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Safe Working Cycle: Is It a Panacea to Combat Construction Site Safety Accidents in Hong Kong?

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Abstract: In Hong Kong, the accident statistics of the construction industry is still comparatively higher than other industries. However, accident rates within the industry have significantly decreased, starting from the implementation of diverse safety initiatives, including the Safe Working Cycle (SWC). In this study, a post-positivist philosophical stance was adopted, and a questionnaire survey was launched to gather empirical data on the application of SWC in construction projects, the effectiveness of the safety initiative, and the benefits thereof. The data gathered from 197 construction participants were analysed using descriptive statistics, mean score, Mann–Whitney U-Test, Kendall's concordance analysis, Chi-square value, Spearman rank-order correlation test and exploratory factor analysis. The findings revealed significant adoption of SWC in the Hong Kong construction industry. Furthermore, daily, weekly, and monthly inspections and supervisions and safety committee meetings are effective items of this safety initiative. The benefits of adopting SWC can be grouped into the safety of frontline workers and increase in the organisation's safety commitment and reputation. This study has created an excellent theoretical platform for future research work on the usefulness of the SWC in the construction industry at large.

Keywords: Safe Working Cycle (SWC); safety initiatives; safety measures; site safety performance; construction industry; Hong Kong

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1. Introduction

The construction industry has been recognised for its immense contribution to socio-economic growth through infrastructure delivery, contribution to countries gross domestic product (GDP), and provision of employment [1–3]. The industry contributes up to 6% of global GDP, adding about 3.6 trillion dollars in value [4]. The construction industry has also created jobs for over 111 million workers worldwide [5]. The reason for this high employment rate is that the industry is labour intensive and requires human input in the delivery of its services [6]. In the United Kingdom, about 6% contribution to GDP has been noted, and up to 2.4 million people are employed by the construction industry alone. This employment rate represents about 7% of the total jobs in the country [7]. The Australian Government [8] noted a 5% contribution of the construction industry to the country's GDP and a significant contribution to job creation. The Legislative Council Commission [9] noted a 5.2% contribution made to Hong Kong's GDP by the construction industry. More so, the industry employed over 353,000 workers and this high number of workers was reflected in the notable growth in the number of construction sites in most parts of Hong Kong.

Albeit the obvious importance of the construction industry to socio-economic development, the industry is still characterised as a dangerous industry for workers. Injuries and fatalities continue to plague the industry in developed and developing countries [10–14]. Cheng et al. [11] submitted that the International Labour Organisation had noted worldwide that about 2.78 million deaths occur every year due to occupational accidents, and the construction industry is responsible for one out of every six deaths recorded. The case is not different in Hong Kong, where the accident statistics of the construction industry is still comparatively higher than other industries. While several studies have emanated on the causes of site accidents around the world [10,12,15,16], the root causes of construction accidents in Hong Kong are poor management, unsafe working conditions and workers' carelessness [17]. Thus, it becomes imperative for organisations to develop and implement safety measures that will help improve site safety performance, enhance operation safety and ensure employees work within a safe and healthy working environment [18–20].

To address the issue of safety in the workplace and minimise the occurrence of accidents, Hong Kong has introduced different safety initiatives since the 1990s. Some of these initiatives included the Safety Management System (SMS) since 1994, Performance Assessment Scoring System (PASS) since 1994, the Pay for Safety Scheme (PFSS) since 1994 and the Safe Working Cycle (SWC) since 2002, among others [20,21]. Implementing these various schemes has led to a significant decrease in accident rates. This current study places particular attention on the SWC, a Japanese concept that strives to enhance safety in the construction space by incorporating safety management into the construction management system [22,23]. The Occupational Safety and Health Council [24] noted that by adopting the SWC, a significant decrease in construction site accidents and an increase in health and safety (H&S) was recorded in Japan. However, while this approach to managing H&S within the working environment continues to gain popularity in some developed countries [23], there is the absence of empirical studies regarding its application and effectiveness in Hong Kong's construction sector. Such a study becomes apparent as, despite the implementation of these aforementioned safety initiatives, the accident rate in the Hong Kong construction industry remains comparatively higher than that of other major industries [25].

Based on the above knowledge, this study was designed to unearth the application of SWC and evaluate its effectiveness to improve construction site safety performance in Hong Kong. As a result, the study's findings have provided empirical evidence into the application, benefits and effectiveness of SWC in managing construction site safety in the Hong Kong construction industry. In addition, its findings will serve as an excellent theoretical platform for future research studies seeking to explore the use of SWC to improve construction site safety performance in countries where such studies have not been conducted.

2. Theoretical Background

2.1. Safety Performance and Initiatives in Hong Kong's Construction Industry

The Labour Department [26] gave the accident statistics of diverse industries in Hong Kong (construction inclusive). The accident statistics from 2000 to 2020, as illustrated in Figure 1, reflect the situation and existing safety performance of the Hong Kong construction industry. There is a decline in the industrial accidents and accident rate per thousand workers as a drop from 11,925 and 149.8 in 2000 to 2532 and 26.1 in 2020 can be seen. This decline represents a significant drop of 78.8% and 82.6%, respectively. Based on the decline in the rate of accidents presented in the figure, it is evident that the various safety measures introduced in Hong Kong in the last twenty years have been effective. However, in comparison with other sectors, as of 2020, the number of construction site accidents stood at 2532 out of a total of 7202 industrial accidents. This implies that the construction industry accounts for 35.2% of the overall industrial accidents in Hong Kong. Therefore, while the decrease in accident rates over the years affirms that employers, employees and all related stakeholders have continued to work together to improve construction safety, the number of accidents is still high when compared to what is obtainable in other industries such as manufacturing, which contribute only 14.5% [26].

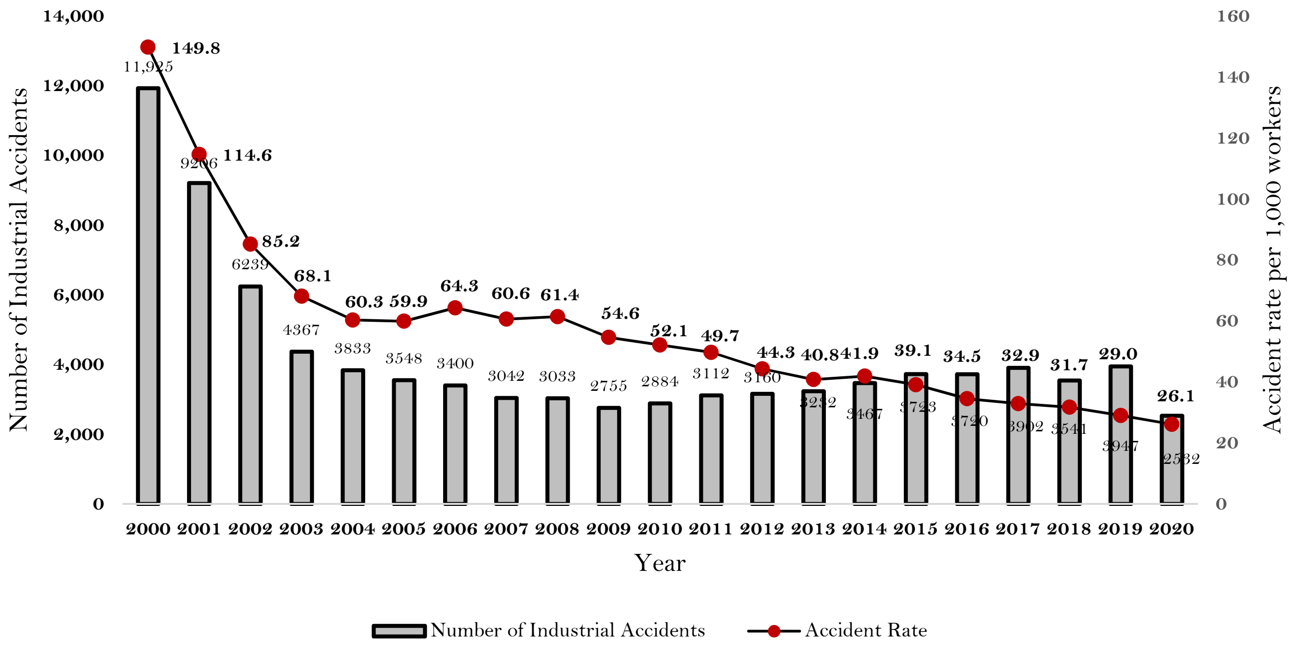

Figure 1. Construction accident statistics from 2000 to 2020; Adapted from Labour Department [26].

The high-risk nature of the construction industry and the incessant occurrence of site accidents necessitated the Government of the Hong Kong Special Administrative Region (HKSAR) and Occupational and Safety and Health Council (OSHC) to introduce diverse safety initiatives. Most of these safety initiatives are compulsory for public works contracts in Hong Kong. However, the case is different for private works where most of these initiatives are adopted voluntarily. Rowlinson [27] and Occupational Safety and Health Council [21] have noted that between 1994 and 2010, a total of 24 safety initiatives were introduced, all in a bid to ensure the reduction of site accidents. The most common initiatives include SMS, PFSS, PASS, and SWC [21,27]. These safety initiatives have diverse implementation mechanisms suitable for various project types and scales.

It has been observed that organisations adopt various safety initiatives to ensure the safety of their workers, and the most widely implemented types are those involving safety incentives [28]. According to Leichtling [29], safety incentive schemes, which involve the elements of safety initiatives earlier mentioned, have been observed to improve organisational safety performance as well as the motivation of employees. As such, they are considered highly effective techniques for achieving accident-free working environments [30]. It has been suggested that safety incentive schemes offer palpable ‘prizes’, such as bonuses, gifts, coupons and certificates, to employees or contractors who achieve good safety performance. These tangible rewards are especially powerful for individual workers to achieve better safety performance [31]. Both Laws [32] and LaBar [33] concurred that safety incentive schemes are generally adopted to eliminate associated job hazards, reduce accidents at the workplace, improve the behaviour of workers towards safety and, in the process, ensure better safety records for the organisation. The use of these incentive schemes has been noted in organisations in the United Kingdom [34]. These incentive schemes were introduced to encourage workers to adopt safe work practices, promote safety awareness, and ensure accidents are eliminated from the working environment [35].

Previous research studies have revealed specific factors that are of utmost importance if satisfactory outcomes are to be attained from safety initiatives. These factors include employee involvement, management commitment, allocation of sufficient resources and teamwork [20,36–39]. Unfortunately, similar to other countries, the subcontracting system in Hong Kong impedes safety as it creates an avenue for a higher potential of having accidents [27,40]. The chain of subcontractors extends to the third or fourth layer in most projects, and when this occurs, safety communication and coordination effectiveness and efficacy decrease [27,40]. One worst scenario would be shifting all safety responsibilities to subcontractors from main contractors even though the subcontractors' capabilities and competencies are in question. As a result, subcontractors may not provide workers with safe working conditions and environments as expected by the main contractor [41]. In addition, [42] noted the important role of safety personnel in the safety culture on construction projects. These leadership skills and knowledge of this personnel is essential to positive safety culture. More so, it has been noted that lack of adequate resources, unaddressed safety issues on construction sites, and the highly competitive nature of the construction industry can deter the seamless implementation of needed safety initiatives [43–45].

2.2. Safe Working Cycle in Hong Kong's Construction Industry

The SWC is a Japanese initiative designed to overcome difficulties in different aspects of management systems [46]. The implementation of this safety initiative revealed a significant decrease in construction site accidents and an increase in H&S in Japan [47]. Furthermore, as a result of the success of the SWC in the Japanese construction industry, this initiative was believed to be a viable option for better safety performance in Hong Kong [24].

By description, SWC is a well-organised SMS that can be classified into daily, weekly, and monthly cycles [48]. This safety initiative is designed to ensure that on a daily basis, the worksite is tidy and that construction workers are aware of the necessary safety precaution in place. More so, it strives to unearth the root causes of accidents with a view to addressing the causes and improving overall safety performance [24]. The actual period of each cycle is ascertained by the importance and urgency of the construction activities. Comparing the three safe working cycles, the daily cycle is most thorough and detailed, while weekly and monthly cycles cover more broadly. In Hong Kong, the SWC initiative was first introduced in the year 2000 when the initiative was embedded in six contracts designed with the PFSS. After two years of testing this approach, SWC was formally launched on 15 August 2002. Since then, it has been widely embraced, especially in public works projects and capital works contracts [46,49].

Over time, it has been observed that the use of SWC on construction projects offers efficient and effective H&S communication between supervisors and workers on construction sites. More so, its adoption creates an avenue for improved safety awareness among workers through the introduction of preventive measures and ensuring that the working environment is kept safe at all times. In the end, the use of SWC will lead to better safety performance and a reduction in the occurrence of site accidents as workers are better equipped and aware of safety measures necessary [49]. Furthermore, Ozaka [50] noted that the use of SWC allows the propagation of safety culture within the construction industry as well as the naturing a safe working behaviour among site workers through daily repetitive actions.

There are some essential elements included in three different cycles of SWC, as summarised in Table 1. The daily cycle has eight crucial items which must be conducted based on the schedule of the project, with time allocated to each item on a time chart. The items cut across all project participants, and the time allotted for conducting each item is regulated by the organisation based on the nature of the project [24]. Every morning it is essential to conduct a safety briefing for at least 15 min. This briefing could include pre-work physical exercise along with common safety hazards and precautions. Furthermore, it is important to conduct hazard identification for another ten minutes, especially on sites where specialised trades are working. After concluding these meetings, engineers, plant operators, and all other competent persons, on-site must conduct a pre-work checkup and safety inspection to ensure the site is safe. Proper guidance and supervision, as well as discussion of process safety, are needed for frontline workers to ensure they are adhering to safety measures that have been put in place. All workers are also required to tidy up after work while the team representatives or supervisors are expected to conduct a final check at the end of every working day. The function of the weekly cycle is majorly to evaluate the performance of the measures put in place in the past week by reflecting on the challenges faced and improving the existing safety measures for the subsequent weeks. The weekly cycle comprises a weekly inspection and checkup, discussion of safety process, and tidying up [24]. In the monthly cycle, recent site safety performances and work progress are reviewed. In this cycle, monthly safety meetings, inspections, training and committee meetings are conducted. The training conducted at this stage improves safety awareness and culture among site workers [24].

Table 1. Elements of the Safe Working Cycle.

Essential Items of SWC	**Type of Cycle**			**Participants Involved**
	Daily	**Weekly**	**Monthly**	
Safety Meeting	√	-	√	Entire project workforce
Hazard identification activity (HIA)	√	-	-	Entire teams
Prior-to-work inspection/Check up	√	√	-	Engineers, competent persons, plant operators
Safety inspection	√	√	√	Project managers, site agents, engineers, competent persons of main contractor and subcontractors
Work guidance and supervision	√	-	-	Team representatives, foremen
Discussion of process safety	√	√	-	Project managers/site agents, safety officers, supervisors, subcontractor representatives
Tidying up after work	√	√	-	Entire project workforce
Final check after work	√	-	-	Team representatives, foremen
Safety training	-	-	√	Safety officers and all workers
Safety committee meeting	-	-	√	Members of the safety committee

Source: OSHC [24].

3. Materials and Methods

This study adopted a post-positivist philosophical stance using a quantitative research methodology, as seen in Figure 2. A questionnaire survey was employed as the instrument for data collection due to its ability to reach a much wider coverage within a limited time frame. Moreover, a questionnaire survey has been noted to offer objectivity and quantifiability in social science research [51–53]. The questionnaire for this study was developed based on a comprehensive review of extant related literature. The survey was launched between October and November of 2020 to gather relevant information regarding the application of SWC in construction projects, its effectiveness, and its benefits. The survey was conducted among knowledgeable professionals involved in construction projects wherein SWC has been used. This was performed to harness valuable information and opinions on the SWC adopted on construction sites. However, it was difficult to determine the exact number of construction professionals who have participated in SWC projects from the inception of the survey. Hence, the snowball sampling technique was relied upon to achieve adequate responses for the study. The snowball sampling method is a referral process [54] that can increase the responses gathered in a study [55]. This approach has continued to garner significant attraction in recent built environment-related studies [56–58]. Using this snowballing method, 197 valid responses were gleaned from the construction industry. This sample was considered large enough for data analysis as a large sample size allows results to be reliable and representative [59].

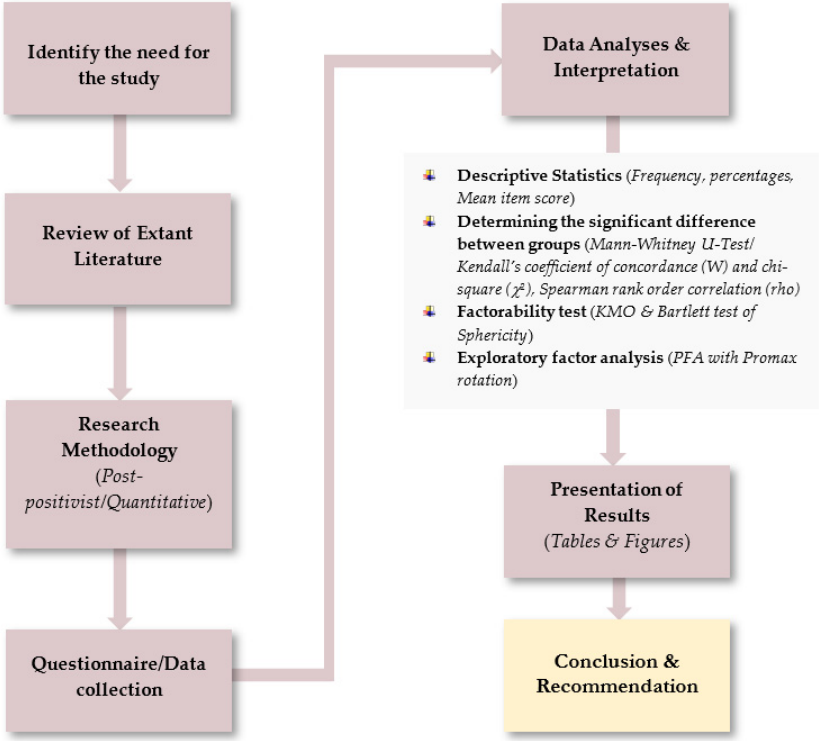

Figure 2. Research methodology adopted.

The questionnaire adopted for the study was designed in sections. The first section sought demographic characteristics of respondents and their organisations. The second section focused on the implementation of SWC, which aims to evaluate the necessary items of SWC in achieving better safety performance in Hong Kong. The last section focused on the perceived benefits of adopting SWC in construction projects. The data gathered from the first section were analysed using frequency (f) and percentage (%) values. More so, mean score ($\overline{X}$) was used to rank in descending order the effectiveness of the items of SWC and the benefits inherent in implementing this safety strategy as rated by the different respondents. Where two or more variables have the same $\overline{X}$ both are assigned the same rank. Since the clients and contractors are principal actors in implementing and enforcing these safety initiatives, the significant difference in the ranking of the assessed variables by these two groups of respondents was assessed using Mann–Whitney U-Test (*M–W*). To determine the strength of the relationship between the rating of both groups with a view to ascertaining whether both sets of respondents gave a unified view, Spearman rank-order correlation test was employed. Furthermore, for a more robust perspective, Kendall's coefficient of concordance (*W*) and chi-square (χ^2) value was adopted to affirm the level of agreement between respondents by considering the disparities in the rankings of the mean of the assessed variables. The χ^2 test was adopted due to its suitability for variables larger than seven [60]. The benefits of SWC were further analysed using exploratory factor analysis (EFA) to regroup the identified benefits into a more manageable subscale. EFA is the process of categorising the best suitable group of variables that will adequately describe a phenomenon [61]. To conduct EFA, a careful assessment of the sample size and the factorability of the data gathered is needed [62]. Past research studies have advocated a large sample [63,64], a good Kaiser–Meyer–Olkin (KMO) value, and a significant p-value for the Bartlett test of sphericity [61,65]. The sample size, KMO value and Bartlett test of sphericity in this study met the required threshold for EFA to be conducted, as seen in the Results section.

4. Survey Results

4.1. Demographic Characteristics of Survey Respondents

Table 2 presents the demographic characteristics of the respondents for the study. The result shows that the respondents mainly worked for main contractors (48.7%) and client organisations (46.7%). Main contractors are responsible for executing and implementing SWC, while clients are usually responsible for giving instruction and spot-checking the performance of SWC implemented by the main contractors. The least represented groups are project consultants and trade subcontractors. The data received from this study was strongly believed to show the effectiveness of SWC in the viewpoints of both implementers and checkers. Furthermore, 99.5% of the respondents were from site supervisory levels or above. These respondents should be partly or fully responsible for managing SWC on their engaged construction projects. More specifically, the senior management level (11.2%) and project management level (49.2%) are accountable for allocating sufficient resources in implementing SWC. They decide the overall working strategies of executing and monitoring SWC. In terms of working experience, the result further shows that 79.2% of the respondents have five years and above working experience, with 32% recording more than 20 years. On average, the respondents for the study have been in the industry for at least 14 years. This indicates that the participants in this study have vast experience in the construction industry, and the answers were based on experience.

Table 2. Demographic characteristics of survey respondents.

Category	Classification	*f*	%
Organisation type	Main contractor	96	48.7
	Client organisation	92	46.7
	Project consultant	8	4.1
	Trade subcontractor	1	0.5
	Total	197	100.0
Role in the organisation	Senior Management level	22	11.2
	Project Management level	97	49.2
	Site Supervisory level	77	39.1
	Workforce level	1	0.5
	Total	197	100.0
Working experience in the construction industry	Less than 5 years	41	20.8
	5–10 years	21	10.7
	11–15 years	31	15.7
	16–20 years	41	20.8
	Above 20 years	63	32
	Total	197	100.0
	Average	14	
Working experience in SWC projects	1–3 projects	68	34.5
	4–6 projects	54	27.4
	7–9 projects	24	12.2
	10 or more projects	51	25.9
	Total	197	100.0
	Average	6	
Reason for implementing SWC	Contractual requirement	143	72.6
	Voluntary basis	33	16.7
	Both contractual requirement & voluntary	12	6.1
	Not sure	9	4.6
	Total	197	100.0

In terms of the respondents' involvement in SWC projects, the result shows that all respondents had experiences in projects with SWC, with 65.5% of respondents being involved in four or more construction projects that adopted this safety initiative. Nearly 26% of respondents worked on ten or more construction projects that adopted SWC. On average, the respondents for the study have executed six projects using SWC to ensure site safety. This indicated that the comments given by respondents are highly valuable in reviewing the implementation of SWC. However, since implementing SWC is not compulsory for all construction projects, 72.6% of respondents stated contractual requirements as the major reason for implementing SWC in the projects they executed. Only 16.7% of the respondents implemented SWC in their engaged projects voluntarily. However, 4.6% of the respondents were unsure of the reason for implementing SWC. This result confirms that SWC is being used for construction project delivery in Hong Kong.

4.2. Effectiveness of the Elements of Safe Working Cycle

Following the understanding that SWC is adopted within Hong Kong's construction industry, it became apparent to ascertain the initiative's effectiveness. To this end, the respondents were asked to rate the effectiveness of the SWC in terms of improved site safety performance. The relevant results are shown in Figures 3 and 4. Almost all the respondents found SWC effectively improved site safety performance. Figure 3 revealed that 180 out of the 197 respondents commented that SWC was fairly effective (86), very effective (87), or even extremely effective (7) in improving site safety performance. Figure 4 further revealed that 123 out of 197 respondents found SWC to give good (90), very good (32) or even excellent (1) safety performance compared to non-SWC construction projects. These figures proved the positive values of implementing SWC in construction projects in Hong Kong.

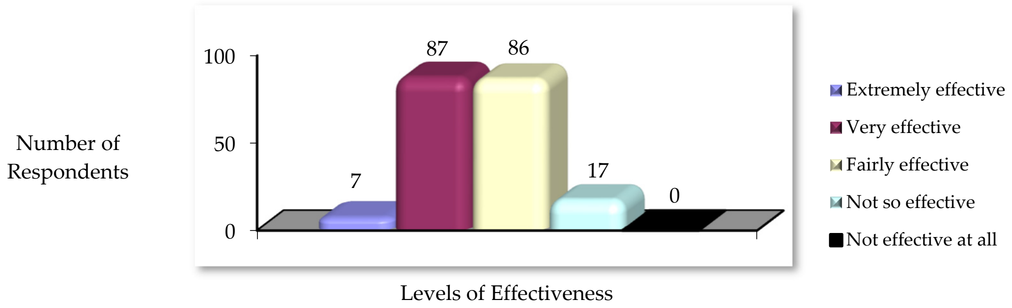

Figure 3. Effectiveness of SWC for improved site safety performance of construction projects.

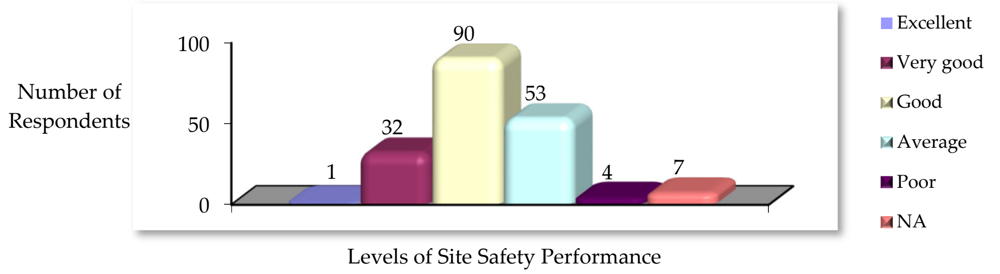

Figure 4. Overall site safety performance compared to other non-SWC projects.

To further ascertain the effectiveness of SWC to deliver safe construction projects, the respondents rated the effectiveness of the different elements of SWC on a scale of one to five, where one is ineffective, and five is most effective. The result in Table 3 shows the ranking of 15 SWC items by the respondents. Since the client and contractors are the two major players in implementing SWC on any given project, their ranking was also presented on the table. The statistical differences in the ranking of these SWC items by both groups (client and contractor) were tested using the *M*–*W* test. This test is a non-parametric test used to assess the significant difference in the view of two groups of respondents. The test gives a *Z*-value and a *p*-value [62]. Items with a *p*-value < 0.05 indicate a statistically significant difference between client and contractor groups. From the client's group (i.e., those working in government organisations responsible for public construction works), Table 3 revealed that safety inspections conducted daily ($\overline{X}$ = 3.78), weekly ($\overline{X}$ = 3.71) and monthly ($\overline{X}$ = 3.67) were identified as the most effective SWC items needed in improving site safety performance. This result stems from the role of the client's group in instructing guidelines and requirements and providing supervision and advice on a construction project. From the contractor's group, the result revealed weekly inspection and checkups ($\overline{X}$ = 3.80), daily safety inspection ($\overline{X}$ = 3.87), and safety committee meetings ($\overline{X}$ = 3.76) as the most effective SWC items.

Table 3. Ranking and Kendall's *W* test results for the effectiveness of the elements of SWC.

Effectiveness of SWC Items	**All**		**Client**		**Contractor**		**Mann–Whitney**	
	$\overline{X}$	**R**	$\overline{X}$	**R**	$\overline{X}$	**R**	**Z-Value**	**Sig.**
Safety inspection	3.79	1	3.78	1	3.80	2	−0.151	0.880
Weekly safety inspection and weekly checkup	3.79	1	3.71	2	3.87	1	−1.335	0.182
Guidance and supervision at work	3.69	3	3.61	4	3.74	4	−0.981	0.326
Safety committee meeting	3.68	4	3.60	6	3.76	3	−1.491	0.136
Pre-work physical exercise and morning safety briefing meeting	3.67	5	3.60	6	3.71	5	−0.616	0.538
Weekly process safety discussion	3.62	6	3.59	8	3.64	7	−0.409	0.683
Monthly inspection	3.61	7	3.67	3	3.55	9	−0.999	0.318
Hazard identification activity (HIA) meeting	3.61	7	3.61	4	3.58	8	−0.271	0.786
Monthly safety meeting	3.61	7	3.51	12	3.70	6	−1.782	0.075
Monthly safety training	3.55	10	3.59	8	3.49	11	−1.048	0.295
Process safety discussion	3.47	11	3.53	11	3.39	13	−1.091	0.275
Prior-to-work inspection	3.46	12	3.55	10	3.37	14	−1.776	0.076
Tidying up after work	3.46	12	3.41	15	3.51	10	−0.698	0.485
Weekly tidying up	3.45	14	3.49	13	3.41	12	−0.814	0.416
Final check after work	3.34	15	3.42	14	3.23	15	−1.291	0.197
n	197		92		96			
Kendall's W	0.058		0.041		0.088			
Actual χ^2 value	110.358		34.235		88.799			
Critical χ^2 value from table	23.69		23.69		23.69			
df	14		14		14			
Asymptotic level of significance	0.000		0.000		0.000			

Note: $\overline{X}$ = mean; R = Rank; χ^2 = Chi square; *df* = Degree of freedom; n = Number.

From a unified perspective, the overall ranking by the respondents revealed that all the 15 assessed items are effective in the delivery of safe construction projects as they all had a $\overline{X}$ value of the above-average of 3.0. However, both daily and weekly safety inspections were the most effective SWC items. These items shared a $\overline{X}$ value of 3.79 each. More so, supervision and monitoring of work ($\overline{X}$ = 3.69; *p*-value = 0.326), monthly safety committee meetings ($\overline{X}$ = 3.68; *p*-value = 0.136) and daily safety briefing meetings ($\overline{X}$ = 3.67; *p*-value = 0.538) were found highly effective on construction sites. The derived *p*-value for these variables from the *M*–*W* test were all above the threshold of 0.05, thereby implying that no significant statistical difference exists between the two groups regarding these most effective SWC items. Also, in assessing the relatedness of the respondents ranking within the groups, the χ^2 analysis derived from the Kendall's *W* test conducted revealed that the calculated χ^2 values for all respondents (110.36) and the different groups (34.24 and 88.80) is greater than the critical χ^2 value (23.69) derived from the statistical table. This result shows that the ranking by the respondents is related to each other within the groups, and no disparity exists [66].

Spearman's rank-order correlation test was conducted to affirm further the relationship in the view of both groups of respondents (client and contractor). This test is used to calculate the strength of the relationship between two continuous variables [62], as evident in this current study. In conducting this test, the null hypothesis (H_0) set was that there is no significant correlation between the two groups, while the alternate hypothesis (H_a) was that there is a significant correlation between the rankings between both groups. The H_0 is rejected when the derived *p*-value is less than the 0.05 (5%) threshold. Table 4 shows a *p*-value of 0.002, which is less than the allowable value of 5%. Therefore, H_0 was rejected and concluded that the rated effectiveness of the SWC items was statistically correlated in both groups of respondents. Thus, the derived result is a true reflection of the effectiveness of the SWC in construction projects executed in Hong Kong.

Table 4. Spearman's rank correlation test results on the effectiveness of SWC elements.

Comparison of Rankings	r_s	**Significance Level**	**Conclusion**
Client ranking vs. Contractor ranking	0.720	0.002	Reject H_0 at a 5% significance level

4.3. Benefits of Implementing Safe Working Cycle

Table 5 shows the ranking of the benefits of SWC by the respondents. The result revealed that the top three ranked benefits from the client's group are the same as those from the contractor's group. This implies that both groups of respondents believe that these benefits were derived from the use of SWC. Overall, the result revealed that all the 11 assessed benefits were derived from the use of SWC as they all have a $\overline{X}$ value higher than the average of 3.0. Improve safety awareness among site workers ($\overline{X}$ = 4.16, *p*-value = 0.914) was considered the most important benefit of executing SWC by all the respondents. Next is improved communication between supervisors and site workers on H&S matters ($\overline{X}$ = 4.15, *p*-value = 0.944), which was adjudged as an important benefit derived from SWC implementation. Since frontline workers carry out site works as instructed daily, safety awareness and effective communication of safety matters becomes vital for a construction site with good safety performance. The implementation of SWC also offers early identification of potential hazards ($\overline{X}$ = 4.01, *p*-value = 0.545) as well as establishing safe habits of frontline workers ($\overline{X}$ = 4.00, *p*-value = 0.493).

Table 5. Ranking and Kendall's *W* test results for the perceived benefits of SWC.

Perceived Benefits of SWC	**All**		**Client**		**Contractor**		**Mann–Whitney**	
	$\overline{X}$	**R**	$\overline{X}$	**R**	$\overline{X}$	**R**	***Z*-Value**	**Sig.**
Improve safety awareness among site workers.	4.16	1	4.17	1	4.15	1	−0.108	0.914
Improve communications between supervisors and site workers on H&S matters.	4.15	2	4.15	2	4.14	2	−0.070	0.944
Identify potential hazards.	4.01	3	4.04	3	3.97	3	−0.605	0.545
Establish a safe habit of frontline workers.	4.00	4	4.04	3	3.96	4	−0.686	0.493
Create better understanding of site conditions and daily operations.	3.99	5	4.03	5	3.94	5	−0.975	0.330
Improve housekeeping on-site.	3.97	6	4.00	6	3.93	6	−0.550	0.583
Prevent construction accidents.	3.86	7	3.88	10	3.83	8	−0.730	0.465
Promote company's safety reputation and image.	3.86	7	3.90	9	3.84	7	−0.640	0.522
Increase safety training.	3.83	9	3.92	8	3.75	9	−1.795	0.073
Improve safety commitment.	3.78	10	3.96	7	3.62	11	−3.674	0.000 **
Minimise accidents/injuries means making more profits.	3.73	11	3.77	11	3.74	10	−0.290	0.772
n	197		92		96			
Kendall's W	0.066		0.053		0.074			
Actual χ^2 value	127.441		48.469		69.200			
Critical χ^2 value from table	18.31		18.31		18.31			
df	10		10		10			
Asymptotic level of significance	0.000		0.000		0.000			

Note: $\overline{X}$ = mean; R = Rank; χ^2 = Chi square; *df* = Degree of freedom; *n* = Number; ** = Significant at $p < 0.05$.

The statistical differences in the benefits ranking by client and contractor groups were further explored using the *M–W* test. The result in Table 5 shows no statistically significant difference exists in the rating of ten of these benefits as they all had a *p*-value of above 0.05. However, there is a difference in the rating of 'improved safety commitment' as a *p*-value of 0.000 was attained. A look at the ranking shows that while the client group ranked this variable as seventh with a $\overline{X}$ of 3.96, the contractor's group ranked it as eleventh with a $\overline{X}$ of 3.62. This disparity can be ascribed to the role and responsibilities of the client and contractor. In general, senior management of the contractor assumes the role of allocating the manpower and cost spent on construction project safety, including SWC, while the client usually instructs guideline and requirements, provide supervision and advice and give incentives in terms of cost-related reward system. The χ^2 analysis revealed that the calculated χ^2 value for all respondents (127.44) and the different groups (48.47 and 69.20) is greater than the critical χ^2 value (18.31) derived from a statistical table. This implies that the respondents ranking is related to each other within the groups on a general view, and no disparity exists.

Spearman's rank-order correlation test was conducted to further affirm the relationship in the view of both groups of respondents (client and contractor). The H_0 set was that there is no significant correlation between the two groups, while the H_a was that there is a significant correlation between the two groups. The H_0 is rejected when the derived *p*-value is less than the 0.05 (5%) threshold. Table 6 shows a *p*-value of 0.000, which is less than the allowable value of 5%. Therefore, H_0 was rejected and concluded that the rated perceived benefits were statistically correlated in both groups of respondents. Thus, the identified benefits are a true reflection of the inherent benefits derived from the use of SWC in construction projects executed in Hong Kong.

Table 6. Spearman's rank correlation test results on the perceived benefits of SWC.

Comparison of Rankings	r_s	Significance Level	Conclusion
Client ranking vs. Contractor ranking	0.879	0.000	Reject H_0 at a 5% significance level

The eleven assessed benefits were further analysed using EFA to regroup them into a more manageable subscale. EFA has been described as an analytical tool used in reducing data into smaller clusters by exploring the fundamental theoretical structure of the variables [62]. To conduct EFA, the factorability of the data was first tested using the KMO test along with Bartlett's test. Table 7 shows that the data gathered were adequate for EFA as a KMO value of 0.890 was derived, which is higher than the acceptable threshold of 0.6 [62]. More so, Bartlett's test gave a significant *p*-value of 0.000, which follows past submission that Bartlett's test must be significant at a *p*-value less than 0.05 for EFA to be conducted [64]. Since the KMO test and Bartlett's test gave acceptable outputs, EFA was conducted using principal factor analysis with Promax rotation. The result revealed two principal factors with an eigenvalue above 1.0. This implies that the eleven benefits can be reclassified into two principal factors.

Table 7. Factor analysis results on the benefits of SWC.

Item	Factor Loading	Eigenvalue	% Variance Explained	Cumulative % Variance Explained
Factor 1-Safety of frontline workers				
Improve safety awareness among site workers.	0.771	4.524	41.124	41.124
Establish a safe habit of frontline workers.	0.732			
Identify potential hazards.	0.717			
Prevent construction accidents.	0.650			
Improve housekeeping on-site.	0.641			
Create a better understanding of site conditions and daily operations.	0.637			
Minimise accidents/injuries means making more profits.	0.625			
Improve communications between supervisors and site workers on H&S matters.	0.621			
Factor 2-Increased organisation's safety commitment and reputation				
Improve safety commitment.	0.787	1.154	24.490	65.614
Promote the company's safety reputation and image.	0.781			
Increase safety training.	0.610			
KMO Test				
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.890			
Bartlett's Test of Sphericity				
Approximate χ^2 value	637.279			
df	55			
Sig.	0.000			

Note: χ^2 = Chi square; *df* = Degree of freedom.

Further assessment of the scree plot in Figure 5 shows a clear change in the shape of the plot from the second component. This affirms the two factors extracted as suggested in past studies [62,63]. Table 7 also shows that the two extracted factors account for a cumulative percentage variance of 65.6%, which is above the threshold of 50% [67].

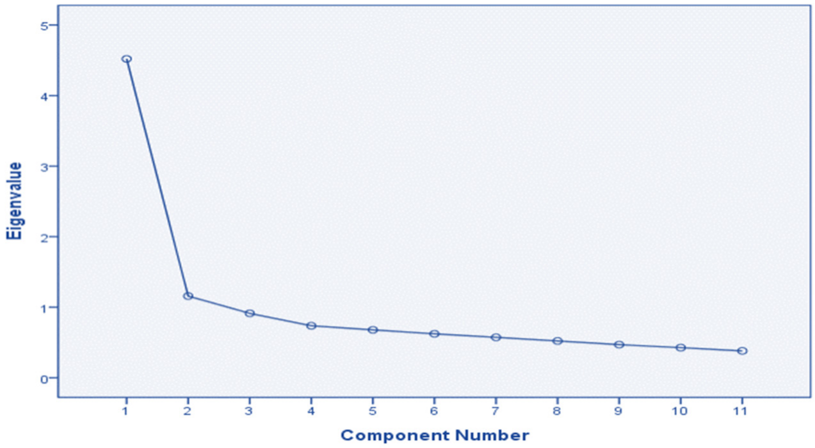

Figure 5. Scree plot after factor analysis of the benefits of SWC.

The first principal factor has an eigenvalue of 4.5 and accounts for about 41.1% of the total variance extracted. This principal factor has eight variables loading on it, and they are: improve safety awareness among site workers, establish a safe habit of frontline workers, identify potential hazards, prevent construction accidents, improve housekeeping on-site, create a better understanding of site conditions and daily operations, minimise accidents/injuries means making more profits, and improve communications between supervisors and site workers on H&S matters. Following the latent similarity of these variables, this factor was named 'safety of frontline workers'. The second principal factor has an eigenvalue of 1.2 and accounts for about 24.5% of the total variance extracted. This principal factor has three variables: improve safety commitment, promote the company's safety reputation and image, and increase safety training. This component was named 'increased organisation's safety commitment and reputation' based on the similarity in the variables.

5. Discussion of Principal Factors

The study's findings revealed that SWC is adequately implemented in the delivery of construction projects in Hong Kong. This further affirms the submissions of Mendis et al. [23] and Rowlinson [27], who earlier noted that the construction industry in Hong Kong is among the industries worldwide at the forefront of promoting the use of SWC for effective site safety. The majority of construction projects that implemented this safety initiative did so because it was a contractual obligation. However, some projects have adopted this safety measure solely on their volution. This could be due to the effectiveness of SWC observed in past projects wherein the safety initiative was adopted.

The findings further revealed that the implementation of this safety initiative effectively enhances site safety performance of construction organisations and yields better results when compared to other projects where this safety measure was not adopted. This finding further affirms the results of Chan and Choi [68] and the Environment, Transport and Works Bureau [49] that the use of SWC offers better site safety performance and, in the process, prevent the occurrence of accidents. Further analysis revealed that daily, weekly and monthly safety inspection, supervision and monitoring, as well as safety committee meetings, have proven to be some of the most effective items within the SWC (see Figure 6). This result implies that inspection and supervision are considered enablers for checking site safety compliance. In contrast, safety meetings can be considered the communication platform to effectively deliver the message to workers or the corresponding person in charge.

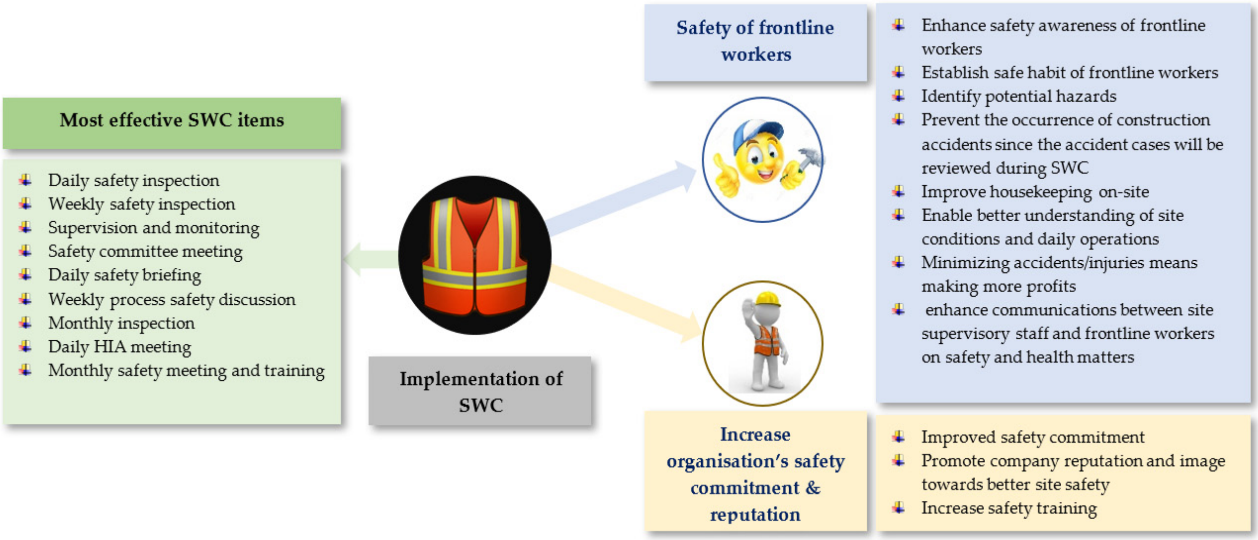

Figure 6. Overview of the effectiveness and benefits of SWC.

The effective implementation of SWC promises significant benefits that can be grouped in two viz; safety of frontline workers and increased organisation's safety commitment and reputation, as seen in Figure 6.

Factor one—'Safety of frontline workers'—past studies have noted that frontline workers are mostly the casualties of accidents on construction sites. As a result, improving their safety awareness and cultivating a safe habit will be the most efficient means of preventing construction accidents from occurring [69,70]. The finding of this current study is in tandem with these past submissions as safety awareness and safe habits are the top benefits relating to the safety of frontline workers. Furthermore, Chau and Lee [71] have noted that SWC has contributed to reducing accident rates. From the findings of this study, it is evident that SWC promotes accident-free construction sites as potential hazards are identified early, and potential accident cases are reviewed during the SWC in a bid to prevent accidents from occurring. Furthermore, Chan and Choi [68] have noted that SWC offers effective communication between site management staff and frontline workers. This is important as effective communication of safety-related information has been a key factor for proper site safety [72]. This current study further corroborates these past findings as it was observed that enhanced communication on H&S issues is achieved through SWC.

Factor two—'Increased organisation's safety commitment and reputation'—Mendis et al. [23], through an interview, noted that improving safety commitments and increased safety training are among the major benefits of adopting SWC in Sri Lanka. The finding of this current study is in line with this submission, as SWC is noted to improve organisations' commitment to safety and allows for increased investment in the training of workers. However, while the study of Mendis et al. [23] did not identify SWC as a measure that will improve a company's reputation and image towards better site safety, it is safe to say that the commitment of organisations towards ensuring better safety on site will most likely improve their reputation.

6. Conclusions

There is no naysaying that the safety of the construction workforce is germane to the success of any construction project and the image of the construction industry worldwide. This fact has been realised in Hong Kong, with several safety initiatives introduced to reduce construction site accidents drastically. An archival search revealed a significant decline in the cases of construction site accidents in Hong Kong since the introduction of these safety initiatives. While the accident rate in the construction sector is still higher than what is attainable in other sectors, comfort can be found in the knowledge that these safety initiatives are yielding results as the reduction rate of accidents are remarkable. Based on the study's findings, it can be concluded that SWC—one of the safety initiatives—is significantly implemented in construction projects in Hong Kong, and it has proved effective in safety performance on construction sites. More so, daily, weekly, and monthly inspections and supervisions and frequent safety committee meetings have proven to be the most effective SWC items that have helped improve construction safety on projects where it has been adopted. The proper implementation of SWC offers significant benefits relating to the safety of frontline workers and increasing the safety commitment and reputation of construction organisations.

This study offers empirical evidence regarding the effectiveness of SWC for construction site safety and the benefits thereof. Management of construction organisations, construction clients and policymakers can adapt these findings as a yardstick to continuously promote the adoption of SWC on construction projects. More so, the findings offer tremendous theoretical contribution as it creates a platform for future researchers to build on in their quest for a safer construction environment. This is because the paper triggers a wider debate on the underlying benefits and effectiveness of the SWC for reference by the construction industry at large. Albeit the significant contribution of this study, care must be taken in generalising its findings due to some of its limitations. It has been noted that the use of SWC is common for public sector projects; as such future works might want to explore the use and effectiveness of this initiative in the delivery of private projects specifically. Furthermore, future studies on SWC can be conducted in specific project types such as facilities service management and large-scale building maintenance in Hong Kong and other countries where such studies are nonexistent.

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