A RESEARCH FRAMEWORK FOR DEVELOPING A "PAY FOR SAFETY SCHEME FOR SUBCONTRACTORS (P_fSS_fS)" FOR BETTER SAFETY PERFORMANCE

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ABSTRACT

The construction safety record in Hong Kong has been improving in recent years, due to a number of initiatives introduced such as Pay for Safety Scheme initiated by the government and the enhanced safety awareness of the industry practitioners. It is however found that the accident rate of the construction industry is still significantly higher than those of other industries and we are still far from claiming that the safety performance of construction industry is satisfactory. Perhaps, extension of Pay for Safety Scheme to subcontractor level would be a solution to further reduce the number of accidents in construction sector in Hong Kong. The aim of the proposed study is to scrutinize whether and how a "Pay for Safety Scheme for Subcontractors (P_fSS_fS)" could lead to better safety performance. To achieve this, the study will investigate the causal relationship between safety performance and profit on construction projects, and recommend a practical way for determining the optimum incentive level and type of P_fSS_fS for different projects. The research results would generate some valuable insights into the future development of PFSS, and facilitate the implementation of PFSS for subcontractors in near future. It is also expected to allow decision makers to have a clearer insight in determining the optimal budget of contract sum allocated for the payable safety items in tender pricing by both main contractor and subcontractor organizations at an early stage of project development, and to investigate how the site accidents can be mitigated via PFSS.

KEYWORDS

Safety Performance, Pay for Safety Scheme, Subcontractors, Research Framework

INTRODUCTION

According to the occupational safety and health statistics of 2008 (Labour Department, 2009), over 20% of the industrial accidents were related to the construction industry. The safety record of the construction industry was poor and much worse than other industries in Hong Kong (Wong et al., 2004). The reasons of the poor safety record may correlate with many factors such as complexity of work or system, risk nature of works, management style, safety knowledge and commitment, and personal behaviour (Stranks, 1994). Multi-layer subcontracting is unique to the Hong Kong construction industry and has been the most common practice being used with long history (Wong et al., 2004).

Earlier study indicates that subcontractors and their workers have a weaker safety awareness culture than their main contractor counterparts. Since subcontracting represents over 80% of project cost for most construction projects in Hong Kong, better motivation of subcontractors is believed to be instrumental in making for further construction safety improvement. Some kind of financial incentive such as "Pay for Safety Scheme (PFSS)", which has been successfully introduced to the main contractors in the mid 90s, should be down-streamed to also cover the subcontractors to further improve safety performance. Therefore, it would be valuable to develop a practical approach for implementing the pay for safety scheme for subcontractors.

SAFETY PERFORMANCE OF THE CONSTRUCTION INDUSTRY

The safety performance of the construction industry has improved significantly over the past decade in Hong Kong (CIRC, 2001). The number of industrial accidents in the construction industry of Hong Kong decreased gradually from 1999 to 2008 (Labour Department, 2009). However, the number of fatal accidents increased to 20 in 2008, higher than 16 in 2006 by 20% (Figure 1). Undoubtedly, one single life killed is still too many and every effort should be put to make further improvement.

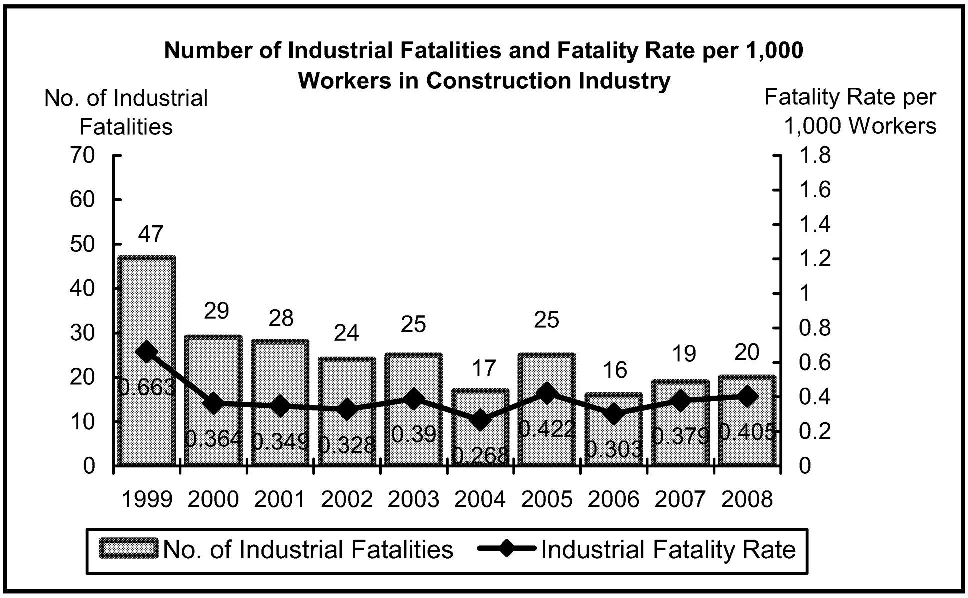

Figure 1 Number of industrial fatalities and fatality rate per 1000 workers in construction industry from 1998 to 2007 (Source: Occupational Safety and Health Branch, Labour Department, 2009)

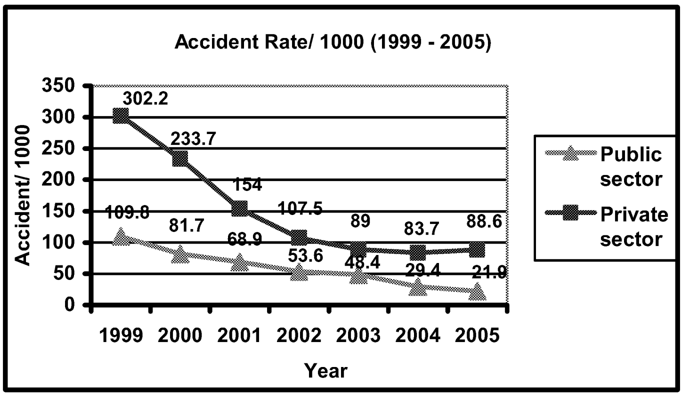

Figure 2 Accident rate per 1000 workers in construction industry from 1999 to 2005 (Source: REDA/HKCA, 2005)

The Works Bureau introduced two major safety initiatives, the Pay for Safety Scheme (PFSS) and the Independent Safety Audit Scheme in 1996 to encourage the setting up and implementation of efficient safety management systems and to enhance the standard of safety performance (Hong Kong Government, 1996a; 1996b). Lau (2005) added that PFSS was designed to encourage establishment of Safety Management System in government construction contracts. Despite these initiatives, the accident rate showed that the safety performance of the Hong Kong construction industry still has plenty of rooms for improvement. In 2005, the accident rate per 1000 workers was 21.9 in the public sector. On the other hand, the accident rate per 1000 workers in the private sector was 88.6 in the same year (Figure 2). To improve the safety performance of the whole Hong Kong construction industry, Mr KC Cheung, the then

Commissioner for Labour, advocated that some of the good practices used in the public sector such as PFSS should be introduced to the private sector as well (Cheung, 2005).

DEVELOPMENT OF PAY FOR SAFETY SCHEME (PFSS)

The objective of PFSS is to eliminate the "cut-corner" considerations on safety provisions which occur as a result of keen competitive tendering. Construction site safety is normally referred to in construction contracts as a general obligation placed upon the Contractor by a combination of a reference to the requirements of the law in the General Conditions of Contract and by some all-embracing preliminaries/preamble wording that expressly transfers as many of the contractual obligations to the Contractor as the law will allow. The Contractor is deemed to have allowed in the tender for the cost of meeting the obligations, but there is no separate, clearly identifiable sum(s) in the tender rates and prices. The result of this situation is that the sum(s) payable for carrying out safety measures cannot be identified, and any failure on the part of the Contractor to perform according to the legal or contractual requirements cannot be valued and the tender price appropriately adjusted to reflect the failure. When money is tight, a contractor may try, to some extent, to "cut corners" on site safety (Development Bureau Online Reference, 2007a).

A similar PFSS was introduced by the Hong Kong Housing Authority (HKHA) in 2000 to set aside a contract sum within the contract provision to encourage contractors to achieve good safety performance. Failure to meet the relevant safety requirements will result in deduction of payment and receiving a poor safety performance rating under the Performance Assessment Scoring System (PASS). Contractors with poor performance may also face suspension from tendering.

The Real Estates Developers Association (REDA) of Hong Kong and the Hong Kong Construction Association (HKCA) also promoted the use of PFSS in the private sector on a voluntary basis since its introduction in 2005. The operation of PFSS in the private sector is similar to that in the public sector and the financial incentive to support the contractor's effort is set between 0.5% and 2% of the contract sum (Figure 3). Encouraged by the success story of this major initiative, the HKCA took the initiative further down the supply chain by signing a "Safety Partnering Programme (SPP)" agreement with the Hong Kong Subcontracting Association (HKSA) to encourage its members to support the Safety Charter, deploy resources for safety devises and equipment, develop and implement various safety management systems (Green Cross, 2007). Since its introduction in March 2007, over 54 members of HKCA have participated in this programme (SPP Online Reference, 2009). It is timely for the proposed study to do the basic research necessary to develop a practical P_fSS_fS to help reinforce this initiative.

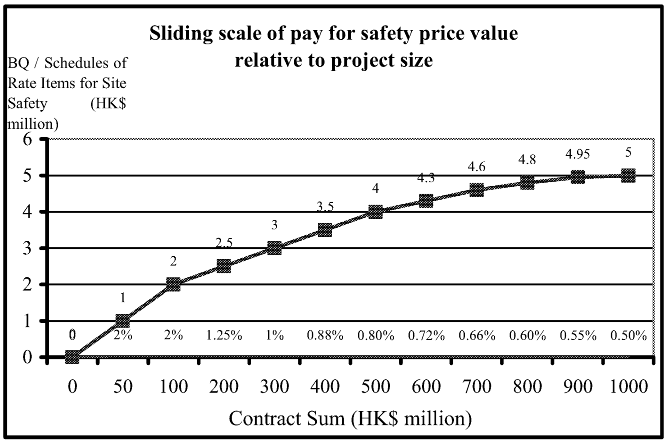

Figure 3 Sliding scale of pay for safety price value relative to project sizes (Source: REDA/HKCA, 2005)

Petersen (2000) stated that 21 safety categories are used in evaluating the effectiveness of a safety system. Those safety categories are also adopted by Ng (2004) to evaluate the effectiveness of PFSS on safety culture improvement in the public sector successfully. Ng (2007) also carried out a pilot study including interviews and survey to explore the effectiveness of PFSS in the public sector construction industry of Hong Kong, and concluded that the industrial practitioners generally supported the use of PFSS and found it effective in reducing the site accident rates.

Many safety experts have differing opinions on the extent of safety investment in a project. Tang et al. (1997) suggested that contractors should spend more than 0.6% of the estimated contract sum on safety investment. Ng (2004) also found in his research that 2% of the contract sum is insufficient for contractors to carry out all the safety elements. However, the ETWB uses 2% of contract sum for the safety related elements. For the private sector, 0.5% to 2% of contract sum is allowed for those items. There are diverging views on the right level of safety investment. The proposed study attempts to determine an optimum level for different types of projects in Hong Kong.

RESEARCH FRAMEWORK

Earlier study indicates that subcontractors and their workers have a less positive attitude towards safety than their main contractor counterparts (OSHC, 2003; Chan et al, 2005). Since subcontracting represents over 80% of project cost for most construction projects in Hong Kong, better motivation of subcontractors is believed to be instrumental in making for further construction safety improvement. It is hypothesized that (a) better safety performance leads to better profit level, and (b) some kind of financial incentive scheme can result in better safety performance. The aim of the proposed study is to scrutinize whether and how a "Pay for Safety Scheme for Subcontractors (P_fSS_fS)" could lead to better safety performance. To achieve this, the study will investigate the causal relationship between safety performance and profit of construction projects, and recommend a practical way for determining the optimum incentive level and type of P_fSS_fS for different projects.

Objectives of the study

a. To explore the relationship between safety performance and project profit, i.e. whether better safety performance contributes to higher profit level.

b. To identify outliers (projects where safety performances differ significantly from the norm) of a data set and then carry out detailed investigation to capture lessons learnt as to why they deviate from the mainstream pattern.

c. To investigate whether and how better motivation of site personnel leads to better safety performance.

d. To determine the optimum level of P_fSS_fS for major trade subcontractors across different types of projects (i.e. building, civil and foundation).

e. To recommend a practical way for implementing P_fSS_fS across different categories of projects.

Regression Analysis

Chan (2000) undertook a research study of 110 building projects to examine the impact of safety programmes on project performance and concluded that projects where effective safety programmes were implemented could lead to better project performance. The proposed study will explore explicitly the relationship between safety performance and profit level based on historical data and information about construction projects which will be obtained from major contractors in town. Safety performance will be measured inversely by a performance indicator (PI) in aggregate terms of cumulative incidence rate (CIR), number of convictions (C) and number of fatal accidents (FA) throughout the whole contract period of a construction project, while the profit level will be measured in terms of profit percentage (gross profit/turnover). PI may be expressed by the following formula:

PI (Performance Indicator)	=	CIR + (No. of conviction *10) + (No. of fatal accident *20) (counted as per the whole contract period, while 10 and 20 as the weightings for that particular variables from numerous of year)
where		
CIR (Cumulative Incidence Rate)	=	(Total No. of reportable accidents / Average workforce per day) * 1,000 (counted as per the whole contract period)
Conviction	=	No. of HS&E related conviction during the contract period
P% (Profit Percentage)	=	Gross Profit / Turnover (%)

By applying Regression Analysis (RA) to the relevant statistical data and information, the relationship between safety performance and project profit will be established. In statistics, RA examines the relation of a dependent variable (response variable) to specified independent variables (explanatory variables). The mathematical model of their relationship is the regression equation. The dependent variable is modeled as a random variable because of uncertainty as to its value, given values of the independent variables. A regression equation contains estimates of one or more unknown regression parameters ("constants"), which quantitatively link the dependent and independent variables. The parameters are estimated from given realisations of the dependent and independent variables. Uses of regression include prediction (including forecasting of time-series data), modeling of causal relationships, and testing scientific hypotheses about relationships between variables (Hair et al, 2006).

Figure 4 shows an indicative pattern of the relationship between safety performance and project profit for different types of projects (i.e. building and foundation). If such an inverse relationship between PI and P% holds, it means that every dollar invested in improving safety performance (such as the cost in implementing $P_f SS_f S$) results in an increase in profit return. Hence it is reasonable to hypothesize that an investment in $P_f SS_f S$ will also pay off.

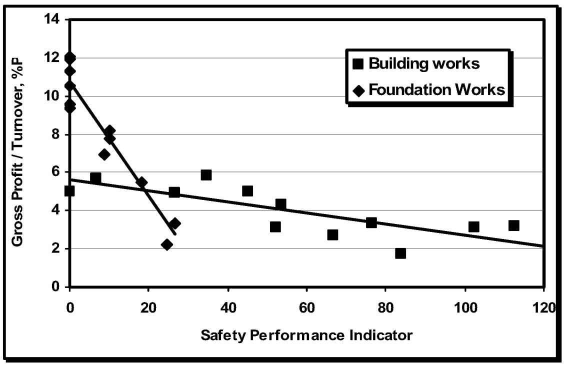

Figure 4: Indicative Relationship Between Safety Performance and Project Performance
(Source: Information Provided by a Major Contracting Firm in Hong Kong, 2007)

Face-to-face Interview

It is essential to identify and isolate outliers (projects where safety performances differ significantly from the norm) of a data set so that an in-depth investigation can be conducted to capture lessons learnt as to why they deviate from the mainstream pattern. In statistics, an outlier is an observation that is numerically distant from the rest of the data. Statistics derived from data sets that include outliers will often be misleading. Outliers may be indicative of data points that belong to a different population than the rest of the sample set. In most samplings of data, some data points will be further away from their expected values than is deemed reasonable. This can be due to systematic error, faults in the theory that generated the expected values, or it can simply be the case that some observations happen to be a long way from the center of the data. Outlier points can therefore indicate faulty data, erroneous procedures, or areas where a certain theory might not be valid. However, a small number of outliers is expected in normal distributions (Hair et al, 2006). Extensive consultations and discussions via face-to-face interviews with some key stakeholders working on these deviated projects will be conducted in order to find out the underlying reasons for the variances and identify strategies to avoid recurrence.

Pairwise Comparison

It is hypothesized that financial incentive is an important motivator to better safety performance. Since P_fSS_fS has not been widely implemented yet, we will investigate the effects of PFSS as a proxy to P_fSS_fS on safety performance. The mean safety performance of projects with PFSS will be compared statistically with those without by an analysis of paired data to test whether there is any significant difference between the sample means. Pairwise comparison generally refers to any process of comparing entities in pairs to judge which of each pair is preferred, or has a greater amount of some quantitative property. The method of pairwise comparison is used in the scientific study of preferences, attitudes, voting systems, social choice, and public choice. In psychology literature, it is often referred to as paired comparison (Hair et al, 2006). If the safety performance of projects with PFSS is found to be superior to those without, it can be hypothesized that P_fSS_fS will similarly be a key driver to motivate major trade subcontractors towards better safety performance. We can then proceed to address objective (4) in determining the optimum level of incentives for major trade subcontractors across different types of projects (i.e. building, civil and foundation).

Linear Programming and Sensitivity Analysis

There are three major types of construction projects undertaken in Hong Kong (i.e. building, civil and foundation). The incentive level given should be *adequate* to generate subcontractor impetus, but should *not* be so *excessive* as to sacrifice the main contractor's own profit. Based on the statistical data and information obtained from the major contractors, the optimum level of incentives with minimum payment to subcontractor in return of maximum profit to main contractor for various types of projects will be determined using some operational research techniques such as linear programming (LP) and sensitivity analysis (SA). A linear programming model usually involves the optimisation of one objective. A modification to this is the formulation of a linear goal programming model, which involves the optimisation of, instead of one objective, several objectives with priorities (Tang, 1999). In this proposed project, the objectives will be, amongst others, optimising the main contractor's profit (priority one), optimising subcontractor's profit (priority two), optimising subcontractor's safety facilities (priority three), and so on. The decision variables of the goal programming model will be safety facilities (e.g. number of safety walks, number of safety committee meetings, number of items of different safety equipment, etc.). The coefficients of the decision variables will be the unit costs of the safety facilities. By doing so, a number of objectives can be optimised subject to a number of constraints (or goals). Computer programmes are available for solving such a linear goal programming model. Sensitivity analysis can then be carried out for the optimal solution of the linear programming model in order to know more about how the safety facilities can be better deployed.

Focus Group Meeting

To develop the pay for safety scheme for subcontractors, focus group meetings will be launched to solicit the opinions from industrial practitioners on such development of such scheme. Focus group meetings have become increasingly popular well known method in collecting qualitative data (Morgan, 1997). This method can enable discussions in small groups to address specific topics. The purpose of running a focus group meeting is to collect data from a group of people at the same time through interactions between the participants (Berg, 2007). The focus group could be used to acquire general background of a topic, generate hypotheses and impressions of products, stimulate ideas, diagnose the potential for problems, learn how respondents talk about the phenomenon of interest, and interpret previously obtained qualitative results (Berg, 2007). The strength of focus group meetings lies on the ability to produce concentrated amounts of data on the topic of interest (Morgan, 1997). This method also enables group interactions in response to questions of researchers and it is particularly suitable to investigate behaviours and motivations (Morgan and Krueger, 1993).

The target participants of the focus group meeting include Project Manager, Safety Manager, Site agent and other related professional of main contractors. More in-depth understandings on the principles of developing the P_fSS_fS could be obtained from the interactions between participants in the focus group meetings. The participants will be encouraged to contribute their views on the possible obstacles, ways to overcome such obstacles and principles of developing the scheme in the focus group meetings.

SIGNIFICANCE OF THE RESEARCH

The findings of the proposed study will allow decision makers a clearer insight into how to determine the optimal budget for the payable safety items when tender pricing by both main contractor and subcontractors at an early stage of project development, and to investigate how the site accidents can be mitigated via P_fSS_fS. It is important to set minimum investment on safety related items in return of maximum profit of a construction project in order to upgrade the prevailing site safety performance and seek further improvement for future use. The proposed study is to carry out the basic research necessary to develop a practical P_fSS_fS for better safety performance. Once P_fSS_fS is widely implemented by the industry, we plan to submit another RGC proposal to evaluate the impact of P_fSS_fS on safety performance by assessing the real cost of P_fSS_fS and the resultant safety performance.

CONCLUSIONS

This study proposed to extend the implementation of the PFSS to the subcontractors' level in construction industry. Wilson (2000) and Mattews et al. (1999) expressed that the vast majority of subcontractors are small and poor in safety management. The safety problem may be exacerbated by the limited financial capability of small subcontractors, which make them unable to implement comprehensive safety programmes (Tam et al., 1996). Therefore, the development of PFSS for subcontractors would possibly be offered more resources in safety management and the number of accidents would hopefully decrease by the implementation of the P_fSS_fS. Tang et al. (2004) indicated that the safety investments made by the contractors may reduce the financial and social costs induced by construction accidents. It is expected that the implementation of this proposed scheme can further improve the safety record of subcontractors who usually undertake the majority of works in construction projects.

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