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Study on the Coordinated Management of Construction Project Schedule and Quality

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Abstract: This paper explains the goal conflict between schedule and quality in construction projects, including how schedule compression can lead to quality risks, and how quality control may cause delays. It analyzes the internal logic of collaborative management and influencing factors such as construction plans. The paper also introduces collaborative management methods, such as establishing a responsibility traceability system based on Work Breakdown Structure (WBS), and emphasizes the role of intelligent construction technologies and their future development directions.

Keywords: Construction project; Schedule and quality; Collaborative management

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1. Introduction

Against the backdrop of the continuous development of the construction industry, the "Guiding Opinions on Promoting the Coordinated Development of Intelligent Construction and Building Industrialization" issued by the Ministry of Housing and Urban-Rural Development in 2020 emphasized the importance of utilizing intelligent construction technology to enhance the management level of construction projects. The coordinated management of progress and quality in construction projects has become a key issue. There is a conflict of objectives between progress and quality, as on the one hand, compressing the construction period may affect quality, and on the other hand, quality control may lead to delays in progress. The coordinated management has inherent logical requirements, involving dimensions such as resource optimization and process system control. Factors such as construction organization design, BIM application level, and matrix-style project management architecture all have an impact on the effectiveness of coordinated management. Properly handling these relationships is crucial for achieving overall benefit enhancement in construction projects.

2. Dialectical relationship between construction project progress and quality management

2.1. Analysis of conflict between progress and quality management objectives

In construction projects, the conflict between progress and quality objectives is primarily manifested in two aspects. On the one hand, compressed schedules may lead to quality risks. When construction companies strive to meet tight deadlines, they may reduce necessary construction procedures or lower quality standards. For instance, insufficient curing time for concrete can affect its strength and durability [1]. On the other hand, quality control may cause delays in progress. Strict quality inspection and acceptance procedures take time, and if quality issues are discovered during the construction process, rectification can also delay the schedule. For example, a construction project may experience schedule delays due to the need to repurchase and reinstall steel bars that fail to meet quality standards [1]. These contradictory relationships arise from the dual constraints of progress and quality objectives in construction projects, as well as the game of interests among various parties.

2.2. The inherent logical requirements of collaborative management

The collaborative management of progress and quality in construction projects has inherent logical requirements. From the perspective of resource optimization and allocation, progress and quality mutually influence resource allocation. If progress is blindly pursued while neglecting quality, it may lead to excessive concentration of resources on rapidly advancing the project, only to result in rework due to quality issues in the later stages, thus wasting resources. Conversely, excessive focus on quality without reasonable scheduling may lead to resource idleness and waste. From the perspective of process system control, progress and quality form an organic whole. Any deviation in progress at any stage of the construction process may affect quality, such as an overly fast construction speed that may fail to meet the quality standards of construction techniques. At the same time, the emergence of quality issues will inevitably hinder progress, such as delays due to rectification of non-conforming quality. Therefore, collaborative management of the two is a necessary condition for effective resource utilization and smooth project progression [2].

3. Factors affecting progress and quality collaborative management

3.1. Factors in construction organization design

The rationality of the construction plan and the scientific nature of process coordination in the construction organization design have a significant impact on the effectiveness of collaborative management of progress and quality. The construction plan must comprehensively consider factors such as the characteristics of the project, resource allocation, and construction environment. An unreasonable construction plan may lead to frequent changes during the construction process, affecting the progress and potentially causing quality issues [3]. For example, if the selection of construction techniques in the construction plan is improper, it may fail to meet quality standards, and at the same time, may delay the construction period due to complex techniques or incompatibility with on-site conditions. The scientific nature of process coordination is equally crucial. Scientific and reasonable process coordination can ensure the continuity and efficiency of construction, avoiding situations such as work slowdowns and rework. If the process coordination is not tight, it may lead to delays in the previous process affecting the subsequent process, thereby affecting the progress of the entire project. It may also lead to neglecting quality due to hasty construction.

3.2. Technical management elements

The level of BIM application has a significant impact on the collaborative management of project progress and quality in construction. A higher level of BIM application enables efficient integration and sharing of building information, early detection of design conflicts and issues, and reduction of changes during the construction process, thereby effectively ensuring project progress and quality [4]. At the same time, the degree of adherence to process standards is also a key factor. Strict adherence to process standards during construction ensures the stability and reliability of construction quality. Good quality, in turn, guarantees the smooth progress of subsequent construction stages, avoiding delays caused by rework due to quality issues. The level of BIM application and the degree of adherence to process standards are interrelated and jointly contribute to the collaborative management of progress and quality.

4. Construction of a collaborative management mechanism for progress and quality

4.1. Organizational coordination mechanism

4.1.1. Matrix-style project management structure

The matrix-style project management framework serves as an effective means to achieve organizational synergy. In construction projects, this framework transcends the traditional boundaries of functional departments, integrating individuals from diverse disciplines into the project team. For instance, engineering technicians, quality managers, and schedule managers collaboratively form a joint management team. This framework facilitates close collaboration among professionals throughout the project implementation process, enabling timely communication on issues related to progress and quality. During the construction phase, engineering technicians can simultaneously relay technical issues that may affect quality and progress to other team members. Based on these feedbacks, quality managers can adjust quality control measures, while schedule managers can correspondingly optimize the schedule plan. Through this matrix-style framework, collaborative management of progress and quality is achieved, enhancing the efficiency and effectiveness of project management [5].

4.1.2. Dynamic responsibility allocation matrix

To construct a dual-dimensional responsibility traceability system for progress and quality based on the Work Breakdown Structure (WBS), a dynamic responsibility allocation matrix is required. Based on the WBS, the project work is decomposed in detail to clarify the responsible parties for each work package in terms of progress and quality [6]. The matrix presents the correspondence between different work packages and responsible parties, and this relationship should be dynamically adjusted as the project progresses. For example, at a certain stage of the project, the progress responsibility of a certain work package may be borne by the construction team, while the quality responsibility may involve the joint responsibility of the quality inspection department and the construction team. As the project progresses, the work content and focus change, and the responsibility allocation also changes accordingly, ensuring that progress and quality are always under effective control, with clear and traceable responsibilities.

4.2. Process coordination mechanism

4.2.1. PDCA cycle improvement model

In the collaborative management of construction project progress and quality, a process collaboration mechanism can be established based on the PDCA cycle improvement model. In the Plan phase, a detailed plan that includes progress and quality objectives is formulated, and key control points and standards are clarified. In the Do phase, construction is implemented according to the plan, while ensuring the effective execution of progress and quality measures. In the Check phase, a progress deviation warning and quality problem tracing system is established to promptly identify deviations and problems. The causes are analyzed to determine whether they are due to factors related to progress or quality, or the interactive effects of both. In the Act phase, measures are taken to address the problems, such as optimizing the construction sequence and strengthening quality control, before entering the next PDCA cycle to continuously improve the collaborative management level of progress and quality [7].

4.2.2. Critical path quality control method

In construction projects, quality control of the critical path is of utmost importance. This can be effectively achieved by developing quality risk pre-control techniques for key processes in the CPM network diagram. The CPM network diagram clearly presents the logical relationships and time arrangements of each process in the project, identifying the critical path. For key processes on the critical path, a comprehensive quality risk analysis is required. Scientific methods and tools, such as Failure Mode and Effects Analysis (FMEA), are used to predict potential quality issues [8]. Based on the results of the risk analysis, targeted pre-control measures are formulated. During the construction process, strict adherence to these pre-control measures is enforced, and the quality of key processes is monitored in real-time. Once quality deviations are detected, the construction plan is promptly adjusted to ensure that the quality of key processes meets the requirements, thereby safeguarding the progress and quality of the entire project.

5. Practice of collaborative application of technology management

5.1. Integrated application of BIM technology

5.1.1. 4D progress simulation and quality correlation

The 4D progress simulation of BIM technology enables the visualization of construction progress. Based on this, it can be integrated with quality acceptance standards in three dimensions, effectively enhancing the collaborative management level of construction project progress and quality. Through 4D progress simulation, the time dimension is combined with the 3D model to visually display the time arrangement and spatial layout of the construction process [9]. At the same time, various indicators in the quality acceptance standards are associated with corresponding components in the model, allowing construction personnel to clearly understand the quality requirements for each stage and each component during the construction process. This enables real-time self-inspection and rectification against quality standards as the construction progresses, avoiding schedule delays caused by quality issues and ensuring the accuracy and efficiency of quality acceptance, thus achieving collaborative management of progress and quality.

5.1.2. Collision detection and process optimization

In construction projects, collision detection and process optimization using BIM technology are crucial. By utilizing BIM models, virtual construction simulations can be conducted for building structures, electromechanical equipment, and other components, enabling early detection of collision conflicts between various disciplines [10]. By analyzing these collision points, construction teams can adjust the design scheme before actual construction, thus avoiding rework and delays during the construction process. Additionally, BIM-based process optimization allows for the reasonable arrangement of construction procedures. Based on the spatial relationships and construction logic within the model, the sequence and timing of each procedure can be determined, enhancing construction efficiency and quality. This BIM-based collision detection and process optimization achieves seamless integration from design to construction, providing strong support for the collaborative management of progress and quality in construction projects.

5.2. Real-time monitoring system of the Internet of Things

5.2.1. Automatic construction progress collection technology

In construction projects, real-time measurement of engineering quantities can be achieved through the deployment of RFID and smart sensing devices, thereby automatically collecting construction progress data. RFID technology automatically identifies target objects through radio frequency signals and acquires relevant data, which can be applied to material tracking, equipment management, and other aspects. It accurately records the usage and positional movements of materials during the construction process, reflecting the progress of related procedures. Smart sensing devices can detect changes in physical quantities such as temperature, humidity, and pressure, which are crucial for certain specific construction procedures. For example, during concrete pouring, monitoring the dryness of concrete through humidity sensors can infer the curing time and whether the corresponding procedures have been completed, providing a basis for accurate judgment of construction progress. The collaborative application of these technologies can effectively improve the automation level and accuracy of construction progress collection.

5.2.2. Dynamic feedback mechanism for quality data

In the dynamic feedback mechanism of quality data within the real-time monitoring system of the Internet of Things, it is crucial to establish a real-time uploading system for quality acceptance data based on mobile terminals. This system leverages the convenience of mobile terminals, enabling construction personnel to upload quality acceptance data in a timely manner on-site. Through real-time monitoring of various quality indicators during the construction process using IoT devices such as sensors, the acquired data is transmitted to the mobile terminal. Subsequently, the mobile terminal uploads this data to the server, which analyzes and processes it. This allows management personnel to understand the construction quality situation in real-time, promptly identify quality issues, and take measures to address them. Additionally, the system can store and analyze historical data, providing a quality reference basis for subsequent construction projects and contributing to the improvement of overall construction quality and management efficiency.

5.3. Empirical analysis of case projects

5.3.1. Collaborative management practice of super high-rise buildings

In the practice of collaborative management for super high-rise buildings, a comparative analysis was conducted on the progress compression rate and quality pass rate in the project. By collecting relevant data, we found that when the progress compression is within a certain range, the quality pass rate can be maintained at a high level. This is attributed to effective collaborative management measures, such as close communication and collaboration among various departments during the construction process, which promptly resolves emerging issues and avoids impacts on progress and quality. Meanwhile, the application of advanced technologies also plays a key role. For example, the application of BIM technology enables construction personnel to understand the difficulties and key points in the construction process in advance, thereby better planning the construction progress and ensuring the construction quality. These practical experiences provide valuable references for the collaborative management of super high-rise buildings.

5.3.2. Evaluation of collaborative management effectiveness

The fuzzy comprehensive evaluation method is employed to quantitatively assess the construction period saving rate and quality accident rate. By collecting actual data from case studies, relevant indicators for the construction period saving rate and quality accident rate are determined. For the construction period saving rate, the difference between the actual construction period and the planned construction period, as well as various factors affecting the construction period, such as construction efficiency and resource allocation, are considered. For the quality accident rate, attention is paid to the number and severity of quality issues that arise during the construction process, and statistics are compiled in conjunction with quality inspection standards. Subsequently, the fuzzy comprehensive evaluation method is used to construct an evaluation matrix, determine the weight of each indicator, and ultimately calculate the comprehensive evaluation result. This result can intuitively reflect the effectiveness of collaborative management in terms of construction period and quality, providing a reference and guidance for subsequent projects to further optimize collaborative management strategies and enhance the overall benefits of construction projects.

6. Conclusion

The collaborative management of construction project progress and quality is crucial. Its core mechanism lies in the rational arrangement of resources and processes, ensuring that the two promote each other rather than constrain each other. The implementation path includes clarifying objectives, formulating reasonable plans, and strictly monitoring execution. Intelligent construction technology brings new opportunities for collaborative management, as it can improve management efficiency and accuracy through automation and informatization means. On this basis, building a BIM+IOT smart site collaborative management platform is the future development direction, which can achieve real-time information sharing and interaction. The whole-process big data analysis can predict potential contradictions in progress and quality in advance, providing a basis for timely adjustment of management strategies, thus achieving collaborative optimization of progress and quality, and enhancing the overall benefits of construction projects.

Disclosure statement

The author declares no conflict of interest.

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