Research on 4D Simulation Technology of Reconstruction Engineering Construction Organization Based on BIM

Chen Wang1,*, Xiangsheng Liu1, Kechao Zhang2,3,*

1 Anhui Transportation Holding Group Co., Ltd, Hefei, Anhui, 230001, China.
2 Research Institute of Highway, Ministry Transport, Beijing 10088, China.
3 China-Road Transportation Verification & Inspection Hi-Tech Co., Ltd, Ministry Transport, Beijing 10088, China.

*Corresponding author’s e-mail: 289812508@qq.com

Abstract. This research is based on BIM technology to achieve 4D simulation of highway construction organization. By correlating BIM model and construction process, it can identify potential process errors or conflicts in advance, optimize construction organization process, and reduce unnecessary capital investment. Relying on the research results, the collaborative management of the quality, schedule and cost of complex projects in the construction process is realized.

1. Development of BIM technology

BIM technology is an important development direction that supports the development of information technology. Its advantage is that through the BIM model, the construction process data and management work are organically linked, from two-dimensional information management to three-dimensional visual information management, greatly increasing the structure.

Before the BIM technology, according to traditional management techniques, no company in the industry could achieve refined management. However, with the development and maturity of BIM technology, this passive situation will be completely changed, and the above management methods can be easily achieved. In huge and complex system engineering such as large-scale transportation infrastructure construction and maintenance, one thing is very important: to obtain the right information at the right time, and then to make the right decision quickly. The emergence of BIM technology just made it possible.

BIM technology is not only the cutting-edge technology of the industry, but also the general trend of the industry development. It is very necessary to discover the application value of BIM technology in reconstruction projects. It is important to ensure the safety of highway construction and ensure that the construction period, cost and quality meet the requirements. Nowadays, how to further improve the quality of highway bridge design and construction is an important issue that engineers need to face and solve.

The application of BIM technology has been included in the important direction of the development of information technology by the country, and it has been gradually recognized by domestic large-scale architectural design, construction and consulting companies. The application of building information model is the only way for the development of construction engineering informatization. At present, the concept of building information model has gained consensus in academia and construction enterprises. With the rapid development of information technology, the
application of BIM products will greatly improve the management efficiency of construction projects and bring economic benefits to the project.

2. Application status of 4D construction simulation technology based on BIM

The application of BIM by most companies is limited to the simple application of 3D models, such as collision inspection, depth inspection of construction drawings, and automatic calculation of engineering quantities. At present, although the application of 4D simulation of construction organizations based on BIM technology has been tried to be applied in some projects, due to the lack of understanding of BIM, it leads to the situation of fragmented applications. As a brand-new technical means, BIM technology integrates the information contained in the entire life cycle of the engineering project and correlates each building component to efficiently achieve sustainable building design. This technology not only saves the resources required for construction projects, shortens the engineering cycle, and improves the design quality.

Virtual simulation technology provides an efficient analysis method for the design and management of complex engineering projects, and has become an indispensable tool for analysis, research, decision-making, design, management and evaluation of complex projects. At this stage, numerical simulation technology has been unable to meet people's requirements for visual display. With the enhancement of computer graphics capabilities, visual simulation can intuitively describe all links and complex logical relationships in engineering construction, which can effectively improve engineering project design efficiency, construction organization quality and engineering management level.

At this stage, combining BIM technology with simulation technology, virtual reality and other computer technologies can strengthen the control and dynamic management of the construction process, predict in advance the problems that may be encountered during the construction phase, and make countermeasures. In addition, the technology associates the engineering data model with time, and can simulate different construction plans and compare them, so as to select the optimal construction plan, improve construction efficiency, improve the overall benefit of the project, and enhance the development level of the highway reconstruction project.

3. Simulation of 4D construction organization

Relying on the reconstruction project of the He-ning Expressway, select the interchange interchange project to explore the establishment of construction organization simulation technology solutions.

3.1 Tilt photography. The use of oblique photography technology to build a real terrain model of the local control area of the highway reconstruction project, on the one hand, provides real data terrain for construction organization simulation, especially for areas with large changes before and after terrain construction such as deep cuts and high fills; at the same time, it is also conducive to enhancement Virtual reality scene of virtual construction technology.

3.2 BIM model construction. The highway reconstruction and expansion project has long lines, many types of projects involved, and contains a large number of existing engineering transformations, which makes the establishment of the BIM model more difficult. In order to meet the needs of the basic model of construction technology simulation, explore the rapid creation technology of BIM model instantiation of typical highway expressway reconstruction and expansion projects such as roads and bridges, and provide basic data support for virtual simulation technology.

3.3 Establishment of 4D simulation of special construction organization plan. (1) Based on the 4D simulation analysis function of BIM technology, establish the overall construction group of key work points and clarify the construction sequence;
(2) Consider the parallel and cross operations in the construction, rearrange the construction time of each unit according to the overall project progress target, determine the key process of the project construction, and simulate the special construction plan and key process.

(3) Optimize the schedule, iterative changes of the model and schedule, mainly optimize the key tasks, adjust the schedule, and ensure the construction time of the construction sequence on the key line without affecting the total schedule.

(4) Visually combine the traditional schedule plan and BIM 3D model, re-divide and process the model in the early stage of simulation, create supplementary 3D model or schedule plan, continuously add new construction information, perform multiple iterations, and finally export the construction Simulation program to complete construction simulation.

3.4 Project optimization. Under the premise of ensuring the construction period requirements, using 4D simulation technology to optimize the work tasks, adjust the construction schedule, optimize the construction plan of the highway expansion project, reduce redundant links, and improve the rationality, logic, and efficiency of the construction sequence.

4. Innovative application of 4D construction simulation

4.1. Refined and visual engineering management. The BIM virtual construction technology simulates the entire construction process, allowing technicians to be familiar with the construction process and the technical process of the construction process before construction, which improves the level of fine management of highway construction skills.

Using BIM's 4D related database, virtual construction technology can quickly and accurately obtain the basic amount of data in the process, provide timely and accurate data support for the formulation of engineering construction plans, and also provide data support for cost management and control.

4.2 Focus on BIM model to improve the quality of project management. In the construction of traditional highway projects, it is often difficult to calculate the cost of engineering projects in real time. The fees already paid and the total fees payable cannot reflect the dynamic costs of the project and the time cost of the project in a timely manner.

According to the BIM technology model, the virtual construction is optimized to reflect the construction difficulties in advance. Based on the animation rendering, a visual display of the construction process is realized. With the effective display of BIM virtual construction technology, the complex space standard design can be displayed more intuitively, which facilitates the understanding and use of construction technicians, and effectively avoids the appearance of deviations in the process of construction drawings review by construction technicians Construction errors and other issues, reducing errors in highway engineering construction.

4.3 Multiple simulations to optimize the construction plan. The three-dimensional model will dynamically display the process of equipment lifting. If a collision occurs, the program will automatically give an alarm. The technician can modify the parameters of the tower crane or crane until the lifting simulation meets the requirements. The technician can improve the lifting equipment according to the simulation results and adjust the lifting equipment until the simulation is successfully completed.

5. Conclusion
This paper carries out special simulation research on construction schemes for key control projects in highway expansion, determine corresponding technical processes and indicators, realize three-dimensional visual planning and technical explanation, and provide guidance for the application of BIM in highway reconstruction and expansion projects. It is reflected in the following aspects.
1. Use tilt photography technology to construct the real scene and the actual situation of the surrounding road network. After processing, the BIM model and the BIM model can be loaded on the GIS platform in a unified manner, providing a real geographical environment for the group simulation and cross group simulation. For large excavation and large fill areas, tilt photography technology can be used to provide real site terrain, landform and other technical data for the smooth application of BIM+GIS.

2. Taking into account the use of tilt photography technology and Nurbs curve modeling and other technical means, while carrying out high-precision simulation of excavation and fill area, it can achieve accurate calculation of the basic volume such as earthwork volume, which is helpful to arrange the subsequent construction schedule. The arrangement also helps to improve the accuracy of earthwork measurement.

3. In order to meet the construction simulation needs of highway reconstruction and expansion projects, BIM models of typical projects such as roads and bridges can be created to facilitate the promotion of similar projects.

4. Use BIM technology to perform three-dimensional visual simulation. Based on the analysis of the existing traffic flow data, through the transportation organization design simulation, the traffic capacity carrying capacity of the transportation organization plan is predicted and analyzed. Depending on the simulation, optimizing the traffic guidance program and improving the feasibility and efficiency of the traffic organization program are of great significance for ensuring road traffic, ensuring construction progress and reducing social impact.

5. The expressway project has a long route and involves many types of projects. For key control projects such as rebuilding of interchanges, subgrade elevation, and old bridges, etc., BIM technology is used to perform three-dimensional visual simulation of the construction plan and construction organization. Inclined photography to model the construction site on the spot, to truly reflect the spatial position relationship between the project and the surrounding environment, to optimize and analyze the construction resources (materials, labor, mechanical equipment), to find and solve problems in advance, and to reduce redundant procedures. The impact of the process, optimize the construction organization plan, and ensure the quality of the project.

References
[1] Blaine Fanning. Implementing BIM on infrastructure: comparison of the two bridge construction projects[J]. Practice Periodical on Structural Design and Construction, 2015, 20(4):1-6
[2] JOHANSSON M, ROUPEM, BOSCH-SIJTSE-MA P. Real-time visualization of building information models(BIM) [J]. Automation in construction, 2015, 54(2): 69-82
[3] Hardin B. BIM and Construction Management: Proven tools, Methods, and Workflows[M]. John Wiley&Sons, 2011
[4] Eastman C, Teicholz P, Sacks R, et al. BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Constructors[M]. John Wiley&Sons, 2011
[5] Jianping Zhang, M. Anson, Qian Wang. A New 4D Management Approach to Construction Planning and Site Space Utilization[C]. Proceedings of the 8th International Conference on Computing in Civil and Building Engineering, California.[S.I.],[S.n], 2002
[6] ISO TC184/SC4, EXPRESS Language Reference Manual, ISO 10303 PART 11[P].1997-06-07