# Risk Evaluation Index System in Construction Stage of High-Rise Building Project

**Xinyi Teng**
*Liaoning Chengshi Engineering Management Co., LTD, Jinzhou, Liaoning, China*

**Abstract: The people's livelihood and infrastructure of a country are inseparable from construction. As urban land density increases and land in the core area becomes increasingly scarce, there are higher number of high-rise and super high-rise projects, so the difficulty of project construction is growing, and the risk is gradually increasing. This paper gives the principle of constructing the risk evaluation index system for the construction phase of high-rise building projects. It analyzes the steps that should be followed in constructing the evaluation index system, and based on this, constructs an overall framework for the risk evaluation of the construction phase of high-rise building projects, and builds up a risk assessment system for the construction phase of the project. The high-rise building construction process is labor-intensive, has a harsh environment, has operational difficulties, and is one of the most accident-prone industries. Therefore, it is necessary to establish a complete risk evaluation system for the construction of high-rise buildings.**

**Keywords: Risk Evaluation; Index System; Project; Construction**

## 1. Introduction

The construction project is an engineering system which involves many aspects and fields, and it will identify risks in the entire process of project construction. The first step of risk evaluation and research in construction phase of the project is risk identification, which is the basis of risk control, risk evaluation and response. How to better conduct risk assessment is an essential part of risk identification. Risk assessment is the systematic analysis of the risk factors of the project and the ranking of the proportion of the total objective of the project according to the risk factors of each construction project [1]. Through the systematic analysis of each risk factor, measure the proportion of each risk factor, to evaluate the risk of construction phase comprehensively and systematically. According to the result of risk identification, the Risk Evaluation Index of construction project is analyzed systematically and comprehensively, and the evaluation level and risk grade of the project are determined. The construction of high-rise buildings involves a wide range of big engineering projects. The safety management work in the implementation is extremely complex and cumbersome. To effectively carry out the safety management work, a variety of factors are considered in the comparison and in-depth analysis. To choose a set of indexes that can reflect the key issues can also be a simple and practical system, which has an important practical significance [2].

## 2. The Basic Principles of Building Risk Assessment Index System

### 2.1 The Construction of the Safety Management Index System

Although there are several factors affecting the risk in the construction of high-rise buildings, what needs to be focused on are those risks that will lead to casualties or damage to mechanical equipment. Through the safety management index system, the focus of safety control can be placed on the risks that are likely to lead to casualties and damage to large-scale mechanical equipment, to achieve a targeted approach.

### 2.2 Appropriately Allocate the Limited Material and Human Resources

The benefits generated by the risk evaluation management work are intangible, so the construction unit's investment in risk management is extremely limited. It is necessary to appropriately allocate the limited material and human resources to focus on the

 

main risks that may cause accidents [3].

In the process of creating the index system, to make it scientific and reasonable while being in line with the practical scenarios of the construction site, the following basic principles should be followed -

(1) Scientific. Creating the evaluation index system, such that the factors that lead to risk and uncertainties in the construction of high-rise buildings are accounted for in the indexes.

(2) Systematic. Means that the selected indexes have a strong integrity and uniqueness.

(3) Comprehensiveness. Means that the index system must reflect all the major problems that may cause casualties or damage to machinery and equipment, in all stages and segments of high-rise construction.

(4) Representativeness. It is critical to the establishment of the index system that the indexes represent all critical factors that pose risks to the construction of high-rise buildings.

(5) Operability. After determining the index system, this paper must also determine its corresponding weight, so each index system should be comparable. As for some uncertain and fuzzy factors, it is necessary to use the evaluation method combining quantitative and qualitative to clarify its meaning and quantify it as much as possible, so that it is operable.

## 3. The Steps of the Construction of the Index System

There are several factors that affect the risk of the construction phase of high-rise building projects. To obtain the main risk factors faced in the construction process, we must obey certain methods and steps, specifically according to the following - As shown in Figure 1.


**Figure 1. The Method of Index System Construction**

### 3.1 Determine the System

Define the construction environment in which the high-rise building under study is located, its own strength and available resources, and the difficulty of the construction of the project in all phases. Determine the construction work tasks and objectives.

### 3.2 Investigation and Collection of Information

By consulting information regarding the risks associated with the construction phase of the high-rise building project and analyzing the gathered data, personally observe the risk assessment work during the construction phase of the high-rise building project in the field.

### 3.3 Selection of Accident Analysis Methods

Based on the collected data, information, and the current situation of the high-rise building to be constructed, integrate the risk management personnel's own experience and available resources to select the most efficient analysis method.

### 3.4 Analyze Common Risk Incidents based on the Perspective of High-rise Buildings

Analyzing common risk incidents at a high level allows us to identify the most fundamental reasons for the occurrence of accidents.

### 3.5 Identify and Filter out the Key Indicators that Contribute to High-Risk Accidents

From the risk factors mentioned in (4), choose the primary risks that result in casualties or significant damage to machinery and equipment [4].

### 3.6 Categorize

Categorize each risk into specific categories.

## 4. The Method of Index System Construction

Analyzing risky accidents and screening and analyzing indices is a complex and cumbersome task. To ensure it is both reasonable and comprehensive, the following methods can be applied.

### 4.1 Empirical Analysis Method

Risk management personnel involved in numerous high-rise building construction projects have encountered various risk situations. Drawing from their own risk

 

evaluation experience, they can conduct an initial analysis of the primary risk indicators in the construction process.

### 4.2 On-Site Observation Method

By observing personnel status, equipment operation, safety protection facilities arrangement, and weather conditions at the construction site, potential risk factors can be promptly identified. This, of course, necessitates that observers are well-acquainted with the construction site and possess knowledge of safety production and construction technology.

### 4.3 Safety Checklist Method

A pre-designed safety checklist is employed for on-site inspection. The checklist serves the purpose of assessing whether there are any safety hazards present on the construction site.

### 4.4 Accident Tree Analysis Method (ATA for Short)

Accident analysis involves a layered examination of the original cause of an accident until the root cause is identified [5]. Subsequently, the analysis of the original cause and the associations between them are depicted in a logical tree diagram.

### 4.5 Causal Analysis Diagram Method

Observing the graphical method involves evaluating objects and their influencing factors, as well as illustrating the associations between these factors.

## 5. High-Rise Building Project Construction Phase Risk Identification

### 5.1 Risk Identification Concept

Risk identification involves analyzing potential risk factors and accident-inducing elements that may exist in the actual production process. It aims to predict the extent of accident damage, ultimately enhancing the level of risk control and providing a foundation for production management. The focus of risk identification is on key production activities, encompassing human factors, materials, facilities, technology, and environmental elements. By addressing risk identification at its source and applying a systems engineering approach, potential risk factors can be formulated, and trigger conditions can be reasonably analyzed [6]. Compliance with relevant laws, regulations, and production standards is essential to determine the necessity of implementing appropriate measures to control identified risk factors. [7].

Risk identification is an essential foundational task for risk evaluation and a focal point in the risk assessment process. In the construction of high-rise building projects, activities often involve high-rise operations, contributing to increased risks at the construction site periphery. The variety of tasks performed frequently involves cross-operation scenarios, and the extensive use of machinery and equipment, coupled with challenges in pit processing, introduces a range of complex issues. Under these construction conditions, risks exhibit dispersion and dynamics, persistently manifesting throughout the construction process, thereby complicating the identification task. Nevertheless, a thorough and reasoned analysis is crucial for effective high-rise building risk identification, as it forms the basis for subsequent evaluation and control efforts.

### 5.2 High-Rise Building Project Construction Phase Risk Identification Content

According to the statistics from the Ministry of Housing and Construction regarding high-rise building construction accidents, the primary types of accidents are collapse and lifting injuries, among others. In line with the risk identification concept, the initial step to ensure the smooth progress of high-rise building projects is to identify the critical risks in construction, as depicted in Table 1.

Through risk identification, the primary risks in the construction phase of a high-rise building project emerge from 14 aspects. These include construction personnel, on-site commanders, leaders, and decision-makers, machinery and equipment, safety protection facilities, large-scale vertical lifting machinery construction, work at height, scaffolding formwork projects, deep pit construction, safety management system, construction scheduling, natural environment, construction environment, and living environment.

In summary, these aspects can be categorized into five groups: personnel, equipment, technology, management, and environmental

 

factors [8]. In comparison with other construction projects, the risks associated with high-rise building construction not only stem from personnel, equipment, and environmental factors but also emphasize specific operational aspects, such as the installation and dismantling of large cranes, scaffolding and formwork installation and dismantling, and deep foundation pit support. Therefore, particular attention should be given to the identification of technical management measures.**Table 1. Contents of Risk Identification in Construction Stage of High-Rise Building Project**

| Identify the angle | Details |
|---|---|
| Personnel factors | Construction personnel, on-site command personnel, leading decision-making personnel |
| Equipment factors | Mechanical equipment, edge protection facilities and equipment, large vertical crane construction |
| Technical measures | High-altitude formwork engineering, scaffolding engineering, Deep Foundation Pit Construction |
| Management factors | Risk management system, construction deployment |
| Environmental factors | Natural Environment, on-site construction environment, living environment |

By conducting literature research and expert surveys, the scope of risk categories was expanded. Nineteen risk factors were carefully selected, leading to the establishment of a comprehensive risk evaluation index system for the construction phase of high-rise building projects.

## 6. The Framework of the Index System

The creation of the risk evaluation index system for the construction stage of a high-rise building project represents a subsequent phase in project risk assessment. The system's target level is focused on the risks associated with the construction stage of high-rise building projects. To establish this target level, primary indices influencing the analysis of the project's construction phase are considered. Through the identification of accident types and associated risks in the construction phase of high-rise building projects, these risks are categorized into several key aspects, as illustrated in Figure 2.

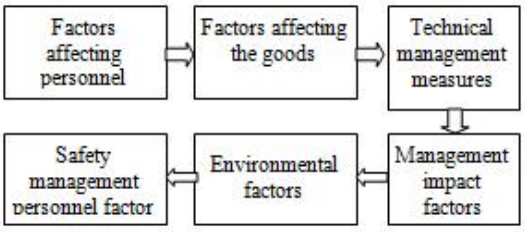


**Figure 2. High-Rise Building Project Construction Phase Index System Overall Framework**

### 6.1 Personnel Influence Factors

In many cases, the primary factor triggering the incident is often the improper behavior of personnel, and this holds true for high-rise building projects during the construction phase. The causes of staff unsafety can be broadly categorized into two aspects. Firstly, it originates from site operators, where certain staff members may not be suitable for the operation due to psychological, physiological, or other factors, or they may lack the specific requirements for the construction occupation. Some construction staff may not have received adequate training in production safety technology, leading to low personal literacy and weak safety awareness. In such cases, when potential hazards are identified, poor subjective judgment and an inability to respond promptly can easily result in major accidents. Secondly, it arises from management personnel. When managers lack awareness of risk prevention or exhibit a negative attitude, they may struggle to identify potential risks. In some instances, enterprises assign on-site managers without the appropriate qualifications, leading to rule violations during organization and coordination, which can also contribute to safety accidents. The emphasis on safety by leaders and comprehensive safety management practices across all aspects also significantly influences safety management.

### 6.2 Objects Influence Factors

Conditions affecting the construction of large and medium-sized high-rise building projects broadly encompass constraints related to mechanical equipment and safety protection devices. In the construction of large and medium-sized high-rise buildings, a

 

substantial amount of construction machinery and equipment is utilized. When this equipment is in an unsafe condition, it poses a heightened risk of fire accidents. Unsafe conditions of machinery and equipment may arise due to technical issues inherent to the equipment itself, prolonged operation without maintenance and repair, and other construction-related problems. The unsafe condition of machinery and equipment not only increases the likelihood of accidents but also poses a significant threat to overall production. Proximity guards also play a crucial role in safety protection [9]. However, their effectiveness in preventing accidents or reducing accident hazards diminishes significantly if they are not installed in accordance with regulations.

### 6.3 Technical Management Measures Factors

The construction process of high-rise buildings is influenced by numerous factors, and particular attention should be given to the key technical factors affecting construction safety to enhance management efforts. Special consideration is needed for large vertical transportation devices, as their improper installation and operation may lead to significant safety accidents. The treatment of deep foundation pits is crucial for the safety of subsequent construction, demanding strengthened measures to ensure safety during the construction stage. Similarly, scaffolding and formwork construction, often conducted at significant heights, pose elevated risk factors, requiring a higher intensity of safety management measures compared to low-level construction. The rational design of each construction technology and the level of control over the construction process also play a pivotal role in preventing and mitigating risk events.

### 6.4 Management Influencing Factors

Management influencing factors are evident on two fronts. Firstly, they are reflected in the completeness of the enterprise safety management system, the implementation of the production safety responsibility system, the rigorous enforcement of safety inspections, and the provision of safety education and training for workers. A robust system serves as an effective guarantee for safety management. Secondly, these factors are reflected in the management of construction deployment [10]. This includes determining whether the enterprise's safety management system is comprehensive and whether it aligns with the objective conditions. Notably, the arrangement of different types of cross-functional work and the allocation of personnel in different construction phases require careful and rational consideration.

### 6.5 Environmental Impact Factors

Construction projects typically take place in open-air environments, and high-rise building projects, given their extended construction periods, are particularly susceptible to the influence of geographic and weather conditions. Adverse conditions at the construction site, including harmful gases, dust, and noise, can adversely affect the physical and mental well-being of operators, increasing the likelihood of various safety accidents. The safety and civilization standards implemented at the construction site also play a pivotal role in construction outcomes. Disorderly and cramped work sites, the haphazard disposal of production and living waste, and challenging construction environments can negatively impact the psychological and physiological health of workers, potentially leading to accidents.

### 6.6 Safety Management Personnel Factors

The allocation of security inspectors can be appropriately adjusted based on the size of the project, allowing for the timely detection of security risks and a significant reduction in project-related risk factors.

## 7. Conclusions

It is evident that safety serves as the foundation for the successful implementation of any project. Comprehensive consideration of risks and their elimination before production is crucial to ensure the smooth progress of a project. This is particularly pertinent for high-level projects. High-rise projects inherently possess characteristics such as labor intensity, challenging construction environments, and complex operations, making them prone to frequent risk accidents. Given the complexity of high-rise buildings, construction difficulty is heightened, emphasizing the prominence of risk issues in

 

the construction process. Establishing a comprehensive project risk assessment system becomes imperative under these circumstances.

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