Analysis of Safety Risk Management in Construction Engineering Projects

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Abstract: As China's urbanization process continues to accelerate, the construction engineering scale is constantly expanding. For example, complex construction environments and multiple work processes have brought many safety risks and hidden dangers. Repeated construction safety accident and appropriate measurement not only put the life of the frontline workers under threat but also brings huge economic loss and negatively influences social harmony. In this article, the significance of safety risk management in construction engineering projects is examined and several safety risk management measures are suggested. It aspires to provide reliable guidance for construction engineering, ensuring the safety and progress of the project in a smooth process throughout all the stages during a construction project.

1. Introduction

The construction industry which is always a pillar industry in national economy, plays an important role in promoting social development and infrastructure construction. In recent years, from China's construction projects together to see, it is obvious that the development trend of "higher, bigger and more difficult" has been presented; There are more and more projects of the super high-rise building, large bridge and tunnel project, complex project venues, etc. At the same time, it will also lead to an increase in high-risk links in construction, such as working at heights, deep foundation pit excavation and lifting operations. This then increases the complexity and uncertainty of safety risks. Against this background, in-depth analysis of the importance of safety risk management in construction engineering and exploration of scientific and effective management strategies are of great practical significance.

2. The Importance of Safety Risk Management in Construction Engineering Projects

2.1 Ensuring the Safety of Construction Personnel

Construction personnel are the main force of construction engineering projects. Not only is their life safety the first precondition to implement successive engineering construction activities, but it directly reflects social equity, justice and humanitarian consideration in the domain of construction. Clearly, the construction environment is itself complex and full of dangers. Eg: As part of working at height if scaffolding is not established as specified, or PPE isn't donned in full then a fall risk can very easily arise. The opening up of controlled ground collapse risk in deep foundation pit construction, which is difficult to deal with and poses a direct threat to the life safety of construction personnel when support measures are not sufficient. The potential threats claimed the lives of workers and affect their health constantly. Utilizing systematic workflows, safety risk management can investigate dangerous links throughout the construction process in advance, accurately identify various kinds of safety hazards and formulate corresponding protective measures based on different types of risks [1]. Through multiple measures such as issuing safety-compliant PPE for operators working at heights, establishing protective facilities in dangerous areas, and dynamic monitoring of the critical links in construction to reduce the risk of relevant safety accidents occurring, a solid barrier can be erected to protect the lives of construction personnel.

2.2 Ensuring Smooth Project Progress

Construction engineering projects, by nature, are long-cycle and multi-link. You get a safety

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accident that leads to work stoppages, and it is just only a matter of time before this arc ends up in significant schedule delays and the bottom line bursting from cost overruns. In terms of schedule progress, after a safety accident occurs, the company is required to cooperate with departments in charge such as the public security department and fire department to investigate the cause and liability of the accident. The downtime measures according to the level of severity of the accident, it could cause an effect in local construction progress on short term or ideally pull off a project for a long time completely thereby thwarting original plan for construction [2]. From a cost control consequence, even in the phase of work stoppage, fixed costs are still handed through to the company which includes equipment rents and personnel salaries, as well as owner claims for delays. Additionally, the expenses of rescue activities and treatment for injured people, repair of damaged habitats, property losses plus those imposed on a company due to its potential faults or negligence, as well as further environmental remediation work prove to be extremely expensive in all civil engineering pipelines. If a safety diagnosis is carried out in advance, then there will be no hazards at the construction site and the effective control of these factors can assist in monitoring every step during the construction process so as to avoid physical harm from occurring. It can ensure that the project proceeds in a planned way and orderly, eliminate a series of unnecessary loss of cost, provide strong support for the economic benefits expected by the project.

3. Strategies for Safety Risk Management in Construction Engineering Projects

3.1 Conduct Comprehensive Risk Identification and Establish a Dynamic Risk Register

Identification of hazards is the first step in safety risk management and the basis for the rest of the work. Only clear understanding of the existence of these risks in various links of construction, can allow construction companies to ensure that subsequent control measures are really targeted and effective, avoiding surplus risk management. For construction companies, instead of using the past model that is a single department responsible for risk identification and mostly using checklists based on what risks have been found in other projects, it should use full participation & multi-dimensional investigation methods depending on actual scale/type/construction environment to identify risks. Various positions of people (including technical staff, construction workers, safety management personnel) should be organized to identify hazards from their own professional point of view to avoid omissions in risk identification. Before the project officially begins, professionals in a company should lead technology, safety and construction personnel to file all processes of the entire construction process according to core documents such as engineering drawings, geological survey reports、Construction planea e.t.c. for analysis and identification of potential risks [3]. Such as geological aspects of insufficient bearing capacity of soft soil foundation or unclear distribution of underground pipeline, technical aspects such as high operation difficulty of complex process or poor adaptability of new technology application, environmental aspects such as heavy rain leading to water accumulation, typhoon affecting work at height and management aspect including insufficient personnel allocation and imperfect safety system that need to be distinguished one by one. Risk identification cannot stop after you enter the construction phase. Such as daily on-site inspections by safety managers, daily pre-shift meetings reminding of risks by various teams, regular special actions for hidden danger investigation, to timely discover dynamic risks arising during construction. For example, component wear that accumulates after long-term use of lifting machinery, progressive aging of temporary power lines due to environmental influences or violation of operating procedures by construction personnel out of convenience all need to be recorded in real-time. Moreover, the company must set up a "Dynamic Risk Register", keeping record of all identified risks by category (new activity) to help clearly mark down the name of each risk and where it was initially rated as a risk, their accidents and consequences, that they can cause and clarify who in which department should control action [4]. The company must also regularly update the register content according to the progress of construction and environmental changes. For example, seasonal risks such as foundation pit water accumulation and slope landslides can be included before the rainy season; during the main structure construction phase, high-frequency risks

such as falls from height and being struck by objects should be tracked. Incorporating a dynamic risk register, which documents the full range of risks in construction and serves as an orderly guide for honest identification of potential risks for later evaluation and control.

3.2 Scientifically Implement Risk Assessment and Implement Graded Control Responsibilities

Risk assessment is the one after risk identification. It is the quantitative analysis of risk occurrence probability and damage degree based on the identified risks, which clarifies the risk level and provides a scientific basis for grade control in subsequent stages. Construction companies should apply a combination of qualitative and quantitative methods during risks assessments instead of using just one assessment model, which is no longer an adequate approach[5]. The expert scoring technique is used for qualitative assessment. It can invite professionals in engineering technology, safety management and emergency rescue to make an initial grade of the identified risk based on core indicators such as occurrence frequency, impact range and severity of harm. Typically, risks are categorized into three types: low, medium and high risk allowing for quick screening of type of risk that demands special attention. A quantitative assessment should be based on advanced mathematical models for risk evaluation, such as the matrix method of risk analysis & management or fault tree& event tree analysis method [5], historical accident data from the project site area as well as dataset of monitoring data from the current construction site to quantitatively deduct probability and loss potentials, which provides a precise, convincing estimation process on risk level. In addition, precise graded control is carried out according to the risk assessment level: for low-risk items, construction teams are responsible for timely dynamic monitoring and regular reporting of changes in risks to the project department; medium-risk items are undertaken by the safety management department of the project department in conjunction with the technical department to formulate special control plans and carry out weekly on-site inspections, adjusting control measures at any time; high-risk items need to be directly organized and supervised at a higher level from corporate headquarters, organizing expert demonstrations to optimize control measures, arrange personnel responsible for daily inspection work, ensure that risks can remain controllable. Simultaneously, the company should include risk control responsibilities into each position's performance appraisal system. Personnel who does not implement, resulting in the escalation of risk entities, should be criticized severely and have points deducted from their performance evaluation; so that control work can go deep down to every level with binding responsibilities without being formalism.

3.3 Introduce Advanced Technical Means to Achieve Real-Time Risk Monitoring

The integration of information technology in construction clearly has expanded the capabilities of traditional safety risk management, and also provides numerous advanced technologies such as IoT, BIM, and big data for effective solutions supporting the safety risk control process [6]. Construction companies should proactively respond to technological changes, apply the technologies in all aspects of the construction process, utilize real-time monitoring and intelligent early warning, through which the timeliness and scientificity of safety risk management can be improved. IoT technology enables construction companies to create smart supervision networks capable of real-time risk monitoring. Deploy sensors in key areas on the construction site Settle and displacement sensor for monitoring stability features and changes of deep foundation pit slopes; Moment limiters and tilt sensors applied to lifting machines keep track of equipment operating parameters; Current and voltage monitors for temporary power lines to detect circuit abnormalities in real-time. These sensors send that data wirelessly to a central management platform where it can be aggregated in real time. Management experts can view data dynamics at any time through the mobile APP and computer terminal; When the data in the platform comes to danger, which is more than its preset safety edge, it can automatically trigger alerts through SMS messages, pop-ups and other forms to remind relevant personnel of related problems in a timely manner so as to adopt corrective measures. BIM technology and big data technology can be the key technologies for risk visualization and predictive management. Through BIM technology, companies can create three-dimensional (3D) models of the project, clearly linking those elements where risk is identified

in the risk register with individual model components and highlighting risks at different levels by color rendering at three levels—high-risk areas (for example work-at-height platforms rendered red), medium-risk (for example temporary power distribution boxes are rendered yellow)—thereby improving managers' intuitive understanding of risk distribution automating targeted control plans [7]. Simultaneously, companies are able to apply big data technology by combining historical accident data from the location of the project with real-time monitoring data from the construction site, using algorithms to analyze patterns of risk evolution in order to identify trends in risk development.

3.4 Improve Emergency Mechanism Construction and Enhance Accident Response Capability

However, as the construction environment is complex, accident cannot be totally avoided even if scientific safety risk control can dramatically decrease its probability. This is why an effective emergency response mechanism needs to be put in place for handling sudden accidents, alleviating casualties and property loss. By systematically strengthening the emergency management capabilities of construction companies from three core dimensions: 1) Emergency plan development, 2) Emergency team building and,3) Reserve of emergency supplies. Companies shall develop emergency plan based on the characteristic of project risk into three-level plan system in technical aspect [8]. The full emergency plan describes the overall organization, method of response, and roles of the departments along with a framework for the local authorities. One is to compile special emergency plans for high-frequency and high-risk links such as deep foundation pit collapse or fall from height, and clearly stipulate the steps of rescue, technical solution and resource allocation methods, so that when conducting rescue operations in case of high-risk accidents, action can be taken according to established procedures.

On-site, the system describes the operating procedures for various positions and some common scenarios (e.g., scaffolding collapse or electric shock), which is an indication of what frontline personnel are empowered to do for immediate response after an accident. The training of emergency team building: the internal formation and external linkage Integrate the core construction personnel, technical basis of internal emergency rescue team. Holding regular drills: Prepare quarterly fire drills to enhance basic emergency capabilities, and hold semi-annual drill on collapses, falls and other rescue operations to test plan feasibility and strengthen coordination of rescue units. Meanwhile, set up routine collusion linkages with local or regional fire rescue departments and hospitals, elucidate linkage procedures in emergency responses, so as to mobilize external professional rescue forces quickly after accidents. The emergency supplies reserve should be set according to needs and with dynamic maintenance. Build an emergency warehouse on the construction site, which sorts and stores firefighting equipment, rescue devices, medical supplies and communication equipment. For special projects such as super high-rise buildings, it is better to set up emergency supply points on different construction planes and store portable first aid materials such as emergency lighting and escape ropes.

4. Conclusion

Normally, safety risk management in construction engineering projects is a systematic project which needs to take all aspects from the planning and construction of the project to its completion into consideration. By now, the construction context is becoming more and more complex, while safety risks are diverse and dynamic by nature. Traditional management mode of situation after accident rectification can not adapt to demand. It must move to a fully process risk management mode with prevention up front, control in-process, and management afterwards. From four perspectives including risk identification, risk assessment and control, technology application and emergency mechanisms, construction enterprises can realize the effective implementation of safety risk management and continuously optimize the safety risk management system to solidly help project construction units achieve zero accidents and zero casualties as per the safe production goal.

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