Research on Optimization Paths for Safety Management at Construction Sites

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Abstract: Safety management at construction sites is a key link in ensuring the smooth progress of projects, the safety of personnel's lives, and the economic benefits of enterprises. This article deeply analyzes the existing problems in safety management at construction sites and proposes optimization paths from multiple dimensions such as system improvement, personnel management, technical means, and on-site environmental control. It aims to enhance the level of safety management at construction sites, reduce the incidence of safety accidents, and promote the safe development of the construction industry.

1.Introduction

The construction industry is one of the high-risk industries. Complex site environments, high mobility of workers, and diverse construction techniques lead to frequent safety accidents. Effective safety management can not only reduce casualties and property losses but also enhance corporate image and market competitiveness. Therefore, researching optimization paths for safety management at construction sites has significant practical importance[1].

2. Problems in Safety Management at Construction Sites

Safety management at construction sites faces numerous problems. Incomplete safety management systems lead to a lack of standardized guidance and strong constraints for management; weak safety awareness among personnel easily leads to behaviors such as violation of operating procedures; backward safety technical means make it difficult to effectively prevent and respond to safety risks; complex and changing on-site environments increase the difficulty and uncertainty of safety management. These problems are intertwined, seriously affecting the safety of construction sites and urgently requiring effective measures to resolve them[1].

2.1 Incomplete Safety Management System

In the construction field, safety management systems in some enterprises have serious flaws, becoming mere formalities and failing to effectively play their role in ensuring safety. These systems often lack precise targeting, not being formulated based on the enterprise's own business characteristics, project scale, and construction environment, leading to an inability to provide effective solution guidance when facing specific safety problems. Moreover, the systems lack strong operability, with provisions that are too general and vague, lacking clear specific execution standards and processes, leaving managers and construction personnel at a loss during implementation. The construction industry is constantly developing and changing, with construction environments and process requirements continuously updating. However, safety management systems in some enterprises are updated lagging behind, unable to adapt to these changes in a timely manner. Newly emerging construction risks and safety hazards cannot find corresponding control measures in existing systems, creating loopholes in safety management. More seriously, lax system enforcement is a common phenomenon[2]. Some personnel, for convenience or to rush progress, ignore system regulations, with failure to follow rules and violation of operating procedures being commonplace. Enterprises lack effective supervision and punishment mechanisms for such violations, severely weakening the authority and effectiveness of safety management and continuously increasing potential safety hazards.

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2.2 Weak Safety Awareness Among Personnel

Weak safety awareness among personnel at construction sites is an important root cause of safety accidents. Among construction personnel, migrant workers constitute a large proportion. Most of them lack systematic safety knowledge training, have insufficient understanding of potential dangers during construction, and have weak self-protection awareness. During operations, they often ignore safety operating procedures for the sake of convenience, with phenomena such as not wearing personal protective equipment and violating operating procedures occurring frequently. Some managers also lack sufficient understanding of the importance of safety work, holding the mistaken belief of prioritizing progress over safety. In their view, completing engineering tasks on time is the primary goal, and safety work is just a secondary task, optional. This mindset leads them to go through the motions in daily management regarding safety work, failing to effectively perform safety management duties, turning a blind eye to safety hazards on site, and failing to take timely measures for rectification. Furthermore, the current poor effectiveness of safety training and education is also one of the reasons for weak safety awareness among personnel[3]. Training content is often disconnected from actual construction situations, lacking relevance and practicality, and fails to meet the actual needs of construction personnel. Training methods are singular, mostly relying on classroom lectures, lacking interactivity and interest, making it difficult to stimulate the learning interest and proactiveness of construction personnel. This renders training a mere formality, unable to truly improve personnel's safety awareness.

2.3 Backward Safety Technical Means

With the rapid development of construction technology, new construction techniques and equipment continuously emerge, bringing higher efficiency and better quality to construction. However, the corresponding safety technical means have failed to keep up in time, leading to huge challenges for safety management at construction sites[4]. Some construction sites still use traditional safety management methods, relying mainly on manual inspections and experience-based judgment by managers to discover safety hazards. This method is not only inefficient but also prone to missed inspections and misjudgments, unable to comprehensively and accurately monitor the safety status of the construction site. Simultaneously, there is a lack of modern monitoring equipment. For instance, the operating status of large equipment like tower cranes and construction elevators cannot be monitored in real-time; safety indicators for high-risk sub-projects like deep foundation pits and high-formwork cannot be grasped timely, making it difficult to promptly discover potential safety risks.

2.4 Complex and Changing On-Site Environment

The environment of a construction site is extremely complex, filled with various dangerous factors, posing great difficulties for safety management. Construction sites typically have multiple dangerous working environments. For example, during simultaneous operations, different trades working in the same area can easily lead to accidents like being struck by objects or falls from height; during work at height, construction personnel face the risk of falling, and once a fall occurs, the consequences are often very serious; during hot work, if fire prevention measures are inadequate, it can easily cause fires and explosions. Moreover, construction sites are greatly affected by natural factors such as weather and geology. Adverse weather conditions like heavy rain, strong wind, and heavy snow can damage temporary facilities, scaffolding, lifting equipment, etc., on the construction site, increasing the possibility of safety accidents. Changes in geological conditions, such as earthquakes, mudslides, and landslides, also pose huge threats to construction sites.

3. Optimization Paths for Safety Management at Construction Sites

Addressing the problems in safety management at construction sites, optimization can be approached from multiple aspects. Improve the safety management system to provide a solid basis and standardized procedures for management; enhance personnel safety quality to strengthen their

safety awareness and operational skills; introduce advanced safety technical means to improve safety safeguarding capabilities and risk response efficiency; strengthen on-site environmental control to reduce safety risks brought by environmental factors. A multi-pronged approach can effectively enhance the level of safety management at construction sites[5].

3.1 Improve the Safety Management System

Construction enterprises building a sound safety management system is the foundation for ensuring safety and order on site. Based on relevant national laws, regulations, and standards, and combined with the enterprise's own scale, business scope, and construction characteristics, carefully formulate a comprehensive, scientific, and reasonable safety management system. This system needs to cover all links of the entire construction process, from personnel and equipment entry inspections in the preparation stage, to various operation specifications during construction, and to safety acceptance in the completion stage, all requiring clear and detailed regulations. Clarifying the safety responsibilities of personnel at all levels is the core point of the system. The enterprise responsible person, as the primary responsible person for safety production, needs to bear overall responsibility for the enterprise's overall safety work, plan safety management comprehensively, and provide necessary resource support; the project responsible person must fully be responsible for the safety implementation of specific projects, ensuring project construction meets safety requirements; full-time safety management personnel are responsible for daily safety supervision and inspection work, promptly discovering and correcting violations[6]. By signing safety responsibility letters, refine safety responsibilities layer by layer, implementing them to every post and every person, forming a responsibility network that is "horizontal to the edge, vertical to the end." And establish a strict safety responsibility accountability system. Once a safety accident occurs, based on the accident investigation results, hold accountable the relevant personnel according to laws and regulations to strengthen the safety responsibility of personnel at all levels and urge them to effectively perform their safety management duties.

3.2 Enhance Personnel Safety Quality

Personnel safety quality is a key factor in safety management at construction sites. It is crucial for enterprises to formulate comprehensive and systematic safety education and training plans. Conduct targeted safety education and training for different positions, such as special operations personnel (electricians, welders, scaffolders, etc.), ordinary construction personnel, managers, etc., combining the characteristics of various construction stages, such as foundation construction, main structure construction, and decoration finishing work. Training content should be rich and diverse, covering safety laws and regulations to make personnel understand their rights and obligations in safety production; safety operating procedures to ensure construction personnel master correct working methods; accident case analysis to make personnel deeply aware of the serious consequences of safety accidents through real cases; emergency rescue knowledge to improve personnel's emergency response capabilities in sudden accidents. In terms of training methods, use a combination of centralized training, on-site demonstrations, case analysis, and simulation drills. Centralized training can systematically impart safety knowledge; on-site demonstrations allow personnel to intuitively learn correct operating methods; case analysis can trigger deep thinking; simulation drills can enhance personnel's practical operation abilities and emergency response capabilities. Also, strengthen safety education and training for enterprise management and project management layers, improve their understanding of the importance of safety work, change the concept of prioritizing progress over safety, and enhance their sense of responsibility and mission in safety management. Regularly organize safety management personnel to participate in professional training and exchange activities, learn advanced safety management concepts and methods, continuously update their knowledge structure, and improve their safety management capabilities and level[7].

3.3 Introduce Advanced Safety Technical Means

With the continuous development of technology, introducing advanced safety technical means is an effective way to enhance the level of safety management at construction sites. Install various

intelligent monitoring equipment on the construction site. For example, tower crane safety monitoring systems can monitor the operating status of tower cranes in real-time, including parameters like lifting capacity, lifting height, and slewing angle, issuing warnings promptly when abnormalities like overload or tilt occur; deep foundation pit monitoring systems can continuously monitor displacement, settlement, and supporting structure stress of the pit, providing data support for pit safety; fall prevention monitoring systems for work at height can monitor the safety status of personnel working at height in real-time, preventing fall accidents. Connect monitoring equipment to a safety management platform through IoT technology to achieve remote monitoring and management of the safety status of the construction site. Managers can check real-time data and video feeds of the construction site anytime in the office or via mobile terminals, promptly discover safety hazards, and issue rectification instructions. Use VR and AR technology to conduct safety education training and simulation drills, providing construction personnel with a more realistic and intuitive safety experience. Simulate various dangerous scenarios on the construction site, such as fires, collapses, and electric shocks, through VR and AR technology, allowing construction personnel to operate and experience in a virtual environment, experience the entire process of an accident occurrence, thereby improving their ability to respond to emergencies and their safety awareness, effectively reducing safety accidents in actual construction.

3.4 Strengthen On-Site Environmental Control

Reasonable on-site environmental control is an important part of ensuring construction safety. Enterprises should scientifically and reasonably plan the layout of the construction site according to construction techniques and progress requirements. Clearly divide construction areas, office areas, and living areas, ensuring safe distances between areas to avoid mutual interference. Set up obvious safety warning signs and signs, such as "No Entry," "Beware of Falling," "Safety Passage," etc., to guide construction personnel and vehicles to pass safely, reducing accidents caused by misoperation or entering dangerous areas by mistake. Additionally, establish a strict material management system, classifying and storing materials on the construction site with clear identification. Different types and specifications of materials should be stored separately to avoid confusion; dangerous materials such as flammable, explosive, toxic, and hazardous should have special storage places with corresponding safety protection measures like fire prevention, explosion prevention, and poison prevention^\[8]^. Strengthen the management of material stacking, ensuring materials are stacked neatly and stably to prevent materials from collapsing and injuring people. Closely monitor weather changes and geological conditions, formulating corresponding emergency plans. When encountering adverse weather like heavy rain, strong wind, heavy snow, or geological disasters like earthquakes and mudslides, stop construction promptly, organize the evacuation of construction personnel to safe areas, and take effective preventive measures, such as reinforcing temporary facilities, drainage and flood prevention, etc., to ensure the safety of construction personnel and equipment.

4. Conclusion

Safety management at construction sites requires construction enterprises to start from multiple aspects such as system improvement, personnel management, technical means, and on-site environmental control, and adopt comprehensive measures for optimization. By implementing optimization paths such as improving the safety management system, enhancing personnel safety quality, introducing advanced safety technical means, and strengthening on-site environmental control, the level of safety management at construction sites can be effectively improved, the incidence of safety accidents reduced, and the safe, stable, and healthy development of the construction industry guaranteed. Meanwhile, construction enterprises should continuously explore and innovate safety management methods and models, adapt to the new situations and requirements of the construction industry's development, and make positive contributions to promoting the high-quality development of the construction industry.

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