Original Research Article

Research on automated modeling of pier column formwork based on BIM technology

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Abstract: This paper explores the automated modeling method for pier column formwork based on Building Information Modeling (BIM) technology. By analyzing the existing design process of pier column formwork, a new automated modeling workflow is proposed to improve design efficiency and accuracy. The paper first introduces the application of BIM technology in pier column formwork design, followed by a detailed description of each step in the automated modeling workflow, including data input, model generation, model verification, and output. Finally, a case study demonstrates the practical application of the automated modeling process.

Keywords: BIM technology; Pier column formwork; Automated modeling; Design efficiency

1. Introduction

1.1. Background

As the construction industry continues to develop, there is an increasing demand for higher engineering quality and construction efficiency. Pier columns are critical structures in bridges and high-rise buildings, and their formwork design and construction quality directly affect the safety and stability of the overall project. However, traditional methods of pier column formwork design are often time-consuming, error-prone, and inefficient, creating a need for innovative technologies to enhance the design process.

1.2. Significance of the study

Building Information Modeling (BIM) has emerged as a promising solution for the construction industry, offering a means to manage the entire lifecycle of a building project. By integrating BIM technology into pier column formwork design, the design process can be made more efficient, accurate, and collaborative, reducing errors and the need for rework during construction.

1.3. Objectives and scope

This paper aims to develop an automated modeling method for pier column formwork using BIM technology. By analyzing the limitations of existing design workflows, this research proposes a new automated modeling process and verifies its effectiveness through a case study. The study evaluates the potential of automated modeling to improve design efficiency and accuracy in real-world engineering projects.

2. Literature review

2.1. Overview of BIM technology

Building Information Modeling (BIM) is a digital representation of a building's physical and functional characteristics. It provides a shared knowledge resource for information about a facility, forming a reliable basis for decision-making throughout its lifecycle. BIM integrates design, construction, and operational data into a

unified model, enhancing collaboration across project teams.

2.2. Current status of pier column formwork design

Currently, the design of pier column formwork primarily relies on traditional 2D drawings and manual calculations. This process is often inefficient and prone to errors. As the use of BIM technology expands, researchers have begun to explore its application in the design of pier column formwork, aiming to streamline the design process and enhance accuracy.

2.3. Development of automated modeling technology

Automated modeling, a key component of BIM technology, involves the use of algorithms and computer programs to automatically generate building models. Automated modeling has been widely applied in building, bridge, and infrastructure design, significantly improving design efficiency by reducing manual input and errors. However, the application of this technology to pier column formwork remains underexplored.

3. Research methodology

3.1. Research design

This study adopts a case study approach to investigate the effectiveness of an automated modeling workflow for pier column formwork based on BIM technology. The case study analyzes the application of this workflow in a real-world engineering project.

3.2. Data collection

Data were collected through literature reviews, expert interviews, and field observations. The collected data include geometric dimensions of pier columns, material properties, construction requirements, and relevant project documentation.

3.3. Automated modeling workflow design

The proposed automated modeling workflow consists of four key steps: data input, model generation, model verification, and output. Each of these steps is designed to improve the efficiency and accuracy of pier column formwork design.

3.4. Model verification

The accuracy and reliability of the automated models are verified by comparing them to actual engineering data. This comparison ensures that the models meet design specifications and can be effectively used in construction.

4. Automated modeling workflow design

4.1. Data input

The first step in the automated modeling process is data input. This step involves collecting and organizing all necessary information related to pier column dimensions, material properties, and construction requirements. BIM technology allows for the integration of this data into a unified model, facilitating efficient data management.

4.2. Model generation

Using BIM software, the collected data are automatically processed to generate a 3D model of the pier column formwork. This model includes all relevant geometric details and material properties, reducing the need for manual drafting and minimizing the risk of human error.

4.3. Model verification

After the model is generated, it is verified by comparing it to actual engineering data and design specifications. Any discrepancies between the model and the design requirements are identified and corrected, ensuring that the model is accurate and reliable.

4.4. Output and application

Once verified, the model is ready for application in the construction process. The 3D model can be used to guide the fabrication and assembly of the pier column formwork, improving construction efficiency and reducing the likelihood of errors and rework.

5. Case study

5.1. Case selection and background

For the case study, a typical bridge construction project was selected. This project involved the construction of multiple pier columns, providing a suitable context for evaluating the automated modeling workflow. The traditional design process used in the project served as a baseline for comparison with the automated modeling approach.

5.2. Application of automated modeling workflow

The automated modeling workflow was applied to the design of the pier column formwork in the case study project. The workflow streamlined the design process by automatically generating 3D models of the pier columns based on input data. These models were then verified against the project's design specifications to ensure accuracy.

5.3. Results and discussion

The case study revealed several advantages of the automated modeling approach. First, the automated workflow significantly reduced the time required for formwork design, compared to the traditional 2D drafting and manual calculation methods. Additionally, the automated models were more accurate, reducing the likelihood of design errors and the need for rework during construction.

However, the case study also highlighted some challenges associated with automated modeling. For example, the initial setup of the automated workflow required significant technical expertise and software customization, which may pose a barrier to widespread adoption. Furthermore, the cost of BIM software and training may limit its use in smaller projects.

6. Discussion

6.1. Advantages and challenges of automated modeling

Automated modeling offers several key advantages, including improved design efficiency, enhanced accuracy, and reduced risk of human error. However, the implementation of automated modeling also presents

challenges, such as the need for specialized software and technical expertise. Additionally, the upfront costs associated with BIM technology may deter its adoption in smaller projects.

6.2. Impact on traditional design processes

The introduction of automated modeling has the potential to significantly alter traditional design workflows. By reducing the reliance on manual drafting and calculations, automated modeling can improve both the speed and accuracy of design processes, leading to more efficient construction projects.

6.3. Future research directions

Future research could explore the application of automated modeling in a wider range of engineering contexts, such as different types of infrastructure projects. Additionally, further studies could investigate ways to simplify the setup and customization of automated modeling workflows, making them more accessible to a broader range of users.

7. Conclusion

7.1. Summary of findings

This paper investigated the use of BIM technology to develop an automated modeling workflow for pier column formwork design. By streamlining the design process and improving accuracy, the automated modeling approach offers significant advantages over traditional methods. The case study demonstrated the practical benefits of this approach, though some challenges remain.

7.2. Recommendations for the industry

To fully realize the potential of automated modeling, the construction industry should promote the adoption of BIM technology, particularly in the design of critical infrastructure components such as pier columns. By investing in BIM software and training, companies can improve design efficiency, reduce errors, and ultimately deliver higher-quality construction projects.

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