

Research on Optimization Paths for Safety Management at Construction Sites

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Abstract: Safety management at construction sites is an important link to ensure the smooth advancement of projects, protect the safety of personnel's lives, and contribute economic benefits to enterprises. This paper deeply analyzes the current problems of safety management in construction sites and puts forward optimization paths from many aspects such as system improvement, personnel management, technical means and on-site environmental control. The objective is to improve the level of safety management at construction sites, prevent the occurrence of safety accidents and promote safe development in the construction industry.

1. Introduction

The construction sector is among the high risk industries. Frequent safety accidents are the product of complex site environments, high mobility of workers and diverse construction techniques. Safety management can reduce casualties and property loss, which can endanger the corporate image and market competitiveness. Hence, it is of great practical significance to study the optimization path of safety management at construction sites ^[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 issues are closely related to each other, seriously endangering the safety of construction sites, and need effective solutions.

2.1 Incomplete Safety Management System

In the construction field, there are great deficiencies (very formalistic in nature) of safety management systems in some enterprises putting them into the role of just a tool without being able to actualize their function. Such systems frequently lack specificity because they are not prepared according to their own set of business features, project sizes and construction conditions, so they cannot effectively guide the solution for specific safety problems at the time of need. Furthermore, the systems have poor operability, with too general and ambiguous provisions, as there are still no clear specific execution standards and processes for many issues, leaving managers and construction personnel unaware of what to do during implementation. The construction industry is dynamic where new trends are continuously emerging and areas in construction environments or process requirements are regularly updated. However, safety management systems in certain enterprises are lagging behind these changes and cannot keep up with the times. Yet in existing systems, there is no corresponding control measures for newly emerging construction risks and safety hazards, resulting in loopholes in the management of construction safety. More seriously, loose enforcement throughout the system is a general issue ^[2]. For some, convenience or urgency leads them to ignore system policies, regulations and unsafe conduct encompassing failure to follow safe practices and violation of operating procedures. 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.

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. In the process of production and operation, in order to avoid trouble or to seek convenience, they often ignore the use of safety operating procedures, resulting in frequent failure to wear personal protective equipment or violating operating procedures. Some managers also do not understand that safety work is important enough, operating under the misconception that safety must be sacrificed for progress. To them, the most important part of the job is to get engineering work done on time, safety work is merely a secondary optional task. This mentality has made them just perform daily management repeatedly in the aspect of safety work without effectively carrying out their responsibilities for safety management, ignoring existing onsite safety hazards and reactive actions not taken timely. In addition, the low effectiveness of safety training or education is also one of the reasons for personnel weak safety awareness^[3]. Reasons for the training limitations are that the content in general is often distant from real-life construction scenarios and it has poor relevance and practicality; therefore failing to meet with actual construction personnel needs. You are still carrying out a single method of training in the form of classroom lectures, which is dull and unreceptive, it is difficult to make construction personnel learn actively. That makes training a mere formality and isn't going to do anything to increase personnel safety awareness.

2.3 Backward Safety Technical Means

Because the construction technology develops quickly, the new construction methods and equipment continues to emerge are putting forward higher efficiency and better quality in housing decoration. But the corresponding safety technical means have been not keeping pace with time, bringing great challenges to the construction site safety management^[4]. Over the years, a handful of sites still applied conventional approaches to safety management; managers would predominantly rely on manual inspections and their personal experience-based judgments in detecting potential hazards. This method is not only characterized by inefficiency but also missed inspection and subjective judgment, which cannot monitor the construction safety status comprehensively and accurately. At the same time there are not enough modern observations devices. Taking the construction industry as an example, it is impossible to monitor the operation status of large equipment such as tower cranes and construction elevators in real time; high-risk sub-projects such as deep foundation pits and high-formwork have no safety indicators that can be grasped timely, which makes it difficult to discover potential safety hazards in a timely manner.

2.4 Complex and Changing On-Site Environment

A construction site is a very complicated environment in terms of diverse dangerous factors which leads to much difficulty within the safety management. There are many hazardous working regions in construction sites. 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 teach safety knowledge; on-site demonstrations allow staff to intuitively learn correct operating methods; case analysis can provoke deep thinking; drill simulations can enhance the practical operation skills and emergency response ability of staff. Strengthen safety education and training for enterprise management and project management layers, increase their understanding of the importance of safety work, abandon the concept that progress is above all else in safety work, improve the sense of responsibility and mission for safety production. Regularly organize the safety management personnel to participate in related professional training and exchange activities, learn advanced concepts and methods of safety management, constantly

update their knowledge structure, and improve their safety management ability and level ^[7].

3.3 Introduce Advanced Safety Technical Means

Due to the continuous development of technology, introducing advanced safety technical means is an effective way to improve the safety management level of construction sites. Deploy different types of smart surveillance devices on the construction site. As an example, tower crane safety monitoring system can monitor the real-time operation status of multiple operating parameters of tower crane, such as lifting capacity, lifting height and slewing angle at different points in time, and give warning signals in timely manner when abnormal situations such as overload or tilt occurred; Deep foundation pit monitoring systems can continuously monitor displacement settlement and supporting structure stress based on retesting data for deep foundation pits to provide exemption basis for deep foundation pit safety; Work-at-height fall prevention monitoring systems allow consistent long-distance online observation of helping personnel's safety status working at heights through various devices that live capture environmental reality to avoid falling accidents. Connect monitoring equipment wirelessly to a safety management platform via IoT technology for real-time remote monitoring and management of safety status at the construction site. In the office or via mobile terminals, managers can view real-time data and video feeds of the construction site at any time, quickly identify safety hazards and issue rectification instructions. Virtual reality and augmented reality technology is used for safety education training simulation drill, gives construction personnel a more realistic and intuitive sense of the safety experience. Utilized VR and AR technology to simulate different dangerous scenarios like fires, collapses, electric shocks on the construction site in a virtual environment where construction personnel could operate and experience it so as to practice the entire process of an accident occurrence, improve their ability to respond to emergencies, get familiar with and remember operation steps of equipment in case safety accidents happen during actual construction.

3.4 Strengthen On-Site Environmental Control

On-site environmental control is another essential aspect of construction safety. According to construction techniques and progress requirements, enterprises should layout the entire site regionally and reasonably. It is clear and strict division of construction area, office area, living area as three areas that need to be ensured separation, safety distance so that the operation of each area does not affect each other. Safety signs and signposting, such as "No Entry", "Beware of Falling", "Safety Passage" should be made prominent to guide the construction personnel for vehicles to pass safely, so that accidents caused by misoperation or mistakenly entering dangerous areas can be avoided. Create a strong supervision of the materials use, identify and store all of these on the construction site properly. Materials of various types and specifications should be stored separately to prevent confusion; dangerous materials, such as flammable, explosive, toxic and harmful substances should have individualized storage places with corresponding safety precautions for fire prevention ^[8]. Reinforce the stacking of materials to ensure that all materials such as wooden boards are stacked neatly and stably, so as not to cause collapse and injure people. Keep a close watch on changes in climate and geological situation, develop countermeasures to these weather conditions. If heavy rain, strong wind, heavy snow and geological disasters such as earthquakes and mudslides are encountered in the background of meteorological data, construction should be stopped immediately; relevant personnel were organized to evacuate to safety zones (safe areas) according to plans; accurate prevention measures shall be implemented through increased temporary facilities. Drainage floods, etc.) guarantee 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. As long as the optimization path is improvements to the safety management system, personnel security level of

quality and increase a new type of safe technical means, strengthen on-site environmental control, to improve construction site security management level in an effective way reduce the occurrence rate of safety accidents at construction sites guarantee that building industry secure stable and healthy development. On the other hand, construction enterprises should actively adapt to and explore the safety management method or model with continuous innovation around the new situation and requirement of construction industry's development, so as to serve for promoting the high-quality development of construction industry.

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