Safety Climate Improvement: Case Study in a Chinese Construction Company

Quan Zhou[1]; Dongping Fang[2]; and Sherif Mohamed[3]

Abstract: A positive safety climate can improve employees' safety awareness and reduce workers' unsafe behaviors. Having consistent key factors that comprise safety climate is paramount in facilitating the measurement and comparison of safety climate over time which helps identify effective approaches to improve safety performance. This paper examines the consistency of safety climate factor structure and safety climate improvements over time in a Chinese construction company. It adopts a case study approach and reports on using the same safety climate instrument to carry out two surveys, three years apart. The exploratory factor analysis showed that the obtained four-factor structure of safety climate remained consistent across the two surveys. Moreover, the confirmatory factor analysis demonstrated that the second-order factor of safety climate was unchanged. Statistically significant improvements were also found on all four identified factors. The governmental or organizational strategies and/or tactics that could stimulate positive improvements on safety climate factors (referred to as stimulators hereinafter) were then identified via interviews with safety management officers in the company. The most effective stimulators were found to include constituting the safety regulations and safety rules, as well as increasing the intensity of safety training and safety promotion. Implications on the consistent factor structure of safety climate and the stimulators are also discussed.

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Introduction

The construction industry incorporates many unique features and conditions including: an intensive and peripatetic workforce, and continuous exposure to bad weather and fluctuating temperatures. Complex projects and organizational management structures also add to the complications experienced in the industry. As a consequence, frequent safety inspections, the provision of sufficient personal protective equipment, and detailed stipulation of technical specifications have not completely succeeded in eliminating construction accidents, especially on-sites where there is inadequate safety awareness. The promotion of employees' safety awareness primarily depends on whether there exists a positive safety climate within the construction company and on its construction sites. Safety climate is inferred from employees' perceptions of the true priority of safety. Meanwhile, safety climate can be measured by comparing the safety priority items with competing operational demands (Zohar and Tenne-Gazit 2008), such as productivity, speed, and profit. A high level of safety climate indicates that a higher priority is being placed on safety, as enacted by top management and perceived by organizational members (Zohar and Luria 2005; Luria 2008). Under a positive climate of safety, the employees develop site safety awareness and accept that the first priority during any site operation is safety. Thus, they will take the initiative to adopt practices that will inevitably reduce the violation of safety rules.

More and more researchers have realized the critical role that safety culture and safety climate play within the workplace. Glendon's (2008) extensive literature search, for the period from 1980 to January 31, 2008, revealed that a total of 203 refereed empirical/review articles have focused on safety culture and/or safety climate. It is worth mentioning that about 50% of these articles were published or accepted as "in press" since 2005.

Safety climate and its definitions have been thoroughly explored by academics over the last three decades (Zohar 1980; Glennon 1982a,b; Brown and Holmes 1986; Cooper and Philips 1994; Niskanen 1994; Coyle et al. 1995; Williamson et al. 1997). The definition adopted in this paper can be stated as: "Safety climate is concerned with the shared perceptions and beliefs that workers hold regarding safety in their workplace (Cooper and Philips 1994). Through questionnaire surveys, the "workers' shared perceptions and beliefs regarding safety" can be revealed through several underlying safety climate dimensions (factors), or, summarized into a few higher order elements. For many years, researchers have been arguing whether or not a common factor structure for safety climate exists. However, to date, no consensus has been reached yet due to the inconsistencies among the ob-

[1]Doctor, Dept. of Construction Management, Tsinghua Univ., Haidian District, Beijing 100084, China.

[2]Professor, Dept. of Construction Management, Tsinghua Univ., Haidian District, Beijing 100084, China (corresponding author).

[3]Professor, Centre for Infrastructure Engineering and Management, Griffith Univ., Gold Coast Campus, QLD 4215, Australia.

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tained factor structures. Glendon and Litherland (2001) have postulated that one explanation for these inconsistencies revolves around the variety of questionnaires, samples and methodologies used by many researchers.

At the outset it must be acknowledged that, it is difficult to obtain a consistent factor structure in samples drawn from different industries or different countries, even when the same (or modified) safety climate questionnaire and same methodology is used. Zohar (1980), one of the early safety climate research pioneers, explored an eight-factor structure with a 40-item questionnaire given to production workers in 20 Israeli companies. Six years later, Brown and Holmes (1986) attempted to assess the validity of Zohar's safety climate measure, with the same questionnaire, but given to an American sample of production workers. Their research failed to support Zohar's safety climate model, with their three-factor structure. In 1991, Dedobbeleer and Beland attempted to validate Brown and Holmes' (1986) three-factor safety climate model by testing it on American construction workers. However, this study revealed a more appropriate two-factor model. Consequently, they postulated that the inconsistency was due to the industrial differences between construction and production. In another study, using Zohar's questionnaire, Díaz and Cabrera (1997) developed a set of evaluation measures for assessing safety climate by testing their instrument, and identifying the essential dimensions of safety climate, for airport ground handling companies. From their study, they obtained a six-factor structure. Coyle et al. (1995) expanded the questionnaires developed originally by Zohar (1980) and Glennon (1982a,b), and distributed them within two clerical and service organizations in Australia. To correspond with the eight-factor structure of Zohar (1980), they set the number of factors to be retained by each analysis at eight. Unexpectedly, they did not resemble the factor structure of either organization. Comparing the seven-factor structure in organization one and the three-factor structure in organization two, the writers argued that safety climate factors were not stable across organizations.

In contrast, similar factor structures have been found in a few cross validation studies in a variety of industries. The 32-item questionnaire used by Varonen and Mattila (2000) were identical to the questionnaires employed in two earlier Finish safety climate studies conducted by Halme (1992) and Seppälä (1992) (cited in Varonen and Mattila 2000). These studies were carried out within the plywood industry (at shipyards), in the forestry industry, and at building construction and stevedoring sites. Varonen and Mattila (2000) extracted four factors, containing 25 items. These factors were proved to be very similar to those obtained by Seppälä (1992), concluding that the safety climate factor structure of Finnish workers was quite stable. In a more recent study, Pousette et al. (2008) successfully replicated for the Swedish construction industry, the first-order factor structure of safety climate reported by Cheyne et al. (1998), cited in Pousette et al. (2008). Their study can be regarded as a cross industrial validation of the safety climate factor structure.

In light of the above, the current study undertook two safety climate surveys within a Chinese construction company at two points in time (November 2004 and November 2007). The study had three aims, which are presented and discussed below.

From the adopted definition of safety climate, it can be concluded that safety climate is an organizational level concept, which integrates the employee perceptions within an organization (Glennon 1982a,b; Brown and Holmes 1986; Williamson et al. 1997). Thus, it would be expected that safety climate dimensions would be replicated by case studies applied to the same organization. Such a study was undertaken by Cooper and Phillips (2004), who distributed a safety climate questionnaire to manufacturing employees at the beginning of a behavioral safety initiative; it was then redistributed to those employees one year later. The hypothesis put forward by Cooper and Phillips (2004) was that a similar factor structure would be obtained, from the same safety climate instrument when used to survey the same sample population, at different points in time. This hypothesis was supported by the same two second-order factors obtained from both distributions. Another case study was carried out in 2001 and then again in 2003, of employees on offshore oil platforms on the Norwegian continental shelf (Tharaldsen et al. 2008). Using structural equation modeling, they found that a five-dimensional safety climate factor structure fitted the data from both 2001 and 2003. As such, the current paper aims to provide further data on the stability of the first-order factor structure. The first aim of this paper was illustrated below.

Aim I. Explore whether a similar *first-order* factor structure could be obtained from the same safety climate instrument when used to survey the same organization at two different points in time.

The higher order factor(s) (Kim and Mueller 1978) of safety climate was based primarily on a survey taken at one time point. For example, in the cross validation research by Pousette et al. (2008), the conclusion supported the hypothesis of the existence of a second-order safety climate factor. However, there has been a lack of case studies on the stability of the higher order factor(s) of safety climate. One exception has been the study by Cooper and Phillips (2004) who obtained the same two second-order safety climate factors by means of two surveys, with a one year time interval. Hence, this paper aims to examine the repeatability of the second-order factor(s). Therefore, the second aim of the paper was listed below.

Aim II. Explore whether the same *second-order* factor(s) could be obtained from the same safety climate instrument when used to survey the same organization at two different points in time.

Thus, it is expected that a case study with multiple surveys could provide significant and meaningful variations in safety climate factor scores at different points in time, as well as identify underlying causations; that information may help other organizations who find themselves under similar conditions. The results of such a study would help to fulfill the existing research gap for multiple comparisons and causation identification on safety climate factors.

Glendon and Stanton (2000) compared two safety climate questionnaire samples from two surveys in 1994 and 1997. They revealed that statistically significant improvements had occurred for seven of the eight factors. However they did not analyze the stimulators of these improvements. Similar findings were identified by Tharaldsen et al. (2008), who found that safety climate was significantly improved from their 2001 survey to their 2003 survey for four of the five dimensions. They concluded that the nonsignificant decline of the fifth dimension (i.e., system comprehension) related to the comprehensive implementation of a new system for Work Permits and Safe Job Analysis in 2003. However, the writers neither discussed nor assessed the stimulators for the improvements of the four safety climate factors. The current study, therefore, seeks to address similar situation through its multiple surveys on safety climate in a Chinese construction company, with a time interval of three years. Thus, the third aim of this paper was as illustrated in the following section.

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Aim III. Identify the governmental or organizational strategies and/or tactics which could stimulate positive improvements on safety climate factors, by exploring the variation on factors' scores of safety climate at two different points in time.

In the following, the "governmental or organizational strategies and/or tactics which could stimulate positive improvements on safety climate factors" will be referred to as stimulators.

Methods

Survey and Participants

The surveyed company (called ABCD within this context) is one of the Engineering News-Record's Top 225 International Contractors. In 2007, the total assets of this company were 19 billion RMB Yuan and the net assets were 3.9 billion RMB Yuan. Its total contracting revenue in 2006 was more than $2.7 billion dollars, with about $90 million dollars coming from projects located outside China. This company offers a complete construction service for a wide range of project types, including commercial and residential properties (this type of projects accounts for more than 90% of the overall contracting revenue of ABCD). Its service extends over the full project life cycle from initial site survey and design through construction to commissioning and ongoing maintenance.

There is tight, cohesive and cooperative relationship between the researchers and ABCD. The company provided the researchers with a list of ongoing projects which could be potential targets for the survey. For each project, the list contained information about project type, location, geometrical dimension, the number of subcontractors and workers, and so on. Then, the researchers selected a number of construction projects, representing the company's core business.

Two surveys of safety climate were carried out, separately, in November 2004 and November 2007, at different construction sites—all operated by ABCD. The selected projects in both 2004 and 2007 were typical commercial and residential projects. The participating workers in 2004 and 2007 were mainly concrete workers, steel workers, electrical workers, ventilation workers, and pipe workers.

With the strong support from the company's top management and the project managers, all site workers on the selected projects were invited to participate in the survey. The questionnaires were distributed to the workers who were required to complete the questionnaire within a specified time period (20 min). The total number of respondents in 2004 (626 respondents) and in 2007 (621 respondents) were equivalent.

The instruments were designed to be anonymous; any personal information was provided voluntarily and a guarantee was given that it would not be shared. In this way, employees felt free to express their true perceptions of the existing safety climate at the two points in time. In 2004, employees at one construction site of ABCD were given the instruments, and a total of 626 questionnaires were collected; 543 were valid responses (86.74%). In 2007, employees at three construction sites of ABCD were given the instruments, and a total of 752 questionnaires were distributed; 621 responses were received (82.58%); 404 were valid (65.06%). The response and valid rates for each construction site surveyed in 2007 are shown in Table 1.

Table 1. Response Rate and Valid Rate for Each Project Surveyed in 2007

Project	Distribution (A)	Response (B)	Validity (C)	Response rate (B/A) (%)	Valid rate (C/B) (%)
I	322	289	157	89.75	54.33
II	321	270	195	84.11	72.22
III	109	62	52	56.88	83.87
In Total	752	621	404	82.58	65.06

The descriptive statistics included age, work experience, gender, and front line workers; the data collected in 2004 and 2007 are shown in Table 2. Age was measured within five 10-year range periods. Work experience was measured by the work period duration respondents had in the construction industry. As Table 2 indicates, the samples collected in 2004 and 2007 were, to a large extent, similar.

Measurements

Initially, Fang and Chen (2006) developed an 87-item safety climate questionnaire survey. They designed the questionnaire to seek the views of managers, supervisors and workers on key aspects of safety climate within an organization. This questionnaire was developed based on the safety climate survey questionnaire of Health and Safety Climate Survey Tool of HSE, United Kingdom, as well as the safety management system in Hong Kong. All the 71 items of the HSE survey questionnaire were incorporated in this safety climate questionnaire, and were combined with 16 additional items covering the fourteen safety management elements developed by the Hong Kong Government in 1995.

Based on 4719 samples collected from 54 construction sites in Hong Kong, Zhou et al. (2008) reduced this 87-item instrument to a 31-item instrument by EFA (Exploratory Factor Analysis). This 31-item instrument was both academically and empirically supported. It is believed that it is the only published construction safety climate instrument in mainland China, and accordingly it was selected as the research instrument in the pilot study for this research. The 31 items were measured using a five-Likert scale (from "strongly disagree" to "strongly agree"). An exploratory factor analysis (EFA) was applied giving rise to a four-factor structure, with 24 items retained (Table 3). The 24-item instrument was then applied to the 2007 survey.

Results

Aim I: First-Order Factor Structure

The data from the 543 responses to the 31-item instrument, in 2004, were analyzed by an EFA, using the principal component extraction method, followed by the varimax rotation. The Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) value was equivalent to 0.838, showing that the EFA could be applied to the data set (Kim and Mueller 1978). Seven factors having an eigenvalue larger than 1 were extracted. The cumulative variance was 60.17%. Next, the following two steps were undertaken:

1. The items with a factor loading of less than 0.40 on any factor were removed (Coyle et al. 1995; Williamson et al. 1997; Varonen and Mattila 2000; Havold 2005; Fang and Chen 2006).
2. All factors listed after factor four, consisting of less than three items, were excluded (Varonen and Mattila 2000; Seo et al. 2004; Fang and Chen 2006).

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Table 2. Descriptive Statistics of Samples Collected in 2004 and 2007

		Samples collected in 2004		Samples collected in 2007	
		Number	Valid percentage (%)	Number	Valid percentage (%)
Age	Below 20	46	9.0	48	12.0
	21 to 30	196	38.3	173	43.4
	31 to 40	186	36.3	114	28.6
	41 to 50	64	12.5	55	13.8
	Above 50	20	3.9	9	2.3
Work experience	Less than 3 years	129	25.1	116	29.5
	3 to 10 years	252	49.0	189	48.1
	11 to 15 years	68	13.2	46	11.7
	16 to 20 years	17	3.3	31	7.9
	Longer than 20 years	48	9.3	11	2.8
Gender (male)		485	96.4	394	99.0
Front line workers		449	83.0	323	80.0

The final four-factor instrument comprising 24 items (Table 3), with a 48.826% cumulative variance was retained. The internal consistencies of the four factors, measured using Cronbach alpha coefficients, were 0.848, 0.812, 0.74, and 0.682, respectively. As a rule of thumb, reliability coefficients around 0.7 and above are professionally acceptable (Muchinsky 2004, cited in Cooper and Phillips 2004). Thus the Cronbach α values for the four factors were all acceptable. The factor loading matrix is shown in Table 4. Based on the nature of the items loaded on each factor, the four factors were labeled as follows: *safety regulations* (six items), *safety supervision*, *safety training and workmates' support* (eight items), *management commitment* (six items), and *safety attitude* (four items).

The 24-item safety climate instrument was then applied to the 2007 survey. It was expected that the comparison of the factor structures at the two points in time (2004 and 2007) would assist exploring the similarity of the first-order factor structures. In the 2007 survey, data collected by the 24-item instrument were analyzed by the EFA, along with the use of the principal component extraction method followed by the varimax rotation. The number of extracted factors was set at four to enable comparison with the four-factor structure obtained in 2004. The KMO value of 0.843, indicated that the EFA would be appropriate. The four extracted factors, cumulatively, explained 50.099% of the total variance. No items had a factor loading less than 0.4; and no factors consisted of less than three items. The Cronbach α values for the four factors were 0.806, 0.810, 0.772, and 0.715, respectively, and showed acceptable reliability.

The minor differences in the factor structures at the two points in time are revealed in Table 4. As can be seen, from among the 24 items, only two items (item 6 and item 20) did not remain within their same original factors. The rest of items however, remained in the same factor keeping the instrument stable in terms of its attributive factors at the two points in time.

Item 6, "There is good preparedness for emergency here," which originally belonged to the factor "safety regulations" in 2004, was categorized into the factor "safety supervision, safety training and workmates' support" in 2007. It could be revealed from the context of Item 6 and the names of these two factors that, Item 6 has closer relationships with the factor safety supervision, safety training and workmates' support. For example, the meaning of Item 6 is similar with Item 9 "Sufficient resources are available for health and safety here." However, the relationship between Item 6 and safety regulations was not supported by the context. Thus, the data in 2007 provide more practicable classification for Item 6.

Item 20, "The company really cares about the health and safety of the people who work here," which originally belonged to the "management commitment" factor in 2004, was categorized into the factor safety supervision, safety training and workmates' support in 2007. The description of item 20 reflects the concern by, and commitment from, top management. Thus indicating from context, item 20 should be categorized into the factor management commitment. It can be stated, therefore, that Aim I was experimentally verified; viz., a similar first-order factor structure was obtained using the same safety climate instrument when surveying the same organization at two different points in time.

Aim II: Second-Order Factor Model

First, the correlations between the four factors at each of the two points in time needed to be examined by the confirmatory factor analysis (CFA). It was expected that correlations between the factors would indicate the existence of a second-order factor (Hau et al. 2004). LISREL 8.70 was used to apply the CFA, using the data collected in 2004 and 2007. In each of the two *first-order factor models*, the correlation matrix was set free so that the software could estimate the matrix automatically (see Table 5). The widely used model fit indices (Seo et al. 2004) used in the current study were:

- First-order factor model (2004): χ^2 (chi-square statistic) $=3{,}184.21$ ($P=0.0$); df (degrees of freedom) $=246$; NFI (normal fit index) $=0.82$; CFI (comparative fit index) $=0.83$; and RMSEA (RMS error of approximation) $=0.13$.
- First-order factor model (2007): $\chi^2=1{,}432.84$ ($P=0.0$); df $=246$; NFI $=0.88$; CFI $=0.90$; and RMSEA $=0.11$.

In the CFA conducted by Toll et al. (2007), they referred to a number of quotations to support the cut-off values and CFA methods: To show a good fit for the model, the chi-square statistic should be nonsignificant (Floyd and Widaman 1995). The NFI and CFI range between 0 and 1, with values closer to 1 indicating a better fit for the model. For these indices, values of 0.95 or higher are most desirable, and values of 0.90 or greater represent an acceptable fit of the model to the data (Hu and Bentler 1999;

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Table 3. Twenty-Four-Item Instrument of Safety Climate

Number	Item
1	Some jobs here are difficult to do safely
2	Some health and safety procedures/instructions/rules do not reflect how the job is now done
3	Some health and safety procedures/instructions/rules are difficult to follow
4	The permit to work system is over the top given the real risks of some of the jobs it is used for
5	Not all the health and safety procedures/instructions/rules are strictly followed here
6	There is good preparedness for emergency here
7	I am clear about what my responsibilities are for health and safety
8	People can always get the equipment which is needed to work to the health and safety procedures/instructions/rules
9	Sufficient resources are available for health and safety here
10	My workmates would react strongly against people who break health and safety procedures/instructions/rules
11	It is important for me to work safely if I am to keep the respect of the others in my team
12	Most of the job-specific safety trainings I received are effective
13	Safety inspection here is very helpful to improve the health and safety of workers
14	I think management here does enough to follow up safety inspections/accident investigations
15	Accidents which happen here are always reported
16	I feel involved when health and safety procedures/instructions/rules are developed or reviewed
17	The company encourages suggestions on how to improve health and safety
18	People here always wear their health and safety protective equipment when they are supposed to
19	There are always enough people available to get the job done according to the health and safety procedures/instructions/rules
20	The company really cares about the health and safety of the people who work here
21	Productivity is usually seen as more important than health and safety by management
22	Sometimes it is necessary to take risks to get the job done
23	Health and safety is not my problem
24	People are just unlucky to suffer an accident

McDonald and Ho 2002). Regarding the RMSEA as a measure of good fit, Brown and Cudeck (1993) suggested that a reasonable value for the RMSEA is less than or equal to 0.08, and they posited that the RMSEA should never be greater than 0.10.

The above introduction of cut-off values would help readers to understand the CFA methods. However, CFA was used in the paper to assess the number of factors and the loadings of variables and to capture the covariance between the different factor items, and not to test how the proposed model fit measures, hence the cut-off values do not apply.

As revealed in Table 5 the four factors were correlated in both 2004 and 2007. The correlations were statistically significant at the 0.05 level. Although the correlation coefficients were not very high, the correlations implied the probability of the existence of a second-order factor at each of the two points in time. Aim II thus sought to explore the *second-order factor model* using the CFA. In each of the two *second-order factor models*, the correlation matrix was set to be zero, while the correlation coefficients between the second-order factor and each of the first-order factors, which were expressed as GAMMA in CFA, were set free. The model fit indices and the completely standardized solutions of GAMMA are listed below:

- Second-order factor model (2004): $\chi^2=3{,}210.55$ ($P=0.0$); df $=248$; NFI$=0.82$; CFI$=0.83$; and RMSEA$=0.13$. GAMMA: 0.29, 0.97, 0.89, 0.65.
- Second-order factor model (2007): $\chi^2=1{,}448.51$ ($P=0.0$); df $=248$; NFI$=0.88$; CFI$=0.90$; and RMSEA$=0.11$. GAMMA: 0.41, 1.01, 0.75, 0.59.

Next comparisons of the model fit indices were conducted between the first-order factor model and the second-order factor model in 2004. The increase in the chi-square was 26.34 ($\Delta\chi^2=26.34$), and the increase of the degree of freedom was 2 (Δdf

Table 4. Factor Loading Matrix in 2004 and 2007

	2004				2007			
Number	SR	SS	MC	SA	SR	SS	MC	SA
1	0.79				0.77			
2	0.77				0.88			
3	0.85				0.78			
4	0.64				0.66			
5	0.76				0.61			
6	0.52					0.52		
7		0.59				0.53		
8		0.56				0.62		
9		0.53				0.64		
10		0.63				0.56		
11		0.69				0.58		
12		0.58				0.62		
13		0.6				0.53		
14		0.59				0.43		
15			0.5				0.55	
16			0.63				0.74	
17			0.69				0.78	
18			0.56				0.74	
19			0.64				0.55	
20			0.65			0.54		
21				0.78				0.56
22				0.57				0.69
23				0.6				0.77
24				0.54				0.87

Note: SR=safety regulations; SS=safety supervision, safety training and workmates' support; MC=management commitment; and SA=safety attitude.

Table 5. Correlations within First-Order Factors in 2004 and 2007

	2004					2007			
Factor	SR	SS	MC	SA	Factor	SR	SS	MC	SA
SR	1.00				SR	1.00			
SS	0.23[a]	1.00			SS	0.39[a]	1.00		
MC	0.36[a]	0.86[a]	1.00		MC	0.39[a]	0.75[a]	1.00	
SA	0.25[a]	0.65[a]	0.53[a]	1.00	SA	0.31[a]	0.60[a]	0.36[a]	1.00

Note: SR=safety regulations; SS=safety supervision, safety training and workmates' support; MC=management commitment; and SA=safety attitude.

[a]Correlation is significant at the 0.05 level (two-tailed).

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Table 6. Comparison of Mean Ratings of the Four Factors between 2004 and 2007

Factor	Year	N	Mean	Standard deviation	T-value	Df	Sig. (two-tailed)
SR	2004	543	3.15	0.77	−5.52	767.09	0.00
	2007	401	3.46	0.92			
SS	2004	542	3.79	0.48	−3.55	804.02	0.00
	2007	401	3.91	0.54			
MC	2004	543	3.70	0.49	−4.25	752.15	0.00
	2007	401	3.86	0.60			
SA	2004	542	3.95	0.66	−4.12	941.00	0.00
	2007	401	4.13	0.72			

Note: SR=safety regulations; SS=safety supervision, safety training and workmates' support; MC=management commitment; and SA=safety attitude.

=2). If the statistically significant level is 0.01, then the chi-square distribution table gives the critical value of chi-square as 9.21, when the degree of freedom equals 2. It could be revealed that the increase in the chi-square (26.34) exceeded the critical value (9.21), thus the first-order factor model seemed to be more appropriate. However, it was expected that the comparison of the two models would be established on the differences in the other model fit indices, as the increase of the chi-square would be influenced by the sample size (Hau et al. 2004). The increases in three other widely used indices (NFI, CF, and RMSEA) all equaled zero, indicating no differences between the two models. As a rule, the better fitted model should be as simple as possible, based on the premise that there are no statistically significant differences in the model fit indices (Hau et al. 2004). For this reason, the second-order factor model (2004) was selected. The result proved the existence of a single second-order factor within ABCD that could represent the safety climate as a whole.

Similar results were obtained by a comparison of the model fit indices between the first-order factor model and the second-order factor model in 2007. The increase in the chi-square was 15.67 ($\Delta\chi^2=15.67$), and the degree of freedom was 2 (Δdf=2). Similarly to 2004, the three model fit indices, (NFI, CF, and RMSEA) did not change from the first-order factor model to the second-order factor model. Thus the single second-order factor also existed in 2007.

From the above, Aim II was experimentally verified, viz., the presence of the same second-order factor was obtained using the same safety climate instrument, within the same organization, at two different points in time. This higher order factor (safety climate) revealed the shared perceptions and beliefs that employees hold regarding safety in their work place. In the current paper, the general element "safety climate" featured prominently in the employees' shared perceptions on safety regulations, safety supervision, safety training and workmates' supports, management commitment, and safety attitude.

Aim III: Stimulators for Improvements

The multiple surveys with the 24-item safety climate instrument explored in this paper revealed the changes to the four safety climate factors. In the current research, an independent sample t-test was applied to assess the significance of the changes in the four factors between 2004 and 2007 (Table 6). For each of the four factors, statistically, the mean rating (2007) was significantly higher than 2004. This result indicated that statistically significant improvements were achieved for all four stable safety climate factors from 2004 to 2007.

Two interviews were then conducted to explore the stimulators for the improvement on all four safety climate factors (2004 to 2007). Two safety management officers from ABCD headquarters participated in the first interview, whereas two safety managers representing two different construction sites participated in the second. The four safety officers had all worked for ABCD for longer than eight years, thus they were experienced, could contribute valuable information and also could identify the stimulators that improved the safety climate factors from 2004 to 2007.

Societal and Legislative Stimulators

Essentially, the improvement of the safety climate in ABCD benefited from the development of Chinese society and economy, as well as the improvement in safety awareness of the public.

For example, the emphasis on safety has been continuously strengthening during these years, specifically related to the Decision on Building a Harmonious Socialist Society, approved in October 2006, by the Sixth Plenary Session of the 16th Central Committee of the Communist Party of China (CPC). The CPC, for the first time in its history, emphasized the need to build a harmonious society as an important aspect of its governance capacity. Such needs included: making economic and social development more people oriented, comprehensive, balanced, and sustainable; solving problems that concern the people and affect their vital interests; and properly balancing market forces and macroeconomic regulations. Thus, the growing emphasis on safety by the government and the improvement of safety awareness of the public can be seen as a driving force in establishing a more positive safety climate in the construction industry.

Additionally, the Chinese Criminal Law was amended 10th National People's Congress Standing Committee in June 2006), with the penalties against those responsible for causing fatal accidents increasing significantly. The maximum sentence for compelling an employee to operate at risk (illegally) and thus causing a fatal accident was lengthened from 7 to 15 years. Furthermore, the Regulations on Administrative Penalties of Production Safety Violations (Order of the State Administration of Work Safety of the People's Republic of China No. 15) came into force in 2007. The regulation imposes heavier administrative penalties on the organizations and/or the most responsible person in charge; these penalties can include warnings, penalties, charges of correction, confiscation of the illegal income, charges to stop production, temporary detainment or revocation of relevant licenses, or even detention. Furthermore, the government strengthened the requirements of supervision on construction projects and increased the penalties for construction companies involved in fatal accidents. In China, the direct cost of fatal accidents has increased from less than 50,000 RMB (2000) to more than 400,000 RMB (after 2007). The increase in the direct and indirect costs has forced the top management of construction companies to highlight the need for safe practices and safety awareness. Important, the safety priority advocated by managements plays a decisive role in the building of a positive safety climate in construction organizations.

Organizational Stimulators

Stimulators to Safety Regulations. The improvement in the first safety climate factor (safety regulations), was occasioned by the government's enforcement of safety regulations, as well as the safety rules and guidelines issued by ABCD. While some of the

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safety regulations were enforced prior to the first survey (November 2004), it was expected that it would take one to two years before the new enforced safety regulations would take real effect and improve the safety climate. The regulations expected to contribute most to safety climate improvements were:

1. The "Administrative Regulations on the Work Safety of Construction Projects" (Decree No. 393 of the State Council of the People's Republic of China) came into force on February 1, 2004. It introduced a marked change in the health and safety provision in relation to construction. For example, it regulated the safety responsibilities of the owner, designer, supervisor, contractor, and relevant stakeholders, as well as the supervisory responsibility of the government for construction projects. After the regulation was promulgated and took effect, any noncompliance with the regulation, or accident hazards, would lead to an investigation and ultimately to penalty. The organization and the responsible entity would be punished accordingly.
2. The "Regulation on Work Safety Licenses" (Decree No. 397 of the State Council of the People's Republic of China) came into force on January 13, 2004. This regulation requires: (1) the contractor to establish and improve the responsibility system for work safety; (2) the employer and the contractor to increase the economic input for work safety; (3) the contractor to establish and improve the management system for work safety, and provide professional safety management personnel; (4) the contractor to ensure the safety training on employees; (5) the contractor to buy employment injury insurances according to law, and pay insurance premiums for the employees; (6) the contractor to identify, evaluate, and supervise the major hazards, as well as compile the emergency programs; and (7) the contractor to being evaluated on work safety according to the law.
3. The "Safety Specification on Temporary Power Usage on Construction Sites" (Code No. JCJ46-2005 of Industrial Standards of the People's Republic of China) came into effect on July 1, 2005. It updated the requirements in relation to the management of temporary power usage and the specifications of fire protection.
4. The "Management Methods on Documents of Production Safety," issued in 2006 by ABCD, required the development of standard inspection tables to be used by safety officers, the updating of the scope for site safety inspections, that photographs be taken as proof of unsafe production, and that safety information be submitted on-line.
5. The "List of Major Hazards on Construction Sites," developed in 2003 by ABCD, has now become an important tool in identifying the potential hazards on a new construction site, and in implementing the appropriate measures. This list has been continuously updated since its inception.
6. Four emergency programs were also planned by ABCD from 2003 to 2005: (a) "The Emergency Plan on Production Safety"; (b) "The Emergency Plan on Fire Protection"; (c) "The Emergency Plan on Acute Occupational Disease"; and (d) "The Emergency Plan on Acute Occupational Poisoning." These programs were seen as enabling ABCD (both the management and the employee) to act quickly and effectively in any emergency situation.

Stimulators to Safety Supervision, Safety Training, and Workmates' Support. The improvement of the second safety climate factor (safety supervision, safety training and workmates' support) benefited from the enhanced safety training within ABCD from 2004. These improvements are discussed below

1. A "video" was used in the safety training from 2007, in the hope that the workers intuitively understand what was being shown. Additionally, the education style of safety training changed to be more interactive, so that the workers' comments were positively encouraged.
2. From 2005, ABCD also published a collection of playing cards with safety promotion pictures on the back, in relation to safety knowledge, skills, and tips. The workers, while playing cards, would see the pictures and be reminded of the work safety rules.
3. Furthermore, the frequency of safety training and safety promotion was increased during the month of March. This is a time after the Chinese New Year (Spring Festival) when the work schedule is not as intense as in other months. March was promoted as the "safety education month." Additionally, May was defined as "Safety Month," while June was promoted as the "National Production Safety Month." Then, from the beginning of October to the end of December, a safety promotion campaign ("Accident Free in One Hundred Days") was instigated. Thus, the series of safety promotion campaigns strengthened the safety training in the whole year.
4. The "Workers' Night School" was established in 2006. It focuses on: the augmentation of quality education in culture and safety education; and the professional skills of the training of different trade employees.

Stimulators to Management Commitment. Improvement to the third safety climate factor, labeled management commitment was facilitated by the safety inspections from the top management of ABCD. The inspections of "Construction Housekeeping and Safety" began at each construction site in 2006. They were conducted by the Deputy General Manager and the Chief Engineer. At the same time, the safety inspections of the subcontractors' labor were conducted by the Chairman of the Trade Union of ABCD, further revealing the commitments on safety from the top management. By November 2007 at the time of the second survey, ABCD had a total of 47 construction projects underway in Beijing. The frequency of inspections on these construction sites also increased; it usually took a half-day for a safety site inspection.

Stimulators to Safety Attitude. The improvements to the fourth safety climate factor, labeled safety attitude, were manifested by the increased safety awareness by workers, and by the priority given to safety by the managers. Additionally, project managers' safety attitudes improved through the annual safety training program, established in 2005, and developed specifically for project managers. The project managers contributed to improved awareness with their insistence that site safety issues must be the first item presented at the regular weekly project meetings. Such an expectation stimulated management teams to identify the need to prioritize safety.

Discussion

Consistence of Factor Structure

Obtaining a consistent factor structure is somewhat difficult due to the variety of questionnaires, samples and methodologies used by different researchers. Nevertheless, similar factor structures of

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safety climate have been occasionally reported when using multiple measurements in the same organization. This indicates that the factor structure, in one organization, might be consistent over time.

This paper has presented and discussed the data and findings from two safety climate surveys conducted in China in 2004 and 2007, within ABCD. A comparison of the factor structures was made possible through the EFA application. A total of 22 of the 24 original items from the applied safety climate instrument were categorized into the same four factors for both years. Similarities were also identified in the first-order factor structures obtained for both years. Such outcomes supported the consistency of the safety climate factor structures in the construction company in China. Additionally, the 24-item safety climate instrument was effectively and consistently used to measure the four-factor structure of safety climate. The repeated measurements (using the two surveys) revealed that the factor structure in the target Chinese company is consistent over a 3-year period. The statistically significant improvements on the four factors were achieved as a result of a combination of governmental and organizational strategies, which have been thoroughly reviewed in this paper. Safety commitment from top management is identified as the core of safety climate (Zohar 2008). In the surveyed company, top management has not changed over the 3-year time period between the two surveys. Their consistent concerns and emphasis on safety helped to promote the consistent factor structure, and to achieve the improvements of safety climate over the 3 years.

The same second-order factor "safety climate" representing the integrative safety climate in the workplace, was also obtained through these two surveys. This factor validated the definition of safety climate: "it is concerned with the shared perceptions and beliefs that workers hold regarding safety in their work place" (Cooper and Philips 1994). The shared "perceptions and beliefs" in this paper are concerned with safety regulations, supervision, training and workmates' supports, management commitment, and attitude toward safety. As an integrative element, the safety climate can be evaluated as a mediating or moderating variable, while at the same time it examines the influences of safety management practices (Cooper 2000; Hofmann et al. 2003; Naveh et al. 2005; Clarke and Ward 2006; Choudhry et al. 2007) or organizational climate (Neal et al. 2000) on safety performance. Additionally, safety climate can be regarded as an integrated variable during the testing of its predictive effects on personal safety performance (Mohamed 2002; Siu et al. 2004; Huang et al. 2006) or psychological features (Siu et al. 2004; Larsson et al. 2008).

Similarity of Factors

Among the large number of research studies focusing on safety climate, a few review papers were more valuable than others as they summarized the contributions of numerous research studies. Flin et al. (2000), for example, identified six common themes in safety climate, by reviewing 18 published studies and recoding the factors extracted from these studies. The four safety climate factors obtained in our research were deemed comparable to Flin et al.'s six common themes. To illustrate, the first factor identified in this research, i.e., safety regulations, referred to the "Procedures/rules" theme identified by Flin et al. (2000). In their summary, the Procedures/rules theme covered the perceptions of safety rules, attitudes to rules and compliance or violation of procedures, and related to risk-taking behaviors.

The second factor, i.e., safety supervision, safety training and workmates' support, was covered by the very broad "safety system" theme (Flin et al. 2000), which encompassed many different aspects of the organization's safety management system, including safety officials, safety committees, permit to work systems, safety policies, and safety equipment. The third factor, i.e., management commitment, referred to the "management" theme identified by Flin et al. (2000), which was the most common and most essential theme identified in almost every safety climate research, and relates to perceptions of management attitudes and behaviors in relation to safety as well as to production or other competing issues.

The fourth factor, i.e., "safety attitude," was embodied by the "risk" theme identified by Flin et al. (2000). This theme was frequently cited in safety climate research studies but appeared under different conceptual constructs, namely, self-reported risk taking, perceptions of risk/hazards on the worksite and attitudes toward risk and safety.

Stimulators for Safety Climate Improvements

Statistically significant differences were found for each of the four safety climate factors from 2004 to 2007, proving that improvements had actually occurred. The interviews and discussions with ABCD safety management officers explored the stimulators for these improvements. The results showed that the stimulators did improve the integrative safety climate in ABCD, while the causes for the improvements were identified.

It could be concluded, therefore, that in China, the government's policy on safety was the most essential stimulator in the improvement of public awareness on safety climate. In construction companies, for example ABCD, the safety rules and safety training were the two most effective management approaches to improve the safety climate. It was identified that the newly enforced safety regulations and amended safety rules had a direct and positive impact on employees' perceptions of the safety climate factor—safety regulations. Meanwhile, by constituting safety related rules, the managers of the construction company showed their commitment to safety and, thus, indirectly influenced the employees' perceptions on the safety climate factor—management commitment. Furthermore, the improvement of the safety climate factor—safety supervision, safety training and workmates' supports, benefited from the strengthened safety training; also the promotion of the safety climate factor—safety attitude was directly stimulated by the enhanced safety training programs.

This research paper objectively studied the improvements in safety climate (factors), and identified the stimulators for these improvements in the context of the Chinese construction industry. Cultural differences pose serious challenges to any attempt inferring or generalizing the conclusions of a particular research study to a wider context. However, developing countries, in general, share a number of common features related to investment in safety, regulations, training availability, and workers competence. In view of this fact, and given the fact that China is a typical developing country, this paper argues that the identified effective safety management strategies (e.g., issuing more appropriate safety rules and conducting more effective safety training) could be somewhat instructive to other developing countries.

Limitations and Future Works

The consistent factor structure of safety climate in this research was obtained from two surveys (three years apart) in one construction company (ABCD) in China, and should be applicable

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within this company. It cannot be concluded; however, from our results that, the factor structure of safety climate would be replicated across different companies or industries. The consistency of the factor structure, in the construction industry in China, should be verified with more samples collected from various construction companies.

Another limitation of this research is the imprecise measurement of "management commitment." Management commitment is recognized as the most common factor in safety climate research (Flin et al. 2000; Guldenmund 2000). Moreover, safety commitment from management, especially top management, was identified as the core meaning of safety climate (Zohar 2008). The measurement of management commitment in this research was a mixture of different management levels, including the items on project-level management and items on company-level management. This mixed measurement was challenged by the imprecise responses given by front line workers (Guldenmund 2000), on the items referring to management on company level. However, the ambiguous measurements on different levels of management have not been solved yet. The instrument measuring top management's commitment on safety, while an improvement on previous instruments, still requires further development and research.

The third limitation of this research is the less explained variance. Hair et al. (1998) suggested that in natural sciences, factor extraction should be continued until all extracted factors account for at least 90% of the explained variance. Unfortunately, this criterion does not readily apply in the less precise social science, where extracted factors could account for less explained variance (e.g., 50%). Due to the descriptive nature of the factor analysis used in social science, the obtained factors should be treated with cautions in that the unexplained variance should be further studied. For example in this social-scientific research, the result of less explained variance indicates that there are other unidentified factors that could optimize the unexplained variance.

Conclusions

The case study conducted within the Chinese construction company (ABCD), reveals the stability of the first-order factor structure as well as the second-order factor of safety climate. The results using the same safety climate instrument were for two points in time (2004 and 2007), and showed statistically significant improvement in all four safety climate factors. More importantly, the stimulators to these improvements, as reported in the discussion, and safety management practices were shown to have effectively improved the safety climate within a construction company under similar conditions. Indeed, the safety rules and safety training were identified as the most effective management approach to improving safety climate. The safety rules included complying with the newly legislated regulations on work safety for construction projects and on work safety licenses, as well as the issuing of more appropriate safety rules to show the management's commitment to work safety. Increase in the frequency and strength of safety training and safety promotion also play an effective role in improving employees' safety attitudes.

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