



A Brief Analysis of Safety and Health Hazard Awareness in Building Construction in China from 2001 to 2022

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Abstract. On the basis of summarizing the research results of domestic and foreign scholars on safety awareness, this paper summarizes the influencing factors of safety awareness into three levels: laws and regulations, safety management, and safety protection, and thus constructs a theoretical model of the impact of safety awareness of construction management personnel in construction enterprises. Then, by using SPSS software to analyze the data obtained from the questionnaire, it is concluded that safety protection is the most important factor affecting safety awareness. In order to verify the reliability of the model, we constructed a structural equation model. Through reliability analysis and confirmatory factor analysis, we found that safety protection had a significant positive correlation with safety knowledge, sense of safety reason, ability to predict the occurrence of injury and self-efficacy of safety awareness.

Keywords: Safety and Health Hazard Awareness; Building Construction; Safety management.

1 Introduction

There has been significant research on awareness of safety and health hazards in the building construction industry in Europe and America. Some key findings and trends include:

(1) Safety culture: A strong safety culture is essential for promoting safety and health awareness in the construction industry. Many studies have focused on how to establish a safety culture in construction firms and the role of management in promoting safety.

(2) Training and education: Safety training and education are important for promoting awareness of safety and health hazards in the construction industry. Research has shown that workers who receive safety training are more likely to engage in safe work practices.

(3) Communication: Effective communication is essential for promoting safety and health awareness in the construction industry. Many studies have focused on how to improve communication between workers, supervisors, and management.

(4) Risk assessment: Risk assessment is an important part of promoting safety and health awareness in the construction industry. Research has shown that workers who

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P. Xiang et al. (eds.), *Proceedings of the 2023 5th International Conference on Hydraulic, Civil and Construction Engineering (HCCE 2023)*, Atlantis Highlights in Engineering 26,

https://doi.org/10.2991/978-94-6463-398-6_77

are involved in risk assessment are more likely to be aware of safety and health hazards.

(5) Personal protective equipment: Personal protective equipment (PPE) is an important tool for protecting workers from safety and health hazards in the construction industry. Studies have examined the use of PPE and the factors that affect PPE use [1].

(6) Work environment: The work environment plays an important role in promoting safety and health awareness in the construction industry. Studies have examined the impact of factors such as lighting, noise, and temperature on worker safety and health.

(7) Technology: Technology can be used to improve safety and health awareness in the construction industry. Studies have examined the use of technology such as virtual reality and building information modelling to promote safety and health.

2 Literature review

Construction safety and health hazards continue to pose significant risks to workers in China's building construction industry. Research has been conducted to examine the awareness and management of these hazards in China's construction industry [2]. The literature on this topic can be organized into three broad categories: (1) the state of safety and health hazard awareness, (2) factors affecting safety and health hazard awareness, and (3) interventions to improve safety and health hazard awareness.

State of safety and health hazard awareness: Studies have found that awareness of safety and health hazards is generally low among workers in China's building construction industry. For example, research has shown that many workers are not aware of the risks associated with working at heights or working with hazardous materials. There is also a lack of awareness of the importance of using personal protective equipment (PPE) to prevent accidents and injuries. Additionally, many workers are not aware of the legal and regulatory requirements related to construction safety and health in China.

Factors affecting safety and health hazard awareness: Several factors have been identified as affecting safety and health hazard awareness in China's construction industry. One of the key factors is the lack of training and education on safety and health hazards. Studies have shown that workers who receive safety training are more likely to be aware of safety and health hazards and to engage in safe work practices. Another factor is the lack of communication and collaboration between workers, supervisors, and management. Poor communication can lead to misunderstandings and a lack of awareness of safety and health hazards. The work environment also plays a role in safety and health hazard awareness. Poor lighting, noise, and temperature can all impact worker safety and health.

Interventions to improve safety and health hazard awareness: Several interventions have been proposed to improve safety and health hazard awareness in China's construction industry. One of the key interventions is the use of safety training and education programs. Studies have shown that workers who receive safety training are more

likely to be aware of safety and health hazards and to engage in safe work practices [3]. Another intervention is the use of technology, such as virtual reality and building information modelling, to improve safety and health hazard awareness. Technology can be used to simulate hazardous work environments and provide workers with a better understanding of the risks associated with their work.

Overall, the literature suggests that safety and health hazard awareness is an ongoing challenge in China's building construction industry [4]. Factors such as the lack of training and education, poor communication, and the work environment all impact worker safety and health. Interventions such as safety training and education programs and the use of technology can be effective in improving safety and health hazard awareness. However, more research is needed to understand the best practices for improving safety and health hazard awareness in China's construction industry.

3 Methodology

The research content of this paper is to analyze the composition of safety awareness and put forward the most important influencing factors. In order to achieve the expected research objectives, this paper uses literature and empirical research methods [5]. The literature method refers to the systematic reading and collation of domestic and foreign literature on the concept of safety awareness, the composition of safety awareness, the impact factors of safety awareness, and other literature before the investigation and research, summarizing the results of previous theoretical research and empirical research, as well as the strengths and weaknesses of the research, and forming research ideas based on the previous research, combined with the situation of construction management personnel of Chinese construction enterprises, and transform into the theoretical basis of this paper. The empirical research method is to collect the required data based on the assumptions put forward in this paper, and use SPSS software to analyze and process the collected data, and finally use structural equation model to verify the assumptions put forward in the study to draw general conclusions [5].

3.1 Model construction

On the basis of literature review and questionnaire design analysis, this paper proposes four dimensions to measure the composition of safety awareness of construction management personnel in construction enterprises [6]: safety knowledge, safety sense of reason, ability to predict injury and self-efficacy; The factors that affect the safety awareness of construction management personnel in construction enterprises are divided into three levels: safety protection, safety management and laws and regulations. On this basis, this paper constructs a conceptual model of the impact of safety awareness of construction managers in construction enterprises, as shown in Figure 1.

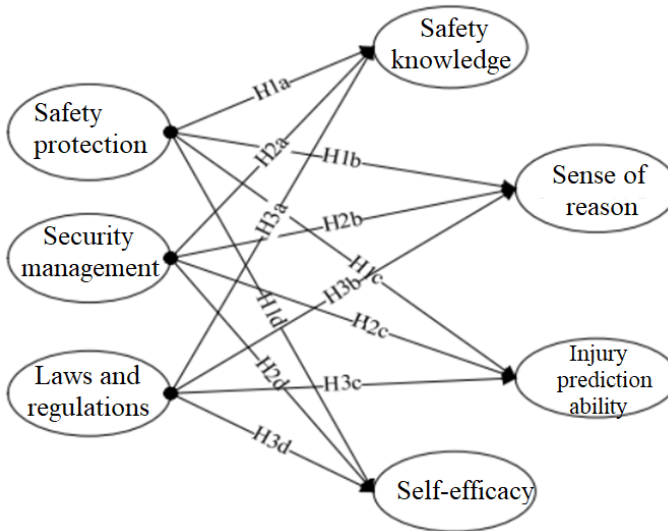


Fig. 1. Conceptual model of safety awareness impact of construction workers.

Based on the above conceptual model, this paper proposes the following assumptions for the conceptual model of the impact of safety awareness of construction managers in construction enterprises.

(1) When the construction enterprise carries out safety production management for the project, during the construction process, it shall take on-site protection and safety measures, formulate accident prevention and emergency treatment plans, and carry out safety publicity, education and training for the construction management personnel to enhance the safety knowledge, safety sense of reason, ability to predict the occurrence of injury and self-efficacy of the construction management personnel, so as to achieve the purpose of improving the safety awareness of the construction management personnel [7]. This paper believes that the material basis guarantee of safety protection will have a direct and significant positive impact on the training of safety awareness of construction management personnel. Therefore, this paper puts forward the following assumptions:

- H1a: Safety protection has a significant positive impact on safety knowledge.
- H1b: Safety protection has a significant positive impact on safety sense of reason.
- H1c: Safety protection has a significant positive impact on the ability to predict the occurrence of injury.
- H1d: Safety protection has a significant positive impact on self-efficacy of construction management personnel.

(2) The safety management work is highly technical, policy-oriented and mass oriented. Construction enterprises, from enterprises to teams, must be equipped with safety organizations, special safety management personnel to conduct periodic safety inspections and provide financial input. It plays a very important role in strengthening the safety awareness of construction management personnel [8]. This paper believes that the supervision and management factors of safety management will have a direct and significant positive impact on the safety awareness of construction management personnel. Therefore, this paper puts forward the following assumptions:

- H2a: Safety management has a significant positive impact on safety knowledge.
- H2b: Safety management has a significant positive impact on safety sense of reason.
- H2c: Safety management has a significant positive impact on the ability to predict the occurrence of injury.
- H2d: Safety management has a significant positive impact on self-efficacy of construction management personnel.

(3) When construction enterprises carry out safety production management for projects, the strict implementation of laws and regulations will play an important role in preventing and promoting the reduction of major casualties and improving the safety awareness level of construction management personnel of construction enterprises in China [9]. This paper believes that the restriction and enforcement of laws and regulations will have a direct and significant positive impact on the cultivation of safety awareness of construction management personnel. Therefore, this paper puts forward the following assumptions:

- H3a: Laws and regulations have significant positive impact on safety knowledge.
- H3b: Laws and regulations have a significant positive impact on safety sense of reason.
- H3c: Laws and regulations have a significant positive impact on the ability to predict the occurrence of injury.
- H3d: Laws and regulations have a significant positive impact on the self-efficacy of construction management personnel.

On the basis of a small survey sample test, this paper revised the questionnaire several times according to the survey results, further checked whether the meaning of the questionnaire items was clear and whether the words were appropriate, and finally determined the formal questionnaire measurement items. According to the composition characteristics and influencing factors of safety awareness, based on the definition and relationship of structural variables in the structural equation model, the design framework of corresponding observation variables and questionnaire items is shown in Table 1.

Table 1. Questionnaire on factors affecting construction safety awareness.

Latent variable		Observed variable	Measurement items
Elements of safety awareness (A1)	Safety knowledge (B1)	C11	Be familiar with the scope of work, including relevant technologies
		C12	Be clear about the types of accidents that are easy to happen at the construction site
		C13	Know safe working methods
	Safety sense of reason (B2)	C21	Be willing to participate in safety knowledge, education and training activities
		C22	Be willing to comply with operating procedures and safety regulations
		C23	Admire colleagues who maintain high vigilance at work
	Injury prediction ability (B3)	C31	Experienced in judging hazards in construction
		C32	Be aware of the signs before the danger in construction
		C33	Make correct judgment on the signs before the occurrence of danger in construction
	Self-efficacy (B4)	C41	Carry out routine inspection of equipment and tools before work
		C42	Consciously avoid dangerous areas when working
		C43	Wear safety instruments and take protective measures when working
Factors affecting safety awareness (A2)	Laws and regulations (B5)	C51	Understanding of building safety laws and regulations
		C52	Familiarity with construction industry standards
		C53	Understanding of safety rules and regulations on construction site
	Safety protection (B6)	C61	Implementation of construction site protection and safety measures
		C62	Accident prevention and emergency treatment plan
		C63	Current situation of safety publicity, education and training popularization
	Security management (B7)	C71	Safety management organization and post setting
		C72	Conduct regular safety inspection
		C73	Guarantee degree of safety investment

3.2 Data collection method

Based on the research of relevant academic literature, this paper has carried out in-depth research by referring to the discussion of the composition of safety awareness and the influencing factors of safety awareness by domestic and foreign scholars. In order to collect data more comprehensively and avoid the misunderstanding of the safety awareness of the construction managers in the same construction enterprise, this paper first interviewed 11 middle-level managers of the construction enterprise,

and then interviewed 8 middle-level managers of the construction enterprises from different regions [10]. The interview materials of the 19 managers are the main source of the formation of the scale items. The whole interview process of the questionnaire lasted six months, and interviewed the personnel who had participated in the construction from 2001 to 2022. A total of 27 statements on safety awareness and influencing factors were summarized, and 27 items corresponding to the composition of safety awareness and influencing factors were designed. In order to better modify the questionnaire, the first draft of the questionnaire consisting of 27 items is used to analyze 103 construction managers of construction enterprises.

The purpose of item analysis is to find out the critical ratio - CR value of individual items in the questionnaire to measure the degree of response of the respondents to the items and measure the identification degree of the questionnaire. The independent sample T test is used to test the questionnaire data. First, the questionnaire data is divided into two groups with 27% as the dividing line, and then the T test is used to test the difference between the two groups of data on each item. If the CR value obtained by T test is in the range of $\alpha < 0.05$ or $\alpha < 0.01$, it means that this item can identify the reaction degree of the subject; If not, delete the item. After analyzing the items in the questionnaire, the components of safety awareness and the analysis of influencing factors are significant.

3.3 Data analysis

In this study, people who participated in construction projects from 2001 to 2022 were selected as the subjects of investigation. A total of 400 questionnaires were distributed and 271 were recovered, with a recovery rate of 67.8%. After selection, 177 valid questionnaires were finally obtained, with an effective rate of 65.3%. At the same time, the valid questionnaire was numbered, and then all data were entered according to the selection of the respondents in the questionnaire. After the data entry, the results were reviewed to ensure the accuracy of the entry.

The first step of data analysis is to understand its internal laws. The usual method is to conduct descriptive statistical analysis on the data first, which is the prerequisite to ensure the correct statistical inference.

Construction seniority distribution.

According to the distribution of the construction years of the personnel filling in the questionnaire, the workers with less than 5 years of service and 5 to 10 years of service are the most, accounting for 39% and 25%, respectively; the least number of people are those who have worked for more than 20 years, accounting for 3%. The above data shows that the difference in the distribution of construction management personnel engaged in construction in this sample enterprise is conducive to the universality test of the research conclusions.

Enterprise scale distribution.

From the perspective of the size distribution of the enterprises in which the questionnaires were filled, more than 501 people and 51 to 200 people filled in the questionnaires, accounting for 42% and 28%; The second is 201 to 500 people and less than 50 people, accounting for 17% and 13%. The above data show that China's large and medium-sized construction enterprises have become the main force of the construction industry.

Enterprise qualification distribution.

From the perspective of the distribution of the qualifications of the units where the personnel fill in the questionnaire, there are many first-level qualifications and special-level qualifications, accounting for 59% and 26%; The second is Grade III qualification and Grade II qualification, accounting for 10% and 5%. The above data shows that the difference of qualification distribution of sample enterprises is conducive to the universal test of research conclusions.

Personnel position distribution.

According to the position distribution of the filling personnel in the questionnaire, the position of the filling personnel is the safety director, followed by the quality director, followed by the production manager and project manager, followed by the technical manager and other management personnel. The above data shows that the difference in the position distribution of the sample enterprises is conducive to the universality test of the research conclusions.

Personnel education distribution.

According to the position distribution of the filling personnel in the questionnaire, the position of the filling personnel is the safety director, followed by the quality director, followed by the production manager and project manager, followed by the technical manager and other management personnel. The above data shows that the difference in the position distribution of the sample enterprises is conducive to the universality test of the research conclusions.

3.4 Reliability analysis

This paper uses SPSS 17 statistical analysis tool for the formal questionnaire data, and uses the Cronbach α coefficient to test the reliability. The consistency of the measurement items and the good internal structure can be accurately reflected through the Cronbach α coefficient.

The influencing factors of safety awareness of construction management personnel in construction enterprises include three levels: laws and regulations, safety protection and safety management. The Cronbach α coefficient method is now used to test the reliability of the total scale and subscale, and the results are shown in Table 2.

Table 2. Reliability test of influencing factors of safety awareness.

Total amount table	Factor dimension	Observed variable	Cronbach α value	Cronbach α value of total amount table
Influencing factors of construction safety awareness	Laws and regulations	C51	0.824	0.763
		C52		
		C53		
	Safety protection	C61	0.881	
		C62		
		C63		
	Security management	C71	0.752	
		C72		
		C73		

The results of the reliability test in the above table show that the standardized Cronbach α coefficient of the total scale of the safety awareness influencing factors questionnaire is 0.761, indicating that the reliability of the total scale is acceptable; The Cronbach α coefficients of laws and regulations, safety protection and safety management are 0.824, 0.881 and 0.752 respectively, which are all above 0.7, indicating that the reliability of the sub-scale of factors affecting safety awareness is good.

3.5 Model validation

This article uses Structural Equation Modelling (SEM) to validate the proposed assumptions. Structural equation modeling is a statistical data analysis tool that combines multiple regression analysis, path analysis, and confirmatory factor analysis. SEM contains two types of variables (latent variables and observational variables) and two models (measurement model and structural model).

Measurement Model.

The measurement model is an important part of SEM, which measures the relationship between observed variables and latent variables. Researchers also refer to measurement models as factor models because latent variables in the model are counted as a factor, and the measurement model measures the relationship between the factor and its project indicators. The measurement model is constructed as follows:

$$X = \Lambda_x \xi + \delta \tag{1}$$

$$Y = \Lambda_y \eta + \varepsilon \tag{2}$$

In the formula, X is the observation variable of ξ , and δ is the Residual term of X ; Λ_x is a matrix with the coefficient $q \times n$ of the factor load of X on ξ ; Y is the obser-

vation variable of η , and ε is the residual term of Y ; Λ_y is a matrix with the coefficient $p \times m$ of the factor load of Y on η .

The measurement model in SEM is essentially a confirmatory factor analysis model, which refers to the degree of adaptation between indirectly measured latent variables and their derived observational variables, that is, the reliability between the various observational variables (items in the questionnaire) that constitute latent variables and their latent variables. Reliability refers to the fitting index between the latent variables obtained through factor analysis and the Cronbach numbers of each observation variable, indicating that the reliability has reached an acceptable level.

Structural Model.

The structural model is another important part of SEM, which measures the relationship between latent variables and latent variables. Researchers also call it the causal model because it measures the causality between potential variables. The structural model is constructed as follows:

$$\eta = B\eta + \Gamma\xi + \zeta \tag{3}$$

In the formula, η is an endogenous latent variable; ξ is an exogenous latent variable; ζ is the error term, that is, the part of η and ξ that cannot be explained; B is a matrix with $m \times m$ coefficient of the relationship between multiple η .

The structural equation model is a composite of causal relationship model and factor relationship model, constructed as follow:

$$\begin{cases} \eta = B\eta + \Gamma\xi + \zeta \\ X = \Lambda_x\xi + \delta \\ Y = \Lambda_y\eta + \varepsilon \end{cases} \tag{4}$$

The use of SEM to solve the problem to be studied is to use the collected data to verify hypotheses. In this process, SEM is used to present the similarity between the established hypothesis model and the actual data model, and the difference is defined as a fitting function. The expected result is to minimize the maximum value of the fitting function. SEM differs from traditional analysis methods in that it can effectively and scientifically explain variables that cannot be directly measured in psychology and management, and can be largely fault-tolerant. The use of SEM to explain phenomena is to explore the covariance matrix between assumptions and reality, which is expressed as follows:

$$\Sigma = \Sigma(\theta) \tag{5}$$

In the formula, Σ is the covariance matrix that can be calculated using observed variable data; θ is the parameter to be estimated in the model; $\Sigma(\theta)$ is the fitting function of the covariance matrix.

Based on the analysis results of the questionnaire data, the path relationship of potential variables in the structural equation model of the impact factors of safety awareness on the dimensions of safety awareness is shown in Table 3.

Table 3. Model validation results.

Assumptions	Impact path	Standardized path coefficient	T value	Result
H1a	Safety protection -> Safety knowledge	0.56	4.94	Ture
H1b	Safety protection -> Sense of reason	0.55	4.75	Ture
H1c	Safety protection -> Injury prediction ability	0.73	6.73	Ture
H1d	Safety protection -> Self-efficacy	0.76	6.01	Ture
H2a	Security management -> Safety knowledge	0.20	2.66	Ture
H2b	Security management -> Sense of reason	0.24	3.26	Ture
H2c	Security management -> Injury prediction ability	0.15	1.82	False
H2d	Security management -> Self-efficacy	0.18	2.20	Ture
H3a	Laws and regulations -> Safety knowledge	0.29	2.19	Ture
H3b	Laws and regulations -> Sense of reason	0.31	2.71	Ture
H3c	Laws and regulations -> Injury prediction ability	0.14	1.15	False
H3d	Laws and regulations -> Self-efficacy	0.09	0.72	False

The path that reaches the significant level (T value is greater than 1.96) means that the hypothesis relationship of this path is true, and the other way round, it means that the hypothesis is false. These adopted assumptions are valid within the scope of this study, which basically proves the main points and specific issues raised in this study.

We used the SEM model to test the proposed impact model on safety awareness of construction management personnel in construction enterprises, and obtained an empirical data graph, as shown in Figure 2.

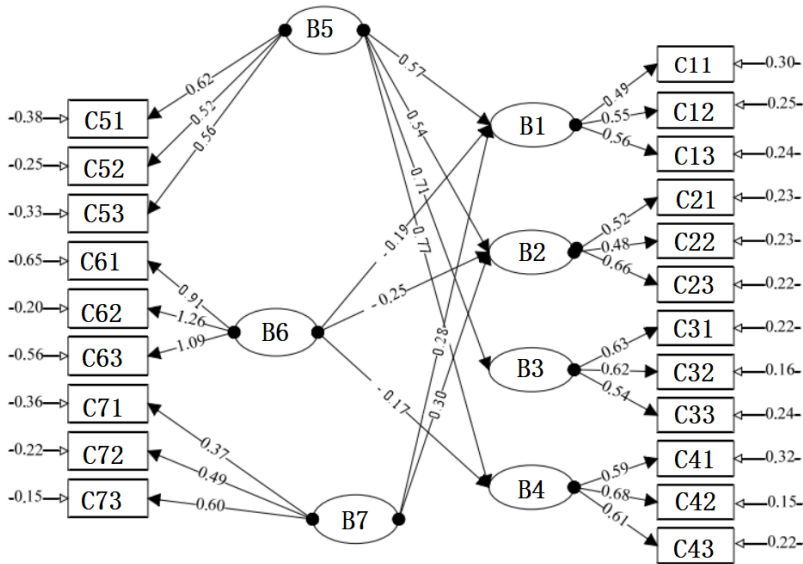


Fig. 2. Empirical data graph of structural equation model.

4 Result and discussion

In the previous theoretical and empirical analysis, this paper conducted a systematic and comprehensive empirical study on the dimensions and influencing factors of safety awareness of construction managers in construction enterprises. This section explains the hypothesis test results of structural equation model and proposes the main influencing factors.

4.1 Impact of safety protection

From the standardized path coefficient, it can be concluded that safety protection has a significant impact on safety awareness and is the most important factor. Safety protection includes site protection and safety measures, accident prevention and emergency treatment, safety publicity and education and training. Regular safety publicity, education and training for construction management personnel by construction enterprises can effectively increase the safety knowledge and safety sense of construction management personnel. The establishment of accident prevention and emergency treatment plans by construction enterprises can effectively strengthen the ability and self-efficacy of construction management personnel to predict the occurrence of injuries [11]. On-site protection and safety measures are the material basis for ensuring on-site environmental safety. Therefore, safety protection can effectively affect the safety awareness of construction management personnel of construction enterprises.

4.2 Impact of security management

From the standardized path coefficient, it can be seen that the impact of safety management on safety awareness is relatively significant, and it is a secondary key factor. Safety management includes three factors: safety management organization and post setting, safety inspection and safety investment. The construction enterprise has set up a full-time safety management department, equipped with full-time personnel to implement the safety construction guidelines, policies and regulations, regularly carry out safety inspection and ensure sufficient safety input, effectively strengthening the safety knowledge of the construction management personnel, improving the safety sense of the construction management personnel, and promoting the self-efficacy of the construction management personnel. Therefore, reasonable safety management can effectively improve the safety awareness of construction management personnel in construction enterprises.

4.3 Impact of laws and regulations

Laws and regulations include construction safety laws and regulations, construction industry standards, and construction site safety rules and regulations. The Party and the government attach great importance to work safety. In order to protect the safety and health of workers, control and reduce various safety accidents, a series of construction safety laws and regulations and industry standards have been issued. Construction enterprises should improve their own safety production management level, formulate a series of construction site safety rules and regulations that are consistent with the actual situation of the construction site and accepted by construction management personnel, and effectively improve the safety knowledge of construction management personnel. Therefore, laws and regulations can effectively supervise the safety awareness of construction management personnel of construction enterprises.

5 Conclusions

Based on the current situation of safety production in domestic construction industry, considering the particularity of construction enterprises, this paper proposes the dimensions and influencing factors of safety awareness of construction management personnel in construction enterprises, and then finds out the main factors that affect the safety awareness of construction management personnel. And use empirical analysis method to verify the hypothesis of the conceptual model, and discuss the gap between the theoretical hypothesis and the empirical results, and put forward targeted management suggestions.

Based on the research of scholars at home and abroad, combined with the concept and characteristics of safety awareness of construction enterprises and the field interviews with construction enterprises, this paper summarizes the factors affecting the safety awareness of construction managers in construction enterprises into three levels: laws and regulations, safety management, and safety protection. On the basis of proposing the dimensions and influencing factors of safety awareness of construction

managers in construction enterprises, this paper constructs a theoretical model of influencing factors of safety awareness of construction managers in construction enterprises. The theoretical model is verified and analyzed by statistical methods, and it is concluded that safety protection has a significant positive correlation with safety knowledge, safety sense of reason, ability to predict injury and self-efficacy; Safety management has significant positive correlation with safety knowledge, safety sense of reason and self-efficacy; Laws and regulations have significant positive correlation with safety knowledge and safety sense of reason.

Finally, according to the research results, three effective ways are proposed to improve the safety awareness of construction management personnel in construction enterprises, improve the high incidence of safety production accidents in construction enterprises in China and improve the current situation of safety production in construction enterprises, including establishing a safety protection system, improving the effective safety management mechanism, improving the legal system construction, and improving the law enforcement.

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