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Gap Analysis Approach for Construction Safety Program Improvement

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Abstract: To improve construction site safety, emphasis has been placed on the implementation of safety programs. In order to successfully gain from safety programs, factors that affect their improvement need to be studied. Sixteen critical success factors of safety programs were identified from safety literature, and these were validated by safety experts. This study was undertaken by surveying 70 respondents from medium- and large-scale construction projects. It explored the importance and the actual status of critical success factors (CSFs). Gap analysis was used to examine the differences between the importance of these CSFs and their actual status. This study found that the most critical problems characterized by the largest gaps were management support, appropriate supervision, sufficient resource allocation, teamwork, and effective enforcement. Raising these priority factors to satisfactory levels would lead to successful safety programs, thereby minimizing accidents.

Keyword: Critical success factors, Safety programs, Safety management systems, Safety performance, Construction industry

INTRODUCTION

Due to its hazardous nature, construction is globally perceived as an accident-prone industry. It has always been reported that construction work has a very high rate of injuries and deaths. Therefore, there is a negative stereotype concerning safety in the construction industry. In recent years, in order to survive in a highly competitive market, many construction companies have begun considering safety to be one of the main factors in reducing costs associated with work-related accidents and and injuries. In Thailand, construction work is generally labor-intensive rather than technology-intensive. Most construction workers are farmers with low levels of education and skills. Many are seasonal workers who divide time between agriculture and construction. Consequently, the rapid expansion of construction work has brought a parallel increase in injuries to unskilled workers. The accident and injuries statistics from 2004 to 2005 showed that the construction industry had the highest rate of deaths, accounting for close to a hundred workers per year, and up to 20,000 workers have suffered minor injuries on sites every year (SSO, 2005). Unfortunately, it has always been higher than all other industries.

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To eliminate construction-related accidents, implementation of safety program is regarded as a key strategy by both government and private sectors. Several studies, conducted by Hislop (1991), Tam and Fung (1998), Hinze and Gambatese (2003) and Findley et al. (2004), revealed that outstanding safety performance is closely related to construction projects where an effective safety program is established, implemented and maintained. Effective safety programs can substantially reduce accidents because they can help management to eliminate unsafe practices by workers and can also create safe working environments (Anton, 1989; Abdelhamid & Everett, 2000). Additionally, Henshaw (2004) stated that an effective safety program could result in a triple win; workers' lives would be saved and protected, cost would be reduced and returns on investments would be maximized, and workers' morale and motivation would be raised which, in turn, would result in the production of high quality products and services.

How can a safety program be improved? Key activities that are associated with, or necessary for, successful outcomes must be taken into serious consideration. Several extended studies have been undertaken to spotlight key activities contributing to strong safety programs such as top management support, sufficient resource allocation, teamwork, worker involvement, etc. In business terms, the key factors are known as critical success factors (CSFs). If these key activities are not implemented successfully, safety programs may fail miserably. Safety researchers have acknowledged and confirmed that safety program performance depends largely upon the satisfactory results of a number of key activities or CSFs. Although the connection between safety programs and safety performance has already been studied extensively, very little research has been undertaken to provide the construction industry with practical guidelines to improve safety programs.

This study is aimed at identifying the critical factors affecting the improvement of safety programs from safety literature and previous research and at evaluating these success factors in order to rank the urgency of improving them. To obtain these rankings, gap analysis was carried out to measure the difference between the degree of importance of CSFs and the actual status of CSFs. The results of the study can help the construction industry to identify and improve the high priority CSFs, shown by the large gaps, in order to improve safety programs.

REVIEW OF THAI CONSTRUCTION SAFETY

The volume of construction projects has rapidly expanded due to high demand. In Thailand, the number of

construction workers is estimated at more than two million during low season with an additional one million during high season (ILO, 2000). Unfortunately, the construction industry has been perceived as the most dangerous industry, with the highest number of injuries and fatalities. Each year from 2002 to 2005, up to 100 people died on construction sites (SSO, 2005). Most of the workers in the construction industry are either semi-skilled or unskilled with a low level of education. These factors make it difficult to maintain high safety standards in the construction industry.

To improve construction site safety, technical issues are no longer emphasized amongst governmental agencies and private sectors. The direction for accident prevention has been shifted to the development of safety management frameworks promoting the implementation of safety programs. Given that the personal safety and health of each employee is of primary concern, the prevention of occupational accidents and injuries is of such consequence that it should be given precedence over operational productivity. Siriruttanapruk and Anantagulnathi (2004) stated that there is a cooperative effort among governmental agencies and non-governmental agencies in promoting the implementation of safety programs on construction sites. Construction contractors have integrated safety programs, as a core function, with day-to-day construction operations.

Governmental agencies have put their efforts into encouraging the implementation of safety programs through law enforcement. The National Institute for the Improvement of Working Conditions and Environment (NICE) is a governmental agency established in 1983 under the Ministry of Labour. It is the main organization in charge of providing advisory services, conducting safety inspections and training, enforcing safety regulations, collecting and disseminating safety information, and developing practical guidelines for safety program implementation.

Non-governmental agencies have also been promoting voluntary safety programs. The Safety and Health at Work Promotion Association of Thailand (SHAWPAT) is a credible non-government organization established in 1987 to promote safety and health, to spread safety knowledge and experience, and to cooperate with governmental agencies in conducting safety activities and in promoting safety program implementation. It was proposed that the following 14 key safety programs must be integrated into day-to-day operations on every construction site in order to improve safety performance: safety policy, safety organization and responsibility, administrative laws and regulations related to safety, safety induction and training, hazard control programs, safety inspections, in-house safety rules, safety

control for sub-contractors, safety audits, accident investigations, safety related promotions, first aid services, emergency preparedness planning, and safety recordkeeping.

Although all relevant organizations have put much effort into improving construction site safety by promoting safety program implementation, there is still a long way to go to achieve the desired outcomes. Thai construction still suffers a high rate of accidents, injuries, and fatalities, unlike the downward trend. Siriruttanapruk and Anantagulnathi (2004) pointed out that poor safety performance in the Thai construction industry is primarily due to inadequate implementation of safety programs. Therefore, it is necessary to conduct this study to provide the Thai construction industry with practical guidelines for improving safety program implementation.

PREVIOUS STUDIES

There is no general consensus on the definition of a safety program. However, several meanings have been defined, and most of them show similarity. Anton (1989) defined a safety program as "the control of the working environment, equipment, procedure, and the worker for the purpose of reducing accidental injuries and losses in the workplace." The Oregon Occupational Safety and Health Division (2002) stated "workplace safety and health program is a term that describes what people (business owners, managers, and employees) do to control accidents and injuries at work. "

In the context of the construction business, there are few records of investigative study on the influence that safety programs have on construction safety performance (Tam & Fung, 1998). One major purpose of safety research is to support interventions of safety programs that can demonstrably improve safety. These few researchers have proven that there is a positive relationship between safety program implementation and safety performance. For example, Liska et al. (1993) conducted research on 25 construction projects to identify a number of safety techniques which are common to safety programs and determine which are the critical zero injury safety techniques. It was found that safety planning, safety training and education, recognition and rewards, drug and alcohol testing, and accident/incident reporting and investigation were significant in achieving zero accidents.

Furthermore, Hinze (2002) carried out the additional research project entitled "Making Zero Injuries a Reality" on 38 construction projects to confirm the study of Liska et al. (1993) and revealed that there were four additional safety management techniques critical for achieving zero recordable injuries. These additional four factors were

demonstrated management commitment, sub-contractor management, staffing for safety, and worker participation and involvement. Duff et al. (1994) conducted a two-phase study on the effectiveness of different intervention strategies. Specifically, they looked at the effects of feedback, goal setting and training on safety performance. They found that participative goal setting is the most effective program among the three in producing marked improvements in site safety.

Lingard and Rowlinson (1998) used a similar design to what Duff et al. (1994) used in the Hong Kong construction industry. They reported significant improvements in site safety when the contractors emphasized housekeeping. Tam and Fung (1998) and Poon et al. (2000) suggested that post-accident investigation is the most effective strategy for reducing site accidents. They concluded that causes for construction site accident can be found by such investigation in order to take appropriate preventive measures. Findley et al. (2004) advocated that the employment of full-time safety managers and safety procedure orientations are the key elements for superior safety performance. They stated that safety functions cannot be run smoothly without the appointment of on-site full-time safety managers who can provide the leadership necessary to provide preventive and corrective guidance.

Lee (1991 cited in Tam & Fung, 1998) stated that the reduction of accident rates can be achieved through the use of safety induction. In the construction industry, safe working conditions are essential. He pointed out that it is often taken for granted that new workers have received prior safety training from previous employers. That assumption could be disastrous for both the company and new workers because the nature of their current work (e.g. layout, equipment) may be totally different from their previous projects.

Based on those previous studies, a number of safety program elements have been broadly discussed. However, it is evident that a successful safety program does not need such extensive elements, but it should at least include the important elements.

CSFS OF SAFETY PROGRAM IMPROVEMENT

There are a set of factors that have a great impact on the success of safety program implementation. In a business context, those factors are known as CSFs. CSFs can be defined as "areas in which results, if they were satisfactory, would ensure successful performance for the organization" (Rockart, 1979). Rungasamy et al. (2002) viewed CSFs as being essential to the success of any program, in the sense that, if objectives associated with the factors were not

achieved, the program would probably fail catastrophically. In general, the success of a safety program's implementation comes from desired events or things that need to happen. Top (1991) and Michaud (1995) pointed out that a successful safety program can be measured by the amount or the extent of injuries to people; damage to equipment, machines and tools; damage to environment; loss of market share; damage to company image or brand name; increased productivity; etc. Based on extensive review of safety literature, Figure 1 shows 16 factors that are potentially essential to obtain improved safety programs.

Clear and realistic goals: Outstanding safety program results can be achieved when safety goals are clearly established (Pierce, 1995a). Safety goals should give a clear picture, direction, and focus for performing day-to-day activities in order to achieve desired results. When realistic and achievable goals are set up, the progress towards accomplishing such goals can be easily measured and monitored (Weber, 1992a; Blake, 1997).

Good communication: Vredenburgh (2002) stated that when the lines of communications between management and the workforce are open, workers can directly report unsafe working practices and hazardous conditions to management. Management can also communicate safety concerns and priorities to gain employees' awareness and compliance (Stranks, 1994).

Delegation of authority and responsibility: A safety program cannot be successful if it is implemented by only one individual. Responsibility for accomplishing safety activities must be effectively delegated to individuals at lower levels of authority (Anton, 1989). Effective delegation involves granting adequate authority and assigning clear responsibility for performing specific tasks with enough resources, such as appropriate completion time, money, and cooperation of all involved individuals (Rue & Byars, 2001).

Sufficient resource allocation*:* The desired goal of a safety program cannot be achieved when resources are lacking. An effective safety program is the result of a commitment by top management to give an appropriate level of resources (Erikson, 1997). Management must consider and allocate sufficient resources to carry out day-to-day activities in order accomplish short and long-term goals. The resources required for an effective safety program may include sufficient staff, time, money, information, methods, facilities, tools machines, etc. (Rue & Byars, 2001).

Management support*:* It is strongly accepted that management plays a very important role in an effective safety program. Management must fully and actively turn ideas into actions. This includes issuing a written comprehensive safety policy, allocating sufficient necessary resources, promptly reacting to safety

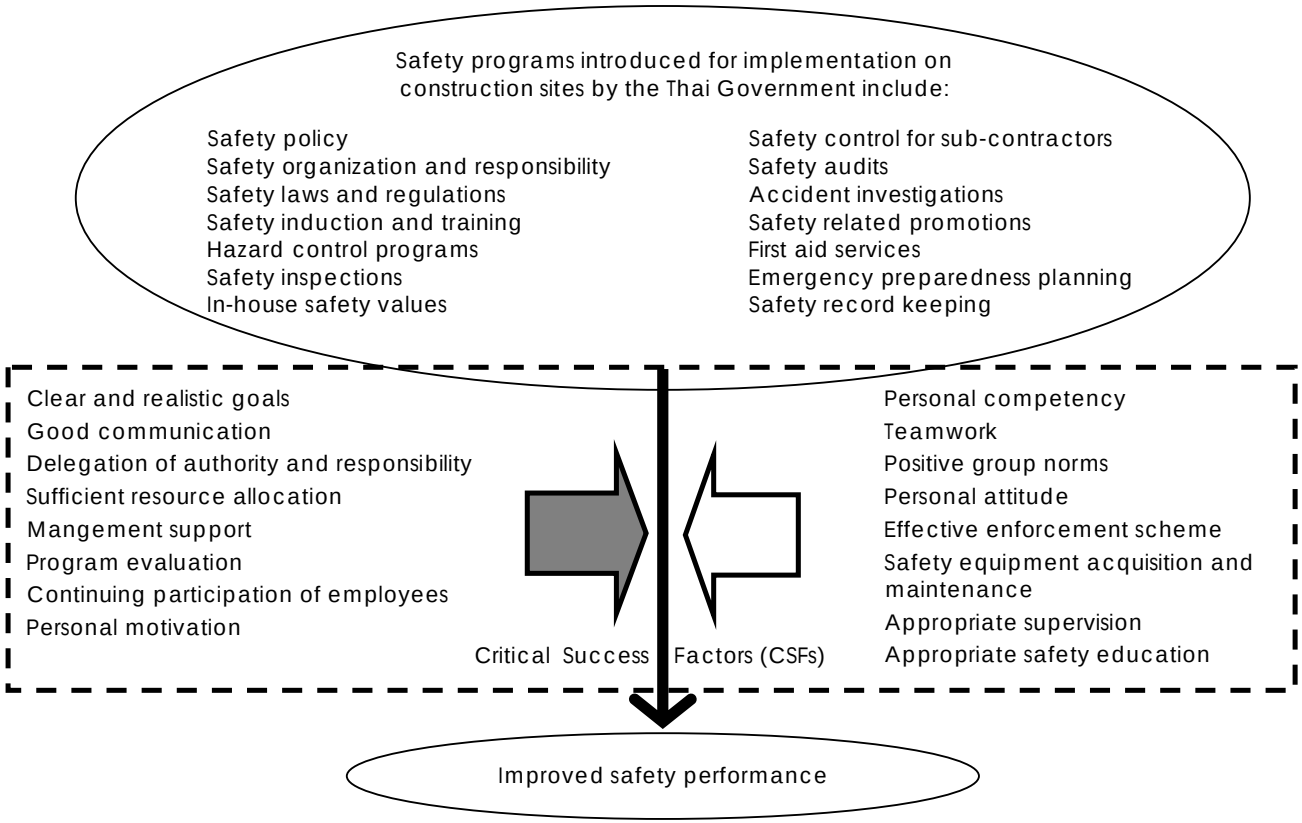

Figure 1. CSFs Contributing to Successful Safety Program

suggestions and complaints, attending regular safety meetings and training, regularly visiting the workplace, following the same safety rules as others, etc. (Stranks, 2000; Rowlinson, 2003).

Program evaluation*:* Every safety program should be periodically evaluated to see how successfully it meets its goals and objectives. When the actual operations of a safety program do not meet their defined goals, an evaluation process can help to identify the program's shortcomings so that improvements can be applied (Rowlinson, 2003).

Continuing participation of employees*:* The success of a safety program depends largely on the level of employee involvement because workers tend to support the activities that they helped to create. According to Ariss (2003) and Smith (2003), workers should be given opportunities to be involved in the design and operation of a safety program, such as joining a safety committee, reporting hazards and unsafe practices to supervisors, identifying training needs, investigating accidents, suggesting required personal protective equipment, etc.

Personal motivation*:* Although people have sufficient knowledge and skills to accomplish their jobs safely, unless they have motivation, they will not normally perform their work accordingly (Neal & Griffin, 2002). Johnson (2003) suggested that, in order to have a better safety record, all people in the workplace must be motivated to perform their jobs safely. Such motivation can include offering opportunities for achievement and recognition, additional responsibilities, rewards, and personal growth.

Personal competency*:* A successful safety program is a result of assigning the right person for the right job. The right person is defined as a person who is physically and mentally capable of carrying out the assigned tasks with the right knowledge, experience and skills (Mohamed, 2002).

Teamwork*:* According to Krause (1997) and Ulloa and Adams (2004), a safety program succeeds when everyone, regardless of rank or status within the company, realizes that accident prevention is everyone's responsibility. Every function must share responsibility in implementing safety activities in order to achieve the goals set by the team. Such goals can be planning and controlling work, handling day-to-day safety problems, etc.

Positive group norms*:* Group norms are the accepted attitudes about various things in a group of people (Stranks, 2000). In practice, Johnson (2003) explained that members of a group try to conform to accepted attitudes to avoid boycott from other members. If a positive group attitude

towards safety can be built and embedded, safety can then be managed successfully.

Personal attitude*:* Attitude is a tendency to respond positively or negatively to certain people, objects or situations and is built up from experience (Stranks, 1994; Schultz, 2004). Individuals, however, differ in their perceptions of risk and willingness to take risks. A successful safety program can be achieved if a positive employee attitude towards safety is reinforced.

Effective enforcement scheme*:* Not conforming to safety rules is known as a violation (Pierce, 1995b). Violation can be countered with enforcement. Management must provide the methods for enforcing obedience to the safety rules and regulations. By providing an effective enforcement mechanism, management can achieve employee compliance (Construction Safety Association of Ontario, 2002).

Safety equipment acquisition and maintenance*:* The workplace must be carefully assessed to determine possible hazards in order to properly select safety equipment. An effective safety program will result in fewer injuries due to good management of safety equipment acquisition and maintenance. Managing a safety equipment program takes up a large percentage of time. This includes purchasing the correct equipment, maintaining it in good condition, and inventory control. Moreover, it requires cooperation from a number of people: safety personnel, purchasing, production, warehouse supervisor, maintenance managers, etc. (Toole, 2002).

Appropriate supervision*:* A sound safety program requires employers to provide sufficient supervision in protecting workers from workplace hazards (Weber, 1992b; Levitt & Samelson, 1993). Successful supervision requires competent personnel for assigning work according to worker's ability, praising workers when they perform their duties safely, communicating by listening and speaking, setting a good example by following safety rules and correcting safety problems (Stranks, 2000).

Appropriate safety education and training*:* A successful safety program can be achieved if all employees are given periodic educational and training programs to improve their knowledge and skill at workplace safety (Cooper & Cotton, 2000).

RESEARCH METHODOLOGY

Gap Analysis Approach

In the context of business, the term "gap analysis" comes from project management and systems analysis. It refers to an analysis of the distance between where you are today versus where you need to be in order to meet your project requirements. PDMA (1996) elucidates gap analysis as a business assessment tool enabling a company to compare its actual performance with its prospective performance. This provides the company with insight into areas for improvement. Gap analysis consists of defining the present state and the desired or target state, and hence the gap between them. Later, it is a problem-solving phase, which aims at finding ways to fill the gaps in order to reach the desired states. As mentioned previously, the success of a safety program depends largely on a set of factors, the so-called CSFs. Therefore, it is necessary to investigate the degree of importance of each of those factors for a successful safety program, and to assess the actual status of such factors. The gaps between degree of importance and actual status level can pinpoint the barriers to successful implementation of a safety program. In practice, a questionnaire was the tool typically used to obtain the required data for gap analysis in several studies (Hwang et al., 2003; Chen McCain et al., 2005; Aksu, 2006). In this study, a questionnaire was therefore used for data collection. It was suggested that prior to actual data collection, a questionnaire must be pre-tested for validity and reliability and to clarify potential areas of misinterpretation. As a result, a valid questionnaire was derived before the main study was conducted.

Validity and Reliability Testing for a Questionnaire

From an extensive literature review, a total of 16 success variables were identified. Before including them in the final draft of questionnaire, they were statistically validated using Content Validity Ratio (CVR). This internal validation was carried out by asking 40 experts (i.e. construction safety managers, safety engineers and senior safety officers who have been involved in managing safety in construction projects for at least 10 years) whether or not the defined 16 variables were "1 = essential", "2 = useful but not essential" or "3 = not necessary". Degrees of necessity were used as success variables for safety program implementation.

The data gathered were then calculated to obtain the CVR based on Lawshe's formula (Lawshe, 1975). According to Lawshe, with a panel of 40 respondents, the minimum value of CVR needs to be at least 0.29 in order for it to be acceptable. As a result, variables which have CVR values less than 0.29 were not included in final questionnaire. This preliminary study showed that all 16

variables had CVR value greater than 0.29, varying from 0.70–1.00. Thus, it was inferred that all 16 CSFs were strongly valid for this research and they could be included in the final form of a questionnaire.

In this study, a questionnaire's reliability was further verified by using Cronbach's alpha coefficient (α), which is a measurement of internal consistency. This reliability test was conducted on a small group of respondents who were requested to complete a final questionnaire. A total of 30 respondents were involved in the reliability test. To obtain α, the Statistical Package for Social Sciences (SPSS) software program was used to analyze raw data. The value of the alpha coefficient for the data obtained from the respondents was 0.746, demonstrating acceptable reliability of the questionnaire (Nunnally, 1978). The results of these analyses implied that the actual data collection could be performed by using this questionnaire.

Questionnaire Survey

A questionnaire survey was designed by incorporating the applicable 16 variables. A complete questionnaire consisted of two parts: (1) questions asking general information and project background of respondents, and (2) questions asking respondents to rate the level of influence of each success variable and to evaluate its actual status. The second part of the questionnaire is the main focus of the survey. It aimed at obtaining the importance of each factor in a successful safety program, as perceived by the respondents. To extract the degree of influence, the respondents were asked to rate each factor on the five-point Likert scale, varying from "not important" (1) to "extremely important" (5). In addition, the respondents were asked to evaluate the actual status of each factor based on the amount of care currently given to it. To elicit the levels of actual status, another five-point Likert scale was utilized, varying from "very poor status" (1) to "very good status" (5). The survey was carried out on medium- and large-scale construction projects in Thailand. A project was considered "medium" when its total project cost was 20–100 million baht with 50–200 workers, and considered "large" when total project cost was greater than 100 million baht with more than 200 workers. Several manners were used to distribute the questionnaires to the respondents. Nevertheless, to motivate the respondents to participate in the survey, face-to-face or direct delivery was preferred. Doing so improved the response rate.

Characteristics of Respondents

The respondents are classified into two groups, namely project managers and safety representatives. A construction project manager is defined as a person with the highest authority in handling day-to-day activities and delivering the project, and who is responsible for managing

the implementation of the safety program, which aims to provide a safe and healthy environment on site. A construction safety representative is defined as an individual, including a safety director, safety manager, or safety inspector, who is in charge of arranging safety for the construction firm. The responses from these two groups are shown in Table 1, which shows a total of 70 responses. Thirty project managers and 40 safety representatives were randomly selected from the large and medium-scale projects to participate in the survey. All respondents have a minimum of 10 years of experience in the construction industry. The socioeconomic information of the respondents is presented in Table 1.

DATA ANALYSIS AND KEY FINDINGS

Rankings of the Importance and the Actual Status of CSFs by Different Respondent Groups

Table 2 displays the breakdown of mean scores for degree of importance and actual status of 16 success factors as rated by the respondents from different occupations, namely project managers and safety representatives. A panel of project managers rated management support (mean = 4.77) as the most important factor, followed by teamwork (mean = 4.70), appropriate safety education and training (mean = 4.53), program evaluation (mean = 4.50), and personal attitude (mean = 4.47). A panel of

Table 1. Socioeconomic Information of the Respondents

Socioeconomic factors	Project managers	Safety representatives	Overall	%
Year of experience				
Less than 10	-	-	-	-
10–15	14	28	42	60
16–20	13	10	23	33
More than 20	3	2	5	7
Total	30	40	70	100
Size of involved project				
Medium	13	22	35	50
Large	17	18	35	50
Total	30	40	70	100

Table 2. Respondents' perceptions towards the importance and the actual status of critical success factors

safety representatives rated management support (mean = 4.60), appropriate safety education and training (mean = 4.48), clear and realistic goals (mean = 4.43), effective enforcement scheme (mean = 4.40), and teamwork (mean = 4.30) as the most important factors. To examine the general similarity in the rankings of degree of importance between the panel of project managers and safety representatives, Spearman's rank correlation test was used to determine whether or not the similarity is significant. The result showed that the Spearman's rank correlation coefficient was 0.718 and the correlation was statistically significant at the 5% level. Therefore, it was concluded that the similarity of the rankings between project managers and safety representatives was very strong.

Furthermore, the results of the study showed that both groups of respondents rated very high mean scores for actual status to five similar factors, namely appropriate safety education and training (mean = 4.43 and 4.38), clear and realistic goals (mean = 4.20 and 4.25), delegation of authority and responsibility (mean = 3.97 and 4.08), safety equipment acquisition and maintenance (mean = 3.77 and 4.25) and good communication (mean = 3.73 and 3.98). Then, Spearman's rank correlation was computed to examine the similarity in the rankings of actual status between two groups of respondents. A coefficient value of 0.878 was obtained, showing that correlation was statistically significant at the 5% level. Therefore, it was inferred that the similarity of the rankings between project managers and safety representatives was very strong.

Rankings of the Importance and Actual Status of CSFs by Different Project Sizes

Table 2 illustrates the breakdown of mean scores of degree of importance and actual status of 16 success factors from different project sizes. The respondents from large-scale projects rated management support (mean = 4.91) as the most important factor for successful safety programs, followed by teamwork (mean = 4.80), clear and realistic goals (mean = 4.71), effective enforcement scheme (mean = 4.63), and personal attitude (mean = 4.60). Meanwhile, the respondents from medium-scale projects rated management support (mean = 4.43), appropriate safety education and training (mean = 4.43), effective enforcement scheme (mean = 4.20), clear and realistic goals (mean = 4.14), and teamwork (mean = 4.14) as the most important factors for successful safety programs. The Spearman's correlation test was carried out to prove the similarity in the rankings of degree of importance between the respondents from large- and medium-scale projects. The result showed that the correlation coefficient was 0.769, which shows that it was statistically significant at the 5% level. Therefore, it was concluded that the similarity of the rankings was very strong.

Furthermore, the results of the study showed that both groups of respondents rated very high mean scores for actual status to five similar factors, namely appropriate safety education and training (mean = 4.40 and 4.40), clear and realistic goals (mean = 4.20 and 4.26), delegation of authority and responsibility (mean = 4.14 and 3.91), safety equipment acquisition and maintenance (mean = 4.06 and 4.03) and good communication (mean = 4.00 and 3.74). A Spearman's rank coefficient value of 0.825 was derived, suggesting that the correlation was statistically significant at the 5% level. Therefore, it was implied that the similarity of the rankings of respondents from large- and medium-scale projects was very strong.

Overall Rankings of the Importance and Actual Status of CSFs

Table 2 illustrates the combined scores of every respondent's perceptions towards actual status and degree of importance for CSFs factors. It was found that management support was the most important factor (mean = 4.67) in reinforcing safety programs to reduce accidents and injuries, followed by appropriate safety education and training (mean = 4.51), teamwork (mean = 4.47), clear and realistic goals (mean = 4.43), and effective enforcement scheme (mean = 4.41). The five factors that had best scores for actual status were appropriate safety education and training (mean = 4.40), clear and realistic goals (mean = 4.23), safety equipment acquisition and maintenance (mean = 4.04), delegation of authority and responsibility (mean = 4.03), and good communication (mean = 3.87).

Gap Analysis Between The Importance And The Actual Status Of CSFs

One of the barriers to the success of a safety program is insufficient attention to CSFs. This study, therefore, makes a gap analysis of the data showing the differences between the degree of importance and actual status for each CSFs. For each evaluation, the gaps are computed by subtracting the mean for actual status from the mean for the degree of importance. The gaps in the mean scores provided by the respondents can be a useful reference for construction managers when considering which factor(s) should be allocated the highest priority for improvement. Table 3 displays the rankings of the gaps between degree of importance and actual status for each of the 16 factors, as rated by the respondents, and it also exhibits the results of t-test analysis. The results indicated that there were significant differences in 11 out of 16 factors (Table 3). It was found that the mean scores between degree of importance and actual status of those 11 factors were significantly different. The mean scores of actual status for all 11 factors were smaller than mean scores of degree of importance. Among the 11 factors, the top five that have

Table 3. Gaps Between the Importance and the Actual Status of CSFs

Success factors	Overall degree of importance		Overall actual status		Gap	Rank	*p*-value
	Mean	S.D.	Mean	S.D.			
Clear and realistic goals	4.43	0.65	4.23	0.66	0.20	14	0.074
Good communication	4.11	0.77	3.87	0.87	0.24	13	0.085
Delegation of authority and responsibility	4.29	0.68	4.03	0.86	0.26	12	0.059
Sufficient resource allocation	4.13	0.78	2.76	0.64	1.37	3	0.000 *
Management support	4.67	0.63	3.21	0.77	1.46	1	0.000 *
Program evaluation	4.31	0.69	3.16	0.55	1.15	6	0.000 *
Continuing participation of employees	4.10	0.87	3.24	0.53	0.86	10	0.000 *
Personal motivation	4.26	0.74	3.33	0.56	0.93	9	0.000 *
Personal competency	3.87	0.74	3.29	0.53	0.58	11	0.000 *
Teamwork	4.47	0.69	3.11	0.72	1.36	4	0.000 *
Positive group norms	4.09	0.91	3.03	0.70	1.06	7	0.000 *
Safety equipment acquisition and maintenance	4.10	0.68	4.04	0.94	0.06	16	0.681
Personal attitude	4.31	0.75	3.31	0.59	1.00	8	0.000 *
Effective enforcement scheme	4.41	0.65	3.13	0.73	1.28	5	0.000 *
Appropriate supervision	4.21	0.63	2.79	0.51	1.42	2	0.000 *
Appropriate safety education and training	4.51	0.55	4.40	0.65	0.11	15	0.256

Notes: * denotes that it is significantly different at 95% level of confidence

the largest gaps between degree of importance and actual status are as follows:

a. Management support (gap = 1.46): The respondents commented that management views safety as a non-profit function; thus, safety is always given low priority for attention and support.

b. Appropriate supervision (gap = 1.42): A supervisor or foreman's actions in closely directing the work are the critical link in ensuring a successful safety program. The respondents stated that foremen more often overlook the maintenance of safe working practices for their crews. They focus on work progress rather than workers' well being.

c. Sufficient resource allocation (gap = 1.37): Respondents view allocation of safety resources as a reflection of the level of management support; thus, lack of management support is parallel to insufficient resource allocation for safety program implementation. Safety budgets and safety personnel are the most preferable resources specified by the respondents.

d. Teamwork (gap = 1.36): Teamwork has been increasingly accepted as the key ingredient of an effective safety program. The respondents pointed out that less effort has been shared among stakeholders in ensuring that construction sites meet safety goals.

e. Effective enforcement scheme (gap = 1.28): The respondents stated that clear enforcement methods for non-compliant workers are not written or provided for on job sites.

Table 3 also shows the results of the t-test analysis which was conducted to evaluate whether the means for degree of importance and actual status for each factor are significantly different from each other. The analysis showed that five of 16 factors were not significantly different, namely delegation of authority and responsibility, good communication, clear and realistic goals, appropriate safety education and training, and safety equipment acquisition and maintenance. From this, it can be concluded that these five factors have been given appropriate consideration and implementation up to a satisfactory level on construction sites. The rest of the factors, meanwhile, should be considered further in order to improve their actual status so they may reach a satisfactory level.

CONCLUSIONS

Safety continues to be one of the major problems in the construction industry. To achieve better site safety performance, emphasis has been placed on implementing effective safety programs. Therefore, this study was conducted to identify the critical areas of safety program implementation that construction management must recognize in order to make continuous improvements. This study identified 16 factors contributing to the improvement of safety programs and then evaluated their degrees of importance and actual status based upon the respondents' perceptions. The results of this study showed that all respondents rate management support as the most important factor, followed by appropriate safety education and training, teamwork, clear and realistic goals, and effective enforcement scheme. On the other hand, positive group norms and personal competency were perceived as the two least important factors. The study also showed that five CSFs, namely appropriate safety education and training, followed by clear and realistic goals, safety equipment acquisition and maintenance, delegation of authority and responsibility, and good communication, have better actual status amongst all factors. In other words, it is implied that these factors have been given appropriate consideration in construction sites. On the contrary, appropriate supervision and sufficient resource allocation were considered the factors with the poorest actual status. Thus, more effort must be made to improve the actual status of these two factors.

In light of this research, gap analysis was carried out to determine how to improve safety programs. This analysis suggested that larger gaps between degree of influence and actual status of success indicate more unsatisfactory practices. Thus, correcting the factors which have large gaps must be emphasized more strongly. This study also found that the first five critical problems of safety program implementation are management support, appropriate supervision, sufficient resource allocation, teamwork, and effective enforcement scheme. These five priority factors should be given more attention in order to achieve a satisfactory level. Meanwhile, there are five factors, namely delegation of authority and responsibility, good communication, clear and realistic goals, appropriate safety education and training, and safety equipment acquisition and maintenance, showing satisfactory practices as characterized by very small gaps.

FURTHER RESEARCH

This study could be broadened to include a larger sample to increase the level of reliability of the research. Additionally, the study could be supplemented by studying

the relationships between those CSFs and actual safety performance. By doing this, the results of the analysis can identify which CSFs have the greatest impact on the improvement of actual safety performance. To measure safety performance, it is suggested that reactive measurement (i.e. accident rate) and proactive measurement (i.e. observation of unsafe acts and unsafe conditions) should be carried out. Reactive measurement can reflect the trend of safety performance on sites but give an unclear indication of management's efforts, whereas the proactive approach can identify potential causes of future accidents and provide necessary feedback to management in order to establish preventive mechanisms.

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