conflicts in road engineering design, and underground pipelines are a very important content. In traditional design, there are often pipeline collisions and rework during construction, resulting in a waste of resources. When designing with BIM technology, in addition to conducting collision experiments to adjust pipeline parameters, BIM technology will also be used to assist the intensive management of pipeline design content, thereby improving the rationality of the analysis content. As shown in Figure 4, the left side is the traditional two-dimensional design content, and the right side is the three-dimensional modeling design. The 3D modeling content can more intuitively understand the cooperative relationship between pipelines, and the obtained analysis results are more reliable [8].
4. CONCLUSION
In summary, in the construction process of road engineering, BIM technology has a very good application prospect. There are many functions that need to be paid attention to in the design of road engineering by combing the technology. For one thing, it can improve the rationality of the content of the design plan and reduce the occurrence of subsequent rework problems. For another, it can speed up the development of construction activities and improve the quality of engineering operations.

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