



APPLICATION OF BIM TECHNOLOGY IN PREFABRICATED CONCRETE BUILDINGS

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ABSTRACT

Currently, the cost of constructing precast concrete buildings in Russia is high compared to monolithic concrete structures, which to some extent hinders the widespread use of precast concrete buildings. However, BIM technology plays a significant role in reducing and controlling the cost of precast concrete buildings. This article analyzes the main reasons for the high cost of precast concrete buildings and proposes strategies for controlling their cost.

Key components of the cost of a traditional monolithic concrete structure include taxes, profit, direct costs, indirect costs, etc., of which direct costs constitute a significant portion and account for the largest share. The cost of precast building structures includes not only the cost of materials and labor, but also the costs of production, installation, and transportation of the assembled components, which are decisive factors in the cost of precast concrete buildings.

The main reasons for the high cost of precast concrete buildings

The reasons why the cost of prefabricated concrete buildings exceeded the established requirements at various stages were as follows:

Lack of rationality in separating precast components. Designers must consider the design of the precast element lifting point, the structural features, and the key requirements for subsequent transportation. They must utilize the drawings provided by the design institute, thoroughly study the component parts contained in the drawings, scientifically divide the dimensions of the precast elements, and avoid repeated dismantling, which would entail additional costs and expenses. At the same time, unnecessary dismantling will significantly increase the complexity of component transportation and structural lifting, further increasing construction costs.

Lack of standardized and unified standards for prefabricated components. Currently, standards for the production and design of prefabricated components are still imperfect, which could significantly reduce the production capacity of prefabricated building structures and lead to the production of overly homogeneous products. At the same time, since standards vary across companies, there are no alternatives, which also reduces the competitiveness of component production and prevents them from reducing prices. For this reason,

standardization of prefabricated component production is urgent and must be radically strengthened to reduce construction costs.

Lack of rationality in the construction hoisting program. Compared to monolithic concrete structures, the actual volume of work involved in installing precast elements is greater, and most of them are transported vertically. When performing actual lifting operations, the choice of tower crane solutions and the number of components can impact the actual construction cost. Regarding material costs, a significant portion of installation costs is attributed to connecting elements. The immaturity of installation technology and the acute shortage of qualified installation specialists will also significantly increase the cost of constructing precast buildings.

Cost control strategies for precast concrete buildings using BIM technology

The cost of constructing precast concrete structures is typically higher than that of monolithic structures, which is a significant issue. Understanding the difference between the costs of traditional monolithic construction and precast construction can help us identify the main reasons for the high cost of precast concrete buildings. In construction project management, BIM technology is an informative method applied at all stages of precast concrete building assembly to improve the production process of precast components, thereby improving design quality and reducing the cost of precast concrete buildings. The use of BIM technology for cost control in precast concrete buildings includes the following:

Application at the design stage

The structural design of precast concrete buildings is primarily based on the optimization of monolithic concrete structures, which is typically performed after the standard design work. The entire structure is analyzed as a whole, then the relevant components are broken down into their various components. Once the breakdown is complete, detailed design work is performed. The factory then carries out precast work based on the detailed design drawings and finally transports the precast elements to the construction site (Fig. 1).

On the construction site, if designers fail to review structural construction drawings and blindly separate them, numerous problems will arise, wasting significant communication time, requiring re-reviews of completed construction drawings, and significantly reducing construction efficiency. This fully reflects the inadequacy and limitations of the traditional approach to construction management. For this reason, BIM technology must be rationally applied to this process, focusing on the standardization of precast components at the initial design stage, meeting the construction needs of different buildings by using fewer component types and creating an ideal library of precast components, thereby realizing visualization, standardization, modeling, and other design processes, demonstrating significant benefits. This design approach consists of three main stages: developing a library of precast components, creating a BIM information model, and refining the BIM information model.

1) Creating a library of prefabricated components

The creation of a precast concrete component library aims to increase the versatility of precast concrete construction and standardize precast concrete construction. This will help improve the efficiency of conveyor construction and meet the requirements for various precast concrete building products.

The first step is to clearly understand the grid and elevation in the building design, then search for similar elements in the precast component library to meet the specific design

requirements. Finally, precast concrete elements not found in the precast component library should be developed based on an understanding of the specific requirements to increase the richness of the component library.

2) Development of a library of prefabricated components

After creating a library of precast elements, the precast concrete structures are laid out, resulting in a BIM information model for designing the assembled structure. In practice, modern software is often used to create groups of precast elements and modify parameters based on various design requirements, resulting in a BIM information model (Fig. 2).

3) Optimization of BIM information models

After the BIM information model is created, its structural safety and reliability are verified once again. BIM is used as an important management tool for constructing building structures in the form of 3D modeling, for thorough clash checking and identifying clash locations to prevent significant economic losses due to design errors. The component manufacturing plant is a crucial location for the production of precast components. Existing production management methods can effectively monitor the quality of precast components, but nodal inspection is a complex issue, as clashes and conflicts between reinforcement and connections must be verified using 3D modeling, which necessitates clash checking. After completing the structural analysis, the BIM model must provide proper guidance for the lifting and construction of precast concrete elements on site to avoid additional costs due to poor design.

Application at the production stage

Although many precast component manufacturing plants have been established in Russia, most have a low level of mechanization, and very little information technology software is used in the actual processing, making it difficult to control the cost and quality of precast components. BIM technology is parametric, visual, and modelable, and its effective integration with the production and processing of precast components can improve production efficiency and achieve cost reduction. Mold depreciation costs account for a significant portion of the cost of precast elements, and good mold design can not only reduce the amount of work and effectively save construction time, but also reduce construction costs. For this reason, the use of 3D BIM technology in mold design significantly simplifies the process and enables direct corrective verification of assembly modeling (Fig. 3).

When building a BIM model, information such as component materials and dimensions can be entered into the specified construction parameters to calculate specific material consumption in the BIM model and develop a daily production plan and steel processing volume plan. BIM technology can also be used to export rebar information, use CNC machines to bend and cut rebar, and then use the BIM-based design information to complete concrete vibration and pouring operations and automatically load the structure to be maintained into the maintenance room, effectively reducing costs and achieving the goal of hazard control at the outset.

Application at the construction stage

In the construction of precast concrete buildings, the intelligent use of BIM technology allows for the early identification of construction problems and the effective avoidance of potential construction risks, thereby minimizing construction costs.

1) Modeling of lifting files

During construction and lifting, heavy and bulky precast concrete elements should be installed manually whenever possible, and therefore require the use of cranes. In reality, the precision of lifting mechanisms does not meet the relevant installation requirements, leading to increased costs and an inability to effectively guarantee and monitor the construction process on site. For this reason, the construction crane modeling function in BIM technology can be used to improve the quality of precast concrete element installation. First, the placement of precast components is determined based on a well-designed BIM model of the building. Then, the entire precast component lifting process on the construction site is simulated based on the construction company's design plan. Finally, an animated video is shown to construction personnel on site to specifically alert them to potential problems and to optimize and improve the lifting plan.

Conclusion:

In general, the factors that contribute to high construction costs are reflected in the design, production, and construction stages of precast concrete building components. Therefore, the intelligent use of BIM technology can effectively address high construction costs and radically improve the production of precast concrete buildings, providing important technical support for reducing the cost of precast concrete buildings.

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