ISSN 2522-3488 Vol. 6, Issue 4: 1-9, DOI: 10.25236/IJNDES.2022.060401

Classified Management and Control of Construction Safety Production Risks

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Abstract: *The construction industry has developed rapidly in recent years and has become an important pillar of the national economy. While the construction industry is booming, the safety management in the industry has not been greatly improved. The accident rate and death rate in the construction industry are second only to the transportation and mining industries. We still have a long way to go to do a good job in the safety management of the construction industry. Safety production management is not to rectify problems that have developed into safety hazards, but to prevent the occurrence of safety production accidents in advance through more effective measures. Based on the current development status of the construction industry, this paper studies the construction of a hierarchical management and control system for safety production risks in construction enterprises, so as to block the possibility of safety production accidents and reduce the incidence of safety accidents. With the continuous progress of social science and technology, the production organization form of the construction industry is also constantly changing. The research on the safety production management system in the construction industry should also be based on the actual development of the industry and enterprises.*

Keywords: *Construction companies, Safety management, Accident prevention, Risk classification management and control system*

1. Introduction

Since the construction industry is a labor-intensive industry, the safety of employees should be paid attention to by enterprises. In recent years, although the safety production work in the construction engineering field has made achievements, the accident rate and death rate have decreased, but compared with other industries, the decline in the accident rate and death rate in the construction engineering field is smaller. There is still a big gap between the expectations of the general public. With the development of social economy and science and technology, many new processes have been innovated in construction, and these new process procedures are more complex and more difficult to construct. Therefore, construction companies need to tightly control the safety issues in construction and control major Dangerous source, to ensure the life safety and property safety of every construction worker, and to ensure the long-term development of construction enterprises.

Jimmie et al. analyzed and counted the construction accidents in the United States for many years [1], and found that there are certain laws in the casualties of construction accidents. Safety production accidents caused by falling from heights are the main safety accidents in the construction industry. Strengthening the management of falling accidents from heights is to improve the An important issue of the level of building safety management. The research results also show that the key factor in preventing production safety accidents is to know the hazard sources of accidents in advance, and strengthening the management and control of hazard sources can effectively prevent the occurrence of safety accidents [2]. Terje Aven of Norway believes that the research in the field of risk is mainly divided into two types of research, one is the use of risk management methods and evaluation methods to study specific activities or behaviors, and the second is the theory of risk principles, theories, models, evaluation tools and other theories Research [3]. The research on risk classification management and control at home and abroad mainly analyzes the risk from two aspects: qualitative and quantitative, so as to obtain classification information. It is early for foreign countries to carry out risk assessment and use quantitative classification, especially in the last century in developed countries. In the field of safety production, there have been many classic analyses and evaluations, which have laid the foundation for the risk classification management and control in the field of safety production [4]. The more representative comprehensive safety evaluation methods are: DuPont's "three-stage safety evaluation" (safety checklist,

ISSN 2522-3488 Vol. 6, Issue 4: 1-9, DOI: 10.25236/IJNDES.2022.060401

fault type and impact analysis-fault tree, event tree), Japan's "six-stage safety evaluation" method, and the United States' "three-stage safety evaluation" method. Dow Chemical Company, Dow Chemical Method, Mond Method, etc. [5]. Foreign mature risk management mainly studies two aspects, one is the application of existing main risk management strategies [6], and the other is how to establish risk management [7]. There are three main existing risk management strategies: risk-informed strategy, warning/precautionary strategy, and discursive strategy. These are the main contents of risk management research. The research on the establishment process of risk management is mainly involved in some standard or risk analysis textbooks, such as foreign IS031000, domestic security risk classification management and control system, etc., mainly to study the establishment steps and process of risk management from assessment to management.

Chinese scholars' research in the field of construction safety management mainly focuses on safety accident losses and accident investigation and analysis. Through the analysis of the types of safety accidents that have occurred in construction projects, through different safety management systems and safety protection measures, the purpose of reducing the occurrence of safety production accidents is achieved [8][9][10][11]. Tang Qingrong's evaluation of the construction site safety risk level of construction sites mainly starts from the aspects of system, technical scheme, personnel and equipment, and then identifies the risk factors on the site and evaluates the risk level [12]; Gao Jindong et al. used the interaction matrix analysis method to evaluate all the safety-related components in the unit by enumerating and evaluating, and using the classification method to simplify the analysis process, because each component interacts to identify hazards and obtain new hazard identifications method [13]. Ye Bin used the accident tree analysis method to analyze and identify the hazards, and obtained the importance order of different risk factors [14]. There are also some scholars who have studied the classification and classification management system. Jin Jianshun improved the management and risk identification by classifying the safety risks of the risk management and control system, so as to ensure that the list of hidden dangers and safety risks can be updated regularly as soon as possible. At the same time, the unit requirements are guaranteed [15]. According to the hazard factors on the construction site, Lei Changqun eliminated two types of inherent and derived hazard factors, and put forward four suggestions for improving the dual prevention mechanism [16]. Zhong Maohua et al. analyzed and discussed the grading, classification and concept of hazard sources. By expanding the hazard source samples, the hazard source level can be adjusted, and the grading results will also change accordingly [17].

2. Current situation and risk grading management theory in construction industry

2.1. Overview of enterprise safety risk management

Using measures such as hazard identification, risk classification, risk evaluation and control, the safety risks are managed and controlled in stages, so as to further reduce the safety risk of the enterprise, eliminate the hidden danger of accidents, and further make the safety standardization have operability and applicability. Important methods of "defense in depth" and "move forward" of accidents [18]. Hierarchical risk management and control is the first line of defense in accident prevention work, and it is linked with the hidden danger screening and governance mechanism, because hidden danger screening and governance belongs to the end of risk management and control. Caution will cause an accident to occur. Therefore, the Ministry of Emergency Management of the People's Republic of China has begun to establish a hidden danger investigation and management system and a safety standardization system, and on this basis, promote a risk classification management and control system, so that the three can be organically combined and complement each other to improve the overall pre-control capability of enterprise safety production.

2.2. The concept of enterprise security risk classification management and control

Governments at all levels have issued a series of regulations and measures for risk management and control. As normative documents, they have a binding effect on enterprises within their jurisdictions, and further implement the requirements of the State Council Safety Committee Office. For example, the People's Government of Jiangsu Province has successively issued the "General Principles of Safety Production Accident Investigation and Management System" and "General Principles of Safety Production Risk Classification Management and Control System", which have determined the basis and guidelines for enterprises to carry out safety risk management and control and industry authorities to assess the overall risk level of enterprises. , which specifies the risk identification and evaluation methods.

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Certain rules are given to carry out risk identification and evaluation methods. For the identification and discrimination of hazard sources in the production process, it is stipulated that the work hazard analysis method (JHA) should be adopted. SCL), the assessment of risk requires the use of (LEC) method, accident tree method, consequence simulation method and risk matrix and other analysis methods. The "Guidelines" require that the risk level should be determined according to the quantitative results obtained from the evaluation. The risk level is divided into 4 levels: level 1 (major risk), level 2 (higher risk), level 3 (general risk), level 4 (low risk). colors, and specify the responsible departments corresponding to different levels of risk. Level 4 risks are managed and controlled by operators, Level 3 risks are managed and controlled by the construction team (including professional subcontracting and labor subcontracting units), Level 2 risks are managed and controlled by the project department, and Level 1 risks are managed and controlled by the enterprise. The external guidelines also stipulate the principles of sub-control, risk control measures, risk notification, and the requirements for the overall supervision department to implement risk-level management and control.

The "Detailed Rules for the Inspection and Governance System of Hidden Hazards of Safety Production Accidents in Construction Enterprises" also provides detailed guidance and research on the inspection cycle of hidden dangers, and determines the relevant content of the hidden danger inspection and management system. A style recommendation is made for the tables involved in the hidden danger inspection and governance system.

3. Identification model of enterprise safety hazard source

3.1. Enterprise safety production hazards

3.1.1. Types of Injury to Consider in Identifying Hazards

1) Collapse; 2) Fall from a height; 3) Electric shock; 4) Object strike; 5) Mechanical injury; 6) Fire; 7) Lifting injury; 8) Bandaging; 9) Vehicle injury; 10) Poisoning and suffocation; 11) scalding; 12) other injuries.

3.1.2. Hazard identification methods and approaches

Records; security inspections; inquiries; site observation; program implementation inspections; access to external information.

3.1.3. Hazard identification steps

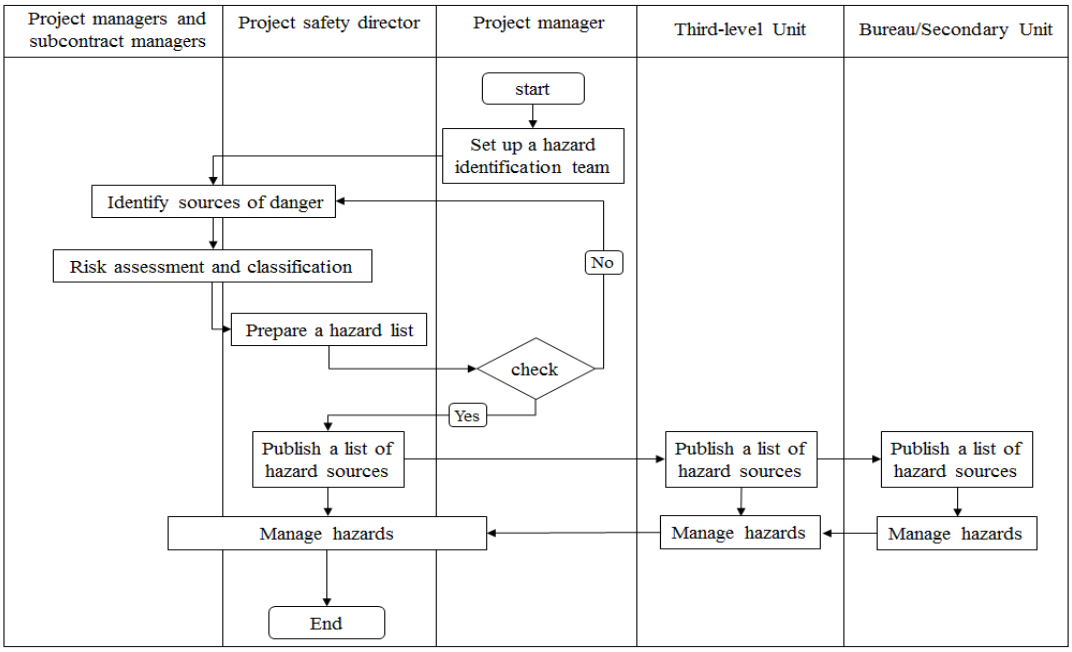

Figure 1: Project Hazard Identification Steps

The identification steps of project hazard sources are shown in Figure 1, and the specific identification process is as follows:

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1) Establishment of a hazard identification team: Before the start of construction, a hazard identification team with the project manager but not the team leader shall be established, and the division of labor such as hazard identification, risk assessment, and determination of control measures shall be clarified according to the position.

2) Identification of hazard sources: According to the division of responsibilities, each post identifies the hazard sources existing in the whole project cycle, and the project safety director summarizes the identified hazard sources of the project. At the end of each month, referring to the requirements for hazard identification, assemble the construction progress plan, and identify the hazards existing in the construction of the next month.

3) Risk assessment and classification: The risk level of hazard sources is divided into three levels. The project should determine the risk level of hazard sources in accordance with the requirements of the enterprise's "Safety Production Risk Classification Management and Control Measures", and formulate control measures to identify responsible personnel.

4) Prepare a list of hazard sources: The list of hazard sources should include construction operation areas, sub-item projects/construction activities, estimated implementation time, hazard parameters, hazard sources, risk levels, control measures and responsible personnel.

5) Publish the list of hazard sources: the project department releases the full-cycle/monthly "List of Hazard Sources" through the project work platform; the project department publicizes the key content of the first-level safety production risk and the second-level safety production risk by setting up publicity boards, and the content of the announcement Including: sub-item project/construction activity name, risk parameters, implementation time, risk level, monitoring personnel, etc. The second-level units publicize the first-level safety production risks through work platforms, etc., and the third-level units publicize the first-level safety production risks and the second-level safety production risks, including: project name, sub-item project/construction activity name, Hazard parameters, implementation time, risk level, monitoring personnel, etc.

6) Control of hazard sources: The first-level safety production risk management and control level is the bureau/second-level unit, and the main departments are related functional departments such as science and technology, engineering, and safety; the second-level safety production risk management and control level is the third-level unit, and the main departments are technology, Engineering, safety and other related functional departments or personnel; the third-level safety production risk management and control level is the project department. Responsible personnel at all levels should implement management responsibilities and control measures step by step according to their job safety responsibilities.

3.2. Enterprise hazard risk assessment

3.2.1. Risk assessment can be scientific and reasonable only if it meets the following requirements:

On the basis of fully identifying the hazard source, evaluate the degree of its hazard, that is, the risk; the risk evaluation method adopts the "operation condition risk evaluation method" (LEC method), the empirical judgment method (the more obvious, easy to Major hazards (unacceptable risk) factors are determined according to the evaluation results; the risk evaluation results should be documented.

3.2.2. Laws and regulations clearly stipulate

Based on the "Provisions on the Safety Management of Sub-projects with Greater Risk" (Order No. 37 of the Ministry of Housing and Urban-rural Development), all sub-projects with higher risks must be classified as secondary (larger) risk sources. Large-scale projects with relatively large risks are classified as first-level (major) risk sources.

3.3. Enterprise hazardoussource risk evaluation model

3.3.1. Work Condition Hazard Assessment Method (Job Risk Analysis, JRA)

Keneth J. Graham and Gilbert F. Kinney of the United States studied the danger of people working in potentially dangerous environments, and proposed that the risk of working conditions should be regarded as the basis of the comparison between the evaluated environment and some reference environments. The dependent variable (D), the likelihood of an accident or hazardous event (L), the frequency of exposure to the hazardous environment (E), and the severity of the hazard (C) were used as independent variables to determine the functional formula between them. which is:

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$$D = L \times E \times C \quad (1)$$

There, D is the hazard of the working condition;

L is the likelihood of an accident or hazardous event occurring;

E is the frequency of exposure to hazardous environments;

C is the hazard severity.

According to practical experience, the scores of the three independent variables in various situations are given, as shown in Table 1, Table 2, and Table 3. Take the method of scoring the evaluated object according to the situation, then calculate its risk score value according to formula (1), and then find out its risk degree in the risk level table that divides the risk score value according to experience. This is a simple and easy way to assess the hazard of working conditions.

Table 1: Likelihood of an accident or hazardous event(L)

Fractional value	Likelihood of an accident or hazardous event
10	Totally predictable
6	It is quite possible; the occurrence of hazards cannot be detected (lack of detection system); the detection, protection, prevention and control measures are lacking on site; such accidents or deviations frequently occur under normal conditions.
3	Possibly and occasionally; it is difficult to detect the occurrence of the hazard, and there is a lack of detection systems and full detection on site; there are control measures on site, but they are implemented improperly or ineffectively; or the hazard occurs frequently or as expected.
1	Lack of protective measures (e.g. protective devices, personal protection); or not strictly following operating procedures; easy to detect the occurrence of hazards (with detection system on site); or experience of detection; or A similar accident has occurred; or a similar accident has occurred in an abnormal state.
0.5	Very unlikely, can be imagined; or once a hazard occurs, it can be detected in time and monitored regularly.
0.2	Very unlikely; or the on-site prevention, monitoring and protection measures are sufficient and can be effectively implemented; or the employees have high safety awareness and strictly follow the operating procedures.
0.1	Practically impossible.

Table 2: Frequency of exposure to hazardous environments(E)

Fractional value	Frequency of exposure to hazardous environments
10	Continuous exposure
6	Exposure during daily working hours
3	Weekly or incidental exposure
2	Exposure once a month
1	Exposure several times a year
0.5	Very rare exposure

Table 3: Severity of danger(C)

Fractional value	Severity of danger	
	casualties	Direct economic loss (ten thousand yuan)
100	More than 10 dead, or more than 50 seriously injured	≥5000
40	2-9 dead, or 10-49 seriously injured	1000-5000
15	1 dead, or 1-9 seriously injured	100-1000
7	Disabled	10-100
3	Minor injury	1-10
1	No casualties	≤1

3.3.2. Risk Grading Mathematical Model

Risk classification is based on the mathematical relationship embodied by the concept of comprehensive risk in safe production: R=f(P, L, S)Based on this, the index system that affects the risk is screened, and the index is quantified, scored, and weighted, so as to establish a risk classification

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evaluation model.

$$IR = R_P \times R_L \times R_S = \sum_i^m w_i d_i \cdot \sum_{j=1}^n w_j d_j \cdot \sum_{k=1}^e w_k d_k \quad (2)$$

There, IR is the comprehensive risk value of safety production.

R_P is the risk value of the likelihood indicator.

R_L is the risk value of the severity indicator.

R_S is the risk value of the sensitivity indicator.

m, n, e is the number of three-level indices of likelihood, severity, and sensitivity.

wi, wj, wk is the weight of the i, j, and k indicators to the first-level indicators.

di, dj, dk is the i, j, k index score.

After getting the risk, it is also necessary to determine the risk grading index. This standard is the fundamental basis for determining the risk assessment object or factor risk level division, and can indirectly affect the inspection level of the assessed object. According to the overall risk of safety production in the construction industry, this paper will divide it into three levels: "first-level, second-level, and third-level", as shown in Table 4.

Table 4: Safety production comprehensive risk classification standard and description

IR	Comprehensive risk level	Risk description
$IR \geq IR_1$	I	Significant Risk - Unacceptable Risk - Eliminate Risk
$IR_2 \leq IR \leq IR_1$	II	Greater risk - Unexpected risk - Control risk
$IR \leq IR_2$	III	General Risk - Limited Acceptance Risk - Warning Risk

Reasonable customization of risk classification standards is the premise and key to the implementation of comprehensive risk classification management and control of safety production. If the assessed risk is absolute risk, then IR1 and IR2 can be fixed values according to the risk assessment model and combined with the ALARP principle (M. Jones-Lee, 2011) [19]. If the evaluated risk is a relative risk, it is in a different way and application range, then the grading standard of the secondary risk is not used, and even there will be a big difference. At this time, the evaluator can manage the target in a timely manner according to the detailed application scope, and then combine with the existing relevant national norms to set the IR1 and IR2 values reasonably.

4. Enterprise security risk classification management and control

4.1. Classification of enterprise risk levels

According to the relative nature of the seriousness of the consequences of the risk event, qualitative or quantitative evaluations are carried out on the classification objects by adopting scientific and reasonable methods, and the classification is classified according to the evaluation results. Risks can be divided into red, yellow and blue. For the risk assessment method with the three-level classification, establish a corresponding hierarchical relationship to meet the needs of assessment and management.

red risk. Level 1 risk: refers to the sub-item projects and construction activities that are likely to cause mass casualties and mass casualties, or cause major economic losses. Among them, the sub-projects with greater risk exceeding a certain scale are all first-level risks. The Bureau Headquarters establishes a ledger of locally controlled risk projects, and supervises the implementation of management and control measures; the second-level units establish a ledger for bureau-controlled and company-controlled risk projects, supervise the implementation of management and control measures, and organize the safety production risk assessment of newly started projects. Risks are publicized, and the implementation of management and control measures is supervised. The management and control levels are shown in Table 5. For the first-level risk, the problem must be corrected immediately and the work cannot be continued. For this level of risk, work can only be continued if the risk is reduced. If unlimited investment in resources does not reduce risk, work is prohibited and immediate action must be taken to address the potential danger.

Yellow risk. Secondary risk: refers to the sub-item projects and construction activities that are likely to cause general production safety accidents or cause greater economic losses. Among them, the sub-projects with greater risk are all second-level risks. The third-level unit supervises the implementation of risk project management and control measures, publicizes first-level risks and second-level risks every

ISSN 2522-3488 Vol. 6, Issue 4: 1-9, DOI: 10.25236/IJNDES.2022.060401

month, and records and implements management and control measures. When secondary risks touch an ongoing project, emergency action should be taken and controls should be developed and monitored in plans and regulations. For the risks of sub-level and above, the company shall take key control and management measures, and the specific division of labor shall be carried out by the competent department of the company according to their responsibilities. When a secondary risk occurs during construction, emergency measures should be taken, and indicators, management plans or resources to reduce the risk should be determined according to the needs, and rectification should be carried out within a certain period of time. Construction can not be carried out until the risk is reduced.

Blue risk. Third-level risk: refers to the sub-item projects and construction activities other than the first-level risk and the second-level risk. The managers of the project department implement the risk project management and control measures, and implement the first-level risk, second-level risk, and third-level risk control measures. For this level of risk, the project department should be aware of and exercise controls and manage its specific implementation team. Establish controls and regulations to minimize risk, carefully identify and limit prevention costs, and implement risk reduction measures within a defined time frame. In cases related to serious injury consequences, an in-depth assessment is necessary to determine the probability of injury and whether control measures need to be improved.

Table 5: Risk level(D)

Fractional value	Risk level	risk color	management level	Dangerous
>320	I	red	Bureau / Secondary Unit	extremely dangerous
160~320	II	yellow	third-level unit	Highly dangerous
<160	III	blue	Project Department	General danger

4.2. Factors to consider in enterprise risk classification management and control measures

4.2.1. Management

Establish a sound risk classification management and control responsibility system: formulate and implement project construction risk safety commitments and on-site safety risk management performance evaluation systems, implement safety risk target management, ensure safe investment, and gradually form a long-term construction safety mechanism. Establish a publicity, follow-up and rectification system for hazardous sources at the construction site.

Establish a risk classification implementation system; improve on-site inspections, identify and register hazard sources that may affect safe production, and regularly publish a list of hazard sources, rectification measures and treatment methods; formulate and implement the installation, operation, and dismantling of large-scale mechanical equipment on site, inspection, maintenance and acceptance system.

Establish a risk grading education system: strengthen publicity and education on the use and management of labor protection supplies and temporary electricity consumption, conduct regular electrical safety inspections, and regularly carry out maintenance of machinery and equipment, and select and use correct safe voltages in different construction environments in accordance with regulations. Strengthen the safety production and management of enterprises, intensify efforts to carry out safety training, and improve the safety awareness, technical level and safety quality of operators.

4.2.2. Technical aspects

Give full play to the guiding role of the construction plan on the construction project, and take technical measures to control risks. Construction units of hazardous sources that exceed a certain scale should formulate a special plan and organize special demonstrations before the start of construction; for some projects with risks exceeding the scale, the construction unit should organize an expert group to demonstrate the special plan; Eliminate outdated technologies and processes, appropriately improve the technical level and management level of construction safety, so as to reduce risks.

4.2.3. Construction

In response to unsafe behaviors, the "three violations" should be strictly prohibited, education should be strengthened, dissemination, assistance and carrying should be done well, and on-site inspection efforts should be improved. Inspection and punishment must be strictly enforced, so as to promote in-depth understanding of operators and master how to ensure Safety. Mechanical equipment should be installed in a fixed and reliable manner. Mechanical safety protection and power-off protection devices should be added. Mechanical equipment should be regularly maintained to operate in a good state, and frequent inspection and debugging should be ensured to avoid mechanical unsafe accidents.

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High-altitude workers must have regular physical examinations before they work, strengthen the education of workers' self-protection awareness, promote conscious compliance with construction standards, complete construction in strict accordance with the construction technical standards issued by the Ministry of Labor, increase investment in protective facilities, and do not arbitrarily simplify Safety protection measures, strictly follow the technical operating procedures for lifting, and correct irregular work habits [20]. It is forbidden to throw building materials, sundries and tools at will. Anyone who finds a source of safety hazards at any time has the right and responsibility to report to the project department, and then the project department reports to the branch. When the risk level reaches the yellow level or above, it should report to the higher-level safety supervision department.

4.3. Hazard control measures

4.3.1. Company/branch hidden danger investigation and governance measures

The established safety production hidden danger investigation and management organization is mainly based on the legal representative, so that each department can clarify their respective responsibilities and improve the safety production responsibility; strictly implement the safety supervision, inspection and punishment of the construction site, and strengthen the safety production responsibility system; Investigate potential safety hazards at the construction site every month, supervise the hidden dangers found by the project department to rectify and rectify the hidden dangers to ensure that the rectification passes the acceptance inspection until the safe production state; every month, a working meeting of hidden danger investigation and management is carried out to summarize the results of the regular investigation and rectification work, and then According to the results, preventive measures can be formulated in a timely manner, and then the tasks and priorities of the investigation work can be arranged in stages.

4.3.2. Project department hidden danger investigation and treatment measures

Establish a complete security system for the investigation and handling of hidden dangers in production safety, formulate an efficient investigation system for hidden dangers in production safety, and carry out investigations in a planned, targeted, effective and efficient manner. All hidden dangers discovered should be registered for better rectification and management through grading. The rectification work should define “responsible persons, fixed time and fixed measures”. Major accidents and hidden dangers should be dealt with in a timely manner, listed as rectification and key monitoring.; Establish and improve the emergency mechanism to prevent and deal with production accidents, so as to respond quickly and decisively and deal with them in accordance with the law. Strengthen the construction of emergency rescue command institutions and full-time/part-time emergency rescue teams to improve emergency response capabilities; for construction sites that fail to meet standards and cannot eliminate hidden dangers in time for rectification, they should be ordered to immediately stop construction and rectify immediately.

4.3.3. Troubleshooting and management measures for hidden dangers of various teams and operators

The team leader promptly carried out the investigation of hidden dangers, highlighted the key points, and stepped up efforts to inspect and supervise the hazardous sources such as lifting equipment, high formwork scaffolding, earthwork excavation, and building electricity. hazard.

Operators must be aware of the presence of hazards and safety precautions in the site environment; before entering the site, operators must be trained in safe operation and passed the exam, and special operators must be trained regularly. Before starting work, managers and project managers must participate in relevant training on safety technology and management, so as to be familiar with and analyze their characteristics and their impact on safety work; Carry out risk assessment of its dangerous points, and carry out detailed analysis and prediction; be familiar with the content and preventive measures of risk assessment of dangerous points of this operation.

5. Conclusions

This paper takes the unbreakable point of safety production management in construction enterprises, and discusses the improvement and improvement of safety production management in construction enterprises by introducing the concept of safety risk classification management and control. Through the theory of risk classification management, safety management responsibilities are gradually refined to labor teams and operators, which is essentially a manifestation of refined management, allowing all

ISSN 2522-3488 Vol. 6, Issue 4: 1-9, DOI: 10.25236/IJNDES.2022.060401

employees to participate in safety management and keep up with the pace of production safety laws. The existing project department model in the construction industry is difficult to change in the short term. Due to the constant changes in the amount of projects undertaken each year, the existence of this variable leads to constant changes in construction workers, resulting in increased risks for enterprises in safety management. If the risk of labor safety production is not fully considered, it will often bring irreparable losses to projects and enterprises. Based on this, the theory of risk classification management and control is necessary and feasible in the construction industry. The theory of hierarchical management and control of safety production in construction enterprises discussed in this paper is still in the preliminary stage. At the national level, with the advanced experience at home and abroad in the western region, the state encourages enterprises to block the possibility of accidents through early management and control of risks, and then reduce the occurrence of accidents. The rate is reduced, so that the safety of the people's lives is guaranteed. In the construction industry, some enterprises do not realize the advantages of hierarchical management and control of enterprise safety risks. The management of safety production in the industry is more inclined to project management rather than enterprise-level management and control. This one-sided understanding also leads to some construction enterprises. Out of control safety production management, the direct cause of the end of the enterprise aisle.

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