

# Exploration and Research on Safety Management Mechanism of Tower Cranes on Construction Sites

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## Abstract

**With the progress and development of society, construction projects are still on the rise, and the frequency of use of tower cranes is also increasing. However, due to its high risk of disassembly, transportation, and lifting, mechanical injury accidents occur frequently. This article analyzes in depth the risks of tower cranes throughout the entire process of transportation, installation, lifting, operation, maintenance, and dismantling, clarifies management priorities and objectives, and proposes targeted recommendations and measures to provide reference for similar lifting equipment.**

## Keywords

**Construction Site; Tower Crane; Security Management.**

## 1. Introduction

In recent years, with the continuous acceleration of urbanization in China and the continuous promotion of large-scale building construction projects, construction lifting machinery and equipment have become an important way to reduce labor force and improve production efficiency on construction sites. Their use has become increasingly widespread and their operations have become more frequent, making their position increasingly important. For tower cranes, they are highly favored by construction sites such as high-rise and super high-rise buildings due to their simple operation and wide applicability. However, due to the high level of danger during the installation, dismantling, and lifting of tower cranes, as well as the existence of blank interfaces and non performance behaviors in the management process, tower crane production safety accidents still occur frequently. It is urgent to improve the regulatory level through technical and management means.

## 2. Research on the Safety Status of Tower Cranes

According to the Notice on the Safety Status of Special Equipment in China in 2023 issued by the State Administration for Market Regulation, there were a total of 80 special equipment accidents and related incidents in China in 2023, resulting in 69 deaths. Among them, there were 20 crane accidents, resulting in 19 deaths, accounting for 28.17% of the total accidents and 27.54% of the total deaths. From this, it can be seen that the safety management situation of tower cranes is still severe, and the level of safety supervision still needs to be improved.

Due to its uniqueness, tower cranes do not come out of the site or be installed as a whole, but are disassembled into various parts for unified assembly before construction operations. Therefore, safety risks are prominent during the installation, dismantling, and transportation of tower cranes; For high-rise construction buildings, tower cranes are lifted with the increase of construction height, mainly through jacking. This activity is the most dangerous during the operation of tower cranes, and there are countless incidents of tower crane overturning due to unstable foundations and unstressed bolts. Meanwhile, during the process of lifting and

hoisting, factors such as improper operation and lack of management may cause lifting injury accidents.

Therefore, this article analyzes the status and construction risks of tower cranes, clarifies the key safety supervision objectives of such equipment, and develops the best handling measures for safety risks and potential hazards to avoid personnel injuries and economic losses caused by safety accidents.

### **3. Main Safety Risk Analysis of Tower Crane**

#### **3.1. Self State Risk**

The state risks of tower cranes mainly manifest in three aspects. Firstly, there are certain defects in the equipment of the tower crane when it leaves the factory. Due to factors such as manufacturers and production quality, tower crane equipment may have certain quality defects, safety performance that cannot meet on-site usage requirements, or safety hazards; Secondly, there are risks during the installation, disassembly, and lifting process. Due to the inability of tower cranes to achieve overall transportation and use, there are risks of equipment wear and collision during their installation, removal, and lifting processes; Finally, there are security risks that arise during the use of the equipment. The tower crane equipment itself is not owned by the construction enterprise, so most construction units carry out daily maintenance and upkeep of the equipment by entrusting third-party organizations or cooperating with equipment rental units. It is impossible to carry out equipment maintenance in a timely and timely manner, and there are time and space gaps, which cannot effectively eliminate the risks of equipment use; At the same time, daily maintenance carried out through cooperation may result in a mismatch between the residual value of equipment and operational safety risks, meaning that equipment that has exceeded its service life or is forced to be scrapped upon expiration is still in normal use.

#### **3.2. Equipment Management Personnel Risks**

Through literature review and online research on the current status of equipment management, it was found that some tower crane production and operation units in China do not attach importance to mechanical equipment management in the production process. They optimize the number and departments of equipment management technical personnel through streamlining institutions, compressing staffing, and other methods, resulting in weak equipment management personnel, most of whom have part-time jobs, a serious decline in safety supervision, and a blank management responsibility interface. In addition, although some enterprises have clearly defined their management personnel and institutions, they lack scientific and effective management systems and process standards, resulting in ineffective equipment management and a lack of effective safety system guarantees for tower cranes.

#### **3.3. Environmental Risks**

Mainly reflected in the environmental impact during the use of tower cranes. Especially during periods of poor working conditions such as strong winds, heavy rain, foggy and snowy weather, and external overhead power lines, failure to promptly identify hazardous factors during the lifting process may result in collisions between the crane arms of nearby tower cranes and contact with high-voltage power lines; At the same time, rainy, snowy, and windy weather can also cause certain damage to the equipment itself and operation, accelerate equipment corrosion, increase operational resistance, and significantly reduce the safety performance of tower cranes during operation.

In addition, when there are adverse environmental factors, they can also pose certain hazards to tower crane operators, such as electric shock.

### 3.4. Security Management Risks

The management level risks mainly manifest in three aspects. Firstly, there is the risk of equipment entry and exit management. Construction companies tend to focus solely on economic benefits, construction progress, and other factors, neglecting the safety performance testing and acceptance of tower cranes when they enter the site, and failing to consider the impact of equipment safety performance after entering the site. At the same time, special construction plans for tower crane installation, dismantling, and lifting are superficial and cannot match the actual construction site conditions. Safety control measures cannot be effectively applied, and the safety risks of equipment installation, dismantling, and lifting operations are further exacerbated; Secondly, there is a shortage of equipment professionals and special operation personnel, and some of them have low professional quality. In recent years, the imbalance of technical vocational education levels has led to a lack of skilled personnel such as senior professional technicians who cannot match the actual needs of construction machinery professionals. Some enterprises hire equipment management personnel from frontline workers or other non related professionals who often participate in management based on traditional management ideas and concepts or narrow personal experience, resulting in low quality equipment management personnel and weak maintenance capabilities that cannot meet the needs of safe use; In addition, there is a shortage of special operation personnel, and the training of special operation personnel organized by the construction administrative department cannot meet the market demand. Criminals produce and sell fake certificates, disrupting the market environment and leading to the repeated prohibition of holding fake certificates or personnel certificates that do not match; Finally, the inadequate investigation and management of safety hazards in mechanical equipment. Enterprises implement project management, and some projects only focus on rushing construction progress, emphasizing economic benefits, without conducting daily or special inspections. The behavior of only using equipment without maintenance is not timely discovered and rectified. Although some hidden dangers are raised in a timely manner, due to insufficient attention, they are not rectified in a timely manner, resulting in machinery operating with problems and violating regulations, causing economic losses to the enterprise, and leading to lifting injuries or mechanical injury accidents.

## 4. Solution Measures and Suggestions

Based on the main problems in the current safety management of tower cranes and combined with the actual situation of the construction site, this article proposes suggestions and measures for tower cranes from both technical and management perspectives.

### 4.1. Strengthen the Risk Control of the Equipment Itself

Establish and improve the equipment entry and exit management system, standardize the acceptance management process standards. Before the tower crane enters the site, it should be jointly inspected by the equipment management personnel of the construction unit and the subcontracting unit. The safety management personnel should supervise and clarify the relevant documents and materials such as qualification certificates, operation team or personnel qualification certificates required for equipment installation and dismantling. After passing the review and on-site inspection of the equipment, it can enter the site for installation, dismantling, lifting and other related construction activities.

At the same time, it is necessary to improve the equipment management system and mechanism as soon as possible, match the current actual situation of equipment management, establish a multi-party cooperation mechanism between construction units, third-party testing

agencies, and equipment rental units, standardize the daily maintenance process and responsibilities of tower cranes, reduce safety risks, and timely eliminate hidden dangers.

#### **4.2. Increase Control Over Equipment Technicians**

Construction units, third-party organizations, and equipment rental units should strictly implement national, provincial, and municipal laws, regulations, and industry standards, improve their own equipment management organizational system, and equip equipment management organizations or departments as needed, as well as complete equipment management technical personnel; At the same time, clarify the internal equipment management process standards and work together to improve the effectiveness of equipment management.

#### **4.3. Strengthen the Risk Control of Equipment Operating Environment**

Strictly implement the requirements of the Level 6 wind control standard, and prohibit the use of tower cranes with Level 6 wind and above; At the same time, the distance requirements between the tower crane and the high-voltage transmission line should be met. The distance between any part of the tower crane and the overhead transmission line should meet industry standards, and effective safety protection measures should be taken. In addition, power backup power can be added to prevent sudden power outages and ensure that the tower crane can unload and complete the hook retraction action; According to the actual situation, rotation limit and amplitude limit can also be set to avoid the travel of the crane trolley crossing high-voltage lines and transformers as much as possible.

If the safety distance between the equipment and obstacles does not meet the requirements, according to the actual situation on the construction site, the tower crane can be raised above the surrounding buildings and their construction equipment by attaching walls, reducing the arm, and other methods to achieve free rotation and ensure safety.

#### **4.4. Improving the Effectiveness of Security Control**

(1) Clarify the safety management responsibilities of management personnel and operators at all levels such as construction units, third-party testing agencies, and equipment rental units, clarify safety operation procedures, systems, and other related guarantees, highlight technical control parameters, standardize the safety behavior of relevant personnel, and ensure their own safety.

(2) Timely conduct safety inspections. Based on the actual situation on site, implement the frequency and requirements for regular and irregular equipment inspections, clarify the key inspection points for the equipment itself, such as tower crane foundation connections, standard section quality and connections, lightning protection and grounding, components, wire ropes, drum hoisting rigging, and electrical systems.

(3) Conduct safety training and briefing. Provide safety education and training for various technical personnel involved in the installation, disassembly, lifting, operation, and maintenance of tower cranes, with a focus on clarifying the risks and control measures associated with each operational activity; At the same time, conduct safety technical briefing for relevant personnel upon entry, clarify technical control parameters and requirements, and ensure that construction meets the requirements.

(4) Do a good job in emergency management. Based on actual needs, prepare emergency response plans for accidents, equip emergency rescue teams and personnel, reserve emergency supplies, and conduct regular training and drills to ensure timely response, rescue, and deployment.

(5) Promote information security supervision. By utilizing smart construction site systems, AI intelligent recognition, camera monitoring and other related intelligent equipment, the entire

process of tower crane operation monitoring and management can be achieved, timely discovering hidden dangers such as personnel operation errors and obstacles, and ensuring operation safety.

## 5. Conclusion

In summary, this article analyzes the risks of tower cranes themselves and their operation processes, clarifies specific solutions and suggestions, and provides guarantees for the operation of tower cranes.

(1) Based on the inherent risks of the equipment, establishing and improving the equipment entry and exit management system, clarifying the acceptance standard process, and promoting collaboration between different units can effectively reduce such risks.

(2) In response to the risks faced by technical personnel, we have established a sound and comprehensive equipment management organizational system, clarified internal equipment management process standards, enriched the strength of equipment management personnel, and effectively improved the effectiveness of equipment management.

(3) Based on the potential risks in the work environment, industry standards and specifications are used to clarify safety technical parameters, manage equipment risks, and optimize the implementation of technical requirements between adjacent equipment and facilities.

(4) In response to risk management, a dual prevention mechanism is established through institutional safeguards, risk identification and hidden danger investigation and governance, safety education and training, and disclosure activities, as well as information monitoring technology, to form a multi-faceted safety control mechanism and improve management quality and efficiency.

## References

- [1] Feng Chaoliang Maintenance and Safety Management of Tower Cranes for Construction Projects [J]. Ju She, 2023, (24):126-129.
- [2] Anran Analysis of Safety Hazard Management and Control Measures for Tower Cranes in Construction Machinery [J]. Public Standardization, 2024, (22):86-88.
- [3] Xu Fa thought On Safety Management of Tower Cranes on Construction Sites [J]. China Residential Facilities, 2024, (07):103-105.
- [4] Zong Liang Analysis of Installation and Management Technology of Tower Cranes [J]. China Equipment Engineering, 2024, (12):243-245.
- [5] Lu Yi Safety Analysis of Tower Cranes in Construction Engineering [J]. Engineering Machinery and Maintenance, 2022, (06):29-31.
- [6] Hu Pan Analysis of Tower Crane Installation and Demolition Technology and Safety Management Countermeasures [J]. Engineering Construction and Design, 2024, (02):209-211.DOI:10.13616/j.cnki.gcjsysj.2024.01.266.
- [7] Wen Chuanshi Analysis of Safety Accidents and Discussion on Preventive Measures for Tower Cranes [J]Technological Innovation and Productivity, 2023, 44 (09): 66-69
- [8] Chen Wei, Wang Liying, Yang Jie, etc Research on the Causal Network Model of Tower Crane Accidents Based on Association Rules [J]. Journal of Safety and Environment, 2023, 23 (04): 1161-1168. DOI: 10.13637/j.issn.1009-6094.2021.2075
- [9] Rongsheng Safety hazards and preventive measures in the installation and operation of tower cranes [J]. Urban Building Space, 2022, 29 (S2): 883-884
- [10] Chen Xianliang Exploration of Application Examples of Fine Management in Safety Management of Tower Cranes in Construction Projects [J]. Construction Workers, 2022, 43 (07): 44.