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REVIEW AND ADOPT A TOOL FOR MEASURING SAFETY CLIMATE IN INTERNATIONAL CONSTRUCTION PROJECTS

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The construction industry is deemed to be one of the most dangerous industries worldwide due to its special characteristics of production process. Globalization has brought about an increasing number of construction companies involving themselves in the international construction market. Due to involvement of participants from different countries and regions, international construction projects possess complexities from national, organizational and individual perspectives which may affect construction safety management adversely and lead to unsatisfactory safety performance. Safety climate, defined as "a unified set of cognitions regarding the safety aspects of the organization", is often considered to be a predictor of safety behavior and performance. After conducting a comprehensive review of existing literature related to safety climate measurement in construction sector, this study highlights several conditions for selecting suitable safety climate instruments specific in international construction projects.

Keywords: Safety culture, Review, Filter conditions, Industry perspectives.

1 INTRODUCTION

Safety climate, as originally defined by Zohar, is "a unified set of cognitions regarding the safety aspects of the organization" based on the experience of social relationships and the organizational environment, which "reflects employees' shared perceptions about the relative importance of safe conduct in their occupational behavior" (Zohar, 1980). Safety climate is often considered a predictor of safety behavior. Several researchers regard safety climate as a snapshot of the features of the underlying safety culture, which could forewarn of problems with safety that might be detected before safety risks activate (Choudhry *et al.* 2007, Flin *et al.* 2000, O'Connor *et al.* 2011).

Globalization has brought about an increasing number of construction companies involving themselves in the international construction market. Due to involvement of participants from different countries and regions, international construction projects possess complexities from national, organizational and individual perspectives which may affect construction safety management adversely and lead to unsatisfactory safety performance. The complicated characteristics of construction sector give safety climate complex contents and pose challenges to safety climate measurement, particularly in an international context. By conducting a comprehensive review of existing literature related to safety climate measurement in construction sector and the characteristics of

international construction, this study aims to find out several conditions for developing and selecting questionnaires to measure safety climate in international projects.

2 SAFETY CLIMATE RESEARCH

Since the term of safety climate was defined (Zohar 1980), it has rapidly become a popular research topic, and many related studies have subsequently been conducted across different industries, including the energy, manufacturing, and construction industries (Choudhry *et al.* 2009, Fang *et al.* 2006) in various countries worldwide (Zohar 2000, Zohar and Luria 2005). Researchers have conducted a substantial number of studies on the topic of safety climate measurement by using mainly the form of self-explained questionnaires (Lingard, Cooke, and Blismas 2011, Lingard, Wakefield, and Cashin 2011, Zohar 1980). As a quantitative method, the questionnaire tends to be more cogent than qualitative methods in studying safety climate (Guldenmund 2000). However, without reliable and valid information, organizations find it impossible to take proper actions to improve the safety climate (O'Connor *et al.* 2011); thus, the use of valid questionnaires is of utmost importance in measuring safety climate.

2.1 Safety Climate Structures

Among studies on safety climate, many scholars have conducted factor analysis to identify its distinct structures and dimensions. This research has reviewed several studies on safety climate measurement in the construction industry from 1991 to 2014, with safety climate dimensions varying from two (Dedobbeleer and Béland 1991) to fifteen (Fang *et al.* 2006). The differences in factor structures can be attributed to the different characteristics of the research objectives, such as diverse national cultures and industry types, by some authors (Dedobbeleer and Béland 1991). However, other authors have also raised several methodological issues that could also explain these differences to some extent, including data appropriateness of factor analysis or principal components analysis, rotation types, bipolar and unipolar dimensions, and level of aggregation (Guldenmund 2000). Cooper and Phillips (2004) attributed these differences to survey-question expressions, generation of questions, sample differences, and means of labeling the factors.

2.2 Multi-Level Safety Climate

Safety climate data are often aggregated to provide information for multi-level units (Cooper and Phillips 2004). In recent years, this multilevel nature of safety climate has received public recognition among many academic researchers. Zohar himself developed his original definition of safety climate in a longitudinal manner twenty years later than the first definition by adding a group-level safety climate to the previous organization-level one (Zohar 2000). Glendon and Litherland (2001) pinpointed differences in safety climate factors of two different job groups of construction and maintenance within one Australian road construction organization. Høivik *et al.* (2009) examined the relative influence of local working environment and company belonging on safety climate by conducting a survey in two groups of operating companies and contractors. The perceptions of co-workers' responses have also been considered in group-level safety climate constructs. Meliá *et al.* (2008) analyzed safety climate from

the standpoint of four safety agents including organization, supervisors, co-workers, and workers in both construction and general industries. A multilevel safety climate model with a structure similar to that in Meliá's study was examined in the Australian construction industry (Lingard *et al.* 2010).

3 METHODOLOGY

A systematic literature review was conducted to study safety climate tools in construction industry. To be specific, the research work was undertaken in two steps. In Step 1, the database "Scopus" was used for a comprehensive search in the field of "article title/ abstract/ keywords". A total of 127 publications were identified, including some unwanted ones, which could meet the search terms but did not actually relate to the safety climate tool in construction industry. After that, all these identified publications were sorted by "relevance" and the abstracts of the studies were reviewed briefly. To avoid missing any important papers, they were sorted by "cited by" and double-checked. From this 127 publications, 36 studies were selected as suitable samples, all of which could meet the following requirements: i) using the quantitative tools to measure safety climate in construction sector; ii) providing relatively detailed features of the tools for analysis; iii) being published in English. Unlike most of other existing reviews of safety climate tools (Flin *et al.* 2000. 2006, Colla *et al.* 2005, O'Connor *et al.* 2011b), this study did not elaborate factor structures of identified safety climate tools in this step, to avoid iffy direct comparisons of factor structures due to methodological variances and expressive differences (Flin *et al.* 2000). In Step 2, according to prototypes that the tools of current studies were developed from, several frequently-used standardized batteries of safety climate tools were confirmed and categorized. Histories, fundamental features, structure factors (dimensions) and other information were investigated and used to select the most proper tool.

4 DISCUSSION

The 36 identified studies reflect general features of the research conducted in the field of safety climate measurement in construction industry. According to statistics of identified studies by published year, it is found that these kinds of studies were of rarity before 2000, although by then 20 years had passed since the definition was presented (Zohar 1980) and nearly 10 years since it was applied in construction industry (Dedobbeleer and Beland 1991). It is not surprisingly to find that the USA conducted most researches of the learned topic, followed by Australia, Hong Kong, Nordic countries and other Asian countries. Questionnaires in diversified languages were used. In addition, nearly 80% of the identified studies had validated the questionnaires they used, whether by pilot tested, statistically tested or previously tested by other studies.

Due to the lack of a uniform theory, inductive methodologies are mainly used in the field of safety climate, resulting in diversified research outcomes of safety climate factor structures (Guldenmund 2000; Flin *et al.* 2000). A substantial number of safety climate tools measuring a set of multidimensional factors identified by literature review of related research in this particular industry are designed (Lingard *et al.* 2011a. 2011b). Besides literature review, exploratory interviews with practitioners (managers, supervisors and workers) are also conducted to reveal potential safety climate

dimensions at workplace and to adjust the tools (Mohamed 2002). By reviewing 36 identified studies, several frequently-used standardized batteries were summarized and tabulated in Table 1, including Zohar's Safety Climate Questionnaire (Zohar 1980), Safety Climate Measure for Construction Sites (Dedobbeleer and Beland 1991), Zohar's Group Safety Climate Scale (Zohar 2000), HSE Climate Survey Tool, Battery Valencia PREVACC, NIOSH Safety Climate Scale and Nordic Safety Climate Questionnaire (NOSACQ-50) (Kines *et al.* 2011).

Table 1. Typical tools for safety climate measurement in construction sector.

Item	Name	Number of questions	Industry originally designed for	Types of employees applied to
1	Zohar's Safety Climate Questionnaire (Zohar, 1980)	40	Metal fabrication Food processing Chemical industry Textile industry	Workers
2	Safety Climate Measure for Construction Sites (Dedobbeleer and Beland, 1991)	9	Construction industry	Workers
3	Zohar's Group Safety Climate Scale (Zohar, 2000)	10	Manufacturing industry	Workers
4	HSE Climate Survey Tool	71	Designed to be generic and used in any industry	Managers Supervisors Workers
5	NIOSH Safety Climate Scale	6	Health care industry	Workers
6	Battery Valencia PREVACC (Meliá et al., 2008)	33	General industry Construction industry	Managers Supervisors Workers
7	Nordic Safety Climate Questionnaire (Kines et al., 2011)	50	Construction industry Food industry	Workers

Among seven mentioned standardized batteries, Zohar's Safety Climate Questionnaire is the earliest one to measure safety climate, and has been reused and validated in many later studies (Zohar 1980). Zohar extended his original definition of safety climate in a longitudinal manner twenty years by adding a group-level safety climate to the previous organization-level one and developed a questionnaire to measure group-level safety climate (Zohar 2000). Dedobbeleer and Beland (1991) developed a short safety climate tool specific for construction industry, which includes 9 questions from two factor dimensions only. The HSE Climate Survey Tool may be the most renowned one among the seven selected safety climate tools due to its high adaptability to organizations of all sizes and employees of all levels. The NIOSH Safety Climate Scale is a 6-item safety climate questionnaire developed by American National Institute for Occupational Safety and Health. The Nordic safety climate questionnaire (NOSACQ-50) was designed to measure multi-level safety climate and be used across industries and countries, and was tested to be valid for construction industry at the very beginning. Battery Valencia PREVACC is a sophisticated safety climate questionnaire that could measure multi-level safety climate and has been applied in construction industry in previous research. This questionnaire considers safety

responses from four main safety agents -- which are organization, supervisor, co-worker, and worker.

To adopt a suitable tool to measure safety climate in international construction projects, several conditions should be considered. Firstly, the multi-level safety climate questionnaires are more proper in an international context. For international projects, the participants usually come from different countries, and share various cultures and customs. These will exert an influence to the formation of safety climate. To diagnose safety problems by measuring safety climate should understand which level the problems derive from. Secondly, survey language is important. Questionnaires usually need different language versions because the workers use different mother languages. Moreover, front-line workers in international projects are usually poor educated, they could not understand a unified language sometimes, and there is a need to translate the questionnaires into local languages, and the consistency and reliability of tools need to be validated as well. According to the review, HSE Climate Survey Tool, Nordic Safety Climate Questionnaire and Battery Valencia PREVACC have relatively extensive use in different countries in different languages, which is an advantage to measure safety climate in an international context. Thirdly, the length of the questionnaires should be considered. HSE Climate Survey Tool, Nordic Safety Climate Questionnaire and Zohar's Safety Climate Questionnaire have relatively numerous items, as well as complex and stable factor structures that derived from organizational theory, safety climate theory and psychological theory. However, this may sometimes become a burden of the research. To use a long and complicated questionnaire increases the possibility of non-random measurement error in collecting safety climate data (O'Connor *et al.* 2011a).

5 CONCLUSIONS

This study has conducted a comprehensive (if not exhaustive) literature review of safety climate tools in construction industry. General features of the studies in this field are found via basic descriptive statistics analysis. Seven typical standardized batteries were brought forth and described. It is difficult to make conclusion that a particular tool is definitely better than others, because they have been applied in diverse situations are distinguished such as different countries, industries and survey participants. This study indicates several filter conditions to choose proper safety climate tools specific to an international context.

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