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Technical Management Strategies and Practices in Construction Project Management

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Abstract: This paper expounds the connotation of construction engineering technology management, including the core points and the application of related theories. Introduce the framework construction of the three-dimensional technology management system, emphasizing the PDCA cycle optimization technology solution and risk early warning. It also involves the application of technologies such as BIM at various stages, green construction technology management, technological innovation, and management in different cases, and finally points out the value of technology management strategies and future directions.

Keywords: Construction engineering technology management; PDCA cycle

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1. Introduction

Technical management in the field of construction engineering is a complex process that covers multiple aspects and has a critical impact on the quality, progress, and cost of the project. In recent years, with the continuous improvement of relevant policies in China's construction industry, such as the "Opinions on Promoting the Coordinated Development of Intelligent Construction and Building Industrialization" released in 2020, the importance of technological innovation and intelligence in construction engineering has been emphasized. Technical management includes core contents such as the formulation of technical standards, process optimization, and technological innovation, while combining systems engineering theory and full lifecycle management theory to construct a reasonable management system framework. On this basis, various technologies such as BIM technology and green construction technology have been applied from architectural design to construction stage, and their important role in engineering management has been demonstrated in different cases. These all reflect the important practical value of technical management in construction projects and the need for future development directions to closely follow policy guidance for innovation.

2. Theoretical framework for technical management of construction projects

2.1. Analysis of the connotation of technical management

In the realm of construction engineering, technical management embodies a comprehensive set of activities that are meticulously planned, organized, directed, coordinated, and controlled to ensure the seamless execution of various technical tasks. At its core, technical management is fundamentally concerned with the rational application and efficient implementation of engineering technology, with the ultimate goal of achieving the project's quality, schedule, and cost objectives. The formulation of technical standards serves as the cornerstone, providing a clear and unified reference for all construction activities by specifying the technical indicators and detailed specifications required during the construction process. Process optimization is another critical aspect, as it focuses on continuously refining construction techniques to enhance production efficiency, reduce costs, and ultimately improve the overall quality of the project. Moreover, technological innovation acts as a powerful driving force that propels the construction industry forward [1]. It encourages the adoption of new technologies, materials, and methods, thereby enhancing the competitiveness of enterprises and ensuring that construction projects remain technologically advanced and adaptable to the ever-evolving demands of the industry.

2.2.Theoretical support for project management

The theoretical support for project management in construction engineering is primarily grounded in two key theories: systems engineering and full lifecycle management. Systems engineering theory advocates for a holistic approach, emphasizing the importance of considering all elements and their interrelationships within a project. In the context of construction engineering technology management, this theory encourages managers to view the project as an integrated and complex system, comprising various components such as personnel, materials, equipment, and technology. By effectively organizing and coordinating these elements, managers can ensure the efficient execution of technical management activities, thereby enhancing the overall quality and efficiency of the project. On the other hand, full lifecycle management theory focuses on the entire project process, from initial planning and design to construction, operation, and eventual dismantling. This theory highlights the need for targeted technical decision-making and resource allocation at each stage of the project, ensuring that the technology used remains applicable and sustainable throughout its lifecycle [2]. By integrating these two theories, construction project management can achieve the maximization of comprehensive benefits, ensuring that projects are not only completed on time and within budget but also meet long-term sustainability goals.

3. Construction of technical management strategy system

3.1. Multi-dimensional management system construction

Constructing a multi-dimensional technology management system framework is essential for effective construction project management, and it involves three critical aspects: organizational structure, institutional processes, and resource assurance. In terms of organizational structure, it is crucial to clearly define the responsibilities and division of labor for each department. This ensures that technical management tasks are carried out in an orderly manner and fosters the formation of an efficient collaborative team that can work seamlessly across different functions. Regarding institutional processes, a robust technical management system and standardized procedures must be established. These should cover key aspects such as technical scheme approval, technical disclosure, and quality inspection, thereby ensuring that technical management is conducted in a standardized and normalized manner [3]. In the realm of resource assurance, the rational allocation of human, material, and financial resources is imperative. This includes ensuring the availability of a professional team of technical talents who possess the necessary expertise, providing sufficient technical equipment and materials to support project execution, and securing adequate financial investment to back technological research and innovation. By addressing these three dimensions comprehensively, the technical level and quality of construction projects can be significantly enhanced, ultimately driving the success of the entire project.

3.2. Dynamic control implementation path

In the technical management of construction projects, it is crucial to establish a dynamic optimization mechanism for technical solutions based on the PDCA cycle. In the plan phase, technical solutions are developed based on project objectives and actual situations, and key indicators and standards are set. During the Do phase, strictly implement technical operations according to the plan to ensure that all technical measures are fully implemented. During the Check phase, monitor and evaluate the effectiveness of technical implementation, compare actual indicators with preset standards, and promptly identify deviations and issues. In the Act stage, analysis is conducted on the problems identified during the inspection, and adjustment measures are taken to optimize the technical solution [4]. At the same time, lessons learned are summarized to provide reference for subsequent projects or the next cycle. This cycle is repeated to achieve continuous improvement of the technical solution. At the same time, a risk warning response strategy should be established to identify and warn of potential risk factors that may affect the implementation of technology. Effective response measures should be taken in a timely manner when risks occur to ensure the effective implementation of dynamic control in technology management.

4. Practice in key technology management field

4.1. Integrated application of BIM technology

4.1.1. Collision detection during the design phase

During the design phase, BIM technology's collision detection function holds immense significance. By creating accurate 3D building information models, it integrates various professional design details. Based on this model, it performs collision detection and analysis across disciplines like building structure, water supply and drainage, electrical, and HVAC systems. It can precisely identify spatial conflicts among different components, such as collisions between pipes and beams, and interference between cable trays and ventilation ducts. Detecting these issues early helps avoid construction phase problems like rework, delays, and cost overruns caused by design conflicts. This not only enhances design quality and construction efficiency but also strongly ensures the project's smooth progress. Additionally, BIM's collision detection helps optimize resource allocation and reduce material waste by identifying and resolving potential clashes in advance. This leads to more efficient use of resources and cost savings [5].

4.1.2.Construction phase progress simulation

During the design phase, BIM technology's collision detection function holds immense significance. By creating accurate 3D building information models, it integrates various professional design details. Based on this model, it performs collision detection and analysis across disciplines like building structure, water supply and drainage, electrical, and HVAC systems [6]. It can precisely identify spatial conflicts among different components, such as collisions between pipes and beams, and interference between cable trays and ventilation ducts. Detecting these issues early helps avoid construction phase problems like rework, delays, and cost overruns caused by design conflicts. This not only enhances design quality and construction efficiency but also strongly ensures the project's smooth progress. Additionally, BIM's collision detection helps optimize resource allocation and reduce material waste by identifying and resolving potential clashes in advance. This leads to more efficient use of resources and cost savings.

4.2. Green construction technology management

4.2.1. Application of energy-saving technology

The application of energy-saving technologies in green construction technology management is crucial in construction project management. By using efficient energy-saving lighting fixtures such as LED lights, the energy consumption of lighting on construction sites can be significantly reduced [7]. At the same time, plan the electricity consumption time and power of construction equipment reasonably to avoid unnecessary energy waste. In terms of heating and cooling, ground source heat pump technology can be utilized to fully utilize the characteristics of underground constant temperature, achieve efficient temperature regulation, and reduce dependence on traditional energy sources. In addition, by using energy-saving construction machinery and equipment, the optimized power system can reduce energy consumption while ensuring construction efficiency. The application of these energy-saving technologies not only helps to reduce construction costs but also enhances the environmental performance of building projects, in line with the concept of sustainable development.

4.2.2. Environmental monitoring system

The establishment of an intelligent monitoring and control system for noise and dust throughout the construction process is crucial for green construction. This system can monitor the noise and dust situation on the construction site in real time and accurately obtain relevant data [8]. Through smart sensors and other devices, it is possible to keenly perceive changes in environmental indicators and transmit data to the control center in a timely manner. Based on these data, the construction team can make reasonable adjustments to the construction activities. For example, when the dust concentration is too high, measures such as watering to reduce dust can be taken in a timely manner. Adjust the operation time or method of construction equipment when the noise exceeds the standard. This system helps ensure that the construction process meets environmental requirements, reduces adverse impacts on the surrounding environment and residents, and achieves the goal of green construction.

5. Engineering practice and effect verification

5.1. Super high-rise building case

5.1.1. Key technology applications

In the case of super high-rise buildings, intelligent monitoring of the formwork system and hydraulic climbing technology played a key role. The intelligent monitoring technology of the mold frame system installs sensors at key parts of the mold frame to collect real-time data on stress, displacement, etc., and transmits it to the monitoring system for analysis and processing [9]. This enables construction personnel to timely grasp the working status of the formwork, detect potential safety hazards in advance, and ensure construction safety. Hydraulic climbing technology provides a guarantee for the rapid and stable climbing of the mold frame. It has the advantages of fast climbing speed, high accuracy, and strong stability, which can effectively improve construction efficiency and reduce construction period. At the same time, this technology can automatically adjust the levelness and verticality of the formwork during the climbing process, ensuring the installation quality of the formwork and laying a solid foundation for the smooth construction of super high-rise buildings.

5.1.2. Management performance evaluation

By studying cases of super high-rise buildings, management performance is evaluated using indicators such as project duration reduction rate and cost savings rate. In terms of construction period, the reduction rate of construction period is calculated by comparing the planned construction period with the actual construction period. If the ratio is positive, it indicates that the management measures have achieved effectiveness in controlling the construction period [7]. In terms of cost, analyzing budget costs and actual costs to obtain a cost savings rate, a positive value also indicates effective cost management. For example, the original planned construction period for a super high-rise building was X days, but the actual construction period was Y days ($Y < X$), with a reduction rate of $(X–Y)/X$. In terms of cost, the budgeted cost is A yuan, the actual cost is B yuan ($B < A$), and the cost savings rate is $(A-B)/A$. These indicators intuitively reflect the effectiveness of management strategies in engineering practice.

5.2. Municipal bridge case

5.2.1. Construction technology innovation

In the case of municipal bridges, innovation in construction technology is crucial. Taking a large-span steel structure bridge as an example, innovative management has been carried out in terms of overall improvement technology. Adopting advanced hydraulic synchronous lifting system, the displacement and load of each lifting point are precisely controlled by computer to ensure the stability and accuracy of the steel structure during the lifting process. At the same time, the connection nodes of the steel structure were optimized and designed using a new high-strength bolt connection method, which improved the load-bearing capacity and reliability of the nodes. During the construction process, BIM technology was also applied to simulate and optimize the installation process of steel structures, identifying and resolving potential issues in advance. Through these technological innovations and management measures, not only has construction efficiency and quality been improved, but construction risks have also been reduced, providing strong technical support for the construction of municipal bridges.

5.2.2. Quality control system

In the quality control system of municipal bridge cases, the intelligent monitoring system for prestressed tensioning based on the Internet of Things has played a key role. The system collects various data during the prestressing process in real time through sensors, such as tension force, elongation, etc. These data are transmitted to the monitoring platform, and technicians can remotely monitor them in real-time. The system can automatically analyze data, determine whether the tensioning process meets the design requirements, and issue timely warnings if deviations occur. By accurately monitoring the prestressing process, quality problems caused by manual errors or non-standard practices are effectively avoided, ensuring the safety and stability of bridge structures. At the same time, the system can also store and trace data, providing a reliable basis for subsequent quality assessment and maintenance.

5.3. Industrial park case

5.3.1. Modular construction management

In the modular construction management of industrial park cases, the coordinated management of prefabricated component production and hoisting under the EPC mode is crucial. From the perspective of component production, it is necessary to accurately plan the production process and time nodes to ensure that the component quality meets the design standards. At the same time, reasonable production batches should be arranged according to the project schedule to avoid backlog or delays. In the lifting process, it is necessary to plan the lifting path and equipment selection in advance to ensure the accuracy and safety of the lifting. The construction team needs to cooperate closely, and the production department should provide timely component information to the lifting team. The lifting team should provide feedback on the on-site situation for production adjustments. Through this collaborative management strategy, construction efficiency has been effectively improved, construction cycles have been reduced, costs have been lowered, and the quality and efficiency of modular construction in the entire industrial park have been enhanced.

5.3.2. Smart construction site practice

In the practice of smart construction sites in industrial parks, the integrated application of AI video surveillance and personnel positioning systems has achieved significant results. Through this integrated system, real-time and precise positioning and behavior monitoring of construction site personnel can be achieved. The monitoring system, with the help of AI technology, can intelligently identify unsafe behaviors of personnel, such as not wearing safety helmets, and issue timely alerts. The personnel positioning system can accurately grasp the location information of personnel, facilitating reasonable scheduling and management. This integrated application not only improves the safety management level of construction sites, reduces the occurrence of safety accidents, but also enhances construction efficiency. Management personnel can optimize the construction process and arrange personnel operations reasonably based on the data provided by the system, ensuring the orderly progress of various engineering tasks and providing strong guarantees for the smooth progress of industrial park construction projects.

6. Conclusion

The technical management strategies in construction project management have important practical value. It can effectively improve the quality of engineering, ensure that the construction process complies with standards and specifications through the rational use of technical management methods, and enhance the quality and performance of buildings. At the same time, it helps to reduce construction costs, optimize resource allocation, and minimize waste. In the future, deep integration of intelligent construction technology is an important direction, which can achieve automation and intelligence of the building process. Optimizing the management decision model is also crucial, as it can improve the scientific and accurate nature of decision-making. In the context of digital transformation, the technology management system needs to continue to innovate to adapt to constantly changing market demands and technological developments, better serve construction project management, and improve the comprehensive benefits of projects.

Disclosure statement

The author declares no conflict of interest.

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