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Research on the Application of Information Technology in Modern Construction Project Management

Qinrong Zhang
Hainan Vocational University of Science and Technology, Haikou 571126, Hainan, China

Abstract: Against the backdrop of digital transformation, modern construction project management has an ever-growing demand for efficiency, quality, and risk control. This paper focuses on the application of information technology in this field and expounds on its significance in improving management efficiency, optimizing resource allocation, enhancing quality supervision, and strengthening risk early warning capabilities. It analyzes the current problems in technology application, such as insufficient depth and breadth of application, shortage of interdisciplinary talents, and imperfect data standards and security systems. Combined with practical application scenarios, targeted strategies are proposed from three dimensions: technology integration, talent cultivation, and security framework construction. This provides practical references for promoting the digital upgrading of construction project management and realizing the high-quality development of the industry.

Keywords: Information technology; Construction project management; BIM technology; Internet of things; Data security; Talent cultivation

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1. Introduction

As a pillar industry of the national economy, the construction engineering industry was undergoing profound changes in its management model along with the wave of digitalization. Traditional project management was relied on manual recording and experience-based decision-making, which has problems such as delayed information transmission, difficult data integration, and slow risk response. It is difficult to meet the development needs of large-scale and complex modern projects [1]. The application of information technology has provided a new way to solve these pain points. From the 3D visual management of BIM models to the real-time data collection of the Internet of Things, and then to the intelligent analysis and early warning of AI, information technology has penetrated into many links of engineering construction, materials, quality, and safety. Studying the application of information technology in construction project management can not only promote the improvement of management efficiency and quality but also inject impetus into the transformation and upgrading of the industry.

2. The significance of intelligent information technology in modern construction project management

2.1. Improving management efficiency and accuracy

In traditional project management, work such as drawing review, progress tracking, and data statistics mostly relies on manual operations, which are prone to information errors and omissions due to human mistakes. Moreover, cross-departmental information transmission requires multiple links and takes a long time [2]. Information technology can break this limitation. With the 3D model built by BIM technology, data from the entire process of design, construction, and operation and maintenance can be integrated. Design changes can be synchronized to all participants in real time, reducing communication costs. Progress management software automatically captures on-site construction data, compares and analyzes it with the planned progress, quickly identifies delayed nodes, and avoids delays and deviations caused by manual statistics.

2.2. Optimizing resource allocation and reducing costs

Construction projects involve various resources such as human resources, materials, and equipment. The traditional allocation method is prone to problems of resource idleness or shortage, resulting in cost waste. Information technology can realize dynamic resource allocation through big data analysis. IoT devices collect real-time data on material consumption and equipment usage status at the construction site. The system automatically generates resource demand plans based on the project progress, avoiding inventory backlogs caused by excessive material procurement or cost losses caused by equipment idleness. In addition, AI algorithms can optimize the scheduling of construction personnel and reasonably allocate personnel according to the human resource needs of different processes, reducing human resource waste [3].

2.3. Enhancing the level of project quality supervision

Project quality supervision needs to cover the entire construction process. In the traditional model, quality inspection relies on on-site inspections by quality inspectors, which has shortcomings such as limited inspection scope and delayed problem detection. Moreover, quality data is mostly stored in the form of paper records, making traceability difficult. Information technology can realize comprehensive and digital quality supervision.

Monitoring equipment based on image recognition technology can automatically identify quality problems such as wall verticality deviations and non-compliant steel bar spacing, and push early warning information in real time. Quality acceptance data is directly uploaded to the management platform through mobile terminals, forming traceable electronic files, which facilitates later quality traceability and analysis.

2.4. Strengthening project risk early warning and response capabilities

Construction projects face various risks such as geological disasters, construction safety, and schedule delays. Traditional risk management mostly relies on post-event handling and lacks forward-looking. Information technology can realize early risk warning through multi-dimensional data collection and intelligent analysis [4]. The AI video monitoring system can identify potential safety hazards such as construction personnel not wearing safety helmets and illegal high-altitude operations, and issue alarms immediately. The big data platform integrates meteorological and geological data, and combines with project progress simulation to predict the impact of natural disasters such as heavy rains and landslides on construction, and formulate response plans in advance.

3. Specific applications of information technology in construction project management

3.1. Intelligent construction management

BIM technology is the core tool of intelligent construction management. Its 3D visual model can integrate data such as engineering design, construction plans, and progress plans to provide accurate guidance for construction. In the construction preparation stage, virtual construction is carried out through the BIM model to simulate the installation sequence of components and the operation path of equipment, and identify conflicts between design and construction in advance, such as pipeline collisions and insufficient space, to avoid on-site rework. During the construction process, the BIM model is connected with the actual on-site construction data. The construction progress and quality inspection results are uploaded in real time through mobile devices [5]. The system automatically compares the planned and actual progress, generates a progress deviation analysis report, and guides managers to adjust the construction plan. In addition, UAV technology also contributes to construction management. UAV aerial photography is used to obtain panoramic data of the construction site, quickly generate aerial maps of the construction progress, intuitively present the construction progress of each area, and provide data support for multi-department collaborative management.

3.2. Intelligent material management

The Internet of Things technology provides a full-process tracking solution for material management. By pasting RFID tags or QR codes on material packaging, information such as the purchase time, specifications and models, and quality inspection reports of materials is recorded. When materials enter the site, staff scan the tags with mobile terminals to automatically complete material acceptance and upload data to the management platform, avoiding errors caused by manual recording [6]. During the material storage stage, the platform monitors the inventory quantity and storage location in real time. When the inventory is lower than the early warning value, it automatically generates purchase suggestions to prevent material shortages from affecting construction. During the material use process, the system tracks the flow of materials, records the material consumption in each construction link, compares the planned and actual material consumption, and timely detects material waste problems. Using big data analysis, the material purchase plan can be optimized based on historical material use data, reducing procurement costs and inventory pressure [7].

3.3. Intelligent quality management

Intelligent quality management based on image recognition and big data realizes the automation and standardization of quality inspection. In the concrete pouring process, high-definition cameras take real-time pictures of the pouring process. The image recognition algorithm automatically analyzes whether the concrete slump and pouring thickness meet the standards, and immediately notifies on-site managers when abnormalities are found. In steel bar construction, the AI system scans the steel bar installation images to detect the steel bar spacing, quantity, and binding quality, compares them with the specification requirements, and generates a quality inspection report, reducing the subjectivity and omissions of manual inspection [8]. During the quality acceptance stage, staff upload acceptance data and on-site photos through mobile terminals. The system automatically determines the acceptance result according to the preset acceptance standards and forms an electronic acceptance file, which is convenient for later quality traceability. The platform integrates quality data of various projects to form a quality database, providing data support for the quality optimization of subsequent projects and promoting the transformation of quality management from “post-event rectification” to “pre-event prevention”.

3.4. Intelligent safety monitoring

AI video monitoring and personnel positioning technology build a comprehensive safety monitoring network. AI cameras are deployed in key areas of the construction site to identify illegal behaviors in real time, such as construction personnel not wearing safety belts, illegal operation of large equipment, and non-standard temporary electricity use. After identification, an acousto-optic alarm is triggered immediately, and the early warning information is pushed to the managers’ mobile phones to realize real-time intervention of illegal behaviors. The personnel positioning system installs positioning chips on the safety helmets of construction personnel to track their positions in real time [9]. When personnel enter dangerous areas, the system automatically issues warnings. At the same time, managers can check the personnel distribution through the platform to ensure rapid evacuation in emergency situations. In addition, safety wearable devices such as intelligent safety helmets can monitor the physiological data of construction personnel, such as heart rate and body temperature, and give timely reminders when the data is abnormal to prevent sudden health risks.

4. Current situation of information technology application in modern construction project management

4.1. Insufficient depth and breadth of technology application

At present, most construction enterprises still apply information technology at a basic level and have not realized full-process and in-depth integration. In the application of BIM technology, most projects only use it for modeling and drawing review in the design stage, and do not extend it to the construction progress management, cost control, and operation and maintenance stages, so the technical value is not fully exerted [10]. Although some enterprises have introduced technologies such as the Internet of Things and big data, various systems operate independently, and data cannot be interconnected, forming information silos. In addition, the scope of technology application is limited to large-scale projects. Small and medium-sized projects still adopt the traditional management model due to cost considerations, resulting in an unbalanced overall informatization level of the industry.

4.2. Severe shortage of professional interdisciplinary talents

The informatization of construction project management requires interdisciplinary talents who not only master professional knowledge of construction engineering but also are proficient in information technology. However, the reserve of such talents in the current industry is seriously insufficient. Traditional project managers have rich on-site management experience, but their ability to operate and apply technologies such as BIM, the Internet of Things, and AI is weak, making it difficult for them to skillfully use information tools to carry out management work. Although information technology professionals are familiar with technical principles, they lack an understanding of the construction process and management needs of construction projects and cannot develop information solutions that are in line with the actual situation of the project.

4.3. Imperfect data standards and security systems

There is no unified data exchange standard in the industry. The data formats of different enterprises and different software systems are incompatible, resulting in difficulties in data sharing. The statistical standards of project management data in different regions and departments are inconsistent, making it difficult to realize data integration and analysis at the industry level. Data security risks are increasingly prominent [11]. Construction project management involves sensitive data such as project drawings, cost budgets, and personnel information. Some enterprises lack perfect security protection measures, and there are risks of data leakage and tampering. Moreover, due to the imperfect data backup mechanism, in case of system failures or natural disasters, data loss is likely to occur, affecting the normal development of project management.

5. Application strategies of information technology in modern construction project management

5.1. Promoting in-depth technology integration and system integration

To address the problems of insufficient technology application depth and information silos, efforts should be made in both standard formulation and technology integration. First, industry associations should work with leading enterprises to formulate unified data exchange standards, clarify the format requirements and statistical standards for BIM models, progress data, quality inspection data or more, use to realize data interconnection between different software and enterprises [12]. For example, specify the component classification and attribute definition of BIM models to ensure that model data can be directly imported into systems such as progress management and cost control.

In addition, promote the integrated application of BIM with technologies such as the Internet of Things, big data, and AI to build a full-process information management platform. In the platform, the BIM model serves as the core carrier, integrating on-site construction data and material consumption data collected by the Internet of Things. It optimizes the construction plan through big data analysis and realizes progress early warning, quality inspection, and safety risk identification with the help of AI algorithms. Enterprises are encouraged to customize the development of information solutions according to project needs, promoting the extension of technology application from the basic level to full-process management, covering the entire life cycle of project approval, design, construction, acceptance, and operation and maintenance.

5.2. Strengthening the cultivation and introduction of interdisciplinary talents

To solve the talent shortage problem, a dual-track model of cultivation and introduction should be established. Universities should optimize the curriculum system, add courses such as BIM technology application, Internet of Things and engineering management, and big data analysis to the construction engineering major. At the same time, interdisciplinary majors should be set up to cultivate graduates with dual knowledge backgrounds. Enterprises need to strengthen cooperation with universities, establish internship bases, and allow students to participate in the information management of actual projects to improve their practical ability. Regular training for in-service personnel should be organized, covering technical operations, system maintenance, data analysis, etc., to ensure that managers can skillfully use information tools. In terms of talent introduction, enterprises should formulate preferential policies to attract information technology professionals to join the construction industry, and at the same time recruit high-end talents with dual backgrounds in construction engineering and information technology [13]. By establishing a talent incentive mechanism, rewards should be given to teams or individuals who have performed well in technology application and innovation to stimulate the enthusiasm and creativity of talents.

5.3. Establishing and improving data standards and security frameworks

Improving data standards and security systems requires advancing from three aspects: standard construction, security protection, and emergency support. Enterprises should actively participate in the standard formulation work organized by industry associations, put forward suggestions based on their own project experience, and promote the implementation of standards. A data management specification should be established within the enterprise to clarify the processes and requirements for data collection, storage, transmission, and use, ensuring the accuracy and consistency of data. Data security protection measures should be strengthened, and encryption technology should be used to ensure the security of data transmission and storage. For example, the SSL encryption protocol is used for the transmission of monitoring data at the construction site, and encrypted hard disks are used for the storage of sensitive data. User permission management should be improved, access permissions should be divided according to job responsibilities, and a multi-level approval mechanism should be set up to prevent unauthorized access. Regular network security testing should be carried out, and professional security service organizations should be introduced to check system vulnerabilities and prevent hacker attacks and virus intrusions. In addition, a data backup and emergency recovery mechanism should be established, using a combination of local backup and cloud backup to regularly back up project management data. A data security emergency plan should be formulated, clarifying the handling process and responsibility division in case of system failures and data leakage, to ensure the rapid recovery of data and system operation in case of emergencies and reduce losses.

6. Conclusion

In conclusion, information technology has brought all-round improvements in efficiency, quality, and risk control to modern construction project management, and its importance has been widely recognized by the industry. Aiming at the current problems in the application of information technology, such as insufficient depth and breadth of application, talent shortage, and imperfect data standards and security systems, these problems can be gradually solved by promoting in-depth technology integration, strengthening the cultivation of interdisciplinary talents, and establishing and improving the data security framework. This will promote the transformation and upgrading of the construction engineering industry towards intelligence, efficiency, and greenization.

Disclosure statement

The author declares no conflict of interest.

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