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THE UNIVERSITY OF HONG KONG

STUDY OF THE IMPACT OF SITE SAFETY CYCLE ON SAFETY PERFORMANCE OF CONTRACTORS IN HONG KONG

A DISSERTATION SUBMITTED TO

THE FACULTY OF ARCHITECTURE

IN CANDIDACY FOR THE DEGREE OF

BACHELOR OF SCIENCE IN SURVEYING

DEPARTMENT OF REAL ESTATE AND CONSTRUCTION

BY

TSE SEE LING

HONG KONG

APRIL 2005

Declaration

I declare that this dissertation represents my own work, except where due acknowledgement is made, and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualification.

Signed: ________________________________

Name: ________________________________

Date: ________________________________

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Abstract

The construction industry in Hong Kong has a long and tarnished reputation of its poor safety records. Until recent years, there have been significant improvements in its safety performance. Site Safety Cycle, a safety management tool which was introduced into the construction industry in Hong Kong in 1998, is believed to be one of the effective safety measures that brought about such improvements. However, there is yet sufficient data in supporting such a belief. Hence, this research aims at studying quantitatively the impact of implementation of Site Safety Cycle on the safety performance of contractors in Hong Kong.

There are three main sections in the research. First, it examines the safety statistics of the contractor before and after the implementation of Site Safety Cycle. Second, it analyzes the information of different site practices of Site Safety Cycle and their respective safety records which was collected through questionnaire. Third, it studies the relationship between the implementation of individual Site Safety Cycle elements and safety performance.

From the results of the analysis in the first two sections, it is found that the Site Safety Cycle does have a positive impact on the safety performance of both the company and project sites. This conclusion is supported by the interview with a safety practitioner, he also explained the reasons for the success of Site Safety Cycle.

The analysis of the third section further discovered that although Site Safety Cycle as a whole is effective in improving safety, not every individual Site Safety Cycle element has been effectively implemented to improve safety. There may be potential

problems with the practice of Site Safety Cycle as required by the Environment, Transport and Works Bureau (ETWB) in public works contracts which should be further modified to suit the construction industry in Hong Kong.

Based on the analysis of the result of this research which proved that implementing Site Safety Cycle as a whole does improve safety, it is recommended that the Government and other construction safety related organizations should further promote the use of Site Safety Cycle by contractors in Hong Kong, especially those small-sized construction companies which currently encounter difficulties in the implementation of such management tool.

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Chapter 1

Introduction

1.1 Background of Research

Being an international city, Hong Kong has long been famous for its densely populated skyscrapers and infrastructure. It can be seen that construction plays a very important part in Hong Kong's economy. After experiencing the Asian Financial Crisis in late 1997, followed by the economic slump due to SARS in 2003, the economy of Hong Kong starts to recover in late 2003 and the construction industry continues to be one main pillar of Hong Kong economy. It can be shown from its contribution to GDP in 2003 which accounts for 3.9%[1], also from its employment of over 66,000 site workers and around 300,000 professionals in related field, such as architects, surveyors, structural engineers etc.[2]

Despite the economic success and its significance, the construction industry has long been notorious for its poor safety record. Nevertheless, although Hong Kong's site safety record continues to be inferior in international standard, there is a significant improvement as shown from the accident statistics since 1998. Such improvement is the result of efforts from various parties, such as the Government, employers, employees, professional and academics, etc. and various safety systems, programmes and measures implemented these years. One of these safety systems, which is widely believed in the construction industry for its effectiveness in improving safety, is Site Safety Cycle[3]. It is believed that the Site Safety Cycle is an effective tool in pooling the effort of all persons working on the site from senior management down to

[1] Source: Census and Statistics Department, http://www.info.gov.hk/censtatd/eng/hkstat/hkinf/nat_account_index.html
[2] Source: Hong Kong Trade Development Council, http://www.tdctrade.com/main/si/spcons.htm
[3] Details of Site Safety Cycle, please refer to Chapter 3, Site Safety Cycle

frontline operatives and workers to improve safety. Yet, there is still no research or data to provide evidence for its effectiveness.

1.2 Research Aim and Objectives

The aim of this dissertation is to investigate the effectiveness of Site Safety Cycle in improving the safety performance of the construction companies and their construction sites and to identify potential areas for improvement of such system.

The objectives of this research are as follows:

1) To examine the common practice of Site Safety Cycle in Hong Kong.
2) To investigate the relationship between implementation of Site Safety Cycle and safety performance.
3) To study the effectiveness of implementation of individual elements of Site Safety Cycle in improving safety.
4) To propose recommendations for the improvement in implementation of Site Safety Cycle.

1.3 Structure of Dissertation

This dissertation consists of 10 chapters. Chapter 1 is the introductory chapter, which briefly describes the background, aim and objectives and the structure of the research.

Chapter 2 focuses on presenting the general overview of the construction safety situation in Hong Kong, which includes the current construction safety performance, the factors attribute to the poor construction safety in Hong Kong, the Government's approach to safety, existing legislations and organizations related to construction safety in Hong Kong.

Chapter 3 provides the background information of Site Safety Cycle which includes the introduction of the nature of Site Safety Cycle, the practice of Site Safety Cycle in Japan, followed by the background information of Site Safety Cycle in Hong Kong and the detailed description of its elements.

Chapter 4 is Relationship between Site Safety Cycle and Safety Performance. It is divided into two parts. First, literature regarding the relationship between the safety performance and three achievements of the trial implementation of Site Safety Cycle mentioned by the ETWB (2002), which are 1) communication between site management and working levels on safety and health matters, 2) workers' safety awareness and 3) housekeeping and site tidiness, will be reviewed. Second, the Site Safety Cycle will be broken down into individual elements. Literature about how these individual elements affect site safety will be presented. Chapter 5 is Safety Performance Measures. Previous researches about the safety performance measures will be summarized and presented.

Chapter 6 to 9 is the main study of the dissertation. Chapter 6 is Research Objectives and Hypothesis, which presents and explains the hypothesis of this research. Chapter 7 is Methodology which describes and explains the research methodology adopted, the procedures of the research and the various assessment and analysis methods selected. Chapter 8 is Questionnaire Result Analysis which presents the results of the analysis of data from questionnaire survey. Chapter 9 is Discussion which includes the explanation of the result obtained in Chapter 8.

Chapter 10 is Conclusion which includes the overall conclusion of the dissertation, recommendation to the implementation of Site Safety Cycle and limitations of the research.

Chapter 2

Overview of Current Construction Safety Situation in Hong Kong

Before studying the details of how Site Safety Cycle affects the safety performance of contractors in Hong Kong, it is beneficial to have a general overview of the current construction safety situation in Hong Kong.

2.1 Safety Performance of the Construction Industry in Hong Kong

Despite a recent improvement in safety, the construction industry in Hong Kong has long been blamed for its poor safety performance when compared with other industries in Hong Kong (Tam and Fung, 1998; Kwok and Tang, 1999). Figure 2.1 and 2.2 show that both the number of accidents and the accident rate per 1,000 workers[4] in the construction industry in Hong Kong showed a downward movement since 1998, it represents that the safety performance of the construction industry in Hong Kong is improving since then.

[4] Accident rate per 1000 workers is calculated by:

$$\frac{\text{Number of injuries or accidents}}{\text{Employment Size}} \times 1000$$

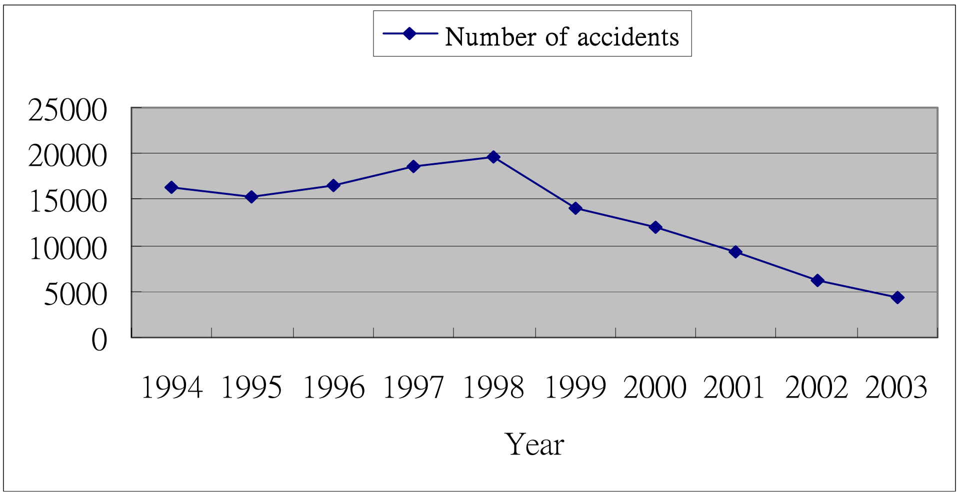

Figure 2.1 Number of Accidents in Construction Industry (1994-2003)

Source: Occupational Safety and Health Council

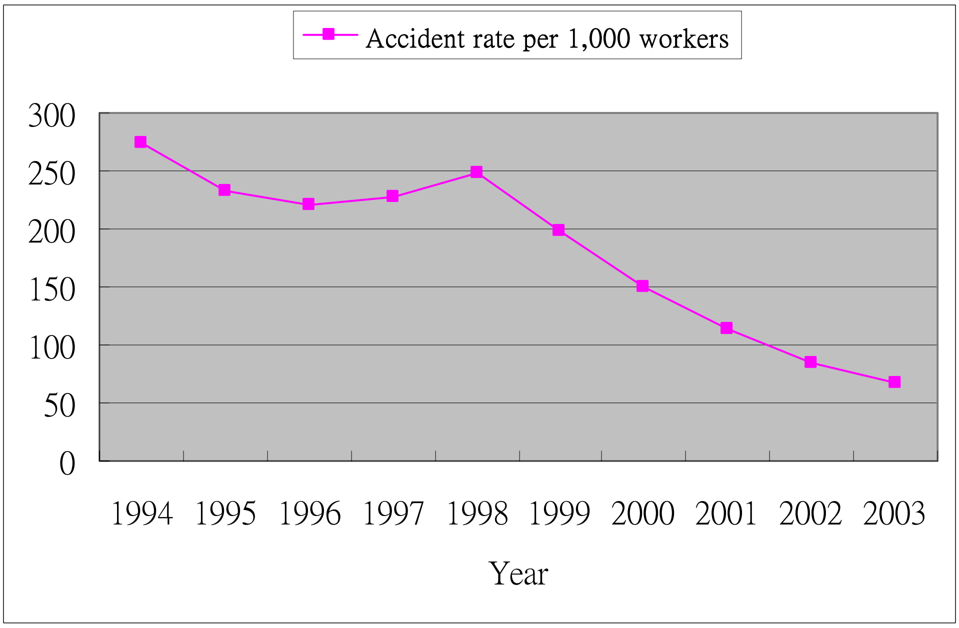

Figure 2.2 Accident rate per 1,000 workers in Construction Industry (1994-2003)

Source: Occupational Safety and Health Council

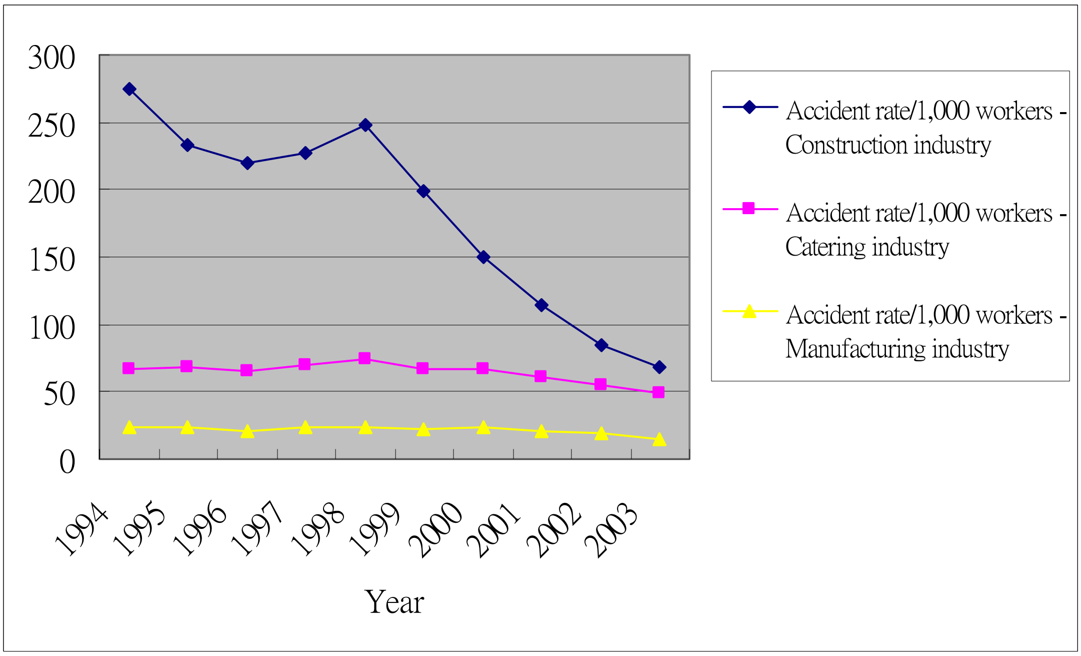

Figure 2.3 Industrial Accidents[5] in Major Industries (1994 - 2003)

Source: Occupational Safety and Health Council

As shown in Figure 2.3, the difference between the accident rate of the construction industry and the accident rates of the other two major industries that are prone to injury and accident (catering industry and manufacturing industry) is narrowing. Nevertheless, the accident rate of the construction industry in 2003 is still 1.4 times higher than that of catering industry, the next highest industry.

In international terms, Hong Kong construction industry also lags behind other major developed countries. In 2001, Hong Kong has an accident rate of 114.6 per 1,000 workers[6], whereas Japan has only 0.52 per 1,000 workers[7], Singapore has 7.9 per

[5] It refers to injuries and deaths arising from industrial activities in an industrial undertaking as defined under the Factories and Industrial Undertakings Ordinance.
[6] Source: Occupational Safety & Health Council, Hong Kong Special Administrative Region, http://www.oshc.org.hk/
[7] Source: Japan Construction Safety and Health Association (2001) Visual Statistics of Industrial Accidents in Construction Industry

1,000 workers in the same period[8] and the UK has 3.75 per 1,000 workers in 2002.[9]

This means that though the safety performance of Hong Kong construction industry is improving, it is still not up to standard and there is still room for improvement. In order to develop efficient measures to improve the safety performance of the construction industry, it is necessary to identify the factors that are attributable to make the construction industry become such a "dangerous" industry.

2.2 Attributes of Hong Kong Construction Industry's Poor Safety Record

There are a variety of factors that attribute to the unsafe nature of Hong Kong construction industry.

1) High levels and multi-layer subcontracting in the industry

With reference to Lee (1996), multi-layer subcontracting is a very common feature in Hong Kong construction industry, the subcontractors frequently further subcontract their work to others. Tang *et al.* (2003) illustrated the common subcontracting situation in Hong Kong that a construction project can have more than 50 subcontractors on site, with more than 80% of work in terms of contract sum are subcontracted.

Mayhew and Quinlan (1997) pointed out that poor occupational health and safety performance is an important consequence of subcontracting. Lee (1996) attempted to explain the multi-layer subcontracting problem by the effectiveness of management

8 Source: Report of Safety Status Analysis for IFAWPCA Members, 33rd IFAWPCA Convention, Singapore, October, 2003, Section E, pp. 31-45

9 Source: Improving health and safety in the construction industry, report by comptroller and auditor general, National Audit Office, 12 May 2004

control. He explained that due to the multi-layer subcontracting, many workers on the same site may be unknown to each other and even to their supervisor; this creates problems for effective management control. Tang *et al.* (2003) proposed a similar explanation that the use of excessive subcontracting practice will adversely affect the efficiency and effectiveness of communication of safety related information and coordination of site activities. Rowlinson (2003) further explained that, the high level of subcontracting leads to problems of inadequate training and lack of control on site and low levels of worker commitment.

Besides, Tam and Fung (1998) suggested that the industry's poor safety performance is due to a very high percentage of labour-only subcontractors. Since these people are rewarded according to work done, they may sacrifice safety for productivity. In addition, due to the high mobility of these people, they are less familiar with the site environment. Furthermore, the main contractors cannot obtain loyalty from these workers, there may be difficulties in enforcing their safety programmes on the workers.

2) Low level of education and lack of safety training for workers

Suggested by Lee (1996) and Tam and Fung (1998), it is a common practice in Hong Kong construction industry for contractors to hire imported labour or illegal immigrants due to labour shortage and law wages. Since many construction workers in Hong Kong come from the Chinese mainland or other developing countries, their educational level is relatively low and their notions of health and safety are less than adequate, the accident rate in Hong Kong construction field is high (Ahmed *et al.*, 2000). According to Rowlinson (2003) and Lee (1996), the reasons for the lack of safety training are related to the temporary nature of the work and the means of hiring day workers which lead to high labour turnover rate.

Laney (1982) opined that lack of training for workers is probably the biggest single cause of accidents. Peyton (1991) pinpointed the purpose of safety training which is to ensure the supervisors and workers understand the company's safety policy, procedures and hazards associated with their work. The merit of safety training for workers is not only conveying the required safety knowledge to them, it is also proved by Sawacha (1999) that there is a positive relationship between training and safety awareness.

3) Tight schedule

Due to the high land price policy adopted in Hong Kong, many clients are forced to expect contractors to build exceptionally quickly so as to realize the return as soon as possible to minimize the interest charges (Rowlinson, 2003). Besides, it is also very common in Hong Kong to have penalty clauses for late completion in construction contract (Lee, 1996). Both of them lead to a very tight construction schedule. As explained by Lee (1996), Li (1997) and Tam and Fung (1998), such unreasonable contract durations will put pressure on contractors to sacrifice safety to the pursuit of time and productivity.

Under the tight construction schedule, working overtime become an avoidable part of workers' life which is also mentioned in Tang *et al.* (2003) and Lee (1996) as a common feature in Hong Kong construction industry that workers worked for an average of 48 hours per week in the fourth quarter of 1999. As proved by Goldenhar *et al*. (2003), health and safety is one of the adverse outcomes related to working overtime. They mentioned that fatigue and reduced alertness will be resulted at the end of a 12-hour shift. This is deemed to be one contributing factor to poor safety.

4) General lack of interest and awareness of safety

As mentioned by Rowlinson (2003), there is a general lack of interest and awareness of safety shown by both the clients and construction companies which is revealed from the traditional and continued practice of accepting the lowest tender in Hong Kong. Fong and Choi (2000) also illustrated similar findings that safety performance is in the lowest priority in the final selection of contractor amongst other criteria like tender price, financial capability, past client/contractor relationship etc. Many contractors are forced to reduce effort and spending on safety procedures so as to submit the lowest bid and secure the job (Tang *et al.*, 2003). Besides, Tam *et al.* (2001) demonstrated that many production personnel will only give some considerations to safety after achieving production objectives of production and cost.

Such low priority of safety can also be viewed from the weak safety culture in Hong Kong. As pointed out by Tam *et al.* (2001), only a few construction organizations in Hong Kong can create a form of safety culture by devoting a lot of efforts in overcoming the resistance of their staff when they first introduce safety programmes.

5) Hot and humid weather

As suggested by Rowlinson (2003), the hot and humid weather in Hong Kong is also one factor that affects site safety. Similarly, Lee (1996) mentioned that it was proved in a study of the rainfall and temperature in Hong Kong that when rainfall and temperature were both high, the accident rate on construction sites was also the highest. He suggested several reasons for such result, such as fall from height because of slippery work surface, electrocution after rain etc.

2.3 Hong Kong Government's Approach to Safety

In the past, Hong Kong Government adopted a laissez-faire approach in managing construction safety, hoping that the safety performance would be regulated by market forces. However, such approach is proved to be ineffective (Tam *et al.*, 2001).

In view of the ineffectiveness of the previous approach, since 1986, the Government has taken a proactive approach in combating construction site safety and has introduced a series of safety measures, such as enactment of the Factories and Industrial Undertakings (safety officers and safety supervisors) regulations, quality assurance scheme, self-regulatory safety management system etc. (Tam *et al*., 2001).

In response to the reactive and non-incentive nature of the enforcement approach that actions will only be taken after accident, and based on the significant improvements in safety standards witnessed in other countries, such as the UK, Japan, Australia and Singapore, by adopting the self-regulatory approach, in July 1995, the Hong Kong Government published a consultation paper on the review of industrial safety in Hong Kong which recommended transforming from the enforcement approach to a self-regulatory approach in tackling workplace safety and heath issues. In such new approach, the responsibility for safety and health at work is put to the shoulders of the proprietor and his workforce. With the introduction of a safety management system, the Government encourages employers and employees to manage safety in a self-regulatory manner, through education, training, promotion of safety concepts and a better understanding of the costs of accidents (Rowlinson, 2003; Kwok and Tang, 1999).

2.4 Existing Legislations related to Construction Safety in Hong Kong

The majority of safety and health legislation in Hong Kong is based on the practice in the United Kingdom. and the Factories and Industrial Undertakings Ordinance (Cap. 59), enacted in 1955, is the principal legislation governing health and safety at work in Hong Kong which is enforced by the occupational safety and health officer of the Labour Department. There are 29 items of subsidiary legislation under the ordinance prescribing detailed safety standards at work. Some of them are specially related to construction site safety, such as Construction Site (Safety) Regulations, Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations, Factories and Industrial Undertakings (Safety Management) Regulation.[10]

Although the safety and health legislation in Hong Kong is a combination of prescriptive and performance-based legislation, a large proportion of them are prescriptive in nature (Rowlinson, 2003). In view of the international trend of transforming to the self-regulatory approach and the illusion given by the prescriptive regulations that health and safety enforcements should be the responsibility of external enforcement agents rather that those at the workplace, an amendment was made in 1989 introducing provisions requiring the employers to be responsible for taking all reasonable practicable steps to ensure the health and safety of all persons employed in the workplace and the workers to exercise reasonable care at work and co-operate with the employers on safety measures (Rowlinson, 2003).

2.5 Existing Organizations related to Construction Safety in Hong Kong

There are many government, non-government, or semi-government organizations

[10] Details of the subsidiary legislation may be referred to the Bilingual Laws Information System, http://www.legislation.gov.hk/eng/home.htm

which are related to construction safety issues in Hong Kong. Examples include: the Labour Department, the Environment, Transport and Works Bureau, the Hong Kong Housing Authority, the Occupational Safety and Health Council, the Construction Industry Training Authority, the Occupational Safety and Health Association, the Hong Kong Construction Association etc. In the following part, two of these major bodies which are relevant to this research will be further elaborated.

2.5.1 The Environment, Transport and Works Bureau (ETWB)

The ETWB, formerly named the Works Bureau, is a government body which is responsible for policy matters on environmental protection and conservation, development of transport infrastructure, provision of transport services, traffic management, public works, water supply, slope safety and flood prevention in Hong Kong. It oversees the operation of eight executive arms, namely, Architectural Services Department, Civil Engineering and Development Department, Drainage Services Department, Electrical and Mechanical Services Department, Environmental Protection Department, Highways Department, Transport Department and Water Supplies Department.[11]

One of the bureau's responsible areas is the safety of the public works which is stated in its policy objectives that "to ensure the effective planning, management and implementation of public sector infrastructure development and works programmes in a safe, timely and cost-effective manner and to maintain high quality and standards."

Since the ETWB has the power to manage all the public works programmes in Hong

[11] Source: Website of the Environment, Transport and Works Bureau, http://www.etwb.gov.hk/index.aspx

Kong, it has a major role in influencing and improving the safety practices in the construction industry by requiring a higher safety standard in the public works or by introducing new safety programs or measures in the public works for trial. In this way, the rest of the construction industry may be stimulated to improve their own safety standards. The Site Safety Cycle studied in this research is also first introduced in several public works for trial implementation by the ETWB.

2.5.2 The Occupational Safety and Health Council (OSHC)

The OSHC is a statutory body established under the Occupational Safety Health Council Ordinance in 1988, for promoting safety and health at work and sustaining the valuable workforce of Hong Kong. There are 18 members appointed by the Chief Executive of the Hong Kong Special Administrative Region representing employers, employees, professional, academic and Government interests to serve the Council. Its main source of funding comes from the Employee's Compensation Insurance Levy, while some other income come from the cost recovery of services such as training courses, consultancy etc. The main services of OSHC include:

1) Promoting occupational safety and health in the community
2) Education and training
3) Consultancy services
4) Research and strategies development
5) Information dissemination
6) Facilitating exchanges between Government, employers, employees, professional and academics.

Regarding construction safety, the OSHC has regularly organized promotional activities to remind the general public to pay attention to safety and health, such as Construction Safety and Health Promotional Campaign which focus on promoting safe working cycle, safety of working at height, confined space and the importance of wearing personal protective equipment. Besides, it offers a variety of safety-related training programmes, such as Safety Supervisor Modular Course (Construction Safety)[12], Foremen Safety Training Course, Construction Industry Safety Card Revalidation Course etc. In addition, it also produces different publications to provide information and guidance related to construction safety.[13]

[12] It is recognized by government departments and is suitable for those who are assigned to carry out duties of safety supervisor under the Factories and Industrial Undertakings (Safety Officers and Safety Supervisors) Regulations.

[13] Source: Website of Occupational Safety and Health Council, http://www.oshc.org.hk/

Chapter 3

Site Safety Cycle

3.1 What is Site Safety Cycle?

Site Safety Cycle (SSC), also named as Safe Working Cycle, or Safety Work Cycle, originates from Japan, is a type of management tool that can be used to enable the organization to regulate its daily working process, provide a model for management to follow, and implement certain elements of the safety management system (Occupational Safety & Health Council, 2002).

Ozaka (2000) stated that "the Safe Working Cycle is a system which incorporates safety management into the construction management system to integrate construction and safety effectively. In other words, the Safe Working Cycle is a system which integrates safety into daily work."

Lam (2000) mentioned that Safe Working Cycle is a tool which draws all the important safety activities, such as inspection, supervision, safety committee meetings, which are in fact requirements under public works contracts and the Factories and Industrial Undertakings (Safety Management) Regulation, together in a systematic manner.

One of the major contractors in Hong Kong, which has implemented SSC and gained remarkable improvement in its safety performance, stated that, it is a set of management techniques that facilitates the smooth implementation of site safety management by transforming work processes into a structured framework with the aim of enhancing safety performance through innovative ideas.[14]

According to the "Safe Working Cycle" Handbook issued by the Occupational Safety & Health Council, the basic concept of SSC is to combine construction quality and construction safety. It stressed that through the safety policy and objectives, as well as the formulation of a safety management system, the company management can change the traditional enforcement on safety measures into a cooperative and coordinated method of dealing with safety issues. This cycle clearly indicates the responsibilities of different workers/ranks. It places particular emphasis on the leadership of the frontline management at construction sites, e.g. group leaders and foremen. The cycle encourages mutual trust between supervisors and workers at the constriction sites and facilities direct communication. In addition, the cycle enables workers to receive and accept relevant safety training and safety message, and finally creates a safety culture. The aim of SSC is to integrate quality and safety aspects of construction so that adequate considerations have been taken for each aspect to achieve a cost effective construction project.

3.2 Site Safety Cycle in Japan

In Japan, major construction companies started to introduce Site Safety Cycle activities into their work as a safety measure as early as 1978. It was then promoted by the Japan Construction Safety and Health Association to construction companies in 1982. Up till now, Site Safety Cycle activities have taken root throughout the Japan's construction industry, contributing to the prevention of industrial accidents (Ozawa, 2000).

[14] Source: Press Release of Shui On Construction and Materials Limited (2003) "Shui On Wins 15 Awards in 'Construction Safety Promotional Campaign 2003'", available at http://irasia.com/listco/hk/shuion/press/p031008.htm

The Site Safety Cycle in Japan is a cycle of basic safety activities that is implemented through careful cooperation between the contractor and subcontractor, in addition to their other responsibilities, to ensure on-site safety. These routine activities are performed daily, weekly, and monthly as shown in Table 3.1 (Ozawa, 2000).

Daily activities	1) Morning safety meeting 2) Safety meeting(danger protection activities KYK) 3) Advance inspection of work procedure 4) Site inspection by site manager 5) Guidance and supervision during work 6) Coordination of safe work process 7) Cleaning up each work area 8) Checking work sites at the end of work
Weekly activities	1) Weekly meetings 2) Weekly inspections 3) Weekly clean up
Monthly activities	1) Safety meetings 2) Regular independent inspections 3) Safety (health) conventions foremen meetings

Table 3.1 Summary of Site Safety Cycle activities in Japan

Source: Ozawa, 2000

There are several goals that the Site Safety Cycle in Japan is aiming to achieve (Ozawa, 2000):

1) Change the culture from contractor-led safety activities to contractor-subcontractor collaborated safety activities

It aims at changing the “do it” safety activities to “let’s do it together” safety activities and ensures the roles of contractors and subcontractors in safety activities are distinct and clear.

2) Incorporate “safety” into “work”

It targets at carrying out the work safely, efficiently, quickly, and inexpensively, so as to eliminate the idea that work and safety are different.

3) Make safety management a habit

It helps to ensure that safety is carried out, not just talked about and facilitates the daily safety instruction of workers who move around a lot.

As mentioned by Dr Ng Tat-lun, Chairman of the Occupational Safety & Health Council, in the Symposium on Safe Working Cycle 2000, the practice of Site Safety Cycle is proven success in Japan that incorporates safety as the key element in their daily routine work procedures (Occupational Safety & Health Council, 2000). The Japanese example of Site Safety Cycle demonstrates the following successful results (Ozawa, 2000):

1) Accidents have decreased with the establishment of Site Safety Cycle activities.
2) Meetings and communication have become more effective, leading to more efficient construction and process management.
3) Pinpointing the causes of accidents by tracing the steps in the daily Site Safety Cycle has made planning preventive measures easier.
4) The Site Safety Cycle serves as the basis of the occupational safety and health management system at the actual construction sites, leading to easier implementation.

5) It promotes a better working environment.

3.3 Background of Site Safety Cycle in Hong Kong

After implementing SSC, the Japanese construction industry has made remarkable progress in safety and health, and the number of accidents declined significantly (Occupational Safety & Health Council, 2002). In view of this, the concepts and elements of SSC originated in Japan have been incorporated in the daily site operations of some contractors in Hong Kong on a voluntary basis as early as 1998, it is subsequently put for trail by the ETWB under the Pay for Safety Scheme (PFSS)[15] in six selected contracts since 2000.

The first two contracts to practice SSC were two building demolition contracts under Architectural Services Department (ASD) in mid-June 2000. As compared with other construction works, the number of subcontractors and trades of workers employed in the building demolition works are less due to its specialist nature. Hence, it is easier for the trail implementation of SSC to start on these two contracts. After the completion of works, it was found that SSC was of great assistance in promoting communication and raising workers' safety awareness though additional resources were required.

Following these two contracts, the trial of SSC was then commenced in a roads and slope works contract under the Territory Development Department in Tuen Mun in

[15] PFSS is a scheme developed by the Environment, Transport and Works Bureau with an objective to remove site safety from realm of competitive tendering by requiring all appropriate tenders under this scheme to include a separate "Site Safety" section in the Bills of Quantities (BQ) or the Schedule of Rates (SOR). Each item should be pre-priced on the basis of a total possible payment to the Contractor of approximately 2% of the estimated Contract Sum/total estimated expenditure, not including the Contingency Sum or any sum for the payment of fluctuations. (Construction Site Safety Manual, chapter 12)

mid-July 2000. In this trial, some modifications on the SSC activities have made. The morning safety meeting was conducted on a weekly basis instead of a daily basis as in Japan and was attended by most of the subcontractors' staff in addition to those of the main contractor. The contractor also took it as an opportunity to present a prize to a worker with good safety performance in the previous week so as to encourage workers to improve their safety performance.

Some other differences in the implementation of SSC had made in another ASD contract which include holding the morning safety meeting indoors when the superstructure works were started, presenting monthly "Safety Model Worker" awards during the morning safety meeting, facilitating the "Hazard Identification Activity" using white boards to record the discussion and the control measure agreed etc.

Because of the obvious differences in safety culture between Japan and Hong Kong, this kind of modifications and alterations of SSC activities was also made on the remaining two trial contracts so as to find out a suitable model for application in Hong Kong.

Since the trial has demonstrated that implementation of the SSC activities successfully enhanced the communication between site management and working levels on safety and health matters, promoted workers' safety awareness and improved housekeeping and site tidiness, all these contributed towards the improvements of safety performance and prevention of accidents at construction sites, in 2002, the Environment, Transport and Works Bureau (ETWB) decided to extend the second stage of implementation of SSC to all capital works contracts including

Design and Build contracts that are included in the PFSS[16]. For the practicing of SSC in term contracts, it will be considered at a later stage when more experience is gained for the implementation due to the special work nature for term contracts (Environment, Transport and Works Bureau, 2002).

Under the second stage of implementation of SSC, all capital works contracts included in the PFSS are required to incorporate the contractual provisions for the implementation of SSC.

Apart from the contractual requirement to implement SSC in the public works, some other major contractors in Hong Kong also practice SSC in their private works on a voluntary basis. Due to the remarkable results achieved by the SSC, the OSHC and 13 other government and professional bodies have jointly launched a Safe Working Cycle competition every year to encourage more companies to adopt the SSC practice. The Best Safe Working Cycle Site award will be judged on its management commitment, participation of corporate level staff, subcontractor and workers such as attendance rate in the morning safety meeting and site inspection, coverage in terms of items of each cycle, time and area, etc.[17]

3.4 Details of Site Safety Cycle in Hong Kong

The Site Safety Cycle includes various activities which can be classified into three categories: 1) Daily Cycle 2) Weekly Cycle and 3) Monthly Cycle. According to Environment, Transport and Works Bureau (2002) and Occupational Safety & Health

[16] For works contracts and Design and Build contracts to be included in PFSS, the estimated contract sum shall be $20M and above, irrespective of whether the contract is BQ or SOR based. (Construction Site Safety Manual, 12.2)

[17] Source: Construction Safety Promotional Campaign 2004, Website of OSHC: http://www.oshc.org,hk

Council (2002), the details of each cycle are as follows:

1) Daily Cycle

The daily cycle basically includes eight items. These items are arranged according to the daily schedule of the project. This means that each person can carry out their responsibilities according to the schedule.

(a) Pre-work Exercise and Safety (PES) meeting

This meeting is arranged by the contractor for all the persons employed for the project including subcontractors' workers. It should be led by the site agent or a senior staff of site management of the contractor, who has attended the training course on SSC or the Safe Working Cycle of the OSHC or Construction Industry Training Authority (CITA). The PES meeting includes 1) the announcement of safety and health matters related to the site such as common hazards and control measures, general fire and safety precautions, specific safety concerns, general defects and irregularities observed in inspections, accidents or near misses etc., 2) the announcement of common safety matters in execution and co-ordination of the works on the site among subcontractors and workers, 3) presentation of awards to workers and subcontractors in recognition of their good safety performances. 4) morning exercises such as stretching exercise, 5) inspection on personal protective equipment and dressing.

The PES meeting gives workers time to prepare themselves psychologically for work and pay special attention to the safety rules and the working environment of the work sites; and reminds them that they must check on their outfits and personal protective equipment. It also gives workers an opportunity to do some stretching exercises before starting wok so as to prepare their bodies for work, therefore reducing chance of injuries. Besides, it helps promote team spirit and cooperation by doing stretching exercise together in the morning safety meeting, provides an opportunity to convey safety message, and raises workers' vigilance.

(b) Hazard Identification Activity (HIA) meeting

The HIA meeting is arranged and held by the main contractor for all work teams immediately after the PES meeting, which provides a chance to strengthen the communication on site because the contractor can arrange persons on the site to take turn to lead the HIA meeting. These persons may be a foreman, ganger, safety officer, safety supervisor or safety representative. During the meeting, hazards and control measures specific to the works or trades, special safety concerns, assurance of safety requirements and measures, reprimand of repeated irregularities and malpractice etc. may be discussed.

Through the participation of front-line workers in the HIA meeting, it reduces resistance to the implementation through recognition and acceptance of the safety measures by front-line workers themselves. Besides, team spirit can be enhanced, through the discussion at the working place, as part of practical safety training. In addition, it facilitates the contact between the main contractors and other subcontractors in order to reduce possible adverse impact on efficiency and prevent accidents that may be induced by lack of communication and misunderstanding.

(c) Pre-work Safety Checks

It is arranged and held by the main contractor immediately after the HIA meeting, which can be carried out by foreman, gangers or safety supervisors according to the trades, work teams or works areas set out by the contractor. The Pre-work Safety

Checks will include checking of personal protective equipment worn by the workers on site such as safety helmet, reflective vest, ear protectors, eye protectors, safety harness, safety footwear etc., and also checking of the safety conditions of facilities, machinery, plant and equipment and materials before commencing work on that day.

The Pre-work Safety Checks helps ensure the tools and equipments are in good condition, which will bring about better efficiency and help reduce accidents. It also reduces losses by identifying problems before the start of work and rectifies them and prevents the problems from getting worse.

(d) Daily Safety Inspection

The daily safety inspection aims at checking any unsafe act or unsafe conditions and ensuring the safety instructions given in PES meetings or HIA meetings have been observed and carried out. In the daily safety inspection, particular attention will be given to those areas identified for improvements in weekly safety co-ordination meetings, weekly safety walks, site safety management committee meetings or site safety committee meetings.

The daily safety inspection demonstrates the company’s commitments to safety, enables senior management to understand site safety problem and solve them.

(e) Guidance and supervision during work

Supervisory staffs are assigned to be responsible for the safety and health of workers on site. They will provide guidance and supervision, which include the implementation of safety instructions given in PES or HIA meeting, for the workers under his/her control, rectify any irregularities, unsafe acts or unsafe conditions for the works on site and look out for on-going changes in the work conditions, such as excessive noise, smoke and dust. It helps facilitate the communication between gang leaders and their workers, and ensure the problems are solved directly and immediately.

(f) Safety co-ordination meeting

This meeting is held each day, with the participation of project manager, general foreman, subcontractor representatives and safety officer, to coordinate safety and health work to be carried out on site on the following day, which may be used to discuss the findings in safety inspections, the matters to be announced in the next PES or HIA meeting, the co-ordination of site safety matters, such as sequence of works, usage times for shared machinery and equipment and works areas, phasing of works at various interfaces, delivery and storage of materials and equipment to the site, etc. This aims at solving problems quickly and enhancing efficiency.

(g) Daily cleaning and tidying up of the Site

This step is designed to ensure that all the equipment, tools, instruments and environment of the workplace are tidied up after a day's work, in preparation for the next day's work. Instead of being just a general cleaning, it is based on the 5S housekeeping practice.[18] Each worker must tidy up his own work area after he finishes his work for the day. This step not only helps maintain a safe working environment, it also improves the working efficiency.

[18] The 5S housekeeping concept (organization, orderliness, cleanliness, standardization, and discipline) originated from Japan. The main idea of this housekeeping method is to cultivate in staff members a habit of keeping the site clean and in good order, with its ultimate goal to improve safety and health level at the work sites. For details of this concept, please refer to Occupational Safety & Health Council (2002) Appendix 7.

(h) Checking of the Site after each day's work

In order to ensure no accident will occur at construction sites after work, e.g. fire, flooding, scaffoldings collapse, trespassing etc., designated person is assigned to check the safety of site after each day's work which may include whether:

i. all flames and heat sources have been extinguished;

ii. keys have been removed from construction machinery and plant and kept in a safe place;

iii. all construction plant are parked properly on level and stable ground;

iv. all machinery and power sources have been turned off;

v. all openings are properly covered and all edges are provided with fall protection measures;

vi. the site has been fenced and guarded against unauthorized entry, etc.

If after the completion of checking, there are any unsafe conditions or imminent danger that requires immediate follow-up actions, the designated person is required to notify the site agent.

2) Weekly Cycle

Weekly cycle aims at making an interim review of the performance in the past week and making arrangements for the future.

(i) Weekly Safety Walk

The main contractor should encourage all the subcontractors to participate in the weekly safety walks. They can then strengthen their cooperation and work on eliminating the safety problems found during inspection and define their respective responsibilities on-the-spot. It would be even better for the weekly safety walks to be carried out in company with the Architect/Engineer's Representative so as to ensure the safety standard meet the client's requirement.

(j) Weekly co-ordination meeting

This meeting aims at promoting the communication between people at various levels and subcontractors, summarizing the safety performances in the last week and planning for construction work for next week. It creates opportunities for bringing problems to attention and for an early remedy. In the meeting, safety performance, housekeeping and tidiness of the site, together with the specific areas of concern, defects and deficiencies observed in weekly safety walks, accidents and near misses occurred on the site, etc. will be discussed.

(k) Weekly overall cleaning and tidying up of the Site

This step aims at thoroughly tiding up the site to prepare for work next week.

3) Monthly Cycle

Monthly cycle is to review the site performance and progress, to improve workers' safety awareness through training and reward schemes, and to recognize their commitment and cooperation.

(l) Site Safety Management Committee meeting (including pre-meeting inspection)

The pre-meeting monthly inspection aims at improving the management of machines, equipment, tools and materials. It can ensure the safety of workers, keep the machines and equipment in constant serviceable condition and prolong the service life of the machinery.

The meeting is used to review accident statistics and identify trends and probable causes of accidents so as to recommend measures to prevent recurrence, co-ordinate the safety measures of subcontractors on site, review emergency and rescue procedures, discuss the contractor’s monthly safety report, study safety audit reports received and review action plan prepared by the contractor, etc.

(m) Site Safety Committee meeting

This meeting is held each month for the site safety committee to discuss health and safety matters on site. Since the full cooperation and commitment of the workers and foremen are very crucial, this meeting provides a chance for them to participate in the making and monitoring of arrangements for safety at their place of work. In the meeting, the site safety committee will review and monitor the effectiveness of the safety and health measures taken on site and recommend improvements, discuss hazards associated with the site operations and necessary safety precautions, co-ordinate the interface safety measures of all sub-contractors, utility undertakers or other construction parties working on site, discuss and review the emergency and rescue procedures, review accidents that have occurred so as to recommend measures to prevent recurrences, review accident statistics and safety performance of sub-contractors, study safety audit reports received and review action plan, etc. This can strengthen communication among workers of different trades, eliminate any misunderstandings or lack of coordination at work, and improve the workers’ safety awareness.

(n) Safety Bulletin Board

Apart from the three cycles mentioned above, a safety bulletin board should be erected on site to promote SSC. The board may contain:

i. promotion of Site Safety Cycle

ii. a chart with names and contact telephone numbers showing the site safety organizational structure from senior site management down to sub-contractors, gangers, foremen, safety officer, safety supervisors and safety representatives according to works trades, work gangs or works areas, together with the emergency teams, first aid personnel etc.

iii. accident statistics with breakdown to sub-contractors

iv. a figure showing a worker wearing all the personal protective equipment plus a mirror to cover the full view of the person when standing in front

v. site plan

vi. safety policies

vii. in-house safety rules and regulations

viii. slogans

ix. colour coding systems for lifting gears, etc.

Chapter 4

Relationship between Site Safety Cycle and Safety Performance

This chapter consists of two main parts. First, focus will be placed on the Site Safety Cycle as a whole. Since the ETWB (2002) claimed that the trial implementation of SSC successfully 1) enhanced the communication between site management and working levels on safety and health matters, 2) promoted workers' safety awareness and 3) improved housekeeping and site tidiness, literature regarding how these three aspects are related to safety improvement will be reviewed.

In the second part, focus of the study will be shifted from SSC as a whole to individual SSC element. Literature regarding the relationship between implementation of these individual SSC elements and safety performance will be reviewed.

4.1 Site Safety Cycle as a Whole

(A) Communication between site management and working levels on safety and health matters

Communication is a two-way process, which requires commitments and involvements from both parties. Several previous researches have found the importance of involving both parties on the safety and health issues. Nishgaki (1994) attributed "humanware", which is defined as a function composed of leadership, fellowship, and the interaction between them, to much of the underlying causes of occupational accident recurrence. According to his research, employers' and employees' attitudes play a major part in safety on site. Both Nishgaki (1994) and Hinze and Raboud (1988) found that regular involvement by the company management improved the safety standards. And Lin(2001) further discovered that companies with involvement of both managers and workers in the occupational health and safety design process has better safety result than those with only managers involved.

There are several reasons for the importance of communication in improving site's safety. First, it helps to improve the effectiveness of the safety systems or programs by incorporating both parties' opinions and suggestions. Research by Dejoy (1985) showed that the safety program is most effective when it involves two-way communication between workers and managers, since high level management often has little first hand experience on site; it is therefore difficult for them to relate to the needs of the workers. Besides, as explained by Kartam *et al.* (2000), workers are the ones who are exposed to the danger of daily job hazards, they should be able to participate in the safety programs. Both Lin (2001) and Koehn and Surabhi (1996) mentioned similar view that employees tend to be more aware of hazards in the work place than employers and can suggest ideas which may reduce accidents. Therefore, they should be involved in the safety program. They can also relate to the safety program easier if they are involved. Simon and Pioquard (1991) suggested that both management communication and employee feedback are critical for suggesting safety improvements and reporting near misses as well as unsafe conditions and practices.

Second, through the communication process between both parties on the health and safety issues, the workers can make contribution and commitment to the safety systems and programs. This commitment can help to ease the implementation of the safety systems. Haper (1998) mentioned that by involving the employee in the safety process, more commitment is gained from the employee. This additional commitment may be attributable to the employee's desire to execute something which he or she has developed or assisted in developing. This type of involvement enables the employee to gain a sense of ownership and increased responsibility which will help to smooth the implementation of the safety systems.

Another major contribution to site safety by communication is it can show the recognition and respect to human resources' values which will motivate the workers to work safely. As suggested by Langford *et al.* (2000), by recognizing the value of human resources, the companies can motivate and assist operatives to work more safely. And effective on site communication is one of the ways to maintain and update their workers' skills and knowledge which in turn show the recognition of the human resources' value. Besides, Andriesson (1978) also mentioned that workers will work more safely with a supervisor who is seen as someone who respects their workers and their contribution.

(B) Workers' safety awareness

In Madison (1999), detailing of safety awareness has been provided. He stated that there are three fundamental elements that cause accidents, which are failure of attitude, failure of safety training, and failure of technical training. Among them, failure of attitude is the most important cause. A good attitude involves full attention given to the job, practicing safe work habits and takes no situation for granted. He further mentioned that each person must have a state of mind (attitude), which vigilantly maintains a sense of urgency about the task at hand, to ensure safety. Similar view has been presented in Harvey *et al.* (2001), which mentioned attitudes and safety behaviors are causally linked, attitudes may change behavior and thus directly and indirectly affect safety culture and accident rates.

Harper (1998) pointed out that a safer work site can be maintained as a consequence of increased employee awareness. In concurrence, Rowlinson (2003) also mentioned the importance of attitudes to safety of different parties involved in the industry which include the site workers. He further explained that safety awareness is so important since it is found that many accidents occur because the workers, supervisors and management are unaware of the dangers that exist in particular work processes and certain areas of the site. Kartam *et al*. (2000) showed similar view that workers' attitudes have a great effect on the implementation of safety measures at the job site. And Sawacha *et al.* (1999) found that "operatives that showed concern for personal safety and reflected this concern in their approach to their work, had a better safety record than those who neglected their personal safety in the course of their work."

Hence, it can be concluded that workers' attitudes towards safety, whether they concern about their personal safety and aware of the importance of safety, are very crucial to the implementation of the safety programs and the improvement of site safety since if they do not accept and incorporate the safety requirements set by the companies into their daily operations, the safety systems or programs will be of no use at all.

(C) Housekeeping and site tidiness

Housekeeping and site tidiness is one of the important factors affecting site safety as proved in many previous researches, such as Harper (1998) and Sawacha *et al.* (1999). According to Harper (1998), reduction in the occurrence of jobsite accidents may be achieved by an increased awareness of good housekeeping procedures. Sawacha *et al.* (1999) also found that sites which are tidy and well planned (layout) are more likely to provide a high level of safety performance. These comply with the explanation suggested by Hill and Trist (1953), which concluded that "the level of accidents in any working organization has been held to depend on the interaction of two major groups of factors. On the one hand, are what may be called ‘opportunities’ for accidents—the actual risk and hazards of the job; on the other, the propensities of individual to take these opportunities, that is, to have accidents”.

Apart from the merit of reducing the physical hazard in the workplace, housekeeping and site tidiness also brings another advantage. Levitt and Samelson (1987) highlighted that “there are various means for increasing safety visibility. One of them is through housekeeping.” He also mentioned that by strictly requiring the site to be kept clean and tidy, it convinces the workers that management’s commitment to job safety is genuine.

In view of the influence of housekeeping and site tidiness on site safety, Shimmin (1980) stated that “managers should realize that they must make every effort to ensure that safe working conditions begin at the design stage and are not jeopardized by poor site co-ordination.”

4.2 Individual Site Safety Cycle Elements

(A) Pre-work activities

The main benefit of pre-work activities is to identify potential hazard and make corresponding planning in advance. This is suggested by Harper (1998) and Hinze and Wilson (2000).

Harper (1998) mentioned that pre-construction site reviews help establish areas of concern. By utilizing a standardized checklist, the site review is completed by the superintendent before mobilization to the job site. Any areas of potential hazard or of particular concern will then be reviewed and addressed prior to beginning work on the job. The information will be relayed to the employees prior to the performance of any on-site work. This ensures the employees are made aware of the hazards inherent in a particular project. According to Hinze and Wilson (2000), it is found that pretask planning is vital to improved safety performance.

(B) HIA meeting

As mentioned by Harper (1998), the weekly “tool box” safety meeting, which is of a similar nature to the daily HIA meeting in SSC, has been implemented by one construction company in the United States and which has brought a great improvement on the company’s safety performance.

Such great impact is attributed to the employee involvement in the discussion of the prearranged safety topic and the rotation of the responsibility of leading the discussion among the personnel in the crew. This increases the awareness of the employees as to the importance of the materials being covered.

(C) Safety Inspection

There are many previous researches showing the importance of safety inspection to site safety, such as Nishgaki (1994), Jaselskis *et al.* (1996) and Hinze and Gambatese (2003). Nishgaki (1994) suggested that regular inspection of the site by safety patrols promotes good job safety, whereas Jaselskis *et al.* (1996) found that increasing the number of informal safety inspections helps improve a company’s recordable incidence rate. Similarly, Hinze and Gambatese (2003) found that projects have better safety records when the forepersons actually conducted the jobsite safety inspections.

There are two main purposes of safety inspection as summarized from the literature. First, safety inspection is used to ensure safety rules, or measures have been carried out and are incorporated into workers' daily operations and to identify hazard zones in the workplace. As mentioned by Harpers(1998), inspection tours of work sites help determine if safety rules are being observed, good housekeeping is maintained, protective devices and equipment are used appropriately, and hazardous or dangerous areas such as open excavations are properly posted and barricaded. Besides, as suggested by Holmes (1999), it is often the case that safety equipment is provided, but employees are reluctant, or neglect, to wear it. Consequently, the provision of safety equipment alone does not improve construction site safety without safety inspection to ensure its use.

Another main purpose of safety inspection is to provide a chance for the supervisors or managers to communicate directly with the workers which in turn helps to build a safety culture. According to Levitt and Samelson (1987), managers who walk the job frequently can obtain evaluations and information from every single person on the project, and also provide direct information to workers on actions taken to correct problems at the same time. Besides, it also mentioned that through communicating the message that safety is of critical importance and is a high priority in direct contacts with employees at all levels in job visits, a safety culture can be built in the organizations.

(D) Regular safety meeting on site

In the Site Safety Cycle, there are various kinds of regular safety meeting, such as daily PES meeting, daily HIA meeting, daily safety co-ordination meeting, weekly safety co-ordination meeting, monthly site safety management committee meeting and monthly site safety committee meeting. The effect of improving safety performance by regular safety meetings have been validated in many earlier researches. For example, in Jaselskis *et al*. (1996), it was proved that projects with more formal meetings to discuss safety performance with field supervisors have better recordable incidence rate. Besides, Sawacha *et al.* (1999) found that in order to have a better safety outcome, site managers and supervisors should engage in regular talks with operatives on site.

There are several advantages of having regular safety meetings. Firstly, Hinze and Raboud (1988) showed that regular meetings on site help to find occupational health and safety problems and solutions and improve accident prevention. Secondly, regular safety meeting can be used as a mean to convey safety information to different parties on site and helps to improve the co-ordination among them. This is supported by Tam *et al.* (2004) which mentioned that regular safety meetings are necessary for communicating safety information to all parties. Besides, according to Wilson and Koehn (2000), if there is a large number of subcontractors involved in a project, it is beneficial to have a weekly safety conference of foremen held by the main contractor, during which appropriate safety information and project scheduling was reviewed. It helps decrease potential problems caused by possible conflicts between various trades and hence increases the safety level at the job site. Thirdly, it provides a frequent contact between workers and supervisors on safety and other job matters, which according to Davics and Stacjo (1964) is most important to accident control efforts.

(E) Safety committee meeting and safety management committee meeting

According to Sawacha *et al.* (1999), it is found that safety committees can play a positive role in the improvement of safety performance. Such positive impact is explained by Lin (2001) that a safety committee, which consists of representatives of employer, worker and subcontractor, can encourage interaction between the parties and helps improve trust and communication and the expertise of each party can be put to use. It also helps to promote accident prevention and safe working habits by the employees. Similar explanation has also been made by Harper (1998) which found that the establishment of safety committees, made up of all levels of craft expertise, who conduct periodic site safety evaluations of their work site and confer with management at regularly scheduled meetings, has helped place an emphasis on safety at the employee level and provided chance for them to make recommendations for improving company safety through their input and ideas regarding modifications to standard work procedures or company safety guidelines. It also helps the safety officer in investigating any reported deficiencies in their work area.

(F) Safety Bulletin Board

Safety bulletin board displaying the safety policy of the contractor and the current accident statistics is one typical safety promotion activity to develop and maintain an awareness of key safety issues amongst all staff and to develop a culture of safety (Rowlinson, 2003).

Ahmed (2000) suggested that safety bulletin boards should be displayed in the vicinity of work areas in order to draw workers' attention to site safety and accident statistics should be posted and updated regularly on the board to encourage workers to constantly improve site safety.

Chapter 5

Safety Performance Measures

In order to conduct this research, it is necessary to measure the safety performance of the contractors and their project sites. There are various methods in measuring safety performance suggested by previous researches, each have their own advantages and disadvantages. Generally, they can be classified into two types, one is reactive measure, and another is proactive measure.

5.1 Reactive Measures

Traditional safety performance measures rely primarily on reactive measures (Mohamed, 2002). There are mainly two kinds of reactive measures; they are accident/injury statistics, and workers compensation statistics. They are reactive in nature since they measure safety performance by recording accidents only after they have occurred (Mohamed, 2003).

5.1.1 Experience Modification Ratings (EMR)

EMR is one example of workers compensation statistics. Based on Levitt and Samelson (1987), it is “a modifier based on a company’s past accident experience as reflected in insurance records at the time that the report is sent to the rating bureau.” For the calculation of EMR, it is a three-year running average starting one year prior to the last full year.

As mentioned by Levitt and Samelson (1987), there are several limits with EMR:

1) Since the time period used in calculating EMR for a given year is the three years prior to the immediate past year, a time lag will be resulted in showing the firm’s

safety performance from the EMR.

2) EMR may not be applied to small companies, their EMRs cannot reflect their own claims experience as good as those for larger companies.

3) Factors other than safety, like the reserving practices of the contractor's insurance company and a contractor's practices on monitoring of reserves, can affect EMRs. This is also supported by Hinze *et al.* (1995), which found that variables like labor cost or company size will drastically alter the EMR value without actual change in accidents.

4) The safety performance of new companies or new joint ventures cannot be directly compared with reference to EMR value since they are automatically rated at 100.

5.1.2 Accident/ Injury Statistics

Accident or injury statistics are one of the most common construction safety performance measures (Mohamed, 2003). Examples of accident/injury statistics include accident rate, OSHA recordable incidence rate (Levitt and Samelson, 1987), lost workday/restricted work activity injuries (Hinze and Godfrey, 2003), first aid injuries (Hinze and Godfrey, 2003) etc. There are several advantages in using the accident or injury statistics as measures of safety performance stated by Duff (2000) such as quantified, cheaply obtained and objective. However, as indicated by Trethewy *et al.* (1999), they have been universally regarded as being unsuccessful in providing meaningful measures of safety performance. There are many drawbacks in the data which make it a poor safety indicator.

First, according to Laitinen (1999), "the use of accidents as a safety indicator of a single building construction site is in most cases impossible" since the construction site's duration is rather short, typically lasts for only 1 year and the average number of workers on site are few. And, "because of random variations, many sites have no accidents and it is not possible to say whether they are safer than other sites with four or five accidents." Duff (2000) presented a similar view that since most construction sites are not very long running, over a shorter period, a safety performance measure based on accidents can be both unstable, reacting strongly to little change in behavior. Second, Glendon and Mckenna (1995) has identified that such data are insufficiently sensitive to improvement in behavior, of dubious accuracy, retrospective and ignore risk exposure. Besides, using accident or injury data will always encourage underreporting which is especially serious where worker safety incentive award programs are in place. As explained by Hinze and Godfrey (2003), "workers who receive minor injuries during the course of their work activities might be reluctant to report their occurrence if this will result in their disqualification from a worker incentive award." Another major problem with the use of such data is associated with the varied definition of accidents among different countries and places in constructing the accident or injury statistics which give rise to problems in international comparison as suggested by Rowlinson (2003). In Hong Kong, a reportable accident is defined as one that requires more than three days absence from work, whereas in Canada one day off work is reportable.

5.2 Proactive Measures

In contrast to reactive measures, safety performance can be measured using proactive measures. There are several examples of proactive measures, such as near misses, jobsite safety inspection, behavior based worker observation etc. Proactive measures mainly measure any event on site which may lead to injuries, or any unsafe conditions, worker behavior prior to the occurrence of accidents or injuries, the data and information collected by these measures can then be investigated and analyzed to find the root cause of the accident or to identify potential hazards. Such information may also provide direction for improvement in jobsite conditions and worker behavior. Therefore, they have the advantage of avoiding focusing on only the negative aspects of safety performance (Hinze and Godfrey, 2003).

5.2.1 Near Misses

Near misses refer to incidents in which no injury actually occurred but the potential for an injury existed. According to Hinze and Godfrey (2003), the occurrence of a near miss can be treated as a signal that a mistake has occurred. Even the injury had not occurred; investigations will be carried out to find the root cause of the accident with the intent of formulating an appropriate plan of action to prevent future occurrences. Thus, it can be a proactive measure to identify potential hazards. However, there are still weaknesses in using near misses. First, there is still no clear definition of a near miss. As mentioned by Hinze and Godfrey (2003), one definition of near miss is any incident that might have resulted in an injury if a worker had been stationed in the "wrong" location. Another definition regards accidents as near misses only if the potential existed for the occurrence of a serious injury. The second weakness of near misses is related to reluctant in reporting near misses. Since there is no clear definition of near miss, it may be treated in a similar manner as the occurrence of injuries which may attract management concern and in turn result in a negative response to near miss reports.

5.2.2 Jobsite Safety Inspections

Another proactive safety measure is jobsite safety inspection which makes use of the data collected from the inspections made on jobsites to assess physical working conditions and to evaluate worker safety behavior (Hinze and Godfrey, 2003). Such inspections may be made by a job superintendent, a safety committee, a safety representative, a consultant, and other company personnel from another project, etc. Such measure is similar to the approach developed by Lingard and Rowlinson (1998), Laitinen *et al.* (1999), Duff (2000) and Trethewy *et al.* (1999) which aimed at estimating the safety level of the site based on systematic observation of the site conditions and workers' behavior which take into account both compliance and non-compliance.

According to Reber *et al.* (1993), behavior observations data are superior to accident statistics as they focus on unsafe behavior prior to accidents occurring. As mentioned by Duff (2000), accidents can only be prevented if the workers are persuaded to change their unsafe behavior; therefore, any safety performance measures should be related to behavior as close as possible. Besides, behavior data are sensitive to changes in safety, allowing for immediate identification of some types of safety problems (Glendon and Litherland, 2001). As suggested by Hinze and Godfrey (2003), the information provided by this measure helps to give the direction for improving jobsite conditions and worker behavior, provided that the inspections are done on a frequent and consistent basis. However, information obtained from this measure by different inspectors may not be used for comparison if they are not trained to have consistent assessment on the nature of physical conditions and worker behavior. In addition, no allowance is made for the severity of the safety breach (Mohamed, 2003).

5.2.3 Behavior Based Worker Observations

Behavior based worker observations are a relatively new approach in measuring site's safety as indicated by Hinze and Godfrey (2003). Similar to the previous measure, this measure also mainly focus on safety behavior. In this measure, one worker will act as an observer to another worker. And after the observation period, the observer will review the observations with the worker and they will then discuss ways that certain tasks could be performed more safely.

One special merit of this method is the improvement on overall safety culture. Since the workers are responsible for assessment and corrections, they need to devise their own solutions in many instances. They will gain a sense of achievements in the process which tends to improve the safety culture on the site. Unfortunately, this method is not without its drawback. Since many different observers will be involved on a single project site, there may have many inconsistencies in the data obtained.

5.2.4 Worker Safety Perception Surveys

In this method, surveys will be conducted regularly to obtain the generic data about the site's safety conditions from worker's perception. Unlike other measures, the data obtained will not identify specific problems; rather, it can only give an overall measure of the quality of safety management on site as perceived by the workers. Besides, another problem with this method as suggested by Hinze and Godfrey (2003) is that the data obtained will be in a more subjective nature than other measures. But on the other hand, this measure gives a good sense of safety culture on site.

Chapter 6

Research Objectives and Hypothesis

The concept of Site Safety Cycle has entered Hong Kong's construction industry for at least 6 years, and according to Mr. K.L Chow, Chief Assistant Secretary (Works) of the ETWB, in the Hong Kong Construction Association Annual Safety Conference 2003, he stressed that *"We firmly believe that the implementation of Site Safety Cycle is the key to success in pooling the effort of all persons working on the site from senior management down to frontline operatives and workers to improve site safety and the feedback from contractors and workers tell us that the implementation enhances the communication on site."* However, he also mentioned that there is yet insufficient data to prove that the implementation of Site Safety Cycle will lower the accident rate of a contract. As a result, this research aims at using a quantitative approach to investigate whether the implementation of Site Safety Cycle has a significant effect on the improvement of company's and project site's safety performance which is summarized in the following hypothesis:

Hypothesis 1: Implementation of Site Safety Cycle improves safety performance.

If Hypothesis 1 is proved to be valid, the research will proceed to the second section which aims at investigating the effectiveness of implementation of the individual SSC elements in improving safety so as to find out the ways for improving the effectiveness of SSC.

Chapter 7

Methodology

7.1 Structure of the Research

The research is divided into three main sections. First is to examine the contractor's safety statistics before and after the implementation of SSC and test it against the entire industry's safety statistics to find out the relationship between implementation of SSC and contractor's safety performance. Second is to investigate the relationship between implementation of SSC and the safety performance of the construction site. Finally is to test the effectiveness of implementation of individual elements of SSC in improving the safety performance.

Information about the practices of SSC in Hong Kong construction sites are collected through questionnaire survey, while an interview will be conducted with the Safety Manager of Gammon Construction Limited to gather his view on SSC in Hong Kong generally. Since the research was originally designed as company-based, i.e. to investigate the relationship between individual contractor's practice of SSC and its safety performance, the pilot questionnaire was designed to ask for company wide information. However, after the pilot questionnaire was tested with one safety officer (who was found through personal network) in December 2004, it was found that each site has its own practice of SSC, even the project sites are under the same company, there would not be a company-wide practice. Thus, it is impossible to conduct a company-based research and the author decided to modify it into a project-based one which aims at comparing each site's safety performance against its own practice of SSC.

7.2 Structure of Questionnaire

The project-based questionnaire consists of three parts with a total of 57 questions as shown in Appendix 1. In order to increase the response rate, apart from the last question about the interviewee's opinion and comment about the SSC implemented in his site, all of the questions require only short or multiple choice answer by filling in numbers or ticking boxes so as to minimize the time and effort spend by the interviewee on the questionnaire.

The first part is designed to collect some background information of the project, e.g. nature of work, contract value, number of workers etc, and the project's safety statistics. The second part aims at collecting information about the site practice of SSC, e.g. how many elements of SSC were implemented, how was each element implemented etc, which is designed on the basis of the Environment, Transport and Works Bureau (2002). The third part is provided to obtain the interviewees' general opinion or comment about the SSC. Name of the interviewee and his contact number were also asked to be provided at the end of the questionnaire so as to facilitate any follow-up action in case the information collected is unclear or ambiguous.

7.3 Distribution of Questionnaire

The questionnaires have been sent to 14 different project sites under Gammon Construction Limited in Hong Kong and the target respondents of this survey is the safety supervisors or safety officers on each project site. Due to the limitation with the use of safety performance assessment method used in this research[19] which restricts direct comparison of the safety performance of project sites under different contractors, only one contractor in Hong Kong is involved in the research. Gammon

[19] For details of the safety performance assessment method used in this research, please refer to 7.5.2.

Construction Limited is chosen base on several reasons. First, it has implemented Site Safety Cycle for more than six years which can provide adequate information in this aspect for study. Second, due to the personal network of the author, the company is willing to provide detailed and complete information for the study. Third, it is one of the contractors in Hong Kong which is well-known for its high safety standard. The 14 project sites were suggested by the Safety Manager of Gammon Construction Limited mainly base on the project duration so as to guarantee adequate safety information and statistics are available for study.

7.4 Interview with Safety Manager of Gammon Construction Limited

In order to gather the general information about SSC in Hong Kong and to investigate the performance of SSC from a practitioner's point of view, an interview has been conducted with the Safety Manager of Gammon Construction Limited, Mr. Jesse Hau. In total, five main questions were asked in the interview (as shown in Appendix 2).

7.5 Assessment Methods

In order to investigate the relationship between implementation of SSC and the safety performance of construction sites, it is necessary to develop a quantitative measurement of the degree of implementation of SSC and the safety performance of the construction sites.

7.5.1 Implementation of Site Safety Cycle

Two ways were used to assess the degree of implementation of SSC. First is by simple calculation of the number of elements in SSC that is implemented. The more elements of SSC that are implemented, the higher degree its implementation is. According to the questions in the questionnaire designed, the maximum number of SSC elements that a site can implement is 14 elements.

Another method is by a scoring system (as shown in Appendix 3) which is developed by basing on the proximity to the ETWB's requirement of implementation of SSC on their public works projects. That means, a higher score will be given for that site's degree of implementation of SSC if its practice is closer to the ETWB's requirement than another site.

7.5.2 Safety Performance of Construction Sites

As mentioned in the literature review, according to Laitinen (1999), "the use of accidents as a safety indicator of a single building construction site is in most cases impossible". Laitinen instead proposed another method in estimating the site's safety level which is based on systematic observation of the conditions on site. And Laitinen's research in 1999 has proven the validity of this observation method, he also insisted this method is even a better indicator of safety on a single building site than the accident rate.

In view of the incapability of accident or injury statistics in representing the site's safety performance, it is preferred to use the behavior observation approach. However, this observation method requires a safety inspector to determine whether the conditions on site are safe or not, and the author has never undertaken any related professional safety training. Due to the limitation of ability and time, the author has given up this method.

It was discovered that the Gammon Construction Limited has used a league table method to rank the safety performance of its project sites. In the league table method, each site's safety performance is ranked according to its number of reportable accidents, fatalities, incidence rate, dangerous occurrence, violation of health and safety legislation, violation of environmental legislation, utilities damage etc. with a different weighting assigned depending on its seriousness. Instead of just relying on the accident rate to determine the safety level of a site which may not be reliable enough due to its random variable nature mentioned in Laitinen (1999), this method gives a more comprehensive picture of the site's safety level. Hence, this method was used in the research to represent the safety performance of the construction sites.

7.6 Analysis Procedures and Methods

All the statistical tests performed in this research will be tested using the statistical software SPSS 12 for Windows. In the following part, the procedures of the analysis and the details of different analysis methods employed in different sections of the research will be elaborated.

7.6.1 Section I

This section mainly consists of two parts (Section IA and IB). First is to test the relationship between implementation of Site Safety Cycle and contractor's safety performance. In order to study the impact of the implementation of SSC on the company's safety performance, the company's safety statistics from 1991 to 2004 will be investigated using intervention analysis which mainly consists of the autoregressive-integrated-moving averages model (ARIMA model) and simple linear regression. The intervention analysis was developed by Box (1975) which involves four stages: (1) developing an ARIMA model for the time series data, (2) adding one dummy variable to represent the timing of the intervention, (3) testing the model with the new dummy variable, (4) interpreting the coefficients of dummy variables as measures of the effect of the intervention (Lingard, 1998).

In the second part, the entire construction industry's safety statistics in the same period will be investigated using the same method to examine whether the improvement bought by SSC shown in the first part is significant when it is compared with the safety performance in the entire industry.

7.6.1.1 ARIMA Model

In order to estimate the effect of the implementation of SSC on the company's safety performance, the company's incidence rate from 1991 to 2004 will be examined in Section IA whereas the construction industry's accident rate[20] for the same period will be examined in Section IB. Two different kinds of data are used for study because on one side, there is no accident rate of the company provided to the author, on the other side, the construction industry's incidence rate is unavailable. Though it is understand that the comparison study should be conducted using same kind of data, under such limitation, and the aim of the study is to investigate the improvement effect bought by the SSC, so the absolute level of safety performance is unnecessary and using two different kinds of data should be acceptable.

Both kinds of data are in the form of time series data. Grander (1986) described a time series as "a sequence of observations ordered by a time parameter". As mentioned by Yaffee (2000), the series used should consist of observations that are equidistant from one another in time and contain no missing observations ideally. According to Box (1975), Lingard (1998) and Goh (2005), if the data are in the form of time series in

[20] This refers to accident rate per 1,000 workers which is available at http://www.oshc.org.hk/.

which successive observations are serially dependent and nonstationary[21], the assumptions underlying simple procedures such as ordinary t test will be violated such that they will not be valid for estimating and testing for a change in mean due to an intervention, like implementation of SSC in this case. Instead, more advanced techniques like the ARIMA model should be used for time series data. ARIMA model, with its full name as autoregressive-integrated-moving averages model, are designed to account for the systematic error present in a time series. It is characterized by three structural parameters (p, d, q), each reflecting a different component of a time series process (Lingard, 1998).

In the first step, it is required to identify the ARIMA model, the autocorrelation coefficient (ACF) and partial autocorrelation coefficient (PACF) plots should be examined. According to Goh (2005), there are six most widely used models and their characteristics are summarized in Table 7.1.

Model	**Theoretical ACF**	**Theoretical PACF**
White Noise	All autocorrelations zero	All partial autocorrelations zero
AR(1)	Tails off towards zero	Cuts off after lag 1
AR(2)	Tails off towards zero	Cuts off after lag 2
MA(1)	Cuts off after lag 1	Tails off towards zero
MA(2)	Cuts off after lag 2	Tails off towards zero
ARMA(1,1)	Tails off towards zero	Tails off towards zero

Table 7.1 Summary of characteristics of six most widely used ARIMA models

(Source: Goh, 2005)

[21] Time series may be stationary or nonstationary. If a series is stationary, the magnitude of the autocorrelation attenuates fairly rapidly, whereas if the series is nonstationary, the autocorrelation diminishes gradually over time (Yaffee, 2000).

7.6.1.2 Simple Linear Regression

After the ARIMA model is identified, the transformed series will be tested in a simple linear regression as a dependent variable, whilst a dummy independent variable will be created to illustrate the implementation of SSC in 1998. This regression analysis is used to test the relationship between implementation of SSC and the company's safety performance which can be shown by the sign of the unstandardized B coefficient of the dummy variable.

The R^2 value found in regression is the proportion of variance in one variable accounted for by the other variable. The larger the R^2 value means the higher proportion of variance in a variable is explained by another variable.

In the regression analysis, a significance value will also be computed which determine the likelihood that the result is occurred by chance. The significance value (p) represents the degree of rarity of a certain result (George, 2003). If p is less than 0.05, that means there is less than a 5% chance that this relationship is occurred by chance, which also means the result is significant at the 95% confident level.

7.6.2 Section II

In this section, the individual project site's safety performance will be tested against its degree of implementation of SSC using 1) scatter diagram, 2) correlation test, 3) simple linear regression.

7.6.2.1 Scatter Diagram

A preliminary study of the relationship between the implementation of SSC and the site's safety performance is obtained by plotting the questionnaire responses on a scatter diagram.

Scatter diagram is a way of displaying the nature of correlations between variables. One dot is drawn for each case in the data file (George, 2003). By using scatter diagram, it is easy to have an overview of the distribution of the questionnaire response so as to get a preliminary understanding of the relationship under test.

7.6.2.2 Correlation Test

After a preliminary understanding of the relationship between the implementation of SSC and the site's safety performance is obtained from the scatter diagram, correlation can be used to get a more accurate analysis of the relationship.

Correlation is a statistical technique which can show whether and how strongly pairs of variables are related. The main result of a correlation is called correlation coefficient (r), ranges from -1 to +1. A correlation of +1 designates a perfect, positive correlation which indicates that one variable is precisely predictable from the other variable and as one variable increases in value, the other variable also increases in value, or vice versa. Similarly, a correlation of -1 designates a perfect negative correlation that means as one variable increases in value, the other decreases, or vice versa. The closer to +1 or -1 the r is, the more closely the two variables are related. A correlation of 0 indicates no relation between the two variables.

7.6.2.3 Simple Linear Regression

Simple linear regression is used as a further step to investigate the strength of relationship between the dependent variable (site's safety performance) and the independent variable (implementation of SSC).

7.6.3 Section III

In this part, the SSC will be broken down into different individual elements. Correlation analysis will be used to test the relationship between each particular element and the site's safety performance so as to find out whether the effectiveness of implementation of individual SSC elements in improving site safety.

Chapter 8

Questionnaire Result Analysis

8.1 Background Information

A total of 14 questionnaires were sent to different types of projects under Gammon Construction Limited and 11 of them were received.

Among the replied projects, 6 of them are private contracts (54.5%) and the remaining 5 are public (45.5%). The contract value ranges from 20 Millions Hong Kong Dollars to 15 Billions Hong Kong Dollars, and the number of workers employed for each project ranges from 25 to 950. All of the replied projects have implemented SSC. Among these, 7 of them replied that the implementation was incorporated as a voluntary nature (63.6%), and the remaining 4 of them implemented the SSC due to the contractual requirements (36.4%).

8.2 Analysis of Section I

8.2.1 Section IA

In this part, the company's incidence rate from 1991 to 2004 will be analyzed by ARIMA model and simple linear regression so as to test whether the implementation of SSC has made an improvement on the company's safety performance.

Before carrying out the regression analysis, the ARIMA model for the time series of the company's incidence rate is developed by examining the autocorrelation coefficient (ACF) and partial autocorrelation (PACF) plots. It is found that AR(1) model should be used. The results of the ACF and PACF plots are shown in Appendix 4 for illustration.

Then, the AR(1) model is used to transform the time-series into data used in simple regression analysis by ARIMA. In the regression analysis, the transformed company's incidence rate is tested as the dependent variable, while a dummy impendent variable is created to represent the implementation of SSC start from 1998. It is found that the relationship between the two variables is:

Company's incidence rate (transformed) = 107.783 – 69.085 Implementation of SSC

The negative sign of the unstandardized B coefficient of the independent variable is actually representing a negative relationship between these two variables, which means implementation of SSC helps lower the company's incidence rate. And a lower company's incidence rate means a better safety performance. The significance value is found to be 0.001 which mean the result is significant at the 99% confident level.

8.2.2 Section IB

In this part, the safety statistics of the entire construction industry will be tested following the same procedures as the previous part. As shown from the autocorrelation coefficient (ACF) and partial autocorrelation (PACF) plots, it is found that AR(1) model should be used. The results of the ACF and PACF plots are shown in Appendix 5 for illustration.

Then, the transformed industry's statistics are used to test in regression with a dummy variable A to represent year 1998 or after. It is found that the relationship between the accident rate of the construction industry and the dummy variable A is:

Industry's accident rate (transformed) = 269.205 – 109.182A

The negative sign of the unstandardized B coefficient of the independent variable is actually representing a negative relationship between these two variables, which means from 1998 onwards the industry's accident rate continues to show a downward movement. The significance value is found to be 0.007 which mean the result is significant at the 99% confident level.

When comparing the unstandardized B coefficient of the independent variable in Section IA and IB, it is found that the one in Section IB is larger that that in Section IA (109.182 > 69.085). This means the improvement in accidents statistics of the whole industry is greater than that of the company from 1998 onwards[22].

8.3 Analysis of Section II

8.3.1 Scatter Diagram

In this part, different sites' degree of implementation of SSC and their respective safety performance will be plotted on a scatter diagram to test preliminarily whether there is a relationship between them. As mentioned above, there are different methods in assessing the site's degree of implementation of SSC and its safety performance. All these different methods will be used to test the relationship.

(A) Number of SSC elements implemented VS incidence rate

In this part, the degree of implementation of SSC is determined by the number of SSC elements implemented which is the X-axis of the diagram while the incidence rate, representing the site's safety performance, is the Y-axis.

[22] Discussion on the reasons for such results will be included in Chapter 9.

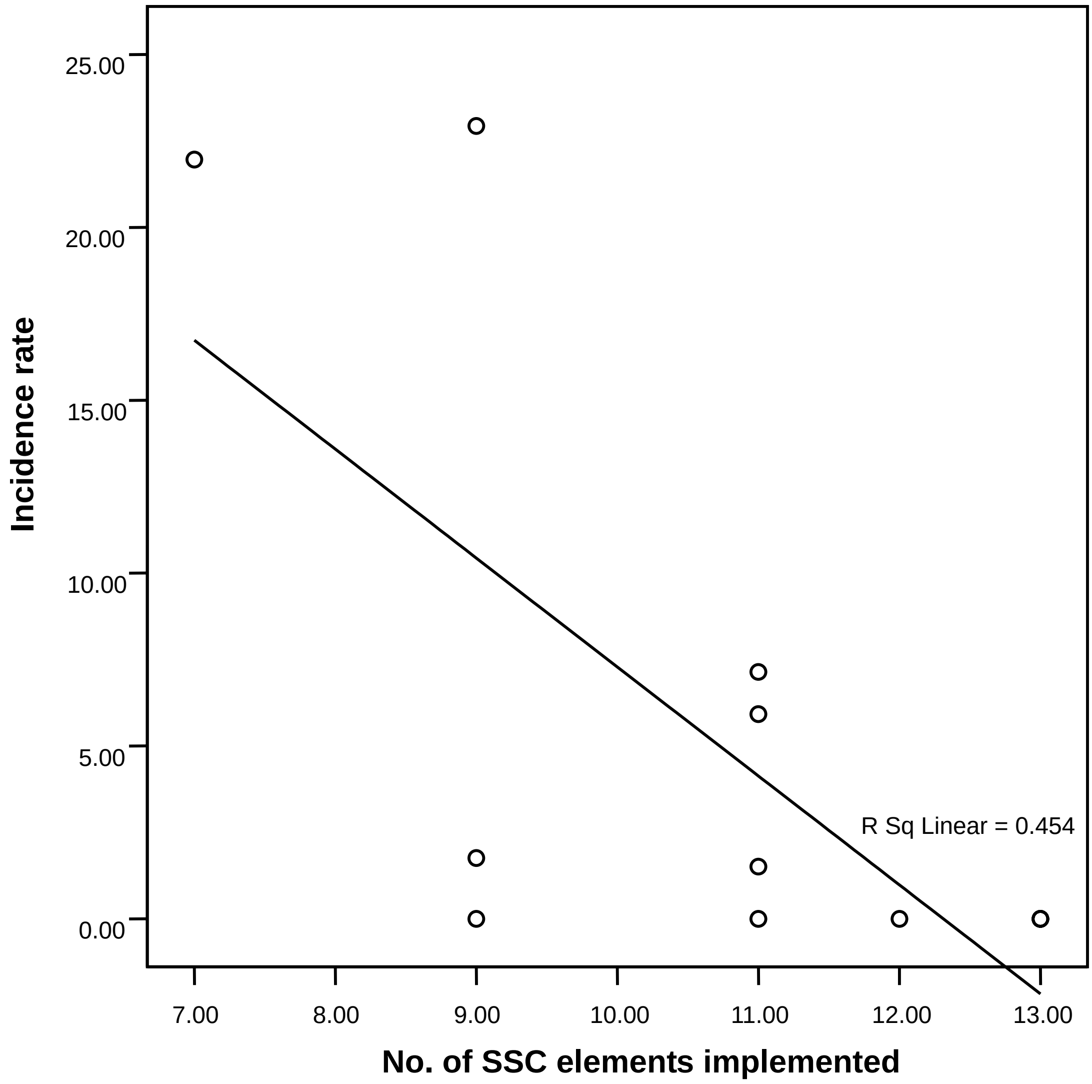

Figure 8.1 Number of SSC elements implemented against incidence rate

As shown from Figure 8.1, roughly it can be seen that the project site with the lowest number of SSC elements implemented have the second highest incidence rate while the remaining sites which showed a similar incidence rate have implemented more SSC elements, from 9 to 13. There is no indication of a strong relationship between the incidence rate and the number of SSC elements implemented.

(B) Number of SSC elements implemented VS league table ranking

In this part, the degree of implementation of SSC is still represented by the number of

SSC elements implemented while the site's safety performance is represented by the league table ranking, a larger ranking number means a lower safety performance.

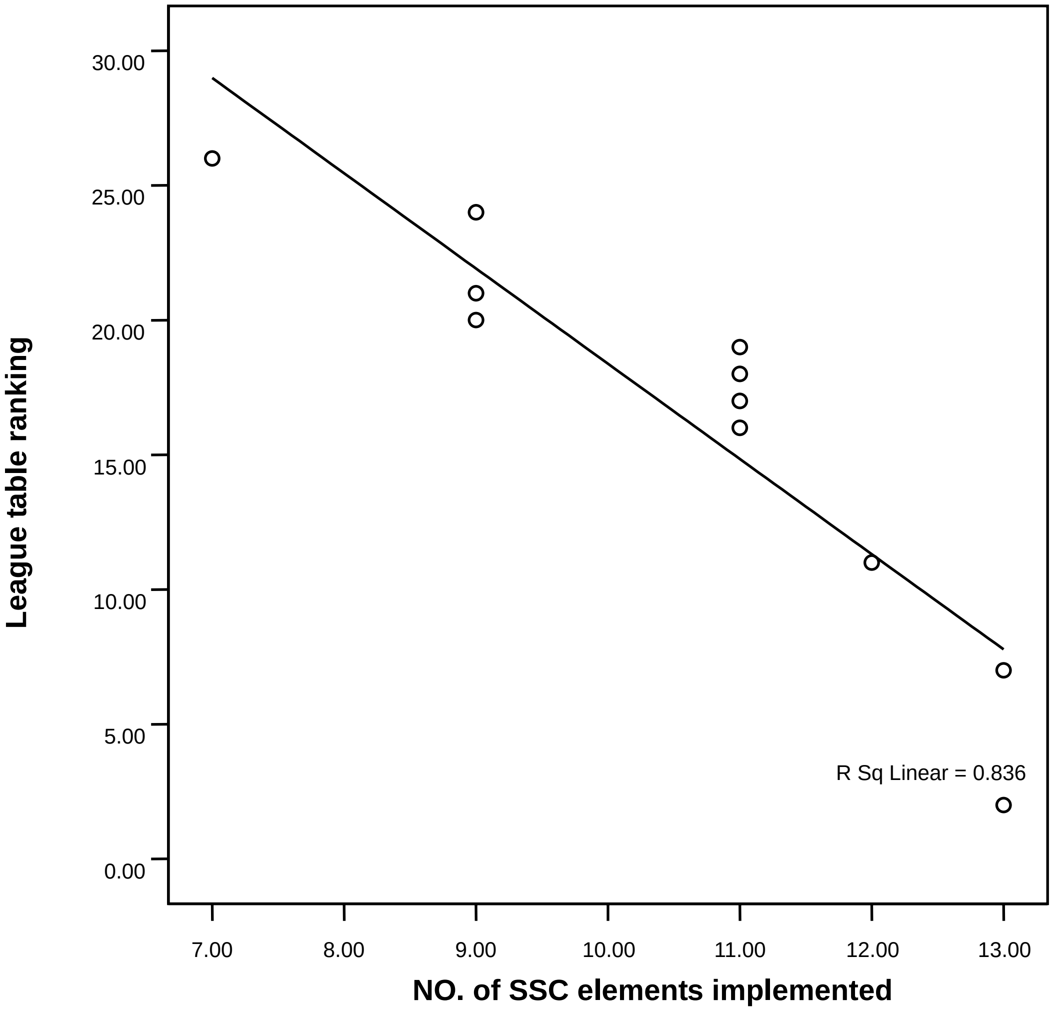

Figure 8.2 Number of SSC elements implemented against league table ranking

When compared with Figure 8.1, Figure 8.2 shows a much stronger relationship between the implementation of SSC and the site's safety performance by a downward sloping line between the league table ranking and the number of SSC elements implemented. It means that the sites with larger league table rank number, i.e. lower safety performance, are those implementing fewer number of SSC elements.

(C) Degree of implementation score VS incidence rate

In this part, the degree of implementation is represented by the SSC score it attains, which is measured by its proximity of implementation of SSC to that required by the ETWB. For the site's safety performance, incidence rate is used.

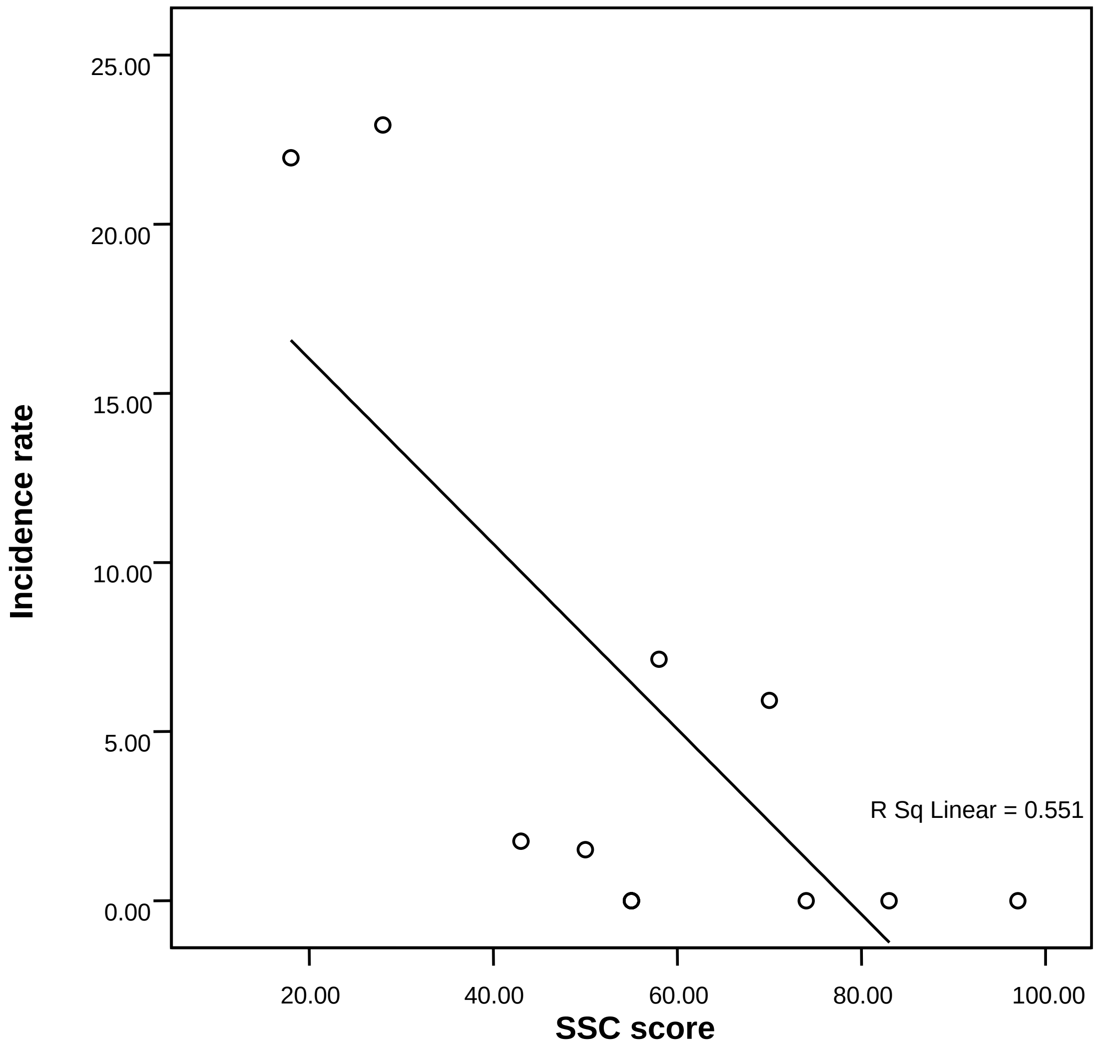

Figure 8.3 SSC score against incidence rate

In this case, a similar result was found with that of the first case, i.e. there is no indication of a strong relationship between the incidence rate and the SSC score except roughly it can be noticed that the two sites with the lowest SSC score are those having the highest incidence rate.

(D) Degree of implementation score VS league table ranking

In this part, the degree of implementation is still represented by the SSC score while the safety performance is changed to be represented by the league table ranking.

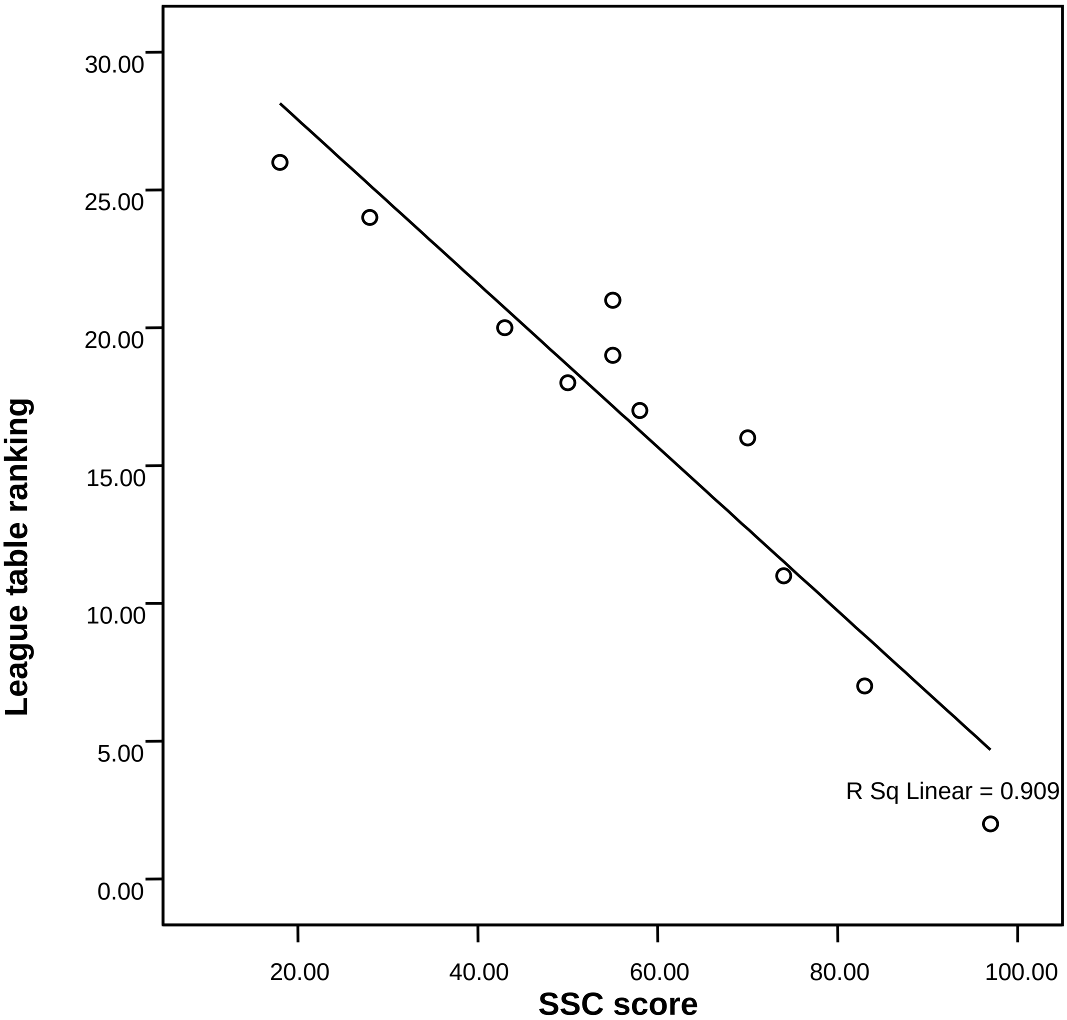

Figure 8.4 SSC score against league table ranking

Figure 8.4 shows a much stronger relationship between the degree of implementation of SSC and the safety performance when compared with Figure 8.3.

In considering the four cases above using different methods in assessing the degree of implementation of SSC and the safety performance, all of them roughly showed similar result of a negative sloping line, which means a site with a higher degree of implementation of SSC usually has a better safety performance.

However, it is found that the two cases using league table ranking to represent the site's safety performance (B and D) have a larger R^2 value of around 0.8 to 0.9 when compared with the two cases using the incidence rate (A and C) which have a R^2 value of around 0.4 to 0.5. This means that there is an indication of a stronger positive relationship between the site's safety performance and the degree of implementation of SSC in the league table ranking cases (B and D) than that in the incidence rate cases (A and C).

One possible factor of having such result is the random variable nature of incidence rate as mentioned by Laitinen (1999) which renders it unreliable to represent the site's safety performance. Since each project's typical duration is short and the average number of workers on each project site is few, it is impossible to determine whether the sites with zero accidents are safer than sites with four or five accidents. This makes it unreliable to be used as site-level safety indicator. As a result, in view of the incapability of the incidence rate in representing the site's safety performance, it is reasonable to expect that it would not be able to show the relationship between the site's safety performance and the degree of implementation of SSC.

8.3.2 Correlation

Same as the previous section, the correlation test has been run in four cases using different assessment methods in representing the site's safety performance and degree of implementation of SSC.

	Pearson Correlation (r)	Significance (p)
(A) Number of SSC elements implemented VS incidence rate	-0.674	0.023 (95% confident level)
(B) Number of SSC elements implemented VS league table ranking	-0.914	0.000 (99% confident level)
(C) Degree of implementation score VS incidence rate	-0.742	0.009 (95% confident level)
(D) Degree of implementation score VS league table ranking	-0.953	0.000 (99% confident level)

Table 8.1 Correlation result of implementation of SSC against site's safety performance

All of the four cases showed negative sign in the Pearson correlation coefficient (r) which indicates a positive relationship between the implementation of SSC and site's safety performance. In the four cases, the r values range from -0.674 to -0.953 with an average value of -0.821, this is quite close to -1. And it means there is a rather strong negative correlation between the two variables.

Besides, same as the scatter diagram part, cases B and D give a more significant result than cases A and C as shown from the significance value (p). It is believed that the same reason of the incapable nature of incidence rate in representing site's safety performance applies.

8.3.3 Simple Linear Regression

In this part, instead of merely assessing the direction of the relationship, the extent that the site's safety performance is influenced by the implementation of SSC will also be investigated. As shown from the previous steps, the league table ranking is better in representing the site's safety performance than the incidence rate by giving more significant result. Hence, in this part the regression test will only be done using the league table ranking in testing the relationship between the two variables: 1) site's safety performance 2) implementation of SSC.

(A) Number of SSC elements implemented VS league table ranking

A simple linear regression analysis is done with the league table ranking being the dependent variable and the number of SSC elements implemented being the independent variable. It is found that the relationship between these two variables is:

League table ranking = 53.723 – 3.534 Number of SSC elements implemented

As shown from the negative sign of the unstandardized coefficient of the independent variable, it complies with the previous analyses that a positive relationship is found again with a significance value of 0.000 that is significant at the 99% confident level. And the R^2 is found to be 0.836, which means 83.6% of the variance in the league table ranking is explained by the variance in the number of SSC elements implemented.

(B) Degree of implementation score VS league table ranking

In this case, the representation of the implementation of SSC is shifted from the number of SSC elements implemented to the degree of implementation score which means the dependent variable is league table ranking while the independent variable is the degree of implementation score.

The relationship is found to be:

League table ranking = 33.484 – 0.297 Degree of implementation score

Similarly, it shows a positive relationship (as shown from the negative sign) between the site's safety performance and implementation of SSC with the significance value of 0.000 which means it is significant at the 99% confident level. The R^2 is found to be 0.909 representing 90.9% of the variance in the league table ranking is explained by the variance in the degree of implementation score.

8.4 Analysis of Section III

8.4.1 Correlation

A correlation test is done for each individual SSC element to investigate its relationship with the site's safety performance. The degree of implementation of each SSC element is represented by the SSC score it attains, whereas the site's safety performance is represented by league table ranking. Table 8.2 shows the summarized result of the correlation test.

	SSC elements	Pearson Correlation (r)	Significance(p)	Order of contribution to dependent variable
A	PES meeting (Daily)	-0.664	0.026	4
B	HIA meeting (Daily)	-0.796	0.003	1
C	Pre-work safety check (Daily)	-0.382	0.247	9
D	Safety inspection (Daily)	-0.695	0.017	3
E	Guidance and supervision during work (Daily)	-0.030	0.931	13
F	Safety co-ordination meeting (Daily)	-0.512	0.108	6
G	Cleaning and tidying up of the site (Daily)	-0.643	0.033	5
H	Checking of site after work(Daily)	-0.233	0.491	10
I	Safety walk (Weekly)	-0.748	0.008	2
J	Safety co-ordination meeting(Weekly)	-0.698	0.017	3
K	Overall cleaning and tidying up(Weekly)	-0.390	0.235	8
L	Site safety management committee meeting (Monthly)	-0.078	0.819	12
M	Site safety committee meeting (Monthly)	-0.163	0.631	11
N	Safety bulletin board	-0.503	0.115	7

Table 8.2 Correlation result of individual SSC element VS site's safety performance

As shown from the negative sign of the Pearson correlation coefficient (r), all the 14 elements showed a positive relationship with the site's safety performance, which means a higher degree of implementation of that particular element results in a better site's safety performance. However, not every element showed a significant result. By using the 95% confident level ($p<0.05$), only the following elements have a significant result: 1) Daily HIA meeting 2) Weekly safety walk 3) Weekly safety co-ordination meeting 4) Daily safety inspection 5) Daily PES meeting 6) Daily cleaning and tidying up.

Chapter 9

Discussion

9.1 Section I and II

In Section IA, it is found that when SSC is implemented starting from 1998, the company showed an improvement in its incidence rate. However, in Section IB, it is found that the improvement in the industry's accident rate is greater than the improvement in the company's incidence rate. So, why is this result obtained?

There are three possible reasons for such result. First, it is possible that since Gammon Construction Limited has long been a well-known construction company for its excellent safety performance, its safety systems have been well-established even before the implementation of SSC. Hence, although there is an improvement resulted after such implementation, the improvement will not be as great as that of other construction companies with safety performance about or below the industrial norm. Therefore, the industry as a whole has a greater improvement in safety.

Second, it is also probable that the improvement in safety performance has not been fully reflected from the accident statistics. According to Glendon and Mckenna (1995), accident data are insufficiently sensitive to improvement in behavior. Since good safety performance does not refer only to no or a few accidents, it should also include the safety behavior. There may be chances that safety behavior is improved, but which cannot be reflected in the accident rate or incidence rate. As a result, it may happen that even the company's safety performance has been improved due to the implementation of SSC, there is no evidence showing it from the incidence rate.

Another possible reason is related to the use of different kinds of data. As mentioned before, due to the limitation of the data available, it is only possible to use these two different kinds of data for the study.

Then, for Section II, all of the tests which include Scatter diagram, Correlation, Regression, showed a similar result that there is a positive relationship between the implementation of SSC and site safety performance. Apart from the statistical analysis, the positive relationship between the implementation of SSC and safety performance, no matter at site or company level, has also been supported by the Safety Manager's opinion obtained from the interview. Therefore, it can be concluded that there is a positive relationship between the implementation of SSC and safety performance, which means Hypothesis 1 has proved to be valid.

The success of SSC in improving the safety performance of contractors in Hong Kong may be attributed to several reasons. First, it helps to incorporate different safety activities into an organized and systematic manner. According to Mr. Hau, the daily, weekly and monthly cycle of SSC helps organizing different safety activities into a systematic manner which are easy to follow by safety staff, workers and subcontractors. Although there are no new safety components in Site Safety Cycle, all of the elements in every cycle exist and many of them have even been used in the industry long before the introduction of Site Safety Cycle, they exist in a piecemeal nature. Without a systematic organization of these elements, it is difficult to have a smooth implementation. Therefore, the main merit of Site Safety Cycle is to act as a management tool to organize and link these piecemeal elements together in a systematic way.

Organizing the piecemeal safety activities into a systematic whole is especially important to workers in Mr. Hau's opinion since the common education level of the typical workers in Hong Kong construction industry is relatively low, they find it difficult to understand and participate in various discrete safety activities without following the SSC.

Second, the SSC helps to raise the safety awareness of workers and even subcontractors. As mentioned by Mr. Hau, SSC is effective in raising both workers' and subcontractors' safety awareness since it incorporates all safety activities in a whole which makes promotion of safety concept much easier and effective.

Another major reason for the success of SSC is related to its emphasis on planning and prevention. By analyzing the nature and objective of various SSC elements, it can be found that many of them have a planning and prevention component, e.g. pre-work safety check which helps prevent accident due to unsafe site conditions or equipments, daily safety co-ordination meeting which aims at planning and coordinating site safety issues for the following day, etc. Mr. Hau pointed out that one major contribution by SSC on the improvement of site's safety is its capacity in identifying the high risk activities before commencement of work by focusing on planning and prevention, which allows some control measures to be developed in advance so as to prevent the occurrence of accident.

To conclude, the success of SSC in improving safety performance are due to two characteristics which result in three implications.

The two characteristics are:

1) it is a systematic system which organizes and incorporates various discrete

elements as a whole;

2) it focus on planning and prevention.

The three implications are:

1) smooth implementation of safety activities;

2) increase in workers' safety awareness;

3) prevent occurrence of accidents.

9.2 Section III

From the correlation test, although all SSC elements showed a positive relationship with safety performance, not every SSC elements showed a significant result on the improvement of site's safety performance. The insignificant elements include 1) pre-work safety check (daily), 2) guidance and supervision during work (daily), 3) safety co-ordination meeting (daily), 4) checking of site after work (daily) 5) Overall cleaning and tidying up (daily), 6) site safety management committee meeting (monthly), 7) site safety committee meeting (monthly), 8) safety bulletin board. The insignificant result for these elements can be explained by two possible reasons. The first one is the problem of effectiveness for the current implementation and practice of these elements. In the correlation test, SSC score attained by each particular element is used to represent its current degree of implementation. The higher the degree of implementation as proximate to the practice set by the ETWB in the technical document, the higher SSC score it will attain. And from the result of the correlation test, the positive relationship between some elements' degree of implementation and safety performance is not significant which means that such relationship may be occurred by chance, it will not always be the case. This implies that even the degree of implementation of such element is high; it does not necessarily mean the safety performance will be improved. Hence, it is believed that there may be problem with the effectiveness of current implementation and practice of these elements. It may then be directed to the problem with the current practice set by the ETWB required in the public works contract. The current practice as required by the ETWB for these elements may not be the most effective one which may still have room for improvement and require modifications to suit Hong Kong construction industry.

Another possible reason for the insignificant result is limitation of the study. Since the sample size is rather small which consists of 11 sites only, but it is expected that there are hundreds of sites in Hong Kong that have implemented SSC now or before, the variations in the practice of the insignificant SSC elements in these 11 sites may not be adequate enough to produce a significant result.

For the SSC elements that have shown a significant result, they are those found from the correlation test with the significance value (p) smaller than 0.05, which include, 1) PES meeting (daily), 2) HIA meeting (daily), 3) safety inspection (daily), 4) cleaning and tidying up (daily) 5) safety walk (weekly), 6) safety co-ordination meeting (weekly).

Most of these elements are in the daily cycle of SSC, which means they are held or conducted on every working day on site. There are three possible reasons for such result. First, according to Sawacha *et al.* (1999), one of the reasons for accidents at work to occur is carelessness. He also suggested that ‘unsafe behavior’ is the most significant factor in the cause of site accidents. By conducting the safety activities as frequent as a daily level, workers’ safety awareness will be greatly enhanced. Everyday they work on site, they will be reminded of the importance of safety through various SSC daily activities, like HIA meeting, safety inspection etc. It will then be less likely for them to have unsafe behavior which helps to avoid the occurrence of accidents on site.

Secondly, even there are numerous safety programs designed for improving site's safety, it will be of no use if they are not properly implemented. The actual success of the safety program depends upon whether it is carried out during daily operations (Agrilla, 1999). Therefore, the daily SSC elements work well in ensuring the companies' safety policy has been incorporated into daily site operations.

Another reason for the importance of daily SSC elements is related to the accident's random variable nature. Since accident may occur at any time and in any place, there is no safety program or system which can 100% guarantee accident will not occur no matter how comprehensive and effective it is. Hence, by increasing the frequency of safety activities to be conducted, the chance of having accident on site will be greatly reduced.

In the following part, the reasons for the significant positive relationship between the implementation of these six particular elements and the site's safety performance will be further elaborated.

(A) Daily PES meeting

From the result of the correlation test, there is a significant positive relationship between implementation of daily PES meeting and safety performance. There are several possible reasons for such result. First, it prepares the workers to start work with safe behavior both physically and mentally. On one hand, the stretching exercises help the workers' body to warm up, so that it will be less likely for them to be injured when they start work. On the other hand, the announcement of the specific safety concern on site helps remind the workers the potential hazard areas and be prepared to avoid such dangers.

Second, the daily PES meeting helps demonstrate the company's care of safety to the workers. Through the daily PES meeting, the workers can directly feel and understand safety is one of the top prioritized issues in the company's policy which is as important as production. According to Andriesson (1978), the workers can be expected to work safely if they understand their supervisor regards safety equally important as production.

Another major reason is related to the presentation of awards to the workers in the PES meeting. Through presenting award to recognize the contribution to safety by the workers, the workers will work more safely as they can feel the respect to their contributions (Andriesson, 1978).

(B) Daily HIA meeting

The result of the correlation test indicates that daily HIA meeting is one of the most effectively implemented SSC elements in improving site's safety. It complies with the results of many earlier researches about the importance of regular safety meeting between the management level's staff and operation level's workers, such as Sawacha *et al.* (1999), Hinze and Raboud (1988) and Harper (1998)[23].

The importance of daily HIA meeting can be explained by several reasons. Firstly, it provides an opportunity for the front-line workers to be involved in the safety

[23] Please refer to Chapter 4 for further details.

planning process. As suggested by Dejoy (1985), the high level management often has little first hand experience on site, it is difficult for them to relate to the needs of the workers when planning the safety program. Also, as supported by both Lin (2001) and Koehn and Surabhi (1996), the front-line workers tend to be more aware of hazards in the work place than the supervisors, their opinion and suggestions should be highly useful to the improvement of the safety program and its workability.

Secondly, through the daily meeting, it improves the communication between supervisors and workers which is a critical component in improving site's safety as supported by previous researches, such as Dejoy (1985) and Simon and Pioquard (1991). Dejoy mentioned that a safety program is most effective when it involves two-way communication between workers and managers. Simon and Pioquard also suggested that both management communication and employee's feedback are critical in improving safety. Besides, as proved by Mohamed (2002), the more effective is the organizational communication dealing with safety issues, the more positive the safety climate is.

Another reason for the importance of the daily HIA meeting is related to the smooth implementation of safety programs achieved by involving the front-line workers in the discussion and planning process. As supported by Langford *et al.* (2000), company's management should hold a positive attitude towards involving workers in safety system development, so that they can have an ownership in the safety system. It not just enhances their understanding and acceptance of the safety program's implementation, but also increases their commitment to safety. As suggested by Harper (1998), an additional commitment can be gained from the workers through this type of involvement since they have a desire to execute the things that they have developed or assisted in developing which will increase their sense of ownership and responsibility in implementing the safety program and hence improve the site's safety.

(C) Daily safety inspection and weekly safety walk

Since both daily safety inspection and weekly safety walk are safety activities of similar nature, they are grouped to be explained here. Many previous researches found that jobsite safety inspection helps to improve and promote good job safety, such as Nishgaki (1994) and Hinze and Gambatese (2003). The result of the correlation test was found to be consistent with these researches that both the daily safety inspection and the weekly safety walk are found to be the most effectively implemented SSC element in improving site safety.

First, the primary objective of safety inspection is to check whether there are any unsafe acts or unsafe conditions and to ensure the safety instructions issued in the daily PES or HIA meeting have been implemented in site's operations. Thus, the safety inspection helps to improve site's safety in two ways. First, it acts as a deterrent to workers' unsafe acts. The workers will always aware not to perform unsafe acts since they know that whatever they have done wrong, the safety supervisors will find out in the safety inspections. Second, it can be seen as providing an incentive for the workers to work safely since the safety inspection is actually demonstrating a signal to the workers that safety is a serious concern by the company's management and any unsafe behavior will not be tolerated. This is supported by the findings from Langford *et al.* (2000), which found that operatives will be motivated to work safely if the management and supervisors have shown a constant attention to safety issues and there is an apparent provision of the necessary safety infrastructure. Besides, Levitt and Samelson (1987) also mentioned that if unsafe behavior is condoned, safety will not be considered a high priority on the job.

Secondly, the safety inspection acts as a chance for providing direct contact between the workers and safety supervisors. As indicated by Davics and Stacjo (1964), “the frequent daily contact between workers and supervisors on safety and other job matters is most important to accident control efforts”. The safety inspection also provides a chance for the site managers to communicate directly with workers which can also be a suitable opportunity to convey the safety importance message to the workers. It is supported by Sawacha *et al.* (1999), which found that if site managers and supervisors are engaged in regular talks with operatives on site, there will be a better safety outcome. Besides, according to Levitt and Samelson (1987), managers who walk the job frequently can obtain evaluations and information from every single person on the project, and also provide direct information to workers, which include the importance of safety and actions taken to correct problems, at the same time.

(D) Daily cleaning and tidying up of site

The correlation test has proved that daily cleaning and tidying up of site is effectively implemented to improve site’s safety which complies with several previous researches, such as Harper (1998) and Sawacha *et al.* (1999). The main reason for such result has been mentioned in Sawacha *et al.* (1999) that clean and tidy site is so important in improving site’s safety since it improves he job condition to minimize the risk of accidents in the physical environment.

Another major contribution by clean and tidy site to safety is related to the signal given to the workers by the company. According to Levitt and Samelson (1987), through strictly requiring the site to be kept clean and tidy, it convinces the workers that management’s commitment to job safety is genuine. Also, if the workers understand that even a little untidiness of the site is not acceptable in the company's point of view, they will realize the importance of safety.

(E) Weekly safety co-ordination meeting

The result of the effectiveness in implementing the weekly safety co-ordination meeting to improve site's safety complies with the result of Hinze and Raboud (1988) that when safety issues are included in regular co-ordination meetings, the safety performance of the projects is better. There are two main reasons for the importance of the safety co-ordination meeting. Firstly, it provides a chance for different parties on site to meet and discuss safety issues which helps to improve the communication and co-operation among each other. It is indicated by Langford *et al.* (2000) that without co-operation between team members and co-ordination of safety systems, the safety system management alone cannot ensure safety on site. Besides, as mentioned by Levitt and Samelson (1987), "many times craft groups are not aware of the safety problems which they are creating for other crafts", through the safety co-ordination meeting, they can understand what other work teams are doing and hence, reduce the chance of creating problems to them.

Secondly, through the safety co-ordination meeting, the health and safety issues can be planned beforehand. As suggested by Levitt and Samelson (1987), planning helps to improve safety performance in two ways. First, it identifies in advance any special equipment, tools, or safety devices needed to do a job efficiently and safely so that the workers will not try to use unsuitable equipment to do the work so as to finish the work as soon as possible and avoid delay. Second, it helps reduce the crisis which occurs in case of unplanned situations. According to Levitt and Samelson's research, stress will be caused by crisis in a project, which will in turn lead to accidents. If an operation is well-planned, there will be fewer crisis, and hence lower stress level, which result in better safety.

Chapter 10

Conclusion

10.1 Conclusion and Recommendation

The safety performance of the construction industry in Hong Kong has shown a significant improvement since 1998 when compared with those of other industries in Hong Kong. It is believed that such improvement is bought about by the effect of various safety measures introduced in Hong Kong construction industry these years and the increased awareness of safety in the industry. Site Safety Cycle is widely believed in the industry that it is one of the safety measures among them. However, there is yet sufficient evidence in supporting this view and since the safety performance of Hong Kong construction industry still lags behind many other developed countries, there should still be room for improvement. Therefore, a quantitative analysis has been conducted in this study to investigate the relationship between implementation of Site Safety Cycle and safety performance, also an attempt has been made to find out whether the current practice of SSC is effective in improving safety.

Through the analysis, it is proved that implementation of Site Safety Cycle improves safety both in company and site level. Besides, it is also found that not every Site Safety Cycle has been effectively implemented to improve safety currently. And from the interview with a safety manager in a construction company in Hong Kong, the merit of implementing Site Safety Cycle has been illustrated from a practitioner's point of view. After analyzing the reasons of obtaining these results, it is suggested that safety performance of the construction industry in Hong Kong may be further improved by the following recommendations regarding Site Safety Cycle.

1) Promotion on the use of Site Safety Cycle

As mentioned by Mr. Hau in the interview, there are already many construction companies in Hong Kong implementing Site Safety Cycle and have gained an improvement in their accident records. Nevertheless, most of them are large or medium-sized construction companies. For the smaller-sized construction companies, many of them have difficulties in implementing Site Safety Cycle as indicated by Mr. Hau. Therefore, it is suggested that the promotion target of Site Safety Cycle in the coming years should be those smaller scale construction companies. It can be achieved by the concerted efforts of various safety related organizations in Hong Kong, such as the Labour Department, the ETWB, the OSHC, etc. by first investigating the difficulties encountered by the small-sized construction companies in implementing Site Safety Cycle, so as to provide some suggested modifications on the current practice which can suit their needs and allow them to implement it easily. Second, by providing incentive to encourage the use of Site Safety Cycle by the small-sized construction companies. It can be achieved by some tailor-made promotional activities, such as the current Safe Working Cycle competition organized by the OSHC modified to focus on small-sized companies. Apart from offering the prize as incentives to attract the companies in using the Site Safety Cycle, these activities can also create an atmosphere that implementation of Site Safety Cycle is an unavoidable trend which is the responsibility of every responsible company.

2) Implementation of Site Safety Cycle as a whole

Another recommendation is to encourage the construction companies to implement Site Safety Cycle as a whole. As shown from the questionnaires replied, it is not uncommon for a project site to choose to implement only part of the Site Safety Cycle.

And it is found from the analysis that the more number of elements in Site Safety Cycle is implemented; the better is the safety performance. Since each element in the Site Safety Cycle has its own role and purpose, and they are actually interdependent on each other, for example, whether the instruction given in the daily PES meeting has been carried out is checked in the daily safety inspection, the follow-up action in dealing with the problems found from the safety inspection is discussed in the safety co-ordination meeting etc., it will reduce their effectiveness if some of them are implemented, while some others are not. As a result, the maximum improvement effect can only be obtained when the Site Safety Cycle is effectively implemented as a whole.

3) Modification on the current practice of Site Safety Cycle

As shown from the last section of the analysis, not every element in Site Safety Cycle is effectively implemented to improve safety. And it is discussed in Chapter 9 that one possible reason is the problem in the current practice required by the ETWB in the public works projects. As a result, it is suggested that the ETWB may further investigate the effectiveness of the current practice of each element in Site Safety Cycle and make modification to them to suit the situation in Hong Kong construction industry. At the same time, it is also recommended that the construction companies should be flexible in practicing each element in the Site Safety Cycle. They may adjust or modify the practice according to their own situation, such as the site condition, the degree of risk involved etc.

10.2 Limitation of Study

The major limitations of the study are twofold.

1) Sample size

From the literature, it is shown that accident or incidence rate is incapable in reflecting the safety performance of a project site. Thus, it is preferred to use behavior observations data to measure the site safety performance. However, due to the limitation of ability and time as explained in Chapter 7, the author has given up this method. Finally, the league table ranking used in Gammon Construction Limited becomes the measures of site's safety performance in this study. Since the safety performance of project sites under other construction companies cannot be directly compared using this measure, only the project sites under Gammon Construction Limited are studied in this research. Since the number of project sites under a single company is limited, the sample size of this study is small. If the sample size could be enlarged, it is believed that the result would be more significant and accurate.

2) Information and data

Since the information of the practice of Site Safety Cycle in each project site is collected through questionnaire, there may be chances of error in filling in the questionnaire, restriction in questions or space in the questionnaire to provide the full picture of the practice of Site Safety Cycle on site, or even misunderstanding of the questions, etc. All of them will affect the accuracy of the information and data collected which will in turn affect the analysis result.

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Appendix 1

Site Safety Cycle in Hong Kong

This questionnaire aims at collecting information about your site's current practice of site safety cycle. The information will be solely used for an academic dissertation study about the relationship between implementation of site safety cycle and safety performance of the contractors. Your information provided is highly valuable to the study. Please answer the following questionnaire by filling in the blanks (______) or putting a tick (☑) as appropriate. If you have any queries regarding the following questions, please feel free to contract Miss Celing TSE via e-mail: h0214820@hkusua.hku.hk or phone: 6078 7447.

A. Basic Information

1) Name of your project:____
2) Contract value:____________________________
3) What is the nature of your project?

   ☐ Public work ☐ Private work ☐ Others, please specify:_________

4) What are the incident rates of your site in the past 12 months?

Dec 03: ________________________	Jan 04: ________________________
Feb 04: ________________________	Mar 04: ________________________
Apr 04: ________________________	May 04: ________________________
Jun 04: ________________________	Jul 04: ________________________
Aug 04: ________________________	Sept 04: ________________________
Oct 04: ________________________	Nov 04: ________________________

5) Number of workers of your project: _________________________________
6) How many reportable accidents did your site have in the past 12 months?

Dec 03: ________________________	Jan 04: ________________________
Feb 04: ________________________	Mar 04: ________________________
Apr 04: ________________________	May 04: ________________________
Jun 04: ________________________	Jul 04: ________________________
Aug 04: ________________________	Sept 04: ________________________
Oct 04: ________________________	Nov 04: ________________________

7) How many mandays did your site have in each of the past 12 months?

Dec 03: ________________________	Jan 04: ________________________
Feb 04: ________________________	Mar 04: ________________________
Apr 04: ________________________	May 04: ________________________
Jun 04: ________________________	Jul 04: ________________________
Aug 04: ________________________	Sept 04: ________________________
Oct 04: ________________________	Nov 04: ________________________

8) Does your site run the practice of Site Safety Cycle (Safe Working Cycle)?

☐ Yes ☐ No

If yes, is it required by contract or voluntarily?

☐ Contract required ☐ Voluntary

B. The Site Safety Cycle of your project

Daily Cycle

(i) Pre-work Exercise and Safety (PES) meeting

1. Does your site have any daily Pre-work Exercise and Safety meeting?

   ☐ Yes ☐ No (please go to question 9)

2. Which of the following parties are required to participate? (you may tick more than one options)

   ☐ On site safety staff

   ☐ On site staff, e.g. quantity surveyor, engineer, site administrative staff etc.

   ☐ Workers of your site

   ☐ Sub-contractors' workers

   ☐ Others, please specify:___________________

3. How often will the Architect/Engineer's Representative attend the PES meeting?

   ☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never

   ☐ Others, please specify:________

4. Are there any qualification requirements for the leader of each PES meeting? (you may tick more than one options)

   ☐ Attended the training course on SSC of the Occupational Safety & Health Council or Construction Industry Training Authority

   ☐ No qualification required

   ☐ Other qualifications required, please specify:_________________

5. Does your site take attendance in each PES meeting?

   ☐ Yes ☐ No

6. What is the average attendance of each meeting?

   ☐ 0-20% ☐ 21-40% ☐ 41-60% ☐61-80% ☐81-100%

7. How long is each PES meeting on average?

   ☐ less than 5 minutes ☐ 5-10 minutes ☐ 10-15 minutes ☐ 15-20 minutes

   ☐ more that 20 minutes

8. What is/are usually included in each PES meeting? (you may tick more than one options)

   ☐ Physical exercise ☐ Common hazards and control measures

   ☐ General fire and safety precautions ☐ Specific safety concerns

   ☐ General defects and irregularities observed in inspections

   ☐ Accidents or near misses

☐ Announce common safety matters in execution and co-ordination of Works among sub-contractors and workers

☐ Present awards to workers or subcontractors for their good safety performance

☐ Others, specify:____

(ii) Hazard Identification Activity (HIA) meeting

9. Does your site have any daily Hazard Identification Activity meeting?

   ☐ Yes ☐ No (please go to question 15)

10. Which of the following parties are required to participate? (you may tick more than one options)

   ☐ On site safety staff

   ☐ On site staff e.g. quantity surveyor, engineer, site administrative staff etc.

   ☐ Workers of your site

   ☐ Sub-contractors' workers

   ☐ Others, please specify:____

11. How long is each HIA meeting on average?

   ☐ less than 5 minutes ☐ 5-10 minutes ☐ 10-15 minutes ☐ 15-20 minutes

   ☐ more that 20 minutes

12. Are there any qualification requirements for the leader of each HIA meeting? (you may tick more than one options)

   ☐ Attended the training course on SSC of the Occupational Safety & Health Council or Construction Industry Training Authority

   ☐ Attended the presentation skill course such as the Occupational Safety and Health Trainer Course of OSHC or the Safety Training Techniques of CITA

   ☐ No qualification required

   ☐ Other qualifications required, please specify:__________________________________

13. What is/are usually included in each HIA meeting? (you may tick more than one options)

   ☐ Common hazards and control measures specific to the works or trades

   ☐ Specific safety concerns

   ☐ Assurance of safety requirements and measures

   ☐ Reprimand of repeated irregularities and malpractice

   ☐ Others, please specify:____

14. How often will the Architect/Engineer's Representative inspect the training materials and the records of the discussion during the HIA meeting?

   ☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never

   ☐ Others, please specify:________________________

(iii) <u>Pre-work Safety Checks</u>

15. Does your site have any daily Pre-work Safety Checks?

☐ Yes ☐ No (please go to question 20)

16. How often will the Architect/Engineer's Representative attend the Pre-work Safety Checks?

☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never

☐ Others, please specify:________

17. What is/are usually included in each safety check? (you may tick more than one options)

☐ Personal protective equipment ☐ Machinery ☐ Plant and equipment

☐ Materials ☐ Facilities ☐ Others, please specify:_________________________

18. Are there any checklists prepared for each safety check?

☐ Yes ☐ No

19. How often will the Architect/Engineer's Representative inspect the completed checklists after the safety check?

☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never

☐ Others, please specify:______________________

(iv) <u>Safety Inspection</u>

20. Does your site have any daily Safety Inspection?

☐ Yes ☐ No (please go to question 25)

21. Does your site keep diary for recording any unsafe act or unsafe conditions observed during inspections?

☐ Yes ☐ No

22. Will the date of rectifying the unsafe acts or conditions be recorded in the diary?

☐ Yes ☐ No

23. Will the Site Agent check the diary?

☐ Yes ☐ No

24. How often will the Architect/Engineer's Representative inspect the safety diary?

☐ Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Never

☐ Others, please specify:___________________

(v) <u>Guidance and Supervision during work</u>

25. Does your site assign any supervisory staff, who needs to provide guidance and supervision to the workers, to be responsible for the safety and health of workers?

☐ Yes ☐ No (please go to question 27)

26. How many workers on average will be under the guidance and supervisor of one

supervisory staff?

☐ less than 5 ☐ 5-10 ☐ 10-15 ☐ more than 15

(vi) Safety Co-ordination meeting

27. Does your site have any daily Safety Co-ordination meeting?

☐ Yes ☐ No (please go to question 30)

28. Which of the following parties are required to attend the Safety Co-ordination meeting? (you may tick more than one options)

☐ On site safety staff

☐ Site agent or senior staff of site management

☐ Sub-contractors

☐ Supervisory staff mentioned in question 26

☐ Others, please specify:______________________________________

29. What is/are usually included in each safety co-ordination meeting? (you may tick more than one options)

☐ Findings in safety inspection

☐ Matters to be announced in next PES or HIA meeting

☐ Discussion and co-ordination of site safety matters e.g. sequence of works, usage time for shared machinery, equipment and work areas, phasing of works at various interfaces etc.

☐ Others, please specify:____

(vii) Daily Cleaning and Tidying up of the Site

30. Does your site have any Daily Cleaning and Tidying up of the Site?

☐ Yes ☐ No (please go to question 32)

31. Are the Daily Cleaning and Tidying up of the Site planned?

☐ Yes ☐ No

(viii) Checking of the Site after each day's work

32. Does your site have any checking of the Site after each day's work?

☐ Yes ☐ No (please go to question 34)

33. Does your site assign any designated person to check the safety of the site after each day's work?

☐ Yes ☐ No

Weekly Cycle

(ix) Weekly Safety Walk

34. Does your site have any Weekly Safety Walk?

☐ Yes ☐ No (please go to question 38)

35. Are there any checklists for the Weekly Safety Walk?

☐ Yes ☐ No

36. Which of the following parties are required to participate in the Weekly Safety Walk? (you may tick more than one options)

☐ Safety Officer ☐ Site Agent

☐ Architect/Engineer's nominated site representative

☐ Others, please specify:____

37. Will the checklists (including the deficiencies identified during the walk, with proposed rectification measures and corresponding completion dates) be agreed and signed by the Safety officer and the Architect/Engineer's nominated representative immediately after the safety walk?

☐ Yes ☐ No

(x) Weekly Safety Co-ordination Meeting

38. Does your site have any Weekly Safety Co-ordination meeting?

☐ Yes ☐ No (please go to question 41)

39. Which of the following parties are required to attend? (you may tick more than one options)

☐ Safety Officer ☐ Site Agent

☐ Supervisory staff of sub-contractors

☐ Architect/Engineer's Representative

☐ Others, please specify:____

40. What is/are usually included in each Weekly Safety Co-ordination Meeting? (you may tick more than one options)

☐ Safety performance

☐ Housekeeping and tidiness of the Site

☐ Defects and deficiencies observed in Weekly Safety Walk

☐ Accidents and near misses

☐ Others, please specify:____

(xi) Weekly Overall Cleaning and Tidying up of the site

41. Does your site have any Weekly Overall Cleaning and Tidying up of the Site?

☐ Yes ☐ No (please go to question 43)

42. Are the Weekly Overall Cleaning and Tidying up procedures planned?

☐ Yes ☐ No

Monthly Cycle

(xii) Site Safety Management Committee meeting (including pre-meeting inspection)

43. Does your site have any Monthly Site Safety Management Committee Meeting (including pre-meeting inspection)?

☐ Yes ☐ No (please go to question 46)

44. Which of the following parties are required to participate? (you may tick more than one options)

☐ Safety Officer ☐ Site Agent

☐ Supervisory staff of sub-contractors

☐ Architect/Engineer's Representative

☐ Others, please specify:____

45. What is/are usually included in each Monthly Site Safety Management Committee Meeting? (you may tick more than one options)

☐ Review safety plan

☐ Update risk assessments for works scheduled to be carried out for the following two months

☐ Report on the outcome of review and revision of method statement and safe working procedures for current and forthcoming tasks

☐ Discuss the adequacy of the above review and revision and point out deficiencies

☐ Others, please specify:____

(xiii) Site Safety Committee meeting

46. Does your site have any Monthly Site Safety Committee meeting?

☐ Yes ☐ No

Safety Bulletin Board

47. Does your site have any Safety Bulletin Board erected on every site?

☐ Yes ☐ No (please go to question 49)

48. Which of the following are contained in the Board? (you may tick more than one options)

☐ Promotion of Site Safety Cycle

☐ Site safety organizational structure chart (with names and contact telephone numbers) from senior site management down to sub-contractors, gangers, foremen, Safety Officer Safety Supervisors and Safety Representatives according to works trades, work gangs or works areas, together with the emergency teams, first aid personnel

☐ Accident statistics with breakdown to subcontractors

☐ Figure showing a worker wearing all the personal protective equipment

☐ Mirror covering the full view of the person when standing in front

☐ Site plan ☐ Safety policies

☐ In-house safety rules and regulations ☐ Slogans

☐ Colour coding systems for lifting gears

☐ Others, please specify:____

C. Other comments

49. Do you have any other comments or suggestions for improvement of the Site Safety Cycle of your site?

____

____

____

____

---End of questionnaire---

---Thank you very much for your time---

Name of contact person: ________________________________

Contact No.: ________________________________

Appendix 2

Interview questions:

1. Do you think Site Safety Cycle helps your company to improve site safety? Is it a successful and effective system?

2. In your opinion, what are the special features of SSC that makes it successful in improving safety?

3. Do you think SSC is suitable for Hong Kong construction industry?

4. How does the current Hong Kong construction industry view about SSC in general? Is SSC widely accepted as a successful and effective tool in improving site safety?

5. Do you think the current promotion of using SSC in Hong Kong by the Government and OSHC is adequate? In what way will you suggest them to promote and improve the use of SSC?

Appendix 3

Scoring system of the questionnaire

Figure in the blanket represents the score it attained

1. Yes (1) No (-1)

2. One tick get 1 mark, if more than one party is mentioned in the “Others” option, each extra party get 1 mark

3. Daily (4) Weekly (3) Bi-weekly (2) Monthly (1) Never (0)

Others (depends on the frequency that it gives, adjusted in proportion to the above score)

4. Attended the training course on SSC of the Occupational Safety & Health Council or Construction Industry Training Authority (1)

No qualification required (-1)

Others (1 mark will be given if it is an additional requirement of the first option, 0 mark for only requiring this other qualification)

5. Yes (1) No (-1)

6. 0-20% (1) 21-40% (2) 41-60% (3) 61-80% (4) 81-100% (5)

7. less than 5 mins (0) 5-10 mins (1) 10-15 mins (2) 15-20 mins (1) more than 20 mins(0)

8. One tick get 1 mark, if more than one activity is mentioned in the “Others” option, each extra activity get 1 mark

9. Yes (1) No (-1)

10. One tick get 1 mark, if more than one party is mentioned in the “Others” option, each extra party get 1 mark

11. less than 5 mins (1) 5-10 mins(2) 10-15 mins(2) 15-20 mins(1) more than 20 mins(0)

12. Attended the training course on SSC of the Occupational Safety & Health Council

or Construction Industry Training Authority (1)

Attended the presentation skill course such as the Occupational Safety and Health Trainer Course of OSHC or the Safety Training Techniques of CITA (1)

No qualification required (-1)

Others (1 mark will be given if it is an additional requirement of the first two options, 0 mark for only requiring this other qualification)

13. One tick get 1 mark, if more than one activity is mentioned in the “Others” option, each extra activity get 1 mark

14. Daily (4) Weekly (3) Bi-weekly (2) Monthly (1) Never (0)

Others (depends on the frequency that it gives, adjusted in proportion to the above score)

15. Yes (1) No (-1)

16. Daily (4) Weekly (3) Bi-weekly (2) Monthly (1) Never (0)

Others (depends on the frequency that it gives, adjusted in proportion to the above score)

17. One tick get 1 mark, if more than one item is mentioned in the “Others” option, each extra item get 1 mark

18. Yes (1) No (-1)

19. Daily (4) Weekly (3) Bi-weekly (2) Monthly (1) Never (0)

Others(depends on the frequency that it gives, adjusted in proportion to the above score)

20. Yes (1) No (-1)

21. Yes (1) No (-1)

22. Yes (1) No (-1)

23. Yes (1) No (-1)

24. Daily (4) Weekly (3) Bi-weekly (2) Monthly (1) Never (0)

Others (depends on the frequency that it gives, adjusted in proportion to the above score)

25. Yes (1) No (-1)

26. less than 5 (3) 5-10 (2) 10-15 (1) more than 15 (0)

27. Yes (1) No (-1)

28. One tick get 1 mark, if more than one party is mentioned in the "Others" option, each extra party get 1 mark

29. One tick get 1 mark, if more than one activity is mentioned in the "Others" option, each extra activity get 1 mark

30. Yes (1) No (-1)

31. Yes (1) No (-1)

32. Yes (1) No (-1)

33. Yes (1) No (-1)

34. Yes (1) No (-1)

35. Yes (1) No (-1)

36. One tick get 1 mark, if more than one party is mentioned in the "Others" option, each extra party get 1 mark

37. Yes (1) No (-1)

38. Yes (1) No (-1)

39. One tick get 1 mark, if more than one party is mentioned in the "Others" option, each extra party get 1 mark

40. One tick get 1 mark, if more than one activity is mentioned in the "Others" option, each extra activity get 1 mark

41. Yes (1) No (-1)

42. Yes (1) No (-1)

43. Yes (1) No (-1)

44. One tick get 1 mark, if more than one party is mentioned in the “Others” option, each extra party get 1 mark

45. One tick get 1 mark, if more than one activity is mentioned in the “Others” option, each extra activity get 1 mark

46. Yes (1)   No (-1)

47. Yes (1)   No (-1)

48. One tick get 1 mark, if more than one item is mentioned in the “Others” option, each extra item get 1 mark

Appendix 4

```
Variable:  VAR00003     Missing cases:  4     Valid cases:  14
Autocorrelations:   VAR00003   Gammon incidence rate
     Auto- Stand.
Lag  Corr.   Err. -1   -.75   -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
  1   .769   .241            .           *********.*****            10.178   .001
  2   .542   .231             .          ********.**                15.668   .000
  3   .245   .222             .          *****   .                  16.886   .001
  4   .063   .211              .         *      .                   16.976   .002
  5  -.037   .200              .      *         .                   17.010   .004
  6  -.097   .189              .     **         .                   17.273   .008
  7  -.150   .177               .   ***        .                    17.997   .012
  8  -.273   .164               . *****        .                    20.777   .008
  9  -.369   .149               *.*****       .                     26.864   .001
 10  -.415   .134             ***.****       .                      36.488   .000
 11  -.377   .116             ***.****       .                      47.113   .000
 12  -.259   .094                *.***      .                       54.605   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .
Total cases:  18     Computable first lags:  13

Partial Autocorrelations:   VAR00003   Gammon incidence rate
   Pr-Aut- Stand.
Lag  Corr.   Err. -1   -.75   -.5 -.25   0   .25  .5   .75   1
  1   .769   .267          .             **********.****
  2  -.118   .267          .         **           .
  3  -.324   .267          .     ******           .
  4   .067   .267          .             *        .
  5   .074   .267          .             *        .
  6  -.115   .267          .         **           .
  7  -.127   .267          .        ***           .
  8  -.254   .267          .      *****           .
  9  -.078   .267          .         **           .
 10   .032   .267          .             *        .
 11  -.011   .267          .           *         .
 12   .045   .267          .             *        .

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .
Total cases:  18     Computable first lags:  13
```

Appendix 5

```
Variable:  VAR00002     Missing cases:  1     Valid cases:  17
Autocorrelations:   VAR00002   Accident rate per 1,000 workers
     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
  1    .826   .223            .         ********.********        13.757   .000
  2    .614   .215            .         ********.***             21.871   .000
  3    .407   .208             .        ********                 25.687   .000
  4    .228   .201             .        *****  .                 26.981   .000
  5    .095   .193             .        **     .                 27.222   .000
  6    .033   .185              .       *     .                  27.255   .000
  7   -.054   .176              .    *        .                  27.351   .000
  8   -.166   .167              .  ***        .                  28.337   .000
  9   -.260   .157               .*****      .                   31.068   .000
 10   -.322   .147               ******      .                   35.864   .000
 11   -.386   .136             ***.****     .                    43.876   .000
 12   -.448   .124            ****.****     .                    56.855   .000
 13   -.404   .111             ****.***    .                     70.050   .000
 14   -.340   .096              ***.***    .                     82.466   .000
 15   -.225   .079                **.**   .                      90.646   .000
Plot Symbols:      Autocorrelations *     Two Standard Error Limits .
Total cases:  18     Computable first lags:  16

Partial Autocorrelations:   VAR00002   Accident rate per 1,000 workers
   Pr-Aut- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1
  1    .826   .243           .          *********.*******
  2   -.212   .243           .     ****          .
  3   -.107   .243           .       **          .
  4   -.056   .243           .        *          .
  5   -.013   .243           .         *        .
  6    .088   .243           .          **       .
  7   -.215   .243           .     ****          .
  8   -.167   .243           .      ***          .
  9   -.045   .243           .        *          .
 10   -.021   .243           .         *        .
 11   -.149   .243           .      ***          .
 12   -.211   .243           .     ****          .
 13    .225   .243           .          ****     .
 14   -.019   .243           .         *        .
 15    .117   .243           .          **       .
Plot Symbols:      Autocorrelations *     Two Standard Error Limits .
Total cases:  18     Computable first lags:  16
```