An Investigation into Safety Culture of Chinese Construction Supervision Organizations

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Abstract:

To prevent casualties from happening and reduce injures, the State Council of China issued Production Safety Regulation on Construction Projects (PSRCP), which set out safety responsibilities of each party in construction project. On-site supervising engineers (who have similar roles to the Engineer in FIDIC Conditions of Contract for Construction), had also been assigned legal responsibility in regard to safety performance according to that regulation. Safety culture is proposed as an effective way to improve safety management performance. However, safety culture needs to be understood, evaluated, developed and fostered. The paper firstly developed a safety culture framework, then, 15 construction sites were surveyed based on the questionnaire designed from the framework. The survey results were analyzed using Factor Analysis with SPSS software. The analysis results show that individual safety consciousness of supervising engineers is good and Construction Supervision Organizations also pays great attention to the safety supervision. The main implications of the research findings are supervising engineers should improve their professional knowledge, the communication skill and apply risk management into their safety management practice. In the meantime, negative influences from the clients and contractors should be paid attention because it is a serious obstacle which deters the effective safety management of supervising engineers.

Key words: safety culture; Construction Supervision Organizations; safety culture model; Factor analysis; safety culture evaluation

1. Introduction

Construction industry has played a great role in Chinese economic development. The economic output of construction industry increased from RMB 2.77 trillion Yuan in 2004 to RMB 7.68 trillion Yuan in 2009, the average increasing rate being 21% each year. However, construction industry always bears the bad reputation of high rate of casualties and injures. Construction is the second risky industry next to mining industry in China (Zou et al, 2009). Table 1 shows the statistics of accidents and casualties from 2001to 2009. From Table 1, it can be seen that there were nearly 1000 people killed every year. Accidents also result in big financial loss, for example, the

financial loss of all accidents was RMB 250 billion Yuan, accounting for 2% of GDP that year in 2004 in China (Sina, 2005).

Table 1: Construction accidents and casualties in China

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009
Accidents	1004	1208	1278	1144	1010	888	859	778	684
Casualties	1045	1297	1512	1324	1195	1048	1012	964	802

Source: Ministry of housing and urban rural development (2001-2009)

To prevent accidents and injuries from happening, Chinese authorities have made a lot of efforts to strengthen safety responsibilities and to constrain unsafe behaviors in construction projects by setting up safety specifications on specific dangerous construction work items and issuing laws and regulations on safety production. For example, Construction Law was issued in 1998 and Production Safety Law of the People's Republic of China in 2002. However, from the data, there was little change in terms of the quantities of accidents and casualties. To be more effective and specific, Production Safety Regulation on Construction Projects (PSRCP) was issued by the State Council to set out safety responsibility of each party in construction project in 2004. In PSRCP, supervisor engineers, one of the parties on site, are assigned the legal responsibilities to supervise safety performance of contractors.

After PSRCP took effect in 2004, many supervising engineers were involved in accidents suitcases, for example, supervising engineers of almost all accidents with 3 deaths and above has been sentenced in prison (MOHURD, 2010). The main reason behind the high duty crime rate of supervising engineers is the lack of safety culture. This can be supported by the following two facts. Wang (2006) states for a long time, great efforts were put on quality, time and cost control of the construction project by participates of construction projects. Though safety responsibilities are required by laws, the participants including supervising engineers still haven't paid enough attention to the safety issues. Secondly, many practitioners of construction industry equaltysafety culture to safety songs, signs and slogans, instead of connecting safety with safety consciousness/actions (Huang et al, 2006). So in many cases, safety management is very ineffective because it is done very superficially.

The Advisory Committee on the Safety of Nuclear Installations defined safety culture as the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determines the commitment to, and proficiency of, an organization's health and safety management. (cited in Health and Safety Commission 1993). From this definition, it can be seen that safety culture is not only about the "soft thing", such as perception, but also about some "solid action" such as behaviors. Health & Safety Executive (2005) defined safety culture based on the work of Cooper (2000), safety culture as a product of three interrelated aspects, (1) Psychological Aspects or 'safety climate' (individual and group attitudes, perceptions and values), (2)

Behavioral Aspects (safety-related actions and behaviors) (3) Situational Aspects (policies, procedures, organizational structures and management systems. This definition further added the importance of situational aspects to safety culture.

Safety management practice develops with the concept of safety culture's evolving. Zou (2011) provided brief summary of the historical development of construction safety management by reviewing literature including Hinze and Harrison (1981), Holmes et al. (1998), Reese (2003), Biggs et al.(2005), Zou et al. (2008), Garavan and O'Brien (2001), Sawacha et al. (1999), Zou and Sunindijo (2010). Current safety management research is focusing on foresting the safety culture within most organizations and industry-wide to improve the safety consciousness and safety performance, (Fung et al. 2005; Lingard and Rowlinson, 2005; Zou,2009). Zhou and Fang (2009) also states that improved safety culture can reduced accidents and injure rate and construction of safety culture which include not only policy making and supervising, but also safety consciousness of climate.

In China, supervising engineer is the party who manages and supervises construction work for clients. To improve their safety management performance, one of the ways should also be to foster a good safety culture in Construction Supervision Organizations (CSO). However, safety culture needs to be understood, evaluated before it is fostered. This paper aims to evaluate safety culture in CSOs to provide the basis for making meaningful safety culture construction measures. Based on the literature review and case studies, the paper firstly present a safety culture model for CSOs, then, a questionnaire survey based on the model was conducted, at last, Factor Analysis with SPSS is employed to analyze the survey results and evaluation of the safety culture is given.

2. The Proposed Safety Culture Model

When evaluating the safety culture of construction supervision organisations, the biggest problem is it is immeasurable. Lee and Harrison (2000) explained that safety culture has many manifestations, complex, and even intangible. Consequently, they argued that measuring safety culture is beyond the scope of any single method. Gellor (2001) investigated a safety triad theory in which he thought that a "Totally Safety Culture" should maintain a continue monitoring process to three domains which are environment, person factors and behavior factors. Lingard and Rowlinson (2005) developed a model that shows how occupational health and safety attitudes might shape related behaviour in construction. Zou (2011) depicts a conceptual model for fostering a strong construction safety culture in which the art balances the science of construction safety management.

This paper proposes a layer model of safety culture for Construction Supervision Organizations (SCMCSO). From inner to outer, the layers are personnel, organization and environment, the outer one being the environment of the inner one. The arrangement is based on the premise that persons are the core of safety culture. They are the receiver of the organizational safety values, police and perform the safety culture by their actions. Persons are also the members of organizations in which they are organized and influenced by organization's value, policy, rules etc., thus, the outer layer of person layer is the organization layer. Organization is an open system, which interacts with its environment as it takes in inputs and distributes outputs. The external environment which consists of forces and institutions outside the organization potentially affects the organization's performance (Robbins et al, 2006). To describe the influences of external environment on organization, the third layer is defined as environment layer.

Personnel

To understand why supervising engineers have been frequently sentenced to be in prison, 50 accident cases which involve at least 3 deaths were analysed (unpublished undergraduate student's thesis by Gu D. Y., 2010). The top 10 criminal evidences are:

(1) not stopping unsafe behaviours of on-site workers

(2) not checking the construction plan or specific construction plan for dangerous sections

(3) not finding/instructing to remove accident hazards

(4) not instructing to suspend part works/ work when serious hazards are not rectified as required

(5) not checking the certificates of the workers who do dangerous works

(6) not supervising and stopping the law-breaking actions of contractors (such as illegal resume of suspended work)

(7) not doing standing-by supervision and touring inspection on the site

(8) not checking the safety protective measures of dangerous works

(9) not reporting construction hazards to competent governmental authorities

(10) not checking the qualification of construction corporations

These top ten evidences are all about supervising engineers' unsafe behaviours. According to Robbins et al (2006), persons' behaviour mainly includes psychological things as attitudes, personality, perception, learning and motivation. Compare these components to the top ten evidences, it can be found that the most serious problems of supervising engineers are the poor safety attitude. As we introduce in the first section, safety has been ignored for a long time, thus, many supervising engineers do safety

management superficially. This situation becomes worse especially when safety conflicts with other objectives, such as, cost, time, etc., in those cases, safety is directly put aside. In the cases involves criminal evidence 1, 2, 4, 6, 7, 8, 9, 10, almost all projects had cost/time constrains. Lacking professional knowledge is the problem supervising engineers have, which contributes to the evidence1, 2, 3, 8. Lingard and Rowlinson (2005) developed a safety behaviour model consists of four elements: " belief about job, job attitudes, behavioural intentions, and the actual behaviour towards safety". Referring to the behaviour theory, case analysis and the literature, this paper measure supervising engineers' safety performance from three aspects, safety attitude, safety behaviour and professional/safety knowledge.

Organization

In terms of organization layer, HSE (2005) described the corporate dimension as what the organisation has, which is reflected in the organisation's policies, operating procedures, management systems, control systems, communication flows, and workflow systems. The three aspects are interrelated and not mutually exclusive. Zou and Sunindijo (2010) classified safety climate of organization into six dimensions, top management's commitment, supervisor's involvement, trainings, communication, employee's involvement and safety policy, rules and guidelines. Referring to the literature on the definition of safety culture and the organization, this paper describe the organization from similar dimensions, safety value, safety policy, rules and guidelines, top management's commitment, employee's involvement, communication and safety Training.

Environment

According to Robbins (2006), the external environment is made up of two components, the specific environment and the general environment. The specific environment directly relevant to the achievement of the organization's goal and is unique and changes with conditions. In terms of safety culture, stakeholders, site environment are all very unique and have direct influence to the safety culture. The general environment includes the broad economic, political/legal, sociocultural, demographic, technological and global conditions that may affect the organization. As for safety culture, the most obvious components should be broad economic, legal, sociocultural, technological according to the characteristic of safety management practice.

It should be noted that the three layers interact, such as, persons are not the passive receiver of organizations, the experience and lessons learned from the practice will inversely influence the organizational safety policies and rule. Another example is though supervising engineers are responsible for supervising contractors' safety management, contractors also influence supervising engineers actions which will be explain later.

The framework of safety culture model for Construction Supervision Organization (SCMCSO) is shown in Fig. 1.

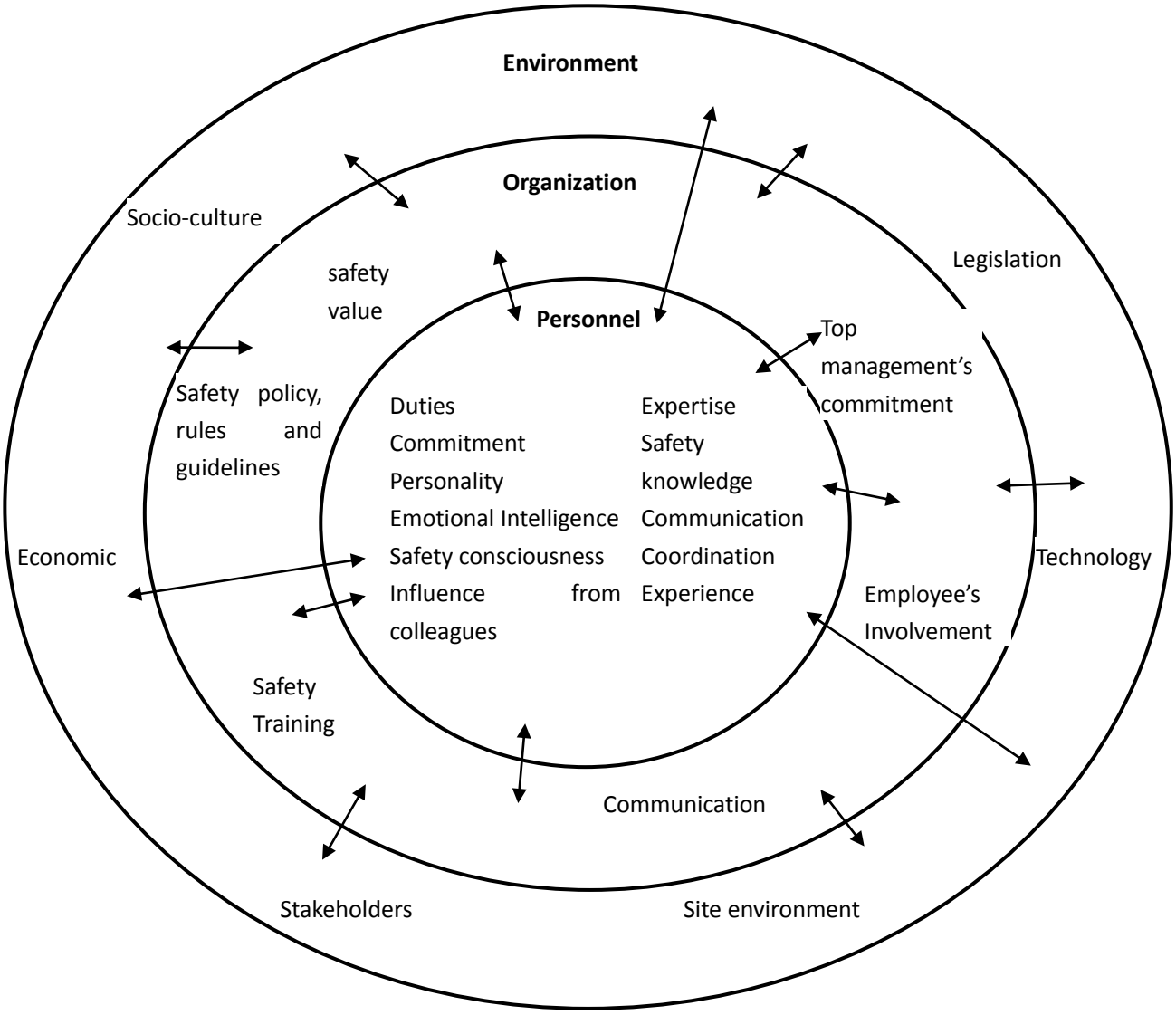

Figure 1: Safety Culture Model for Construction Supervision Organizations (SCFCSO)

3. Data Collection and Analysis

Questionnaire Design

Questionnaire survey is employed to collect data to evaluate the level of safety culture of Construction Supervision Organizations. The questionnaire is designed based on SCFCSO in section 2. It consists of 3 groups of questions to cover the factors in the three layers. The question list under the three groups is shown in Table 2. For each question, 5 options were given (strongly agree, agree, neutrality, disagree or strongly disagree). White spaces were provided for the respondents to provide qualitative

comments. There are total 38 questions in the questionnaire. Among the 38 questions, the first 23 questions are positive and the scores for each
option are 5, 4, 3, 2, 1. The last 15 are negative and the scores the other way round, namely, 1, 2,3,4,5. Given that participants may tend to choose neutral, reminder is given trying not to choose neutrality as much as possible. To prevent the respondents from following the authors thinking pattern, the order of the questions are arranged in random to some degree.

Table 2: questions included in the questionnaire

1 Person	
1.1 Supervision behavioral	
Q1	I know clearly about the responsibility of my job and I will fulfill it.
Q 2	I will ask workers to amend defects immediately if I find them when checking.
Q 3	We will re-examine the amendments after they are finished.
Q 4	If workers do not respond to the instructions, I will report to the corporation to do further actions.
Q 29	When other supervisors turn blind eyes to safety problems, I will follow them, even though I don't think I should do so.
Q 30	I often fail to report some safety violations to governmental authorities which are supposed to be to avoid conflicts with clients.
Q 31	I fail to report some safety violations to governmental authorities/clients which are supposed to be to avoid conflicts with contractors.
1.2 Safety attitude	
Q 5	I think safety is the top issue in the construction work.
Q 6	It is the important work to stress on safety in my work.
Q 7	I think most accidents could be avoided upon proper risk management.
Q 32	I become aware of the importance of safety only after accidents happen.
Q 33	I do not think big accidents would happen in the work I supervise.
Q 34	Sometimes I put safety rules aside to speed the work.
Q 35	I would not interfere with or report unsafe behaviors/work procedures if I

	think they have little negative effect on work.
Q 36	I think it is the head of supervisors who should be responsible for the safety supervision, which have little business with other supervising engineers.
1.3 Professional knowledge and safety knowledge	
Q 8	I am have enough professional knowledge to be a competent supervision engineer .
Q 9	I know clearly what measures we should take to ensure safety at each stage of a project.
Q 10	I know laws and regulations on construction works well.
Q 11	I know how to deal with safety problems well.
Q 12	I know clearly the hazards which cause construction accidents well.
Q 38	Poor communications between workers and I have negative effect on safety supervisions.
Organization	
Q 13	We often discuss construction hazards and pre-active measures with clients.
Q 14	We often discuss construction hazards and pre-active measures contractors.
Q 15	We often discuss construction hazards and pre-active measures in-house.
Q 16	We can settle the disputes between clients and contractors well.
Q 17	The head of our corporation place great importance to safety supervisions.
Q 18	Our corporation often holds safety training classes for us.
Q 19	Safety supervision trainings are very helpful for us.
Q 20	We know safety value and policies of our corporation well, which have been conveyed to us in various ways.
Q 21	We learn lessons from accidents happened in the works we supervise.
Q 22	We have well-structured safety supervision system in our corporation.
Q 23	I am satisfied with my present job.
Q 37	We often discuss pre-actions to accidents after they happen.
Environment	
Q 24	High turnover of staff in the corporation brings negative effect on safety

	supervision.
Q 25	The lack of the sense of stability of my job makes me feel uneasy.
Q 26	I feel irritated when accidents happen.
Q 27	Sometimes the depression outside of my job projects negative effect on my work.
Q 28	Sometimes the poor site conditions make me feel irritated when I am working.
Q 30	I often fail to report some safety violations to governmental authorities which are supposed to be to avoid conflicts with clients.
Q 31	I fail to report some safety violations to governmental authorities/clients which are supposed to be to avoid conflicts with contractors.

Survey

To improve the quality and the suitability of the questionnaire, pilot survey is conducted before formal survey. The respondents of pilot survey were supervising engineers and supervisors came from 4 different construction projects in Nanjing area. After pilot survey, the structure of the questionnaire is adjusted and 7 questions are deleted. The final questionnaire consists of 38 questions as seen in Table 2. In formal survey, 15 construction projects were chosen from Nanjing area because of the convenience of collecting data. There are 97 supervision engineers and supervisors got the questionnaire, 77 came back and 70 valid. The return rate is 79% and validity rate 72%, which are acceptable.

The respondents' information is shown in Table 3.

Table 3: Basic Information of respondents

Age				Education			Work experience in current Corporations				Work experience in construction industry			
< 30	31-40	41-50	> 51	J. high	S. high	Ba. and above	1-5	6-10	11-15	> 16	<3	3-10	11-15	> 16
26	25	11	8	2	21	47	36	24	8	2	10	30	15	1

From above information, it can be seen that the age of the respondents span from less 30 to more than 50, which means the survey results represent the opinions of staff at

all ages. More than 60 respondents have more than 3 years' work experience in construction industry and half of them have more than 5 years' work experience in current corporations. Therefore, their opinions can reflect the real situation of Construction supervision organizations. The majority of the respondents are well educated from the data of their education background, which is very helpful to improve the reliability of the data.

Safety Culture Factor Analysis

Factor analysis (FA) is employed to analyze the survey data. FA is a statistical method used to describe variability among observed variables in terms of a potentially lower number of unobserved variables called factors. In other words, it is possible, for example, that variations in three or four observed variables mainly reflect the variations in a single unobserved variable, or in a reduced number of unobserved variables. Factor analysis searches for such joint variations in response to unobserved latent variables. (Bryant and Yarnold, 1994). The procedures of factor analysis are: (1) Fitness test of the data; (2) Establishment of factor Model and determination of the number of factors; (3) Factor rotation; (4) Interpretation of factors structure; (5) Construction of factor scores (DeCoster, 1998).

4. Results

Fitness tests

The reliability of the survey data is tested by the Cronbach's Alpha. The computed result is 0.896, which reflects the survey is highly reliable.

The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) is 0.692, which is close to 0.7 and means the survey data is appropriate to do factor analysis.

Bartlett's Test of Sphericity is 1525.219, $p<0.001$. This result shows the correlation matrix is not an identity matrix, the survey date appropriate for factor analysis.

Factor extraction

Principal components are chosen as the method to extract factors and Varimax as the method of performing factor rotation. The rotation results are shown in Table 4. Five factors are extracted from 38 questions whose eigenvalue are all above 1. The cumulative percentage of five factors is 52.740%, which though is not very high, but is good enough considering that these 5 factors explain the original 38 questions. The average communalities between each question and the corresponding factor is above 0.5, which present the high reliability of the explanation of the factors.

Table 4 Results of Factor Analysis

1	2	3	4	5	6	7
Factors / Variables	Factor 1 The importance of safety in corporation's management	Factor 2 Negative influence from the third person and environment	Factor 3 Professional knowledge and safety knowledge	Factor 4 Individual safety consciousne-ss	Factor 5	Commu-nalities
Q 20	0.860					0.784
Q 18	0.776					0.639
Q 13	0.755					0.602
Q 22	0.744					0.583
Q 17	0.700					0.643
Q 23	0.690					0.530
Q 21	0.646					0.666
Q 16	0.643					0.512
Q 15	0.640				0.400	0.593
Q 19	0.501					0.335
Q 14	0.485					0.414
Q 8	0.478					0.422
Q 3	0.468		0.435			0.548
Q 30		0.684				0.504
Q 34		0.671				0.697
Q 29		0.656				0.605
Q 32		0.653				0.464
Q 26		0.617				0.572
Q 31		0.610				0.487
Q 38		0.585				0.500
Q 25		0.584	-0.486			0.621
Q 28		0.577				0.458

Q 27		0.543				0.388
Q 24		0.522				0.418
Q 35		0.514				0.602
Q 10			0.663			0.500
Q 12			0.598			0.405
Q 9			0.538			0.461
Q 11	0.553		0.433			0.567
Q 6				0.776		0.617
Q 7				0.739		0.664
Q 5				0.602		0.440
Q 2			0.463	0.455		0.425
Q 36		0.533		0.434		0.530
Q 4					-0.551	0.514
Q 33					0.537	0.357
Q 37		0.453			0.508	0.585
Q 1						0.394
Total	6.902	5.172	3.021	2.844	2.102	20.041
% of variance	18.16%	13.61%	7.95%	7.49%	5.53%	
Cumulative %	18.16%	31.77%	39.72%	47.21%	52.74%	

It should be noted that though factor 5 could explain question 4, 33 and 37, it couldn't be named because the variations between the questions are too big. Thus, this factor will not be considered in following analysis. In addition to that, question 1 couldn't be explained by any factor because any factor loading on which 1 is lower than 0.4, so it will not be considered as well.

For understanding purpose, question 11 is adjusted from factor 1 to factor 3. This is acceptable because its factor loading to factor 1 and factor 3 is close. This slight adjustment is permitted due to the random errors appearing in the survey. Same adjustment also happens to question 2, which is adjusted from factor 3 to 4.

Evaluation of safety culture

Factor scores After doing FA, the 38 questions have been reduced to the 4 factors which could then be used to evaluate safety culture in an efficient way. To do the quantitative evaluation, each factor must be set value. The method used to score the factors in this paper is to calculate the average score of the questions in a specific factor. Each question's score is shown in Table 5 which is the average value of 70 respondents' scoring, as well as the score of each factor.

Table 5: The average score of the survey question

Factor 1 The importance of safety in corporation's management												
Q20	Q18	Q13	Q22	Q17	Q23	Q21	Q16	Q15	Q19	Q14	Q8	Q3	**Ave.**
4.31	4.11	3.78	4.36	4.63	3.83	4.5	4.17	4.31	4.41	4.3	4.11	4.49	**4.25**
Factor 2 Negative influence of the third person and environment												
Q30	Q34	Q29	Q32	Q26	Q31	Q38	Q25	Q28	Q27	Q24	Q35		**Ave.**
3.07	3.81	3.6	4.13	2.51	3.81	3.69	2.83	2.59	2.96	2.59	3.83		**3.28**
Factor 3 Professional knowledge and safety knowledge												
Q10		Q12		Q9		Q11		**Ave.**				
4.04		4.07		4.21		3.79		**4.03**				
Factor 4 Individual safety consciousness												
Q5		Q6		Q7		Q2		Q36		**Ave.**		
4.83		4.57		4.09		4.74		3.89		**4.42**		

The evaluation of safety culture of construction supervision corporations

The overall level of safety culture can be graphically shown in a safety culture radar

plot based on Table 5, see Figure 3.

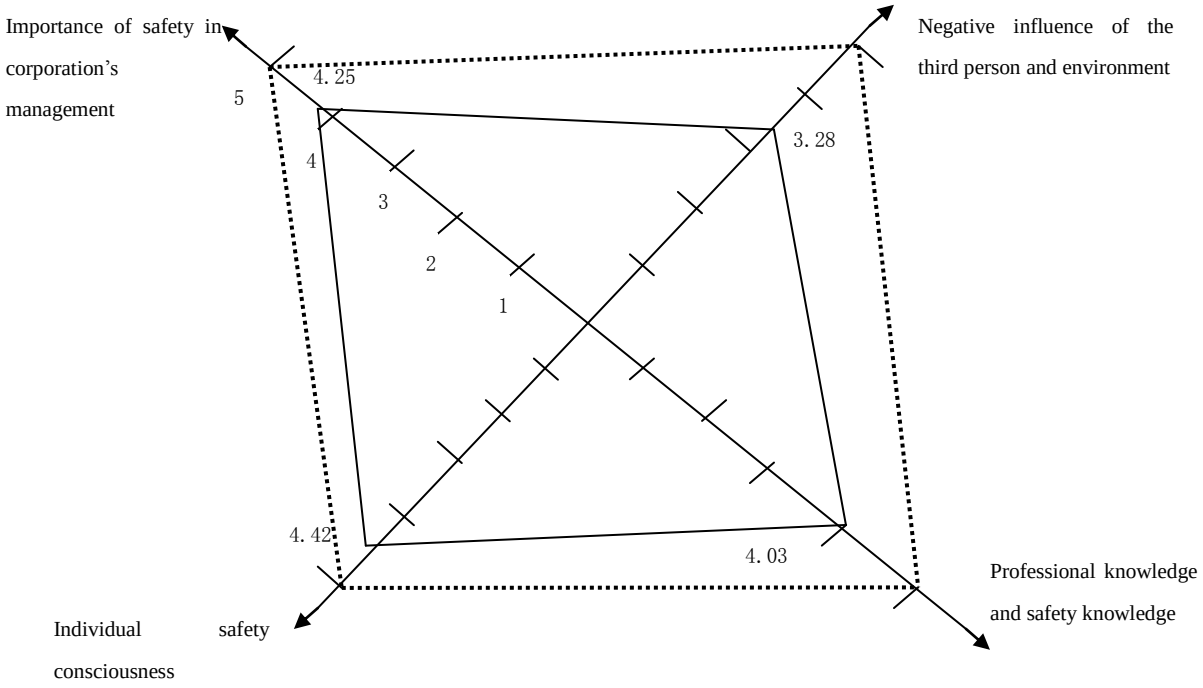

Fig.3: Radar Plot of safety culture of Construction Supervision Corporation

The area bounded with dotted line represents the highest level of safety culture. Correspondently, the area bounded by the solid line represents the level of safety culture of Construction Supervision Organizations in China. From the area comparisons, the overall level of safety culture is not bad. To know more details of the safety culture, each factor is analyzed in the following.

Individual safety consciousness (factor 4) ranks the top. This is a good phenomenon because individual safety consciousness is the key to improve safety management performance. This seems conflicted with the top ten criminal evidences, but is reasonable because most supervising engineers still pay a great attention to safety issues except the ones who commit the duty crime.

The importance of safety in corporation's management (factor 1) ranks the second. Q17, Q21, Q3, Q22, Q15 and Q19 are all positive questions and scored high. They represent that top managements' commitment, group behavior, internal communication and safety training are paid great attentions in organizations. This is beneficial to improve organizational safety performance.

Professional knowledge and safety knowledge (Factor 3) ranks the third. It only includes 4 questions, only Q9, "I know clearly what measures we should take to ensure safety at each stage of a project", scored relatively high. Q12 "I know laws and regulations on construction works well" and Q10 "I know clearly the hazards which cause construction accidents well", just got middle scores. These represent that

supervising engineers lack confidence to the laws and risk management knowledge in terms of safety management. Question "I know how to deal with safety problems well" scored lowest. This seems a little conflicted with Q9. However, it is reasonable if we know that many supervising engineers simply equal the "measures" to technical measures. For safety management, only technical knowledge is not enough. The 50 accident cases (mentioned in the second section) show most accidents were caused not by techniques, but poor safety behaviors. Therefore, how to help contractors improve the safety consciousness is the key improve safety management on site. To reach this objective, communication is very important. So the problem behind this question is poor communication skill with contractors.

Negative influence of the third person and environment ranks the last. The influence sometimes come from colleagues (see Q29, Q34), sometimes from the stakeholders (see Q31, Q30). Questions 31 and 30 reveal the negative influence from the contractors and the clients. This reflects the awkward satiation of supervising engineers in China. There are some owners who don't want supervising engineers to do management of the project, but have to according to the laws, thus they don't authorize enough rights to supervising engineers. The insufficient authorities put supervising engineers in another awkward situation, that is, some contractors don't follow the supervising engineers' instructions if supervising engineers don't get along well with them. The obstacles from the contractors and clients seem the worst problems which deter the effective safety management considering that supervising engineers have high safety consciousness and supervision organizations pay great attention to safety management. Q32 "I become aware of the importance of safety only after accidents happen" scored the highest under the factor. This can be explained on the one hand that safety had been ignored for a long time. On the other hand, considering the high safety consciousness of supervising engineers, this can be explained that they didn't identify the hazard in advance. To solve this problem, risk management should be introduced into safety management.

5. Conclusions

The paper aims to evaluate the current safety culture of construction supervision organizations (CSO). The layer safety culture model proposed in the paper try to express such kind of assumption that persons are the core element of an organizational safety culture, they are influenced and interact with organization and in turn the organization is influenced and interact with external environment. The three layers are dynamic and interacted.

After doing FA to the data collected from the questionnaire survey based on the safety culture model, four factors were extracted to evaluate the level of safety culture of CSO. They are, according to the positive order from top to down, individual safety consciousness, the importance of safety in corporation's management, professional knowledge and safety knowledge and negative influence of the third person and

environment. The overall level of safety culture of CSO is good. After doing detailed analysis of each factor, it is found that individual safety consciousness of supervising engineers is good and SCOs also pays great attention to the safety supervision. The main problems are supervising engineers need improve their professional/safety knowledge, the communication skill and should apply risk management into their safety management practice. In the meantime, negative influences from the clients and contractors should be pay more attention because it is a serious obstacle which deter the effective safety management of supervising engineers.

The findings of the paper could provide useful information for CSO in terms of how to improve their safety management. It also provides a good basis to do further study, such as, the scheme of construct good safety culture.

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