

Analysis of Key Methods for Technological Innovation and Application in Construction Safety Management

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Abstract: *With the rapid development of the social economy, the process of urbanization is also constantly advancing. As a key pillar industry driving social and economic progress, the safety management efficiency of the construction industry is directly related to the safety of people's lives and property, as well as the harmony and stability of society. Security management is a comprehensive task involving multidimensional elements, which not only covers technological innovation, but also deeply touches on various aspects such as personnel quality improvement, management system improvement, and technology application integration. This paper will delve into the key methods of technological innovation and application in construction safety management, in order to provide effective safety management strategies for construction enterprises and improve construction safety and efficiency.*

Keywords: *construction; safety management; technological innovation*

1. Introduction

With the continuous leap of technology and rapid iteration of construction technology, construction safety management is facing unprecedented complex challenges and valuable opportunities. The traditional safety management paradigm has gradually shown insufficient adaptability to the current diversified and dynamic construction environment, and is difficult to meet the growing demand for safety protection. Therefore, actively exploring and applying technological innovation methods to optimize the safety management strategy system has become the only way to improve the intrinsic safety level of construction.

2. Analysis of the Current Situation of Construction Safety Management

Currently, construction safety management is facing several burning issues, including insufficient safety awareness among construction personnel, inadequate construction of safety management systems, and outdated safety supervision techniques. These issues are directly related to the high-risk situation of frequent construction accidents, which brings heavy personal injury and economic burden to construction enterprises and individuals. Therefore, innovating safety management strategies and optimizing safety management efficiency have become key issues that urgently need to be addressed in the construction industry, and have profound significance for promoting the professionalization and standardization of construction safety management.

3. Technological Innovation in Construction Safety Management

3.1 Introduction of Information Technology

3.1.1 Building Information Modeling Technology

Building information modeling (BIM) technology, with its powerful 3D visualization capabilities, has brought revolutionary changes to the field of construction safety management. By constructing a building information model, this technology can simulate various stages of the construction process in detail, thereby assisting safety management personnel in proactively identifying potential safety risks and hazards. This simulation based predictive security management method greatly improves the efficiency of identifying and solving security issues. In addition, BIM technology can refine, adjust,

and optimize construction plans based on simulation analysis results. By optimizing the construction sequence and improving construction techniques, the risk level during the construction process can be effectively reduced, ensuring smooth and orderly progress of construction activities.

3.1.2 Internet of Things Technology

The application of Internet of Things (IoT) technology in the field of construction safety management has achieved real-time monitoring and tracking of key information such as equipment conditions and personnel distribution on construction sites. By deploying a series of sensor networks and intelligent monitoring devices on construction sites, IoT technology can continuously collect and transmit diverse data from the construction site. These data are processed by advanced analysis algorithms, which can quickly reveal and respond to potential security risks, such as abnormal equipment operation, personnel violations, and other situations[1]. In addition, IoT technology also has precise real-time positioning capabilities, providing efficient personnel tracking and emergency evacuation methods for safety management personnel. This enables them to quickly locate personnel in emergency situations, ensuring maximum protection of the lives of construction site personnel.

3.1.3 Cloud Computing and Big Data Analysis

The integration of cloud computing and big data technology in construction safety management has empowered safety management personnel with excellent data processing and deep analysis capabilities. By systematically collecting massive safety data from construction sites and utilizing cloud computing platforms and big data algorithms for efficient analysis, safety management personnel can accurately grasp the safety situation of the construction site. These deeply analyzed data not only help security management personnel to keenly perceive potential security risks and hazards, but also provide reliable data support for formulating scientifically rigorous security management strategies. In addition, big data analysis technology can also reveal safety trends and patterns during the construction process, providing valuable experience reference and decision-making basis for the continuous optimization and future planning of construction safety management.

3.2 Promotion of New Construction Materials and Technologies

3.2.1 Application of high-strength and high-performance materials

With the continuous advancement of materials science and technology, a series of new building materials such as high-strength steel bars and high-performance concrete have been widely adopted and applied in the field of construction. These new building materials significantly enhance the structural safety level of buildings with their excellent mechanical properties and durability. Specifically, the introduction of high-strength steel bars endows buildings with stronger resistance to deformation and load-bearing capacity when subjected to external loads, effectively reducing the risk of structural failure. High performance concrete, with its outstanding compressive strength, impermeability, and durability, has laid a solid foundation for the long-term stable operation of buildings. By vigorously promoting and applying these high-performance building materials, we can further enhance the overall safety performance of buildings, extend their service life, and make positive contributions to promoting the sustainable development of the construction industry and enhancing social welfare.

3.2.2 Innovative Practice of Intelligent Construction Technology

The rise of intelligent construction technology has brought huge changes to the field of construction. The adoption of cutting-edge construction methods such as drone inspection technology and intelligent robot construction systems has significantly reduced the direct participation of personnel in high-risk operations, thereby significantly improving the safety level during the construction process. Drone inspection, with its efficient and accurate monitoring capabilities, can quickly identify potential safety risks on construction sites and provide real-time and accurate information feedback for safety management personnel. Intelligent robot construction replaces manual labor in dangerous or complex working conditions, effectively reducing the risk of personnel injury. The innovative practices of these intelligent construction technologies not only promote the dual improvement of construction efficiency and quality, but also play a crucial role in the safety protection of construction personnel[2].

3.3 Intelligent Security Management System

3.3.1 Intelligent safety helmet

As an important component of the intelligent safety management system, the intelligent safety

helmet integrates advanced sensor technology and precise positioning system, achieving real-time dynamic monitoring of the safety status of construction personnel. The built-in biometric sensor can accurately capture the vital sign parameters and movement status of construction workers, including emergency situations such as abnormal heart rate monitoring and fall detection. Once the preset safety threshold is triggered, the system will immediately activate the alarm mechanism. At the same time, the positioning module of the intelligent safety helmet can accurately record and track the geographical location information of construction personnel. In the event of an emergency, the rescue team can quickly locate the trapped personnel based on the location data, providing timely and effective rescue guidance and support. This real-time monitoring and rapid response intelligent function significantly enhances the safety management level and emergency response efficiency of the construction site.

3.3.2 Intelligent monitoring system

The intelligent monitoring and early warning system utilizes high-definition camera equipment and high-precision sensors to achieve comprehensive and blind spot monitoring coverage of the construction site. These monitoring devices can accurately capture subtle changes in the construction site, including information on the behavior patterns of workers, the operating status of mechanical equipment, and changes in environmental parameters. By utilizing advanced intelligent analysis algorithms, the system is able to automatically identify and label potential safety risk factors, such as operator violations, equipment failure warnings, etc., and immediately trigger warning mechanisms. This intelligent feature of comprehensive monitoring and risk warning enables safety management personnel to quickly locate and properly handle safety hazards, effectively preventing accidents from occurring[3]. At the same time, the intelligent monitoring and early warning system can also transmit real-time video streams and image data of the construction site, providing intuitive and detailed on-site information support for safety management personnel, and assisting them in making more scientific and accurate decisions and judgments.

4. Key methods in construction safety management

4.1 Strengthening safety management system

4.1.1 Establishing a comprehensive safety management system

Establishing a sound safety management system is the foundation for ensuring construction safety. This system needs to clearly define the responsibilities, authorities, and scope of responsibility of security management personnel at all levels to ensure the organization and efficient execution of security management work. Safety management work is actually a dynamic process of self adjustment and improvement, and the safety management department must strictly follow the principles of the construction safety management system to carry out a series of engineering management work. During the construction process, always adhere to the construction principle of safety first and prevention oriented. Enterprises need to develop a scientific and reasonable safety production responsibility system based on actual situations to provide guarantees for the safety of construction personnel. In addition, it is necessary to specify in detail the period, content, and implementation methods of safety inspections to ensure that all aspects of the construction process can be comprehensively and strictly supervised and inspected.

4.1.2 Strengthening safety education and training

Safety education and skill training are important ways to enhance the safety awareness and professional skills of construction personnel. Before the project starts, comprehensive and systematic safety education and training must be provided to all construction personnel to deepen their understanding of potential safety risks on the construction site and corresponding preventive measures. The training content should include basic theories of construction safety, detailed explanations of operating procedures, emergency response, and accident handling. In addition, it is necessary to regularly plan and execute safety drill activities, simulate real scenarios, and enable construction personnel to proficiently master the methods and skills of responding to emergencies in practical operations. By continuously strengthening safety education and skill training, the safety awareness and operational skills of construction personnel can be significantly improved, effectively reducing the probability of accidents and ensuring the smooth progress of the construction process[4].

4.2 Strengthening safety supervision and assessment

4.2.1 Establishing a sound safety supervision system

Building a comprehensive safety supervision framework is a key means to ensure the safety of construction sites. Construction units should establish professional safety supervision agencies or positions, responsible for regularly conducting safety inspections of construction sites, timely discovering and rectifying safety hazards. At the same time, it is necessary to establish an efficient information feedback mechanism to motivate construction personnel to actively report safety issues and hidden dangers, in order to ensure the breadth and timeliness of regulatory work. In addition, it is also important to strengthen communication and collaboration with external entities such as government regulatory agencies and industry associations to jointly promote the deepening development of safety supervision work. By building a comprehensive safety supervision framework, it is possible to achieve comprehensive control over the safety situation on the construction site.

4.2.2 Implementing a safety performance evaluation system

The safety performance evaluation system is an effective incentive mechanism that drives employees at all levels to actively engage in safety management work. By incorporating the effectiveness of safety management into the scope of organizational performance evaluation, it is possible to clearly define the responsibilities and goals of personnel at all levels in safety management, and take corresponding reward and punishment measures based on their achievement. Specifically, it is necessary to design detailed safety performance evaluation criteria and quantitative indicators, such as accident frequency, hazard rectification efficiency, safety training coverage, etc., and regularly evaluate the performance of personnel at all levels. Individuals and teams who have demonstrated outstanding performance in safety management should be commended and rewarded to stimulate their enthusiasm and innovation ability. Immediate corrective actions and punitive measures should be taken to address existing safety hazards or management omissions, in order to achieve a warning effect. By implementing a safety performance evaluation system, a positive atmosphere of "all staff paying attention to safety and all staff participating in safety management" can be created, promoting the continuous optimization and upgrading of safety management work.

5. Conclusion

Technical innovation is the key to improve the safety management level of building construction. By introducing information technology, popularizing new construction materials and technologies, building an intelligent safety management system and other innovative means, combined with key ideas such as strengthening safety management system and strengthening safety supervision and assessment, construction risks can be effectively reduced, construction safety level and efficiency can be improved, and a solid foundation can be laid for the sustainable development of the construction industry. In the safety management of building construction, the role of technological innovation is increasingly prominent. The introduction of information technology, such as BIM technology, Internet of Things technology, cloud computing and big data analysis, provides powerful tools for security managers. BIM technology simulates the construction process through three-dimensional visualization, identifies safety risks in advance and optimizes the construction plan; The Internet of Things technology can realize real-time monitoring of equipment and personnel on the construction site, discover potential safety hazards in time and provide emergency evacuation means; Cloud computing and big data analysis give security managers excellent data processing and in-depth analysis capabilities, providing solid data support for security management decisions. Popularizing new construction materials and technologies, including the application of high-strength and high-performance materials and the innovative practice of intelligent construction technology, has significantly improved the structural safety level of buildings and the safety factor in the construction process. New building materials such as high-strength steel bars and high-performance concrete enhance the deformation resistance and bearing capacity of buildings and prolong their service life; Intelligent construction methods such as unmanned aerial vehicle patrol technology and intelligent robot construction system reduce the direct participation of personnel in high-risk operations and reduce the risk of casualties. The intelligent safety management system, such as intelligent safety helmet and intelligent monitoring system, is constructed, which realizes real-time dynamic monitoring of the safety status of construction workers and comprehensive monitoring coverage of the construction site without dead ends. The built-in biometric sensor and positioning module of the smart helmet can give an alarm in time and provide rescue guidance in case of emergency; Intelligent monitoring and

early warning system uses high-definition camera equipment and high-precision sensors to automatically identify potential safety risk factors and trigger early warning mechanism. At the same time, strengthening the safety management system and strengthening safety supervision and assessment are also important measures to improve the safety management level of construction. Establish a sound safety management system, clarify the responsibilities and authorities of safety management personnel at all levels, strengthen safety education and training, and improve the safety awareness and professional skills of construction personnel; Establish a sound safety supervision system, implement a safety performance appraisal system, encourage employees at all levels to actively participate in safety management, and create a positive atmosphere of "all employees pay attention to safety and participate in safety management". To sum up, technological innovation is of great significance in the safety management of construction. By continuously introducing advanced technical means, combined with perfect safety management system and effective safety supervision measures, the construction industry can effectively reduce construction risks, improve construction safety level and efficiency, and realize sustainable development. In the future, with the continuous progress of science and technology, the field of construction safety management will usher in more innovative opportunities and challenges. We should actively explore and apply new technologies to contribute to the safe development of the construction industry.

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