Study on the Risk Factors of the Dual Prevention Mechanism in Port Area

Tianyang Bai[a], Zhihui Zhou[b,*]

China Waterborne Transport Research Institute, Beijing, 100088, China

[a]1031802181@qq.com, [b]*472153949@qq.com

Abstract. In recent years, following the enactment of the new Safety Production Law, the port industry has progressively implemented the dual prevention mechanism, which encompasses graded safety risk control and hidden danger investigation and treatment. This initiative has generated a substantial volume of data concerning risks and hidden hazards. Currently, there is a notable lack of systematic analysis within both practical applications and research pertaining to the data. By examining the risk factors associated with port operations identified through risk assessments, this study facilitates a quantitative evaluation of these safety risks. Such an approach effectively aids in formulating targeted risk control measures, thereby enhancing both the capacity for managing operational risks in ports and advancing the construction level of the dual prevention mechanism, ultimately achieving the objective of preventing and resolving major security risks in the very beginning.

Keywords: Risk Factors, Dual Prevention Mechanism, Port Area

1 Introduction

China's port development has achieved remarkable progress, establishing the country as a global leader in port operations and playing a crucial role in supporting the national economy and foreign trade. In recent years, following the enactment of the new Safety Production Law, requirements for construction of the dual prevention mechanism have been progressively implemented. In 2016, the Office of The State Council issued guidelines aimed at preventing major accidents [1], prompting localities to comprehensively develop their own dual prevention mechanisms with distinctive characteristics [2-5]. Implementing this dual prevention mechanism, which is focused on multi level safety risk control and hidden danger investigation in the port industry, is vital for preventing major accidents in port area. The dual prevention approach emphasizes two critical aspects: risk identification and hidden danger screening. Risk identification involves discovering, confirming, and describing potential risks. Risk events are defined as accidents or hazardous scenarios arising from deficiencies related to personnel, facilities and equipment (including goods or materials), environmental factors, or management factors. Effective risk identification within port safety production requires delineating risk scopes, segmenting operational units, identifying risk events based on actual safety

Y. Qiu et al. (eds.), *Proceedings of the 2024 7th International Conference on Civil Architecture, Hydropower and Engineering Management (CAHEM 2024)*, Advances in Engineering Research 256,
https://doi.org/10.2991/978-94-6463-650-5_29

management conditions, and analyzing contributing factors from personnel issues, facility reliability, environmental influences and management compliance.

A substantial amount of data concerning risks and hidden dangers has emerged from developing this dual prevention mechanism. Currently, there is a notable lack of systematic analysis within both practical applications and research pertaining to the data. By examining the risk factors associated with port operations identified through risk assessments, this study facilitates a quantitative evaluation of these safety risks. Such an approach effectively aids in formulating targeted risk control measures, thereby enhancing both the capacity for managing operational risks in ports and advancing the construction level of the dual prevention mechanism, ultimately achieving the objective of preventing and resolving major security risks in the very beginning.

2 Research Methods

The research presented in this paper necessitates the transformation of multiple indicators into a singular metric that accurately reflects the overall situation for evaluation purposes. Thus, a comprehensive evaluation method has been selected. Initially, various evaluation indicators are extracted from existing data of constructing dual control and prevention mechanisms across various enterprises and subsequently weighted according to their significance. The resulting evaluation is not merely a statistical index with specific meaning but rather a ranking of the 'comprehensive status' of participating units based on index or score values. Numerous comprehensive evaluation methods have been proposed both domestically and internationally, depending on different weight assignment techniques and model structures. Given that the Analytic Hierarchy Process (AHP) facilitates more straightforward quantitative and qualitative analyses of complex and ambiguous issues as proposed by American operations research scientist Professor A.L. Saaty at the University of Pittsburgh during the 1970s [7-9], this study employs AHP to construct an evaluative index model, assign weights to its indicators, and ultimately synthesize multiple indicators into a single metric for the evaluation system.

3 Port Operation Risk Factors Analysis

3.1 Risk Factor Index System

Risk factors refer to the potential causes or conditions that promote the occurrence of all kinds of emergencies, or increase the possibility of their occurrence, or expand the extent of their losses, or increase their adverse social impact. Risk factors generally include the following four aspects [6]:

(1) Human Factors: employee safety awareness, safety and emergency skills, safety behavior or status;

(2) Facility/Equipment/Material Factors: reliability of operational machinery, integrity of storage systems and loading/unloading processes, inherent dangers associated with goods/materials;

(3) Environmental Factors: the safety of port operating conditions and the impact of natural environment on port operations;

(4) Management Factors: compliance and completeness of safety management organization, management system and operating procedures.

In conjunction with data gathered regarding current dual prevention mechanism implementations, the risk factor index system from four aspects has been established as in Table 1.

Table 1. Risk Factor Index System

Primary indicator	Secondary indicator
X1 Human factor	X_{11} Risk-taking psychology X_{12} Physical overload exceeded X_{13} Personnel certificate is invalid or uncertified X_{14} Illegal operation or operation error X_{15} command failure X_{16} Improper custody X_{17}Engaged in contraindicated work (workers with contraindicated diseases, such as red-green color blindness) X_{18}Other behavioral risks and harmful factors (drinking on the job, smoking/cell phone use during the work process, obstructing work behavior, inattention)
X2 Facility/Equipment/Material Factors	X_{21} Inadequate Emergency supplies X_{22} Defects in equipment, facilities, tools, accessories X_{23} Protection device and facility defect X_{24} The presence of the first type of hazard in the working area (including energy, noise, high and low temperature substances, combustible and inflammable substances, etc.) X_{25} Logo defects, including unclear and non-standard logo X_{26} Insufficient safety protection distance X_{27} Improper personal protection is X_{28} Unclear signal
X3 Environmental Factors	X_{31} The work place is cluttered and there are obstacles that affect the sight of personnel. X_{32} The space of the workplace is narrow and the movement of the operator is limited X_{33} Harsh climate and environment (wind, lightning, fog, etc.) X_{34}Sudden bad weather (sudden gusts, thunderstorms, severe convection, typhoons) X_{35}Uneven and slippery ground in the workplace X_{36} Workplace temperature discomfort (outdoor/indoor temperature is too high or too low) X_{37} Insufficient lighting in the workplace X_{38} Poor ventilation on site

X4 Management Factors	X_{41}Insufficient security investment X_{42}Insufficient management rules and regulations X_{43} Insufficient safety education and training X_{44} Faultiness operation management X_{45} Lack of risk assessment and prevention in operations X_{46} Inadequate emergency response capacity X_{47} Lack of regular inspection and maintenance of mechanical equipment X_{48} Lack of occupational health management

3.2 The Weight Value of the Evaluation Index

The AHP method is employed to evaluate indicators. In conjunction with relevant experts and research data, enterprise indicators were assessed and scored using a 1-9 scale method. This led to the establishment of a judgment matrix for evaluation indicators across all levels, from which the weight value of each indicator was ultimately derived based on the AHP calculation process. Specifically, Table 2 presents the judgment matrix and results for primary indicators. The secondary indicator was calculated, and the results all passed the consistency test (the operation method was the same as that in Table 2). Finally, the weight of the evaluation index was summarized, as shown in Table 3.

Table 2. Judgment matrix and calculation result of primary index

Primary indicator	X_1	X_2	X_3	X_4	X_5	Weights	λ_{max}	CI	CR	Consistency test
X_1	1	2	3	1	1	0.3439	4.1020	0.0340	0.0378	pass
X_2	1/2	1	3/2	1/2	1/2	0.1719				
X_3	1/3	2/3	1	1/3	1/3	0.1146				
X_4	1	2	4	1	1	0.3695				

Table 3. Index Normalized weights

Primary indicator	Primary indicator weight	Secondary indicator	Secondary indicator weight	Normalized weights
X1 Human factor	0.3439	X11 X12 X12 X14 X15	0.0667 0.2000 0.1333 0.2667 0.0667	0.0229 0.0688 0.0459 0.0917 0.0229

		X16 X17 X18	0.0667 0.0667 0.1333	0.0229 0.0229 0.0459
X2 Facility/Equipment/Material Factors	0.1719	X21 X22 X23 X24 X25 X26 X27 X28	0.0625 0.1875 0.1250 0.3125 0.1250 0.1250 0.0625 0.0625	0.0107 0.0322 0.0215 0.0537 0.0215 0.0215 0.0107 0.0107
X3 Environmental Factors	0.1146	X31 X32 X33 X34 X35 X36 X37 X38	0.0833 0.0833 0.1667 0.3333 0.0833 0.0833 0.0833 0.0833	0.0096 0.0096 0.0191 0.0382 0.0096 0.0096 0.0096 0.0096
X4 Management Factors	0.3695	X41 X42 X43 X44 X45 X46 X47 X48	0.0769 0.2308 0.2308 0.1538 0.0769 0.0769 0.0769 0.0769	0.0284 0.0853 0.0853 0.0568 0.0284 0.0284 0.0284 0.0284

3.3 Evaluation Results and Analysis

According to the Table 3, the significance of various indicators has been systematically ranked and analyzed. The top 6 risk factors are: X14 Illegal operation or operation error, X42 Insufficient management rules and regulations, X43Insufficient safety education and training, X12 Physical overload exceeded, X44 Faultiness operation management, X24 The presence of the first type of hazard in the working area (including energy, noise, high and low temperature substances, combustible and inflammable substances, etc.). Based on the evaluation results and analysis, control measures should be taken from the following aspects: (1) Review and revise management rules and regulations; (2) Strengthen safety education and training of workers; (3) Reasonable arrangement of work to prevent physical overload exceeded; (4) Reinforce operation management, (5) Strict control for the presence of the first type of hazard in the working area.

4 Conclusions

The research can be used to improve the level of safety management in port operation safety, put forward the corresponding basis for the continuous monitoring, assessment and early warning of risk factors, and provide more support for the construction of dual prevention mechanism. Future research will focus on the relationship between risk and hazard data in the dual prevention mechanism, providing a basis for reducing the probability of port safety accidents in the dual prevention mechanism construction.

References

1. Office of The State Council Security Commission. (2016) “Notice of the Office of the Safety Commission of The State Council on Issuing and Distributing Guidelines on Preventing and Controlling Both Symptoms and Root Causes of Major Accidents.”.
2. Wang Dongzhao, Zhai Ruisong. (2018) “Huai 'an Model of double prevention mechanism of safety production.” Jiangsu Work Safety, (2) : 3.
3. Zhang Xinjian. (2019) “Construction and application of 123456 Double prevention System in Chensilou Coal Mine.” Zhongzhou Coal, 42(2) : 14-19, 24.
4. Hu Bo. (2020) “Henan: Clarify the direction of construction of dual prevention system for small and micro enterprises.” China Emergency Management, 167(11) : 96.
5. Bian Binbin, Huang Yuqing, Liu Zhijian, Tian Xianmin, Zhang Kai. (2022) “Construction of safety evaluation index system based on dual prevention mechanism.” Chinese Journal of Safety Science, Vol. 32 Supp.1.
6. Ministry of Transport. (2019) “Port Safety Production Risk Identification and Control Guide.” No. 48.
7. Huang Baohua, Zhang Hua, Sun Zhijun. (2014) “Research on forest fire risk regionalization based on Hierarchical Analysis (AHP) in Shandong Province.” Fire Science, 23 (4) : 225-232.
8. TAN Peizong. (2009) “Research on comprehensive evaluation of accident emergency response capability in chemical industry Park.” Chongqing University.
9. Chen LiLi. (2010) “Fire risk assessment and application research of Public buildings.” Jilin University.