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Safety Culture Model and Influencing Factors Analysis in Construction Enterprises of China

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Abstract: The construction industry is one of the most injury-prone industries and an increasing number of scholars are paying great attention to safety culture in this industry. This study aims to construct a conceptual model of safety culture through recognizing the significance of related influencing factors, helping improve the safety condition of construction enterprises. First, we review the related concepts and the structure of safety culture. Then we propose the level of safety culture in Chinese construction enterprises and construct safety culture model based on the structure of safety culture. After that, we extract several influence factors in connection with safety culture from the original literature and utilize the questionnaire to collect data in spot investigation. And factor analysis is used to process the collected data to get the affecting coefficient that the different influence factors contribute to safety culture. Through analyzing the collected data, we improved the conceptual model in order to reflect the influence of different factors on safety culture better. And construction enterprises can get some enlightens from the improved model when they engage in improving the safety condition of their enterprises.

Keywords: construction enterprise, factors analysis, model of safety culture, safety culture

INTRODUCTION

Construction industry plays an important role in current global economic environment, but the safety record in this field is far from satisfaction. Fig. 1 shows that the number of accidents are up to 2000 or more in the last 5 years, causing more than 2000 deaths per year reported by the State Administration of Work Safety (2006) in China. In view of the current situation in China, construction industry has been among the most dangerous industries, with annual deaths standing right behind the mine industry, taking up the second place in all industrial departments. Consequently, the research on safety culture is of high theoretical value and practical significance for improving the safety condition of Chinese construction industry.

However, as the causes of accidents are various, the research on safety culture is complicated. Yushi (2006) categorized the causes of accidents into four aspects on the basis of their causes, namely wrong speculation and act of individuals (unsafe act in general), unsafe state of object, dangerous environment as well as poor management. Meanwhile, of all the reasons causing the accidents, act of individuals and unsafe state of object are the direct causes. It has been proved by practice that when the two reasons mentioned above occur at the same time and place, accidents are usually triggered. Moreover, individual, as a leading role, changes tremendously in the worksite where individuals, object and environment interact frequently within a relatively scattered operation space, which undoubtedly makes it harder to supervise individual safety act effectively. Because of the intrinsic characteristic of construction industry in China, just relying on improving protection measures and propagandizing the safety system is far from enough. Only when safety ideology and safety culture are both improved fundamentally all over the whole organization, the hidden dangers will be prevented and controlled, and the current passive situation could be reversed. It is generally accepted wisdom that an organization that develops and maintains a strong safety culture is more effective at preventing individual and large scale accidents (Baram and Schoebel, 2007). Lots of international scholars agree that safety culture is a pivotal factor for the safety of an organization (Pidgeon, 1998) and is also the fundamental guarantee to achieve a high performance of safety management (Tor-Olav, 2010; Yihong *et al*., 2012).

Recognizing the pivotal impact of safety culture on safety outcomes such as injuries, fatalities and other incidents, scholars have shown increasing interests in the research of safety culture in construction industry (Pidgeon, 1998; Choudhry *et al*., 2007). But gaps still remain in the literature, the previous safety culture models don't fit in the situation of construction industry in China. The studies of safety culture which are carried out in the Western environments can to some degree provide implications to guide us when we step in Chinese construction industry (Guldenmund, 2000; Hudson, 2007). Furthermore, it is well known that state act

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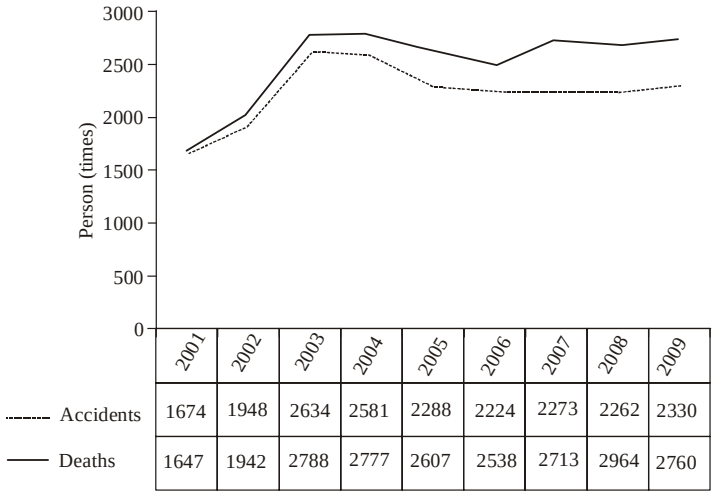

	2001	2002	2003	2004	2005	2006	2007	2008	2009
Accidents	1674	1948	2634	2581	2288	2224	2273	2262	2330
Deaths	1647	1942	2788	2777	2607	2538	2713	2964	2760

Fig. 1: The statistics of accidents and deaths in mainland construction industry of China (Resource: State administration of work safety in China)

influences the organizational culture (Hofstede and Hofstede, 2005). However, there is little research on the influence of state act on safety culture (Kathryn and Steven, 2009).

In an attempt to fill in these gaps in the literature, this paper aims to propose a conceptual model of safety culture to help Chinese construction enterprises improve their safety system. With this objective, we carry out an expansive review of the previous studies on the related concepts of safety culture which will provide the basis for the establishment of this model. Based on previous research, we separate the safety culture of Chinese construction enterprises into four levels, videlicet, physical culture, behavior culture, management and norm culture as well as ideological culture. In that way, the connotation of safety culture can be reflected soundly and clearly. We also take into account the influence of state act and social effect on safety culture, both of which play an authoritative and coercive role in the establishment of safety culture in construction enterprise, but there is little research on the influence of them in the situation of Chinese construction enterprises. Considering the characteristics of construction enterprises, we conduct a spot investigation among project staff in Chinese construction enterprises and four projects under construction have been chosen to conduct a face-to-face questionnaire with the staff. Subsequently, we utilized factor analysis to process the data collected through spot investigation. After analyzing the collected data, we improve the conceptual model so as to better reflect the impact of factors on each level of safety culture. This paper can contribute to the promotion of safety theory in Chinese construction industry and provide practical implications for construction enterprises when they engage in improving the safety condition of their enterprises.

THE RELATED CONCEPTS OF SAFETY CULTURE

Organization climate and organization culture: In the 1970's, many scholars started to conduct researches on organization climate, which touched off a debate over the concepts of organization climate. In general, the term climate has been replaced by culture in safety culture research since 1980s. So, the development of these concepts is not consecutive but parallel (Guldenmund, 2000).

Jones and James (1979) described climate as a mental attribute based on a set of perception, then separated climate from attitude and job satisfaction. Contrasting with influence and assessment of attitude, he proposed a hypothesis that there was a dynamic interaction between influence of attitude and assessment.

Ekvall (1983) distinguished the organization climate and organization culture by dividing an organization's social system into four aspects, that is:

- Organization culture, i.e., group, teams, beliefs and values shared by all members in organization or community
- Social structure, i.e., especially the informal organization;
- Organization climate, i.e., common characteristic of behavior and emotion expression of organization members;
- Working relationship, i.e., the nature of the relationship between employees and employers.

Ekvall (1983) pointed out that the four aspects were interrelated but still different to each other. Then Glick (1985) distinguished climate and culture in the view of application, because they were originated from different

subjects. He believed that the research on safety climate was from the framework of social psychology while safety culture was derived from the study of anthropology. In general, different subjects adopt different research paradigms. The researches on safety climate adopt more quantitative analysis, while the researches on safety culture adopt more qualitative analysis technology. Glick (1985) believed that the study of culture was the inheritance of climate and it was proved that the difference between climate and culture was more noticeable than reality

Van Hoewijk (1988) described organization climate as the combination of "several correlating views, habits and atmosphere", but he didn't define the concept of organization culture. Hofstede (1986) narrowed the concept of organization climate to be "job satisfaction and to something that was typically the concern of lower and middle management", while organization culture was a matter that top management should pay more attention than others.

Schein (1992) conceived climate as pre-culture, namely culture in the making, further on, climate was a reflection and manifestation of cultural assumptions. Then, Schein(2010) proposed organization culture is "a pattern of shared basic assumptions learned by a group as it solves its problems of external adaptation and internal integration, which has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems".

But now, the term climate has been replaced by culture, which could interpret the former one comprehensively and express more extensive and profound meaning. From another perspective, both climate and culture are still used in the field of safety climate and safety culture. The term organization climate refers to an integrated and comprehensive concept which constitutes organization activities and processes, while organization climate often refers to the representation within the organization culture (Guldenmund, 2000). Therefore we conclude that climate derives from culture, while organization culture expresses itself by organization climate.

And organization culture influences on the behavior of the employees, the operations and the performance of the organization. Making a good fit between the strategy and the organization culture can make the influences more positive (Irani *et al*., 2004). However, the organization culture is not the only factor affecting the performance of the organization. Two other impacting factors are the organizational structure and its processes (Guldenmund, 2007).

Zohar (2002, 2008) suggested that employees should perceive safety climate at multiple levels within organizations. And Susan and Lawrence (2008) thought the organization with strong safety climate tends to have fewer employee injuries, not only because the workplace has effective safety programs, but also because the existence of programs sends hint to employees regarding management's commitment to safety. Probst *et al*. (2008) also found that the organization with a more positive safety climate appears to have less underreporting of errors. He proposed that after-action reviews are a setting where error reporting can occur or be encouraged or discouraged.

Safety climate and safety culture:

Safety Culture: The term safety culture was first proposed by International Atomic Energy Agency (IAEA) on the Post-Accident Review meeting on the Chernobyl Accident, published by the IAEA as Safety Series No. 75-INSAG-1 in 1986, and was further extended in Basic Safety Principles for Nuclear Power Plants, Safety Series No. 75-INSAG-3, issued in 1988 (Probst *et al*., 2008). The report (INSAG -4) published in 1991, gave safety culture a narrow definition: safety culture is combination of all kinds of quality and attitude existing in group and individual. Health and Safety (1993) Commission Advisory Committee on Safety of Nuclear Installations (HSCASNI) modified the definition which was given by International Safety Advisory Group (INSAG), believing that: organization of safety culture is comprehensive product of personal and collective values, attitude, ability and behavior, which determines the commitment made by organization for health and safety management, style of work and proficiency (INSAG, 1991). Nowadays, this concept of safety culture is widely accepted and applied by most scholars.

Since the term "safety culture" arises, both foreign and domestic scholars have had a great number of discussions about its meaning, the conclusions were varied. The definition of safety culture in the previous studies is summarized in Table 1.

Despite the definition of safety culture made by international scholars are not identical, there is a consensus that: these definitions are inclined to tell us "what safety culture is" instead of "what safety culture has". Moreover, there is a tendency among these definitions, namely to reflect the concept of safety culture from the view of attitudes or behaviors.

Safety culture researchers tend to focus on the values and assumptions of organizational members with respect to safety and emphasize the role of organizational norms and socialization influences on safety behavior and safety outcomes usually studied via qualitative methodologies as observation and interviews (Diaz-Cabrera *et al*., 2007). Diaz-Cabrera *et al*. (2007) considered safety culture can be construed to be manifested in shared values and meanings, and in a particular organizational structure and processes, safety policies, strategies, goals, practices and leadership styles related to safety management system. Meanwhile, safety culture should be understood as an expression of organizational culture, in such a way that it

Table 1: The definition of safety culture in the previous studies

Author	The views of safety culture	The reflected dimensions of safety culture
Cox (1991)	The employees' common attitude towards safety related issues, beliefs, cognitive and values	Ideological culture
Ostrom *et al*. (1993)	The belief and attitude of organization showed in activities, policies and regulations, which can affect organizational safety performance.	Ideological culture, Behavior culture, Management and norm culture
Lee (1996)	The product of group values, attitudes, perceptions, competencies as well as patterns of behavior, and determines the commitment, style and proficiency of organization's health as well as safety management.	Behavior culture, Ideological culture
Williamson *et al*. (1997)	A recapitulative concept used to describe the safety standards of organization or workplace, and is reflected through the safety beliefs of employees.	Ideological culture, Management and norm culture
Hale (2000)	Refers to a group attitude, beliefs and cognition deciding the reaction of group members to risk.	Ideological culture
Glendon and Stanton (2000)	The combination of attitudes, behavior, rules and values, personal responsibility as well as human resource characteristic.	Behavior culture, Ideological culture, Management and norm culture
Cooper (2000)	The observable degree of efforts made by all the members in daily to improve safety attention and activities.	Behavior culture
Guldenmund (2000)	Meanings, interpretations, attitudes, values, beliefs, rules and procedures related to safety.	Ideological culture, Management and norm culture
Hale (2000); Pidgeon and O'Leary (2000); Wilpert (2001).	Safety culture is a polemic and complex concept that requires considerable theoretical and empirical clarification	
Richter and Koch (2004)	The shared and learned meanings, experiences and interpretations of work and safety—expressed partially symbolically—which guide peoples actions towards risks, accidents and prevention.	Behavior culture Ideological culture
Hopkins (2005)	Organizational collective practices and characteristic of groups and of organizations.The expansion concept includes health, working environment and environment introduced factors other than major accidents and catastrophes which is the background for the safety culture concept.	Behavior culture, Physical culture
Diaz-Cabrera *et al*. (2007)	Reflect and highlight the conceptual divergences around organization culture regarding their central components, visibility or invisibility, and how its basic dimensions can be evaluated.	

implies values and meaning systems linked to safety developed through negotiations between members, which could result in subcultures. The safety maturity model by Hudson (2007) divided reigning safety cultures into five different categories, based on only two criteria: being informed and trust. The safety culture in these five categories varies from "pathological" to "generative". Anastacio *et al*. (2010) proposed a safety culture maturity model, using to measure the stage of maturity of safety culture of an organization. But the model does not identify the influence of national culture on safety culture. If the safety culture maturity model is applied in one multi-national organization in different countries with different culture, it could identify the same stages of maturity in this organization in different countries.

Safety climate: Gregory (2010) considers safety climates as a comprehensible version of safety culture. And safety climate as a symbol of what an organization might want or hope to be, managers can have a hand in its construction. In healthy organizations, safety climate works well. At face value, they are oriented toward safety after all. But when the organization is pathological, safety climate devolves into superstructure, propaganda or sideshows.

Susan and Lawrence (2008) proposed safety climate refers to shared perceptions of employees about the safety of their work environment, and provides a background against which day-to-day tasks are performed. These shared perceptions derive from several factors, including management decision making, organizational safety norms and expectations, and safety practices, policies, and procedures which together serve to communicate organizational commitment to safety. Susan and Lawrence (2008) found that safety climate most strongly relates to measures of effective communication and feedback. They pointed out these relationships seem quite reasonable as commitment to safety are transmitted through communication by management. And they considered safety climate also relates to a variety of positive experiences, such as job involvement and higher levels of decision making. Employee perceptions about safety are important because safety climate has been linked to better adherence to safe work behaviors (Susan and Lawrence, 2008) and fewer injuries (Varon and Mattila, 2000; Barling *et al*., 2002; Gillen *et al*., 2002). One important purpose of safety climate is as a 'leading indicator', a forewarning of problems with safety that might be detected before injuries-the outcome of poor safety occur (Mearns *et al*., 2003).

The difference between safety climate and safety culture: Organizational safety culture and organizational safety climate are subsets of organizational culture and organizational climate. By literature review, Flin *et al*. (2000) found that the concept of safety culture originated from organizational culture and organizational climate. The concept of organizational culture is commonly used to describe corporate shared values which influence employees' attitude and behavior. As a subset of organizational culture, safety culture is deemed to be the degree of observable efforts of all members who improve safety awareness and activities in daily life, which can affect employees' attitude and behavior to consolidate health development and safety performance of organization.

Despite issues on safety climate can be traced back to Keenan's research, based on assessment of car factory employees' pondering over themselves in 1951, the research on safety culture and safety climate acknowledged by academia could be originated from Zohar (1980) work, with concept developed in the field of nuclear power industry after the chernobyl nuclear leaking disaster (Guldenmund, 2000; Keenan *et al*., 1951; Zohar, 1980). It has been 30 years since safety culture and safety climate were under research internationally, and then a great number of valuable reviewing articles were published.

One argument is proposed by Guldenmund (2000), he considered that safety climate in organization consist of its member's safety attitude, while safety culture is the reason it forms. And the result of safety climate is the measurable response which could be cognitive, affective or behavioral one. And Guldenmund (2000) also distinguished culture and climate on the basis of Schein's research on culture classification. Another argument is proposed that safe climate is one of plenty of elements which are able to influence on safety culture. Cooper (1998) defined safety culture as a "multi-objective oriented product made by interaction of individuals (mental), work (behavioral), organization (environmental) ". Cooper admitted that this kind of triangle interaction relationship was also proposed in some earlier literature. Still, he retained the concept of safety climate and thought the concept was related to the individuals, and the psychological factors about individuals were got from the safety climate questionnaire. In his opinion, safety climate is not only time point sampling of safety culture, but also a part of it.

Some authors also described the relationship between safety culture and safety climate. Flin *et al*. (2000) considered that safe climate was a concept closely related with safety culture, but they were entirely different. And safe climate could be taken as surface characteristics of safety culture, or the reflection of present safety state. Cox and Cheyne (2000) thought climate was temporarily presentation of culture, presenting through cognition shared in certain organization in specific time. Silva *et al*. (2004) considered that both organizational climate and safety climate were about shared organization values, standards, practice and norm, which can be observable and measurable.

As can be seen from the original researches, safety culture refers basically to specific organization, and attitude, belief, perception as well as values are expression forms of safety culture. Safety climate is based on specific organization or workplace, which is mainly embodied in employees' entire perception or attitude. Through the analysis of the definition, it is obvious that safety climate is a concept at the same level with safety culture in the organization, but at a lower level under specified conditions, i.e., specific workplace or group in organization. At organization level, safety climate is regarded as a form of expression of safety culture, while it is safety perception or attitude formed by specific group in certain background at lower level.

Structural levels of safety culture: The researches on the concepts of safety culture give us a clear understanding of "what is safety culture", but in order to make certain "the role of safety culture", the scholars undertake the researches on the structure of safety culture. Deshu and Cheng (2004) divided safety culture into four respective levels, namely safety implement level, safety institution level, safety spiritual intelligence level and safety value and normal level. Both safety implement level and institution level are materialized level or object level of spiritual intelligence level. Safety value standard level, lying in the deep of the culture system, is a stubborn ingredient most difficult to change in culture.

Safety culture plays a vital role in employees' safety of workplace. Workers' unsafe activities lead to accidents, in order words, accidents often happen on workers who are lack of security protection equipment (Choudhry and Fang, 2008; Helms and Johnson, 1998). Lee and Halpin (2003) illustrated the relationship between safety performance and supervision and training in construction enterprises, then Arboleda *et al*. (2003) differentiated management activity and worker's activity, which was used as a way to analysis and classify safety culture. Management activity and worker' activity should be treated as independent phenomenon but there are also some relations between them. Dongping and Chen (2005) divided safety culture of construction enterprise into four levels, that is, enterprise level, project level, project middle management level and worker level. From the enterprise level, safety culture is an attitude of enterprise towards safety. Every enterprise should have an accuracy

positioning at the development of safety culture. On project level, there is a close relationship between safety culture and safety management and safety management can reflect and affect the company's safety culture. More specifically, safety culture in project level is also embodied by project manager's behavior.

Considering the reality of construction industry in China, it is crucial to construct active safety culture in construction enterprises. Through the improvement of existing safety culture in construction enterprise or establishment of a set of safety culture system, project safety will be developed towards a correct direction and safety awareness of staff will be strengthened.

The conceptual model of safety culture: Safety management is essential for the construction enterprises, so in the process of safety reform, we treat the transformation of safety management concept as a priority task at all times. Safety management should involve all members and let every employees recognize the intrinsic value of safety production. Sustainable training let the workers acknowledge the safety culture of enterprise and help them promote their ideological consciousness fundamentally.

The four levels of safety culture proposed by Dongping Fang just consider the impact from the project level, but ignore the impact from enterprises' external environment. Based on the previous researches, we take into account the internal and external factors affecting the safety culture and establish the conceptual model of safety culture. The factors include six aspects, that is, state act, social effect, industry environment, internal enterprise, project condition and group effect. Meanwhile, safety culture in construction enterprise is separated into four levels, videlicet, physical culture, behavior culture, management and norm culture as well as ideological culture. The conceptual model is shown in Fig. 2.

As can be seen in Fig. 2, the six aspects constitute an environment system to impact on safety culture. Every aspect has influence on each level of safety culture. Among all the aspects, state act plays an authoritative and coercive role in the establishment of safety culture in construction enterprise, and has directive significance and normative effect to the lower influencing factors. However, Kathryn and Steven (2009) argue that there is little research on the influence of national culture on safety culture. So we take state act into consideration in order to research its influence on the safety culture. Social effect, which reflects the safety attitude of the state from a more universal view, is the extension of state act, reflecting the safety ideology of a state and blending the safety anticipation of the mass. Industry environment absorbs the safety ideology from the state and society, playing a directive supervising role in the establishment of safety culture in construction enterprise. And it regulates the safety production of construction enterprise by making industry safety criterion according to safety system of state as well. The construction enterprise, as an executor of culture as well as a master of the projects and employees, locates in the center of establishment of safety culture. Safety environment and sufficient facilities in workplace where it is the right spot of accident are important to safety production.

Meanwhile, the diverse conditions of different projects also make it more difficult for safety production. The condition of the project should be guaranteed so as to reduce the accident harm fundamentally. As the most basic factor to impact on safety culture, the importance of project condition should not be ignored. The safety act and safety attitude of the staff decide the situation of the project and even that of entire enterprise, which at the same time embodies the fact that group effect is the most fundamental part of safety culture and the best

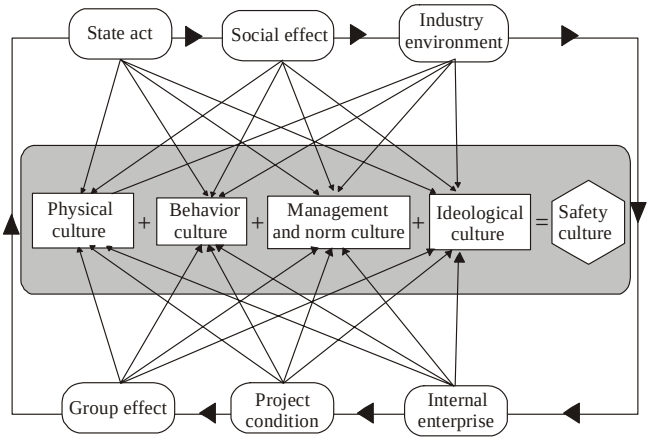

Fig. 2: The conceptual model of safety culture in construction enterprise of China

Table 2: Influence factors of safety culture in construction enterprises of China

Dimensions	No.	Influence Factors
State act	C1	The influence of perfecting safety legislation of state in construction
	C2	The supervision of relevant departments of the state
Social effect	S1	Degree of safety propaganda in society
Industry environment	I1	The supervision of safety production in the construction industry
Internal enterprise	E1	The establishment of good working environment
	E2	The improvement of the construction equipment and hardware facilities
	E3	The effect of safety training
	E4	The improvement of safety construction institution
	E5	The support of safety management from enterprise
	E6	The effect of perfecting the rewards and punishments system
Project condition	P1	The effect of making a safety schedule
	P2	Attitude of safety supervisor
	P3	The effect of promoting status and role of the safety committee
	P4	The control of risk on the worksite
Group effect	G1	Improving employees' participation of safety production
	G2	Promoting the satisfaction of staff to safety management
	G3	Improving the sensitivity of staff to risk
	G4	Effectively communication

reflection of safety culture. Therefore, the effect of group is crucial for safety production, and will greatly promote the process of establishment of safety culture in construction enterprise.

ANALYSIS OF SAFETY CULTURE MODEL IN CONSTRUCION ENTERPRISE

The selection of influence factors: The conceptual model analyses the factors of safety culture in construction enterprise from six aspects state act, social effect, industry environment, internal enterprise, project condition and group effect. Then we study further on what kind of factors of these six aspects influence the safety culture. By reviewing of previous literature, we extract eighteen influence factors as the emphasis of the research showing in Table 2 and evaluate the influence degree of them on each part of safety culture by using questionnaire survey.

Key factors extraction: According to the influence factors extracted above, it is necessary to study further how to measure the influence degree of these factors to each part of safety culture in construction enterprises. In order to demonstrate the influence degree of these factors, we investigate the effect of influence factors through questionnaire method, and then use mathematical statistics analysis method to evaluate and analyse the data collected from questionnaire.

Questionnaire design: According to the influence factors above, questionnaire is designed as a rating scale, let respondents evaluate the influence of the factors on physical culture, behavior culture, management and norm culture as well as ideological culture. There are a total of eighteen items in one questionnaire needed to be scored in four levels of safety culture and the influence degree is divided into five categories according to the influence degree, namely, almost no impact (1 point), less impact (2 points), general impact (3 points), great impact (4 points), enormous impact (5 points).

Questionnaire administration: Considering the characteristic of construction enterprises, the subjects selected in this research are project staff in construction enterprises of China, mainly involving project managers and construction workers. And four projects under construction have been chosen from one construction enterprise to have a face-to-face questionnaire to the staff. In the each project site, a fixed investigator is in charge of filling and collecting the questionnaire. In order to make the investigation more objective and rational, investigators elaborate the content of this research at the beginning, mainly to explain the meaning of four aspects of safety culture. Safety physical culture means the various tools, materials, utensils, and other entities for culture establishment in construction enterprises. Safety behavior culture is towards safety behavior performance and construction of individual or organization in construction enterprises. Safety management and norm culture is towards the construction of all relevant safety system and laws and regulations in construction enterprises. Safety ideological culture refers to the understanding and construction towards safety concepts for personnel in construction enterprises, or the integrated performance of safety thoughts, feelings and will. In this way, the respondents are made better understanding of the content of the questionnaire. And the questionnaire survey is conducted anonymously, and the result is used merely in this study.

The analysis of survey results: A total of 192 useable questionnaires were recovered from the respondents of four projects, representing a 68.6% response rate. Respondents' profiles and their characteristics are displayed in Table 3. In the sample, 59.38% of respondents were construction workers, 18.75, 9.90 and 7.81% were technicians, security officers and others

Table 3: Profile of respondents from construction industry (n=192)

Characteristics of Respondents		Frequency	%
Project	Project A	46	23.96%
	Project B	53	27.60%
	Project C	32	16.67%
	Project D	61	31.77%
Job title	Project manager	8	4.17%
	Security officer	19	9.90%
	Technician	36	18.75%
	Construction workers	114	59.38%
	Other	15	7.81%
Years of working experience in construction industry	Less than 5 years	37	19.27%
	6-10 years	63	32.81%
	11-15 years	48	25.00%
	16-20 years	29	15.10%
	More than 20 years	15	7.81%
Years of company tenure	Less than 5 years	59	30.73%
	6-10 years	62	32.29%
	11-15 years	41	21.35%
	16-20 years	21	10.94%
	More than 20 years	9	4.69%
Age	Less than 25 years	32	16.67%
	26-30 years	33	17.19%
	31-35 years	42	21.88%
	36-40 years	51	26.56%
	41-45 years	31	16.15%
	More than 45 years	3	1.56%
Frequency of safety training	Never	28	14.58%
	1-3 times	73	38.02%
	More than 3 times	91	47.40%

Frequency: means the number of respondents who belong to the item. %: means the ratio of the number of the item account for the total number.

respectively. Only 4.17% respondents hold the position of project manager. This study aims to survey the safety culture in construction enterprises, so the construction workers, technicians and security officers are considered more useful than those of project manager or others.

In order to ascertain whether respondents actually understand the safety culture in construction enterprises, we asked the respondents how long they had worked in construction industry. The results shows that just 19.27% of respondents have worked in construction industry less than 5 years, and nearly 50% more than 10 years, suggesting the respondents have abundant practical experience to accept the survey.

It is considered important to examine respondents' tenure in their current companies to determine whether they are really aware of the safety culture of their companies. From Table 3, we can know that nearly 40% of the respondents have worked in their present company for more than 10 years. Moreover, Table 3 also shows the age of respondents and their training experience. 14.58% of respondents have never taken any safety training, 38.02% had safety training experience but less than 3 times, while the vast majority of respondents (47.40%) had safety training more than 3 times.

Table 4: Cronbach's Alpha Coefficient of safety culture

The dimension of safety culture	Cronbach's alpha coefficient (n = 18)
Physical culture	0.864
Behavior culture	0.882
Management and norm culture	0.883
Ideological culture	0.873

n = 18: means there is 18 questions involving to the calculation of Cronbach's alpha coefficient.

Table 5: The KMO and Bartlett test of safety culture

		Bartlett Test	
The dimension of safety culture	Kaiser- Meyer - Olkin	Approximation chi-square	Sig. of F
Physical culture	0.862	1155.178	.000
Behavior culture	0.877	1164.672	.000
Management and norm culture	0.883	1160.285	.000
Ideological culture	0.870	1170.104	.000

Questionnaire reliability analysis: In order to prove the results of questionnaire are reliable, we make the reliability assessment to the questionnaires firstly, and the questionnaire is consist of four parts, namely physical culture, behavior culture, management and norm culture, ideological culture. We adopt the Cronbach's alpha coefficient to examine the internal consistency of each part of safety culture. Cronbach's alpha coefficient is used to evaluate the internal consistency or the percentage of the total variance of all the factors in certain dimension. And according to the results we can judge if these factors greatly contribute to the dimension. We use the Statistical Product and Service Solutions (SPSS) to process the collected data and get the Cronbach's alpha coefficient of each part of safety culture. And Table 4 shows that internal consistency of each part is favorable, so the data from questionnaire survey can be used in the further analysis.

Questionnaire validity analysis: After proving the reliability of the collected data, we use validity analysis to examine whether we can use the method of factor analysis to process the data. We adopt correlation coefficient method for validity analysis in the paper. It can be seen from the result (Table 5) that the correlative relationship is extremely significant between factors and total scores (due to $p = 0.000<0.01$), indicating that the factors selected before are of significant influence on each part of safety culture, thus, the selected factors are consistent to investigation purpose.

Factor analysis of results: To further discuss the influence of selected factors to each part of safety culture, we use the factor analysis technology to extract the main factors. After calculating the KMO (Kaiser-Meyer-Olkin)

Table 6: Factor structure by factor analysis and varimax rotation

Number	Item	Factor Loading
Part 1 Common factors of safety physical culture		
Factor 1: The attitude of safety management (from Project condition and Internal enterprise); Eigenvalue 5.728; % of Variance 31.822; Cumulative% 31.822		
P3	The effect of promoting status and role of the safety committee	0.787
E5	The support of safety management from enterprise	0.697
P1	The effect of making a safety schedule	0.641
P2	Attitude of safety supervisor	0.618
Factor 2: Group effect; Eigenvalue 1.895; % of Variance 10.531; Cumulative% 42.353		
G1	Improving employees' participation of safety production	0.782
G3	Improving the sensitivity of staff to risk	0.760
G4	Effectively communication	0.666
G2	Promoting the satisfaction of staff to safety management	0.647
Part 2 Common factors of safety behavior culture		
Factor 1: Group effect; Eigenvalue 6.134; % of Variance 34.080; Cumulative% 34.080		
G1	Improving employees' participation of safety production	0.762
G2	Promoting the satisfaction of staff to safety management	0.746
G3	Improving the sensitivity of staff to risk	0.701
G4	Effectively communication	0.615
Factor 2: The safety institution and police(from Internal enterprise, Social effect and Project condition) ; Eigenvalue 1.591; % of Variance 8.841; Cumulative% 42.921		
E4	The improvement of safety construction institution	0.695
E3	The effect of safety training	0.651
S1	Degree of safety propaganda in society	0.623
P1	The effect of making a safety schedule	0.622
Part 3 Common factors of safety management and norm culture		
Factor 1: The measures of enterprise (from Group effect, Project condition and Internal enterprise); Eigenvalue 6.171; % of Variance 34.285; Cumulative% 34.285		
G1	Improving employees' participation of safety production	0.746
E3	The effect of safety training	0.732
G2	Promoting the satisfaction of staff to safety management	0.660
G4	Effectively communication 0.587	
P1	The effect of making a safety schedule	0.582
E5	The support of safety management from enterprise	0.565
G3	Improving the sensitivity of staff to risk	0.513
Factor 2: The attitude of safety management (from Project condition, Internal enterprise and Industry environment); Eigenvalue 1.715; % of Variance 9.529; Cumulative% 43.814		
P3	The effect of promoting status and role of the safety committee 0.770	
E4	The improvement of safety construction institution 0.634	
P4	The control of risk on the worksite 0.578	
I1	The supervision of safety production in the construction industry 0.570	
P2	Attitude of safety supervisor 0.539	
Part 4 Common factors of safety ideological culture		
Factor 1: The attitude of safety management and the safety institution and police (from Project condition, Internal enterprise and Social effect); Eigenvalue 5.969; % of Variance 33.159; Cumulative% 33.159		
P1	The effect of making a safety schedule	0.789
E4	The improvement of safety construction institution	0.723
E3	The effect of safety training	0.609
S1	Degree of safety propaganda in society	0.609
P4	The control of risk on the worksite	0.564
E5	The support of safety management from enterprise	0.551
P3	The effect of promoting status and role of the safety committee	0.520
Factor 2: Group effect; Eigenvalue 1.725; % of Variance 9.584; Cumulative% 42.743		
G2	Promoting the satisfaction of staff to safety management	0.849
G1	Improving employees' participation of safety production	0.795
G3	Improving the sensitivity of staff to risk	0.531
G4	Effectively communication	0.500
Factor 3: The improvement of facility and safety legislation (from Internal enterprise and State act); Eigenvalue 1.353; % of Variance 7.514; Cumulative% 50.257		
E2	The improvement of the construction equipment and hardware facilities	0.773
C1	The influence of perfecting safety legislation of state in construction	0.744

Note: % of Variance: means the contribution values of eigenvalue; Cumulative%: means the cumulative total contribution values of eigenvalue

statistics which is used to examine whether the original partial correlation coefficients between variables are tiny and Bartlett test, it can be seen that the KMO value of each part of safety culture is larger than 0.7, which indicates that it is available to adopt factor analysis. Meanwhile, through Bartlett test, the approximate chi-square test value is 1155.178, 1164.672, 1160.285, 1170.104 for each part, and the corresponding probability $p = 0.000<0.01$, which also shows the feasibility of factor analysis (Table 5).

In the research of safety physical culture, it is found in the process of the factor analysis that 42.353% of the variance was explained in the two-factor solution. After determining the extraction of two common factors, we make the variance maximum rotation of original variable and the loading matrix of the factors is demonstrated in Part 1 of Table 6.

When analysing original variables of safety behavior culture in construction enterprise, it is found that the cumulative total contribution values of eigenvalue of 2 common factors are up to 42.921% ,shown in Part 2 of Table 6. As can be seen from Part 3 and Part 4 in Table 6, 43.814% of the variance was explained in the two-factor solution after factor analysis during the research of safety management and norm culture, while 50.257% of the variance was explained in the three-factor solution during the research of safety ideological culture.

It is necessary to mention here that the difference between the common factor and each original variable is not significant in the loading matrix of factors before rotation, which makes it difficult to use original variables to explain the meaning of every common factor, while in the loading matrix of factors after rotation, the data polarizes to 0 and 1, which can clearly explain the relationship between the common factors and the original variables, so the loading matrix of factors after rotation is employed to illustrate the relationship between common factors and the original variables.

Safety physical culture: As can be seen in Part 1 of Table 6, after factor analysis of safety physical culture, the information of 8 original variables is included in 2 common factors extracted. Factor 1 reflects the influence of safety management attitude to physical culture. And Factor 2 shows that the importance of group effect to the construction of safety physical culture.

Factor 1 mainly consists of the effect of promoting status and role of the safety committee, the support of safety management from enterprise, the effect of making a safety schedule, as well as attitude of safety supervisor, the effect of promoting status and role of the safety committee, the support of safety management from enterprise, all of which mainly embodies the influence of each original factor to safety physical culture from project condition and internal enterprise. And the factor loading of each factor is also high, showing that Factor 1 includes most of the information of the four variables above. From the data in Part 1 of Table 6, 31.822% of the variance can be explained by Factor 1, meaning safety management attitude is in the leading place during the construction of physical culture. When the enterprise pays more attention to the safety management, the construction of safety physical culture will be better.

In addition, Factor 2 mainly includes improving employees' participation of safety production, improving the sensitivity of staff to risk, effectively communication, as well as promoting the satisfaction of staff to safety management, which mainly embodies the influence of each variable to safety physical culture from group effect. The variables from the group effect can be an integral whole to influence safety physical culture. It can be concluded by analysis that when constructing physical culture, it will be started with project condition, internal enterprise and group effect, especially highlighting the safety management, promoting the construction of physical safety through improving the status of safety management committee and increasing the strength of safety management. Meanwhile the factor extraction of group effect, the second common factor, indicates that the original variables of group effect have a trend of convergence, and the effects is consistent, so it is considerable to combine the original factors mentioned in the process of selecting group effect in constructing physical culture to help build physical culture in the suitable group.

Safety behavior culture: And in the analysis of safety behavior culture, 2 common factors are extracted and include the information of 8 original variables. Factor 1 shows the importance of group effect to the construction of safety behavior culture, while Factor 2 shows the role of safety institution and police to that.

From the Part 2 of Table 6, Factor 1 mainly consists of improving employees' participation of safety production, promoting the satisfaction of staff to safety management, improving the sensitivity of staff to risk, as well as effectively communication, which explains 34.080% of variance. The data in Table 6 indicates that group effect plays a larger role in construction of safety behavior culture than others. Act is based on individual and group which composed by individuals can also affect the behavior of the individuals. So it is an inevitable conclusion that the construction of safety behavior culture will be effectively promoted by emphasizing the

implementation of each variable in group effect. And the factor loading of variables in Factor 1 is 0.762, 0.746, 0.701, 0.615 respectively, the numerical difference of them are not large, showing almost the same importance of them. If the enterprise fully exerts the effect of group and positively mobilizes the passion of staff, the safety behavior culture will improve better and faster.

And Factor 2 mainly embodies the improvement of safety construction institution, the effect of safety training, the degree of safety propaganda in society as well as the effect of making a safety schedule, which from the project condition, internal enterprise and social effect. Combining with the institution and police from different aspects will effectively facilitate to establish a perfect institution system. Under the institution system, the safety behaviors of staff, enterprises and still industries will be regulated, supervised and improved systematically and normative. In the structure of institution system, social effect is in the top position, regulating the institution and policy of construction industry on the whole and showing an overall Viewpoint and universality. While, different enterprises have their own characteristics, deciding the necessity to reify and detail the institution and policy from country and social. In that way, the staff's behavior will be regulate effectively in construction enterprises. Project level is a direct place where employee's behaviors occur, so need the enterprise pay more attention to it. When implementing the policy from the upper system, the enterprise should combine with project's characteristics to establish effective policies in order to ensure the safety of staff's behaviors and the safety of project. This combination of institution and policy from different levels reflects the actual situation in China. China has a vast territory and the distribution of construction enterprises is wide, so the establishment of good safety climate in the construction needs layers of institutions to regulate. When ensuring the universal, the construction enterprises further develop the unique institution according to their characteristics at the same time. Only by following this process, the construction industry of China is able to gradually establish a sound institutional system in order to regulate and supervise the safe behavior and give support to the development of safe behavior culture.

Safety management and norm culture: After the factor analysis of safety management and norm culture, the information of 12 original variables is mostly included in 2 common factors extracted, showing in Part 3 of Table 6. Factor 1 is about the measures of enterprise, and Factor 2 is mainly consisted of attitude of safety management.

Factor 1 is composed by improving employees' participation of safety production, the effect of safety training, promoting the satisfaction of staff to safety management, effectively communication, the effect of making a safety schedule, the support of safety management from enterprise as well as improving the sensitivity of staff to risk, which from group effect, project condition and internal enterprise. So when developing the safety management and culture in construction enterprises, the effect from internal enterprise, project condition and group effect should be noticed. And the cumulative total contribution values of eigenvalue of Factor 1 are up to 34.285%. From the original variances we can see that Factor 1 includes the information about measures of construction enterprise. The result indicates all of these measures above make sense to construct safety management and norm culture in construction enterprise. The enterprises can use the different combination of these measures to construct or improve their safety management and norm culture according to their characteristics. Meanwhile, Factor 1 contains the most information of original factors in group effect, which indicates that group effect is of great significance to develop management and norm culture.

Besides, Factor 2 mainly consists of the effect of promoting status and role of the safety committee, the improvement of safety construction institution, the control of risk on the worksite, the supervision of safety production in the construction industry as well as attitude of safety supervisor. Factor 2 represents 9.529% of information in all contains the most information of project condition and internal enterprise, reflecting the significance of internal enterprise and project condition in building safety management and norm culture which cannot be ignored.

And we also find that: there is correlation between safety behavior culture and safety management and norm culture, the bilateral significance is 0.629 when significance level $p<0.01$. The fact points that the development of safety management and norm culture is positive contributed to the development of safety behavior culture.

Safety ideological culture: As can be seen in Part 4 of Table 6, the information of 13 original variables is mostly included in 3 common factors during the research of safety ideological culture. Factor 1 is about the importance of the attitude of safety management, as well as the safety institution and police. Factor 2 indicate group effect have great influence on the construction of safety ideological culture. And Factor 3 shows the improvement of facility and safety legislation.

Factor 1 is mainly composed by the effect of making a safety schedule, the improvement of safety production

system, the effect of safety training, degree of safety propaganda in society, the control of risk on worksite, the support of safety management from enterprise, as well as the effect of promoting status and role of the safety committee , which indicates that the effect of project condition, internal enterprise and industry environment is of great significance to the construction of safety ideological culture. And these original variables can be summarized as two aspects, videlicet, the attitude of safety management and the safety institution and police. And 33.159% of the variance can be explained by Factor 1, showing that we must pay special attention to the attitude of safety management and safety institution and police when impelling the safety ideological culture in construction enterprises. We can treat the attitude of safety management as "soft pressure" and treat the safety institution and police as "hard pressure". The former leads the staff to acknowledge the safety ideological of their enterprises and then identify the safety ideological culture, the latter regulates the staff's behaviors, tells them the safety ideological of enterprise directly and then requires them learning and following the safety ideological culture of enterprises. Both of them have effect to the construction of safety ideological culture, but the approaches are different. Applying the two approaches to different enterprises, the results are also distinct, which depend on the characteristics of the enterprise.

And Factor 2 includes promoting the satisfaction of staff to safety management, improving employees' participation of safety production, improving the sensitivity of staff towards risk as well as effective communication. And 9.584% of variance is explained by Factor 2 and the information is all from group effect, indicating group effect is also influence the construction of safety ideological culture. As have mentioned above, act of individuals is the direct reason to cause the accidents. So individual is also the key factor to solve the construction accidents. From the Table 6, we can also observe that the group effect has influence on all of part of safety culture. Consequently, grasping the effect of group is the priority task of construction enterprises.

Moreover, Factor 3 mainly contains the improvement of the construction equipment and hardware facilities as well as the influence of perfecting safety legislation of state in construction. The improvement of the construction equipment and hardware facilities gives the staff an intuitionistic impression of safety ideological of enterprise, letting staff know that their enterprise takes much count of their safety and then they will improve their own safety notion. And Factor 3 first mentions the influence of perfecting safety legislation of state in construction, which from the state act. This result reflects that legal assurance is a more effective measure than others in China. The provisions of law encourage people to improve the safety notion and force the construction enterprises to promote the level of safety ideological culture.

The improved model of safety culture: After the factor analysis, we can improve the conceptual model proposed above. The conceptual model of safety culture constructed above is only a basic framework, and it didn't reflect the difference between various influencing aspects and their degree of impact on every level of safety culture. After analyzing the data collected in social investigation using statistics analysis technology, it can definitely see the degree of impact on every level of safety culture caused by different influencing aspects. The influence from the six aspects is not only distinct in every level of safety but also in the whole of safety culture in construction enterprise, which make it better to elaborate the influence of six aspects to safety culture in construction enterprises.

The improved model highlights the degree of impact on every level of safety culture by different influencing aspects, and demonstrates the 4 levels and 6 influencing factors of safety culture in construction enterprise, which can be seen in Fig. 3. The safety culture is composed by physical culture, behavior culture, management and norm culture as well as ideological culture, which represents the different level of safety culture in construction enterprises. We conclude from the analysis above that behavior culture and management and norm culture are correlation and interact with each other. The development of safety management and norm culture is positive contributed to the development of safety behavior culture. So we use a cirque with the arrow to connect them in order to demonstrate the relevance of them in Fig. 3.

And we point out six influencing factors which interact and influence all levels of safety culture respectively in the construction enterprise. In Fig. 3, we use one to three pentagrams to show the different influence degree of factors. The factor has more pentagrams under it, meaning that the impact of it is greater. The great area presents the prominent impact, with its information of influencing factors expressed by Factor 1 or Factor 2. As has shown Fig. 3, group effect, internal enterprise and project condition have enormous impact on all levels of safety culture. So when construction enterprises structure their own safety culture, they have to attach importance to these influencing factors than any others. And with the reduction in the number of pentagram, the impact degree of influencing factors is also dropping. But it doesn't mean these factors don't need to be considered in the construction of safety culture.

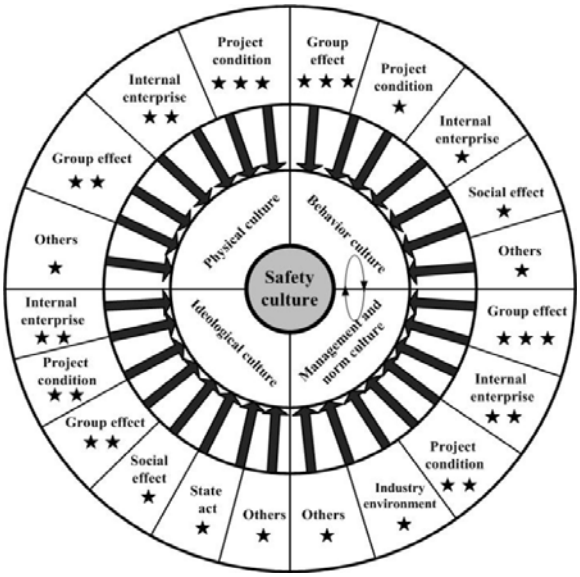

Fig. 3: Improved model of safety culture in construction enterprises of China

These secondary factors can influence the construction of safety culture indirectly through the important factors.

On the whole, construction enterprises lie in a complex environment containing lots of impacts, so the construction of safety culture is also bound to various impacts. Under the encirclement of various factors, different factors have diverse impacts to each level of safety culture. And how to use the outside and enterprises' own factors to improve the safety culture correctly and effectively is the key issue that construction enterprises need to think about. Under limited capacity and conditions in the enterprise, more resources should be given to important factors in order to achieve efficient allocation of resources and realize the maximum improvement of safety culture.

CONCLUSION AND DISCUSSION

The factors affecting safety culture in construction enterprises are multifaceted, but the importance is distinct. In the paper, we summarized the influencing factors from previous literatures and generalized them to six aspects. Then we considered their impact on safety culture. Meanwhile, we applied factor analysis method to extract the common factors from the original variances, and then obtained the factors which have great impact on each level of safety culture. Next, we constructed the improved model to show the different impact degrees of different factors.

It can be seen from the improved model that: internal enterprise, project condition and group effect have greater influence on safety culture in construction enterprises than social effect, state act as well as industry environment. This fact indicates that the influencing factors, more relevant to the project itself, are of greater contribution to the establishment of safety culture model. So it is necessary for construction enterprises to input more resources into the influencing factors closer to the project, such as improving the safety training, promoting the support for safety management, etc. Of course, in the process of constructing safety culture, the enterprise should grasp and control comprehensively the influencing factors so as to achieve the purpose of establishing excellent safety culture.

Since the respondents' cognitive level and understanding level to safety culture are not alike, there are differences between the survey result and the reality condition. However, the sample we selected is large enough and we also introduce the survey content to the respondents in advance. Consequently, the survey result of the research is reliably. And from the results of the research, we find that there is correlation between safety behavior culture and safety management and norm culture. In the future research, we will start from this point to study the correlation of two levels penetratingly.

Appendix.1: Survey questionnaire of safety culture in construction enterprise

Dear Sir/Madam,

- We are conducting a survey on safety culture in construction enterprise. Your response will be beneficial in helping us find the influence factors of safety culture. And this is an anonymous questionnaire, the information you fill in is only used in this study and we will keep the information confidential.

Appendix.1: The score table of factors

No.	Factors	Physical Culture	Behavior Culture	Management and Norm Culture	Ideological Culture
1	The influence of perfecting safety legislation of state in construction				
2	The supervision of relevant departments of the state				
3	Degree of safety propaganda in society				
4	The supervision of safety production in the construction industry				
5	The establishment of good working environment				
6	The improvement of the construction equipment and hardware facilities				
7	The effect of safety training				
8	The improvement of safety construction institution				
9	The support of safety management from enterprise				
10	The effect of perfecting the rewards and punishments system				
11	The effect of making a safety schedule				
12	Attitude of safety supervisor				
13	The effect of promoting status and role of the safety committee				
14	The control of risk on the worksite				
15	Improving employees' participation of safety production				
16	Promoting the satisfaction of staff to safety management				
17	Improving the sensitivity of staff to risk				
18	Effectively communication				

- It would be appreciated if you could convey your views by answering the questions below.

Thank you for sparing your valuable time.

A. The survey of your basic information: Please select and tick against the categories which best describe yourself.

- **Your Age:** [ ] 26-30 years [ ] 31-35 years [ ] 35-40 years [ ] More than 45 years
- **Your job title:** [ ] Project manager [ ] Security officer [ ] Technician [ ] Construction worker [ ] Others
- **Your working experience in construction industry:** [ ] Less than 5 years [ ] 6-10 years [ ] 11-15 years [ ] 16-20 years [ ] More than 20 years [ ] Less than 25 years
- **Frequency of safety training:** [ ] Never [ ] 1-3 times [ ] More than 3 times

B. The survey of safety culture: There are a total of 18 items in the questionnaire needed to be scored in 4 aspects of safety culture and the influence degree is divided into 5 categories according to their influence degree, namely almost no impact (1 point), less impact (2 point), general impact (3 point), great impact (4 point), enormous impact (5 point). Please give your points from 1to 5.

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