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Research and Analysis on the Application of BIM Technology in Municipal Tunnel Engineering Design

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Abstract: ***As a special kind of municipal engineering, municipal tunnel engineering not only has the characteristics of complex structure and high safety risks, but also needs to comprehensively apply various special construction technologies in the design stage, and fully consider the terrain, tectonics, vehicle access, tunnel support and other factors, which is relatively difficult to design. Therefore, BIM technology is applied to the design of municipal tunnel engineering, It can help relevant designers successfully solve various design problems and provide guarantees for the rationality of engineering design schemes. Based on this, from the perspective of rational design of municipal tunnel engineering, the advantages and effects of BIM technology are analyzed, and specific discussions are conducted around the application points of BIM technology in municipal tunnel engineering design work, in order to provide some inspiration for relevant designers.***

Keywords: Municipal tunnel engineering; BIM technology; Design.

With the continuous promotion of theoretical research and application practice in the field of BIM, the application scope of BIM technology in China has gradually expanded in recent years. In addition to the initial construction industry, BIM technology has played a very important role in the design and construction of various engineering projects such as highway and bridge engineering, water conservancy engineering, chemical engineering, etc. In situations where the design difficulty of municipal tunnel engineering is relatively high and the design is unreasonable, it is naturally very feasible and necessary to apply BIM technology to the design of municipal tunnel engineering.

1. APPLICATION ADVANTAGES OF BIM TECHNOLOGY IN MUNICIPAL TUNNEL ENGINEERING DESIGN

This line Figureshows the changes in tourist satisfaction score over time, with time on the horizontal axis and satisfaction score on the vertical axis. The data is sourced from social network analysis, where tourism planners analyze tourist behavior data on social media to better understand their interests, preferences, and other related information. This enables them to provide more personalized and demand-driven tourism products and services, such as customized travel itineraries, personalized recommendations for attractions, and tailored accommodation options. As a result, tourists are more likely to have a positive travel experience, which can lead to increased loyalty and repeat business. Social network analysis has become an important tool in tourism planning due to its ability to analyze and interpret social relationships and behaviors on social media platforms. Social network analysis has the following advantages in tourism planning.

1.1 Design information integration and sharing

Compared with railway and highway tunnel engineering, although municipal tunnel engineering is relatively small in scale, the design work is also relatively complex, requiring collaborative collaboration among multiple professional designers to obtain a complete and reasonable design plan. If the transmission and statistics mode is used, it is often easy to affect the overall efficiency of design work due to asynchronous updates of design information among different professions, and even lead to unreasonable design issues. Applying BIM technology to municipal tunnel engineering design can effectively compensate for the shortcomings of traditional design in updating design information. Through the BIM software platform, different professional design information can be integrated, shared, and updated in real-time, and tunnel engineering models can be constructed based on constantly updated design information. In this way, regardless of the modifications made by the designers to the tunnel engineering model, the modified information can be updated in a timely manner to the platform model,

elevation, profile, and material list, without the need for repeated communication and coordination by different professional designers. This significantly improves the efficiency of design work. In addition, due to the fact that the modification of design information for each profession is shared across the BIM software platform and the modification records are sent to other platform users (designers), the design information held by all designers can be highly consistent, effectively avoiding design problems caused by asynchronous acquisition of design information. In different domains, social network analysis has turned into an essential tool to comprehend and construe social connections. As social media continues to gain popularity, social network analysis has also been extensively utilized in tourism planning to offer tourists customized and demand-driven services and products.

1.2 Effective avoidance of design issues

In the context of a large amount of municipal tunnel engineering design work and the need to comprehensively consider multiple factors, various detailed design problems are often difficult to completely avoid. Relevant designers must conduct a comprehensive inspection of the relevant design drawings and documents after preliminary completion of the design work, in order to accurately identify potential design problems and ensure the rationality of the design drawings and document content If there is negligence during the document inspection process, potential detailed design issues can easily be overlooked and have a serious impact on the construction process. By effectively applying BIM technology to the design work, we can use the collision detection and other functions of the BIM software platform to carry out a comprehensive rationality analysis of the model while completing the tunnel model according to the design drawings and document components, so as to accurately find the design problems in terms of inadequate tunnels and supports, insufficient structural stability, etc., and modify the design problems in a timely manner, so as to prevent the final submitted design drawings There is a design issue with the file.

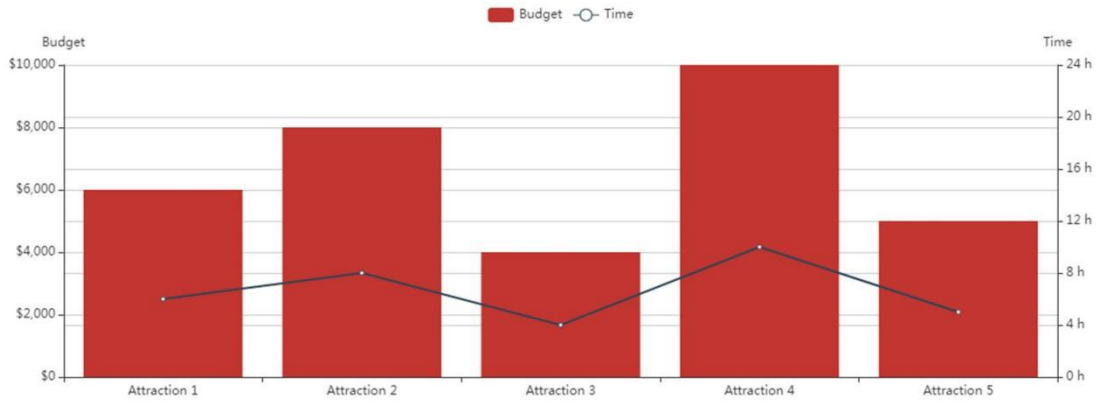

Figure 1: This Figuredisplays the budget and time allocation of tourists

The x-axis represents the names of tourist attractions, while the y-axis is divided into two axes. The left axis represents the budget of the tourists, and the right axis represents their time. The unit of the left axis is in US dollars, while the right axis is in hours. This Figureprovides a clear visualization of the budget and time allocation of tourists at each attraction, helping them to plan their travel path more effectively.

1.3 Visualization of Design Content

In the design phase of municipal tunnel engineering, due to the visual nature of BIM, it is possible to construct a three-dimensional model based on relevant information of the engineering project. Therefore, after determining the basic model of the tunnel engineering, designers can also conduct comprehensive observations of the model to directly understand the various construction requirements of the tunnel engineering, and incorporate the design content of each part into the entire tunnel engineering Clarify the connection in order to expand the design concept and avoid affecting the design effect of tunnel engineering due to spatial imagination limitations [2]. In addition, with the support of three-dimensional models, designers can also use the models to visualize and interpret the design content of various parts of the tunnel project after completing all design work, in order to achieve effective communication with construction units and other stakeholders, help them accurately understand the design intent of the tunnel project, and clarify various design requirements.

Figure 2: The Figureuses a bar graph to represent the key features that tourism recommendation systems based on social media data analyze to generate personalized travel plans and destination recommendations.

The x-axis shows the categories "Location", "Price", and "Amenities". The y-axis represents the number of systems that analyze each feature. The legend displays one data series, "Tourism Recommendations", and is positioned at the top of the chart. The color blue is used to represent the data series.

2. KEY APPLICATION POINTS OF BIM TECHNOLOGY IN MUNICIPAL TUNNEL ENGINEERING DESIGN

Another advantage of social network analysis in tourism planning is its ability to promote the development and innovation of the tourism industry. Social network analysis can identify tourist behavior patterns and consumption habits, providing more accurate market analysis and prediction for tourism enterprises. This information can help tourism businesses to develop more scientific and effective marketing strategies, as well as to design and offer innovative tourism products and services that meet the changing needs and preferences of tourists. In addition, social network analysis can also help tourism enterprises to optimize their resource allocation and management, leading to improved efficiency and profitability.

Overall, social network analysis has the potential to significantly enhance the competitiveness and sustainability of the tourism industry by improving tourist satisfaction and experience, and promoting the development and innovation of tourism businesses. Social network analysis in tourism planning involves the collection and analysis of a large amount of personal data, such as tourist behavior data on social media platforms. Therefore, ensuring the quality and security of the collected data while protecting the privacy of tourists is a key challenge that needs to be addressed.

2.1 Building a Collaborative Design Platform

For municipal tunnel engineering design units, in order to achieve effective application of BIM technology in tunnel engineering design work, it is necessary to first select appropriate BIM software tools as the basic modeling platform, and through the application of BIM software related functions, build a collaborative design platform that is oriented towards tunnel engineering and can achieve design information disclosure, update, and efficient sharing. At present, the BIM software in the engineering field mainly includes Revit3D, Civil3D, Open Roads Designer, Open Bridge Modeler, and AECO sim Building Designer, Archi CAD, etc., relevant design units need to reasonably select BIM software tools according to their own actual conditions on the premise of ensuring that the platform has the basic functions of efficient data processing, document query, data interaction, data information security protection, etc., while the specific selection criteria need to consider the three factors of model display, information integration and model update.

Figure 3: This radar Figuredisplays the preferences of tourists in terms of different types of tourism activities, such as outdoor activities, cultural experiences, and shopping

The radar Figureuses a circular layout with spokes representing each category and a line connecting the data values for each category. By analyzing the behavior patterns of tourists on social media platforms, social network analysis algorithms can identify their preferences and generate personalized recommendations to improve their travel experience. This Figureis useful for visualizing the overall preference profile of tourists and identifying areas where they may be more or less interested in engaging in certain activities.

Among them, model display refers to the strict control of the model display function of BIM software tools, ensuring that various models such as tunnel models and geological 3D models can be comprehensively, accurately, and intuitively displayed, and can present various drawings such as cross-sectional and elevation views, in order to avoid situations where the model display is not detailed enough and the display function does not meet design requirements. Information integration refers to taking full account of the long-term characteristics of tunnel engineering design, ensuring that BIM software has a powerful information integration function, which can effectively process and integrate data information from geological survey data, remote sensing image maps, tunnel engineering construction requirements and initial planning and design, and apply it to the construction of BIM model to effectively improve the rationality of tunnel engineering design [3]. Model update refers to the selection of BIM software that cannot only consider design requirements, but also needs to evaluate the construction data processing and model update function of the software platform from the perspective of tunnel engineering construction, ensuring that the tunnel model can be flexibly adjusted according to changes in the construction site, and providing assistance for various work during the construction phase.

2.2 Design location on-site survey

Due to the fact that tunnel engineering construction usually needs to be carried out inside or underground, which is greatly affected by factors such as terrain, geomorphology, and ecological environment, in order to improve the rationality and pertinence of municipal tunnel engineering design, designers not only need to use various information such as geological survey reports provided by the previous construction unit, but also need to flexibly use GIS technology, drone technology, tilt photogrammetry technology, and other technical means, Go to the design location for another on-site survey to obtain high-precision and high-resolution real-world data, and establish a real-world model of the tunnel engineering design location to provide basic support for tunnel model construction. During the design process, relevant designers can also conduct terrain and ecological environment analysis around the real-life model of the tunnel engineering design location, and use the analysis results as an important reference for selecting design ideas and optimizing design plans, so that the tunnel engineering design drawings and plans can be more in line with reality.

2.3 Tunnel Model Construction

After determining the real scene model of the engineering design location, tunnel model construction can be carried out on the basis of the real scene model. Although there are certain differences in model construction among different BIM software tools, the general process is basically the same, which can be divided into several stages: target selection, terrain display, opening model creation, and horizontal channel model creation. Target selection refers to marking the design location on the built-in map of the real scene model or BIM software based on the coordinates, elevations, and other data of the design location. Terrain construction refers to the special display of geological condition information within the area covered by the design location after marking the design location of the tunnel project, making the terrain and rock changes in the area more clear and providing auxiliary support for designers. In the process of creating a tunnel portal model, designers need to determine the location of the tunnel portal, and then use the functional modules provided by BIM software to design higher-order surfaces. The tunnel portal plan is determined, and then based on the plan, software functions are used to gradually complete the 3D contour route generation, 3D surface filling, and other plan processing work. Finally, the portal model is generated on the design location real scene model [4]. In the final stage of creating a horizontal channel model, designers need to first determine the basic size parameters such as tunnel height and width, as well as the central route of the tunnel, based on the basic construction requirements of the tunnel project. Then, these data are input into the directory library system to create the initial model and model design table. The system automatically generates a horizontal channel model based on the data in the design table and presents it on the actual model, Combined with the opening model.

2.4 Engineering Detail Design

After determining the basic model of tunnel engineering, subsequent detailed design work can be carried out based on the BIM software platform and the basic model, and more detailed and specific design drawings and schemes can be determined [5]. For example, when designing the excavation surface of a tunnel foundation pit, designers need to first divide the entire tunnel into multiple sections based on data such as tunnel burial depth and geological conditions, and determine the excavation parameters of each section of the tunnel. Then, based on the tunnel transverse channel model, the excavation surface skeleton is generated to obtain the final excavation surface model of each section of the tunnel. At the same time, due to the diversity of construction techniques and methods for tunnel excavation, designers can also choose multiple construction techniques and repeatedly parameterize the excavation situation of tunnel foundation pits. The construction effects of tunnel foundation pit excavation supported by different construction techniques are clarified, and comparative analysis is conducted based on the adaptive situation between the excavation surface and the terrain surface to select the most suitable construction technique for tunnel foundation pit excavation [6]. When designing the retaining structure of the tunnel foundation pit, it is necessary to determine appropriate tunnel support parameters based on the previously determined tunnel excavation construction technology and the geological conditions of each section of the tunnel. Then, the tunnel support parameters are input into the tunnel design table, and the retaining structure skeleton is generated based on the tunnel excavation surface model, gradually constructing the tunnel maintenance structure model. In the selection of tunnel enclosure methods, it is also possible to compare and analyze the maintenance and construction effects of tunnel foundation pits supported by different enclosure methods through repeated parametric design.

2.5 Design Optimization

After the excavation and maintenance of the foundation pit in the municipal tunnel project are basically completed, the design, Designers also need to use the relevant functions of BIM software for design optimization based on a complete tunnel model to accurately identify potential problems in current tunnel engineering design. For example, in the case of using an anchor rod system (or a combination of anchor rods and other support methods such as bored piles) for tunnel foundation pit support, BIM software can be used for collision detection to check whether there are collisions between anchor rods in various parts of the tunnel support model. If the detection results show that some anchor rods are colliding, the design position of the anchor rods should be adjusted in a timely manner. However, in the case of large pressure bearing of the tunnel vault, the BIM software can be used to carry out finite element analysis of the tunnel model for lining deformation, and accurately calculate the vault subsidence under different pressure bearing states to clarify the tunnel bearing capacity and structural stability. If it is found that the tunnel bearing capacity is lower than the design load, the reason should be found in time and the design scheme

should be modified [7].

2.6 Construction Activity Simulation

From the perspective of the overall construction effect of municipal tunnel engineering, after the relevant design units have preliminarily determined the tunnel engineering design plan and obtained a complete tunnel model, BIM technology can also be used to simulate various forms of construction activities, providing support for engineering cost control, construction technology application evaluation, and other work. For example, in the case of tunnel engineering using the quota design method, BIM software can be used to comprehensively extract the engineering quantity data from the tunnel engineering design information, and complete the engineering quantity statistics for each part or section of the tunnel. Then, based on the engineering quantity statistics results, the project cost can be predicted. If the predicted cost of tunnel engineering exceeds the limit target, it is necessary to conduct in-depth analysis of the statistical results of the engineering quantity, identify the reasons for the high engineering cost, and optimize the existing design scheme to effectively reduce the engineering cost. In terms of construction technology application evaluation, the construction simulation function of BIM software can be used to present relevant construction activities in the form of animations, and then communicate with the construction unit or construction unit to analyze whether the construction activity can be completed under existing construction conditions. If the requirements for various aspects of simulated construction activities do not meet the actual construction conditions, it is necessary to make adjustments to the construction technology and methods.

2.7 Vehicle driving simulation

At present, as municipal tunnel engineering is mostly a component of subway engineering or municipal road engineering, it needs to fully meet the driving needs of subway trains or cars. Therefore, designers can also rely on the BIM software platform for vehicle (train) driving simulation detection, with the driver of the car or subway train as the first perspective, Real simulation of the driving effect at specific locations (such as tunnel entrances and exits, uphill and downhill locations) and in specific environments (such as daytime driving, nighttime driving, rainy driving, etc.) to achieve accurate evaluation of the overall rationality and feasibility of tunnel engineering design, and provide important reference for subsequent design decisions.

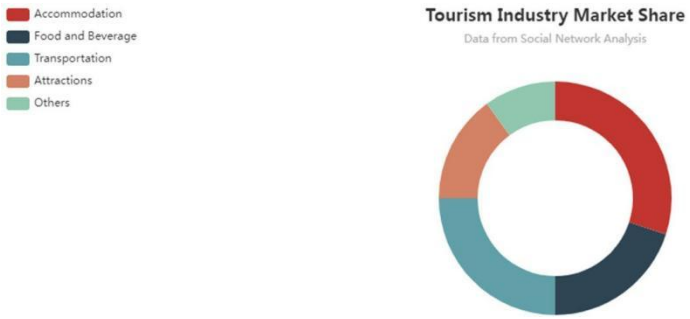

Figure 4: This pie Figureshows the changes in the market share of the tourism industry, and the data is derived from social network analysis.

3. CONCLUSION

In summary, BIM technology can provide important assistance for the rational design of municipal tunnel engineering. To achieve effective application of BIM technology in relevant design practices, it is necessary to grasp the key points of BIM technology application in the construction of collaborative design platforms, on-site survey of design locations, tunnel model construction, construction activity simulation, vehicle driving simulation, and other aspects.

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