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Construction Machinery Construction Risk Assessment Based on Artificial Intelligence Algorithm

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Abstract: Construction machinery (CM) is widely used in engineering construction projects, and the completion of the project is inseparable from the role of CM. However, generally speaking, the construction period of a project is very long, and it is inevitable that various problems with machinery and equipment will cause construction accidents, so it is necessary to identify CM construction safety risks through risk to ensure construction quality and keep up with the construction schedule. In this regard, this paper studies the risk factors triggering CM construction safety accidents, constructs an evaluation index system applicable to CM construction risks, calculates the weight of the impact indicators using the fuzzy comprehensive evaluation method of artificial intelligence(AI) algorithm, and assigns points to each indicator risk through experts. The paper also concludes with a risk control strategy and management mechanism for CM construction, which provides a basis for staff to make safety risk decisions.

1. Introduction

In recent years, based on the development status of CM, construction safety accidents have occurred frequently due to the failure of CM and equipment, machinery operators without certification. In order to reduce the occurrence of accidents, it is necessary to examine the CM at the site where it is located, to fully consider the characteristics of CM construction, and to study the risks of CM construction safety in China.

The research on CM construction risk assessment has achieved good results. In terms of the types of CM construction safety accidents, some scholars analyze the processes that use a large number of CM based on many years of construction experience, and the risks are prone to mechanical tipping, twisting and breaking, and broken arm accidents during the construction of CM [1]. Some scholars identify and evaluate the risk of CM, give CM safety control methods, and believe that the lack of safety measures will lead to greater safety accidents [2]. Some studies analyze the types, characteristics, and causes of CM accidents, pointing out that the types of crane accidents include installation and dismantling accidents, accidents using machinery, falling object accidents, and the causes of accidents including cranes themselves, man-made, and natural factors, resulting in the definition of CM extrusion, falling, and tipping, and analyzing the risks of accidents in terms of operation and equipment [3-4]. Some studies have shown that the two most important risks in the construction phase are quality risk and schedule risk, for quality risk can establish a raw material incoming inspection system, establish a raw material incoming inspection system; for schedule risk, should strengthen the scientific control of the preliminary engineering design, and improve the construction work to ensure the quality of the project and avoid the consumption of resources caused by rework [5]. Taken together, many studies have assessed construction risks from the perspective of CM construction accidents, which provides reference for scholars to analyze CM construction risk types afterwards.

This paper firstly introduces various types of CM such as cranes and concrete machines; then identifies CM construction risks and classifies them; then establishes a risk assessment model based on AI algorithm, uses the model to calculate construction risk index weights and analyzes risk scoring results according to expert scoring method; finally proposes risk control strategies and analyzes the application effect of CM construction risk management.

2. CM and its Construction Risks

2.1. Types of CM

Lifting machinery: because most structural elements in high-rise buildings are cast-in-place, a large amount of materials and construction personnel have to be transported during construction, and the efficiency of vertical transportation largely determines the construction period, so the correct use of vertical transportation machinery is an important part of the main construction of high-rise buildings [6]. A tower crane is a kind of lifting machinery, which consists of steel structure, operating system, safety system and other structures. The steel structure consists of the boom, load-bearing structure and other structures. The operating system consists of lifting, slewing and other mechanisms. The safety system consists of the lifting torque, hook height and other limiters [7].

Concrete machinery: it is mainly divided into preparation, transportation, compacting and forming and spraying concrete machinery. Preparation machinery has mixers, mixing plants, etc.; transportation machinery has transport trucks, pump trucks and transfer pumps, etc.; vibrating and forming machinery has vibrators and spraying machinery [8]. Pumped concrete machinery can better adapt to the requirements of complex structures, narrow sites and tight schedules, and high construction efficiency.

Piling machinery: mainly rotary drilling rigs, pile drivers, pile presses, etc. The piling machinery has high body height, poor construction environment conditions, high mobility, fast construction speed, heavy machinery itself, and easy to master operation [9].

Excavation machinery: used to excavate and carry materials such as soil. Excavation machinery construction efficiency, poor adaptation to the environment, intelligent manipulation of flexible, heavy and bulky machinery and other characteristics [10].

2.2. Classification of CM Construction Safety Risk Identification

(1) Operation project safety risk identification: CM construction is composed of different

operation projects, to carry out operation project safety risk identification, is based on the construction project to identify the construction of personnel, equipment, environment, management of the four aspects of safety risk factors or substances, analysis of the possible consequences [11-12].

(2) Construction area safety risk identification: identify and analyze the safety risks existing in the construction area and site environment, and exclude the unsafe state of the construction area, unsafe site environmental conditions and other risk factors [13].

(3) Equipment failure safety risk identification: in the actual construction operation, due to long working hours, poor working conditions, high work intensity and other factors, CM may have some sudden failures at any time, affecting normal operation and construction safety. Identify and analyze the possible failures of equipment components as well as the modes, causes and phenomena of failures, and analyze the impact on the equipment and system [14].

3. CM Construction Risk Assessment Based on AI Algorithms

3.1. Risk Assessment Model Based on AI Algorithms

In the field of engineering construction, the application of AI is also very deep. At present, in construction quality management, intelligent quality management system can be established by using AI algorithms such as genetic algorithm and neural network algorithm, while in construction risk assessment, this paper intends to establish a risk assessment model by fuzzy comprehensive evaluation method [15].

The matrix of fuzzy evaluation indexes can be expressed as:

$$X = \begin{pmatrix} x_{11} x_{12} \cdots x_{1m} \\ x_{21} x_{22} \cdots x_{2m} \\ \cdots \qquad \cdots \\ x_{n1} x_{n2} \cdots x_{nm} \end{pmatrix} = X_{n\times m} = (X_1, X_2, \cdots, X_m) \tag{1}$$

The fuzzy composite evaluation score is calculated by the formula:

$$f_i = x_i / (x_1 + x_2 + \ldots + x_j) \tag{2}$$

Where fi represents the fuzzy composite score result of index xi, and X is the fuzzy evaluation matrix, which contains several indicators such as X1 and X2.

3.2. Risk Index Selection

In this paper, we take single bucket excavator as an example to calculate the risk score of excavator in the construction process. Therefore, the indicators selected to evaluate the construction risk of single bucket excavator are X1-corrod rust with cracks, X2-excavator regular maintenance is not in place, X3-failure of early warning protection system, X4-excavator personnel are not certified to work, X5-crawler gears do not match, X6-excavator foundation load capacity is insufficient, and X7-motor arm cylinder rust with cracks [16].

3.3. Construction Risk Assessment Results

Table 1. Single bucket excavator construction risk index weights

	X1	X2	X3	X4	X5	X6	X7
Importance	0.10	0.15	0.5	0.2	0.4	0.55	0.15
Weights	0.064	0.064	0.27	0.064	0.27	0.27	0.064

As shown in Table 1, from the single bucket excavator indicator weights, track gears do not match, early warning protection system failure, excavator foundation load-bearing capacity and other indicators weight of 0.27, this part of the factors belong to the major sources of danger, should focus on prevention, such factors are prone to cause the excavator body overturning and injury accidents. The moving arm cylinder rust crack, rod rust crack, excavator personnel without a license to work, excavator regular maintenance is not in place and other indicators weighted 0.064, these factors are prone to break the shovel smashing accidents; excavator personnel without a license to work easily caused by illegal operation, prone to electrocution casualties, the body overturned and other safety accidents.

Table 2. Expert scoring results

	X1	X2	X3	X4	X5	X6	X7
Expert 1	1.6	2.4	7.8	3.1	2.5	6.7	3.8
Expert 2	2.1	2.6	8.2	2.7	2.2	6.5	3.4
Expert 3	1.8	2.7	8.1	3.2	2.6	6.7	4.0

After the determination of the above index weights, the risk score of each index is judged by expert classification, and the results are shown in Table 2. Combined with Table 1 and Table 2, it can be seen that the indicator weights are high and their risk scores are high, indicating that the construction phase to prevent and control the major hazards.

4. Risk Control and Risk Management

4.1. CM Construction Risk Control Strategy

(1) Risk avoidance

Risk avoidance refers to a strategy to eliminate safety risks by taking the initiative to stop the construction project or change the construction plan after the risk assessment, the risk value is large, and there is no suitable measure to control the safety risk. Such as in bridges, tunnels, turnouts and other special sections of mechanical screening operations in the presence of large safety risks, in order to control the safety risks of this type, part of the engineering machinery section to adopt the strategy of risk avoidance, that is, the use of manual screening instead of mechanical screening [17].

(2) Transfer risk

Transfer risk is mainly the use of certain means to transfer the safety risk appropriately, so as to reduce the risk borne by itself. For example, purchasing insurance is a typical risk transfer strategy, but it requires a certain amount of insurance premium. Because the transfer of risk cannot substantially eliminate the safety risk, and our country's implementation of the joint and several system of safety responsibility, so the CM industry basically does not use the transfer of risk as a safety risk control strategy [18-19].

(3) Prevention of risk

Prevention of risk is mainly to take various measures to control the occurrence of risk, which is a positive risk control strategy. There are two approaches, one is to avoid the appearance of risk factors or reduce the risk factors that already exist or isolate them, and the other is safety education and training and setting management standards. Both ways can play a role in the prevention of risk.

4.2. CM Construction Safety Risk Management Guarantee Mechanism

In order to implement effective CM construction safety risk management and strengthen safety management, it is necessary to establish three levels of CM construction safety management institutions at the leadership, management and executive levels, and control the safety risks of different levels at different levels. That is, a safety management leadership group is established, and the management level is divided into five working groups for risk identification, risk assessment, standards and measures management, emergency management, and personnel education and training, as shown in Figure 1.

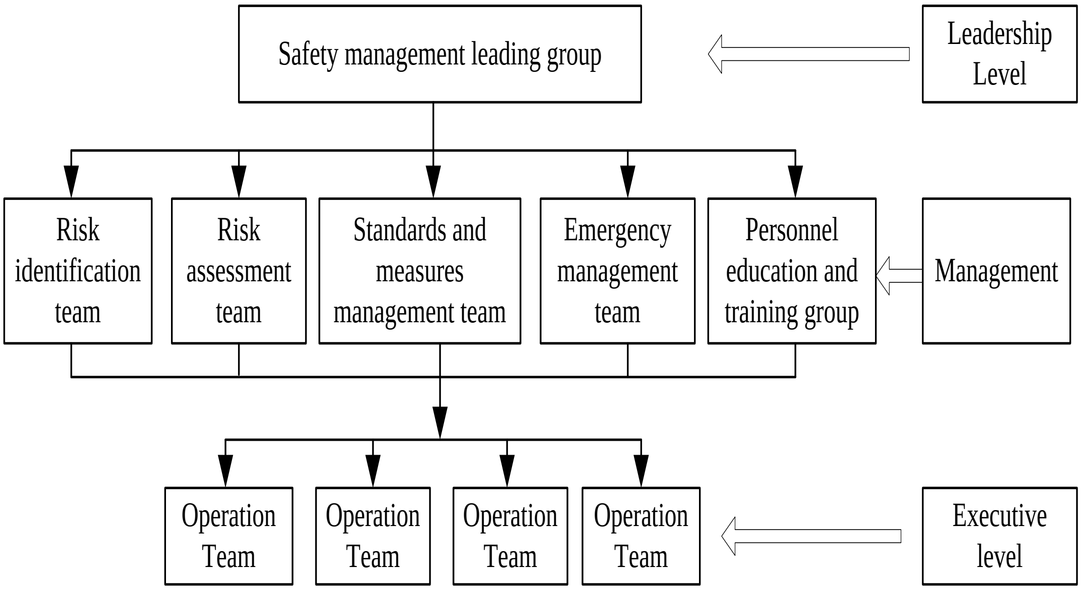

Figure 1. Organizational chart of risk management of CM

(1) Responsibilities of safety management team (leadership level)

To make decisions, formulate the policy and objectives of the system, support and participate in the management in the process of implementing the system, etc., supervise and manage the implementation of the work of the operational level, and be responsible for the prevention and control of major safety risks.

(2) Responsibilities of each working group (management)

Responsible for the construction and supervision of the risk pre-control management system, help teach the operational layer to implement the system's work and system measures and supervise the implementation, and responsible for the prevention and control of medium safety risks.

(3) Responsibilities of the operation team (executive level)

Responsible for implementing the decisions of the leadership, participating and implementing the work and system measures organized by the management, and responsible for the prevention and control of general safety risks.

4.3. CM Construction Risk Management Application Effect

Table 3. Construction risk distribution

	Operation project	Equipment failure	Construction area	Total
Major risk	15	8	21	44
Moderate risk	282	136	40	458
General risk	243	175	13	431
Total	540	319	74	933

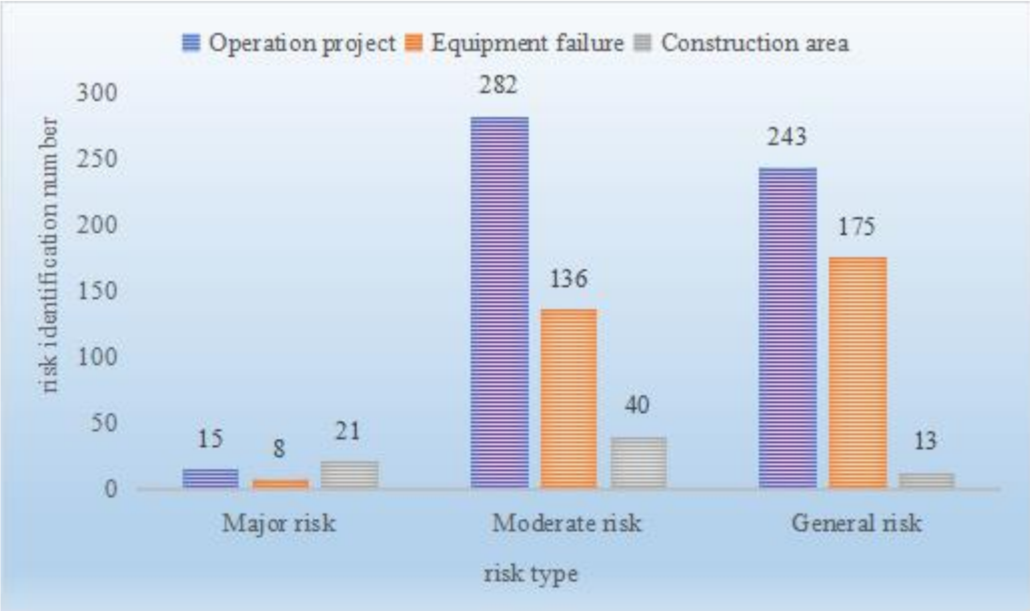

Figure 2. Risk identification effect

A section of engineering machinery from the beginning of the implementation of construction safety risk pre-control management, through continuous research and proof and summary correction, and constantly improve the identification of safety risks, standardize the assessment of safety risks, optimize the control of safety risks, and gradually establish a clear process, clear responsibility, card control effective CM construction safety risk pre-control management system. As shown in Table 3 and Figure 2, a total of 933 safety risks were identified in the whole section, among which 540 were identified in the operation projects, 319 risks of possible equipment failure were identified in the machinery models, and 74 were identified in the construction area. After the safety risk assessment, there are 44 major risks, 458 medium risks and 431 general risks; all the safety risks are formulated with effective safety prevention and control measures according to the level.

5. Conclusion

In this paper, the construction risk of CM is evaluated to ensure construction safety and avoid affecting the construction plan for various reasons during the construction process. Therefore, the construction risk evaluation model of fuzzy comprehensive evaluation is established, combined with the expert scoring method to evaluate the risk factors affecting the construction of CM. Through the research and analysis, it is obtained that to avoid construction risks, it is necessary to land on the details in the project implementation both before and after the project design in order to kill the risks in the cradle.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Vm A, Shao Z B, Tlkr B. Early construction cost and time risk assessment and evaluation of large-scale underground cavern construction projects in Singapore -ScienceDirect. Underground Space, 2020, 5(1):53-70. https://doi.org/10.1016/j.undsp.2018.10.002

[2] Amarasinghe I A, Hadiwattege C. Enablers for facilitating life cycle assessment: key stakeholder perspectives of Sri Lankan construction industry. Built Environment Project and Asset Management, 2021, 12(4):590-612. https://doi.org/10.1108/BEPAM-02-2021-0033

[3] Didehkhani H, Khalili-Damghani K, Farahani A F, et al. A framework for interactive risk assessment in projects: case study of oil and gas megaprojects in presence of sanctions. Journal of Modelling in Management, 2021, 17(2):569-600.https://doi.org/10.1108/JM2-07-2020-0180

[4] Kayhan B M, Cebi S, Kahraman C. Determining and Prioritizing Main Factors of Supplier Reliability in Construction Industry. Journal of multiple-valued logic and soft computing, 2019, 32(1-2):111-134.

[5] Me A, Af A, Mf B, et al. Hybridization of AI models with nature inspired optimization algorithms for lake water level prediction and uncertainty analysis - Science Direct. Alexandria Engineering Journal, 2021, 60(2):2193-2208. https://doi.org/10.1016/j.aej.2020.12.034

[6] Jones W, Gibb A, Goodier C, et al. Nanomaterials in construction-what is being used, and where?. Construction materisls, 2019, 172(CM2):49-62. https://doi.org/10.1680/jcoma.16.00011

[7] Karimi T, Yahyazade Y. Developing a risk assessment model for banking software development projects based on rough-grey set theory. Grey Systems: Theory and Application, 2021, 12(3):574-594. https://doi.org/10.1108/GS-05-2021-0074

[8] Getuli V, Sorbi T, Bruttini A, et al. A smart objects library for BIM-based construction site and emergency management to support mobile VR safety training experiences. Construction Innovation, 2021, 22(3):504-530. https://doi.org/10.1108/CI-04-2021-0062

[9] Fazeli A, Mohandes S R, Hajirasouli A, et al. Augmented reality in design and construction: thematic analysis and conceptual frameworks. Construction Innovation, 2021, 22(3):412-443.

[10] Lau C K, Chen H. Stakeholder perceptions on the risk factors, challenges and benefits of business sustainability practices in the Singapore construction industry. Property Management, 2021, 40(2):149-168. https://doi.org/10.1108/PM-02-2021-0014

[11] Oyegoke A S, Powell R, Ajayi S, et al. Factors affecting the selection of effective cost control

techniques in the UK construction industry. Journal of Financial Management of Property and Construction, 2021, 27(2):141-160. https://doi.org/10.1108/JFMPC-07-2020-0050

[12] Mustaniroh S A, Radyarini D, Silalahi R. Supply Chain Risk Mitigation of Enting Geti with Fuzzy Failure Mode and Effect Analysis and Analytical Hierarchy Process (Case Study at Small Medium Enterprises of Kuda Terbang, Blitar District, East Java Province, Indonesia). Advance journal of food science and technology, 2019, 17(2):18-27. https://doi.org/10.19026/ajfst.17.5998

[13] Dhandapani K. Systematic Approach to the Reliability Characterization of System-in-Package (SiP). Advancing Microelectronics, 2019, 46(3):6-11.

[14] Wenceslao Rodríguez, Marquina M, Mazzeo I, et al. Quality assurance and new public management: transformations in organizational structures, functions and roles in Argentine universities. Quality Assurance in Education, 2021, 30(3):352-369. https://doi.org/10.1108/QAE-10-2021-0160

[15] Lau C, Li Y. Making or remaking people and places through festivals: an island tourism perspective. International Journal of Event and Festival Management, 2021, 13(3):249-266. https://doi.org/10.1108/IJEFM-10-2021-0078

[16] Silvia Inês Dallavalle Pádua, Bernardo R, Nogueira C A. A map for the holistic BPM diagnosis. Business Process Management Journal, 2021, 28(3):630-655. https://doi.org/10.1108/BPMJ-04-2021-0197

[17] Leeks A. Jkc Australia Lng Pty Ltd V Inpex Operations Australia Pty Ltd. Building & Construction Law, 2019, 34(5):405-418.

[18] Br A, Ms A, Xtf B. Ground behaviour analysis, support system design and construction strategies in deep hard rock mining - Justified in Western Australian's mines - ScienceDirect. Journal of Rock Mechanics and Geotechnical Engineering, 2020, 12(1):1-20. https://doi.org/10.1016/j.jrmge.2019.01.006

[19] Hocke K. Gulf Island begins construction on second research vessel. Work Boat, 2019, 76(7):27-28.