Safety Culture in Construction Projects

Dongping Fang\textsuperscript{4} and Haojie Wu\textsuperscript{5}

Tsinghua University, China

Abstract

Safety culture and its impact on safety performance attract increasing attention in both academia and the construction industry. However, the conceptual understanding and measurement of safety culture, as well as the complex environment, management practice and organizational structure in construction project settings have not been roundly addressed. The objective of this paper is to review and summarize the major problems of safety culture in construction from both academic and practical perspective, and to propose recommendations for improvements. The review on the history and development of safety culture finds out that the conceptual understanding of safety culture remains controversy; the relationship between safety culture and organization development was lack of discussions in construction and the methodology for comprehensive measurement and improvement is missing. On the other hand, the knowledge gained from a consulting project reveals practical problems on construction site. Thereafter, a new model of safety culture for construction projects is proposed and the key points of the model are discussed as the recommendations for improvements in safety culture for construction projects.

Keywords

Safety culture, interactive mechanism, construction projects, temporary organization, safety culture model.

INTRODUCTION

Construction is one of the most dangerous industries all over the world. There are several unique characteristics that differentiate the construction industry from others. First of all, the way of operation in terms of construction process, management practice and organization structure is different from general organization management. Nearly all of the products in construction are delivered through the way of project. A new temporary organization, usually called project team, therefore will be built for specific objectives. Subcontracting is another common, so the construction project could be regarded as a multi-organization (Cherns and Bryant, 1984) that mainly consists of owner, contractor and subcontractors where the safety perception and behaviors held by the personnel in those parities may contradict each other. Besides, comparing to manufacturing or nuclear industry, construction has a much more dynamic and inconsistent working environment, and site safety management is rather a challenge for construction projects.

Safety culture is one of the most popular issues in both academic research and management practice to improve the safety performance on a construction site. However, since the above characteristics in construction project settings have not been fully addressed, the understanding of safety culture in construction projects remains lots of controversies.

\textsuperscript{4} fangdp@tsinghua.edu.cn
\textsuperscript{5} wuhj08@mails.tsinghua.edu.cn
The debate about the definition and relationship between construction safety culture and safety climate usually results in the confusion and some kind of misunderstanding of safety culture and safety climate (Mearns and Flin, 1999; Cooper, 2000; Guldenmund, 2000; Cox and Flin, 1998; Zohar and Laura, 2005). Besides, the framework for measuring safety culture remains another source of argument. For instance, the design of safety culture survey varies significantly in terms of questionnaires content, style, statistical analysis, and sample-size, sample composition (managers, supervisors, workers, industry or country) (Zhou et al., 2009), and consequently the factor structure obtained from the survey also vary from 2 (Dedobbeleer and Beland, 1991) to 28 (Lee and Harrison, 2000). Therefore, a shared, validated approach on how to define, assess and measure safety culture remains a lot to be learned and shared in this field (Mengolini and Debarberis, 2007).

As for the construction industry, the problems are more complicated. Hinze (1997) indicated that many of the characteristics discussed above were negative to safety and would challenge safety planning and control. Therefore, safety culture in construction projects may discriminate from the organization safety culture in other industries. Those characteristics should be fully studied and well addressed to reach a convincing path to evaluate and foster safety culture for construction projects.

The major academic and practical issues of safety culture study in construction will be discussed based on the intensive review on the history and development of safety culture, and the implementation of a consulting project. To deal with these problems, a new model of safety culture for construction projects is developed to provide a clear definition and a holistic approach addressing the aforementioned issues to reach a better understanding and framework of safety culture for construction projects.

HISTORY AND DEVELOPMENT OF SAFETY CULTURE

UNDERSTANDING SAFETY CULTURE

The start of the study on safety culture and safety climate was from the one conducted by Zohar (Zohar, 1980). From then on, numerous definitions of safety culture have been arising in the academic literature. The one proposed by Safety of Nuclear Installations Report (ACSNI, 1993) received wide acceptance and citations. The author has reviewed the studies including the concepts of safety culture and safety climate, and provided a definition of safety culture as ‘a set of prevailing indicators, beliefs, and values that the organization owns in safety’ (Fang et al., 2006). As for the safety climate, there is not a common definition either. Zohar (1980) suggested that the sum of the common perceptions regarding safety shared by workers in different companies is the safety climate.

However, the distinction between safety culture and safety climate remains a source of debate and confusion in the safety field (Guldenmund, 2000, Rafiq et al., 2009, Zhou et al., 2011). It is suggested by some researchers that safety climate can be regarded as a subcomponent of the safety culture (Cooper 2000; Neal et al., 2000; Choudhry and Fang 2007), a reflection of actual safety culture (Lee and Harrison, 2000; Flin et al., 2000; Guldenmund, 2000) and an indicator of the overall safety culture of an organization (HSL, 2002). Mohamed (2003) further stated that the safety climate is largely a product of safety culture and the two terms should not be viewed as alternatives. Similarly, since the value of safety could spread through all level of organization, Guldenmund (2007) indicated that safety climate (attitudes) and safety culture are not separate entities but rather different approaches towards the same goal of determining the importance of safety within an organization.
The influence on safety culture accompanied with the development of an organization is another major issue discussed in recent research studies. Basically, organization structure and process are the two key factors related to the emergence and evolvement of safety culture. In Grote’s (2000 and 2008) socio-technical model of safety culture, the proactive integration of safety into organization structures and processes was addressed, which is usually taken into account in the discussions of good safety management and safety culture (Cox and Flin, 1998; Hale, 2000). In a case study on an aircraft maintenance organization, Atak (2011) highlighted the value of a process view on organizational development for the analysis of safety culture, and concluded that safety culture was an outcome of wider organizational development and became problematic in the startup phase in the case of a newly formed company. The negative impact on existing safety culture and the foundations of safety work, which are brought about during change process, were also analyzed (Ek, 2007). Meanwhile, since culture is socially constructed in groups, it is unlikely that these processes will generate the same culture in different parts and on different levels of an organization (Antonsen, 2009).

As for the construction industry, where the project team, as a temporary organization, is usually built for the project objectives, the issue of organization development and the evolvement of safety culture are in need of full consideration. Unfortunately, there were few research studies for construction projects had been undertaken exploring this point of view.

MEASURING SAFETY CULTURE

Since safety climate is usually considered as the reflection and the indicator of actual safety culture, safety culture survey is often used as a predictive tool to examine employees’ perceptions which helps to understand how safety is perceived within the organization (Choudhry et al., 2009). On the other hand, some researchers argued that there is no shared, validated approach on how to define, assess and measure safety culture, and many issues remain to be learned and shared in this field (Mengolini and Debarberis, 2007). Specifically, it is to some extent acknowledged that safety climate questionnaire has been the predominant measurement instrument in safety culture research (HSL, 2002; Guldenmund, 2000). However, it has not been particularly successful in exposing the core of an organizational safety culture in view of the factors found and the relations between these factors (Guldenmund, 2007). Meanwhile, the substantial variation in questionnaire content, style, statistical analysis, sample size, and sample composition (managers, supervisors, workers, industry, or country) is another big problem (Choudhry et al. 2009). Zhou et al. (2009) discussed the techniques of questionnaire simplification and sample percentage identification in factor analysis in detail through an empirical study, which provides a comprehensive framework for measuring safety climate by question survey. One of the critical arguments among researchers for many years is whether or not a common factor structure for safety climate exists. Though Zhou et al. (2011) confirmed the consistencies among the obtained factor structures of safety climate across the two surveys conducted in a Chinese construction company, the safety culture indicators are still hard to replicate (Guldenmund, 2007). Another problem for safety culture survey is the measures of attitudes are often relatively too general so that the prediction of a specific behavior on the basis of more general predictors are always challenged (Ajzen, 1991).

Therefore, Guldenmund (2007) concluded that it might very well be that safety value assessment simply requires different research strategies instead of questionnaire survey only. Unfortunately, except for the improvement on identifying cultural dimensions within the context of organizational processes and structure, there was no specific approach proposed as an alternative of questionnaire. Goh et al. (2010) pointed out that the current causal analysis tools were not designed to analyze dynamic complexity of major
incidents and safety culture. They discussed the use of causal loop diagrams in such tasks and proposed a system thinking tools which can be used to explain the systemic structure sustaining a safety culture and to identify effective interventions for improving safety culture and preventing a recurrence. In order to reduce conceptual ambiguity and discriminate the difference between policy and practice, Zohar (2008) pointed out that safety climate should be evaluated at the organization-level and workgroup-levels as distinct constructs with separate measurement scales. Flin (2007) conducted a safety climate survey to evaluate workforce perceptions and attitudes towards both worker and patient safety in healthcare organizations by dividing safety climate into two groups that were organization and department/team safety climate.

Obviously, the measurement framework and measurement tools are the two key points for safety culture evaluation, which should be built upon the theoretical discussion of safety culture for construction projects. Meanwhile, safety culture evaluation and safety culture improvement design should also be integrated with each other to enhance and maximize the effect.

CASE STUDIES ON SAFETY CULTURE IN DIFFERENT FIELDS

In this section, several case studies on safety culture conducted in different fields other than construction since 2007 are reviewed, including aircraft maintenance company, air traffic control, oil and gas companies, healthcare organizations, research and development organizations, fishing vessels, nuclear power plant, offshore platforms, air navigation service provider, railway industry etc (Atak and Kingma, 2011, Ek et al., 2007, Flin, 2007, Havold, 2009, Mariscal et al., 2012, Navestad, 2010). Some interesting results and conclusions that can be referred in construction safety culture studies are as follows.

Discussions about the theoretical foundation of safety culture were made in some papers. Atak and Kingma (2011) focused on the working mechanism of safety culture as the outcome of wider organizational processes in which the startup phase of the newly formed organization was found causing the problems in safety culture. In an assessment of safety culture at one administrative and two operative units in a Swedish air traffic control setting, it was found that the two operative units generally had somewhat higher average scores for safety culture aspects than the administrative unit (Ek et al. 2007), indicating the misalignment on safety culture among different levels of organizations. Similar phenomenon was also found in construction in which the administrative unit contrarily has a better record (Fang and Wu, submitted to Safety Science, 2012). Such a misalignment indicates the reason why a holistic approach to evaluate safety culture is needed. Flin (2007) proposed a model of safety climate and injury outcome to illustrate the explanatory mechanism between safety climate and both patient and health care worker injuries but failed to examine the components in the model. However, he attempted to address the issue of changing behaviors in the research studies of safety culture and safety climate, which would be elaborated in the latter part of this paper.

Besides, a few key points for a better safety culture improvement design were also come up with. Atak and Kingma (2011) indentified the weak structural position of quality assurance and conflicting interests between safety and production as the two major causes so that a sound internal safety system with a structurally strong position for safety and top-management commitment were suggested. Havold (2009) found that the safety attitude of management had a strong influence on a company’s safety policy via safety climate survey among fishermen on fishing vessels. Mariscal et al. (2012) concluded that the safety climate questionnaire could help obtain evidence to identify the strong points in safety culture attributes and also the areas for improvement. They addressed the use of working groups to improve safety culture by providing opportunities for people to talk about the relevant behaviors and generate more feedback and effective
communications. Navestad (2010) confirmed the role of specifically tailored safety culture campaign in successful culture changes and emphasized the bottom-up approach focusing on work groups and sub-cultures. With regard to the human factors, Wu et al. (2010) confirmed the roles and behaviors of employers, operating managers, and safety professionals in relations to safety culture, and therefore recommended that organizations should develop the training programs to help managers at all levels to understand their safety roles and learn to be safety leaders to improve safety culture effectively. By evaluating the mechanisms behind the patterns of interventions between successful and not successful projects, Hale et al. (2010) verified the distinguishing function of constructive dialogue between shop-floor and line management in conjunction with the energy and creativity injected by top managers and, above all, by the coordinator (safety professional), which could provide motivations to line managers and strengthen the monitoring and learning loops.

SAFETY CULTURE IN CONSTRUCTION

Kulchartchai and Hadikusumo (2010) concluded that the problems related to workers were the main concern of most management levels in charge of developing a safety culture by use of a grounded theory approach. Unskilled workers, unsafe worker habits, and high worker turnover were the three most frequent specific problems. In contrast, the results of structural equation model identified the company’s safety commitment, the safety incentives, the subcontractor involvement, the field safety accountability and dedication and the disincentives for unsafe behaviors as five latent variables that describe corporate safety culture and may be used as indicators of safety performance (Molenaar et al. 2010). Pungvongsanuraks and Chinda (2010) proposed and implemented a method of investigating the key enablers for safety culture improvement among the 2 working levels (management and workers). They studied the safety culture divergences and alignments between the two levels as the baseline for enhancement design. Due to the lack of uniform theoretical framework for safety culture and its evaluation, both the methodology and the dimensions drawn from the above research studies varied significantly.

Besides, the relationship between safety climate and safety performance in construction was also discussed. Choudhry et al. (2009) confirmed that two climate factors, “management commitment and employee involvement” and “inappropriate safety procedure and work practices” were significant predictors of workers’ perceptions of safety performance so that safety climate can be used as an effective measure of assessing and improving site safety for projects under construction. In the following research, Zhou et al. (2011) confirmed the consistent factor structure of safety climate across two surveys in a Chinese construction company over three years, and identified the effective approaches to improve safety performance based on the statistical improvements on the certain factors.

KNOWLEDGE GAINED FROM A CONSULTING PROJECT

BACKGROUND AND IMPLEMENTATION

A consulting project was undertaken focusing on the safety culture on two construction sites in Singapore. The purpose of this project is to promote the project safety culture and achieve a higher safety standard in client’s projects through safety culture survey and Behavior-Based Safety (BBS) implementation. In addition, the project also helps to examine the existing approaches for safety culture evaluation and improvement, and to figure out the weaknesses or problems of the approaches on construction sites.
The safety culture survey was conducted at the owner level and the project level simultaneously to evaluate and compare the owner's Organizational Safety Culture and the Project Safety Culture. A nine-week BBS scheme on the same two construction projects was implemented subsequently. The workflow of the project is shown in Figure 1.

![Figure 1. Workflow for the Singapore Case](image)

**RESULTS AND DISCUSSIONS**

The owner’s organizational safety culture and the project safety culture for two projects were evaluated by 6 elements based on the results of face-to-face interview and questionnaire survey. In general, the overall score of owner’s safety culture was 93 while the average score for the two projects safety culture was 71. The comparison between the owner’s safety culture and project safety culture was made for each element to find out the alignment and the misalignment between the two. As for the BBS part, the overall scores of the two sites increased from 64.12 percent and 63.96 percent to 86.25 percent and 92.55 percent respectively due to the intervention. The results of two-week follow up observation without intervention were 87.24 percent and 91.95 percent, which, to some extent, validated the sustaining effect of the adopted BBS scheme.

The method of safety culture survey adopted in this case provides an effective way to measure the safety culture at different levels so that the weaknesses within the organization could be identified. The modified BBS scheme has also been proved to be a useful tool for behavior improvement and fostering the safety culture from behavioral perspective on construction sites. Meanwhile, some problems about safety culture evaluation and improvement on construction sites needs to be highlighted.

Firstly, there was a misalignment between owner’s safety culture and project safety culture, which was mainly caused by the weak safety culture of subcontractors. This issue is closely related the management practice of construction projects and the organization structure of project team, but usually not addressed in general safety culture.
evaluation. Therefore, the safety culture survey is suggested to conduct among major players of the project (owner, contractor and subcontractors) so that their specific contributions to safety culture and the interactive relationship between them could be explored.

Secondly, 53 interviews conducted on the two sites revealed that information comprehension problems and improper work arrangement were the first two major specific causations for employees’ unsafe behaviors, which verified the role of management played in generating unsafe behaviors on site. Another obstacle for safety culture improvement on construction sites is lack of the analysis and intervention to management behaviors, which actually have a great impact on workers’ behaviors in construction projects.

Therefore, a more suitable methodology for safety culture evaluation and improvement requires the characteristics of construction projects and the problems identified from the consulting project being well addressed in terms of research plan and program design. The characteristics of construction projects and the recommendations for improvement in light of the academic and practical concerns will be discussed in the following section.

A NEW MODEL OF SAFETY CULTURE FOR CONSTRUCTION PROJECTS

Based on the discussion about the characteristics of construction projects and the reviews on previous definitions and models of safety culture, the definition of safety culture was proposed for construction projects as a mixture of attitudes, beliefs, values, behaviors and norms held by the individuals and groups from different parties in a construction project (for both workers and management) team, and it is gradually formed and evolved in the construction project environment that would influence the commitment to, and the style and proficiency of how all parties involved in the project and its personnel act and react in terms of the ongoing safety performance (Fang and Wu, submitted to Safety Science, 2012).

A new model of safety culture for construction projects is proposed in Figure 2 (Fang and Wu, submitted to Safety Science, 2012). The model provides a holistic framework and a multi-methodology approach for better understanding, evaluation and improvement design of safety culture for construction projects. Several key points of the model are emphasized below.

1. Germinating in the earth of the national culture and societal culture, safety culture for construction is formed and evolved in construction project settings, as a mixture and outcome of interaction between organization safety cultures of owner, contractor and subcontractors on a construction site.

2. There are three constructs representing the subjective internal psychological factors, observable ongoing safety-related behaviors and objective environmental features respectively. A two-layer structure (workforce and management) among the three constructs is suggested to address the construction process and site management.

3. A multi-methodology approach for evaluating the three constructs, which is a combination of qualitative and quantitative methods and includes multi-level evaluation, offers an opportunity for a better depiction of safety culture for construction projects.
In addition, the model needs to be further developed and improved from the following aspects: 1) Developing appropriate measurement tools for workgroup and management in the environment construct of safety culture; 2) Developing the checklist for management unsafe behaviors and the intervention methods for management behaviors from organizational perspective; 3) Validating the reliability and validity of the measurement tools to improve the multi-methodology approach.

CONCLUSION

This paper reviews the literature about the history and development of safety culture in terms of conceptual understanding, measurement methodology and the specific case studies of safety culture in construction and other fields. Together with the authors’ experience on a consulting project conducted in Singapore, the major problems of safety culture in construction from both academic and practical perspective are discussed. A new model of safety culture for construction projects is proposed to address the characteristics of construction projects and provide a holistic framework for understanding, evaluating and improving safety culture on construction sites.

Based on the proposed model, the future study on safety culture in construction should include: 1) Exploring the interactive mechanism among the major players of construction projects during the evolvement of safety culture by longitudinal study or other time series analysis; 2) Investigating and evaluating the management behaviors under behavior construct, and examining the connections of influence between management and workforce in order to enhance the safety culture improvement design with regard to behavioural issues.

ACKNOWLEDGEMENTS

Support from Land Transport Authority of Singapore and the Natural Science Foundation of China (Grant No. 71172013 and 50978155) are gratefully acknowledged.
REFERENCES


