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Application Strategies of BIM Technology in Highway Electromechanical Engineering

Li Liu*

China Merchants Chongqing Communications Technology Research & Design Institute Co., LTD., Chongqing 400067, China

***Corresponding author:** Li Liu, cqliuli@cmhk.com

Abstract: The transportation system is vital for social and economic development. With the rapid economic development, the demand for highways has been increasing. Mechanical and electrical engineering is a crucial part of highway construction, affecting the expressway's later use. Applying building information modeling (BIM) technology in highway electromechanical engineering allows for the visibility and simulation of mechanical and electrical engineering construction, providing scientific guidance for construction. In this research, the author analyzes the advantages of BIM technology in highway electromechanical engineering and the basic composition of electromechanical engineering. The research proposes strategies and cases for applying BIM technology in highway electromechanical engineering. The ultimate goal of this research is to improve the construction of highways in terms of electromechanical engineering.

Keywords: BIM technology; Highway; Mechanical and electrical engineering

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1. Introduction

We are currently in the information age, so it is important to have a comprehensive understanding of the role of BIM technology in highway electromechanical engineering. In this way, BIM technology can be incorporated seamlessly into the construction of mechanical and electrical projects. By doing so, we can fully leverage the advantages of BIM technology to ensure that the mechanical and electrical projects are completed smoothly within the specified construction period while maintaining both quality and quantity standards.

2. Advantages of applying BIM technology in highway electromechanical engineering

The safe and reliable operation of highways is closely related to the construction of electromechanical projects, and the construction of electromechanical projects is relatively complex. The application of BIM technology can ensure the construction effect of the project. BIM technology has a strong visualization function and can effectively reduce pipeline conflicts. The electrical nodes of some highways are relatively complex. In these

cases, BIM technology can be used to simulate its construction, and the mechanical and electrical engineering construction of the road can be presented through a three-dimensional visual model. By doing so, existing problems can be intuitively discovered and addressed [1].

Expressways are important transportation routes in our country that make traveling much more convenient. Mechanical and electrical engineering is a very critical part of highway construction as the construction of highways involves many links and is complicated. If the quality of mechanical and electrical engineering is poor, the safe use of highways will be impacted. The advantages of applying BIM technology in highway mechanical and electrical engineering are mainly reflected in the following aspects: The first aspect is visualization. Through the application of BIM technology, three-dimensional visual models of the project can be created, which helps to discover and eliminate hidden dangers in the project. The second aspect is simulated detection. Mechanical and electrical engineering for highways involve many disciplines. Before construction, the lines and equipment can be tested through simulated construction of each part to better optimize the construction plan [2]. Thirdly, BIM provides a guide for the construction process. BIM technology can be applied before and during the construction of mechanical and electrical projects. It can effectively guide the overall construction through the establishment of three-dimensional digital models.

3. Basic components of highway electromechanical engineering

The basic components of highway electromechanical engineering include a communication system, monitoring system, power supply system, lighting system, and toll collection system. The main components of each system are shown in **Table 1**.

Table 1. Composition of highway electromechanical engineering system

System name	Components
Communication systems	Communication pipelines, optical cables, cables, information transmission systems, digital switching systems, emergency communication systems, wireless communication systems, and power supplies.
Surveillance system	Meteorological monitoring system, vehicle detection system, surveillance system, optical cable, electrical cable, monitoring equipment and software, large screen system, and monitoring network.
Power supply system	Distribution equipment, power cables.
Lighting system	Lighting equipment, trunking, switches, and distribution boxes
Charging system	Lane entrance and exit equipment, toll collection equipment and software, IC card issuance equipment, surveillance systems, intercom and alarm systems, optical cables, electrical cables, and toll collection computer networks.

4. Effective strategies for applying BIM technology in highway electromechanical engineering

4.1. Optimizing mechanical and electrical engineering design drawings

BIM technology can be used to conduct in-depth and comprehensive analysis and processing of the parameters to optimize the design of the project. The amount of detail in the design drawing should be emphasized when designing highway electromechanical projects [3]. Parameters of highway construction mainly include the size, specification, material, function, and model of each mechanical and electrical equipment. Reliable and accurate data parameters should be used to ensure the accuracy of data model establishment, thereby better guiding the construction of mechanical and electrical projects.

The information involved in the engineering construction should be well-documented digitally, including

information like the construction progress, construction quality, and construction cost of each sub-item. It lays a good foundation for managing and controlling the construction quality, progress, and cost of the project [4].

When designing a highway electromechanical project, the actual conditions of the construction site should be investigated through site surveys. This forms the basis for optimizing the overall design, particularly focusing on the layout of pipelines for various electromechanical equipment [5]. Additionally, establishing three-dimensional models allows for comprehensive and detailed inspections of design drawings, enabling the identification of any inconsistencies or issues before construction begins and facilitating further optimization of the design drawings.

4.2. Strengthen the establishment of integrated monitoring system

It is necessary to establish integrated monitoring systems when applying BIM technology in highway electromechanical projects. On the one hand, through the application of BIM technology, the entire cycle of engineering construction could be monitored remotely. When establishing a digital video surveillance system, an open interface should be set up on the BIM platform to collect multiple types of data automatically [6]. On the other hand, the construction of highway electromechanical engineering is complex and challenging. Therefore, the integrated monitoring system should also include a personnel monitoring system. The personnel monitoring system should include a registration module for personnel entering the construction site, a personnel positioning module, a critical area monitoring module, and a daily management module. With this system, access to certain areas can be restricted. Once the system detects that a construction worker has entered a dangerous area, an early warning will be issued to prompt the worker to leave the area as soon as possible. This approach ensures the safety of mechanical and electrical engineering construction [7].

4.3. Applying BIM technology in project management

Through BIM technology, the uncertain factors that may hamper the construction process may be explored. This enhances the reliability of highway electromechanical construction, enables effective control of construction changes, and facilitates cost control, ensuring the economic viability of construction projects [8].

Next, by utilizing BIM technology, corresponding models for electromechanical engineering on highways are established. These models are used to verify and inspect various parameters of construction, the quality of construction materials, and the engineering structure, thereby ensuring the construction quality of electromechanical engineering.

Thirdly, utilizing BIM technology allows for the scientific simulation of the overall electromechanical engineering construction on highways. This involves visually analyzing the usage of various resources at different stages of construction and establishing a monitoring system to dynamically and in real-time monitor construction progress and quality. This approach enables the scientific control of construction progress and quality [9].

Finally, BIM technology is utilized to achieve coordinated management of electromechanical engineering construction on highways. Video clips can be used to visually demonstrate the entire construction process, facilitating clear communication and breaking down complex tasks. This approach enables the coordinated construction of various components, thereby avoiding instances of interference and obstruction.

4.4. Strengthening the application of BIM technology in resource control

Resource control is a critical element in the cost control of highway electromechanical projects. Mechanical and electrical engineering construction generally takes a long time and involves a large amount of data and many parties [10]. If resource control is done manually, the workload of the staff will be very heavy, leading to human

errors. With the help of the BIM platform, the planned consumption of workforce, material resources, and funds in each construction link of the electromechanical project can be analyzed. The planned consumption of various resources can be intuitively displayed using visual curve charts to guide resource control. Secondly, leveraging the query function of the BIM platform enables the comparison of actual consumption of manpower, materials, and funds during different construction periods with planned consumption, facilitating timely identification of discrepancies and enabling prompt corrective actions through resource control to ensure efficient utilization of all resources.

5. Cases of application of BIM technology in highway electromechanical engineering

5.1. General information of the project

The total length of a certain highway electromechanical project was about 346 kilometers, passing through multiple regions and serving as a major transportation route in the province. The total investment in the project was approximately 14 billion yuan. It was large in scale with a tight construction schedule. It traverses several ecological reserves, water reserves, and farmland. Additionally, the highway intersects with multiple local roads. Therefore, the requirements for the construction of the project are relatively high.

5.2. Building highway mechanical and electrical engineering models using BIM

There were two steps involved in building a model for this highway's electromechanical project, namely creating files and building models. In the file creation stage, it is important to establish basic rules for storing BIM models to ensure clear and precise storage. This includes naming folders according to basic rules, ensuring they not only include project numbers and information but also match the actual project names with the system-stored model names. This facilitates future information retrieval and use. In the actual model construction phase, two types of models were built: the comprehensive construction site model and the electromechanical engineering design model. The former includes aspects like construction sites, road conditions, on-site drainage, and equipment areas. The latter encompasses design drawings, design plans, and various parameters. Through the establishment of BIM models, the overall situation of the highway electromechanical project can be determined.

5.3. Applications of BIM technology

Firstly, BIM technology was used for clash detection. As the construction of highway electromechanical projects usually takes a long time and intersects many roads, clash detection can be implemented using BIM technology. A three-dimensional model of the pipelines and road intersection of the construction site could be established using the BIM software. This helps in testing pipeline collision situations and analyzing whether there are any issues with the design scheme, preventing potential problems during construction that could adversely affect construction quality and progress. When conducting clash detection for this project, both hard clashes, meaning solid objects intersecting in space, and soft clashes, where the distance between them is less than the standard distance, need to be considered.

Secondly, BIM technology was used for the progress management of this project. BIM allows the sectioning of construction content and the simulation of each part's construction process and material consumption. Based on this, the construction period of each construction link can be estimated. **Table 2** shows the construction cycle arrangement of the monitoring system in this electromechanical project.

Table 2. Monitoring system construction cycle schedule

Electromechanical system name	Construction link	Construction schedule (D)
Surveillance system	Optical cable laying and splicing	37
	Camera installation	87
	Switching installation	95
	Storage installation	73
	Management server installation	15
	Large surveillance screen installation	33
	Computer room equipment installation	31

Finally, BIM technology was used for cost management of this project. This project is relatively complex, with a tight schedule, and it also intersects many roads. BIM technology can be used to estimate project costs. By establishing models, simulate the allocation of resources in various construction stages to ensure the rationality of construction resource allocation and prevent wastage.

6. Conclusion

In summary, highway electromechanical projects involve a wide range of tasks, large quantities of work, and generally tight construction schedules. Moreover, with the continuous development of society, the requirements for highway electromechanical projects are constantly increasing. To effectively ensure the construction quality, efficiency, and rational control of construction resources, it is essential to keep pace with the times and strengthen the application of BIM technology. First, through the application of BIM technology, the electromechanical engineering design drawings are optimized to ensure the rationality of each content and avoid changes in the design during the construction process. Secondly, the implementation of integrated monitoring systems enables comprehensive oversight of construction sites and personnel, thereby ensuring orderly progress and personnel safety. Thirdly, adopting BIM technology facilitates construction management, ensuring both progress and quality. Lastly, through the application of BIM technology, resource control can be effectively executed, leading to enhanced utilization rates of resources.

Disclosure statement

The author declares no conflict of interest.

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