IN-DEPTH INVESTIGATION OF SAFETY MANAGEMENT SYSTEM IN HONG KONG CONSTRUCTION INDUSTRY – LITERATURE REVIEW AND RESEARCH AGENDA

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Abstract - The construction industry is one of the major contributors to industrial fatalities. The safety management system has been introduced in 1980s to proactively tackle risks in construction work activities, so as to promote healthy and safe working environment to all employees on construction sites. However, there has been so far no comprehensive review on the effectiveness of the implementation, except the accident rate. Against this background, the reliability, efficiency and effectiveness of the safety management system need to be evaluated and investigated. This study would carry out an in-depth investigation into the safety management system for the Hong Kong construction industry. The research results would generate some valuable insights into the development of corresponding effective strategies for enhancing the prevailing safety management system and facilitate a zero harm working environment in Hong Kong construction industry.

Keywords - Safety management system, safety performance, safety characteristics, construction industry

I. INTRODUCTION

Construction industry is one of the industries with the highest accident rates over the world because of its high risk and fast changing work nature. In Hong Kong, the Government of Hong Kong SAR introduced the Factories and Industrial Undertakings (Safety Management) Regulation on 24 November 1999 to empower the mandatory implementation of a SMS in certain industrial undertakings, including construction sector. There was lack ofcomprehensive review on the effectiveness of SMS (Robson et al. 2007). This research study aimed to examine the implemented SMS, and to identify any areas requiring improvements so as to achieve a safer and even zero harm working environment in Hong Kong construction industry. In order to achieve the research aims, the specific objectives of this study are (1) to identify the key characteristics of construction project with outstanding safety performance; (2) to evaluate the current application of the safety management system in the Hong Kong construction industry; and (3) to examine the relationship between safety management system and safety performance of construction works. The research findings were expected as useful references for recommending strategies to improve site safety performance in Hong Kong and further development of SMS in Hong Kong and other countries.

II. BACKGROUND OF RESEARCH

2.1. Safety Performance in Construction Industry

There are a few well-recognized key performance indicators that represent the safety performance in construction industry. Accident rates are considered as a common key performance indicator. Accordingly to the accident rates in construction industry from 2000 to 2015 in Hong Kong (Figure 1), the industrial accident rate per 1,000 workers decreased significantly from 2000 to 2012. Accident rates do not have much improvement in recently years.

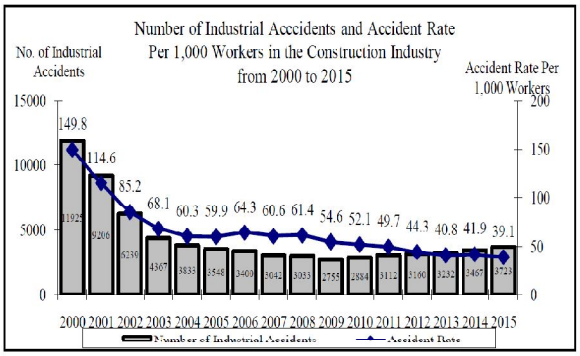

Figure 1. Number of industrial accidents and accident rate per 1,000 workers in the Hong Kong construction industry from 2000 to 2015 (Labour Department, 2016).

2.2. Introduction of Safety Management System (SMS)

Health and Safety Executive of UK (2016) defined SMS as system or framework can help you manage health and safety. Safety Management System (SMS) was introduced to the construction industry in 1980s which aimed at reducing the number of injury cases, eliminating harmful conditions to workers and preventing material damage at work. In Hong Kong, Labour Department (2002) defined 'safety management'' as ''the management functions connected with the carrying on of an industrial undertaking that relate to the safety of personnel in the undertaking, including - (a) the planning, developing, organizing and implementing of a safety policy; and (b) the measuring, auditing or reviewing of the performance of those functions'' while SMS means a system that provide the safety management

function in an industrial undertaking. Construction site is a typical example of an industrial undertaking in Hong Kong. Examples of reference standards include BS OHSAS 18001:2007 Occupational health and safety management systems, BS EN ISO 9001:2008 Quality management system, in-house standards, procedures and codes.

2.3. Enforcement of SMS in Hong Kong Construction Industry

For countries with mandatory requirements of development, implementation and maintenance of SMS, framework and guideline of the execution of SMS were usually offered. Examples include Hong Kong, Singapore, United Kingdom and Australia. In Hong Kong, the Hong Kong SAR Governmentenacted the Factories and Industrial Undertakings (Safety Management) Regulation and published the Code of Practice on Safety Management SystemCoP(SM)in 1999 and 2002 respectively. In Hong Kong, the introduced SMS consisted of 14 key elements, quoted from the Labour Department (2002), are as follows:-

1. A safety policy which stated the commitment of the contractor to safety and health at work.
2. Safety organisation structure which assured the implementation of the commitment to safety and health at work.
3. Safety and health training programme that equipped personnel with knowledge to work safely and without risk to health.
4. In-house safety and health rules that provided instruction for achieving safety management objectives.
5. Safety inspection programme that identified hazardous conditions and for the modification of any such conditions at regular intervals or as appropriate.
6. Hazard control programme, usually named use of personal protective equipment in practice, which identified hazardous exposure or the risk of such exposure to the workers and to provide suitable personal protective equipment as a last resort where engineering control methods are not feasible.
7. Incident investigation programme which found out the cause of any accident or incident and to develop prompt arrangements to prevent recurrence.
8. Emergency preparedness which was developed, communicated and executed plans suggesting the operative management of emergency situations.
9. Evaluation, selection and control of sub-contractors arrangement which ensured that subcontractors are aware of their safety responsibilities and are actually meeting them.
10. Safety committees which identified, recommended and kept under review measures to improve the safety and health at work.
11. Evaluation of job related hazards or potential hazards and development of safety procedures.
12. Safety and health awareness programme which promoted, developed and maintained safety and health awareness in a workplace.
13. Accident control and hazard elimination programme which involved process controls to eliminate hazards before exposing workers to any adverse work environment.
14. Occupational health assurance programme which protected workers from occupational health hazards.

With reference to the Table 1, contractors are required to implement the first ten or eight elements of SMS accordingly to the workforce and number of construction sites. For the last 4 elements, Labour Department suggests that contractors can decide the appropriate time to force these elements into operation after implementation of SMS for a year. Therefore, a contractor which operates construction sites at different locations is legally required to develop, implement and maintain a SMS both at the corporate level and at the project level as shown as duty holders on Table 1.

Duty holder	Aggregate number of workers working			
	Category 1	Category 2	Category 3	Category 4
Contractor of construction work	≧100 in a day in a single construction site ; or contract value ≧ $100 million	≧50 but < 100 in a day in a single construction site	≧100 in a day in 2 or more construction sites	≧50 but < 100 in a day in 2 or more construction sites
Duties in respect of safety management system	Implement the first 10 elements in the safety management system	Implement the first 8 elements in the safety management system	Implement first 10 elements in the safety management system	Implement the first 8 elements in the safety management system
	Conduct of safety audit	Conduct of safety review	Conduct of safety audit	Conduct of safety review

Table 1. Mandatory Enforcement of SMS in Hong Kong

2.3. Construction Project with Outstanding Safety Performance

There were totally 18 characteristics found the literatures which could be used for distinguishing safety performance for construction industry (Table 2). Senior management's commitment and support was most frequent found on construction sites with outstanding safety performance (Yang & David, 2013; Tam, Zeng, & Deng, 2004; Zubaidah, et al, 2012). Commitment and support could also be demonstrated by a clearly defined safety organization with specified job responsibilities and proper allocation of competent manpower and project resources (Yang & David, 2013; Tam, Zeng, & Deng, 2004; Zubaidah, et al, 2012; Matthijs et al., 2014).

Key characteristics to distinguish safety performance in Hong Kong Construction Industry		References
1	More support and commitment from senior management	Yang & David, 2013; Tam, Zeng, & Deng, 2004; Zubaidah, et al, 2012
2	Better logistic arrangement of site materials	Tam, Zeng, & Deng, 2004; Matthijs et al., 2014
3	Clear understanding of construction work activities	Matthijs, Eric, Coen, & Ben, 2014
4	Lower accident rates	Beatriz et al., 2009
5	Good planning of project execution	Beatriz et al., 2009
6	Clear site activities / working sequences	Tam, Zeng, & Deng, 2004
7	Strong financial performance	Beatriz et al., 2009
8	Well-functioned communication system	Beatriz et al., 2009
9	Higher education level of workers	Tam, Zeng, & Deng, 2004
10	Strict operational procedures	Beatriz et al., 2009
11	Higher teamwork spirits	Tam, Zeng, & Deng, 2004
12	Clear safety organization with defined responsibilities and accountabilities	Tam, Zeng, & Deng, 2004; Zubaidah, et al, 2012; Matthijs et al., 2014
13	Incentives offered for employees' participation	Beatriz et al., 2009; Zubaidah, et al, 2012
14	Rigorous enforcement of safety regulations	Tam, Zeng, & Deng, 2004; Zubaidah, et al, 2012
15	Availability of site safety manual	Tam, Zeng, & Deng, 2004
16	Innovative technology	Tam, Zeng, & Deng, 2004
17	Project manager with higher safety awareness	Tam, Zeng, & Deng, 2004
18	Active participation in OSH activities by employees	Beatriz et al., 2009

Table 2. Key characteristics to distinguish safety performance in Hong Kong construction industry

III. RESEARCHMETHODOLOGY

3.1 Literature Review

A comprehensive desktop review will be conducted from related literature, such as journal articles, textbooks, conference papers, research monographs, dissertation reports and online materials, to provide an abundant background about construction safety management in terms of the statutory requirements and actual experience in general, and the critical elements in the implementation of safety management system in particular across different countries, e.g. United Kingdom, United States, Australia, Japan and Hong Kong. It will enable the overall conceptual framework for the research study and preparation work of the questionnaire survey and interview.

3.2 Interview

A structured interview, as a qualitative method, was selected for this study because it allows pre-designed questions on a careful selected topic. Interview questions should be designed with thorough though so as to avoid misleading cases. In this study, interviews were conducted with the following three pre-designed open-end questions to obtain the opinions from the participants with sound experience in implementation and maintenance of safety management in Hong Kong.

3.3 Delphi Survey

The Delphi method was conducted to validate the interview findings. It is a method that structures a group of experts, as a group decision-making process, to deal with a complex problem in an effective group communication process. Experts are asked to show the relative importance of the critical success factors which are found in the literature review and interviews. The panel of experts answers questionnaires in two or more rounds. It facilitates more thoughtful and unbiased results as a whole and also allows individuals to think independently, give feedback, and change their opinions after considering others' opinions (Linstone and Turoff, 1975; Okoli and Pawlowski, 2004). General practitioners in the construction industry may not easily identify and prioritize these specific factors. Therefore, this Delphi study involves valuable insights from the group of experienced safety practitioners from clients, main contractors and consultants in Hong Kong construction industry.

3.4 Questionnaire Survey

Questionnaire survey was used to collect large volume of quantitative data which enable generalization of the findings. In order to control the quality of the data, briefings were provided to those companies or organisations that were willing to participate the questionnaire survey. (Neuman, 2004; Hox et al., 2008). A sampling frame was set to enlist key stakeholders that with experience in executing or supervising construction safety management in Hong Kong construction industry to participate in this study: client organization, main contractor, safety consultant, trade subcontractor, supplier/ manufacturer, government and statutory body.

The questionnaire was divided into three parts –(1) questions relating personal attributes, background information and performance indicators of selected project; (2) questions relating the compliance level of implementation; and (3) questions relating the compliance level of the characteristics of the construction project. The questions in both Part B and Part C were set based on the findings of the literature review and Delphi survey. These questions were evaluated by the respondents in a five-point Likert scale, with 100% being fully complied at all times and 0% being not complied at all. A pilot questionnaire was reviewed by an expert panel beforedissemination. The participated expert panel was to provide advice and industrial support to ensure the design and objectives of this research meeting the needs and concerns of theindustry.

3.5 Data Analysis and Structural Equation Modelling

Data collected from Delphi survey and quantitative survey were analyzed with theuse of Microsoft Excel 2010 and software Statistical Product and Service Solutions (SPSS) 24.0for general statistical analysis which leading to the achievement of project objectives.

Structural equation modeling (SEM) was also employed to establish the relationship the site safety performance and the compliance levels of SMS in construction projects.SEM allows more flexible assumptions than multiple regression, and itis a statistical technique based on general linear model that examines a set of relations between one or more independent variables (IVs) and oneor more dependent variables (DVs). IVs and DVs can either be measured variables(directly observed), or latent variables (unobserved) (Ullman, 2006). Crowley and Fan (1997) suggested the samples size should be at least 200 and each estimated parameter should have 5 to 10 participants to support for SEM. SEM offers unique features over other multivariate techniques. By specifying model of SEM, SEMcould scrutinize a series of separate, but interdependent and multiple regressionequations at the same time. Comparing with other multivariate techniques, most of them are less appropriate as data analysis technique in this study because of their descriptive and exploratory nature(Crowley and Fan, 1997).

CONCLUSIONS

This study introduced the research framework and background literatures of an in-depth investigation of implementation and maintenance of SMSin Hong Kong Construction Industry. Triangulation methods, including interview, Delphi survey and questionnaire survey, would be adapted in this study in order to have comprehensive investigation of implemented SMS. All results would also be cross-reference with each other as well as the published literaturesto ensure the credibility of this research findings in this study. The results would be particular important for recommending strategies for improving the development, implementation and maintenance of SMS and hence to improve site safety performance and reduce work accidents in construction projects locally and internationally.

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