International Journal of Business and Technology Management
e-ISSN: 2682-7646 | Vol. 5, No. 3,95-107, 2023
http://myjms.mohe.gov.my/index.php/ijbtm

Causal Effects of Safety Measure Practices on Safety Performance and Project Performance

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Received: 15 June 2023 | Accepted: 10 August 2023 | Published: 1 September 2023

DOI: https://doi.org/10.55057/ijbtm.2023.5.3.8

Abstract: *Although many improvements in the prevention of fatalities in construction industry, however, the fatality rates in Malaysian Construction Industry continue at an unacceptable rate. Data extracted from Department of Occupational Safety & Health (DOSH) Malaysia, indicated that Safety Measure Practices (SMP) were the main cause of workers' high fatality. The purpose of this study is to investigate the relationship of SMP, Safety Performance, and Project Performance at Occupational Health & Safety Management System (OHSMS) certified Malaysia construction projects. This study was conducted using purpose sampling, a self-administrated questionnaire at 31 project sites consisting of 401 respondents within the safety management team members in the state of Selangor, Malaysia. The data analysis in this study was carried out using SPSS Amos (v21) of IBM. The findings show that Safety Rules & Procedures, Safety Acts and Adoption of OHSMS of SMP are positively related to safety performance and project performance. Furthermore, these elements of safety components shall upgrade company image and improve financial gains of the project. Within the scope of the unique nature of the project, implementing SMP in OHSMS environment, with special reference to Safety Rules & Procedures and Safety Acts of the workers results in less workplace accidents. Also, project performance (company competitiveness and financial performance) will be enhanced through better safety performance. The key findings may prompt the top management and project managers to re-think the current conservative approach to run the projects where safety issues are fully responsible by the safety team. Top management need to top-up resources to manage safety as like other functions of the business. Project managers need to manage safety besides the other functions of the organization such as production, maintenance, marketing and finance to achieve business objectives.*

Keywords: Safety Rules & Procedures; Unsafe Acts; OHSMS; Safety Performance; Project Performance.

1. Introduction

The Malaysian construction industry has been the backbone of the Malaysian national development (Wesam et al., 2021), but the industry also faced a high incidence of accidents and fatality occurrence. The construction sector remained the highest risk of occupational fatal accident rate of 6.90 per 100,000 workers. It also reported second highest accident rate of 3.37 per 1000 workers which below the manufacturing sector of 4.12 per 1000 workers (DOSM, 2021).

The high incident is linked to poor safety measure practices (SMP). The fatality data extracted from Department of Occupational Safety & Health (DOSH) Malaysia from 19/5/2014 to 18/7/2020 of 330 cases, indicated that the main causes of SMP are: - Lack of/or no Safety Rules & Procedures -108 cases, Unsafe Working Conditions -77 cases, Unsafe Acts of the workers - 39 cases, No Conclusive comments -75 cases, and the balance of 29 cases were make-up of accidents, lack of supervision from the employer and lack of training (JKKP Fatal Accident Case).

This renders the necessity to investigate the causes of these fatal accidents. The outcomes of the study will facilitate project teams to take prerequisite actions to minimize accidents and fatality rates.

2. Aim and objectives

The aim is to identify the success factors of safety measure practices which instigate high fatality rates in construction sites, and highlighting of these factors to the project team members including top management in order to identify the best solutions to minimize incidents.

Objectives

i. To identify the success factors of Safety Measure Practices in OHSMS certified construction companies
ii. To formulate a model to investigate the causal effects of Safety Measure Practices in OHSMS certified construction companies in Malaysian.

3. Literature review

Human errors have primarily caused occupational accidents and injuries (Reyes RM et al., 2015; Salminen & Tallberg, 1996) which also aligned with the concept of Heinrich Domino theory of accident causation and control. Succeeding the Domino theory, which formulae the foundation of Behaviour-Based Safety theory (BBS), BBS addressed that there are additional reasons for the cause of injuries, such as environment, equipment, procedures and attitudes. BBS approaches have been introduced to mitigate casualty (Pardy W and Andrews T, 2010). The cornerstone of these approaches is to encourage workers to carry out their job tasks in a safe manner by following the prescribed safety rules and procedures and safety standards (Yiu S N et al., 2019). Studies by Bellamy et al (2013) indicated that safety involvement by workers shall significantly reduce workplace injuries. Safety rules and procedures are generally written methods that define how work tasks are performed while minimising risks to people, equipment, materials, environment, and processes. Some rules concentrate only on the safety aspect, for example, in the use of personal protective equipment. Others are associated with additional objectives such as quality, productivity, health, environment, and sustainability. For an effective safety rules & procedures, they must be regularly reviewed together with the workers which then safety will be improved (Choudhry et al., 2009).

On top of the workers responsibility to practise safety behaviour at work, the organisation must commit and promote safety compliance in a supportive working environment. One way for the organisation to promote safety compliance is the implementation of SMP within a systematic safety management system. OHSAS 18001/ISO 45001 is a worldwide recognised safety management system. Since 1999, many organisations have adopted OHSMS in their workplace (OHSAS Project Group). The adoption of OHSMS has recorded many benefits in terms of safety performance. Supportive environment or conducive workplace is paramount in every

industry, more so in the construction sector in order to promote the well-being of both employees and employers. All industries have inherent safety risks but it is the management's responsibility to devote time and resources to this aspect of safety management.

The Director General of DOSH(Malaysia) (Malay mail 2016), and chairperson of National Institute of Occupational Safety and Health (NIOSH) Malaysia (the star 2014) also specified mentioned that the fatality occurrence were due to lack of safety rules and procedure and contractors' lackadaisical attitudes towards safety practices. These effects need to be fully assessed to predict SMP. Multivariate models able to analyse the complex relationship between directly and indirectly latent variables and to forecast the possible outcomes. Application of Structural Equation Modelling (SEM) was demonstrated to determine the effective factors of SMP particularly in the construction industry in this present study. Prevention of occupational accidents and fatality can be achieved via the analysis of multiple factors simultaneously. SEM technique is able to explain the problems with multiple factors. The results of the field survey were analysed using Confirmatory Factor Analysis (CFA). Finally, the structural model was constructed to examine the impacts of safety rules & procedures, unsafe acts of workers, supportive environment, adoption of OHSMS on the benefits of project performance.

SEM has been substantially used in numerous studies in safety behaviour. An analysis of methodologies used by researchers on safety and health management, the most commonly modules adopted were quantitative research method, collection of data using questionnaire survey and analysis data using SEM (SPSS) (Sawacha et al., 1999; Chen et al., 2009; Omran et al., 2008; Mohammadfam et al., 2017; Bottani et al.,2009; Yoon et al., 2013; Fernandez-Muniz et al., 2009).

A number of literature reviews by researchers on the implementation of good SMP have revealed a significant reduction in both accidents and fatalities. However, Heras-Saizarbitoria et. al (2019) and Ghahramani and Summala (2015), both pointed out that certification of OHSAS 18001 and practising good SMP is not completely related to better safety performance. With these contradicting findings, the study further investigates the effectiveness of practising good SMP.

4. Datasets and methodology

4.1 Theoretical model and hypotheses

This study has constructed a conceptual framework based on two underpinning theories; - Heinrich Domino Theory and Behavior-Based Safety Theory. Figure 1 depicts the conceptual framework of safety measure practices and project performance (Mossink,2002).

The research model includes seven constructs namely safety rules & procedures, supportive environment, unsafe acts, adoption of OHSMS, safety performance, company competitiveness and financial performance of the project.

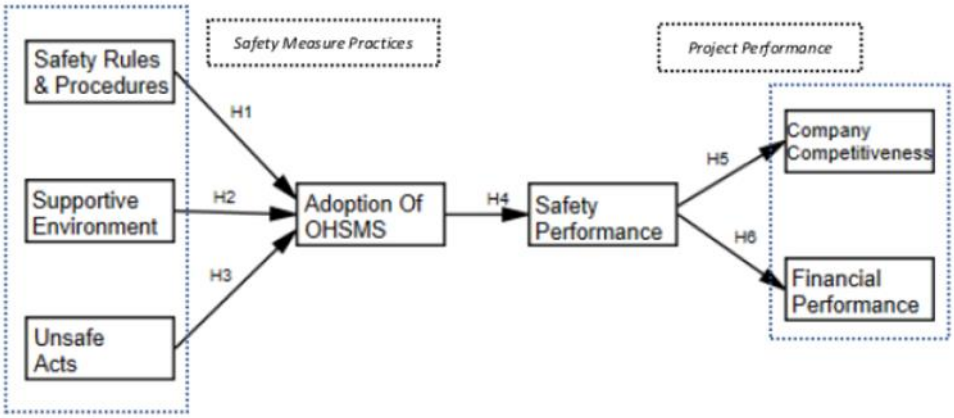

Figure 1: Conceptualization of the relationship between SMP and performance outcomes

According to the above theories, the following hypotheses have been considered in the statistical population of safety management team at construction projects with the state of Selangor, Malaysia. The hypotheses are: -

H1 - *Safety Rules & Procedures will have a positive and significant effect on Adoption of OHSMS*
H2 - *Supportive Environment will have a positive and significant effect on Adoption of OHSMS*
H3 - *Unsafe Acts will have a positive and significant effect on Adoption of OHSMS*
H4 - *Adoption of OHSMS will have a positive and significant effect on Safety Performance*
H5 - *Safety Performance will have a positive and significant effect on Company Competitiveness*
H6 - *Safety Performance will have a positive and significant effect on Financial Performance*

4.2 Research methodology

The research methodology adopted an analytical approach by means of quantitative survey. The process is in line with Bryman and Cramer (2001). The target respondents approached for this survey were the safety management team of construction projects within the state of Selangor. The projects were registered with Construction Industry Development Board (CIDB) Malaysia G7 category with ISO 45001, or OHSAS 18001 or MS 1722: Part 1 certification. The state of Selangor was selected as the study site due to its stature as the most developed and progressive area in Malaysia (State Socioeconomic Report 2019, DSM). The final data set of 401 observations met the minimum sample size expounded by Yamane's formula (Yamane, 1967) (399 respondents), Cochran's formula (Cochran, 1977) (384 respondents), and F-Test (119 respondents) (Faul et al., 2009). A majority of the respondents were 26-35 years (51.9%), male (81.3%) and completed their bachelor degree (62.6%). The number of workers employed per site was between 100 to 499 (49.1%). There was a mix of system and conventional method of construction (64.6%), while strata property ≥ 20 storey was 65.1%.

4.3 Instrument and Measurement

All the elements selected for the measurement scales were adapted from past research with a five-point Likert scale (where 1 indicates strongly disagree and 5 indicates strongly agree). In parts 1 and 2 of the questionnaire, demographic information and project details were collected. As a measure of safety rules & procedures, supportive environment and unsafe acts, the items

examined were adopted from the studies by Vinodkumar and Bhasi, (2011) (4 items), Tan et al. (2015) (7 items) and Mohammad and Hadikusumo, (2017) (6 items), respectively. Adoption of OHSMS was measured using ten components from Tan et al. (2015). Safety performance was operationalised using four first-order constructs adopted from Mohd Nawi et al. (2016), namely, safety culture (5 items), safety behaviour (5 items), safety awareness (5 items), and management commitment (6 items). Both constructs of company competitiveness and financial performance were measured using five and four items respectively adopted from Fernandez-Muniz et al., 2009. To test the six hypotheses, the statistical software used was AMOS (V21) of SPSS of IBM.

4.4 Sample and data collection

A questionnaire was developed in this study. The data were collected using the purpose sampling method (non-probability selective sampling), the project sites need to be registered with ISO 45001 or OHSAS 18001, geographically located within the state of Selangor, Malaysia. The participants were from the project site safety management team. The data collected through a five-point Likert scale questionnaire. 58 content items were pre-tested through expert evaluation (5 SHO, 2 DOSH officers and 2 university lecturers). Questions were written both in English and Malay to cater for multi-lingual society in Malaysia. To achieve accurate translation, 'translate-back-translate' method was used. Pilot testing was conducted, the Cronbach's α test was used to determine the measurement items' reliability. A final ground survey of 57 content items were established.

Collectively, 442 respondents from 31 project sites were returned, however, 36 forms were rejected due to incomplete of survey questions, and 5 rejected due to outlier, making a total of 401. Table 1 presented the demographic profile of the sample.

Table 1: Demographic Profile

Variable	Classification	Frequency	Percentage (%)
Gender	Male	326	81.3
	Female	75	18.7
Age	25 years old and below	55	13.7
	26-35 years old	208	51.9
	36-45 years old	83	20.8
	46-55 years old	37	9.2
	Above 56 years old	18	4.4
Education	High Schools and Below	12	3.0
	Certificate and Diploma	129	32.2
	Professional Certificate	9	2.2
	Bachelor Degree	216	53.9
	Master Degree	35	8.7
Experience	5 years & below	166	41.4
	6 to 10 years	113	28.2
	11 to 15 years	52	12.9
	16 to 20 years	30	7.5
	Over 21 years	40	10.0
Position	Project Manager/Sr Manager	65	16.2
	Engineer	108	26.9
	Supervisor/Coordinator	139	34.7
	SHO/SSS/Safety Profession	48	12.0
	QS	9	2.2
	Others	32	8.0
Sum		401	100.0

5. Data analysis and results

CFA is a statistical technique used to verify the factor structure of a set of observed variables. It allows the researcher to test the hypothesis that a relationship between observed variables and their underlying latent constructs exists.

5.1 Validating the measurement model

Common Method Variance (CMV) may result in a false internal correlation and consistency among the variables, Harman-Single Factor test of the largest variance explained was 33.60% (<40%) and Common Latent Factor test, the highest value difference between the two estimates of standardized regression weight was 0.172 (<0.2) (Cohen, 1988). This confirms that CMV is of no concern for this survey.

The existence of multicollinearity in combined variables in the data set has been carried out based on the value of detection-tolerance (TOL) and the variance inflation factor (VIF). The presence of multicollinearity issue will be identified if the values of TOL and VIF are <0.2 and >5.0 respectively (Allison, 2003). Table 2 shows the values of TOL (0.418 to 0.822) and VIF (1.217 to 2.394), indicating that these constructs are distinct and are measuring different aspects of SMP

Table 2: Detecting Multicollinearity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std Error	Beta	t	Sig	Tolerance	VIF
1	(Constant)	-.006	.248		-.024	.981		
	Safety Rules And Procedures	.009	.067	.007	.133	.894	.489	2.044
	Adoption of OHSMS	.316	.070	.222	4.514	.000	.487	2.052
	Unsafe Act	.016	.069	.012	.233	.816	.418	2.394
	Supportive Env	-.090	.065	-.069	-1.389	.166	.477	2.098
	Company Competitiveness	.678	.048	.602	13.987	.000	.637	1.570
	Safety Performance	.026	.039	.025	.660	.509	.822	1.217

a Dependent Variable: Financial Performance

The reliability and validity of the constructs were evaluated through CFA, this is the test whether the data fit a hypothesized measurement model. The process started with assessing the individual item reliability as shown in Table 3. The factor loadings (FL) were well above the acceptable threshold value of 0.60. As to the construct validity, all constructs achieved composite reliability (CR) greater than 0.82 and Average Variance Extracted (AVE) greater than 0.5.

Table 3: Convergent validity for the variables

Variables	Items	F.L.	AVE (>0.50)	CR (>0.70)
Safety Rules & Procedures	4	0.710-0.789	0.567	0.839
Supportive Environment	3	0.741-0.817	0.612	0.825
Unsafe Act	3	0.706-0.826	0.617	0.828
Adoption of OHSMS	7	0.686-0.759	0.532	0.888
Safety Performance	16	0.617-0.909	0.771	0.929
Company Competitiveness	5	0.766-0.902	0.688	0.916
Financial Performance	4	0.828-0.905	0.741	0.920

F.L. = factor loading, AVE = average variance extracted, CR = composite reliability

In order to satisfy discriminant validity, the diagonal value should be greater than the off-diagonal values in the corresponding rows and columns as shown in Table 4, the condition was met.

Table 4: Discriminant validity for the variables

	AVE	CR	1	2	3	4	5	6	7
Adoption of OHSMS	0.532	0.888	**0.729**						
Safety Rules & Procedures	0.567	0.839	*0.555*	**0.753**					
Supportive Environment	0.612	0.825	0.472	*0.718*	**0.782**				
Unsafe Acts	0.617	0.828	0.716	0.697	*0.761*	**0.785**			
Safety Performance	0.771	0.929	0.401	0.206	0.203	*0.289*	**0.878**		
Company Competitiveness	0.688	0.916	0.512	0.487	0.440	0.524	*0.273*	**0.829**	
Financial Performance	0.741	0.920	0.523	0.383	0.289	0.429	0.266	*0.737*	**0.861**

Note: The diagonal entries (in Bold) represent the squared roots average variance.
The off-diagonal entries (in Italics) represent the variance shared between constructs.

Upon satisfying the requirements of the validity, reliability, and CMV of the instrument, SEM was performed in order to establish a theoretical causal relationship model consisting of a set of predicted covariances between variables and then assess whether it is valid when compared to the observed data. In this study, SEM has been used to test the interrelationships of safety rules and procedures, supportive environment, unsafe acts, adoption of OHSMS, safety performance, company competitiveness and financial performance for OHSAS 18001 / ISO 45001 certified projects in the state of Selangor, Malaysia. The overall fit of the structural model was examined to determine model fit and valid prior to proceed with analysis of structural links.

5.2 Structural model

The results have indicated that the structural model was shown to be reasonably fit. The goodness-of-fit indices obtained in this study are summarised in Table 5. The values are RMSEA = 0.055; CFI =0.916; TLI = 0.909; Normed Chi-Square = 2.219; Chi-Square = 1773.077 and degree of freedom = 799. All the goodness-of-fit indices fulfilled the basic threshold values.

Table 5: Goodness-of-fit (GOF) results for the Structural Model

Goodness of Fit Statistics	Desired Range of values for a good fit	Values
Root-Mean Square-Error of Approximation (RMSEA)	≤ 0.08	0.055
Comparative-Fit-Index (CFI)	> 0.90	0.916
Tucker Lewis Index (TLI)	> 0.90	0.909
Normed Chi-Square (χ^2 / df)	< 5.0	2.219
Chi-Square		1773.077
Degree of Freedom		799

5.2.1 Path analysis

The inferential statistical analysis of SPSS Amos (v21) software was used and the path analysis of H1 to H6 are shown in Table 6.

Table 6: Results of Path Analysis

Paths	β	SE	Beta	CR	P value
H1: Safety Rules & Procedures → Adoption OHSMS	0.249	0.078	0.277	3.189	0.001
H2: Supportive Environment → Adoption OHSMS	-0.169	0.098	-.178	-1.72	0.085
H3: Unsafe Acts → Adoption OHSMS	0.596	0.092	0.675	6.483	0.000
H4: Adoption OHSMS → Safety Performance	0.653	0.087	0.441	7.525	0.000
H5: Safety Performance → Company Competitiveness	0.275	0.047	0.324	5.804	0.000
H6: Safety Performance → Financial Performance	0.076	0.038	0.083	1.968	0.049

Note: SE: Standardized Error, CR: Critical Ratio

The statistical results are shown in Table 6. The path analysis indicated that only 5 hypotheses paths in the research model were significant, except H2, the relationship between supportive environment and adoption of OHSMS due to insignificant p value ($p > 0.05$).

The review of the findings from these data gathered revealed the following noteworthy outcomes:

a) Safety rules & procedures and workers' behavioural actions have a positive impact on the OHSMS ($p < 0.05$). These indicate that the practising of safety rules & procedures, safety behaviour of workers will effectively impact on the OHSMS. The enforcement of safety rules & procedures will predict the safety behaviour of the workers (Vinodkumar and Bhasi, 2011).
b) Adoption of OHSMS was significantly related to the safety performance of the project ($p < 0.001$). This concludes that the practising of OSHMS, contemporary with worker's involvement and worker's influence on the consciousness of safety rules and procedures will have a positive relationship with safety performance (Chan et al., 2017).
c) Safety performance was significantly related to company competitiveness and financial performance ($p < 0.05$). This indicates that safety performance will effectively improve project performance positively. Practising an effective OHSMS will result improvement in financial performance, such as sales and profit (Fernandez-Muniz et al., 2009). Also, will improve in higher labour productivity (O Paas et al., 2015) and company image (Chen et al., 2009).

SEM is a combination of two statistical methods, there is the confirmatory factor analysis and path analysis. The objective of CFA is to test whether the data fit a hypothesized measurement model. To check the validity of the measurement model, the factor loading latent variables should be greater than 0.6 (or R2 > 0.4, where R is the square of factor loading) and the

appropriate model fit indices. Path analysis is to test the structural equation. SEM's goal is to find the most parsimonious summary of the interrelationship among variables that accurately reflects the associations observed in the data. The significant association between 2 latent variables are determined by the coefficient is significant (critical ratio (z) >= 1.96 for p <= 0.05).

6. Discussion

Established a well written and practising safety rules & procedure in a workplace will not be sufficient in the context of Occupational Safety and Health (OSH). It needs to be engaged together with safety behaviour of the workers who need to be fully committed and understand the rightful safety rules & procedure in relation to the appropriate job tasks. An OHSMS certified workplace will create desired working environment for the workers, which practices proactive approach to manage workplace safety and health. The training of safety rules & procedures to the workers need to be based on the activity-training theory, especially for those not so well educated or language barrier workers. Giving and receiving feedback during training is a good exercise.

According to study results, thorough and detail thinking of job procedures is essential to achieve positive outcomes. Workers who failed to follow rules, or not thinking the task thorough will increase accidents. Safety rules & procedures must be regularly reviewed together with the workers (O'Dea and Flin, 2001; Choudhry et al., 2009). The findings from this study shall motivate site and top management teams to comprehend the importance of maintaining and improving safety performance. It is suggested that Safety Rules & Procedures and Workers' Safety Behavior are imperative in the context of construction project because most site workers' working behavior and attitudes depends largely on the input of safety rules & procedures through safety training and safety awareness from the site safety management team. And the evidence revealed that these factors are vital components and integrated in the OHSMS environment.

The project manager needs to manage safety as they manage other function of the organisation such as production, maintenance, marketing and finance. They should also focus on providing up to date technology and review method statements to carry out works rather than just routine tasks by the workers.

7. Conclusions

Ultimately, these findings demonstrate that the implementing of SMP especially Safety Rules & Procedures and Workers' Behavioral Acts will promote better safety performance and project performance in OHSMS. These safety outcomes will impact different dimensions of business performance, such as accident-free workplace environment, which resulted in minimizing the risks of production delays. It assures productivity in a well-organized work organization, and generating long-term benefits both to the work force and organization. It also helps to create company competitive advantages and financial gains for the project. This suggests that top management and project manager ought to use this framework as a mechanism to improve overall business operations. The prime objective guiding this study was to examine the roles of good safety measures practices in OHSMS company and its effects on project performance.

This research significantly recognises that both safety rules & procedures and workers' safe behavioural acts are crucial strategic components that not only augment a safe workplace, but also help to create better safety performance, company competitive advantages and sound business operation. Specifically, as a function of safety yardstick related to work accidents, the implementation of an effective safety rules & procedures helps to cultivate workers' safety awareness and behaviour.

The findings from this study provide significant insight for the construction project site, specifically concerning the improvement of company image and reputation and ultimately the business goal of financial gains. It is proposed that project managers should apply this framework as a system for improving safety at site as this will eventually improve the business operations. The outcome of this study revealed that the impact from the implementation of the safety framework is not unfounded. It has proven that it can be a long-term strategic tool for achieving business objectives beyond safety outcomes. Notably, these research findings serve as a benchmark for project managers in formulating and implementing effective safety strategies in the company. The primary purpose is to boost project profit margin, to better handle with ease the excessive authority compliances, to address the intense competition within the construction industry, and to maintain sustainability in the long term.

7.1 Practical Applications

The research findings presented in this study affirm that there was a strong and significant interdependence between variables in the construction industry in the State of Selangor, Malaysia. This has resulted in several important practical inference for both the management and authorities towards the essential and effective implementation of SMP.

Ultimately, from a managerial perspective, practising SMP within an OHSMS is vital for the success and survival of a project. A well improved and effective OHSMS settings assists the project to maintain an accident-free workplace and be able to avoid an inferior public image. The management team and Person-In-Charge (PIC) must fully understand and acknowledge the essence and objectives of OHSMS compliances. At the project level, the safety management team needs to ensure improvement of safety behaviour of the individual workers and interrelationship within the group through safety induction courses, tool box meeting and specified training for non-standard method of construction.

It is recommended that top management set aside business allocations for safety management and integrate with other functions, budgets and strategies.

Furthermore, the evidence disclosed from this study revealed that safety performance was an obvious and a very effective means to uphold company competitiveness and to improve financial gains. In view of the importance of safety performance, the project manager or PIC are recommended to recognise the need to upkeep and upgrade product quality (due to systematic, cohesive workforce) through productivity (because of accident-free workplace, less absenteeism) via innovation of work processes. The project manager needs to manage safety besides the other functions of the organisation such as production, maintenance, marketing and finance. They should also focus on providing up to date technology and review method statements to carry out works rather than just routine tasks by the workers.

As for the context of compliance to Occupational Safety and Health Act (OSHA), this study ought to provide a good perception to authorities such as DOSH(Malaysia) and CIDB that the safety issues and methods executed by the contractor are above the compliances of the OSHA

acts and regulations. It is suggested that the safety management team members should demonstrate excellent efficacy in safety issues especially safety rules & procedures in relation to the construction methods employed in the project. In order to gain confidence from officers from DOSH(Malaysia) and CIDB, particular attention should be paid to the technical skills and professionalism in carrying out the jobs. This would minimise disruptions of the project due to unwanted conditions imposed by the authorities.

Acknowledgement
The authors would like to thank the UTAR for providing the supports for this study.

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